OP 14 Appendix F -   
Wind Plant Operator Guide

**Effective Date: Draft**

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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 |

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# Introduction

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|  | 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]](#footnote-2). |

# Definitions

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|  | 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]](#footnote-3). |
|  | ***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 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**



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|  | ***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. |

# Standard Operational Practice and Requirements

## Wind Plant Data

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|  | 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. |

## Reclosing and Restarts

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|  | 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. |

## Ramp Rate Limitations

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|  | 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. |

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| 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 |

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## Outage Coordination

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|  | 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. |
|  | 1. 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. |
|  | 1. For each Wind Plant with a CSO or that is a Qualified Generator Reactive Resource, the Wind Plant Operator must submit: |
|  | 1. Wind Plant Future Availability to ISO for the Wind Plant; and, |
|  | 1. 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. |

# Static Plant Data Requirements

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|  | 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: |
|  | * 1. 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 |
|  | * 1. Number of wind turbines in the Wind Plant |
|  | * 1. Turbine model(s) for each type of wind turbine in the Wind Plant including IEC wind class |
|  | * 1. 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 |
|  | * 1. Hub height(s) for each turbine in the Wind Plant (in meters to one decimal place |
|  | * 1. Maximum Wind Plant nameplate capacity (in MW to two decimal places) |
|  | * 1. 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.) |
|  | * 1. Cut-out wind speed(s) and time constants (if any) for each type of wind turbine in the Wind Plant |
|  | * 1. Cut back in wind speed(s) and time constants (if any) for each type of wind turbine in the Wind Plant |
|  | * 1. Cold temperature cutoff threshold(s) for each type of wind turbine in the Wind Plant (in Degrees C to one decimal place) |
|  | * 1. High temperature cutoff threshold(s) for each type of wind turbine in the Wind Plant (in Degrees C to one decimal place) |
|  | * 1. 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 |
|  | * 1. 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.) |
|  | 1. Triggers for release from icing related shutdowns (e.g., manual reset, temperatures, hysteresis, etc.) |
|  | * 1. 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 |
|  | 1. 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) |
|  | * 1. 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. |
|  | * 1. 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. |
|  | 1. Met Gathering Station(s): |
|  | * 1. 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 |
|  | * 1. Equipment type for each Met Gathering Station (i.e., model specifications and operating principle e.g., make and model type, measurement heights) |
|  | * 1. 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) |

# Real-Time Data Collection and Transfer

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|  | 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. |

## Required Data Collection Points

### Meteorological Data

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|  | 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 |
|  | 1. 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. |
|  | 1. The wind turbine nearest the capacity-weighted centroid of the Wind Plant must also report nacelle-level wind speed and wind direction measurements. |
|  | 1. 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. |

### Wind High Limit

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|  | The Wind High Limit of a Wind Plant should be calculated as follows:   1. When a Wind Plant is not being Curtailed, its Wind High Limit shall be calculated to be equal to the net generation. |
|  | 1. 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. |
|  | 1. Wind High Limit must be greater than or equal to 0 |
|  | 1. Wind High Limit must be less than or equal to Real Time High Operating Limit |
|  | See Attachment B and Attachment E to this Appendix F for additional guidance and examples. |

### Real-Time High Operating Limit

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|  | 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. |

### Wind Plant Future Availability

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|  | 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> |

## Recommended Data Collection Points and Practices

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| --- | --- |
|  | 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). |
|  | 1. 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): |
|  | * 1. Turbine hub height |
|  | * 1. A second height at least 20 meters less than hub height. |
|  | 1. 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. |
|  | 1. 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. |
|  | 1. 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. |
|  | 1. 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]](#footnote-4)). |
|  | 1. 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 for purposes of calculating the Wind High Limit.  * If the Wind Plant DNE limit is lower than the possible power production, this would be considered a Curtailment. * If the Wind Plant DNE limit is not lower than the possible power production, this would not be considered a Curtailment. |
|  | 1. Maximum leading and lagging reactive capabilities should reflect values that can be reached within 1 minute and maintained for no less than 1 hour. |

# 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 | |
| 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[[4]](#footnote-5)& | 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 |
| 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 (oC) | Instantaneous | to 0.1oC with accuracy+/- 1.25oC | 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 (oC) | Average over 5 minute interval | to 0.1oC with accuracy+/- 1.25oC | 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 (oC) | 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 |
| 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 D***ata (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 |
| 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 (oC) | Average over 5 minute interval | to 0.1oC with accuracy+/- 1.25oC | 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 |

