An Off-Grid Primer

By: © - 2003 William H. Kemp

I remember the day I popped the "big question" on Lorraine. The anticipation and excitement were now quickly coming to a conclusion. She was clearly caught off guard. After a moments pause, the reply, "But can I still use my hairdryer?".

That was her only concern? The rest I was sure, would be easy…

Nine years have passed and yes, Lorraine can still use her hairdryer. Living off the grid in rural Almonte, Ontario is both comfortable and satisfying. The road to a reliable, off-grid system was a bit more difficult, like a country lane after a heavy rain. You can use it, but it is not always the easiest route.

Welcome to the first issue of Private Power Magazine. The articles in this and future issues will provide you with valuable information. We hope it will make your journey down the path of energy independence and management just a little bit smoother, whether on or off the electrical gird.

Our motivation for leaving "life on the grid" was fairly simple. Lorraine wanted to move closer to her family and still have the room and privacy to support her "addiction" to animals. The lot at the back of the family farm fit the bill (and the wallet). There was only one downside. It was about $13,000 from the nearest hydro lines.

My work as an electrical/electronics engineer made me think. Why not try to make our own juice? Surely, I could whip up something for around $13,000.

In hindsight, that was a bit naï ve. In the end, our system has grown to the point where it supports our lifestyle and is far more reliable than Hydro. It also provides an interesting conversation piece for those Sunday afternoon tourists who stop by. Enjoying a cup of solar power brewed coffee they mull over why they don't do it too.

At this point in our conversation, we are usually confronted with the same story. "Our hydro bill is about a hundred bucks a month. How can we get it down to zero like you?" It's a good question and the answer is always the same. It does not matter whether you want to save a few dollars on your hydro bill or cut the lines to the Pickering Nuclear Plant completely, the path starts in the same place: Energy conservation.

Energy conservation: Why is this such a big deal? We just want to make energy, right? Wrong. Dead wrong. Trying to live off-grid is destined for complete failure without first grasping the need for energy conservation. Put very simply, the more energy you need to operate your house, the larger the size of the power station you must own. It will get expensive.

Doesn't energy conservation mean giving up things, living a Spartan life of near poverty? Certainly not living the middle class dream Canadians have come to expect. Well, yes and no. Yes, energy conservation does mean giving up things, mostly wasteful, inefficient things. What it does not mean is compromising the quality of your lifestyle.

To prove this point, we should take a quick tour of our off-grid house. See if you think we have given up anything in our bid for energy independence. Our home is typical of many rural properties, with a house of over 3,000 square feet, 3 car garage and a stable for our horses. The similarity ends with the 100 foot tall wind turbine tower and, on closer examination, the 1,200 Watt photovoltaic panel . We will discuss these items later. For now, lets keep looking at the energy conservation side of the equation.

This off-grid property is typical of many rural properties, with the exception of the wind turbine, photovoltaic panel, and lack of hydro bill!

The biggest changes are hard to see. Actually, they are almost impossible to see until you really look, or ask. As Cam Mather discusses in his article on energy conservation, "You must reduce your electrical loads before you invest." Fine, but no one wants to give up their TV, stereo, DVD player, computer, coffee machines, hairdryers and the like. How can we reduce our electrical loads to embrace energy conservation, without giving anything up?

The answer is efficiency. Do more with less, like the corporate downsizing mantra of late. Lets start with the house itself. It seems quite typical, so what makes it more efficient? Lets look at some of the most obvious design features that can be incorporated into a building design, regardless of whether it is off-grid or not:

Design for Solar Heating (and Cooling):

Orient the house to accept as much solar gain as possible during the winter months. This generally means orienting the house's long axis to face "solar south".[1] Minimise glazing on the northern side of the house. Ensure the low winter sun can penetrate as far into the house as possible. Likewise, ensure the higher summer sun angle is blocked from entering the house by using roof overhangs and the leaves of deciduous trees. Following these rules will reduce heating and cooling loads, making the house more comfortable all year round.

Build for Canada's Weather:

The Canadian Building Code is the minimum requirement used to design a house. You can do better. Building a tight, well insulated home with well-sealed wind and vapour barriers will pay for itself many times over. A well constructed house will not only be less expensive to heat, it will also be much easier to cool and control humidity levels. Use high quality insulation materials such as spray packed cellulose. Watch out for problem areas such as rim joints, where fibreglass and polyethylene don't work well. In those areas, use spray urethane foams which have excellent R values and provide an integral vapour barrier seal.

Ensure that doors and windows fit properly and air leakage is well controlled. Natural Resources Canada and C.M.H.C. provide numerous volumes on high quality construction techniques.[2]

Control Fresh Air Intake:

A well sealed house is like living inside of a plastic bag. Fresh air needs to be circulated within the house to ensure clean air and to control humidity. Your Municipal Building Code may require the use of such items as a Heat Recovery Ventilator. Determine if they are necessary or if they can be replaced by a passive "air circulation plan" designed by your heating contractor. HRVs have a place in society, but not in an off-grid house, because of their high electrical load.

