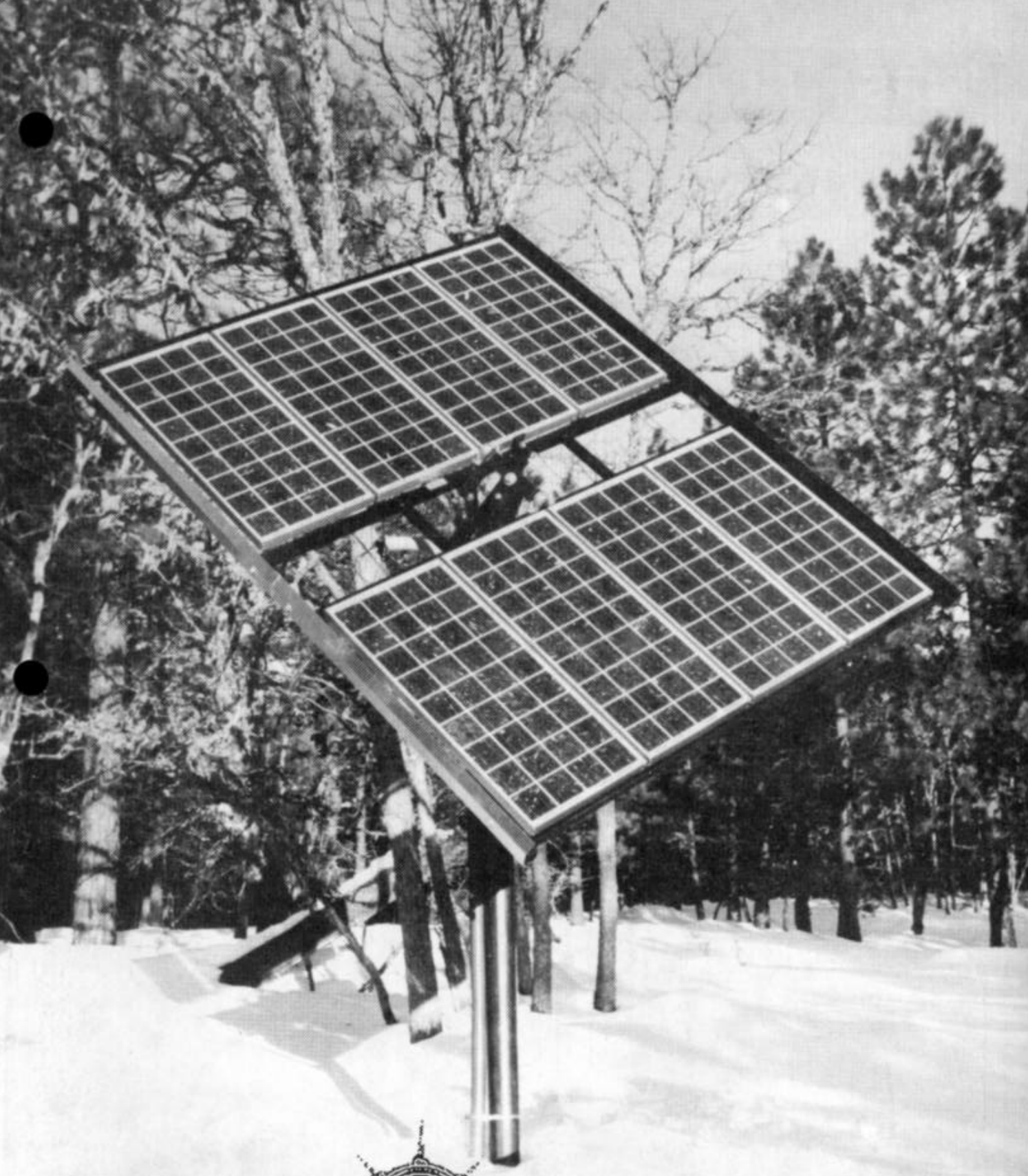

•HOME POWER 9

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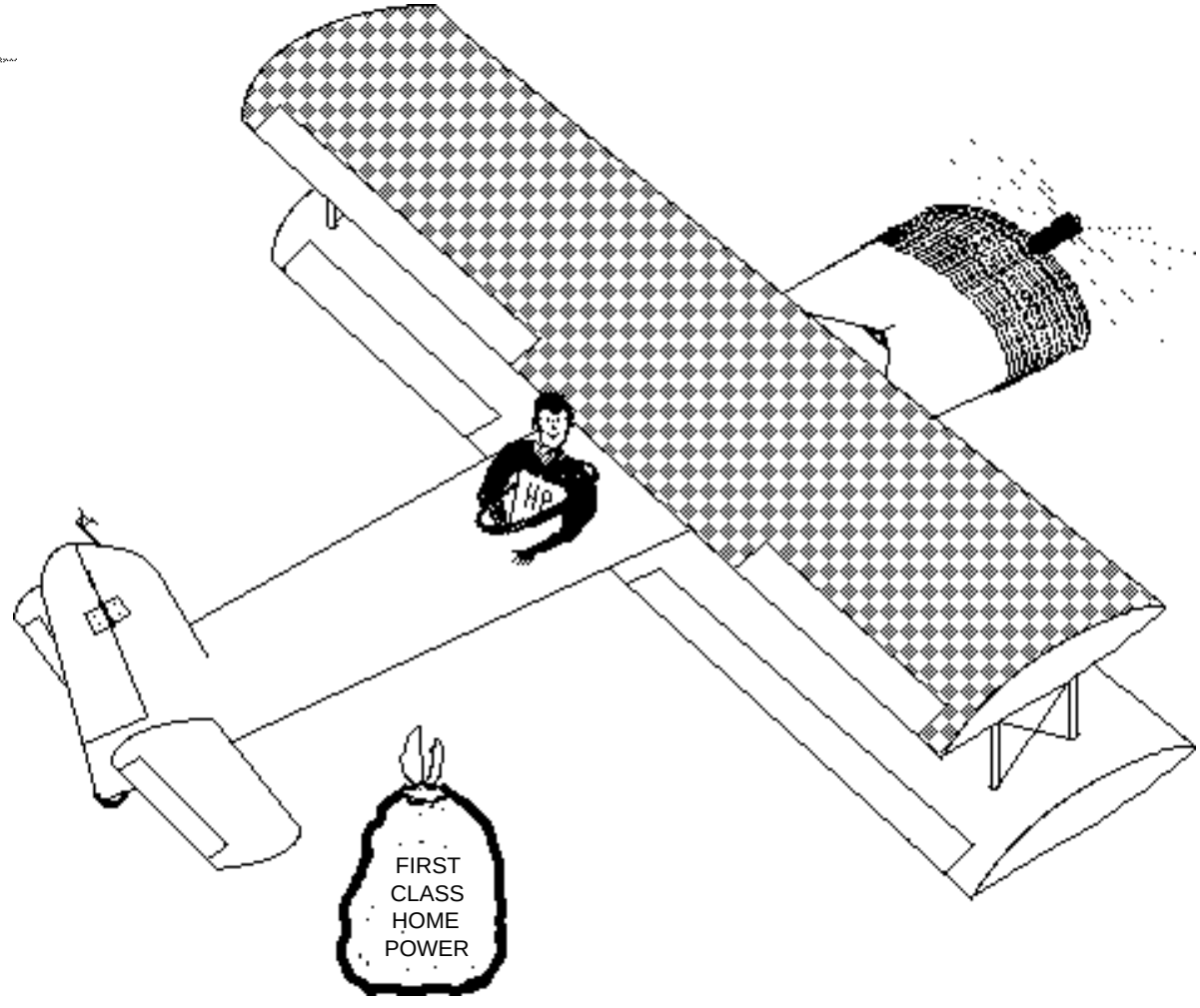

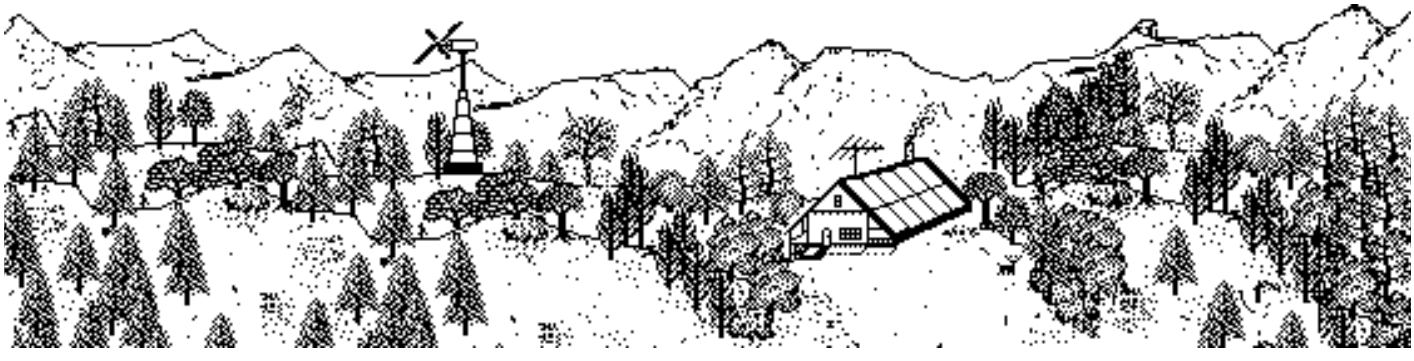

Home Power

People

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Think About It

"Everybody's dancing the Ring around the Sun, ain't nobody finished, near even

Jerry Gracia 1967

Cover

Photovoltaics track the Sun at Roger & Ana Murray's mountain home.

Photo by Brian Green

Welcome to Home Power #9

Many readers have written us that Home Power is worth money, that we should charge a subscription fee for this information, and folks don't respect what they don't pay for, etc. Well, Home Power is still free. We'll mail it via Third Class US Mail to anyone who's interested. Free. Why? Because there is more at stake here than just a magazine. We are publishing Home Power because we know that renewable resources offer this planet the energy solutions we critically need. Home Power is our attempt to influence the future of our planet.

We do hear all of you who are complaining about the Third Class service that the US Post Office offers. Well, the USPO considers Home Power advertising junk mail. As such, Home Power moves last, is not forwardable, and can be trashed if the Post Office has trouble delivering your copy (imperfect address or whatever). We tried to get Second Class magazine mailing status from the Post Office, but were refused because our parent company (Electron Connection) is in the renewable energy business. So if we want to distribute Home Power free, there is only one avenue-Third Class mail.

Cheer up, we do offer a solution: First Class Home Power. I guess you could call it a subscription, except for the fact that we'd mail it free to you anyway via 3rd Class. First Class Home Power means that we'll send you a years worth of issues (6) via FIRST CLASS US MAIL, in a protective envelope, for twenty bucks. Now to be honest, the magazine will make some money on this transaction, and this money will be dedicated to making Home Power magazine grow. More pages, more info, more durable paper and who knows, maybe a color picture someday… For your twenty bucks you get faster, more secure, forwardable delivery of your year's issues (also with address correction should you move and forget to tell us). And you help Home Power spread the word about renewable energy resources. If you want to help out Home Power, if you feel that HP's info is worth something, or if you just want your copy quickly & securely, then First Class Home Power is for you. One more thing, if you should let your 1st Class Home Power subscription lapse, then we will automatically put you back on the free Third Class mailing. Incidently, if you have made a donation to Home Power of $20 or more since the magazine started (Nov 87), then you are now and forever a First Class Home Power Person. As such, you get HP via 1st Class mail from now on with our compliments and sincere thanks.

Richard, Karen & the Crew

STAY IN THE SUN

© Daniel K. Statnekov

West Virginia coal mine
Lured us off the land
To burrow down beneath the ground
It's not what we had planned

But work was sure and all year round
The hours set each day
No risk there was like farmin's storms
To ruin a man's earned pay

So young we was to make that choice
But seen sich misery
Amongst the folks we loved the best
A change we'd thought it be

Learned soon enough the price we paid
To get out of the sun
Pale as death our faces turned
Didn't know what we'd begun

The dust that covered us with black
So fine it made you choke
Was worse'n we knew at the time
Didn't figure it a joke

And coughin' fits did bad erupt
That kep' us up at night
Like smokin' Lucky Strikes non-stop
Then losin' in a fight

Some of us jist up and quit
But others stuck it out
Steddy money every week
He'ped overcome the doubt

Unions fixed conditions some
John Lewis pioneered
Taft-Hartley didn't change the dark
But lessoned all our fears

The years went by, and used we got
To that there enterprize
But those of us who did the job
Hid truth behind our eyes

Old friends they seemed to age so fast
And shrink in size and weight
Some of them jist up and died
Coal miner's turn of fate

We could of left, it was our right
Jist couldn't quite decide
How to go about our lives
And most of all provide

For famblys that'd come along
Depended on that pay
And all the debts contracted for
It seemed the only way

To make ends meet in this here world
Grown big and mechanized
And us so poor, unlearned, and sich
Was truth we reco'nized

But breathin' coal dust underground
In holes dug without light
Is work that wears a man away
Turns life into one night

So if I had to start ag'in
Advise a son or two
I'd say to him "Stay in the sun
No matter what you do."

Sunshine & Mountain Home Power

Richard Perez

Many of the best rural home sites in America are a mile or more from commercial electrical power. This prime, unspoiled land has only one real liability- no electricity. Technology has provided the tools to solve this problem. And usually at far less cost than commercial electrical service. Here's the story of a family that lives high in the Siskiyou Mountains of southwestern Oregon. They live beyond the commercial power lines. They make their electricity on site using sunshine. And they did it at about 1/3 the cost of running the commercial power lines just 4,000 feet.

A view from Roger & Ana's driveway. Ashland, Oregon is fog covered in the Valley below. The diagonal line across the far mountains is Interstate 5. Photo by Brian Green

System Location

Roger, Ana and Kirk Murray live on a mountain side some 5 airline miles southeast of the small town of Ashland, Oregon. Of course, airline miles don't mean much in the mountains unless you're a bird. By road, the Murrays are about 18 miles from town. Sixteen of these miles are on serpentine pavement winding up the 6,000 foot bulk of Soda Mountain. At about 4,000 feet altitude, the Murrays leave the blacktop and use a 2 mile stretch of dirt road to reach their homesite.

Their home is located on the 4,600 foot level on Soda Mountain's northwest face. This location has enough altitude to receive heavy snow and other bad weather associated with mountain living. Snow depth can reach over 5 feet during the winter. Transportation in the winter varies from rough going in a 4WD to cross county skis. While Roger and Ana's site may be hard to get to, it's definitely worth the trip. The Pacific Crest Trail runs within a mile of their house. The panoramic vastness of the mountains is stunning.

Roger & Ana's home is located about 4/5ths of a mile from the nearest commercial electrical line. At the local power company's going rate of $5.35 per foot for new service, this adds up to about $21,000. This is the cost of JUST running in the power line. It doesn't include the cost of the electricity (about 7.5¢ per kWh locally). In addition, because of this site's remote location, the power company also charges a minimum power consumption fee of $50. per month. If Roger & Ana don't use $50 worth of electricity in a month, then the utility bills them for it anyway.

Roger and Ana decided to investigate alternatives to commercial power. They contacted their neighbors at Electron Connection and together we specified and installed a self-contained electrical system. The first step in any renewable energy system is a thorough survey of how much and what kind of electricity is needed. And this is where we started with Roger and Ana.

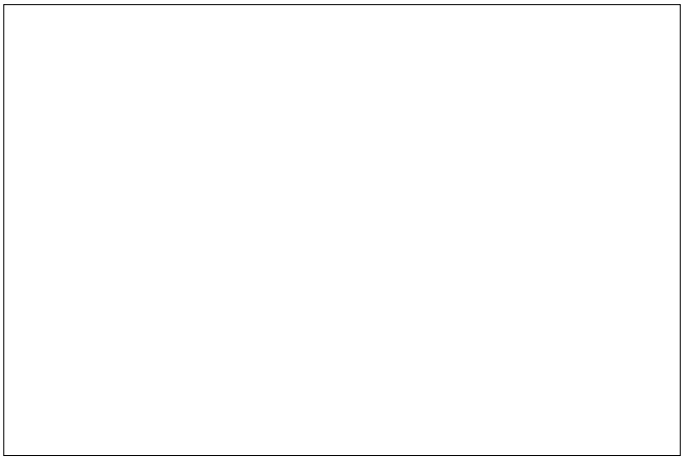
Electrical Power Requirements

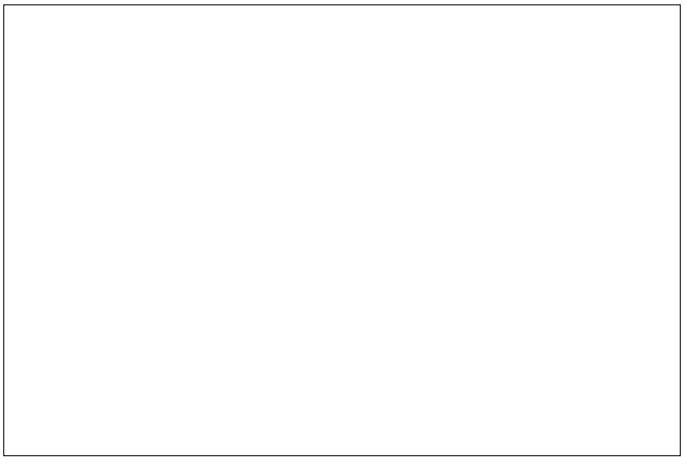
Roger and Ana Murray decided early on to use only very efficient appliances within their system. And they decided to practice the cardinal rule of energy conservation, "Turn it OFF if you aren't using it." As such, their electrical power consumption is much smaller than the average household. Their choices of appliances represents the same compromises every user of renewable energy faces.

The majority of the electricity required by Roger and Ana was in the form of 120 vac. The appliances requiring this power are detailed in Figure 1. The largest consumers are lighting, a computer and a washing machine. Some of the appliances condensed into the "Misc" category are a food processor, blender, vacuum cleaner, computer printer, and sewing machine. 120 vac power consumption was estimated to be about 1,270 watt-hours per day.

The remainder of the required energy is consumed as 12 VDC directly from the batteries. DC appliances include a 12 Volt refrigerator, lighting, stereo, and TV. These appliances are detailed in Figure 1. We estimate that this system consumes an average of 804 Watt-hours per day directly as low voltage DC from the batteries.

Total electrical power consumption specified for this system is





Top: Roger & Ana's driveway, often this deep in snow. Just getting there was a real adventure for the HP crew.
Bottom: Exterior view of Roger & Ana's house showing the solar collector.
Photos by Brian Green

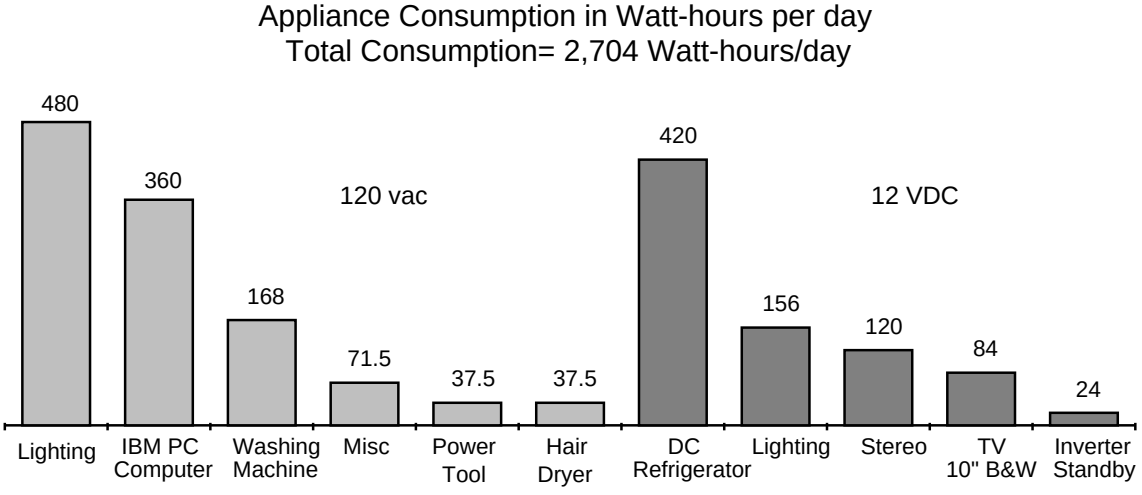


Figure 1. The Murray's Electrical Consumption Estimate.
Appliances powered by 120vac are on the left and appliances powered by 12VDC are on the right.

2,704 Watt-hours per day. This is about 1/5th of average for the grid connected American home. Roger and Ana use propane for cooking and water heating. Their 1,300 square foot home is well insulated and equipped with three systems for space heating. First is passive solar from the greenhouse attached to the south side of the house. Second is a wood fire space heater in the house's main room. And third, a propane space heater that's not often needed.

System Components

These components were selected to provide the most cost effective power for Roger and Ana. A renewable energy system is more personalized than a pair of shoes. One size does not fit all. This set of components is a specific match for their energy requirements, site and lifestyle. A system for different folks in a different location would have different amounts and types of equipment. A renewable energy system's success or failure depends on the amount and quality of the planning done before a single piece of hardware is ever purchased. Consult an individual or company with the experience necessary to see that you get the system you require without spending more than necessary.

