Comments on *Progress Report on Small Wind Energy Development Projects Receiving Funds from the Massachusetts Technology Collaborative (MTC)*, The Cadmus Group, Inc., 4/14/2008)

The above referenced Progress Report discusses the status of small wind turbines which have been funded by MTC. The paper also discusses installer performance, measured by the term "relative production". The paper states that energy production data was examined and compared using capacity factor and relative production. Capacity factor is not defined anywhere in the paper. Relative production is defined as the quotient of actual energy output divided by the installer's estimate of energy output.

The population from which the data was derived consists of 19 small wind turbines which have been reporting to MTC's Production Tracking System (PTS). The PTS (not described in the paper) consists of a requirement by MTC that all small wind rebate recipients report power production on a monthly basis to MTC for the period of one year from the date of project completion. The information reported consists solely of monthly readings from a kilowatt hour meter installed at the turbine location. The meters are believed to be located between the wind turbine inverter and the load so that they measure net power, i.e., both power produced and power consumed by the turbine/inverter. There is no requirement by MTC that the rebate recipient collect or report wind speed information.

The paper concludes that:

1. The average capacity factor of the 19 turbines is 4%.
2. Installers are overestimating energy production of the turbines by a factor of 3 to 4.
3. The most prolific installer's 6 installations have an average capacity factor of 3%.
4. The Bergey Excel S has an average capacity factor of 4%
5. Known factors contributing to poor performance are inverter synchronization/standby time, higher than expected site turbulence and lower than expected average wind speeds.
6. Six of the 19 systems inspected met the 10% capacity factor.

The *Massachusetts Technology Collaborative Small Renewables Initiative Wind Energy Estimator Workbook Instructions and Background Information* defines capacity factor as representing the "…equivalent hours that the system would have to operate at full capacity." Although this definition doesn't lead the reader very far down the road to understanding what capacity factor means, the example given does make it clear. It states that a 15% capacity factor for any sized turbine can be calculated by multiplying the rated capacity of the turbine by 8,760 (the number of hours in a year) and multiplying the result by 15%. The 15% is the capacity factor used in the example, but it could be any number. MTC requires that all turbines receiving rebates have at least a 10% estimated capacity factor. See *Attachment A, Minimum Technical Requirements for Renewable Energy Installations Funded by the Small Renewables Initiative*, which states that the estimated output for the system must result in a capacity factor of at least 10%.

Because comparisons and conclusions in the Report depend on capacity factor it is worth taking a close look at what capacity factor is and to what extent it can be reasonably relied upon to provide us with meaningful information. Most experts in the wind energy field would probably agree that capacity factor is a notoriously unreliable method of predicting wind turbine performance. Even the *Energy Estimator Workbook* qualifies capacity factor stating that it is "…a very rough estimate of the energy production possible from ideal site conditions, equipment, and installation." It seems likely that any reasonable person reading the Cadmus report would conclude that, with the possible exception of the Martha's Vineyard site, none of the other sites discussed therein would fall into this category. If, as the Energy Estimator Workbook states, capacity factor is a very rough estimate of energy production at an ideal site with ideal equipment and an ideal installation, to what level does the "rough estimate" degrade to when site conditions, equipment and installation are all less than ideal? Should we expect a very, very, very, very rough estimate? While capacity factor may be useful when discussing power plants which use fuel, it is much less useful and even potentially misleading when used to describe wind turbine performance.

The American Wind Energy Association (AWEA) states that "It is important to note that while capacity factor is almost entirely a matter of reliability for a fueled power plant, it is not for a wind plant—for a wind plant, it is a matter of economical turbine design. With a very large rotor and a very small generator, a wind turbine would run at full capacity whenever the wind blew and would have a 60-80% capacity factor—but it would produce very little electricity. The most electricity per dollar of investment is gained by using a larger generator and accepting the fact that the capacity factor will be lower as a result. Wind turbines are fundamentally different from fueled power plants in this respect." http://www.awea.org/faq/wwt_basics.html

The reader is referred to the article on capacity factor by Paul Gipe entitled "Generator Ratings & Capacity Factors: Why You Should Avoid Them, January 23, 2006. http://www.wind-works.org/articles/generatorratingandcapacityfactors.html Mr. Gipe is an internationally recognized authority on wind, particularly small wind, and author of at least 6 books on wind energy.