Modern catalytic wood stoves are not your Grandpa's stove. These units are clean and burn much smaller amounts of wood, which translates into less cost and work.

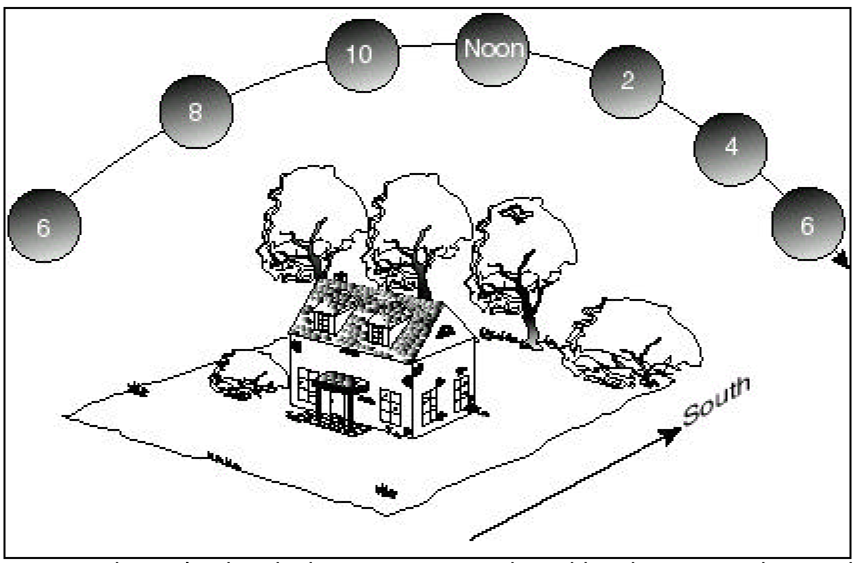
Design the Heating/Cooling System:

Assuming you are building a rural home, design the primary heating system around a high-quality, catalytic wood stove. These units are a far cry from Grandpa's stove, the ones that seemed to need constant feeding, especially in the middle of the night. Modern units are approved for safe operation, meet EPA requirements for smoke output and only require feeding a couple of times per day. Our home uses roughly two cords of wood (a cord is 4x4x8 feet of tightly packed wood) per heating season. Another reason for using wood is that the heat it generates can be distributed throughout the house by convection, without the need for a central furnace. What, no furnace? That's right. That $5,000 box in the basement uses a circulating fan which eats up far too much energy. A wood stove, possibly mixed with some high-efficiency ceiling fans, will easily heat any house and be easy on your off-grid system at the same time.

What happens when you are away? Rather than missing the trip to the in-laws at New Years, install a propane fireplace or freestanding unit (high-efficiency of course) similar to the one in our dining/kitchen area. Not only do these modern units not require any electricity, they can be sized to heat any home. Besides, they are a lot nicer to look at than the old furnace in the basement.

Propane fireplaces, radiant heaters and free standing units such as this model require no electricity and can be sized to meet the heating requirements of any house. They also look a lot better than the $5,000 furnace in the basement.

Cooling is another story. Central air conditioning is by far the largest and least efficient loads in the home. It does not belong in an off-grid home. The best way to keep your home cool is to stop the heat from getting inside in the first place. This might sound simplistic, however, a well insulated home, with shading that blocks the summer sun from entering the house will go a long way to prevent overheating. Let the prevailing breezes cool the house at night by opening the windows that face it and those on the opposite sides of the house.



Proper site selection is important to assist with winter warming and summer cooling. Deciduous trees and proper roof overhangs will prevent the hot summer sun from entering the longer South axis.

For those of you lucky enough to have relative humidity levels below 30% in the summer, an evaporative cooling unit[3] may be the ticket. These devices are very common in the U.S. South-West and use very little electrical energy to boot. When the mercury and humidity rise, even the best built house will need a little help. A one ton (12,000 btu) per 1,500 square foot, high efficiency window style air conditioner will help. In our house, one unit is installed on the main floor with a second installed in the bedroom area upstairs. Both units are permanently mounted into the walls, with the condenser (the part outside) facing as far north as possible, out of direct sunlight. Although these units are very large loads on the off-grid system, they are just the ticket to bring the humidity and temperature down to a comfortable level. Every A/C installer will swear up and down that this size is too small. If you are the sort who needs to wear a nice wool cardigan in your house in July, then maybe they are right. For the energy conserver, this size works quite well.

Technically speaking, most A/C systems are sized far larger than needed. This is usually an effort to make sure that "you are getting what you paid for", a very fast, obvious cooling of the indoor air. It also ensures you don't call the installer back because the A/C isn't working well. On the other side of the coin, a large unit cools the air, but does not have sufficient time to reduce indoor humidity levels. A smaller unit running for a longer period will ensure lower indoor humidity and temperature. One big plus for these smaller A/C units is they tend to be used only when there is a surplus of energy. Normally on those long, hot summer days that make the PV panels so happy. Of course, if you still need more A/C run time than can be supplied by the renewable sources, the backup generator can always be used (sparingly) to compensate.

