Low Voltage Living

If you're just about ready to give up your power bill, maybe it's time to look into... Low Voltage Living

Do you sometimes feel as if you're at the mercy of your mailbox and the monthly utility bill it contains? You're not alone: Power company per-kilowatt-hour (kwh) rates are pushing up over 15e in some parts of the country-enough to suck better than $ 100 out of many people's monthly budgets-and there's not the slightest reason to suppose that we've seen more than the tip of this financial iceberg. Maybe it's just about time to abandon ship!

The alternative-a personal electrical system using a renewable resource-can offer you an insurance policy against the inexorable escalation of utility electricity prices. Researchers such as Hunter and Amory Lovins (see the Plowboy Interview in issue 88) have argued persuasively that investments in conservation and renewable energy are among the wisest that anyone can make. But there are other equally convincing arguments for making the move toward electrical independence among them, the personal satisfaction that can be gained by taking control.

The power grid that public-owned utilities and the government have supplied us with is a marvel of reliability. And the awesome size and complexity of that system make it hard to recall just how simple an electrical supply can actually be. But, in fact, a small, well-conceived home power station need be no more complex than an automobile's electrical system.

In the following paragraphs, we're going to give you an overview of what *we've* found to be the simplest, least expensive method of achieving electrical independence. We've been working with low-voltage, direct-current power systems for a number of years now and have found that they offer a practical combination of low initial cost, expandability, flexibility, simplicity, and reliability. For people on a limited budget who are willing to conserve, low-voltage living is assuredly the most sensible way to cut the utility umbilical.

WHAT IS LOW-VOLTAGE LIVING?

For our purposes, low-voltage means producing 12-volt direct current (VDC) and using it at that level whenever possible. For technical reasons, low-voltage electricity limits the size of a given appliance and the total amount of power that will be available in a day. Therefore, to keep the system simple, we've more or less arbitrarily decided that the largest 12-volt appliance we'll use will draw 150 watts and that the maximum amount of power that will be *produced* in a day is 3,000 watt-hours . . . or 3 kilowatt-hours (kwh). As you'll soon see, there are ways around both of these restrictions, but a low-voltage house hold will still end up being one that uses far less electricity than the norm of about 900 kwh per month.

Much of the margin between 900 kwh per month and 90 can be made up simply by not using electricity to power major heating appliances (a water heater, stove, or space heater, for instance). Solar energy is a good choice for water heating . . . gas or wood can be used for cooking . . . and passive solar heating backed up with a little wood in the stove should keep you comfy.. Those three changes alone will trim at least 500 kwh/month from the U.S. average. But before we get too deeply into how to *use* electricity in a low voltage house, we'd better figure out where that power will come from in the first place.

TAPPING NATURE'SPOWER SYSTEM

To a great extent, the alternative power source you choose will be determined by the resource you have available. As attractive as hydropower is in comparison with wind or solar, it requires that you have flowing water that goes downhill some distance. For those of you who have the luxury of choosing, the following chart sums up the relative advantages of each system, and should give you a basic idea of what natural and financial resources are required.

To withstand high-amperage 12-volt DC power, switches should be equipped with 47microfarad capacitors wired in parallel to tame arcing between the contacts. Use only snap (as opposed to silent) switches for DC power.

The success of your project will hinge on correctly estimating your renewable resource. With hydropower, you must accurately measure the fall and flow, and the volume of water must be figured at the hourly *minimum* to prevent installing equipment that will demand more water than is available. Average annual wind speed will determine the *size* of wind machine you need to buy. If your site has a 10-mph average, you'll need a 2,000watt plant, but at 15 mph you can get by with only 1,000 watts capacity. The number of photovoltaic (PV) panels you might need will also be profoundly affected by the area in which you live. In New Mexico, for example, 20 panels will provide 3,000 watt-hours per day, but 30 would be needed to do the job in overcast areas in upstate New York.

