

Lease payment Caluations and Land Use Area

****Subject to Final design****

Turbine Size: 2 megawatts						Operating Fees (annual payment)	Installation Fee (one time)	
# of Turbines	Road Length	Road Width	Road Area	Turbine Area	Land Use (Acres)			
12	900	16	172800	94200	6.13	\$ 96,000.00	\$ 5,000.00	
Total Land Used and Annual Payments						6.13	\$ 96,000.00	\$ 5,000.00

30 Year Contract Value		
Operating Fees		\$ 2,886,050.27
Installation Fees		\$ 5,000.00
Alternative Use Fee		\$ -
Development Fees	1985 acres	\$1.25 2 years
Total Lease Value		\$ 2,896,013.27

Operating Fees 1.5% Annual Increase	
Year	Operating Fee
1	\$96,000.00
2	\$97,440.00
3	\$98,901.60
4	\$100,385.12
5	\$101,890.90
6	\$103,419.26
7	\$104,970.55
8	\$106,545.11
9	\$108,143.29
10	\$109,765.44
11	\$111,411.92
12	\$113,083.10
13	\$114,779.34
14	\$116,501.03
15	\$118,248.55
16	\$120,022.28
17	\$121,822.61
18	\$123,649.95
19	\$125,504.70
20	\$127,387.27
21	\$129,298.08
22	\$131,237.55
23	\$133,206.12
24	\$135,204.21
25	\$137,232.27
	\$2,886,050.27

Ac

WIND ENERGY LEASE AND WIND EASEMENT AGREEMENT

This **WIND ENERGY LEASE AND WIND EASEMENT AGREEMENT** (this "**Agreement**") is made, dated and effective as of the Effective Date (defined below), by and between Landowner (defined below) and **PREVAILING WINDS, LLC**, a South Dakota limited liability company ("**Lessee**").

1. **Basic Provisions.** The following terms used in this Agreement have the meanings set forth below:

1.1	"Landowner"	Xxx, xxx.
1.2	"Property"	The real property consisting of approximately xxx acres located in Charles Mix County, State of South Dakota, that is described in <u>Exhibit A</u> attached hereto and incorporated herein by this reference.
1.3	"Effective Date"	November 1st, 2017.
1.4	"Development Period"	The period commencing on the Effective Date and expiring on the date five (5) years thereafter.
1.5	"Development Period Payments"	An annual payment equal to One and 25/100 Dollars (\$1.25) per one (1) acre of the Property leased by Lessee under this Agreement; provided, however, that if the Property consists of less than 160 acres, the annual Development Period Payment shall be \$200.00.
1.6	"Operating Fees"	An annual payment of Four Thousand Dollars (\$4,000.00) for each megawatt of installed capacity of wind turbine installed on the Property by Lessee, based on such wind turbine's name-plate rating (as determined by the wind turbine manufacturer). The Operating Fees shall increase one and one-half percent (1 1/2%) per year in accordance with Section 5.4 below.
1.7	"Installation Fee"	Five Thousand Dollars (\$5,000.00) for each wind turbine installed on the Property by Lessee in any particular phase of construction.
1.8	"Extended Term"	The thirty-year period commencing upon the date described in <u>Section 4</u> of this Agreement.
1.9	"Annual Alternative Rent"	An annual payment during the Extended Term equal to Five Dollars (\$5.00) per acre of the Property leased by Lessee under this Agreement.
1.10	"Alternative Use Fee"	An annual payment during the Extended Term equal to Twenty Dollars (\$20.00) per acre for the Impacted Area of the Property, (i) with a minimum payment equal to Five hundred dollars (\$500.00) for an Access Road Easement, and (ii) with a minimum payment equal to Three hundred dollars (\$300.00) for a Transmission Easement.
1.11	"Met Tower Development Fee"	An annual payment during the Development Period equal to One Thousand Dollars (\$1,000.00) per year for each meteorological tower installed on the Property by Lessee during the Development Period.
1.12	"Met Tower Operating Fee"	An annual payment of Five Thousand Dollars (\$5,000.00) for each meteorological tower installed on the Property by Lessee during the Extended Term. The Operating Fees shall increase one and one-half percent (1 1/2%) per year in accordance with Section 5.2 below.

2. **Lease and Confirmation.** For good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged by Landowner, Landowner hereby leases the Property to Lessee.



3. Purpose of Lease; Permitted Uses.

3.1 Purpose of Lease. The lease created by this Agreement is solely and exclusively for wind energy purposes, and throughout the term of this Agreement, Lessee shall have the sole and exclusive rights to use the Property for wind energy purposes and to convert all of the wind resources of the Property. Lessee shall have no right to use the Property for agricultural, conservation or recreational purposes. For purposes of this Agreement, "wind energy purposes" means: wind resource evaluation; wind energy development; converting wind energy into electrical energy; collecting and transmitting the electrical energy converted from wind energy; and any and all other activities related to the foregoing.

3.2 Permitted Uses of Property by Lessee. The rights granted to Lessee in this Agreement permit Lessee, without limitation, to do the following:

3.2.1 Extract soil samples, perform geotechnical tests, and conduct other tests, studies, inspections and analysis on the Property as Lessee deems necessary, useful or appropriate.

3.2.2 Construct, erect, install, reinstall, replace, relocate and remove from time to time, the following "**Windpower Facilities**" on the Property, on adjacent property or elsewhere:

(a) meteorological and wind measuring equipment, including but not limited to anemometer towers and all necessary and proper appliances and fixtures for use in connection with said towers, to determine the feasibility of wind energy conversion on the Property, on adjacent property or elsewhere;

(b) wind turbines, steel towers, foundations and concrete pads, support structure, footings, anchors, fences and other fixtures and facilities, maintenance, security, office and/or guest facilities, staging areas for the assembly of equipment, power generation facilities to be operated in conjunction with large wind turbine installations, control buildings, laydown areas, crane pads, and related facilities and equipment;

(c) electrical wires and cables required for the gathering and transmission of electrical energy and/or for communication purposes, which may be placed overhead on appurtenant support structures or underground and one or more substations or interconnection or switching facilities from which Lessee may interconnect to a utility transmission system or the transmission system of another purchaser of electrical energy, together with the appropriate rights of way on, along, in and under the Property; and

(d) any other improvements, including roads, facilities, machinery and equipment that Lessee reasonably determines are necessary, useful or appropriate to accomplish any of the foregoing.

3.2.3 Use, maintain and operate Windpower Facilities on the Property, on adjacent property or elsewhere.

3.3 Ingress and Egress. This Agreement includes the right of ingress of and egress from the Windpower Facilities (whether located on the Property, on adjacent property or elsewhere) over and across the Property by means of any existing roads and lanes thereon, and by such other route or routes as Lessee may construct on the Property from time to time.

3.4 Survival of Covenants. The covenants, conditions, rights and restrictions in favor of Lessee under this Agreement and Lessee's reliance on and benefit from those covenants, conditions, rights and restrictions may be necessarily be a portion of a larger wind energy project which will from time to time share structural and transmission components, ingress and egress, utility access,

and other support, with the Windpower Facilities located on the Property; accordingly, the covenants, conditions, rights and restrictions in favor of Lessee pursuant to this Agreement shall not be deemed invalid or inoperative or otherwise be disregarded while any portion of the Windpower Facilities on the Property or an adjacent property are under development, being replaced, or operational.

3.5 Grant of Wind Easement. Any obstruction to the free flow of the wind by Landowner or persons other than Lessee or a Tenant or Assignee (as defined in Section 10.1 below) or persons claiming through or under Lessee or a Tenant or Assignee is prohibited throughout the entire area of the Property, which shall consist horizontally three hundred and sixty degrees (360°) from any point where any Windpower Facilities are or may be located at any time or from time to time (each such location referred to as a “Site”) and for a distance from each Site to the boundaries of the Property, together vertically through all space located above the surface of the Property, that is, one hundred eighty degrees (180°) or such greater number or numbers of degrees as may be necessary to extend from each point on and along a line drawn along the surface from each point along the exterior boundary of the Property through each Site to each point and on and along such line to the opposite exterior boundary of the Property. Trees, structures and improvements located on the Property as of the Effective Date of this Agreement shall be allowed to remain and Lessee may not require their removal. Landowner may not place or plant any trees, structures or improvements exceeding 60 feet in height or likely to exceed 60 feet in height on the Property after the date of this Lease which may, in Lessee’s sole judgment, impede or interfere with the flow of wind to any Site or Windpower Facilities, unless Landowner has received approval from Lessee for any such trees, structure or improvement. So long as Landowner is not otherwise in default under this Lease, Lessee agrees not to unreasonably withhold its approval for those structures or improvements Landowner proposes to place or construct on that portion of the Property not occupied by Windpower Facilities. The provisions of this Section 3.5 shall survive the termination of this Agreement for the full term hereof.

4. Development Period; Extended Term; Renewal Terms. Lessee’s rights under this Agreement shall continue initially throughout the Development Period. If Lessee or any Assignee or Tenant (as defined in Section 10.1 below) either (i) installs one or more wind turbines on the Property, and any such wind turbine generates electricity during the Development Period, or (ii) pays Landowner the first Annual Alternative Rent payment, the first annual Alternative Use Fee or the Met Tower Operating Fee prior to the expiration of the Development Period in connection with the installation or construction of any Windpower Facilities on real property associated with the wind power project of which the Property is a part, then this Agreement shall automatically be extended for the Extended Term of thirty (30) years. In the event of any such extension for the Extended Term, the 30-year Extended Term shall commence on the first to occur of (i) the Operations Date (as defined in Section 5.4 below), (ii) the date Lessee pays the first Annual Alternative Rent payment (as defined in Section 1.9 above) or (iii) the date Lessee pays the first Alternative Use Fee (as defined in Section 1.10 above) or the or the Met Tower Operating Fee (as defined in Section 1.12 above). During the Extended Term, Lessee and any Tenant or Assignee (as defined in Section 10.1 below) may, by notice to Landowner no later than thirty (30) days prior to the expiration of the Extended Term, elect to extend this Agreement for an additional five-year period commencing upon the expiration of the Extended Term (the “**First Renewal Term**”). Similarly, Lessee and any Tenant or Assignee may, by notice to Landowner no later than thirty (30) days prior to the expiration of the First Renewal Term, elect to extend this Agreement for a second five-year period commencing upon the expiration of the First Renewal Term (the “**Second Renewal Term**”). With respect to each extension of the term of this Agreement, Landowner and Lessee shall execute in recordable form, and Lessee shall then record, a memorandum evidencing the extension, satisfactory in form and substance to Lessee.

5. Payments. Lessee will pay Landowner the following amounts:

5.1 Development Period Payments. In order to keep this Agreement in effect during the Development Period, Lessee shall pay Landowner annual Development Period Payments. The

first annual Development Period Payment shall be due within sixty (60) days of the Effective Date, and each subsequent annual Development Period Payment shall be due on each anniversary of the Effective Date during the Development Period. Development Period Payments will automatically discontinue the earlier of (i) the Operations Date, (ii) the date Lessee delivers the first Annual Alternative Rent payment to Landowner, (iii) the date Lessee delivers the first Annual Alternative Use payment or the or the Met Tower Operating Fee payment to Landowner, or (iv) any termination of this Agreement. Lessee, at its sole and absolute discretion, shall have the right to terminate this Agreement at any time during the Development Period upon thirty (30) days written notice to Landowner.

5.2 Met Tower Fees. During the Development Period, Lessee shall pay Landowner the annual Met Tower Development Fee for each meteorological tower, if any, installed on the Property by Lessee that operates during the Development Period. Lessee's obligation to pay the Met Tower Development Fee for each such meteorological tower will automatically discontinue the earlier of (i) the removal of the meteorological tower from the Property, (ii) the commencement of the Extended Term, or (iii) any termination of this Agreement. The Met Tower Fee shall be due, if at all, within forty-five (45) days after the end of each calendar year during the Development Period. During the Extended Term, Lessee shall pay Landowner the annual Met Tower Operating Fee for each meteorological tower, if any, installed on the Property and for so long as each meteorological tower so installed remains on the Property until its physical removal therefrom. The annual Met Tower Operating Fee, commencing with the thirteenth (13th) month during the Extended Term, and continuing for each and every year thereafter during the Extended Term, First Renewal Term and Second Renewal Term, shall increase by one and one-half percent (1 1/2%) per year over the Met Tower Operating Fee for the preceding year. Met Tower Operating Fee shall be paid annually and shall be due within forty-five (45) days after the end of each calendar year during the Extended Term and, if applicable, the First Renewal Term and Second Renewal Term. For purposes of this Section 5.2, the first calendar year of the Extended Term will commence on the Operations Date and shall end on December 31 of that year in which the Operations Date occurs.

5.3 Installation Fees. Lessee shall pay to Landowner the one-time Installation Fee for each wind turbine installed on the Property by Lessee in any particular phase of construction. No additional Installation Fee shall be due upon any replacement or repower of an existing turbine or installation of a wind turbine on a relocated turbine site within the boundaries of the Property during the Extended Term, First Renewal Term, or Second Renewal Term. Each Installation Fee shall be paid fifty percent (50%) within forty-five (45) days after Commencement of Construction (as defined below) and fifty percent (50%) at the Operations Date (as defined in Section 5.4 below). "**Commencement of the Construction**" shall mean commencement of work consisting of the installation or construction of any wind turbines on the Property for the particular phase of construction, but shall not include survey or wind measurement work, site clearing, the installation of fencing, temporary storage buildings or trailers, placement of equipment or construction materials on the Property or construction of roads.

5.4 Operating Fees. If and when a wind turbine is installed on the Property and such wind turbine generates electricity (the "**Operations Date**") and for so long as each wind turbine so installed remains on the Property until its physical removal therefrom, Lessee shall pay to Landowner on an annual basis the Operating Fees. The annual Operating Fees, commencing with the thirteenth (13th) month during the Extended Term, and continuing for each and every year thereafter during the Extended Term, First Renewal Term and Second Renewal Term, shall increase by one and one-half percent (1 1/2%) per year over the Operating Fees for the preceding year. Operating Fees shall be paid annually and shall be due within forty-five (45) days after the end of each calendar year during the Extended Term and, if applicable, the First Renewal Term and Second Renewal Term. For purposes of this Section 5.4, the first calendar year of the Extended Term will commence on the Operations Date and shall end on December 31 of that year in which the Operations Date occurs.

5.5 Annual Alternative Rent. If Lessee does not install one or more wind turbines on the Property or terminate this Agreement prior to the end of the Development Period, Lessee shall

extend the term of this Agreement for the Extended Term, prior to the expiration of the Development Period, by paying to Landowner the Annual Alternative Rent payment. Until such time, if any, as Lessee has installed one or more wind turbines on the Property (at which time Operating Fees shall be payable pursuant to Section 5.4, in lieu of Annual Alternative Rent payments), subsequent Annual Alternative Rent payments shall be paid annually within forty-five (45) days after the end of each calendar year of the Extended Term, the First Renewal Term and the Second Renewal Term. For purposes of this Section 5.5, the first calendar year of the Extended Term will commence on the date Lessee pays Landowner the first Annual Alternative Rent payment and shall end on December 31 of that year. Annual Alternative Rent for partial years shall be prorated. For any calendar year in which Landowner is eligible to receive an Annual Alternative Rent payment and the Alternative Use Fee, any acreage included in the Impacted Area will be excluded in calculating the acreage on which any Annual Alternative Rent payment will be due.

5.6 Alternative Use Fee. If Lessee does not install one or more wind turbines on the Property but requires an Access Road Easement or a Transmission Easement (each as defined below), Lessee shall prior to the end of the Development Period extend the term of this Agreement for the Extended Term, by paying to Landowner the Alternative Use Fee payment. Until such time, if any, as Lessee has installed one or more wind turbines on the Property (at which time Operating Fees shall be payable pursuant to Section 5.4, in lieu of Alternative Use Fee), subsequent annual Alternative Use Fee payments shall be paid annually within forty-five (45) days after the end of each calendar year of the Extended Term, the First Renewal Term and the Second Renewal Term. The Alternative Use Fee will apply only with respect to the Impacted Area (defined below) of the Property and will only apply in cases where Lessee requires an Access Road Easement or a Transmission Easement (each as defined below). For any calendar year in which Landowner is eligible to receive an Annual Alternative Rent payment and the Alternative Use Fee, any acreage included in the Impacted Area will be excluded in calculating the acreage on which any Annual Alternative Rent payment will be due.

5.6.1 For purposes of the Agreement, an “**Access Road Easement**” shall mean Lessee has exercised Lessee’s right granted pursuant to Section 3.2 above to install one or more service roads within the Property from a public road right of way or a road existing on the Property as of the date hereof for purposes of Lessee’s and its invites non-exclusive right of ingress and egress to any Windpower Facilities. If Lessee exercises the Access Road Easement, the easement shall be deemed to apply along the strip of land (the “**Access Strip**”), up to [sixty] feet wide, as measured from the center point of any such service road installed within the Property. The “**Impacted Area**” of any Access Road Easement shall equal the product, as expressed in acres (and in any case rounded up to the nearest five acres), of the width of the Access Strip multiplied by the length of the service road.

