1. Performance Guarantees

1.1. Functional Tests

1.1.1. The equipment shall be tested for performance prior to commercial operation. This process shall verify the installed system is performing per the design based on the current weather variables.

1.1.2. Prior to the performance test, the Contractor shall perform functional tests. As part of the commissioning process of the newly constructed solar array, the Contractor shall perform a functional test on each of the circuits to verify that they are all operating as expected and designed.

1.1.3. The Contractor shall start up and commission each of the inverters and ensure they are running under their MPPT (Maximum Power Point Tracking) range for optimal performance. The Contractor shall perform an infrared scan to confirm site DC system health prior to conducting the performance tests. The Contractor shall perform repairs or replacements for each string that is not performing as designed.

1.2. Availability Test

1.2.1. This portion of the performance test shall be conducted after the Contractor completes the functional tests and is required for commercial operation. The Availability Test shall be conducted in accordance with the standard outlined in Section 2. Availability Test below.

1.3. Capacity Test

1.3.1. The Capacity Test shall be conducted prior to commercial operation per the detailed test procedures in Section 3. Capacity Test. The basis for the Capacity Test procedures is ASTM E2848 – Standard Test Method for Reporting Photovoltaic Non-Concentrator System Performance

1.3.2. The performance test boundary for the solar array shall be Contractor supplied weather station and the production power meter.

1.3.3. The weather data and MWh (megawatt hour) output data shall be recorded during the test with the Owner-approved SCADA software. The measured total MWh output during the test shall be the actual output of the solar array. The measured total MWh output shall include the accuracy of the production power meter, line loss between inverters and meter and temperature coefficient correction factor (defined by panel manufacturer).

1.3.4. The weather data recorded during the test shall be entered in the PVsyst or equal model included in the As-Built design. The PVsyst model or another numerical model shall be used to calculate the expected MWh output over the duration of the test. The solar irradiance input in the PVsyst model shall be corrected for the accuracy of the weather station pyranometers.

1.3.5. This portion of the performance guarantee shall be met if the actual measured MWh output is greater than or equal to the expected MWh output calculated by PVsyst or another numerical model. If the actual measured MWh out is less than the expected MWh output, the Contractor shall repair or replace components as required and retest the solar facility to meet this portion of the performance guarantee.

1.3.6. This portion of the performance test may be suspended and restarted due to transient weather conditions as mutually agreed to by the Owner and Contractor. The data collected during the test suspension shall be excluded from the performance calculations. The test suspension period shall not extend the overall test period.

2. Availability Test

2.1. Purpose

2.1.1. The Availability Test will verify the inverters are fully commissioned and ready for commercial operation by demonstrating all inverters are able to operate for at least 3 consecutive days. The Availability Test may run in parallel to other performance related tests, provided the other tests do not negatively impact the inverter or plant operation.

2.2. Definitions

2.2.1. Availability Test – A short term, plant wide test meeting the requirements of this Exhibit K.1 and a condition to Substantial Completion used to verify all inverters are fully commissioned and ready for commercial operation.

2.2.2. Availability Test Calculator– An Excel file provided by the Owner to be used to calculate the Measured Availability during the Availability Test Measurement Period.

2.2.3. Availability Test Measurement Period – A three (3) day period during which the Availability Test is conducted to verify inverter operation, as such period may be extended as permitted in paragraph 5 of the Procedures set forth in this Exhibit K.1.

2.2.4. Availability Test Procedures – A detailed plan for administering the Availability Test to be provide by Contractor 45 Business Days prior to Availability Test, which plan shall meet all of the requirements therefor set forth in Appendix 1 to this Exhibit K.1 and include, at a minimum, all points to be monitored and identification of key personnel and parties.

2.2.5. Availability Test Report – A summary report of the Availability Test results, conditions during the test, the Inverter Availability Test Procedures, and calibration certificates of equipment used in the test, which report shall meet all of the requirements therefor set forth in this Attachment.

2.2.6. Eligible Time Intervals – Total number of time intervals during Availability Test Measurement Period where the plane of array irradiance is greater than 400 W/m2. The selected time interval shall be 5 minutes.

2.2.7. Guaranteed Availability –99.0%

2.2.8. Inverter Operational Time Intervals – For each inverter, the total number of Eligible Time Intervals during Availability Test Measurement Period when the inverter is producing power at all possible inverter stages, taking into account the incident irradiance.

2.2.9. Measured Availability – A percentage (rounded up or down to the nearest 0.1%), calculated as the quantity of Inverter Operational Time Intervals divided by the quantity of Eligible Time Intervals, multiplied by the number of inverters.

2.2.10. Multiple Measurements – Any measurement device or sensor where multiple devices or sensors measure the same parameter.