A Look Inside:

Unless you are the sort who gets excited about dimensional lumber and sheeting material, the structural stuff will be contracted out. Inside the house, you can influence every Watt of electricity that you use and actually see and measure where it goes. We will review a little bit of the math, to help you understand how it all works. This will also help explain those cryptic power bills.

Compact fluorescent lamps (CF lamps) last longer and are cheaper to operate than regular light bulbs. A typical 15 Watt CF lamp is as bright as a standard 60 Watt incandescent.

Almost everyone has heard that compact florescent lamps (CF lamps) last longer and are cheaper to operate than regular light bulbs. Lets examine the difference between the two. Understand that every appliance in the home, consumes electricity in the same way, albeit at different rates.

The picture shows four lamps. A standard incandescent 60 Watt style is on the left. The others are different styles of compact fluorescent bulbs. A typical 15 Watt CF lamp is as bright as a standard 60 Watt Incandescent.

The Watt is a unit of electrical power which is calculated by multiplying the Voltage (or pressure of the electricity) of the appliance (typically 120 Volts) by the current in Amps (or flow) of electricity through it at a given instant. The more Watts an appliance requires to operate the more electricity it consumes. You do not pay for power (or Watts). Your electrical bill is for energy, which is simply Watts of electricity consumed multiplied by the amount of time the appliance is on.

Lets try an example. Bear with me, this is not too difficult and is quite important!

Assume that our 60Watt standard bulb is turned on for 10 hours. What is the energy consumed?

60 Watts (of power) x 10 hours = 600 Watt-hours (of energy)

Now, electricity delivered to your door, with all of the nice additional charges that the government can find is about 10 cents per 1,000 Watt hours (or 1 kilo-Watt hour, kWh.):

600 Watt-hours (of energy) x $0.10 per 1kilo-Watt hour = $0.06 or 6 cents per hour

If we run the same equation for the 15 Watt CF lamp, we will find the cost to be 4 times lower, owing to its lower energy consumption, or 1.5 cents per hour.

This is not a great deal of money, but when you add up each electrical appliance's energy consumption over the course of a month, the bill can become quite high (remember last summer before the rate cap in Ontario?).

The general rule for an off-grid house is to purchase the most efficient appliances you can reasonably afford. It is also important to keep high electrical energy consuming appliances such as electric stoves, electric clothes dryers, space heaters, and the like, off the list.

The typical home refrigerator is a large consumer of electricity. Recent advances in appliance design lower electrical consumption by more than half. Our Kenmore 22 cubic foot, 2 door unit, uses only 435 kWh of electricity per year, which is 1,200 Watt hours per day, (12 cents at current rates) according to the Natural Resources Canada (NRCan) Energuide rating.[4] All major home appliances have the EnerGuide rating and they should be compared before purchasing any appliance. This is especially true of off-grid installations.

This Kenmore 22 cubic foot, frost-free refrigerator is large enough for most families and uses less than ½ of the energy of the same size unit manufactured 10 years ago.

Large heat producing appliances that use electricity do not belong in an off-grid house because of the enormous amount of energy they consume. This applies to ovens, stoves, clothes dryers, space and water heaters, car block heaters, etc. Our cook stove is an excellent example of a modern efficient appliance, with a nod to a rustic country look. The heating source is propane gas. In the typical off-grid house, propane gas fired appliances will be used for the bulk of the heating functions.

You can almost smell Grandma's bread baking in the oven, except it will be coming from the bread machine in our home. This modern propane stove from Heartland can still handle the job.

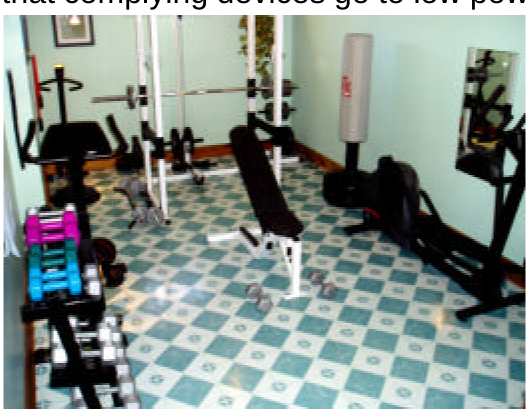
Other large appliances found in our home include: propane clothes dryer, propane water heater (either storage or on-demand types can be used), high-efficiency, front loading washing machine and central vacuum system.

This wall of home entertainment equipment proves that life off-grid, does not mean having to do without.