5.6.2 For purposes of the Agreement, an “**Transmission Easement**” shall mean Lessee has exercised Lessee’s right granted pursuant to Section 3.2 above to install any electrical collection system or electrical transmission system on the Property and shall continue for so long as each electrical collection system or electrical transmission system so installed remains on the Property until its physical removal therefrom. If Lessee exercises the Transmission Easement, the easement shall be deemed to apply along the strip of land (the “**Access Strip**”), up to [sixty] feet wide, as measured from the center point of any such installed cable within the Property. The “**Impacted Area**” of any Transmission Easement shall equal the product, as expressed in acres (and in any case rounded up to the nearest five acres), of the width of the Access Strip multiplied by the length of the cable so installed.

5.7 Pooling. Lessee is hereby granted the right to pool or combine the Property and the wind easement granted herein, or any part of parts thereof, with any other land for the production of wind energy. Pooling in one or more instances shall not exhaust the right of Lessee hereunder to pool this Agreement or portion hereof into other or different wind energy projects for the purpose of sharing structural and transmission components, ingress and egress, utility access and other support, all of which are specifically designed to be interrelated and integrated in operation and use for the full life of the wind energy project. To effect a unit, Lessee shall record a written project designation and surveyor’s plat

outlining any such wind energy project and describing the participating tracts of such wind energy project in the public records of the county in which the Property is located. For purposes of calculating the Annual Alternative Rental payments as set forth in Section 5.5, or Alternative Use Fees as set forth in Section 5.6, such pooling or combining of the Property and wind easement shall not operate to reduce or reallocate such Annual Alternative Rental payments or Alternative Use Fees.

5.8 No Representation. Other than those representations and warranties set forth in Section 8 below, Lessee has neither made, nor makes, any representations or warranties, verbally, in any written estimates of production, in this Agreement or otherwise, concerning the likelihood that Lessee will install Windpower Facilities on the Property.

5.9 Consideration for Overhead Lines. As additional consideration, Lessee shall pay to Landowner a one-time payment of Two Dollars (\$2.00) per lineal foot of any Overhead Line Easement area located within the Property (based upon the centerline of the Overhead Line Easement area) actually used for the location of overhead lines, if any. The payment shall be paid to Landowner no later than sixty (60) days after the Operations Date. "**Overhead Line Easement**" means an easement for the construction, erection, operation, maintenance, and replacement of overhead transmission and related communications lines, together with standards, towers, poles and other supports related thereto.

6. Ownership of Windpower Facilities. Landowner shall have no ownership or other interest in any Windpower Facilities installed on the Property or any environmental attributes produced therefrom, including without limitation any and all credits, benefits, emissions reductions, offsets and allowances of any kind, howsoever entitled, attributable to the Windpower Facilities or the electric energy, capacity or other generator-based products produced therefrom. The manner of operation of the Windpower Facilities, including but not limited to decisions on when to conduct maintenance, is within the sole discretion of Lessee.

7. Taxes. Lessee shall pay any increase in the real property taxes levied against the Property directly attributable to the installation of Windpower Facilities on the Property, including any reclassification of the Property as a result of the Windpower Facilities or this Agreement, to the extent that such increase is not separately assessed to Lessee and paid directly by Lessee to the taxing authorities. Lessee shall not be liable for taxes attributable to facilities installed by Landowner or others on the Property, or to the underlying value of the Property itself. It is a condition to Landowner's right to payment or reimbursement of any such increased taxes hereunder that Landowner submit the real property tax bill to Lessee within ten (10) days after Landowner receives the bill from the taxing authority. Lessee shall have the right to pay its portion of the real property taxes directly to the taxing authority. Landowner shall pay its portion of the real property taxes, and if Landowner fails to do so, Lessee shall be entitled (but not obligated) to make payments in fulfillment of Landowner's obligations to the taxing authority and may offset the amount of such payments from amounts due Landowner under this Agreement.

8. Lessee's Representations, Warranties and Covenants. Lessee hereby represents, warrants and covenants to Landowner as follows:

8.1 Landowner Activities. Landowner expressly reserves the right to use the Property for purposes of ranching, farming, conservation and recreation to the extent such use by Landowner does not, currently or in the future, interfere with Lessee's operations hereunder or enjoyment of the rights hereby granted. Lessee shall make reasonable efforts not to disturb Landowner's activities on the Property to the extent such activities are consistent with Lessee's rights under this Agreement. Lessee shall consult with Landowner on its site development plan prior to construction of any Windpower Facilities, showing Landowner the proposed location of wind turbines, roads and electric power lines, before making Lessee's final decisions as to location of Windpower Facilities on the Property, but Lessee shall make all final siting decisions in its sole and absolute discretion. Lessee shall post the access roads

it constructs going to the Windpower Facilities as being private roads only for use by authorized personnel in connection with the Windpower Facilities. Landowner may use or cross such roads only to the extent that Landowner does not interfere with Lessee's rights under this Agreement.

8.2 Insurance. Lessee shall, at its expense, maintain a commercial general liability insurance policy insuring Lessee and Landowner against loss or liability caused by Lessee's occupation and use of the Property under this Agreement, in an amount not less than Three Million Dollars (\$3,000,000) of combined single limit liability coverage per occurrence, accident or incident, which has a commercially reasonable deductible. Certificates of such insurance evidencing the coverages required by this Agreement shall be provided to Landowner at Landowner's reasonable request. Lessee shall have the right to use a qualified program of self-insurance to meet the insurance requirements.

8.3 Indemnity. Lessee will indemnify Landowner against liability for (i) third party claims against Landowner relating to Lessee's operations or activities on the Property, or Lessee's development of the Project on the Property, or (ii) physical damage to property and for physical injuries or death to Landowner, Landowner's property or the public, to the extent caused by Lessee's construction, operation or removal of Windpower Facilities on the Property, except to the extent such damages, injuries or death are caused or contributed to by the negligence or willful misconduct of Landowner or Landowner's tenants, invitees or permittees. The reference to property damage in the preceding sentence does not include any damages to crops (which are governed solely by the provisions of Section 8.7 below) or any losses of rent, business opportunities, profits and the like that may result from Landowner's loss of use of any portions of the Property occupied by, or otherwise attributable to the installation of, Windpower Facilities pursuant to this Agreement. Landowner authorizes Lessee, at Lessee's sole expense, to take reasonable safety and security measures to reduce the risk of damage to the Windpower Facilities or the risk that the Windpower Facilities will cause damage, injury or death to people, livestock, other animals and property, including without limitation, fencing around the perimeter of the Windpower Facilities as Lessee may deem necessary or appropriate to secure or enclose the same, without unduly burdening Landowner's use of the Property.

8.4 Requirement of Governmental Agencies. Lessee, at its expense, shall comply in all material respects with valid laws, ordinances, statutes, orders and regulations of any governmental agency applicable to the Windpower Facilities. In its sole discretion and through appropriate legal proceedings brought in the name of Lessee or in the names of both Lessee and Landowner where appropriate or required, Lessee shall have the right to contest the validity or applicability to the Property or Windpower Facilities of any law, ordinance, statute, order, regulation, property assessment or the like now or hereafter made or issued by any federal, state, county, local or other governmental agency or entity. Landowner shall cooperate in every reasonable way in such contest, provided Lessee reimburses Landowner for its reasonable and actual out-of-pocket expense directly incurred in connection with such cooperation, to the extent Lessee has approved such expense in advance. Any such contest or proceeding, including any maintained in the name of Landowner, shall be controlled and directed by Lessee, but Lessee shall protect Landowner from Lessee's failure to observe or comply during the contest with the contested law, ordinance, statute, order, regulation or property assessment.

8.5 Construction Liens. Lessee shall keep the Property free and clear of all liens and claims of liens for labor and services performed on, and materials, supplies or equipment furnished to, the Property in connection with Lessee's use of the Property pursuant to this Agreement; provided, however, that if Lessee wishes to contest any such lien, Lessee shall, within sixty (60) days after it receives notice of the filing of such lien, remove or bond around such lien pursuant to applicable law.

8.6 Hazardous Materials. Lessee shall not violate, and shall indemnify Landowner against, any violation by Lessee or Lessee's agents or contractors of any federal, state or local law, ordinance or regulation relating to the generation, manufacture, production, use, storage, release or threatened release, discharge, disposal, transportation or presence of any substance, material or waste

which is now or hereafter classified as hazardous or toxic, or which is regulated under current or future federal, state or local laws or regulations, on or under the Property.

8.7 Crop Damage.

(a) During initial construction, Lessee shall pay Landowner crop damage on a per acre basis (prorated for fractional portions), for any and all portions of the Property that are taken out of commercial crop production during the construction of the Windpower Facilities and any and all crops that are removed or damaged as a direct result of Lessee's construction of Windpower Facilities on the Property. Portions of the Property shall be deemed to have been taken out of commercial crop production only to the extent Lessee's construction of Windpower Facilities on the Property materially interferes with Landowner's ability to farm such portions of the Property in which such construction occurs, assuming that Landowner was actually farming such portions of the Property immediately prior to Lessee's commencing construction of the Windpower Facilities on the Property. Such crop damage shall be paid one time per growing season in which such construction and crop damage occur.

Crop damage will equal "Amount of damaged acres" multiplied by "Average yield in the County of Property" multiplied by "Price" multiplied by 1.50.

"Amount of damaged acres" shall be based on Landowner's reasonable estimate as reasonably reviewed and agreed by Lessee's representative.

"Average yield in the County of Property" shall be based on the average yield for the latest 3 years of corn in the County as published by the National Agricultural Statistical Service through the website (www.nass.usda.gov), or if unavailable, another publicly available information source for average yields in the County.

"Price", regardless of the actual type of crop, shall be based on the corn future price for December delivery during the year that crop damages occur, and will be the closing price of that year's December futures quoted on the 15th of the month in which the damages occur as posted by the Chicago Board of Trade, or if unavailable another publicly available information source.

(b) After initial construction is complete, Lessee shall be responsible to pay for Landowner any losses of income, rent, business opportunities, profits or other losses arising out of the damage by the Lessee of any crops growing on the Property as a result of the existence or operations of the Windpower Facilities to the extent, but only to the extent that such damage occurs outside the boundaries of the access roads and Windpower Facilities installed on the Property pursuant to this Agreement or otherwise outside the graveled area surrounding the base of any Windpower Facilities installed on the Property. It is the intention of the parties that compensation under Sections 5.4 and 5.5 includes a payment for crop damage incidental to such existence and operation. Such crop damage, if any, occurring after initial construction is complete, will equal "Amount of damaged acres" multiplied by "Average yield in the County of Property" multiplied by "Price" multiplied by 1.50.

"Amount of damaged acres" shall be based on Landowner's reasonable estimate as reviewed and agreed by Lessee's representative.

"Average yield in the County of Property" shall be based on the average yield for the latest 3 years of corn in the County as published by the National Agricultural Statistical Service through the website (www.nass.usda.gov), or if unavailable, another publicly available information source for average yields in the County.

"Price", regardless of the actual type of crop, shall be based on the corn future price for December delivery during the year that crop damages occur, and will be the closing price of that year's December

futures quoted on the 15th of the month in which the damages occur as posted by the Chicago Board of Trade, or if unavailable another publicly available information source. In the event that, after initial construction is complete, a crop type different from corn becomes the prevalent crop type in the County of the Property, then the "Price" shall be the future price for that new prevalent type of crop for December delivery during the year that crop damages occur, and will be the closing price of that year's December futures quoted on the 15th of the month in which damages occur as posted by Chicago Board of Trade or if unavailable another publicly available information source.

9. **Landowner's Representations, Warranties and Covenants.** Landowner hereby represents, warrants and covenants to Lessee as follows:

9.1 **Landowner's Authority.** Landowner is the sole fee owner of the Property and has the unrestricted right and authority to execute this Agreement and to grant to Lessee the rights granted hereunder. No rights to convert the wind resources of the Property or to otherwise use the Property for wind energy purposes have been granted to or are held by any party other than Lessee. Each person signing this Agreement on behalf of Landowner is authorized to do so, and all persons having any ownership of possessory interest in the Property (including spouses) are signing this Agreement as Landowner. When signed by Landowner, this Agreement constitutes a valid and binding agreement enforceable against Landowner in accordance with its terms.

9.2 **No Interference.** Landowner's activities and any grant of rights Landowner makes to any person or entity, whether located on the Property or elsewhere, shall not, currently or in the future, impede or interfere with: (i) the siting, permitting, construction, installation, maintenance, operation, replacement, or removal of Windpower Facilities, whether located on the Property or elsewhere; (ii) the flow of wind, wind speed or wind direction over the Property; (iii) access over the Property to Windpower Facilities, whether located on the Property or elsewhere; or (iv) the undertaking of any other activities of Lessee permitted under this Agreement. In no event during the term of this Agreement shall Landowner construct, build or locate or allow others to construct, build or locate any wind energy conversion system, wind turbine or similar project on the Property. Notwithstanding the foregoing or Section 3.5, Landowner shall have the right to replace or repair any structures or improvements located on the Property as of the Effective Date, so long as such structures or improvements do not exceed the height of the existing structure, and are replaced or repaired in substantially the same location as the structures or improvements in existence on the Property as of the Effective Date. Further, Landowner shall have the right to construct not more than one (1) Small Turbine (as defined below) on the Property for Landowner's personal use, so long as such Small Turbine is sited within two hundred fifty (250) feet of Landowner's existing building site. A "Small Turbine" shall be defined as a wind turbine for residential or farm use by Landowner, with a nameplate capacity of 40 kW or less and a hub height of sixteen (16) meters or less.

9.3 **Title Review and Cooperation.** Landowner shall cooperate with Lessee to obtain nondisturbance, subordination and other title curative agreements from any person with a lien, encumbrance, mortgage, lease or other exception to Landowner's fee title to the Property to the extent necessary to eliminate any actual or potential interference by any such person with any rights granted to Lessee under this Agreement. If Lessee and Landowner are unable to obtain such agreements from any third party holding an interest in the Property, Lessee, and any Assignee or Tenant, in addition to any other rights provided for herein, shall be entitled (but not obligated) to make payments in fulfillment of Landowner's obligations to such third party and may offset the amount of such payments from amounts due Landowner under this Agreement. Landowner shall also provide Lessee with any further assurances and shall execute any estoppel certificates, consents to assignments or additional documents that may be reasonably necessary for recording purposes or otherwise reasonably requested by Lessee.

9.4 **Requirements of Governmental Agencies/Lenders.** Landowner shall assist and fully cooperate with Lessee in complying with or obtaining any land use permits and approvals, tax-

incentive or tax-abatement program approvals, building permits, environmental impact reviews or any other approvals required or deemed desirable by Lessee in connection with the development, financing, construction, installation, replacement, relocation, maintenance, operation or removal of Windpower Facilities, including execution of applications for such approvals and delivery of information and documentation related thereto, and execution, if required, of any orders or conditions of approval. Lessee shall reimburse Landowner for its reasonable and actual out-of-pocket expense directly incurred in connection with such cooperation, to the extent Lessee has approved such expenses in advance. Landowner shall make available to Lessee copies of all field tiling surveys, environmental, geotechnical and other site assessments, surveys, plans and other such records of Landowner to the extent such information relates directly to the proposed Windpower Facilities.

9.5 Indemnity. Landowner will defend, indemnify and hold harmless Lessee for, from and against liability for physical damage to property (including, without limitation, Lessee's roads) and for physical injuries or death to Lessee or its tenants, invitees, contractors or the public, to the extent caused by the operations, activities, negligence or willful misconduct of Landowner or its invitees, permittees or tenants.

9.6 Hazardous Materials. Landowner shall not violate, and shall indemnify Lessee for, from and against any violation (past, present or future) by Landowner or Landowner's agents or contractors of, any federal, state or local law, ordinance or regulation relating to the generation, manufacture, production, use, storage, release or threatened release, discharge, disposal, transportation or presence of any substance, material or waste which is now or hereafter classified as hazardous or toxic, or which is regulated under current or future federal, state or local laws or regulations, on or under the Property.

9.7 Quiet Enjoyment. Landowner covenants and warrants that Lessee shall peacefully hold and enjoy all of the rights granted by this Agreement for its entire term without hindrance or interruption by Landowner or any person lawfully or equitably claiming by, through, under or superior to Landowner subject to the terms of this Agreement.

