OP 14 Appendix F - Wind Plant Operator Guide

Effective Date: July 18, 2023

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References:

ISO New England Operating Procedure No.5 – Resource Maintenance and Outage Scheduling (OP-5)

ISO New England Operating Procedure No.14 - Technical Requirements for Generators, Demand Response Resources, Asset Related Demands and Alternative Technology Regulation Resources (OP-14)

ISO New England Operating Procedure No. 18 - Metering and Telemetering Criteria (OP-18)

ISO New England Operating Procedure No. 18 Appendix C - Minimum Accuracy Standards for New and Upgraded Metering, Recording and Telemetering Installations and Calibration of Existing Equipment (OP-18C)

ISO New England Operating Procedure No. 18 Appendix F - ISO Communications Front End (CFE) Interface Specifications (Confidential) (OP-18F)

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 – RETIRED 07/20/21

Attachment E – RTHOL and WHL Calculation Examples

Contents

1. Introduction

This Appendix F describes Wind Plant operating requirements and the data reporting requirements that Wind Plant Operators shall submit to ISO New England (ISO). The submittal of such data supports the operation of a centralized regional wind power forecasting system and therefore, the reliable and efficient integration of wind power into the ISO New England Balancing Authority Area (ISO-NE BAA). The requirements stated in this Appendix F apply to all Wind Plants that will be or are dispatched by ISO and represented in the ISO Energy Management System (EMS). Included also are requirements for data that will be integrated into the ISO EMS in order to facilitate operator system awareness and allow for the utilization of automated dispatch for wind Generator Assets[1].

2. Definitions

Below are definitions of relevant terms in this Appendix F:

Curtailment or Curtailed – Wind Plant Operator action (whether manual, scheduled, or automatic), resulting from an ISO Dispatch Instruction, that limits the amount of power produced by wind turbine(s) within a 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.

Met Gathering Station – a permanent purpose-built and/or sited station dedicated to the collection of Meteorological Data.

Meteorological Data– The real-time data (e.g., wind speeds and directions) collected at a specific Wind Plant's location.

Plant Wind Directions (nacelle-level) – The instantaneous wind direction 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).

Real Time High Operating Limit – Is defined in Section I of the ISO-NE Transmission Markets and Services Tariff ("Tariff")[2].

Wind High Limit – Is defined in Section I of the ISO-NE Transmission, Markets, and Services Tariff ("Tariff").

Wind Plant – For the purpose of this Appendix F, a Wind Plant is a collection of one or more wind turbine generators and the additional equipment required to interconnect these wind turbines into the electrical power system, consistent with the

1 Note that this Appendix F discusses Wind Plant data reporting and operating requirements. To the extent that there are other operating, transmission service and market requirements applicable to Wind Plants, the Wind Plant Operator must refer to and comply with the applicable ISO New England Operating Documents.

2 ISO New England Inc. Transmission , Markets, & Services Tariff Section I, General Terms and Conditions (Tariff): http://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_1/sect_i.pdf

definition of a Generator Asset stated in Section I of the Tariff. A Wind Plant shall be comprised of one or more Wind Turbine Groups.

Wind Plant Future Availability (WPFA) – Is defined in Section I of the ISO-NE Transmission, Markets, and Services Tariff ("Tariff").

Wind Plant Operator – for the purposes of this Appendix F, is the Lead Market Participant (Lead MP), or its designee, who operates a Wind Plant and/or reports the data to ISO as required in this Appendix F, as applicable.

Wind Turbine Counts: - shall include the following 4 (four) values (see Figure 1 below for a visual representation of the definitions):

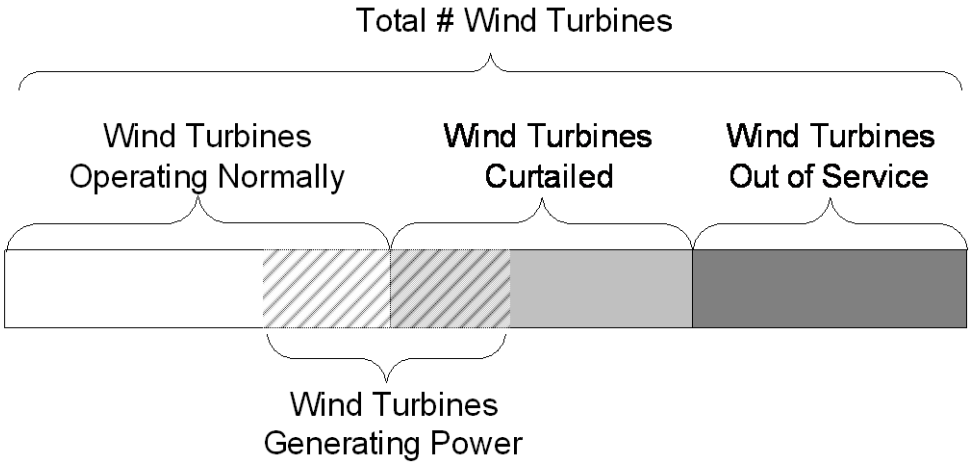
Wind Turbines Curtailed – is the total number of wind turbines in the Wind Plant that are Curtailed.

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

Wind Turbines Operating Normally – is the total number of wind turbines at a Wind Plant that are operating normally (i.e., **not** out-of-service and **not** Curtailed) regardless of whether or **not** those wind turbines are generating real power (MW).

Wind Turbines Generating Power – is the total number of wind turbines at a Wind Plant that are generating real power (MW) at any level regardless of whether or **not** those wind turbines are limited due to Curtailments.

Figure 1 - Wind Turbine Counts



Wind Turbine Group – is a group of wind turbine generators within the Wind Plant where all wind turbines generators are within a 10 (plant wide average) rotor diameter radius from the nearest neighboring wind turbine generator. One or more Wind Turbine Groups shall comprise a Wind Plant. See Attachment A - Wind Turbine Groups of this Appendix F for examples of Wind Turbine Group configurations.

3. Standard Operational Practice and Requirements

3.1 Wind Plant Data

Unless other modeling and data arrangements are agreed upon by ISO, Wind Plant data (whether static or telemetered) that is submitted by a Wind Plant Operator in accordance with this Appendix F shall be consistent with the definition of Wind Plant.

3.2 Reclosing and Restarts

A Wind Plant shall be designed and operated (including the performance of reclosings and restarts) by the Wind Plant Operator in accordance with ISO New England Operating Documents, which apply to all generating unit Resources within the ISO-NE BAA.

