OP-14 Appendix H - Solar Plant Operator Guide

Effective Date: April 24, 2025

Review By Date: April 24, 2027

References:

ISO New England Inc. Transmission, Markets, and Services Tariff, Section I – General Terms and Conditions (Section I)

ISO New England Inc. Transmission, Markets, and Services Tariff, Section II – Open Access Transmission Tariff (OATT)

ISO New England Inc. Transmission, Markets, and Services Tariff, Section III – Market Rule 1 – Standard Market Design (Market Rule 1)

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 For 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)

Attachments:

Attachment A – Solar Plant-Static Data Information Form Exemplar

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Contents

1. Introduction

This Appendix H describes Solar Plant operating requirements and the data reporting requirements that Solar Plant Operators shall submit to ISO New England (ISO). The submittal of such data supports the operation of a centralized regional power forecasting system and therefore, the reliable and efficient integration of solar power into the ISO New England Balancing Authority Area (BAA). The requirements stated in this Appendix H apply to all Solar Plants, not operating as part of a Continuous Storage Facility (CSF), that will be or are dispatched by ISO and/or 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.

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

The following examples were written primarily for solar Generator Assets that produce energy using photovoltaic (PV) panels and inverters. If the solar Generator Asset uses alternative technologies for converting solar insolation to electrical energy delivered to the Point of Interconnection (POI), data requirements may be modified at the discretion of ISO.

2. Definitions

The following are the definitions for terms used in this Appendix H:

Curtailment or Curtailed – Solar Plant Operator action (whether manual, scheduled, or automatic), resulting from an ISO Dispatch Instruction, that limits the amount of power produced by the Solar 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 Solar 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., Global Horizontal Insolation, Direct Normal Insolation, wind speeds and directions) collected at a specific Solar Plant's location.

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

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

Plant Wind Directions – the instantaneous wind direction measured by wind measuring equipment (e.g., wind vane).

Plant Wind Speeds – the instantaneous wind speeds measured by wind measuring equipment (e.g. anemometry).

Real-Time High Operating Limit – is defined in the ISO New England Inc. Transmission, Markets, and Services Tariff Section I - General Terms and Conditions (Section I).

Solar High Limit (SHL) – is defined in the ISO New England Inc. Transmission, Markets, and Services Tariff Section I-General Terms and Conditions (Section I) See Section 5.1.2 of this Appendix H and Attachment B hereto for more details regarding SHL.

Solar Plant – for the purpose of this Appendix H, a Solar Plant is a collection of one or more solar-collecting/electricity-generating equipment and the additional equipment required to interconnect these collectors/converters into the electrical power system, consistent with the definition of a Generator Asset in Section I.

Solar Plant Future Availability (SPFA) – is defined in the ISO New England Inc. Transmission, Markets, and Services Tariff Section I - General Terms and Conditions (Section I).

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

3. Standard Operational Practice and Requirements

3.1 Solar Plant Data

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

3.2 Reclosing and Restarts

A Solar Plant shall be designed and operated (including the performance of re-closings and re-starts) by the Solar Plant Operator in accordance with ISO New England Operating Documents, which apply to all resources within the ISO-NE BAA.

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

3.3 Ramp Rate Limitations

Due to the very fast ramping capabilities of Solar Plants, there is potential for the equipment with which they are interconnected, to become significantly loaded or unloaded. This condition may lead to operational and reliability concerns, therefore ramp rate limits have been determined as described below. As operational experience is gained, ISO shall reevaluate these limits on either a Solar Plant-by-Solar Plant basis, or as applied to all Solar Plants in New England, as warranted. Where alternative ramp rates are determined to be acceptable on a Solar Plant-specific basis (e.g., for the provision of ancillary and/or essential reliability services), those plant-specific limits shall be provided to the Lead MP by ISO.