One reason that capacity factor is not a useful measure of wind turbine performance, is that it depends solely on the nameplate rating of the wind turbine it seeks to describe. Wind turbine nameplate ratings have little or nothing to do with the amount of power a particular turbine is likely to produce. In his article, Mr. Gipe describes a manufacturer who intentionally connected a 95 kW generator to a rotor only capable of driving a 25-30 kW generator. This was apparently done primarily to increase the capacity factor of the turbine in order to increase its share of available subsidies. Mr. Gipe states that *"In jurisdictions where capacity factors are used as a measure of performance and tariffs or subsidies are a function of capacity factor.., manufacturer's can manipulate generator size-for the same size turbine- to maximize subsidies rather than the generation of electricity."*

A second problem with capacity factor is that different manufacturers use different wind speeds to rate their turbines. Because capacity factor does not take this into consideration it cannot be a reliable method of comparing turbines from different manufacturers, or even similar turbines, having different wind speed ratings, from the same manufacturer. When, as Mr. Gipe suggests, capacity factor is used as a basis for funding, inequities are likely to result. As an example, the Bergey Excel-S is rated at 10 kW at 31 MPH. http://www.bergey.com The ARE 442 wind turbine is rated at 10 kW at 25 MPH. http://www.abundantre.com/ARE_Wind_Turbines.htm#ARE442 Both of these turbine models have been funded with MTC rebates and both are discussed in the report under consideration. Capacity factor would rate the power output of these turbines identically. Under the formula given in the *Estimator Workbook*, at a capacity factor of 10% both turbines would be expected to produce 8,760 kWH/year (10kW * 8760 H * 0.1 = 8,760 kWH). If the published output figures for the turbines are correct, it would be expected that the ARE, which is presumably capable of producing more power at a lower wind speed, would produce more power, on average, than the Bergey when installed in a similar wind regime. In fact, the Report claims that the ARE 442 has operated at a capacity factor nearly 3 times the average capacity factor of the Bergey Excel. This statement is qualified however when we are informed that the ARE may not be a superior turbine, because the Martha's Vineyard site is an extremely windy location.

The problem is that a turbine with a high capacity factor rating will receive a greater rebate under present MTC rules than a turbine with a low capacity factor even though the turbine with the low capacity factor may produce more power. In general, a turbine that produces more power at a lower wind speed than a competing turbine will have a larger rotor. It will probably cost more to manufacture so its selling price will be higher than a turbine with a smaller rotor. If both turbines have the same size generator their capacity factor will be identical. The inequity arises as a result of the more productive and more costly turbine receiving the same rebate award as the less productive, less costly model.

The Report, in Figure 2, uses capacity factor to compare four turbines. However, the text discussing this figure implies that poor site selection, insufficient tower height or low wind speeds – not capacity factor- are the driving forces for poor system performance.

There is no data or other factual information in the Report that would support an argument that capacity factor is a reliable or even meaningful measure of turbine performance. In fact, the report states that, based on site surveys conducted by Cadmus, relative production may be a better indicator of system production.

Relative production has already been defined as the quotient of actual energy output divided by the installer's estimate of energy output. The Report uses relative production as a measure of turbine performance. It states that relative production gives a sense of actual turbine output. The report also states that "With 12 installations, the relative performance of the Bergey Excel-S remains surprising low. At 38% relative production, this indicates that, on average, the Excel is producing only about one third of its predicted energy output." However, relative production is not a measure of turbine performance at all. It is a measure of an installer's ability to predict how much power a particular turbine will produce at a particular location. It would more accurate to state that the relative performance of the dealers estimates is surprisingly low, not that the relative performance of the Excel is surprisingly low.

In fact, the Report does go on to discuss relative production as a measure of installer performance. For example, the Report states that the best producing system had an average "relative production of 81%, as shown in Figure 4". This appears to be incorrect in that figure 4 does not show any installer relative performance above 58%.