If the Wind Plant main breaker is opened (i.e., the plant is manually or automatically disconnected from the rest of the New England Transmission System) the Wind Plant Operator must receive permission from ISO and the LCC prior to reclosing (i.e., reconnect to the New England Transmission System). In other words, an automatic restart of the Wind Plant is **not** permitted following a fault to the Distribution System or Transmission System that is severe enough to disconnect the Wind Plant [e.g., an Low Voltage Ride Through (LVRT) event that is **not** "ridden through"] or following any Wind Plant-wide out-of-service event.

The automatic restart of a Wind Plant following high wind speed cut-out events is allowed.

3.3 Ramp Rate Limitations

Due to the very fast ramping capabilities of Wind Plants, there is potential for the transmission equipment with which they are interconnected to become significantly loaded or unloaded, which may lead to operational and reliability concerns, therefore ramp rate limitations have been established as described below. As operational experience is gained, ISO shall reevaluate this limit on a Wind Plant-by-Wind Plant basis, or as it applies to all Wind Plants in New England, as warranted. Where alternative ramp rates are determined to be acceptable on a Wind Plant-specific basis, those plant-specific limits shall be provided to the Lead MP by ISO.

For Wind Plants totaling 200 MW or less 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 requested by ISO.

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 per minute (in MW/min) averaged over 5 (five) minutes is **not** to be exceeded unless otherwise requested by ISO; see example below.

Plant nameplate 210 MW. Limit: **no** more than 21 MW per minute when averaged over five (5) minutes							
Minute1	**Minute2**	**Minute3**	**Minute4**	**Minute5**	**Average rate**	**Sat./ Unsat.**	**Corr. Action**
100 MW/ min	0 MW/ min	0 MW/ min	0 MW/ min	0 MW/ min	20 MW/ min	Sat	None
100 MW/ min	10 MW/ min	0 MW/ min	0 MW/ min	0 MW/ min	22 MW/ min	Unsat	Limit ramp in either first or second minute

3.4 Outage Coordination

ISO New England Operating Procedure No.5 - Resource Maintenance and Outage Scheduling (OP-5) requires a generating unit Resource to submit an outage request via ISO Outage Application software whenever a Resource is "out of service", meaning that the Resource is **not** able to provide real power MW onto the electrical grid. Outage requests can be for planned or unplanned outages. In the case of Wind Plants, OP-5 requirements that the Wind Plant Operator submits advance daily outage requests in order to perform routine maintenance work on a Wind Plant component [i.e., individual wind turbine(s)] which may have **no** effect on their overall MW capability of the Wind Plant.

Therefore:

1. Each Wind Plant Operator shall submit Wind Plant Future Availability to ISO for each Wind Plant. The Wind Plant Future Availability shall serve as the Wind Plant Operator "notification" of an outage for OP-5 purposes.

2. If a Wind Plant does **not** have a CSO and is **not** a Qualified Generator Reactive Resource as stated above, a Wind Plant Operator must submit to ISO the Wind Plant Future Availability for the Wind Plant; but a Wind Plant Operator is **not** required to submit outage requests for the Wind Plant to ISO.

3. For each Wind Plant with a CSO or that is a Qualified Generator Reactive Resource, the Wind Plant Operator must submit:

   A. Wind Plant Future Availability to ISO for the Wind Plant; and,

   B. When the outage will de-rate the Wind Plant to the point that the total available nameplate is less than its CSO or when the outage will reduce the available VArs to less than the Qualified VArs, submit an

outage request for the Wind Plant to ISO with timing consistent with OP-5.

4. Static Plant Data Requirements

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 maintained and submitted by the Wind Plant Operator to ISO on Attachment C, Wind Plant Static Data Information Form to this Appendix F. 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 at RenewableResourceInt@iso-ne.com. A sample Attachment C is included in this Appendix F. Instructions are included on the form on how to request, complete, and submit the required information. Consistent with Schedules 22 and 23 of Section II of the Tariff and OP-14, the Wind Plant Operator shall verify that the static plant data for each Wind Plant is kept current and changes are communicated to ISO via an Attachment C submittal if any data point changes in a material fashion. For example:

- if a wind turbine in the Wind Plant is replaced with a different make or model type, information for the new wind turbine must be supplied;
- if the permitting requirements change, the new requirements must be specified;
- if wind measuring equipment is replaced with non-identical measuring equipment, the make and model information for the new equipment must be supplied.

Static 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 turbine ground elevation (in meters, to one decimal place) for each wind turbine in the Wind Plant

   B. Number of wind turbines in the Wind Plant

   C. Turbine model(s) for each type of wind turbine in the Wind Plant including IEC wind class

   D. Density dependent turbine nominal power curves for each type of turbine in the Wind 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) for each turbine in the Wind Plant (in meters to one decimal place

F. Maximum Wind Plant nameplate capacity (in MW to two decimal places)

G. Cut-in wind speed(s) and time constants for each type of wind turbine in the Wind Plant (if any, e.g., wind speed must be above 3.4 m/s for at least 5 minutes, etc.)

H. Cut-out wind speed(s) and time constants (if any) for each type of wind turbine in the Wind Plant

I. Cut back in wind speed(s) and time constants (if any) for each type of wind turbine in the Wind Plant

J. Cold temperature cutoff threshold(s) for each type of wind turbine in the Wind Plant (in Degrees C to one decimal place)

K. High temperature cutoff threshold(s) for each type of wind turbine in the Wind Plant (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.) for each type of wind turbine in the Wind Plant

M. Wind turbine icing behavior for each type of wind turbine in the Wind Plant

   (1) Triggers for icing related shutdowns (e.g., temperatures, relative humidities, out-of-balance conditions, etc.)

   (2) Triggers for release from icing related shutdowns (e.g., manual reset, temperatures, hysteresis, etc.)

N. For all plant wind speed and direction measuring devices associated with the Wind Plant (i.e., nacelle-level wind measuring devices):

   (1) Equipment type (i.e., model specifications and operating principle e.g., make and model type, measurement heights) and calibration curves and/or reports

   (2) Dimensions and/or site plan of any nearby potential obstructions that would substantially reduce the quality of the wind speed 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 for the Wind Plant or any wind turbine(s) that are part of the Wind Plant 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 by ISO or its designee to be provided.

