Operating Procedures

ISO New England Operating Procedure No. 14

Technical Requirements for Generators,Demand Resources and Asset Related Demands – Appendix F – Wind Plant Operators Guide

Effective Date: September 9, 2011
Revision No. 0

OP 14 Appendix F -
Wind Plant Operator Guide

Effective Date: September 9, 2011

REFERENCES:

1. None

Local Control Center Instruction No:

None

Attachments:

Attachment A – Wind Turbine Groups

Attachment B – Wind Plant Power Generation Diagram

Attachment C – Wind Plant Static Data Information Form

Attachment D – Wind Plant-Specific Ramp Rate Limitations: Confidential

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1 INTRODUCTION

This guide is intended to describe to Wind Plant operators the data reporting requirements that will support successful operation of a centralized regional wind power forecasting system and therefore, the reliable and efficient integration of wind power into the New England Balancing Authority Area. Included also are requirements for data that will be integrated into ISO-NE's Energy Management System in order to facilitate operator system awareness and potentially allow for the utilization of automated dispatch for wind generation resources. Additional requirements may apply depending on market participation (e.g. Regulation Market) as specified in the documentation regarding the rules and procedures governing those particular markets. To the extent that other ISO-NE documents are referenced and any specifications listed in those other ISO-NE documents differ from those listed in this guide, the specifications in those other ISO-NE documents are to be used. These requirements pertain to all Wind Plants that will be dispatched and represented in the ISO New England Energy Management System.

2 DEFINITIONS

Below are definitions of all relevant terms in this guide:

Curtailment – Wind Plant operator action; whether manual, scheduled, or automatic; to limit the amount of power produced by a wind turbine and/or Wind Plant to below the maximum amount of power that could be produced by the normally operating available equipment given the current weather conditions at the wind turbine and/or Wind Plant. This definition specifically excludes wind turbine/plant normal operation according to Physical Resource Constraints.

Met Gathering Station – a permanent purpose-built and/or sited station dedicated to collection of meteorological data (in particular wind speeds and directions, at or near wind turbine hub height) for a Wind Turbine Group that can be used among other purposes to provide wind data for wind power forecasting.

Meteorological Data (i.e. Met Data) – The real-time local wind resource-type data (e.g. wind speeds and directions) collected at a specific Wind Plant site.

Minimum Update Frequency – The minimum frequency that a particular parameter must be transmitted to ISO New England and/or the regional wind forecast vendor(s).

Physical Non-Resource Constraints – These limitations include those that have occurred due to abnormal mechanical and/or electrical limitations within the Wind Plant (e.g. wind turbine blade stress cracks, individual or plant main step-up transformer shorted primary winding, shorted feeder) and/or external to the Wind Plant (e.g. grid voltage outside of limits) that must be observed in order to prevent damage to the wind turbine or some other component of the Wind Plant.

Physical Resource Constraints – These limitations occur due to weather conditions at the Wind Plant. This category includes such conditions as turbine icing, and wind speeds and/or temperatures above cut-out or below cut-in.

Plant Max Reactive Lagging Capability – the maximum reactive capability in the lagging direction (i.e. VAr management that will tend to increase local voltage) that the plant can supply at the interconnection point given the existing voltage, in a continuous manner within one minute and maintain for at least one hour.

Plant Max Reactive Leading Capability – the maximum reactive capability in the leading direction (i.e. VAr management that will tend to decrease local voltage) that the plant can supply at the interconnection point given the existing voltage, in a continuous manner within one minute and maintain for at least one

hour.

Plant Power Generation – The current plant-wide net power delivered (MW) that is being produced by the Wind Plant. (See Attachment B)

Plant Reactive Power Production – The current plant-wide net reactive power delivered (MVAr) that is being produced by the Wind Plant.

Plant Wind Directions (nacelle-level) – The instantaneous wind direction measured by nacelle-mounted wind measuring equipment (e.g. wind vane) or wind turbine nacelle yaw, corrected at all times to report wind direction between 0 degrees and 359.9 degrees and calibrated for True North equal to 0 degrees.

Plant Wind Speeds (nacelle-level) – The instantaneous wind speeds measured by wind measuring equipment (e.g. anemometry) that is mounted in, on, or nearby the nacelle/rotor assembly with reasonable attempt to minimize the effects of rotor "prop-wash", obstruction, and nacelle speed-up effects such that power output can be estimated to within 10% of actual using suitable calibration and the turbine power curve(s) (see for example NREL/CP-500-32494[1]).

Real Time High Operating Limit – defined in the Market Rule, the Real Time High Operating Limit value is the maximum output, in MW, of a resource that could be achieved[2]. For purposes of clarity due to the unique nature of a wind resource this value is based on real-time operating conditions and the physical operating characteristics and operating permits of the unit (i.e. the physical conditions at the plant). This is a total capacity (MW) value representing the physical capability of the plant, based on all turbines at the Wind Plant that are currently in service. The Real Time High Operating Limit value for the purposes of this procedure will be the plant's total nameplate capacity less any reductions in plant capacity due to Physical Resource Constraints or Physical Non-Resource Constraints, other than wind speeds between cut-in and cut-out, that would reduce the plant's output below nameplate. (See Attachment B)

Wind High Limit – The estimated plant-wide power output (MW) ignoring any curtailment. Except for conditions immediately following a release from curtailment, when a Wind Plant is operating in an uncurtailed mode, the Wind High Limit will equal its Power Plant Generation. When a Wind Plant is being curtailed for any reason, the Wind High Limit and the Power Plant Generation will diverge. Each individual wind turbine will possess its own individual theoretical maximum limit that is a function of wind speed, turbine manufacturer's density corrected power curve, turbine availability, and any loss factors. The Wind High Limit is the sum of the individual wind turbine theoretical maximum limits minus any plant-wide loss factors (e.g. electrical collector system losses) and will approximate the Plant Power Generation were there no curtailment. (See Attachment B)

Wind Plant – a Wind Plant is a collection of wind turbines and the additional equipment required to interconnect these wind turbines into the electrical power system consistent with the definition of Generator stated in ISO-NE OP-14.

Wind Plant Future Availability – The forecasted Real Time High Operating Limit of the Wind Plant for each hour for two time horizons: 1) An hourly updated rolling forecast for each hour of the next 48 hours to be provided at the top of every hour 2) a daily updated rolling forecast for each hour of the next 49 to 168 hours to be provided by 1000 Local Time of each day (consistent with OP-5). These two forecasts will in total cover the approximate timespan of the next seven days ahead.

