SITE UTILITY ANALYSIS AND PROJECT SIZING

METHODOLOGIES

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CONTENTS

GLOSSARY

Certified Retail Electricity Supplier (CRES): A company that provides a competitive electric service in a deregulated electricity market.

Kilowatt-Hour Rate: The total cost of electricity for a billing period divided by the number of kilowatt-hours used within the billing period.

Long-Term: Describes a consecutive period of the most recent 30 years.

Marginal Cost of Energy (MCOE): The cost associated with using one additional kilowatt-hour over a billing period ($/kWh).

Measure-Correlate-Predict (MCP): A statistical technique that is used to create a simulated, long-term dataset by relating a concurrent short, measured target dataset to a long-term reference dataset.

Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA2): A satellite-derived long-term reanalysis data source from NASA. Contains 30+ years of global hourly reanalysis data, which include wind speed, direction, and temperature.

Net-metering: A billing mechanism for on-site generation where the net amount of energy used throughout the billing period is used to determine electricity costs. The consumer's meter can run forwards and backwards.

Power Curve: The relationship between the wind speed and power output of a specific wind turbine.

Prudent Wind Industry Practices: The practices, methods, specifications and standards of safety, performance, quality, dependability, efficiency, and economy generally recognized by industry members in the US as good and proper. Other practices, methods, or acts which, in the exercise of reasonable judgment by those reasonably experienced in the industry in light of the specific projects and facts known at the time a decision is made, would be expected to accomplish the result intended at a reasonable cost and consistent with applicable laws, reliability, safety, and expedition. Prudent Wind Industry Practices are not intended to be limited to the optimum practices, methods, or acts to the exclusion of all others, but rather to be a spectrum of good and proper practices, methods, and acts.

Public Utility Regulatory Policies Act (PURPA): Enacted in 1978, this Act was passed in part with the National Energy Act. It is meant to promote energy conservation and use of domestic and renewable energy sources.

Qualifying Facility (QF): Small power producers and cogenerators that comply with the definition established within 18 CFR Part 292.

Rate Schedule: A collection of pricing rules for a set of customers, typically based on facility demand needs and interconnection voltage. In electricity utilities, also referred to as a Tariff.

Rider: A temporary credit or charge that may appear on utility bills. Typically used to recover additional and unpredictable energy costs by the utility.

Wind Resource Assessment Report (WRA): Includes the site wind resource analysis, Gross AEP, and Wake Loss. The outcome is the Net Annual Energy Production.

1. INTRODUCTION

One Energy performs an electricity utility analysis to aid in project sizing and calculation information used within financial modeling of the project. Projects are sized to be compliant with state and federal laws, to determine if existing grid infrastructure is sufficient, to maximize financial viability, and to follow customer requirements. Project sizing also is dependent on whether net metering policy is applicable to the project. This methodology details how One Energy determines project size for a *Wind for Industry®* project.

The objective of this methodology is to allow for explanation and definitions of electricity utility costs and understanding of the factors that impact project sizing. Included in each section are the deliverables of the analyses for guidance in understanding the report within the Project Due Diligence Package **Appendix 4: Site Utility Analysis and Project Sizing**. The deliverables within the report from each section are designated in bold text throughout this document.

This Site Utility Analysis and Project Sizing Methodology is version 2021.0.

2. RATE ANALYSIS

A. MARGINAL COST OF ENERGY

The Marginal Cost of Energy (MCOE, $/kWh) is defined as the cost associated with using one additional kilowatt-hour (kWh) over the billing period. To determine the facility's MCOE, the rate schedule from the electric service provider is needed. The rate schedule is public information and can be found on the electric service provider's website or can be obtained directly from the electric service provider. Under the facility's specific rate schedule, a list of applicable tariffs and riders along with their amounts is recorded. Each tariff or rider is on either a per-kilowatt basis, a per-kilowatt-hour basis, or is a flat fee. The tariffs and riders only associated with the per-kilowatt-hour basis are combined to determine the amount charged specifically for energy from the electric service provider.