- For Solar Plants totaling 200 MW or less in nameplate, under all conditions except for emergencies and decreasing solar 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 Solar Plants totaling greater than 200 MW in nameplate, under all conditions except for emergencies and decreasing solar 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 110 MW. Limit: no more than 20 MW per minute when averaged over five (5) minutes							
Minute1	**Minute2**	**Minute3**	**Minute4**	**Minute5**	**Average rate**	**Exceeds Ramp Rate**	**Corr. Action**
100 MW/ min	0 MW/ min	0 MW/ min	0 MW/ min	0 MW/ min	20 MW/ min	No	None
100 MW/ min	10 MW/ min	0 MW/ min	0 MW/ min	0 MW/ min	22 MW/ min	Yes	Limit ramp in either first or second minute

4. Static Plant Data Requirements

The static plant data requirements that describe the physical layout of the Solar Plant and any associated meteorological equipment as well as data relevant to the design and operation of the Solar Plant are listed below. This data must be maintained and submitted by the Solar Plant Operator to ISO using the Solar Plant-Static Data Information Form. The Solar Plant-Static Data Information Form is an editable Excel workbook file and must be requested from ISO, completed, and returned as an Excel workbook file to the ISO at RenewableResourceInt@iso-ne.com. A sample Solar Plant-Static Data Information Form is available to in Attachment A of this Appendix H. Instructions are included, on the form, on how to complete and submit the required information. Consistent with ISO New England Inc. Transmission, Markets, and Services Tariff Section II - Open Access Transmission Tariff (OATT) Schedules 22 and 23, and OP-14, the Solar Plant Operator shall verify that the static plant data for each Solar Plant is kept current and changes are communicated to ISO if any data point changes in a material fashion.

Static plant data requirements:

1. Solar Plant:

    a. Latitude, Longitude, and elevation above sea level (in meters to one decimal place) of polygon corners determining spatial location of the solar project using WGS84 DD-MM-SS.SS using GPS WAAS, or comparable, methodology

    b. Solar module type(s) and model number(s)

    c. Panel tilt angle(s) – if fixed-axis, or indication of tracking along this axis

    d. Panel azimuth angle(s) – if fixed-axis, or indication of tracking along this axis

    e. Total MW DC Nameplate Capacity

    f. Total MW AC Nameplate Capacity

    g. Inverter module type(s) and model number(s)

    h. Inverter-by-inverter breakdown of relative DC nameplate feed

    i. Location and types of weather measurement devices (e.g., pyranometer type & manufacturer) and manufacturer's data specification sheets

    j. High and Low temperature cutoff threshold(s)

    k. High Wind Speed cutout threshold(s) and behaviors

    l. Descriptions of any permitting or administrative restrictions for the Solar Plant or any portion of the Solar Plant such as requirements to reduce or to cease power production during certain hours or during certain events or weather conditions.

m. For model training purposes, the ISO or its designee may require that any available historical information 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 insolation, which are required by the solar power forecaster, be provided.

5. Real-Time Data Collection and Transfer

This section presents the real-time operational and meteorological data requirements for Solar Plant Operators. In accordance with Table 6.1 to this Appendix H, data required under this Section must be electronically and automatically transmitted by the Solar Plant Operator to ISO as detailed in OP-18 section V - Internal New England Metering And Telemetering For Dispatch, Market, And Reliability Purposes. In addition, if any recommended (i.e. not required) data is provided by the Solar Plant Operator, it must also follow the same OP-18 requirements. Solar 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 required information must be provided with a high degree of accuracy and reliability.

5.1 Required Data Collection Points

5.1.1 Meteorological Data

Ambient air temperature, ambient air pressure, ambient air relative humidity, solar irradiance, wind speed, and wind direction must be measured, at a minimum, at one location within the Solar Plant (preferably as near to the capacity-weighted centroid of the Solar Plant as possible) whose height above ground may be in the range of 2 m to 10 m and the measurement height above must be stated to within 10 cm.