2.3. Procedure

2.3.1. No less than 45 Business Days prior to the first day of the scheduled Availability Test Measurement Period, the Availability Test Procedures shall be submitted to the Owner by the Contractor for Owner's review and comment. Contractor shall incorporate all of Owner's reasonable comments into the final Availability Test Procedures and resubmit the same for Owner's review and approval (such approval not to be unreasonably withheld or delayed).

2.3.2. The Contractor shall give written notice to the Owner 5 Business Days prior to the start of the Availability Test (including any re-performance thereof).

2.3.3. Contractor shall perform the Availability Test in accordance with the final approved

Availability Test Procedures.

2.3.4. During the Availability Test Measurement Period the Contractor shall record all inverter power, revenue meter, and plane of array irradiance data in accordance with the Data Quality and Instrumentation Requirements set forth in this Attachment. Such date shall be made available during and after the test as requested by Owner.

2.3.5. During the Availability Test, the Contractor shall document all inverter or plant-related interruption events, including the identification of the event, the reason for the interruption, the time and duration of the event and any corrective actions undertaken. In the event that inverter or plant-related interruptions do occur, the Contractor has the option to restart the Availability Test, provided that Contractor shall notify Owner thereof and provide detailed documentation of identified issues and proposed resolution to rectify such issues prior to re-performing the Availability Test.

2.3.6. During the test, the Contractor shall document all interruption events caused by grid operations, including the identification of the event, the reason for the interruption, and the time and duration of the event, and any corrective actions undertaken. To the extent that such interruption event was not caused by the Project, such events are excusable, and the test shall be extended by the amount of excluded time on a minute-by-minute basis in order to achieve 5 complete days of data.

2.3.7. The result of the Measured Availability shall be calculated as follows:

$$\frac{The\ Sum\ of\ All\ Inverter\ Operational\ Time\ Intervals}{Eligible\ Time\ Intervals * Total\ Number\ of\ Inverters}$$

2.3.8. The Project must be capable of continued operation, without intermittency or downtime during the Availability Test Measurement Period except for excused events described in paragraph 6 above. If the Measured Availability of the Project does not meet or exceed the Guaranteed Availability, the Contractor shall identify and promptly resolve the source of the problem and promptly perform the Availability Test again in accordance with these procedures (other than Paragraph 1 hereof) until the Measured Availability of the Project achieves the Guaranteed Availability.

2.4. Availability Test Report

2.4.1. No later than five (5) Business Days following the end of the Availability Test Measurement Period in respect of a Successfully Completed Availability Test, a draft Availability Test Report will be submitted to the Owner by the Contractor. Owner shall have five (5) Business Days to accept or reject the results of the draft Availability Test Report, and provide in writing any comments of Owner on such draft Availability Test Report. In the event that Owner rejects all or any part of the draft Availability Test Report, Contractor shall, within five (5) Business Days thereafter address any comments of Owner and re-submit the draft Availability Test Report to Owner. This procedure shall continue until Owner accepts the draft Availability Test Report. Any dispute regarding the results of the Availability Test or the Availability Test Report shall constitute a Dispute as described in the Agreement, Section 23.

2.4.2. The Availability Test Calculator, along with all raw data and QC disposition for each input data record, shall be provided electronically to the Owner with the Availability Test Report.

2.5. Appendix 1: Additional Requirements

2.5.1. Test Plan

2.5.1.1. The Availability Test Procedures shall include (at a minimum) the following information:

2.5.1.1.1. The test procedure set forth herein.

2.5.1.1.2. Identification of key personnel and parties to be involved in the test

2.5.1.1.3. Identification of the Project under test (at a minimum)

- Number and make/model of PV modules
- Array orientation
- Location (latitude, longitude, street address)
- Racking type and tilt
- Tracker range of motion (if applicable)
- Number and make/model of Inverters
- Row to row spacing (ground coverage ratio)

2.5.1.1.4. Identification of all data points to be monitored during the test

2.5.1.1.5. The scheduled starting and ending dates of the Availability Test Measurement Period.

2.5.1.1.6. Table of all sensors and transducers to be used, including cut sheets, calibration records, map of sensor locations with sufficient detail to allow observers to locate the sensors and transducers. This includes sensors required for all applicable input parameters (MET station sensors, inverters, and Revenue Meter).

2.5.1.1.7. MET station and pyranometer quality assurance and/or commissioning documentation (as an appendix).

2.5.1.1.8. Identification of SCADA nomenclature for data channels, and any SCADA calibration parameters (default or custom) for those data channels

2.5.1.1.9. Identification of SCADA data channels intended for use as auxiliary measurements

2.5.1.1.10. Identification of known data quality concerns, such as time intervals when inter-row shading may be expected to occur

2.5.1.1.11. Time-stamp convention and data logger averaging technique/interval to be used in reporting data

2.5.1.2. Measured data are to be made available to the Owner upon request during the Availability Test Measurement Period, for use in evaluating the progress of the Availability Test.

