by Dan Casale

An Introduction To Solar Electric For Your House

I'm so bright, I generate my own electricity ... I need a T-shirt and a bumper sticker with that saying! I was designing a base and space station power generation system for a moon/Mars colony group (**www.1000planets.com**), when a co-worker asked me to help design a stand-alone solar power (PV) system for an off-grid home she was planning to build.

As we worked through the design, I kept thinking, I need one of these. The year was 2003, gas was at the ridiculously high price of $1.50/gallon, I had just purchased a "you must be crazy to buy that thing" Prius and California was doing a very innovative thing — energy deregulation.

Like any good project, the more research I did the more options became apparent, and the more the project cost. But here's how I built my system.

Energy Storage

While this might seem like the last thing to decide, it will affect how the whole system is designed. Luckily for the homeowner, there are only two real options and one "fringe" option.

• **Storage Option #1:** Most homes are already connected to the local utility grid, so the easiest storage method is simply to spin the electric meter backwards. This option is often referred to as "net-metering." Not all utilities have a net-metering provision, so this might be the first factor limiting the size of your future system. I say this because if you put on a large system and your power bill is negative, you will quickly have the full undivided attention of the utility company. Smaller "unauthorized" systems are often referred to as "Gorilla Solar" systems.

• **Storage Option #2:** Batteries. If you have decided that being attached to the local utility is not for you, or you want a whole house UPS, then batteries are in your future.

• **Storage Option #3:** Hydrogen. Be the first person on your block to invest in the hydrogen economy.

Energy Collection

Solar panels require a large, south facing area that is free from shadows. Figure about 100 square feet for each 1,000 watts of peak power production. Additionally, the panels should be tilted at an angle equal to your latitude for best year-round performance.

The roof is generally a winning location. However, most roofs are not steep enough for optimum power production, so some type of tilt-up racking may be necessary. The available area is likely to be the second limiting factor on the size of your future PV system.

There are two basic types of mounting systems: fixed orientation or tracking. Each of these types has two options. For the fixed orientation, the options are fixed or seasonally adjustable. Seasonally adjustable racks are used to change the panel angle to optimize winter and summer performance.

The two types of tracking systems are single axis and dual axis. Single axis systems will track the sun across the sky while dual axis systems track the sun across the seasons. Trackers follow the sun like flowers and can increase a system's output by

Winter angle.

Summer angle.

Fuse box wiring.

Inverters.

more than 20%. This is ideal for someone with limited space.

On the downside, a windy day will cause the panels to "feather" by laying flat. Also, any moving part will eventually require maintenance and, as panels have a 40 to 50 year life expectancy, at least one replacement should be factored into the system life cycle costs. Tracking systems generally use top-of-pole mounting and require a monolithic footing for structural integrity.

Sizing the PV System

For a grid attached home, add the last 12 month's consumption from utility bills and divide by 365. This is your average daily consumption.

Next, consult **http://rredc.nrel.gov/solar/pubs/redbook/** and find the group of readings that match the type of system you plan to install (fixed, single axis, dual axis). On the line that indicates the correct tilt angle, read across to the year column for the average and min/max readings. This is the average number of hours of full sun available each day.

If you are evaluating trackers, use these figures to evaluate the effectiveness of a single or dual axis tracker by dividing those numbers by the fixed panel number. In my case, I live in an above average area with 5.8 hours of full sun per day. A single axis tracker would increase that amount by 36% to 7.9 hours, and a dual axis tracker by 41% to 8.2 hours.

The size of the PV system is:

<Daily Consumption (kWH)> / <Hours of full sun> = <Size in kW>

In my case, 20 kWH / 5.8 = 3.448

At this point, begin searching for system kits on the Internet. Generally, a kit will include panels, one or more inverters, an AC disconnect, and a DC disconnect. Sometimes the disconnects will be bundled inside the inverter or mounted together on a board, and will generally be called a power panel. The easiest way to compare systems is by using COST/WATTS. Be sure to check for UL listings and NEC compliance.

