BUYER'S GUIDE TO SOLAR PHOTOVOLTAIC SYSTEMS

Green Home Gnome

www.greenhomegnome.com

WWW.GREENHOMEGNOME.COM

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1.0 IS SOLAR RIGHT FOR YOU?

With climate change threatening the planet, constantly rising electricity prices hurting your budget, and solar photovoltaic (PV) technology becoming increasingly affordable and efficient there's no better time to make the switch to a solar PV system. This guide will help you find the right system for your needs, but before anything it first asks you to take a step back and assess whether buying a system makes the most sense for you.

1.1 Solar power purchase agreements

After pricing out solar panels you may find that buying isn't possible for you. Fortunately there are alternatives, such as a solar power leasing program or solar lease that allows you to power your home by solar without having to buy a PV system.

As long as you own a home and qualify, a third party provider such as REC Solar will enter into a contract with you to install and maintain a PV system on your property at no cost. Under a solar power purchase agreement (SPPA) they own the panels and charge you a set rate for the electricity that their system generates. A solar lease is the same except you pay a fixed monthly rate to rent the system regardless of how much power your panels produce.

To help you decide whether to buy or lease, read through this list of pros and cons in going with a solar power purchase agreement.

1.1.1 Pros

Free - First and foremost, the greatest benefit to leasing is not having to pay the substantial upfront costs of purchasing and installing a solar PV system (aside from possibly paying a small installation cost). But is it really yours? No. You can't say you actually own it, but should you generate the funds at some point in the future you may be able to buy the system from them.

Predictable pricing - The two most common pricing options under these arrangements are fixed price and fixed escalator. You could choose to lock in at a fixed rate, which may result in higher initial costs, but can save you in the long-term as electricity prices rise. The fixed escalator alternative translates to a lower initial cost, with slight annual increases. Either option means you can count on a predictable electricity rate for years to come.

Minimal concerns - You neither have to worry about your system not performing up to par nor concern yourself with the complicated permitting process and installation and maintenance headaches.

1.1.2 Cons

Lack of ownership - You don't actually own the system under this arrangement. And since it isn't yours, you're at the mercy of the contract and can't do what you want with the panels.

Incentives - Government tax credits and rebates offered by utility companies go to the third party provider, not you.

Contracts - If you don't like dealing with paperwork and signing contracts, this type of arrangement could cause aggravation.

Additional costs – Putting panels up on your home may raise your property taxes.

2.0 Sizing a solar PV system

2.1 Calculate your home's electricity usage

If you've decided that you'd like to buy, the first step is to size out your system, both in terms of energy needs and physical space.

1. Collect your electricity bills for the past year so you can calculate your average monthly electricity usage. Calculating an average is essential because electricity use peaks in the hottest months due to the high air conditioning demand.

2. Add up the kWhs for all 12 months and divide that number by 12 to determine your average monthly energy consumption.

3. Divide the monthly figure by 30 to determine your daily kWh usage.

OPTIONAL: To more accurately assess your home's electricity needs, make a list of all your appliances, listing the power consumption for each in wattage and whether it is AC or DC power. Track how many hours you use each of those appliances per week, then for each appliance, multiply the watts by the hours/week to determine the number of watt-hours per week you use each appliance. Alternatively, you can figure out the energy usage for particular appliances by installing an electricity usage monitor between the appliance and outlet. Leaving the monitor in place for a week will give you the appliance's watt-hours per week. Enter the data you have collected into a load sizing worksheet (see Resources at end of section). Work through the worksheet's remaining calculations to determine the total number of Amp hours per day that your appliances use.

2.1 Determine insolation

1. Locate a solar insolation table online (see Resources) to determine the insolation, the average number of hours per day that the sun produces peak sunlight (or an accumulation of all sunlight equivalent to that amount of peak sunlight), for your area.

