

STATE OF MINNESOTA
ENVIRONMENTAL QUALITY BOARD

In the Matter of the Request of Moraine Wind, LLC for Approval to Locate Wind Turbines Within Five Rotor Diameters of the Site Boundary and to Modify Wind Turbine Array Spacing Requirements Authorized by the MEQB's Site Permit Issued to Moraine Wind, LLC for a 130.5 Megawatt Large Wind Energy Conversion System in Pipestone and Murray County, Minnesota

**MINNESOTA ENVIRONMENTAL
QUALITY BOARD'S FINDINGS OF
FACT, CONCLUSIONS, AND ORDER
AUTHORIZING EXCEPTIONS TO
BUFFER SETBACK AND AMENDING
RESTRICTIONS ON TURBINE SPACING**

SITE PERMIT NO. 01-10-LWECS-NE

The above-entitled matter came before the Minnesota Environmental Quality Board at a regular meeting on February 20, 2003, pursuant to a request by Moraine Wind, LLC, to approve the location of six turbines near the west and east boundaries of the project and to amend Site Permit No. 01-10-LWECS-NE to modify the permit restrictions on internal turbine spacing. Moraine Wind has requested approval to place six wind turbines within five rotor diameters of the site permit boundary and an amendment of the permit to reduce internal turbine spacing requirements from four rotor diameters crosswind and eight rotor diameters downwind to three rotor diameters and six rotor diameters, respectively.

STATEMENT OF ISSUE

Should the MEQB grant the request of Moraine Wind, LLC, to locate six turbines near the project boundary and to amend Site permit No. 01-10-LWECS-NE to modify restrictions on internal turbine spacing.

Based upon the record and proceedings herein, the Minnesota Environmental Quality Board makes the following:

FINDINGS OF FACT

Background

1. On May 17, 2001, the Minnesota Environmental Quality Board issued a site permit in accordance with its authority under Minnesota Statutes section 116C.694 to Navitas Energy, LLC, for a 130.5 megawatt large wind energy conversion system in Murray and Pipestone Counties.

2. On April 18, 2002, the MEQB approved a transfer of Site Permit No. 01-10-LWECS-NE to MAPP Wind I, LLC, a limited liability company owned by PacifiCorp Power Marketing, Inc. (PPM). Subsequently, PPM changed the name of the limited liability company from MAPP Wind to Moraine Wind, LLC, and on December 19, 2002, the Board authorized a transfer of the permit to Moraine Wind. Moraine Wind is the present permittee and the company requesting the change in the site permit conditions.
3. Moraine Wind plans on building this project in three phases. Phase I consists of 34 turbines to generate approximately 51 megawatts of electricity. Phase II consists of 33 turbines to generate approximately 49.5 megawatts, and Phase III consists of 20 turbines to generate another 30 megawatts. Moraine's request for a change in the permit conditions applies only to Phase I of the project – the first 51 megawatts and 34 turbines.
4. Phase I of the Moraine Wind project is to be located in Sections 7, 16, and 19 of Cameron Township in Murray County and Sections 2, 13, 24, and 25 of Rock Township in Pipestone County. The projects bordering the Moraine project are the existing Florida Power and Light project ("NSP Phase III" or "Lake Benton Power Partners II") with turbines located in section 13 of Rock Township, and the Chanarambie Power Partners project scheduled for construction in summer 2003, with turbines to be located in section 30 of Cameron Township. See Exhibit 1A, a map of the project area, which is attached to these Findings.
5. Moraine Wind is planning to install General Electric Wind 1.5 Megawatt turbines. The turbine blades are approximately 35 meters (115.5 feet) long. The rotor diameter is approximately 70.5 meters (232 feet).
6. Moraine desires to maintain a schedule that ensures construction completion and commissioning prior to the end of the year due to adverse weather conditions and the current December 31, 2003, expiration date of the federal production tax credits. Moraine must order electrical equipment and cabling by early March for May delivery to maintain such a schedule, which requires roads to be completed by June for the first wind turbine deliveries in late June and early July. Prior to ordering this long lead equipment Moraine must complete final micrositing, i.e. final turbine locations, so that all final engineering and design aspects can be completed. An earlier commercial operation date also allows earlier delivery of the wind energy to NSP, and avoids any potential unfavorable economic consequences to NSP under the power purchase agreement.