2.5.2. Availability Test Report

2.5.2.1. The Availability Test Report shall contain:

2.5.2.1.1. The Availability Test Procedures, including all requirements as outlined herein.

2.5.2.1.2. The actual start and end date/times of the Availability Test Measurement Period

2.5.2.1.3. Comments on environmental conditions during the Availability Test Measurement Period that affect the results of the test

2.5.2.1.4. Summary of data quality control results for all data records

2.5.2.1.5. Summary of test results

2.5.2.1.6. All calibration certificates for pyranometers, temperature sensors, and revenue meters used in the test

2.5.2.2. Raw data used as input to the Availability Test, along with QC disposition for each input data record, shall be provided electronically (via CSV, XLS, or XLSX formats) to the Owner with the Availability Test Report.

2.5.3. Data Quality and Instrumentation Requirements

2.5.3.1. Data quality shall be identified as one item from a set of quality categories for each data record analyzed. Only data from records where all input parameters are valid and within specified limits shall be used in computing capacity estimates.

2.5.4. Sensor Requirements

2.5.4.1. Irradiance sensors shall be at a minimum "High Quality" classified pyranometer(s) as defined in ASTM2848-A1.2 (Secondary Standard per ISO 9060). Pyranometers shall include device-specific characterization data that shall, at minimum, include cosine and temperature response. Alternative pyranometers may only be used if approved by the Owner.

2.5.4.2. Pyranometers shall be used only within their valid calibration period and shall be cleaned at the start of the Availability Test Measurement Period and cleaned daily during the test if the Availability Test Measurement Period extends beyond one (1) week.

2.5.4.3. All measurement devices and sensors shall meet the minimum accuracy requirements and range requirements set forth in the table below:

Sensor Requirements

Table 12 Sensor Requirements

Measurement	Instrument Type	Test Function	Range	Accuracy
Irradiance	Pyranometer (Global Horizontal Irradiance (GHI))	Primary for Energy Performance Test	0 to 1600 W/m^2 285 to 2800 nm	±2.0% daily
	Pyranometer (Plane of Array (POA))	Primary for Capacity Test and Availability Test		
Ambient Air Temperature	Temperature Probe	Primary for both Capacity Test and Energy Performance Test	-40°C to +60°C	±1°C
Wind Speed	Sonic Wind Sensor	Primary for Capacity Test and Energy Performance Test	0 – 60 m/s	±5%
PV Plant Power	PV Power Revenue Meter	Primary for both Capacity Test and Energy Performance Test primary for Capacity Test	0 to PV Power Plant size +20%	ANSI C-12.20
Inverter Power	Inverter Meter	Primary for Availability Test and Capacity Test	determined from inverter data sheet	determined from inverter

				data sheet
Soiling	Soiling Monitoring System (SMS)	Primary for Energy Performance Test	0 to 100%	±0.2%

2.5.5. Multiple Measurements

2.5.5.1. Multiple Measurements shall be recorded for all environmental data throughout the Site in order to capture the operating conditions for all regions of the array. There is a high probability that there will be periods of time in which portions of the Project are exposed to significantly different irradiance conditions than other portions, e.g. due to isolated clouds.

2.5.6. Below are the main measurement devices and sensors to be used in the Availability Test:

2.5.6.1. Plane of Array Irradiance (POA): A minimum of one sensor shall be installed for each orientation (within ±2°). Multiple orientations or large arrays shall require Multiple Measurements. For projects or unique project Blocks within a project with potentially different irradiance conditions (like change in azimuth, tilt, or tracking range of motion) greater than 5 MW, at least 3 POA sensors shall be installed.

2.5.6.2. Inverter Meter: The power reading for each inverter.

2.6. Appendix 2: Availability Test Calculator

2.6.1. The table below provides the file names for all files needed for the Availability Test Calculator. Contractor shall provide the Availability Interval Data file once the test is complete.

Table 23 Availability Test Calculator Files

File Name	File Type	Comments
Availability Test Calculator	.xlxs	Used to log all raw measured data, Inverter Interval Data, and calculate the availability
Availability Interval Data	.csv	Interval values of measured Inverter Power Output, plane of array irradiance (POA), and Revenue Meter.

3. Capacity Test

3.1. Purpose

3.1.1. The Capacity Test will verify the plant is fully operational and ready for commercial operation by achieving the Guaranteed Capacity.

3.2. Definitions

3.2.1. Capacity Test – A short-term, plant-wide test meeting the requirements of ASTM E2848 – Standard Test Method for Reporting Photovoltaic Non- Concentrator System Performance and this Attachment K.1 and a condition to Substantial Completion used to verify the plant is fully commissioned and ready for commercial operation.

3.2.2. Capacity Test Calculator – An Excel tool to be used to calculate the Target Capacity and Measured Capacity during the Capacity Test Measurement Period.