A home entertainment system might not seem to be energy efficient. Won't the big screen TV, Satellite dish, DVD, VCR, CD player, and surround sound system simply chew up power? Actually, no. Modern electronic appliances are a marvel of efficiency. Just think of the huge "boom boxes" that run on a few "C" cell batteries (and never seem to die). Provided you don't watch the tube 24 hours a day, almost any off-grid system can handle these loads.

The same basic rules apply to most home office/computer installations. Laptop computers with ink jet printers are the best. Replace the old picture tube monitor with a flat screen LCD unit and save big time (just the excuse you needed for the upgrade). Laser printers tend to be the worst office equipment electrical load. Just make sure you switch it off after you use it. The U.S. Government has created a program similar to EnerGuide for use with data processing equipment. This program, called Energy Star, ensures that complying devices go to low power mode when sitting idle.

Computers, printers, and modern office equipment work perfectly in an off-grid setting. Just keep an eye on efficiency by purchasing products with the "Energy Star" logo.



Being off-grid is no excuse to become lazy, as you can still use most cardio equipment and watch the latest yoga instructional video.

Energy conserving or off-grid, living is not a Spartan living. A gym filled with electrical and electronic gadgets, big screen TV, computers, and the like are examples of devices that may be found in the home. Add in the lights and stereo in the horse stable, the garage with electric door openers and you might even think this house is a large electrical consumer. In fact, the opposite is true. We operate the house on between 3 and 6 kWh per day, depending on the season. Contrast this with an average Canadian house that uses 40 to 75 kWh per day.

Phantom Loads:

Phantom loads are unnoticed electrical loads that burn holes in your energy conservation pocket. Examples are doorbells, "instant on" electronics and anything plugged into a "power adapter" like this one.

As the name implies, phantom loads are defined as any electrical load which is not doing immediate work for you. This includes items such as doorbells (did you know that your door bell is always turned on, waiting for someone to push the button!), "instant on" televisions with remote controls, clock radios, and power adapters.

So, what is the big deal? First, these devices are consuming energy without doing anything for you. That electric toothbrush was probably charged about 15 minutes after you put it back in the holder. The remaining 23 hours and 45 minutes until the next time you use it represents wasted energy. A television set that uses a remote control is actually "mostly on" all the time, just waiting to receive the "on" command from your remote.

While the total dollar cost for these luxuries is small on-grid, (on the order of $10.00 per month for an average house), this consumption off-grid is unacceptable.

Another reason for the concern is the inverter unit (discussed below). This device will go into a sleep mode when the last light is turned off at night, conserving a fair amount more energy. Any phantom load will keep the inverter "awake" consuming more energy than it otherwise would.

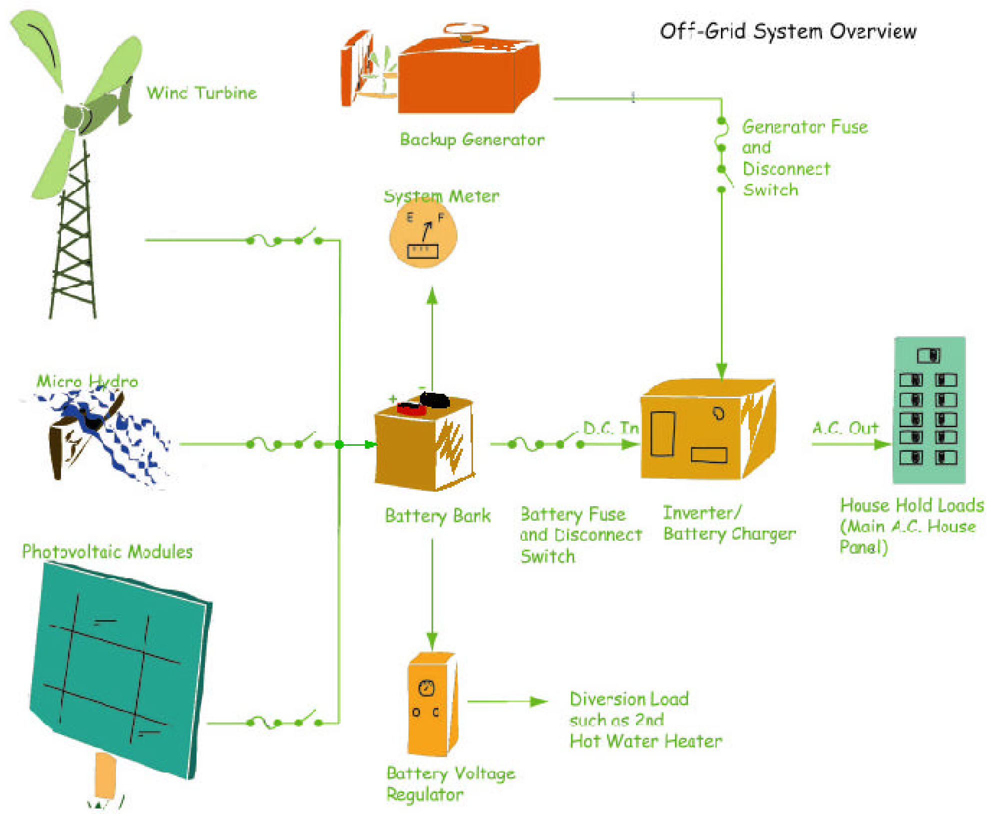
We will review the corrective action for this item later.