Power Sources- Photovoltaics (PVs) & Engine

The main source of power for Roger and Ana are eight 48 Watt Kyocera PV modules. These modules convert sunlight directly into direct current electricity. Roger and Ana's array of eight PV modules produce 384 peak Watts and about 2,500 Watt-hours per average sunny day.

The 8 PV modules are mounted on a Zomeworks passive tracker. This tracker increases the average electrical output of the PV array by 25% annually. The Zomeworks trackers use the sun's heat to keep the PV array constantly facing the sun. The tracker swivels on a steel pipe set in a hole in the ground filled with concrete. The tracker has two tubes along its sides that are filled with compressed freon gas. If the tracker is not directly facing the sun, then the tubes are unevenly heated. This causes gas to move from one side of the tracker to the other. This changes the tracker's balance and it rotates to face the sun. This tracker is totally passive and requires no electricity in its operation. The Zomeworks trackers work as if by magic. Roger says one of his favorite pastimes is trying to visually catch the tracker actually moving.

As Roger and Ana's site is heavily wooded, we had to go quite a way from the house to find a good solar location for the tracker. If a tracker is to be cost effective, then it MUST have all day access to the sun. We finally settled on a clearing that required only minimal tree cutting to give the tracker all day sun. The tracker's location is about 118 feet (one way or about 240 feet round trip wire length) from the battery compartment. This long run of 12 VDC wiring required "0" gauge copper cable to efficiently transfer the low voltage energy from the PV array to the house.

The PV array is kept under control by the Heliotrope CC-60 PWM Taper Charge Controller. This device is inserted in series between the PV array and the battery pack. The function of this controller is to see that the array doesn't overcharge the batteries. The Heliotrope is user programmable and capable of handling up to 60 Amperes of array current. This controller not only protects the batteries, but also assures they are as fully charged as possible. This control works very well and we highly recommend it. See Home Power #8, page 31, for a "Things that Work!" test of the Heliotrope CC Series Charge Controllers.

Roger and Ana's system uses an engine/generator for backup power during extended cloudy periods. This generator, which Roger has used for years, is powered via gasoline and produces 4kW of either 120 or 240 vac. The generator can power loads too large for the inverter. It can also recharge the system's batteries via the charger built into the inverter. Roger and Ana's well uses a submersible 240 vac water pump to fill a large cistern which gravity flows the water to the house. The generator supplies 240 vac for the pump. Roger is investigating putting his water supply on solar too, but that's another story…

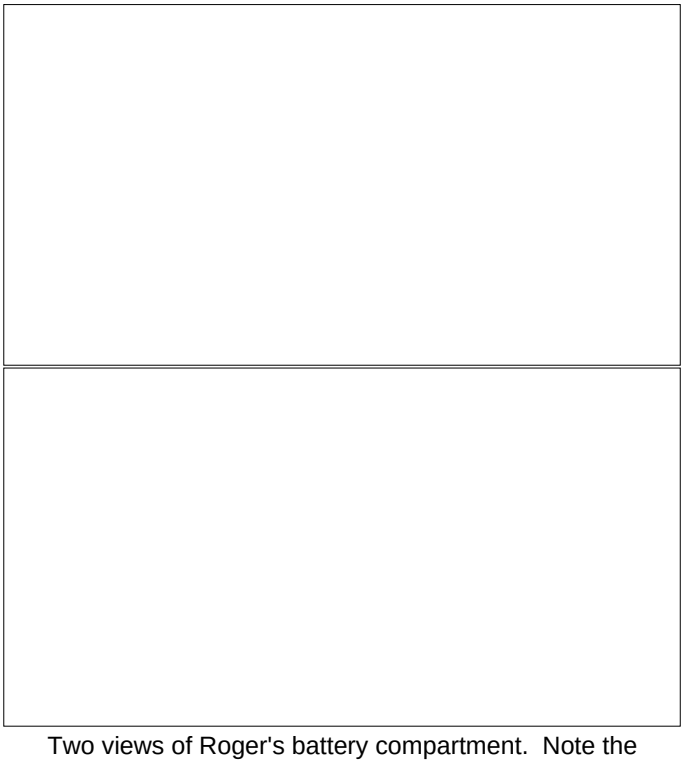
Energy Storage- Batteries

Roger and Ana's system uses six Trojan L-16W deep cycle, lead acid batteries for storing the PV produced electricity. The Trojan L-16W is a battery containing three lead-acid cells developing 350 Ampere-hours each. Each L-16W battery contains 350 Ampere-hours at 6 VDC. We combined, via series and parallel wiring, six of these batteries into a pack of 1,050 Ampere-hours at 12 Volts DC. This pack contains enough stored energy to power the system for about 5 sunless days before requiring recharging. For more details on battery sizing, recharging and maintenance see the Battery article in this issue.

One interesting feature of this system is the outside battery compartment Roger constructed. This compartment is on the outside of same wall where the inverter and ac mains panel are located inside. This allows for short wiring lengths through the wall. The battery compartment is insulated with foil backed, rigid foam insulation to keep the batteries warmer in the winter. When we were at Roger's site shooting the photos you see here, the battery compartment was a good 15° to 20°F. warmer than the outside sub-freezing temperature. The batteries stay warm because their compartment is thermally locked to the house.

Energy Conversion - Inverter/Battery Charger

Roger and Ana's system employs a Trace 2012 inverter/charger. This marvelous device converts the 12 VDC energy stored in the batteries into 120 vac housepower for appliances. This inverter is



Two views of Roger's battery compartment. Note the insulation to help the batteries stay warmer in the winter.
Photo by Brian Green

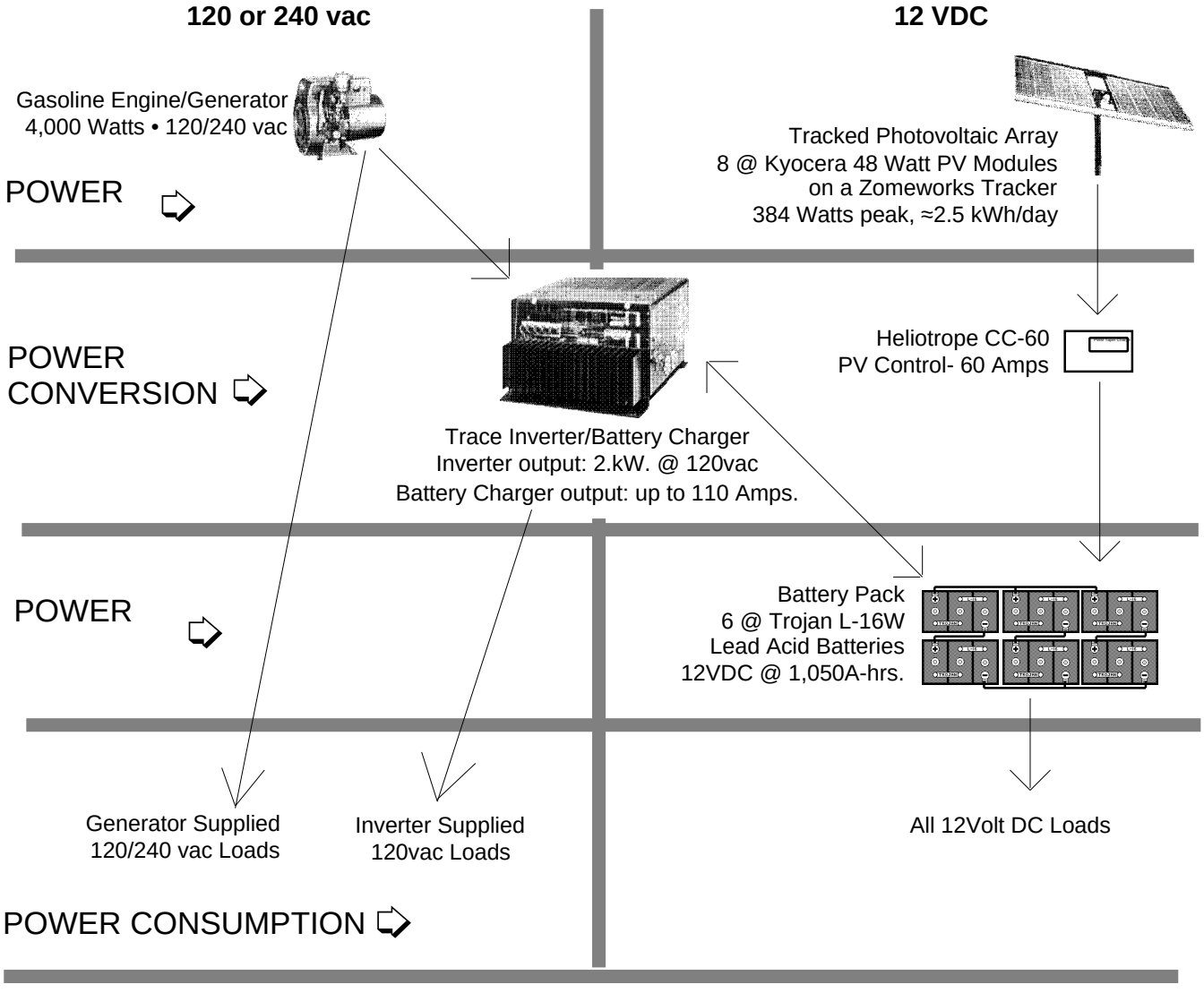


Figure 2. A schematic of Roger & Ana's Renewable Energy System.
On the left side of the heavy vertical grey line are 120 or 240 vac circuits. On the right side of the heavy vertical grey line are 12 VDC circuits. The illustration is divided into four levels by the heavy horizontal lines. The top level is Power Sources, the next level down Power Conversion & Control, the next Power Storage, and finally Power Consumption.

capable of producing 2,000 watts (surge to 6,000 watts) of power that will efficiently (>90%) power virtually any standard appliance. This inverter is connected directly to the batteries via short (<6 foot) "0" gauge copper cables with permanent, soldered connectors. The inverter's 120 vac output is connected to the input of the house's ac mains distribution panel. TECHNO NOTE: Consider this when wiring inverters into mains panels. Household ac mains panels are designed to accept 240 vac (actually two 120 vac legs, 180° out of phase, in techno lingo) as input. In order to get the inverter's 120 vac output into BOTH sides of the panel, simply wire the two hot sides of the panel in parallel.

The Trace inverter contains a battery charger that can stuff up to 110 Amperes into the 12 VDC battery pack. The charger is built into the inverter and accepts 120 vac as input. In charge mode, this converts 120 vac into 12 VDC for battery recharging, exactly the reverse of its function when it is inverting. This inverter/charger is very smart. Let's follow what happens when the inverter's charger is plugged into an operating 120 vac engine/generator. First of all the charger waits several seconds during which it tests the incoming generator power. If the power is acceptable (i.e. not too low in voltage, etc.), then the inverter stops inverting and automatically begins battery recharging. All loads normally supplied by the inverter are automatically transferred to the generator. The charger is programmable for charge rate &voltage level during the recharging process. For a "Things that Work!" test of the Trace 2012, please see Home Power #8, page 29.

Is This A System?

You bet it is. Figure 2 shows how the individual components are grouped together. The power sources, PV and engine, are at the

top. The illustration shows 120 vac circuits on the left and 12 VDC circuits on the right. Note the inverter/charger spanning the differences between the two types of electricity.

System Performance

Roger and Ana's system is basically solar powered. They produce about 2,500 Watt-hours from the tracked PV array on a sunny day. They store about 5 days worth of energy in their battery pack. The PV array's almost daily production stretches the time between engine/generator battery recharging to over 16 days on the average. Most of the only 300 hours per YEAR of generator operation happens during the winter's cloudy periods. This system will not require starting the generator at all during the summer.

Routine maintenance for this sytem will consist of occassionaly greasing the Tracker's bearings, filling the batteries with DISTILLED water, and regular engine/generator oil changes, etc. It is the occasional generator use that produces most of the maintenance and operating cost of this system. It is still, however, very cost effective to rely on the generator for only back up power. The Murray's PV system is sized to provide their average daily electrical requirements. If the same system were sized to suit their worst case requirements instead of their average requirements, then the system would be very different. It would have to contain a battery pack that was twice the size. The additional PVs necessary to refill this larger battery pack, during the short sunny periods between extended cloudy times, would more than double the array's size. In other words, lots hardware JUST to meet the short requirements of deep winter. At 300 operating hours year, their generator should last at least 10 years and the operating cost of <$7. monthly is small. Using the generator to back up the solar is the most cost-effective alternative at this time. This allows the system to be sized for average rather than worst case usage.

System Cost

The initial investment in this system was $7,380.83. This is broken down as follows: PVs- $2,848.00, Batteries- $1,470.00, Inverter/ charger- $1,465.00 Tracker- $801.50, Cable & Wire- $444.43, Installation Labor- $184.50, and PV Charge Controller- $167.50. See Figure 3 for a graphical presentation of where the bucks went. Please note, the inverter's cost includes the optional battery charger and the optional digital metering package. The high cost of the cables and wire is due to the some $300. for "0" cable between the tracked PVs and the house.

We estimate that Roger and Ana will run their engine/generator about 300 hours per year. This generator operation is the only regular system operating expense and amounts to about $6.75 per month or $81.02 per year for fuel, oil and generator maintenance.

All cost and operating figures (like $/kWh) for this system are calculated and amortized on a ten year period. The PVs are guaranteed by Kyocera not to lose more than 10% of their output power over a 12 year period (incidently this is the best PV gaurantee in the business). The Trace is warranteed for two years, and field experience has shown this inverter to be ultrareliable. The Heliotrope controller has a limited 10 year warranty. While the batteries are not guaranteed, they will last 10 years with proper cycling and maintenance. A renewable energy system is a long term investment. While the equipment must be purchased, we are really buying more than a pile of hardware. What we are buying is dependable, nonpolluting electrical power for at least the next ten years. This energy is ours and already paid for, just as sure as the sun rises in the morning.

Well, it cost Roger and Ana $7,380.83 to buy and install their system. It will cost them an additional $810.20 over the next ten years to operate and maintain their generator. Their total electrical cost, both to buy **and** operate this system, for the next ten years will be around $8,191. This is $12,800 less than the $21,000. that the power company wanted just to run in the wires. And the Murray's don't get a monthly bill for their electricity.

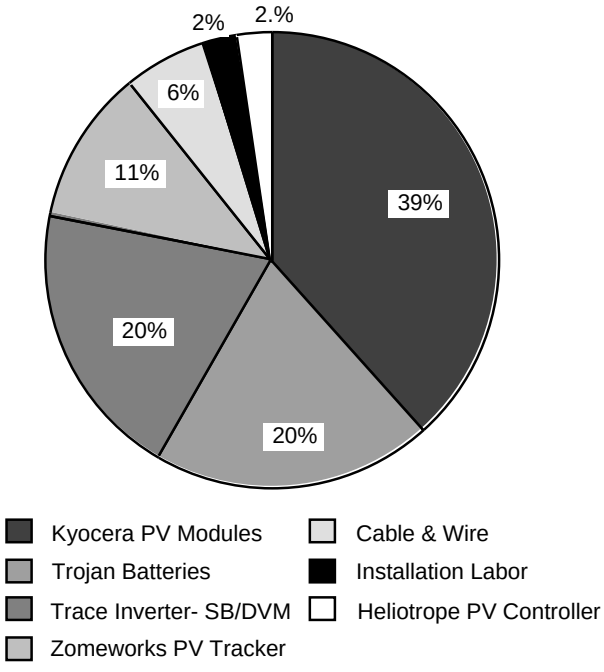


Figure 3. Where the Bucks Went.

How Do PVs Affect This System's Cost?

If the PVs and the tracker aren't used in this system, then it would have to be sourced via the engine/generator. Without the PVs, the generator would have to be operated about 1,250 hours per year at a cost of $66.57 per month or $798.84 per year. This amounts to a ten year cost to buy and run the system of $11,720 without the PVs. With the tracked PV array in this system, its ten year cost is reduced to $8,191. This amounts to a savings, over ten years, of $3,529. by using the photovoltaics instead of a noisy smelly generator.

The chart, Figure 4, illustrates the economic impact of photovoltaics on Roger and Ana's system. The left hand vertical axis of this graph is the system cost (both Initial Cost & 10 Yr. Cost) in dollars and the right hand vertical axis is the dollars per kiloWatt-hour cost of the electricity produced. The horizontal axis at the bottom of the graph indicates the number of tracked PV modules in the system. The vertical column elements on the graph represent the system's initial cost, and it's TOTAL cost to both buy and operate for a ten year period (called "10 Yr. Cost" on the graph). The line element in the graph depicts the cost of the electricity in dollars per kiloWatt-hour. Note that the graph shows that eventhough the PVs are an initial investment, they quickly pay for themselves by reducing the overall electrical cost via reducing the system's operation costs. The slight wobble in the data at 4 panels is due to the cost of the tracker. The rise in cost between 6 and 8 PV panels is due to the fact that Roger decided on two more PV panels than they actually now require. This allows for future electrical expansion (smart idea).

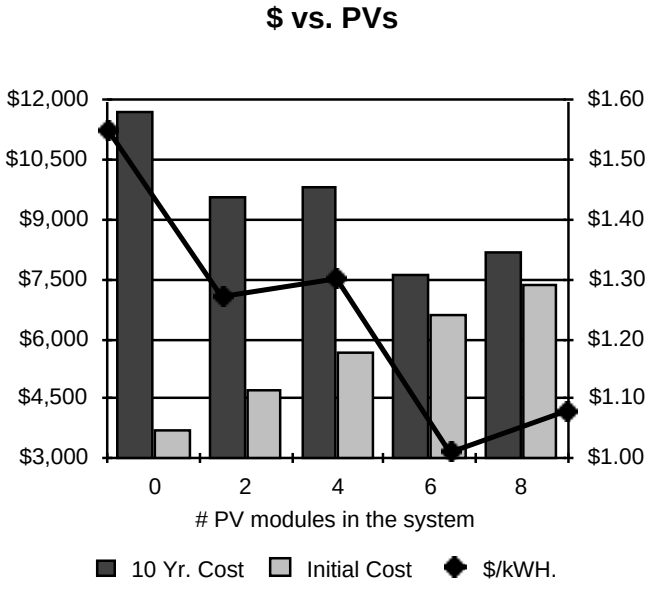


Figure 4. This graph shows the economic impact of photovoltaics on the Murray's system.

System Overview

The use of renewable energy sources, modern energy storage and conversion devices have allowed Roger and Ana Murray to live in their home free from commercial power. Their system initially cost them about 1/3 of the money the power company wanted just to hook them up to the monthly bill syndrome.

But I don't want to imply that only monetary reasoning decided that renewables should source this system. Roger and Ana are very concerned about the environmental consequences of electrical energy production. They live on the edge of the wilderness because that is where they belong. They want to be sure that the wilderness is still there for their son to enjoy. And so do I…

ACCESS

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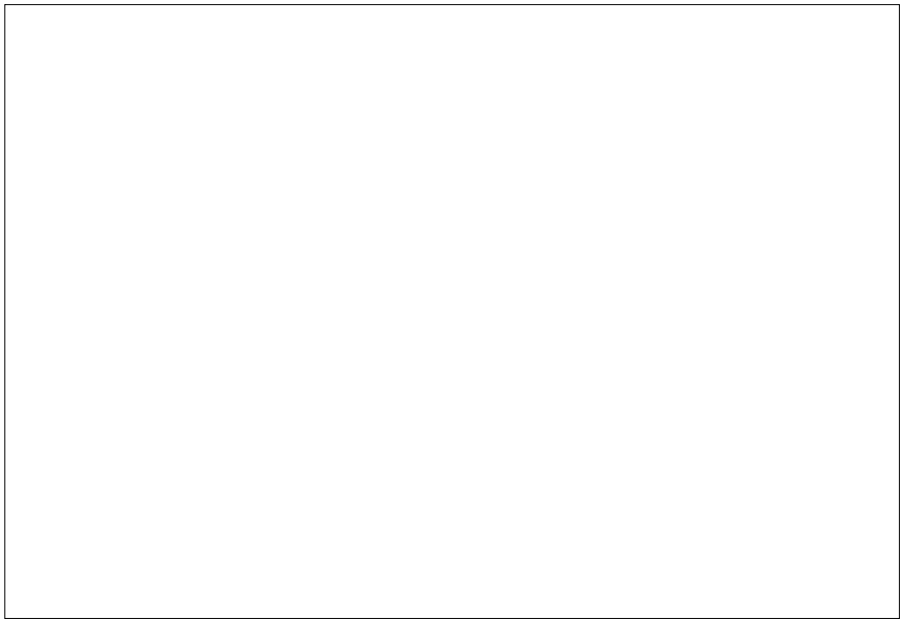

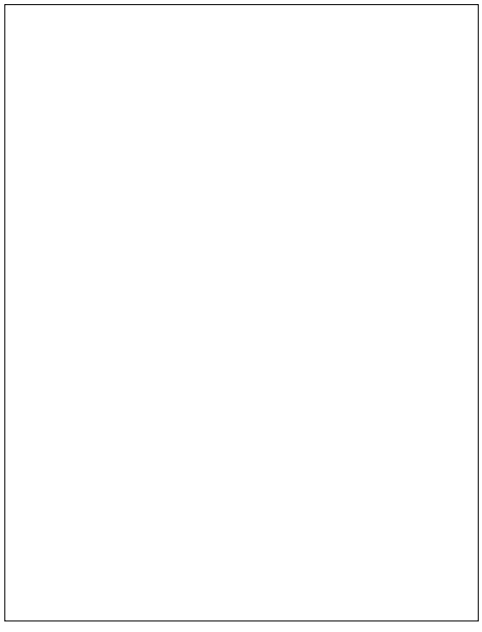

Left: Ana, Roger & Kirk after making it in their driveway.
On this day they walked in through thigh deep snow pulling small sleds with mail and groceries.
Right: Kirk seems to find Mountain living a joy.
Photos by Brian Green

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The Hybrid-Configured Electric Vehicle

Michael A. Hackleman

The general public currently perceives electric vehicles as poor performers -- slow to accelerate, and limited in speed and range. This belief is based on limited, first-hand experience with "pure EVs" -- ones using only batteries and is, for the most part, accurate. I have rarely experienced an EV, scratch-built or a converted vehicle, that is not sluggish. This turns me off since I find it difficult to ride in, or drive a sluggish vehicle. Accordingly, I find it difficult to advocate the use of electric vehicles to the general public. EVs are idyllic for environmental reasons and will gain prominence for this reason alone. However, if the North American driving public is to be weaned away from transportation using oil-based technology without a lot of kicking and screaming, performance and range of vehicles are major issues to address. I know that most people -- for the money, time and effort they might invest -- would be disappointed in EV performance today.