If the facility is within a deregulated electricity market and uses a Certified Retail Electricity Supplier (CRES), each total monthly bill is divided by the number of kilowatt-hours for that month. The results for all months are then calculated for the average generation cost. If the facility does not have a CRES, the generation cost should be either within the rate schedule or located on the electric service provider's bill.

The facility's MCOE is the combination of the generation cost and the kWh tariff/riders cost. Some riders are tiered rates, and adjusting the kWh needs by using a *Wind for Industry®* project will affect the MCOE. An MCOE will also be calculated using the expected grid energy needs while assuming no change in demand needs for comparison.

Also calculated, only for reference, is the Kilowatt-Hour Rate and the Demand Rate. These values are the total bill cost divided by the billed kilowatt-hours or billed kilowatts, respectively. These rates are often used in electricity cost assessments but are not the correct rate to use within financial modeling for a *Wind for Industry®* project.

B. FULL BILL COMPARISON

Using the monthly facility consumption and billing demands (see Section 3: Facility Load & Consumption), total expected electricity costs can be modeled both with and without a *Wind for Industry®* project. An assumption is made that the facility will not change rate schedules and the rider rates are from the current set of tariffs (no attempt is made to match sets of tariffs to the same period as the provided bills). These assessments use the most recent tariff for all estimated EDU electricity costs.

The months of provided bills are used as the 'Without Wind' reference. This includes costs from the EDU, CRES (if applicable), and any additional electricity costs that may be associated.

To calculate the 'With Wind' total electricity costs, the monthly P50 energy production values (see **Appendix 2: PPR**) are used as the expected wind production to offset the facility energy needs. If net-metering is available, the EDU electricity cost uses the net consumption (facility needs less the wind energy production) from the grid is used as the billing kWh value, while keeping the billing demand value constant. The net consumption value is used for CRES cost calculation (if applicable). The P50 energy production is used to calculate the costs associated to wind and then added to the new EDU electricity costs (and CRES costs if applicable) as the total electricity cost for the specified month.

If net-metering is not available, the facility usage for the specified month is used for EDU billing, while keeping billing demand constant. The same usage used for EDU billing is used for CRES cost calculation (if applicable). A credit is calculated for the specified month's energy sent back to the grid (see Section 4C: Overproduction Model) as a ratio for energy produced with the estimated avoided cost rate. The full P50 energy production is billed to the facility. The sum of the EDU costs, One Energy costs, CRES costs (if applicable) and the overproduction credit is the total electricity cost for the specified month.

The following information is presented in Site Utility Analysis and Project Sizing Section 2 – Rate Analysis:

1. **Facility electricity utility provider and rate class**
2. **Current facility MCOE, Kilowatt-Hour Rate, and Demand Rate**
3. **Figure of total electricity bill breakdown by per-kilowatt, per-kilowatt-hour, and flat fees**
4. **Table of total monthly electricity costs with and without wind (if applicable)**
5. **One-page summary of total monthly electricity costs with and without wind (if applicable)**

3. FACILITY LOAD & CONSUMPTION

One Energy uses the facility's annual consumption to determine project sizing. A facility's annual consumption is calculated by analyzing utility data and other information provided by the customer. Net-metered projects are generally sized not to exceed the facility's annual consumption.

If net-metering is not available for a project, interconnection is still possible though project sizing is affected. The project is sized to limit the energy exported back to the grid when the facility cannot use it. In this scenario, energy exported back to the grid is compensated at avoided cost rates instead of retail rates, which affects the project financial implications.

An additional load analysis will be needed to aid in project size determination if net-metering is not expected to be available for the project. A full year of meter interval data from the facility is necessary to show the load characteristics. The baseload is determined, and the monthly interval peak demand values are investigated. Analyses of estimated time sending power back to the grid is important for financials and project sizing. For more information on this model, see Section 4C: Overproduction Model.

Interconnection voltage is also an important piece of understanding the facility's current electricity needs. The interconnection voltage is the voltage at which the facility takes electricity at the tie-in point to the distribution grid. These voltages can indicate different rate classes from the utility, as well as different requirements for the electrical design.

