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This document has been prepared by Terry Matilsky, Professor of Physics at Rutgers University. For almost 40 years, he has been funded by NASA and other federal agencies to do data analysis from various scientific satellites; to examine what information tells us about a phenomena, and draw rational and solid, scientific conclusions from them.

In the course of his career, he has testified on several occasions as an expert witness concerning various laws of physics and their environmental effects, most recently in March, 2005, when he was requested to appear in front of the Vermont Public Service Board concerning matters of ice throw from Wind Turbines. His CV appears at the end of this paper as Appendix A.

As problems have developed from world-wide installations of large scale wind turbine generators, study has begun on many previously ignored environmental and health concerns. These studies have yielded much data that can be used to assess the impact of proposed installations, and thus assure that these installations be sited correctly, with due understanding of the potential negative effects that such installations will entail. They come primarily from universities, where there is less economic incentive to overlook potentially important phenomena.

Being able to calculate sound levels and probabilities of ice throw from physical models is a huge advantage over doing measurements, but a physical model is never the same as reality. If the model is incorrect, large discrepancies can exist between what is measured and what is predicted. This is the case with wind turbine sound, where very relevant atmospheric and climatic behavior has been ‘overlooked’.

The following is a detailed appraisal of Ecogen’s section **3.7 Noise impacts** and section **3.10.1 Ice Shedding**. For your convenience, I am presenting each comment that requires an answer with a sequential number and a bullet, to aid in your preparation of responses. For noise impacts, there are **28 POINTS** needing action, and for ice shedding there are **6 POINTS** needing action, for a total of **34 POINTS** requiring action.

3.7 Noise Impacts

- **1** On page 3-90, it is stated that "increases in ambient and background noise levels are expected during the warmer seasons…"

This is NOT true. It ignores the presence of radiative cooling[i,ii,iii,iv,v,vi] an effect which has been shown [1,2] to systematically and dramatically change predicted noise impacts from wind turbines. When ignored, faulty models systematically underpredict actual noise levels at the surface of the Earth during times of stable atmospheric conditions that prevail during clear nights. When explicitly included, the models adequately represent actual measurements for many different situations, and can thus be utilized for predictions. The most important consequence of this phenomenon for our purposes here is the fact that the wind profile changes from the standard logarithmic variation of speed as a function of height. This steepening of the velocity gradient has the consequence that extremely quiet background conditions can prevail near the ground (because the wind is calm at zero altitude), while winds aloft are sufficient for the turbines to be operating at peak noise levels. In fact, it is to be expected[vii,viii] that these effects will be most prevalent in the summer months, which were NOT studied at all by Ecogen's noise program. However, as we shall show later, there *are* a few instances of radiative cooling in Ecogen's data from the winter of 2004-2005, which can be used as minimal examples to demonstrate what the real effects of turbine noise generation might be like. ISO 9613, the "standard" that Ecogen uses, is known to be antiquated, and in fact, is currently being revised by the International Standards Organization.[ix] It has already been called into question by groups studying everything from firearms noise[x] to attenuation of aircraft noise at airports.[xi] It explicitly does *not* take into account radiative cooling effects. **Ecogen must present wind data obtained during the summer months and explicitly take into account radiative cooling in their models before it can adequately assess ANY predicted noise impact from their proposed installation.**

Although I have cited over a half dozen references concerning radiative cooling, many more could be found with a minimum of effort. Indeed, this phenomenon is *so* widely known, explaining everything from sound propagation over land-water boundaries[xii] to understanding the calling distances of the African elephant[6], that it is truly remarkable that no mention of this ubiquitous phenomenon is made in *any* noise document associated with wind turbine development proposals. Certainly NYSDEC is familiar with this effect, stating in their guidance paper: "Temperature inversions may cause temporary problems when cooler air is next to the earth allowing for more distant propagation of sound."[xiii] It would be a good idea for SCIDA to thoroughly familiarize itself with this effect, as it will be of profound importance throughout this discussion.

- **2** On page 3-90, and Appendix F, page 28, the SPLs for the turbine prediction impact is given. **Where did these numbers come from?**

It is well known, even from staunch wind turbine advocates, that manufacturers are not providing representative values for their machines.[xiv] A quotation from Reference 14 presents the problem:

The discussion came to concentrate on how to certify the manufacturers specifications. When measuring noise emission from prototypes the conditions are often perfect and the prototypes optimised. The noise level will therefore most probably be as low as it can be for that type of turbine. An emission level of about 2-3 dB compared to more realistic conditions is quite common. Some authorities also always assume that the turbines will emit 2-3 dB more than stated while others warn developers who are to close to the regulation limit that measurements will be done after the installation. There is also an ageing effect that needs to be considered; a wind turbine will often emit more noise some time after the installation.
Today the manufacturers often only measure on one turbine. If they measured the emission from 2-3 turbines the result could be a bit more accurate but the measurements would still be done at unrealistic conditions. Franco Guidati suggested that an artificial roughness could be applied to the blades to obtain a more correct emission. Random measurements during the production are also an idea.
It was concluded that it would be beneficial for both the manufacturers themselves and others to know the production uncertainty for emission from wind turbines.

- **3 Ecogen must address the added noise levels expected for non-optimised and aging turbines.** A simple trip to an existing installation such as Fenner amply demonstrates the fact that some towers are significantly noisier than others.