More appropriate attitudes are needed. Rethinking the role of the automobile is one piece of the puzzle. Mindlessly using it to go just anywhere is nuts. Alas, we're "techie" junkies. Our addiction is obvious in light of impending oil depletion, widespread pollution and congestion, and social degradation from automobile-related issues.

When it IS called for, personal transportation is archaic, lagging far behind the available technology. Major car manufacturers are NOT, for the most part, helping to change this situation. R&D efforts toward innovative vehicles are underfunded and the results of such work is undervalued, often shelved. Electric vehicle ventures rarely focus on weight, aerodynamic enclosures, or power train losses. Instead, exotic (high-density) batteries and alternate fuels get top billing -- at prices well beyond affordable levels.

Even the hybrid EV is hard-pressed to compete with the convenience and performance of IC-engined vehicles. One way this gap closes is when the driver assumes some responsibility for vehicle operation. Again, appropriate use of the automobile is the best first bite. Driving habits also make a difference. Lower driving speeds of EVs ensures the highest electro-chemical efficiency in the batteries. That spells greater range for the same amount of power. Gentle acceleration and negotiating uphill grades at a slower speed also helps. Battery depletion is postponed by a significant amount. The life span of the battery pack increases, too.

Transportation consumes more than 70% of our annual energy budget (not the low 13% I erroneously reported in my first article). Careful attention to issues like weight, aerodynamics, and hybrid energy systems will help the evolution of earth-minded transportation. I can easily envision operating my own high-performance, hybrid commuter EV within 1-2 years time. It must be affordable, efficient, and environmentally-benign. I call it the MBG prototype. (MBG comes from Michael, Brett, and Glenn, my three sons.)

This article will discuss factors related to the MBG's design. Topics include: definitions, number of wheels, 3 versus 4 wheel design, the hybrid configuration, batteries, the onboard charger unit, photovoltaic panels, regenerative braking, instruments and controls, aerodynamics and crashworthiness.

Definitions

Several terms need immediate definition: hybrid-configured, high performance, and unlimited range.

Hybrid-configured means that the vehicle uses two or more energy sources. In fact, the MBG will utilize four energy sources: batteries, an onboard charger unit (engine-generator assembly), photovoltaic cells, and regenerative braking.

High Performance, by my definition, is the ability to accelerate quickly, reach freeway speeds, and climb grades at a reasonable rate.

Unlimited Range is the ability to "keep going" as long as you add fuel, much like you would experience in a standard car. The addition of an onboard charger unit (OCU) -- a small, gas-fueled engine driving a generator, makes this possible. Specific design choices in the MBG enhance this feature by ensuring that the vehicle can, indeed, operate on the OCU alone, even when the main battery pack is depleted. It also means you won't get stuck somewhere because of a dead battery pack.

Number of Wheels

Our generation is used to seeing cars with four wheels. The Morgan, a 3-wheeled British commuter, was quite popular many years back. Three-wheeled vehicles are inherently more stable. (Think about it: you'll never see a 3-leg table teeter!). In vehicles, this stability is lost when two of the wheels are closer together than about 60 percent of the distance to the third wheel. The biggest advantage of 3-wheeled vehicles is that they are considered "motorcycles" in most states; this substantially eases the job of CRLI (Certification, Registration, Licensing, and Insurance) for an operational vehicle.

Wheel Configuration

There are two basic configurations of the 3-wheeled vehicle: the motorbike and trike. The MOTORBIKE has twin-steered wheels up front and a single-drive wheel in the rear. The TRIKE has one steered-wheel in front, and two drive wheels in the rear. Other

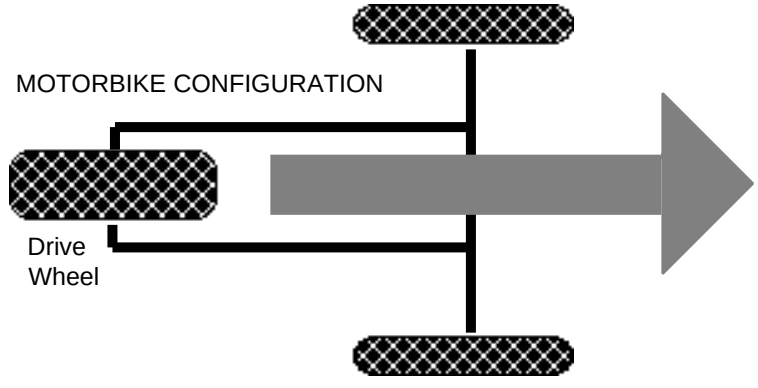
arrangements are possible, but these two are the safest.

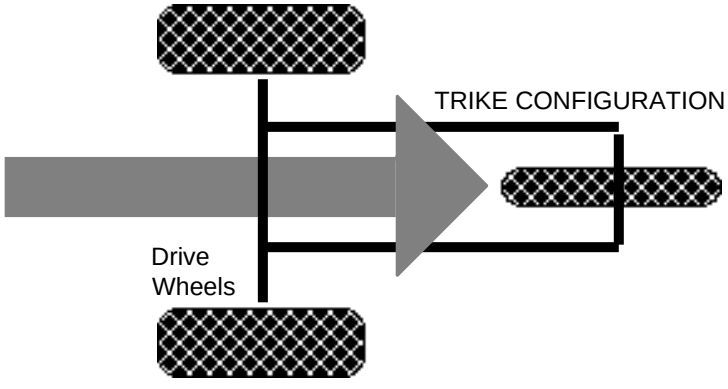
Of the two designs, a MOTORBIKE is usually the easiest to build for several reasons. First, you're halfway there if you start off with the rear portion of a motorcycle. This gives you suspension, a sprocketed drivetrain, a wheel and tire, and a framework to which you attach the front half of the vehicle. If you're lucky enough to find a shaft-driven rear end, chances are the transmission will be separate from the engine (like in the BMW's) and you have the option of using it and the clutch as part of your design. Since most damaged motorcycles are crunched in the front end (ugh!), there's lots of hardware out there, ready and waiting to be recycled. Be picky! You want the registration and license plate! With those in hand, CRLI is simple and straightforward.

The TRIKE is so-called because it looks like a big tricycle (you know, the old-timey version of Hot Wheels). Think CRLI. Either use the front end of a motorcycle with papers and license plate or the rear end of something that is certified and licensed (i.e., a small imported car, a Harley-Davidson Trike rear end, a Honda ATV, etc.) and hope that this is acceptable to the DMV.

Note: A scratch-built EV without "carry over" papers is, if a 3-wheeler, normally registered as a motorcycle or "experimental". Meeting all vehicle codes is essential. Of all aspects of CRLI, insurance can be the formidable wall. You may have to pay a premium for your uniqueness. IF someone will insure you. Take heed.

There are Motorbike advocates and Trike advocates. Each design has inherent advantages and disadvantages. High-speed folks generally prefer the Motorbike design. Twin-steered wheels up front means positive steering traction on corners and stable braking in fast stops. The MBG prototype is a Trike configuration and its advantages are strongly tied to the body design (more on this later). If you list what's important to you, the basic design you use, Motorbike or Trike, is usually quite clear.





The Hybrid Configuration

Why hybrid? Why the need for so many energy sources? Admittedly, hybrid sources increases complexity, initial costs, and overall vehicle weight. I offer these points in favor of a hybrid configuration.

1. Different energy sources are both available and most useful at different times. You, not the vehicle, know how far you're going. You can select the appropriate source for the task.

2. All sources have inherent advantages and disadvantages. Utilizing two or more sources frequently adds the good features of each source and offsets the shortcomings inherent in any one source.

3. Hybrids may increase vehicle reliability. In short, if a part fails or becomes inactive (discharged pack, out of gas, etc.), you may still get home. This is not inherent to hybrid usage. Take care not to compromise the capacity for independent as well as complimentary operation of the sources you select.

4. Combining sources ensures that propulsive power is always available.

Here's more detail on the MBG's four energy sources-- batteries, OCU, photovoltaics, and regenerative braking -- and their functions:

Batteries

Initial design of the MBG prototype calls for three onboard sets of batteries to serve propulsion, control and instrumentation, and regeneration tasks.

a. PROPULSION pack. Eight 12-volt, lead-acid batteries at 100AH capacity each. These are wired to a series/parallel arrangement of 48 or 96 volts and used with a 5-stage in-line resistive controller.

b. INSTRUMENTATION pack. A dedicated NiCad pack for instrumentation, communication, microprocessor, and cooling system pumps and blowers. Rated 12-volt at 20 AH.

c. REGENERATION pack. A NiCad pack for regenerative braking energy. Designed to store the energy generated by a full stop from 55 mph. Wired for series-parallel arrangements of 24 and 48 volts. Rated 48-volt at 3 AH.

These battery packs can make use of one or more sources of EXTERNAL power (power from a utility grid or standby generator) or ONBOARD power -- OCU, photovoltaics, and regenerative braking.

EXTERNAL power, utility-supplied or an owner-operated standby generator, will charge the Propulsion pack through a simple bridge rectifier. One benefit of a 96-volt propulsion system is that direct charging from utility power (or a 110-volt AC generator) is possible without a battery charger. For example, a 20-amp outlet will replenish the MBG's propulsive batteries in less than 5 hours. The timer and rectifier are carried onboard, cost $20, and weight less than 2 lbs. The Instrumentation pack is also chargeable from utility power via a small battery charger (also carried

onboard).

Onboard Charger Unit

OCU (Onboard Charger Unit) power is available via a small engine-generator unit. As detailed in the first *Home Power* article, this provides power at a constant rate for direct use in the motors, for storage in the Propulsive battery pack, or both. By manual selection, both the Instrumentation and Regeneration pack can be recharged by the OCU via their respective onboard battery chargers.

Two engine-generator combinations will be tested for the OCU in the MBG vehicle. Both use an IC (internal combustion) engine fueled by gasoline. Eventually, this will be converted to propane or alcohol. An 8-HP horizontal-shaft Honda engine is the present choice.

One test bed will use a 110-volt ac alternator as the generator part of the OCU. This is a standard package: a 2500-watt unit. Its output will be directed into a transformer to supply full rated wattage at either 60 or 120 Volts after rectification into DC. This arrangement ensures that the OCU will "follow" the propulsive pack through its two arrangements, 48 and 96 Volts, during vehicle operation.

The other test bed will use a ganged set of special-built PM generators, shaft-to-shaft coupled to themselves and the IC engine. One of the PM generators serves double-duty as the starter motor for the OCU. Each PM generator produces 1,250 watts at 3,600 RPM, and is wired in series or parallel with the other for the needed 60 or 120-volts output.

The OCU engine will have manual linkage to control engine speed, with settings for idle (warm up), 3/4 speed (half power), or full speed (rated power).

The Onboard Charger Unit (OCU) wears many hats. It operates as a battery charger (vehicle parked, propulsive effort low), a primary source of power (propulsive effort high, i.e., acceleration, hill climbing, freeway speeds), the sole source of power (battery pack depleted, vehicle stopped), an emergency source of power (for drills, lights, motors, or 110-volt ac loads through an inverter, etc.), and as one way to provide vehicle cabin heating (through resistive coils, as in a floor heater). These are all potential side-benefits. For me, the OCU is there to give the EV range and to avoid the stuck-in-the-outback blues.

Photovoltaic Panels

PHOTOVOLTAIC power is used in the MBG vehicle as an energy source. It is designed to supply daylight power full-time to the Instrumentation battery pack. When this pack is charged, solar power is load-diverted to the Propulsive pack where it serves a battery maintenance function.

In the MBG vehicle, solar energy is not supplying a significant amount of Propulsion power. This is not an intentional constraint. Photovoltaics have a place in the transportation scheme. However, while the solar car race in Australia proved that it could be DONE for propulsion, the pricetag is too high to call it "practical". Consider that the average entry used $4,000 worth of solar panels, $20,000 worth of battery pack (silver-zinc), and at least another $5,000 dedicated to motor, controller, and lightweight material usage.

Solar-electric technology is most practical in EVs in the following applications:

1. A large, fixed array that charges an EV during daytime hours. Or charges a spare EV battery pack that can be exchanged with the one in the EV.

2. A super-lightweight vehicle (i.e., bicycle or tricycle) needing less than 1/2HP of power occasionally.

3. A small onboard system to help with battery maintenance, instrumentation and DC loads (lights, horn, turn signals, radio, wipers, etc.) control system power, thermal management (components, and driver and passengers), blowers, etc.

It is this last function that photovoltaics serve in the MBG hybrid. I expect to have room for 120-160 watts of solar panels.

Regenerative Braking

Regenerative braking is a process whereby the energy normally consumed in braking the vehicle's momentum (as heat in brakes) is made into electricity and "recovered" for use. Electric vehicles are an ideal platform for this wizardry because their motors can be "wired as generators" during the braking effort, and the electricity can be stored in the battery pack. Thus, the energy of a moving mass can be reclaimed and will slow down the vehicle at the same time!

It's wonderful theory but, in practice, regenerative braking in most electric vehicles is impractical because the application is plagued by a combination of these factors:

a. Complexity of circuitry needed to quickly "re-wire" many motor types as a "generator" and maintain correct controller usage.

b. Mismatch of voltages, currents, RPM, and load between motor and drive wheels throughout the speed range of the vehicle and a variety of braking conditions.

c. Low efficiency of the regeneration cycle due to the accumulative inefficiencies of generating electricity, storing it, and then using it. Batteries involve an electro-chemical conversion that occurs once during charge and again (reversed) on discharge. Losses occur in both phases.

Regenerative braking in the MBG design is more practical than most EVs because it circumvents these obstacles as follows:

a. The MBG involves relatively low-density power conversion. Lower electrical currents ease switching issues.

b. PM (permanent magnet) motors readily convert from a "motor" to a "generator" configuration.

c. PM motors are efficient as motors or generators.

d. Power from regeneration is stored in a variable-voltage, high-efficiency battery pack. Nickel-Cadmium batteries are more efficient than lead-acid batteries.

The KEY ingredient is the dedicated battery pack for regenerated energy. This bypasses the complexity of circuitry surrounding the main propulsive battery pack. A big plus is the variable voltage of the NiCad pack (series or parallel of 48 or 24 volts). It permits easy voltage/load matchup as vehicle speeds and braking needs vary.

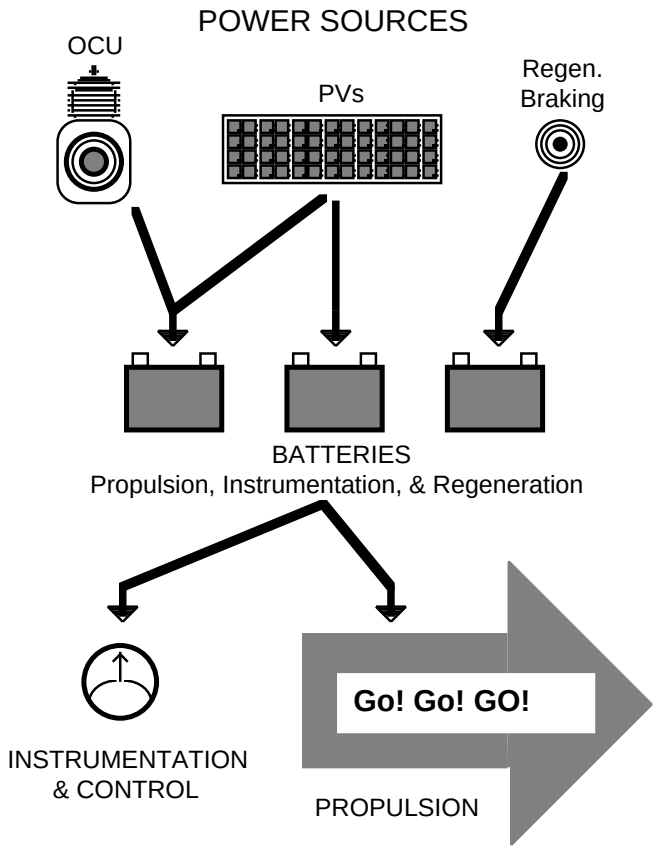
The energy salvaged during regeneration is used immediately in the next startup of the vehicle from a dead stop. With the first pressure on the accelerator pedal, the Regeneration battery pack is connected directly to the motors in the 48-volt configuration. Once a preset level of discharge is reached, this pack is disconnected and the main propulsive pack engaged. An unexpected bonus to this circuitry is that the Regeneration NiCad pack partially alleviates the voltage spike and high energy consumption attributed to stall motor current, a condition that exists at vehicle startup.

Some voltages or vehicle speeds are too low to provide

"recoverable" levels of electricity. However, this low-grade electricity can be channeled into resistive coils (like those found in floor heaters) to continue the braking effect. This is called dynamic braking. The use of dynamic braking minimizes the amount of hydraulic braking required to slow the vehicle. Also, both drum and disc brakes release asbestos dust to the environment as the brakes wear. Dynamic braking decreases asbestos pollution by reducing the rate of brake wear. Your pocketbook will appreciate the greater time between brake jobs, too!

Both the regenerative and dynamic braking circuits are made to work off the standard brake pedal in the MBG. As the pedal is depressed, it moves through various detents. The regenerative braking circuit uses the first two (1 and 2) detents and dynamic braking uses the following two (3 and 4). Further pedal depression engages the vehicle's hydraulic brakes. Indicator lights on the MBG dashboard will inform the driver when regenerative, dynamic, and hydraulic braking modes are engaged. The braking effort, then, is completely under the control of the driver; he or she simply presses the pedal until the desired degree of braking effort is reached.

There's one more feature here: coast versus slow down. In standard cars, when you take your foot off the accelerator pedal, some vehicle slow down occurs automatically. This is due to "compressive braking", an engine-related retardation of timing. This is pollution intensive, but a good safety feature because it acts like a "dead man switch". An electric motor cannot be compressively-braked. To duplicate this slow down feature, the MBG's motors are automatically put into a dynamic braking mode when the accelerator is released.



Long-time EV Owners advocate the benefits of "coasting" in electric vehicles. Little wonder! It certainly increases vehicle range! It takes practice to anticipate traffic and stoplight timing, letting off on the accelerator pedal to take upmost advantage of this effect. But it pays off. I like this feature, too. So, the MBG will have a dash-mounted switch to defeat the "auto-slow" circuit described above. When selected, it permits the maximum coasting effect, letting vehicle speed bleed off to the natural resistance of bearings, tires rolling on a surface, and general aerodynamic losses.

Instrumentation & Controls

The MBG prototype will be equipped with lots of monitoring capability. So that the dashboard doesn't look like the cockpit of a Boeing 747, a microprocessor will be used to automatically scan through all of the onboard sensors (i.e., voltages, currents, temperatures, etc.). An audio and/or visual indicator will alert the driver of any parameter that moves outside the range of preset values, and display the errant reading for further evaluation. I prefer this system to idiot lights or gauges since I always seem to notice them too late! This may be too costly to include in a production version.

Aerodynamics

A standard car, speeding down the highway at 55 MPH requires fully 50% of its propulsive effort to move air aside. As more attention is given to the ways a vehicle can slip through the air, this power consumption is reduced, as is the need for the size of propulsive machinery. There is no mystery to this (we wouldn't have aircraft that could do 2,000 MPH if there were) but, for a long time, solid aerodynamics has been lacking in most cars. The main culprit is "style", truly aerodynamic vehicles are thin and taper at each end. Since we are quickly reaching the point where conspicuous consumption of fuel is no longer possible, the "style" is getting cleaner, softer edges, lean lines, recessed fixtures, and more attention to detail. However, there's a lot more "trend" than "slick" in most manufactured bodywork.