2. Met Gathering Station(s):

   A. Center of structure(s) coordinates (i.e., latitude and longitude in WGS84 DD-MM-SS.SS using GPS WAAS, or comparable methodology using the same method listed above for turbine in the Wind Plant) and ground elevation of each Met Gathering Station

   B. Equipment type for each Met Gathering Station (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. In accordance with Table 6.1 to this Appendix F, data required under this Section must be electronically and automatically transmitted by the Wind Plant Operator to ISO over a secure network using the protocol approved by ISO. In addition, if any recommended (i.e. not required) data is provided by the Wind Plant Operator, it must also be electronically and automatically transmitted over a secure network using the protocol approved by ISO. 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 Required Data Collection Points

5.1.1 Meteorological Data

The following Wind Plant data shall be provided by the Wind Plant Operator to ISO.

At a minimum:

1. 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) in each Wind Turbine Group within the Wind Plant

2. Nacelle-level wind speed and wind direction measurements must be provided from 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 Wind Plant.

3. The wind turbine nearest the capacity-weighted centroid of the Wind Plant must also report nacelle-level wind speed and wind direction measurements.

4. Ambient air temperature, ambient air pressure, and ambient air relative humidity must be measured, at a minimum, at one location within the Wind 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 50 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

If any wind turbine within a Wind Turbine Group satisfies more than one of the data points required in items 1-4 above, 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 (or Wind Turbine Group) wake effect from the prevailing wind direction(s). Finally, where a Wind Turbine Group contains 10 or fewer 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 identified in Section 4 above.

The Wind Plant Operator shall verify that the number of nacelle specific sensors providing wind direction data at the Wind Plant meets or exceeds the requirements above and that each sensor measures with minimum resolution to 1 degree and with minimum accuracy to +/- 5 degrees.

The Wind Plant Operator shall verify that the Plant Wind Directions are determined by either:

- Wind measuring equipment (e.g., wind vane) that is mounted in, on, or nearby the nacelle/rotor assembly with reasonable attempt to minimize the effects of rotor “prop-wash” or obstruction or

- Wind turbine nacelle yaw, corrected at all times to report wind direction between 0 degrees and 359.9 degrees

The Wind Plant Operator shall verify that the number of nacelle specific sensors providing wind speed data at a Wind Plant meets or exceeds the requirements above. 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 wind speeds 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.

5.1.2 Wind High Limit

The Wind High Limit of a Wind Plant should be calculated as follows:

When a Wind Plant is not being Curtailed, its Wind High Limit shall be calculated to be equal to the net generation.

When a Wind Plant is being Curtailed, its Wind High Limit shall be calculated to equal the Wind Plant's possible power production given current wind/weather conditions and equipment status if the curtailment were not in place. This will be greater than the net generation.

See Attachment B and Attachment E to this Appendix F for additional guidance and examples.

5.1.3 Real-Time High Operating Limit

For purposes of clarity due to the unique nature of Wind Plants, a Wind Plant Real-Time High Operating Limit (RTHOL) is the maximum power production (MW) the Wind Plant would be capable of in real-time, given ideal wind conditions and **no** Curtailment. (See Attachment B and Attachment E to this Appendix F for additional guidance and examples).

Wind speeds should not affect the calculation of RTHOL; this includes both wind speeds that are below cut-in as well as wind speeds that are above cut-out.

When icing, or other similar conditions occur, the RTHOL should be reduced to reflect the generation capability given those conditions. If one or more turbines are unable to produce energy given the conditions it should be reported equivalent to a turbine outage.

5.1.4 Wind Plant Future Availability

Wind Plant Future Availability is equivalent to the future hour's expected RTHOL and should therefore be calculated using the same methodology as RTHOL but with the expected turbine conditions for the hour being calculated.

In contrast to all other Real-Time data which is provided to the ISO via telemetry, Wind Plant Future Availability is provided to the ISO using the ISO-NE Wind Integration web services. This web service can also be used to gather wind plant power forecasts provided by the ISO-NE wind power forecaster. Information on using the web service platform, including data specification and sample files are available in the following Zip file: https://www.iso-ne.com/static-assets/documents/2016/08/wind_integration_data_exchange_specification_and_sample_files_AssetID_change.zip

5.2 Recommended Data Collection Points and Practices

In order to provide that data of a high quality will be incorporated into the centralized forecasting system and allow for greater situational awareness, ISO recommends that Wind Plant Operators follow the practices for data collection/calculation for each Wind Plant as outlined below:

1. Collect and provide to ISO, 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 to a minimal extent by plant operations (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. The Met Gathering Station equipment should be located at well-exposed sites that are upwind of the Wind Plant and **no** closer than two rotor diameters to the nearest wind turbine. It is recommended that each wind turbine in the Wind Plant should be within 5 km of a met gathering station.

4. If ambient air temperature, ambient air pressure, and/or ambient air relative humidity are measured by nacelle-level equipment, ISO prefers 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 (e.g., from nacelle-level wind speeds) it is recommended that additional “backup” nacelles are selected in addition to the required data specified in Section 5.1.1 for the number of nacelles providing data 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 Wind Turbine Group, the second farthest North wind turbine in the Wind Turbine Group, etc.) and the wind turbine locations should also be referenced to the static plant data supplied location(s). If available, ISO prefers to receive nacelle-level data from all the wind turbine nacelles within the Wind Plant.

6. Nacelle-level Plant Wind Speeds should be measured by equipment 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)[3]).

7. Utilize the Do-Not-Exceed (DNE) Dispatch Limit provided by the ISO over the RTU, along with the Wind Plant’s possible power production capability when determining if the Wind Plant is operating in a Curtailed mode.

   - If the Wind Plant DNE limit is lower than the possible power production, this may be considered a Curtailment.

[3] See for example NREL/CP-500-32494 within 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

- If the Wind Plant DNE limit is not lower than the possible power production, this would not be considered a Curtailment.

8. Maximum leading and lagging reactive capabilities should reflect values that can be reached within 1 minute and maintained for no less than 1 hour.