Solar irradiance, wind speed and wind direction measuring equipment (e.g. pyranometry and anemometry) should be mounted in, on, or near the Solar Plant with reasonable attempt to minimize the effects of obstruction. Wind direction should be calibrated for True North equal to 0 degrees and reported between 0 degrees and 359.9 degrees

5.1.2 Solar High Limit

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

1. When a Solar Plant is not being Curtailed, its Solar High Limit shall be calculated equal to the net generation.
2. When a Solar Plant is being Curtailed, its Solar High Limit shall be calculated equal to the Solar Plant's possible power production given current sun/weather conditions and equipment status if the curtailment were not in place. This will be greater than the net generation.
3. Solar High Limit must be greater than or equal to 0
4. Solar High Limit must be less than or equal to Real Time High Operating Limit

(See Attachment B to this Appendix H for additional guidance and examples).

5.1.3 Real-Time High Operating Limit

A Solar Plant Real-Time High Operating Limit (RTHOL) is the maximum power production (MW) the Solar Plant would be capable of in real-time, given ideal sun conditions and **no** Curtailment. (See Attachment B to this Appendix H for additional guidance and examples).

RTHOL should not be impacted by less than ideal sun conditions (e.g. cloudiness), or time of day (e.g. before the sun has risen, or after the sun has set), except if the Solar Plant is disconnected based upon a day/night cycle. If the Solar Plant is disconnected solely because of day/night cycle, the RTHOL should be set to zero but an outage is not required pursuant to OP-5.

When snow, ice, or other materials are fully or partially covering the PV panels, the RTHOL should be reduced to reflect the generation capability given those conditions. If panels are unable to produce energy given the conditions, it should be reported equivalent to a full or partial outage as applicable.

5.1.4 Solar Plant Future Availability

Solar 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 equipment status for the hour being calculated.

In contrast to all other Real-Time data which is provided to the ISO via telemetry, Solar Plant Future Availability is provided to the ISO using the ISO-NE Wind and Solar Integration web services. In the future, once a solar power forecast can be developed, this web service could also be used to gather solar plant power forecasts provided by the ISO-NE solar 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 ensure that data of a high quality will be incorporated into the centralized forecasting system, ISO requests that Solar Plant Operators follow the practices for meteorological data collection for each Solar Plant as outlined below:

1. Collect and provide to ISO, Meteorological Data from at least one met station that is strategically placed or utilized so that it will be impacted to a minimal extent by plant operations.

2. The Met Gathering Station equipment should be located at well-exposed sites. It is recommended that each solar panel in the Solar Plant should be within 5 km of a Met Gathering Station.

3. In order to avoid outage of data, it is recommended that additional "backup" data collection sites are selected in addition to the required data specified in Section 5.2.1.

4. The method(s) of measuring solar irradiance (e.g. Global Horizontal Irradiance, Direct Normal Irradiance, etc.) should be identified to the ISO during the data collection points setup so they can be utilized properly within forecasting systems.

5. Utilize the Do-Not-Exceed (DNE) Dispatch Limit provided by the ISO over the RTU, along with the Solar Plant's possible power production capability when

determining if the Solar Plant is operating in a Curtailed mode for purposes of calculating Solar High Limit.

a. If the Solar Plant DNE limit is lower than the possible power production, this would be considered a Curtailment.

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

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)								
Solar Plant Future Availability 1. Hourly values for the next 48 hours 2. Hourly values for the 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)(iii)
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)(ii) OP-14 App. H Section 5.1.3
Solar High Limit (SHL)	Required	Plant-wide total	M/A	MW	Instantaneous	0.01 MW with accuracy of +/- 1%	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(ii) OP-14 App. H 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