Conservation and Load Conclusion:

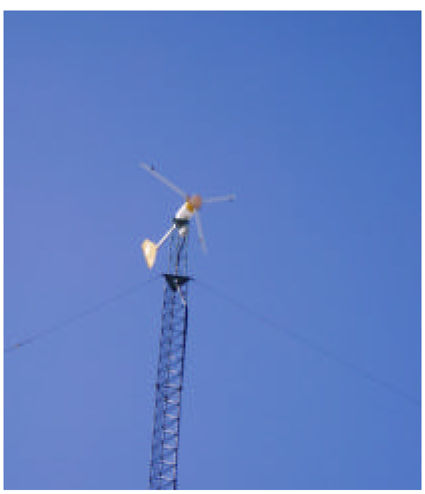
Our house has much of the same "stuff" as a regular house, but it uses 10 times *less* electricity than the average home. Before you run off saying, "Yes, but all the expensive things to operate are on propane." remember that most people use natural gas for the majority of these loads and also dollar for dollar, electricity is the most expensive way to make heat. Ask someone who just paid their electric heating bill for this past winter.

The Fun Stuff:

So, we now know how to stretch our electrical energy dollar further and live within the means of an off-grid system. Let's see how to make the energy that we need to run a household. It should be obvious if we consume 3 to 6 kWhr per day, we need to produce about that much too:



Off-grid systems rely on one or more renewable energy sources charging a storage battery bank. An inverter converts the energy stored in the battery to regular household power to operate your appliances.



With advances in materials technology, wind power is being used in every location on earth. Small turbines such as this Bergey 1500 are designed specifically for off-grid applications.

All off-grid systems work much in the same fashion. Collect energy from a renewable source (wind, sun, stream), convert it to electricity and store the energy, usually in a battery bank. When we need this energy to power our appliances, we take some of the energy from the battery, convert it to alternating current (just like Hydro) and feed it to our unsuspecting appliances. (Don't worry about the technical jargon just yet, there will be plenty of space left in the article to put even the worst insomniac to sleep).

In theory, it seems simple, but just like everything else in life, the devil is in the details. Take a look at the overview drawing and lets follow the system through its operation.

All of the Earth's energy comes from the sun. In the case of renewable sources, the link is often very clear: The Sun's rays striking a photovoltaic panel are converted directly into electricity. The Sun's energy causes the winds to blow, striking the blades of a wind turbine, causing the generator shaft to spin and produce electricity. The rains that fall in the mountains are caused by the Sun evaporating water. The rain becomes a stream that runs down hill into a micro hydroelectric generator.

Unlike fossil fuels or nuclear energy, renewable sources are just that, renewable. No matter how much sunlight we capture with our photovoltaic panels, there will always be more for everyone else, and no dumping today's pollution on tomorrows children. A 1200 Watt peak output PV array on a sun tracker mount.

As well as a being renewable, these energy sources are also variable or intermittent. The Sun generally goes down at night or may not shine for several cloudy days. If we just wanted to use our energy when it was available, the system would be much simpler. However, humans are just not that content. I know for a fact most people want their lights to turn on at night, even though the sun stopped falling on the PV panels hours ago. In order to ensure that electricity is available when we need it, a series of wire cables, fuses and disconnect switches, delivers the energy to a battery storage bank.

Although there are many different types of storage batteries in use, the most common and reliable by far, is the deep-cycle, lead-acid battery. You may be familiar with smaller ones used in golf carts or warehouse forklift trucks. Batteries allow you to store energy when there is a surplus and hand it back out when you are a bit short. So why are we using a battery bank? Why not store the electricity by some other means?

An off-grid system requires a means of storing the electrical energy generated by the renewable sources for later consumption. A sizeable battery bank provides the needed storage.

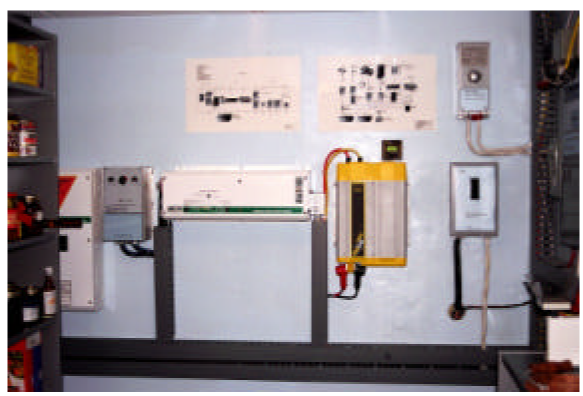
Great questions, simple answer: There just isn't any other feasible method of storing electrical energy. Maybe down the road, but if you want an off-grid system now, batteries are the only way to go. Today's industrial deep cycle batteries are a solid investment that should last 20 years with a minimum amount of care. At the end of their life, the old batteries are recycled (giving you back a portion of their value) and new ones installed.

