ENERGY SELF SUFFICIENCY NEWSLETTER

November 2005

Off-Grid Living
Biofuels
Hydro
Solar
Wind

A Rebel Wolf Energy Systems Publication

Photo by Ron Fev

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Rebel Wolf Energy Systems

From The Editor's Laptop

by Larry D. Barr, Editor

Field Expedient Engineering

I'm a member of several email groups and one of them posts a "Question of the Week" each Sunday. Just to make us think and to encourage us to share with the other members of the group. This week the question was, "What is one self sufficiency skill that you have learned/developed that you are most proud of?"

I thought about it for a while, mentally ran through the list of skills that I have, and responded to the question with "Field Expedient Engineering." That's the ability to construct a working device out of a bunch of spare parts, leftover pieces and general junk. The ability to fix a piece of equipment with, as they say, bubble gum and baling wire. Sometimes it's called "MacGyver-ing" after the TV show starring Richard Dean Anderson. But, whatever you call it, it's a handy self sufficiency skill to have.

And of course, I hear you thinking, you have to be born with it. Now, admittedly there are some folks who seem to have been born with one skill or another. I know there are some things that just came naturally to me. Things like understanding electrical and mechanical devices. That makes it a lot easier.

However, if you're not one of those to whom things like that come naturally, don't despair. The skill of Field Expedient Engineering – or as my friend Steve Spence calls it "Imagineering" – can be learned. And learning it will give you a great advantage in your quest for self sufficiency.

"How do I learn it?", you ask. The Internet is a great place to start. A Google search for "how things work" returned about 363 million responses. The first two were a couple of excellent ones. They were http://www.howstuffworks.com/ and http://howthingswork.virginia.edu/.

There are lots of other resources out there for your perusal and study. At least one series of books, maybe more, on the subject. Speaking of books, one of my favorite technical bookstores is Opamp Technical Books in Los Angeles. If you spend a little time on their site, you can browse through the abstracts of most, if not all, of the books they have in stock.

Another wonderful, and very sociable, way to learn is to join one or more of the Internet email groups, or listservs, that are available. There are literally thousands of them, covering every imaginable subject and interest. At the risk of a bit of blatant self-promotion, I'd like to invite you, if your interests include the generation and use of 12 VDC power in your off-grid home, to join my 12 VDC Power group on Yahoo! The group URL is http://groups.yahoo.com/group/12VDC_Power/ There's a lot of knowledge, experience and talent in the group, and that's typical of many of the groups online.

You'll find a great mix of folks in all the groups. A core of experienced experts and a large contingent of those who are new, or relatively new to the field and seeking answers to their questions. There are a lot of questions and answers, some intense discussions and, occasionally, differences of opinion. But, it's a great way to learn and a lot of fun. Just remember, in any of the groups that you join, to always debate the issue and not the other poster. We're all there to exchange ideas, not engage in personalities.

I encourage all of you to continually learn, to hone your skills and to always educate yourself in our chosen subject of self-sufficiency. Field Expedient Engineering can be learned, and someday, it may make things much easier or even save a life.

Peace,
ldb

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NIFTY GADGETS

by Larry D. Barr

I admit it. I'm a sucker for neat little gadgets and devices that make life easier. One of the areas of life (mine, at least) that's always been somewhat problematical is the 12 VDC power connections to all the various pieces of equipment that seem to collect around me. As you know, I've simplified the system considerably by standardizing on the Anderson PowerPole connectors for every 12 VDC powered device I own.

I get all my PowerPoles and related gear from Powerwerx and on my last order (some HS-4s) I acquired a couple new products that Ken and the gang there are stocking now. I have one of the 12 position West Mountain RigRunners that I'll be building into my 'command center', but that's a lot of power distribution for small portable applications.

The new PS-4 Plus from JO-COMM is an outstanding little 4-way power block for any PowerPole distribution project that needs to be small and portable. It fits in your pocket, or in your 'go bag' if you're a bit better organized, and past the pocket stage. It's rated at 58 VDC for a total amperage of 45 amps. Just pick the PowerPole pair that you want for the input and the other three connectors are available for outputs to your chosen devices, such as lights, radio gear or what--ever. Remember to keep the total current through the device under 45 amps. Also remember to use the proper contact for the load when you make up your PowerPoles.

If you're concerned about dirt or moisture getting into your PowerPole connectors as the cables rattle around in the tool box or wherever between uses, be concerned no more. JO-COMM has solved that problem too. The new PPC-1 protective cover keeps the crud out of your connectors. They're an excellent accessory if you don't always keep the power cables in a clean place.

Powerwerx also offers other JO-COMM power distribution products in various ampacities and configurations, including some with the "T" connector used on Yaesu, Icom and Kenwood amateur transceivers.

Any ham operators that haven't changed to PowerPoles yet, why not make the move? They're the approved DC connector for both the ARES and RACES organizations, and simply the best connector for the job.

If you're looking for the answer to DC power distribution, point your browser toward Powerwerx and check out the West Mountain and JO-COMM products. You'll very probably find the solution to your problem. ldb

Circulation Info

ESSN exceeds 23,500 downloads!

Monthly circulation of ESSN, measured by downloads of the PDF and HTML files, continues to rise and now stands at over 23,500!!! As the word of our existence spreads, and our content increases, we will continue to share our experiences (and yours) in off-grid living and energy self-sufficiency with folks around the world. Thanks for your interest and your support. ldb

A DAY IN THE CLASSROOM

by Larry D. Barr, Editor

My boss teaches a class at the university I work at called "Great Ideas in Physics." I admit it's kind of a 'cutesy' title (he didn't name it), but it's a good solid class designed to provide an overview of physics for non-science majors. One of the most important things that a teacher can provide to his students is relevant subject matter, and Mike decided to invite me to talk to his class today about renewable energy sources and utilization. I think the students learned something today, and it was certainly an education for me to see the varying levels of both interest and knowledge of renewable energy among the class members. It also very gratifying to see that most of the students did have a basic knowledge of the various types of renewable energy sources and, in many cases, were able to discuss them in some depth.

I'm not really a fan of teaching by lecture, I'd rather get everyone involved in a rousing discussion. I kicked it off (after a glowing introduction by Mike that I wasn't sure I could live up to) with a question – "When I say 'renewable energy' what does that phrase mean to you?"

I got some great answers. Wind, solar, hydro, biodiesel, ethanol, hydrogen, fuel cells – and nuclear. That last one isn't one of my favorites, but it gave us something more to talk about. We spent the rest of the lab discussing each of the answers in some detail, and I was able to share some of the available online resources with the students.

Some of their questions showed an understanding of the subject that really surprised me. As I was talking about biodiesel one of the students raised his hand and asked, "But don't you need to put in some special heater to run that?" Have you ever heard a more perfect segue into a discussion of waste vegetable oil (WVO)? Neither had I. So we talked about WVO for a bit, got into the heating requirements and the fact that you can't start a cold engine on cold WVO and even talked about the shutdown procedure.

We discussed underground and earth sheltered homes, passive solar construction, the necessity of good insulation and the importance of conservation. After some of the discussions I've been involved in online, I found it interesting that most of them perceive the term "off-grid" to mean "not connected to an electric utility", which has always been the definition that I use. Recently there have been some folks in the RE community who've been referring to the "water grid", the "sewage grid", the "fuel grid" and even the "food grid." The various definitions of the term led us into a very spirited discussion on the difference between "off-grid" and "energy self sufficient". It's always fun to watch the reaction as folks become aware of the many types of energy that we use and the difficult path that we must walk to be truly energy self sufficient. The question was brought up, "Is it truly necessary to become energy self sufficient? Or can I help the planet and the environment just by conserving?" Questions each person must answer on their own.

I came away from the lab with a really good feeling about today's university students. For all you 'old farts' (I can say that, I am one) that are worrying about the future, it's not as bleak as you might think. There are some mighty sharp, very dedicated young adults coming along. If we help them, mentor them and nurture their interest in the environment and the sciences, I think we'll be pleasantly surprised.
Peace, ldb

TAKING THE PLUNGE!