Parameter	Required/ Recommended	Location	Height	Units	Instantaneous / Average	Minimum Resolution/ Accuracy	Minimum Update Frequency	Requirement Reference(s)
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 OP-18 App.F
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 H Section 2
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 H Section 2
Average Real-Time Solar plant ambient information / Meteorological Station (data typically sampled at 1Hz) (***SCADA***)								
Ambient air temperature	Required	One location within Solar Plant	Between 2 and 10 meters	Degrees Centigrade (^oC)	Average over 5 minute interval	to 0.1^oC with accuracy+/- 1.25^oC	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. H 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 temperature	Required	One location within Solar Plant	Between 2 and 10 meters	Degrees Centigrade (^{o}C)	Average over 5 minute interval	Same as above	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. H Section 5.1.1
Ambient air pressure	Required	One location within Solar Plant	Between 2 and 10 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)(i) OP-14 App. H Section 5.1.1
Standard deviation of ambient air pressure	Required	One location within Solar Plant	Between 2 and 10 meters	Kilopascals (kPa)	Average over 5 minute interval	Same as above	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. H Section 5.1.1
Ambient air relative humidity	Required	One location within Solar Plant	Between 2 and 10 meters	(Percent)	Average over 5 minute interval	to 1% with accuracy to +/- 3%	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. H Section 5.1.1
Standard deviation of ambient air relative humidity	Required	One location within Solar Plant	Between 2 and 10 meters	(Percent)	Average over 5 minute interval	Same as above	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. H Section 5.1.1

Parameter	Required/ Recommended	Location	Height	Units	Instantaneous / Average	Minimum Resolution/ Accuracy	Minimum Update Frequency	Requirement Reference(s)
Solar irradiance	Required	One location within Solar Plant	Between 2 and 10 meters	W/m^2	Average over 5 minute interval	To 1 W/m^2	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. H Section 5.1.1
Wind speed	Required	One location within Solar Plant	Between 2 and 10 meters	m/s (scalar)	Average over 5 minute interval	to 0.1 m/s accuracy of +/- 0.5 m/s	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. H Section 5.1.1
Standard Deviation of Wind speed	Recommended	One location within Solar Plant	Between 2 and 10 meters	m/s (scalar)	Average over 5 minute interval	Same as above	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. H Section 5.1.1
Wind direction	Required	One location within Solar Plant	Between 2 and 10 meters	Degrees from True North (vector)	Average over 5 minute interval	to 1 degree with accuracy to +/- 5 degrees	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(i) OP-14App. H Section 5.1.1
Standard Deviation of Wind direction	Recommended	One location within Solar Plant	Between 2 and 10 meters	Degrees from True North (vector)	Average over 5 minute interval	Same as above	Every 5 minutes	Market Rule 1 Section 1.11.5(c)(i) OP-14 App. H Section 5.1.1

7. Revision History

Rev No.	Date	Reason
Rev 0	07/20/21	Initial version
Rev 1	07/18/23	Biennial review performed by procedure owner; 5.1.3 Real-Time High Operating Limit: Added Solar Plant day/night cycle disconnection clarification; Table 6.1 Real-Time Data: Added clarifications to headers, removed at point of interconnection from Voltage Parameter, and updated references in Minimum Resolution/Accuracy, Minimum Update Frequency, and Requirement Reference(s) columns.
Rev 2	04/24/25	Periodic review performed by procedure owner; Include language making Curtailment an explicit function of DNE - exactly as in OP14-F

Attachment A - Solar Plant-Static Data Information Form Exemplar

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

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	**OP-14 Appendix H Attachment A**													
2	**Instructions for filling out this form. Version 3.0**													
3	**1)**	This form is an editable Excel Workbook and must be requested by sending an e-mail with the subject line "Solar 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 "Solar Plant Static Data Form Submission" also to ISO-NE's Renewable Resource Integration department.												
4	**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. 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 tabs have sufficient space for all plant statistics and met gathering measurements to be listed and the characteristics to be filled out. 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 Solar 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. The user must edit and only edit the text that is in the Calibri, italicized, non-bold, 11 pt font.												
5	**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.												
6	**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 weather conditions) that will potentially affect the power output of the solar plant. Include in the description the expected frequency of occurrence, expected duration, and expected impact of the restrictions. The effect of any restrictions on the potential power output of the plant must be fully described.												
7	**5)**	Manufacturers data sheets that specify operational characteristics (e.g., temperature efficiency curves, etc.) for the solar modules comprising the plant must be submitted.												
8	**6)**	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.												
9	**7)**	On the "Solar Plant Data-Ambient" tab: Data for the one required ambient station and any other ambient solar plant measurement equipment must be listed on the "Solar Plant Data-Ambient" tab. 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.												
10														

Attachment A - Solar Plant-Static Data Information Form (cont.)

