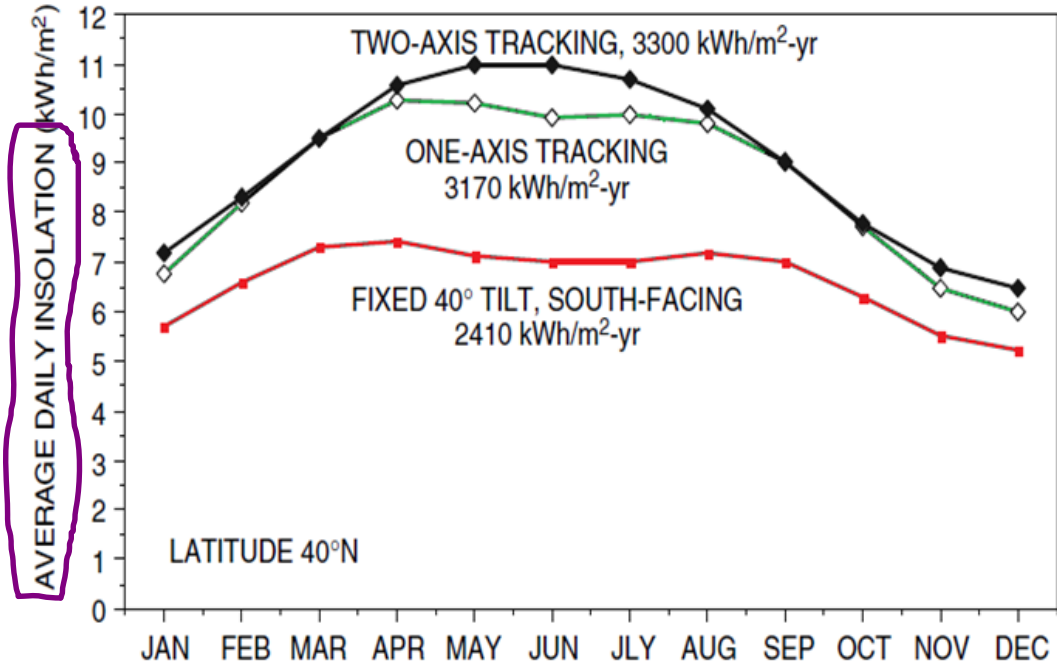


# Average Daily Insolation



Calculation is complex, so we need

- ❏ Pre-computed Data such as ***Solar Radiation Data Manual for Flat-Place and Concentrating Collectors*** (NREL, 1994): **AVERAGE DAILY INSOLATION** Per MONTH



## Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors

The *Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors* Individual PDF files are available for the main body of the manual. Compressed files containing the individual PDFS are available in the following formats: PC, Macintosh and Unix. [Maps](#) derived of the

The screenshot shows the OSTI.GOV website interface. The browser address bar displays the URL: <https://www.osti.gov/biblio/10169141-solar-radiation>. The page title is "OSTI.GOV / Technical Report: Solar radiation data manual for flat-plate and concentrating collectors". The main heading is "Solar radiation data manual for flat-plate and concentrating collectors". Below the heading, there are tabs for "Full Record" and "Related Research". The "Full Record" tab is active. On the left side, under "TECHNICAL REPORT:", there is a green button labeled "View Technical Report" and a link to the report: <https://doi.org/10.2172/10169141>. Below this, there is a "SAVE / SHARE:" section with options for "Export Metadata" and "Save to My Library". On the right side, under "Abstract", the text reads: "For designers and engineers of solar energy-related systems, the Solar Radiation Data Manual for Flat-Plate and Concentrating Collectors gives the solar resource available for various types of collectors for the US and its territories. The data in the manual were modeled using hourly values of direct beam and diffuse horizontal solar radiation from the National Solar Radiation Data Base (NSRDB). The NSRDB contains modeled (93%) and measured (7%) global horizontal, diffuse horizontal, and direct beam solar radiation for 1961-1990."