6. Real Time Data Table

Table 6.1 Real-time data

Parameter	Required/ Recommended	Location	Height	Units	Instantaneous / Average	Minimum Resolution / Accuracy	Minimum Update Frequency	Requirement Reference(s)
Future Availability Data (Web Services)								
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	0.01 MW	1.) Every hour at the top of the hour 2.) By 1000 hours each day.	Market Rule 1 Section 1.11.5(c)(iv)
Instantaneous Real-Time Data (SCADA)								
Real Time High Operating Limit (RTHOL)	Required	Plant-wide total	N/A	MW	Instantaneous	0.01 MW with accuracy of +/- 1%	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(iii) OP-14 App. F Section 5.1.3
Wind High Limit	Required	Plant-wide total	N/A	MW	Instantaneous	0.01 MW	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(iii) OP-14 App. F Section 5.1.2
Plant Power Generation	Required	Plant-wide total	N/A	MW	Instantaneous	As required by OP-18	As required by OP-18	OP-18 Section V.C OP-18 App.F
Plant Reactive Power Production	Required	Plant-wide total	N/A	MVAr	Instantaneous	As required by OP-18	As required by OP-18	OP-18 Section V.C OP-18 App.F

Parameter	Required/ Recommended	Location	Height	Units	Instantaneous / Average	Minimum Resolution / Accuracy	Minimum Update Frequency	Requirement Reference(s)
Voltage	Required	Plant	N/A	kV	Instantaneous	As required by OP-18	As required by OP-18	OP-18 Section V.C OP-18 App.F
Plant Main Breaker Status	Required	Plant	N/A	binary	Instantaneous	N/A	As required by OP-18	OP-18 Section V.C OP-18 App.F
Plant Voltage Regulation Mode	Required	Plant	N/A	binary	Instantaneous	N/A	As required by OP-18	OP-18 Section V.C
Wind Turbines Curtailed	Required	Plant-wide	N/A	N/A	Instantaneous	Integer	Every 5 minutes	OP-18 Section V.C
Wind Turbines Out-of-Service	Required	Plant-wide	N/A	N/A	Instantaneous	Integer	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(iii)
Wind Turbines Operating Normally	Required	Plant-wide	N/A	N/A	Instantaneous	Integer	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(iii)
Wind Turbines Generating Power	Required	Plant-wide	N/A	N/A	Instantaneous	Integer	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(iii)
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	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. F Section 5.1.1
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	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. F Section 5.1.1

[&] See Section 2 - Definitions: Plant Wind Speeds (nacelle-level)

Parameter	Required/ Recommended	Location	Height	Units	Instantaneous / Average	Minimum Resolution / Accuracy	Minimum Update Frequency	Requirement Reference(s)
Plant Max Reactive Lagging Capability	Recommended	Plant-wide total	N/A	MVAr	Instantaneous	0.01 MVAr with accuracy of +/- 1%	Every 4s or every 10s	OP-14 App. F Section 5.2.8
Plant Max Reactive Leading Capability	Recommended	Plant-wide total	N/A	MVAr	Instantaneous	0.01 MVAr with accuracy of +/- 1%	Every 4s or every 10s	OP-14 App. F Section 5.2.8
Ambient air temperature	Recommended	See Data Collection Points section	Nacelle	Degrees Centigrade (°C)	Instantaneous	to 0.1°C with accuracy+/- 1.25°C	Every 30 seconds	OP-14 App. F Section 5.1.1.4
Ambient air pressure	Recommended	See Data Collection Points section	Nacelle	Kilopascals (kPa)	Instantaneous	to 0.1 kPa with accuracy to +/- 1.5 kPa	Every 30 seconds	OP-14 App. F Section 5.1.1.4
Ambient air relative humidity	Recommended	See Data Collection Points section	Nacelle	(Percent)	Instantaneous	to 1% with accuracy to +/- 3%	Every 30 seconds	OP-14 App. F Section 5.1.1.4
Average Real-Time Wind Plant Ambient Data (SCADA)								
Ambient air temperature	Required	One location within Wind Plant	2 meters	Degrees Centigrade (°C)	Average over 5 minute interval	to 0.1°C with accuracy+/- 1.25°C	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(ii) OP-14 App. F Section 5.1.1
Standard deviation of ambient air temperature	Required	One location within Wind Plant	2 meters	Degrees Centigrade (°C)	Over 5 minute interval	Same as above	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(ii) OP-14 App. F Section 5.1.1
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	Market Rule 1 Section 1.11.5(c)(ii) OP-14 App. F Section 5.1.1

Parameter	Required/ Recommended	Location	Height	Units	Instantaneous / Average	Minimum Resolution / Accuracy	Minimum Update Frequency	Requirement Reference(s)
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	Market Rule 1 Section 1.11.5(c)(ii) OP-14 App. F Section 5.1.1
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	Market Rule 1 Section 1.11.5(c)(ii) OP-14 App. F Section 5.1.1
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	Market Rule 1 Section 1.11.5(c)(ii) OP-14 App. F Section 5.1.1
Average Real-Time Meteorological Station Data (typically sampled at 1Hz) (***SCADA***)								
Wind speed	Recommended	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	OP-14 App. F Section 5.1.1
Standard deviation of Wind speed	Recommended	For each met gathering station	Same as above	m/s (scalar)	over 5 minute interval	Same as above	Every 5 minutes	OP-14 App. F Section 5.1.1
Maximum wind speed	Recommended	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	OP-14 App. F Section 5.1.1

Parameter	Required/ Recommended	Location	Height	Units	Instantaneous / Average	Minimum Resolution / Accuracy	Minimum Update Frequency	Requirement Reference(s)
Wind direction	Recommended	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	OP-14 App. F Section 5.1.1
Standard deviation of Wind direction	Recommended	For each met gathering station	Same as above	Degrees from True North (vector)	over 5 minute interval	Same as above	Every 5 minutes	OP-14 App. F Section 5.1.1
Ambient air temperature	Recommended	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	OP-14 App. F Section 5.1.1
Ambient air pressure	Recommended	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	OP-14 App. F Section 5.1.1
Ambient air relative humidity	Recommended	For each met gathering station	2 meters	(Percent)	Average over 5 minute interval	to 1% with accuracy to +/- 3%	Every 5 minutes	OP-14 App. F Section 5.1.1