OP-14 Appendix H Attachment A

Solar 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: _____

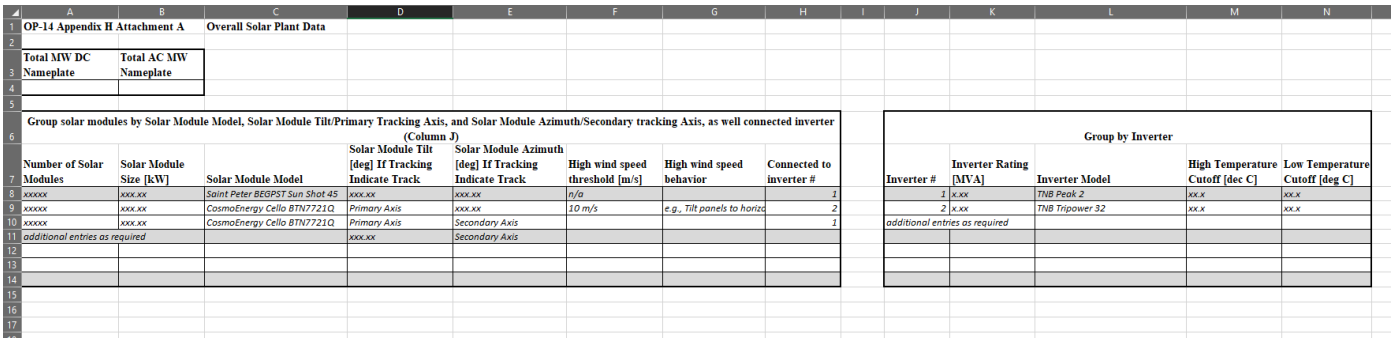
Name: _____ **Title:** _____

Date: _____

Solar Plant Permitting Operational Restrictions

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 conditions) that will potentially affect the power output of the solar plant. Include in the description the expected frequency of occurrence, expected duration, and expected impact of the restrictions. The effect of any restrictions on the potential power output of the plant must be fully described.

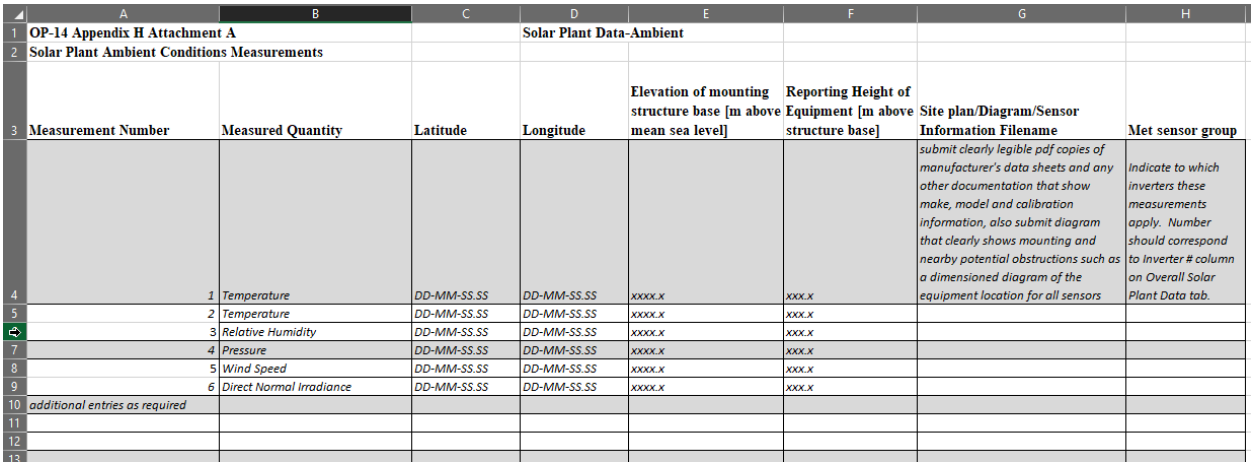
Attachment A - Solar Plant-Static Data Information Form (cont.)