Wind Turbine Counts:

[1] Smith, et al: "Applicability of Nacelle Anemometer Measurements for Use in Turbine Power Performance Tests," NREL/CP-500-32494 available at: http://www.nrel.gov/docs/fy02osti/32494.pdf

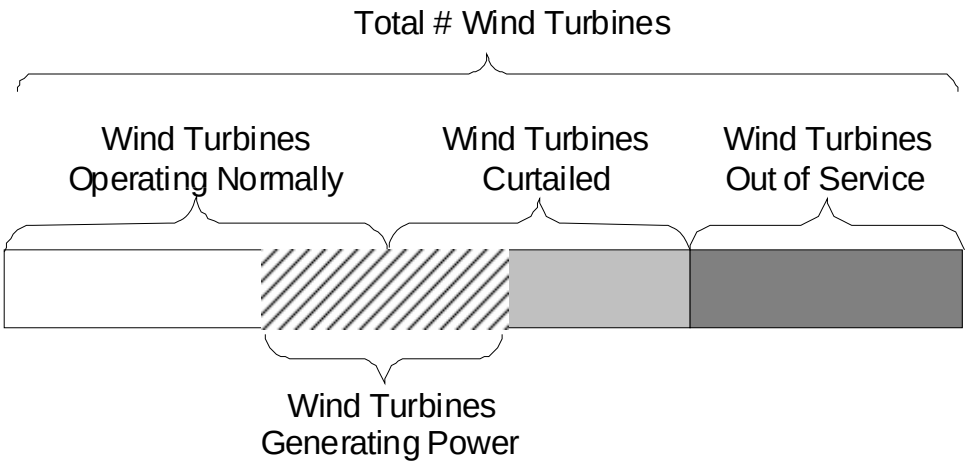
[2] ISO Market Rule I section i: http://www.iso-ne.com/regulatory/tariff/sect_1/sect_i.pdf

Wind Turbines Curtailed – is the total number of wind turbines in the Wind Plant that are curtailed.

Wind Turbines Out-of-Service – is the total number of wind turbines that are out of service for any reason.

Wind Turbines Operating Normally – is the total number of wind turbines in the plant that are operating normally (i.e. not out-of-service and not curtailed). This status indicator will include those wind turbines that are operating normally but are constrained due to Physical Resource Constraints.

Wind Turbines Generating Power – is the total number of wind turbines in the plant that are generating power at any level whether or not those wind turbines are constrained or curtailed in any manner.



Wind Turbine Group – is a group of wind turbines within the Wind Plant where all wind turbines are within a 10 (plant wide average) rotor diameter radius from the nearest neighboring wind turbine. A Wind Plant will consist of one or more Wind Turbine Groups. See Attachment A for examples of Wind Turbine Group configurations.

3 STANDARD OPERATIONAL PRACTICE AND REQUIREMENTS

3.1 WIND PLANT DATA

Overall Wind Plant data (whether static or telemetered) should be consistent with the definition of Wind Plant unless other modeling and data arrangements are agreed upon with ISO-NE.

3.2 RECLOSING AND RESTARTS

Wind plants should be designed and operated in a manner similar to any other Resource within the ISO-NE Balancing Authority Area (BAA): if the plant main breaker is opened (i.e. the plant becomes disconnected from the rest of the BAA) the plant operator must receive permission from ISO-NE and the LCC in order to reclose (i.e. reconnect). In other words, plant automatic restart is not permitted following a grid fault severe enough to disconnect the plant (e.g. an LVRT event that is not "ridden through") or following any plant-wide out-of-service event not specifically related to resource-type conditions (e.g. main transformer damage). Automatic restarts following high wind speed cut-out events are allowed.

3.3 RAMP RATE LIMITATIONS

For Wind Plants of 200 MW or smaller in nameplate, under all conditions except for emergencies and decreasing wind conditions, a default maximum ramp rate of 20 MW/min averaged over five minutes is not to be exceeded unless otherwise required by ISO-NE. For Wind Plants of greater than 200 MW in

nameplate, under all conditions except for emergencies and decreasing wind conditions, a default maximum ramp rate of 10% of nameplate MW/min averaged over five minutes is not to be exceeded unless otherwise required by ISO-NE. This limit is initially placed in service due to the very fast ramping capabilities of Wind Plants and the potential for those plants to significantly load and unload the transmission equipment they are connected that may potentially lead to overloads. As operational experience is gained, the ISO will reevaluate this limit on a generator-by-generator basis, or on a New England Fleet basis, as warranted. Where alternative ramp rates are determined to be acceptable on a Wind Plant specific basis, those plant-specific limits will be documented in the Appendix F Confidential Attachment D.

3.4 PLANT VOLTAGE REGULATION MODE

Though Wind Plants may not have an actual Automatic Voltage Regulator (AVR) as is required in conventional generation, many Wind Plants do have the capability to participate in voltage regulation at some specified bus (e.g. the point of interconnection). When a Wind Plant is using this AVR–like functionality in order to manage VAr production and/or consumption in order to participate in voltage regulation, this status indicator should be set to a "1" in the binary convention. When a Wind Plant is not actively participating in voltage control (e.g. it is operating at a fixed power factor, fixed VAr production level, or the voltage regulation function is disabled for some reason) this status indicator should be set to a "0" in the binary convention.

3.5 NACELLE LEVEL WIND DIRECTION DATA REQUIREMENTS

The number of nacelles providing wind direction data must (at least) meet the minimum requirements outlined in the Data Collections Points section and must measure with minimum resolution to 1 degree and with minimum accuracy to +/- 5 degrees. The minimum sampling and reporting frequency should be at least once per every 30 seconds.

3.6 NACELLE LEVEL WIND SPEED DATA REQUIREMENTS

The number of nacelles providing wind speed data must (at least) meet the minimum requirements outlined in the Data Collections Points section. In order to help to ensure that calculated power will be able to be estimated to within 10% of actual power over the range of most interest (i.e. the combined ranges of maximum impact and highest error sensitivity) wind speed measuring equipment must measure with minimum resolution to 0.1 m/s and must possess minimum accuracy of within 0.5 m/s over the range of 0 m/s to rated plus 1 m/s, and within 5% of reading above this range up to the highest cut-out wind speed (e.g. the cut-out wind speed for a short term gust) plus 5 m/s. For example if a wind turbine has cut-in, rated, and highest cut-out windspeeds of 3 m/s, 12 m/s, and 30 m/s, the wind speed measuring equipment on the nacelle must have accuracy to within 0.5 m/s within the range of 0 m/s to 13 m/s, and within 5% of reading over the range of 13 m/s to 35 m/s. The minimum sampling and reporting frequency should be at least once per every 30 seconds.

3.7 OUTAGE COORDINATION

OP-5 requires generators to submit an outage request via the Control Room Outage Window (CROW) tool whenever units are "out of service", meaning that the unit is unable to provide MWs onto the electrical grid. Outage requests can be for planned or unplanned outages. In the case of Wind Plants, this would potentially require the Wind Plants to submit daily outages in advance to perform routine maintenance work which in many cases may have no effect on their overall MW capability.

Therefore:

1. All Wind Plants must submit Wind Plant Future Availability. This serves as the generator's "notification" for OP-5 purposes.
2. If the Wind Plant does not have a CSO and is not a Qualified Generator Reactive Resource, only Wind Plant Future Availability must be reported; CROW, based outage reporting is not required.
3. Any Wind Plant that does have a CSO or that is a Qualified Generator Reactive Resource, must report Wind Plant Future Availability, and also submit an outage request into CROW only when the outage will derate the plant to the point that the available nameplate is less than its CSO and/or Qualified VARs.

4 STATIC PLANT DATA

Below are the static plant data requirements that describe the physical layout of the Wind Plant and any associated meteorological equipment as well as data relevant to the design and operation of the Wind Plant. This data must be supplied on Attachment C, Wind Plant Static Data Information Form. The Wind Plant Static Data Information Form is an editable Excel workbook file and must be requested from, completed, and returned as an Excel workbook file to the ISO-NE Renewable Resource Integration Department. A sample Attachment C is included in this OP. Instructions are included on the form on how to request, complete, and submit the required information. Consistent with Schedule 22 and 23 of Part II of the Tariff and this OP, these data must be kept current and must be updated if any datapoints change in a material fashion. For example if a wind turbine in the plant is replaced with a different make or model type, information for the new wind turbine must be supplied; or if the permitting requirements change, the new requirements must be specified; or if wind measuring equipment is replaced with non-identical measuring equipment, the make and model information for the new equipment must be supplied.

