Rooftop Solar PV System Design and Optimization

Part 1.

Choose a site location within the continental US to focus on for this project. For your chosen location report the city and state, latitude and longitude coordinates in decimal degrees to the nearest 0.01, lowest historical temperature on record, average high temperature for the hottest month (all temperatures should be in ºC). The site weather.com offers good historical weather data for locations under the "monthly" tab.

Choose a roof mounted system size target between 2 and 10 kW to the nearest 0.1 kW. Choose a roof azimuth angle that deviates from due south by 6 to 15 degrees in either direction, and select one of the standard roof pitches below to use for all your system calculations. and other relevant items from the basic installer checklist. Use PV Watts to calculate and report the total annual hours of full sun at your location under the site conditions. Use the default PV Watts values for all other sections in the calculator.

Report the chosen system size (nameplate rating in kW), system azimuth angle, and system tilt, along with the calculated annual hours of full sun for this system setup at this location from PV Watts.

Roof pitch	**Roof Tilt in Degrees**
4/12	18.43º
6/12	26.57º
8/12	33.69º
10/12	39.81º
12/12	45º

Ans:

- Location: New York, NY Latitude: 40.73°
- Longitude: -74.02°
- Lowest Historical Temperature on Record: -26.11°C
- Average High Temperature for the Hottest Month: 28.89°C
- System nameplate rating: 4 kW
- System Azimuth Angle: 195°
- System Tilt: 26.57º
- Annual Hours of Full Sun: 1660.75 Full Sun Hours

Part 2-

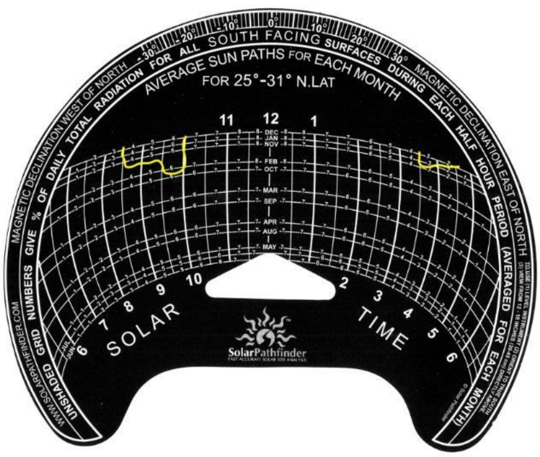
Calculating shading losses

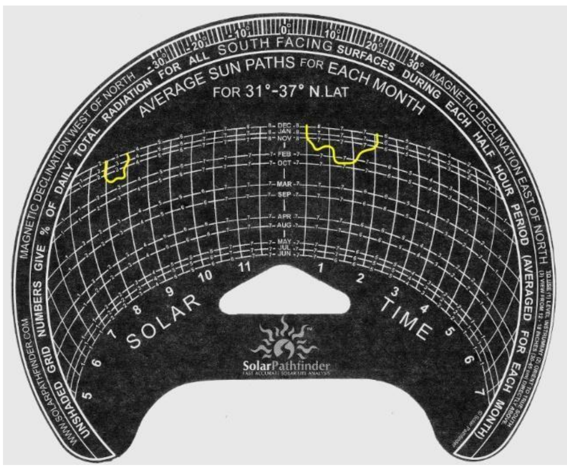
Select the solar pathfinder sheet below appropriate for use at your chosen location. The latitude range is included in the file name. Calculate percent of sunlight lost in each month with shading based on that solar pathfinder diagram.

