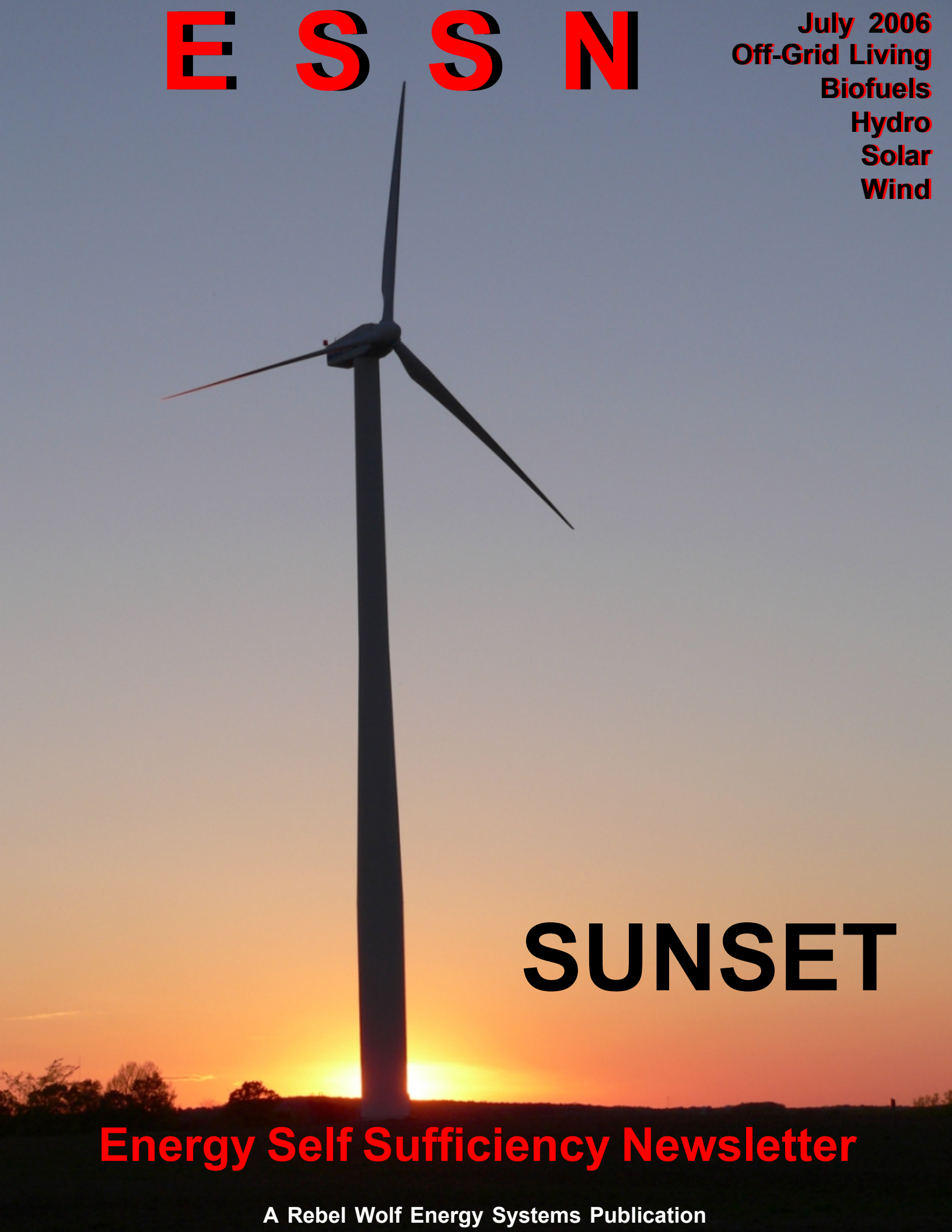
E S S N

July 2006
Off-Grid Living
Biofuels
Hydro
Solar
Wind



SUNSET

Energy Self Sufficiency Newsletter

A Rebel Wolf Energy Systems Publication

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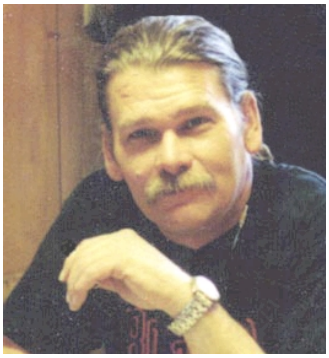
FAREWELL EDITION

Rebel Wolf Energy Systems

From The Editor's Laptop

by Larry D. Barr, Editor



Almost two years ago, I started planning for the online introduction of a publication that had been a dream of mine since about 1992. I'd first conceived the concept of the magazine during a long, cold winter in the Sierra Nevadas of California. Sitting in my wood heated cabin, snowbound had it not been for the 1949 Dodge Power Wagon in the driveway and just waiting for a tree to fall across a transmission line up in the high country and knock out the power for an unknown period of time, I kept the back-up genset ready to go and remembered my very enjoyable experiences living off-grid back in the '70s, and I wanted to share that with others.

I envisioned a publication wherein folks dedicated to shedding the surly bonds of the electric company, taking responsibility for generating their own power and living more simply could come together and share their visions and their techniques for achieving those visions. Then, as now, the name of the magazine was Energy Self Sufficiency Newsletter. I like the word "newsletter" because it implies currency and immediacy of information transfer. It tells the reader that our information is timely and, dare I say it, newsworthy.

ESSN

Energy Self Sufficiency Newsletter was published quarterly online at www.rebelwolf.com. The publication was free and unlimited printing and distribution was, and still is, encouraged for the benefit of the renewable energy community.