An Off-the-Grid Home Tour to learn the basics of a renewable energy system
by William H. Kemp

I remember the day I popped the "big question" on Lorraine. The anticipation and excitement were now quickly concluding. She was clearly caught off guard. After a moment's pause came 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-grid is both comfortable and satisfying. Our motivation for leaving "life on the grid" was 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 hydropower 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 naïve, but in the end, our system has grown to the point where it supports our lifestyle and is far more reliable than the power utility. Since that time I have shared my experience and knowledge with dozens of homeowners who have since taken the renewable energy off-grid or grid-interconnected plunge.

What is the trick? A willingness to give it a try and a touch of adventurousness sure, but most of all it's about energy efficiency.

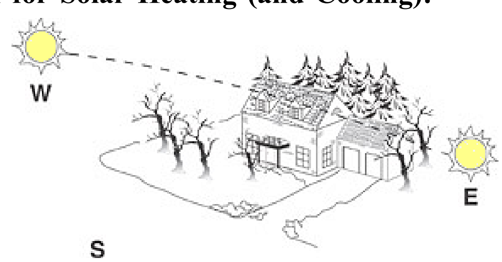
Energy conserving on- or off-grid does not mean you have to live a Spartan lifestyle. A big screen TV, computers, and a cappuccino maker are examples of appliances and devices that are in our off-grid home. Add in the lights and stereo in the horse stable, a hot tub on the deck, garage with electric door openers and you might think that this house is a large electrical consumer. In fact, the opposite is true.

We operate our house on between 3 to 6 kWh per day, depending on the season. Contrast this with other homes that use 40 to 75 kWh per day.

An energy efficient 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 appliances to operate use propane", remember that most people use natural gas for the majority of their large loads, and dollar-for-dollar, electricity is the most expensive way to make heat. Ask someone who just paid his or her electric heating bill for this past winter.

Let's look at some of the most obvious design features that can be incorporated into a building design, regardless of whether or not it is off the electrical grid.

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". Minimize 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.

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Build for Your Local Weather:
Your local 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 vapor 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 joists, where fiberglass and polyethylene don't work well. In those areas, use spray urethane foams that have excellent R-values and provide an integral vapor barrier seal.

Ensure that doors and windows fit properly and air leakage throughout the house is well controlled.

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.

Design the Heating/Cooling System:
Assuming you are building a rural home, design the primary heating system around a high quality, catalytic or ultra-high efficiency 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 that eats up far too much energy. A wood stove, possibly mixed with some high-efficiency, direct current ceiling fans, will easily heat any house and be easy on your off-grid system at the same time.

Active solar heating, propane fireplaces and free-standing units such as this model that require no electricity and can be sized to meet the heating requirements of any home. They also look a lot better than the $5,000 furnace in the basement.

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 shown in Figure 4. 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.

Cooling is another story. Central air conditioning is by far one of 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.

When the mercury and humidity rise, even the best built house will need a little help. For those of you lucky enough to have relative humidity levels below 30% in the summer, an evaporative cooling unit may be the ticket. These devices are very common in the U.S. South-West and use very little electrical energy to boot. A one-ton (12,000 btu) per 1,500 square foot, high efficiency window style air conditioner may also 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 a bit longer will ensure lower indoor humidity, greatly improving comfort. One big plus for these smaller A/C units is they tend to be used only when there is a surplus of energy. Normally this occurs on those long, hot summer days that make the PV panels so happy.

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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.

Almost everyone has heard that compact fluorescent 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 compact fluorescent (CF) lamp is the bulb of choice in the modern, energy efficient home. 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 that 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 60-Watt 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 x $0.10 per 1kilo-Watt hour = $0.06 or 6 cents

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.

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. (Check out peak daytime rates for electricity in California).

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.

A standard Sears 18.5 Cubic foot, 2-door refrigerator like this one will save hundreds of dollars and kilowatt-hours of energy over its 20+ year operating life.

The typical home refrigerator is a large consumer of electricity. Recent advances in appliance design have lowered 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 EnergyGuide ratings. All major home appliances have the EnergyGuide rating and they should be compared before purchasing any appliance. This is especially true for off-grid installations.

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. The clothes dryer shown in Figure 7 is an example of a modern efficient appliance. 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.

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

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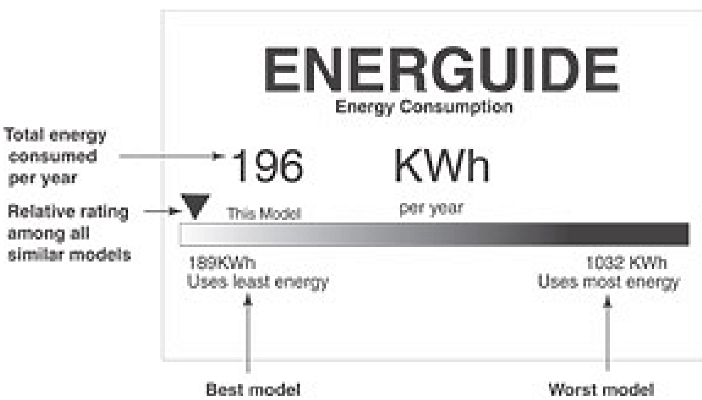
This Sears high efficiency clothes washer uses five-and-a-half times less energy than a similar sized unit. Coupled with the propane dryer to the left, this makes an excellent choice for any renewable energy based home.



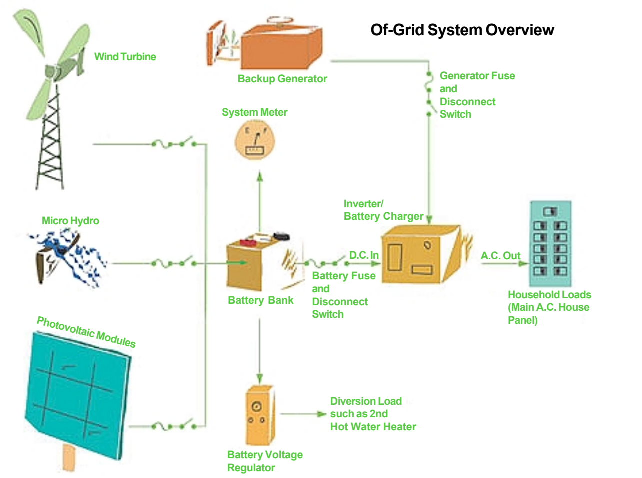
The EnergyGuide in the U.S. and EnerGuide in Canada labels allow for easy energy consumption comparison between appliances. This label belongs to the washing machine shown above.

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 Government has come to our aid by creating 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.

Money Isn't All You're Saving

Fun Stuff - Making Electricity

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 kWh per day, we need to produce about that much too.



All off-grid systems work much in the same fashion. Collect energy from a renewable source (wind, sun, and/or 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 the power utility) and feed it to our unsuspecting appliances. Most off-grid systems also contain a backup power source, usually in the form of a propane, gasoline or diesel generator or genset for short. These units supply power to charge the battery bank in periods when the renewable system is not able to support the necessary electrical loads.

On-grid or grid-interconnected systems are very similar to off-grid systems. The renewable energy is fed directly to the inverter and converted into alternating current, which in turn supplies the grid. If you produce more energy than you require, the surplus is sold to the grid, so that your neighbor down the street can also use some. Selling energy causes your electrical meter to run backwards, providing you with a credit in your electrical energy "bank account". When you require more energy than you are producing, the electrical grid supplies you with "make up" energy causing your meter to debit your account in the normal manner. Every once in a while, your utility will send you a statement indicating whether you owe money or the

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present balance in your energy account is positive. The selling of electrical energy back and forth is called net metering. It is the law in many North American jurisdictions, requiring the utility to purchase your excess energy at the same retail price you pay for theirs. This really is a great deal.

Grid-interconnected systems do not require a battery bank and voltage regulation equipment, or backup generation. This lowers the installed cost of the equipment as compared to off-grid systems. On the other hand, if you have no batteries or backup generation source, your home will be just as dark as your neighbor's during the next electrical blackout.

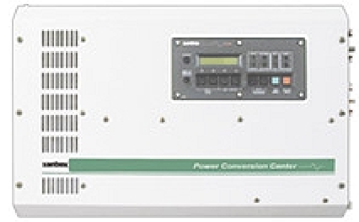
In theory, it seems simple, but just like everything else in life, the devil is in the details. Look at the overview shown in Figure 10 and lets follow the system through its operation.