Static Wind Plant data:

1) Wind Plant:
   a) Wind Turbine tower center coordinates (i.e. latitude and longitude in WGS84 DD-MM-SS.SS using GPS WAAS, or comparable, methodology) and ground elevation of turbines (in meters, to one decimal place)
   b) Number of turbines
   c) Turbine model(s) including IEC wind class
   d) Density dependent turbine nominal power curves for each type of turbine in the plant for standard test conditions (e.g. air density equaling 1.225 kg/m^3) and for three additional values of density (for which the density values must be supplied): one power curve for normal operation at the long-term average density expected for the plant and one power curve each for normal operation at approximately 85% (+/- 10%) and approximately 115% (+/-10%), respectively of the expected long-term average Wind Plant air density
   e) Hub height(s) (in meters to one decimal place)
   f) Maximum plant nameplate capacity (in MW to two decimal places)
   g) Cut-in wind speed(s) and time constants (if any, e.g. windspeed must be above 3.4 m/s for at least 5 minutes, etc.)
   h) Cut-out wind speed(s) and time constants (if any)
   i) Cut back in wind speed(s) and time constants (if any)
   j) Cold temperature cutoff threshold(s) (in Degrees C to one decimal place)
   k) High temperature cutoff threshold(s) (in Degrees C to one decimal place)
   l) Any cold weather operation packages and their effects on wind turbine operational envelope (e.g. blade and/or gearbox heaters, etc. that extends cold temperature cut-out to below xx degrees, etc.)
   m) Wind turbine icing behavior
      i. Triggers for icing related shutdowns (e.g. temperatures, relative humidities, out-of-balance conditions, etc.)
      ii. Triggers for release from icing related shutdowns (e.g. manual reset, temperatures, hysteresis, etc.)
   n) For all plant wind speed and direction measuring devices (i.e. nacelle-level wind measuring devices):
      i. Equipment type (i.e. model specifications and operating principle e.g. make and model type, measurement heights) and calibration curves and/or reports
      ii. Dimensions and/or site plan of any nearby potential obstructions that would substantially reduce the quality of the data and the mitigation measures employed (e.g. diagram of location with respect to the nacelle and rotor)
   o) Descriptions of any permitting or administrative restrictions such as requirements to reduce or to cease power production during certain hours or during certain events or wind conditions.
   p) For model training purposes, any available historical information required by the wind power forecaster regarding plant power output, plant meteorological conditions, and conditions that may

have caused power output to be below theoretical maximum power output given the experienced wind speeds may also be required to be provided.

2) Met gathering station(s):
   a. Center of structure(s) coordinates (using the same method listed above for turbine in the Wind Plant) and ground elevation of met station(s)
   b. Equipment type (i.e. model specifications and operating principle e.g. make and model type, measurement heights)
   c. Dimensions and/or site plan of any nearby potential obstructions that would substantially reduce the quality of the data (e.g. met-tower dimensions and profile) and the mitigation measures employed (e.g. mounting arm dimensions and orientations)

5 REAL-TIME DATA COLLECTION AND TRANSFER

This section presents the real-time operational and meteorological data requirements for Wind Plant operators. All of the required data must be electronically and automatically transmitted over a secure network using the protocol approved by ISO New England. In addition, if the recommended data is provided, it must also be electronically and automatically transmitted over a secure network using the protocol approved by ISO New England. Wind power forecasting accuracy is highly dependent on the availability of the real-time meteorological, power production, and status data for tuning the forecaster models. As such this information is required with a high degree of accuracy and reliability.

5.1 AVAILABILITY

The Wind Plant operator's real-time data transfer process and data gathering equipment shall be designed to operate at all times.

5.2 DATA COLLECTION POINTS

Required
At a minimum, nacelle-level wind speed and wind direction measurements must be provided from the highest wind turbine (i.e. wind turbine hub elevation in terms of elevation above mean sea level) and a minimum of one wind turbine at the maximal value of each of the four true cardinal directions (i.e. the farthest true North, South, East, and West) in each Wind Turbine Group within the plant. Additionally, the wind turbine nearest the capacity-weighted centroid of the Wind Plant must also report wind speeds and directions. If any wind turbine within a Wind Turbine Group satisfies more than one of these conditions then it may be used to fulfill all conditions that it satisfies (e.g. if the highest wind turbine in a Wind Turbine Group is also the farthest North and the farthest East, it may be used to supply data for all three of these categories). Where more than one turbine satisfies these conditions, preference should be given to those turbines that will be least affected by Wind Plant wake effect from the prevailing wind direction(s). Finally, where a Wind Turbine Group contains 10 or less wind turbines only the nacelle-level data from the highest wind turbine nacelle is required. The locations of wind turbines with nacelle-level equipment providing data must be referenced to the Static Plant Data supplied locations.

In addition to the nacelle-level data, ambient temperature, air pressure, and relative humidity must be measured, at a minimum, at one location within the plant (preferably as near to the capacity-weighted centroid of the Wind Plant as possible) whose height above ground may be in the range of 2 m to 10 m (or up to 30 m above mean sea level for offshore Wind Plants) and the measurement height above ground (or mean sea level for offshore Wind Plants) must be stated to within 10 cm.

Recommended
In order to ensure that data of a high quality will be incorporated into the centralized forecasting system, ISO New England requests that Wind Plant operators follow the practices for meteorological data

collection outlined below:

1.) Collect meteorological data from at least one met tower or other equivalent met equipment (e.g. remote sensing equipment such as SODAR or LIDAR) that is strategically placed or utilized so that it will be impacted by plant operations to a minimal extent (i.e. it is generally capable of providing "free stream" data).
2.) The collection equipment should be capable of collecting measurements at, at least, two heights (with the exception of air temperature, air pressure, and relative humidity):
    a. Turbine hub height
    b. A second height at least 20 meters less than hub height.
3.) In general, the met equipment should be located at well-exposed sites that are upwind of the plant and no closer than two rotor diameters to the nearest wind turbine. As a rough guideline, it is recommended that each turbine in the Wind Plant should be within 5 km of a met gathering station.
4.) If ambient temperature, pressure, and/or humidity are measured by nacelle-level equipment, it would be preferred to receive any of this data from all of the nacelles providing wind speed data, in addition to the single plant-wide measurement required.
5.) In order to avoid outage of data (from e.g. nacelle-level wind speeds) it is recommended that additional "backup" nacelles are selected in addition to the minimum requirements specified for the number of nacelles providing data in the Data Collection Points section to simultaneously collect and transmit the required data. When this recommendation is followed, as near as possible the "next most…" wind turbine in each group should be used to supply data (e.g. the second highest wind turbine in a group, the second farthest North wind turbine in the group, etc.) and these turbines' locations should also be referenced to the Static Plant Data supplied location. Alternatively, nacelle-level data can be reported by all the wind turbine nacelles within the Wind Plant.

5.3 FREQUENCY

Minimum frequencies of the real-time data Wind Plant operators must provide are listed in Table 6.1.