3.2.3. Capacity Test Measurement Period – The period when the Capacity Test is performed, which period shall be at least 2 days, and shall continue until for consecutive additional days until the Minimum Irradiance has been met, which may be up to a total of 15 days depending on weather conditions during the test.

3.2.4. Capacity Test Procedures –A detailed plan for administering the Capacity Test to be provide by Contractor 30 Calendar Days prior to the first date of the scheduled Capacity Test Measurement Period, which plan shall meet all of the requirements therefor set forth herein and include, at a minimum, all points to monitored and identification of key personnel and parties.

3.2.5. Capacity Test Report – A summary report of the Capacity Test results, conditions during the test, the Capacity Test Procedures, Data Quality and Instrumentation Plan and applicable calibration certificates for equipment used in the test, which report shall meet all of the requirements therefor set forth herein.

3.2.6. Capacity Test Bifacial Gain (CTBG) – The bifacial gain as calculated using the CTBG procedures outlined herein.

3.2.7. Guaranteed Capacity – A Measured Capacity Ratio of at least 100.0% or greater.

3.2.8. Minimum Guaranteed Capacity – A Measured Capacity Ratio of at least 97.0% or greater.

3.2.9. Minimum Datapoints – Occurs when at least 150 allowable data points meeting the requirements set forth in this Exhibit K.1 are recorded after all data filtering has occurred as outlined herein. If the Minimum Irradiance criteria set forth is causing a delay in the test and pushing it beyond the Guaranteed Project Substantial Completion Date, the test procedure may, subject to prior agreement by both parties, be modified to allow fewer data points.

3.2.10. Minimum Irradiance. 400 W/m2.

3.2.11. Measured Capacity – The measured capacity as calculated using the procedures outlined herein.

3.2.12. Measured Capacity Ratio – The Measured Capacity divided by the Target Capacity, calculated to the nearest 0.1%.

3.2.13. Monthly Reporting Conditions – The plane of array irradiance (POA), ambient temperature, and wind speed calculated for each month using the Project Model and P50 weather file as agreed to by the Parties and recorded in Table 4 of Appendix 2 attached herein.

3.2.14. Project Model – The Contractor PVSYST generation model for the Project, including post-processing that occurs outside of the program.

3.2.15. Project Capacity Model –The Project Model as adjusted to remove assumptions for snow, availability, and module degradation losses.

3.2.16. Revenue Meter – The revenue meter for the Project as agreed by the Parties.

3.2.17. Capacity Test Bifacial Gain (CTBG) – The bifacial gain as calculated using the CTBG procedures outlined herein.

3.2.18. Target Capacity – The target capacity as calculated using the procedures outlined herein.

3.3. Procedure

3.3.1. No less than 45 Business Days prior to the first day of the scheduled Capacity Test Measurement Period, a draft Capacity Test Procedures shall be submitted to the Owner by the Contractor for Owner's review and comment. Contractor shall incorporate all of Owner's reasonable comments into the final Capacity Test Procedures and resubmit the same for Owner's review and approval (such approval not to be unreasonably withheld or delayed).

3.3.2. The Contractor shall give written notice to the Owner 12 Business Days prior to the start of the Capacity Test (including any re-performance thereof).

3.3.3. Contractor shall perform the Capacity Test in accordance with the final approved Capacity Test Procedures.

3.3.4. Capacity Test Procedures shall identify the final Monthly Reporting Conditions and Target Capacities using the Project Capacity Model, and data filters described below.

3.3.5. The Capacity Test Measurement Period shall last no less than two (2) consecutive days. If the Minimum Irradiance requirement is not met during such 2-day period, the Capacity Test Measurement Period shall be extended for consecutive days until the Minimum Irradiance requirement is met.

3.3.6. The following input parameters shall be measured during the Capacity Test (collectively, the "Input Parameters"):

3.3.6.1. Plane-of-Array Irradiance (POA): An estimate of the average irradiance incident upon the PV array in the Project. No provision is allowed for shading, so any significant shading during any aggregation interval is causing to exclude that data record from the regression.

3.3.6.2. Ambient Temperature: As recorded by the Project meteorological stations as defined in Appendix 1 to this Exhibit K.1.

3.3.6.3. Wind Speed: As recorded as recorded by the Project meteorological stations as defined in Appendix 1 to this Exhibit K.1.

3.3.6.4. CTBG Parameter: Power measurement from the bifacial reference modules and monofacial reference modules

3.3.6.5. Revenue Meter Energy Generation: Energy as recorded by the Revenue Meter during the Capacity Test Measurement Period.

3.3.6.6. Inverter-Level Energy Generation: AC output data for each inverter shall be provided for the purposes of identifying periods of inverter clipping.

3.3.7. During the Capacity Test Measurement Period, irradiance data shall be sampled at no greater than five (5) second intervals. Irradiance data shall be reported at no greater than five (5) minute intervals, consisting of averaged five (5) second sampled data. Power generation data shall either be sampled and reported at the intervals required for irradiance, as noted above. Other data shall be sampled at no greater than one (1) minute intervals and shall be reported at no greater than five (5) minute intervals, consisting of averaged one (1) minute sampled data. All data shall be reported in time-synchronized intervals.

