Appendix 1

Resource Assessment and Energy Production Estimate Requirements

Proposers are required to provide a Resource Assessment and an Energy Production Estimate for the Bid Facility that fulfills the technology-specific Viability Threshold requirements listed below. The requirements for the Bid Facility Resource Assessment and Energy Production Estimate are based on the Bid Facility's technology (see technology specific sections below) and are comprised of:

1. A Resource Assessment, which approximates the renewable resource typically available on an annual basis to power the Bid Facility.

2. An Energy Production Estimate, which estimates the Bid Facility's ability to convert the renewable resource to electric power at the P(50)[1] level.

The Resource Assessment and Energy Production Estimates must be consistent with and representative of the Bid Facility, the long-term conditions at the site, and if applicable, Energy Storage as proposed to NYSERDA. The Bid Quantity may not exceed the P(50) long-term Energy Production Estimate.

Bid Facilities including co-located Energy Storage shall include a P(50) Energy Production Estimate that considers Energy Storage for the Bid Facility, including anticipated losses resulting from the addition of Energy Storage. Solar facilities including Energy Storage must specify if the Energy Storage is AC or DC coupled.

Solar

Minimum Threshold

The Resource Assessment is a report that should consist of the following components:

1. An analytical evaluation of at least three (3) but ideally five or more sources of measured data at a nearby meteorological station or via satellite-based models which are within 50 km of the Bid Facility.

2. Consist of the following base meteorological data:

    i. global horizontal irradiance (GHI)
    ii. diffuse irradiance (DIF),
    iii. direct normal irradiance (DNI)
    iv. ambient temperature (T)

[1] P(50) represents a level of resource projection or production estimate with a 50% likelihood of being exceeded in any future year. The P(50) value shall be the expected value (*i.e.*, the mean) based on the Proposer's Resource Assessment diligence in accordance with the minimum requirements listed in the section herein for the respective renewable technology.

3. Table with a column for each annual mean value per meteorological data source along with the number of years measured by the data source.

4. Identification of the meteorological source was found to be most representative of the site and describe why it was selected for use in the Energy Production Estimate. Statement on the completeness, reliability, and percent of certainty associated with the data.

5. Resource Assessment requirement can be met with a combination of any of the following:

   i. NREL or similar government issued dataset Typical Meteorological Year (TMY2)[2] or National Solar Radiation Database (NSRDB) 1991-2010 (TMY3)[3] data from a site 50km or closer to the Bid Facility location.

   ii. A satellite-based resource estimate using Meteosat, GMS, GOES or AMTSAT or similar data (*e.g.*, 3 Tier (now Vaisala); Solar GIS; SolarAnywhere or Meteonorm.

   iii. At least one year of hourly measured site data. The measured data must be annually and climatologically adjusted via one or more high quality, long-term[4] reference station or data sets.

The Energy Production Estimate is a report that which characterizes how well the Bid Facility will convert solar radiation into electric power on a project lifetime scale consistent with the Bid Proposal from a system performance model, using industry standard tools such as PVSyst or equivalent. The Proposer should include initial estimated inputs, parameters and technical losses, and describe the methods employed to estimate the losses, or the assumptions made to assign initial values. Any losses not accounted for in the performance model software are documented in a post-production loss summary section of the report and reflected in the net energy production estimate and net capacity factor percentage. The report outline for the Energy Production Estimate shall include:

1. Executive Summary: briefly describe the location, facility capacity, P50 net energy (MWh), specific yield (kWh/kWp), net capacity factor;

2. Introduction: describe the methods and software employed for assessing gross and net energy production, stage of the engineering design modeled;

3. Solar Resource Selection: insert the Resource Assessment report here;

4. System Configuration: tilt, azimuth, pitch, collector width, shade limit angle, ground coverage ratio, module and inverter manufacturer and model numbers, quantity of modules in series, quantity of strings per inverter, quantity of inverters;

5. System Loss Factor Inputs: albedo factor, electrical effect, transposition model, array soiling, thermal loss factors, DC ohmic loss, light induced degradation, module quality, module

[2] Available from NREL by State http://rredc.nrel.gov/solar/old_data/nsrdb/1961-1990/tmy2/State.html
[3] Available from NREL http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2010/
[4] Long-term conditions are considered to be 10 years or more of data.

mismatch, string mismatch, incidence effect, AC ohmic loss, transformer, auxiliary, grid limitations, and availability;

6. Energy Estimate Losses: Irradiance values (global incident in collector plane, near shadings loss %, incidence angle modifier loss %, soiling loss factor %); PV system(loss due to irradiance level %, loss due to temperature %, electrical loss according to strings %, module quality loss %, light induced degradation %, array mismatch loss %, DC ohmic loss %); Inverter Losses (loss during operation %, loss over nominal inverter power %, loss due to power threshold %, loss over nominal voltage %, loss due to voltage threshold %, night consumption loss %); Other (AC ohmic loss %, external transformer loss %, other);

    - If bifacial module technology is being proposed, provide the additional Energy Production Estimate loss values: ground reflection on front, global incident on ground, ground reflection loss %, view factor from rear %, sky diffuse on rear %, beam effective on rear %, shadings loss on rear %, effective irradiation on rear %, and bifaciality factor.