6 REAL TIME DATA TABLE

Table 6.1 Real-time data

Parameter	Required/ Preferred	Location	Height	Units	Instantaneous /Average	Minimum Resolution/ Accuracy	Minimum Update Frequency
Non-SCADA							
Wind Plant Future Availability 1.) Hourly values for the next 48 hours 2.) Hourly values for next 49 to 168 hours	Required	Plant-wide total	N/A	MW	N/A	Consistent with OP-18* [e.g. to 0.01 MW]	1.) Every hour at the top of the hour 2.) By 1000 hours each day.
SCADA							
Real Time High Operating Limit	Required	Plant-wide total	N/A	MW	Instantaneous	Consistent with OP-18* [e.g. to 0.01 MW with accuracy of +/- 1%]	Every 5 minutes
Wind High Limit	Required	Plant-wide total	N/A	MW	Instantaneous	Consistent with OP-18* [e.g. to 0.01 MW]	Every 5 minutes
Plant Power Generation	Required	Plant-wide total	N/A	MW	Instantaneous	Specified in OP-18* [e.g. to 0.01 MW with accuracy of +/- 1%]	per OP-18** [e.g. every 4 s]
Plant Reactive Power Production	Required	Plant-wide total	N/A	MVAr	Instantaneous	Specified in OP-18* [e.g. to 0.01 MVAr with accuracy of +/- 1%]	per OP-18** [e.g. every 4 s or every 10 s]

* ISO-NE OP-18 Appendix F: Analog Inputs to ISO CFE, MW, MVAR & Appendix C: Security Analysis, Watts/VARs, Digital/Analog Telemetry, per OP-18 tighter accuracy standards may apply if the plant is on Automatic Generation Control

Parameter	Required/ Preferred	Location	Height	Units	Instantaneous /Average	Minimum Resolution/ Accuracy	Minimum Update Frequency
Voltage at point of interconnection	Required	Plant	N/A	kV	Instantaneous	Specified in OP-18[*] [e.g. to 0.01 kV with accuracy of +/- 0.7%]	per OP-18[**] [e.g. every 4 s or every 10 s]
Plant Main Breaker Status	Required	Plant	N/A	binary	Instantaneous	N/A	per OP-18[**] [e.g. every 4 s]
Plant Voltage Regulation Mode	Required	Plant	N/A	binary	Instantaneous	N/A	per OP-18[**] [e.g. every 4 s]
Wind Turbines Curtailed	Required	Plant-wide	N/A	N/A[***]	Instantaneous	Integer	Every 5 minutes
Wind Turbines Out-of-Service	Required	Plant-wide	N/A	N/A[***]	Instantaneous	Integer	Every 5 minutes
Wind Turbines Operating Normally	Required	Plant-wide	N/A	N/A[***]	Instantaneous	Integer	Every 5 minutes
Wind Turbines Generating Power	Required	Plant-wide	N/A	N/A[***]	Instantaneous	Integer	Every 5 minutes
Plant Wind Speeds	Required	per Wind Turbine Group See Data Collection Points section	Nacelle	m/s (scalar)	Instantaneous	to 0.1 m/s accuracy of +/- 0.5 m/s over the range of 0 m/s to 1 m/s above rated wind speed[&]	Every 30 seconds
Plant Wind Directions	Required	per Wind Turbine Group See Data Collection Points section	Nacelle	Degrees from True North (vector)	Instantaneous	to 1 degree with accuracy to +/- 5 degrees	Every 30 seconds

[**] ISO-NE OP-18 Section C: Telemetered Data Scan Rates

[***] See Section: Wind Turbine Counts

[&] See section: Plant Wind Speeds (nacelle-level)

Parameter	Required/ Preferred	Location	Height	Units	Instantaneous /Average	Minimum Resolution/ Accuracy	Minimum Update Frequency
Plant Max Reactive Lagging Capability	Preferred	Plant-wide total	N/A	MVAr	Instantaneous	Consistent with OP-18* [e.g. to 0.01 MVAr with accuracy of +/- 1%]	Consistent with OP-18** [e.g. every 4 s or every 10 s]
Plant Max Reactive Leading Capability	Preferred	Plant-wide total	N/A	MVAr	Instantaneous	Consistent with OP-18* [e.g. to 0.01 MVAr with accuracy of +/- 1%]	Consistent with OP-18** [e.g. every 4 s or every 10 s]
Ambient air temperature	Preferred	See Data Collection Points section	Nacelle	Degrees Centigrade (^{o}C)	Instantaneous	to 0.1^{o}C with accuracy+/- 1.25^{o}C	Every 30 seconds
Ambient air pressure	Preferred	See Data Collection Points section	Nacelle	Kilopascals (kPa)	Instantaneous	to 0.1 kPa with accuracy to +/- 1.5 kPa	Every 30 seconds
Ambient air relative humidity	Preferred	See Data Collection Points section	Nacelle	(Percent)	Instantaneous	to 1% with accuracy to +/- 3%	Every 30 seconds
Wind plant ambient information							
Ambient air temperature	Required	One location within Wind Plant	2 meters[&&]	Degrees Centigrade (^{o}C)	Average over 5 minute interval	to 0.1^{o}C with accuracy+/- 1.25^{o}C	Every 5 minutes
Standard Deviation of Ambient air temperature	Required	One location within Wind Plant	2 meters[&&]	Degrees Centigrade (^{o}C)	Over 5 minute interval	Same as above	Every 5 minutes
Ambient air pressure	Required	One location within Wind Plant	2 meters[&&]	Kilopascals (kPa)	Average over 5 minute interval	to 0.1 kPa with accuracy to +/- 1.5kPa	Every 5 minutes
Standard Deviation of Ambient air pressure	Required	One location within Wind Plant	2 meters[&&]	Kilopascals (kPa)	Over 5 minute interval	Same as above	Every 5 minutes

[&&] See section Data Collection Points

Parameter	Required/ Preferred	Location	Height	Units	Instantaneous /Average	Minimum Resolution/ Accuracy	Minimum Update Frequency
Ambient air relative humidity	Required	One location within Wind Plant	2 meters[&&]	(Percent)	Average over 5 minute interval	to 1% with accuracy to +/- 3%	Every 5 minutes
Standard Deviation Ambient air relative humidity	Required	One location within Wind Plant	2 meters[&&]	(Percent)	Over 5 minute interval	Same as above	Every 5 minutes
Meteorological Station data typically sampled at 1Hz							
Wind speed	Preferred	For each met gathering station	1) Hub 2) at least 20 meters from hub	m/s (scalar)	Average over 5 minute interval	to 0.1 m/s accuracy of +/- 0.5 m/s over the range 0 m/s to 1 m/s above rated wind speed[&]	Every 5 minutes
Standard Deviation of Wind speed	Preferred	For each met gathering station	Same as above	m/s (scalar)	over 5 minute interval	Same as above	Every 5 minutes
Maximum wind speed	Preferred	For each met gathering station	1) Hub 2) at least 20 meters from hub	m/s (scalar)	Over 5 minute interval	to 0.1 m/s with accuracy of +/- 0.5 m/s	Every 5 minutes
Wind direction	Preferred	For each met gathering station	1) Hub 2) at least 20 meters from hub	Degrees from True North (vector)	Average over 5 minute interval	to 1 degree with accuracy to +/- 5 degrees	Every 5 minutes
Standard Deviation of Wind direction	Preferred	For each met gathering station	Same as above	Degrees from True North (vector)	over 5 minute interval	Same as above	Every 5 minutes
Ambient air temperature	Preferred	For each met gathering station	2 meters[&&]	Degrees Centigrade (^{o}C)	Average over 5 minute interval	to 0.1^{o}C with accuracy+/- 1.25^{o}C	Every 5 minutes
Ambient air pressure	Preferred	For each met gathering station	2 meters[&&]	Kilopascals (kPa)	Average over 5 minute interval	to 0.1 kPa with accuracy to +/- 1.5kPa	Every 5 minutes
Ambient air relative humidity	Required	For each met gathering station	2 meters[&&]	(Percent)	Average over 5 minute interval	to 1% with accuracy to +/- 3%	Every 5 minutes

7 REVISION HISTORY

Rev. No.	Date	Reason
Rev 0	09/09/11	Original draft

ATTACHMENT A. WIND TURBINE GROUPS

A total of five different example Wind Plant configurations are shown in order to depict which wind turbine nacelles must provide nacelle-level data for each configuration. Figure A-5 includes a "zoomed-out" version of Figure A-4.