7. Revision History

Rev No.	Date	Reason
Rev 0	09/09/11	Initial version
Rev 0.1	06/30/15	Periodic review performed requiring no changes;
Rev 1	09/02/15	Periodic review completed by procedure owner; Updated for FERC Order 764 compliance, Added new Section 3.5, Plant Frequency Response and renumbered following Section
Rev 1.1	09/19/16	Periodic review performed requiring no changes; Added required corporate document identity to all footers;
Rev 1.2	05/23/18	Periodic review performed requiring no changes; Made administrative changes required to publish a Minor Revision, including an update of the OP-14 title in headers, Reference Section and Section 2 (in the Wind Plant definition) and updated the OP-5 title in the Reference Section and Section 3.8;
Rev 1.3	04/09/19	Periodic review performed requiring no changes;
Rev 1.4	11/05/20	Periodic review performed requiring no changes;
Rev 2	07/20/21	Cleanup of Section 2 and Section 3 to remove duplicate information given in Tariff, OP-14, and OP-5; Cleanup of Table 6.1 and addition of Requirement References column; Added Attachment E – RTHOL and WHL Calculation Examples
Rev 2.1	11/01/22	Biennial review performed by procedure owner requiring no intent changes; Made administrative changes required to publish a Minor Revision.
Rev 3	07/18/23	Periodic review completed by procedure owner; Updated Table 6.1 Real-Time Data: Removed at point of interconnection from Voltage Parameter and updated references in Minimum Resolution/Accuracy, Minimum Update Frequency, and Requirement Reference(s) columns.

8. Attachments

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.

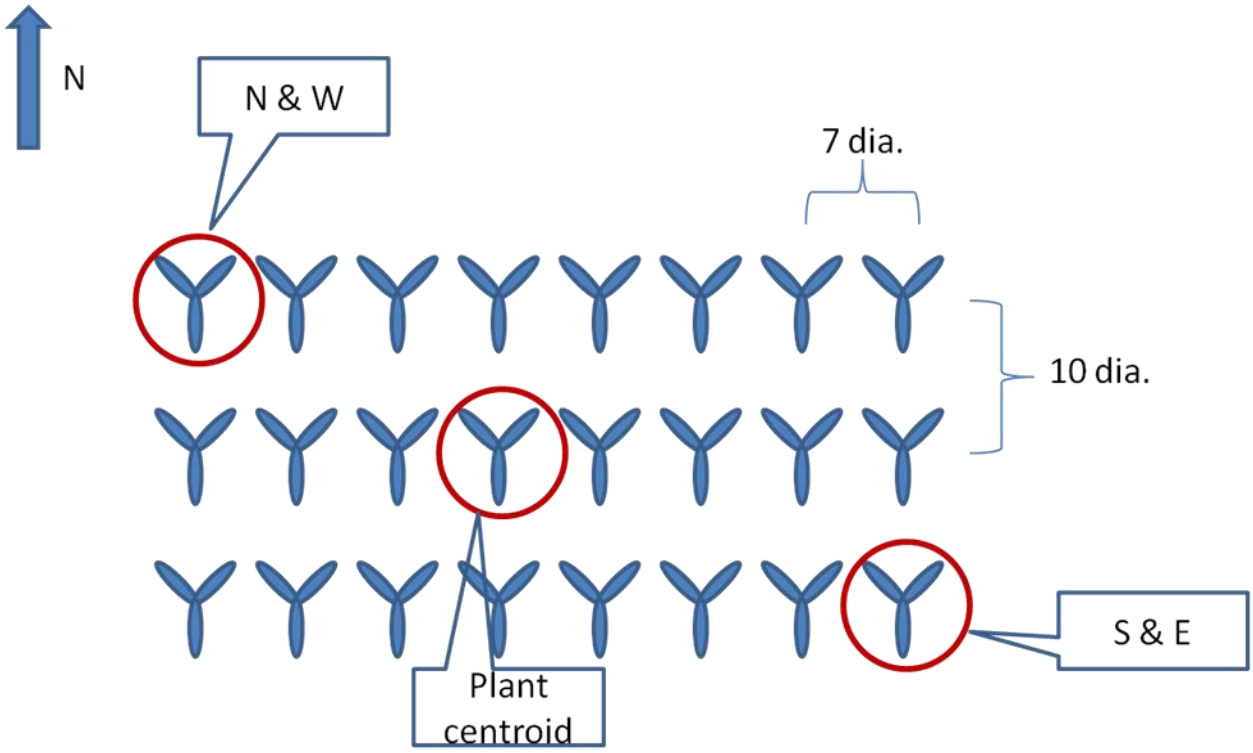
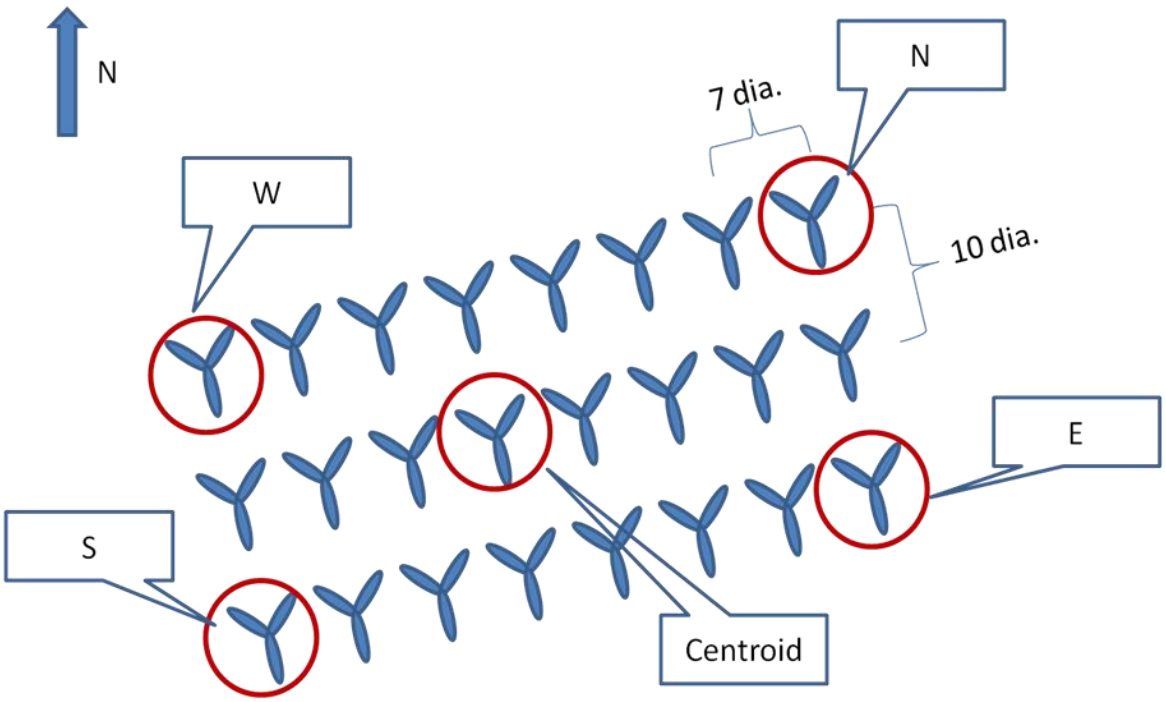
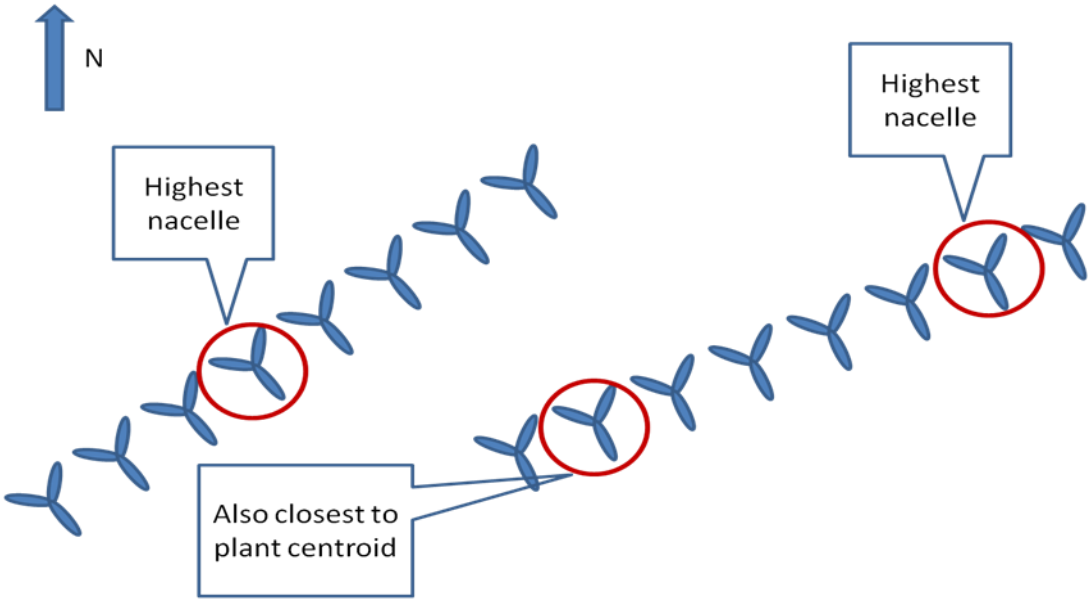


