Making Sense

of Solar-Electric System Costs

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As *Home Power's* marketing director, I spend a lot of time at fairs and other events aimed at getting people interested in renewable energy. Without a doubt, the question I get more than any other is, "What does a solar-electric system cost for an average home?" Understandably, these folks are looking for the sticker price of a grid-tied solar-electric system, something to walk away with and compare to other home energy or greener living "investment" possibilities.

The truth is, it's not much easier to answer, "How much will a solar-electric system cost me?" than it is to answer, "How much will it cost me to build a house?" In either case, the answer has to start with two words—"It depends…"

That's because several variables influence the cost of a grid-tied solar-electric (photovoltaic; PV) system. Although there's no pat answer to the price question, the guidelines and examples here will help you estimate your costs, and get you started on your path to energy independence.

How Hungry Is Your Home?

The average American home uses roughly 830 kilowatt-hours (KWH) of electricity each month. But basing system costs solely on that number would most likely give you an inaccurate and unhelpful result. Your electrical use may vary wildly, depending on the season, what kind of appliances you use, and your usage habits.

So how can you gauge your electrical appetite? For a quick snapshot of your electrical usage, check out your monthly electricity bill. Most bills will include KWH usage figures for the last twelve months; this will give you a good idea of how much electricity your home uses each year.

Once you've got a handle on your electrical appetite, taking steps to improve the efficiency of your home will be your next best move. This can have a tremendous impact on the cost of the system you install. Every dollar you spend on making your home more efficient decreases the cost of your system by approximately US$3 to $5. (For more information, see "Calculating Your Energy Appetite," in *HP102*.)

A huge disparity exists between home sizes, efficiencies, and personal electrical appetites, and there's also a similar gap in the efficiency potential of different homes. If you live in an efficiently built, well-insulated home, with modern appliances, compact fluorescent lighting, and high performance windows, you may only be able to reduce your average electricity use by 5 or 10 percent. But if you're

on the other end of that spectrum, by implementing efficiency measures you may be able to reduce your use by 40 percent or more, shaving several thousand dollars off the cost of your system. For example, just replacing an older model refrigerator with a modern, more efficient one could reduce your electrical usage by 50 KWH per month. Combine this with household-wide efficiency strategies and you can make a pretty sizeable dent in your system cost.

A Sharp 175-watt solar-electric module, 62 x 32.5 inches. The author, 66.25 x 18.5 inches.

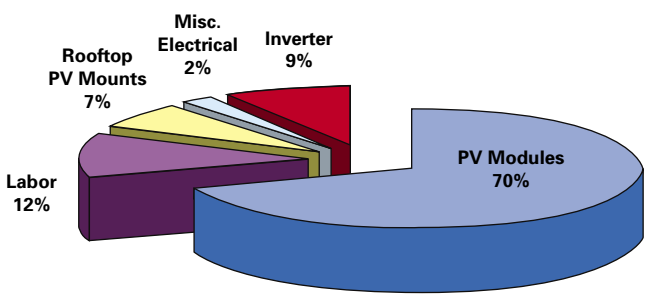
Location, Location, Location

Where you live also affects your system costs. Less sunny locales will call for larger systems to generate the same amount of electricity that a smaller system in a sunnier spot can produce. In the solar world, sunlight is measured in units called "peak sun hours." Phoenix, Arizona, receives an annual average of 6.5 peak sun hours per day, while Seattle, Washington, only gets 3.7 peak sun hours per day. To determine the peak sun hours in your region, visit the Renewable Resource Data Center's Web site (see Access).

Besides the number of peak sun hours in your region, average annual temperatures where you live also affect your system size, and its relative cost. In colder regions, you may use lots of electricity for space heating and water heating. In warmer regions, air conditioning can dramatically amplify your electricity use.

Climate and other site-specific variables will also determine your solar-electric system's size and its production. PV panels operate more efficiently in cooler climates and less efficiently in hot ones. Some locations regularly receive morning fog or afternoon thunderstorms. In dry, dusty climates without regular rains to clean the panels, accumulated dust and dirt will reduce the output of the system. All of these variables need to be considered when sizing a system and estimating its annual production.