What are the important aerodynamic considerations in landborne vehicles? A brief but accurate list includes four factors: shape, frontal area, closure, and ground effect.

The ideal SHAPE of vehicles in the 0-60 MPH range is a teardrop, rounded at the front and slowly tapering to a point in the rear. FRONTAL AREA is the number of square feet of silhouette when the vehicle is viewed "head on". You want this as low as possible, suggesting that the vehicle be a thin teardrop. Exhaustive tests have concluded that unless the CLOSURE (the way the vehicle tapers in the rear) stays at less than a 14 degree angle (7 degrees each size of a centerline through the vehicle), you might as well chop it off abruptly. Rattail-looking vehicles have limited appeal, so you'll see mostly sharp cutoffs.

GROUND EFFECT, in this context, defines a natural relationship between a road surface (or any surface) and the sky. A vehicle interacts with, and generally messes up, this intimate relationship in a way that defies easy description or remedy. It gets progressively worse with speed. Vehicles minimize the resultant drag with SKIRTS (shrouding that dips down to the surface to keep air from getting under the vehicle), UNDERPANS (smooth bottoms that minimize the yo-yo'ing of air between vehicle and ground), and ISOLATION (maintaining an elevation above the road surface that fools the road surface into thinking your car is an airplane).

A measure of a vehicle's aerodynamics is its drag coefficient. (This is not directly affected by the vehicle's propulsive power or its weight.) The desirable value of drag coefficient is low.

Streamlining is the art of achieving a low drag coefficient but it is thwarted by the air's propensity to cling to a surface. When it does, the air is turbulated at the parting, rolling and dodging, producing a thing called a vortex that's a real drag to the vehicle that experiences it. Careful attention to the four factors above, a clean shape, low frontal area, good closure, and minimal ground effect, will help.

The MBG vehicle chops the typical frontal area of a passenger vehicle in HALF. One MBG prototype will be a single-seater, so no explanation is required for how this is achieved. However, the second MBG will be a twin-seater (one driver, one passenger). It will also have HALF the frontal area of a standard car because the passenger is positioned behind the driver. This is called tandem seating. An alternate arrangement is "offset tandem", which places the passenger behind and slightly to the right of the driver. This would result in a slightly greater frontal area but afford the passenger a direct view ahead instead of a "view of a head".

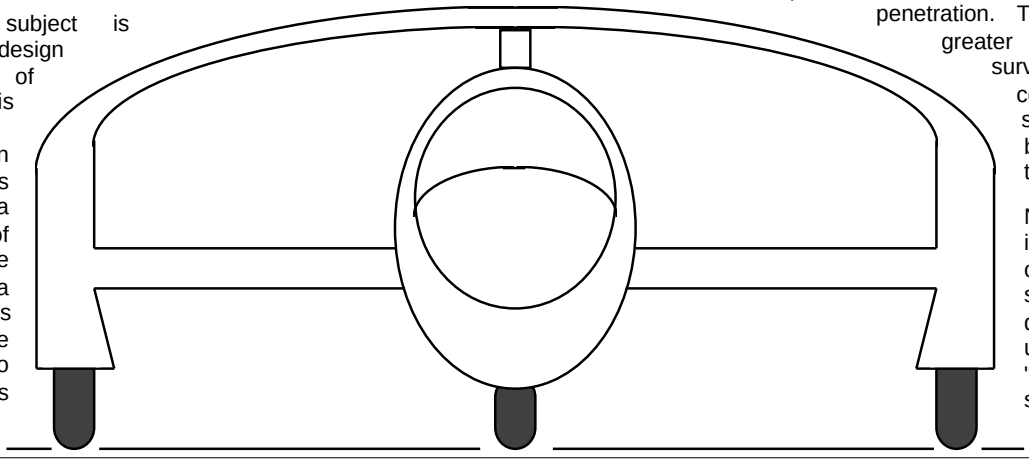
The MBG prototype will have a low drag coefficient because of a painstaking attention to detail. For example, there will be no scoops. A scoop is a protrusion that is intended to force some of the air moving past the vehicle to enter and, hopefully, move through some portion of the vehicle. Scoops are used for ventilation (of driver and passengers), combustion air (for engines), and cooling air (thermal management) -- the latter application typically requiring the highest CFM (cubic feet per minute) of airflow. Scoops interfere with aerodynamics. An alternate technique is to identify high and low-pressure points on the vehicle's body, and position inlets and outlets at these points for any internal cooling needs. As well, one test bed will investigate an alternate cooling technique for engine, motors, and batteries to eliminate most inlets/outlets.

Various aspects of the specific body layout also help to keep the drag coefficient low in the MBG vehicle. However, since these are side benefits of the vehicle's crashworthiness, they are better revealed in the next section.

Crashworthiness

If a transportation system were proposed today that killed 25,000 people worldwide each year, and injured or maimed another 2 million human beings annually, we'd reject it out of hand, right? I guess not. That describes our current system using automobiles! A major concern and design effort must be expended in scratch-built vehicles in the area of crashworthiness -- the effect of collision from the front, side, or rear of the vehicle. This could be a two-vehicle interaction or a collision involving the vehicle with a stationary object.

Although this subject is important in the design of ANY type of vehicle, it is especially important in lightweight vehicles because it is a basic LAW of physics that more of the energy of a collision is transferred to the lighter of two vehicles. Weight is a linear function.



Speed is a square function. At twice the relative speed of collision, the effect of the collision is four times as great.

In view of this, if you're neurotic, you don't drive. If you're sane, you drive as little as possible. If you're cautious, you drive something slow and heavy. If you concede that life is all about risks, you drive small and lightweight and stay very, very alert. If you're building your own, stay aware of things that help: strength, collapse distance, and design.

In vehicles, STRENGTH is often confused with weight, massiveness, and metals. Carbon fiber and fiberglass materials, and composite construction (fiberglass sandwiching) techniques make a lightweight vehicle tough. Stronger, in fact, than a vehicle several times heavier.

COLLAPSE DISTANCE recognizes the importance of spreading the impact of a collision over the greatest amount of time possible, decreasing the RATE of energy transfer. All that sculpting of metal that occurs in vehicle crashes actually helps the occupants. It dissipates energy. It slows things down. It converts energy into noise, heat, and motion. The idea is to absorb energy that a softer body, like a human being, dissipates in a more messy and irreversible fashion.

Good DESIGN confronts the possibility of a collision from any direction. It figures out how to be tough, malleable but rigid, dissipating and slowing energy. You do NOT worry about what happens to the vehicle. Every reasonable effort is made to keep a careening car or a telephone pole from penetrating or malforming the driver/passenger space AND it occupant(s).

Lightweight EVs, with their fiberglass materials and long aerodynamic bodies, are typically a designer's nightmare when it comes to crashworthiness. Front and rear impact are relatively easy directions to fortify. Side impact is the tough guy. How can you be slim and still withstand a side impact?

The MBG vehicle incorporates a TRIKE layout, as shown. In my opinion, this is one of the very best when it comes to overall collision protection and, most importantly, side impact protection. The MBG vehicle (see diagram) borrows heavily from the Amick windmobile (pictured in last month's issue).

Note that, in this layout, a side-impact will first contact the vehicle some 1-1/2 to 2 feet away from the driver. Due to the vehicle's unique wing-like structure and the rear wheel housings, this would be a tough distance to collapse. At least, it will dissipate much of the collision energy. Then, simply because the vehicle is so lightweight, the vehicle will start sliding. Certainly, at lower vehicle speeds, this will occur before cabin penetration. The end result is a greater degree of survivability, since the collision energy is spread out over both distance and time.

Note: One individual challenged this last statement, questioning the use of the word "survivability" since, almost assuredly, the

vehicle in question would go careening off to collide with something else. Without any thought at all, I responded, "That's okay. I'd love to be in a position to worry about the second collision!" I don't expect absolutes and, like life, I'll take things as they come.

The MBG, then, uses a Trike arrangement, utilizing twin motors, one at each of the rear wheels. This eliminates the differential -- with its attendant weight and inefficiency -- as required in vehicles using one propulsive source, i.e., an engine. It's likely that the MBG motor/wheel assemblies will use fixed gear ratios, eliminating the weight and inefficiency of a transmission. The motors act independently of one another. So, one motor will bring you home if the other decides to play dead.

The MBG vehicle is similar or different to the Amick windmobile in several ways. More specifically, the MBG prototype:

1. is NOT designed to use wind as an energy source. In the area I intend to operate the vehicle, there just isn't enough side wind to justify using it. Accordingly, the arch is lower. This will keep the wind's effect to a minimum and decrease the frontal area.

2. has a vertical fin between the uppermost point of the arch and the vehicle body. The arch is already a natural roll bar, and this fin strengthens this feature. It also stiffens overall structural support, increasing the side-impact protection. While this will affect the aerodynamics a bit, it also means that a side-impact must collapse the horizontal lower wing (compressive), the arched upper wing (compressive), the vertical fin (shear), and the wing which is attached to the outermost point of the horizontal wing on the other side of the vehicle (expansive).

3. has a narrower fuselage. As much as 9-12 inches in the width of the center vehicle body is removed since no true collapse distance need be added around the driver. This would decrease frontal area, assist with a proper tapering closure, and lower the drag coefficient.

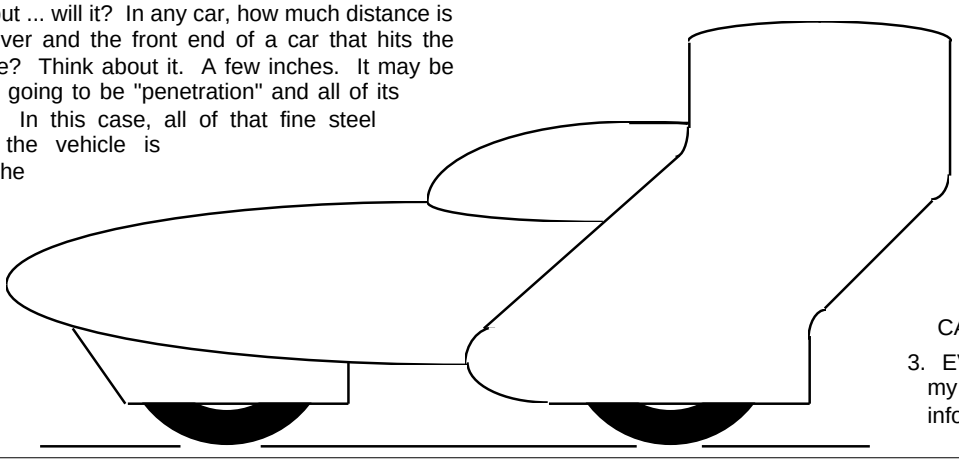
4. has a flattened arch. This makes it able to accommodate rigid photovoltaic modules.

5. has, when viewed from the side, the arch angled backward. This retains the crashworthiness of the horizontal low-wing positioning (aligned to the driver) but permits better side visibility for the driver.

6. employs the arch as a means of promoting high visibility of the slight-figured MBG body. The overall MBG design, incidentally, helps drivers "see" in front of the MBG because there's so little of the MBG body to interfere with their view!

7. may use the arch as a "radiator" in MBG proprietary thermal-management system.

How safe is safe? Buying a big, heavy car might exorcise your fears about collision, but ... will it? In any car, how much distance is there between the driver and the front end of a car that hits the vehicle on the left side? Think about it. A few inches. It may be good steel but there's going to be "penetration" and all of its nasty consequences. In this case, all of that fine steel everywhere else in the vehicle is working against the driver because it "plants" the vehicle massively (no pun intended), resisting the forces that would, for a lighter vehicle, cause it to start sliding.



Final Comments

I could go on and on. But -- it's time to zip this off to the Home Power folks. Besides, I've logged 22 hours on the Mac in three days doing this thing, and the key cooling system is going to come on at any second. It's writ-and- rewrit, edited and rearranged. A blackout right now would ruin the elation I feel in doing & finishing it.

I've given up a lot of my gameplan for the MBG in this article and that makes me happy and sad. Happy because experience, like love, is something you can share without using any of it up. Sad because I'd like to make a million dollars and finish the MBG, and I can't sell what's in the public domain. Oh, well.

The first article in Home Power #8 generated bushels of mail. Thanks! That's a welcome stroke. (I sometimes wonder if I sail strange seas of thought alone.) The EV networking newsletter is evolving into what may be a magazine (tentative title is Alternate Transportation Magazine.) EVs and HPV (human-powered vehicles), airships and ultralights, solar cars and waterbuggies. Shooting for a March release, newsletter or mag, of the 1st issue.

Do you feel teased into building your own hybrid EV. Great! Give it LOTS of thought, glean every bit of info you can from anyone who is doing anything that looks interesting, and go at it. Please -- be careful. Too little knowledge is SO dangerous. None of what is written here is gospel truth. I'm talking at the edge of integrating all this technology & I could get something wrong. Feel free to correct me, if you think I've done that. Be gentle; I have good intent. The final arrangement of this stuff -- into something you'll drive down the road -- is a process. Winnow through the factors and see what fits. Good fortune.

Wait! Lead-acid batteries always take it on the chin when it comes to propulsive power packs. Okay, so they do have low electro-mechanical efficiency and low energy density. In a hybrid EV, they work adequately because there's less to do, and storage isn't an issue like it is in pure EVs. In the MBG, there is an OCU there to recharge them immediately. These factors tickle the thought that standard SLI (Starting-Lighting-Ignition) batteries COULD be used for the battery pack. Although not intended for deep-cycle, they are adept at the higher charge/discharge currents involved, and good performance may justify more frequent battery replacement. It's worth investigating!

Want more info on electric vehicles? Here's some options:

1. Electric Vehicles: Design and Build Your Own , Michael Hackleman, 214 pages, 1977. $10 from Earthmind, P.O. Box 743, Mariposa, CA 95338.

2. EV Sources & References. Lists publications, catalogs, manufacturers, and sources for components related to EV vehicles. Send $3 to Michael Hackleman, P.O. Box 1161, Mariposa, CA 95338.

3. EV Mailing List. Get on my mailing list for information on Alternate

Transportation Magazine, Video Lending Library of EV films, and EV documentary film (now in postproduction). Send an SASE or postal money to Michael Hackleman, P.O. Box 1161, Mariposa, CA 95338.

Sweet, colorful, detailed visions! Michael Hackleman

Efficient Lighting for the Independently Powered Home

Incandescent vs. Quartz-Halogen vs. Fluorescent Light

DC vs. ac Power

Windy Dankoff

Three types of electric lights are used for indoor illumination. Each one has its place in the energy-efficient home. The efficiency and economy of your lighting depends on your choice of the right light for each application AND on the way the light is installed. Wise choices in lighting design can reduce energy requirements by 40-80%! Every $100 spent on high efficiency lighting can save $300 or more in system cost (for a typical photovoltaic system). There are two ways to power an alternative energy lighting system, LOW VOLTAGE DC from your battery bank (12 or 24 volts) and 120 VOLTS ac from your inverter or generator. (Readers who are not remote from the utility lines should follow our suggestions for efficient ac lighting.)

Three Types of Electric Lights

(1) **INCANDESCENT** (the common light bulb): Electric current passes through a thin tungsten metal filament causing it to heat white hot and emit light. The absence of oxygen in the glass bulb prevents rapid oxidation (burning) of the filament. The tungsten evaporates gradually, causing thin spots on the filament (while clouding the glass) leading to reduced efficiency &eventual failure.

(2) **QUARTZ-HALOGEN** (also called Quartz-Iodide, Tungsten-Halogen): An improvement on the incandescent bulb, works on the same principle except the tungsten filament is run at a higher temperature resulting in brighter, whiter light and higher efficiency. Ordinarily, this would result in short bulb life, so the bulb is (1) filled with "halogen" gas which slows the rate of evaporation of the tungsten (2) made smaller so the glass temperature is much hotter (this helps prevent tungsten from condensing on the bulb) and (3) made of a special "quartz" glass to tolerate the high temperature. Quartz-Halogen light is a very bright white (less red component) which aids the eye in perceiving detail. The most common applications are vehicle headlights, projectors, and spot-lights for displaying art work and merchandise.

(3) **FLUORESCENT**: Electric current flows thru a gas-filled glass tube, generating ultraviolet light (invisible). The tube is coated on the inside with a phosphorescent material which absorbs the ultraviolet and glows white. Very little heat is generated and efficiency is high. All fluorescent tubes require over 100 volts to operate, so low voltage fluorescents use a transistorized "ballast" to step up the voltage. LOW VOLTAGE DC FLUORESCENTS USE THE SAME TUBES AS 120 vac LIGHTS.

Incandescents, quartz-halogen and fluorescent lights differ in five major ways: (1) efficiency (2) life expectancy (3) installed cost (4) light quality and (5) light dispersion. Consider each separately.

(1) EFFICIENCY: Quartz-Halogen bulbs average 30% higher efficiency than incandescents. (Higher efficiency claims are based on comparison with worst-case incandescents.)

Fluorescent lights average 3 times the efficiency of low voltage incandescents (5 times compared with 120V incandescents!). We are assuming high quality fluorescents. (Some cheap ones are dim and less efficient in comparison).

Efficiency may vary widely even within the same class of light. For instance, low voltage (12 or 24V) incandescents are more efficient than 120 volt (common household) bulbs. This is because the low voltage bulb has a shorter, thicker filament (to pass higher current) so it is physically stronger, allowing a higher operating temperature. Just the shift from 120 volt incandescent bulbs to 12/24V bulbs (inexpensive RV and automotive bulbs) can reduce energy usage by an average 40%! Within the same voltage, incandescents vary. Long life and rough service bulbs run a cooler filament and have the lowest efficiency.

(2) LIFE EXPECTANCY: Incandescents have the shortest life, typically 1,000 hours (about a year of every-evening use.) Quartz-Halogen bulbs last longer--about 3,000 hours. Unlike incandescents, quartz-halogen bulbs do not blacken over time. They retain peak efficiency until the end. High quality DC fluorescents last longer yet--up to 10,000 hours, which can be 10 years of living room use!

(3) INSTALLED COST: Most fluorescent lights come with their own fixtures, ready to screw right to the wall or ceiling. The installed cost of a quartz-halogen or incandescent bulb must include the cost of a light fixture. Quartz-halogen bulbs cost 3 to 10 times as much as incandescents. However, their superior performance make them popular in renewable energy homes. Good fluorescents also cost 3 to 10 times aa much as incandescents (when you count the cost of incandescent fixtures). But, their cost is easily justified by radical gains in efficiency and life expectancy.

WIRING COST (FOR DC CIRCUITS): 1/3 the power requirement means wire may be two sizes smaller. Smaller wire costs less and requires less labor to install. Undersized wire causes voltage drop and reduced light output. For fluorescent lights, a voltage drop of 10% will cause a 10% drop in light output. But, in incandescent or quartz-halogen light circuits, BEWARE! Light output will drop by 25% because lower filament temperature causes further reduction in efficiency! Where wire runs are long (or existing wire is small) fluorescents may be clearly economical even for lights that are seldom used--their INSTALLED cost is less.

A 12 volt DC home using incandescent lights must use AVERAGE #10 wire, which is stiff and awkward to work with. The smaller #12 and #14 wire used in conventional ac homes can cause 12V lights to burn dimly. High efficiency lighting allows use of these smaller wire sizes, at least for some of the wiring in a 12V home, but NOTE: A 24 volt system requires one quarter the wire size of 12V, so conventional home wiring can handle nearly all 24V lighting. See wire size charts in most alternative energy catalogs and reference books for specifics. (24V systems may also run 12V lights and appliances using a "Battery Equalizer"--See HP#6.)

(4) QUALITY OF LIGHT: "Warm Spectrum" light is rich in the red/ orange end of the light spectrum (like candle light). "Cool White" is rich in the blue/violet end of the spectrum. Warm spectrum light is the most pleasant in the home. Incandescents generally produce a warm to medium spectrum, depending on bulb design and voltage at the bulb (beware, an overly warm orangy looking incandescent indicates very low efficiency, as low as %5!). Quartz-halogen bulbs produce medium to cool, best for reading and seeing fine details and colors. Fluorescents may be cool or warm, depending on the tube you select. Because low voltage DC fixtures use the same tubes as ac fluorescents, you may choose from a wide variety of tubes available on the market, including color-enhancing, full spectrum and plant-growing tubes. (Check with a well-stocked lighting supplier. In small stores you may find nothing but the standard "cool white" which many consider harsh and unpleasant.)

In the past, fluorescents have been notorious for harshness, color distortion, flicker, and poor life expectancy. The strobe-like flicker (caused by 60 cycle/second ac power) and unnatural spectrum have been blamed for behavioral disorders, nervousness and eye strain. But, use of DC power and recent advances in fluorescent light technology have overcome these problems. The human eye can detect the 60 cycle per second flicker of ac fluorescents. The DC fluorescents are being driven at 1,000 and 30,000 cycles per second, far too fast for the human eye to detect. Compact fluorescents now fit into bulb sockets. Better phosphors produce full-spectrum, color true light. We have customers who are artists and they PAINT under them! Problems with radio interference have also been solved. Many PV users who have rejected fluorescents in the past, now use them extensively with complete satisfaction. We use them in our living room, kitchen and shop too!