STORAGE

The weakest link in any low-voltage electrical system is almost always its batteries. Why? Well, usually because they're the wrong type for the application, they're improperly sized, they're poorly monitored, or they don't receive adequate maintenance. This information was covered thoroughly in TJ Byers' article in MOTHER NO. 74, page 114, but we're going to review a few of the key points again.

First of all, you must choose the right type of battery for your generating method. There are essentially three types: lead-calcium, lead antimony, and pure lead. Lead-calcium cells should be cycled through only about the upper 30°70 of their total capacity, which makes them suitable only for consistent power sources, such as hydro. Their advantage is that they're quite efficient. Lead-antimony batteries can be deeply discharged without rapidly degrading but aren't quite as durable as pure lead cells. Unfortunately, the latter are more expensive. Both of the last two lose some power just standing around waiting. In any event, you must not use auto batteries . . . heavy-duty, deep-cycle cells are mandatory for reliability.

What's more, a battery bank that's too small or too large for the generator output and your use will have its life span cut severely. Batteries are designed to be discharged and recharged at certain rates, and using or replacing too much too quickly will damage them. Likewise, a huge battery bank that's underutilized and receives only a tiny charge will deteriorate.

Monitoring and maintenance consist of checking the specific gravity of each celi once a week, keeping a daily eye on the system's voltage (which is an indicator of charge), cleaning the terminals whenever they become corroded, maintaining the fluid level, and providing a shelter where the temperature will stay between about 40 and 90°F.

The battery bank should be centrally located, to avoid long runs of expensive cable, and must be well-ventilated to prevent toxic and explosive gases from accumulating. If you have a remote point where you need powersuch as a well-consider locating a *slave* battery (or batteries) at that location. The amperage demands from a well pump are much greater than the peak charging current, so placing the battery at the point of use will allow the heavy current to be transmitted a short distance. The modest charging current can make the long haul from the generator or centrally located bank.

WIRING

As we've already suggested, there are certain technical limits to the size of appliances or generators in a low-voltage electrical system. Because wattage is a function of both voltage and amperage, when one goes down the other must rise. Unfortunately, amperage determines the carrying capacity of wire. Therefore, proper wiring and switching are particularly important in a low-voltage electrical setup. In general, No. 10 copper wire will serve any load of less than 150 watts in a normal-size home. There will, however, have to be some appliances that draw more than 150 watts.

To give you an example of what this can mean, let's suppose that you have an appliance that needs 480 watts to run-a vacuum cleaner, for example. At a normal utility household voltage of 120, you could use a 740-foot extension cord of No. 10 wire if you wanted to; but at 12 volts, you would be limited to 7.4 feet of wire from the battery to the vacuum. If you used a No. 8 wire, you could stretch out 12 feet into the room; No. 6 would give you a range of 18 feet; and No. 2 (which is heavy and costs upwards of $1.00 per foot) would let you swing around for 46 feet.

Obviously, all of these situations are pretty much intolerable. The solution is to run large appliances on 110-volt alternating current (VAC). One way to get 110 VAC at a remote site is to use a motor-driven generator. If used infrequently, one of these fossil-fuel burners can be really handy to have around. A more sophisticated alternative, however, is to use a solid-state inverter of about 1,000 watts capacity. This device transforms 12 volts to 120, for efficient transmission, and makes alternating current---the sort of power that utilities supply. An inverter will allow you to use appliances that run on normal household current and may be the ideal solu tion for operating large devices such as vacuum cleaners or for supplying appliances that require alternating current. You can refer to TJ Byers' two-part article on inverters in MOTHER NOS. 80 and 81 for the lowdown on such devices.

Just as independent power systems require special wiring, they also need switches that are up to the task of handling heavy direct currents. There are devices designed especially for this sort of use, but it's possible to get by with a standard snap (not silent) switch equipped with a 50-volt, 47-microfarad capacitor in parallel, to tame arcing. An accompanying photo shows you how this is done. Normal outlets are capable of handling DC loads, but it's a good idea to use a style different from normal 120-VAC receptacles, so that no one can plug a 120-VAC device into your 12- VDC system. Some people prefer automotive cigarette lighter-type receptacles, while others use outlets designed for 220 VAC.