Figure 5 shows the actual energy output relative to the predicted energy output for installers and for Cadmus for 19 small wind systems. The Report states that installer estimates tend to be significantly less than estimates completed by Cadmus. The report goes on to say that installers have overestimated production by as much as 60%. Analysis of Figure 5 does show that installer estimates are lower than Cadmus. Ignoring the revised Cadmus estimates for the present, installer estimates averaged 24% while Cadmus averaged 34%. While the difference between these figures may appear to be significant, when considered in light of the ability of either of these groups to reasonably predict actual performance, both are abysmally low. Cadmus suggests that a lack of installer education may be responsible for the low scores. Even if Cadmus employees do have a higher education level than installers, the Cadmus success rate of 34% cannot, by any reasonable standard, be considered an acceptable measure of performance.

One interesting outcome from Figure 5 is the ability of the groups to provide consistent results. Standard deviation is a measure of the spread of data about the mean. It is a measure of uncertainty or precision. Small standard deviations are an indication of greater precision and less uncertainty. The standard deviation of the data is 0.13 for the installers and 0.16 for Cadmus. Although the difference is small, it does provide evidence that the installers were more consistent in their estimates than Cadmus and that their ability to predict was statistically more reliable. This could be important because the installers consist of discrete unconnected groups or individuals so it seems unlikely that such uniformity would exist unless they all relied on common information and/or used similar methods to achieve their results. This could very well imply that the methods and data which were relied upon played a larger role in the outcome than did a lack of installer education, as Cadmus suggests.

The revised Cadmus estimates presumably occurred after the fact so the information relied upon for these estimates would not have been available to the installers. These results, while potentially useful for other purposes, should not be used in any comparison of actions occurring before the new data was made available to the installers.

The primary purpose of the Report, as stated in the title and first paragraph of the document, is to evaluate trends in the performance of wind systems installed under the SRI (the MTC Small Renewables Initiative). It is clear from the Report, and from reliable sources not contained in the Report, that capacity factor provides us with little or no meaningful information as to turbine performance in the real world. This being the case, the Report goes on to examine relative production. However, as we have seen, relative production is not a measure of turbine performance at all. At best, it might be a measure of installer performance, although the Report fails to make a convincing argument in support of such a conclusion. So, if neither of these criteria can be reliably used to evaluate wind turbine performance, what criteria can be used? Even if valid criteria does exist, there must be sufficient reliable data available from which reasonable conclusions may be drawn.

If our goal is to evaluate wind turbine performance we need access to two fundamental quantities. The first quantity is the power output of the turbine under investigation at a particular wind speed. The second quantity is wind speed. These numbers could be based on average or instantaneous values. Conclusions concerning turbine performance which do not derive from these fundamental quantities will unavoidably be fraught with a high level of uncertainty.

The power outputs of the wind turbines under consideration are available from the manufacturers. For example, instantaneous power curves for both the Bergey Excel and the ARE 442 are readily available on their respective web sites. The web sites also provide estimated average power values for both turbines. It is important to understand that average power values are highly dependant on the wind speed distribution making up the average wind speed. Because these distributions can vary substantially from site to site and, to a certain extent, with weather conditions, average power values tend to have greater uncertainty than instantaneous values.

Wind speed values comprise the second quantity necessary to determine wind turbine performance. As the Report correctly states, small errors in wind speed estimates can result in very significant impacts on energy production. The same is true with actual wind speeds. Even small changes in wind speed have substantial effects on power production. The reason for this is that the available power in the wind varies with the cube of the wind speed. For example a drop in wind speed from 12.5 MPH to 10 MPH halves the available power in the wind.

Table 1 in the Report lists wind speeds for a few locations in Massachusetts. It is presumed that the wind speeds listed are average wind speeds, although the Report does not tell us that they are. The Report does not tell us when the measurements were made or for how long the data was gathered for each of the sites, so it is impossible to know if the measurements were for the same period of time or for different months or years. No height is given for the AWS Truewind map under consideration. Because the anemometer heights differ between sites and probably differ from the Truewind map it would have been necessary to correct the data to a common datum in order to make valid comparisons. Making these corrections would have required, at a minimum, knowing the wind shear exponents for each of the sites. The missing information makes it difficult or impossible for any reader to draw their own conclusions from the information given. Because the Report does not cite sufficient data or methods in support of its conclusions, readers are left with little choice but to view these conclusions with a certain amount of skepticism.