All of the earth's energy comes from the sun. In the case of renewable energy sources and how we harness that solar energy, the link is often very clear: sunlight shining through a window or on a solar heating panel creates warmth, and when it strikes a photovoltaic (or PV) panel the sunlight is converted directly into electricity; the sun's energy causes the winds to blow, which moves the blades of a wind turbine, causing a generator shaft to spin and produce electricity; the sun evaporates water and forms the clouds in the sky from which the water, in the form of raindrops, falls back to earth. The rain falling in the mountains becomes a stream that runs down hill into a micro hydroelectric generator.

While these energy sources are renewable, they are also variable and intermittent. 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 out when you are a bit short. So why are we using a battery bank? What other means do we have to store electricity?

Great questions, simple answer: There just is not 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, old batteries are recycled (giving you back a portion of their value) and new ones are 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, electricity is stored in a battery at a low voltage or pressure. You probably know that most of your household appliances use 120 Volts, whereas off-grid batteries commonly store electricity at 12, 24, or 48 Volts. The electricity stored in a battery is in a direct current (DC) 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 the utility to your home is alternating current (AC). This means the direction of flow on the supply wires changes direction at a rate of 60 cycles per second or 60 Hertz.

In order to increase the voltage (pressure) of the electricity stored in the batteries and convert it from DC to AC, a device known as an inverter is required. 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 do not consider it for anything but the smallest of summer cabins or camps. A house full of middle class dreams means a house full of 120 Volt, AC appliances. Standard electrical power also means standard wiring, standard electricians and happy electrical inspectors who enforce safety standards.

The information provided here describes a basic system. A supply of electrical energy from wind, water, or sunlight feeds low voltage 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 DC low voltage to AC higher voltage to feed the house electrical panel and the waiting appliances.

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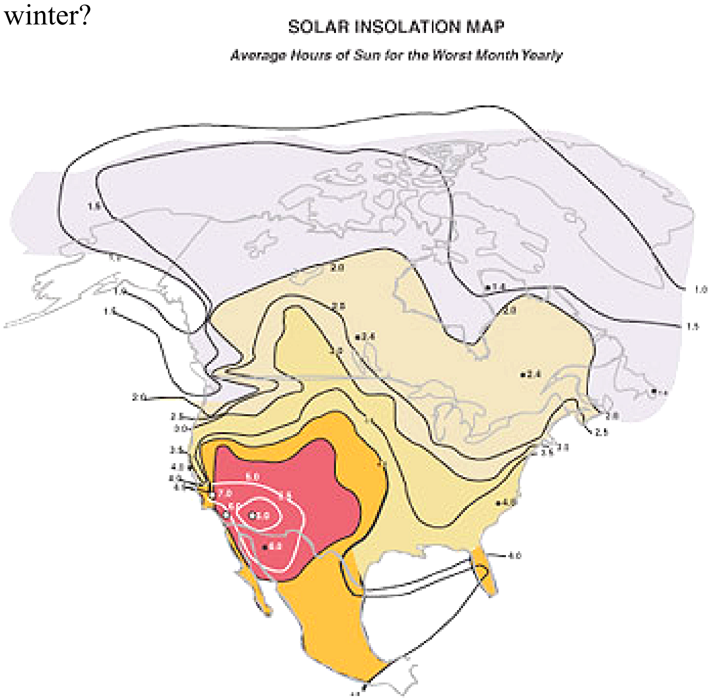
The Changing Seasons

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?



Seasonal variability is extreme in the northeastern section of North America. The amount of sunlight shining in December is approximately half as much as is shining in September, and even less than in June. Obviously, the PV panels' output reduces accordingly, and the amount of stored energy varies with it. This creates an odd paradox. There is too much electricity in summer and not enough in November and December. How do we design around this problem?

Hybrids (Winter Season)

Hybrid design simply means adding more than one source into our energy mix. In our overview example, we have PV, wind and micro hydro, plus a backup generator. This design is not typical, as most off-grid systems typically start with PV as the main renewable source, a backup 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 may be the only energy source you will require.

Grid-interconnected systems are typically PV based. Wind and water based sources are not commonly grid-connected, owing to the rural nature of these energy sources.

Back to watts and nuts and bolts for a second. Remember that we talked about consuming 3 to 6 kWh of electricity per day. Now we have to look at what we produce, to see how well they even out. Our PV panels' rating is 1200 Watts peak-power output (28 Volts x 43 Amps DC). 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. The worst amount of sunlight for our location provides an average of 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 money 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 assumes 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 average loads means the batteries need to supply:

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

So, what happens at the end of 4 days? This is where the hybrid design comes in, you either have another renewable source pickup some of the load or rely on your backup genset. 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. The house electrical loads automatically receive power 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 is definitely worth the few extra bucks!)

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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. However, do not believe that having PV and wind will eliminate the need for a backup generator; it will not. The combination will reduce the running hours of the generator considerably, but it will not eliminate its necessity. Our house still requires over 100 hours of generator time per year.

Hybrids (Summer Season)
During the summer months, the increase in sunlight 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 kWh 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

We may or may not need this surplus, depending on whether or not we require any air conditioning that day. As mentioned earlier, an air conditioning unit uses an enormous amount of energy, approximately 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. You must consume this energy or the batteries would reach a fully charged state and would eventually "overcharge". To prevent this from happening, a battery voltage regulator connects to a diversion load. A typical diversion load consists of an electric water heater, plumbed "before" the regular gas water heater. Converting the electric water heater to the same voltage rating as your battery bank makes the diversion load (24 Volts in our home).

While operating, the battery voltage regulator monitors the battery voltage or state of charge. When the batteries become fully charged, the regulator 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, the water can easily reach 140 degrees F. (60 C.), 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, energy dollars and the environment; energy is never wasted in this system!

Phantom Loads
As the name implies, phantom loads are any electrical loads that are 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 (around $10.00 per month for an average house), this consumption off-grid is unacceptable. By the way, this "small" bit of waste equals quite a few million dollars a month in North America alone.

Another reason for the concern about phantom loads in off-grid installations is the inverter unit waste. This device goes into a sleep mode when the last light is turned off at night, conserving a fair amount more energy. Any phantom load keeps the inverter "awake" consuming more energy than it otherwise would.

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!

Continued on next page

Television sets and 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.

Many people cannot live without some phantom loads such as a fax machine, cordless phone, cell phone, PDA and laptop chargers. For these items, use 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 an inexpensive, 100-Watt inverter that 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 small devices you 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.

Take note about this "small" inverter powering phantom loads. 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

A load of 2.4 kWh is almost half of most renewable-energy systems' daily total energy production; tread lightly!

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, within your average production limits, 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.

For grid-interconnected designs, the system is invisible. The only notification you get that all is well is a statement from the utility advising you that you have a $500.00 credit.

As with any piece of complex machinery, a bit of care and management is required. I would include a multi-function meter in the mix. This unit monitors the energy produced and consumed, and calculates all the nasty mathematics necessary to tell you how much juice is really in the battery. By monitoring the meter and other data, you will have a comprehensive snapshot of the health of your own power station.

Is it Economical?

This is a tough question, because the answer is not straightforward. Let's start by looking at an off-grid system. The cost of a turnkey (i.e. you do none of the installation work), off-grid PV-based system running house loads similar to ours is about $12,000 to $18,000 for all of the materials and installation labor. Do some of the work yourself and it can be lower. Add a wind turbine and, of course, the cost increases. Can you work with used equipment and do you like to tinker around? Can you live with smaller or fewer electrical loads? Swap a 15 inch TV for the big screen, use regular telephones, charge the cell phone in the car, there are a million ways to lower your loads and system costs. If you do not do any energy conservation, expect to pay between five and ten times the amounts discussed. (Once again, energy conservation is important!)

How far the installation is from the hydro grid determines the break-even point for most off-grid homeowners. If your hydro utility is more than a half mile (0.8 km) from your house, it may pay for itself from the second you turn on the first light. You can also add to that the benefits of no hydro bill, zero environmental pollution and the feeling of self-sufficiency you get the next time your neighbor's lights go out during that dark and stormy night.

Will your private power system remain connected to the electrical grid? If so, the installed rate will tend to be lower, because of fewer equipment requirements. Remember that you will not require a battery bank, voltage regulator, battery compartment and many other components. On the other hand, most grid-interconnected systems tend to be larger than off-grid units.

What leads to this apparent contradiction?