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But, it wasn't to happen then. Situations changed and I lived a rather peripatetic lifestyle for several years. Then I found the city that's become my adopted hometown, settled in, made contact with some like-minded folks and in late 2004 we began the task of bringing ESSN to life. Not as a print publication – the costs of pre-press and printing was one of the things that had stymied the project back in '92. No trees would be harmed in the publication of ESSN since it would be an online magazine. And we vowed to provide humane treatment for all affected electrons.

We put together a really great crew and the first issue of ESSN went online at the stroke of midnight on 1 January 2005. Things were going well, the first issue was very well received, but on 9 January tragedy struck our online family. We lost the Methane Man, Al Rutan. Al was working on a methane plant at a friend's place and passed on in his sleep. Al's death was a terrible blow to the renewable energy community, for we had lost one of the driving forces of our movement. I never had the privilege and pleasure of meeting Al in person, but through our email correspondence, I knew that he was a kindred spirit. What cinched the deal was when he told me in his first email that if he wouldn't be free to talk about proper treatment for the animals who provide the raw materials for our methane, he wasn't interested in writing for my publication. That's when I decided I had to have Al as one of our writers. People who love critters are special folks. Al, my friend, you left us before we were ready, but we treasure your memory, your knowledge and your willingness to share your vast experience with us. Rest in peace.

As the year progressed, we had our ups and downs. Some issues were thinner than others, but some were thicker. We always tried to give you, our readers, information that would be useful in your quest for energy self-sufficiency. Our list of contributing writers changed from month to month depending on what was going on in their lives. I really wanted each of them to write every month, but you can't flog troops that are working for free. Regardless of the variety amongst our writers, we managed to produce an issue each month and our readership increased. In fact, our readership increased to the point that I was exceeding the bandwidth allotment on the website each month and paying extra fees each month. So, when it came time to renew the hosting contract, I also upgraded to a package that afforded twice the bandwidth each month. At twice the cost, of course.

My original intention for ESSN had been to use the advertising revenue to accomplish three things. One, cover the hosting costs. Two, give the writers some kind of pittance for their efforts and, three, provide for ongoing projects in renewable energy that I could share with our readers in the electronic pages of ESSN. The projected (and counted on) advertisers never materialized in the numbers that we needed, and it turned out that I had made a strategic mistake. The difference between a strategic and a tactical mistake is that with a tactical mistake you lose a battle. If you make a strategic mistake, you lose the whole war.

I had promised you, my readers, that ESSN would always be free of charge. We held to that, attempting to maintain the operation on just the advertising revenues and the few donations that we received. It just wasn't enough. I subsidized the hosting costs from my own pocket, none of the writers ever got a penny and there wasn't any money in the coffers for the projects that I was dedicated to building and sharing with you.

I don't know, and probably never will, how many of you would have been willing to pay a yearly subscription fee to receive your monthly copy of ESSN. We'll never know if enough of you felt strongly enough about what we brought to you each month to have paid for that information had we asked.

When all was said and done, we only had one advertiser who believed strongly enough in our mission to commit to a one year contract. I will be eternally indebted to that company for their support, and you can bet the homestead that if they sell it and I need it, they have my business exclusively – forever.

By the beginning of this year, the coffers were empty, there was no influx if funding on the horizon and I made the decision to cease publication after the January issue. The writers got all bowed up, and vowed to keep on writing if I'd keep putting the publication online. So we published our April issue. Again, and despite our best efforts to sell some more ads, there was no money incoming. It may very well be a matter of "perceived value". By which I mean that folks may attach no value to something they are able to get for free. Not charging a subscription fee was my strategic mistake.

Given the dearth of advertising and the lack of donations, I've made an irrevocable and painful decision. This is the last issue of Energy Self Sufficiency Newsletter. Working for free on a project you love is understandable. But continuing to go further in the hole, with no change in sight, is, in the words of my Irish friends, the act of a "right eejit".

I've told the writers that, if they choose, I'll host a page on Rebel Wolf Online for any of them who want to keep writing. So, you may be able to read some of the authors you've grown accustomed to on an ongoing basis. It's their call.

I've sincerely enjoyed, and will always treasure, the period that we published ESSN. Talking about renewable energy is one of my favorite things to do, and it's all been fun. Except for that red ink part. I just can't do that anymore. I'll always be involved in the renewable energy movement, and I do have several projects underway. When they come to fruition, you'll be able to read about them on Rebel Wolf Online. I don't think it's too far out of line to tell you that one of those projects is a book on 12 VDC power systems.

I shall remain eternally proud of ESSN and of the wonderful staff of unpaid writers who made it possible. Steve Spence, Laren Corie, Al Rutan (RIP), Mike Nixon, Maria (Girl Mark) Alovert, Al Eggen, Bryan Ball, Wolfgang Rougle, Michael "Spike" Lewis, Joeri Verschaeve, Ben Jarisch, Charris Ford, Peter Asmus, Chandra Warmoth, Suzanne Ubick, Jerry Dycus, Tom Ogren, Dan Fink, Leonard Jones, Kelly Boyd, Hemant Thite, William Kemp, Graydon Blair, Arnold Offner, Reece Foxen, Melvin Martin, Luray Martin, Victor Creazzi and Dave Gibson. My heartfelt thanks to each of you. Special thanks to Mike Nixon for taking over the paste-up detail from me and applying an artist's touch and eye in place of my mechanic's approach.

Thanks beyond words to each of you, our readers, for your devotion each month to ESSN. From the entire staff of Energy Self Sufficiency Newsletter we wish you the very best in your quest for energy independence and a simpler way of life. Thank you for being here with us for the last eighteen months. We'll miss you. Peace, ldb

EVERY WATT YOU DON'T HAVE TO GENERATE IS A WATT YOU DON'T HAVE TO PAY FOR

by Suzanne Ubick

It is sad to come to the last issue of ESSN. I've learnt a lot about energy, of all sorts, whether therms, BTUS, watts, calories, or dollars, in my time with the newsletter.