# 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. |
| Rev 4 | Draft | Biennial review completed by procedure owner;  Include reasonability limits on WHL in Section 5.1.2. |
|  |  |  |

# 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. |

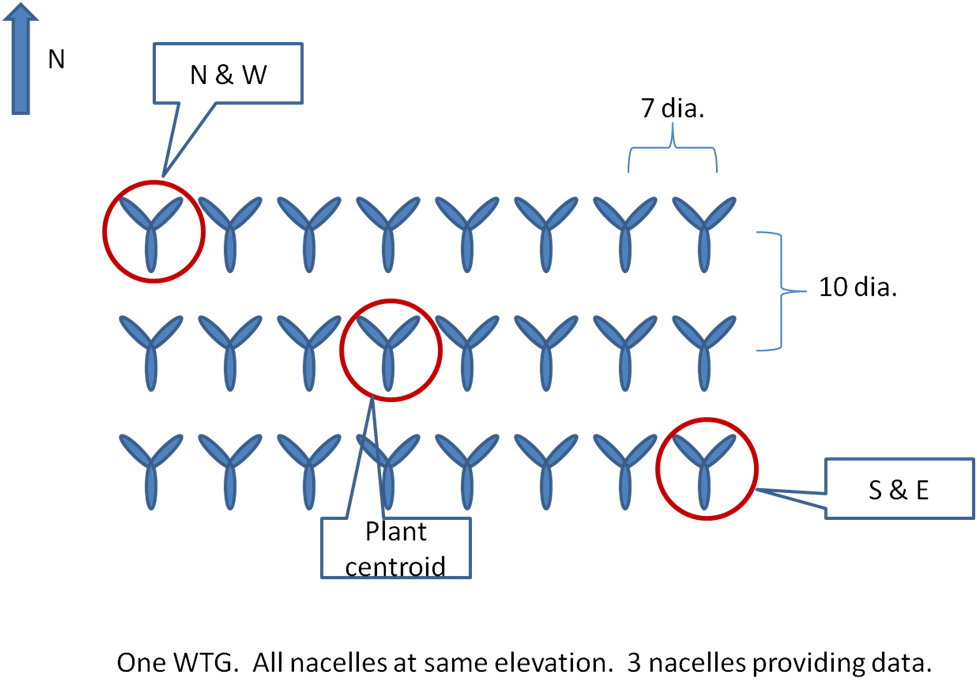


Figure A‑1

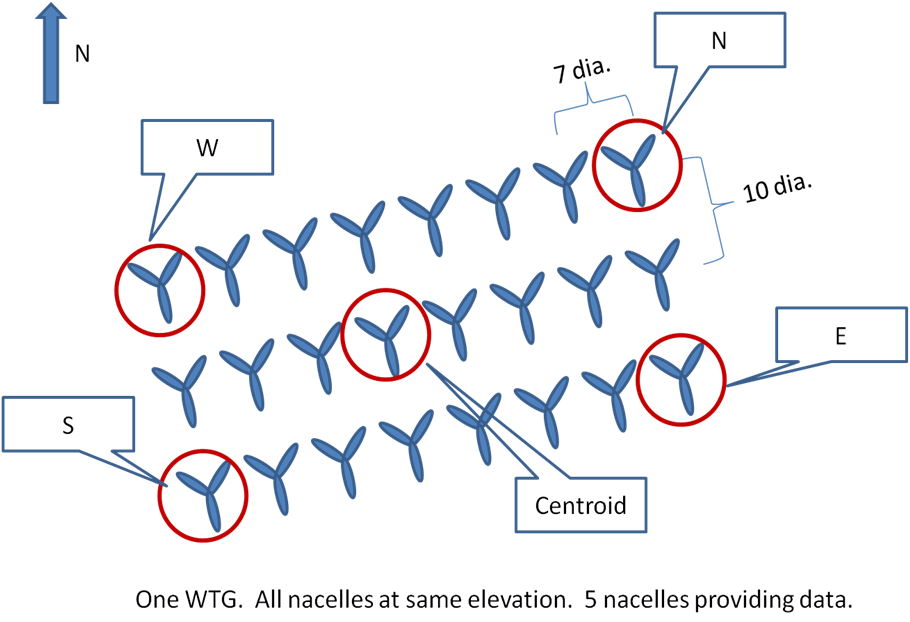


Figure A‑2