3.7.1 Existing Setting for Noise

- **4 Missing Data**--- Even though 7 receptor locations were included in their 'study', calibration data for only 4 sound level meters and 3 FF microphones were provided. Some of the meters were used in different locations on different days, but we still do not have calibration curves for one of the microphones. It is unaccounted for in appendix F-2. **Given the problems with the equipment stated on page 14 of Appendix F, we need to see the results of ALL calibrations.**

- **5 Missing Data---** Ecogen states that they used 3 towers to measure wind speed. Yet there are no separate plots of what speeds these towers measured. So we really have no idea of the true correlation between measured wind speed, and ambient noise levels (and hence turbine impact) at each location. The vast area of this proposed project requires a better understanding of the range of wind speeds that might be expected at any given time. Furthermore, if this variability is significant, it would likely increase the times when turbine noise will be at a maximum, while ground level noise will be a minimum, *even beyond* those times predicted by radiative cooling effects. Furthermore, it has been shown[2] that in a stable atmosphere the turbines run almost synchronously, because the absence of large scale turbulence leads to less variations of rotor blade speed. Thus, coherence effects and beat phenomena (both ignored by Ecogen) will exacerbate the noise levels predicted by Ecogen. This variability data can show us what we might expect for the coherent sounds that would be produced by the turbines. **All these additional sources of noise are ignored entirely by Ecogen.**

- **6 Missing Data**--- Ecogen has omitted all sound level measurement data from 6652 Baker Road. The data must exist, because they have presented analysis in Appendix F-5, pages 5-37 to 5-39. Furthermore, these data would show the effects of radiative cooling most clearly. The reason for this is that this location included measurements for **two** radiative cooling events, on Dec. 21 and Dec. 28, 2004, while some other dates when a neutral atmosphere was present were not recorded. Thus, this data is less subject to the faulty regression analysis supplied that essentially masks this effect (and is documented below in **Points 17 and 18**). Notice the graph #113 on page 5-38. Note the large number of points from 8-11 m/s that are as much as 12 dB above the regression line, which is what Ecogen claims the effect of the turbines will be. Even *without* selecting the data on the basis of the presence of radiative cooling**, we see here concrete evidence of noise far in excess of that claimed by Ecogen.** Their faulty analysis will be discussed below. For now**, it is imperative that wind speed/ambient noise vs. time data be provided for 6652 Baker Road so that we can adequately assess the impact of these machines.**

- **7 Missing Data**--- No third-octave raw data of measured wind speed vs. ambient noise levels is provided for **any** of the locations. Again, the regression analysis charts are presented for third-octave results, so the data must exist. Only with the third-octave data can we adequately assess the effects of tonal noise on the ambient sound spectrum. From their impact noise model, Ecogen explicitly ignore "tonal" components, although it is quite clear that these components do exist at wind turbine installations[xv,2]. It is well known that tonal noise is far more intrusive than would otherwise be the case for their level intensities. (see for example, Ref. 3, Chap. 3). **You must have the third-octave raw data to adequately assess the impact of narrow bandwidth tonal noise.**

3.7.2 Assessment of Noise Impacts

Errors and Omissions in Analyses

- **8 Regression Analysis- General---** Ecogen fits a single polynomial to their noise analyses of Appendix F-5. It is deceptive to quote such a fit without a discussion of a "goodness of fit" criterion, such as a standard deviation, σ. Without such a discussion of standard deviations and correlation coefficients, it is impossible to estimate how well the chosen polynomial models the data. Yet no mention is made of this in the document. Moreover**, by lumping together a mass of data for wind speeds less than 7 m/s, they effectively mask the impact of the turbines by as much as 30 dB, as we will see shortly in the third-octave data below.** The polynomial is **unweighted**, so it essentially ignores the points that are most relevant for when the turbines are operating at speed. However, we can see the effects in the most of the graphs displayed in Appendix F-5.

- **9 Figure 7- Noise Underestimated by ~30 dB** See the deviation from the regression line of the set of points from 7-11 m/s.
- **10 Figure 8- Noise Underestimated by ~30 dB** See the deviation from the regression line of the set of points from 7-11 m/s.
- **11 Figure 9- Noise Underestimated by ~25 dB** See the deviation from the regression line of the set of points from 7-11 m/s.
- **12 Figure 17- Noise Underestimated by ~20 dB** See the deviation from the regression line of the set of points from 7-11 m/s.
- **13 Figure 18- Noise Underestimated by ~20 dB** See the deviation from the regression line of the set of points from 7-11 m/s.
- **14 Figure 35- Noise Underestimated by ~20 dB** See the deviation from the regression line of the set of points from 7-11 m/s.
- **15 Figure 36- Noise Underestimated by ~15 dB** See the deviation from the regression line of the set of points from 7-11 m/s.
- **16 Figure 53- Noise Underestimated by ~25 dB** See the deviation from the regression line of the set of points from 7-11 m/s.
- **17 Figure 54- Noise Underestimated by ~20 dB** See the deviation from the regression line of the set of points from 7-11 m/s.

These are merely representative selections; this effect can be seen in most of the presented "impact" graphs of Appendix F-5. Note that these values are really **lower limits,** as they are selected as deviations from the regression line, and **not** from the lower background levels measured during times of radiative cooling.

To see how radiative cooling might impact the raw data, go to page 19, Figure 71 of Appendix F-3. Starting at midnight, the wind is blowing at about 12 m/s at the height of the met tower, yet the background noise levels are near 20 dB, quiet enough to hear a pin drop (if it weren't for the presence of wind turbine noise). Another example of this is in

Figure 77, page 21. At about 18:00 (when the effects of radiative cooling are expected to start), the wind speed rises to 14 m/s (about 40 mph) and yet the background noise levels are **dropping** at the same time.

- **18 These effects are typical of what might be expected on a large scale in the summer, due to radiative cooling. Moreover, these examples are virtually ignored by the Ecogen analysis due to their faulty regression analyis. What needs to be done is separate out the times when this effect is dominant (at night, in a stable atmosphere), and look at the results separately.**

What you will find are resultant differences yielding even **greater underestimates** than those shown above, because your background measurements will be lower due to the wind speed profile deviating from the assumed neutral, logarithmic increase typical of daylight hours. Thus, the background levels are depressed, while the turbines are spinning and producing more than 104 dB.