The following information is presented in Site Utility Analysis and Project Sizing Section 3 – Facility Load & Consumption:

1) **Monthly energy consumption (if available)**
2) **Annual energy consumption**
3) **Single month peak demand**
4) **Current interconnection voltage**

4. PROJECT SIZING

A. REGULATORY LIMITATIONS

As stated previously, the electricity utility and State Utility Commission has regulations regarding distributed generation interconnection and how excess energy not used at time of generation is financially accounted for.

Searches within the electricity utility and the State Utility Commission will be required to note any limitations that would affect the project and its size. For example, in Ohio, State Codes require net-metering projects to be on land that is on or contiguous to the facility it will be tied into, which would affect potential locations for the project to be sited. How the project will be compensated for excess generation also plays into size. If full retail rates are available for excess generation, then the project is sized to not exceed the facility's annual consumption. If avoided cost rates are available for excess generation, then the project is sized to minimize the amount of power being sent back to the grid (see Section 4C: Overproduction Model). The information needed can be found on the electricity utility website within the Tariffs documents, and on the State's Utility Commission website which likely contains links to its State Statutory and Administrative Codes.

There are also federal, state, and local laws that may impact project sizing. An analysis will be performed to assess those laws on a state and project basis.

The following information is presented in Site Utility Analysis and Project Sizing Section 4A – Regulatory Limitations:

1) **If net-metering is applicable for this project**
2) **Statement if any electricity utility limitations on excess generation for distributed generation projects**
3) **Statement if any federal, state, or local law limitations**

B. SITING LIMITATIONS

The size of the project is also limited by the land area available to safely site the wind turbines. One Energy makes all efforts to have ownership of any land a project is sited on if not on customer land, so the land available to purchase may limit the number of wind turbines that may be safely sited. Within the turbine siting phase (see **Appendix 3: Project Siting**), assessments on which parcels of land to use are completed. A parcel is chosen during that phase dependent on many factors, such as price and facility vicinity. The facility may be able to accept more power, but based on the parcel assessments, the parcel used for project siting may require a reduction in turbines to be safely sited.

The following information is presented in Site Utility Analysis and Project Sizing Section 4B – Siting Limitations:

1) **Statement if land is a limiting factor.**

C. OVERPRODUCTION MODEL

One Energy has developed a statistical model to determine a site's wind energy production distribution which is then compared to a site's power load profile to determine approximately how much energy will be sent back to the grid annually. Typically, in the solar and wind industry, the amount of energy exported is determined by looking at hourly interval demand data at the facility and comparing it to the expected power output based on time of day. Assumptions are made that facility demand remains consistent throughout the year. Both the wind speed and facility demand are variable by month and should be treated as such. Instead of matching hour-by-hour demand and wind speed data, this approach utilizes distributions by month for both and applies statistics.

This model is used when the electricity utility does not allow for net metering, whether it is utility-specific or from the State's Utility Commission.

One Energy developed this model to determine how often power would be exported to the grid in each month, as well as annually, and the average amount exported per month.

Data Requirements

The model requires a full year of load (demand) data at the facility. A full year of load data is necessary to determine the seasonality of energy usage. If the full year is not provided, even though requested, it is assumed that there is no seasonality in the facility's energy usage and each month is determined to be the same full set of data.

The power curve used within Appendix A: WRA for energy production is needed for this analysis to find the most representative relationship between wind speed and power generation.

In addition to the load data and the turbine power curve, wind resource data at hub height is also needed for a minimum of one year. The simulated long-term dataset used within Appendix A: WRA that is used for energy produced is used here to create a normalized year-long hub height wind speed dataset.

Distribution Creation

The Overproduction Model is a purely statistical model that uses a Monte Carlo method. Two distributions need to be created for input into the statistical model: the facility's demand needs and the wind turbine power generation.

Facility Load Distribution

The facility load data is broken into twelve distinct monthly datasets. Each month generates its own distribution. A full year distribution is also calculated from the full year of load data.