And what I've come to espouse as my personal mantra is something that Larry Barr wrote to me long ago, when I first started hanging out on the 12V DC forum. "Every watt you don't have to generate is a watt you don't have to pay for."

This is something that should be written in letters of fire and hung across the sky of any would-be ESS-er. Every watt I don't have to generate is a watt I don't have to pay for.

The costs are multitudinous, many more than just the often horrifyingly high price tag on the alternative technology items.

First and foremost, there's the life energy you pay out to get the dollars that you have to generate to pay for the wind generator, solar panels, biomass digester, composting toilet, pelton wheel, ram pump, deep-cycle gel batteries – any or all of these as required.

There's the ecological cost; use of resources, some of which are non-renewable. The oil cost involved in shipping the panels or light bulbs to you.

There's the cost of appliances: Sundanzer refrigerator, aforesaid composting toilet, inverter and all the tie-ins for things like washing-machines.

There are the costs of maintenance and upkeep, and replacement of batteries.

Very recently I was overwhelmed by a post on the group – the poster estimated his needs at 50KW per day, and his costs for a system to provide this much energy at $170,000. My last surviving neuron started shorting out as my half-formed ideas of what it would cost to make my future tiny house autonomous yielded to panic. When I read further, about the numbers of TVs, video machines, pcs and the like that this household "needs," I snorted with laughter.

But it isn't really funny and I certainly have no grounds for either smugness or scorn. Looking around our apartment, my husband and I have FIVE computers between us. Each of us uses one pc laptop. Then there's the Mac SE that DH bought when they were cutting-edge, and on which he wrote his Master's thesis. This machine is tucked away in the garage as he can't bear to part with it, and also because we'd have to pay somebody to take it away. Our local computer shop gives them away as doorstops. There's the iMac I used to use, which DH wants to keep to run a particular program – he's a research biologist who studies the relationships of spiders and harvestmen. No, no – not that kind of relationship! Evolutionary relationships. No pc program has the power and speed of the Mac-based PAUP. There's an ancient Mac laptop that neither of us uses because it's so slow and because it only speaks French.

Circulation Info The First Year

Monthly circulation of ESSN in its first year of circulation steadily rose to over 23,500, firmly establishing it as one of the most popular and informative global sources of practical information about off-grid living and energy self-sufficiency. Sadly, the pressures of producing top quality articles from a dwindling pool of contributors, not to mention the costs of running the Rebel Wolf website with little income from advertisers, finally forced us to bite the bullet and cease publication. However, we hope the popularity of this Newsletter indicates a growing interest in self sufficiency that will continue to grow. ldb

We acquired it for free because we hoped it might be able to read disks from the SE, translate them into a form that the iMac could read. We would then, our idea went, use the iMac to email the various files to my husband's work, where the IT guys could translate everything to a pc-usable format which could then be downloaded to his laptop. My head hurts too. The Apple laptop failed, by the way, so we still have three surplus computers. At least they never get plugged in! They're just taking up space. We also own a printer and a scanner, used sporadically and put away when not in use.

But there are things that are permanently plugged in; the cordless telephone, the digital camera, the stereo system, my husband's beloved tape deck (he hasn't progressed to CDs), the ancient television concealed in a curtained closet. There are the home-made growlights in the broad windowsill next to my desk, where I nurse a half-dozen pots of primulas to try offset the mind-numbing greyness of foggy San Francisco. The modem for my DSL connection, my laptop. I've got the growlights, camera, and stereo system on a powerstrip which is switched off when I go to work. I unplug the coffee percolator. I frequently give the evil eye to our ancient refrigerator, which I'm longing to replace with an energy-efficient, smaller version – but DH says it's still good and won't part with it! And there's the water heater, which we turned down to Medium and haven't yet suffered any ill effects. The water is still hot enough for a very pleasant soak in the bath tub.

There are the washing machine and clothes dryer, shared with my parents-in-law, who live on the upper floor of this house. I have an iron, but being both lazy and a slob I iron only going-out clothes and my husband's work trousers. I wear jeans to work, and they soon lose their wrinkles once I'm inside them. We also share a chest style deep freezer with the folks.

Other items: we own but rarely use a vacuum cleaner and a blow-dryer. We own, and use once a month, two crockpots. And we have an electric coffee-grinder that we used only when I wanted to try grinding my home-grown wheat. It worked so well that I ground up all kinds of things, just for fun, and ended up with jars full of black bean powder, rice flour and the like. Our cooking stove is fed by natural gas. The parents-in-law use gas-fired central heating, we don't. Our radiator outlets are covered by bookcases. On very cold days I use a blower heater under my desk to keep my feet and legs warm. I have an electric sewing machine.

Electric lights are probably the single convenience I'd be most unhappy to give up. I've done the candles and kerosene lamps routine, and while the light is adequate, soft, and comforting, there are drawbacks. The kerosene lamps, to my new way of thinking, are doomed. I'd have to BUY the kerosene and it's a petroleum derivative, i.e. OIL…I don't want people dying to tank up my lamps, or supply paraffin wax for my candles. So I'd have to switch to olive oil for lamps and beeswax for candles. And I'd still have to wash the lamp chimneys every day, and keep matches all around the house, and whine whine whine. I guess I'm saying I want to flip a switch.

Suppose now I wanted to retire to a little house that was energy self-sufficient and CONVENIENT to live in…what would it cost me to set up systems to provide the power? I could go around, get all the specs for each item, plug the data into one of the web-based calculators, then have a stiff brandy to recover from the shock and relapse into mournfulness.