- **19 Regression analysis—Systematic Error** In Appendix F-5, Ecogen uses the L_{90} background levels to compute their impact regression polynomials. This would represent the **lowest** turbine impact value, as it uses as a baseline all data above the 10% lowest values. But then, unbelievably, in Table A of Appendix 8, they choose to subtract the $L_{A,eq}$ background values to report the excess noise produced by the turbines. This, of course, lowers the actual excess by the difference between the $L_{A,eq}$ values and the L_{90} values. Basically, what Ecogen has done here is show the minimal impact of turbine noise, while characterizing the pre-existing noise levels at their receptor locations with a higher overall value in the absence of the turbines. A pretty neat trick that works out to an **underestimate of anywhere between 5-20 dB, depending on location**, as you can readily see by looking at the raw data from Appendix F-3, where both sets of data (L_{90} and L_{eq}) are plotted as function of time. Please note that these are **broadband** values, so they **directly** yield noise impacts that are miscalculated by 5-20 dB. Perhaps Ecogen actually used $L_{A,eq}$ values for their predicted impact, and merely “mislabeled” their plots somehow. But then why do they show **only** the L_{90} curves in Appendix F-5? Just presenting a packaged set of 5 values for L_{eq} listed in Appendix F-8 is insufficient. Where did those numbers come from?

- **20 Coherence effects are completely ignored**--- The proper equation for adding multiple sources of sound must include the possibility that the sound adds coherently. Indeed, this is *precisely* the case with wind turbines. Every single time the blades pass the tower, a “swish” is clearly heard. A trip to an installation like Fenner demonstrates this dramatically. For example, for two towers, we get:

  $$P_T^2 = P_1^2 + P_2^2 + 2P_1P_2 \cos(\beta_1-\beta_2)$$

  This third term adds 6 dB to the incoherent source values. More towers will add even more noise. These effects can **dominate** the sound spectrum at various positions relative to the turbines.[2] In Rhede, Germany, because of the synchronization of the blades in stable atmospheric conditions, it was found that as much as 10 dB more sound was produced in this manner. Fortunately, you don't have to go to Germany to observe this effect. On a trip to Fenner on June 7, 2005, a group of observers could clearly hear these effects at distances up to 1 km. It was a clear night, typical of this glorious Spring, and if we had measuring devices at our disposal, they undoubtedly would have shown that we were in a stable atmosphere indicative of radiative cooling. Indeed, if we had persisted and gone even further, it is certain that sound from these machines would have been heard beyond this distance. Subjectively, there was little or no diminuation in sound level as distance increased. For a large installation, these results will be catastrophic. Even at Rhede, (a very small installation of 10 turbines) the excess sound "did not decrease with distance, but even increased 1 dB when distance to the wind farm rose from 400m to 1500m."[2] Thus, we can expect significant impact from this phenomenon at distances in excess of one mile from the nearest turbines. This will be exacerbated by the fact that Ecogen's site selection contains random clusters of 10-15 turbines, which will have the effect of having **multiple** turbines adding phases coherently, with little diminuation as a function of distance. Those who visit a wind turbine in daytime will usually not hear this and probably not realize that the sound can be rather different in conditions that do not typically occur in the daytime.

- **21 Impulsive "Tonal" character of noise is ignored---** It should be obvious by now that wind turbine sound measurements must take into account atmospheric stability. At least some of the problems that have been examined throughout the world are due to modulation effects that alter the steady component of noise. Human perception is most sensitive to modulation frequencies close to 4 Hz with a sound frequency of 1 kHz.[2] This is very close to the characteristic sound measured near Rhede and is typical of all wind turbines, including those proposed by Ecogen. The spectrum is that of a beat frequency due to each blade passing the tower at about 1 Hz**.** Pulse-like character of noise was not expected. Yet that is what was found.[1] This is because when measurements are made at a single turbine, there is no effect. You need at least two turbines to produce the beats observed.

  Moreover, NYSDEC states: "In determining the potential for an adverse noise impact, consider not only ambient noise levels, but also the existing land use, and whether or not an increased noise level or ***the introduction of a discernable sound, that is out of character with existing sounds, will be considered annoying or obtrusive."*** [xvi] *This is certainly in keeping with accepted principles of psychoacoustics, and reflects the well known facts associated with sounds that possess identifiable patterns and frequencies.*[15]
  Ecogen needs to calculate these impacts during times of atmospheric stability and explicitly take the tonal character of wind turbine sound into account.

- **22 Erroneous depiction of ambient conditions and changes---** Section ***3.12 of Appendix F, page 5***, *states,* "As wind increases, the noise emission from the wind turbines will start to rise as will the ambient noise levels at a receptor location. However, this rise in ambient levels at the receptor location is dependent upon the nature of the topography and ground cover in the vicinity of the receptor. Specifically, if the location is exposed and has little ground cover, i.e., trees and bushes, then ambient noise levels will rise quickly with wind speed. Whereas, a location which is sheltered by topography from the prevailing wind will have a reduced rate of increase of ambient noise with increasing wind speed." **This is simply untrue on clear nights, especially in the summer time. Ambient noise will not rise, ANYWHERE, during these conditions. Indeed, it was shown to be untrue in the data cited above after POINT 17. Thus, Ecogen's own data contradicts their claim. The scientific community would be quite eager to see more data like that shown on Figure 71 and Figure 77 of Appendix F-3. The nights of Dec. 21 and Dec. 28, 2004 clearly exhibit this phenomenon of ambient noise falling and/or low, while winds aloft are considerable. We would encourage Ecogen to undertake a study of this effect for the benefit of all concerned.**

However, one *does* wonder why Ecogen ignores very real topographical issues that exacerbate the sound levels that will occur in the proposed area. This is dealt with below.

