Peer Review Committee, Offshore Wind Energy, New England
Technical Review of Preliminary Screening Criteria for the Cape Wind EIS
Consolidated comments on Section 2.0 and 3.0 of the Draft EIS
September 30, 2003

Summary

The Peer Review Committee consists of six internationally recognized experts in wind energy (see below) who have kindly volunteered to review draft documents to support the decision-making process of the US Army Corps of Engineers New England District (USACE) regarding the Cape Wind project. All six reviewed and commented upon Sections 2.0 and 3.0 of the draft Environmental Impact Statement, and their comments have been consolidated into this document. Reviewers had nuances to their comments that would have been unfortunate to lose in the consolidation, so there is necessarily some repetition in this presentation.

There was general support for the approach to the issues taken in Section 2.0 "Project Purpose and Need" and Section 3.0 "Alternatives Analysis." The reviewers felt that the discussion of need could be expanded to further highlight the benefits of wind energy, particularly that power is produced with no CO2 emissions. The reviewers felt that in general the document appears to reach reasonable conclusions; however, some reviewers noted that there were some cases in which there was insufficient supporting documentation provided to reach the conclusions. Some felt that the document could be written with a more objective tone.

The reviewers felt that the screening criteria were appropriate. There were various opinions expressed on the issue of wind power classification, ranging from "it depends on the economics," to a strong belief by one reviewer that offshore wind was not viable at less than Class 6. Most reviewers felt that using wind resource classification, per se, as one screening criteria was too simplistic, however they saw the utility of using it. More detailed evaluation of wind resource requires more information than may be available at this stage for a possible site. Transmission capacity was viewed by several reviewers as a key criterion. Without the ability to get the power to market, a project isn't viable. There was some concern expressed about the 200 MW minimum size, with reviewers noting that most wind projects were significantly smaller than that and were still "utility scale." One reviewer agreed, however, that a minimum size of 200 MW was practical, given that the costs of interconnection will be borne by the proponent. One reviewer strongly recommended that USACE include multiple smaller land-based projects as an alternative. The reviewer felt that while there are advantages and disadvantages to the development of both a large offshore project and multiple small land-based projects, the cost of energy might end up to be about the same. Under legal and regulatory constraints, concern was expressed about environmental impacts, particularly in areas of some uncertainty, such as avian impacts, and the effect of underwater noise, vibration, and electromagnetic fields on marine creatures.

Serious concern was expressed about the long-term viability of the project and the possibility of project failure. One reviewer observed that an abandoned wind farm at sea would seem to be the worst possible environmental outcome, with no benefits to offset the impacts. The history of wind projects in the United States has included numerous technology problems, and several failed, bankrupt projects. One reviewer was concerned about the proposed turbines, an early commercial use of turbines that size, let alone in the marine environment. The reviewer felt that a project scaled within the limited industry offshore experience base could help insure the long-term viability of the proposed wind farm.

Some comments were quite extensive and detailed, and provide additional background on the issues, which is helpful to the USACE decision-making process. These specific comments by various reviewers have been consolidated below. In addition, one reviewer offered a proposed application of the selection criteria, which is also included in this document.

Specific Comments

Section 2.0 ''Project Purpose and Need''

In general, it was felt that this section succeeds at its purpose. As noted above, some attention should be given, however, to the “voice” of the section. For example, at Line 68 it is stated, “the project will help reduce cost...” It may be preferable to say: “the project is intended to help reduce cost…” Similarly, the following bullet, beginning at Line 70, presents as fact an opinion that the project’s ability to bid into the ISO-NE system with a zero marginal cost will “provide more competitive market pricing.” That may well be a reasonable theory, but it has certainly not been proven that it will. Again, the following bullet, beginning Line 73, states as fact the project will provide an “economically efficient source…” It is not clear what that actually means. The remaining bullets should also be checked to make sure that they refer to the intent of the proponent, rather than appear to accept the proponent’s statements as fact.

The first sentence in the Section (beginning on Line 5) could also use some elaboration. In particular, and as reflected later in Section 3, the purpose is clearly more than “provid[ing] utility-scale renewable power…” The purpose, as far as the proponents are concerned, is to make an acceptable return on their investments. This statement is important, since it bears on many of the assumptions implicit in Section 3.