You'll also need a control panel, which you can either buy or fabricate yourself. We've built several of these at Eco-Village-they're shown in the photos-and they're really not difficult to put together. At the minimum, a control panel will need an ammeter to show the rate at which you're using electricity, a voltmeter to indicate battery voltage, and fuses to protect against shorts. Circuit breakers can be used instead of fuses, but they must be designed for 12 FDIC.

Unless your system sizing turns out to be so accurate that power production exactly matches what you use, you'll also need a battery charge controller. These devices reduce charging current as the batteries become "full," and there are essentially three types. The *reduction* controller reduces the current going to the battery bank as its voltage rises, wasting the excess. The *diversion* controller shunts excess current (that which the batteries don't need) to a resistance heating load, such as a water heater. The *balance of systems* controller, a relatively new development, allows a wind or PV generator to produce at maximum useful voltage (and thereby also at maximum amperage) and then reduces that level to whatever the batteries happen to need.

APPLIANCES

Just about any appliance that you can imagine having is available for 12-volt living. You'll discover quickly that these items are somewhat more expensive than their 120V AC counterparts, but they're generally quite well made. Low-voltage items should last for decades with an occasional replacement of brushes in their motors. Furthermore, 12

These are a few of the many options for 12volt direct-current lighting. The large devices are fluorescent bulbs in various shapes, and the two small bulbs are incandescent lamps from recreational vehicles.

VDC brushless motors are gradually becoming available, which should make the lowvoltage appliances virtually maintenance-free. The chart below shows you an example of what can be done on 3,000 watts per day.

Modern 12-volt refrigerators are true marvels. They can do with 500 watts what your run-ofthe-mill home icebox takes 3,000 watts to get done. But, as you'll discover when thumbing through catalogs, this incredible efficiency doesn't come cheap. The Arctic Kold, Marvel, and Sun Frost refrigerator freezers all retail for between $1,500 and $3,000. For the low-voltage home, however, the only commercial alternative to these units is to find an absorption-cycle icebox that runs on a fossil fuel. The Sibir, which is sold by Lehmann Hardware, appears to be a fine unit. There are also used refrigerators around that run on propane or even kerosene.

The only 12-volt washing machines we've come across are conversions of standard machines from companies such as Real Goods Trading Company or Windlight Workshop. This isn't as difficult as it sounds: Just about any wringer washer can be converted easily, and conversion kits are available that help you to alter many popular modern machines. David Copperfield's book, *Convert Automatic Washers to 12 Volts*, is also helpful.

Television and home entertainment systems are no problem at all. Quality 12-volt color and black-and-white televisions are readily available from recreational vehicle suppliers, and automotive stereo systems can rival the fidelity of the best 120-VAC equipment.

And, yes, you can even pump your domestic water with 12-volt electricity. Many of the companies listed in the accompanying sidebar offer shallow-well and submersible pumps, and there are even a few deep-well pumps available. Of course, the actual amount of power that will be consumed by the pump will depend on the flow and head pressure you demand from it. So 800-watthours-per-day is just an estimate.

There are a number of very good low voltage lighting options. Fluorescent is the preferred choice, because it's so much more efficient than incandescent lighting. Our own informal testing showed that a 13-watt Norelco fluorescent was able to put out as much light as a 60-watt normal household bulb. And 120VAC fluorescent units can be converted to 12 VDC by switching ballasts. Replacement low voltage ballasts are available from most of the companies mentioned in our sidebar.

What else would you like to have in your low-voltage, energy-efficient household? A blender, perhaps? A toaster? A hair dryer or an electric curling iron? All of these things are available in 12-volt versions. There's really very little that you will be forced to give up when living independent from the power grid.

The question really isn't whether low-voltage living is possible, practical, or even pleasant. It's whether you *want* to take a hand in the production of the energy that you use while living on this planet. You'll work a little harder for your electricity than you do now-checking batteries, cleaning PV panels, devising new ways to use 12-volts, etc.-but you won't dread the trip to the mailbox nearly as much.