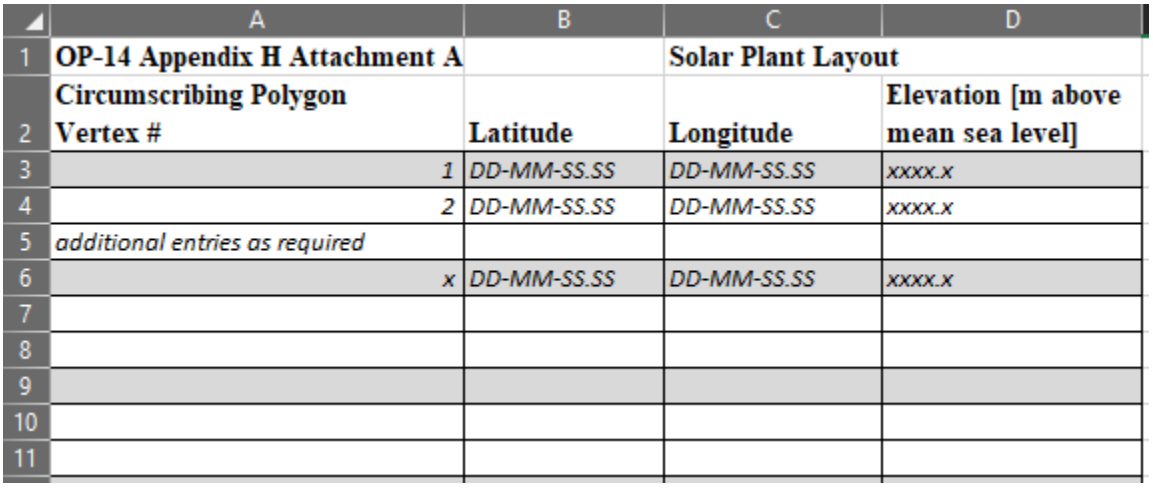
OP-14 Appendix H Attachment A		Overall Solar Plant Data											
Total MW DC Nameplate	Total AC MW Nameplate												

Group solar modules by Solar Module Model, Solar Module Tilt/Primary Tracking Axis, and Solar Module Azimuth/Secondary tracking Axis, as well connected inverter (Column J)							
Number of Solar Modules	Solar Module Size [kW]	Solar Module Model	Solar Module Tilt [deg] If Tracking Indicate Track	Solar Module Azimuth [deg] If Tracking Indicate Track	High wind speed threshold [m/s]	High wind speed behavior	Connected to inverter #
xxxxx	xxx.xx	Saint Peter BEGPST Sun Shot 45	xxx.xx	xxx.xx	n/a		1
xxxxx	xxx.xx	CosmoEnergy Cello BTN7721Q	Primary Axis	xxx.xx	10 m/s	e.g., Tilt panels to horizo	2
xxxxx	xxx.xx	CosmoEnergy Cello BTN7721Q	Primary Axis	Secondary Axis			1
additional entries as required			xxx.xx	Secondary Axis			

Group by Inverter				
Inverter #	Inverter Rating [MVA]	Inverter Model	High Temperature Cutoff [dec C]	Low Temperature Cutoff [deg C]
1	x.xx	TNB Peak 2	xx.x	xx.x
2	x.xx	TNB Tripower 32	xx.x	xx.x
additional entries as required				



OP-14 Appendix H Attachment A			Solar Plant Data-Ambient				
Solar Plant Ambient Conditions Measurements							
Measurement Number	Measured Quantity	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 Filename	Met sensor group
						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	Indicate to which inverters these measurements apply. Number should correspond to Inverter # column on Overall Solar Plant Data tab.
1	Temperature	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x	xxx.x		
2	Temperature	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x	xxx.x		
3	Relative Humidity	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x	xxx.x		
4	Pressure	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x	xxx.x		
5	Wind Speed	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x	xxx.x		
6	Direct Normal Irradiance	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x	xxx.x		
additional entries as required							