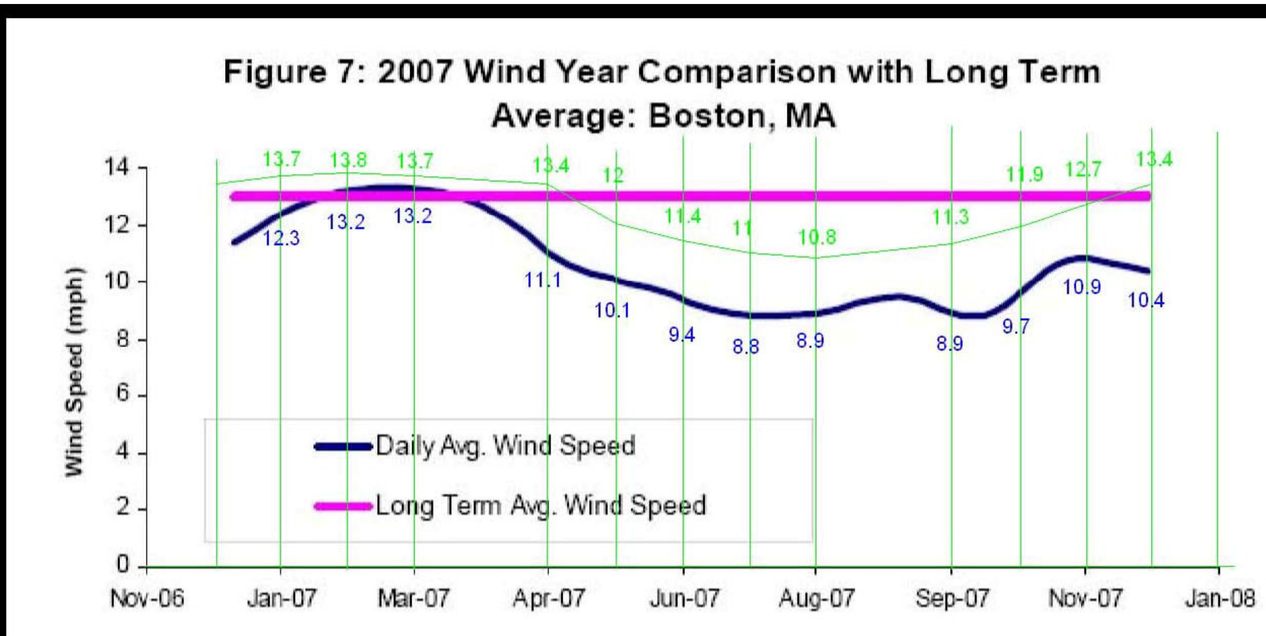
The Report states that along the south coast and Cape Cod, the Truewind Map may be overestimating wind speeds by 10-20%. We are not told how the data supports this conclusion. We are told that certain "adjustment factors" were "incorporated" into the energy production estimates but we are not told what these factors were or how the adjustments were applied. We are then told that even with these adjustment factors applied, they do not fully account for the poor performance of most systems shown in Figure 5.

Table 1 lists certain wind map corrections. These corrections were presumably calculated based on differences between RERL wind speed measurements and Truewind Map information for the same location. Considering Barnstable for the moment, Table 1 gives an average correction to the Truewind Map of 0.83. This presumably means that the wind speeds shown on the Truewind map should be decreased by 17% in order to arrive at expected wind speeds at Barnstable. The table gives a RERL wind speed of 4.87 m/s and 5.9 m/s for the Truewind map. If we apply the cube power law to these wind speeds, the Truewind wind speed would provide 1.8 times more power than the RERL wind speed would. In other words, an installer using the Truewind map in order to estimate power production would overestimate by almost a factor of two. MTC requires that all rebate applicants base the estimated system output on wind speeds shown on the Truewind map. See *Attachment A, Minimum Technical Requirements for Renewable Energy Installations Funded by the Small Renewables Initiative.* If the Report is correct that the Truewind wind speeds are too high and the RERL wind speeds are accurate, this may go a long way toward explaining why the power output of small wind turbines may be lower than the values estimated by the installers. The Report conclusion that the adjustment factors do not fully account for the poor performance may be technically correct, but the alleged Truewind inaccuracies may well account for most of the poor performance.