10. Assignment; Subleases; Cure.

10.1 Assignees and Tenants. Lessee and any Assignee (as defined below) shall have the right, without need for Landowner's consent, to do any of the following, conditionally or unconditionally, with respect to all or any portion of the Property: finance Windpower Facilities; grant co-leases, separate leases, subleases, easements, licenses or similar rights (however denominated) to one or more Assignees or Tenants (as defined below); or sell, convey, lease, assign, mortgage, encumber or transfer to one or more Assignees or Tenants this Agreement, or any right or interest in this Agreement, or any or all right or interest of Lessee in the Property or in any or all of the Windpower Facilities that Lessee or any other party may now or hereafter install on the Property. An "Assignee" is any of the following: (i) anyone or more parties involved in financing or refinancing of any Windpower Facilities, including, without limitation, any lender to or investor in Lessee or in any Windpower Facilities; (ii) any purchaser or lessee of any of the Windpower Facilities, or any purchaser of all or substantially all of the membership interests in Lessee or of all or any portion of Lessee's interest in this Agreement; (iii) a corporation, limited liability company, partnership or other entity now existing or hereafter organized in which Lessee, or any affiliate, owns (directly or indirectly) at least fifty-one percent (51%) of all outstanding shares of voting stock or ownership interests; (iv) a partnership now existing or hereafter organized, a general partner of which is such a corporation or limited liability company; or (v) a corporation, limited liability company, partnership or other entity that acquires all or substantially all of Lessee's or Lessee's business, assets or capital stock, directly or indirectly, by purchase, merger, consolidation or other means. A "Tenant" is any person who succeeds to the leasehold interest of Lessee as an Assignee or to whom a sublease is conveyed by Lessee or an Assignee. Lessee or an Assignee that has assigned an interest under this Section, or that has conveyed a sublease, will give notice of such

assignment or sublease (including the address of the assignee or sublease thereof for notice purposes) to Landowner, provided that failure to give such notice shall not constitute a default under this Agreement but rather shall only have the effect of not binding Landowner with respect to such assignment or sublease until such notice shall have been given.

10.2 Assignee/Tenant Obligations. No Assignee or Tenant which does not directly hold an interest in this Agreement, and no Assignee or Tenant which holds an interest in or lien on or security interest in this Agreement for security purposes, shall have any obligation or liability under this Agreement prior to the time that such Assignee or Tenant directly holds an interest in this Agreement or, in the case of an interest, lien or security interest for security purposes, the holder thereof succeeds to absolute title to such interest, in this Agreement. Any such Assignee or Tenant shall be liable to perform obligations under this Agreement only for and during the period such Assignee or Tenant directly holds such interest or absolute title. Any assignment permitted hereunder shall release the assignor from obligations accruing after the date that liability is assumed by the Assignee or Tenant.

10.3 Right to Cure Defaults/Notice of Defaults/Right to New Lease. To prevent termination of this Agreement or any partial interest therein, Lessee, or any Assignee or Tenant, shall have the right, but not the obligation, at any time prior to the termination, to pay any or all amounts due hereunder, and to do any other act or thing required of any Assignee, Tenant or Lessee hereunder or necessary to cure any default and to prevent the termination of this Agreement. As a precondition to exercising any rights or remedies as a result of any alleged default by Lessee, an Assignee or a Tenant, Landowner shall give written notice of the default to each Assignee and each Tenant, concurrently with delivery of such notice to Lessee, specifying in detail the alleged event of default and the required remedy. Each such Assignee and each such Tenant shall have the same amount of time to cure said default as is given to Lessee pursuant to this Agreement, which cure period for each Assignee and each Tenant shall commence to run with the end of the cure period given to Lessee in this Agreement. If Lessee or an Assignee or Tenant holds an interest in less than all the rights and interests under this Agreement, the Property or the Windpower Facilities, any default under this Agreement shall be deemed remedied, as Lessee's or such Assignee's or Tenant's partial interest, and Landowner shall not disturb such partial interest, if Lessee or the Assignee or Tenant, as the case may be, shall have cured its pro rata portion of the default by paying the fees attributable to the Windpower Facilities in which Lessee or the Assignee or Tenant, as the case may be, holds an interest. In the event of an uncured default by Lessee, or by an Assignee of Lessee's entire interest in this Agreement, or in the event of a termination of this Agreement by agreement, by operation of law or otherwise, each Assignee of a partial interest in this Agreement, and each Tenant who is a sublessee of Lessee or of an Assignee of Lessee, shall have the right to demand, and the Landowner shall grant and enter into, a new lease, substantially identical to this Agreement, by which such Assignee of a partial interest in the rights and interests under this Agreement, or such Tenant by a sublease, shall be entitled to, and Landowner shall not disturb, the continued use and enjoyment by such Tenant or Assignee of the Property, or portion of the Property, for the full term of this Agreement, as set forth in Section 4 of this Agreement, or such shorter term as said Assignee or Tenant may otherwise be entitled pursuant to its assignment or sublease. Further, in the event of an uncured default by Lessee or by an Assignee of Lessee's entire interest in this Agreement, or in the event of a termination of this Agreement by agreement, by operation of law or otherwise, Landowner hereby agrees that, if and for so long as (i) a Tenant who is a sublessee of Lessee or of an Assignee is not in default under the sublease (beyond any period given Lessee, an Assignee or a Tenant under this Agreement to cure such default), (ii) such Tenant attorns to the Landowner, and (iii) the terms and conditions of the Tenant's sublease do not contravene the terms and conditions of this Agreement, Landowner shall (a) recognize such sublease, (b) not diminish nor interfere with such Tenant's possession of the portion of the Property covered by the sublease or with any term extension or renewal rights in the sublease, and (c) not disturb such Tenant's occupancy of such portion of the Property for the full term of this Agreement or such shorter term to which such Tenant may be entitled under the sublease. A Tenant which is, or in the future becomes, a sublessee of Lessee, or a sublessee of an Assignee, is an intended third party beneficiary of the provisions of this Section 10.3 and entitled to enforce this provision.

10.4 Acquisition of Interest. Except as otherwise provided in Section 10.1 above, the acquisition of all or any portion of Lessee's or an Assignee's or Tenant's interest in the Property or the Windpower Facilities or this Agreement by another Assignee or Tenant or any other person through foreclosure or other judicial or nonjudicial proceedings in the nature thereof or any conveyance in lieu thereof, shall not require the consent of Landowner or constitute a breach of any provision or a default under this Agreement, and upon such acquisition or conveyance Landowner shall recognize the Assignee or Tenant, or such other party, as Lessee's or such other Assignee's or Tenant's proper successor.

10.5 New Lease. If this Agreement is rejected by a trustee or debtor-in-possession in any bankruptcy or insolvency proceeding or this Agreement is terminated as result of any incurable default, and within sixty (60) days after such rejection or termination Lessee or any Assignee or Tenant shall have arranged to the reasonable satisfaction of Landowner for the payment of all fees or other charges due and payable by Lessee or other Assignees or Tenants as of the date of such rejection or termination, then Landowner shall execute and deliver to Lessee or such Assignee or Tenant, as the case may be, a new lease to the Property which (i) shall be for a term equal to the remainder of the term of this Agreement before giving effect to such rejection or termination, (ii) shall contain the same covenants, agreements, terms, provisions and limitations as this Agreement (except for any requirements that have been fulfilled by Lessee or any Assignee or Tenant prior to rejection or termination of this Agreement), and (iii) shall include that portion of the Property improved with Windpower Facilities in which Lessee or such other Assignee or Tenant had an interest on the date of rejection or termination.

10.6 Extended Cure Period. If any default by Lessee or an Assignee or Tenant under this Agreement cannot be cured without obtaining possession of all or part of the Property and/or all or part of the Windpower Facilities and/or all or part of Lessee's or another Assignee's or Tenant's interest in this Agreement, then any such default shall be deemed remedied if (i) within sixty (60) days after receiving notice from Landowner as set forth in Section 12.2 hereof, either Lessee or an Assignee or Tenant shall have acquired possession of all or part of the Property and/or all or part of the Windpower Facilities and/or all or part of such interest in this Agreement, or shall have commenced appropriate judicial or nonjudicial proceedings to obtain the same; and (ii) Lessee or the Assignee or Tenant, as the case may be, shall be in the process of diligently prosecuting any such proceedings to completion; and (iii) after gaining possession of all or part of the Property and/or all or part of the Windpower Facilities and/or all or part of such interest in this Agreement, Lessee or the Assignee or Tenant performs all other obligations as and when the same are due in accordance with the terms of this Agreement. If Lessee or an Assignee or Tenant is prohibited by any process or injunction issued by any court or by reason of any action by any court having jurisdiction over any bankruptcy or insolvency proceeding involving Lessee or any defaulting Assignee or Tenant, as the case may be, from commencing or prosecuting the proceedings described above, the 60-day period specified above for commencing such proceeding shall be extended for the period of such prohibition.

10.7 Certificates, Etc. Landowner shall execute such estoppel certificates (certifying as to such matters as Lessee may reasonably request, including without limitation that no default then exists under this Agreement, if such be the case) and/or consents to assignment and/or nondisturbance agreements as Lessee or any Assignee or Tenant may reasonably request from time to time. Landowner and Lessee shall cooperate in amending this Agreement from time to time to include any provision that may be reasonably requested by Lessee, Landowner or any Assignee or Tenant for the purpose of implementing the provisions contained in this Agreement or of preserving an Assignee's security interest.

11. Lender Protection. Lessee and any Assignee or Tenant may, at any time and without the consent of Landowner, grant to any person or entity (herein, together with that person's or entity's successors and assigns, a "**Lender**") one or more mortgages, trust deeds or similar security interests in all or any part of its interests under this Agreement (a "**Mortgage**"). In the event any such Mortgage is granted, the Lender thereunder shall, for so long as its Mortgage remains in effect, be entitled to the

protections described in the following provisions of this Section 11, upon delivery to Landowner of notice of its name and address.

11.1 Consent to Modification Termination or Surrender. So long as any Mortgage remains in effect, this Agreement shall not be modified, and Landowner shall not accept a surrender of any of the Property or a termination or release of this Agreement prior to expiration of all periods described in Section 4, without the prior written consent of all Lenders.

11.2 Notice of Default; Opportunity to Cure. As a precondition to exercising any rights or remedies for any alleged default under this Agreement, Landowner shall give written notice of the default to each Lender concurrently with delivery of such notice to Lessee, an Assignee or a Tenant, as applicable, specifying in detail the alleged default and the required remedy. In the event Landowner gives any such notice, the following provisions shall apply:

(a) The Lender shall have the same period after receipt of the default notice as is given to Lessee, the Assignee or Tenant to remedy or cause to be remedied the default plus, in each instance, (i) an additional thirty (30) days after receipt of the default notice in the event of any monetary default (meaning any failure to pay when due any rent, real property taxes, insurance premiums or other monetary obligation under this Agreement); and (ii) an additional thirty (30) days after receipt of the default notice in the event of any other type of default, provided that such 30-day period shall be extended for the time reasonably required to complete such cure, including the time required for the Lender to perfect its right to cure such default by obtaining possession of the Property (including possession by a receiver) or by instituting foreclosure proceedings, provided the Lender acts with reasonable and continuous diligence. Lenders shall have the absolute right to do any act or thing required to be performed by Lessee, an Assignee or any Tenant under this Agreement, and any such act or thing performed by a Lender shall be as effective to prevent a default under this Agreement and/or a forfeiture of any rights under this Agreement as if done by Lessee, the Assignee or Tenant itself.

(b) During any period of possession of the Property by a Lender (or a receiver requested by such Lender) and/or during the pendency of any foreclosure proceedings instituted by a Lender, the Lender shall pay or cause to be paid the rent and all other monetary charges payable by Lessee, an Assignee or any Tenant which have accrued and are unpaid at the commencement of such period and those which accrue thereafter during such period. Following acquisition of Lessee's, an Assignee or any Tenant's leasehold estate by the Lender or its assignee or designee as a result of foreclosure or assignment in lieu of foreclosure, or by a purchaser at a foreclosure sale, this Agreement shall continue in full force and effect and the Lender or other party acquiring title to the leasehold estate shall, as promptly as reasonably possible, commence the cure of all other defaults hereunder and thereafter diligently process such cure to completion, whereupon Landowner's right to terminate this Agreement based upon such defaults shall be deemed waived; provided, however, the Lender or other party acquiring title to the leasehold estate shall not be required to cure those defaults which are not reasonably susceptible of being cured or performed by such party ("**Non-Curable Defaults**"). Non-curable defaults shall be deemed waived by Landowner upon completion of foreclosure proceedings or acquisition of Lessee's, Assignee's or Tenant's interest in this Agreement by such party.

(c) Upon the sale or other transfer of the leasehold interests acquired pursuant to foreclosure or assignment in lieu of foreclosure, the Lender or other acquiring party shall have no further duties or obligations hereunder.

(d) Neither the bankruptcy nor the insolvency of Lessee, an Assignee or any Tenant shall be grounds for terminating this Agreement as long as the rent and all other monetary charges payable by such Lessee, Assignee or Tenant hereunder are paid by the Lender in accordance with the terms of this Agreement.

(e) Nothing herein shall be construed to extend this Agreement beyond periods contemplated in Section 4 or to require a Lender to continue foreclosure proceedings after the default has been cured. If the default is cured and the Lender discontinues foreclosure proceedings, this Agreement shall continue in full force and effect.

11.3 New Lease to Lender. If this Agreement terminates as a result of any default, foreclosure or assignment in lieu of foreclosure, or bankruptcy, insolvency or appointment of a receiver in bankruptcy, Landowner shall give prompt written notice to the Lenders. Landowner shall, upon written request of the first priority Lender that is made within ninety (90) days after notice to such Lender, enter into a new lease of the Property with such Lender, or its designee, within thirty (30) days after the receipt of such request. Such new lease shall be effective as of the date of the termination of this Agreement, shall be upon the same terms, covenants, conditions and agreements as contained in this Agreement, and shall be subject to all existing subleases entered into pursuant to this Agreement, provided that the subtenants are not then in default. Upon the execution of any such new lease, the Lender shall (i) pay Landowner any amounts which are due Landowner from Lessee, the Assignee or Tenant, (ii) pay Landowner any and all amounts which would have been due under this Agreement (had this Agreement not been terminated) from the date of termination to the date of the new lease, (iii) perform all other obligations of Lessee and/or the Assignee or Tenant under the terms of this Agreement, to the extent performance is then due and susceptible of being cured and performed by the Lender; and (iv) agree in writing to perform, or cause to be performed, all non-monetary obligations which have not been performed by Lessee, the Assignee or Tenant that would have accrued under this Agreement up to the date of commencement of the new lease, except those obligations which constitute Non-Curable Defaults. Any new lease granted to the Lender shall enjoy the same priority as this Agreement over any lien, encumbrance or other interest created by Landowner. The provisions of this Section 11 shall survive termination of this Agreement and shall continue in effect thereafter and, from the effective date of termination to the date of execution and delivery of such new lease, such Lender may use and enjoy said Property without hindrance by Landowner or any person claiming by, through or under Landowner, provided that all of the conditions for a new lease as set forth in this Section are complied with.

11.4 Subleases. During any periods following termination of this Agreement thereafter in which any Lender is entitled to enter into a new lease of the Property pursuant to Section 11.3, Landowner will not terminate any sublease or the rights of any sublessee thereunder unless the sublessee is in default under such sublease. During such period, if the Landowner receives any rent and other payments due from sublessees, including any sublessees whose attornment Landowner has agreed to accept, Landowner will do so as agent of such Lender and shall deposit such rents and payments in a separate and segregated account in trust subject to a right of setoff against amounts due to Landowner. Upon the execution and delivery of a new lease with Lender, Landowner shall account to its counter-party under such new lease for the rent and other payments made under such subleases, and the counter-party shall then assign the rent and other payments due under such subleases to any Lenders under this Agreement. The collection of rent by Landowner acting as an agent pursuant to this Section 11.4 shall not be deemed an acceptance by Landowner for its own account of the attornment of any sublessee unless Landowner shall have agreed in writing with such sublessee that its subtenancy shall be continued following the expiration of any period during which a Lender may be granted a new lease, in which case such attornment shall take place upon the expiration of such period but not before. Landowner shall not be under any obligation to enforce any subleases.

11.5 No Waiver. No payment made to Landowner by any Lender shall constitute an agreement that such payment was, in fact, due under the terms of this Agreement or a waiver of the Lender's rights with respect to any wrongful, improper or mistaken notice or demand with respect to such payment.

11.6 No Merger. There shall be no merger of this Agreement, or of the leasehold estate or other interests created by this Agreement, with the fee estate in the Property by reason of the fact

that this Agreement or any such interests may be held, directly or indirectly, by or for the account of any person or persons who shall own the fee estate or any interest therein, and no such merger shall occur unless and until all persons at the time having an interest in the fee estate in the Property, and all persons (including Lenders) having an interest in or under this Agreement and any portion of the fee estate shall join in a written instrument effecting such merger and shall duly record the same.

11.7 Further Amendments. Upon request, Landowner shall (1) amend this Agreement to include any provision reasonably requested by a proposed Lender, provided such amendment does not materially impair Landowner's rights or substantially increase the burdens or obligations of Landowner under this Agreement, and (2) execute such estoppel certificates (certifying as to such matters as Lender may reasonably request, including, without limitation, that no default then exists under this Agreement, if such be the case) and other additional instruments reasonably requested by any Lender to evidence the status of this Agreement and Lender's rights under this Agreement.