Regarding project need, the offshore wind energy project in the first instance will serve the purpose of diversifying sources of available energy and displacement of fossil fuels (CO_2 reduction). As the wind energy resource is variable the capacity credit is limited and thus wind energy can only be used to a limited degree to meet minimum reserve capacity requirements. Based upon experience in Europe, economic laws of scale dictate offshore wind farms to be relatively large compared to land based wind farms. Indeed future offshore wind farms are likely to have utility-scale dimensions, while this is not necessarily the case with land-based systems. It also should be noted that the electricity cost ($/kWh) of wind energy is completely independent of fuel cost and forms a pricing hedge against varying prices of fossil fuel cost.

Section 2 – Lines 70-72 reference bidding into the ISO-NE system by the project. This implies that the price received for the energy from the project will not be known in advance. It seems highly unlikely that this will happen in the first 10-20 years of the project's life, while the project debt is being repaid. Lenders will almost certainly require a clear definition of the prices to be paid for the energy for the life of the debt. Also, the marginal cost of operating the plant is not zero, but very low compared to non-renewable sources of energy.

Section 3.0 ''Alternatives Analysis''

The consensus of the reviewers was that the screening criteria were appropriate, including wind power classification, electric transmission capacity, commercially available land or permissible use of offshore water area, engineering and design limitations, and legal/regulatory constraints. One reviewer suggested adding harbor facilities at reasonable distance. For the transport, installation and maintenance of large scale offshore WTG's these facilities are required. Choosing to focus on potential wind energy projects within the New England region seemed quite reasonable, however as noted above, some reviewers suggested consideration of a number of smaller, land-based projects.

Section 3 – Lines 18-21

This analysis is used to imply that the scale of the project must be greater than 200 MW to connect onto the ISO system. While all the reviewers were not familiar with the ISO-NE, they noted that it seems unlikely that no projects smaller than 200 MW have been interconnected in the past 15 years. This also implies that projects need to be 200 MW or greater to be "utility scale." Many wind power plants with capacities under 100 MW are installed in the U.S., and continue to be installed in the U.S., and utilities purchase energy from wind power projects rated less than 100 MW. There is no question that, everything else being equal, a large project (onshore or offshore) will have better economics than a small project, but most reviewers feel that a project didn't necessarily need to be over 200 MW to be utility-scale or to interconnect to the ISO-NE.

Wind Power Classification of 4 or Greater.

Some reviewers believe that land based wind farms located at Class 4 sites are currently economically feasible only with the Federal Production Tax Credit (PTC), and that to consider locating an offshore wind farm with the associated higher technical risks and costs in a Class 4 wind regime would be unfeasible.

One reviewer felt that for an offshore wind farm to be technically and economically viable "today", even with the PTC, the site needs to be Class 6. The technical challenges and higher costs for offshore wind farms can only be paid for by a significant increase in energy capture. The reviewer suggested that Class 6 for offshore sites would be the minimum acceptable. Depending on how strictly the screening criteria are to be used USACE may wish to consider using a minimum wind speed, and a wind frequency distribution rather than the wind class designation. This would be the best approach if energy capture estimates need to be made as part of the screening process. For example, USACE could suggest an 8m/s minimum mean wind speed with the assumption of a Wiebull wind speed frequency distribution with a typical k parameter, selected for offshore conditions in New England.

One reviewer felt that calculating the energy capture ratio for two different wind sites using the ratio of the wind speeds cubed only works for certain special situations. For example, a wind turbine sited at a location where the wind speed is always above the turbines rated wind speed (maximum Power output wind speed) gives a constant power production, no matter how high the wind speed. On the other extreme, a turbine with a very large generator would behave according to the cubic relationship as described in Appendix 3-A. Real wind turbines are somewhere in between, and to really understand the difference that wind speed has on yearly energy capture requires a reasonable model of the wind speed distribution and a representation of the turbines power curve. In general for real turbines placed at different locations, the energy capture tends to be initially cubic at very low site mean wind speeds, and then rolls over and becomes a constant for very high mean wind speeds. The important range is in the middle, of course. The best way to estimate the energy capture would be to use actual site wind data, or theoretically derived site data, and convolve it with the approximate turbine power curve. Other estimators can also be developed depending on the degree of accuracy required.

Where it is generally true that a Class 4 wind resource is needed for projects to be economically competitive in the U.S. today, one reviewer noted that there are many wind turbines in Europe and some projects in the United States that are in lower wind resource areas. The key is whether the price paid for energy and "green attributes" is sufficient to cover the costs of generation. The wind resource is not the only relevant variable. This reviewer felt that there should be some justification for the conclusion that Class 4 or better winds are required.