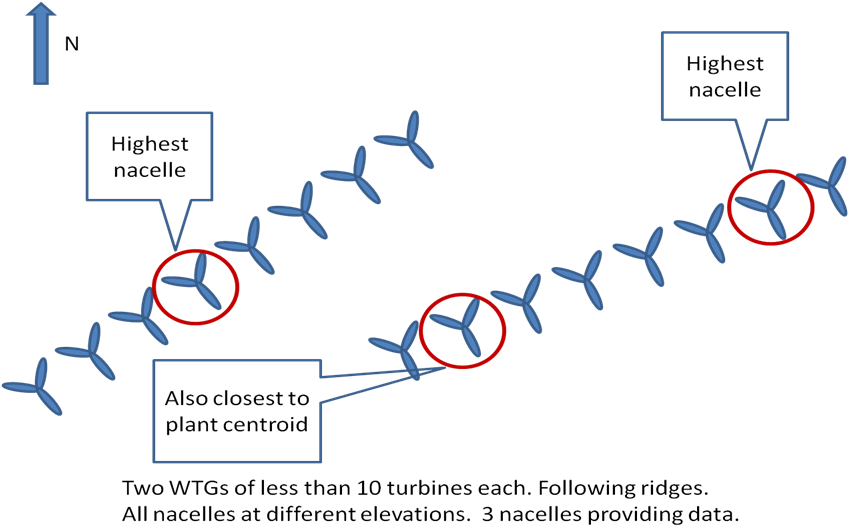


Figure A‑3

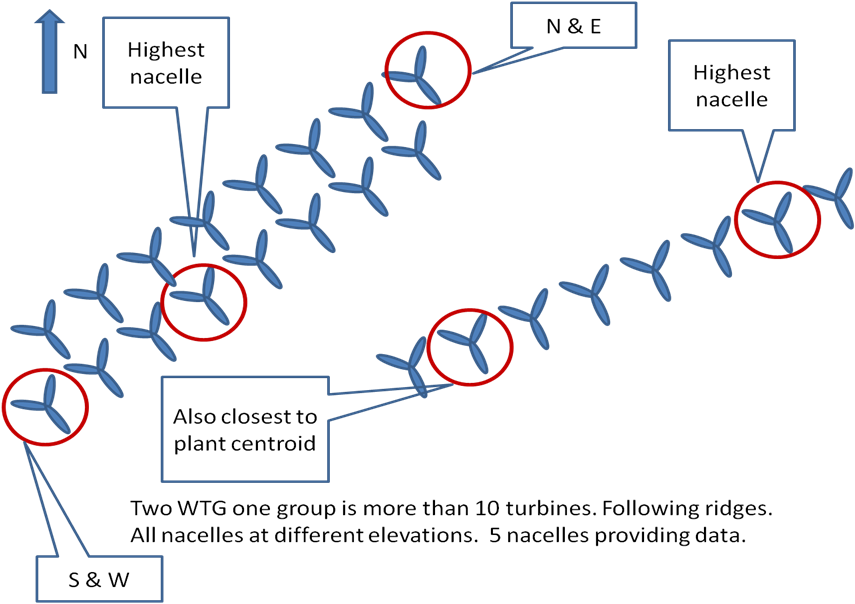


Figure A‑4

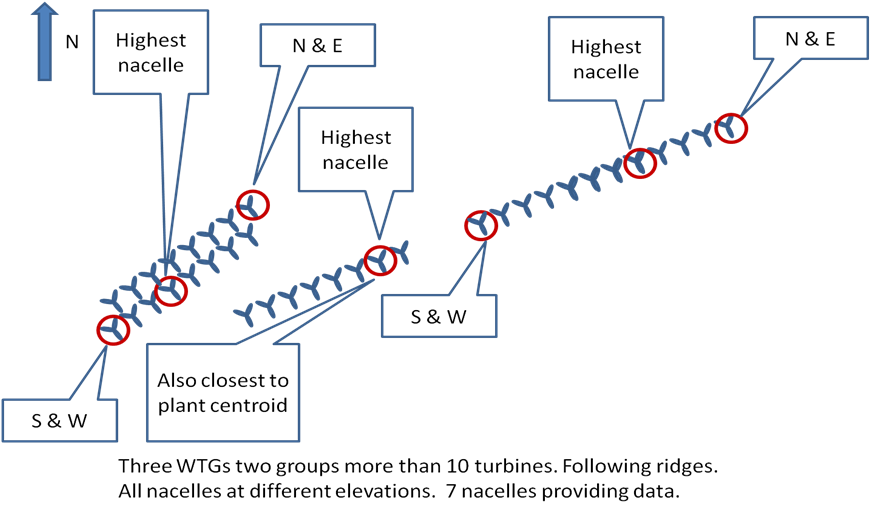


Figure A‑5

## Attachment B - Wind Plant Power Generation Diagram

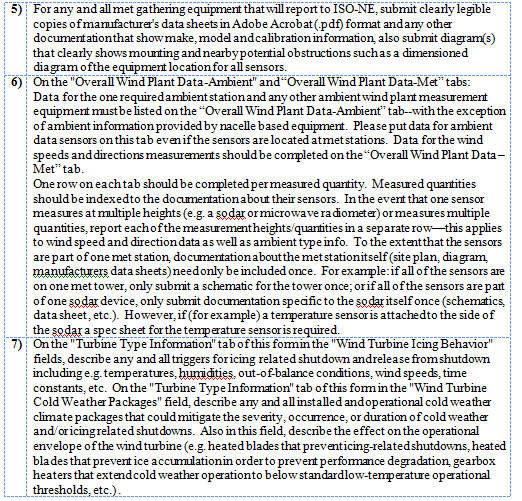
|  |  |
| --- | --- |
|  | The following diagram shows the relationship of the capacity parameters of a Wind Plant. |