12. Default and Termination.

12.1 Lessee's Right to Terminate. Lessee shall have the right to terminate this Agreement, and Assignees and Tenants shall have the right to terminate their respective interests in or under this Agreement, as to all or any part of the Property at any time, effective upon thirty (30) days' written notice to Landowner. If such termination is as to only part of the Property, this Agreement shall remain in effect as to the remainder of the Property.

12.2 Landowner's Right to Terminate. Except as qualified by Section 10 and by Section 11, Landowner shall have the right to terminate this Agreement if (i) a material default in the performance of Lessee's obligations under this Agreement shall have occurred and remains uncured, (ii) Landowner simultaneously notifies Lessee and all Lenders, Assignees and Tenants in writing of the default, which notice sets forth in reasonable detail the facts pertaining to the default and specifies the method of cure, and (iii) the default shall not have been remedied within sixty (60) days after Lessee, or within one hundred twenty (120) days in the case of all Assignees and Tenants, receive the written notice, or, if cure will take longer than 60 days for Lessee or 120 days for any Assignee or any Tenant, Lessee, or an Assignee or Tenant on Lessee's behalf, has not begun diligently to undertake the cure within the relevant time period and thereafter diligently prosecutes the cure to completion.

12.3 Effect of Termination. Upon termination of this Agreement, whether as to the entire Property or only as to part, Lessee shall (i) upon written request by Landowner, execute and record a quitclaim deed to Landowner of all of Lessee's right, title and interest in and to the Property, or to that part thereof as to which this Agreement has been terminated, and (ii) as soon as practicable thereafter, remove all above-ground Windpower Facilities and the foundation shall be removed to a depth of four (4) feet below grade from the natural surface of the Property or portion as to which this Agreement was terminated, exclusive of any continuing right established pursuant to this Agreement to survive the term of this Agreement, and restore the soil surface to a condition reasonably similar to its original condition. If Lessee fails to remove such Windpower Facilities within eighteen (18) months of termination of this Agreement, Landowner may do so, in which case Lessee shall reimburse Landowner for reasonable and actual costs of removal incurred by Landowner, less any salvage value received by Landowner, within thirty (30) days after receipt of an invoice from Landowner.

12.4 Cumulative Remedies. Subject to the other terms and conditions of this Agreement, each party shall have all rights and remedies available at law and in equity for any breach of this Agreement by the other party.

13. Miscellaneous.

13.1 Force Majeure. If performance of this Agreement or of any obligation hereunder is prevented or substantially restricted or interfered with by reason of an event of “Force Majeure” (defined below), the affected party, upon giving notice to the other party, shall be excused from such performance to the extent of and for the duration of such prevention, restriction or interference. The affected party shall use its reasonable efforts to avoid or remove such causes of nonperformance and shall continue performance hereunder whenever such causes are removed. “Force Majeure” means fire, earthquake, flood or other casualty or accident; strikes or labor disputes; war, civil strife or other violence, any law, order, proclamation, regulation, ordinance, action, demand or requirement of any government agency or utility, or any other act or condition beyond the reasonable control of a party hereto.

13.2 Confidentiality. Landowner shall maintain in the strictest confidence, for the benefit of Lessee, any Assignee or Tenant, all information pertaining to the financial terms of or payments under this Agreement, Lessee’s site or product design, methods of operation, methods of construction, power production or availability of the Windpower Facilities, and the like, whether disclosed by Lessee, any Assignee or Tenant, or discovered by Landowner, unless such information either (i) is in the public domain by reason of prior publication through no act or omission of Landowner or its employees or agents; or (ii) was already known to Landowner at the time of disclosure and which Landowner is free to use or disclose without breach of any obligation to any person or entity. Landowner shall not use such information for its own benefit, publish or otherwise disclose it to others, or permit its use by others for their benefit or to the detriment of Lessee, any Assignee or Tenant. Notwithstanding the foregoing, Landowner may disclose such information to Landowner’s lenders, attorneys, accountants and other personal financial advisors solely for use in connection with their representation of Landowner regarding this Agreement; any prospective purchaser of the Property who has made a written offer to purchase or otherwise acquire the Property that Landowner desires to accept; or pursuant to lawful process, subpoena or court order requiring such disclosure, provided Landowner in making such disclosure advises the party receiving the information of the confidentiality of the information and obtains the written agreement of said party not to disclose the information, which agreement shall run to the benefit of and be enforceable by Lessee. Landowner shall get Lessee’s written consent before issuing a press release or having any contact with or responding to the news media with any operational, sensitive or confidential information with respect to this Agreement, the wind power project to be constructed on the Property by Lessee, or any other existing wind power project owned or operated by Lessee. The provisions of this Section 13.2 shall survive the termination or expiration of this Agreement.

13.3 Successors and Assigns. This Agreement shall burden the Property and shall run with the land. This Agreement shall inure to the benefit of and be binding upon Landowner and Lessee and, to the extent provided in any assignment or other transfer under Section 10 hereof, any Assignee or Tenant, and their respective heirs, transferees, successors and assigns, and all persons claiming under them. References to “Lessee” in this Agreement shall be deemed to include Assignees and Tenants, which hold a direct ownership interest in this Agreement and actually are exercising rights under this Agreement to the extent consistent with such interest.

13.4 Memorandum of Lease. Landowner and Lessee shall execute in recordable form and Lessee shall then record a memorandum of the lease evidenced by this Agreement reasonably satisfactory in form and substance to Lessee and Landowner. Landowner hereby consents to the recordation of the interest of an Assignee in the Property.

13.5 Notices. All notices or other communications required or permitted by this Agreement, including payments to Landowner, shall be in writing and shall be deemed given when personally delivered, or in lieu of such personal service, five (5) days after deposit in the United States mail, first class, postage prepaid, certified, or the next business day if sent by reputable overnight courier, provided receipt is obtained and charges prepaid by the delivering party. Any notice shall be addressed as follows:

If to Landowner:

xxx-Name
xxx-Address
xxx-City

Telephone: _____

Cellphone: _____

Email: _____

If to Lessee:

Mnioka Construction, LLC
C/O Prevailing Winds, LLC
PO Box 321
Chokio, MN 56221

Facsimile: 320-324-7121
Telephone No: 320-324-7122

With copy to:

Ron Hornstra
C/O Prevailing Winds, LLC
40662 313th Street
Avon, SD 57315

Telephone No: 605-369-2301

If to any Assignee or Tenant:

At the address indicated in the notice to
Landowner provided under Section 10.1 hereof

Any party may change its address for purposes of this paragraph by giving written notice of such change to the other parties in the manner provided in this paragraph.

13.6 Entire Agreement; Amendments. This Agreement constitutes the entire agreement between Landowner and Lessee respecting its subject matter. Any agreement, understanding or representation respecting the Property, this Agreement, the Lease or any other matter referenced herein not expressly set forth in this Agreement, or in a subsequent writing signed by both parties, is null and void. This Agreement shall not be modified or amended except in a writing signed by both parties. No purported modifications or amendments, including, without limitation, any oral agreement (even if supported by new consideration), course of conduct or absence of a response to a unilateral communication, shall be binding on either party.

13.7 Legal Matters.

13.7.1 This Agreement shall be governed by and interpreted in accordance with the laws of the State of South Dakota. If the parties are unable to resolve amicably any dispute arising out of or in connection with this Agreement, they agree that such dispute shall be resolved in a state or federal court located in the county in which the Property is situated, or if none, then a state or federal court nearest the county in which the Property is situated.

13.7.2 NOTWITHSTANDING ANYTHING TO THE CONTRARY IN THIS AGREEMENT, NEITHER PARTY SHALL BE ENTITLED TO, AND EACH OF LANDOWNER AND LESSEE HEREBY WAIVES ANY AND ALL RIGHTS TO RECOVER, CONSEQUENTIAL, INCIDENTAL, AND PUNITIVE OR EXEMPLARY DAMAGES, HOWEVER ARISING, WHETHER IN CONTRACT, IN TORT OR OTHERWISE, UNDER OR WITH RESPECT TO ANY ACTION TAKEN IN CONNECTION WITH THIS AGREEMENT.

13.7.3 EACH OF THE PARTIES KNOWINGLY, VOLUNTARILY AND INTENTIONALLY WAIVES THE RIGHT TO A TRIAL BY JURY IN RESPECT OF ANY LITIGATION BASED ON THIS AGREEMENT, OR ARISING OUT OF, UNDER OR IN CONNECTION WITH THIS AGREEMENT AND ANY AGREEMENT CONTEMPLATED TO BE EXECUTED IN CONJUNCTION HERewith, OR ANY COURSE OF CONDUCT,

COURSE OF DEALING, STATEMENTS (WHETHER VERBAL OR WRITTEN) OR ACTIONS OF ANY PARTY HERETO. EACH OF THE PARTIES TO THIS AGREEMENT WAIVES ANY RIGHT TO CONSOLIDATE ANY ACTION IN WHICH A JURY TRIAL HAS BEEN WAIVED WITH ANY OTHER ACTION IN WHICH A JURY TRIAL CANNOT OR HAS NOT BEEN WAIVED. THIS PROVISION IS A MATERIAL INDUCEMENT TO EACH OF THE PARTIES FOR ENTERING INTO THIS AGREEMENT.

13.8 Partial Invalidity. Should any provision of this Agreement be held in a final and unappealable decision by a court of competent jurisdiction to be either invalid, void or unenforceable, the remaining provisions hereof shall remain in full force and effect and unimpaired by the court's holding. Notwithstanding any other provision of this Agreement, the parties agree that in no event shall the term of this Agreement be longer than the longest period permitted by applicable law.

13.9 Tax Credits. If under applicable law the holder of a leasehold interest in the nature of that held by Lessee, an Assignee or a Tenant under this Agreement becomes ineligible for any tax credit, benefit or incentive for alternative energy expenditure established by any local, state or federal government, then, at Lessee's option, Landowner and Lessee shall amend this Agreement or replace it with a different instrument so as to convert Lessee's interest in the Property to a substantially similar interest that makes Lessee eligible for such tax credit, benefit or incentive.

13.10 No Partnership. Nothing contained in this Agreement shall be construed to create an association, joint venture, trust or partnership covenant, obligation or liability on or with regard to anyone or more of the parties to this Agreement.

13.11 Counterparts. This Agreement may be executed with counterpart signature pages and in duplicate originals, each of which shall be deemed an original, and all of which together shall constitute a single instrument.

13.12 Acknowledgement of Waiting Period. Landowner acknowledges that SDCL 43-13-20.4 provides that no wind easement or wind lease may be executed by the parties until at least ten business days after the first proposed easement or lease has been delivered to Landowner. Landowner acknowledges that at least ten business days have passed since the first proposed easement or lease was delivered to the Landowner.

<u>Initials</u>	<u>Landowners</u>	<u>Date</u>
_____	Xxx	_____, 2017
_____	Xxx	_____, 2017

IN WITNESS WHEREOF, Landowner and Lessee have caused this Agreement to be executed and delivered by their duly authorized representatives as of the Effective Date.

[THIS SPACE INTENTIONALLY LEFT BLANK]

LESSEE:

PREVAILING WINDS, LLC
a South Dakota limited liability company

By: _____

Printed Name: Ronnie Hornstra

Title: President

STATE OF _____)

) ss.

COUNTY OF _____)

The foregoing instrument was acknowledged before me this _____ day of _____, 2017 by Ronnie Hornstra, the President of Prevailing Winds, LLC, a South Dakota limited liability company, on behalf of the limited liability company.

Notary Public

My commission expires: _____

Commission No.: _____

LANDOWNER:

xxx

xxx

STATE OF _____)

) ss.

COUNTY OF _____)

On this _____ day of _____, in the year 2017, before me, the undersigned officer, personally appeared xxx, xxx, known to me or satisfactorily proven to be the person(s) whose name(s) is subscribed to the within instrument, and acknowledged that he/she/they executed the same for the purpose therein contained.

In witness whereof, I hereunto set my hand and official seal.

Notary Public

My commission expires: _____

Commission No.: _____

HOW DOES PREVAILING WINDS DECIDE WHERE THE WIND TURBINES GO?

11-11-2015 C. DRISON

In light of a few comments in local papers recently and approval of new wind energy zoning in Bon Homme County we thought it would be helpful this week to briefly explain how wind turbines get placed and who makes the final decisions.

First we work with landowners to determine if they want a wind turbine. The fact is that local landowners through their participation, actually create the project footprint. Prevailing Winds can only place turbines on property where the landowner agrees to have them; we cannot force anyone to accept a turbine.

Then within that project footprint we look for sensitive areas that we will have to avoid. These include places like wildlife areas, historic sites, wetlands, streams, natural prairie remnants, parks and Towns. Then we identify all homes and farms in the project footprint. Yes, we do everything we can to avoid them too! Then we add County, State, and Federal setbacks and limits to the project footprint.

We need to stop here for just a minute and clarify how setbacks work for wind energy. **Setbacks that control where turbines go are NOT 1000 or 500 foot setbacks, what controls are limits on sound and shadow flicker. Limits placed on sound and shadow flicker act as setbacks and create a much greater setback than 1000 feet.** The 1000 foot or 500 foot setback in County Zoning is simply a safety standard and are never used because the requirements for sound and shadow flicker far exceed these minimums.

Now with this site information Prevailing Winds wind assessment staff begin to look at the best places to locate the turbines. Their job is to create preliminary layouts that produce the most electricity based on the information above and onsite wind data. They then use those layouts to create very accurate sound and shadow flicker computer models to determine if there is any sound and shadow flicker impacts at any homes, farms or receptors inside or outside the project footprint. Following the results of this work the turbines with impacts are adjusted again to reduce any sound and shadow flicker impacts further. We keep doing this adjustment until we begin to see a reduction in energy output of the Wind Project to ensure we keep the turbines as far away as possible.

Finally, after all this work is done and redone many times then the turbine locations are given to Prevailing Winds local Board of Directors. The Board reviews the layout and has veto power on all locations if in their opinion any turbines impact anything too much. If that veto happens then the wind resource staff process starts over, because wind turbine layouts are like dominos move one and it triggers other moves.

After months of work a layout is ready to present to landowners and get their comments on it. We typically create several more versions of the turbine layout to incorporate landowner's requests and comments.

We hope that you realize that a great amount of thought and care goes into laying out the turbines before any turbine is constructed and Prevailing Winds Board has final say on everything. Also please realize that the reality is that the more places we have to put turbines the more we can avoid homes, farms, towns, any place where people are. Luckily the new wind energy zoning adopted by the County allows us the flexibility to place turbines in the right places and avoid impacts to people and sensitive areas. Unluckily, the opposition to Prevailing Winds is actually removing good areas where we could place turbines that would help reduce impacts to everyone... Beethoven Wind used this same process and because everyone in that project worked together we were able to create a great project for everyone.

Thank You for your time and support!

Paid for by Prevailing Winds, LLC;
a locally developed wind energy project.

EXHIBIT

Int. I-19

010617

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

**IN THE MATTER OF THE APPLICATION
BY PREVAILING WIND PARK, LLC FOR
A PERMIT OF A WIND ENERGY
FACILITY IN BON HOMME COUNTY,
CHARLES MIX COUNTY AND
HUTCHINSON COUNTY, SOUTH
DAKOTA, FOR THE PREVAILING WIND
PARK PROJECT**

**APPLICANT'S RESPONSES TO
INTERVENORS' THIRD SET OF DATA
REQUESTS**

EL 18-026

Below, please find Applicant's Responses to Intervenor's Third Set of Data Requests to Applicant.

3-1) What is the closest distance in which two turbines can or should be placed to one another? Provide all documents supporting your response.

Scott Creech: General Electric recommends spacing turbines 3 rotor diameters apart in regards to the predominant wind directions. The separation is recommended for the long term reliability of the turbine. As wind passes by a turbine there is turbulence created behind the turbine. This distance allows for the wind to smooth out before reaching the next turbine.

The rotor diameter on the GE 3.8-137 model turbine is 449 feet which results in a minimum separation distance of 1,347 feet (449 feet x 3). The minimum distance between turbine locations in the Project is 1,442 feet.

3-2) Refer to the attached document titled, "Ice Shedding and Ice Throw-Risk and Mitigation." Explain why a setback distance for property lines and rights of way should not be the distance proposed in that document, namely 1.5 x (hub height+ rotor diameter).

Scott Creech: The document attached to this data request does not apply to the proposed Project. The Project complies with manufacturer recommended setbacks. See Attachment 1-2 (2018) which identifies the applicable setbacks for the Prevailing Wind Park Project. The turbines will be equipped with ice detection systems; therefore, the recommended setback from property lines and rights-of-way is 1.1x tip height.



Dated this 5th day of October, 2018.