The Report contains two graphs of wind speeds measured in 2007 at Falmouth and Boston. The purpose of these maps is to examine the possibility that 2007-2008 wind speeds were lower than long term averages. If the wind speeds were lower in 2007 this may account for the alleged low power output of the turbines. The Report goes on to say that examination of wind speed data at the two locations does not support an argument that 2007 wind speeds were lower than average and that wind speeds in Falmouth were actually higher than long term averages. The report states that "the low production of many of the MA small wind systems does not appear to be due to a low wind speed year in 2007".

It is curious that the long term wind speed data on the two graphs is shown as a yearly average (straight line) as opposed to showing monthly long term averages. The X axis of the graphs are labeled in months. The Report makes no attempt to compare the annual long term average with monthly variations in wind speeds. Because the Report appears to only discuss yearly averages, not monthly averages, the charts are essentially superfluous in the context of the Report discussion, because the data to be compared only consists of two points. One point would be the long term average wind speed. The second point would be the 2007 yearly average wind speed.

Let us consider Figure 7 which compares the annual long term average wind speed for Boston with the monthly average wind speeds. The curved line is labeled "Daily Avg. Wind Speed" but the X axis is labeled in months so we will only consider monthly averages.



Green Line is the long term average of 44 years ending in 2001. Yearly average = 12.4 MPH.
Data from the National Weather Service, graphed by Paul Gay.
2007 Average = 10.57 MPH
Delta = 1.62 MPH
Using the cube power law, in 2007 wind turbine production should be about 60% of long term average.

Monthly data for Boston has been added to Figure 7 in order to provide a more meaningful comparison between long term average wind speeds and 2007 wind speeds. Data is from the National Weather Service and represents 44 years of wind speed data ending in 2001. This data is shown as the green line. It is instructive that the monthly variation in wind speed for both the long term and 2007 follow very similar trends. It is also apparent from the graph that the 2007 monthly wind speeds are lower than the long term averages for the corresponding months. The yearly average for 2007, scaled from the Report graph is 10.57 MPH. The long term average for 44 years is 12.4 MPH, which appears to be very close to the straight line shown by Cadmus.

The difference in wind speeds between the long term average and 2007 is 1.62 MPH. The year 2007 therefore represents a 13% decrease in wind speed from the long term average. This number is very close to the average Truewind map correction of 11% given in the Report Table 1. This should not be surprising if the wind map is compiled from long term data. Applying the cube power law, one would expect power production in 2007 to be about 60% of the long term average. The Report conclusion that the low production of many of the MA small wind systems is not the result of low wind speeds in 2007, is clearly not supported by the Boston wind speed data. In fact, the Boston data supports the opposite conclusion – that 2007 had an average wind speed lower than the long term average.

The text describing Figure 8 suggests that most sites be derated by a factor of 0.6 to 0.8. However, if the Boston data is correct and applicable to other areas in the state, so that low wind speeds largely explain the alleged low outputs, these suggested factors may be superfluous.

The Report represents an important step in the direction of investigating wind potential in our area and in bringing to light issues which must be considered in order to properly site wind turbines. Unfortunately, the Report lacks sufficient reliable data which must be available before valid conclusions can be drawn. The erroneous conclusion surrounding the Boston wind speed data is but one example. In all fairness, it may well be that an adequate supply of data is simply not yet available.

