System sizing

The size of your solar electric system depends on:

- How much electricity is used and the percentage of solar electricity to be generated
- Type of PV material used — crystalline silicon or thin-film
- Roof or other PV-material mounting surface orientation, tilt, area and condition
- Local solar resource (solar radiation) and direct hours of sunlight
- Budget

You or a system installer can review past utility bills to determine how much electricity you use, typically shown in kilowatt-hours (kWh). If the information is not on your bill, contact your electricity provider and ask for your average monthly electricity use in kWh.

One method for approximating system size is using daily peak sun hours:

1. Determine your average monthly electricity use in kWh.
2. Divide by 30 to determine average use per day.
3. Find the peak sun hours for your location. Peak sun hours are the hours of direct sunlight that fall on a PV panel — not total hours of daylight.
4. Divide the answer calculated in step two by your peak sun hours. Step four's answer is a rough estimate of the solar electric system size (in kW) you will need to generate 100 percent of your electricity load.

Example:

1. A home in St. Louis has an average monthly electricity use of approximately 1,000 kWh.
2. 1,000 kWh ÷ 30 = 33.3 kWh average per day
3. St. Louis gets an annual average of 4.8 peak sun hours per day.
4. 33.3 ÷ 4.5 = a 7.4 kW PV system would be needed to produce 100 percent of this home's electricity load.

NOTE: This provides a rough estimate and shouldn't be used to size a system. The actual system will likely be larger because of many system-related factors.

For more accurate sizing, use the worksheet on the following page. It takes conservation and efficiency measures and system component inefficiencies into account.

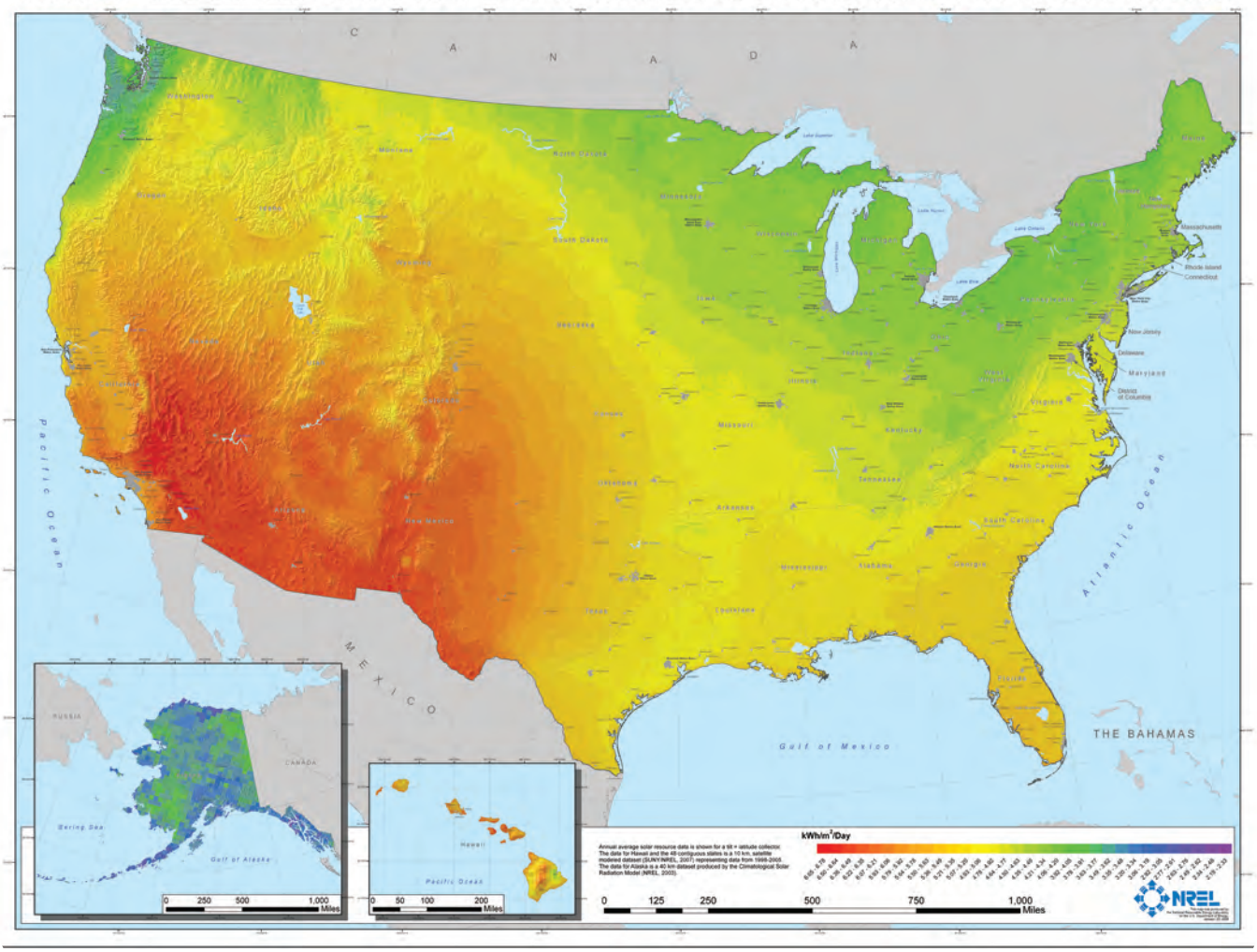
Table 1. Solar electric PV system worksheet, based on a south-facing PV module at a fixed tilt (latitude angle)