Figure A-1



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

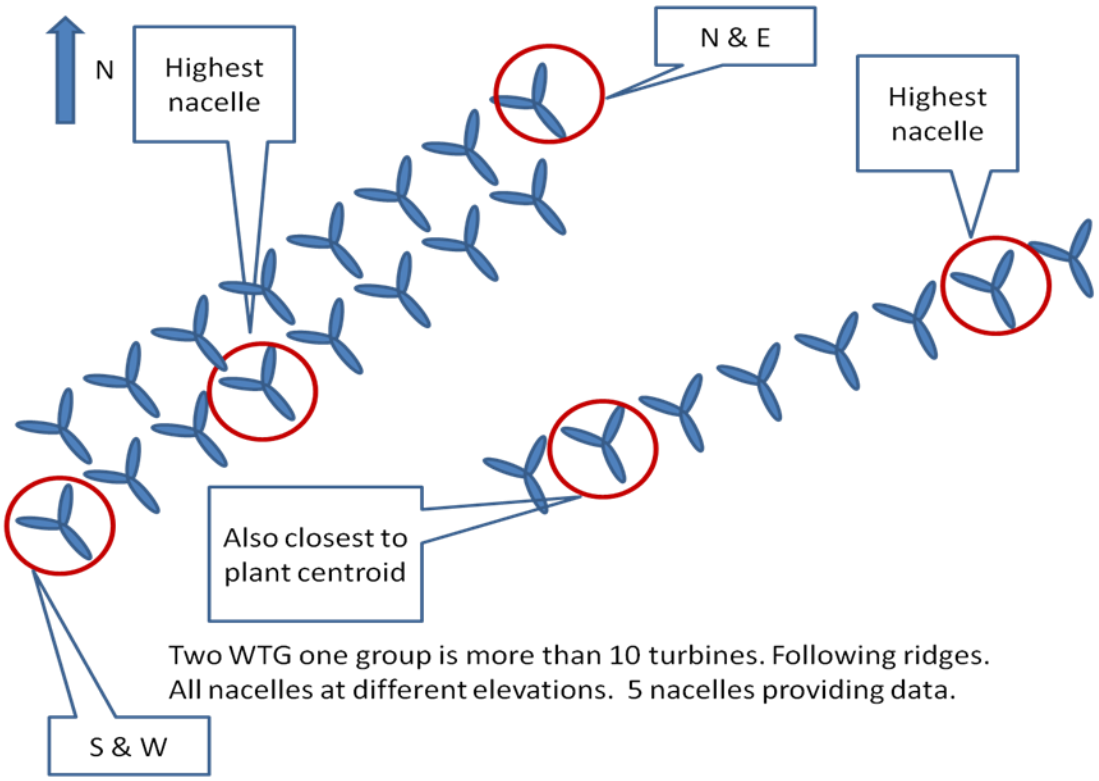


Figure A-4

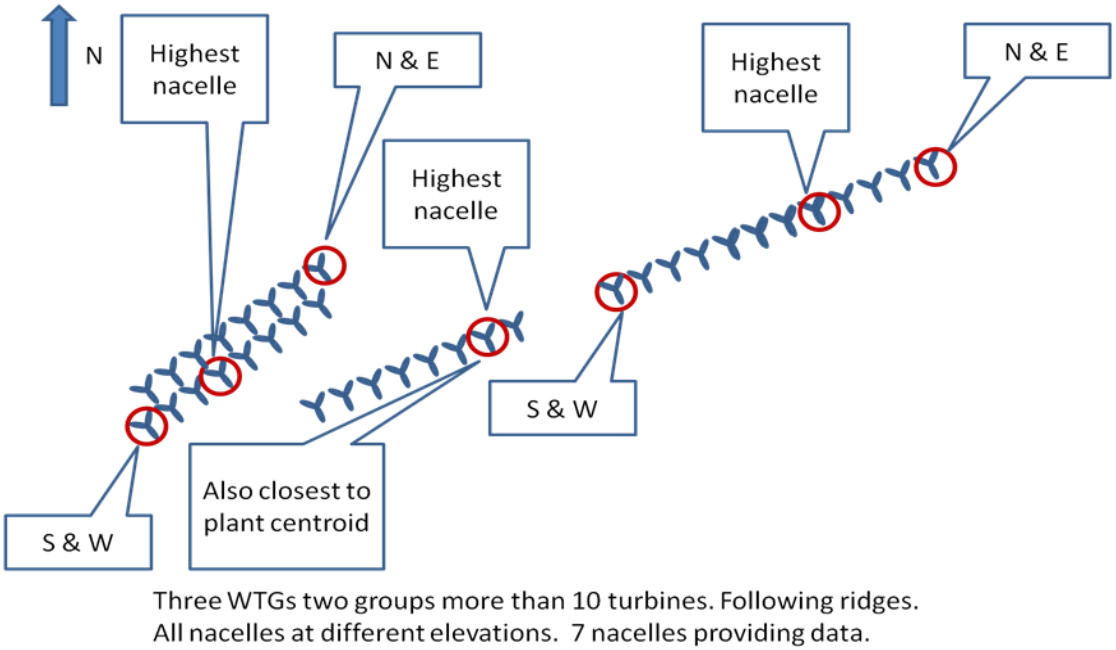
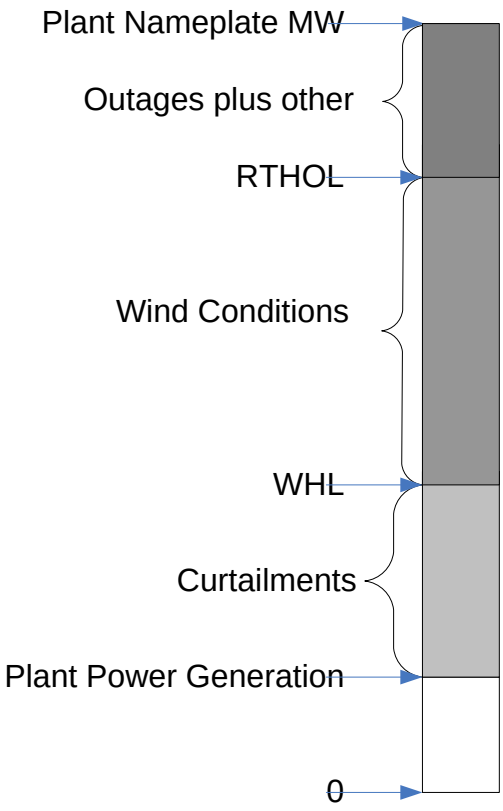


Figure A-5

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

Sample only – For a functioning version of this Excel workbook file contact the ISO at RenewableResourceInt@iso-ne.com.

OP-14 Appendix F Attachment C	
Instructions for filling out this form. Version 2.0	
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: renewableresourceint@iso-ne.com. 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 II.N (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 measurements, and met gathering measurements 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 on the "Main Page" tab, and the "Overall Wind Plant Data" tab) in order to help the user enter in the correct values with the correct formatting. These "dummy" values should be overwritten by the user. 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 and/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 EDT to 0700 EDT. 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 of 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(s) that clearly shows mounting and nearby potential obstructions such as a dimensioned diagram of the equipment location for all sensors.
6)	On the "Overall Wind Plant Data-Ambient" and "Overall Wind Plant Data-Met" tabs: Data for the one required ambient station and any other ambient wind plant measurement equipment must be listed on the "Overall Wind Plant Data-Ambient" tab--with the exception of ambient information provided by nacelle based equipment. Please put data for ambient data sensors on this tab even if the sensors are located at met stations. Data for the wind speeds and directions measurements should be completed on the "Overall Wind Plant Data–Met" tab. One row on each tab should be completed per measured quantity. Measured quantities should be indexed to the documentation about their sensors. In the event that one sensor measures at multiple heights (e.g. a sodar or microwave radiometer) or measures multiple quantities, report each of the measurement heights/quantities in a separate row—this applies to wind speed and direction data