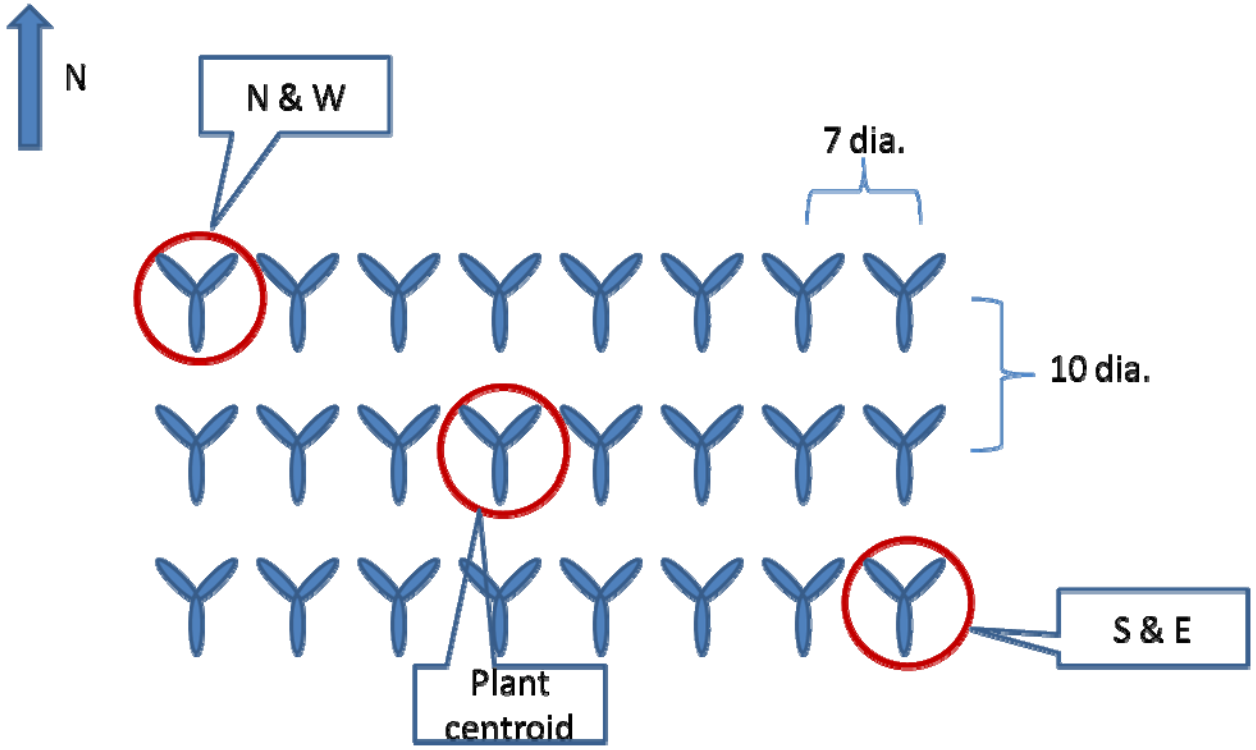
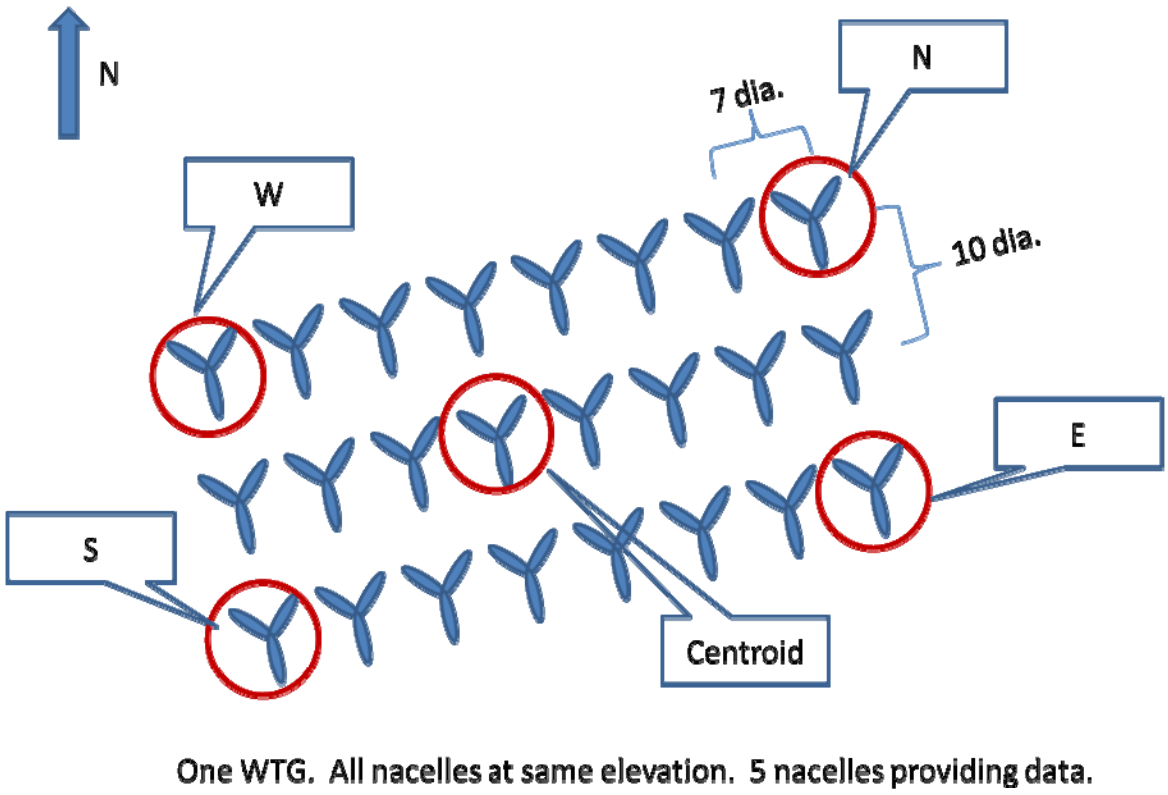
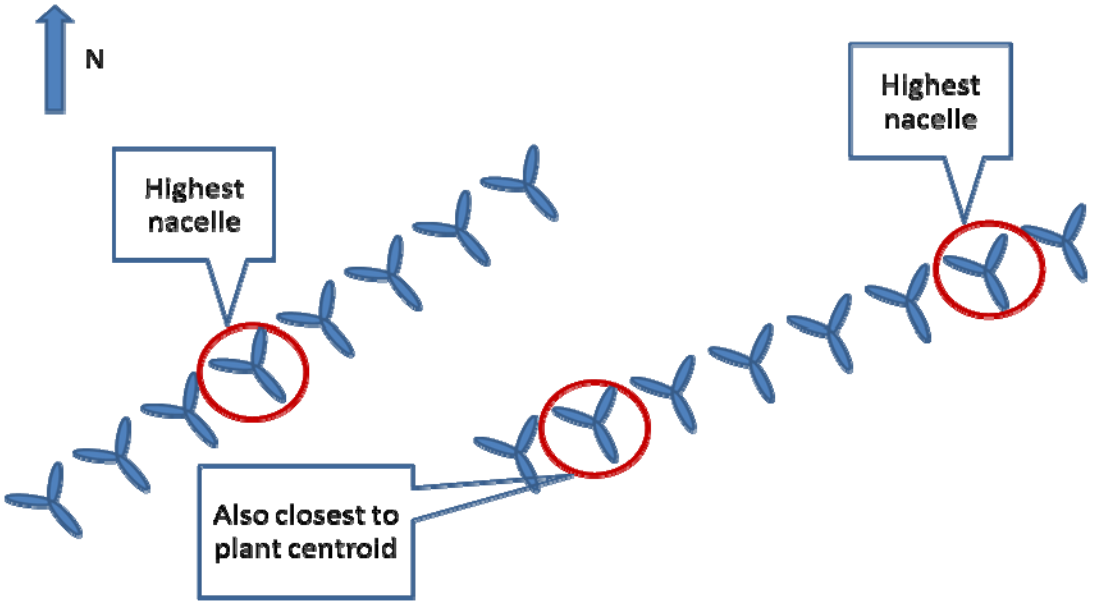