Full spectrum fluorescent light has been found to alleviate wintertime depression that some people experience. If you are not pleased with the quality of your fluorescent lights change to better, more modern tubes. (Reference: HEALTH AND LIGHT by John Otte.)

(5) DISPERSION OF LIGHT: Incandescent and quartz-halogen bulbs are small, intense light sources. This suits them to localized placement and use of reflective fixtures to concentrate light where it is needed. The quartz-halogen bulb is extremely small, practically being a "point source" of light. This makes it easy to reflect in a tight spot or flood beam. (Reflectors can multiply the intensity of light MANY times.) Point source light is good for "task lighting" of small areas but produces sharply defined shadows. Most fluorescent tubes are long and produce a highly diffuse light (from many directions)) good for lighting medium to large sized areas with a minimum of shadows. Diffuse fluorescent light is also perfect for kitchen counters, sinks, and work benches because your hands and tools will cast a minimum of shadow.

To be effective, light must shine onto the surfaces to be seen! Light that is absorbed by the surroundings or that shines into your eyes is wasted. Factors influencing overall lighting efficiency include positioning of lights, fixture design (reflective properties) and the color of ceiling and walls. A 5-watt quartz-halogen spot lamp can light the pages of a book better than a 100 watt bulb hanging from a dark ceiling! Placement of switches is also important in determining how handy it is to turn lights on and of as needed.

DC/LOW VOLTAGE vs. ac/120 VOLT LIGHTING

Renewable energy systems that depend on storage batteries (photovoltaic, hydro-electric, wind-electric) produce low voltage DC power. Utility companies supply high voltage ac power (more appropriate for mass-distribution). We live in a world of two electrical standards. Neither form of power is "best". What's important is to use the available form in an efficient, simple and reliable manner. Every step of energy conversion (ie. inverters) involves both a loss of energy and extra complexity. If you are producing DC power, it is best to use DC lights.

For the independently powered home, we design lighting circuits especially for low voltage DC, using larger wire than usual and maintaining isolation from ac appliance circuits. This results in the best overall economy in spite of higher installation cost. DC/ac dual wiring is simple enough for the average electrician when wiring a new home. If you are adapting alternative energy to a conventional ac home (retrofitting) you may choose to use ac power from your inverter to run all of your lighting. If so, be aware of the following:

(1) INVERTERS are complex high-tech devices, not usually serviceable locally (they are also expensive). Modern inverters are highly reliable, but anything can fail as the years go by. Running DC lights from a DC source requires two wires. Running ac lights efficiently requires microprocessor chips, transistors, transformer and other complexities within the inverter. We prefer to use inverters primarily for "luxury" appliances and leave essential lighting, well pumping and refrigeration to DC power, both for peak reliability and efficiency.

(2) LOW VOLTAGE DC LIGHTS are more efficient than ac lights, the exception being "electronic ballast" fluorescents which are the same either way (see below). Low voltage incandescents use half the power of ac bulbs for the same light (see efficiency analysis above). Quartz-halogen are also superior on the low voltage forms, so much so that ac quartz-halogen fixtures (like track lights) use 12V bulbs powered by a transformer! The use of an inverter to convert 12V to 120 only to have it converted back to 12V again (with additional losses) is a technical absurdity ala Rube Goldberg!

(3) INVERTERS loose energy, generally about 10% (that's 90% efficiency). Efficiency can be much lower for a large inverter running just one or two lights. An ac incandescent requires almost twice the power of a DC bulb, causing the inverter to waste still more.

(4) INVERTERS only approximate the properties of utility power. Most ac fluorescent lights work less efficiently than normal on inverter power and may emit an annoying buzz. This is because utility (or generator) power produces current that alternates smoothly (like a swinging pendulum) producing what's called a "sine wave". Inverters produce alternating current (ac) by switching, which produces a choppier waveform often called a "modified sine wave". Common fluorescent lights contain a "magnetic coil" ballast which does not respond well to non-sinewave (most other appliances work fine).

ELECTRONIC BALLAST FLUORESCENTS offer the best solution for efficient ac lighting from inverter power. Screw-in versions are available from many lighting suppliers. They may be bulkier and heavier than standard bulbs and cost about $15 each, but last about 7 times as long and use 1/4 the energy of ac incandescent bulbs. They produce a pleasing warm light. Electronic ballasts are also available for common long-term fluorescent fixtures, but you will need to contact an industrial lighting supplier. They are more efficient on any ac power source and they eliminate the strobe-like flicker that conventional fluorescents produce, so we recommend them to everyone. *Editor's Note: In the PV system featured in this issue, Roger and Ana Murray power GE "Compax" fluorescents via their inverter. These miniature fluorescents have a standard candela base (like a lightbulb). The General Electric "Compax" model FLG15 consumes 15 Watts and produces the equivalent light output of a 40 watt 120 vac incandescent lightbulb. These "Compax" fluorescents produce a warm natural light, not the harsh cold stuff we normally associate with fluorescents. They also run*

very quietly from inverter produced 120 vac. RP

FURTHER REMARKS

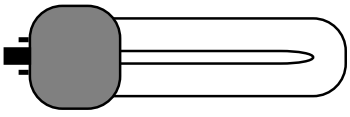
EFFICIENCY may not be critical for lights that are not used often. You may have closets, storage rooms or outbuildings where lights are seldom used. You need not spend extra money on energy-efficient light there unless line loss is a factor. Likewise, you may wish to run only ac to a garage or outbuilding rather than dc, if the distance is more than 100 feet, especially if the lights are not used for long periods. Some of our customers have generously sized PV systems to run summer irrigation pumping. In winter, they have so much excess energy that they don't need to spend a lot of money on efficient lights.

OUTDOOR LIGHTS: Some fluorescent fixtures will not work at low temperatures. For unheated spaces where temperatures may drop below 40°F., special fluorescents are available.. "Low Pressure Sodium" lamps are even more efficient, but have poor color rendition and need long warm-up time. They are frequently used for yard and security lighting. Any incandescent or quartz-halogen bulbs will work fine outdoors if protected from moisture.

CONCLUSION

Lighting is the biggest electrical load in many PV homes. It is needed the most when there is the least amount of solar energy available! High efficiency lighting design reduces generating, storage and distribution costs so much that it can make PV power more affordable than most people realize.

Windy Dankoff is owner/visionary of FLOWLIGHT SOLAR POWER, P.O. Box 548, Santa Cruz, NM, 87567. 505/753-9699. High efficiency lights are available by mail from Flowlight Solar Power and from other Home Power advertisers. An earlier version of this article originally appeared in the PV NETWORK NEWS ($15/year from PV Network, Rt 10, Box 86PV, Santa Fe, NM 87501).



PL Series 120 vac Fluorescent vs. ? 120 vac Incandescent Light Bulb

TYPE OF LAMP	LIGHT OUTPUT (LUMENS)	POWER USED (WATTS)	AMPS USED (A.@12VDC)	EFFICIENCY LUMENS PER 12 VDC AMP	LAMP LIFETIME (HOURS)
PL-5 Fluorescent	250	5	0.40	625	10,000
25 watt Incandescent	235	25	2.10	112	1,250
PL-9 Fluorescent	575	9	0.75	767	10,000
40 watt Incandescent	455	40	3.30	138	1,000
PL-13 Fluorescent	900	13	1.10	818	10,000
60 watt Incandescent	860	60	5.00	172	1,000
PL-18 Fluorescent	1,250	18	1.50	833	12,000
75 watt Incandescent	1,180	75	6.20	190	750
PL-24 Fluorescent	1,800	24	2.00	900	12,000
100 watt Incandescent	1,750	100	8.30	211	750

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I NOW use alternative energy (check one that best applies to your situation).

☐ **As my only power source** ☐ **As my primary power source**

☐ **As my backup power source** ☐ **As a recreational power source (RVs)**

I want to use alternative energy in the FUTURE (check one that best applies).

☐ **As my only power source** ☐ **As my primary power source**

☐ **As my backup power source** ☐ **As a recreational power source (RVs)**

My site has the following alternative energy potentials (check all that apply).

☐ **Photovoltaic power** ☐ **Water power**

☐ **Wind Power** ☐ **Other** _____

I now use OR plan to use the following alternative energy equipment (check all that apply).

NOW	FUTURE		NOW	FUTURE	
☐	☐	Photovoltaic cells	☐	☐	Gas/Diesel generator
☐	☐	Wind generator	☐	☐	Batteries
☐	☐	Water power generator	☐	☐	Inverter
☐	☐	Battery Charger	☐	☐	Control systems
☐	☐	Instrumentation	☐	☐	PV Tracker

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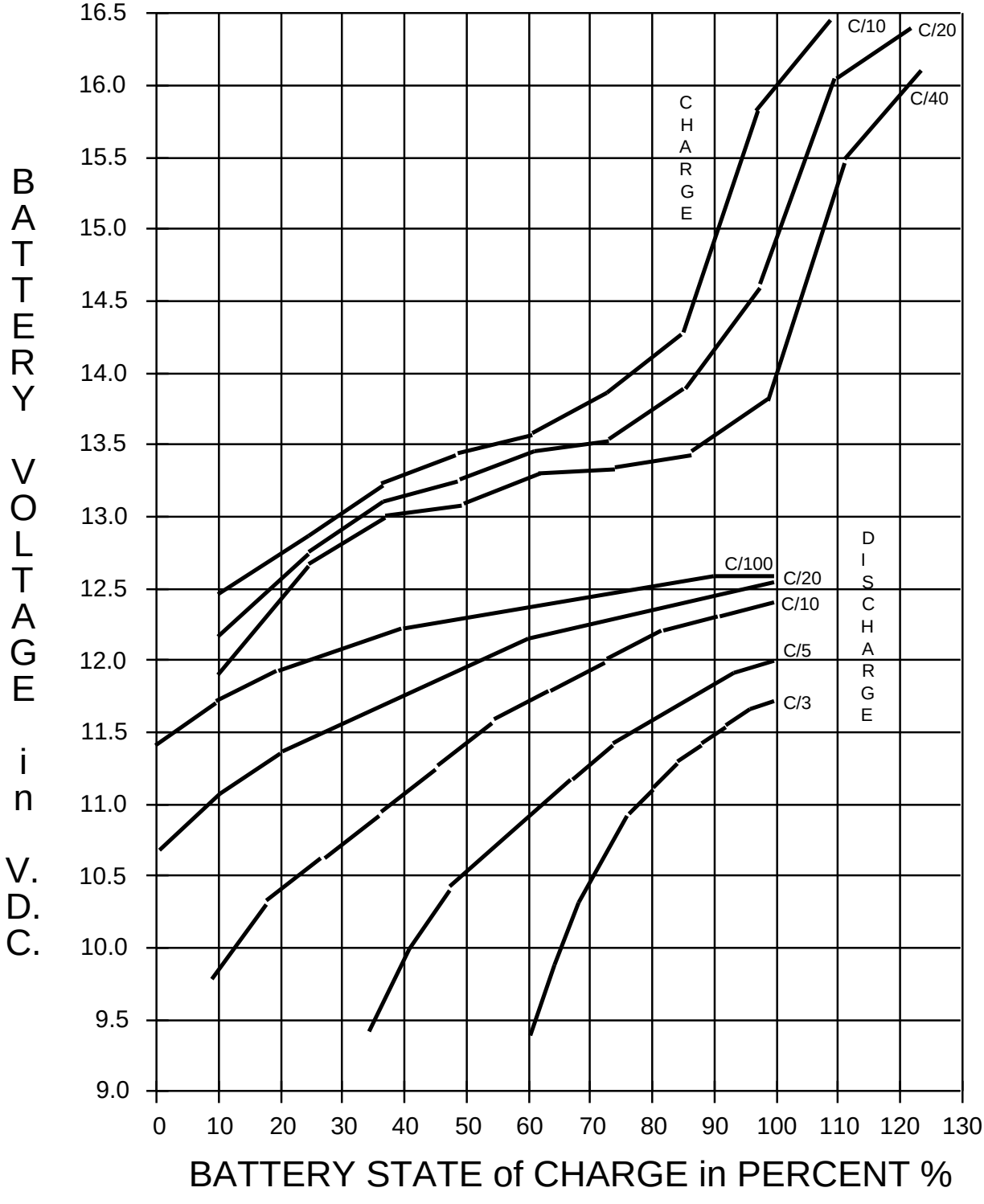
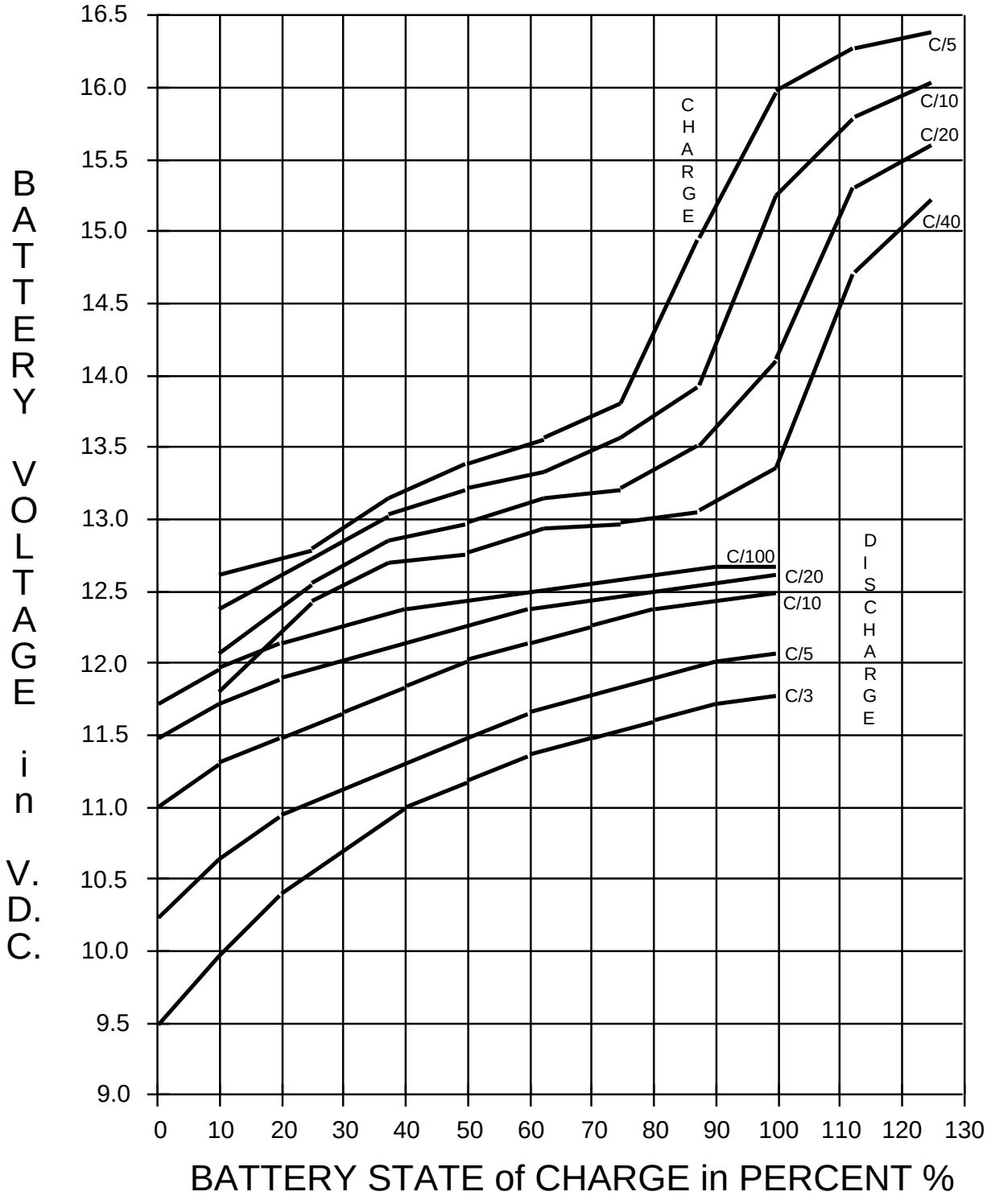
12 Volt Lead-Acid Battery Chart- 34°F.



12 Volt Lead-Acid Battery Chart- 78°F.



Lead-Acid Batteries for Home Power Storage

Richard Perez

In 1970, we moved to the Mountains. The only desirable property we could afford was in the outback. Everything was many miles down a rough dirt road, far from civilized conveniences like electricity. We conquered the bad roads with a 4WD truck and countless hours of mechanical maintenance. The electrical power problem was not so easy to solve. We had to content ourselves with kerosene lighting and using hand tools. The best solution the marketplace could then offer was an engine driven generator. This required constant operation in order to supply power, in other words, expensive. It seemed that in America one either had power or one didn't.

We needed inexpensive home power. And we needed it to be there 24 hours a day without constantly running a noisy, gasoline eating, engine. At that time, NASA was about the only folks who could afford PVs. We started using lead-acid batteries to store the electricity produced by a small gas engine/generator. We'd withdraw energy from the batteries until they were empty and then refill them by running a lawnmower engine and car alternator. Since we stored enough energy to last about 4 days, we discharged and recharged the batteries about 100 times a year. Over years of this type service, we have learned much about lead-acid batteries-- how they work and how to best use them. The following info has been hard won; we've made many expensive mistakes. We've also discovered how to efficiently and effectively coexist with the batteries that store our energy. Batteries are like many things in Life, mysterious until understood.

Before we can effectively communicate about batteries, we must share a common set of terms. Batteries and electricity, like many technical subjects, have their own particular jargon. Understanding these electrical terms is the first step to understanding your batteries.

Electrical Terms

Voltage

Voltage is electronic pressure. Electricity is electrons in motion. Voltage is the amount of pressure behind these electrons. Voltage is very similar to pressure in a water system. Consider a water hose. Water pressure forces the water through the hose. This situation is the same for an electron moving through a wire. A car uses 12 Volts, from a battery for starting. Commercial household power has a voltage of 120 volts. Batteries for renewable energy are usually assembled into packs of 12, 24, 32, or 48 volts.

Current

Current is the flow of electrons. The unit of electron flow in relation to time is called the Ampere. Consider the water hose analogy once again. If voltage is like water pressure, then current is like FLOW. Flow in water systems is measured in gallons per minute, while electron flow is measured in Amperes. A car tail light bulb consumes about 1 to 2 Amperes of electrical current. The headlights on a car consume about 8 Amperes each. The starter uses about 200 to 300 Amperes. Electrical current comes in two forms-- direct current (DC) and alternating current (ac). In DC circuits the electrons flow in one direction ONLY. In ac circuits the electrons can flow in both directions. Regular household power is ac. Batteries store electrical power as direct current (DC).

Power

Power is the amount of energy that is being used or generated. The unit of power is the Watt. In the water hose analogy, power is can be compared to the total gallons of water transferred by the hose. Mathematically, power is the product of Voltage and Current. To find Power simply multiply Volts times Amperes. The amounts of power being used and generated determine the amount of energy that the battery must store.

Battery Terms

A Cell

The cell is the basic building block of all electrochemical batteries. The cell contains two active materials which react chemically to release free electrons (electrical energy). These active materials are usually solid and immersed in a liquid called the "electrolyte". The electrolyte is an electrically conductive liquid which acts as an electron transfer medium. In a lead acid cell, one of the active materials is lead dioxide (PbO_2) and forms the Positive pole (Anode) of the cell. The other active material is lead and forms the Negative pole (Cathode) of the cell. The lead acid cell uses an electrolyte composed of sulphuric acid (H_2SO_4).

During discharge, the cell's active materials undergo chemical reactions which release free electrons. These free electrons are available for our use at the cells electrical terminals or "poles". During discharge the actual chemical compositions of the active materials change. When all the active materials have undergone reaction, then the cell will produce no more free electrons. The cell is now completely discharged or in battery lingo, "dead".

Some cells, like the lead-acid cell, are rechargeable. This means that we can reverse the discharge chemical reaction by forcing electrons backwards through the cell. During the recharging process the active materials are gradually restored to their original, fully charged, chemical composition.

The voltage of an electrochemical cell is determined by the active materials used in its construction. The lead-acid cell develops a voltage of around 2 Volts DC. The voltage of a cell has no relationship to its physical size. All lead acid cells produce about 2 VDC regardless of size.

In the lead acid cell, the sulphuric acid electrolyte actually participates in the cell's electrochemical reaction. In most other

battery technologies, like the nickel-cadmium cells, the electrolyte merely transfers electrons and does not change chemically as the cell discharges. In the lead-acid system, however, the electrolyte participates in the cell's reaction and the H_2SO_4 content of the electrolyte changes as the cell is discharged or charged. Typically the electrolyte in a fully charged cell is about 25% sulphuric acid with the remaining 75% being water. In the fully discharged lead-acid cell, the electrolyte is composed of less than 5% sulphuric acid with the remaining 95% being water. This happy fact allows us to determine how much energy a lead-acid cell contains by measuring the amount of acid remaining in its electrolyte. Figure 1 illustrates the electrochemical workings of a lead acid cell.