Because of the fact that the power density of the wind is proportional to the wind speed cubed, the value of the wind speed at the site is the most important criterion for evaluating the feasibility of wind farms. Reviewers agreed with the general conclusion of the given analysis; in particular with the analysis of the minimum average wind speed required for economic operation of wind farms. However one reviewer did not agree with the causal relation that the author assumes between wind power classification and capacity factor. The annual energy output of a wind farm is primarily determined by the local wind speed (at hub height) and the rotor swept area. The installed power is a parameter of less importance and can be chosen to achieve a certain value of capacity factor in relation to the wind speed and rotor swept area. Within a certain interval this choice has little impact on the annual energy production. Thus in Europe there is a consequence to design offshore turbines with a relatively low specific power (= installed power per m2 swept rotor area) in order to achieve capacity factors exceeding 30%, even 35%. So the capacity factor is not a site-specific parameter or a parameter to characterize the performance or quality of a turbine, but a design parameter. The reason offshore wind farms are designed for higher capacity factors (even accepting somewhat lower energy outputs) is that the capacity of the cable connecting the wind farm to the grid is better used. This is important because cable cost of offshore wind farms tend to be relatively higher than those of land-based farms with similar capacities. Several reviewers agreed with fact that wind power classifications is utmost important and one suggested that USACE not use capacity factor as a site-specific criterion.

Other reviewers found some of the discussion regarding wind power classification a bit misleading, even though the broad conclusions concerning the project are reasonable, given the current state of the technology. One reviewer noted that there is nothing magic about wind power classification per se. The reviewer observed that to state that an area must have a wind power classification of at least a particular value makes an assumption about economics rather than technology. The fundamental concerns are (1) the installed cost of the wind turbines, (2) the amount of energy they produce, and (3) what the value of the energy is. At the present time, in the United States, given the pricing structure, the type of incentives available, and the state of the technology, the statements made in this Section are broadly correct for merchant plants of the type discussed here. The situation will change as the technology in the future and could well be different, even in the near term, if the incentives were to change. In particular, the applicant no doubt expects to take advantage of the federal Production Tax Credit and the Massachusetts Renewable Portfolio Standard via Renewable Energy Credits (REC's). If these incentives were not available, it is doubtful if the offshore project proposed would be economically viable regardless of the wind power classification. If the incentives were increased, or a different type of entity was considering a project (such as LIPA in New York), sites with a lower wind classification (or locations where it would be more expensive to build the wind farm) might be worth considering.

A fundamental issue that is implicit in discussion of wind energy economics is the matter of so-called "external costs" of energy production in general, and the presumed benefits of wind energy in comparison with other forms of generation. There is little argument that such costs exist, although there much debate as to how large they are. These external costs are the costs associated with effect on the environment due to the energy production. Costs most commonly associated with fossil fuel based generation include those due to particulates, oxides of nitrogen or sulfur, and carbon dioxide. The presumed benefit of wind energy is that there are essentially none of those compounds produced. For the case in point, they are assumed to be reflected in the PTC and the value of the REC's.

Sufficient surplus electric transmission capacity to transport 200-1500 MW to load centers throughout the ISO-NE transmission system.

Reviewers felt that this criterion is essential. The project is not needed and has no purpose unless there is sufficient utility transmission capacity to deliver the electricity to a market. One reviewer suggested applying this criterion first, and if it is not met then there is no point in considering other criteria.

This criterion could be rewritten to make it more generic and perhaps applicable to other wind projects. The reviewer suggested restating it as follows:

"Sufficient electric transmission capacity must be available at the planned time of the wind generating plants commissioning to transport the projects full output to electric load centers throughout ISO-NE."

The footnote in Section 3 indicates that a preliminary screening criterion of less than 25 miles to the nearest transmission connection point will be used. This is reasonable for preliminary screening, but reviewers felt that this distance should not be used as a hard and fast rule to either allow, or exclude, a specific project. Technical and economic considerations for a specific site may allow a longer transmission tie line, or require a shorter line.

One reviewer agreed with the transmission criterion as long as energy policy considers offshore wind (or other large scale renewable energy plants) as marginal additions to the electricity supply system. In some European countries and regions already more than 20% of the electricity demand is covered by means of wind energy. Further expansion of the supply is possible only if the grid infrastructure is strengthened or adapted to more dispersed systems. This in particular is the case in the UK (targets for 6000 MW offshore wind), Denmark (4000 MW in 2030), Northern Germany, the Netherlands (targets for 6000 MW offshore wind energy by 2020) and Sweden. Reviewers also agreed with the conclusions concerning HVAC versus HVDC technologies for grid connection in Appendix 3-C.