3.3.8. Data shall be averaged and filtered in accordance with the procedures below:

3.3.8.1. Missing Data: Missing records shall be marked as missing with a non-numeric identifier. Missing records shall not have a value included in the analysis, but shall be documented.

3.3.8.2. SCADA Equipment Malfunction: Data records with invalid Input Parameters (e.g. all sensor readings reported as out of range by the SCADA) shall also be marked as invalid.

3.3.8.3. Below Minimum Irradiance: To avoid large uncertainty in results due to increased impact of variable losses at low irradiance, all records with a minimum plane-of-array irradiance input parameter of 400 W/m^2 or less shall be marked as irradiance too low.

3.3.8.4. Unstable irradiance: Irradiance measurements shall be deemed stable if i) all individual sensor readings are within 25 Watts per meter squared of the average of all the sensor readings and ii) the average of all sensor readings is not more than 10% greater or less than the previous interval reading. If both conditions above are not met, the irradiance will be deemed unstable, flagged and the data will not be used in the test.

3.3.8.5. Inverter clipping: Any intervals where the power output of one (or more) inverters is greater than 98.0% of the rated or programmed power limit.

3.3.8.6. Power Factor: Any intervals where the inverter power factor is less than ±0.98 will be excluded from the test data.

3.3.8.7. Array shading by internal (array self-shading) or external (nearby objects). A schedule of expected shade times shall be defined in the Capacity Test Procedures. This schedule may be altered during the Capacity Test. Records occurring during these shade intervals identified during testing shall be marked as shaded and excluded from the test. Photographic evidence of array conditions shall be provided.

3.3.8.8. Array shading by environmental conditions (e.g. frost, snow or debris). Onsite observers shall record time intervals when such conditions exist as the Capacity Test progresses. Photographic evidence of array conditions shall be provided.

3.3.8.9. Wind Speed: Any intervals where average wind speed is greater than 15 meter per sec will be excluded from the test data.

3.3.9. Data will be collected for a minimum of 3 days until at least 150 allowable data points are collected.

3.3.10. Using the Capacity Test Calculator and the data filtering described herein, calculate the linear regression coefficients and Measured Capacity.

3.3.11. Calculate the Measured Capacity Ratio using the calculated Measured Capacity and appropriate monthly Target Capacity identified in the Table 4 of Appendix 2 attached herein.

3.3.12. If the Measured Capacity Ratio of the Project does not meet or exceed the Minimum Guaranteed Capacity, the Contractor shall identify and promptly resolve the source of the problem and promptly perform the Capacity Test again in accordance with these procedures (other than Paragraph 1 hereof) until the Measured Capacity of the Project achieves the Minimum Guaranteed Capacity. If the Measured Capacity Ratio is more than the Minimum Guaranteed Capacity but is less than the Guaranteed Capacity, then Contractor shall be responsible for the liquidated damages as set forth in the Agreement.

3.4. Capacity Test Bifacial Gain Calculation Procedure

3.4.1. This will be calculated by directly comparing the irradiance measured from the mono-facial reference modules to that of the bifacial reference modules. The calibrated reference modules shall be used in this test and their serial numbers shall be recorded to correlate to flash test data.

3.4.2. The power will be measured in 5-minute intervals from these reference modules at each MET station. The data shall be filtered as follows:

3.4.2.1. Dataset shall be limited to allowable data points of the Capacity Test.

3.4.2.2. Bifacial gain shall be calculated for each MET station and instances where the gain differs more than 5% from the average gain shall be excluded

3.4.2.3. Missing, unavailable, or NaN (Not a Number) data points will be excluded.

3.4.3. The CTBG for each module type shall be calculated as follows:

$$CTBG_i = \frac{\sum_{i=1}^{n} \frac{Power_{bi}/Power_{bi,STC}}{Power_{mono}/Power_{mono,STC}}}{n}$$

Where:
$CTBG_i$ = Capacity Test Bifacial Gain of module type i (%)
n = total number of filtered 5-minute data points (unitless)
$Power_{bi}$ = Power measured by the bifacial reference module (Watts)
$Power_{bi,STC}$ = STC Power of the bifacial reference module (Watts)
$Power_{mono}$= Power measured by the monofacial reference module (Watts)
$Power_{mono,STC}$= STC Power of the monofacial reference module (Watts)

3.4.4. Both the mono-facial and bifacial modules shall be cleaned prior to the Capacity Test. The CTBG shall be calculated specifically for the duration of the Capacity Test. For example, if the Capacity Test takes place from April 10 to April 20, the CTBG shall be calculated for all the filtered 5-minute data points in that time period.