A Battery

A battery is a group of electrochemical cells. Individual cells are collected into batteries to either increase the voltage or the electrical capacity of the resulting battery pack. For example, an automotive electrical system requires 12 VDC for operation. How is this accomplished with a basic 2 VDC lead-acid cell? The cells are wired together in series, this makes a battery that has the combined voltages of the cells. A 12 Volt lead-acid battery has six (6) cells, each wired anode to cathode (in series) to produce 12 VDC. Cells are combined in series for a voltage increase or in parallel for an electrical capacity increase.

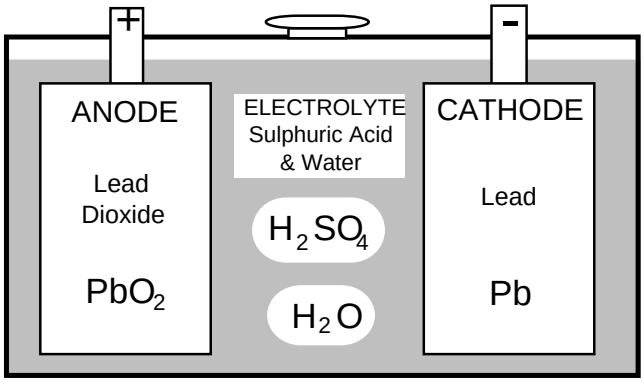
Battery Capacity

Battery capacity is the amount of energy a battery contains. Battery capacity is usually rated in Ampere-hours (A-h) at a given voltage. Watt-hours (W-h) is another unit used to quantify battery capacity. While a single cell is limited in voltage by its materials, the electrical capacity of a cell is limited only by its size. The larger the cell, the more reactive materials contained within it, and the larger the electrical capacity of the cell in Ampere-hours.

A battery rated at 100 Ampere-hours will deliver 100 Amperes of current for 1 hour. It can also deliver 10 Amperes for 10 hours, or 1 Ampere for 100 hours. The average car battery has a capacity of about 60 Ampere-hours. Renewable energy battery packs contain from 350 to 4,900 Ampere-hours. The specified capacity of a battery pack is determined by two factors-- how much energy is needed and how long the battery must supply this energy. Renewable energy systems work best with between 4 and 21 days of storage potential.

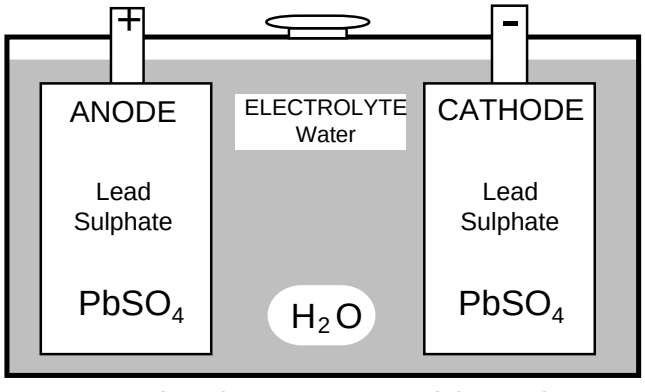
A battery is similar to a bucket. It will only contain so much electrical energy, just as the bucket will only contain so much water. The amount of capacity a battery has is roughly determined by its size and weight, just as a bucket's capacity is determined by its size. It is difficult to water a very large garden with one small bucket, it is also difficult to run a homestead on an undersized battery. If a battery based renewable energy system is to really work, it is essential that the battery have enough capacity to do the job. Undersized batteries are one of the major reasons that some folks are not happy with their renewable energy systems.

Battery capacity is a very important factor in sizing renewable energy systems. The size of the battery is determined by the amount of energy you need and how long you wish to go between battery rechargings. The capacity of the battery then determines the size of the charge source. Everything must be balanced if the system is to be efficient and long-lived.



LEAD-ACID CELL FULLY CHARGED

$$PbO_2 + Pb + 2H_2SO_4 \underset{\text{DISCHARGE}}{\overset{\text{CHARGE}}{\rightleftharpoons}} 2PbSO_4 + 2H_2O$$

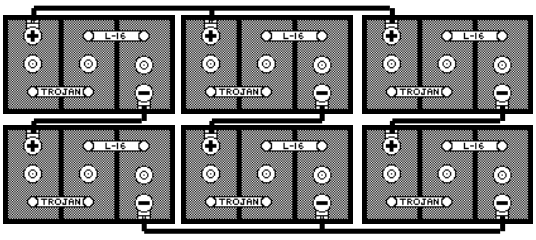


LEAD-ACID CELL FULLY DISCHARGED

Figure 1- An electrochemical schematic of the lead-acid cell.

State of Charge (SOC)

A battery's state of charge is a percentage figure giving the amount of energy remaining in the battery. A 300 Ampere-hour battery at a 90% state of charge will contain 270 Amperes-hours of energy. At a 50% state of charge the same battery will contain 150 Ampere-hours. A battery which is discharged to a 20% or less state of charge is said to be "deep



Lead- Acid Battery-- 12 VDC at 1,050 Ampere-hours.
6 each Trojan L-16W (6 VDC at 350 Ampere-hours)
Each L-16 CELL contains 350 Ampere-hours at 2 VDC, and the L-16 battery has 3 cells(in series) within its case.

cycled". Shallow cycle service withdraws less than 10% of the battery's energy per cycle.

Lead-Acid Batteries

Lead-acid batteries are really the only type to consider for home energy storage at the present time. Other types of batteries, such as nickel-cadmium, are being made and sold, but they are simply too expensive to fit into low budget electrical schemes. We started out using car batteries.

Automotive Starting Batteries

The main thing we learned from using car batteries in deep cycle service is **DON'T**. Automotive starting batteries are not designed for deep cycle service; they don't last. Although they are cheap to buy, they are much more expensive to use over a period of several years. They wear out very quickly.

Car Battery Construction

The plates of a car battery are made from lead sponge. The idea is to expose the maximum plate surface area for chemical reaction. Using lead sponge makes the battery able to deliver high currents and still be as light and cheap as possible. The sponge type plates do not have the mechanical ruggedness necessary for repeated deep cycling over a period of many years. They simply crumble with age.

Car Battery Service

Car batteries are designed to provide up to 300 Amperes of current for very short periods of time (less than 10 seconds). After the car has started, the battery is then constantly trickle charged by the car's alternator. In car starting service, the battery is usually discharged less than 1% of its rated capacity. The car battery is designed for this very shallow cycle service.

Car Battery Life Expectancy & Cost

Our experience has shown us that automobile starting batteries last about 200 cycles in deep cycle service. This is a very short period of time, usually less than 2 years. Due to their short lifespan in home energy systems, they are more than 3 times as expensive to use as a true deep cycle battery. Car batteries cost around $60. for 100 Ampere-hours at 12 volts.

Beware of Ersatz "Deep Cycle" Batteries

After the failure of the car batteries we tried the so called "deep cycle" type offered to us by our local battery shop. These turned out to be warmed over car batteries and lasted about 400 cycles. They were slightly more expensive, $100. for 105 Ampere-hours at 12 volts. You can spot these imitation deep cycle batteries by their small size and light weight. They are cased with automotive type cases. Their plates are indeed more rugged than the car battery, but still not tough enough for the long haul.

True "Deep Cycle" Batteries

After many battery failures and much time in the dark, we finally tried a real deep cycle battery. These batteries were hard to find; we had to have them shipped in as they were not available locally. In fact, the local battery shops didn't seem to know they existed. Although deep cycle types use the same chemical reactions to store energy as the car battery, they are very differently made.

Deep Cycle Physical Construction

The plates of a real deep cycle battery are made of scored sheet lead. These plates are many times thicker than the plates in car batteries, and they are solid lead, not sponge lead. This lead is alloyed with up to 16% antimony to make the plates harder and more durable. The cell cases are large; a typical deep cycle battery is over 3 times the size of a car battery. Deep cycle batteries weigh between 120 and 400 pounds.

We tried the Trojan L-16W. This is a 6 Volt 350 Ampere-hour battery, made by Trojan Batteries Inc., 1395 Evans Ave., San Francisco, CA (415) 826-2600. The L-16W weighs 125 pounds and contains over 9 quarts of sulphuric acid. The "W" designates a Wrapping of the plates with perforated nylon socks. Wrapping, in our experience, adds years to the battery's longevity. We wired 2 of the L-16Ws in series to give us 12 Volts at 350 Ampere-hours.

Deep Cycle Service

The deep cycle battery is designed to have 80% of its capacity withdrawn repeatedly over many cycles. They are optimized for longevity. If you are using battery stored energy for your home, this is the only type of lead-acid battery to use. Deep cycle batteries are also used for motive power. In fact, many more are used in forklifts than in renewable energy systems.

Deep Cycle Life Expectancy & Cost

A deep cycle battery will last at least 5 years. In many cases, batteries last over 10 years and give over 1,500 deep cycles. In order to get maximum longevity from the deep cycle battery, it must be cycled properly. All chemical batteries can be ruined very quickly if they are improperly used. A 12 Volt 350 Ampere-hour battery costs around $440. Shipping can be expensive on these batteries. They are corrosive and heavy, and must be shipped motor freight.

Deep Cycle Performance

The more we understood our batteries, the better use we made of them. This information applies to high antimony, lead-acid deep cycle batteries used in homestead renewable energy service. In order to relate to your system you will need a voltmeter. An accurate voltmeter is the best source of information about our battery's performance. It is needed in answering the two questions of battery operation-- when to charge & when to stop charging**.**

Voltage vs. Current

The battery's voltage depends on many factors. One is the rate, in relation to the battery's capacity, that energy is either being withdrawn from or added to the battery. The faster we discharge the battery, the lower its voltage becomes. The faster we recharge it, the higher its voltage gets. Try an experiment- hook the voltmeter to a battery and measure its voltage. Turn on some lights or add other loads to the battery. You'll see the voltage of the battery is lowered by powering the loads. This is perfectly normal and is caused by the nature of the lead-sulphuric acid electrochemical reaction. In homestead service this factor means high powered loads need large batteries. Trying to run large loads on a small capacity battery will result in very low voltage. The low voltage can ruin motors and dim lights.

Voltage vs. State of Charge

The voltage of a lead-acid battery gives a readout of how much energy is available from the battery. Figure 2, on page 26, illustrates the relationship between the battery's state of charge and its voltage for various charge and discharge rates. This graph and its companion, Fig.3, are placed in the center of the magazine as a tearout so you can put them on your wall if you wish. This graph is based on a 12 Volt lead-acid battery at room temperature. Simply multiply the voltage figures by 2 for a 24 Volt system, and by 4 for a 48 Volt system. This graph assumes that the battery is at room temperature 78°F. Use the C/100 discharge rate curve for batteries at rest (i.e. not under charge or discharge).

Temperature

The lead-acid battery's chemical reaction is sensitive to temperature. See the graph, Figure 3 on page 25, which shows the same info as Figure 2, but for COLD lead-acid batteries. Note the voltage depression under discharge and the voltage elevation under charge. The chemical reaction is very sluggish at cold temperatures. Battery efficiency and usable capacity drop radically at temperatures below 40° F. At 40°F., a lead acid battery has effectively lost about 20% of its capacity at 78°F. At 0°F., the same battery will have effectively lost 45% of its room temperature capacity. We keep our batteries inside, where we can keep them warm in the winter. Batteries banished to the woodshed or unheated garage will not perform well in the winter. They will be more expensive to use and will not last as long. The best operating temperature is around 78° F..

The situation with temperature is further complicated by the lead-acid system's electrolyte. As the battery discharges the electrolyte loses its sulphuric acid and becomes mostly (≈95%) water. IT WILL FREEZE. Freezing usually ruptures the cell's cases and destroys the plates. Lead-acid batteries at < 20% SOC will freeze at around 18°F. If you're running lead acid batteries at low temperatures, then keep them fully charged to prevent freezing on very cold nights.

Determining State of Charge with a Hydrometer

A hydrometer is a device that measures the density of a liquid in comparison with the density of water. The density of the sulphuric acid electrolyte in the battery is an accurate indicator of the battery's state of charge. The electrolyte has greater density at greater states of charge. We prefer to use the battery's voltage as an indicator rather than opening the cells and measuring the electrolyte's specific gravity. Every time a cell is opened there is a chance for contamination of the cell's inards. Lead- acid batteries are chemical machines. If their cells are contaminated with dirt, dust, or other foreign material, then the cell's life and efficiency is greatly reduced. If you insist on using a hydrometer, make sure it is spotlessly clean and temperature compensated. Wash it in distilled water before and after measurements.

Rates of Charge/Discharge

Rates of charge and discharge are figures that tell us how fast we are either adding or removing energy from the battery. In actual use, this rate is a current measured in Amperes. Say we wish to use 50 Amperes of current to run a motor. This is quite a large load for a small 100 Ampere-hour battery. If the battery had a capacity of 2,000 Ampere-hours, then the load of 50 Amperes is a small load. It is difficult to talk about currents through batteries in terms of absolute Amperes of current. Battery people talk about these currents in relation to the battery's capacity.

Rates of charge and discharge are expressed as ratios of the battery's capacity in relation to time. Rate (of charge or discharge) is equal to the battery's capacity in Ampere-hours divided by the time in hours it takes to cycle the battery. If a completely discharged battery is totally filled in a 10 hour period, this is called a C/10 rate. C is the capacity of the battery in Ampere-hours and 10 is the number of hours it took for the complete cycle. This capacity figure is left unspecified so that we can use the information with any size battery pack.

For example, consider a 350 Ampere-hour battery. A C/10 rate of charge or discharge is 35 Amperes. A C/20 rate of charge or discharge is 17.5 Amperes. And so on... Now consider a 1,400 Ampere-hour battery. A C/10 rate here is 140 Amperes, while a C/20 rate is 70 Amperes. Note that the C/10 rate is different for the two different batteries; this is due to their different capacities. Battery people do this not to be confusing, but so we can all talk in the same terms, regardless of the capacity (size) of the battery under discussion.

Let's look at the charge rate first. For a number of technical reasons, it is most efficient to charge deep cycle lead-acid batteries at rates between C/10 and C/20. This means that the fully discharged battery pack is totally recharged in a 10 to 20 hour period. If the battery is recharged faster, say in 5 hours (C/5), then much more electrical energy will be lost as heat. Heating the battery's plates during charging causes them to undergo mechanical stress. This stress breaks down the plates. Deep cycle lead-acid batteries which are continually recharged at rates faster than C/10 will have shortened lifetimes. The best overall charging rate for deep cycle lead-acid batteries is the C/20 rate. The C/20 charge rate assures good efficiency and longevity by reducing plate stress. A battery should be completely refilled each time it is cycled. This yields maximum battery life by making **all** the active materials participate in the chemical reaction.

We often wish to determine a battery's state of charge while it is actually under charge or discharge. Figure 2, on page 25, illustrates the battery's state of charge in relation to its voltage for several charge/discharge rates. This graph is based on a 12 Volt battery pack at room temperature. For instance, if we are charging at the C/20 rate, then the battery is full when it reaches 14.0 volts. Once again the digital voltmeter is used to determine state of charge without opening the cells and risking contamination. Figure 3, on page 24, offers the same information as Figure 2, but in Figure 3 the information pertains to a lead-acid battery at 34°F. Note the depression of voltage under discharge and the voltage elevation under charge. This reflects an actual change in the batteries internal resistance to electrical flow. The colder the battery becomes, the higher its internal resistance gets, and the more radical the voltage swings under charge and discharge become.

The Equalizing Charge

After several months, the individual cells that make up the battery may differ in their states of charge. Voltage differences greater than 0.05 volts between the cells indicate it is time to equalize the individual cells. In order to do this, the battery is given an equalizing charge. **An equalizing charge is a controlled overcharge of an already full battery. Simply continue the recharging process at the C/20 rate for 5 to 7 hours after the battery is full.** Batteries should be equalized every 5 cycles or every 3 months, whichever comes first. Equalization is the best way to increase deep cycle lead-acid battery life. Battery voltage during the equalizing charge may go as high as 16.5 volts, especially if the battery's temperature is < 40°F.. This voltage is too high for many 12 Volt electronic appliances. Be sure to turn off all voltage sensitive gear while running an equalizing charge.

Wind machines and solar cells are not able to recharge the batteries at will. They are dependendent on Mama Nature for energy input. We have found that most renewable energy systems need some form of backup power. The engine/generator can provide energy when the renewable energy source is not operating. The engine/generator can also supply the steady energy necessary for complete battery recharging and equalizing charges. The addition of an engine/generator also reduces the amount of battery capacity needed. Wind and solar sources need larger battery capacity to offset their intermittent nature. Home Power #2 discusses homebuilding a very efficient and supercheap 12 Volt DC source from a lawnmower motor and a car alternator.

Self-Discharge Rate vs. Temperature

All lead-acid batteries, regardless of type, will discharge themselves over a period of time. This energy is lost within the battery; it is not available for our use. The rate of self-discharge depends primarily on the battery's temperature. If the battery is stored at temperatures above 120° F., it will totally discharge itself in 4 weeks. At room temperatures, the battery will lose about 6% of its capacity weekly and be discharged in about 16 weeks. The rate of self-discharge increases with the battery's age. Due to self-discharge, it is not efficient to store energy in lead-acid batteries for periods longer than 3 weeks. Yes, it is possible to have too many batteries. If you're not cycling your batteries at least every 3 weeks, then you're wasting energy.

If an active battery is to be stored, make sure it is first fully recharged and then put it in a cool place. Temperatures around 35° F. to 40° F. are ideal for inactive battery storage. The low temperature slows the rate of self-discharge. Be sure to warm the battery up and recharge it before using it.

Battery Capacity vs. Age

All batteries gradually lose some of their capacity as they age. When a battery manufacturer says his batteries are good for 5 years, he means that the battery will hold 80% of its original capacity after 5 years of proper service. Too rapid charging or discharging, cell contamination, and undercharging are examples of improper service which will greatly shorten any battery's life. Due to the delicate nature of chemical batteries most manufacturers do not guarantee them for long periods of time. On a brighter note, we have discovered that batteries which are treated with tender love and care can last twice as long as the manufacturer's claim they will. If you're using batteries, it really pays to know how to treat them.

Battery Cables

The size, length, and general condition of your battery cables are critical for proper performance. While the battery may have plenty of power to deliver, it can't deliver it effectively through undersized, too long or funky wiring. Battery (and especially inverter) cables should be made of large diameter copper cable with permanent soldered connectors. The acid environment surrounding lead-acid system plays hell with any and all connections. Connectors which are mechanically crimped to the wire are not acceptable for battery connection. The acid gradually works its way into the mechanical joint resulting in corrosion and high electrical resistance. See Home Power #7, page 36, for complete instructions on home made, low loss, soldered connectors and cables.

Battery Safety

Location plays a great part in battery safety. A battery room or shed, securely locked & properly ventilated, is a very good idea. Children, pets, and anyone not aware of the danger should never be allowed access to battery areas. Lead-acid batteries contain sulphuric acid, and lots of it. For example, a medium sized battery of 12 VDC at 1,400 A-h will contain some 18 gallons of nasty, corrosive, dangerous acid. Such a battery pack is capable of delivering over 4,000 Amperes of 12 VDC for short periods. Direct shorts across the battery can arc weld tools and instantly cause severe burns to anyone holding the tool. Be careful when handling wrenches or any metallic object around batteries. If tools make contact across the batteries electrical terminals, the results can be instantly disastrous.

When a lead-acid battery is almost full and undergoing recharging, the cell's produce gasses. These gasses are mostly oxygen and hydrogen- a potentially explosive mixture. Battery areas should be well ventilated during recharging and especially during equalizing charges to dissipate the gasses produced. If a blower is used in ventilation, make sure that it employs a "sparkless motor". See Home Power #6, pg. 31, for info on venting lead-acid batteries.

Battery Maintenance

There is more to battery care than keeping their tops clean. Maintenance begins with proper cycling. The two basic decisions are when to charge and when to stop charging. Begin to recharge the battery when it reaches a 20% state of charge or before. Recharge it until it is completely full. Both these decisions can be made via voltage measurement, amperage measurement and the information in Figures 2 and 3.

A few suggestions for lead-acid battery use…

1. Don't discharge a deep cycle battery greater than 80% of its capacity.

2. When you recharge it, use a rate between C/10 and C/20.

3. When you recharge it, fill it all the way up.

4. Keep the battery as close to room temperature as possible.

5. Use only distilled water to replenish lost electrolyte.

6. Size the battery pack with enough capacity to last between 4 to 21 days. This assures proper

rates of discharge.

7. Run an equalizing charge every 5 charges or every 3 months, whichever comes first.

8. Keep all batteries and their connections clean and corrision free.

More detailed information on all types of batteries and their usage in renewable energy systems is available in The Complete Battery Book (ISBN# 0-8306-0757-9) by Richard A. Perez. This book is available from your local library, your local bookseller, or from Electron Connection Ltd., POB 442, Medford, OR 97501 for $19.45 first class postpaid.

ENERMAX

Backwoods Solar

Like Lemmings to the Sea

an editorial by

J. Michael Mooney

ELECTRICAL POWER GENERATION IS DRAINING OUR RESOURCES AND POLLUTING OUR PLANET.

Gas and oil-fired generating plants are drinking up the materials we need as chemical building blocks, for transportation, and for heating our homes & offices. Fuels which will be depleted by the turn of the century, less than 11 years away.