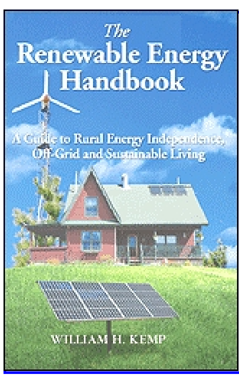
Continued on next page

Some reasons:

Connecting a renewable energy system to the grid is not currently economical at all, environmental issues aside. Why bother hooking up expensive equipment to the grid, when the payback period is dozens of years, if ever. Most people are not so committed to conservation that they are willing to spend loads of cash just to help the environment. The answer is net metering and subsidized paybacks in the form of capital equipment rebates. We discussed net metering above. This program allows you to sell power back to the utility at the same retail price you pay. Net metering laws are springing up all over the planet and for good reason. Electrical power from centralized fossil fuel plants is becoming an albatross that needs removing from society's neck. Power brownouts in California, grid disruption along the north east coast and damaging ice storms are all reasons why governments wish to encourage distributed electrical generation. Never mind the environmental concerns which speak for themselves.

At the time of writing this article, California has the best support program to encourage renewable energy, distributed generation of electricity. The program is the "Emerging Renewables Buy down Program", which provides a cash rebate for up to 50% of the cost of these systems. One typical system having 2,500 Watts of PV, grid-interconnected, after rebate costs $7,500.00. Payback periods with these rates are not much different from typical energy efficient appliances.

Use care when calculating system payback. Do not assume you can use your current rate of electrical consumpt on in the payback equation. Just because your home is grid-interconnected does not mean that you should forego energy conservation. It is better to spend one dollar on high-efficiency equipment to reduce loads than it is to spend five dollars on renewable energy production. The payback on renewable generation equipment will look worse once you have reduced your electrical loads by 5 or 10 times.



William Kemp, Balance Solutions for Today Inc., is a consulting electronics/software designer who develops control systems for low environmental impact hydroelectric utilities worldwide. He is also an author, sustainable living and clean energy advocate working in such areas as renewable energy heating, energy efficiency, photovoltaic, micro-hydro and wind electric systems. Bill is a leading expert in small and mid-scale (<20MW) renewable energy technologies. He is the author of the best selling books The Renewable Energy Handbook and $mart Power – An urban guide to renewable energy and efficiency, and his third book Biodiesel, Basics and Beyond, will be available soon. In addition he has published numerous articles on small-scale private power and is the chairman of an electrical safety standards committee with the Canadian Standards Association. He and his wife Lorraine, live off the electrical grid on their hobby/horse farm in eastern Ontario.

SUMMER ON ŠIPAN

Suzanne Ubick

GRIDLOCK!

I've been thinking a lot about The Grid lately, what with spending three months in Croatia and dreaming about a little house there, and now with my return to San Francisco. I've been trying to clearly define, in my own mind, what The Grid really is.

Is The Grid the network that supplies electricity to us? Should the definition include mains water and sewerage? Electricity is carried over very long distances and supplied State and transState wide, whereas mains water and sewerage tend to be local boys.

But if wideness of reach, scope of influence, is to be the criterion, The Grid brings in luxury cars, supermarket chains, and toilet paper. Seriously.

I had a rather fuzzy idea that The Grid is somehow not really good for people – but that too requires a good definition of Griddedness. Why is it bad for people to have their fuel and water brought to them, and their wastes taken away?

I got a clue while browsing through a store in Dubrovnik – I had three hours to go before the ferry left for Šipan. I'd just picked up a pack of brightly coloured scouring pads, made in China. I'd already gathered up a toweling apron, made in China; three decorative bottle corks, made in China; a nail polishing board, made in China; a cute little notebook made of bamboo leaves and paper, bound with bark wrapped around a twig – made in China. But it was the scouring pads that really did it.

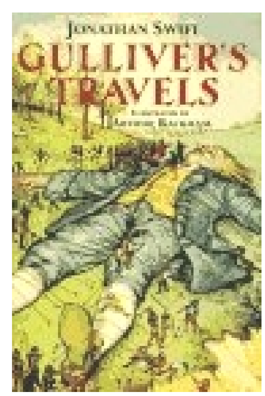
Here I was, in Dubrovnik, Croatia. And I was locked into A Grid. The same Grid that I am locked into, in San Francisco. Or, for that matter, in Pretoria, South Africa. Or anywhere else in the developed world. Yet I had never seen it before; I don't watch TV, very rarely go to movies, and am highly selective in my radio time. Although my apartment is On Grid – electricity, gas, water, sewerage – I consciously reduce my use of these commodities and feel rather smug about it. I tell myself happily that I could manage just fine without the utilities. I have, even, a vague feeling that the utilities companies should be grateful to me for being hooked up at all. Ouch!

So that gave me a hook on my real beliefs about The Grid.

It's not that these goods are all made in China. It wouldn't matter if they came from India, or Scotland, or Colombia, or New Jersey. The goods are merely fed into this Grid and fed out to consumers in exactly the same way as electrons run through power lines, and is neither good nor bad. Like emotions, The Grid simply is. Shakespeare, darn him, is always way ahead; he said "Nothing is either good nor bad, but thinking makes it so." And to continue with other people's wisdom, The Grid is like Ambition: a good servant but a bad master.

I think the scourers popped my bubble simply because I'd already proved to my own satisfaction that sections through palm fronds work superbly in that role. They're also very good foot scrubbers – not the same chunks, though!

I'd found my experiments very satisfying to my inner hermit. Yet my inner jackdaw triumphed effortlessly when it came to whiling away the three hours before the boat was due to leave. My eyes are definitely not bigger than my stomach, but I fear that they may be bigger than my mind.



Sitting on the boat as it slowly made its way to Šipan, I realized that it's these small things, each in itself a cobweb strand, that can mesh me into the Grid as securely as the Lilliputians' ropes ever immobilized Gulliver.

With the new sight, new images bubbled into my mind. Not only washing machines, microwaves, and a plethora of highly specialized gadgets, but movies and television, fashionable clothes, celebrity mania. And I realized that my uneasy feeling about being Gridlocked were based on a fear that The Grid, in this sense, has replaced Connections.

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Connections are good. Connections are about interpersonal relationships, about personal awareness and responsibility, about healthy interdependence. Connections are about talking with others, rather than TO or AT them. Connections are about belonging, emotional security, and ultimately trust and a safe, thriving, prosperous society.

I listen to conversations at family gatherings, watch people on streetcars, look at magazines while glumly awaiting my turn at the dentist. For the most part, people connect not directly with each other, but through The Grid. They talk about movies, TV shows, sports teams, shoes, clothing items. There's no discussion, no interchange of ideas and beliefs. No connection. No personal reality – my friend Pat is very hot on this subject of perception management and reality formation! Nobody seems to argue any more; there's a lot of quarreling, but very little real argument in the sense of debate.

I know now why I'm so uneasy about the concept of The Grid, whether it supplies electricity, goods, or predigested brightly packaged "culture". It's easy, and it's convenient, and somehow succeeds in looking efficient.

The allure of ease and convenience comes at a high price. The dollars are not an issue; that's just money after all.

Say we go out and cut a chunk of palm frond to scour a pot – we're paying out small amounts of time and energy for a boost to our self-esteem, job satisfaction, and a whole slew of spinoffs. The scourer is now one less item to buy, so we need that much less money; the pressure eases and our stress level drops a notch. Our confidence rises a notch. Every time we use that palm chunk, we get another pleasant little tickle.

We know that this chunk required no fossil fuels, no use of environmentally unsafe techniques in its manufacture or transport. There's no packaging. And when the chunk is past its prime, we have a clear conscience about disposing of it. It can be soaked with grease and used as a fire starter, or shredded for mulch, or chucked whole into the compost heap. And we can step over to the palm and get another scourer.

When a few dollars a month have The Grid coming to take away all the waste we generate, why bother to generate less? If it took something real, our own time, our own energy, our own physical labour to ethically dispose of it, would that change the way we approach shopping and usage of goods?

It seems to me that each time we do something for ourself, work out a problem for ourself, take a step back and look at things, it's strengthening and nurturing our soul.

What if our energy, our goods, our ideas all come to us prepacked and predigested? Will ego and status concerns take the place of healthy self respect? Will it start to matter more that our feet don't fit into Manolo Blahnik shoes, to the point where we'll consider having toes amputated, than that the people who make those shoes are paid literally pennies per day and live on the edge of starvation? Will we question why somebody would, in the first place, design shoes that have no relation to the real shape of the human foot?