Commercially available land or permissible use of offshore water sheet area sufficient to accommodate a 200-1500 MW wind energy project.

Land-based projects have considerable variation in the MW per unit of land area; however, this is generally driven by the energy capture potential of the particular site and the wind conditions. For example, a site with a strong prevailing wind direction can be laid out with closer side-to-side spacing, whereas sites with good winds from two or more directions may need a wider spacing side-to-side to minimize interference effects when the wind blows along a row. This should all be part of the project feasibility study and energy capture analysis, and one reviewer didn't understand why a specific project size range needs to be specified. There may be locations where a 50-100 MW project would be reasonable, particularly for land–based projects. There simply needs to be enough commercially available land or permissible sea area to place the planned project. While it is clear that a larger project could have better economic viability, that consideration would seem to fall under a different criterion.

One alternative to a single offshore installation that has not been addressed directly is the potential to develop multiple smaller land-based projects. A 400 MW land-based project might be difficult to site in New England, but multiple smaller projects may be feasible. While the costs of a smaller land-based project will be larger per MW than a larger land-based project, and the wind resource may be lower than for an offshore project, the cost of energy from multiple land-based projects may not be higher than for an offshore project. Factors which make multiple land-based projects challenging include multiple permitting processes, multiple areas with environmental impact, multiple power purchase negotiations and multiple utility interconnection studies. Advantages of multiple land-based projects may include potentially easier integration into the existing transmission system, geographic dispersion smoothing energy delivery to the grid, and dispersed environmental impacts. If there is a specific reason that a multiple land-based alternative is not considered, that reason should be stated. Otherwise, the study should include an evaluation of dispersed land-based projects.

Regarding wake interactions it has been correctly stated that turbulence intensity offshore is relatively lower than on land because of differences in surface roughness. For fatigue loading of the turbine rotors offshore locations have a significant advantage over land locations. Even at higher wind speeds offshore, the fatigue loading of offshore machines is lower. As a consequence of lower turbulence intensity the turbulence mixing in the wakes will be lower and it takes longer distances between the turbines before the kinetic energy of the wind at a location within the park is again close to the undisturbed value. A disadvantage of offshore location thus is that the spacing between turbines tends to be larger than on land, thus requiring relatively larger areas. This of course has a consequence for the cost of cabling. That is why in the design phase trade-offs are being made in determining spacing between turbines in cases accepting lower energy output versus lower cabling cost. Typical distances between wind turbines vary between 5 and 10 rotor diameters.

From the above discussion it can be concluded that the required open space per MW of installed power may vary considerable. However there is a fundamental difference between wind farms and line configurations. The generating capacity of a wind farm is almost insensitive to the size of the wind turbines applied (as long as the mutual distances between the turbines remain relatively the same, e.g. 8 times rotor diameter). The capacity increases slightly with the tower height, as the turbines face higher wind speeds, which occur at higher heights. So it is correct to state that approximately 20 acres is needed per MW installed power. The exact figure depends on the mutual distances between the wind turbines, typically varying between 6 and 8 rotor diameters. However the installed power of wind energy plants placed in line configurations is (slightly more than) proportional to the rotor diameter, as long as the distance between the turbines remains relatively the same, e.g. 5 times rotor diameters. So one cannot say that a certain number of MW's can be installed per kilometer, without specifying the size of the rotors.

Typical figures for configurations with a mutual distance between turbines of 6 rotor diameters are:

Rotor diameter (m)	MW's per km for p=400W/m2 (medium wind speed areas)	MW's per km for p=600W/m2 (high wind speed areas)
40	2.0	3.0
80	4.2	6.3
120	6.3	9.5

N.B. p is installed power per m2 rotor swept area. Increase of wind speed with height is not taken into account.

The conclusion concerning the effect of higher wind speeds offshore on the required surface is correct. See also remarks above, on fatigue loading and cabling cost.

Section 3 – Lines 39-64

No evidence is presented that it would be impossible, or would be economically infeasible, to obtain land rights to the amount of land needed for a 400 MW land-based project, or multiple smaller projects totaling 400 MW. What would be helpful would be some analysis showing areas in New England with the required wind speeds, the amount of land required, and the costs of transmission upgrades needed for grid access. This information would allow an objective assessment of a land-based alternative.

Section 3 – Lines 48-50

The typical spacing between turbines is not sufficient to completely eliminate the wake of upwind machines. The spacing allows time for both the turbulence and energy deficit in the wake to be reduced. The former is important to minimize loads on the downwind turbines, the latter to maximize energy production while still having a reasonable project area. It is unlikely that laminar flow exists at downwind rows of turbines with typical array spacing.