Distributions are determined by binning the occurrences of demand values in 100-kilowatt bin intervals up to 100 kilowatts above the highest demand value recorded for the full year dataset. The bin value corresponds to the bin maximum. The binning of the demand data creates the true distribution of the demand profile, which is then converted into a cumulative distribution function of the demand profile using standard probability rules. This conversion is done for each months' dataset, as well as the full annual dataset. Each month has its own cumulative distribution function in relation to the demand data sets, in 100 kilowatt (kW) increments. Figure 1 shows an example of a month's worth of demand data counted and binned in 100 kW increments and the associated cumulative distribution function.

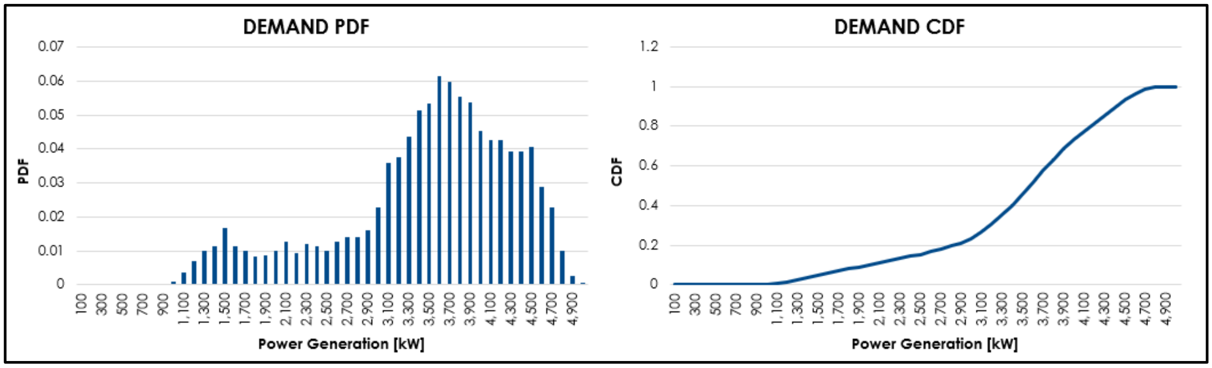

Figure 1: Load Distribution Example

If the full year of load profile data is not provided, the full demand data set provided is used to determine the cumulative distribution function in the same manner as previously stated. This cumulative distribution is assumed to be representative of each month, even if multiple months of demand data were utilized to create the distribution.

Wind Speed/Power Generation Distribution

The hub height wind speed dataset is split similarly by month. The wind speed distributions are determined by binning the occurrences of wind speeds in the same wind speed increments as the power curve, where the bin value corresponds to the bin maximum. This wind speed range is used due to typical power curve wind speed values. The true distribution of the wind speed is calculated by month and is then used to create the probability density function for each month. This probability density function is converted into the cumulative distribution function of the wind speeds using standard probability rules. Each month has its own cumulative distribution function in relation to wind speed, in the same wind speed increments as the power curve.

The wind speed distribution is translated into power generation distribution by using the manufacturer power curve. The corresponding power output is used in place of the wind speed value for each bin. Figure 2 shows an example of a specific month's worth of wind speed data counted and binned in one mile-per-hour increments, the related power generation probability density function, and the associated cumulative distribution function.