# Baltimore, MD

WBAN NO. 93721

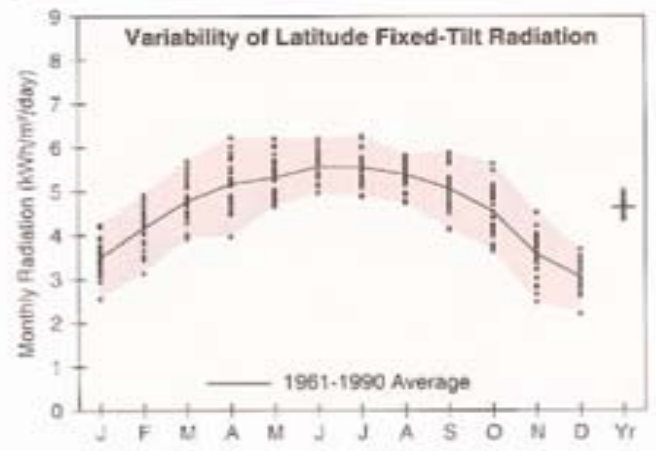
LATITUDE: 39.18° N

LONGITUDE: 76.67° W

ELEVATION: 47 meters

MEAN PRESSURE: 1012 millibars

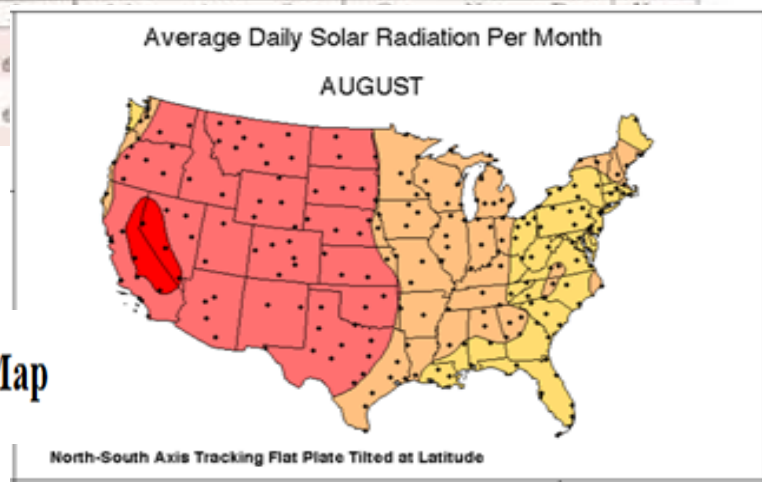
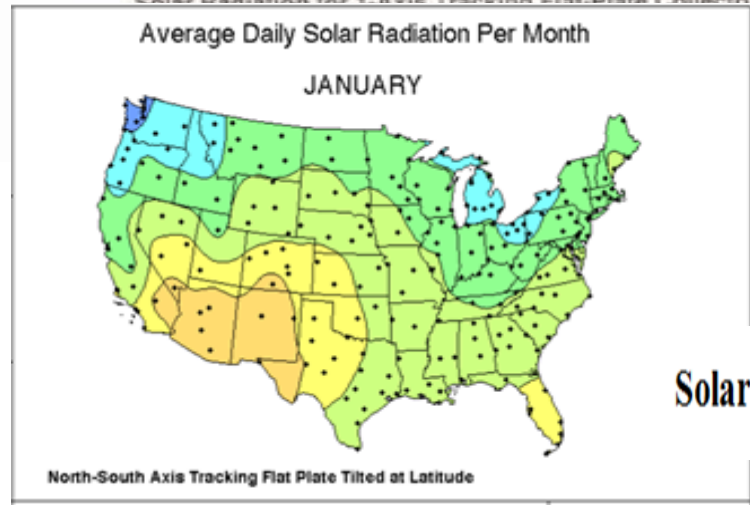
STATION TYPE: Secondary



Solar Radiation for Flat-Plate Collectors Facing South at a Fixed Tilt (kWh/m<sup>2</sup>/day), Uncertainty ±9%

Tilt (°)		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Year
0	Average	2.1	2.9	3.9	4.9	5.6	6.2	6.0	5.3	4.4	3.3	2.2	1.8	4.0
	Min/Max	1.7/2.4	2.4/3.2	3.4/4.5	3.9/5.8	5.0/6.5	5.5/6.9	5.3/6.8	4.7/5.7	3.7/5.0	2.9/3.9	1.8/2.6	1.5/2.0	3.8/4.3
Latitude -15	Average	3.1	3.8	4.6	5.3	5.7	6.0	6.0	5.6	5.0	4.3	3.2	2.7	4.6
	Min/Max	2.3/3.7	3.0/4.4	3.8/5.4	4.1/6.3	5.0/6.6	5.4/6.7	5.2/6.7	4.9/6.0	4.1/5.8	3.5/5.2	2.3/4.0	2.0/3.2	4.3/4.9
Latitude	Average	3.5	4.2	4.8	5.2	5.3	5.6	5.5	5.4	5.1	4.6	3.6	3.1	4.6
	Min/Max	2.5/4.2	3.1/4.9	3.9/5.7	4.0/6.2	4.7/6.2	5.0/6.2	4.9/6.3	4.7/5.8	4.1/5.9	3.6/5.6	2.5/4.5	2.2/3.7	4.4/5.0
Latitude +15	Average	3.7	4.3	4.7	4.8	4.7	4.8	4.9	4.9	4.8	4.6	3.7	3.3	4.4
	Min/Max	2.6/4.6	3.2/5.1	3.8/5.6	3.7/5.8	4.1/5.5	4.3/5.3	4.3/5.5	4.3/5.3	3.9/5.7	3.6/5.7	2.5/4.8	2.3/4.0	4.1/4.8
90	Average	3.4	3.7	3.5	3.0	2.6	2.4	2.5	2.9	3.3	3.7	3.3	3.0	3.1
	Min/Max	2.3/4.4	2.7/4.5	2.8/4.2	2.4/3.6	2.3/2.9	2.2/2.6	2.3/2.8	2.6/3.1	2.7/3.9	2.8/4.6	2.2/4.3	2.0/3.7	2.9/3.4