The following are some minor comments on Section 3. The sentence in Lines 48 and 49 refer to laminar flow. The flow does not become laminar. The effect of the spacing is to allow the wind impinging on down wind turbines to be re-energized by mixing with the more energetic winds of the upper air.

Section 3 – Lines 53, 54, 55

The amount of land required to support a project is dependent on many variables. The numbers used here appear to be biased toward large land areas being required. For example, a one-mile ridgeline (5,280 ft or 1,600 m) can hold ten 80-meter, 2 MW turbines spaced two diameters apart. This would total 20 MW not 10 MW. Two diameter spacing is only acceptable if the predominate wind direction is at right angles to the ridge, which is not uncommon.

Section 3 – Line 55

It is not clear why lower wind sites require more area per MW unless the thought is that larger spacing is needed because of larger wake losses in low wind environments. This should be explained. It is also possible that the author has confused MW (capacity or power) and MWh (energy).

Section 3 – Lines 57 to 64

This paragraph is misleading and confusing. It appears the writer has confused power and energy, and uses averages inappropriately. It is correct that more land will be required to get the same amount of energy at a lower wind speed site (all else being equal), but it is not correct that the wind speed will affect the rated power of the plant that can be installed. It is also correct that the power in the wind is proportional to the velocity cubed; however, the amount of energy that will be generated from a given project is not proportional to the velocity cubed because the turbines cannot extract all of the additional energy available. In particular, once a wind turbine has reached its rated capacity in high-wind situations, it cannot produce more power as wind speeds continue to increase. Thus, the idea that you will get 20% more power (or energy) from a turbine placed in a 7.75 mps average wind speed site than from a 7.25 mps average wind speed site is incorrect. In fact, using typical wind speed frequency distributions and wind turbine power curves, the actual percentage increase in energy is on the order of 12%.

The lack of obstructions on offshore projects would be expected to produce relatively smooth winds compared to many on-shore sites. This relatively smooth wind may have some, relatively small, impact on the performance of the machines (typical losses assumed for turbulence, when they are assumed at all, are 2% or less). The relatively smooth wind will induce lower loads on the turbines and thus increase their reliability.

The paragraph beginning on Line 57 includes a few questionable assumptions. One significant issue has to do with wind turbine spacing in offshore applications. The question of spacing is essentially an economic one, but it is known that the distance required for the wakes to recover their energy is greater offshore than on shore, due to reduced turbulence offshore. Greater spacing reduces the impact of the wakes; on the other hand, greater spacing also results in increased cable costs within the wind farm. At least one reviewer does not believe that there is yet a consensus on what the optimum spacing of wind turbines should be in offshore wind farms.

Section 3 – Lines 74-77

This implies that to build a state-of-the-art facility on land or water requires a 2.7 MW turbine. This is not correct. Modern wind turbines are offered in the range of 600 kW to over 3 MW. The proper turbine for a given application depends on many factors, one of which is the accessibility of the site and the available construction equipment. The largest wind turbine that will be installed in the U.S. in 2003 in a utility-scale project (with the exception of demonstration units) will be 1.8 MW, the smallest will be roughly 600 kW, and the majority will be between approximately 1.5 and 1.8 MW. These are all state-of-the-art for land-based applications.

Engineering and Design Limitations: Physical geological and environmental site conditions

For a commercial project, this criterion should focus on eliminating alternative sites that would push the project into engineering and design situations where there is currently no real world experience, and thereby unknowingly increasing the technical and financial risk. From an environmental point of view the largest risk that reviewers see is a failed project leaving behind an offshore wind farm that is not operational, without sufficient income to address essential maintenance. An abandoned wind farm at sea would seem to be the worst possible environmental outcome.

To trade-off alternative sites, consideration of differing wind speed, wave height and wave period statistical correlations will be very important. Different sites many have similar significant wave height values, but the wind-wave correlations could be quite different. The site environmental characteristics are tied to the water depth, wind direction and the upwind surface roughness conditions. Another important site design parameter is the sea floor geology at the site and on the route of the undersea cable. In addition, the site environment ties directly to the environmental footprint of the project. The wind environment in particular determines the number of turbines required, and in turn the distance between turbines. The better the wind, the fewer the turbines needed, and the shorter the cabling and trenching, which minimizes the environment footprint, and improves long-term project viability.   Interestingly, larger turbines also tend to minimize the environmental footprint, which conversely increases view shed concerns.