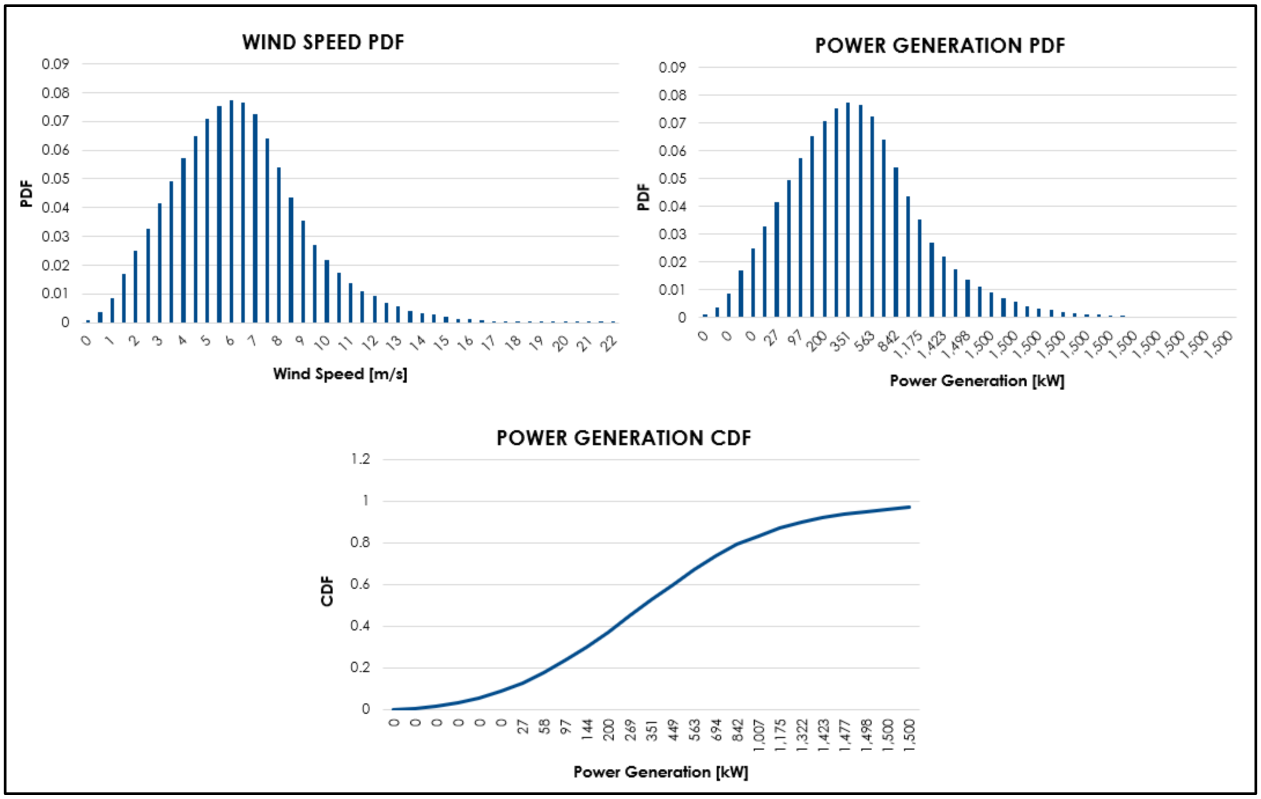

Figure 2: Wind Speed/Power Generation Distributions Example

Model

Determining the cumulative distributions for both the demand and wind speed data takes the time element out of the calculations. By looking at the distributions only, the analysis becomes strictly statistical with two unknowns within the model: the wind speed and the demand value. To see the distribution of the amount of power that will be consumed by the facility, as well as the amount of power that is generated by the wind turbine, a Monte Carlo method is used. Fifteen thousand trials are run for each month to determine a distribution of how much power will be needed from the grid in relation to what the wind turbine will be producing. That number of trials is chosen due to four degrees of freedom (n) within the model, so a minimum number of trials necessary would be 10^n. Because this model is not computationally expensive, the decision to run ($10^n + 10^n/2$) trials was made.

For each trial, two random numbers between zero and one are generated: one that is used for the wind turbine production submodel and one that is used for the facility consumption submodel. This ensures independence between the two submodels.

For the wind turbine production submodel, the generated random number is assumed to be the cumulative distribution value for the month currently being analyzed. The corresponding wind speed value is determined from the wind speed distribution of the current month analyzed and then matched with the power curve to determine the wind turbine power production for that run.

For the facility consumption submodel, the generated random number is assumed to be the cumulative distribution value for the month currently being analyzed. The corresponding demand value is determined from the demand distribution of the current month analyzed and is then considered the facility consumption for that run.

The net amount of demand needed from the grid is then calculated from the wind turbine production value and the facility consumption value. The net demand is calculated by:

$$C_{j,i} - G_{j,i} = D_{j,i}$$

where C is the facility consumption, G is the wind turbine generation, D is the net demand from the grid, j is the month, and i is the trial run number. If $D_{j,i}$ is a positive value, it is an indication that the facility is pulling extra power from the grid. If $D_{j,i}$ is a negative value, it is an indication that the facility will be putting power onto the grid.