Solar Radiation for 1-Axis Tracking Flat-Plate Collectors with a North-South Axis (kWh/m<sup>2</sup>/day), Uncertainty ±9%



Solar Map

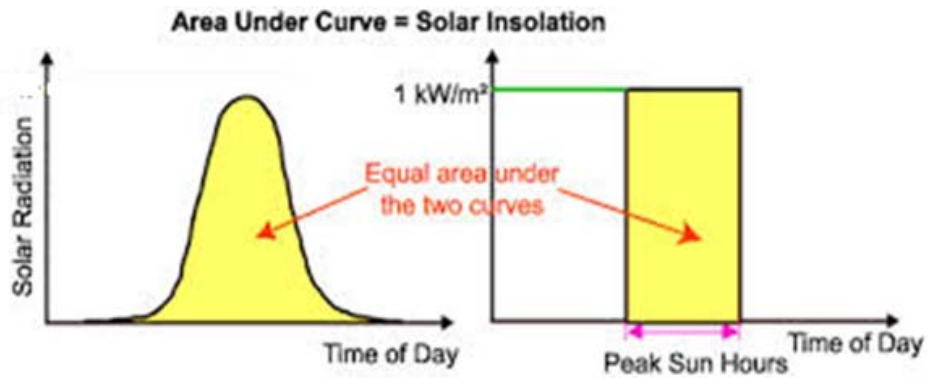
kWh/m<sup>2</sup>/day

- 10 to 14
- 8 to 10
- 7 to 8
- 6 to 7
- 5 to 6
- 4 to 5
- 3 to 4
- 2 to 3
- 0 to 2
- none

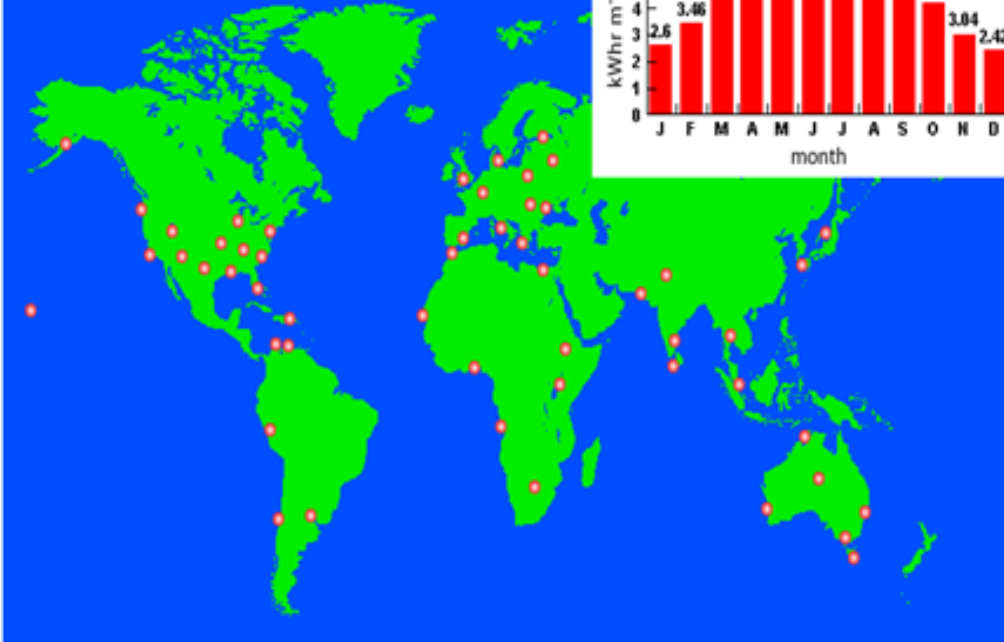
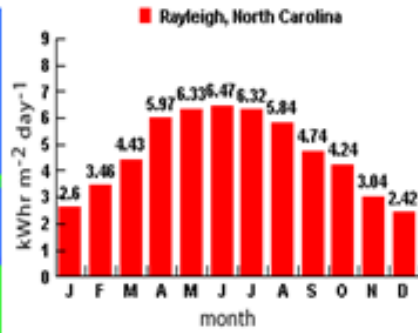
North-South Axis Tracking Flat Plate Tilted at Latitude