2. Find the nearest city to you on the table and write down the average daily figure. To determine specific insolation data for individual days of

the year, use NASA's Atmosphere-Ocean Model. (http://aom.giss.nasa.gov/srlocat.html)

2.2 Calculate energy needs

1. Plug the figure from Section 1.1, Step 3 "Daily kWh" into the following calculation. Use the average insolation value from 1.2, Step 2 for the "# hours" to determine how many kW you need your solar system to generate per day:

Daily kWh / # hours = # kW

e.g. 12 / 4 = 3

2. Plug the answer from the previous step into the following calculation, which accounts for standard energy losses of solar PV systems:

kW x 1.3 (increase size of PV system by 30%) = # kW (actual size of PV system you need)

e.g. 3 x 1.3 = 3.9

In this example, you would need a 3.9 kW solar PV system to satisfy your home's energy needs.

2.3 Selecting a PV system

1. Measure how much space you have to mount your solar panels.

2. Decide on a budget for your system.

3. Find a system that satisfies your power requirements, but still fits within your space restrictions. Monocrystalline silicon panels are the most efficient. Therefore, you would need less panels than a thin film system.

When purchasing a PV system, bear in mind that warranties vary between 10 to 25 years. If you don't have the funds to purchase a longer lasting system, make sure it will at least pay back your initial investment in energy savings. Also, remember to look into the many incentives that your government offers. Switch to solar and every time you look up at the sun you'll have yet another reason to thank it.

Resources:

Solar PV Load Sizing Sheet (http://www.solarexpert.com/Pvload.html)

Solar Insolation Chart (http://www.solarpanelsplus.com/solar-insolation-levels)

SolarEstimate.org (http://www.solar-estimate.org)

DSIRE: Database of State Incentives for Renewables & Efficiency (http://www.dsireusa.org)

3. 0 Solar panels

3.1 How to choose the right panels

As solar cell technology advances costs have been dropping and efficiency soaring. There has never been such abundant choice as now. Choosing the right solar panels can result in a sizeable impact in energy savings over the years, so making the optimum purchase for your needs is essential.

Solar cells come in two main types: crystalline silicon and thin film. Both have their own set of advantages and disadvantages. In general, crystalline silicon technology has been around longer so offers the peace of mind that newer thin film cells do not. They do not perform as well in extreme heat, nor in the shade as thin film, but are better in cooler

weather. Thin film is cheaper and, being a newer technology, is improving rapidly.

CELL TYPE	CRYSTALLINE SILICON		THIN FILM		
	Monocrystalline	Polycrystalline	Cadmium Telluride	CIGS	Amorphous Silicon
EFFICIENCY (avg.)	14 – 17.5%	13 – 15%	9-11%	10-12%	5 – 7%
HIGH TEMP. PERFORMANCE	drops 10-15%	drops 20%	0% drop	0% drop	0% drop
OPTIMAL TEMP.	performs well in cool weather, but poorly in extreme heat	performs well in cool weather, but poorly in extreme heat	performs well in hot weather, even extreme heat	performs well in hot weather, even extreme heat	performs well in hot weather, even extreme heat
COST	most expensive crystalline silicon	cheapest crystal-line silicon	cheaper than crystalline silicon—most cost-effective thin film	cheaper than crystalline silicon	cheaper than crystalline silicon
ADDITIONAL DETAILS	oldest solar cell technology and most widely used	economical choice due to its cost to performance ratio	cadmium is toxic, though very small amounts are used	some CIGS panels have posted impressive 20% efficiency figures	requires a lot of roof space and can take longer to install than other cell technologies

1. Determine what type of solar cell technology is most appropriate for your application. If you need to re-shingle your roof in the near future, consider solar shingles, otherwise look at standard panels. Refer to the following list when making your decision:
2. Hop online and check out SolarDesignTool, a great resource that lets you line up solar panels side by side for easy comparison (see Resources).
3. Find the prices of your selected panels.
4. Perform a cost-benefit analysis for the panels you've chosen. Compare peak efficiency to sales price while taking the warranty period into account. Though one panel may be 25% less efficient, if it costs 50% less and is guaranteed to last the same length of time, it's likely the better bet.
5. Measure your roof to establish how much space you have for your panels.
6. After having determined your energy requirements Section 1.0, add up the power ratings, also on SolarDesignTool, for your selected panels to calculate how many panels you need.
7. Write down the dimensions of your chosen panels, then multiply the length by the width for an individual panel to determine each panel's surface area in square inches. Multiply that figure by the number of panels you need to see if they will fit on your roof or yard.
8. Look into government incentives for solar panels (see Resources).
9. When purchasing your panels, take the time to thoroughly inspect the fine print of their warranties.
10. Select professionally engineered heavy duty mounting racks. Once you've bought your panels, there's no point skimping on the small stuff. Not only could high winds send your panels flying, but you could be liable for any damages they cause.