Figure A-1



One WTG. All nacelles at same elevation. 5 nacelles providing data.

Figure A-2



Two WTGs of less than 10 turbines each. Following ridges.
All nacelles at different elevations. 3 nacelles providing data.

Figure A-3

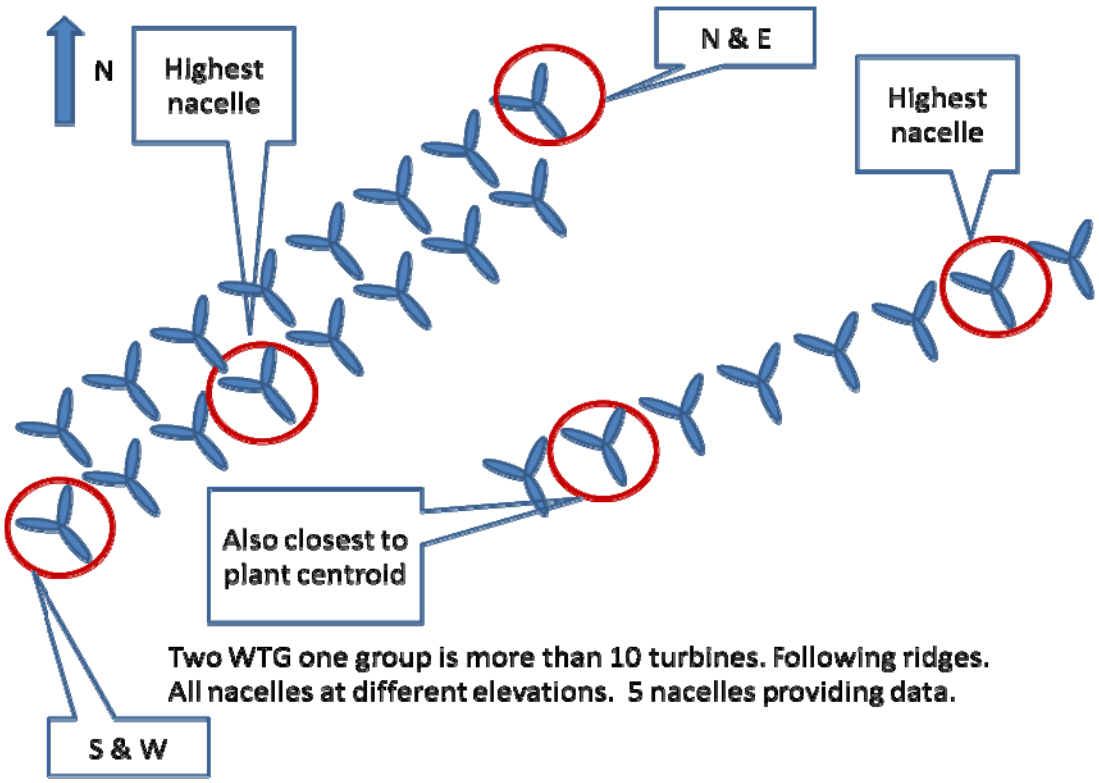


Figure A-4

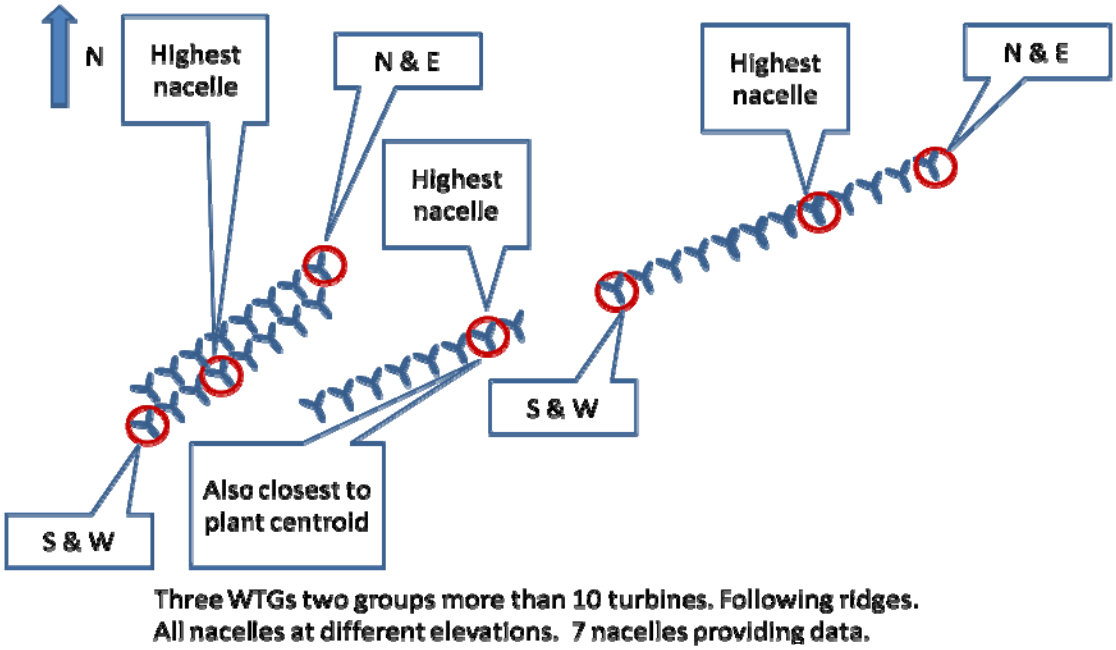
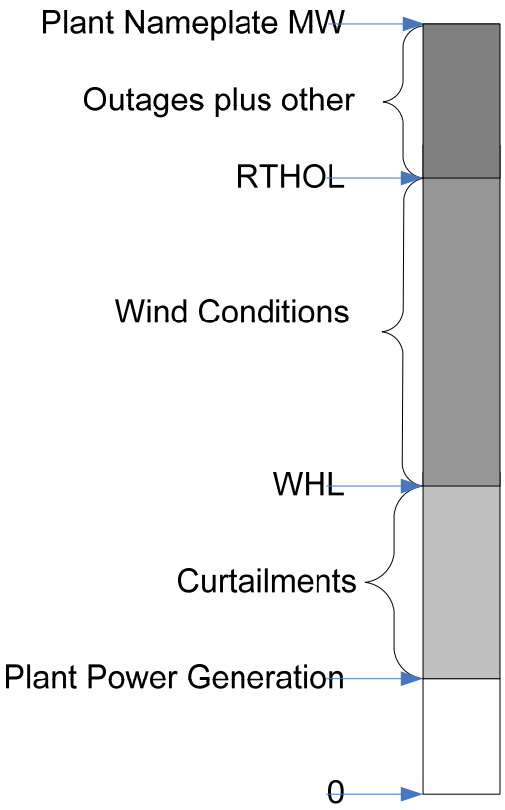