Storing electrical energy is simple, just connect the renewable energy source to the battery and away it goes. Getting it out is a bit more complex. First of all, electricity stored in a battery is done at a low Voltage or "pressure". You will probably know that most of your household appliances use 120 Volts, whereas off-grid batteries commonly store electricity at 12, 24, or 48 Volts. Second, the electricity stored in a battery is in a direct current (D.C.) form. This means that electricity flows "directly" from one terminal to the other terminal of the battery. Direct current loads and batteries are easily identified by a red "+" and black "-" symbol marked near the electrical terminals.

The electricity supplied by Hydro to your home is delivered as "alternating current" (A.C.). This means the direction of flow on the supply wires changes direction at a rate of 60 cycles per second or 60 Hertz. (Many of the terms used in electricity are named after the early inventors who discovered the physics surrounding a term. James Watt, Count Volta, Heinrich Hertz, are a few of these experimenters).

In order to increase the Voltage (pressure) of the electricity stored in the batteries and convert it from D.C. to A.C. a device known as an inverter is used. Without an inverter, your choices in electrical appliances and lighting would be reduced to whatever 12 Volt appliances you could find at the local RV store. Early off-gridders did in fact choose this path, but don't consider it for anything but the smallest of summer cabins or hunting camps. A house full of middle class dreams means a house full of 120 Volt, A.C. appliances. Standard electrical power also means standard wiring, standard electricians and happy electrical inspectors who enforce safety standards.

The modern off-grid world runs its electrical appliances on alternating current supplied by inverters such as this.

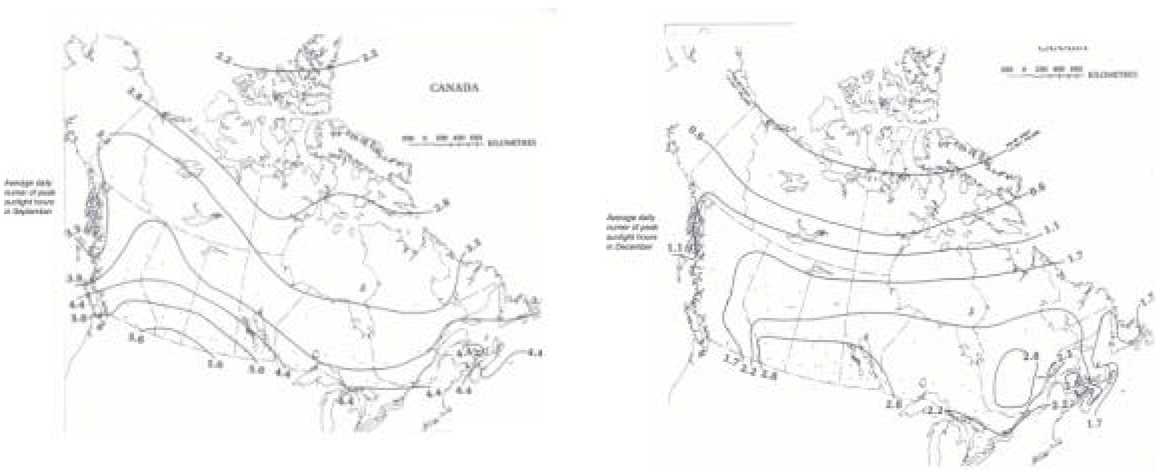


An off-grid system should be neat, simple and well laid out, ensuring smooth sailing with electrical inspectors and your insurance salesman.

So that forms the basic system. A supply of electrical energy from wind, water, or sunlight feeds low Voltage (pressure) electricity into a battery bank. The batteries store the electrical energy within the chemistry of the battery "cells". When an electrical load requires energy to operate, current flows from the battery and/or the renewable energy source at low Voltage to the inverter. The inverter transforms the direct current (D.C.), low Voltage to higher 120 Volts, Alternating Current (A.C.) to feed the house electrical panel and the waiting appliances.

The Changing Seasons:

As a bad July sunburn will remind you, the amount of sunlight in summer is much greater than in winter. Simply put, the longer the sun's rays hit a PV panel, the more electricity the panel will push into the battery. The months of November and December tend to be dark and dreary by contrast. How does this affect the system and will there be enough energy in the winter?



Sunlight hours per day is subject to extreme seasonal variability in Canada as a comparison of these maps show.

Seasonal variability is extreme in Canada. The two maps show the average amount of sun hours in September and December across the country. These months are only separated by 90 days, yet the amount of sunlight falling in December is approximately ½as much as September and even less than in June. Obviously, the PV panels' output will reduce accordingly, and the amount of stored electricity will vary with it.