North-South Axis Tracking Flat Plate Tilted at Latitude

# Peak Sun Hours



move the mouse over a city to see the average daily solar radiation measured on the horizontal in units of kWh m<sup>-2</sup> day<sup>-1</sup>



## Energy Calculation with **Rated Power** and **Peak Sun Hour**

## PV Energy Delivery Calculation - Example

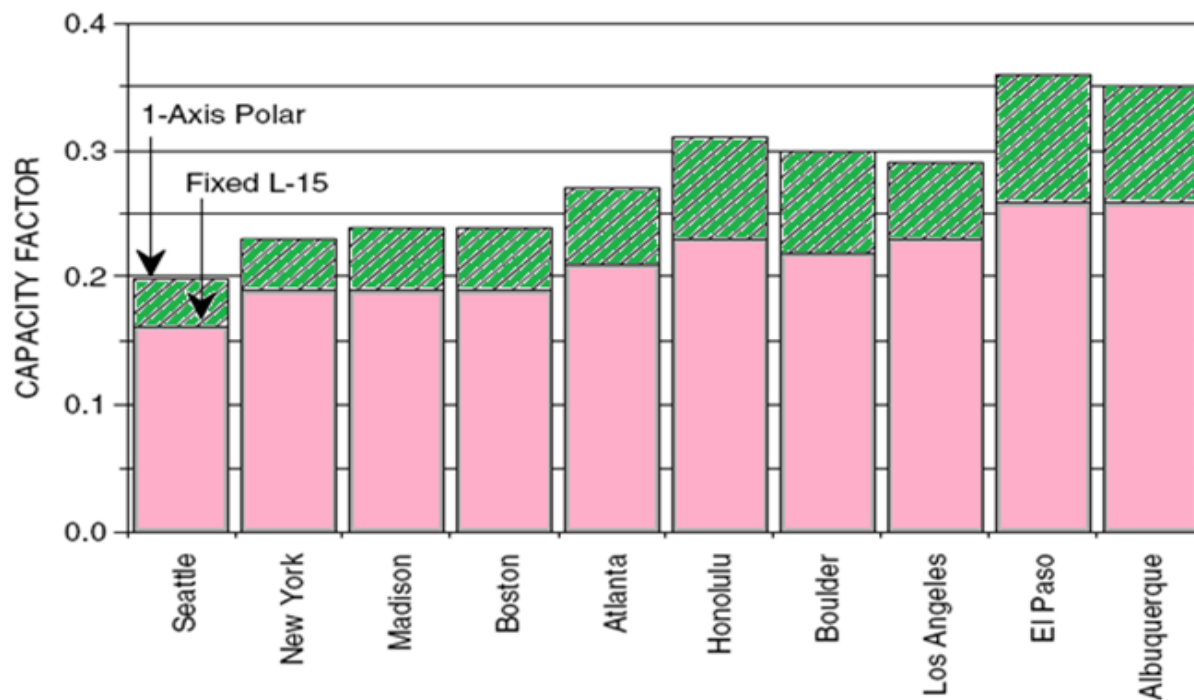
⌘ Estimate the annual energy delivered by the 1-kW (dc) array in Madison, WI, which south-facing, and has a tilt angle equal to its latitude minus 15°. Assume the dc-to-ac conversion efficiency at 72%.

⌘ Insolation Table for Madison, WI

Tilt	Madison, WI												Year
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	
Lat - 15	3.0	3.9	4.5	5.1	5.8	6.2	6.2	5.7	4.8	3.8	2.5	2.3	4.5
Lat	3.4	4.3	4.7	5.0	5.5	5.7	5.8	5.5	4.8	4.0	2.8	2.6	4.5
Lat + 15	3.6	4.4	4.6	4.6	4.8	4.9	5.0	5.0	4.6	4.0	2.9	2.8	4.3
90	3.5	4.0	3.7	3.2	2.9	2.8	2.9	3.2	3.4	3.3	2.6	2.7	3.2
1-Axis (Lat)	3.9	5.0	5.8	6.4	7.3	7.8	7.7	7.1	6.0	4.8	3.2	3.0	5.7
Temp. (°C)	-4.0	-1.1	5.3	13.7	20.5	25.7	28.0	26.4	21.9	15.5	6.7	-1.2	13.1

Capacity Factor = [“Peak Sun Hour”/24 ]

CFs for a number of U.S. cities



## Example Problem

- ⌘ A PV system is installed on top of the Engineering building (Latitude:  $38.9^\circ$ ). The PV system is composed of fifteen (15) 150 W (dc) solar panels, and is installed south-facing, tilted with an angle to its latitude. A DC-to-AC converter is installed which has a conversion efficiency of 75%. Calculate the annual energy the PV system can deliver (ac kWh) if the annual insolation is  $4.5 \text{ kWh/m}^2\text{-day}$ .

