

Appendix 4

to

Solar BOT Scope Book

Rev. 0

September 14, 2023

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| REVISION RECORD |
| Revision No.  | Approval Date | Section / Page Revised  | Reason / Description of Change |
| 0 | 9/14/2023 | All | Initial Issue |
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# Appendix 4: Energy Model

The following table will be used to establish Seller’s bid basis in regard to the PV Plant performance and estimated annual Energy Yield. Seller shall complete all of the information requested in the below table in order to establish said basis of their bid. These Energy Yield model inputs, once agreed to and finalized as part of the Agreement will form the basis of the Appendix 7 – Performance Test Plant Capacity Model inputs, except as modified in Appendix 7 to account for adjusted system losses which are applicable at the time of the test vs. the assumed annual Energy Yield, such as soiling losses and module degradation / Light Induced Degradation (LID).

Once Seller and Buyer agree to the inputs, any Seller change in the inputs that may decrease performance must be approved by Buyer.

Refer to examples in Table 1 below for guidance on various testing scenarios:

Table 1: Energy Model Examples

|  |  |  |
| --- | --- | --- |
| Input | Annual Energy Yield Estimate Model | Plant Capacity Model |
| Soiling Rates | Include reasonable/agreed to monthly soiling profile estimates for the year. | Soiling stations’ measurements are averaged during test period and then entered into all of the monthly averages for the model. |
| LID  | Year-1 guaranteed module losses less the Year 2 – 30 annual degradation (Year-1 = 2.00% / 0.45% Annual, so modeled LID would be 2.00 – 0.45 = 1.55%) | Module manufacturer guidance for LID test data may be used. This can be adjusted down from the guaranteed rate, to remove the margin included in the OEM warranty rates. 50% of the LID warranty rate or 1.0% have been accepted values in the past.Annual Degradation is then added to this value as the average installed life of the modules on the site. e.g., average installed duration for the modules is 6 months, add on 0.45% \* 6/12 = 0.225%, overall LID = 1.225% |
| Annual Degradation | OEM Guaranteed Rate (e.g. 0.45%) | 0.00% (included in LID) |
| Module Quality  | If flash test data is not available, 25% of the positive bin tolerance. e.g., 625W module +5/-0 bin tolerance. 5/625 = .008 = 0.8%, so take 25% of that and it gives you a -0.2% module quality model input value.  | Actual average positive binning tolerance based on flash test results. So if average flash test for all modules was +2.5W then you would use 2.5/625 = .004 = 0.4% or a -0.4% modeling input for the capacity test. |