OP-14 Appendix H Attachment A		Solar Plant Layout	
Circumscribing Polygon Vertex #	Latitude	Longitude	Elevation [m above mean sea level]
1	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x
2	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x
additional entries as required			
x	DD-MM-SS.SS	DD-MM-SS.SS	xxxx.x

Attachment B – RTHOL and SHL Calculation Examples

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

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

The following Solar Plant is used within all subsequent examples:

A Solar Plant has three strings of solar panels each connected to dedicated inverters as follows:

String #	Solar Panel Type	Solar Panel Capacity [MW DC]	Inverter Rating [MW AC]	Inverter Efficiency [%]
1	A	5	3	95
2	B	4	3	95
3	C	3	2	97

Each solar panel type can produce power according the amount of solar irradiance as follows:

Solar Panel Type	Solar irradiance [W/m^2]										
	0	**100**	**200**	**300**	**400**	**500**	**600**	**700**	**800**	**900**	**1,000**
A	0	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
B	0	9%	18%	27%	36%	45%	54%	63%	72%	81%	90%
C	0	12%	24%	36%	48%	60%	72%	84%	96%	100%	100%

Example 1:

Solar irradiance is measured to be 500 W/m^2 by the pyranometer in the Solar Plant. All three strings are fully available.

Individual String Details

String #	Available	DC Panel Capacity	Power % based on irradiance	DC Potential MW	Inverter Efficiency	AC Potential MW	Inverter Capability MW
1	Yes	5	50%	2.5	95%	2.375	3
2	Yes	4	45%	1.8	95%	1.71	3
3	Yes	3	60%	1.8	97%	1.746	2
Total		12		6.1		5.831	8

Solar Plant Totals

DNE Limit	8.0 MW
Net Generation:	6.0 MW
RTHOL:	8.0 MW
SHL:	6.0 MW

Explanation:

Based on the solar irradiance, the % of DC Panel Capability can be determined. With that value determined, it can be used to calculate the DC Potential MW. Applying the Inverter Efficiency, the AC Potential MW values are calculated. Note, that there could be some error in the calculation of AC Potential MW (e.g., in this example, the AC Potential MW does not equal the actual Net Generation – this is intentional in the example and is to illustrate correct calculation of SHL). For all three strings, it can be seen that AC output is not limited by Inverter Capability. The RTHOL is the maximum output that could be achieved given available equipment. In this case that is 8 MW (limited by the Inverter Capability). The Solar High Limit is 6.0 MW because the Solar Plant is not Curtailed (i.e., the DNE is not limiting the total possible power production) and therefore SHL equals Net Generation. If the Solar Plant receives a DNE limit of 4 MW, the SHL would be 5.831 MW, based upon the AC Potential MW of each string, adjusted for losses.

Example 2:

Solar irradiance is measured to be 800 W/m^2 by the pyranometer in the Solar Plant. String 3 is unavailable due to maintenance on the inverter.

Individual String Details

String #	Available	DC Panel Capacity	Power % based on irradiance	DC Potential MW	Inverter Efficiency	AC Potential MW	Inverter Capability MW
1	Yes	5	80%	4	95%	3.8	3
2	Yes	4	72%	2.88	95%	2.736	3
3	No	0*	0*%	0*	0*%	0*	0*
Total		9		6.88		6.536	6

**Set to 0 due to being unavailable*

Solar Plant Totals

DNE Limit	4.5 MW
Net Generation:	4.5 MW
RTHOL:	6.0 MW
SHL:	5.736 MW

Explanation:

With String 3 unavailable, its capability is excluded from all calculations. Values for String 1 and 2 are determined in a similar manner as in Example 1, however, in this example it can be seen that String 1's AC potential MW capability exceeds the inverter rating. The RTHOL would be 6 MW (limited by inverter capability). Because the DNE limit is 4.5 MW (i.e., below what the Solar Plant would otherwise be capable of producing), the Solar Plant is Curtailed (i.e., its Net Generation is limited to 4.5 MW) and the SHL is therefore 5.736 MW (3 MW from String 1, limited by the inverter; plus 2.736 MW from String 2, limited by the AC Potential MW)

Attachment C – Solar Plant Power Generation Chart