Steps	Example home in St. Louis	Your home or building
1. Average monthly electricity used in kilowatt-hours (kWh).	1,000 kWh/month	
2. Multiply by 1,000 to convert to watt-hours used per month.	1,000 × 1,000 = 1,000,000 watt-hours/month	
3. Divide by 30 for total average watt-hours used per day.	1,000,000 ÷ 30 = 33,333 watt-hours/day	
4. Subtract daily watt-hours eliminated through energy conservation and efficiency.	33,333 – 8,953 = 24,380 watt-hours/day	
5. Multiply by the percent of electricity you want provided by the sun.	For 50 percent: 24,380 × 0.50 = 12,190 watt-hours/day	
6. Divide by the average monthly solar radiation for your city or the city nearest you, found in **Table 2**.	12,190 ÷ **4.8 kWh/m²/day** = 2,709 watts	
7. Multiply by 1.2 to account for system inefficiencies (wire losses, etc.)	2,709 × 1.2 = 3250.8 watts	
8. Divide by 1,000 for the size of the overall system in kilowatts (kW), which will be used to approximate system cost.	3250.8 ÷ 1,000 = **3.25 kW** PV system size	
9. Divide the answer from step 7 by the peak power (in watts) of the PV panel to be installed. (230 watts is typical)	3250.8 watts ÷ 230 watts = 14.1 panels	
10. Round *up* to a whole number. This is the number of PV panels needed to provide electricity based on the selected criteria.	14.1 ≈ **15** 230-watt PV panels (15 × 230 = 3,450 watts)	

Worksheet notes

1. Missouri homes used an average of 1,000 kWh per month in 2012.
2. One kilowatt-hour (kWh) = 1,000 watt-hours
3. 365 days per year divided by 12 months = average of 30 days per month.
4. Energy conservation and efficiency measures can reduce the size of your system. This example shows a 27 percent savings from energy conservation measures.
5. PV panels can be added to a system over time.
6. The solar radiation value used to rate panels is 1 kW/m² and thus the results are in watts.
7. The amount of PV-produced electricity decreases as it flows through wires, the inverter and other system components. NREL's PV Watts online tool addresses this using a de-rate factor.
8. Converts watts back to kilowatts, which use the units used to describe a system's size.
9. If you know what PV panel you will use, divide step seven's watts by the peak power in watts of the panel to determine the number of panels needed. Do you have enough space on your roof?

After determining the number of panels, the remaining system components can be sized accordingly. The kW output calculated in step eight above is specific to the PV panels, the kW number is also referred to as the system size.



These Missouri cities have National Solar Radiation Database collection stations. The NREL website provides adjusted panel angles and tracking system data.

If your city is not listed in Table 2 or is not near the listed cities, find your solar resource number on the map below — or you can access the map at *http://www.nrel.gov/gis/solar.html*.

Online sizing tools allow you to consider a combination of PV system options for specific locations using your address or zip code. Know how much electricity you use in a year (in kWh) and the approximate PV system size you are considering before using these free programs.

Table 2. Solar radiation data for flat-plate collectors and panels (south-facing, fixed tilt at latitude angle)

Missouri city	kWh/m²/day
Columbia	4.9
Kansas City	4.9
Springfield	4.9
St. Louis	4.8

Source: U.S. DOE/National Renewable Energy Laboratory (NREL): http://rredc.nrel.gov/solar/pubs/redbook/

PV Watts is an online calculator that provides energy production and cost savings estimates for grid-tied systems: *http://mapserve3.nrel.gov/PVWatts_Viewer/index.html*.

NOTE: After you type in your zip code and select "Send to PVWatts," a screen will appear that allows you to make selections. Under "PV System Specifications," "DC Rating," change the number to 1.0 because it is set by default at 4.0. After you select "Calculate," two tables appear. Under the "Results" table, look for the "Year" result (in kWh) under the "AC Energy" column. Divide your yearly electricity use (in kWh) by the "Year" number from the "AC Energy" column to determine the PV system size needed to provide 100 percent of your electricity from the sun. The "Energy Value" column shows electricity cost savings.

The NREL's **PVWatts Calculator** estimates solar electric or wind turbine system electricity production: *http://pvwatts.nrel.gov/*.

My Solar Estimator estimates solar electric, wind and solar hot water system sizes: *www.solar-estimate.org*.

These exercises provide a sense of what system size will work for you. A consultant or installer

can provide a more detailed analysis and advise on what will work best for your particular needs.

If you're interested in solar electricity because you want to reduce your environmental footprint, the U.S. Environmental Protection Agency's Greenhouse Calculator can help determine how much greenhouse gas you are not adding to the atmosphere by installing a solar electric system. In the calculator, use Option 1 and insert the kWh provided by the solar electric system: *www.epa.gov/cleanenergy/energy-resources/calculator.html.*

References

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