Or I could go back to Larry's advice: every watt I don't have to generate is a watt that I don't have to pay for. I could make a chart: necessity, comfort, luxury, and assign each item to one of these categories.

Oho. This is looking downright affordable. Some of it could even be done while living in my present semi-suburban energy-hog of a house.

Suzanne

Little Miss Muffit's Revenge!

OFF GRID STORY WITHOUT A CATCHY TITLE

by Steve Spence

Power upgrades at Green-Trust never stop. It is a constant process of rewiring, rebuilding, or increasing efficiency to deliver a few more watts (or consume a few less) to reduce generator run times. This summer has been especially busy. Thanks to the generosity of our supporters, we were able to obtain some major upgrades. Since grid power is not available, we have adjusted our lifestyle to match what power we can produce. We have not had to give up the standard gadgets in life, but we use them more effectively. Our kitchen stove is powered with propane, as is the refrigerator/freezer, the water heater and the clothes dryer. TV's and computer monitors are LCD for low current draw. With two teens still at home, Internet and Satellite TV are popular activities. The well pump is a 1/2hp jet pump that runs just fine from inverter, as does the microwave. The clothes washer is a very efficient front loader from Sears. Dish washing is accomplished by twin dishwashers, named Steven and Matthew, age 15 and 17, and seem to be defective, as they make lots of groaning noises during operation.

Battery Upgrade

We had a bank of 6 Trojan T-105's, 6 volt 225ah batteries wired in a 2 x 3 matrix for 12 volts at 675 ah. These batteries were over 10 years old, and we needed more storage, so we gave them to a friend and replaced them with 6 Trojan L16's (6v x 420ah) obtained from New England Solar. These are also wired in a 2 x 3 arrangement, for 12volts at 1260ah. They are charged with a 50 amp RV charger connected to the generator, and a Trace C30+ Charge Controller connected to the PV array. They feed the 2500 watt AC-Delco MSW inverter and the 12vdc breaker box.

Wind Upgrade

The old AIR 303 wind turbine was struck by lightning a while back and fried the electronics. At 300 watts, it wasn't real effective anyway, so it was time to replace it instead of fixing it. Inspired by Hugh Piggott and the two Dan's from Otherpower.com, we built a 1000 watt axial flux alternator based wind turbine. This unit uses two rotating permanent magnet rotors and a fixed 3 phase coil stator, so no brushes or slip rings were necessary. We mounted twelve N50 Magnets on each of the 12" steel rotor plates, and placed 9 hand wound coils in a mold and encased them in fiberglass resin for the stator. The coils are two strands of 14 gauge magnet wire wound 35 times around a form. The three 5' blades are carved from 2x6's. We use a diode bridge to rectify the ac to dc, then feed the power to our charge controller for battery charging. I still have to grease the fittings, paint the parts, and build the tail assembly for rotating the turbine out of the wind at wind speeds greater than 30mph. We will be constructing a 80' tower to replace the 30' tower we currently have. The goal is to place the turbine 30' above any obstruction within 300'. We hope to dump about 2 kWh's daily into the batteries.

Fridge Upgrade

The old 700 watt electric fridge/freezer was sucking our batteries dry each day, so we replaced it with twin 6.3 cubic feet propane units from PPL Motor Homes. These are 3 way fridges with 12v and 120v options. They are designed to be inserted into cabinetry, so I still have a cabinet project to work on. We run the electronic control panel and gas ignition from the 12v battery bank, and the cooling is accomplished with the propane flame. These units will revert to 12vdc if the propane is unavailable. This is called an absorption fridge. The absorption cycle works like this:

Heat is applied to the generator. The heat comes from burning something like gas, propane or kerosene. In our case, propane with optional electric heating elements.
In the generator is a solution of ammonia (or lithium bromide) refrigerant and water. The heat raises the temperature of the solution to the boiling point of the refrigerant.
The boiling solution flows to the separator. In the separator, the water separates from the refrigerant gas.
The refrigerant gas flows upward to the condenser. The condenser is composed of metal coils and fins that allow the refrigerant gas to dissipate its heat and condense into a liquid.
The liquid refrigerant makes its way to the evaporator, where it mixes with hydrogen gas and evaporates, producing cold temperatures inside the refrigerator.
The refrigerant and hydrogen gases flow to the absorber. Here, the water that has collected in the separator is mixed with the refrigerant and hydrogen gases.
The refrigerant forms a solution with the water and releases the hydrogen gas, which flows back to the evaporator. The refrigerant -and-water solution flows toward the generator to repeat the cycle.
Reference: http://home.howstuffworks.com/refrigerator5.htm

Photovoltaic Upgrade

Our old Quadrams are still putting out 80% of their original 90 watt rating, but we needed to catch more sun. We added an additional 180 watts of PV with 45 watt sets from Harbor Freight. We don't have them sitting in an optimal position as of yet. There is too much shade where they are, and they are at the wrong angle. I'll be roof mounting them soon. Here in NY, we can expect about 3 full sun hours daily, so on a sunny day without clouds, these will dump about 750 watt-hours into the batteries.

Lighting

When we first moved here a few years ago, we replaced all but one of the propane and all the incandescent lights with compact fluorescent. We obtained about 50 Mega Bright (130,000 mcd) 10mm white LED's from a friend, so we are looking to deploy these for task lighting requirements. Lighting the outside stairs and the bathroom will be the first spots we try these.

Veggiegen Rebuild

The VeggieGen is still offline. This is a Detroit Diesel 2-71 engine with a 12kw alternator installed. We broke a stud on the injector rack, and toasted the starter windings. We will eventually get it back online for emergencies, but not as a prime power unit. I no longer have free oil available to me to run it like we used to.

