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Sent: Tuesday, September 28, 2010 12:10 PM
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Subject: Draft Flicker Mitigation Plan
Attachments: NEES APW Shadow Flicker Mitigation Plan Draft 092810.docx

Bill, Steve, Bob,

Attached please find the draft Flicker Mitigation Plan for the Douglas Woods Wind Farm project. You suggested that it would be better to get the draft to you, Steve, Bob and the Planning Board so that we can receive feedback and comments in a more timely basis. We ask that you, Steve, Bob and the Planning Board members provide feedback by the end of this week, so that we can make revisions and mail out the proposed plan to affected neighbors with notice that the Flicker Mitigation Plan will be presented to the Planning Board at the next Planning Board meeting, currently scheduled for 10/12/2010. I will bring hard copies of the attached plan tonight for you and the Planning Board

Regards,

Rod

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Douglas Woods Wind Farm

Flicker Mitigation Plan

American Pro Wind, LLC

September 28, 2010

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Background

American Pro Wind, LLC (APW) is developing a commercial-scale wind farm project on a 298-acre site in Douglas, Massachusetts located off of Route 16 and abutting the Webster town line. The project consists of 11 wind turbines. Each wind turbine is affixed to the top of a 100-meter tower with three 50-meter blades. Each turbine has a nameplate capacity of 2.5 MW. With a total capacity of 27.5 MW, the project is estimated to generate approximately 61 to 65 million KW hours of clean, renewable electricity annually, enough to power all the households in the towns of Douglas and Webster combined. It is estimated that the clean, renewable energy generated by this facility will avoid between 45,000 to 49,000 tons of CO2 emissions annually. It is also expected that the project will generate approximately \$150,000 in additional annual PILOT (Payment-in-Lieu-of-Taxes) revenues for the town of Douglas and \$82,000 in additional annual tax revenues for the Town of Webster. The project parcel has received a Height and Use Variance from the Douglas Zoning Board of Appeals (ZBA) establishing the legal right to construct up to 13 turbines on the project site and establishing 22 approval conditions. Among the conditions are the project's setback requirements including a requirement to construct the wind turbines no closer than 1,000 feet to any residential building existing as of May 6, 2009.

Shadow Flicker Explanation

During certain times of the day, usually very early morning or late afternoon when the sun is low on the horizon, the wind turbines may cause shadow flicker (moving shadow) at buildings within a certain distance of the turbines. The shadow flicker happens only when the turbine is located directly between the sun and the building. It is caused by the sunlight being intermittently blocked by the rotating blades as the sunlight passes through the turbine blades. This flicker effect is typically caused only in certain conditions when the sun is shining, the sun is low on the horizon, and the wind is blowing at a sufficient speed to rotate the blades. In addition, the amount of shadow flicker observed is influenced by the direction of the wind. For instance, when the wind is blowing in a direction which results in the blades rotating at a 90 degree angle to a direct line between the sun and the receptor (residential building), then the amount of shadow flicker is maximized. When the wind is blowing in a direction that results in the blades rotating in parallel to a direct line between the sun and the receptor (residential building), then the amount of shadow flicker is reduced to a minimum. Shadow flicker dissipates over distance and is typically not observed at all from distances of 1,000 meters (3,280 feet) or more from the turbines. In the case of the Douglas Woods Wind Farm, all of the residential buildings within 3,280 feet of the turbines are located to the west (specifically northwest, west, and southwest) of the affecting turbines. Therefore, the expected shadow flicker will occur only in the morning hours with the vast majority of it in the very early morning hours.

While the "moving" or "on-off" effect of shadow flicker does not pose any health risks, it can be annoying. Therefore, most commercial-scale wind farms provide for mitigation by shutting off the affecting turbines for a sufficient amount of time to ensure that the shadow flicker is not experienced by nearby residents for a prolonged period of time during the course of a day and the course of a year. Shadow flicker can also be mitigated by trees and vegetation acting as obstructions so that the shadow flicker is not observed, or it can be mitigated by the use of shades or blinds in the building.

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There are no state laws or local bylaws that restrict shadow flicker. Common practice is to minimize the amount of shadowing/flicker through siting and/or mitigation such that prolonged impacts are not felt by neighboring residences. A typically applied standard for wind farms in North America is that shadow flicker will be reduced to 30 expected (or experienced) hours per year or less for nearby residences. This standard results in residences experiencing no flicker for at least 99.7% of the time during any given year.