|  | **CERTAIN ENERGY MODEL INPUTS** |
| --- | --- |
| **Nº** | **CHARACTERISTICS** | **UNITS** | **DATA** |  | **NOTES** |
| **1** | **REFERENCE SITE CONDITIONS** | - | Bid Basis – Annual Energy Yield Estimate | Performance Test Plant Capacity Model |  |
| 1.1 | Annual Global Horizontal Insolation (GHI) @ ground level | kWh/m²/year |  |  |  |
| 1.2 | Annual Diffuse Horizontal Insolation (DHI) @ ground level | kWh/m²/year |  |  |  |
| 1.3 | Altitude (above sea level) | ft |  |  |  |
| **2** | **WEATHER DATA** | - |  |  |  |
| 2.1 | Data source | - |  |  |  |
| 2.2 | Period of data collection | months |  |  |  |
| 2.3 | Distance from site or spatial resolution | km |  |  |  |
| 2.4 | Uncertainty | % |  |  |  |
| **3** | **MODEL PARAMETERS** | - |  |  |  |
| 3.1 | Installed Capacity (DC) | MWp |  |  |  |
| 3.2 | Nominal Power (AC) | MW |  |  |  |
| 3.3 | Nominal Power at Electrical POI (AC) | MW |  |  |  |
| 3.4 | DC/AC ratio | - |  |  |  |
| 3.5 | PVsyst Software Version (should be as bid) | - |  |  |  |
| 3.6 | Transposition Model | - |  |  |  |
| 3.7 | Meteorological File Parameters (should be as bid) | - |  |  | Interval end is preferred |
| 3.8 | Post Processed Losses | % |  |  |  |
| 3.9 | **PV Modules** | - |  |  |  |
| 3.9.1 | PV module manufacturer and model | - |  |  |  |
| 3.9.2 | PV module power at STC | Wp |  |  |  |
| 3.9.3 | Technology | - |  |  |  |
| 3.9.4 | Number of PV Modules per string | - |  |  |  |
| 3.9.5 | Total number of PV Modules installed | - |  |  |  |
| 3.9.6 | Total number of strings | - |  |  |  |
| 3.10 | **Inverters** | - |  |  |  |
| 3.10.1 | Inverter manufacturer and model | - |  |  |  |
| 3.10.2 | Input voltage rating | Vdc |  |  |  |
| 3.10.3 | Number of strings per inverter | - |  |  |  |
| 3.10.4 | Number of inverters | - |  |  |  |
| 3.11 | **Mounting System** | - |  |  |  |
| 3.11.1 | Tilt angle of rotation limits of tracking system | ° |  |  |  |
| 3.11.2 | Backtracking | Yes / No |  |  |  |
| 3.11.3 | Orientation of PV Modules (azimuth) | ° |  |  |  |
| 3.11.4 | Installation type (portrait / landscape) | - |  |  |  |
| 3.11.5 | Rows and columns per mounting structure | - x - |  |  |  |
| 3.11.6 | Ground Coverage Ratio | % |  |  |  |
| 3.12 | **Array losses** | - |  |  |  |
| 3.12.1 | Module quality loss | % |  |  | See example in Table 12 |
| 3.12.2 | Module mismatch losses | % |  |  |  |
| 3.12.3 | String mismatch losses | % |  |  |  |
| 3.12.4 | Light induced degradation losses | % |  |  | Refer to example in Table 12 |
| 3.12.5 | IAM losses defined by manufacturer | Yes / No |  |  |  |
| 3.12.6 | Constant thermal loss factor | W/m2/k |  |  |  |
| 3.12.7 | Wind loss factor | W/m2/k/m/s |  |  |  |
| 3.12.8 | Soiling lossesJanuaryFebruaryMarchAprilMayJuneJulyAugustSeptemberOctoberNovemberDecember | % |  |  | Refer to example in Table 12 |
| 3.12.9 | Ground AlbedoJanuaryFebruaryMarchAprilMayJuneJulyAugustSeptemberOctoberNovemberDecember |  |  |  | Average Annual and Monthly |
| 3.12.10 | Spectral correction applied | Yes / No |  |  |  |
| 3.13 | **Cabling** | - |  |  |  |
| 3.13.1 | DC ohmic losses @STC (Max/Calculated) | % |  |  |  |
| 3.13.2 | AC ohmic losses @STC (Max/Calculated) | % |  |  |  |
| 3.14 | **Transformers** | - |  |  |  |
| 3.14.1 | Transformer type | - |  |  |  |
| 3.14.2 | Number of transformers | - |  |  |  |
| 3.14.3 | Constant Loss | W |  |  |  |
| 3.14.4 | Peak Power Loss | W |  |  |  |
| 3.15 | **System losses** | - |  |  |  |
| 3.15.1 | Year 1 (starting at the Substantial Completion Payment Date) degradation | % |  |  |  |
| 3.15.2 | Annual degradation | % |  |  | Refer to example in Table 12 |
| 3.15.3 | Light soaking effect | % |  |  |  |
| 3.15.4 | Inverter losses | % |  |  |  |
| 3.15.5 | Auxiliary losses | % |  |  |  |
| 3.15.6 | Unavailability | % |  |  |  |
| 3.15.7 | Combined Uncertainty | % |  |  |  |
| **4** | **ANNUAL PERFORMANCE RESULTS** | - | **PVsyst Results** | **Final Results** | Final Results include all post-processing work (assume 0% unavailability for model) |
| 4.1 | Net electricity production (P50) | MWh/yr |  |  |  |
| 4.1.3 | 30-year average, P50 | MWh/yr |  |  |  |
| 4.2 | Specific Yield (Year 1, starting at the Substantial Completion Date, P50) | kWh/kWp/yr |  |  |  |
| 4.3 | Performance Ratio (Year 1, starting at the Substantial Completion Date, P50) | % |  |  |  |

**\*\*\* END OF APPENDIX 4 \*\*\***