By: /s/ Lisa M. Agrimonti
Mollie M. Smith
Lisa M. Agrimonti
FREDRIKSON & BYRON, P.A.
Attorneys for Applicant
200 South Sixth Street, Suite 4000
Minneapolis, MN 55402
Phone: (612) 492-7270
Fax: (612) 492-7077

64940104.2

Technical Documentation Wind Turbine Generator Systems All Onshore Turbine Types



General Description

Setback Considerations for Wind Turbine Siting



imagination at work

Visit us at
www.gerenewableenergy.com

All technical data is subject to change in line with ongoing technical development!

Copyright and patent rights

All documents are copyrighted within the meaning of the Copyright Act. We reserve all rights for the exercise of commercial patent rights.

© 2018 General Electric Company. All rights reserved.

This document is public. GE and the GE Monogram are trademarks and service marks of General Electric Company.

Other company or product names mentioned in this document may be trademarks or registered trademarks of their respective companies.



imagination at work

Table of Contents

1	Introduction.....	5
2	Falling Objects.....	5
3	Tower Collapse.....	5
4	Ice Shedding and Ice Throw.....	5
5	Blade Failure.....	5
6	Industry Best Practices.....	6
7	Setback Considerations	7

1 Introduction

This document provides setback guidance for the siting of wind turbines. This guidance considers potential safety risks associated with wind turbines such as objects (maintenance tools, ice, etc.) directly falling from the wind turbine, unlikely occurrences such as tower collapse and blade failure, and environmental / operational risks such as ice throw. The guidance is general in nature, and is based on the published advice of recognized industry associations. Local codes and other factors may dictate setbacks greater than the guidance in this document. The owner and the developer bear ultimate responsibility to determine whether a wind turbine should be installed at a particular location, and they are encouraged to seek the advice of qualified professionals for siting decisions. It is strongly suggested that wind developers site turbines so that they do not endanger the public.

2 Falling Objects

There is the potential for objects to directly fall from the turbine. The objects may be parts dislodged from the turbine, or dropped objects such as tools. Falling objects create a potential safety risk for anyone who is within close proximity to the turbine, i.e., within approximately a blade length from the turbine.

3 Tower Collapse

In very rare circumstances a tower may collapse due to unstable ground, a violent storm, an extreme earthquake, unpredictable structural fatigue, or other catastrophic events. Tower collapse presents a possible risk to anyone who is within the distance equal to the turbine tip height (hub height plus $\frac{1}{2}$ rotor diameter) from the turbine.

4 Ice Shedding and Ice Throw

As with any structure, wind turbines can accumulate ice under certain atmospheric conditions. A wind turbine may shed accumulated ice due to gravity, and mechanical forces of the rotating blades. Accumulated ice on stationary components such as the tower and nacelle will typically fall directly below the turbine. Ice that has accumulated on the blades will likewise typically fall directly below the turbine, especially during start-up. However, during turbine operation under icing conditions, the mechanical forces of the blades have the potential to throw the ice beyond the immediate area of the turbine.

5 Blade Failure

During operation, there is the remote possibility of turbine blade failure due to fatigue, severe weather, or other events not related to the turbine itself. If one of these events should occur, pieces of the blade may be thrown from the turbine. The pieces may or may not break up in flight, and are expected to behave similarly to ice thrown from the blade. Blade failure presents a possible risk for anyone beyond the immediate area of the turbine.

6 Industry Best Practices

Recognized industry practices suggest the following actions be considered when siting turbines in order to mitigate risk resulting from the hazards listed above:

- Place physical and visual warnings such as fences and warning signs as appropriate for the protection of site personnel and the public.
- Remotely stop the turbine when ice accumulation is detected by site personnel or other means. Additionally, the wind turbine controller may have the capability to shut down or curtail an individual turbine based on the detection of certain atmospheric conditions or turbine operating characteristics.
- Restrict site personnel access to a wind turbine if ice is present on any turbine surface such as the tower, nacelle or blades. If site personnel absolutely must access a turbine with ice accumulation, safety precautions should include but are not limited to remotely shutting down the turbine, yawing the turbine to position the rotor on the side opposite from the tower door, parking vehicles at a safe distance from the turbine, and restarting the turbine remotely when the site is clear. As always, appropriate personnel protective gear must be worn.

7 Setback Considerations

Setback considerations include adjoining population density, usage frequency of adjoining roads, land availability, and proximity to other publicly accessed areas and buildings. Table 1 provides setback guidance for wind turbines given these considerations. GE recommends using the generally accepted guidelines listed in Table 1, in addition to any requirements from local codes or specific direction of the local authorities, when siting wind turbines.

Setback Distance from center of turbine tower	Objects of concern within the setback distance
All turbine sites (blade failure/ice throw): 1.1 x tip height ¹ , with a minimum setback distance of 170 meters	<ul style="list-style-type: none"> - Public use areas - Residences - Office buildings - Public buildings - Parking lots - Public roads <ul style="list-style-type: none"> - Moderately or heavily traveled roads if icing is likely - Heavily traveled multi-lane freeways and motorways if icing is not likely - Passenger railroads
All turbine sites (tower collapse): 1.1 x tip height ¹	<ul style="list-style-type: none"> - Public use areas - Residences - Office buildings - Public buildings - Parking lots - Heavily traveled multi-lane freeways and motorways - Sensitive above ground services²
All turbine sites (rotor sweep/falling objects): 1.1 x blade length ³	<ul style="list-style-type: none"> - Property not owned by wind farm participants⁴ - Buildings - Non-building structures - Public and private roads - Railroads - Sensitive above ground services

Table 1: Setback recommendations

The wind turbine buyer should perform a safety review of the proposed turbine location(s). Note that there may be objects of concern within the recommended setback distances that may not create a significant safety risk, but may warrant further analysis. If the location of a particular wind turbine does not meet the Table 1 recommended guidelines, contact GE for guidance, and include the information listed in Table 2 as applicable.

1 The maximum height of any blade tip when the blade is straight up (hub height + ½ rotor diameter).

2 Services that if damaged could result in significant hazard to people or the environment or extended loss of services to a significant population. Examples include pipelines or electrical transmission lines.

3 Use ½ rotor diameter to approximate blade length for this calculation.

4 Property boundaries to vacant areas where there is a remote chance of future development or inhabitancy during the life of the wind farm.

Condition/object within setback circle	Data Required
If icing is likely at the wind turbine site	- Annual number of icing days
Residences	- Number of residences within recommended setback distance - Any abandoned residences within setback distance
For industrial buildings (warehouse/shop)	- Average number of persons-hours in area during shift - Number of work shifts per week - Any abandoned buildings within setback distance
For open industrial areas (storage/parking lot)	- Average number of persons-hours in area during shift - Number of shifts per week. - Any abandoned buildings within setback distance
For sports/assembly areas	- Average number of persons in area per day - Average number of hours occupied per day - Number of days area occupied per week - If area covered, what type of cover
For roads/waterways	- Plot of road/waterway vs. turbine(s) - Average number of vehicles per day - Type of road and speed limit (residential, country, # of lanes, etc.)
For paths/trails (walk, hike, run, bike, ski)	- Plot of paths/trails vs. turbine(s) - Average number # of persons per day by type of presence (walk, hike, etc.) - Flat or uneven/hilly terrain

Table 2: Setback recommendations

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

**IN THE MATTER OF THE
APPLICATION BY PREVAILING
WIND PARK, LLC FOR A PERMIT OF
A WIND ENERGY FACILITY IN BON
HOMME COUNTY, CHARLES MIX
COUNTY AND HUTCHINSON
COUNTY, SOUTH DAKOTA, FOR
THE PREVAILING WIND PARK
PROJECT**

**APPLICANT’S RESPONSES TO
INTERVENORS’ FOURTH SET OF
DATA REQUESTS**

EL 18-026

Below, please find Applicant’s Responses to Intervenor’s Fourth Set of Data Requests to Applicant.

- 4-1) Explain what efforts and attempts were made to communicate the details of the Project to Kevin Andersh, Kelli Pazour, Paul and Lisa Schoenfelder, Sherman and Lori Fuerniss, and Jerome Peters. In doing so, provide any documents that relate or refer to said efforts and attempts.**

Peter Pawlowski: Prevailing Wind Park, LLC (“Prevailing Wind Park”), acquired the Project assets and development rights in October 2017. At the time of acquiring the Project, much of the leasing had been completed. Since acquiring the Project, Prevailing Wind Park has participated in various permitting and/or Project-related meetings in Bon Homme, Hutchinson, and Charles Mix Counties, for which the respective counties provided public notice. We are aware that one or more of the above-named individuals attended those meetings, and communications were exchanged during those meetings. In addition, Prevailing Wind Park sent the above-named individuals notice of the public input hearing on the Project’s Energy Facility Permit Application in this proceeding, and one or more of the individuals attended the public input hearing where information was exchanged in the form of a Project presentation and public input comments. In addition to the specific interactions noted above, there were other opportunities for interaction through Prevailing Wind Park’s office in Avon, and the Western Area Power Administration open house that was held as part of its environmental review process.

- 4-2) Refer to your response to Intervenor’s Data Request no. 1-14. Provide the names of the 35 landowners who will have a turbine on their property. In doing so, identify the county in which the landowner owns the land where the turbine will be placed.**

Bridget Canty: See Attachment 4-2.

- 4-3) Refer to your response to PUC Staff’s Data Request no. 1-14. You identified three different types of agreements with landowners (i.e. (1) full rights agreement; (2) “no turbine” lease; and (3) setback waiver – no facilities). Identify the number of**



agreements that have been executed for each of the three different types of agreements.

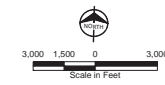
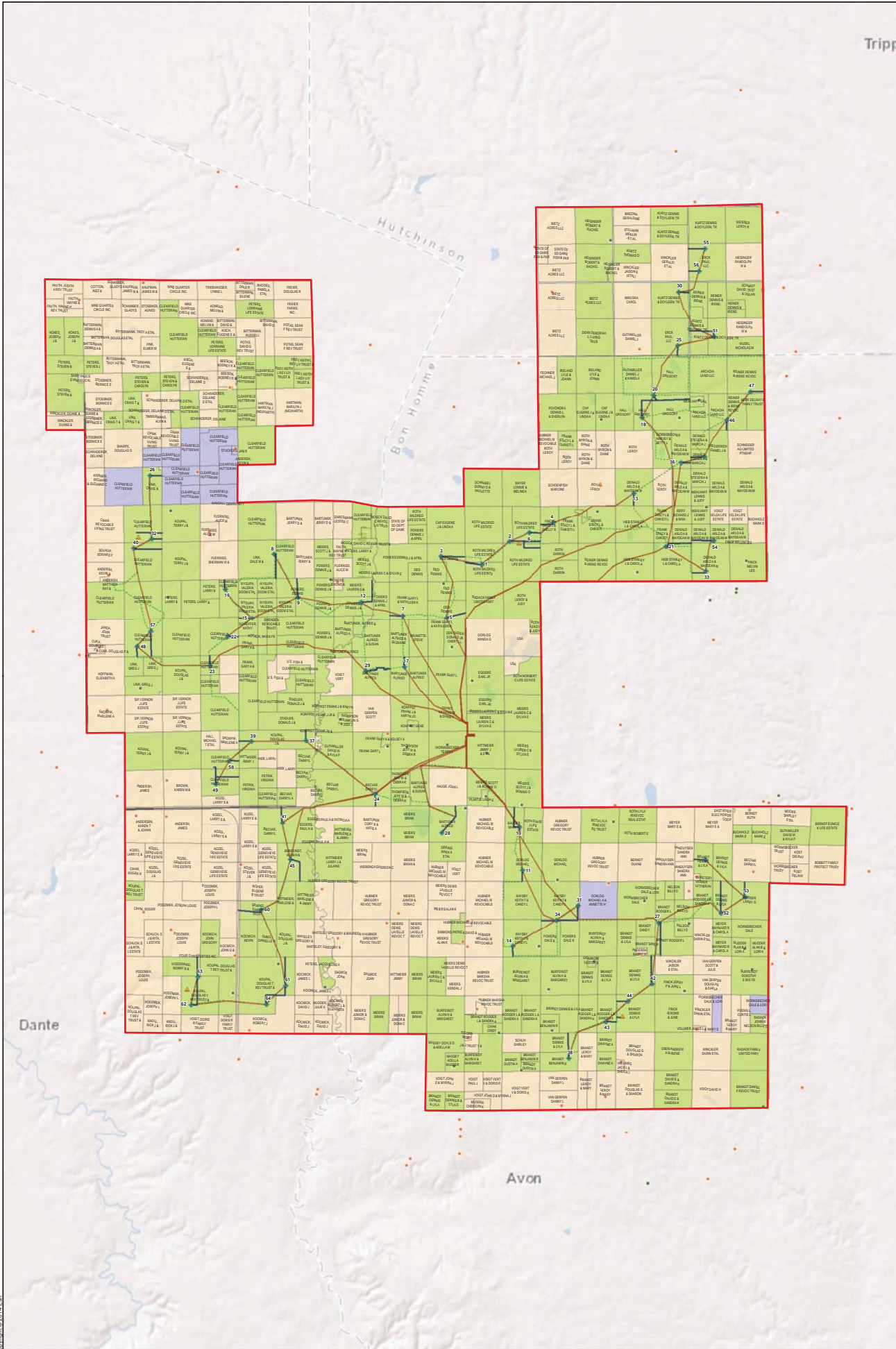
<u>Jessica Sosna:</u>	Full rights agreement:	136
	No turbine lease:	5
	Setback waiver	3

Dated this 5th day of October, 2018.

By: /s/ Lisa M. Agrimonti
Mollie M. Smith
Lisa M. Agrimonti
FREDRIKSON & BYRON, P.A.
Attorneys for Applicant
200 South Sixth Street, Suite 4000
Minneapolis, MN 55402
Phone: (612) 492-7270
Fax: (612) 492-7077

64966244.2

Tripp



Revised Layout
Prevailing Wind Park
Wind Energy Facility
SDPUC Application

Path: Z:\Resource\Local\clients\KCM\ENR\Power\G00104234_PrevailingWind\GIS\Geoprocessing\Outputs\MapDocs\PUC_Data_Requests\22-24_PUCalr.mxd Date: 10/5/2018
 COPYRIGHT © 2018 BURNS & McDONNELL ENGINEERING COMPANY, INC.
 SOURCE: SOURCE: ESRI, BURNS & McDONNELL ENGINEERING COMPANY, INC., SOUTH DAKOTA GIS, PREVAILING WINDS, LLC

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

**IN THE MATTER OF THE APPLICATION)
BY PREVAILING WIND PARK, LLC FOR)
A PERMIT OF A WIND ENERGY)
FACILITY IN BON HOMME COUNTY,)
CHARLES MIX COUNTY AND)
HUTCHINSON COUNTY, SOUTH)
DAKOTA, FOR THE PREVAILING WIND)**

**STAFF'S RESPONSE TO
INTERVENORS' FIRST DATA
REQUEST**

EL18-026

- 1-1) Identify each instance in which David Hessler has been hired by a wind turbine company to perform sound tests on a wind project. In doing so, provide the name and location of the project and a brief explanation as to why he was hired.**

Response

Kristen Edwards: Objection this question is overly vague, specifically as it relates to what is meant by a "wind turbine company." Subject to and without waiving its objection, Mr. Hessler provides the following response:

The projects specifically involving field sound testing of operational wind turbines that I have personally carried out are listed below. This list represents all such projects to the best of my recollection, but there may have been others. It should be noted that many, if not most, wind projects are not tested after becoming operational; consequently, opportunities to carry out such testing are somewhat of a rarity.

Glacier Hills Wind Park, Columbia County, WI

Extensive 17 day monitoring survey of project sound levels at 11 of the nearest residences, including two complaint locations, to evaluate compliance with State and local noise conditions. The project consisted of 90 Vestas V90 wind turbines spread out over a roughly 36 square mile area. Testing involved temporarily shutting down turbines to verify background sound levels and the use of additional off-site monitors to create a record of background levels vs. time over the entire survey period.

Wethersfield Windpark, Town of Wethersfield, NY

18 day monitoring survey of project sound levels at 8 of the nearest residences to turbines, including all complaint locations, to evaluate compliance with local noise ordinance requirements. Testing involved the use of additional off-site monitors to create a record of background levels vs. time over the entire survey period.



Hopkins Ridge Wind Farm, Columbia County, WA

One month long monitoring survey of project sound levels on behalf of the Columbia County Planning Department to evaluate the project's sound emissions at a complaint location for compliance with applicable noise standards. Project set up involved numerous monitoring locations and frequency analysis at the house, close to the nearest turbines and at remote, off-site locations to record simultaneous background levels.

Bliss Windpark, Town of Eagle, NY

15 day monitoring survey of project sound levels at 14 of the nearest residences to turbines, including all complaint locations, and other points of interest to evaluate compliance with local noise ordinance requirements. Testing involved the use of additional off-site monitors to create a record of background levels vs. time over the entire survey period.