3.5. Capacity Test Report

3.5.1. No later than three (3) Business Days following the end of the Capacity Test Measurement Period of a Successfully Run Capacity Test, a draft Capacity Test Report will be submitted to the Owner by the Contractor. Owner shall have five (5) Business Days to accept or reject the results of the draft Capacity Test Report, and provide in writing any comments of Owner on such draft Capacity Test Report. In the event that Owner rejects all or any part of the draft Capacity Test Report, Contractor shall, within five (5) Business Days thereafter address any comments of Owner and re-submit the draft Capacity Test Report to Owner. This procedure shall continue until Owner accepts the draft Capacity Test Report. Any dispute regarding the results of the Capacity Test or the Capacity Test Report shall constitute a Dispute as described in the Agreement.

3.6. Appendix 1: Additional Requirements

3.6.1. Test Plan

3.6.1.1. The Capacity Test Procedures shall include (at a minimum) the following information:

3.6.1.1.1. Identification of key personnel and parties to be involved in the test

3.6.1.1.2. The Project Model

- For the purposes of the Capacity Test, the Project Model shall exclude array soiling loss, module/system degradation and assume 100% availability
- Meteorological data used for calculation of the Monthly Reporting Conditions

3.6.1.1.3. Identification of the Project under test (at a minimum)

- Number and make/model of PV modules
- Array orientation
- Location (latitude, longitude, street address)
- Racking type and tilt
- Tracker range of motion (if applicable)
- Number and make/model of Inverters
- Row to row spacing (ground coverage ratio)

3.6.1.1.4. Identification of all data points to be monitored during the test

3.6.1.1.5. The Monthly Reporting Conditions and Target Capacity values

3.6.1.1.6. The starting and ending dates of the scheduled Capacity Test Measurement Period.

3.6.1.1.7. Table of all sensors and transducers to be used, including cut sheets, calibration records, map of sensor locations with sufficient detail to allow observers to locate the sensors and transducers. This includes sensors required for all applicable Input Parameters (MET station sensors, inverters, and Revenue Meter).

3.6.1.1.8. MET station and pyranometer quality assurance and/or commissioning documentation (as an appendix).

3.6.1.1.9. Identification of SCADA nomenclature for data channels, and any SCADA calibration parameters (default or custom) for those data channels

3.6.1.1.10. Identification of SCADA data channels intended for use as auxiliary measurements

3.6.1.1.11. Identification of known data quality concerns, such as time intervals when inter-row shading may be expected to occur

3.6.1.1.12. Time-stamp convention and data logger averaging technique/interval to be used in reporting data

3.6.1.1.13.

3.6.1.2. Measured data are to be made available to the Owner upon request during the Capacity Test Measurement Period, for use in evaluating the progress of the Capacity Test.

3.6.2. Capacity Test Report

3.6.2.1. The Capacity Test Report shall contain:

3.6.2.1.1. The Capacity Test Procedures, including all requirements as outlined herein.

3.6.2.1.2. The actual start and end date/times of the Capacity Test Measurement Period

3.6.2.1.3. Comments on environmental conditions during the Capacity Test Measurement Period that affect the results of the test

3.6.2.1.4. Summary of data quality control results for all data records

3.6.2.1.5. Summary of test results

3.6.2.1.6. Regression coefficients used to calculate Target Capacity and Measured Capacity

3.6.2.1.7. Comparison of test results with Minimum Guaranteed Capacity and Guaranteed Capacity

3.6.2.1.8. All calibration certificates for pyranometers, temperature sensors, and revenue meters used in the test

3.6.2.2. Raw data used as input to the Capacity Test, along with QC disposition for each input data record, shall be provided electronically (via CSV, XLS, or XLSX formats) to the Owner with the Capacity Test Report.

3.6.3. Data Quality and Instrumentation Requirements

3.6.3.1. Data quality shall be identified as one item from a set of quality categories for each data record analyzed. Only data from records where all input parameters are valid and within specified limits shall be used in computing capacity estimates.

3.6.4. Sensor Requirements

3.6.4.1. Irradiance sensors shall be at a minimum “High Quality” classified pyranometer(s) as defined in ASTM2848-A1.2 (Secondary Standard per ISO 9060). Pyranometers shall include device-specific characterization data that shall, at minimum, include cosine and temperature response. Alternative pyranometers may only be used if approved by the Owner.

3.6.4.2. Pyranometers shall be used only within their valid calibration period and shall be cleaned at the start of the Capacity Test Measurement Period and cleaned daily during the test if the Capacity Test Measurement Period extends beyond one (1) week. Bifacial reference modules (same batch from the field) shall be installed to measure bifacial plane of array and monofacial reference module to measure plane of array irradiance.