Will we feel powerless and helpless, and react violently to even an imagined threat to our supply?

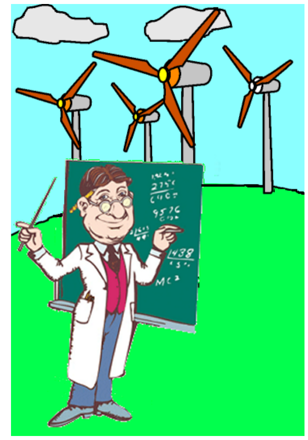
It's not use of the grid that's the real problem. It's the way we allow The Grid to use us.

Suzanne Ubick

Šipanska Luka

THE WIND BAG

by Dan Fink



From Anita:
Dear Mr. Windbag: I'm a high-school student and have a class assignment on renewable energy. We have all semester to build and test a project that saves energy or makes energy, and we have to document our results. I'm really interested in wind power, and I'd like to build small wind turbine that will light up a light bulb. Where do I start?

Hi Anita.

Wind power is fun to experiment with, and not that difficult or expensive. But you should first have realistic expectations of what kind of result you'll be able to get with how much work and expense. Another important aspect of science projects (and required at science fairs) is demonstrating your use and understanding of the Scientific Method of observation, hypothesis, predictions, testing, and conclusion. Hopefully I'll be able to give you some good background knowledge so you can decide how to proceed with your project.

First, it would be an excellent idea to familiarize yourself with how wind turbines extract energy from the wind, and their basic components and how they work together. Take a look at Part 1 of my "Small Wind Turbine Basics" article in the ESSN for the math involved – it's very simple. Familiarize yourself with Ohm's Law – a Google search will fill you in. There are also excellent introductions to wind power and wind turbine components at Windpower.org – be sure to take all their "guided tours", not just the one for kids.

The two most important design issues you'll have to decide on are:

- Can your wind turbine fly outside in real wind to test your design and gather data, or does it have to fly inside using wind from an electric fan, such as at a science fair inside a gymnasium?
- Do you only need to show and measure power output on a meter, or does your wind turbine have to do something physical like power a small light bulb or LED, or make a small pump turn?

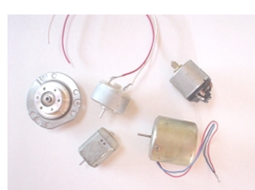
If fan power must be used, options for your turbine's power output are more limited. But for younger students, fan power is the best way to go – a very safe, fast and easy way to demonstrate wind power. The safety precautions needed are minimal. Fan power may frequently be the only option if the turbine must be demonstrated indoors. However, it's very difficult to do anything with fan power besides making a meter move and measuring the results. Powering light bulbs and LEDs with fan power takes lots of extra complexity and expense – but it can be done.

The "real wind" can be from mounting the turbine outside on a tower, or from mounting it on a vehicle and collecting data while an adult drives – slowly, on a rural road with little traffic – and calls out the vehicle's speed. If real wind can be used for power, more options for experiments are available, but everything must be built better and sturdier.

The problem is that a small, experimental turbine designed to fly and make power efficiently in real wind won't even start to move with a fan, while a small turbine that can turn under fan power will quickly blow apart in real wind. Wind made by a fan is very slow and very turbulent, so it doesn't have much power available in it.

As for choosing your load, whether it's a light bulb, LED, charging a battery, or some other type of load, it's simpler to first choose your generator and then decide on a load. Here's an overview to get you started.

DC Hobby Motors



Many people decide to go this route, since a DC motor when driven acts as a generator, and it's easy – put a rotor on a DC motor, mount it, and let 'er rip! It's quite suitable for younger students who have not yet learned any more than the basics of electricity in class, and for classes that will not be studying electricity further.

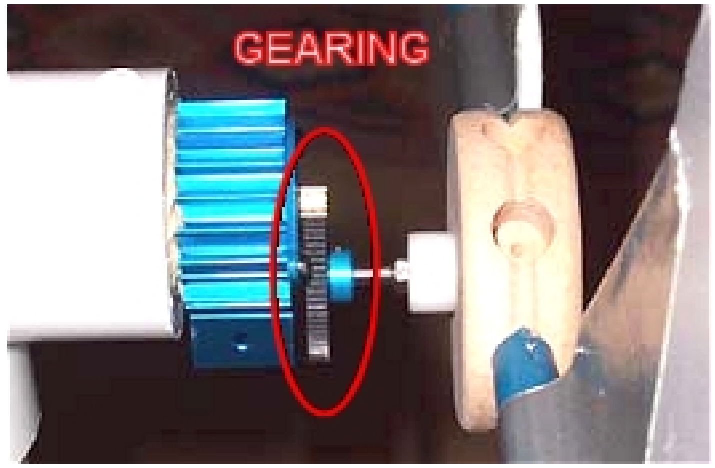
Continued on next page

However, the results are usually disappointing as far as what loads you can run. The problem is that most DC hobby motors are made to spin at very high RPMs, many being rated 5000-10000 RPM. To get the motor's rated voltage as output, you'll have to spin it about 20% faster than its rated RPM. Most small wind turbines never spin faster than 500 RPM, with 1000 RPM as an absolute maximum on smaller ones. Many of them, especially if bought as surplus, don't have their ratings printed on them.

However, there are DC hobby motors that do work at low RPM. Computer fan motors may be the right kind, but some are brushless and won't work for this application. To test a motor, you'll need an inexpensive multimeter (available at Radio Shack). You'll need a multimeter for ANY kind of electrical experiment, so it will get used throughout your school career! Note! If the motor has more than 2 leads coming out, it's the wrong kind and can't be used! Connect the multimeter to the 2 leads and set it for DC volts in the 2-12 volt range. Spin the motor by hand and record the reading, then try spinning it with a cordless drill set at low speed and record the reading.

The voltage you get using the cordless drill at low speed is probably the most you can ever expect from your project. The hand-spun voltage will be more typical. Compare your numbers to the following MINIMUM voltage requirements for some common loads:
Red LED: 1.7v
White LED: 3.6v
Flashlight bulb: 3v to 6v
Tiny water pump: 3v to 6v
Battery charging: Voltage of battery, plus at least 1 volt, then another 1 volt for the diode.

If you can't get to these levels with your motor, you'll need to find another motor to test, try one of the other gearing or generator options below, or settle for just using a meter to measure your power output. The accuracy of your data won't suffer, only the visual drama. Analog meters (the kind with the moving needle) are much more dramatic to watch than digital! There's also more to it than just voltage – the amperage is also important in a real-world wind power application, because volts times amperes equal Watts – and Watts are what power output is measured in. Volts are only "potential" power –they don't do any "work" until a complete circuit is formed (like from your wind turbine to an LED). But the typical loads listed above are very low power, and most hobby motors should have no problem running them.



Another option is to gear up the the hobby motor to make it spin faster. Michael Arquin of KidWind.org came up with a really clever geared hobby motor system that boosts the output in the 1.5v-3v range, enough for almost any application, including water pumps, charging batteries or tiny demonstration hydrogen fuel cells, and a large variety of lights.

You can order his kit from the KidWind Store. The gearing makes it harder to get the blades spinning but, once they are moving, the power output is excellent.

There are plenty of sources for hobby motors in addition to KidWind. You can find them at local Radio Shack stores, online retailers like All Electronics, C&H Sales, and MECI – and even by disassembling your little brother's motorized toys!

Keep in mind that if you want to charge batteries with your experiment, you'll need to put a diode in the line to keep the batteries from just spinning the motor—and the diode will drop your output voltage by about a volt.

