

Reality Math

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Photovoltaic Electricity II

1. Square Feet of PV panels

A typical household in the US needs about 1 kW all the time, which translates to

$$1 \text{ kW} \times 24 \text{ hours} = 24 \text{ kWh per day.}$$

Of course the household needs more than 1kW at times, so both excess capacity (or the ability to draw from the grid) and storage (or the ability to put back into the grid) are important parts of all these scenarios.

PV panels convert the energy in sunlight to electricity. Remember that 1 square meter of peak sunlight provides 1 kW, so 5 square meters of 20% efficient PV panels are needed to provide 1 kW at peak sun hours.

If a location has 6 hours of peak sun, it will need a 4 kW system to provide 24 kWh/day since

$$4 \text{ kW} \times 6 \text{ hours} = 24 \text{ kWh}$$

A 4 kW system needs about $4 \times 5 = 20$ square meters of 20% efficient PV which is about 220 square feet since one square meter is about 11 square feet.

Hours of peak sun	Size of system needed kW	Size of panels m ²	Size of panels ft ²
6	24 kWh / 6 hrs = 4 kW	4 kW x 5 sq meters = 20	20 x 11 = 220
5			
4			
3			

- To provide 24 kWh/day in a location with 5 hours of peak sun daily give
 - size of system in kW
 - size of panels in square meters
 - size of panels in square feet
- To provide 24 kWh/day in a location with 4 hours of peak sun daily give
 - size of system in kW

(b) size of panels in square meters

(c) size of panels in square feet

3. To provide 24 kWh/day in a location with 3 hours of peak sun daily give

(a) size of system in kW

(b) size of panels in square meters

(c) size of panels in square feet

2. Will the Roof Be Big Enough for the PV?

Now let's think about a typical small one-story house. About 1000 square feet of living space is a cozy small house, which would provide a flat roof of at least 1000 square feet in area.

Say we lived in rainy Seattle, WA. Would this small roof have enough room for the required PV? If you go to <http://www.bigfrogmountain.com/SunHoursPerDay.html> you will find that the annual average daily hours of peak sun in rainy Seattle is 3.57 hours/day.

Since Seattle has more than 3 hours of peak sun per day, we know from 3. (c) that 440 square feet of PV will be enough. If the roof of the 1000 square foot house is flat, it obviously has 440 square feet and is more than enough.

Say we are building a 1000 square foot living space house in Seattle with a pointed roof, and we locate the house properly so half of its pointed roof faces the South.

4. (a) The total area of half of pointed roof must be (more, less) than half of the floor area of the house? (Visualize collapsing the roof to make it flat.)
 - (b) With only half a roof of a very small house, would we still have enough space on our roof for solar panels to provide the average electricity needed in Seattle, a low sunlight region?

If the house is pointed the wrong way, the PV panels are installed on the roof with metal supports to face toward the sun.

Photovoltaic electric electricity was prohibitively expensive in the past, but prices are coming down rapidly. In 2019, the average national solar panel cost is \$3.05/watt installed.

5. At \$3.05/watt,
 - (a) How many dollars would a 6 kw system cost?

- (b) What would the cost be after the 30% federal tax credit?
- (c) If your location got 4 hours of peak sun per day, would this system provide the 24 kWh/day that you need?
- (d) How many kWh/year of electricity would this system provide?
- (e) In NC, electricity costs about 10¢/kWh. What is the value of the year's electricity provided in (d)?
- (f) How many years would it take to payback the cost of the system (b)?

3. \$1/watt Installed Makes Photovoltaic Electricity Cheaper than Nuclear Power

June 1, 2019 (SeeNews) - The price for large fixed-tilt ground-mount solar parks in the USA will fall to USD 0.99 (EUR 0.89) per watt by 2020, which is below the USD 1/watt targeted by the SunShot initiative. Currently, the price of utility-scale solar is around USD 1.25 per watt.

- 6. A decrease from \$1.25/watt to \$0.99/watt is what percent decrease?

An ordinary nuclear power reactor produces 1000 MW = 1 million kW flow of electricity providing

$$1,000,000 \text{ kW} \times 24 \text{ hours} = 24,000,000 \text{ kWh/day}$$

Such a reactor costs about \$10 billion to build. Obviously maintaining a PV system is way cheaper than running a nuclear power reactor.

A 1000 MW photovoltaic system produces much less electricity.

$$1,000,000 \text{ kW} \times 4 \text{ hours of peak sun (conservative)} = 4,000,000 \text{ kWh/day}$$

- 7. In a location receiving 4 hours of peak sun daily
 - (a) How many kW of photovoltaic would be required to equal the electrical production of a 1000 MW nuclear reactor?
 - (b) \$1/watt = \$_____/kW
 - (c) At \$1/watt construction cost, what would the photovoltaic equivalent of a nuclear reactor cost?
 - (d) Which would cost more at \$1/watt for PV, a 1000 MW nuclear reactor or the equivalent 6000 MW PV?

8. Which of the following statements favor PV electricity over nuclear power?

- (a) no lethal long-lived radioactive waste
- (b) provides power 24 hours/day
- (c) no chance of catastrophic accident
- (d) no connection to nuclear weapons
- (e) can be small-scale or utility scale
- (f) can provide freedom from centralized utilities
- (g) can produce electricity where it is needed