Micrositing

7. Once a large wind energy conversion system (LWECS) site permit is issued, project developers engage in micrositing of the turbines. Micrositing of the turbines allows the permittee to factor in the site permit requirements while seeking to maximize production and reduce the infrastructure costs associated with project development. This involves considering topographical features, environmental limitations (wetlands, streams, lakes, native prairie), cultural resources, occupied residences, roads, electric feeder line routes to get the power to a substation, compatibility with crop farming, access roads, other landowner preferences, wake or array losses, and other various setback and location requirements. Most of these considerations limit or reduce the amount of land available for siting turbines by excluding portions of land parcels from use. On the remaining portions that may be possibly available, the developer needs to consider production capability and costs to find the most efficient sites. In certain situations, these considerations can identify a conflict between specific permit conditions and the turbine layout that best promotes the objective of an efficient use of resources.
8. Regionally, the three prevailing wind directions are south, southeast and north-northwest. Along Buffalo Ridge, the wind blows from all directions. However, the prevailing winds are from south-southeast and northwest. Southerly winds are most frequent in the summer. The northerly winds typically occur in winter. Less than 10 percent of the turbine energy is from the west-east directions.
9. When wind turbines extract energy from the wind, they change the air flow behind the turbine (downwind wakes). The air flow in the wake is more turbulent and its forward velocity is reduced. As the wake moves away from the turbine's rotor, it expands into the atmosphere and diminishes. Eventually, normal wind flow is restored by mixing the unaffected wind flows around the wake with the wake.
10. Wakes have several important effects on those downwind turbines that are close enough to be within the wake. The wind's strength is reduced, thus less energy is produced from the downwind turbines. The reduction in energy is called wake loss. In addition, turbulence from turbine wakes has long-term effects on the reliability and maintenance of turbines. More turbulence increases mechanical stress in the blades and rotating mechanisms. Wake effects intensify downwind and across successive turbines when they are spaced close enough together for each downwind turbine to be in the wake of its predecessor. However, crosswind spacing has a negligible effect on adjacent turbines.

11. Wind turbines are sited in clusters or strings along hilltops and ridgelines within the site boundaries. The wind turbines are sited on Buffalo Ridge so as to have good exposure to winds from all directions, with emphasis on exposure to the prevailing southerly wind direction. Sufficient spacing between the turbines is utilized to minimize array wake losses.
12. The terminology used to discuss spacing between turbines is based on “rotor diameters.” One rotor diameter (RD) is the longest distance from blade tip to blade tip during rotation of a horizontal axis turbine. Turbines are constructed in strings in the direction from which the wind occurs less often, or the crosswind direction. Space must be provided between strings, in the downwind direction. MEQB wind permits have included spacing requirements both between turbines in a string and the distance between the strings. The restriction is expressed in terms of rotor diameters, such as 3 RD crosswind and 6 RD downwind. Such spacing would be referred to as 3 x 6 spacing. The crosswind restriction applies to turbines within a string, and the downwind restriction applies to the separation between the strings. Turbine spacing in the crosswind direction can be less.
13. The key factors remain how close turbines are in every direction, how many turbines are within contiguous wakes, and how the winds are distributed around the compass (known as the “wind rose”). Spacing is also affected by available land, site topography, cost issues, who has the associated risks, and the effects of various setback requirements. Due to topography, turbines on Buffalo Ridge are not in neat parallel rows or have consistent spacing.
14. Moraine’s proposed turbine rows (strings) are laid out in a west-east orientation. Spacing of turbines within strings is closer because they are perpendicular to the prevailing southerly winds. The distance between strings is greater, with respect to the predominant energy production directions. Given the prevalence for southerly winds, the spacing is greatest in this direction. Greater or lesser spacing between the turbine strings is used where terrain dictates spacing.