This creates an odd paradox. Too much electricity in summer and not enough in November and December. What to do?

Hybrids: (Winter Season)

Hybrid design simply means mixing more than one source of energy. In our overview example, we have PV, wind and micro hydro, plus a back-up generator. This design is not typical as most off-grid systems typically start with PV as the main renewable source, a back-up generator second and possibly a wind turbine third. For those of you lucky enough to have a year round stream sufficient to operate a micro hydro system, that is probably the only energy source you will require.

Back to Watts and nuts and bolts for a second. Remember that we talked about consuming 3 to 6 kiloWatt-hours of electricity per day. Now we have to look at what we produce, to see how well they match. Our PV panels are rated for 1200 Watts peak power output (28 Volts x 43 Amps D.C.). In reality, they tend to output approximately 950 Watts under ideal conditions, less if it is hazy and nearly zero if the day is cloudy. The entire assembly is mounted on a sun tracker unit, which allows the panels to face the sun as it moves from early morning through late afternoon, winter and summer.

Referring to the December sun hours map for our location, we find our average to be 2.2 sun hours per day:

2.2 sun hours per day x 950 Watts output = 2,090 Watt-hours per day or approximately 2 kWh per day

With 2 kWh of production and an average consumption of 4 kWh per day, the system will loose 2,000 Watt-hours per day. If this was your bank account and you kept taking out more than you put in, guess what happens? Depending on how deep your pockets are, you run out of cash. The off-grid system batteries are no different. In fact, normal battery sizing is based on the assumption that you should be able to run your house “normally” for 3 to 5 days without having *any* input from your renewable energy sources. For our household, running all average loads means the batteries need to supply:

5 days supply x 4 kiloWatt-hours per day = 20 kiloWatt-hours usable capacity


This large 7.5 kWatt diesel backup generator will last several lifetimes and be economical to operate as well.

So, what happens at the end of 4 days? This is where the hybrid design comes in. Depending on the degree of automation in your system, you either manually start the backup generator (gas, diesel or propane) or a generator control device starts the generator for you. In either case, the inverter now switches to battery charging mode and fills the batteries back up. Electrical loads in the house are powered automatically from the generator during this charging time. Once the batteries have reached full charge, the generator turns off automatically or you run out in your housecoat and slippers to shut it down. (I think the automatic feature was definitely worth the few extra bucks!)

If your system contains more than one renewable source, you will find that they tend to be complementary. A dull day in November often has brisk winds and conversely the air on a sunny summer day is hot, still and stifling. But don't believe that having PV and wind will eliminate a back up generator, it won't. The combination will reduce the running hours of the generator considerably, but it won't eliminate it. Our house still requires approximately 150 hours of generator time per year.

Hybrids: (Summer Season)
During the summer months, the increase in sun light hours, coupled with a lower need for lighting and less time spent indoors creates a surplus of energy based on consumption levels at 3.5 kWatt-hours per day.

Production:
6.0 sun hours per day x 950 Watts output = 5,700 Watt-hours per day
or approximately 6 kWh per day

Surplus:
6 kWh/day produced – 3.5 kWh/day used = 2.5 kWh/day surplus

This surplus may or may not be needed, depending on whether or not we require any air conditioning that day. As I mentioned earlier an air conditioning unit uses an enormous amount of energy, on the order of 1,100 Watts per hour operated. Based on a surplus of 2.5kWhr/day, we should be able to operate the air conditioner for up to 2.5 hours per day, without dipping into the energy bank.

On days that we do not need the air conditioning, the surplus energy produced must go somewhere. If it were not consumed, the batteries would reach a fully charged state and would eventually "overcharge". To prevent this from happening, a battery voltage regulator is installed in the system and connected to a diversion load. A typical diversion load consists of an electric water heater, plumbed "before" the regular gas water heater unit. The 240 Volt heating elements supplied with the electric heater are removed and replaced with new ones rated the same as your battery bank voltage (24 Volts in our home).

In operation, the battery voltage regulator monitors the battery voltage or state of charge. When the batteries become full, it starts to divert surplus electricity to the electric water heater. The water starts to heat as it absorbs the extra energy produced by the renewable energy sources. Over the course of a day or two, this water can easily reach 60 degrees, which in turn flows into the regular gas water heater. As the incoming water is already hot, the gas heater remains on standby, thus conserving propane gas!

A small inverter such as this one can be wired to special outlets throughout the house, strategically placed for those "always on" loads.

Phantom Load Management:

Some phantom loads can simply be eliminated. Try a doorknocker instead of a doorbell and a battery powered digital clock instead of the plug-in model. I have even heard that some people use manual toothbrushes.

Television sets, CD, DVD, and VHS players with instant on and remote control functions should be wired to outlets that can be switched off. This could mean having the electrician wire in the switch for you or using a power bar with an integral switch.