as well as ambient type info. To the extent that the sensors are part of one met station, documentation about the met station itself (site plan, diagram, manufacturers data sheets) need only be included once. For example: if all of the sensors are on one met tower, only submit a schematic for the tower once; or if all of the sensors are part of one sodar device, only submit documentation specific to the sodar itself once (schematics, data sheet, etc.). However, if (for example) a temperature sensor is attached to the side of the sodar a spec sheet for the temperature sensor is required.
7)	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.

Wind Plant Static Data Information Form Main Page

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
								If Yes, submit clearly legible pdf copies of manufacturer's data sheets and any other documentation that show make, model and calibration information, plus 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)	*If yes, submit clearly legible pdf copies of manufacturer's data sheets and any other documentation that show make, model and calibration information, plus 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 95mpe*	*Ac*	*1*			*1*
2	*DD-MM-SS.SS*	*DD-MM-SS.SS*	*xxxx.x*	*xxx.x*	*Windmeister 95mpe*	*A1*	*2*	*n*	*n*	*1*
additional entries as required										
X	*DD-MM-SS.SS*	*DD-MM-SS.SS*	*xxxx.x*	*xxx.x*	*Windmeister 3.0Tube*	*S*	*N*	*n*	*n*	*F*

Overall Wind Plant Data-Turbine

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 95wpe*	*A-I*	*1*			*1*
2	*DD-MM-SS.SS*	*DD-MM-SS.SS*	*xxxx.x*	*xxx.x*	*Windmeister 95epe*	*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*

Overall Wind Plant Data-Turbine (cont.)

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					

Overall Wind Plant Data-Ambient

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

	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					

Overall Wind Plant Data-Met

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 reloted 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.).

Turbine Type Information

Attachment D – RETIRED 07/20/21

Attachment E – RTHOL and WHL Calculation Examples

The following examples are presented to illustrate how RTHOL and WHL would be calculated under various conditions.