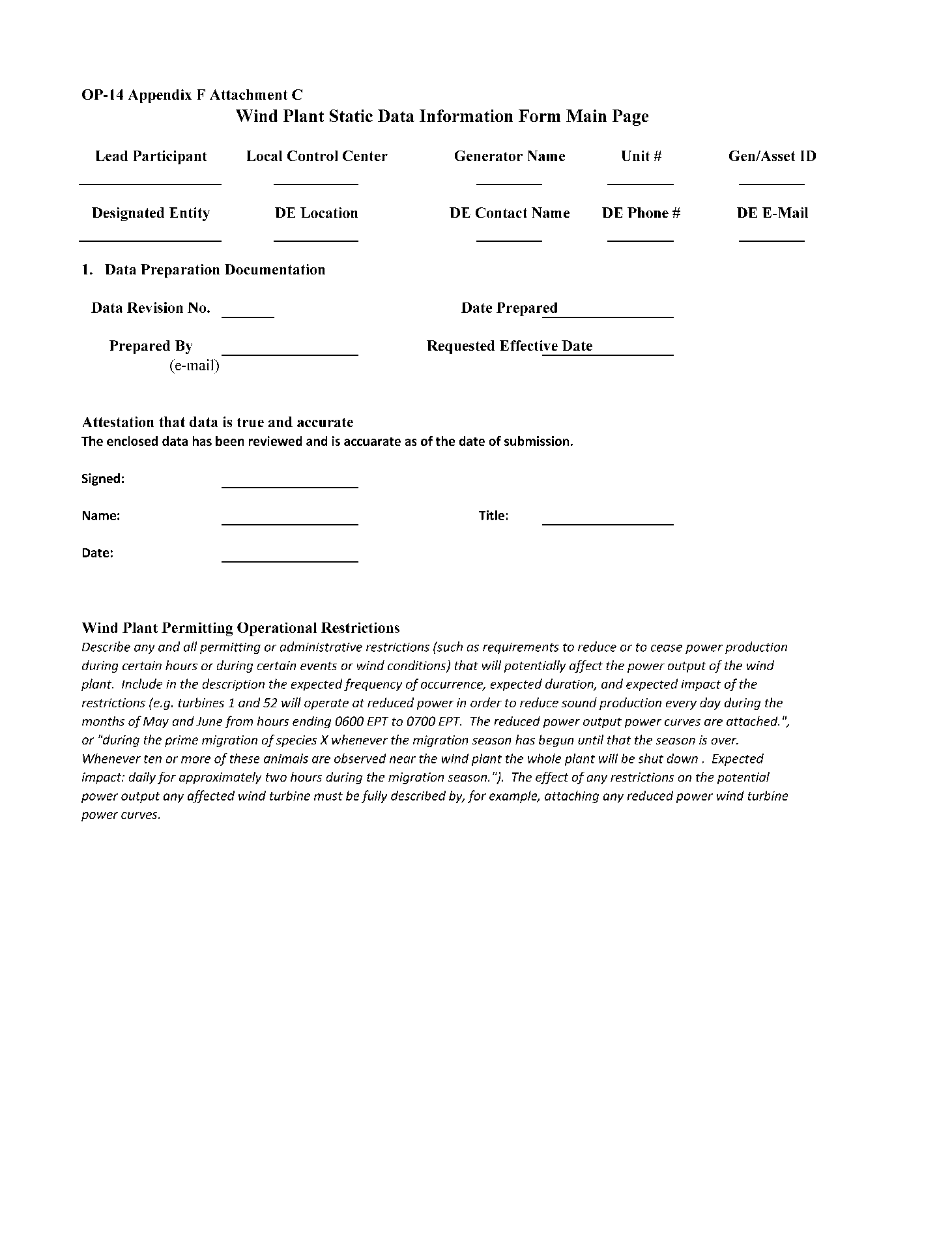


## Attachment C - Wind Plant Static Data Information Form

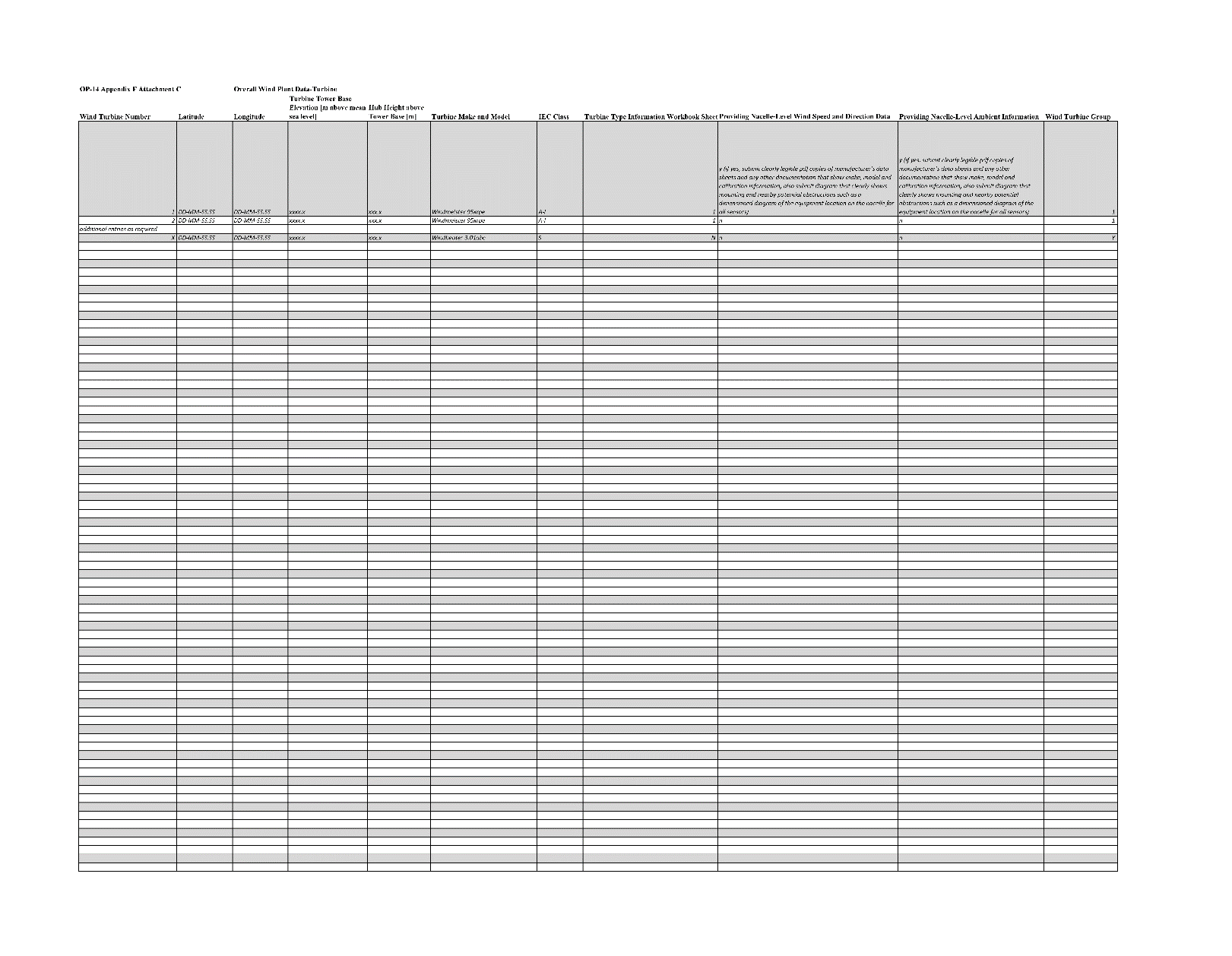
***Sample only*** – For a functioning version of this Excel workbook file contact the   
ISO at RenewableResourceInt@iso-ne.com.