- **23   Topographic effects ignored---** Sound propagation to distances of several kilometers is relevant for prediction schemes for noise around airports or other loud sound sources. **At 104 dB, the wind turbines are producing more than the noise equivalent of a jet flying overhead at an altitude of 1000 feet.**[xvii] Thus, this is definitely an appropriate context to examine this issue. It is known[5] that topography and meteorology are more important than at shorter distances. At Vancouver Airport[xviii] a ridge of hills rises 100m above a flat plain, starting at about 4 km from a major runway, and running parallel to it. **Sound spectra were obtained, with the result that at 5500m. , the sound levels had *increased* at least 20 dB compared to those at 4000m! This is because increasing angles at the ground surface reduced phase changes on reflection, which more than nullified the expected 3 dB decrease that would occur due to increasing distance. Thus**, **ground waves and perhaps a trapped surface wave are important.** Moreover, changing meteorological conditions can easily cause fluctuations in sound levels by 10-20 dB over time periods of minutes.[xix] The longer the transmission path, the larger are the fluctuations in levels. **Ecogen must take these variables into account.**

- ***24 Model inadequacy vs. NYSDEC Guidance---*** NYSDEC Environmental Analyst, Rudyard Edick, who was the DEC representative dealing with the Ecogen Prattsburgh project sent an email to Tom Hagner of Ecogen, LLC and SCIDA in which he said the following:

"First of all, in order to determine noise levels at the property lines of non-leasing land owners, it would be necessary to do an assessment of the noise generated by each SPECIFIC (Mr. Edick's emphasis) turbine with respect to the surrounding vegetation, existing structures, and topography…Ecogen, uses a computer model to predict noise levels with EACH (Mr. Edick's emphasis) turbine at its PRECISE (Mr. Edick's emphasis) proposed

location. The model would need to include attenuating and potentially channeling factors such as vegetation, existing structures and topography between the turbine and receptor (with receptor defined as nearest property lines of non-leasing neighbor)." ***Ecogen is not doing this. Even forgetting the fact that the precise locations have never been defined, their model explicitly does not include the dominant meteorological phenomenon that might lead to a proper assessment.***

- **25 Actual Expected Noise Impacts---** The above considerations amply demonstrate that Ecogen's data is inadequate and/or missing, and their analyses are flawed. However, independent data and analyses are available from turbine installations in Rhede, Germany[1,2] and Toora, New Zealand[xx], which fully document many flaws in the standard model used by developers (It should be noted however, that the unique topographic elements introduced by the proposed Prattsburgh project can only be addressed by Ecogen. These elements will only add to the level of impact, in ways that will be similar to **POINTS 22 and 23** given above.) **Data at these installations shows that the standard acoustic models (virtually identical to those used by Ecogen), underestimated noise present from these machines by at least 15 dB (a factor of 32).** Thus, instead of the 6 dB increase expected above background stated by Hayes-McKenzie in the DGEIS, **one can expect increases greater than 20 dB, a level that the New York DEC characterizes as "very objectionable to intolerable."** [xxi] Note that this value is consistent with my heuristic attempts to calculate approximate impacts in the absence of vital data that Ecogen chose to omit. Moreover, it has been shown [xxii] that at dwellings where the sound level due to wind turbines exceeded 35 dB(A), 16% of 128 respondents reported sleep disturbance by this sound. According to Ecogen's Appendix F-8, **this value will be exceeded even with 880m. setbacks.**

- ***26 Mitigation---*** *In a letter dated November 16, 2004 to Al Wordingham from James Sherron, Executive Director, SCIDA, Mr. Sherron goes on record: "Confirming SCIDA's position relative to any environmental recommendations made by the DEC let me simply state that SCIDA will adhere to such recommendations." Given this, setbacks of 225m. are grossly inadequate. To bring noise levels down to 6 dB, given the excess stated above, requires approximately a factor of 6 increase in distances.* ***Thus, the minimal value for setbacks should be 1350m.*** *However, the simple reliance on the inverse square law is not appropriate here, The source of the dominant low frequency noise ("blade swish") does* ***not*** *behave like a point source. It results from a* ***line*** *disturbance that runs the length of the tower as the turbine blades pass at high speeds. Line disturbances propagate as 1/r instead of* $1/r^2$*. This is undoubtedly the reason these objectionable sounds persist over large distances and are the subject of much concern in other installations.* ***Thus, even 1350m. setbacks will be insufficient to comply with NYSDEC guidelines.*** *Ecogen claims (p. 2 Appendix F)* ***"To use the collected noise data to determine acceptable set back distances between sensitive receptors and the proposed wind turbine to be consistent with the requirements of the New York State Department of Environmental Conservation Policy Document for noise assessment." If this is to be the case, SCIDA needs to have them adhere to greater than 1350m. setbacks for this project. Exact requirements will be dependent on turbine placement geometry. This is also ignored by Ecogen.***

- ***27 Mitigation---*** In section 3.7.3, page 3-96 main text DGEIS, Ecogen says *"As with the daytime condition, even though the change in ambient levels may exceed 6 dB, the* *absolute level of noise associated with WTG operations is not intrusive." They are correct! They are not intrusive; instead, the changes are* ***"Very Objectionable to Intolerable."*** [20] **Ecogen's approach is neither consistent with nor supported by the DEC Guidance and is therefore unacceptable. If SCIDA is to uphold the NYSDEC Guidance, they cannot allow Ecogen to produce excessive noise level increases.**

- ***28 Expected Community Response---*** *In the University of Massachusetts White Paper (ref. 15 p. 7), it is stated that:*

  "A change in sound level of 5 dB will typically result in a noticeable community response."