Wind speeds in the following examples are assumed to be constant. Variability of wind conditions will likely introduce some error into the calculation of WHL; this is expected. Losses between the wind turbine and the Point of Interconnection (POI) are not taken into account in these simplified examples, but should be in the WHL calculation such that the WHL reports the net power injection at the POI rather than the gross production.

Wind plant with three identical 3.3 MW wind turbines, each with the following site-specific power curve:

Wind Speed [m/s]	Power [MW]
1	0.0
2	0.0
3	0.0
4	0.1
5	0.3
6	0.5
7	0.9
8	1.4
9	2.0
10	2.6
11	3.0
12	3.2
13	3.3
14	3.3
15	3.3
16	3.3
17	3.3
18	3.3
19	3.3
20	3.3
21	3.3
22	3.3
23	3.3
24	3.3
25	3.3
26	0.0

Example 1:

Individual Turbine Details

Turbine #	Available	Wind Speed	RTHOL	Possible Power Production
Turbine 1:	Yes	3 m/s	3.3 MW	0.0 MW
Turbine 2:	Yes	5 m/s	3.3 MW	0.3 MW
Turbine 3	No	6 m/s	0.0 MW	0.0 MW

Wind Plant Totals

DNE Limit:	6.6 MW
Net Generation:	0.4 MW
Possible Power Production:	0.3 MW
RTHOL:	6.6 MW
WHL:	0.4 MW

Explanation:

Turbine 3 is not available so its RTHOL would be 0 MW. Even though the wind speed of Turbine 3 would normally support 0.5 MW of generation, because it is not available, the possible power production would also be 0 MW.

Turbines 1 and 2 are available so their RTHOL would both be 3.3 MW even though Turbine 1 is below the cut-in speed. The individual turbines possible power production are determined using the power curve and wind speeds.

Adding the RTHOL of each individual turbine, the Wind Plant RTHOL is 6.6 MW.

Adding the possible power production of each individual turbine, the total possible power production would be 0.3 MW, however, because the Wind Plant is not being curtailed (e.g. their DNE is not limiting their total possible power production), the WHL should equal the net generation so the WHL is calculated to be 0.4 MW. Given that the net generation is 0.4 MW, which is higher than possible power production, this would indicate a potential situation where the possible power production estimation does not have sufficient information to perfectly estimate the net generation and is why the WHL should be reported at 0.4 MW (because it is capable of generating 0.4 MW given the current conditions).

Example 2:

Individual Turbine Details

Turbine #	Available	Wind Speed	RTHOL	Possible Power Production
Turbine 1:	Yes	8 m/s	3.3 MW	1.4 MW
Turbine 2:	Yes	11 m/s	3.3 MW	3.0 MW
Turbine 3	Yes	10 m/s	3.3 MW	2.6 MW

Wind Plant Totals

DNE Limit:	5.0 MW
Net Generation:	5.0 MW
Possible Power Production:	7.0 MW
RTHOL:	9.9 MW
WHL:	7.0 MW

Explanation:

All three turbines are available so each RTHOL is 3.3 MW. Together that results in a Wind Plant RTHOL of 9.9 MW.

Using the wind speeds at each turbine, the total possible power production is estimated using the power curve to be 7.0 MW. The current DNE limit is 5.0 MW, meaning the wind plant is currently being curtailed below what it could potentially achieve. Because it is curtailed, the WHL should not match the net generation and would remain at 7 MW.

Example 3:

Individual Turbine Details

Turbine #	Available	Wind Speed	RTHOL	Possible Power Production
Turbine 1:	Yes	10 m/s	3.3 MW	2.0 MW
Turbine 2:	Yes	9 m/s	3.3 MW	2.6 MW
Turbine 3	Yes*	10 m/s	1.0 MW	1.0 MW

*Due to a small accumulation of ice on the blades of Wind Turbine 3, it has been limited to 1 MW of generation by the Wind Plant Operator.

Wind Plant Totals

DNE Limit:	6.0 MW
Net Generation:	4.9 MW
Possible Power Production:	5.6 MW
RTHOL:	7.6 MW
WHL:	4.9 MW

Explanation:

Turbine 3 is available but limited to a maximum of 1 MW, so its RTHOL would be 1 MW. Even though the wind speed of Turbine 3 would normally support 2.0 MW of generation, because it is only available up to 1 MW, the possible power production would also be 1 MW.

Turbines 1 and 2 are fully available so their RTHOL would both be 3.3 MW. The individual turbines possible power production are determined using the power curve and wind speeds.

Adding the RTHOL of each individual turbine, the Wind Plant RTHOL is 7.6 MW.

Adding the possible power production of each individual turbine, the plant total would be 5.6 MW. The DNE limit is currently 6.0 MW, which while is being lower than the RTHOL, is above the 5.6 MW the wind plant is capable of producing, so it is not being curtailed. Because it is not curtailed, the WHL should equal the net generation so the WHL is calculated to be 4.9 MW.

Example 4:

Individual Turbine Details

Turbine #	Available	Wind Speed	RTHOL	Possible Power Production
Turbine 1:	Yes	22 m/s	3.3 MW	3.3 MW
Turbine 2:	Yes	26 m/s	3.3 MW	0.0 MW
Turbine 3	Yes	23 m/s	3.3 MW	3.3 MW

Wind Plant Totals

DNE Limit:	6.0 MW
Net Generation:	4.9 MW
Possible Power Production:	6.6 MW
RTHOL:	9.9 MW
WHL:	6.6 MW

Explanation:

Turbine 2 is available so its RTHOL would be 3.3 MW even though, based on the wind speed being above cut-out speed, the possible power production is 0.0 MW. The RTHOL should still be reported as 3.3 MW as long as it is available, because if the wind speed drops down within the operable range, the wind turbine would immediately be able to begin generating again.

Turbines 1 and 3 are also available so their RTHOL would both be 3.3 MW. The individual turbines possible power production are determined using the power curve and wind speeds.

Adding the RTHOL of each individual turbine, the Wind Plant RTHOL is 9.9 MW.

Adding the possible power production of each individual turbine, the total would be 6.6 MW. With a DNE limit of 6.0 MW, this would indicate the Wind Plant is being curtailed and the WHL would be calculated to be 6.6 MW. Under this condition, the Wind Plant would be normally be expected to increase the generation up to the DNE limit. If this were not possible it would indicate an error in the possible power production calculation, and subsequently WHL, which should be corrected to the amount of generation that was possible, or 4.9 MW in this example.