Figure A-5

ATTACHMENT B. WIND PLANT POWER GENERATION DIAGRAM

The following diagram shows the relationship of the capacity parameters of a Wind Plant.



ATTACHMENT C. WIND PLANT STATIC DATA INFORMATION FORM

OP-14 Appendix F Attachment C

Instructions for filling out this form

1) This form is an editable Excel Workbook and must be requested by sending an e-mail with the subject line "Wind Plant Static Data Form Request" to the ISO-NE Renewable Resource Integration department at the following address: _____. Once the form is completed, it must be returned via e-mail using the subject line "Wind Plant Static Data Form Submission" also to ISO-NE's Renewable Resource Integration department.

2) This form (i.e. this Excel workbook and all tabs within it except this "Instructions" tab) must be completed, certified to be accurate and true by the Lead Participant by completing the attestation on the "Main Page" tab of this form, and submitted to ISO-NE prior to commercial operation or to the enforcement of Section M (Additional Requirements for Wind Powered Generators) of ISO-NE OP-14--whichever occurs later. It must be updated and certified to be accurate and true by the Lead Participant by completing the attestation on the "Main Page" tab of this form within two weeks of any changes to any of the parameters listed. The "Overall Wind Plant Data" tabs (Turbine, Ambient, and Met) have sufficient space for all wind turbines, ambient wind plant conditions stations, and met gathering stations to be listed and the characteristics to be filled out. One "Turbine Type Information" tab must be created and completed for each type of make, model, and version of wind turbine used within the plant: all wind plants must contain at least one wind turbine type, some may contain more. Some "dummy" values have been inserted in the user editable fields (e.g. the permitting restrictions section above, and the Turbine Type Information N tab) in order to help the user enter in the correct values with the correct formatting. With the exception of changing the name of the "Turbine Type Information tab" (in order to correctly reflect the identification number of the wind turbine type) the user must edit and only edit the text that is in the Calibri, italicized, non-bold, 11 pt font.

3) In order to certify that the data contained in this form is accurate and true, the "Main Page" tab of this form must be completed, attested to, printed and hand-signed and dated by the Lead Participant. An Adobe Acrobat (.pdf) version must then be electronically submitted with this form.

4) On the "Main Page" tab of this form, describe any and all permitting or administrative restrictions (such as requirements to reduce or to cease power production during certain hours or during certain events or wind conditions) that will potentially affect the power output of the wind plant. Include in the description the expected frequency of occurrence, expected duration, and expected impact of the restrictions (e.g. "turbines 1 and 52 will operate at reduced power in order to reduce sound production every day during the months of May and June from hours ending 0600 EPT to 0700 EPT. The reduced power output power curves are attached.", or "during the prime migration of species X whenever the migration season has begun until that the season is over. Whenever ten or more of these animals are observed near the wind plant the whole plant will be shut down . Expected impact: daily for approximately two hours during the migration season."). The effect of any restrictions on the potential power output any affected wind turbine must be fully described by, for example, attaching any reduced power wind turbine power curves.

5) For any and all met gathering equipment that will report to ISO-NE submit clearly legible copies of manufacturer's data sheets in Adobe Acrobat (.pdf) format and any other documentation that show make, model and calibration information, also submit diagram that clearly shows mounting and nearby potential obstructions such as a dimensioned diagram of the equipment location for all sensors.

6) On the "Turbine Type Information" tab of this form in the "Wind Turbine Icing Behavior" fields, describe any and all triggers for icing related shutdown and release from shutdown including e.g. temperatures, humidities, out-of-balance conditions, wind speeds, time constants, etc. On the "Turbine Type Information" tab of this form in the "Wind Turbine Cold Weather Packages" field, describe any and all installed and operational cold weather climate packages that could mitigate the severity, occurrence, or duration of cold weather and/or icing related shutdowns. Also in this field, describe the effect on the operational envelope of the wind turbine (e.g. heated blades that prevent icing-related shutdowns, heated blades that prevent ice accumulation in order to prevent performance degradation, gearbox heaters that extend cold weather operation to below standard low-temperature operational thresholds, etc.) .

OP-14 Appendix F Attachment C

Wind Plant Static Data Information Form Main Page

Lead Participant	Local Control Center	Generator Name	Unit #	Gen/Asset ID

Designated Entity	DE Location	DE Contact Name	DE Phone #	DE E-Mail

1. Data Preparation Documentation

Data Revision No. _____ **Date Prepared** _____

Prepared By _____ **Requested Effective Date** _____
(e-mail)

Attestation that data is true and accurate
The enclosed data has been reviewed and is accuarate as of the date of submission.

Signed: _____

Name: _____ **Title:** _____

Date: _____

Wind Plant Permitting Operational Restrictions

Describe any and all permitting or administrative restrictions (such as requirements to reduce or to cease power production during certain hours or during certain events or wind conditions) that will potentially affect the power output of the wind plant. Include in the description the expected frequency of occurrence, expected duration, and expected impact of the restrictions (e.g. turbines 1 and 52 will operate at reduced power in order to reduce sound production every day during the months of May and June from hours ending 0600 EPT to 0700 EPT. The reduced power output power curves are attached.", or "during the prime migration of species X whenever the migration season has begun until that the season is over. Whenever ten or more of these animals are observed near the wind plant the whole plant will be shut down . Expected impact: daily for approximately two hours during the migration season."). The effect of any restrictions on the potential power output any affected wind turbine must be fully described by, for example, attaching any reduced power wind turbine power curves.