Derating the System

The system must now be derated for panel temperature, inverter inefficiencies, and wiring losses. Panels are rated by the manufacturer using the STC method. STC stands for Standard Test Conditions of 1,000 watts per square meter, 70°F panel temperature, and no wind. Additionally, a temperature performance curve is developed for each size of panels and this becomes very important for cold weather performance.

Because of complaints that panels were not performing as expected, California developed the PTC rating. The amount of light is the same

Definitions

- *PV* — Photovoltaic
- *HOA* — Home Owner's Association
- *Grid-Tied* — A house attached to the utility grid
- *Stand-alone* or *Off-Grid* — House not attached to the utility grid
- *Panel* — A collection of solar cells group together with one positive and one negative lead
- *Array* — A collection of PV panels in series
- *Charge Controller* — A device that uses power from a solar array to charge batteries
- *Inverter* — A device for converting DC to AC
- *System* — One or more inverters with one or more arrays attached
- *NEC* — National Electric Code
- *UL* — Underwriter's Laboratories
- *PTC* — Practical Test Conditions, California testing standard
- *STC* — Standard Test Conditions,used by manufacturers to rate panels

System Economics

Item	Cost
Initial cost	$52,689
Green energy credits sold	-25,000
Tax credits & deductions (over 5 yrs.)	-16,000
Total Cost	$11,689
Payback Period (Yrs.)	7.2
Annual Electricity Savings	$1,519
Annual Gas Savings (Electric Heating)	$105

Pipe trench.

(1,000/Watts/Meter^2), however, the temperature was increased to 90°F and a wind of one meter per second was used for cooling. This rating results in about a 20% decrease in panel performance.

Check the panel's PTC rating at **www.consumerenergycenter.org/cgi-bin/eligible_pvmodules.cgi**. Some retailers will include both the STC and PTC ratings.

Check the inverter's CEC rating at **www.consumerenergycenter.org/cgi-bin/eligible_inverters.cgi**. If the retailer includes a CEC rating, this is the PTC rating derated by the inverter efficiency.

Wiring efficiency will vary with the size of the wire and the length of the wire runs. Unless you calculate and specify the wire yourself, figure 97% efficiency.

Links

- **www.consumerenergycenter.org/erprebate/equipment.html**
- **http://abcsolar.com/pdf/2001-09-04_500-01-020.pdf**
- **www.nmsu.edu/~tdi/pdf-resources/A%20Critical%20Look%20at%20PV%20Module%20Grounding2.pdf**
- **www.nmsu.edu/~tdi/Photovoltaics/Codes-Stds/Codes-Stds.html**
- **www.zomeworks.com/solar/trackrack/Homepower_june2004.pdf**
- **www.the-mrea.org/download/Off%20GridPVFactSheet.pdf**

In my case, the 187 watt panels were rated at 167 and the inverter was rated at 94%, so I calculated my wiring at 98% efficient. To size my system for 100% utilization, I needed a system rated for

<Daily Consumption (kWH)> / <Hours of full sun> / <inverter efficiency> / <Wiring efficiency> = <system size in kW>

or

20 / 5.8 / .94 / .97 = 3.782 kW CEC.

The selected system should be this size or larger.

Financials of a Solar System

On **www.affordable-solar.com/residential.solar.home.htm**, the Sunwize 5 kW system has a PTC rating of 4.717 kW. The Fronius IG 5100 inverter has an efficiency of 94.5%. This would give a CEC rating of 4.457 kW and a price tag of $35,400 ($7.94/watt) — no small sum.

In addition to financing, there are generally a number of federal, state, and utility rebates that are available — easily totalling many thousands of dollars. Most large solar installation companies will give you the information you need to apply for the rebates and tax credits.

In addition, many companies now offer package deals that will even include assortments of compact fluorescent light bulbs to help you minimize consumption of your freshly converted sunlight!

Conclusion

If you have the itch to "go solar" on your house, now is a great time to take the plunge. Panel efficiencies are higher than ever and the technology/dollar ratio is certainly moving in your favor. With energy prices guaranteed to always steadily increase, this is one capital upgrade to your house that not only adds resale value, but might even earn you a check from the utility company instead of a bill! **NV**