  "A 6dB increase is equivalent to moving half the distance towards a sound source."

  "A 10dB increase is subjectively heard as an approximate doubling in loudness, and almost always causes an adverse community response."

  Allowing Ecogen's project to proceed as proposed will <u>guarantee</u> that you have an extremely disgruntled, sleepless population covering a vast area in Steuben and Yates Counties. How will SCIDA address these complaints?

ANALYSIS OF ICE AND ROTOR THROW FROM WIND TURBINES

PART I---basic kinematics

The calculation provided below demonstrates that:

ICE, DEBRIS OR ANYTHING BREAKING OFF THE WIND TURBINE BLADES (including the blades themselves) CAN IMPACT A POINT ALMOST 1700 FEET AWAY FROM THE BASE OF THE TURBINE… This is dependent on which model wind turbine you examine. Details follow using parameters from GE wind turbines that Ecogen is proposing.

WHAT WE KNOW:

RADIUS OF BLADE: OVER 100 FEET
ROTATIONAL SPEED: UP TO 1 REVOLUTION EVERY 3 SECONDS (OR ABOUT 20 REV/MIN)

PRELIMINARY RESULTS:

ROTOR TIP SPEED:

IN ONE REVOLUTION, THE BLADE TIPS SWEEP OUT A CIRCLE WHOSE RADIUS IS OVER 100 FEET. THIS DISTANCE IS $2\pi R$ OR ABOUT 628 FEET. IF IT TAKES 3 SECONDS TO MOVE THIS DISTANCE, OUR SPEED IS 628/3 FEET PER SECOND. THIS IS ABOUT 210 FEET/SECOND OR 150 MPH.

When you do the mathematics in detail, you find that launching the fragment horizontally is NOT the worst case scenario for maximum horizontal range. (LAUNCHING FROM THE TOP OF THE TURBINE (horizontally) YIELDS A RANGE OF SLIGHTLY MORE THAN 1000 FEET.) Instead, this maximum distance occurs when debris is released with the blade at a 45 degree angle from the vertical.

Imagine the blade at 45 degrees from its vertical position. At this point, the projectile will be launched about 70 ft. from the horizontal position of the hub. (This is 100 times the cosine of 45 degrees). Also, it will be about 70 feet higher (vertically) than the hub. (Again, we assume that the blades are 100 ft. in length). Thus, the vertical distance it has to fall is 300 feet (hub height) plus 70 feet (vertical distance that the piece of ice, or whatever, is from the hub).

Now, the range for this projectile is:

$R= v^2/g$

This is the range to come back down to the ORIGINAL vertical height. So after this distance, it is BACK at 370 feet off the ground.

R=(210 ft/sec x 210 ft/sec)/(32ft/sec/sec). or about 1400 ft.

Now, at this position, (neglecting air resistance), its vertical velocity is the same as when it was launched (except that it's now going DOWN instead of up). So, the vertical velocity is about 140 ft/sec. (210 x .7 or v cos 45)

The extra time it takes to fall to the ground from this height is:

$s= vt + 1/2\ g\ t^2$.

SO,
$370=140\ t + 16\ t^2$

Solving for t, we get about 2.5 seconds. In 2.5 seconds the increase in the range is:

$v(horizontal) \bullet t = 140 \times 2.5 \approx 350$ feet.

Thus, the TOTAL range of a projectile is: 1400 + 350 = 1750 feet. From this we subtract the 70 feet that the projectile was behind the hub when it was launched, and you end up with 1680 feet for the horizontal range from the base of the hub.

PART II---comments on inclusions of drag coefficients and risk assessment

1) Friction is NOT a fundamental force. What this means in practice is that any attempt to take into account air resistance in a description of ice throw can be fraught with model dependent errors. The drag coefficient usually quoted in wind developers' "papers" of 1.0 is totally inappropriate for the study. Variability in the Reynolds number is completely ignored. They assume a perfect ice cube of size = 4 inches. Then, they assume it always tumbles. But these are chunks of ice that are forming on propeller blades! Ice that forms on propeller blades tends to be shaped like propeller blades. And they can be QUITE aerodynamic (as are the blades). Any models employing ice cubes are at best, useless, and at worst, deceptive. Interestingly, when the chunks become larger, the Reynolds number increases, and viscosity becomes less important. What this means is that the larger, more dangerous chunks will tend to travel further than small ones.

Moreover, the study of "harvested" ice that is subjected to wind tunnel testing is likewise demonstrably without merit. The procedure is to break off chucks of ice, make molds, and then subject them to wind tunnel tests. But real ice melts. It changes shape. It becomes smoother. The "studies" ignore this, instead adopting a drag coefficient = 1.0 This is close to the drag that a half a tennis ball (say) would present if it were thrown into the wind with the open "cup" catching the wind at all times! A rather silly assumption, and one that is totally inappropriate. Ice is NOT like this. While the developers tout their results as being representative (decidedly untrue), they ignore MacQueen's 1983 study that concluded that a maximum range of 800m (about 2500 feet) was quite possible. Indeed, even a range of 2 km. (over one mile) was conceivable. Developers discount this because he "assumed that the ice 'fragments' were actually large flat slabs weighing perhaps 80 kg." Actually, he was modeling BLADE throw, another issue that seems to be ignored despite the fact that within the past year there has been at least one documented instance of this; an entire rotor blade broke off from the hub. (Wethersfield, N. Y.) Incidentally, as near as I can tell, the MacQueen study is the ONLY peer reviewed analysis for throw possibilities. The rest are calculations done by wind company employees and/or consultants.