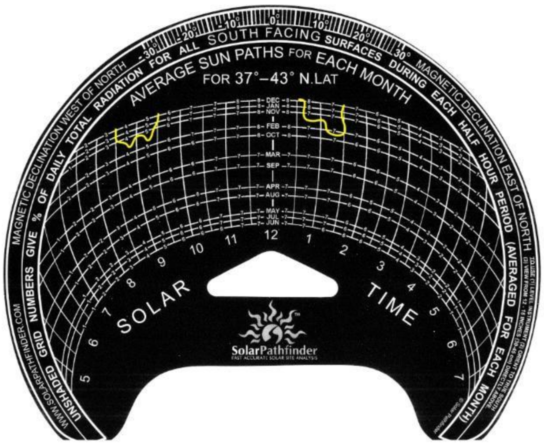
Create a table or spreadsheet with the following columns of information and calculations:

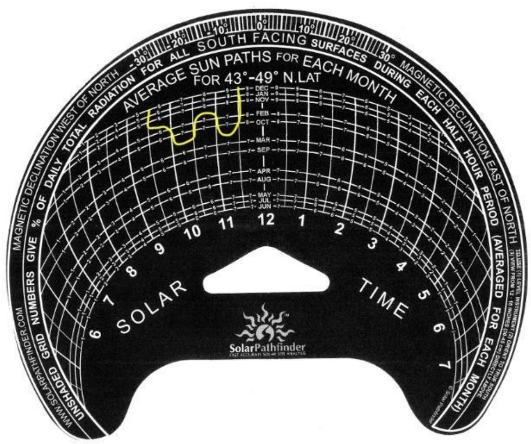
- Month= Include a row for each month starting in January, include an additional row at the bottom labelled Annual.
- Days= The number of the days in the month (or year in the Annual row).
- Daily solar radiation= The average daily solar radiation for each month from the PV Watts output for your particular location and system specs.
- Monthly solar radiation= The total solar radiation received each month (kWh/m² or full sun hours), and include the annual total in the last row.
- Shading= The portion of sunlight lost each month due to shading based on the solar pathfinder sheet, report as the decimal value rather than a percent. Use 0 for months that don't have any shading.
- Solar loss= The amount of the monthly solar radiation lost to shading in that month. Include the total of all the monthly shading losses in the Annual row.

Finally, calculate the annual percentage of sunlight lost due to shading relative to the same setup without shading to the nearest 0.1%. Include your calculated annual shading loss somewhere below your table with a label of "Annual Shading Loss". Also be sure to include the name of your location, the location's latitude, and which solar pathfinder sheet you used somewhere nearby to your table. Attach your completed table as a pdf in a single docum







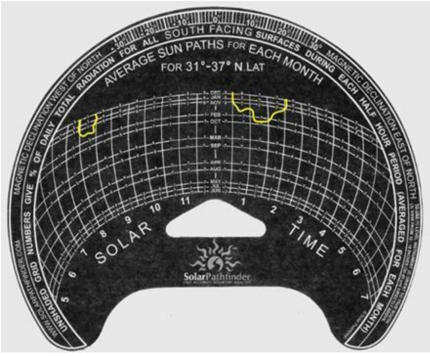


Ans:

Location:	New York, NY		
Latitude:	40.73	Longitude:	-74.02
Pathfinder sheet ID:	31°-37°		

Month	Days	Daily solar radiation	Monthly Solar Radiation	Shading %	Radiation lost due to shading
January	31	3.19	98.89	24	23.7336
February	28	4.02	112.52	7	7.8764
March	31	4.48	138.88	0	0
April	30	5.21	156.30	0	0
May	31	5.62	174.22	0	0
June	30	5.95	178.50	0	0
July	31	6.02	186.62	0	0
August	31	5.58	172.98	0	0
September	30	5.06	151.80	0	0
October	31	3.86	119.66	0	0
November	30	2.97	89.10	24	21.384
December	31	2.59	80.29	25	20.0725
Annual	365	4.55	1660.75	4.3996	73.0665

Annual Shading Loss	73.0665
Annual % Shading Loss	4.3996



Part 3:

Module Selection and Array Power

Choose a readily available polycrystalline PV module to construct your PV Array from among one manufacturer's linked below. You can choose any PV module, but include the following key specifications in your response in the text box: the company and specific model name, a link to the module specification sheet (usually pdf), along with the module's Voc, Vmp, Isc, Imp, Pmax, and voltage-based temperature coefficient (often listed as Temp. Coefficient of Voc). **Module manufacturers**

- SunPower (E-series)
- Trina Solar
- LG Solar
- First Solar (4 or 6 series)

Then, calculate the number of modules required to build a system as close to the target system size you chose in part 1. Calculate the actual system power nameplate rating in kW to the nearest 0.01 based on the PV module you have selected.