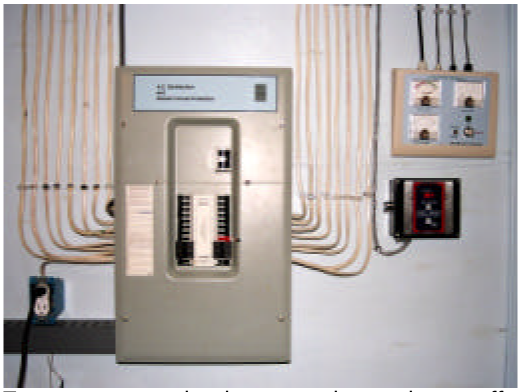
There are some phantom loads which even we cannot live without. These include the fax machine, our cell phone, PDA and laptop computer chargers and wireless telephones. For these items, I have a separate wiring circuit run through the house, which connects to specially marked outlets. These outlets are reserved for ESSENTIAL "always on" loads like the ones described above.

The power for these outlets comes from a $60.00, 100 Watt inverter which is wired directly to the batteries. Such an arrangement ensures the main inverter can go to sleep at night and still provide power for the devices I desire. If your home is already built, it may be possible to group all of these special loads at one central location and run the inverter to a power bar at that point.

One note about this "small" inverter. If you load it up with all of your toys, it is possible to burn up nearly 100 Watts of power. Over the course of 24 hours, this is a lot of juice:

100 Watts x 24 hours per day = 2,400 Watt-hours or 2.4kWh

That's almost ½ of your daily total energy consumption, tread lightly!



Every power station has metering and your off-grid system should be no exception. A proper meter will lead to increased system reliability.

Metering and Such:

At this point you are probably wondering if I run around the house with a note pad and calculator, chastising Lorraine for using her hair dryer too long or making the toast too dark, while recording every Volt and who knows Watt.

Actually, we hardly look at the system at all. Once you install your system and load the house with all the electrical goodies imaginable, the system will almost take care of itself. If we use more energy than we produce, the generator may run for a while. If we make more energy than we use, the next shower is free due to the savings in hot water. The system is almost invisible.

But as with any piece of complex machinery a bit of care and management is required. I would suggest a multi-function meter be added to the mix. These units monitor the energy produced and consumed and do all the nasty mathematics to tell you how much juice is really in the battery. When this and other data are monitored, you will have a comprehensive snapshot of the health of your own power station.

But is it economical?

This is a tough question, because the answer is not straightforward. The entry level for a turn-key (i.e. you do none of the installation work) PV based system running house loads similar to ours is about $25,000 to $35,000 (Canadian) for all of the materials and installation labour. Do some of the work yourself and it can be lower. Add a wind turbine and it will go up. Can you work with used equipment and tinker some? Our fairly large system based on today's costs would be approximately $50,000.

If you don't do any energy conservation, expect to pay between 5 and 10 times this amount. (I told you energy conservation is important).

Will your private power system remain connected to the electrical grid? The installed rate will tend to come down, because of lower equipment requirements. Jerry Horak discusses some of these issues in his article on "Pumping into the grid".

For most Canadians, the break even point is based on how far the installation is from the hydro grid. If your hydro utility is more than ½km from your house, it may pay for itself from the second you turn the first light on. Add in the benefits of no hydro bill, zero environmental pollution and the feeling of selfsufficiency you get the next time your neighbour's lights go out during that dark and stormy night.

Summary:

If you were able to read this far without your head spinning off, congratulations! We have covered a lot of ground on our dual paths of energy conservation and off-grid design. It is just not possible to provide all of the details in one "short" article like this.

Don't despair! In future editions we will cover a more detailed analysis of each area, including reviews of actual equipment installed in the tough Canadian environment. Regular columns will deal with basic electricity theory, electrical code and safety issues as well as reviews of other Canadian off-grid and grid-interconnected systems.

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P.S. If you have any specific questions you would like addressed by the Private Power Magazine, please write or email us. We would be pleased to hear from you.

1: If you use a compass to help you orient your PV panels and home so that it is facing south, you will be relying on magnetic south, instead of true or "solar south". In some parts of Canada, the deviation is large enough to significantly affect the performance of both your home and PV arrays performance. This information will be discussed in further detail in a future article.

2: "Keeping the Heat In" by Natural Resources Canada, ISBN 0-662-12481-2
"The Clean Air Guide" by Central Mortgage and Housing at www.cmhc-schl.gc.ca

3: Evaporative cooling units work by passing hot, dry outside air through a porous pad which is kept constantly wet. The process of evaporating the water, removes heat from the air, which is then passed into the building structure.

4: Natural Resources Canada in conjunction with Canadian Standards Association operates the EnerGuide program. The EnerGuide program provides the estimated operating cost of every major appliance sold in Canada as well as compares its energy consumption to other models in the same size and performance category. For the off-grid home, purchasing the model with the lowest consumption rating is mandatory, for on-grid homes it is just plain smart.