Although capacity factor is a poor measure of performance by any standard, because the majority of the turbines installed appear to be Bergey Excels, i.e., the same turbine, the fact that the production appears to vary widely is an indication that the turbines are experiencing substantial variability in wind speeds. As the Report suggests, this could be caused by many factors including towers which are too low, turbulent site conditions, poor site selection, etc. Lower than average wind speeds would presumably tend to affect all turbines more or less equally and not selective ones, at least not to the degree which the graphs appear to indicate. The high variability in production suggests that the wind speeds from the RERL sites and the Truewind map are not generally applicable to specific sites in our area. It is likely that local topography and site conditions play a substantial role in affecting local wind speeds and turbulence. Although it may be possible to model these effects, the software necessary to do so would probably be complex, and expensive. Even the best software would still require a comprehensive wind data set for our region – something we have yet to acquire.

The revised Cadmus estimates peak at about 39%. This is presumably after the fact, at a point in time when Cadmus had the opportunity to review all available data and make use of all available modeling tools. The fact that, even with these advantages, Cadmus has not been able to predict power even approaching the toss of a coin, implies that either the analysis tools are much too elementary for the task at hand or the data being relied upon is bad or so sparse that it is unfit for the purpose. Perhaps both of these elements are part of the problem.

The Report concludes that the key to unlocking the potential of small wind will be to obtain a better understanding of the available wind resource, technology capabilities, and improving estimation methods. The Report goes on to make a number of recommendations. Some of the Cadmus suggestions make perfect sense. For example, given the relative paucity of local wind speed data and the fact that all wind turbines are installed on towers, installing wind speed data collectors is both an economical and practical solution to gathering much needed data. There are issues of turbine rotor interference with wind speed measurements, but research into the matter is likely to mitigate this problem. See the NREL paper entitled *"Applicability of Nacelle Anemometer Measurements for Use in Turbine Power Performance Tests"*, http://www.nrel.gov/docs/fy02osti/32494.pdf . The paper discusses how wind speed measurements from anemometers mounted on wind turbines were adjusted to yield reliable results. Cadmus suggestions of improving the resolution of wind speed data and modeling methods are also important goals that should be pursued.

Although the above discussed suggestions are good ones, the Cadmus suggestions to adjust program structure to minimize risk of underperformance are troublesome at best. First and most important, the Report fails to make a case that underperformance actually exists. As discussed extensively herein, using capacity factor as a measure of turbine performance is unwarranted and misleading at best. Relative production, a term which does not seem to exist in the wind power industry and which appears to be invented specifically for this report, is a measure of an installer's ability to predict, not a measure of turbine performance. The only other primary source of information that Cadmus appears to rely on is wind speed data from a few sites and some long term wind speed data. The Report does not provide us with a single example where data is collected from a site which has both an operating wind turbine and wind measuring equipment. The Report acknowledges that there are substantial local variations in wind speed that likely have substantial effects on power production, yet it relies on remote wind speed data in order to support a claim of low power production. The Report is also misleading when it claims that wind speed values for 2007 are higher than average when data for Boston clearly shows that the reverse is true. In fact, the data suggest that average wind speeds may substantially account for the alleged low power production.

The Report states that rebate dollars paid by MTC for small wind installations have not generated the expected benefits. We are not informed exactly what benefits are being referred to, although from the context it would not be unreasonable to infer that the statement relates to power production. Many if not most of the systems have only a year or so of service, and some substantially less. If, as the data suggests, 2007 was a year of statistically low wind speeds, more time will be required before any reliable conclusions can be drawn.

There are many other "benefits" which the Report fails to consider. One of these benefits is distributed power generation. Distributed small wind energy systems enhance the reliability and power quality of the power grid, reduce peak power demands, increase in-state electricity generation, diversify the Commonwealth's energy supply portfolio and make the electricity supply market more competitive by promoting consumer choice.

Renewable power generation using wind lessens the Commonwealth's dependence on power generated by nonrenewable sources. These energy sources are increasing pollution and putting large amounts of carbon into the atmosphere, accelerating global warming. The cost to Massachusetts residents of a kilowatt hour of electricity generated by nonrenewable sources far exceeds what they pay the utility company. Even if a small wind installation did not produce, "expected results", as Cadmus claims, the power that it did produce is worth far more than simple mathematics would suggest.