The net demand is compiled after the fifteen thousand trials are completed for each month. With this net demand data set, a distribution can be determined in addition to how often power will be sent back to the grid. The percentage of time power is exported back to the grid is calculated by:

$$E_j = \frac{T_j}{n_j}$$

where E is the percentage of time exporting power back onto the grid, T is the count of the net demand values for month j where the net demand is less than zero, n is number of trials that did not produce undefined values, and j is the month. This is done for each month, as well as the full year.

Figure 3 shows a schematic of an example of one trial run for one month's analysis. Two random numbers were generated and applied to the cumulative distribution for both the demand and the power generation (wind speed converted to power via the power curve). The red circles are the values used for the facility consumption and the wind turbine generation to determine this trial's net demand.

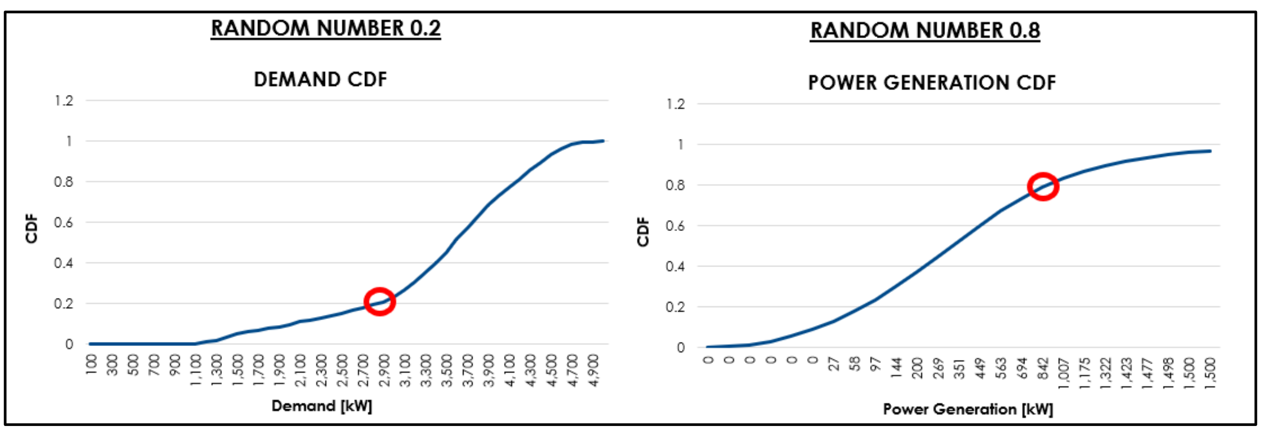

Figure 3: Example of a single trial simulation of the Monte Carlo Analysis

For each month, the percentage of time exporting power back to the grid is recorded as well as the average quantity of power exported back to the grid. The monthly quantity of power exported is calculated by multiplying the number of hours in the month, the average quantity exported to the grid for the same month, and the percentage of time exporting to the grid.

To obtain the average annual percentage of time exporting to the grid, the average of all month's percentage of time exported is calculated.

D. FINAL PROJECT SIZE

The project is sized dependent on all the factors discussed in this document. The turbine capacity and project siting are also factors when sizing a project.

All regulatory and land limitations must be adhered to when finalizing the project size. If the project will be net-metered, the anticipated consumption must be lower than the facility's energy consumption. If the project will be selling excess power back in real-time, then the project size is optimized to minimize the amount of power sent back monthly and to mainly offset the facility baseload.

The following information is presented in Site Utility Analysis and Project Sizing Section 4D – Final Project Size:

1) **Project size in megawatts**
2) **Number and capacity of turbines**
3) **Future MCOE with proposed project size**
4) **Expected electricity offset percentage**

5. CONCLUSION

One Energy completes a Site Utility and Project Sizing assessment that is necessary for project sizing and customer financials. Within this portion of the Project Due Diligence Package for a project, assessments of the interconnecting utility, the customer's electricity costs, as well as any regulatory or engineering limitations that may affect project sizing, are discussed. The result of the produced document is an appropriate project size in megawatts and a customer's Marginal Cost of Energy for use in financial modeling.