Methane Digester

The goal this summer is to replace the propane that fires the fridges, the kitchen stove, the water heater and the dryer with bio-methane. We are working with Clarkson University on a smaller version of their farm sized unit and will be feeding it manure slurry and cafeteria food scraps. We are still trying to co-ordinate with Al Rutan's family for the materials and documentation he left on his methane digesters.

Future Upgrades

Our wish list consists of a MPPT Charge Controller, a Xantrex 12v 2000 watt inverter/charger/transfer switch, another set of 6 Trojan L16 batteries, 4 more sets of 45 watt panels, a second wind turbine, and a wood fired boiler for hot water and heating.

Steve Spence

HOMEBREW WIND TURBINE CONSTRUCTION SEMINAR 2006

or

How to turn metal, wood, engineers, and chaos into electricity

by Dan Fink

We were flattered when the Midwest Renewable Energy Association (MREA) hired the Otherpower.com crew to give a 6-day seminar for 15 students about how to build homebrew wind turbines. It was held in mid-May at wind power expert Mick Sagrillo's workshop near beautiful Forestville, WI, on the Door Peninsula, surrounded by Lake Michigan. Mick is a founding member of the MREA, founder and former owner of Lake Michigan Wind and Sun, teaches wind power seminars world wide, and writes on wind power for numerous national publications. He's installed over 700 wind turbines, and was awarded the US Department of Energy Wind Powering America Small Wind Advocacy Award in 2005. We were fortunate enough to meet him at a wind power seminar he was teaching last Fall for Solar Energy International (SEI).

The view from Mick's house is, appropriately, filled with wind turbines—he flies a vintage Jacobs 14 footer that's grid-tied. Every dairy farm in the area has an old waterpumper in the yard too, but the most dramatic turbines in sight are big ones—660 kW Vestas on 210 foot towers.

A 660 kW Vestas wind turbine, located about 2 miles from our seminar workshop. It was impressive to watch these machines in action

He was instrumental in helping the State of Wisconsin and local utilities realize how much wind power potential the Door Peninsula really had available. Before Mick stepped in with advice, wind power monitoring stations around Wisconsin were often installed on short towers, fence posts, and near roadways—fine for the Highway Department, but not a realistic picture of wind power feasibility. Anemometers at key sites on tall towers soon showed that utility-scale wind power was very likely to be a success. And the resulting wind farms are far more beautiful to watch in operation than the nuclear power plant 20 miles down the road. They make less noise, too!

The Students and Instructors

We had an excellent mix of students, all highly motivated and wanting to learn how to build a wind turbine from scratch. About half the class was practicing mechanical engineers, who had to explain to us that no, they didn't drive trains for a living! We also had a band instrument repairman, an EMT, a carpenter, an ER doctor, an IT specialist from the local ISP, and more. Three staffers from the MREA also took the class. Only one student already lived completely off grid, the others were considering it for their homes in the future, considering grid-tied applications, or wished to provide power for remote vacation property. Most were from Wisconsin, Minnesota and Michigan, with one student from upstate New York and another from Kansas. We had the longest drive – 1200 miles each way.

The mixed group of job specialties and outlooks really helped us three instructors, Dan Bartmann (owner of otherpower.com), myself, and George Clous (our otherpower.com windmill shop foreman). The idea was for us to keep our hands clean and off the workpieces, since these folks were paying for the privilege of learning how to do each step in building a wind turbine. Mick scolded us if he found our hands too dirty...so we tried to circulate around to each work station, show how things were done and how to use the tools involved, and prevent screw-ups before they happened.

The class also served as the testing ground for our new book, "Homebrew Wind Power," due to be published in Fall 2006. We had enough of the first draft manuscript printed so that students could use it as a textbook for constructing the turbines.

The Project

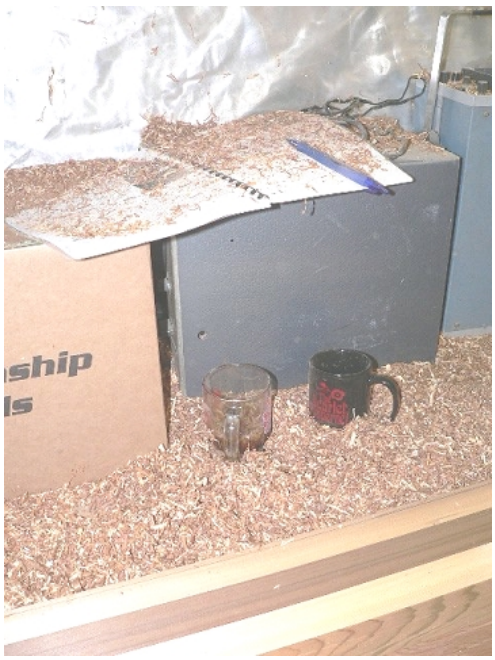
We decided on an ambitious plan—have the class build three turbines during our six days, and plan to fly one of them on Mick's test tower. We chose the 10-footer for the test flight, since it's completely dimensioned, illustrated and discussed in our book. We picked a a big 15-footer and a cute little seven-footer for the other two turbines, which also gave DanB a chance to focus our theory lectures not just on how wind power and the 10 footer work, but on how we come up with the designs in the first place. Taking a successful turbine design and scaling it up and down is a challenge, and the resulting theory and math were useful to all involved. Our big challenge, though, was coordinating these 15 eager students so that all the various parts of the project were ready for assembly at nearly the same time.