Some of the wind turbines installed under the SRI, such as the Bergey Excel, were developed in the late 1970s and early 1980s. Almost all the other turbines are more recent. There seems to be no question that small wind equipment is an emerging technology. Given the tremendous interest and rapid growth of wind energy in the past few years, the technology will almost certainly see major advances in equipment reliability and efficiency during the near future. As with many new technologies that have the potential to provide substantial benefits to society, small wind depends on continued support in the form of subsidies in order for it to grow to the point where the systems achieve enough cost effectiveness to survive on their own. Cadmus suggests there is a risk that MTC may heavily fund systems that do not produce sufficient clean energy to justify the subsidy. Even if there was adequate proof that most of the turbines presently installed under the SRI were performing below manufacturer's claims, proof which Cadmus has yet to convincingly provide, the additional important values of distributed power generation and renewable energy production would go a long way toward mitigating this deficiency.

Of the five suggestions put forth by Cadmus, some would almost certainly result in additional expense, red tape and time delays. These disadvantages would likely not be offset by substantial or material gains. The money for this expense would presumably come from renewable trust funds making less available to be used to install equipment. Implementing site reviews prior to committing funds would surely cause delays and use valuable trust funds. It would seem that getting small wind turbines installed and producing power would be a greater service to the public than spending money on impediments, even if installations are not 100% perfect.

And who would perform these site reviews and make recommendations? Because the Cadmus group presently performs the post installation inspections it seems likely they would play some role in the site reviews. However, the Report demonstrates their poor success rate in predicting wind turbine performance. From a practical point of view their success rate is on the same order of magnitude as the installers. Their margin of performance over the dealers is relatively insignificant and hardly justifies the additional expense and potential delays which are certain to accompany burdensome requirements. It would probably be more productive for Cadmus to concentrate on developing better data sets and models which could then be made available for use by installers. This paragraph is not meant to disparage the Cadmus Group or the capabilities of its employees in any way. The point is that given the data and resources presently available to Cadmus, or any one else for that matter, there does not appear to be a substantial enough advantage or sufficient certainty in the proposed outcome to support the measures being suggested.

The small wind portion of the SRI, as it is presently implemented by MTC, is remarkably practical and well designed. Compared to other jurisdictions where it can take years by the time a small wind system is finally installed, we are fortunate in Massachusetts that our small wind program is efficient and capably staffed and that it has a minimum of procedural red tape. Installers here can be well on their way to performing an installation in a matter of weeks from the date of application to MTC. The money in the renewable energy trust fund doesn't help our friends and neighbors unless it can be quickly and efficiently used to put renewable technology to work. The fact that the program not only enables and encourages but also facilitates new installations of small wind is a credit to the organization and a model that other states should look to. In order to ensure that the present supportive climate for small wind continues to be fostered we must consider, and consider very carefully, measures that could well serve as an impediment or disincentive to future installations.

The Report suggests that capacity factor be strictly enforced. If the small wind program does have a serious flaw, it is the imposition of capacity factor as a means of wind turbine qualification. The reasons for this should be obvious by now and it does not bear repeating. If a substantial purpose of MTC is to distribute rebate funds in an equitable manner and promote small wind in the Commonwealth, it should abandon the use of capacity factor and consider a more meaningful and appropriate measure of performance. The simplest and most accurate method of rating wind turbines is by their rotor diameters or swept areas.

If we grant the assumption that most wind turbines currently in production have similar efficiencies, the amount of power a turbine can extract from the wind will be a function of its diameter or swept area. In fact, most small wind turbines do operate at similar efficiencies. Using rotor diameter or swept area allows anyone to easily compare turbines from different manufacturers. See "Wind Turbine Swept Area" by small wind expert Mick Sagrillo on the AWEA web site:
http://www.awea.org/smallwind/sagrillo/ms_swept.html

Because photovoltaics operate at similar efficiencies, it is common to rate them in terms of power per unit area, for example watts per square meter. Wind is no different. The energy available in the wind is a function of wind velocity. With photvoltaics, the amount of solar energy which can be converted is dependant on the area of the panels. In a similar manner, the amount of energy that a wind turbine can extract is dependant on how much wind the rotor intercepts. This is a function of the swept area or rotor diameter. New York takes rotor diameter into consideration when calculating rebates. California presently uses rated capacity but policymakers recognize the inequities created by this measure of performance and are hoping to adopt the more equitable measure of swept area.