Exceeding the Threshold: The Resource Assessment is produced using a dataset with low uncertainty data set (*e.g.*, using a Global Horizontal Irradiance (GHI) resource data set with less than or equal to 5% uncertainty) and location proximate to Bid Facility location (*e.g.*, within 5 km of the Bid Facility project site).

The Energy Production Estimate is based on the Resource Assessment, and includes:

1. Use of an advanced performance model, such as: PVSyst (v.6 or later);

2. System loss factors which are representative of an engineering drawing set. An acceptable engineering drawing set includes a constrained site layout that shows the proposed Bid Facility's equipment with recent aerial imagery underlain, parcel boundaries and topography of the site and typically includes civil and electrical sheets which have been issued for permitting purposes. The engineering drawing set is provided as an attachment.

3. Monthly soiling loss profile that reasonably captures the effects of measured historical winter snowfall, rainfall patterns and other site-specific soiling factors (*e.g.*, pollen, agricultural airborne particulates, or other);

4. A detailed near shading scene that accounts for the designed row pitch, module configuration, collector widths, tilts, topography of modules and near shadings (*e.g.*, trees, buildings, transmission lines or other);

5. Far-shadings horizon profile representative of the Bid Facility site location;

6. Expected efficiency as a result of bifacial panels, if applicable;

7. System loss factors are expanded to include auxiliary and parasitic loss %, availability loss %, if applicable curtailment/operational loss % due to Utility/Transmission Operator requirements (*e.g.*, deliverability limitations, VAR/Power Factor support, or other losses);

8. An uncertainty analysis that includes an initial estimate of Bid Facility net energy uncertainty, including projected annual degradation % profile;

9. Description of the planned operations and maintenance activities which allow the Bid Facility to achieve the modeled soiling loss assumptions (*e.g.*, planned module washings, snow removal, or other);

10. Major equipment datasheets (panels, inverter and mounting system); and

11. An 8760 hourly profile of the Energy Production Estimated for each operating year of the proposed contract tenor.

Wind

Minimum Threshold:

The Resource Assessment characterizes the Bid Facility's wind resource using either measured data or modeled data.

1) Measured Data: Wind and temperature measurements that are taken at elevations below the planned hub height must be extrapolated to represent hub height speed, direction and air density conditions. Measurement campaigns must include least six (6) continuous months of observed wind data on the site. The measured characteristics must be annually and climatologically adjusted via one or more high quality, long-term[5] reference station or data sets. If measured data is used, the Resource Assessment must include, but is not limited to, the following:

    i. Measured data summary per meteorological tower including measurement period, long-term wind speed at hub height, and wind frequency and energy rose; and

    ii. Map including proposed turbine layout, meteorological tower location(s), and wind speed at hub height adjusted to on-site date.

2) Modeled Data: Modeled data must be representative of long-term average Bid Facility conditions at hub height. If modeled data is used, the Resource Assessment must include, but is not limited to, the following:

    i. Modeled wind frequency and energy rose; and

    ii. Map including proposed turbine layout, meteorological tower location(s), and modeled wind speed or existing validated wind speed map at hub height produced by an experienced 3rd party.

The Energy Production Estimate characterizes how well the Bid Facility will convert available wind into electric power. The Energy Production Estimate is presented on an annual and/or a project lifetime scale consistent with the Bid Proposal. It must be based upon the Resource Assessment and combined with an assumed project configuration consistent with the Bid Facility that must include, but is not limited to, the following:

[5] Long-term conditions are considered to be 10 years or more of data.

1) Turbine specific details including manufacturer, model, hub height, rotor diameter, rated capacity, and number of turbines;

2) Energy output details including capacity, average hub height wind speed, P50 net energy, and net capacity factor;

3) Initial loss details including methods employed to estimate the losses, or the assumptions made to assign initial values. Initial estimated technical losses include wake effects, availability, electrical, turbine performance, environmental, and curtailment/operational strategies.