Prairie Star Wind Farm, Grand Meadow, MN

20 day monitoring survey of Vestas V82 sound levels at numerous scientifically laid out regression positions to measure the actual sound emissions of this model turbine at typical setback distances through a wide variety of wind and weather conditions for comparison to model predictions.

Sheffield Wind, Town of Sheffield, VT

Four 2 week long monitoring surveys of project sound levels, one during each season, at the nearest residences to a group of 12 mountaintop Clipper C93 turbines, including all complaint locations, to evaluate compliance with the unique noise requirements imposed by the Vermont Public Service Board that limited interior sound levels, rather than exterior levels. The complex test procedure involved exterior monitoring at the test points and at remote background locations combined with outside to inside transmission loss testing of the houses to derive the interior sound levels.

Cohocton and Dutch Hill Windparks, Town of Cohocton, NY

Extensive monitoring survey of project sound levels at 9 of the nearest residences to turbines, including all complaint locations, to evaluate compliance with local noise ordinance requirements. Testing involved the use of additional off-site monitors to create a record of background levels vs. time over the entire survey period.

Cohocton and Dutch Hill Windparks, Town of Cohocton, NY

Further diagnostic testing was subsequently carried out at this site to identify nacelle noise abatement options for the Clipper C93 turbine to minimize mechanical noise. Testing involved measurements inside the nacelle and at progressive far field distances from the test unit.

Twin Ridges Wind Farm, Somerset County, PA

18 day monitoring survey of project sound levels at 7 of the nearest residences to turbines, including all complaint locations, to evaluate compliance with the noise requirements contained in a local development agreement with the towns. Testing involved the use of additional off-site

monitors to create a record of background levels vs. time over the entire survey period. On and off testing (temporarily shutting down certain units) was also carried out to verify background sound levels during a variety of wind and weather conditions.

Shirley Wind Farm, Brown County, WI

Highly specialized testing funded by the Wisconsin Public Service Commission (PSC) was carried out at this site to investigate the cause of complaints from some residents in the project area who associated symptoms of nausea and vertigo with the turbines; to the extent several chose to leave their houses. A collaborative study was organized involving four different acoustical consulting firms to evaluate ultra-low frequency sound levels at the three complaint locations using several different techniques. While the blade passing tone signature of the turbines at around 1 Hz could be detected with specialized instrumentation its extremely miniscule magnitude did little to suggest a link to the complaints. The impetus for the study was my recommendation to test the site, which was expressed during oral testimony before the Wisconsin PSC in conjunction with the proposed Highland Wind Farm project, which planned to use the same Nordex 100 turbines.

Blue Mountain Renewables Jamaica Wind Farm, St. Elizabeth's Parish, Jamaica

11 day sound monitoring survey of the newly operational project using Vestas V100-3.3MW turbines at the nearest residences to evaluate compliance with Jamaican National noise standards (50 dBA at night at homes and 45 dBA at schools). Testing involved the use of additional off-site monitors to create a record of background levels vs. time over the entire survey period.

Barton Chapel Wind Farm, Jack County, TX

18 day monitoring survey of project sound levels at several of the nearest ranches/residences to the Gamesa G87 turbines where concerns about noise had been expressed to the project. The testing indicated that the noise issue was associated with some special nacelle cooling fans that are only used at sites with high ambient temperatures. Beyond the testing at the ranches, additional controlled on/off tests were conducted on an isolated unit to determine its sound power level in accordance with IEC 61400-11.

Patton Wind Farm, Town of Patton, PA

12 day monitoring survey of project sound levels at 6 of the nearest residences to turbines, including 2 complaint locations, to evaluate compliance with local developer agreement noise limit (45 dBA). Testing involved the use of additional off-site monitors to create a record of background levels vs. time over the entire survey period.

Bent Tree Wind Farm, Freeborn County, MN

Extensive 15 day monitoring survey of project sound levels at 7 of the nearest residences to turbines, including 2 complaint locations, to evaluate compliance with the State and local noise standards (L50 of 50 dBA at night). Testing involved the use of 3 additional off-site monitors to create a record of background levels vs. time over the entire survey period.

Cedar Ridge Wind Farm, Towns of Eden and Empire, WI

14 day pre-construction and post-construction monitoring sound surveys of the project were carried out at the same time of year at 8 of the nearest residences to turbines to evaluate any differential in sound levels and to determine compliance with a local regulatory limit of 50 dBA. Testing involved the use of 4 additional off-site monitors to create a record of background levels vs. time over the entire survey period. In accordance with Wisconsin procedures short-term manned samples were also taken at several times of day.

1-2) Provide an estimate of the amount of money David Hessler has received from wind companies.

Response

Kristen Edwards: Objection this question is vague. Subject to and without waiving that objection, Mr. Hessler is paid by his employer, Hessler Associates, Inc.

Dated this 5th day October 2018.



Kristen N. Edwards

Amanda Reiss

Attorneys for Staff

South Dakota Public Utilities Commission

500 East Capitol Avenue

Pierre, SD 57501

Wind turbines: is there a human health risk?

[Print](#)

Title Annotation: SPECIAL REPORT
Author: Roberts, Jennifer D.; Roberts, Mark A.
Article Type: Report
Geographic Code: 1USA
Date: Apr 1, 2013
Words: 7738
Publication: Journal of Environmental Health
ISSN: 0022-0892

Introduction

Humans have been using wind power since 500-900 A.D. when the first windmills were developed in Persia (Dodge, 2006). Wind, a form of solar energy, is altered in its flow pattern by the earth's land and water surfaces. Through these flow patterns, humans have developed highly sophisticated techniques and machinery to harness wind energy for several purposes such as sailing, pumping water, cutting lumber, and even generating electricity. One such machine is the wind turbine, which is a rotary device that extracts and converts the kinetic energy from the wind into mechanical power and then transforms this power into electricity through the use of a generator.

In the 2011 State of the Union address, President Obama set a new goal for America's energy future and stated that 80% of electricity should come from clean energy sources by 2035, including wind energy. As the use of wind energy and the emphasis on renewable energy have continued to grow, concerns have been raised regarding the impacts of these wind turbines on human health and well-being.

Wind Turbine Trends in the U.S.

By the end of 2011, the U.S. had over 46,900 megawatts (MW) of installed wind power, yet wind power accounts for less than 3% of the country's total net electric generation (U.S. Energy Information Administration [EIA], 2011a, 2011b, 2011c, 2011d). According to the American Wind Energy Association (AWEA), a 35% increase in new wind power capacity occurred over the past five years (AWEA, 2011, 2012). And at the end of 2011, it was also determined that 38 states had utility-scale wind installations with 14 of those having more than 1,000 MW of wind power capacity (AWEA, 2011, 2012). Furthermore, the top five states with the highest number of wind project installations through the first quarter of 2012 were Texas (10,648 MW); Iowa (4,419 MW); California (4,287 MW); Illinois (2,852 MW); and Minnesota (2,718 MW) (AWEA, 2012; EIA, 2011b, 2011d). As of today, the U.S. represents more than 20% of the world's installed wind power (AWEA, 2012).

For several years, wind energy has been the fastest growing source of new electric power generation (EIA, 2011b). Compared to the prior year, in 2006, 2007, 2008, 2009, and 2010 the generation from wind power increased by 49.3%, 29.6%, 60.7%, 33.5%, and 28.1%, respectively (Figure 1) (EIA, 2011b). The current wind energy capacity in the U.S. has generated enough electricity to power the equivalent of nine million homes (EIA, 2011a). And since 1999 the wind power in the U.S. has increased exponentially from 2,472 to 46,918 MW in 2011 with GE Energy being the largest domestic wind turbine manufacturer (AWEA, 2009; EIA, 2011d).

Typically in the U.S., small turbines have been used to power a single home or business and larger turbines have often been grouped into wind farms that can provide power to the electrical grid. The smaller wind turbines have a capacity of less than 100 kilowatts while larger commercial sized turbines may have a capacity of 5 MW.

Sound and Human Perception

The two components of sound, which allow for its perception and recognition, are frequency and pressure. The indicator of pressure or loudness is the decibel (dB), which is a logarithmic ratio of sound pressure level to a reference level. Likewise, the frequency or pitch of sound is expressed in Hertz (Hz), a unit defined as the number of cycles per second.

Human hearing of sound loudness ranges between 0 dB, a threshold of sound for humans, and 140 dB, a sound level that is very loud and painful for most humans (Baker & National Agricultural Safety Database, 1993; Navy and Marine Corps Public Health Center, 2009). Sound pressures are not all perceived as being equally loud by the human ear. This is because the human ear does not respond equally to all frequencies and the perception is less sensitive to lower and higher frequency sounds. For young individuals, the frequency range of human hearing has been found to be between 20 and 20,000 Hz with an inverse relationship between the upper frequency range and age (Berglund, Hassmen, & Job, 1996). Again, since the human ear does not have a flat spectral sensitivity or frequency response, sound pressures have regularly been frequency weighted so that the measured level corresponds to loudness as perceived by the average human ear.

Several weighting networks, such as A-weighting or C-weighting, have been defined by the International Electrotechnical Commission (IEC) in the IEC 60651 and American National Standards Institute (ANSI S1.1-1994) standards (British Wind Energy Association [BWEA], 2005; Hansen & World Health Organization [WHO], 1995). These networks filter the contributions of the varying frequencies to the overall sound level by reducing or increasing the sound pressure as a function of frequency (Hansen & WHO, 1995). Thus, A-weighting, labeled dB(A), approximates the response of the human ear to moderate sound levels and has been the most commonly used network (BWEA, 2005). C-weighting (dB[C]) is used to measure peak levels and G-weighting (dB[G]) is specifically designed for infrasound (BWEA, 2005).

Ultrasound or sound frequencies above 20,000 Hz and infrasound, which is approximately between 0 and 20 Hz, are generally considered to be inaudible (Berglund et al., 1996). Low frequency sound (LFS) in the range of 10-20 Hz and 100-250 Hz includes a field of audibility (Table 1) (Berglund et al., 1996; Leventhall, 2007). The audibility of LFS is often dependent on the individual. Furthermore, in order for infrasound to be audible at frequencies lower than 20 Hz, a very high-pressure level is required. Infrasound detection by the human ear has been theorized to result from nonlinearities of conduction in the middle and inner ear, which produces a harmonic distortion in the higher frequency range in addition to subjective reactions and through the resonance of other body organs (Berglund et al., 1996).

Wind Turbine Sound

One type of sound generated from wind turbines is a mechanical sound, which originates from the mechanical components of the turbines (e.g., gearbox). Aerodynamic sound is the other type of sound; the source of this sound is the flow of air around the blades and tower that produces a "whooshing" sound in the range of 500 to 1000 Hz (Hau, 2006). Manufacturers have improved the engineering of wind turbines and have been able to reduce the mechanical sound. Thus, the aerodynamic sound is now typically the dominant component of wind turbine sound (Pedersen & Waye, 2004; Rogers, Manwell, Wright, & Renewable Energy Research Laboratory, 2006). A great deal of variability exists in the whooshing sound, which is dependent upon mechanical and atmospheric conditions.

Many of the modern wind turbines are now upwind and the size of the turbine is variable. The earlier turbines were often downwind devices with the blades and rotor positioned on the downwind side of the tower. LFS with a range of 20 to 100 Hz was most commonly produced by downwind turbines when the turbine blade encountered localized flow deficiencies due to the flow around a tower (Rogers et al., 2006). The new upwind turbines minimize LFS and infrasound (Musial, Ram, & National Renewable Energy Laboratory, 2010; Szasz & Fuchs, 2010).

Wind Turbine Syndrome

"Wind Turbine Syndrome: A Report on a Natural Experiment" was self-published in late 2009 by Nina Pierpont, MD, PhD, a pediatrician, who coined the term "Wind Turbine Syndrome." In the book, Dr. Pierpont theorized how a multitude of symptoms such as headache and dizziness resulted from wind turbines generating LFS that "scrambled" the body's balance, motion, and position sensors. The reported symptoms, gathered from a case series study design, were based on a collection of subjective responses from 37 participants (age <1 to 75 years) comprised from 10 families who resided (1,000 to 4,900 ft.) near wind turbines erected since 2004 in Canada, Ireland, the United Kingdom, Italy, and the U.S. The study participants, who were not masked from the purpose of the study, were interviewed by telephone by Dr. Pierpont to collect a narrative account, symptom checklist, and past medical history (Pierpont, 2009). Accordingly, this "Wind Turbine Syndrome" phenomenon has instigated a heightened level of panic and fear with respect to living near wind turbines.

The purpose of our article is to provide a summary of the peer-reviewed literature on the research that has examined the relationship between human health effects and exposure to sound in the lower frequency range as well as sound generated from the operation of wind turbines. An objective of this review is to infer conclusions through weighing the evidence from this research about the theory of "Wind Turbine Syndrome" and this possible association.

Methods

In 2009, we were commissioned to write a white paper by the Wisconsin Public Service Commission on the scientific literature regarding health effects associated with wind turbines and LFS (Roberts & Roberts, 2009). This article expounds on the research of that white paper and further examines the currently available research in the peer-reviewed literature that addresses the possible association between human health effects and LFS or noise generated by wind turbines. The PubMed search engine, maintained by the U.S. National Library of Medicine, was the source of this peer-reviewed literature and the search terms used were as follows: (1) "Infrasound AND Health Effects"; (2) "Low-Frequency Noise AND Health Effects"; (3) "Low-Frequency Sound AND Health Effects"; (4) "Wind Power AND Noise"; (5) "Wind Turbines"; (6) "Wind Turbines AND Noise."

It should be noted that the word "sound" and "noise" are terms that can be used interchangeably. "Noise" often implies an unwanted sound and often depends on the intensity of the sound. The classification of a "sound" or "noise" may also depend on cultural factors, the receiver, or the time and circumstance (Berglund et al., 1996). Likewise, both terms were used as search criteria for this research review.

Results

When this literature search was conducted, 16, 59, 40, 18, 20, and 3 articles using the "Infrasound AND Health Effects"; "Low-Frequency Noise AND Health Effects"; "Low-Frequency Sound AND Health Effects"; "Wind Power AND Noise"; "Wind Turbines"; and "Wind Turbines AND Noise" search terms were identified, respectively. A portion of these search results contained overlapping articles and many of the articles in the search output were not relevant because they focused on animal and not human responses or the sound studied was above the established range of LFS. Likewise, of the original 156 articles, nearly 30 articles (n = 28) were identified that addressed any human health effects associated with LFS and that were relevant to wind sound using the previously mentioned search terms.

Research on Human Health Effects and LFS

LFS is often accompanied by vibrations (Maschke, 2004). High levels of LFS, at a frequency of 50 to 80 Hz, can excite body vibrations (e.g., chest resonance vibration) (Leventhall, 2007). Additionally, these chest wall and body hair vibrations have also been shown to occur in the infrasonic range (Mohr, Cole, Guild, & Vongierke, 1965; Schust, 2004). A human tendency often occurs to confuse vibration with

sound on its own, which results in people "hearing" more sound than is actually present. Likewise the reverse has been shown to occur as evident by the association found between motion sickness and LFS even without accompanying vibration (Berglund et al., 1996; Yamada, Sueki, Ha giwara, Watanabe, & Kosaka, 1991).

Castelo Branco and Rodriguez first documented vibroacoustic disease among airplane technicians, commercial and military pilots, mechanical engineers, restaurant workers, and disc jockeys for exposure to large pressure amplitude and low frequency sound ([greater than or equal to] 90 dB sound pressure level, [less than or equal to] 500 Hz) (Castelo Branco & Rodriguez, 1999; Maschke, 2004). Vibroacoustic disease was described as a thickening of cardiovascular structures, such as cardiac muscle and blood vessels. Castelo Branco and Rodriguez revealed that workers who were exposed to high-level LFS for more than 10 years exhibited extra-aural symptoms (Castelo Branco & Rodriguez, 1999; Maschke, 2004; Takahashi, Yonekawa, & Kanada, 2001). A causal association and a dose response relationship were not established.

Takahashi and co-authors have explored the effects of both human body vibration and LFS (Takahashi et al., 2001; Takahashi, Kanada, Yonekawa, & Harada, 2005; Takahashi, Yonekawa, Kanada, & Maeda, 1999). In a small study, six male subjects were exposed to pure tones in the 20 to 50 Hz frequency range, and vibration was measured on the chest and abdomen of the subjects. It was determined that sound-induced vibration was inversely correlated with the body mass index of the subject. Takahashi and co-authors concluded that the health effects of LFS depended on the physical constitution of the human body, yet it was still unclear if or how vibrations measured on the body surface related to vibrations in the body's internal organs (Takahashi et al., 1999). No conclusions could be determined as to the possible chronic health effects caused by long-term exposure to LFS (Takahashi et al., 1999).