Blades

For the 10 foot and 15 foot turbines, we brought laminated cedar blade blanks out from Colorado with us. The blades for the 10 footer were simply laminated and nothing else. For the 15 footer, we had our blade fabricator Scotty taper them to length on his big-throated bandsaw and brought them out that way. It ended up that we didn't have a bandsaw available at the workshop, so this was fortunate – there's a lot of wood to be removed just to taper the blades for a 15 foot machine. As it turned out, DanB and George were able to make some emergency repairs on Mick's beautiful antique bandsaw, and students got to taper the thickness of two of the 5 foot blades that way. After the bandsaw was removed from service again, the last blade (and all three for the seven foot machine) were tapered with a handheld power planer.

This worked out well, as we wanted to demonstrate that only a minimum of power tools are needed to make a turbine. It COULD be done with only hand tools and no electricity, but would be much more time consuming. The combination of a bow saw for cutting the deep kerfs near the blade root, a drawknife for rough shaping, a power planer for bringing things down to their exact proper thickness, and a power palm sander for finishing proved to be fast and efficient. We started two groups of students on 7.5 foot and 5 foot blades on day one, to be sure they would be finished in time. Our group of students were extremely excited to both learn and teach—so after someone mastered, for instance, how to carve and shape a blade, they then taught another group of students how to handle the tools, what to watch out for, and such.

A coarse-toothed bow saw turned out to be an easy way to make the straight, deep kerfs at the blade roots.



One hazard of blade carving. "Wow, my coffee sure has a gritty, resinous taste this morning!

Clay from the MREA uses a mallet and chisel on a 7.5 foot blade to remove wood chunks that were kerfed out with the bow saw.

An example was roughing out a blade with a drawknife—since the knife can take a plunge into twisting wood grain, it's best used only when lots of material must be removed. A mistake with a drawknife when the blade is nearly finished can mean scrapping the entire blade blank, so it's best to switch to the power planer, then move on to the sander. One five foot blade ended up too thin at the tip, but a simple fix of laminating a thin piece of wood to the trouble spot with epoxy and sturdy clamps solved the problem—it was easy to taper and carve the blade down to proper size the next day.

Josh from the MREA carves the airfoil on the back of the blade with a drawknife. Anyone who starts making blades will quickly become a 'connoisseur' of drawknives. Bad ones make your life miserable.

The 7.5 foot turbine blades were a lot of work, with lots of material to be removed. They took all week, with different people rotating into blade carving chores. The 3.5 foot blades for the 7 foot machine were a quick, fun project. We didn't bring wood for them with us, and we enjoyed the very rural setting of Mick's shop and nearby Algoma, WI so much that we were loathe to drive to the 'big city' (Green Bay or Sturgeon Bay) to locate suitable wood at a lumberyard.

So, while DanB and George distracted Mick and his wife, I 'borrowed' Mick's cordless drill and proceeded to start pulling up redwood boards from his deck in a non-chalant manner. Fortunately, Mick had some extra redwood in his garage and stopped me before I'd done too much damage. We don't usually recommend using redwood for blades, but the boards we found had nice, tight grain and few knots. Redwood is easy to carve, and we were not too worried about strength because the blades were only 3.5 feet each. They came out beautifully—in fact, ALL the blades were carved to near-perfection. We were impressed!

Three nicely carved blades, with a bit of epoxy and sawdust mix added to fill the voids.

We specify in our wind turbine design that the owner should maintain the machine at least once per year, either in place on the tower top or by lowering it to the ground on the tilt up tower. Greasing all bearings and checking for loose nuts and bolts annually is extremely important, and since the owner built the turbine it's an easy chore.

We simply use many thick coats of boiled linseed oil on our turbine blades here in Colorado. Folks in other areas of the country may need something stronger—or they may not. But with yearly maintenance, any problems with a choice of finish will become apparent before they become serious issues. Giving the blades a couple fresh coats of linseed oil every year is also a simple chore. High-end enamel automotive paint, with the proper priming system, is what's usually specified for wooden wind turbine blades, and that's what Mick used at Lake Michigan Wind and Sun for finishing their replacement Jacobs blades.

It's a big expense and difficult to apply properly in a home workshop, so here we stuck with linseed oil. It is interesting to see what results folks all over the world, in vastly different climates, are having with various blade finishes—many are sharing their information on the internet. (See 'internet resources' at the end of this article for homebrew wind power discussion groups and mailing lists)

The 7.5 foot blades for the 15 foot turbine were daunting in their size and how much material had to be removed while carving – but the finished product was beautiful! Here the big blades are getting their first coat of finish.

No reason at all for this picture – except I like it!
(and it fills an awkward white space in the page)

Building the Tools

A few specialty tools are needed for building a turbine, so while part of the class went to build blades on day one, the rest starting building molds and a coil winder. Mick's shop is split between woodworking and metalworking areas, which was excellent for us. The molds for the stator and the magnet rotors are constructed from plywood, and bandsaw is the best way to cut them accurately. We didn't have one available for day one, so the molds were cut out with a table saw and handheld power jigsaw. Both the 7 foot and 10 foot machines use the same molds, and the 15 footer requires different (larger) molds for both magnet rotors and stator.

While the molds were being fabricated and blade carving (continually) proceeded, another crew fabricated a coil winder. With a little simple welding and woodworking, a sturdy coil winder can be made that will work for many turbines. By changing the shaped core insert piece, coils of many different sizes and shapes can be wound on the same machine. Students made interchangable cores and wound the coils for all three machines on the winder that they built.

Wiring the first phase coils in series. We do it in the mold so all the wire lengths all come out right.

Some of the folks who attended are already planning to build and swap out molds and coil winders as they get ready to build their own turbines, since these tools can be re-used indefinitely.

