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6.10 On-Site Power Generation

Building projects may incorporate other on-site electricity generation equipment, such as cogeneration plants or fuel cells that make electricity and produce heat. Projects may also include wind turbines. These systems may be modeled in various ways and the building descriptors described below should be considered an example of one set. In all cases, the baseline building will be modeled without on-site generation equipment. If there is no thermal link between the power generation equipment and building equipment (such as heat recovery from CHP), on-site power generation can be modeled in a separate process, otherwise, it needs to be linked to the building simulation.

6.10.1 Photovoltaic Systems

Candidate buildings may have photovoltaic (PV) systems and the energy generated by these systems may offset the power used by HVAC, lighting, and other building systems. Since most PV systems work under a net metering arrangement whereby the utility grid is used as a storage battery, accepting excess energy when it is available and providing power back to the building at night and other times when the PV system is not generating, the simulation of PV systems need to be on an hourly time step so that it can be aligned with the building loads and the utility rate structure.

This section describes one set of building descriptors for specifying a PV system. This set of building descriptors is based on the five-parameter model[1]. Other models may be used for PV systems. The inputs apply only to the proposed design, as the baseline building is modeled without a PV system.

Configuration

This set of building descriptors addresses the overall layout and design of the PV system, including the orientation and slope of the collectors, how they are wired together, and how they are linked to an inverter that converts DC power to AC and synchronizes it with the grid.

PV System Name	
Applicability	All PV systems
Definition	A unique identifier that can be used to reference the PV system and associate it with the construction documents
Units	Text, unique
Input Restrictions	The name should provide a link to the construction documents.
Baseline Rules	None (PV not modeled for the baseline building)
Number of Modules in a String	
Applicability	All PV systems
Definition	This is the number of modules in a series string. Modules in series increase voltage which is often needed in order to match output voltage with the inverter requirements; modules in parallel increase current.
Units	Numeric: integer
Input Restrictions	As designed
Baseline Rules	None (PV not modeled for the baseline building)
Number of Strings	
Applicability	All PV systems
Definition	This is the number of strings of modules in parallel. Modules in series increase voltage; modules in parallel increase current.
Units	Numeric: integer
Input Restrictions	As designed
Baseline Rules	None (PV not modeled for the baseline building)
Collector Area	
Applicability	All PV systems
Definition	The area of the collector module.
Units	Square feet (ft²)
Input Restrictions	From manufacturer's specification
Baseline Rules	None (PV not modeled for the baseline building)
Slope	
Applicability	All PV systems
Definition	The slope of the collector modules relative to the horizontal.
Units	Degrees (°)

Input Restrictions	As designed
Baseline Rules	None (PV not modeled for the baseline building)

Azimuth

Applicability	All PV systems
Definition	The orientation of the collector modules relative to due North. An azimuth of 180° faces due south; 90° faces east, etc.
Units	Degrees (°)
Input Restrictions	As designed
Baseline Rules	None (PV not modeled for the baseline building)

PV Mounting Height

Applicability	All PV systems
Definition	The height of the collectors above the ground.
Units	Feet (ft)
Input Restrictions	As designed.
Baseline Rules	None (PV not modeled for the baseline building)

Shading

Shading of PV systems results in significant reduction of production and must be accounted for in an acceptable manner. A method is implied in the following building descriptors that is consistent with the NSHP Calculator[2]. With this method, the area around the solar system is divided into 22.5° cones and the height and distance to shading objects is entered for each quadrant. Other methods may be used, including use of the building shade inputs (see *building site characteristics* under *project data*)

Shading Azimuth

Applicability	All PV systems
Definition	A quadrant where the height and distance of shading objects is specified.
Units	List: ENE, E, ESE, SE, SSE, S, SSW, SW, WSW, W, WNW
Input Restrictions	As estimated from existing surrounding buildings and shading structures
Baseline Rules	None (PV not modeled for the baseline building)

Shading Object Height

Applicability	All PV systems
Definition	The height of the building or shading object in the 22.5° cone
Units	Feet (ft)
Input Restrictions	As estimated from existing surrounding buildings and shading structures
Baseline Rules	None (PV not modeled for the baseline building)

Shading Object Distance

Applicability	All PV systems
Definition	The horizontal distance from the shading object to the collectors
Units	Feet (ft)
Input Restrictions	As estimated from existing surrounding buildings and shading structures
Baseline Rules	None (PV not modeled for the baseline building)

Collector Performance

The collector performance can be characterized by the following five variables that are available from PV array manufacturers: the open-circuit voltage, the short-circuit current, the voltage and current at the maximum power-point, and the temperature coefficient of the open-circuit voltage. These are described below.