Purpose of the Plan

On May 6, 2009 a Height and Use Variance was granted by the Douglas ZBA allowing construction of up to 13 turbines on the project site. The site plan currently being proposed is for the construction of 11 wind turbines. The Variance Agreement created conditions for the construction of the wind energy project. For example, it established setbacks and requires that all turbines are constructed at least 1,000 feet from any existing residential buildings. This setback requirement in itself will reduce the number of nearby residents that will experience shadow flicker impact.

Condition #7 of the Variance Agreement specifically requires that "During Site Plan Review, the Applicant shall present mitigation of shadowing or flicker impacts as follow. As to any residential location existing as of May 6, 2009, where estimated shadowing/flicker exceeds 30 Experienced Hours per year, the Applicant shall provide to the Board with copies to the affected property owners, a Flicker Mitigation Plan for the Board's review and approval, prior to the submission of the building permit application. Said Mitigation Plan shall either: (i) provide for mitigation where shadowing/flicker is reduced to thirty (30) Experienced Hours or below per year; or (ii) set forth such other acceptable resolution that may be approved as part of the Mitigation Plan. "Experienced hours" are defined as hours a residence is in use and the occupants are awake. The purpose of this Flicker Mitigation Plan is to completely satisfy the requirements of Condition #7.

Shadow Flicker Analysis Study

A Shadow Flicker Analysis Study was conducted on behalf of American Pro Wind, LLC by Atlantic Design Engineers and completed on September 14, 2010. The study without Appendix A, which is 93 pages of very detailed data print-outs, is attached to this plan. The complete Shadow Flicker Analysis Study with Appendix A is available to the public at the Douglas Town Clerk's office. The study utilizes WindPRO software, which is commonly used within the wind energy industry to determine shadow flicker impacts. By entering the exact locations (GPS coordinates) and dimensions of the 11 turbines, the software can calculate the amount of shadow flicker hours/year that is expected to be observed in areas of close proximity to the project site. Figures 3 and 4 in the Shadow Flicker Study show aerial photos that utilize colored iso lines to show the areas that will receive certain ranges of expected flicker hours per year.

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As the Study shows, there are 34 residential buildings located within the orange line (50-74 hours), gold line (30-49 hours), and yellow line (20-29 hours) combined. All of these 34 residences are located in Webster, MA in the areas of Blueberry Hill, Douglas Road, and Old Douglas Road. The locations (GPS coordinates) of these 34 residential buildings were entered into the WindPRO software, which calculated the shadow flicker hours per year at each of the 34 locations – both the “astronomical (or theoretical)” worst case hours and the actual expected hours/year of shadow flicker. The “astronomical (or theoretical)” worst case hours assume that the sun is shining 100% of the time, the wind is blowing 100% of the time, the wind is blowing 100% of the time from the direction that will result in the rotors rotating perpendicular to the line from the residential building to the turbine creating maximum shadow flicker, and the turbine is available for operation 100% of the time. Of course, this scenario will never happen which is why it is called the “astronomical (or theoretical)” worst case.

In reality, the actual expected hours will be much lower because of times when it is cloudy, because of times when the wind is not blowing, because of times when the wind is not blowing in a direction that results in the blades rotating at a 90 degree angle to the line between the sun and the residential building, or because of times when the turbine is shut down for scheduled maintenance or repair. The expected hours can therefore be calculated by the Wind PRO software by starting with the “astronomical (or theoretical)” worst case hours and reducing that number to account for the percentage of time it is sunny versus cloudy, the percentage of time the wind speed is sufficient to rotate the blades, and the percentage of time that turbine is available for operation (and not down for planned maintenance or repair). The expected hours calculation is further reduced to account for the fact that the wind is not always blowing in a direction that results in the blades rotating at a 90 degree angle to the line between the sun and the residential building. Historical data for sunshine, wind speed, turbine availability, and wind direction were entered into the WindPRO software to make these calculations.