One reviewer suggested that this criterion be focused on selecting sites that are within the limited industry offshore experience base, thereby insuring “long term viability” of the wind farm. Experience in the 1980’s for land-based projects has demonstrated that failed projects in bankruptcy present many unsolvable problems and offshore projects would probably present bigger challenges.

Legal and regulatory constraints

The underlying issue in considering alternatives is thus the relative environmental impact, in the broadest sense. Accordingly, there needs to some explicit recognition of the environmental issues associated with the project, both positive and negative. State and federal land and water regulations should encompass the areas of environmental effects already identified in the European EIS’s, which include effects on:

Human beings, fauna and flora
Soil (seabed erosion), water quality, air quality, climate, and the view shed
Material assets and cultural assets
Other conflict of interest issues, among competing uses of a site.

In the U.S. the positive impacts of wind projects have not been well documented, so that the positives and the negatives can easily be presented side-by-side. In the case of a wind project, the positive benefits are the reductions in air emissions CO_2, SOX, and NOX. These should be quantified for the ISO-NE operating area. These benefits can also be used to screen sites in a simple way. Higher energy production for a site implies a larger air emissions reduction for the region. A simple ratio of emissions reduction values to the projects environmental footprint could serve as a simple preliminary screen metric for alternative sites.

In the final analysis, it is clear from experience with land-based projects and from the EU offshore work to date that it is the detailed studies of a few biological issues which are considered to be problematic, that are the real focus of the EIS. Both EU and U.S. land-based wind experience indicates the following are likely to be important:

Collision of birds with turbines
Destruction or disruption of habitat, roosting, breeding and feeding areas of birds
Unknown effects of low frequency noise on fish and sea mammals
Unknown effect on fish larvae
Disturbances to seabed and fauna during construction

From the European work the general conclusion has been that avian effects are the major environmental concern expressed, and that a number of studies are currently in progress. However, these studies are not going to be directly applicable to U.S. projects due to the different avian species involved.

The impact of underwater noise and vibration on marine wildlife will need to be considered at various stages of the project development.

Sediment transport patterns and geotechnics will determine type of foundation to be used, the need for scour protection and the potential for the mitigation of cable impacts through cable burial or armoring. Further work may be required to assess the potential impacts of electromagnetic fields on certain species of fish such as elasmobranches.

One reviewer noted that safety aspects concerning collisions of ships with wind turbine structures need to be addressed in the design phase. As the North Sea in Europe is a very intensively used shipping "lane", experiences to be gained here will be very relevant to other areas. As environmental impacts (birds, sea mammals) cannot be predicted accurately in advance, environmental monitoring after commissioning of the project might be necessary. Impact of the wind farm on transport of seabed sediments has to be taken into account. Wind farms could have a positive impact on commercial fishery. Research and development in this area indicates that wind farms could form a breeding area for certain fish species. Some future offshore wind farm operators are negotiating fishing rights within the wind farm boundaries to the fishing industry.

Appendix 3-A

Many of the issues identified in the main document originate in this document. The following additional observations are made:

On page 2, the statement “Currently, class three wind regimes are not commercially viable for private development since infrastructure costs are greater for the larger wind turbine units of today” takes two correct statements, relates them with “since,” and creates a false statement. Class 3 wind resources are not commercially viable today using either large turbines or small turbines. If class 3 sites were ever really viable, it was because the power markets and economic climate were different at the time. Infrastructure costs are generally larger on a per turbine basis for the larger turbines, but the overall cost of energy is generally lower for modern turbines than for the smaller turbines available in 1986. This statement should be deleted.

On page 3, the statement referring to gravity foundations that states, “Experience has shown that they are not suitable for the larger offshore wind farms” is completely unsupported. It is not known if this is correct or not, but as is the case with many other general statements in the documents, it would be far stronger if supported with case studies or independent analysis.

The reviewers do not claim to be experts in offshore foundation design, but several found that pages 4 through 8 do not provide a well-supported argument for the conclusions. The section appears to be trying to argue that for technical reasons the project must be built in areas where the Extreme Storm Wave (ESW) is less than 20 feet and the water depths are less than 50 feet. This argument is not supported with references or the contents of these pages. With respect to water depths, current projects have not exceeded 50 feet in depth, however, 70 feet seems to be the current depth limit at which projects can still be installed on an economic basis and this is even being exceeded by the depths of the some of the projects recently awarded in the United Kingdom. The section concludes that to design a wind turbine to withstand the forces associated with plunging breakers is not practical; however, the case study references the Blyth project which is reported to have an ESW of 28 feet and to be experiencing breaking waves. Reviewers thought that it is technically feasible to design for breaking wave conditions; however, the costs and risks of doing so may be prohibitive. The costs are high due to the higher loads and the risks are high because of the limited experience in this area. These factors could easily combine to make the project uneconomical. If this is the case, it should be stated as such. As it now stands, the conclusions are poorly supported.