Building the Frame

Some students had never welded metal before, so George went to work as the welding instructor. As folks became proficient, they were able to take over teaching the new ones how to weld. We've considered frame designs that require no welding before—but the potential problems of weakness at thread-coupled joints and the possibility of frame fasteners loosening from vibration have made us specify welded frames for all our sizes of wind turbine. If you don't have the knowledge or equipment to weld at home, almost any welding shop can quickly and cheaply do the fabrication for you. We've gone to having metal frame parts pre-cut and drilled with a CNC water jet cutter, and we (and others) offer these for sale. Many others have done the same—try cutting out a 12 inch diameter, ¼ inch thick steel disk with a torch, then the large center hole to fit around the bearing housing – and then get the 4 mounting holes for the trailer bearing perfectly aligned and drilled to fit the studs! It's difficult and precise, and balance is an issue when getting ready to fly the machine. Buying a pre-machined magnet rotor from any of these sources will cost a bit, but save hours of labor. But it CAN be done with only a cutting torch and grinding tools.

George demonstrates how welding should be done, while students look on.

The alignment of the various metal frame parts is critical for the furling system to function properly, and for metal to metal clearance. Here at Otherpower.com HQ, we've built jigs to accomplish this easily. We didn't bring them to the seminar, since it's not something that a home builder would likely take the time to construct. Instead, we developed some methods to lay everything out quickly for welding by starting with a level work surface and using shims, torpedo levels, protractors and swangles for layout.

Magnets make excellent clamps for layout, but will greatly affect any welding done near them – they'll pull on the molten metal you are trying to lay into a joint and can ruin the weld. Our students got to learn this first hand, and got around it by first tack welding things together, then removing the magnet clamps for the final weld.

Magnet Rotor Assembly

Placing the magnets properly onto the magnet rotors is a tricky task. We brought a CNC-cut aluminum template for the 10 foot and 7 foot machine's magnet rotors, but the magnet template for the big machine had to be both laid out and cut by hand—we've only a built a couple of these big machine here, and we never made a CNC file for a big magnet template. DanM, our brass instrument repairman, took on this tedious task and came out with a perfect quarter inch thick wooden template for it.

Instructor George chuckles while Jay places a big magnet on one of the 15 foot machine's big magnet rotors. The magnet placement template makes a nearly impossible task easy. The template is removed before resin is poured in to cast the magnets in place.

With the CNC cut templates, magnet placement is fairly easy, except for the inherent danger of strong magnets near thick steel. Everyone took a turn at placing magnets and feeling 'the force' – the magnets must alternate in polarity, and a misplaced magnet will render the machine useless. Before and after casting, we stored the magnet rotors in a safe place, away from all metalworking activities and human contact. Flying bits from welding or grinding stick to magnet rotors and are tedious to remove, and getting ones' hand trapped between a pair of rotors could be be disastrous – broken bones or worse. Completed magnet rotors are dangerous items!

Casting

With crews working simultaneously on coil winding, stator wiring, and magnet rotor construction, we ended up with all the bits needed for casting ready at the same time—two magnet rotors and a stator—excellent. We did the resin casting out in the open barn to reduce fumes, and made sure everyone wore rubber gloves. Once the hardener catalyst is added to the resin, you have a time bomb waiting to off, and any mistakes you make will be preserved for hundreds of years. Fortunately, the whole class took a break to watch the first casting session, so we had plenty of helpers when the casting crew snapped, "Nurse! Get me a stir stick and a greased mold lid!"

In addition to the normal Bondo brand polyester resin we've always used, we tried some new resin types that we found available in large quantities on the internet. We've always been somewhat concerned about casting strength on the 15 foot machines, and we've used West System epoxy for the big magnet rotors successfully in the past, though it's very expensive. The new epoxy we tried ended up being too brittle for comfort, so the new owner of the machine will be re-casting them. The new vinyl ester resin we tried for the big machine's stator was a success—stronger, more heat resistant, and just as easy to mix and cast.

NO – this is NOT a barbeque!!

The casting operation is in progress. Since it's a critical step, everyone took a break to observe the harried caters at work – and (incidentally) fetch tools, mold lids, and clamps!

Jay triumphantly holds up a newly-cast stator. Opening the molds the day after casting reminds us of unwrapping Christmas morning presents when we were little kids!

Assembly

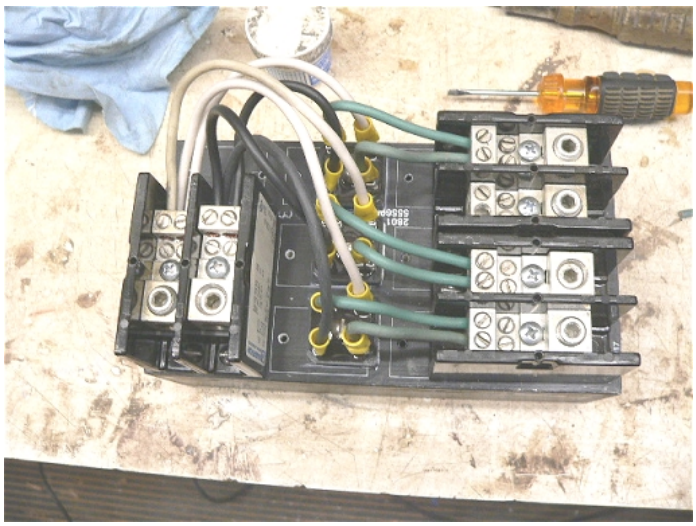
DanM shows the proper look of intense concentration while slowly lowering the front magnet rotor into place on the big 15 foot machine with the jacking screws

Final assembly is always a tricky part of the project. The magnet rotors are dangerously strong, and must be gently lowered into place with jacking screws. Next, the clearance between the stator and both rotors is adjusted. Then, the alternator can be tested. The first simple test is to spin the alternator by hand – it should spin freely. The next test is to short two phases with a jumper and spin it by hand—it should feel 'lumpy.' With all three phases shorted, it should resist attempts to turn it very strongly, but be very smooth to turn again. The next test is for cut-in speed. We use an optical tachometer and a voltmeter, with a volunteer spinning the alternator. The 10 foot machine we built was for a 48 volt system, so we simply recorded at what RPM the alternator hit 48 volts—that's the 'cut-in' RPM. Though the alignment of the stator coils to the path of the magnets was off by a quarter inch, the machine cut it within 3 RPM of what we predicted – 140 RPM.