The output of the analysis includes the table on page 6 of the Shadow Flicker Analysis (attached) entitled “Estimated Shadow Flicker”, which lists the 34 residences, their address, the “astronomical (or theoretical)” worst case shadow flicker hours/year, the expected shadow flicker hours/year, the astronomical (or theoretical) maximum shadow flicker minutes/day, and the expected shadow flicker minutes/day. As the table below shows, 17 of the 34 residential locations are expected to experience shadow flicker of more than 30 hours/year and will, therefore, require mitigation. In addition to the summary table, the output of the analysis also provides us with the calculated expected shadow flicker hours by day for an entire calendar year at each of the 17 residential buildings. This is shown in the attachment entitled SHADOW - Main Result, which shows for each of the 17 residences the daily flicker impact in minutes, the time at which the flicker is expected to begin and end, and the particular number of the turbine(s) causing the shadow flicker (see Shadow Flicker Analysis for project layout and turbine #'s). The Flicker Mitigation Plan submitted to the Planning Board will include this annual calendar with expected daily shadow flicker impacts for all 17 residences. The Plan submitted to affected residents will include the calendar of expected daily shadow flicker impact for their particular residence.

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In reality, many of the 34 residences listed are located in close proximity to trees which may act as an obstruction that can reduce or eliminate any potential shadow flicker impacts. As a result, it is likely that some of the 34 residences listed will experience substantially reduced shadow flicker times compared to those shown in the analysis. However, the extent of the benefit of these obstructions is hard to predict and could be variable (i.e. foliage disappears in the winter on non-evergreen trees). Therefore, in order to be appropriately conservative, APW has assumed in this analysis that no trees or obstructions exist. This will help assure that all potential shadow flicker impacts on nearby residences will be fully captured by the analysis.

Flicker Mitigation Plan - Objectives

In order to satisfy Condition #7 of the Height and Use Variance Agreement, the objective of the Flicker Mitigation Plan is to reduce shadow flicker hours to 30 Experienced Hours/year or less at all residential buildings existing as of May 6, 2009. "Experienced Hours" is further defined by the Variance Agreement as hours that the residence is in use and the occupants are awake. This definition would typically reduce the amount of expected shadow flicker hours at many households because much of the flicker occurs very early in the morning when occupants may be sleeping. In reality, it is virtually impossible to determine at any given time who in the residence is awake or sleeping. Therefore, to be appropriately conservative, the calculation of expected shadow flicker hours/year assumes that the occupants are always awake. To be additionally conservative, the target maximum Experienced Hours/Year allowable at each of the 17 affected residences (after mitigation) has been reduced from 30 to 29 hours to reduce any potential margin of error. Based on the Shadow Flicker Analysis, Exhibit A (next page) lists the 17 residences that will receive more than 30 expected hours/year of shadow flicker, and therefore will be provided with mitigation. It also lists the expected shadow flicker hours/year for each of the 17 residences and the corresponding mitigation hours/year required to reduce the net expected shadow flicker hours (after mitigation) to 29 hours, which is below the 30 hour maximum required by Condition #7. For example, the table below shows that the calculated expected shadow flicker hours/year for 70 Old Douglas Road prior to mitigation is 38 hours and 55 minutes. As Exhibit A shows, the estimated mitigation required to reduce the shadow flicker hours/year at 70 Old Douglas Road to 29 hours/year is 9 hours and 55 minutes per year. Exhibit A shows that the worst case shadow flicker occurs at 4 Dream Street, which is expected to experience 54 hours and 2 minutes of shadow flicker per year prior to mitigation. The estimated mitigation hours/year required at this residence is 25 hours and 2 minutes in order to reduce the shadow flicker hours/year to 29 hours.

A secondary objective of the Flicker Mitigation Plan, although not required by the Variance Agreement, is to mitigate the shadow flicker for the 17 residences in a way that assures that none of the 17 residences in Exhibit A receive more than 30 minutes of shadow flicker in any one day. This objective was added to the plan as a result of input from the Douglas Planning Board.