Exceeding the Threshold:

The Resource Assessment should characterize the long-term hub-height wind conditions across the Bid Facility area and include:

1) Monitoring Campaign: One (1) full year of data at the Bid Facility site with meteorological towers at least 2/3 of planned hub height of Bid Facility turbines. Towers must be equipped with 1) high quality wind speed, direction and temperature sensors or 2) sonic detection and ranging (sodar) and/or light detection and ranging (lidar) remote wind speed sensors.

2) Data Analysis: Independent 3rd-party description of methods used to perform 1) climatological data adjustment with one or more specified high quality reference stations 2) quality control, assurance and validation including adjustments performed to treat erroneous, bad, and/or suspect measurements (*e.g.*, removal and/or treatment of sensor failure, icing, tower shadow, *etc.*), 3) data gap reconstruction, and 4) sensor measurement adjustment. Description should include reference stations used, the relationship(s) with the observed data, and assessment of their quality.

3) Vertical and Horizontal Extrapolation: Description of the 1) vertical extrapolation method and results in the context of the observations on site and the regional climatology, and 2) wind flow modeling approach, that includes the model(s) used, model configuration and input data, use of onsite data and estimate of the model performance at the site.

4) Measured Data Summary per Meteorological Tower: meteorological tower location and elevation, measurement height, measurement period, average wind speed at measurement height, long-term wind speed at hub height, and wind frequency and energy rose.

5) Map: Include turbine layout, meteorological tower location(s), wind speed at hub height adjusted to on-site data, and surrounding wind farm locations, if applicable.

The Energy Production Estimate is based on the Resource Assessment and includes at least 10 years of long-term average wind resource combined with a Bid Facility specific project configuration (*i.e.*, turbine characteristics, layout, site conditions, and losses). The Energy Production Estimate is based on an hourly P(50) 8760 schedule that considers long-term, net energy production presented on an annual and/or Bid Facility life time scale. The Energy Production Estimate must include:

1. Turbine specific details including manufacturer, model, hub height, rotor diameter, rated capacity, and number of turbines;

2. Energy output details for the full wind farm and on a per-turbine basis including hub height wind speed, P50 gross energy, P50 net energy, and net capacity factor;

3. Detailed description of the methods and/or software employed for assessing gross and net energy production, including the wake model used. Eligible software packages include, but are not limited to:

    i. OpenWind: https://aws-dewi.ul.com/software/openwind/
    ii. Wind Farmer: https://www.dnvgl.com/services/windfarmer-3766
    iii. WindPro: https://www.emd.dk/windpro/
    iv. WindFarm: http://www.resoft.co.uk/

4. Turbine performance characteristics defined as accurately as possible for site conditions, including air density-adjusted power curves, cut-out and restart values, special operating packages (*e.g.*, cold temperature packages), and any other site-specific operational characteristics;

5. Brief description of surrounding wind farms and their wake impacts on the Bid Facility;

6. Detailed estimates of wind resource and energy production uncertainties, including a total uncertainty on the net energy estimate;

7. Curtailment criteria estimation including any known or expected curtailments associated with permitting (*e.g.*, bat curtailments, noise curtailments), or grid conditions (*e.g.*, grid-mandated curtailments);

8. Detailed estimates of Bid Facility-specific technical losses and/or efficiencies associated with the six standard loss categories listed below. The Proposer should describe the methods employed to estimate the losses and any effects of proximate operating and/or under development large-scale wind facilities. The defined values must be aggregated into a total loss value that is used to convert gross energy generation estimates to net energy production estimates. Loss categories are as follows:

    i. Wake Effects: includes the internal wake effects of the proposed Bid Facility turbines, as well as the effects of any existing or planned projects in the vicinity.

    ii. Availability: includes losses associated with the availability of the Bid Facility wind turbines, balance of plant and the grid.

    iii. Electrical: includes the electrical efficiency of the Bid Facility between the low or medium voltage side of the wind turbine transformer and the energy measurement point (meter), including any facility parasitic consumption.

    iv. Turbine Performance: includes all losses associated with any sub-optimal plant performance and expected deviations from the assessed power curve, along with any losses expected from the hysteresis loop between high wind cut-out and re cut-in.

v. Environmental: includes loss effects due to environmental parameters such as icing, blade degradation, high/low temperature shutdown, exposure changes, *etc.*

vi. Curtailment/Operational Strategies: includes the effects of curtailments, including any required for turbine loading, grid, or environmental permits. Also includes the effects of any other operator-defined operational strategies, not captured in the power curve.