Coal-fired plants are belching enormous amounts of pollutants into the earth's respiratory system - our atmosphere.

Nuclear powered plants pose the threat of meltdown, and are producing radioactive waste by the ton, waste which we cannot dispose of - or live with.

All are operated and regulated by organizations which pass along 100% of the costs for their blunders and waste to those whom they vow to serve.

It is we who absorb all of the costs and PCBs, bathe in and drink the acid rains, tiptoe around the poorly stored radioactive wastes, live in anticipation of the next Chernobyl, and continue to purchase the product.

WE PAY DEARLY FOR ELECTRICAL POWER PRODUCTION - THEN WASTE 67% OF IT.

We squander electrical power on resistive loads which convert it into heat.

Loads like incandescent lighting, when fluorescent lighting is eighty (80) percent more efficient. Loads like space and water heating, baking and clothes drying - all tasks which gases can do 50+ percent more efficiently.

We squander power by purchasing appliances on the basis of cheap initial cost, and without regard to operating costs. We give little, or no, thought to conservation - ignoring the devastating drain on our natural and financial resources.

THE AVERAGE U.S. HOME CONSUMES OVER 16-1/2 KWH OF ELECTRICAL POWER EACH DAY!

If we were to "turn on" to fluorescent lighting, pick and choose our appliances, use gas where gas is most efficient, and make just a modest effort to conserve, we could live in total comfort - consuming only 5-1/2 KWH per day.

TODAY'S "OFF THE SHELF" PV HARDWARE WILL CONVERT THE SUNLIGHT FALLING UPON A 12 X 16 FOOT AREA OF ANY U.S. ROOFTOP INTO A SILENT, RELIABLE, NON POLLUTING, STAND-ALONE, 5-1/2 KWH PER DAY ELECTRICAL SYSTEM WITH 5 DAYS AUTONOMY.

The use of efficient and appropriate appliances, coupled with solar energy, offers immediate relief to our electrical power problems and their associated environmental nightmares.

CQ HOME POWER HAMS

Windy Dankoff KE5HV
Bob-O Schultz KG6MM
& Brian Green N6HWY

Here's the HP skeds for hams:

Regional Home Power Nets (local times indicate local nets)
7.230 MHz on Sundays at 1330 Pacific.
3.900 MHz on Wednesday at 2000 Pacific and Eastern time).
14.290 MHz Sunday at 1900 UTC.

Novices
7.110 MHz on Wednesdays and Saturdays at 0500 UTC.
Regional nets will keep Local Standard time until Daylight Savings Time happens This Spring/Summer.

Solar Box Cookers

Barbara Kerr

The Solar Box Cooker is a design at this time focused almost entirely on home built, low cost, low skill cookers that can be pulled together from materials often available within the home in the U.S. or surely within the closest shopping center. Although they reach 275°F. to 300°F. in full sun, solar box cookers look deceptively simple when placed next to some of the other solar cooking equipment. Yet they can cook 10 to 15 pounds of food on a sunny day; on semicloudy days, they continue to function at reduced temperatures on as little as 15 minutes of sun per hour or equivalent partial cloud cover. They require minimal attention often not needing focussing for an entire cooking period. They have capacity for three or four pots which allows menus with the customary variety of meats, root vegetables, grains, breads or deserts to be prepared simultaneously.

Solar Box Cookers are large insulated boxes with one reflector. The heavy ones are resistant to wind and can stay "on their feet" in the face of gusts that topple the wind scoop designs. This is important in many places in the world. The light ones are very portable, weighing 10 to 20 pounds and handling like a large, light suitcase. They are regular box shapes when closed so they carry, stack, ship and store conveniently. There are three SBC oriented cook books.[1]

Dr. Robert Metcalf of California State University at Sacramento[2] has tirelessly demonstrated and talked about and gratefully used SBCs for the past 12 years. He probably has logged more miles and certainly made more contacts and given more SBC demonstrations than anyone in the world. As a volunteer he has put on solarques of wide ranging menus for 50 to 60 people at a time, repeatedly cooking for mass events. Professor Metcalf and Dave Ciochetti, one of his graduate microbiology students at CSUS, published the results of their scientific study of pasteurization by means of solar box cookers.[3] He, along with many other supporters, have joined together to form Solar Box Cookers International[4] because they believe this simple solar box concept will have multiple impacts on major global problems including making reforestation projects more successful, as well as providing safe food and safe water and freeing time and strength now devoted to gathering firewood and tending cooking fires. This assessment was reinforced by a recent special article in Christian Science Monitor.[5] As well as in the Official Magapaper of the Filipino-American Society of Architects and Engineers.[6]

Both the Deptartment of Energy and the State of Arizona have been given awards in recognition of the value of solar box cookers. The Department of Agriculture provided a grant that made possible a video on SBCs called "Four Square Feet of Sunshine," which is available for rent or purchase from SBCI. Fred Barrett of DOA-AID has been responsible for development of a device to be reused indefinitely that will tell if water has reached pasteurization temperatures, allowing water as well as food to be processed even if the "cook" is away from the SBC until after dark.

At least one very good-looking version of a solar box cooker using redwood, King-Lux reflectors and tempered plate glass is available commerically.[7] However, for the bulk of the people in need of solar cookers, sheet metal and tempered glass are out of reach. And local skills usually do not cover the sheet metal work needed for many other designs.

There are teaching models, kits, and light-weight SBCs available commerically, prepared out of corrugated cardboard. There are durable wooden versions of two designs. And there are plans for home building.[8]

The commerical field for SBCs appears to rather limited. Currently the major thrust is to use extremely low resources, mainly cardboard, non-toxic glue and paint, aluminum foil, single strength window glass, and silicon sealant. Even with these "non-durable" materials we have SBCs that have been in use for 10 years or more with only occasional maintenance.

The major field for this design is where resources for cooking are rapidly becoming either too scarce or too expensive for many people. Solar Box Cookers International has been very successful using one-day workshops to teach people with little or no building experience to make and use this form of solar cooker. They are being made of local materials in Guatamala, Bolivia, Nicaragua, Haiti, Honduras, Mexico, Djibouti, South Africa, Senegal and elsewhere. And they are teaching their neighbors and relatives how to make theirs. They are being made in the U.S. and Canada. It is gratifying to see that SBCs are beginning to interest volunteer organizations in this country who care for the poverty stricken and homeless.

Since it is very important if an organization is donating food to be sure it can be safely and inexpensively cooked, it fits into the guidelines for assiting people to help themselves and to learn techniques fostering renewed independence along with food relief.

In setting up workshops in an area, it is customary to work through a local private charity or non-commerical base organization; one familiar with the language and culture as well as stable in the area with local staff. In Bolivia it was Food for the Hungry and Pillsbury Company's Nutrition Project. In Guatamala it was Foster Parents International and Pillsbury Company. In Djibouti it was the UN-FAO and the Djibouti government. In Sierra Leone it will probably be DOA-AID. In other locations it has been church organizations and private individuals. The base volunteer organization provides a focal point for preworkshop publicity and acts as an on-going source of information. Sometimes it provides supplies a person cannot otherwise obtain. They also make local arrangements for

food and lodging and provide transportation and a counterpart (cultural representative and translator) for the workshop) for the workshop team.

The goal of SBCI and other solar box cookers advocates is that every adult in the world (almost) should know how to make their own SBC just as they know how to make a cooking fire if necessary. They are spreading this information as quickly as possible to help stop global environmental degradation. To this end, they have prepared many teaching tools and workshop materials so individuals can quickly prepare themselves to tell others effectively. Many menbers schedule SBC workshops into vaction plans thus combining travel, very intimate contact with people, and this good work into an exciting package. Training on giving workshops is given frequently by SBCI. As you may have guessed, they are always looking for new members and for donations to expand their work.

I am looking forward to the 7th Annual Tucson Solar Potluck next Spring. Circumstances permititng, I will surely be there to meet old and new friends. I will bring a few of these designs and some wonderful photos of them in use around the world. Be sure to let me know when it will be held. Barbara Kerr

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the Wizard Speaks…

A Further Look at Entropy

The present scientific concept of entropy is that the amount of energy available for doing work is continually decreasing. Another way of putting this is that the basic order (the relationship between elements) of the Universe is breaking down and the entire cosmos is headed for uniformity. This means all elements in the same energy state.

Consequently, there comes the statement that no process can be more than 100% efficient. That is, there exists no gain multiplier for work. However, look at another meaning of Entropy. Entropy is the measure of relative order in the Universe - the more order, the less entropy, the greater the work potential.

In the human system higher degrees of order are realized by that synthesis of knowledge and experience we call "information". Information delineates order inherent in experience. The more information we have, the more well defined this order becomes. By applying this information we create a more ordered, more well defined system that produces a greater potential for useful work.

For example consider a system in a state of order A. By using our internal information transformed into energy, we may change the state of order to B. If the amount of energy (internal information) that the system B produces over its lifetime is greater than the amount of energy necessary to transform it from A to B, then we have an anti-entropic system. The system here must be defined as including all external energy sources necessary to its functions.

The conclusion here is that ORDER =INFORMATION = ENERGY. Seen another way, order is the spacial matrix of a system, energy its temporal matrix and information is the operator allowing it to be changed.

Finally, we may use an analogy drawn from the equations of Special Relativity. Simply stated this equation states that the spacial aspect minus the temporal aspect of any continuum is invariant under transformation. In this case, it is stated as the order minus the energy of any system is invariant under transformation. If the order of our system is increased through use of the information operator then the energy also must be increased.

Ergo:

INFORMATION OPERATING ON ORDER YIELDS ENERGY.

Letters to Home Power
we print 'em unedited.

In Response to DC powered Washing Machines

DEAR HP,

12 VOLT WASHING MACHINE: In response to A.L.'s letter in #8, we offer a solution. We have produced an AUTOMATIC WASHER CONVERSION KIT since 1983, for both 12 and 24 volts. It adapts Kenmore and Whirlpool washers (only). 120 vac power is required to run the timer and controls, but the smallest available inverter (100 watt) can handle that. The big job of running the machine is handled by a high efficiency DC motor. This eliminates the need for a 2000 watt inverter, and uses much less energy too (average 25 amps at 12V). The kit is pre-wired and simple to install. A similar conversion is available for gas driers.

Thank you for being the finest source of user information in the field! We are proud to contribute articles to the cause.

Windy Dankoff, Flowlight Solar Power, Santa Cruz, NM.

(Washer Conversion Kit is listed in Flowlight's Catalog & Handbook -- See advertisement in this issue.) KP

And More on DC Washers

Dear Friends,

Thank you for the fine publication.

For the people who wonder about automatic washing machines I give my experience: In 1982 I installed a 15 year old Kenmore washer. Motor starting load was too much for the inverter I had at the time. I replaced the 1/3hp ac motor with a 32V DC 1/4 motor, the ac motor leads went to a relay & the relay points energizes the 32V motor. It takes 8 amps of 32V and a peanut size - 100 watt ac inverter to run the washing machine controls (it has an ac clock timer). This necessitates 2 cords but allows my battery bank to directly run the 1/4hp washer motor and the inverter need only run the controls. I've used the same system on a gas dryer with a 32V 1/4hp motor - double end shafts - and ac controls - relay to motor. Never change the brushes on the gas dryer. Change brushes once a year on the washer motor. I'm very happy with both machines.

Anyone with questions can write me.

Tim McDonald, McDonald Electric, 26823 Lake Riley Rd., Arlington, WA 98223

A Pat on the Back for the Folks at Trace Engineering!

Dear Home Power,

I just wanted to put in a quick note about the folks at Trace Engineering. We had a problem with our Trace 1512 and they handled it so graciously that I almost feel compelled to let all the other Home Power readers know what an incredibly fair and reasonable group of people Trace is comprised of. I never imagined that having a difficulty with a product would ever actually induce me to recommend it further or be somehow more content in my purchase of it. Well.... the way our problem with the 1512 was handled leaves me even MORE satisfied we chose a Trace.

With a whole lot of sincerity and thanks, John Mottl, Orcas, WA

It's not often that a Trace Inverter fails, but it's very good to know that Trace folks will fix'em fast. Of all the Trace inverters we've seen and sold over the years, we've only had one problem and it was fixed within three days of arriving at Trace. These folks a serious about service…RP

Proposed Alternative Energy Discussion Group in Waterloo, NY

Hi!

I'm just getting around to writing to you to say I love your magazine!! It has been an enormous help understanding how things work and how to pull a system together.

I have 7 acres of land and am 1200 ft. from the main road. The utility company wanted $4,000.00 to put poles in, which was not acceptable. We lived with no electricity (I have a 5 yr old son) and used kerosene lamps for lights and a cooler for refrigeration. We finally had the phone installed in January 1988 after hassling with the phone company over the $2,000 they wanted for that. They finally put the first 600 feet in free and I had to pay $1.00 per foot for the rest. A lot cheaper than the $2,000 they had originally quoted.

My house is only 18' x28' at this point, but I plan to add on to it sometime in the future. I had a building party after saving materials up for a year and have spent the last 4 years finishing it off and working on getting such luxuries such as electricity, etc.

I have a 4,000 watt generator that's hooked up to a 40 amp battery charger which charges 2 deep cycle golf cart batteries that I picked up used. I have 2 30 watt fluorescent lights, battery monitor and DC service panel purchased from Steve Willey, who has been quite helpful with any questions I had.

Anyway, we have electricity now and this could not have happened without the aid of your wonderful articles on how systems work and what all the components do. Keep up the good work!!

I hope to expand my system in the future and was glad to see by your survey that more and more people are becoming interested in alternate energy. I think that if people become aware of how something works and how important it is to find alternate routes of energy sources they will become more willing to invest in alternate energy.

I was wondering if you had any names of people in the Waterloo area who are interested in the same. It would be great to get together with others who feel the same and possibly form some kind of alternate energy group. That would be fantastic! I'd appreciate your cooperation in any way.

Thanks again for a wonderful magazine and I look forward to receiving the next issue.

Linda Ochs, 2400 Homestead Dr, Waterloo, NY 13165

Well, Linda, we've promised not to give out the names or address of Home Power readers to anyone. We can, however, print your letter and ask HP people to directly respond to you. We hare thinking about starting an ACCESS column in which readers can put their interests, names and addresses for contact and exchange with others. What do you think, Readers? RP.

Wind Machine Info Needed

Your magazine is great! I look forward to each issue. I have learned a lot from your articles and have gotten quick responses from your advertisers.

I am a do-it-yourselfer. I have assembled my own PV panel from surplus 4" square cells which I got at a Hamfest. I also built a wind generator from an old permanent magnet generator from a gasoline power plant originally 2500 watts. I carved a prop from a 10 ft. 2 x 6 and built an air brake like the one used on Windchargers. It works great. I have started building a second wind generator but

would like to build it so that it will automatically turn the the prop out of the wind when the wind speed reaches about 30 mph. instead of making an air brake. I have not been able to find any information on how this is done. If anyone could tell me how to do this or where to get information on how to do it I would appreciate it.

Also for those on a low budget or who like to build your own equipment who need a voltage regulator or load diverter. I found a circuit in November 1987 Modern Electronics originally for a 120 volt battery charger but a PV or wind generator or other source can be substituted in place of the battery charger. Instead of the relay the current to a second set of batteries or other load when the first set is fully charged. It has adjustable voltage range and the current it can handle is dependent on the relay you use. If you should build one note there is a mistake on the circuit board layout. There should be a circuit trace from the cathode of D1 to the cathode of D2.

Kevin Crawford, RD3 Box 381, Port Allegany, PA 16743

P.S. This was printed with alternate power.

Thanks for the info on the regulator. Any readers got a design for feathering a wind machine? RP

Home Power Afloat

I'm going to spread the word about your publication in our anchorage. At least a dozen wind generators here, photovoltaics are growing, but not efficient yet (size constraints). We also need support for alternative lifestyles. Bureaucrats believe boaters are either rich and should be ripped off or welfare cases to be run out of town. There's a large middle class afloat that needs information like yours RE: equipment and support from reading about other folks surviving on their own...

Milanne Rehor, Miami, FL

It's amazing how many salties read Home Power. I guess we landbound home power types have more in common with boaters than just a battery. RP.

Wind to Compressed Air to Electricity

Dear Home Power People:

This idea has been bugging me for a long time. Remember the old windmills that used to pump water? Slow but sure?

Why couldn't that same jack pump be used to compress air in a pressure tank? An automatic switch to start an air motor to run a generator at an easily governed speed, then stop when the pressure approached too low.

This could overcome the fact that the wind is variable. It looks like a simple and logical way to get some useful ac especially. It would be easy to rig a pump that would put out volume when pressure was low, or wind light, then put out higher pressure when conditions warranted.

I would sure like to have some younger person thinking and working on the idea. Is this worth printing, to get some feedback?

More power to you people, you make me feel good.

Sincerely, Cecil Paul, 6320 156th St NW, Gig Harbour, WA 98335

I've no direct experience with the water pumping windmills compressing air as you mention. I have seen these old water pumpers driving a car alternator via a large diameter (>2 feet) pulley. The old windmills put out a fair amount of power, but at very slow speeds. Their slow RPM usually limits them in electrical generation service. Your idea of compressing air may be able to use the slow speed of the windmill to great advantage. RP

Solar Energy Convention in Georgia

Dear Friends,

Thanks to you - Our free Solar Energy Convention in Georgia was the beginning of Great events to come.

The day of the convention finally arrived, there was a cloudless sky, the sunlight poured in. According to the sun dial it was high noon. Time for the convention to start. What could be more appropriate than to start a Solar Energy Convention at high noon?

Our AE guests, the Mieselers from Wheeler, WI, had arrived several hours before high noon. Since no local people has showed at high noon yet, Leon Mieseler, after driving 1,742 miles just said, "That's okay, if nobody else comes, that means more time for you to learn Pete".

We did not burn any daylight wastefully. Leon taught me about resistance, diodes on my welding generator, deep cycle batteries, solar hot water panels, size of wiring for our "to be" AE earthhouse, series, parallel, PV panels, batteries, also inverters and more.

Sometime later our friends came by in ones, twos and threes. We were ready so 75 people could be seated. The presentation table was 32 ft. by 3 1/2 ft. We borrowed a school blackboard. We had info from ARCO, Heart Interface, Heliotrope General, Hydro Cap Corp., Trace Engineering, 12 Volt Products and Zomeworks. We had a program, handwritten by my wife Martha. We were READY. Eleven local people came. I must remember that Giant Oaks start as acorns. I think a lot of people were not finished with their holiday preparations. The convention was the weekend before Christmas. We had the convention then as December 22 is the Winter Solstice. Again an appropriate time for a Solar Energy Convention.

I think it real important for us, in our daily lives to quietly tell our co-workers, our newspaper editors, our president, how living and producing by AE really is.

I thank all the people who sent us info. I really thank our new friends Leon, Jan, Aaron and Daniel Mieseler for driving 1,742 miles, ONE WAY, just for us! Thank you too Home Power Crew for such a tremendous publication.

Sincerely Pete and Martha Sipp, Rt3 Box 484, Hephzibah, GA 30815

I think that maybe everything worth having in this life starts out as a dream, a wish within our imaginations. Dreams grow slowly; they need to be nourished into realization by perserverence. Home Power Magazine started as a dream two years ago. It took us eight months of disappointments and hard work to make the dream real. I won't tell you how many times I gave it all up in despair. But we (especially my loving friend Karen, who inhales adversity & exhales courage) hung in there. You are holding the proof that dreams can be made real in your hands now. Solar energy is such a dream. Each one of us who dreams it brings it closer to reality for us all… RP.

Q&A

We try our best to answer all your questions. Please remember that we are limited by our own experiences. If we don't have the direct personal experience to answer your question, we won't. We'll print the question anyway and hope that a Home Power Reader will have the experience to answer it. So this column is not only for questions , but also for answers from readers. Thanks for your patience-- Richard

---

On Kerosene Refrigerators…

Thanks for the great magazine!

Thanks also to those who gave me info on 12VDC color TVs & water pumps. In response to David St. John's request for info on Kerosene refrigerators and carb. kits for generators: Lehman Hardware and Appliances, Inc. has a catalog which offers two models of kerosene refrigerators and carb. kits for generators: their address is Box 41, Kidron, OH 44636, Ph: 216/857-5441. The catalog has a wide variety of non-electric items.

Garretson Equipment Co., Inc., Box 111, Mt. Pleasant, Iowa 52641, Ph: 319/385-2203 has carb. conversion kits for generators.

I'm also interested in small scale production of farm methane gas. Anyone experimenting with this? Thanks again, Lisa Reynolds, Pearson, WI 54462

See Art Krenzel's article in HP8. He's into gassification. RP

and again…

In answer to David St. John's inquiry in issue #7. We have a Dometic Kerosene refrigerator we purchased from Lehman Hardware, Box 41, Kidron, OH 44636. They have been a most helpful and courteous establishment to deal with and supply a variety of products useful in a back-to-the-land life styles as they cater to a large Amish community. They also publish a catalog.