Resources:

- SolarDesignTool (http://www.solardesigntool.com/)
- DSIRE: Database of State Incentives for Renewables & Efficiency (http://www.dsireusa.org/)

4.0 Choosing a battery bank

If you're going off-grid with your solar PV system you'll need a battery bank to store your energy for nighttime and cloudy days. Lead-acid batteries, the dominant battery type for solar PV systems, have been around for years. Though they look similar to car batteries, solar PV batteries operate on a deep-cycle principle—they are intended to deliver small charges for a long time rather than short bursts of intense energy as with car batteries. Aside from the most common flooded lead-acid type of battery, a couple of other options exist: gel-cell and sealed absorbent glass mat (AGM). Batteries are often considered the weakest link in a solar PV system since they will wear out quicker than the other

parts, reducing the system's performance. Keep the chain as strong as possible by purchasing the right product and purchasing high quality.

4.1 Deciding on a battery bank

1. Determine how many watt-hours your system will consume by following the directions in Section 1.0.

2. Decide how many days of stored energy you would like for your system. Ask yourself how important autonomy is to you. Are you fine with being grid-tied? If so, you don't even need batteries. Are you OK with using a backup fossil fuel energy source or do you want your system to be powered by renewable energy at all times? Are you going off the grid completely or not? Do you want to be prepared for long blackouts? Once finding the answers to those questions decide how many days of storage you need. Most systems are sized for 1 to 5 days of storage capacity.

3. Determine what type of battery is best for your application:

	Flooded lead-acid	AGM	Gel-cell
EFFICIENCY	charges and discharges at 35% amperage	highly efficient—charges and discharges at 100% amperage	charges and discharges at 35% amperage
MAINTENANCE	requires regular maintenance—adding distilled water, venting and cleaning corrosive acid from terminals	maintenance-free	maintenance-free
DURABILITY	can leak and will corrode without maintenance	spill-proof, vibration and impact-resistant	durable—even if the battery cracks it will still function
COST	cheapest, most widely used	more expensive than flooded lead-acid	more expensive than flooded lead-acid

4. Since lead-acid batteries typically drop 20 to 25% of their capacity while operating in 30ºF temperatures, plan to house them somewhere warm (ideally between 50 and 85ºF, with 77ºF as the optimal temperature). If you cannot keep them somewhere warm, purchase additional batteries to compensate.

5. Simple is best when deciding on a battery bank. Choose a single series string of cells because there is less that can go wrong than with multiple strings and they are easier to replace when broken.

6. If you foresee yourself expanding your system, buy a larger battery bank than you think you will need since battery banks cannot be easily expanded. Overtaxing your battery bank also leads to a chronic undercharged condition that can cause the batteries to fail prematurely. As a general rule of thumb, aim for 30 to 40% more energy than the load demands.

4.2 Additional components

1. Buy a battery monitor and install it where it's easily visible. Using these devices to manage your batteries can increase their lifespan and make maintenance easier.

2. Purchase a charge controller that includes temperature compensation as one of its features. This is important since it can prevent warm batteries from overcharging and assist cold batteries in getting the extra charge they need. In order for temperature compensation to work, you have to purchase a temperature sensor and place it next to the batteries.

3. Assess how likely you are to regularly water your batteries. Just like your plants, if you neglect your batteries, they will die. In that case, buy a battery watering system.

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Greenhouse Gnome is your source for all that is greenhouse, delivered daily with garden gnome sensibility! You'll find everything you need to get your own greenhouse started, but beyond that you'll find inspiration. We're big believers in food DIY, some would say militant in fact! Of course you'll get all that warm and fuzzy gardening chatter here, but you'll also understand our world view about self-sufficiency—we've outsourced much of our lives; time to start insourcing, and no better place to start than food! Visit us at: www.greenhousegnome.com.