Starting Smart

Calculating Your Energy Appetite

Scott Russell

From solar to microhydro, in Barbados or Barrow, for a hen house or a townhouse, every renewable energy system should begin with a load analysis. This analysis is an assessment of your site's electrical use—your electrical "load profile." You'll need to ponder and juggle a lot of numbers in the process of selecting, sizing, and installing a solar-electric system. A reliable load analysis is essential to get your calculations off on the right foot.

While a load analysis is a necessity for an off-grid system, it's also an excellent idea for a grid-intertied system. For most grid-tied systems, your old electricity bills are an excellent record of how much energy your new RE system will need to produce. But only a thorough load analysis can enable you to target efficiency opportunities and ultimately minimize your system costs. Even if you plan to have a professional installer handle the entire project, your help with this critical task will ensure the highest possible value for your money.

As any RE veteran will tell you, for every dollar you spend on efficiency measures, such as replacing old, energy-hogging appliances or lighting, you'll save US$3 to $5 on the final cost of your system. Note that we're talking about increased efficiency, not necessarily conservation. While conservation is a wonderful thing, you don't need to be a puritan to use less electricity and "buy down" the cost of your system. Most important—you don't need to sacrifice the conveniences that you enjoy to afford an RE-based electrical system!

Where Does My Electricity Go?

The load analysis process can take a little time, but it's easy. A form like the sample featured in this article is available in the Promised Files section on our Web site (see Access) in Microsoft Excel format. This spreadsheet can make the necessary calculations for you. Or you can just grab a calculator and a blank sheet of paper.

The idea is to itemize everything in your house that uses electricity, and then estimate how much each item uses in "watt-hours per day." All the information you need is already either in your house or in your head. Just write it down. Many system articles in *Home Power* include an abbreviated load table, so good examples are readily available.

A complete load analysis collects and calculates several bits of data. What follows is a column-by-column breakdown of the form, describing what each piece of information means and how to get it.

Load

The term "load" refers to an electricity-consuming item—a toaster, DVD player, water pump, alarm clock, lightbulb, or power drill. List everything in your house that uses electricity, no matter how insignificant you think it is. The more complete this list, the more accurate your load profile will be. For multiple, identical loads that are on for the same length of time—for example, ten, 60 watt lightbulbs—list the item once and indicate the quantity in the next column. Multiplication will take it from there.

Load Voltage & Run Watts

Time for a little legwork. For each item, you'll need to specify both its voltage and wattage ratings. No cause for panic—every electrical load is required to have this

information printed directly on it. All you need to do is march around with your clipboard and jot down the numbers.

Voltage, amperage, and run wattage data is usually located on a sticker or plate found on the bottom or back of the appliance. There is no universal standard for how the information appears. Voltage can be listed in a number of forms: 120 volts, 120 V, 120 volts AC, or 120 VAC. Sometimes an appliance nameplate will just list voltage and current, and leave off the watts (W). Current is expressed as amperage, and appears in a number of forms: 0.5 amps, 0.5 A, or 500 mA. To figure out the run wattage, just multiply the volts and amps (V x A = W).

Nearly all of the standard electrical loads found in North America run at 120 volts AC (alternating current). Larger appliances, such as electric stoves, clothes dryers, and electric water heaters usually run at 240 volts AC.

Although increasingly rare, if you happen to have any DC (direct current) loads in your off-grid home, they'll probably operate at 12, 24 or 48 volts DC. Battery operated appliances, such as cordless drills, cordless phones, or (unplugged) laptop computers, operate on DC. But for your load analysis, use the information on their battery recharging units, rather than on the appliances themselves, unless you're running them directly off of DC.

For each load, indicate whether its voltage is AC or DC in the next column of the spreadsheet. Although voltage type isn't terribly important to your load analysis, it's critical for off-grid system design purposes. As long as you're collecting data, better to do it now.

Run wattage is usually the *maximum* an appliance will draw during operation. The watt rating on the appliance typically represents a "worst case" estimate, but since you rarely watch your television at full volume or use your jigsaw to cut granite, feel free to reduce this number by about 25 percent for "variable wattage" items such as these. For the most accurate readings on these and all of your loads, consider getting a handy watt-hour meter to breeze through the task with digital precision.

Helpful Tools & Aids

- Load profile chart
- List of approximate wattage for common loads
- Clipboard and pencil
- Watt-hour meter
- Calculator
- Willing assistant (must have opposable thumbs)
- Flashlight
- Stepladder

Hours & Days

Now comes the sitting-and-thinking part of the exercise. It may involve some collaboration with others in your household to get the most accurate estimates possible. The task simply requires that you approximate how many hours

Two typical name plates are shown here.

The sticker on the left lists the running watts as 18 W.

The sticker on the right reports the voltage as 120 V and current draw as 9 A. From this information, we can estimate that this vacuum draws about 1,080 watts.

What's a Watt-Hour Meter?