Takahashi and co-authors also examined the level of unpleasantness of human body vibration and LFS and identified a significant correlation between the measured body surface vibration induced by the LFS and the rating of unpleasantness (Takahashi et al., 2005). Inukai and co-authors found a similar association previously (Inukai, Nakamura, & Taya, 2000). The research findings of Takahashi and co-authors and Inukai and co-authors supported the notion that hearing sensation was an influential component in the perception of unpleasantness or annoyance among those exposed to LFS (Inukai et al., 2000; Takahashi et al., 2005). It was also found that the perception of unpleasantness was independent of the audibility of the sound. Inukai and coauthors qualified three factors: (1) sound pressure, (2) vibration, and (3) loudness in addition to hearing sensation to be predictors for the human psychological responses to LFS, such as unpleasantness or annoyance (Inukai, Taya, Miyano, & Kuriyama, 1986; Takahashi et al., 2005).

Cardiovascular and respiratory effects have also been a focus of research with respect to LFS exposure. Studies have shown changes in heart rate in subjects who were exposed to LFS (Berglund et al., 1996; Yamada, Watanabe, Kosaka, Negishi, & Watanabe, 1986). Respiratory effects such as suspended or reduced respiration, gagging, and coughing have been documented in humans after exposure to LFS, but only with a sound pressure of 150-154 dB (Berglund et al., 1996; von Gierke & Nixon, 1976).

Studies conducted by Karpova and coauthors and Slarve and Johnson indicated that study subjects reported aural complaints after exposure to industrial infrasound below 20 Hz (Karpova et al., 1970; Slarve & Johnson, 1975). Increased diastolic blood pressure, decreased systolic blood pressure, and significantly decreased respiration rate were a few examples of reported nonaural effects (Karpova et al., 1970; Schust, 2004). Karpova and co-authors reported complaints of fatigue, feelings of apathy, loss of concentration, somnolence, and depression following exposure to LFS. Furthermore, a relationship between fatigue and tiredness after work and increasing LFS exposure was found among 439 employees working in offices, laboratories, and industries in a later study (Schust, 2004; Tesarz, Kjellberg, Landstroem, & Holmberg, 1997).

Some studies have looked at the effect of LFS on nighttime sleep in adults and children (Ising, Lange-Asschenfeldt, Moriske, Born, & Eilts, 2004; Maschke, 2004). Ising and co-authors found that children (aged 5-12 years) who were highly exposed to truck noise at a maximum of 100 Hz had a significantly increased morning saliva cortisol concentration compared to a control population. This increased cortisol concentration indicated an activation of the hypothalamus-pituitary-adrenal axis and thus an indication of restless sleep and a further aggravation of bronchitis in the children (Ising et al., 2004). Adult case studies have reported that LFS affects sleep quality and results in insomnia and concentration problems (Berglund et al., 1996; Waye, 2004). In a cross-sectional study of 279 individuals, however, it was determined that no significant differences were detected in reported sleep among those exposed to a high level of LFS compared to those exposed to a medium level of LFS from ventilation and heat pumps (Waye & Rylander, 2001).

Annoyance, which will be discussed later, seemed to play a role in these findings. Fatigue, difficulty falling asleep, and feeling tense and irritable were reported significantly more often among those individuals who were annoyed by LFS than those who were exposed to the same sound but did not report being annoyed. Lastly, a study that exposed sinusoidal tones, or pure tones at a single frequency of 10, 20, 40, and 63 Hz with sound pressure levels ranging from 75 to 105 dB for 10 Hz and 20 Hz and 50 to 100 dB for 40 Hz and 63 Hz to six participants found no significant difference between the exposure and control nights in sleep efficiency index, number of changes in sleep state, or changes in the proportion of each sleep stage evaluated by electroencephalogram recordings (Gage, 2010; Inaba & Okada, 1988; Waye, 2004).

Research on Wind Turbines, Health Effects, and Annoyance

Health Effects

Most recently some research has been done specifically on sound produced by wind turbines and the possible association of a human health risk (Salt & Kaltenbach, 2011; Smedley, Webb, & Wilkins, 2010). Salt and Kaltenbach concluded that A-weighting wind turbine sound was not appropriate because A-weighted sounds present a misleading representation of whether the sound affects the human ear or if it is physiologically mediated by the outer hair cells (OHC). OHC have demonstrated stimulation by LFS as low as 3 to 4 Hz, but the A-weighted spectrum arrest measurement of all sound components below 14 Hz (Salt & Hullar, 2010; Salt & Kaltenbach, 2011). A proposed alternative to A-weighting is to use G-weighted measurements, a weighting curve based on the human audibility curve below 20 Hz and with a steep cutoff above 20 Hz (Salt & Kaltenbach, 2011). It was determined, however, that with the use of G-weighted sound measurements, the level of infrasound produced by wind turbines is often too low to be heard by the human ear even though the level is still sufficient to cause OHC stimulation (Jakobsen, 2005; Salt & Hullar, 2010; Salt & Kaltenbach, 2011; Schust, 2004).

Other researchers have examined the possible association of sound produced by wind turbines and epileptic seizures. Through modeling, Smedley and co-authors found that, unlike smaller wind turbines, larger 2 MW wind turbines with a blade width of 2m and a height of 120 m were unlikely to rotate fast enough to induce epileptic seizures due to shadow flicker (Smedley, Webb, & Wilkins, 2010).

Annoyance

The World Health Organization (WHO) considers annoyance an adverse health effect of noise in addition to sleep disturbance, performance effects, and psychological effects such as irritability (WHO, 2001). Annoyance was also defined as a feeling of displeasure with varying tolerance levels. WHO characterized annoyance as a feeling that increases with noise impulses as opposed to a steady noise (WHO, 2001). Likewise, the primary, and most frequently reported, perceived effect of LFS is annoyance as opposed to the loudness or noisiness (Berglund et al., 1996; Broner, 1978).

To date, four epidemiological studies have specifically examined the effects of sound generated by wind turbines on human health (Pedersen, van den Berg, Bakker, & Bouma, 2009; Pedersen & Waye, 2004,

2007; Shepherd, McBride, Welch, Dirks, & Hill, 2011). Pedersen and Wayne identified a dose response relationship between calculated A-weighted sound pressure levels from wind turbines and noise annoyance in a cross-sectional study (N = 351) that was conducted in five dwelling areas in Sweden. The study respondents were annoyed by the upwind wind turbines, which had a blade passage frequency of 1.4 Hz, at a higher level than other community noises, such as road traffic (Pedersen & Wayne, 2004). Noise annoyance was also found to be related to visual or aesthetic interference and attitude or sensitivity toward the wind turbine (Pedersen & Wayne, 2004).

In another Swedish cross-sectional study (N = 754), the relationship between wind turbine noise and self-reported health and well-being factors was also examined (Pedersen & Wayne, 2007). No correlation existed between A-weighted sound pressure levels from wind turbines and any health or well-being factors, such as the respondent's status of chronic disease, diabetes, or cardiovascular disease (Pedersen & Wayne, 2007). Nevertheless, 31 out of 754 respondents stated that they were annoyed by the wind turbine noise and among this subset 55% reported being tired or that their sleep was disturbed (Pedersen & Wayne, 2007). These findings were statistically significantly higher in comparison to those respondents who were not annoyed. Noise annoyance was also found to be associated with a negative attitude toward the visual impact of wind turbines in this study (odds ratio [OR] = 14.4, 95% confidence interval [CI]: 6.37-32.44) as well as another field study conducted (N = 725) in The Netherlands (OR = 2.8, $p < .001$) (Pedersen et al., 2009; Pedersen & Wayne, 2007). Living in a rural area compared to an urban area increased the risk of perceiving wind turbine noise and annoyance, especially at sound levels above 40dB(A) (Pedersen & Wayne, 2007).

Most recently Pedersen analyzed the self-reported health status among the participants in both the aforementioned Swedish and Dutch cross-sectional studies (Pedersen, 2011). The prevalence of diabetes was found to be weakly associated with A-weighted sound pressure levels due to wind turbines (OR = 1.13, 95% CI: 1.00-1.27) in addition to outdoor (OR = 1.70, 95% CI: 1.14-2.56) and indoor (OR = 1.62, 95% CI: 1.10-2.40) annoyance (Pedersen, 2011).

Finally, a cross-sectional study in New Zealand reported a lower mean physical health-related quality of life (HRQOL) domain score ($F [1, 194] = 5.816, p = .017$) among "The Turbine Group" as compared to "The Comparison Group" (Shepherd et al., 2011). HRQOL measured general well-being and well-being in the physical, psychological, and social domains (Shepherd et al., 2011).

Discussion

A rapid growth of wind generation capacity has occurred throughout various parts of the world. In 1970, virtually no wind power existed as a source of renewable energy in the U.S. Despite this rapid growth over that last 40 years, a very minimal amount of effort has been put into researching the human health impacts of wind power development until recently. The National Research Council (NRC) published a report in 2007 that reviewed the positive and negative environmental impacts of wind energy development, including effects on landscapes, views, wildlife, habitats, air pollution, and greenhouse gases. NRC noted that the potential impacts on human health and well-being were those from noise and from shadow flicker, economic and fiscal impacts, and the potential for electromagnetic interference with television and radio broadcasting, cellular phones, and radar (NRC, 2007). NRC also stated that the effects of sound below 20 Hz on humans have not been well documented or understood, but then concluded that the noise produced by wind turbines is generally not a major concern beyond one half-mile (NRC, 2007).

At present, a specific health condition or collection of symptoms has not been documented in the peer-reviewed, published literature that has been classified as a "disease" caused by exposure to sound levels and frequencies generated by the operation of wind turbines. It can be theorized that reported health effects are a manifestation of the annoyance that individuals experience as a result of the presence of wind turbines in their communities. As described previously, it has been found in the peer-reviewed literature that the presence of wind turbines or wind turbine sound is statistically significantly associated with being annoyed. Thus, the annoyance response that many residents and others have

experienced as a result of being exposed to LFS may act as a mediator to other adverse physical effects. In this proposed mediation model and as illustrated in Figure 2 (Pathway I), annoyance can be the third variable (M), which intervenes in the relationship between the wind turbine LFS, the independent variable (X), and a physical health outcome, the dependent variable (Y), such as headache and dizziness. Alternatively, it can also be theorized that annoyance is the dependent variable (Y), which has been mediated by a physical health outcome, or a third variable (M), as result of LFS exposure generated by wind turbines (Figure 2 [Pathway II]).

Takahashi and co-authors and Inukai and co-authors characterized a pathway to annoyance or unpleasantness through body surface vibrations induced by LFS (Inukai et al., 2000; Takahashi et al., 2005). Although the sample size was small in their studies, a significant correlation was found between the measured body surface vibration and the rating of unpleasantness. This finding supports this alternative theory, which is that the response of annoyance resulting from LFS exposure can occur after an adverse physical effect, such as body surface vibration, has already occurred.

The underlying complaint of annoyance is not a disease, but instead a universal human response to a condition or situation that is not positively appreciated by the human receptor. Annoyances are highly variable in type (e.g. noise, smell, temperature) and vary from person to person. One can be annoyed by the action of others in addition to their own individual actions. WHO considers annoyance an adverse health effect of noise. Based on this definition and the incomprehension of the role of annoyance in the association between LFS and physiological or physical symptoms, exploring whether or not wind turbine sound is a human health risk through additional research is warranted. Such research should be conducted by a method that minimizes biases among the study participants (e.g., use of objective vs. subjective metrics) and in the selection of participants (e.g., randomization). None of the epidemiological studies, to date, have collected objective measurements, such as blood pressure readings or other biomarkers, to support or attenuate the subjective responses provided in questionnaires by the participants.

In addition to using objective measurements, it would also be beneficial to identify some participants who are not visually impacted by wind turbines because their level of annoyance may be minimized or mitigated, which would in effect create a control-like quality of a portion of the participant sample. Lastly, studies on this highly debated subject matter should employ a single or if possible a double-blinded process of data collection. For example, Pedersen and co-authors (2004, 2007, 2009) concealed the study purpose from the participants in their studies, which was essential because the variability of annoyance and its link to undesirable factors make it a prime indicator for the possibility of recall bias. Like so many outcomes, the effects of LFS on annoyance are challenging to establish because of differences in confounding and biases between exposed and non-exposed populations to LFS, which is precisely why further research is recommended.

Our review explored and summarized the peer-reviewed literature on the research that has examined the relationship between human health effects and exposure to LFS and sound generated from the operation of wind turbines (Table 2 on pages 14 and 15). One of the main limitations of our study involved the use of the search terms. Although all efforts were employed to create search terms that were the most inclusive as well as overlapping, a chance existed that some articles were missed in the search. In order to abate this shortcoming, additional searches were conducted in multiple time periods. Furthermore, the only search engine that was used was PubMed, which created a limitation to accessing foreign articles. By using the reference list of retrieved articles, some additional articles, but not all, were identified. Finally, the use of human only as opposed to animal-based research articles was limiting. Animal models and research can often be very useful in gaining an understanding of the pathway from exposure to health outcome especially when the epidemiological data are scarce.

Conclusion

The answer to the question of whether or not exposure to wind turbine sound is a human health risk is still under review and warrants further research. Although limited, research has demonstrated that LFS

can elicit adverse physical health effects, such as vibration or fatigue, as well as an annoyance or unpleasantness response. The current research on exposure to wind turbine sound and the mere presence of wind turbines have also demonstrated a significant annoyance response among study participants. But the association and particular pathway between LFS specifically generated from wind turbines, annoyance, and adverse physical health effects have yet to be fully characterized. What is known is that communities are experiencing a heightened sense of annoyance and fear from the development and siting of wind turbine farms, which seems to be more than just "NIMBYism" (not in my back yard). Hence, the research on the potential health effects, including annoyance-associated health effects, claimed as a result of exposure to sound generated by wind turbines is essential to determine if an actual risk exists. An actual risk versus a perceived risk is very much the same for some communities. High-quality research and effective risk communication can advance this course from one of panic to one of understanding and exemplification for other environmental advancements and developments. As we push to a more sustainable environment, efforts will continue to use and rely on alternative and renewable energy sources, such as wind.

Acknowledgements: The views expressed in this article are those of the author and do not necessarily represent those of the Uniformed Services University of the Health Sciences, Department of Defense, or the U.S. Government.

References

- American Wind Energy Association. (2009). Annual wind industry report: Year ending 2009. Retrieved from http://www.awea.org/_cs_upload/learnabout/publications/5094_1.pdf
- American Wind Energy Association. (2011). AWEA year end 2010 market report. Retrieved from http://www.awea.org/learnabout/publications/upload/4Q10_market_outlook_public.pdf
- American Wind Energy Association. (2012). AWEA industry statistics. Retrieved from http://www.awea.org/learnabout/industry_stats/index.cfm
- Baker, D.E., & National Agricultural Safety Database. (1993). Noise: The invisible hazard. Retrieved from <http://www.nasdonline.org/docs/d000801-d000900/d000882/d000882.html>
- Berglund, B., Hassmen, P., & Job, R.F. (1996). Sources and effects of low-frequency noise. *Journal of the Acoustical Society of America*, 99(5), 2985-3002.
- British Wind Energy Association. (2005). Low frequency noise and wind turbines--technical annex. Retrieved from <http://www.bwea.com/pdf/lfn-annex.pdf>
- Broner, N. (1978). The effects of low frequency noise on people: A review. *Journal of Sound and Vibration*, 58(4), 483-500.
- Castelo Branco, N.A., & Rodriguez, E. (1999). The vibroacoustic disease--an emerging pathology. *Aviation, Space, and Environmental Medicine*, 70(3 Pt. 2), A1-6.
- Dodge, D.M. (2006). The illustrated history of wind power development. Paper presented at the U.S. Federal Wind Energy Program, Littleton, Colorado. Retrieved from <http://telosnet.com/wind/index.html>
- Gage, N.M. (2010). Chapter 7: Hearing and speech. In B.J. Baars & N.M. Gage (Eds.), *Cognition, brain, and consciousness: Introduction to cognitive neuroscience* (2nd ed., pp. 183-223). Berlin: Elsevier.
- Hansen, C.H., & World Health Organization. (1995). *Fundamentals of acoustics*. Retrieved from http://www.who.int/occupational_health/publications/noise1.pdf
- Hau, E. (2006). *Wind turbines: Fundamentals, technologies, application, economics* (2nd ed.). Berlin: Springer.