In Appendix 3-A, Introduction, it could be noted that the wind velocity will affect the design of the turbines as well as how and where they are sited.

In Appendix 3-A, Comparison of DOE…it should be noted that the mapping referred to was commissioned and supported by the Connecticut Clean Energy Fund and Northeast Utilities as well as MTC.

In Appendix 3-A, Wind Park Economics, the comparison of production from turbines in sites with different wind classifications is not strictly correct. Even though the power in the wind varies with the cube of the wind speed, the production from wind turbines does not necessarily follow the same relation. To predict actual energy production one must include the affect of the wind turbine power curve, which is often closer to linear than it is to cubic.

In the paragraph beginning, “Expanding the comparison…” note that the correct abbreviation for megawatt-hours is MWh, not mWh.

In the paragraph beginning, “In addition to wind…” Other important factors (especially for offshore) include soil conditions, distance to shore, and water depth.

Appendix 3-B

Appendix 3-B considers in detail the hydrodynamic effects on OWT support structures by focusing on wave-induced hydrodynamics. This is welcomed but it is also important to consider the potential impact of sediment scour around the WTG foundation. Modeling will be required to ensure that all these aspects of hydrodynamics are considered fully.

For Wind Turbine Generator (WTG) Components, strictly speaking, the nacelle is the entire turbine structure above the yaw bearing but not including the rotor.

In Appendix 3-B, Transition Piece, the word meant is “monopile”, not “monopole.”

In Appendix 3-B, “Offshore Environment” and “Wave Characteristics”, there is no discussion of reference to the design standards for offshore wind turbines which are being developed by the International Electrotechnical Commission Technical Committee 88, Working Group 3 (IEC TC88, WG3). These standards, which should be released shortly in draft form, will be of paramount importance in offshore wind turbine design, and so should be noted in this document. In this regard, the wave models that will be used will be either the Pierson-Moskowtiz or JONSWAP, depending on the location.

In Appendix 3-B, “Wave Characteristics”, the discussion of spectral wave period needs to be checked. “Period” refers to time. As used here, Hm0 is considered to be a height. What is presumably meant is the definition that can be found at http://sandbar.wes.army.mil/public_html/pmab2web/htdocs/dat_desc.html:
“Wave Height (Hm0): Spectrally-derived wave height, in meters; equivalent to time-domain-derived significant wave height in deep water”

Appendix 3-C

The reviewers identified no apparent technical errors or inaccuracies. One apparent inconsistency is in the second paragraph on Page 9 where the document states that “...the

Nantucket Shoals site has the potential to reduce the net peak output by an estimated 63 MW, if HVAC transmission is used. This is an approximate 15% reduction...” This is inconsistent with the statement near the bottom of Page 7 “...AC losses at peak load are anticipated to be approximately 1.5% at the proposed Horseshoe Shoal location and 4.5% were the location moved 24 miles further to Nantucket Shoal.” One reviewer felt that the statement on Page 9 is a worst-case example and the Page 7 statement is closer to the losses that would be expected.

Proposed Application of criteria to eliminate alternative sites

One reviewer suggested the following approach for eliminating alternative sites:

Transmission capability and a cooperating utility partner within proximity (25 miles?) of the site.

This criterion should be satisfied in order to proceed to the next criteria, otherwise drop the site from consideration. The distance to the proposed site may need to be increased to 50-60 miles in order not to screen out excellent sites, with higher wind that could potentially pay the added transmission costs. An impractical site would be eliminated by environmental, or project viability criteria IV and V. if the transmission length or trenching requirements are excessive.

Available land or permissible sea area for the project.

This criterion must also be satisfied to proceed to the next. If the required area is unavailable the site should be eliminated.

Wind energy potential for the site: Class 4 or better for land-based sites and Class 6 for offshore sites.

It may be better to work with a minimum wind speed and the frequency distribution curve, because the effect on energy capture can be dramatic, as noted earlier. This criterion should be used in conjunction with criteria IV and V. below to eliminate the least feasible sites from consideration. This is a critical criterion for site screening, because all of the environmental benefits flow out of energy production due to the associated air emissions reduction. This needs to be estimated as accurately as possible given the available site data and turbine specifications.