OP-14 Appendix F Attachment C **Overall Wind Plant Data-Turbine**

Wind Turbine Number	Latitude	Longitude	Turbine Tower Base Elevation [m above mean sea level]	Hub Height above Tower Base [m]	Turbine Make and Model	IEC Class	Turbine Type Information Workbook Sheet	Providing Nacelle-Level Wind Speed and Direction Data	Providing Nacelle-Level Ambient Information	Wind Turbine Group
								y (If yes, submit clearly legible pdf copies of manufacturer's data sheets and any other documentation that show make, model and calibration information, also submit diagram that clearly shows mounting and nearby potential obstructions such as a dimensioned diagram of the equipment location on the nacelle for all sensors)	y (If yes, submit clearly legible pdf copies of manufacturer's data sheets and any other documentation that show make, model and calibration information, also submit diagram that clearly shows mounting and nearby potential obstructions such as a dimensioned diagram of the equipment location on the nacelle for all sensors)	
1	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x	xxx.x	Windmeister 95erpe	A-I	1			1
2	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x	xxx.x	Windmeister 95erpe	A-I	1	n	n	1
additional entries as required										
X	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x	xxx.x	Windbeater 3.01abc	S	N	n	n	Y

OP-14 Appendix F Attachment C **Overall Wind Plant Data-Ambient**
Wind Plant Ambient Conditions Collection Station

	Latitude	Longitude	Elevation of mounting structure base [m above mean sea level]	Reporting Height of Equipment [m above structure base]	Site plan/Diagram/Sensor Information
1	*DD-MM-SS.SS*	*DD-MM-SS.SS*	*xxxx.x*	*xxx.x*	*submit clearly legible pdf copies of manufacturer's data sheets and any other documentation that show make, model and calibration information, also submit diagram that clearly shows mounting and nearby potential obstructions such as a dimensioned diagram of the equipment location for all sensors*
additional entries as required					

OP-14 Appendix F Attachment C
Wind Plant Met Gathering Stations

Overall Wind Plant Data-Met

	Latitude	Longitude	Elevation of mounting structure base [m above mean sea level]	Reporting Height of Equipment [m above structure base]	Site plan/Diagram/Sensor Information
1	*DD-MM-SS.SS*	*DD-MM-SS.SS*	*xxxx.x*	*xxx.x*	*submit clearly legible pdf copies of manufacturer's data sheets and any other documentation that show make, model and calibration information, also submit diagram that clearly shows mounting and nearby potential obstructions such as a dimensioned diagram of the equipment location for all sensors*
additional entries as required					

OP-14 Appendix F Attachment C

Wind Turbine Density Dependent Power Curve

density [kg/m^3]		1.225 Normal Long-term	Below normal	Above Normal
wind speed [m/s]	Power [MW]	*specify density*	*specify density*	*specify density*
0	0.000	0.000	0.000	0.000
0.5	0.000	0.000	0.000	0.000
1	0.000	0.000	0.000	0.000
1.5	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000
2.5	0.000	0.000	0.000	0.000
3	0.016	0.015	0.014	0.017
3.5	0.025	0.024	0.022	0.027
4	0.038	0.036	0.032	0.040
4.5	0.054	0.051	0.046	0.056
5	0.074	0.070	0.063	0.077
5.5	0.099	0.094	0.084	0.103
6	0.128	0.122	0.109	0.134
6.5	0.163	0.155	0.138	0.170
7	0.203	0.193	0.173	0.212
7.5	0.250	0.238	0.213	0.261
8	0.303	0.288	0.258	0.317
8.5	0.364	0.346	0.309	0.380
9	0.432	0.410	0.367	0.451
9.5	0.508	0.483	0.432	0.531
10	0.593	0.563	0.504	0.619
10.5	0.686	0.652	0.583	0.717
11	0.789	0.749	0.670	0.824
11.5	0.901	0.856	0.766	0.942
12	1.024	0.973	0.870	1.070
12.5	1.157	1.100	0.984	1.209
13	1.302	1.237	1.107	1.361
13.5	1.458	1.385	1.239	1.524
14	1.626	1.545	1.382	1.699
14.5	1.807	1.716	1.536	1.888
15	2.000	1.900	1.700	2.000
15.5	2.000	1.900	1.700	2.000
16	2.000	1.900	1.700	2.000
16.5	2.000	1.900	1.700	2.000
17	2.000	1.900	1.700	2.000
17.5	2.000	1.900	1.700	2.000
18	2.000	1.900	1.700	2.000
18.5	2.000	1.900	1.700	2.000
19	2.000	1.900	1.700	2.000
19.5	2.000	1.900	1.700	2.000
20	2.000	2.000	1.700	2.000
20.5	2.000	2.000	1.700	2.000
21	2.000	2.000	1.700	2.000
21.5	2.000	2.000	1.824	2.000
22	2.000	2.000	1.955	2.000
22.5	2.000	2.000	2.000	2.000
23	2.000	2.000	2.000	2.000
23.5	2.000	2.000	2.000	2.000
24	2.000	2.000	2.000	2.000
24.5	2.000	2.000	2.000	2.000
25	2.000	2.000	2.000	2.000
25.5	2.000	2.000	2.000	2.000
26	2.000	2.000	2.000	2.000
26.5	2.000	2.000	2.000	2.000
27	2.000	2.000	2.000	0.000
27.5	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000
28.5	0.000	0.000	0.000	0.000
29	0.000	0.000	0.000	0.000
29.5	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.000
30.5	0.000	0.000	0.000	0.000
31	0.000	0.000	0.000	0.000
31.5	0.000	0.000	0.000	0.000
32	0.000	0.000	0.000	0.000
32.5	0.000	0.000	0.000	0.000
33	0.000	0.000	0.000	0.000
33.5	0.000	0.000	0.000	0.000
34	0.000	0.000	0.000	0.000
34.5	0.000	0.000	0.000	0.000
35	0.000	0.000	0.000	0.000
35.5	0.000	0.000	0.000	0.000
36	0.000	0.000	0.000	0.000
36.5	0.000	0.000	0.000	0.000
37	0.000	0.000	0.000	0.000
37.5	0.000	0.000	0.000	0.000
38	0.000	0.000	0.000	0.000
38.5	0.000	0.000	0.000	0.000
39	0.000	0.000	0.000	0.000
39.5	0.000	0.000	0.000	0.000
40	0.000	0.000	0.000	0.000

Turbine Type Information

Cut-in Wind Speed [m/s]	Time Constant [minutes-seconds]
3.0	5m-0s
5.0	2m-30s
7.0	0m-30s
additional entries as required	
additional entries as required	

Cut-out Wind Speed [m/s]	Time Constant [minutes-seconds]
27.5	1m-0s
30.0	0m-30s
40.0	0m-5s
50.0	0m-0.1s
additional entries as required	
additional entries as required	

Cut-back-in Wind Speed [m/s]	Time Constant [minutes-seconds]
26.0	5m-0s
20.0	1m-0s
12.0	0m-30s
additional entries as required	
additional entries as required	

Temperature Cut-out [deg C]	Time Constant [minutes-seconds]
-40.0	1m-0s
-20.0	0m-30s
40.0	0m-5s
50.0	0m-0.1s
additional entries as required	
additional entries as required	

Wind Turbine Icing Behavior

Describe any and all triggers for icing related shutdown including e.g.
temperatures, humidities, out-of-balance conditions, wind speeds, time constants, etc.

Describe any and all triggers for release from icing related shutdown including e.g.
temperatures, humidities, out-of-balance conditions, wind speeds, time constants, etc.

Wind Turbine Cold Weather Packages

Describe any and all installed and operational cold weather climate packages that could mitigate
the severity, occurrence, or duration of cold weather and/or icing related shutdowns.
Describe the effect on the operational envelope of the wind turbine (e.g. heated blades that prevent
icing-related shutdowns, heated blades that prevent operational thresholds, etc.)
ice accumulation in order to prevent performance degradation, gearbox heaters that
extend cold weather operation to below standard low-temperature operational thresholds, etc.).

ATTACHMENT D. WIND PLANT-SPECIFIC RAMP RATE LIMITATIONS

The information in this Attachment is Confidential