2) I never claim my calculation to be anything other than a maximum calculation of distance, beyond which you don't have to worry. I am not usually accused of being conservative in many ways, but when it comes to human life, I suppose I am. Why worry when you can just adopt my calculation and not be concerned at all with tragedy in the future? Moreover, any risk assessment data is useless, since the calculations are not assuming an appropriate model to begin with! I remember when de-icing airplane wings was said to be unnecessary, posing no risk to public safety, and only after tragedy struck is it now "de rigeur" to do it (and do it carefully and thoroughly). All other mumbo jumbo is exactly that unless they get the basic physics right.

3) If you are going to invoke air, and air resistance, it is the height of deception not to include the effects of lift. Frisbees fly far. Why? Because of air. If you throw a frisbee facing the direction of travel, it will travel only a few feet. The drag coefficient is probably of order unity in this situation. If you sling it in the direction of travel, it goes very far. And rime ice, of course, will likely be shed from the rotors in a similar aerodynamic fashion. The wind companies assume that the fragment will tumble; thin blades of ice may not (as a frisbee does not, when properly oriented).

4) Throughout these discussions, the wind developers have been groping for setback distances that they can live with. They started with 1.5 times the ground-tip distance: about 150m. As near as I can tell, this was just pulled out of a hat. (In physics, we call this a "toy model".) Then, the distance was increased to 200m. in several " papers." Now, in a recent " paper", 400m is quoted. They are getting closer to my original number!

What about data? If you refer to the Atlantic Wind Test Site memo of March 27, 2002, they state:
"Summary---Following the moderate wind icing event at AWTS on March 27, 2002, fragments of ice, large enough to cause injury, have been observed being thrown from the turbine blades. Concerns over dangers of flying ice are legitimate. In 15 m/s winds, ice was observed to travel approximately 200m." Instead of recognizing this, companies present a figure from an utterly useless and anecdotal "questionnaire" that purports to show that ice throw is "unlikely" more than 100 meters from the site. This figure is a completely misleading representation of "data" that has been bandied about for years by developers.

5) In the beginning, the claim was that the rotor sensors would stop the blades because of ice buildup.   Now, even the papers put forward by the companies admit their error here. They state: "...rime ice formation appears to occur with remarkable symmetry on all turbine blades with the result that no imbalance occurs and the turbine continues to operate." Another failure of their initial assumptions and models.

In conclusion, there are some problems with wind turbines that have unavoidable consequences. Birds will die, bats will die. In these scenarios you NEED to adopt a risk analysis study. But here, YOU CAN ELIMINATE THE ENTIRE PROBLEM, if you just adopt a conservative value for your setbacks.

REFERENCE: J. F. MacQueen, et. al, IEE Proceedings, Vol. 130, Pt. A, No. 9, pp. 574-586 (1983).

PART III-Detailed commentary on Ecogen's Section 3.10

The four page presentation authored by Bruce Bailey, a consultant with AWS Truewind (!) is a rather bizarre document. In these pages, Bailey does little more that define rime ice and glaze ice, and then say that there is no problem. No data, no model, no analysis, no numbers, no nothing! The one quantity he estimates (rime icing potential at 4-8%) is so unbelievably naive that an intelligent seventh grader would cringe at its sight.

Fortunately, the Vermont Public Service Board (Docket 6911) contains hundreds of pages of testimony taken in March, 2005 (including that of Bruce Bailey) that shows conclusively that icing is indeed an issue in the Northeast, and one that many wind companies are starting to worry about.

- **29   Rime icing will occur more than 20% of the time, not 4-8% as quoted by Ecogen**

Bailey completely neglects the existence of Lake Effect phenomena which dominates the weather patterns in the Finger Lakes. This is the same effect that allows wine grapes to flourish in our area, while contributing to the severe icing events such as the one that occurred in Victor in 2003. **How can you ignore the biggest meteorological anomaly in the region, when you are talking about climate?** Could it be that Mr. Bailey had forgotten HIS OWN PRESENTATION at the March 2005 AWEA (American Wind Energy Association) conference in Boston, where he presented a slide that said: "Icing frequency increases sharply above 700 m. in elevation"?[xxiii]   [Note that the project's rotors will extend to 770m. on the highest points in Prattsburg.] This slide contained data in graphical format EXPLICITLY ATTRIBUTED TO NY STATE concerning icing frequency and cloud cover. **Cloud cover (and therefore potential icing conditions) at the relevant elevation is shown to be present 25% in the winter.** This data was taken from the Adirondack area, and Mr. Bailey implied[24] that the western areas of NY state closer to the Great Lakes are subject to even higher percentages of potential icing conditions. It is also true that weeks might go by in the winter where the temperature does not rise above freezing.

Anyone who lives in the Prattsburg area knows that these ridges are embedded in fog a large part of the time. Indeed, the intersection of Block School Road and Route 53 is notorious for signposts being knocked down during fog, and cars routinely go off into ditches as they round the curve at the summit, due to the inability to see through the heavy fog.