Sample Grid-Tied PV System Costs (%)



A Place in the Sun

Even the sunniest regions won't guarantee you good system performance unless you have unobstructed solar access at your site. This daily access to the sun is called your "solar window." You'll need a location on your rooftop or elsewhere on your property that:

- Ideally faces south, but east- or west-facing arrays make sense in some cases;
- Provides enough space for the number of PV panels needed, possibly including room for expansion;
- Enables the entire array of modules unshaded exposure to the sun between the hours of 9 AM and 3 PM, year-round.

Compromising any of these three conditions can mean having to increase the size of your system, which increases its cost.

A Nibble or a Bite?

One of the best features of solar electricity is its scalability. With a little foresight, you can start small and build your system gradually if that better suits your budget.

A starter system can be designed to meet just a portion of your home's daily electricity needs. This is one great benefit of a grid-tied system—the remainder of your electricity can be purchased from your electric utility, just as before. And, if you plan your design for future expansion, adding more modules to your array as your pocketbook allows is relatively simple.

Estimated System Costs Comparison

	San Diego, CA				Seattle, WA			
Average monthly electricity use (KWH)	500		1,000		500		1,000	
Portion of electricity from solar energy*	25%	75%	25%	75%	25%	75%	25%	75%
Average sun hours per day	5.7	5.7	5.7	5.7	3.7	3.7	3.7	3.7
Approximate system efficiency	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Number of 175 W modules needed*	6	18	12	36	10	28	19	56
Total system size (W)	1,050	3,150	2,100	6,300	1,750	4,900	3,325	9,800
Roof space needed (sq. ft.)	85.9	257.8	171.8	515.5	143.2	401.0	272.1	801.9
Estimated system cost per KW (US$)	10	8	9	6	9	6	8	6
Price of installed system (US$)	10,500	25,200	18,900	37,800	15,750	29,400	26,600	58,800
State rebates (US$; excludes tax incentives)	2,940	8,820	5,880	17,640	0‡	0‡	0‡	0‡
Cost after rebates (US$)	7,560	16,380	13,020	20,160	15,750	29,400	26,600	58,800

* Module counts are rounded up, since it's not possible to install "fractions" of a module. The result is that all of the examples will produce more than this nominal percentage.
‡ Washington State is currently implementing production-based incentives up to US$2,000 per year.

Free Money

Perhaps the most powerful impetus behind the exploding popularity of grid-tied solar electricity is the availability of generous financial incentives. In some states, rebate programs refund as much as 60 percent of the system's installed cost to the homeowner! Illinois residents can recoup from 25 to 50 percent of their costs; New York's PV incentive program pays up to 60 percent of total installed costs; and Oregon homeowners can receive up to US$10,000 in rebates. Add to that state tax credits and exemptions, and low-interest state loans, and the picture gets brighter still. You can get up-to-date information on financial incentives at the Database of State Incentives for Renewable Energy Web site (see Access).

DIY or Go Pro

Whether to install your solar-electric system yourself or hire a professional is a decision not to be taken lightly. Doing it yourself can cut 15 to 25 percent from the total cost, but be sure to realistically gauge your ability to design and install an efficient, code-compliant, and safe system, and don't forget to consider what your time is worth. If you're adept at wiring and home improvement projects, and have the considerable time required to learn the specialties of solar-electric installation, you can join the ranks of homeowners who successfully self-install. (For a list of recommended tools, see "Tools of the Solar-Electric Trade," in *HP105*.)

The vast majority of grid-tied systems are quickly and competently installed by licensed professionals who bring with them the experience to ensure a system design that provides safe, maximized performance. Some rebate programs require that a pro installs your system; be sure to inquire. (For a directory of professional installers, see Access.)

Even a small system can reduce your utility bills while producing clean energy.

Estimating Installed Costs

The U.S. Department of Energy (DOE) estimates that a 2 KW (2,000 watt) system costs US$8 to $10 per watt to install, while a 5 KW (5,000 watt) system can cost US$6 to $8 per watt installed. The actual cost of an installed system may vary widely depending upon installation complexity, location, component availability, and the size of the installed system.