Watt-hour meters are great tools for anyone interested in collecting and analyzing electrical energy consumption data. Although effective on any 120 VAC electrical load, they're particularly useful for variably cycling appliances, such as washing machines, that are difficult to measure based solely on their run time. Most watt-hour meters can tell you the instantaneous power (watts) and the total energy used (watt-hours or kilowatt-hours) by an appliance. They take the guesswork out of your load analysis by providing actual numbers instead of estimates.

Common models include the Kill A Watt by P3 International, several models by Brand Electronics, and the Watt's Up? meters by Electronic Educational Devices. Meters from all three of these companies have been reviewed in past issues of *Home Power* (see Access). All of these meters are easy-to-use, plug-and-play models. Retail prices range from US$40 to $350, and features vary accordingly.

Three common watt-hour meters (from left to right): the Kill A Watt, Brand Electronics, and Watt's Up?

(or fractions of hours) per day and days per week each of the items you've listed is used or may be used down the road.

In most cases, this is perfectly straightforward, but a couple of notable exceptions will apply. Appliances that turn themselves on and off automatically based on need have what are called "duty cycles." Refrigerators, water pumps, and any thermostatically controlled electrical devices fit this description. You can try estimating the percentage of time that they run by observing how often they turn on and for how long they stay on. But a watt-hour meter is the only way to obtain accurate consumption information for such loads (see sidebar).

The second exception is with "phantom loads" and always-on loads. Phantom loads are electrical loads that use energy even when turned "off." Instant-on TVs, microwave ovens, computer printers and modems, and many other devices consume electricity 24 hours a day unless unplugged or "interrupted" using a plug strip. Always-on loads include answering machines, fax machines, VCRs that you don't want to reprogram, smoke detectors, and others. Some of these loads can be eliminated, for example by using a voicemail service instead of an answering machine.

Unless you plan to get rid of your phantom and always-on loads, they should all be listed in your load profile as 24 hour, 7 day loads. Most phantom loads draw less than 15 watts, but that adds up to a whole lot of energy over a span of weeks or months. Use a watt-hour meter for a precise measurement of phantom loads. Sometimes you will need to list a load twice—once for its phantom load and once for its full, "on" load. The two together should add up to 24 hours.

Before you accept your hours-per-day and days-per-week numbers as final, it might be a good idea to compare them to a few weeks of real life. Pay attention to your electricity habits for two or three weeks and then revise your estimates as needed. You can also check your estimate against your monthly utility bill. It's also important to consider seasonal variations in your electricity use. For instance, you may use your lights much more in winter and fans more in summer. Ultimately, for most grid-connected installations, you want a load profile that represents a year-round daily average.

Average Watt-hours per Day

Light math, anyone? With the essential data now in hand, use the formula below to calculate "Average watt-hours per day" for each item. This is the average amount of electrical energy that each load consumes in a day.

Quantity x run watts x hours per day x days per week ÷ 7 days = average watt-hours per day

Once completed, the sum of this column in your load profile will represent an estimate of the total amount of electricity you use on an average day. This is the consumption rate that your renewable energy system must support if you plan to produce 100 percent of your energy. When you get around to system sizing and component selection, you'll adjust this number to account for a number of seasonal and technological variables.

Lightening Your Load

At this point, it's helpful to add a column for calculating the percentage of your total load that each individually itemized load represents.

Individual load average watt-hours per day ÷ the sum of all items' average watt-hours per day = percentage of average daily load

This information will help you target specific, high consumption loads when taking efficiency measures—your next step following a load analysis. One of the best examples of the potential impact of such measures is described in John Robbins' article, "Recipe for a Solar Office: 1 Part Solar, 5 Parts Load Reduction" (see *HP97*). John reduced his home-office loads by more than 85 percent at a cost of US$1,500, saving him US$5,000 on the cost of his solar-electric system. That's real money.

Home Load Profile

Loads (Before Efficiency Measures)	Qty.	Volts	AC / DC	Run Watts	Hours / Day	Days / Week	Avg. WH / Day	% of Total WH / Day
Refrigerator, 18 ft.^{3} (old)	1	120	AC	400	7.00	7	2,800.0	35.20%
Well pump 1/3 hp	1	120	AC	850	1.25	7	1,062.5	13.36%
Television, 24 in. color	1	120	AC	170	5.00	6	728.6	9.16%
Incandescent bulbs	12	120	AC	60	1.00	7	720.0	9.05%
Computer monitor	1	120	AC	90	8.00	5	514.3	6.47%
Combined phantom loads	1	120	AC	21	24.00	7	504.0	6.34%
Light fixture (4 incandecent bulbs)	1	120	AC	240	2.00	7	480.0	6.03%
Washing machine (old)	1	120	AC	500	0.75	7	375.0	4.71%
Mac G3 computer	1	120	AC	60	8.00	5	342.9	4.31%
Microwave	1	120	AC	800	0.16	7	128.0	1.61%
Vacuum cleaner	1	120	AC	840	0.50	2	120.0	1.51%
Alarm clock	1	120	AC	3	24.00	7	72.0	0.91%
Toaster	1	120	AC	1,050	0.06	5	45.0	0.57%
VCR	1	120	AC	40	3.00	2	34.3	0.43%
Food processor	1	120	AC	600	0.05	3	12.9	0.16%
Coffee grinder	1	120	AC	150	0.05	7	7.5	0.09%
Power drill, 1/2 inch	1	120	AC	600	0.05	1	4.3	0.05%
Printer	1	120	AC	15	0.30	5	3.2	0.04%
Totals Before Efficiency Measures				6,489			7,954.4	