3.6.4.3. All measurement devices and sensors shall meet the minimum accuracy requirements and range requirements set forth in the table below:

Table 34 Sensor Requirements

Measurement	Instrument Type	Test Function	Range	Accuracy

Plane of Array Irradiance	**Front Pyranometer** **Rear Pyranometer** **Bifacial reference module** **Monofacial reference module**	Primary for Capacity Test	0 to 1600 W/m^2 285 to 2800 nm	**±2.0% daily**
Global Horizontal Irradiance	**Pyranometer**	Secondary for Capacity Test	0 to 1600 W/m^2 285 to 2800 nm	**±2.0% daily**
Ambient Air Temperature	Temperature Probe	Primary for Capacity Test	**-40°C to +60°C**	**±1°C**
Wind Speed	Sonic Wind Sensor	Primary for Capacity Test	0 – 60 m/s	±5%
PV Plant Power	PV Power Revenue Meter	Primary for Capacity Test	**0 to PV Power Plant size +20%**	ANSI C-12.20
Inverter Power	Inverter Meter	Primary for Capacity Test	**determined from inverter data sheet**	determined from inverter data sheet

3.6.5. Multiple Measurements

3.6.5.1. Multiple Measurements shall be recorded for all environmental data throughout the Site in order to capture the operating conditions for all regions of the array. There is a high probability that there will be periods of time in which portions of the Project are exposed to significantly different irradiance conditions than other portions, e.g. due to isolated clouds.

3.6.5.2. Below are the main sensors to be used in the Capacity Test:

3.6.5.2.1. Plane of Array Irradiance (POA): Plane of Array readings shall be averaged from sensors installed as outlined in SOW (MET Spec). To be clear, MET station will include front pyranometer, back pyranometer, bifacial reference module and monofacial reference module.

3.6.5.2.2. Ambient Air Temperature: Ambient temperature readings shall be averaged from sensors installed as outlined in SOW (MET Spec).

3.6.5.2.3. Wind Speed: wind speed sensors shall be averaged from sensors installed as outlined in SOW (MET Spec).

3.6.5.2.4. Inverter Meter: The power reading for each inverter.

3.6.5.2.5. PV Plant Meter: The power reading of the Revenue Meter.

3.7. Appendix 2: Project Capacity Model and Reporting Conditions Definition

3.7.1. Project Capacity Model

3.7.1.1. The requirements for the Project Capacity Model to be used for evaluating the Measured Capacity is detailed in this Exhibit K.1. This section outlines all input parameters required to create the PVSYST simulation, in the event that PVSYST electronic project files are no longer available. This section shall be populated and submitted with the Capacity Test Procedures.

3.7.2. PVSYST Model Files

3.7.2.1. The table below provides the file names for all model files necessary to run the PVSYST simulation in the PVSYST version specified in the subsequent section. Contractor shall provide all Project Capacity Model files to the Owner.

Table 1: PVSYST File Names

Table 45 PVSYST File Names

PVSYST File Type	File Name
Project file [PRJ, VC0] Including all variants	
Meteorological file [MET]	
Site file [SIT]	
Module file [PAN]	
Inverter file [OND]	
Shade file [SHD]	
Horizon file [HOR]	

3.7.3. PVSYST Input Parameters

3.7.3.1. In the event that data files are lost or corrupted, all PVSYST inputs and assumptions have been documented in this section. The table below provides many of the PVSYST inputs required in the simulation.

Table 2: PVSYST Input Parameters

Input Parameter	Value	Comment
PVSYST Software Version		
Transposition Model		
Meteorological File		It is critical that the time stamp and other parameters are accurately accounted for when importing meteorological data. Data import files and techniques shall be documented and provided with

Input Parameter	Value	Comment
		the Performance Test Report.
Latitude / Longitude		
Altitude [m]		
Ground Albedo		
Array Orientation (PVSYST Field Type)		
Tilt		
Azimuth		0° is due South
Tracker Backtracking		
Min / Max Rotation Angle		
Number of sheds		
Ground Cover Ratio (GCR)		
Pitch [m]		
Collector width [m]		
Inactive band, Left (m)		
Inactive band, Right (m)		
Near Shading Type		
Electrical Effect		
Number of strings in row width		
Horizon		
Module Type		
Qty. of modules		
Qty. of modules per string		
Qty. of parallel strings		
Inverter Type		
Qty. of inverters		
Heat Transfer: Constant loss factor		
Heat Transfer: Wind loss factor		
DC circuit ohmic loss at STC		
Module Bifaciality factor	Off	Gain from bifacial module as per manufacturer specsheet
Module Quality	MQ - CTBG	CTBG is calculated during the capacity test and MQ is typical module quality factor that is used in the modeling
Mismatch [%]		
LID – Light Induced		

Input Parameter	Value	Comment
Degradation [%]		
Soiling Loss [%]	1%	1% soiling to be assumed for test unless a soiling station is installed. Then the soiling station soiling will be used.
Incidence Angle Modifier Factors or ASHRAE b0 value		User defined profile
AC circuit ohmic loss at STC		If modeled in PVSYST
External Transformer No Load Loss [%]		If modeled in PVSYST
External Transformer Full Load Loss [%]		If modeled in PVSYST
External Transformer Nighttime disconnect		If modeled in PVSYST

3.7.3.2. There are many additional settings required to recreate PVSYST files such as meteorological data import techniques, module file [PAN], inverter file [OND], etc. PVSYST version and model files will be placed in escrow to perform simulation. The files to be included in escrow include (a) all files listed in Table 2 of this Appendix 2 of Exhibit K.1, and (b) a copy of PVSYST version X.