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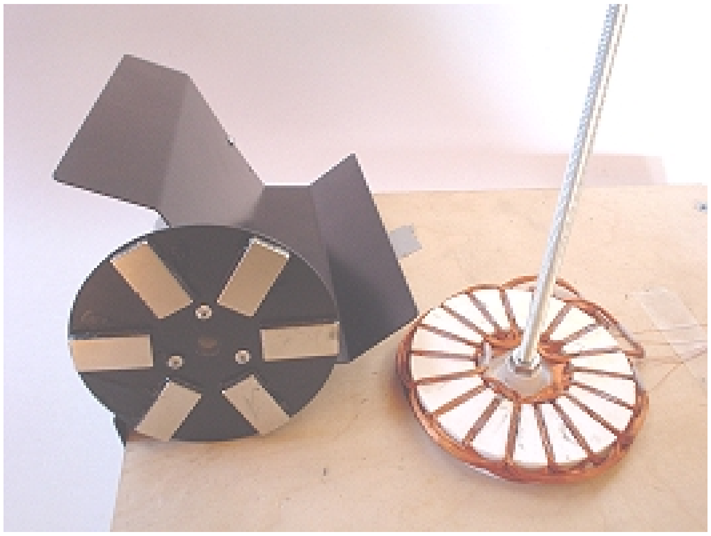
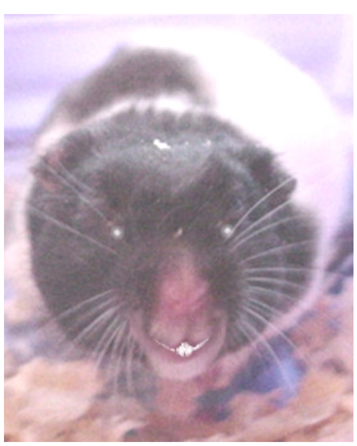
Homebuilt Alternators



While hobby motors are a quick and easy option, you can see their limitations ... primarily the high RPMs needed to get useful power out of them. If you have the time to spend, or are a more advanced student studying electrical theory, a homemade alternator can be an excellent choice. The unit can be designed from the start to generate usable voltage at low RPM! The most interesting alternator kit I've seen is a small 3-phase unit available from our friends at Windstuffnow.com. The price is reasonable, and during my tests the performance was good enough to light LEDs under table-fan power. The unit is designed with a simple, easy to build vertical axis blade design, and it can be converted to horizontal axis.

Michael from KidWind has already successfully tried this. The rectifier diodes to convert the 3-phase AC output to DC are included in the kit, and I recommend it highly.

Another kit option is the PicoTurbine, with both a kit and free on-line plans available. It's also a vertical axis machine, though it would be harder to convert to horizontal than the Windstuffnow design. If you are interested in designing and building your own small alternator from scratch, a good place to start is reading through my Hamster-Powered Alternator pages for a design that can light LEDs at only 40 RPM – it was originally powered by Skippy the Hamster, but could be easily converted to wind power instead of rodent power.



Tape Drive Motors

Some larger tape-drive motors are powerful enough to get you into the realm of real wind turbines, with rotor sizes ranging from 3 to 5 feet in diameter and generating significant power. Such designs must be extremely sturdy, and can be quite dangerous in higher winds. So, this scale of project is best suited for a teacher and entire class to undertake, or an older, advanced student with experienced help. Some of these designs can produce up to 100 Watts in output at 12 volts! Perfect for charging a deep cycle marine battery.

For fan power, you'll need large, wide blades to get enough torque out of the limited wind to start things spinning. Blades salvaged from a table fan or homemade balsa wood blades, such as these shown here at a KidWind Seminar, are a good place to start experimenting. KidWind also sells machined plastic hubs so students can experiment with different numbers of blades easily. With fan power, the blades won't get spinning fast enough for lift to help performance, so airfoils and twist won't make any difference in performance—though you might want to include these elements for demonstration purposes.

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Blades

Here we come back to the issue of fan versus real wind power. In a good, efficient wind turbine design, the blades will be matched in size to the generator's output in lower, more normal wind speeds. If the blades are too small for the generator, it will be difficult to start and will stall in higher winds. If the blades are too large, the generator won't be able to extract enough energy, and the turbine may fall apart in higher winds!

None of this is an issue with fan power, but the problem then is that there's very little power available, and a good design for real wind would most likely not even spin under a fan.

A good design for real winds would resemble the blades in this photo – skinny and thin at the tips with only a small pitch, and thicker and fatter at the root with as much pitch as the wood thickness allows, plus an airfoil carved on the back for lift. These blades were made with a CAD machining system by a friend, contact me at windbag@rebelwolf.com if you are interested in trying a set.

Wide, multi-bladed designs, while great for fan power, will often break in real winds – however, testing different blade designs in real winds makes for an excellent experiment.

In my experience, computer fan blades are too small to work well in either real wind or fan power—they don't sweep enough area to get spinning rapidly enough. Model airplane props are also marginal—they must be reversed (the curved side faces back in a wind turbine blade) and that also reverses the airfoil. They are also difficult to get started spinning. Instead, I recommend carving your own blades or trying a set of the wooden ones similar to those shown above.

Measurements and Meters

Once you have something working, whether from fan power or wind power, you'll need to take measurements. In many experiments, only the output voltage is measured. This gives a direct correlation to how fast the blades are spinning, but is only part of the story. Watts (volts x amps) are the important figure, and measurement requires a load. The amperes will be determined by how large a load you attach – how many LEDs or light bulbs, for example. If you built a system good enough to charge batteries, your load will change with how full the batteries are.

What you measure and how are dependent on the goals of your project. A digital or analog multimeter (for volts and amps) might be all you need. For an advanced project, you could even get a computer-interfaced multimeter (available at Radio Shack) that connects to a PC for data logging!

I hope this month's column at least helps you get a start in experimenting with wind power. As always, if you or any other readers have more questions, please feel free to send them to me at windbag@rebelwolf.com

Dan Fink - our Resident Wind Expert

ANDERSON POWERPOLES

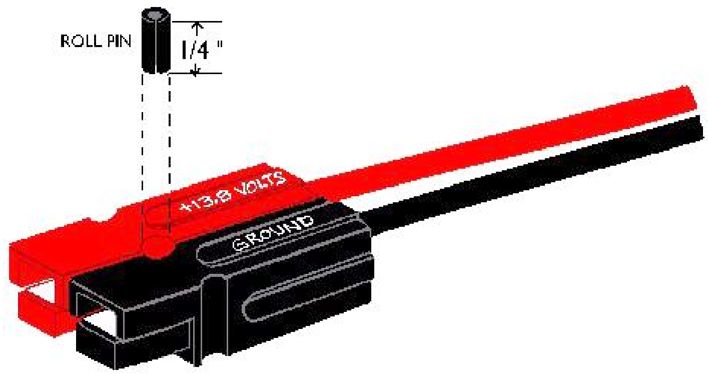
From GreenTrust, the free encyclopedia

by [Larry D. Barr] & [Steve Spence]

The Renewable Energy community has long been in need of a standardized connector for our low-voltage DC connectors. In the past few years as moderator of the 12VDC Power group on Yahoo! I've seen recommendations for all kinds of connectors. Everything from 240 VAC plugs (as long as there's no 240 in the house, you understand), to foreign plugs of various types and often questionable quality. And there's always someone holding out for the ubiquitous lighter plug. If those plugs had the same ampacity as the lighter recep in the car, that might be a possibility. But lighter plugs vary in quality and ampacity so that you can't count on them to do the job you bought them to do. Other industries and groups have standardized on their connectors – why can't we?

We can, and we must. There is too much disparity in the RE community and our choice of DC connectors. I recommend that we immediately adopt the same connectors chosen by the Amateur Radio Emergency Service (ARES) and Radio Amateur Civil Emergency Service (RACES). These two organizations have specified that Anderson PowerPoles shall be the DC connector used by their members. This specification allows for complete inter-connectibility of equipment among participating 'hams' during either exercises or actual emergencies.

It is time for the RE community to standardize on these excellent and economical connectors. Anderson PowerPoles are a reliable and inexpensive solution to the problem of supplying 12VDC power to end-use devices in our off-grid homes.



By selecting PowerPoles as our standard, we will reap the benefits of universal interchangeability in our end-use devices. We will enable manufacturers to finally begin building and selling quality appliances for the RE market. And we will gain the advantage of reliability and ease of connection. PowerPoles are simple to fabricate as shown in the composite photo below.

The connector housing size is the same for ratings from 15A – 45A, only the contact sizes change. However, the contacts will mate with each other, so that a 15A connector and a 45A connector will mate. This permits a great degree of flexibility in the interconnection of properly protected circuits.