Loads (After Efficiency Measures)								
Refrigerator, 20 ft.^{3} (Energy Star)	1	120	AC	175	7.00	7	1,225.0	29.62%
Well pump 1/3 hp	1	120	AC	850	1.25	7	1,062.5	25.69%
Television, 24 in. color	1	120	AC	170	5.00	6	728.6	17.61%
iMac G4 computer w/ LCD display	1	120	AC	45	8.00	5	257.1	6.22%
Light fixture (4 fluorescent bulbs)	1	120	AC	80	2.00	7	160.0	3.87%
Compact fluorescent lights	12	120	AC	13	1.00	7	156.0	3.77%
Microwave	1	120	AC	800	0.16	7	128.0	3.09%
Vacuum cleaner	1	120	AC	840	0.50	2	120.0	2.90%
Washing machine (Energy Star)	1	120	AC	120	1.00	7	120.0	2.90%
Alarm clock	1	120	AC	3	24.00	7	72.0	1.74%
Toaster	1	120	AC	1,050	0.06	5	45.0	1.09%
VCR	1	120	AC	40	3.00	2	34.3	0.83%
Food processor	1	120	AC	600	0.05	3	12.9	0.31%
Coffee grinder	1	120	AC	150	0.05	7	7.5	0.18%
Power drill, 1/2 inch	1	120	AC	600	0.05	1	4.3	0.10%
Printer	1	120	AC	15	0.30	5	3.2	0.08%
Totals After Efficiency Measures				5,551			4,136.4	

If John could save that much money on RE equipment by making his office efficient, think of the potential for a whole house. Compare the tables above for the electrical loads of a modest home before and after efficiency measures. By replacing incandescent bulbs with compact fluorescents, replacing the old refrigerator and washing machine with modern Energy Star appliances, replacing the desktop computer and separate CRT monitor with a model that has an LCD screen, and switching off phantom loads, the home's energy use was reduced by nearly 50 percent.

A few of the ideas in Zeke Yewdall's article in *HP101* focus on home electricity efficiency, and many more solutions can be found. The U.S. government's Energy Star and energy efficiency and renewable energy Web sites are great places to start (see Access).

An Essential Cornerstone

Without a load analysis, designing a renewable energy system is a shot in the dark. It's like trying to plan your weekly food shopping trip without knowing how many

This plug strip is used to control multiple phantom loads with the flip of one switch.

guests you'll have and how much they'll eat. It's also where you'll save the most energy and money. Many people get excited about making their own electricity, and lose sight of the fact that analyzing energy usage and increasing efficiency is where you get the most bang for your buck. Don't skip this step!

It's easy to make the case for a comprehensive load analysis. So take the time to do a good job and then reap the rewards. Not only will it tune you in to how and where you use the electricity you pay for, but it enables you to construct a lean, green foundation on which to build your renewable energy system.

Access

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Brand Electronics, 421 Hilton Rd., Whitefield, ME 04353 • 888-433-6600 or 207-549-3401 • Fax: 207-549-4568 • info@brandelectronics.com • www.brandelectronics.com • Brand watt-hour meters

Electronic Educational Devices, 2345 South Lincoln St., Denver, CO 80210 • 877-928-8701 or 303-282-6410 • Fax: 303-282-6411 • info@doubleed.com • www.doubleed.com • Watts Up? meters

P3 International Corp., 132 Nassau St., New York, NY 10038 • 888-895-6282 or 212-741-7289 • Fax: 212-741-2288 • sales@p3international.com • www.p3international.com • Kill A Watt meter

U.S. DOE energy efficiency and renewable energy info • www.eere.energy.gov/consumerinfo

Energy Star • www.energystar.gov • Info on energy efficient products & tips for home energy efficiency

Load Calculation Excel spreadsheet • www.homepower.com/magazine/downloads.cfm

"Watts Up? Pro KWH Meter" by AJ Rossman & Joe Schwartz, *HP95*

"Things that Work: P3 International's Kill A Watt Watt-Hour Meter" by Joe Schwartz, *HP90*

"Things that Work: Brand Electronics' Digital Power Meter," by Richard Perez, *HP67*

"Doing a Load Analysis: The First Step in System Design," by Ben Root, *HP58*