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Exhibit A

ESTIMATED SHADOW FLICKER AND MITIGATION PLAN

SHADOW RECEPTOR	ESTIMATED SHADOW FLICKER			
Receptor Name	Astronomical Maximum Value Hours/Year	Expected Hours/Year	Mitigated Hours/Year	Net Expected Hours/Year After Mitigation
A. – 135 Douglas Road	122:59 hours/year	34:03 hours/year	≈ 5:03 hours/year	≈ 29 hours/year
B. – 78 Old Douglas Road	101:08 hours/year	32:25 hours/year	≈ 3:25 hours/year	≈ 29 hours/year
C. – 4 Dream Street	153:28 hours/year	54:02 hours/year	≈ 25:02 hours/year	≈ 29 hours/year
D. – 63 Blueberry Way	97:49 hours/year	37:19 hours/year	≈ 8:19 hours/year	≈ 29 hours/year
E. – 133 Douglas Road	112:44 hours/year	30:44 hours/year	≈ 1:44 hours/year	≈ 29 hours/year
H. – 76 Old Douglas Road	99:22 hours/year	32:25 hours/year	≈ 3:25 hours/year	≈ 29 hours/year
I. – 74 Old Douglas Road	132:39 hours/year	45:18 hours/year	≈ 16:18 hours/year	≈ 29 hours/year
J. – 72 Old Douglas Road	116:51 hours/year	40:29 hours/year	≈ 11:29 hours/year	≈ 29 hours/year
K. – 70 Old Douglas Road	112:04 hours/year	38:55 hours/year	≈ 9:55 hours/year	≈ 29 hours/year
L. – 68 Old Douglas Road	89:03 hours/year	30:15 hours/year	≈ 1:15 hours/year	≈ 29 hours/year
M. – 66 Old Douglas Road	89:38 hours/year	31:53 hours/year	≈ 2:53 hours/year	≈ 29 hours/year
P. – 61 Blueberry Hill	99:15 hours/year	37:38 hours/year	≈ 8:38 hours/year	≈ 29 hours/year
T. – 53 Blueberry Hill	89:20 hours/year	32:34 hours/year	≈ 3:34 hours/year	≈ 29 hours/year
U. – 51 Blueberry Hill	102:35 hours/year	37:02 hours/year	≈ 8:02 hours/year	≈ 29 hours/year
V. – 49 Blueberry Hill	120:21 hours/year	43:51 hours/year	≈ 14:51 hours/year	≈ 29 hours/year
W. – 47 Blueberry Hill	97:36 hours/year	34:55 hours/year	≈ 5:55 hours/year	≈ 29 hours/year
Y. – 3 Dream Street	115:43 hours/year	41:53 hours/year	≈ 12:53 hours/year	≈ 29 hours/year

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Flicker Mitigation Plan - Method

In order to mitigate the shadow flicker hours sufficiently to reduce experienced hours to 30 hours/year or less at each of the 17 residential locations, APW will install a Shadow Impact and Switch Off Module as well as a photo voltaic light sensor to control Turbines # 1, 4, 7, and 9. These are the primary turbines causing the greatest amount of shadow flicker impact on the 17 residences. A single Shadow Impact Module can monitor and control up to 12 wind turbines in up to 100 receptors (residential locations). The Shadow Impact Module is manufactured by NorthTec GmbH and will be installed by Nordex, the manufacturer of the turbines. Detailed information regarding the module is provided by the attachment entitled "Shadow Impact Module SIM - Manual for Version 3.0." This automated method of shutting down turbines to mitigate the Experienced Hours of shadow flicker to 30 hours/year or less is the most effective way to ensure proper mitigation. Setting a fixed schedule would not work. Even though we can provide a fairly accurate estimate of the expected hours of shadow flicker per year, we cannot predict the exact timing of the flicker because we cannot predict the exact times when the sun will shine, the exact times when the wind will blow, and the exact times when the wind is blowing a certain direction. The automated module determines when these conditions exist and shuts down the turbines accordingly. It will track the actual hours of Experienced shadow flicker at each of the 17 affected residences and automatically shuts the affecting turbines off when the maximum allowances have been reached. Therefore, it is the most reliable method to mitigate the shadow flicker impact to a specific number of Experienced Hours.

The module is programmed with the exact locations (GPS coordinates) of the turbines (#1, 4, 7, and 9) and the exact locations (GPS coordinates) of the 17 residences that require mitigation. The Shadow Impact Module determines the position of the sun relative to the turbine(s) and relative to each residence and calculates the times of the year and the times of each day that shadow flicker is theoretically possible. This is essentially the same as the "astronomical (or theoretical)" worst case calculated in the Shadow Flicker Analysis described above. Whenever the shadow flicker is theoretically possible based upon the position of the sun, then the automatic module and light sensor detect if the conditions exist (sunshine, wind speed, wind direction) that can result in potential shadow flicker actually occurring. If all the conditions exist which can result in actual experienced shadow flicker at any one of the 17 residences, the module starts counting the minutes of flicker for that particular residence. When the counter reaches the maximum limit of 30 minutes/day or 29 hours/year for a particular residence, the module will automatically shut off the affecting turbine(s) for the rest of the day or for the rest of the year whenever the conditions allowing actual shadow flicker impact are present. This will ensure that each of the 17 residences will receive a maximum of 29 Experienced Hours of flicker per year and a maximum of 30 Experienced Minutes of flicker per day.