One of the common responses from folks who are considering using PowerPoles in their homes is, “How do I mount them?” That question has been answered by Green-Trust and Rebel Wolf Energy Systems with the release of these finely crafted and decorative wall plates specifically designed for the PowerPole chassis mount receptacle. Now, your 12 VDC (up to 45 amps) receps can be displayed and used in style. For more information on the various wood plates and the metal plates (as shown in the image with the battery), E-mail Steve Spence. It was our goal to provide these primarily to the off-grid homeowner, but they work well in RV’s, Campers, and boats. Anywhere a neat low voltage DC solution is needed.

Our suggested backbone for these units is the Super Powergate 40S, and the CSI 1869 40 amp power supply.

The Super Powergate 40S is a 12 volt backup power system that can supply up to 40 amperes continuously from either a Power Supply or a Battery, and can also charge the battery with its 10 amp high performance charger. It acts as an automatic transfer switch for the devices it powers, so if the generator is fired up, the batteries are charged, and loads switched to the generator automatically, without delay or glitches. It’s the ultimate UPS.

The CSI 1869 40 Amp Power Supply

The size of battery bank you need will, of course, depend on your load requirements. If, like most of us, you’re operating on a budget, the EverStart deep cycle trolling batteries from WalMart are a good value. The ones we recommend are the Group 27 115 amp-hour units, that sell for about US$55. Just remember, because of the outgassing of corrosive and explosive gasses, you don’t want to use the flooded lead-acid batteries in the house. You’ll want a sealed AGM type battery for in-house use. Larry is currently using a 100 Ah Power-Sonic AGM battery to power his ham radio and computer on his desk. The AGM batteries are more expensive, but the safety is well worth the added cost.

The Super Powergate 40S

Further information on the Anderson PowerPole series of connectors is available from Anderson Power Products and from Power Werx.com

You can purchase the CSI 1869 40 and the Super Powergate 40S from Homeland Energy Solutions

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Steve Spence
is the Director of Green-Trust.org, a contributing editor for ESSN, a moderator of the 12VDC Power group at Yahoo and an off-grid homeowner.)
http://www.rebelwolf.com
http://www.green-trust.org
http://groups.yahoo.com/group/12VDC_Power/

GETTING STARTED MAKING BIODIESEL

by Graydon Blair from

Utah Biodiesel Supply

Welcome to the wonderful world of Biodiesel. It is a fun and rewarding hobby in which you can make your own fuel to run in diesel engines.

Biodiesel is most commonly made by chemically altering an organic oil through the use of a catalyst and an alcohol, typically Methanol. The chemical reaction that occurs through this process breaks down the oil molecules and replaces the glycerin portion of the molecule with an alcohol molecule. The glycerin falls to the bottom and is drained off resulting in Biodiesel.

The Biodiesel is then typically washed, to remove any extra impurities and is then used as a fuel in a diesel engine without making any modifications to the engine.

Biodiesel is known chemically as a 'fatty acid methyl ester'. Which is just a fancy way of saying it's a product made from Methanol and an organic oil with fatty acid chains in it. It is easily made and has many benefits, including environmentally friendlier tailpipe emissions and improved engine performance.

Below is a guide to some of the things you'll need to know to get started.

PRECAUTIONS

When making Biodiesel, it's important to be safe. Because you are dealing with toxic chemicals, the potential to seriously hurt, injure, and even kill yourself and others exists!

!!! BE SAFE WHEN MAKING BIODIESEL !!!

You'll be dealing with some fairly caustic chemicals, an alcohol called Methanol, fair amounts of heat, and the transferring of flammable fluids from one container to container so it's a good idea to have a fire extinguisher around that is capable of putting out an oil based fire.

Biodiesel should **always** be made in a well-ventilated area away from children and pets with the proper safety equipment utilized.

Before making large batches of Biodiesel, check with your local municipality and fire marshall to ensure that any chemicals, alcohol, or other substances you will use are being stored and used within the proper laws and ordinances for your area. Some area's refer back to state and federal fire codes. It's always a good idea to check before you get started.

Using home made Biodiesel in a diesel engine vehicle may void your manufacturer's warranty. Although the steps outlined to make it are fairly bullet proof and have been tested in several thousands of vehicles all over the world, there's no guarantee your engine manufacturer will honor your warranty.

Biodiesel is considered a fuel so if you plan to use it in a vehicle for on-road use, it may be subject to taxes. Check with your state and federal taxing agencies if in question.

Biodiesel itself, when properly made, is actually quite safe. It's less toxic than table salt and degrades faster than sugar. It has a higher flash point (point at which it ignites) than regular petrodiesel and if spilled isn't considered toxic.

HOW IT'S MADE

Both Maria "Mark" Alovert and Steve Spence have already written excellent articles on this subject in the May and July 2005 Issues of ESSN respectively, and demonstrated that biodiesel is actually very simple to make. It's made by chemically altering the molecular structure of any organic oil through the use of a chemical catalyst and an alcohol.

To do this, oil is simply heated to a designated temperature (to help with the chemical reaction) and then a mixture of catalyst and an alcohol are added to the oil. The oil, catalyst, and

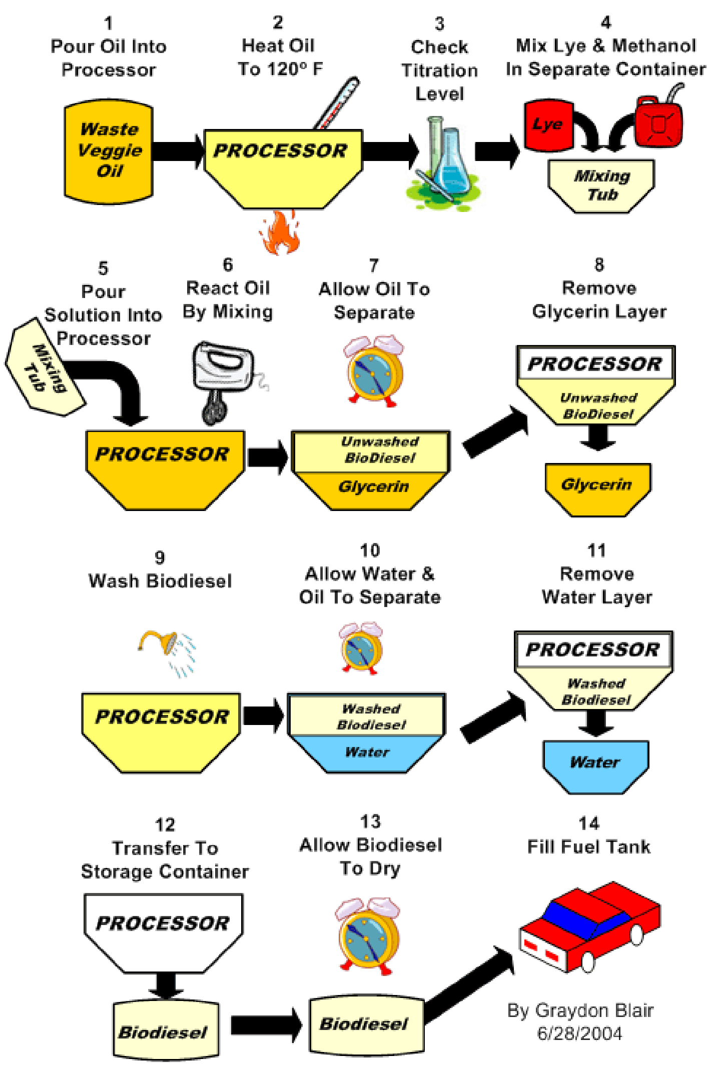
Continued on next page

alcohol mixture are then mixed for a period of time and then allowed to settle. If successful, the chemical reaction between the oil, alcohol, and the catalyst will have broken down the oil into several layers. The top layer will be biodiesel, chemically called an Ester, the next layer may contain soap, and the bottom layer will be glycerin.

Once the layering has occured, the glycerin and soap are drained off. The biodiesel is then washed with either a mist-wash, a bubble-wash, or both. The washing is done to remove any additional soap, alcohol, or other impurities in the biodiesel.

After it's been washed, it is then dried to remove any water. Commonly it is then filtered through fuel filters and is then ready to be used.

THE PROCESS



TIMING

Biodiesel typically takes a couple of days to a week from start to finish to make a batch. Most people making biodiesel make anywhere between 20 to 100 gallons at a time in a batch process.