Of course, in Vermont, where Mr. Bailey testified, he claimed that you didn't really have to worry about the New York data, because "…after crossing the Great Lakes, they [NY] generally have a higher frequency of low level clouds."[xxiv] Thus, he claims that in Vermont the clouds have lost their moisture from passing over the Adirondacks, while in Prattsburg he just uses the Adirondack data, without ever mentioning the higher moisture content in the atmosphere near the Great Lakes. It doesn't take a rocket scientist to observe the weeks that sometimes transpire with continual cloud cover in our region due to Lake Effect conditions. **Ecogen must explicitly use data indigenous to the region to estimate their icing potential. Any other data are misleading at best, and deceptive, at worst.**

- **30 How will Ecogen deal with icing events?**

There are two alternatives that are possible in icing conditions: either keep the windmills shut down until the ice melts, accepting the reduction in electrical production that this implies, or risk ice throw from the site that will have real potential to damage people and property, without adequate setbacks. Given this situation, why does Ecogen say nothing about the consequences of icing in the DGEIS report, other than stating in Appendix G, p.3: "The impacts of icing on wind turbine performance are expected to be minor at the Project." Yet Bruce Bailey states in his summary slide of his AWEA presentation: " Icing reduces turbine output and has real and perceived public risks."?[xxv] **Given the now standard practice of remote operation, how will Ecogen know when to stop the turbines. And how will they know when to restart?**

- **31 The duration of icing events is incorrectly calculated**

On page 3 of Appendix G, Mr. Bailey states: "In most cases, icing impacts on production are expected to be short-lived (less than 24 hours) due to improving weather conditions." This is utterly absurd and without any merit or data to back it up. During the winter, in Prattsburg, it is often **weeks** before the temperature rises back up to 0^{o} C. The ice will stay on the turbines until it melts, unless the machines are restarted during unsafe conditions, which is what is usually done. **Ecogen must provide legitimate data to calculate a realistic estimate for icing event duration in the region.**

- **32 Ecogen ignores completely the problems associated with rime ice buildup. Specifically, what are their criteria for stopping and restarting the turbines? Where is their assessment of economic impact during these times of idle machinery?**

Even the industry consultants have now acknowledged that these risks are real. Garrad Hassan, Inc. (a major player in the industry consultant business) acknowledges that the standard industry responses to problems associated with ice used to be:
 Ice can only form on a stationary rotor as blade flexing prevents formation during operation.
 Ice formation on an operational turbine will set off a vibrational trip halting the turbine.
 As a consequence of the above points, ice will only be thrown off when the turbine initially starts up and the risk is restricted to an area immediately beneath the turbine. He then goes on to say: "**The observed data later presented in this paper casts some doubt on the accuracy of these claims. As regards preventative action, the only steps so far discovered are the use of public warning signs."** [xxvi] Further on, he even admits:

"There is significant evidence that rime ice continues to form when the turbine is operating and is not shaken off by blade flexing, even though this may be the case for other types of ice formation. Also, rime ice formation appears to occur with remarkable symmetry on all turbine blades with the result that no imbalance occurs and the turbine continues to operate."

In other words, the problems are real, and the problems must be addressed. **Ecogen says NOTHING about this in their report.**

- **33 Amount of potential ice throw fragments are not calculated by Ecogen**

In testimony filed with the Vermont Public Service Board, a spokesman for Garrad Hassan acknowledged that his firm calculated that a total mass of 400 kg. of ice is shed per year **per turbine** when there are 5 days per year of rime icing conditions. [xxvii] Let us see what that implies for Ecogen's proposed project. Let us for the sake of this calculation adopt their absurdly low estimate of 6% icing between November through April (Ecogen's estimate for "winter" conditions). This yields 11 days of icing in the area. Thus, each turbine will produce 4400 kg. of ice shedding per year. 50 turbines will produce 220,000 kg. of ice each year!

Garrad Hassan always assumes in their assessments that a typical ice fragment has a mass of 1 kg. **This means that even using the industry's own data, there is the potential for 220,000 ice throw events each year from the proposed project. Ecogen ignores any consequences from this entirely, even assuming their unrealistically low estimates of icing frequency.**

- **34 No setback criteria are given to take into account ice and blade throw.**

In 2002, turbines in Prince Edward Island were restarted with knowledge that there was still ice on the blades. Operators observed ice fragments being thrown. "Summary---Following the moderate wind icing event at AWTS on March 27, 2002, fragments of ice, large enough to cause injury, have been observed being thrown from the turbine blades. Concerns over dangers of flying ice are legitimate."[xxviii] Yet the industry is unwilling to look at this problem in depth, and report actual occurrences and distances to allow the public to see the actual impacts.

Given the recent disaster in Oklahoma, and problems with brand new turbines in Illinois and elsewhere around the world, it is important to examine the possibility of blade failure and throw. In New Zealand in March, 2005, out of balance forces on the rotors caused the gearbox and rotor to snap off and fall to the ground.[xxix] **Hundreds of accidents** at wind turbine sites have occurred and have been documented[xxx] including **blade throw events with distances traveled in excess of 1500 feet.** Recently, a rotor blade blade broke off from the hub in Weathersfield, N. Y. These events happen with regularity.

In this context, it is useful to explore what distances may be expected from blade throw accidents. MacQueen's 1983 study concluded that a maximum range of 800m (about 2500 feet) was quite possible.[xxxi] **Ecogen must address these concerns with adequate setbacks.**

In summary, If SCIDA accepts this draft GEIS, they will be accepting a document that is demonstrably false and deceitful, contrary to known facts and data, harmful to the population and will be forsaking their stated mission to advance the general prosperity of the people of Steuben County.

APPENDIX A

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EDUCATION

B.S.	Astronomy, University of Michigan With honors and distinction, Phi Beta Kappa	1967
M.A.	Astrophysical Sciences, Princeton	1969
Ph.D.	Astronomy, Princeton	1971

POSITIONS

Senior Scientist American Science and Engineering Cambridge, MA	1971-1973
Project Scientist (UHURU X-ray Satellite) American Science and Engineering Cambridge, MA	1973-1974
Research Staff, MIT	1974-1976
Assistant Professor, Rutgers University	1976-1981
Associate Professor, Rutgers University	1981-
Director, Rutgers College Honors Program	1989-1996

<u>CONSULTING, ETC.</u>

Harvard-Smithsonian Center for Astrophysics	1978-
NRL Astrophysics Division	1981-
NASA Headquarters Satellite Selection Committee	1981-
General Electric Space Shuttle Committee	1981-1984

REFEREED JOURNAL ARTICLES

Radiative Lifetimes of Ultraviolet Transitions of Argon II, Terry A. Matilsky and J.E. Hesser, J. Opt. Soc. Am. 59, 579-582 (1969).