Blade assembly is also tricky – the blades must be aligned perfectly at 120 degree angles. Once assembled, the blade assembly can be mounted to the alternator and balanced on a test stand, or even on the tower top. It was breezy that day, so we did it on test stand in the casting barn. Balancing both the alternator and the stator at the same time like this is very simple, easy and effective. Because each of the three blades was carved by different people at different stages, one blade was significantly heavier than the other two, though they looked identical. We mounted lead weights to the blade roots at different spots to correct this, and ended up with the machine fairly well balanced.

Electronics

During this process, another group of students constructed the rectifier assembly to prepare for the test flight. The circuit itself is simple – a full wave bridge rectifier for each phase mounted on a big heat sink, and large terminal blocks for the connections. The tricky part is simply to make everything look neat, with no extra wire length. The result was excellent, it looked like a professional job. Yet another reason why having so many mechanical engineers on hand was great for the seminar!



The completed rectifier and terminal block assembly, built onto a big aluminium heat sink.

Test flight

The 10 footer turbine gently rises into place, as thunderstorms off Lake Michigan loom. Each pair of observers has been assigned a specific task during the raise – everyone else is watching from outside the 'fall zone'.

Mick gave the lecture on tower raising safety, and assigned people to different tasks—watching a set of guy wires for problems like too much strain or a tangle, directing the tractor driver during the raise, and so on. The 80 foot tilt-up tower was beefy, one of Mick's designs that was sold by Lake Michigan Wind and Sun. Anyone with no task had to stand well away from the possible 'fall zone.' The ground was grassy and slippery with recent rain, so the raise was quite exciting – the tractor started to spin its wheels. Mick solved that problem by adding extra weight to the back of the tractor, and chaining student Helen's SUV to the back of the tractor too. The tractor operator was always looking at the scene during the raise, and pulling in reverse – that's the safe way to do it.

Many students thought we were joking when we asked for volunteers who would loan us their car battery for the test flight. The machine was wound for 48 volts, and we didn't have a 48 volt battery bank available, so we put four car batteries in series with jumper cables for the test.

Four borrowed car batteries make up our 48 volt battery bank for testing, and a rectifier assembly with ammeter and shutdown switch change the 'wild AC' output of the wind turbine into usable form.

A band of thunderstorms was rapidly approaching off of Lake Michigan, and students nervously monitored their cell phone weather maps as we got every last detail covered. The turbine went up smoothly, dropped its tail into operating position, and immediately spun up. We had meters attached, and the turbine hit one kilowatt output (1kW) quickly and just sat there at that power output in the strong breeze. It exceeded our expectations – we would have been quite happy at 800 Watts, and we told everyone to expect only 600 Watts.

A nice little 10 foot wind turbine flying on the test tower. It spun up to 1 kW output quickly in the strong breeze we had, exceeding our expectations.

The 10 foot turbine looks tiny when observed from the ground, 8o feet below.

The other machines

After the day of the exciting test flight, the 7 foot and 15 foot machines still needed final assembly. Both came out beautifully – the 7 footer is adorably cute and tiny, while the 15 footer is daunting in its scale. The 7 foot machine will be touring the country with the MREA at renewable energy fairs, no doubt with many questions as to why it has only one magnet rotor, and thus an incomplete magnetic circuit. The reasons are – simplicity and interchangeable parts. The small machine uses the same frame, magnets and magnet rotor as the 10 footer, and the stator is the same size. It's not the most cost-effective use of the magnets – but the magnet bill is still half what it would be for the 10 foot machine, and we could use all the same molds for building it.

The cute little 7-foot machine, ready to begin its nationwide tour of renewable energy fairs with the MREA. Don't let turbines spin on the test stand! Short them out and tie the blades down.

It's hard to visualize just how large a 15 foot diameter wind turbine is, until you have to remove it from the test stand and carry it across the yard!

The 10 foot turbine that we flew on Mick's test tower will have a new home at the MREA offices, on display for visitors. The 15 footer will soon be living on a farm in Kansas, and eventually be tied to the grid.

Learning to build wind turbines

We can't emphasize enough how useful seminars can be for learning to build a wind turbine. It's one thing to read a book and look at blueprints, but the actual project has many tricky procedures that are not obvious from 'book learning.' We'll be giving more seminars in the upcoming months, Hugh Piggott's seminars are excellent, and others build turbines similar to these have been giving successful seminars, too—in fact, there's an article about one of those in this issue of the ESSN, too! They range from official non-profit organizations and paying students, to free, informal get-togethers for trading turbine building advice and ideas. The best places to watch for a possible seminar near you are the various internet discussion boards and mailing lists listed below.

Internet resources

Where wind turbine enthusiasts get together to exchange ideas:

The Otherpower.com discussion board:
http://www.fieldlines.com/

The Axial Flux group on Yahoo:
http://groups.yahoo.com/group/axialflux/

The American Wind Energy Association (AWEA) Yahoo group:
http://groups.yahoo.com/group/awea-wind-home/

Happy flying!
Dan Fink

Mike Nixon, together with his close friend and colleague Mike McCaw, founded The Amphora Society several years ago. One of the first things they did was to write a book about distillation that is now widely acknowledged as the clearest book that has ever been written on the subject – so much so that it is now used as a text by many schools and colleges around the world.

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