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Maintenance

Nordex will be responsible for the maintenance of the Turbines and the Shadow Impact Module. The Shadow Impact Module itself requires little maintenance. However, the light sensors will be checked for dirt and cleaned on a regular basis, at least every 4 months. Also, the proper functioning of the Radio Controlled Clock (RCC) module will be checked every 4 months. After commissioning the Shadow Impact Module, Nordex will check the shut-down times for plausibility in order to exclude potential errors in the shadow impact module configuration. Finally, Nordex assures reliable operation of the Shadow Impact Module by reviewing the daily logs and quarterly reports to confirm that the maximum allowable flicker limits of 30 hours per year and 30 minutes per day have not been exceeded at any of the 17 affected residences that require mitigation, and if the limits have been reached to verify that the affecting turbines are being automatically shut off accordingly when flicker conditions exist.

Tracking/Reporting

APW will install an optional log function on the Shadow Impact Module which tracks, records, time stamps (using the radio controlled clock installed on the turbine) and stores all shadow flicker impact events at each of the 17 residential locations (referred to as "Places of Immission" in the attached Shadow Impact Module manual) during the course of a one year period. The events recorded by the log include:

1. **Shadow Impact:** Real shadow flicker impact is actually occurring at a specific residential location.
2. **Theoretical Shadow Impact:** Theoretically, shadow flicker impact may occur at a specific residential location based on the position of the sun. However, all of the conditions (sunshine, wind speed, turbine availability, wind direction) are not present that would allow actual shadow flicker to occur.
3. **End of Shadow Impact:** Since the sun has changed its position, the corresponding wind turbine can no longer cause actual shadow flicker impact at the corresponding residential location.
4. **Stop WTG:** The corresponding wind turbine generator was stopped by the shadow flicker impact module because either the daily or annual maximum limit of actual experienced shadow flicker hours has been exceeded at the corresponding residential location.
5. **Start WTG:** The corresponding wind turbine generator was released and allowed to turn back on because the conditions (sunshine, sun position, wind speed, wind direction) that would allow potential shadow flicker to occur no longer exist.

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By reviewing the logs, one will be able to tell the following information on a daily or annual basis for each of the 17 residential locations:

2. The number of hours of "theoretical (or astronomical)" worst case shadow flicker when the sun was in a position to create potential shadow flicker impact assuming that all the conditions (sunshine, wind speed, wind direction, turbine availability) necessary to allow flicker impact are present all the time.
3. The number of hours of expected shadow flicker (prior to mitigation) when all the conditions (sunshine, wind speed, wind direction, turbine availability) required to cause shadow flicker impact are present.
4. The number of hours that the affecting turbines were shut down to provide mitigation because the maximum limits of daily or annual shadow flicker had been exceeded at that particular residential location.
5. The number of net (after mitigation) actual Experienced Hours of shadow flicker at a particular residential location.

APW will investigate the feasibility of providing on-line access to these reporting logs. If this capability exists, then the reporting logs will be made accessible to the public via the Town of Douglas web site. In any case, a quarterly tracking report will be submitted by Nordex to the Town of Douglas, which will be available for public viewing. The quarterly report will list the following information for each of the 17 affected residences being provided with mitigation:

1. The theoretical (worst case) of shadow flicker – both the number of minutes for each day during the quarter and the cumulative hours year-to-date
2. The actual expected (pre-mitigation) shadow flicker – both the number of minutes for each day during the quarter and the cumulative hours year-to-date
3. The mitigation time when the affecting turbines are shut off automatically because either the daily maximum or the annual maximum has been exceeded – both the mitigation minutes per day for each day during the quarter and the cumulative mitigation hours year-to-date
4. The net Experienced (after mitigation) shadow flicker – both the Experienced minutes for each day during the quarter and the cumulative hours year-to-date