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BOOK AND MAGAZINE ARTICLES

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IUE Observations of Blue Horizontal Branch Globular Clusters and UV-Bright Stars, in the Future of UV Astronomy: Six Years of IUE, 1985.

Hot Stars in Globular Clusters: spatial Reslution Studies with IUE, in Proceedings of IAU Colloquium #95, 1987.

RECENT PRESENTATIONS (INVITED AND CONTRIBUTED)

1. Exploring the X-ray Universe using Chandra and DS9. Paper presented at AAS meeting, San Diego, California, January, 2005.

2. "X-ray astrophysics research in high school" invited seminar at Rutgers University, George Pallrand Colloquium Series. May 2002.

3. "Using technology to conduct authentic research in a high school" paper given at Computers and Advanced Technology in Education (CATE 2000) IASTED International Conference, Cancun, May 2000.

4. "Astrophysics research by high school students" , paper

given at National Convention of the American Association of Physics Teachers, Rochester, NY, July 2001.

5. “X-ray research: An Unbelievable Story of What High Students Can Do.” Presentation in the Department of Physics and Astronomy, Rutgers University, October 1999

6. “Astrophysics Summer Institute: A model for introducing research to high school students” paper given at the national convention of the American Association of Physics Teachers, Trinity University, San-Antonio, Texas, August 1999.

7. “Astrophysics research by high school students” paper given at the National Science Teachers Association Convention in Boston, Massachusetts, March 1999.

RECENT INVITED WORKSHOP PRESENTATIONS

1) Chandra Summer Workshop (five days), Medford, Mass. 6/05

2) Chandra Summer Workshop (three days), Cambridge, Mass. 8/04

3) Chandra Summer Workshop (8 hours), Cambridge Mass. 7/03

4) Short Course for the National Science Teachers Association, (4 hours), Portland Or. 11/02

5) 4 hour Short Course for Space Science XVII: Cosmology Workshop, Tufts University, 6/02

6) 4 hour workshop, “The Chandra X-ray Observatory”, AAPT, Philadelphia, 1/02

7) Tufts Space Science Workshop, (4 hours), Somerville, MA 6/01

RECENT INVITED TALKS
TALKS AT INTERNATIONAL MEETINGS
TELEVISION APPEARANCES

Observations of 4U 1700-37 Using SAS-3, Innsbruck Austria. Meeting of the COSPAR Division of the International Astronomical Union.

“Order From Chaos” with J. Ostriker and N. Bahcall WNET, 1980. (Also made into a movie distributed to high schools in the N.Y.-N.J. area).

New Eyes on the Universe: Astronomy from Satellites, American Museum of Natural History and Hayden Planetarium, N.Y. 4/80.

Life on Other Planets? A symposium at Stevens Institute 5/80.

X-ray Observations of Quasars, University of Pennsylvania 1/82.

X-ray Observations of Quasars, Naval Research Laboratory 4/82.

New Light From Old Objects, Union College, 4/82.

200 Second Variability from a Quasar, Harvard University, 3/83.

Observational Cosmology and the Centaurus Cluster of Galaxies, Harvard University, 1/84.

Observational Cosmology and the Centaurus Cluster of Galaxies, Rutgers University, 10/84.

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Observational Cosmology, Princeton Astronomy League, 1986.

The Big Bang and Other Creation Myths, A. A. I., 1986.

“CURRENTS” WNET-TV, Professors and the Pentagon, 1986.

Chaos in the X-ray Sky?, Naval Research Laboratory, 5/87.

The Big Bang and Other Creation Myths, Princeton Astronomy League, 1988.

“Morton Downey Show” WOR-TV, Is College Worth It?, 1989.

Everything You Always Wanted t Know About Eclipses But Were Afraid To Ask, Kona, Hawaii, July, 1991.

<u>"Did the big Bang Happen"</u>, a TV debate with Eric Lerner, Feb. 1992.

<u>"New Light From Old Objects"</u>, Princeton Astronomy League, 1993.

<u>GRANT FUNDING HISTORY</u>
<u>(Principal Investigator)</u>

Title	*Year*	*Award*
Education/Outreach Projects for AXAF	*2003*	*$597.3 K*
Education/Outreach Projects for AXAF	*1996*	*$361.7 K*
Observations of 1525+227 Using ROSAT	*1991*	*$ 15.0 K*
Statistical Analyses Using the HEAO-1 Database	*1983-1985*	*$ 21.3 K*
Investigation of Theta 1 B Orionis Using IUE	*1981*	*$ 16.0 K*
Observation of Ultraviolet Emission from Globular Using IUE	*1980*	*$ 12.5 Clusters*
Investigation of X-ray Emission from Broad-line and Narrow-line Radio Galaxies Using HEAO-2	*1980*	*$ 7.0 K*
A Search for X-ray Emission from Nearby QSO's Using HEAO-2	*1980*	*$ 8.0 K*
Investigation of the Detailed Light Curve of 3U 1700-37 Using SAS-3	*1977-1978*	*$ 10.0 K*
Total level of funding		*$ 1,068.8 K*

Although I do not mention here proposals on which I am a co-investigator, one remark is in order. I had a graduate student, Bruce Altner, who has been involved with the UV observations of globular clusters for eight years. He had obtained grants from NASA under my direction for three years (1983-1985). I urged him to be the P.I. simply because I felt it would be more important for him to be able to list these grants on his resume than for me to add a few to mine. He obtained $74 K in this manner, with me "underwriting" his proposals.

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