The environmental footprint, and lifetime impacts of the proposed project at the candidate site.

The objective of this criterion is to minimize the initial and long-term environmental impacts relative to the environmental benefits. These impacts can be quantified in terms of miles of cable, numbers of turbines, disturbance area required, and rotor swept area. The actual impacts, on avian and other species, would need to be quantified in terms of habitat loss, bird collisions, and other quantifiable impacts, and then weighed against the benefits. Quantifiable metrics could be developed using the ratio of the impacts values to the benefit values. This criterion must be used in conjunction with criteria III and V.

Project viability over the long term considering: engineering, design limitations, and technical risks; and the projects financial viability and long-term financial risks.

Emphasis here should be on the long-term risks and unknowns. The worst possible environmental outcome would be a failed and derelict project, with the owners in bankruptcy court. This would leave an unattended wind farm exposed to the elements for an extended period of time, with no clear legal path to alternatively refurbish the project, salvage the remains, or decommission the project. This scenario has previously been played out in the late 1980's in California.

To address future unknowns, either technical or environmental, the project must have "long-term viability". The wind industry has seen a number of unexpected technical problems after several years of initial operation. These include rotor and gearbox failures, higher than expected O&M costs, as well as the need for unplanned environmental studies, such as to further understand avian impacts. It is critical to have a viable project generating the financial resources with access to the technical expertise necessary to address unexpected problems, and to maintain and improve the facility over time. This also reflects back on the turbine manufacturer, and the ability to stand behind the warrantee, as well as to provide technical support for retrofit improvements.

Peer Review Committee, June 2003
Offshore Wind Energy, New England

Members	**Background**
Mr. H.J.M. (Jos) Beurskens Netherlands Energy Research Foundation Energy Centre of the Netherlands Solar & Wind Energy – Westerduinweg 3 P.O. Box 1 – 1755 ZG Petten The Netherlands Tel: +31-224-564184 (direct) or 564115 Fax: +31-224-563214 E-Mail: beurskens@ecn.nl	Mr. Beurskens is Vice President of the European Wind Energy Association and has been involved as an independent researcher on numerous European wind projects.
Dr. Carolyn Heeps Environmental Policy Manager Marine Estates Crown Estate, Great Britain 16 Carlton House Terrace London SW1Y 5AH United Kingdom Tel: +44-207-210-4323 (direct) Fax: +44-207- E-Mail: carolyn.heeps@crownestate.co.uk	The United Kingdom recently went through a selection process for offshore leasing of wind development sites, which was overseen by the Crown Estate, a national environmental regulatory body.
Dr. James F. Manwell Renewable Energy Research Lab College of Engineering - E Lab 219 Department of Mechanical and Industrial Engineering University of Massachusetts – Amherst Amherst, Massachusetts 01003 Tel: 413-545-4359 Fax: 413-545-1027 E-Mail: manwell@ecs.umass.edu	Dr. Manwell heads this well-respected academic institution that has trained many of today's practicing wind engineers. He is a professor in the Department of Mechanical and Industrial Engineering and has studied wind projects worldwide.
Robert Z. Poore President Global Energy Concepts, LLC 5729 Lakeview Drive NE, Suite 100 Kirkland, WA 98033-7340 Tel: 425-822-9008 Fax: 425-822-9022 E-Mail: rpoore@globalenergyconcepts.com	Mr. Poore has over 20 years experience in the design, test, and analysis of wind energy technology. In 1999 he received the American Wind Energy Association's award for technical excellence and was elected to the Association's Board of Directors by its corporate members.

rpoore@globalenergyconcepts.com	
Dr. Robert W. Thresher U.S. Department of Energy National Wind Technology Center National Renewable Energy Laboratory 1617 Cole Boulevard, MS 3811 Golden, Colorado 80401-3393 Tel: 303-384-6922 (direct) or 303-275-3000 Fax: 303-384-7097 E-Mail: robert_thresher@nrel.gov	Dr. Thresher has more than 30 years experience in wind technology, engineering, and aerospace systems. He is Director of NREL's technology center and was awarded a Lifetime Achievement Award from the American Wind Energy Association in 2001.
Mr. Daniel Zaweski Long Island Power Authority 333 Earle Ovington Boulevard, Suite 403 Uniondale, New York 11553 Tel: 516-719-9886 (direct) or 516-222-7700 Cell: 516-650-1477 Fax: 516-222-9137 E-Mail: dzaweski@lipower.org	LIPA has undertaken a multi-phase siting process to award a contract to develop 100 MW of wind off the shores of Long Island, New York.