- Inaba, R., & Okada, A. (1988). Study on the effects of infra- and low frequency sound on the sleep by EEG recordings. *Journal of Low Frequency Noise, Vibration and Active Control*, 7(1), 15-19.
- Inukai, Y., Nakamura, N., & Taya, H. (2000). Unpleasantness and acceptable limits of low frequency sound. *Journal of Low Frequency Noise, Vibration and Active Control*, 19(3), 135-140.
- Inukai, Y., Taya, H., Miyano, H., & Kuriyama, H. (1986). A multidimensional evaluation method for the psychological effects of pure tones at low and infrasonic frequencies. *Journal of Low Frequency Noise, Vibration and Active Control*, 5(3), 104-112.
- Ising, H., Lange-Asschenfeldt, H., Moriske, H.J., Born, J., & Eilts, M. (2004). Low frequency noise and stress: Bronchitis and cortisol in children exposed chronically to traffic noise and exhaust fumes. *Noise and Health*, 6(23), 21-28.
- Jakobsen, J. (2005). Infrasound emission from wind turbines. *Journal of Low Frequency Noise, Vibration and Active Control*, 24(3), 145-155.
- Karpova, N.I., Alekseev, S., Erokhin, V.N., Kadyskina, E.N., & Reutov, O.V. (1970). Early response of the organism to low frequency acoustical oscillations. *Noise and Vibration Bulletin*, 11(65), 100-103.
- Leventhall, G. (2007). What is infrasound? *Progress in Biophysics and Molecular Biology*, 93(1-3), 130-137.
- Maschke, C. (2004). Introduction to the special issue on low frequency noise. *Noise and Health*, 6(23), 1-2.
- Mohr, G.C., Cole, J.N., Guild, E., & Vongierke, H.E. (1965). Effects of low frequency and infrasonic noise on man. *Aerospace Medicine*, 36, 817-824.
- Musial, W., Ram, B., & National Renewable Energy Laboratory. (2010). Chapter 5: Offshore wind energy technology--status and trends. In W. Tong (Ed.), *Large-scale offshore wind power in the United States* (pp. 69-98). Washington, DC: National Renewable Energy Laboratory; Diane Publishing.
- National Research Council. (2007). *Environmental impacts of wind-energy projects*. Washington, DC: National Academy Press.
- Navy and Marine Corps Public Health Center. (2009). *Physics of sound*, April 15, 2009. Retrieved from <http://www-nmcphc.med.navy.mil/downloads/occmcd/toolbox/PHYSICSOFSOUND.ppt>
- Pedersen, E. (2011). Health aspects associated with wind turbine noise--results from three field studies. *Noise Control Engineering Journal*, 59(1), 47-53.
- Pedersen, E., van den Berg, F., Bakker, R., & Bouma, J. (2009). Response to noise from modern wind farms in The Netherlands. *Journal of the Acoustical Society of America*, 126(2), 634-643.
- Pedersen, E., & Waye, K.P. (2004). Perception and annoyance due to wind turbine noise--a dose response relationship. *Journal of the Acoustical Society of America*, 116(6), 3460-3470.
- Pedersen, E., & Waye, K. P. (2007). Wind turbine noise, annoyance and self-reported health and well-being in different living environments. *Occupational and Environmental Medicine*, 64(7), 480-486.
- Pierpont, N. (2009). *Wind turbine syndrome: A report on a natural experiment*. Santa Fe, NM: K-Selected Books.
- Roberts, M.A., & Roberts, J.D. (2009). *Evaluation of the scientific literature on the health effects associated with wind turbines and low frequency sound* (Prepared for Wisconsin Public Service

- Commission [Docket No. 6630-CE-302]). Retrieved from <http://www.maine.gov/dhhs/mecdc/environmental-health/documents/windturbine-wisconsin-assessment.pdf>
- Rogers, A.L., Manwell, J.F., Wright, S., & Renewable Energy Research Laboratory. (2006). Wind turbine acoustic noise. Retrieved from [http://www.minutemanwind.com/pdf/Understanding Wind Turbine Acoustic Noise.pdf](http://www.minutemanwind.com/pdf/Understanding_Wind_Turbine_Acoustic_Noise.pdf)
- Salt, A.N., & Hullar, T.E. (2010). Responses of the ear to low frequency sounds, infrasound, and wind turbines. *Hearing Research*, 268(1-2), 12-21.
- Salt, A.N., & Kaltenbach, J.A. (2011). Infrasound from wind turbines could affect humans. *Bulletin of Science, Technology & Society*, 31(4), 296-302.
- Schust, M. (2004). Effects of low frequency noise up to 100 Hz. *Noise and Health*, 6(23), 73-85.
- Shepherd, D., McBride, D., Welch, D., Dirks, K.N., & Hill, E.M. (2011). Evaluating the impact of wind turbine noise on health-related quality of life. *Noise and Health*, 13(54), 333-339.
- Slarve, R.N., & Johnson, D.L. (1975). Human whole-body exposure to infrasound. *Aviation, Space, and Environmental Medicine*, 46(4 Sec. 1), 428-431.
- Smedley, A.R., Webb, A.R., & Wilkins, A.J. (2010). Potential of wind turbines to elicit seizures under various meteorological conditions. *Epilepsia*, 51(7), 1146-1151.
- Szasz, R.Z., & Fuchs, L. (2010). Chapter 5: Wind turbine acoustics. In W. Tong (Ed.), *Wind power generation and wind turbine design* (pp. 153-181). Billerica, MA: WIT Press.
- Takahashi, Y., Kanada, K., Yonekawa, Y., & Harada, N. (2005). A study on the relationship between subjective unpleasantness and body surface vibrations induced by high-level low-frequency pure tones. *Industrial Health*, 43(3), 580-587.
- Takahashi, Y., Yonekawa, Y., & Kanada, K. (2001). A new approach to assess low frequency noise in the working environment. *Industrial Health*, 39(3), 281-286.
- Takahashi, Y., Yonekawa, Y., Kanada, K., & Maeda, S. (1999). A pilot study on the human body vibration induced by low frequency noise. *Industrial Health*, 37(1), 28-35.
- Tesarz, M., Kjellberg, A., Landstroem, U., & Holmberg, K. (1997). Subjective response patterns related to low frequency noise. *Journal of Low Frequency Noise, Vibration and Active Control*, 16(2), 145-149.
- U.S. Energy Information Administration. (2011a). Energy efficiency and renewable energy wind program. Retrieved from <http://www1.eere.energy.gov/wind/>
- U.S. Energy Information Administration. (2011b). Independent statistics analysis: Electric power annual. Retrieved from http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html
- U.S. Energy Information Administration. (2011c). Today in energy: Wind generating capacity is distributed unevenly across the United States. Retrieved from <http://www.eia.gov/todayinenergy/detail.cfm?id=2470>
- U.S. Energy Information Administration. (2011d). U.S. installed wind capacity by state from 1999 to 2011. Retrieved from http://www.windpoweringamerica.gov/wind_installed_capacity.asp
- von Gierke, H.E., & Nixon, C.W. (1976). Effect of intense infrasound on man. In W. Tempest (Ed.), *Infrasound and low frequency vibration* (2nd ed., pp. 115-150). London: Academic.

Waye, K.P. (2004). Effects of low frequency noise on sleep. *Noise and Health*, 6(23), 87-91.

Waye, K.P., & Rylander, R. (2001). The prevalence of annoyance and effects after long-term exposure to low-frequency noise. *Journal of Sound and Vibration*, 240(3), 483-497.

World Health Organization. (2001). Presentation at the TRB session 391: Setting an agenda for transportation noise management policies in the United States. Retrieved from <http://www.adc40.org/docs/schwela.pdf>

Yamada, S., Sueki, M., Hagiwara, S., Watanabe, T., & Kosaka, T. (1991). Psychological combined effects of low frequency noise and vibration. *Journal of Low Frequency Noise, Vibration and Active Control*, 10(9), 130-136.

Yamada, S., Watanabe, T., Kosaka, T., Negishi, H., & Watanabe, H. (1986). Physiological effects of low frequency noise. *Journal of Low Frequency Noise, Vibration and Active Control*, 5(3), 14-25.

Jennifer D. Roberts, MPH, DrPH

F. Edward Hebert School of Medicine

Uniformed Services University

Mark A. Roberts, MD, PhD

Exponent[R]

Corresponding Author: Jennifer D. Roberts, Assistant Professor, Division of Occupational and Environmental Health Sciences, Department of Preventive Medicine and Biometrics, F Edward Hebert School of Medicine, Uniformed Services University, 4301 Jones Bridge Road, Bethesda, MD 20814. E-mail: jennifer.roberts@usuhs.mil.

TABLE 1

Sound Frequency Spectrum

Frequency (Hz)				
0	10	20	100-250	20,000
Infrasound (with body resonance)	Infrasound	Low frequency sound	Non-low frequency audible sound	Ultrasound
Range of infrasound		Range of human hearing		Inaudible

Note. Adapted from Berglund et al., 1996.

TABLE 2

Reviewed Literature

Year	Author	Title
1965	Mohr, G.C. et al.	Effects of low frequency and infrasonic noise on man
1970	Karpova, N.I. et al.	Early response of the organism to low frequency

		acoustical oscillations
1975	Slarve, R.N. & Johnson, D.L.	Human whole-body exposure to infrasound
1978	Broner, N.	The effects of low frequency noise on people--a review
1986	Inukai, Y. et al.	A multidimensional evaluation method for the psychological effects of pure tones at low and infrasonic frequencies
1986	Yamada, D. et al.	Physiological effects of low frequency noise
1988	Inaba, R. & Okada, A.	Study on the effects of infra and low frequency sound on the sleep by EEG recordings
1996	Berglund, B. et al.	Sources and effects of low-frequency noise
1997	Tesarz, M. et al.	Subjective response patterns related to low frequency noise
1999	Castelo Branco, N.A. et al.	The vibroacoustic disease--an emerging pathology
1999	Takahashi, Y. et al.	A pilot study on the human body vibration induced by low frequency noise
2000	Inukai, Y. et al.	Unpleasantness and acceptable limits of low frequency sound
2001	Waye, K.P. & Rylander, R.	The prevalence of annoyance and effects after long-term exposure to low-frequency noise
2001	Takahashi, Y. et al.	A new approach to assess low frequency noise in the working environment
2004	Ising, H. et al.	Low frequency noise and stress: Bronchitis and cortisol in children exposed chronically to traffic noise and exhaust fumes
2004	Maschke, C.	Introduction to the special issue on low frequency noise
2004	Pedersen, E. & Waye, K.P.	Perception and annoyance due to wind turbine

noise--a dose-response
relationship

- 2004 Schust, M. et al. Effects of low frequency noise up to 100 Hz
- 2004 Waye, K.P. Effects of low frequency noise on sleep
- 2005 Jakobsen, J. Infrasound emission from wind turbines
- 2005 Takahashi, Y. et al. A study on the relationship between subjective unpleasantness and body surface vibrations induced by high-level low-frequency pure tones.
- 2007 Pedersen, E. & Waye, K.P. Wind turbine noise, annoyance, and self-reported health and well-being in different living environments
- 2009 Pedersen, E. et al. Response to noise from modern wind farms in The Netherlands
- 2010 Salt, A.N. & Hullar, T.E. Responses of the ear to low frequency sounds, infrasound, and wind turbines
- 2010 Smedley, A.R. et al. Potential of wind turbines to elicit seizures under various meteorological conditions
- 2011 Pedersen, E. Health aspects associated with wind turbine noise--results from three field studies
- 2011 Salt, A.N. & Kaltenbach, J.A. Infrasound from wind turbines could affect humans
- 2011 Shepherd, D. et al. Evaluating the impact of wind turbine noise on health-related quality of life

Year Study Design

- 1965 Experimental: Subjects (noise-experienced officers) were exposed to high intensity broad-band, narrow-band, and pure-tone low frequency noise (1-100 cps [cycle/second = hertz]) for two minutes to observe the effect on cardiac rhythm, hearing threshold, visual acuity, fine motor control, spatial orientation, speech intelligibility, and subjective tolerance.
- 1970 Experimental: Subjects were exposed to industrial

- infrasound (5, 10 Hz/100, 135 dB) for 15 minutes.
- 1975 Experimental: Subjects were exposed to infrasound ranging 1 to 20 Hz for a period of eight minutes up to levels of 144 dB re 20 micropascal.
- 1978 Review: The effects of low frequency noise are reviewed.
- 1986 Experimental: Subjects were exposed to pure low and infrasonic (3-40 Hz) tones generated by loudspeakers in a pressure chamber and then rated the tones on a response device.
- 1986 Experimental: Subjects were exposed to both rattling noises and to unspecified signals at frequencies between 16 and 125 Hz, at levels between 60 and 100 dB in a test chamber and electrophysiological measurements were collected.
- 1988 Experimental: Subjects were exposed to sinusoidal tones at 10, 20, 40, and 63 Hz with sound pressure levels ranging 75 to 105 dB for 10 and 20 Hz and 50 to 100 dB for 40 and 63 Hz.
- 1996 Review: The sources of human exposure to low-frequency noise and its effects are reviewed.
- 1997 Cross-sectional: The relationship between low frequency noise exposure and subjective symptoms were studied in a group of persons working in offices, laboratories, and industries.
- 1999 Cross-sectional: Analyzed the medical files of 140 patients (male aircraft technicians) with vibroacoustic disease (VAD) in order to classify VAD by a function of time.
- 1999 Experimental: Subjects were exposed to pure tones in the frequency range of 20 to 50 Hz using a designed measuring method with a miniature accelerometer and vibration was measured on the chest and abdomen of subjects.
- 2000 Experimental: Subjects were exposed to pure tones at 16 one-third octave band center frequencies between 20 and 500 Hz and then rated the tones on a five-category scale, of which the highest two categories were "quite unpleasant" and "very unpleasant."
- 2001 Cross-sectional: A cross-sectional questionnaire and noise measurement survey was undertaken among randomly chosen persons exposed to noise (low frequency or middle frequency noise) from heat pump/ventilation installations in their homes.
- 2001 Experimental: Subjects were exposed to 15 kinds of low frequency noise stimuli (5 frequencies x 3 sound pressure levels) reproduced by 12 loudspeakers installed in the wall in front of the subject in order to collect measurements of noise-induced vibration on the body surface and to estimate the equal acceleration level contours of the vibration.
- 2004 Cross-sectional: To examine the correlation of respiratory diseases to traffic related air pollution and noise, nitrogen dioxide as an indicator for vehicle exhausts and the mean nighttime noise level were measured outside children's windows.

- 2004 Review: An introduction and overview of human exposure to low-frequency noise.
- 2004 Cross-sectional: In order to evaluate the prevalence of annoyance due to wind turbine noise and to study dose response relationships, responses were obtained through questionnaires and doses were calculated as A-weighted sound pressure levels.
- 2004 Review: This review concentrates on the effects of low frequency noise up to 100 Hz on selected physiological parameters, subjective complaints, and performance.
- 2004 Review: An overview of the effects of low frequency noise on sleep.
- 2005 Review: A critical survey of all known published measurement results of infrasound from wind turbines.
- 2005 Experimental: Subjects were exposed to high-level low-frequency pure tones and body surface vibrations were measured at the chest and the abdomen. At the same time, the subject rated the unpleasantness that he had just perceived during the exposure to low-frequency noise stimulus.
- 2007 Cross-sectional: In order to evaluate the prevalence of perception and annoyance due to wind turbine noise among people living near the turbines, a cross-sectional study was carried out in seven areas in Sweden across dissimilar terrain and different degrees of urbanization through a postal questionnaire and measurements of outdoor A-weighted sound pressure levels were calculated for each respondent.
- 2009 Cross-sectional: To assess possibly unacceptable adverse health effects, a field study exploring the impact of wind turbine sound on people living in the vicinity of wind farms was carried out in The Netherlands in 2007.
- 2010 Review: An overview of the responses of the ear to low frequency sounds, infrasound, and wind turbines.
- 2010 Experimental: To determine the risk of seizures from wind turbines in persons with photosensitive epilepsy, the light-dark contrasts of turbine shadows for worst case conditions were modeled.
- 2011 Meta analysis: Data from three cross-sectional studies comprising A-weighted sound pressure levels of wind turbine noise and subjectively measured responses from 1,755 people were used to systematically explore the relationships between sound levels and aspects of health and well-being.
- 2011 Review: An overview of the responses of the ear to infrasound generated by wind turbines.
- 2011 Cross-sectional: To compare the health-related quality of life of individuals residing in the proximity of a wind farm to those residing in a demographically matched area sufficiently displaced from wind turbines, a cross-sectional study was conducted in semirural New Zealand.

Year Study Population

1965	Male and female volunteers (N = 5)
1970	Male volunteers (N = 3)
1975	Male Volunteers (N = 4)
1978	N/A
1986	Male and female volunteers (N = 17)
1986	Male and female volunteers/ complainants (N = 21)
1988	Male and female volunteers (N = 6)
1996	N/A
1997	Male and female workers (N = 439)
1999	Male workers (N = 140)
1999	Male volunteers (N = 6)
2000	Male and female volunteers (N = 39)
2001	Male and female volunteers (N = 279)
2001	Male volunteers (N = 9)
2004	Male and female volunteers (N = 68)
2004	N/A
2004	Male and female volunteers (N = 351)
2004	N/A
2004	N/A
2005	N/A

2005	Male volunteers (N = 9)
2007	Male and female volunteers (N = 754)
2009	Male and female volunteers (N = 725)
2010	N/A
2010	N/A
2011	Male and female volunteers (N = 1,755)
2011	N/A
2011	Male and female volunteers (N = 197)

COPYRIGHT 2013 National Environmental Health Association
Copyright 2013 Gale, Cengage Learning. All rights reserved.