3.7.4. Additional Losses (Post-Processed Loss)

3.7.4.1. There are multiple losses associated with an operating Project that may not be accounted for in PVSYST. Such losses include night-time demand of inverters, as well as auxiliary loads including but not limited to HVAC, lighting, security, SCADA, etc.

3.7.4.2. These losses have been included in the modeled power generation, the details of which are defined in the table below.

Table 3: Model Additional Loss

Parameter	Value	Comment
AC circuit ohmic loss [%]		
External Transformer Iron loss [%]		
External Transformer Resistive loss [%]		
External Transformer Nighttime disconnect		
Availability loss [%]		Not Included in Project Capacity Model
Curtailment loss [%]		Not included in Project Capacity Model
Auxiliary Loads [%]		

Parameter	Value	Comment
Nighttime Loads [%]		

3.7.5. Reporting Conditions and Target Capacities Identification

3.7.5.1. The Monthly Reporting Conditions and Target Capacities are to be specified below. Table 4 will be completed by Contractor and approved by Owner once the Project Capacity Model is complete. The following algorithm is recommended for identifying Reporting Conditions.

3.7.5.1.1. The Reporting Conditions shall be determined based on measured data set. Data records shall include the measured POA irradiance, ambient temperature and wind speed input parameters, as well as any simulated auxiliary parameters necessary for marking data records according to the primary data exclusion criteria.

3.7.5.1.2. Apply the primary data exclusion criteria identified in Section 3.3.8 of this procedure to the measured data records. (The secondary data exclusion is not applied.)

3.7.5.1.3. Grouping the remaining data records by month, compute the median values of incident plane-of- array irradiance, ambient air temperature, and wind speed. The reporting condition for plane-of-array (POA) irradiance shall not be less than 400 W/m².

3.7.5.1.4. Round median irradiance to the nearest integer W/m², median temperature to the nearest °C, and corrected median wind speed to the nearest 0.1 m/s. Use values as reporting conditions in Table 4.

3.7.5.1.5. Procure PVSyst hourly output from the Project Capacity Model. Project Capacity Model shall include following parameters:

- Soiling, Availability and Curtailment Losses shall be assumed 0%
- Module Quality Factor shall be adjusted with Capacity Test Bifacial Gain (CTBG) for bifacial modules
- Bifaciality factor in PVSyst simulation shall be turned off

3.7.5.1.6. The PVSyst hourly output, after post-processing, must contain at a minimum the plane of array irradiance, the ambient temperature, wind speed, inverter energy output, modeled power generation, shade loss, and clipping loss (GlobInc, TAmb, WindVel, EOutInv, POI Limited, ShdBLss, and IL Pmax) respectively.

3.7.5.1.7. Apply the data exclusion criteria identified in Section 3.3.8 to the simulation data records.

3.7.5.1.8. Compute regression coefficients and Target Capacity for the month(s) of the test. If the Capacity Test overlaps two months a weighted average based on the proportion of Qualifying Data points for each month will be used to calculate the Target Capacity.

Table 4: Example Monthly Reporting Conditions and Target Capacities Table

Month	Reference POA Irradiance (W/m^2)	Reference Ambient Temperature (°C)	Reference Wind Speed (m/s)	Target Capacity (kW)

Month	Reference POA Irradiance (W/m^2)	Reference Ambient Temperature (°C)	Reference Wind Speed (m/s)	Target Capacity (kW)

3.8. Appendix 3: Capacity Test Calculator

3.8.1. The table below provides the file names for all files needed for the Capacity Test Calculator. Contractor shall provide the Project Capacity Model Hourly Data file once the Project Capacity Model is complete. If the Project design changes significantly, the Project Capacity Model Hourly Data shall be updated by the Contractor to reflect the As Built design and such updated Project Capacity Model Hourly Data shall be submitted to the Owner for review and approval. All Changes to Project Capacity Model shall be documented and approved by the Owner.

Table 1: Capacity Test Calculator Files

File Name	File Type	Comments
Capacity Test Calculator	**.xlxs**	Used to calculate reporting conditions, regression coefficients, Measured Capacity, and Target Capacity values
Project Capacity Model Hourly Data	**.csv**	Hourly Plane of Array (Global Incident in PVSYST), Ambient Temperature, Wind Speed, and Energy (after post processing, as necessary)