State Policy and Site Permit Conditions

15. Minnesota law directs the MEQB to site large wind energy conversion systems in an orderly manner compatible with environmental preservation, sustainable development, and the efficient use of resources. Minn. Stat. § 116C.693.
16. Site Permit No. 01-10-LWECS-NE contains a number of conditions that apply to site preparation and design, construction, restoration, operation, maintenance, abandonment, decommissioning and all other phases of the proposed project. Two of the permit conditions establish restrictions on how close together the permittee may place the turbines and how close to the project boundary the permittee may locate a turbine.

17. Condition III.C.1.of the Site Permit restricts how close to the project boundary the permittee may locate turbines. That conditions states:

Wind turbine towers shall not be placed less than 5 rotor diameters from the perimeter of the site without the approval of the MEQB.

18. Condition III.E.6 of the Site Permit requires that turbines be sited within the site with spacing of no less than four rotor diameters (4 RD) for cross-wind purposes (distance between turbines) and no less than 8 RD for downwind purposes (distance between strings of turbines). The permit allows the permittee to site up to 20 percent of the turbines closer together if necessary to account for topographic conditions.

Moraine Wind Access Buffer Request and MEQB Staff Analysis

19. The wind access buffer requirement at III.C.1 of the site permit has been a condition in all of the LWECS site permits, except one, issued by the Board. The purpose of this condition is to insure that each developer provides a wind buffer to protect its project and neighboring projects from what is known as “turbulence” or “wakes” described in Findings 9 through 14. The effects of wake are significantly dissipated at a distance of ten rotor diameters. Therefore, the MEQB has required a five-rotor diameter setback in site permits, so that one project would not affect another one, thereby protecting the wind resource of each developer.
20. In a letter dated January 31, 2003, Moraine requested that the MEQB allow the placement of six wind turbine towers closer than 5 rotor diameters from the site permit boundaries along the west-east (crosswind spacing) axis. The six turbines are numbers 33, 16, 10, 4, 11 and 26. These turbines are identified in the map attached hereto as Exhibit 1A. Specific information about each turbine is included in the following table:

Turbine Number	Township & Sec.	RD Setback	Supporting Information
33	Cameron 7	1.5	No turbines in the adjacent parcel to the west. Project boundary is west of the turbine location, which is not the prevailing wind direction. Residences in both the SE and NE ¼ of Section 12 may impede development in those areas. Setbacks from residences are complied with.
16	Cameron 19	2	No turbines planned north and east of this turbine in sections 17 or 20. Phase II of the project is expected to be adjacent to the east of the Phase I project and is a part of the site permit. Home in NW ¼ of Sec. 20 may restrict other turbine locations due to other setback requirements.
10	Cameron 19	1.5	Discussion immediately above applies to this turbine, except home in SW ¼ of Sec.20 may limit additional turbine locations due to setback requirements.
4	Rock 24	2	No turbines planned on the adjacent western parcel.
11	Cameron 19	4	Van Beek State Wildlife Management Area west of this turbine will limit any additional development to the west of this turbine.
26	Rock 12	4.5	No turbines planned in adjacent parcel and the boundary is to the west.

21. The six turbines that Moraine Wind wants to locate closer than 5 RD to the project boundary are all located on the eastern or western permit boundary for Phase 1 of the project. The fact that the prevailing winds are not in the direction of the nearest boundary will result in only minor impacts on neighboring projects if there is any impact at all.
22. Turbine No. 11 will be 4 RD from the west site boundary. A portion of the parcel west of turbine 11 is a Department of Natural Resources Wildlife Management Area (Van Beek Wildlife Management Area) which is also a natural buffer, because wind turbines will not be located there. The Van Beek WMA also

provides an additional buffer between Phase I of the Moraine Wind project and the NSP Phase III project owned by Florida Power and Light. This turbine will be more than 10 RD from the three nearest FP&L turbines located in the northern half of the southeast ¼ of section 13 in Rock Township.

23. The closest turbines (10 and 33) to the nearest project boundary will be 1.5 RDs from the boundary. See Finding No. 20 and the table. Since these turbines are located along an eastern or western site boundary, if another project should be proposed near these turbines, it will still be possible to maintain a minimum crosswind separation of 3 RD from any new turbines that are proposed. The minimum internal turbine array spacing for the FP&L project is 2 by 6 RDs. A 1.5 RD setback will still allow for adequate crosswind spacing between projects. The other four turbines are 2 RDs or more from the boundary and an adequate crosswind separation should be possible if new turbines are proposed to be located nearby. In all other instances, Moraine, along with Florida Power and Light, Chanarambie Power Partners and Stoneray Power Partners, will maintain the 5 RD separations from any north-south project boundary.