Clearly it is ecologically superior to utilize solar, wind and water to satisfy one's personal power needs. This is followed in ecological acceptability by more slowly renewable resources such as wood and agricultural waste. It is less acceptable in terms of long term consequences to the planet to use fossil fuels such as kerosene but I feel we need to remain open to the wide range of possibilities. For us the use of a kerosene refrigerator and lamps enabled us to disconnect from the power grid eight years ago with virtually no complications and at an investment we could afford THEN! We have decreased our overall power consumption, learned to live lightly, bought time to really think through the sort of system we ultimately want and saved the bucks that will make it a reality. Our utilities average $110.00 per year - two 55 gallon drums of kerosene. My guess is it would have taken more fossil fuel per year to supply our needs had we remained hooked to the grid.

Our system has been quite durable and utilitarian, requiring little maintenance (10 minutes 3 or so times a week). We have a freezer compartment in the refrigerator which is handy. We fill the refrigerator once a week and occasionally need to adjust the flame height when the outdoor temperature varies. Most maintenance time is spent filling the lamps.

I'd be the first to admit that the use of such a system is much less than ideal because of it's dependence on fossil fuels. I'm not happy about that - at times I feel very guilty. But then few folks are "pure" - few forego cars powered by fossil fuel, sometimes recycling gets neglected, whatever. The truth is that moving to a more ecologically sound lifestyle is demanding of a family's time and energies - part of the quest is coming up with ways to make the process work. (Often it seems my critics are folks who are still "back to the land dreamers" sitting in their all electric suburban homes surrounded by old issues of "MOTHER EARTH NEWS" telling me to shape up.")

It seems that our system maybe as acceptable as one that utilizes a fossil fuel generator, a system of recharging batteries with a car or whatever. As I understand energy transfer, each time energy is changed from one form to another a significant energy loss is incurred. If one employs fossil fuels it seems more efficient to use them directly for the desired purpose.

And, as I said before, our system is temporary. Come spring we start our new home, planned around renewable energy sources. Ultimately it will evolve solar, wind and wood in the form of both a wood stove and a sterling engine which will supply electricity, hot water, household heating and energy for cooking at various times.

So to David - do what works for you. You'll learn as you work with your system. You'll figure out what you want. If you can start with renewable energy alternatives do it. After all we're all in this because, at some level, we want to care for this beautiful planet. But if you can't do everything in an ideal way from day one that's OK too. Take it from someone who's been there and fielded criticism - it's better to start, however imperfectly, than never to venture at all. Linda Rogers, Frankfort, OH

I totally agree, and apologize for suggesting that the high dollar solution of electric refrigeration is the ONLY way to go. To tell the truth, Karen and I are still using an ice box and dreaming of a Sun Frost. If there's one thing we've learned from back country living it's making do with what we have. Thanks for reminding me and sorry that you needed to do it… RP

Jacobs Wind Machine Conversion from 32 to 24 VDC

I am writing in regards to Jake Biondo's letter in "Q's & A's" in HP#7. As far as running his 32 volt Jacobs at 24 volts, he'll have no problems, provided he does not go over his rated current. The batteries will more or less "clamp" the generator output voltage at whatever the battery voltage is at. Generator voltage is dependent upon rotor RPM's, which is dependent upon wind speed. You can extract a given wattage from a given wind speed, that wattage being dependent upon the swept area of the rotor and the rotors efficiency. If the rotor diameter remains constant, you can extract more amps from a given wind if you lower the voltage. If you raise the voltage, the current will go down. Remember, watts = volts x amps. The constants in Jake's case are rotor diameter and rated current. Because the batteries are at 24 volts, the generator will obviously begin delivering current to the batteries at a lower wind speed. Conversely, the generator will peak out at a lower wind speed, again because the working voltage is lower. Jake's 2kw Jacobs is designed to produce about 50 amps maximum and generally runs in the 30 to 40 amp range. Because Jake will be running his Jacobs at only 24 volts, or about 2/3's of its rated voltage, he can only expect 2/3's of the wattage, or about 1400 watts, out of his system at its rated current. A 2kw Jacobs is designed to peak out in about a 21 mph wind. At Jake's site, which he says averages 14 to 16 mph, his Jacobs should be running at pretty near full output, current wise, most of the time if he runs it at 24 volts.

Mick Sagrillo, Lake Michigan Wind & Sun, 3971 E. Bluebird Rd., Forestville, WI 54213

Propane Powered Portable Soldering Iron

Re: Letter from G.L. Brown on pg. 42 of Aug/Sept issue.

A better bet for soldering is a portable propane fueled iron made by Portasal, 1077 E. Edna Place, POB 1678, Covina, CA 91722. It's

fueled from standard cig. lighter capsules and has a built-in light in the cap. Overall size is 20% larger than the old "Parker" fountain pen of the 30's & 40's.

The figure of 90-98% efficiency (Kiszeta letter, pg 39) for inverter ballasts is hard to believe. The usual 1 transistor blocking oscillator circuits are more like 30-40%. I would certainly like to get in touch with the IOTA Company he refers to. I haven't been able to reach him for info. Sincerely, Harold May, Hinsdale, IL

I'd like to second this recommendation. I've one of these propane soldering irons, given to me by Bob-O Schultze, and it works very well indeed.

Inverter ballasts for fluorescents are actually reaching greater than 90% efficiency. This is not due to any radical new design, but to the wonder of the MOSFET switching transistors. The MOSFETs (Metallic Oxide Semiconductor Field Effect Transistors) waste only miniscule amounts of the energy they transfer (ON resistances are <.02Ω). These jewels are also responsible for the efficiency inverters and PV controllers now on the market. RP.

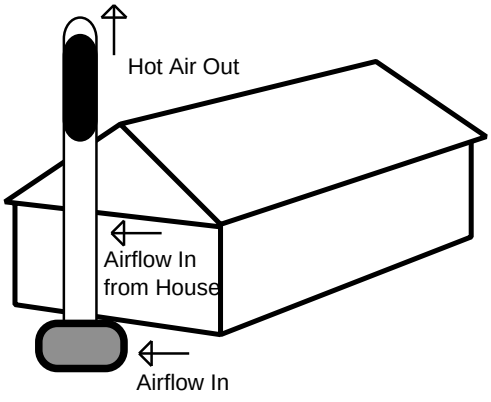
Using Heat to get Cool!

I'm writing in response to a question from a reader, Judy McVey of Atlanta, GA.

After some thought about air conditioning I realized we are trying to "dump energy". Heat is a form of energy, why not use it to help remove itself. Heat rises in a chimney-let's put a chimney around a stack of radiators or cooling coils and let the heat we are "dumping" provide the draft to keep the bottom set of coils cooled. To help induce a draft the top of the chimney could be painted black. Grass or shrubs in the area of the base of the chimney could help keep incoming air cooler. Remember a forest is 10° cooler due to the shading and evaporation than an open field.

Would the looks be objectionable? Many homes have wood stoves with sheetmetal flue pipes sticking out and this has been accepted by society.

My best recommendation is good ceiling insulation and a ridge vent. A ridge vent alone cut my cooling cost in half! Also keeps the



insulation dry all year. Shade the south and west sides well and I've seen 12V ceiling fans.

Sorry, I don't know of any gas powered air conditioners. Oh, one last idea-paint the roof white. Thanks for the great magazine. Randy Huatel

The Wiz and I have been working on a home heating and cooling system driven by solar heated air. The heat portion of the system is obvious. The cooling system design uses the expansion of heated air to PULL outside air through an evaporative cooler and into the house. While all our work is still on paper, initial mathematical estimates indicate that a solar heated face can effectively cool a well insulated area to less than 20°F. below ambient temperature in low humidity environments. RP

Electric Vehicles

Keep up the good work. I find Home Power very informative.

Does staff or any of your readers know of a source of supply for an adaptor plate for attaching an electric motor to a VW transaxle?

Also appreciate any comments regarding sources for other components, such as motor, controller, etc. Ross Wagner, Erie, MI

Get in touch with Michael Hackleman, his address is in his electric vehicle article in this issue. He knows sources for EV parts and conversions. RP

Gas Powered Refrigeration

Two questions: (1) I also am interested in converting a small gasoline generator to propane. (See letter from David St. John in issue #7)

Perhaps some of your readers will have answers to that question.

(2) We want to convert a natural gas Servel refrigerator to propane and would appreciate whatever information your other readers may have on this subject. The nameplate data are as follows: B11486-G, 4244765, Type C burner.

Home Power is excellent, but I was disappointed in the non-answer given to St. John's very valid concern. Best wishes for Home Powers' success. 73's Nash Williams, Bonsall, CA

You're not the only one who thought it was a non-answer (we did too after a few good nights sleep, sorry we messed up). Another source is Mr. James Clayton, 13417 Tutelo Rd., Apple Valley, CA 92308-6462, 800-999-5909 wrote to say he sells conversion kits (natural gas, propane, & butane) for small engines. Send the name of the manufacturer, model number, serial number, fuel type needed, & a check for $5 for literature and a price quotation. Mr. Clayton also says that Natural Gas Sibir Refrigerators are easily converted to propane. KP

Ampere-hour Metering

Thanks for the great information.

In the story about your place in HP#7 you mention that George Patterson helped you install a cumulative ampere-hour meter. Do you have information on where I could get or make such a meter. Perhaps for both incoming and outgoing amps.

Also in your articles on equalizing batteries so voltage in the individual cells don't differ by more than .05 VDC. How do you measure the voltage of an individual cell?

Thanks Much, Doug Patrick, Trapper Creek, AK

First on the Ampere-hour meter: we were using an experimental lash up of some very versatile and expensive gear (all on loan I might add). This setup, while it works, contains >$2K worth of hardware. Amperage measurement is via a shunt and a 5 1/2 digit digital voltmeter (a Hewlett Packard 3468A) that talks to a Hewlett Packard 71B handheld computer. The program for the computer was written by George in Basic. This setup gave us a start on designing a dedicated Ampere-hour meter. We are currently working on a new Amp-hr. meter using the Motorola 68HC11A8 microprocessor. This single chip computer is optimized for data acquisition and process control. It contains eight channels of A/D conversion directly accessible to the microprocessor. George and

the Wiz have already written the necessary code in 68HC11A8 assembly language. George is now experimenting with teaching the microprocessor to communicate with a 2 line, 32 character smart LCD display. Our eventual goal is the production of a cumulative Ampere-hour (and Watt-hour) meter that is software programmable to fit just about any system. It will be micropowered (<1 Watt) by the system it is measuring and cost less than $200. We'll be marketing this device through Home Power and will publish all technical info for those wanting to build their own.

On measuring the voltage of individual lead-acid cells: this is possible if the connecting straps or wiring between the cells is accessible. For example, the Trojan L-16Ws have external connecting straps between the cells, while in the ordinary car type battery, the intercell connections are concealed beneath the case. The process is simple, IF you can get at the intercell connections. Use a good Digital VoltMeter (DVM), like the Fluke 77, with accuracy down to ±0.002 VDC. RP

Inverters: Sine Wave vs. Quasi Sine Wave

In your "Things That Work" article on the Heliotrope inverter, you neglected to mention whether the wave form was square, pure sinusoidal or the so-called quasi-sine. This is important to us who have quality stereo systems since square and quasi-sine inverters will frequently cause a buzz in the systems. Also, be advised that for every 12 and 24 volt system (out "there") there are probably just as many 32, 36, and 120 volt (DC) systems. Don't go neglecting us folks by over emphasizing 12 volt systems. I for one have both 12 and 32 volts available from my wind system. I keep the 12 volt bank charged directly from the 32 volt bank via a Newport Marine (Newmar) high efficiency "pulse" type 32 volt-12 volt direct converter. When I expand my system to include PV, my first low budget purchase will be to charge the 12 volt bank right off the first PV panel. As I expand with more panels I intend to augment the wind generator output with series 32 volt (feeding 32 volt battery bank) arrays, as well as more parallel 12 volt panels. Right now I produce 60% of my domestic power 9 months out of the year with a Whirlwind Power Company 4kw unit and a 3kw Heart Interface (new style, not the old Darlington unit) inverter. The rest, unfortunately comes off of Minnesota Power and Light Co.'s Coal, but that too will change when I start getting into solar. You have a really GREAT magazine here. Keep up the good work. Thanks, Tony J., Duluth, MN

The Heliotrope produces what is known in the industry as a "modified sine wave". Actually this waveform is closer to a modified square wave than a modified sine wave. This is what happens when you let ad people write the copy instead of engineers… You are correct, the "modified sine wave" inverters will buzz out the audio and video of many types of electronics. This is not the fault of the inverter, but due to incompatibility between the inverter's power and the device under power. The manufacturer of the device intended the power supply to be sinusoidal and didn't include the additional filtration necessary for quiet operation via "modified sine wave" power. Most electronics techies can add additional capacitive filtration to the device's power supply. This, in most cases, makes the device operate quietly from an inverter.

We don't mean to leave folks with DC system voltages above 12 out of our info. The fact is that most of the systems we sell and install are 12 Volts, as is our personal system. We only write about what we personally know and have experience with. If you folks with 24 VDC and higher systems want to contribute your info, then please do so. RP

Disposal and/or Recycling Spent Batteries

What is the proper disposal/recycling method for spent household batteries? Don Seeberger, Minneapolis, MN

We'll have to ask our readers for info about proper disposal of non-rechargeable batteries. We personally have avoided this problem by moving sideways. We use rechargeable ni-cads to power up the flashlights, etc., then there isn't anything to dispose of. From my knowledge of battery chemistry, there are a number of potentially nasty materials employed in a non-rechargeable battery. These batteries use a variety of chemical technologies: zinc/carbon with an ammonium chloride & zinc chloride electrolyte (regular flashlight batteries), zinc/manganese dioxide with a potassium hydroxide electrolyte (alkaline cells), and other lithium/silver/mercury based battery technologies. Electrochemical batteries work by the intense chemical activity of their materials. As such, they represent a potential hazard to all living things. Electrolytes used in batteries are always either corrosive (chemically basic in nature), or acidic (chemically acid in nature). Electrolytes can cause acid or caustic burns. RP

Sun Frost Info, Water Tanks & Paloma Demand Water Heaters

Excellent magazine. I am another "off the grid" enthusiast. My system consists of four PV panels, 2 big Trojan six volt batteries in series, a Sun Frost 12 cu ft. refrigerator. As the days shorten, I have less power to spend so one thing I have done is to set the thermostat on the refrigerator down to about 65°F. This turns the freezer compartment into a refrigerator and the lower refrigerator section becomes only moderately cool. It is hard to control the temperature of the freezer though. The temperature monitor must be in the refrigerator section, and that is OK. I find the Sun Frost to be a good unit. But one improvement would be to have it work so that only one compartment is used when desirable without having to have two independent compressors.

There has been some talk of the virtues of plastic water tanks. I am open to that. Then the precast concrete water tanks were suggested. That is better, but what I would like to suggest is the ferro-cement water tank. I have built a few of these from five to twenty thousand gallons in size. These are much bigger than the kind that a truck can deliver and be put anywhere, not just next to the road. You can build these yourself too, inexpensively. You will not want to bury these. More likely you will place the tank on the highest point of your property so you have gravity flow to anywhere.

The 5000 gallon tank is a good size and it has the advantage of not needing a building permit according to the Uniform Building Codes. I have designed, built and tested a simple, easy to build 5000 gallon tank and anybody interested should write me at the address given at the end of this letter.

People generally think you must have a well drilled. I collect rainwater. Totally passively a wet year will fill your tank to the brim. On a dry year maybe only half full. But that can be enough if you use it wisely.

But I need help on something. I live not too far downhill from the tank so my water pressure at that point is not very high. I am about 12 feet lower than the tank water surface. If we figure about 2.4 feet of head equals 1 psi, I have about 5 psi of pressure. I am just finishing a batch type solar hot water heater, but as a backup I installed a Paloma propane fired on-demand hot water heater, only to find that it would not go on no matter what I did. The unit is supposed to work down to 4 psi according to the manufacturers, which is why I bought it. The problem is my own. Some pressure is lost in the lines. Somebody probably knows how to adjust the unit (a Ph 6) so that it will work at the low pressure or how it could be operated manually on or off as needed. Any ideas? TimoThy Traquair, POB 862, Glen Ellen, CA 95442

The Sun Frost does indeed have a single thermostatic sensor and it is located in the refrigerator section of the unit. We tested the Sun

Frost RF12 in "Things that Work!" HP5, pg 33. This refrigerator/ freezer can be powered by two PV panels in most locations (and most certainly anywhere in CA). Consider adding another panel or two and turning your Sun Frost's thermostat down 38°F. Think ice cream in July… As to the pressure problem on the water heater, how about it Paloma users? RP.

Kodak Projector Unhappy on Inverter Power

I have 4 ARCO M55 panels, HF-1200X2 inverter, 4@6VDC 220 amp Hour batteries, SCI charge controller. My Kodak slide projector burns out its fuse link after 1 hours operation. Runs OK on generator or power company current, for hours. The inverter has been checked. All other TV, audio (including 120vac turntable) etc., work fine. What's the problem? HELP!! I love Home Power, you are doing a great. W.E.S., Sanger, TX

See Tony J's. of Duluth, MN, letter above. When Kodak designed your projector they were planning on sinusoidal power input. I'm not familiar enough with projectors to know what type of power supplies are built into the unit. I suspect that the power supply in the projector can be modified by a technician for inverter operation. Consult with Kodak & your local techie. Meanwhile, how about it readers?

Techno Notes:

Many of you have asked about the computer equipment and software we use to make this magazine. Home Power is published on two full time Apple Macintosh™ computers, with occasional assistance from a third. Our main machine is a Mac SE with 1 MB RAM and a 20 MB hard disk. We also use an ancient Mac (originally bought in '83 with 128 KB RAM) with 512 KB RAM, and two floppies. The smaller Mac did the first four issues of HP, but is now used mostly for article entry & subs entry. We manage our subscriber's database (now over 1.8 MB) on the SE. We use an ImagewriterI dot matrix, impact printer for proofs and mailing labels. As we can't afford our own laser printer yet, we rent a LaserWriter IINTX for printing the Home Power Issue Masters. Our only casual acquaintance with the laser printer accounts for some of the layout vagaries and graphical misadventures you surely have spotted within our pages.

We use a variety of word processors: WriteNow, Microsoft Word, and MacWrite. Our graphics programs include: SuperPaint, MacDraw and MacPaint. We maintain our subscriber's database on ReflexPlus. Page layout is accomplished on Ready, Set, Go 4.0. The spreadsheet tables, graphs and charts you see in Home Power are done on Microsoft Excel 1.5.

We owe a great debt to the folks at Apple Computer. Without their marvelous machines we wouldn't stand a rat's ass of a chance producing this magazine on the budget we have.

We, like most nerds, are only to happy to share our computing experiences with anyone interested. If you want more info, then drop us a line.RP

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HEART 2500 WATT CASCADABLE INVERTER, 24 volt input, excellent condition, $800, plus shipping. James Crewdson, P.O. Box 870278, Wasilla, AK 99687, (907) 373-3803

COLORADO MOUNTAIN COLLEGE

Here's at post card Home Power received from our friend Steve McCarney. Steve is an instructor at Colorado Mountain College's wonderful Solar program (write: CMC, 3000 County Road 114, Glenwood Springs, CO 81601 or call 303-945-7481) .

Greetings from the Altiplano of the Andes,
Down here (up here at 13,000 feet above sea level) home power means a whole different thing. Most have no electricity and many still cook traditionally over fires fueled with dung or whatever. Bottled gas is a luxury. So you can imagine the interest when a gringo arrives with PVs. Have just installed PV vaccine refrigerators (SunFrost) in three North Chile health centers. Also setup some solar powered insolometers in Bolivia and did a little maintenance & trouble shooting of a home PV in Peru (TV, radio, lights) while preparing a Flowlight pump installation.

Power to All,
Steve McCarney

Sunnyside Solar's PV home electric system seminars and workshop is a one day program that provides a good introduction to independent SOLAR ELECTRIC SYSTEMS and hands-on experience in assembling a small four module system. Dates for 1989 include 18 Mar, 22 Apr, 3 Jun, 15 Jul, 26 Aug, 23 Sep, and 28 Oct. Included in the day's program is lunch, a packet of product information, related articles and Komp & Davidson's "The New Solar Electric Home". Program fee is $85 per person, but if you come with a friend and share the course materials, then the second person's fee is $60. Advance registrations only with $25 deposit to secure a place in the 8 person seminar.

For further info contact:
Carol Levin, SUNNYSIDE SOLAR, RD4 Box 808, Green River Road, West Brattleboro, VT 05301
802-257-1482

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...And that's when I told Cookie, "Absolutely no more beans for breakfast."

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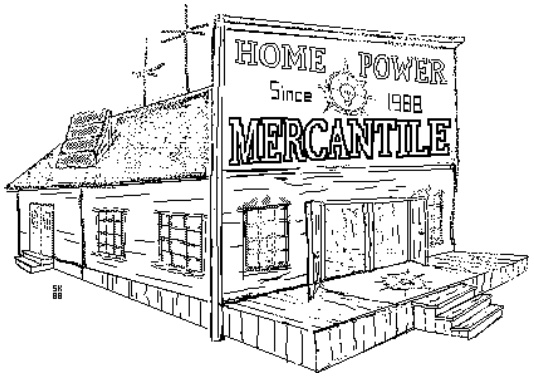

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