Rated System Size (W)	Cost Per Installed Watt (US$)
1,000 to 4,000 W	$8 to $10
5,000 W+	$6 to $8

Duluth, MN				Atlanta, GA				Boston, MA			
500		1,000		500		1,000		500		1,000	
25%	75%	25%	75%	25%	75%	25%	75%	25%	75%	25%	75%
4.4	4.4	4.4	4.4	5.1	5.1	5.1	5.1	4.6	4.6	4.6	4.6
0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
8	24	16	47	7	21	14	41	8	23	15	45
1,400	4,200	2,800	8,225	1,225	3,675	2,450	7,175	1,400	4,025	2,625	7,875
114.6	343.7	229.1	673.0	100.2	300.7	200.5	587.1	114.6	329.4	214.8	644.4
10	7	8	6	10	7	9	6	10	7	8	6
14,000	29,400	22,400	49,350	12,250	25,725	22,050	43,050	14,000	28,175	21,000	47,250
2,800	8,000	5,600	8,000	0	0	0	0	4,200	12,075	7,875	23,625
11,200	21,400	16,800	41,350	12,250	25,725	22,050	43,050	9,800	16,100	13,125	23,625

Next Steps

It's easy to see why there's no such thing as a "one-size-fits-all" sticker price for a solar-electric system, but a little homework and understanding your options both go a long way toward reliable planning and budgeting. To give you an even better idea of the costs involved, check out the Estimated System Costs Comparison table above, which compares the energy production, efficiency, and costs of two sizes of solar-electric systems in five U.S. cities.

To take a first pass in estimating costs yourself, consider each of the variables discussed above and determine the:

- Average KWH used by your home each month
- Peak sun hours for your location
- Quality of your solar window
- Financial incentives, if any, available in your state

Use this information to fill in the worksheet on the right to figure your approximate system size in watts. Finally, project your costs based on the sliding scale that specifies total cost per installed watt. This will give you a rough cost projection from which to work.

To get a better picture of what such a system might cost you, two options exist: phone a local professional for a quote or work through the calculations yourself. (Before you call, gather a

Calculate Your Costs

Use this easy worksheet to figure out what a professionally installed solar-electric system might cost. If you have last year's electricity bills handy, grab them and your calculator, and get started!

1. First, figure the daily output needed from your PV system:

Average Monthly Electricity Use _____ KWH

x 1,000 [converts KWH to Watt-Hours] = _____ WH

x Percent (_____ %)* of Monthly Electrical Use from PVs = _____ WH

÷ 30 days

= Daily PV Output Needed _____ WH

(*Example: for 25%, multiply by 0.25)

2. Then, calculate the minimum system size [in watts]:

Daily PV Output Needed [from Step 1] _____ WH

÷ Average Peak Sun Hours (_____ hrs.) Per Day = _____ W

÷ 0.7 [for 70 % System Efficiency Factor]

= Minimum System Size _____ W

3. Next, determine the number of PV modules you'll need:

Minimum System Size [from Step 2] _____ WH

÷ Wattage Rating (_____ W) of Chosen Module

= Number of Modules Required _____ Modules

4. Now you can figure the size of the system:

Number of Modules Required [from Step 3; round up] _____Modules

x Wattage Rating (_____ W) of Chosen Module [also from Step 3]

= System Size [in Watts] _____ W

5. Last, find the approximate system cost:

System Size [from Step 4] _____ W

x System Cost Per Watt [from sidebar opposite] $_____

– Rebates & financial incentives $_____

= Approximate System Cost $_____

few of your recent electric utility bills for easy reference.) The pros know what questions to ask and the relevant data for your geographic location, and should be able to provide a preliminary estimate by phone. An on-site visit will be necessary before they can give you a firm quote, and get you on your way to making some or all of your electricity with clean, renewable energy.

Access

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Database of State Incentives for Renewable Energy • dsireinfo@ncsu.edu • www.dsireusa.org

National Renewable Energy Laboratory (NREL) • http://rredc.nrel.gov/solar/pubs/redbook • Solar insolation data • http://rredc.nrel.gov/solar/calculators/PVWATTS • PVWATTS calculator

Directories of Solar-Electric System Installers:

Home Power's Installers Directory, see page 124 or visit www.homepower.com/resources/directory.cfm

www.renewableenergyaccess.com/rea/market/business/home

www.seia.org/about/statechapters.asp

Renewable Resource Data Center • http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/