The Cadmus suggestion of strictly enforcing capacity factor, if followed, would perpetuate existing inequities. MTC should base rebate awards on rotor diameter or swept area. An additional benefit is that, unlike capacity factor, swept area and rotor diameter are concepts anyone can easily understand.

The Report also suggests establishing additional criteria, "such as minimum wind speed to help filter out systems likely to under perform". The meaning of this language is far from clear. Refusing to fund a system because the site has too low a wind speed might make sense under certain circumstances, but what does this have to do with filtering out systems? The suggestion goes on to say that "if these systems perform well, future applications may gradually become less stringent". This language is also ambiguous. If systems have been "filtered out" and presumably not installed, how could we expect them to perform well? Clearly, if a system is uninstalled, it is incapable of any performance whatsoever.

Limiting funding only to sites which have a minimum wind speed may seem to make sense, but the rule would have to be carefully designed in order to ensure fair treatment of applicants. If, after reading the Report, we come away with one clear impression, it is that quantities needed to reliably predict turbine performance have a very high level of uncertainty. There are substantial differences in average wind speeds for our area. Real questions exist about how to apply average wind speeds, even if they were known accurately, to specific sites. Turbine performance varies widely. Turbine performance cannot be reliably predicted from average wind speeds. Even with Cadmus, who are presumably experts in this field, prediction levels are in the 30% range. These are but a few of the uncertainties which the Report brings to light.

If we are planning to deny funding to an applicant who has contributed to the renewable energy trust fund, equity demands that we have a reasonably high level of certainty that the wind site under consideration is so poor there is no question regarding it unsuitability. There is nothing in the Report to suggest that this is even a remote possibility. Even if we did have a firm grasp on reliably predicting wind speeds at a specific site, what wind speed would we choose as a cut off, below which funding would be denied? The Report suggests 5 meters/second (11.2 MPH) at 30 meters (100'). Although this may be a reasonable number, we are not informed as to the basis on which this speed was selected. Is this value based on existing wind turbine technology or does it anticipate technological advances?

The Report closes with the statement that the "underperformance of small wind remains unexplained and more data is needed..." Although this statement is true in that the Report does not explain underperformance, a more accurate statement would have been that the report fails to cite sufficient reliable data to even make plausible argument that poor performance actually exists.

The Report is correct that more data is needed, and MTC and the Cadmus group are in the unique position of helping to insure that installers have access to reliable data and competent analysis tools. The future and ultimate success of small wind in the Commonwealth will depend almost entirely on MTC policies. Small wind cannot possibly survive without substantial subsidies and freedom from burdensome regulations. Massachusetts has taken the lead in wind energy and this is rightly so. We are blessed with some of the best wind resources in the country. We are also fortunate in having unprecedented and unfettered access to financial assistance for the installation of small wind systems.

The implementation of new regulations which do not have the support of quantifiable data is likely to do more harm than good to small wind. The small amount of production data from a scant 19 turbines collected for a year or less can hardly be considered a robust data set. Although it makes perfect sense to continue to monitor performance, and to take steps to increase the amount and type of data being collected, implementation of burdensome regulations unsupported by scientific evidence and the scientific method is a course of action destined to end in disappointment.

Massachusetts has made great strides in paving the way toward energy independence. Small wind has the potential to play an increasingly larger role in helping us maintain this momentum. We have an administration committed to insuring that our state continues on its course toward a clean energy future. Let us all work together to insure that small wind plays the greatest possible role in furthering these important goals.

Paul L. Gay
Northeast Windpower Corp.

Please join the Massachusetts Small Wind Alliance at:

http://groups.google.com/group/small-wind-alliance

Group Email: small-wind-alliance@googlegroups.com

The alliance is a group of small wind turbine installers, policymakers, turbine owners, manufacturers and all others interested in small wind in Massachusetts and elsewhere. The alliance is a forum for the discussion of wind turbines, siting issues, zoning, legislation, state and federal incentives, wind rescources and monitoring, publications and studies and other topics related to small wind.