****





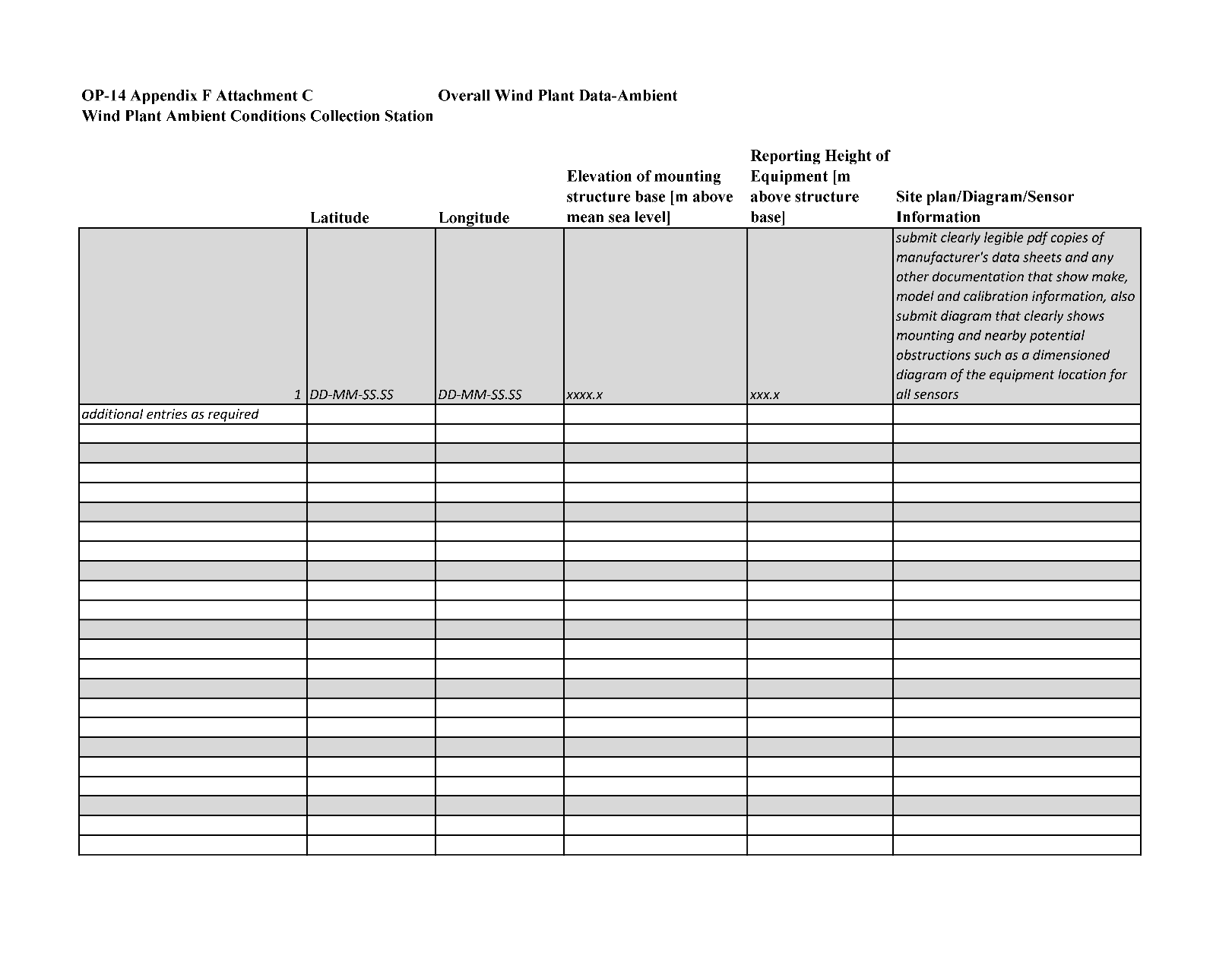
Wind Plant Static Data Information Form Main Page