Turbine Spacing Amendment Request and MEQB Staff Analysis

24. The separation required between turbines and between strings of turbines under condition III. E.6 of the site permit has varied from one site permit to another. A 3 RD by 6 RD restriction is within the parameters established in other site permits. For example, the NSP Phase III site permit, adjacent to west side of this project and extending northward has a minimum spacing of 2 by 6 RD, but most of the turbines are further apart. Generally, because the separation is of concern to the project proposer, the MEQB has accepted the separation requested by the permittee. In this case, the original applicant – Navitas Energy – requested a 4 RD by 8 RD separation. The purpose of the restriction is to minimize wake loss effects, but there has not been one specific restriction regarding turbine spacing that has been required in all permits.
25. In a letter dated January 31, 2003, and e-mails dated February 4, 7 and 11, Moraine has requested that the MEQB amend the internal turbine spacing requirements from four rotor diameters crosswind and eight rotor diameters downwind to three rotor diameters and six rotor diameters, respectively. Moraine has determined as a result of its micrositing analysis that up to 13 of the turbines would be located closer than 4 RD in a crosswind direction and three turbines would be located closer than 8 RD between strings. The specific turbines and the separations are shown in the following tables. The turbine locations are shown on the map attached hereto as Exhibit 1A.

East West Spacing (Between Turbines)

Turbine Numbers	Spacing in feet	Spacing in RD
7-8	770	3.33
8-9	770	3.33
12-13	700	3.03
13-14	760	3.29
14-15	695	3.00
15-16	765	3.31
17-18	912	3.94
19-20	790	3.42
21-22	815	3.52
22-23	890	3.85
28-29	760	3.29
29-30	775	3.35
30-31	830	3.59

North-South Spacing (Between Strings)

Turbine Numbers	Spacing in feet	Spacing in RD
1-2	1,475	6.38
2-3	1,650	7.15
25-27	1,175	5.08

26. Moraine has determined that its proposed layout is best suited to efficient use of resources within the site, while preserving adequate land and wind resources for the project's two other proposed phases. Moraine believes that its final siting appropriately considers all factors leading to its site layout proposal.

27. A reduction of spacing between turbines and between strings will result in additional losses due to the wake loss effect. However, there are other factors, such as transmission line losses, losses due to turbulence and icing, and turbine availability that also contribute to the overall project performance and project costs. The precise location of each turbine affects an individual turbine's performance in relation to other turbines. Moraine has determined that reducing the turbine spacing slightly, although it will increase wake loss, allows Moraine to optimize energy production and to minimize project development costs.

28. Moraine has used a computerized model to evaluate wake losses. Moraine estimates that there will be an approximate 3.2% increase in losses from the proposed configuration as compared to one that complies with a 4 x 8 RD separation. However, there are countervailing considerations that must be considered. Placing the turbines more closely reduces other costs, such as those associated with turbine access roads and underground feeder lines. It also reduces the overall size of the project and preserves land for additional future development.

29. Moraine Wind has requested a permit amendment to change the turbine spacing from 4 X 8 to 3 X 6. Moraine is prepared to accept any additional energy losses resulting from the proposed configuration if the MEQB should approve the request.
30. Moraine Wind intends to conduct further analysis of wake loss effects after Phase I is constructed and in operation. Permit Condition III.I.1 requires the Permittee to provide the MEQB with any wake loss studies.

Review and Comments by Adjacent Wind Turbine Developers

31. Upon receipt of the request by Moraine Wind to locate six turbines closer to the project boundary than 5 rotor diameters, on January 31, 2003, the MEQB staff contacted both Florida Power and Light and Chanarambie Power Partners by e-mail. On February 7, 2003, Mr. John Cross of Florida Power and Light submitted a letter to the MEQB requesting that the MEQB withhold a decision on Moraine's request to be located closer than 5 RD from the project boundary for a period of 45 days until Florida Power and Light could investigate Moraine's request further. Chanarambie Power Partners has not raised any concerns over Moraine's request.
32. It is not unreasonable for Florida Power and Light to request additional time to evaluate the Moraine proposal. for turbine 11, although, as stated in Finding 22, turbine 11 is more than 10 RD from the nearest FPL turbines.