Short-circuit Current

Applicability	All PV systems
Definition	I_{sc} - current measured with zero voltage
Units	Amps
Input Restrictions	From manufacturer's specification
Baseline Rules	None (PV not modeled for the baseline building)

Open-circuit Voltage

Applicability	All PV systems
Definition	V_{oc} - voltage measured with an open circuit
Units	Volts
Input Restrictions	From manufacturer's specification
Baseline Rules	None (PV not modeled for the baseline building)

Maximum Power-Point Voltage and Current

Applicability	All PV systems

Definition	I_{mp}, V_{mp} - current and voltage at the maximum power-point condition. These parameters are typically reported at Standard Test Conditions of 1000 W/m2 and a cell temperature of 25°C.
Units	Amps and Volts
Input Restrictions	From manufacturer's specification
Baseline Rules	None (PV not modeled for the baseline building)

Open-circuit Temperature Coefficient

Applicability	All PV systems
Definition	V_{oc} - temperature coefficient at open-circuit voltage
Units	I/C
Input Restrictions	From manufacturer's specification
Baseline Rules	None (PV not modeled for the baseline building)

Short-circuit Temperature Coefficient

Applicability	All PV systems
Definition	V_{oc} - temperature coefficient at short-circuit current. This is supplied the manufacturer.
Units	V/C
Input Restrictions	From manufacturer's specification
Baseline Rules	None (PV not modeled for the baseline building)

Normal Operating Cell Temperature (NOCT)

Applicability	All PV systems
Definition	The normal operating cell temperature, typically between 45°C and 55°C
Units	Degrees Celsius (°C)
Input Restrictions	From manufacturer's specification
Baseline Rules	None (PV not modeled for the baseline building)

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1. De Soto, W., S.A. Klein, and W.A. Beckman, “Improvement and validation of a model for photovoltaic array performance”, Solar Energy, Volume 80, Issue 1, January 2006, Pages 78-88
2. More information is available at http://www.gosolarcalifornia.ca.gov/nshp/ [1].

6.10.2 Wind Systems

Wind systems produce electricity and their output depends on the availability of wind at the project site. Wind speed and direction is contained on the climate file used for the building simulation. The building descriptors below assume that the wind turbine is free to pivot to face the wind.

System Name

Applicability	All wind systems
Definition	A unique identifier that makes a link to the construction documents
Units	Text, unique
Input Restrictions	None
Baseline Rules	None (Wind not modeled for the baseline building)

Rated Output

Applicability	All wind systems
Definition	The rated output of the wind turbine at a given design condition, e.g. wind speed
Units	Kilowatts (kW)
Input Restrictions	As specified by the manufacturer
Baseline Rules	None (Wind not modeled for the baseline building)

Rate Wind Speed

Applicability	All wind systems
Definition	The wind speed at which the rated output is measured
Units	Miles per hour (mph)
Input Restrictions	As specified by the manufacturer
Baseline Rules	None (Wind not modeled for the baseline building)

Cut-in Wind Speed

Applicability	All wind systems
Definition	The wind speed above which the system will produce useful power
Units	Miles per hour (mph)
Input Restrictions	As specified by the manufacturer
Baseline Rules	None (Wind not modeled for the baseline building)

Part Load Performance

Applicability	All wind systems
Definition	The rated capacity gives the power production at one wind speed. The part load performance will generally be a curve that gives the output for wind speeds that are greater or lower than the rated wind speed.
Units	Data structure
Input Restrictions	As specified by the manufacturer
Baseline Rules	None (Wind not modeled for the baseline building)

6.10.3 Cogeneration and Fuel Cells

System Name	
Applicability	All cogeneration systems
Definition	A unique identifier that makes a link to the construction documents
Units	Text, unique
Input Restrictions	None
Baseline Rules	Not applicable
Rated Output	
Applicability	All cogeneration systems
Definition	The rated electric power that the cogenerator can produce
Units	Kilowatts (kW)
Input Restrictions	None
Baseline Rules	Not applicable
Rated Efficiency	
Applicability	All cogeneration systems
Definition	The efficiency of converting a fuel to electricity
Units	Unitless
Input Restrictions	None
Baseline Rules	Not applicable
Heat Production Rate	
Applicability	All cogeneration systems
Definition	The rate of heat production at the rated output
Units	Btu/h
Input Restrictions	None
Baseline Rules	Not applicable
Heat Temperature	
Applicability	All cogeneration systems
Definition	The temperature of the water produced
Units	Degrees Fahrenheit (°F)
Input Restrictions	None
Baseline Rules	Not applicable
Modulation	
Applicability	All cogeneration systems
Definition	The capability of the cogeneration system to modulate output with corresponding modulation of input energy and waste heat
Units	Data structure
Input Restrictions	None
Baseline Rules	Not applicable
Schedule	
Applicability	All cogeneration systems
Definition	A schedule that indicates when the cogeneration system will operate and perhaps at what capacity (if there is a means for modulation)
Units	Data structure: schedule, on/off or fractional
Input Restrictions	None
Baseline Rules	Not applicable

Source URL: http://www.comnet.org/mgp/content/610-site-power-generation

Links:
[1] http://www.gosolarcalifornia.ca.gov/nshp/