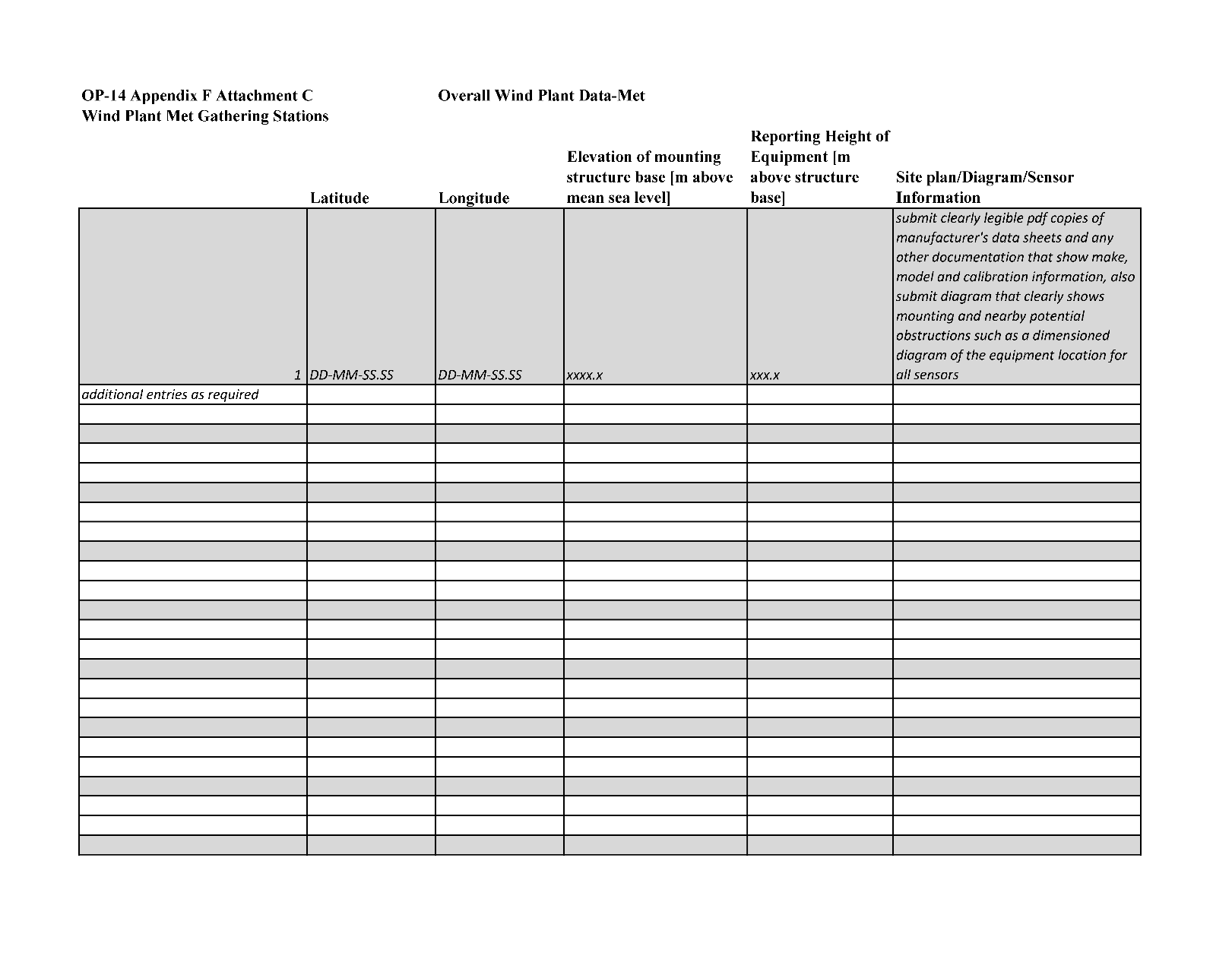
Overall Wind Plant Data-Turbine

## Wind Plant Static Data Form_Page_3Wind Plant Static Data Form_Page_3

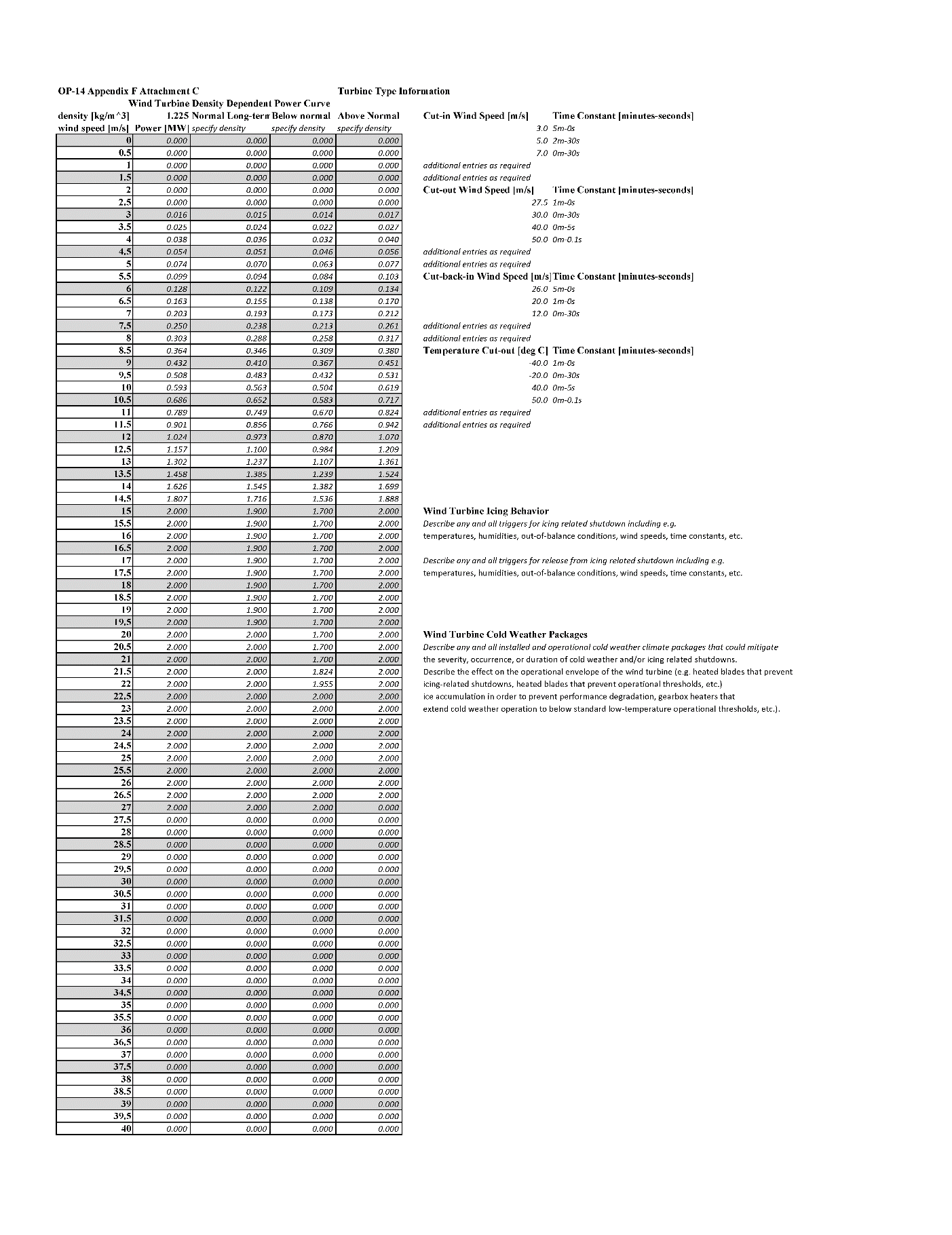
Overall Wind Plant Data-Turbine (cont.)



Overall Wind Plant Data-Ambient



Overall Wind Plant Data-Met



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.

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. [↑](#footnote-ref-2)
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 [↑](#footnote-ref-3)
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> [↑](#footnote-ref-4)
4. & See Section 2 - Definitions: Plant Wind Speeds (nacelle-level) [↑](#footnote-ref-5)