Inverter Selection

Next, identify a single matching inverter (not microinverter) that meets the input and output requirements for power and energy. Choose from the available manufacturers linked below. Include the following key specifications in your response: the company and inverter model name, a link to the inverter specification sheet, the number of series inputs, V input - max, Turn-on Voltage, I input - max, P input - max, P output - max. Note that sometimes inverter specifications may be towards the end of Technical or Installation guide documents. If the selected inverter specs are located in a long document also include the page number where the spec sheet is located within the document next to the link to the document. **Inverter Manufacturers**

- Fronius Primo
- SMA Sunny Boy
- SolarEdge single-phase

String sizing

Finally, determine the optimal configuration for connecting the panels of your array to the inverter. Be sure to include the number of strings connecting to the inverter, the number of modules connected together in series, and (if applicable) any parallel connections of modules or strings. For the connection(s) to the inverter, calculate the Vmp and Imp of the string as it connects to the inverter, the Isc of the string, and the cold and warm temperature voltages of concern for the string.

Make sure all your calculated connection specs will safely work with your selected inverter specifications. Always try to favor higher voltage over higher current if you have options. Ans:

Module

- Company: LG Solar
- Model: LG420QAK-A6
- Datasheet (https://www.lg.com/us/business/neon-r/lg-lg420qak a6#pdp_spec)
- Voc: 48.0
- Isc: 10.83 A
- Vmp: 41.3 V
- Imp: 10.19 A
- Pmax: 420.0 W
- Temp. Coefficient of Voc: -0.24 %/°C
- Modules to nameplate rating 4 kW: 10 modules

Inverter

- Company: Solar Edge Model: SE5000H-US
- Datasheet (se-hd-wave-single-phase-inverter-datasheet-na.pdf)
- V input – max: 480 V
- Turn – on Voltage: 211 V
- I input – max: 13.5 A
- P input – max: 7750 W
- P output – max: 5000 VA

String

- Number of String Connections: 1
- Number of Modules connected in series: 8
- Vmp of the String: 384 V
- Imp of the String: 10.19 A
- Isc of the String: 10.83 A
- Vmp due to Cold Weather: 53.89 V
- String output due to Cold Weather: 431.12 V
- Vmp due to Warm Condition: 37.94 V • String output due to Warm Condition: 303.52 V

All Specs will work safely.

Part 4.

NREL

NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at //sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

5,395 kWh/Year*

System output may range from 5,179 to 5,576 kWh per year near this location.

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	3.19	350
February	4.02	393
March	4.48	467
April	5.21	516
May	5.62	554
June	5.95	555
July	6.02	572
August	5.58	528
September	5.06	476
October	3.86	395
November	2.97	304
December	2.59	283
Annual	**4.55**	**5,393**

Location and Station Identification

Requested Location	New York, NY
Weather Data Source	Lat, Lng: 40.73, -74.02 1.3 mi
Latitude	40.73° N
Longitude	74.02° W

PV System Specifications

DC System Size	4.2 kW
Module Type	Standard
Array Type	Fixed (roof mount)
System Losses	15.32%
Array Tilt	26.57°
Array Azimuth	195°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4
Albedo	*From weather file*
Bifacial	No (0)

Monthly Irradiance Loss

Jan	Feb	Mar	Apr	May	June
0%	0%	0%	0%	0%	0%
July	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
0%	0%	0%	0%	0%	0%