Other Permit Considerations

33. Condition III.I 2.of the Site Permit allows the MEQB to establish final site permit boundaries. That condition states:

After completion of construction, the MEQB shall determine the final boundaries of the site permit required for this project. This Permit shall be modified, after notice and opportunity for public hearing, to determine the actual site required by the Permittee to operate the project authorized by this Permit. After final designation of the site, land included in this Permit but removed from the final authorization will become available for other wind projects.

34. Moraine will make this request sometime after completion of construction for Phase I of the project. Moraine's efforts to minimize the project footprint (Condition III.E.7.) and the requested changes represent a positive effort to minimize the Phase I project footprint. Moraine is also trying to scale back its expected "final site permit boundary." This will eliminate the need to assume obligations for land that may not be needed because the proposed Phase I site layout optimizes energy production and minimize project costs, while preserving future land for development.

Based on the foregoing Findings of Fact, the Board makes the following:

CONCLUSIONS

1. Minnesota Statutes section 116C.694 gives the MEQB authority to place conditions in a site permit and to modify a site permit.
2. Allowing Moraine Wind, LLC, to construct the requested six turbines within five rotor diameters of the expected as-built project boundaries will not result in an adverse impact on any neighboring projects, nor will it jeopardize the use of these neighboring lands for wind development in the future.
3. Amending Site Permit No. 01-10-LWECS-NE to change condition III.E.6 to allow a turbine separation of three rotor diameters between turbines and six rotor diameters between strings may result in an increase in wake losses associated with the project but these will be offset to some extent by other cost savings, and Moraine Wind is prepared to accept any losses that result from the new configuration.
4. It is reasonable to afford Moraine's neighbors, Florida Power and Light, an opportunity to petition the Board for reconsideration of its decision allowing Moraine to locate turbine 11 within 5 RD of the project boundary within thirty days of the issuance of this Order.
5. Any Finding of Fact more properly considered a Conclusion, or any Conclusion more properly considered a Finding of Fact, is hereby expressly adopted as such.

Based on the Findings of Fact and Conclusions contained herein, and the entire record of the proceeding, the Minnesota Environmental Quality Board hereby makes the following:

ORDER

1. The Minnesota Environmental Quality Board hereby grants approval to Moraine Wind, LLC to locate Turbines No. 4, 10, 11, 16, 26, and 33 closer than five rotor diameters from the property boundary and in the approximate locations shown on Exhibit 1A. This approval is conditioned on the right of the MEQB to reconsider this approval for Turbine No. 11 if Florida Power and Light should request the MEQB to do so within 30 days of the date of this Order and provide information to the MEQB that is not available at this time in support of the request.

2. The Minnesota Environmental Quality Board hereby amends condition III.E.6 in Site Permit 01-10-LWECS-NE to read as follows:

6. TURBINE SPACING

The turbine towers shall be constructed within the site as shown on the maps attached as Exhibits 1 and 1A. For phases II and III of the project, the turbine towers shall be spaced no closer than 4 rotor diameters (RD) for crosswind spacing (distance between turbines) and 8 RD downwind spacing (distance between strings of turbines). If required during final micrositing of the turbine towers to account for topographic conditions, up to 20 percent of the towers (11 towers) may be sited closer than the above spacing but the Permittee shall minimize the need to site the turbine towers closer. For phase I of the project, the turbine towers shall be spaced no closer than 3 rotor diameters (RD) for crosswind spacing (distance between turbines) and 6 RD downwind spacing (distance between strings of turbines) and one turbine may be spaced closer than the above spacing.

3. Exhibit 1A, a map of Phase I of the project, shall be incorporated into the Site Permit as amended.

Approved and adopted this 20th day of February, 2003

Bruce Bomier, Vice Chair
Minnesota Environmental Quality Board