Here's a breakdown of typical timing intervals from start to finish:

- **START**
- **Collecting Oil** - 1-2 hours
- **Filtering Oil** - 1-2 hours (depends on amount of oil)
- **Titration Of Oil** - 10-15 minutes
- **Transferring Oil To Processor** - 10-20 minutes
- **Heating Oil** - 1-4 hours (depends on amount of oil, voltage & wattage of element)
- **Making Methoxide** - 5-20 minutes (depends on amount of methanol and catalyst used)
- **Mixing Methoxide Into Oil** - 20-30 minutes
- **Mixing Oil & Methoxide** - 2-3 hours
- **Settling Oil** - 8-10 hours (usually overnight)
- **Draining Glycerin** - 5-10 minutes
- **Transferring Biodiesel To Wash Tank** - 10-20 minutes
- **First Mist Wash** - 2-3 hours
- **Second Mist Wash** - 2-3 hours
- **First Bubble Wash** - 6-8 hours (usually overnight)
- **Second Bubble Wash** - 6-8 hours (usually overnight)
- **Transferring Biodiesel To Drying Containers** - 10-20 minutes (depends on amount)
- **Drying Biodiesel** - 2 hours to 1 week (depends heavily on weather and amount made)
- **Transferring To Storage Containers** - 10-20 minutes (depends on amount)
- **FINISH**

BIODIESEL RECIPES

The method described above is just the basic information of how Biodiesel can be made. Below are some links to detailed methods for making Biodiesel.

- Collaborative Biodiesel Tutorial A great tutorial page on making biodiesel complete with plans for building biodiesel processing equipment.
- Kitchen-Biodiesel based off of Tilly's World Famous Dr. Pepper Method.
- Basic Biodiesel Production Information from Journey to Forever. Good primer to go through before attempting to make biodiesel for your first time.
- Mike Pelly's Recipe from the Journey to Forever website. Seems to be a gold-standard for making Biodiesel among the community.
- World Famous Dr. Pepper Method - Part 1 Part I of a recipe for making a small batch of Biodiesel in a Dr. Pepper bottle. Followed by many the first time they make biodiesel.
- World Famous Dr. Pepper Method - Part 2 Part II for finishing up the batch made in the Dr. Pepper bottle.
- Dangerous Laboratories Great instructions for making a batch of Biodiesel for the first time. Complete with pictures and detailed instructions.

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EQUIPMENT

Biodiesel can be made in anything from a small 2 liter pop bottle to an elaborate processor complete with separate tanks for processing, washing, methoxide mixing, settling, and filtering.

Obtaining equipment is relatively easy. Complete processing equipment can be custom made using plans off of the web or by buying pre-made kits ready to assemble.

Most people get started by making small batches with minimal equipment and then gradually move up to making large batches using large processors built specifically for making biodiesel.

Many homebrewers either buy a variety of premade processors designed for processing biodiesel or custom make their own processors either from kits or from plans on the web.

Professionally built processors can cost as little as $500 to several thousands of dollars. Kits can be purchased for making your own from several online retailers for as little as $200 on up to elaborate systems complete with methanol recovery condensors.

Most commonly, homebrewers build their own processors using plans from the web. Building a processor can be done in an afternoon in a garage. In fact, most folks have their processors built and ready to process biodiesel within a few hours of starting. Parts are relatively cheap to obtain and help is readily available through forums, workshops, and local cooperatives. Click Here for plans on making a simple water-heater based biodiesel processor.

Additionally, most homebrewers obtain equipment, such as pumps (either manual or electric) for transferring oil, methanol, and glycerin with as well as several containers for storing oil and biodiesel in.

USING BIODIESEL

Biodiesel can easily be used in any diesel engine vehicle. Once processed, washed, and dried, biodiesel can be simply poured into the fuel tank of any diesel engine. Biodiesel can also be mixed with petrodiesel in any ratio. It easily mixes with petrodiesel and is commonly sold commercially blended with petrodiesel.

When getting started, most homebrewers typically purchase commercially made biodiesel to test in their diesels first, just to get an idea of how it reacts with their engines. From there, they may use commercially made biodiesel as a benchmark against the fuel they make, comparing their homemade biodiesel to the commercially made biodiesel.

Within minutes of biodiesel being added to the fuel tank, and especially when used in high blend ratios (50% to 100%) a noticeable difference in engine noise begins. Most report a reduction in engine noise, a smoothing of the engine, and a noticeable change in the smell of the exhaust. The longer the biodiesel is run in the engine, the better things become.

Research has been done comparing biodiesel to petrodiesel across a wide range of measurements. One of the most significant differences is the drastic reduction in tailpipe emissions biodiesel produces over petrodiesel. Reductions in hydrocarbons, carbon dioxide, and particulate matter have been significant. For many using biodiesel, these emission reductions are reason enough to use this incredible alternative fuel. Besides better emissions, research has indicated an increase in engine longevity, a decrease in engine maintenance, and a better performing engine. Because biodiesel has solvent properties by nature, it acts as a cleaning agent on the fuel system in diesel engines. This means that it cleans things up the more it's used.

Because of these solvent properties, some have noted that fuel lines in older diesel engines may degrade because the biodiesel breaks them down. Particularly susceptible are fuel lines made from natural rubber. Most of the susceptible fuel lines can easily be replaced with inexpensive fuel line that are biodiesel compatible. If in doubt, check with your local dealer. The lines usually degrade over time and develop small seeping leaks instead of large leaks.

Diesel engines made after 1993 and sold in the United States typically won't have this problem as the fuel lines are already biodiesel compatible. This is because of a reduction in sulphur in diesel fuel in 1993 in the United States that necessitated manufacturer's needing to change the fuel lines with non-rubber lines.

Homebrewers use biodiesel in varying blends but most commonly it's used in blends between 20% to 100% with 100% being the preferred method when weather allows. When the weather drops below 50° F, it's recommended to blend biodiesel with petrodiesel or add anti-gel additives to prevent biodiesel from gelling.

Continued on next page

Another thing most biodieselers do when getting started is to change their fuel filters before using biodiesel and then change them again a few thousand miles later. This is to prevent the filters from plugging up due to biodiesel's solvent properties. As it's used, it may knock some of the "gunk" off of the walls of the fuel tank and fuel lines that have built up from the use of petrodiesel. Replacing the fuel filter's is just a precaution to ensure the engines keep on running.

TAXES & REGULATIONS

Biodiesel, if used as an on-road fuel in a vehicle, may be subject to road taxes. The taxation laws are changing all the time so check with your local tax consultant to identify which taxes biodiesel may be subject to. Currently (April 2005), the first 400 gallons of homemade biodiesel is exempt from Federal excise taxes. Anything over 400 gallons is subject to the normal tax rate. You will need to check your State Tax Code for exemptions on State Excise Taxes.

It's also important to check with your local fire marshal on fire codes for the manufacture and storage of biodiesel as well as the chemicals and alcohol used to make it. These laws and regulations are there in most cases to protect you and your neighbors. Most city officials will never have heard of biodiesel, so it may be your job to properly educate them on what it is and what you'll be using it for. Go prepared with as much information as you can and you'll improve your chances of receiving permission to make it.

THE BIODIESEL COMMUNITY

Luckily, there are several other people out there that have made and continue to make their own biodiesel. Most are incredibly helpful and willing to share what they've learned with anyone interested.

The internet has made getting help incredibly quick and easy. As always, not everything you read may be true, but for the most part those publishing web pages and sharing information via the web are willing to go the extra mile to help you out.

There are several others out there that have been making it for several years and are more than happy to share with you what they have learned and help solve any problems you may run into.

CONCLUSION

So, in a nutshell, biodiesel is an incredibly fun and rewarding thing to get into. With a fair amount of caution and safety, you can easily make your own fuel for your diesel powered vehicles and maybe even find a few friends along the way.

To get started, really all you need to do is:

1. Give it a try in your vehicle
2. Make a few small batches
3. Build a processor
4. Make a few large test batches
5. Begin making large batches

So get started. Give it a try. You may just find it to be an incredibly fulfilling adventure!

Graydon Blair

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On the other hand, if you’d rather not do your own writing, this forumis the place where you can get together with folks who’d like to do some writing with you: http://www.green-trust.org/forum/viewtopic.php?p=1050 . So, if you’re one of those folks who wants to work on a collaborative article, just post here that your available and check out the posts from the folks who are looking for you.

I’m hoping to see a lot of fresh content for ESSN come from this forum. We’ll be waiting for your posts. All of you!

Peace,
ldb

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