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HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #37
October / November1993
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Features

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RE Systems

Fundamentals

Cover: A homemade thirteen foot water wheel produces 2000 watts of power. Photo by Richard Perez

Homebrew

Columns

Regulars

Access and Info

Access Data

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Recyclable Paper

Who owns the sun?

Richard Perez

Energy is an essential element of modern life. Ever since the industrial revolution, our energy consumption and dependence has skyrocketed. Budding industrialists clearly saw our future use of energy at the close of the 19th century. These early energy pioneers bought, controlled, and distributed the then known sources of energy — coal, oil, and natural gas. The descendants of these early energy entrepreneurs are our modern energy businesses — electric utilities, oil companies, and natural gas companies.

Energy as a commodity

Energy companies sell us their product. Who among us does not pay an electric bill, or a gas bill, or pay the gas station for fuel for a car? It has been this way since the early days when these companies cornered the then difficult to access, process, and distribute energy sources. Oil, coal, and natural gas are, and always have been, commodities to be bought and sold. And in the business of owning and selling energy, energy companies have been very successful.

In 1963, I first heard that electric power could be made directly from sunlight — photovoltaics. The real implications of the photovoltaic module didn't dawn on me for over twenty years. Here is an energy source that is free to access, already processed, and delivered daily everywhere to everyone. Sunlight is freely offered to us all rather than hidden in holes in the ground which can be owned and controlled. PVs convert sunlight directly into electricity in a single silent step. Contrast this with an oil refinery, coal mine, or natural gas plant.

Photovoltaics are the first widely applicable electric power source which is not a commodity. Solar energy is the first power source that can break the energy companies' monopoly on power. While this revolutionary aspect of solar power remains unrealized by most of us, energy-selling companies were quick to see sunshine's impact on their businesses. Just as the early energy pioneers saw our coming dependence on oil, coal, and gas, modern energy companies see our future dependence on solar energy.

Utilities, both public and private, are now planning on selling solar energy to their ratepayers. The specific scenarios vary from large utility scale solar power plants, to distributed production with PVs on everybody's roof, to utility leasing of PV systems to off-grid homes. In common to all scenarios is that the utility sells us the solar power — we don't own it.

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Bob-O Schultze
Michael Welch
John Wiles
LeRoy Wolins

" Think about it…"

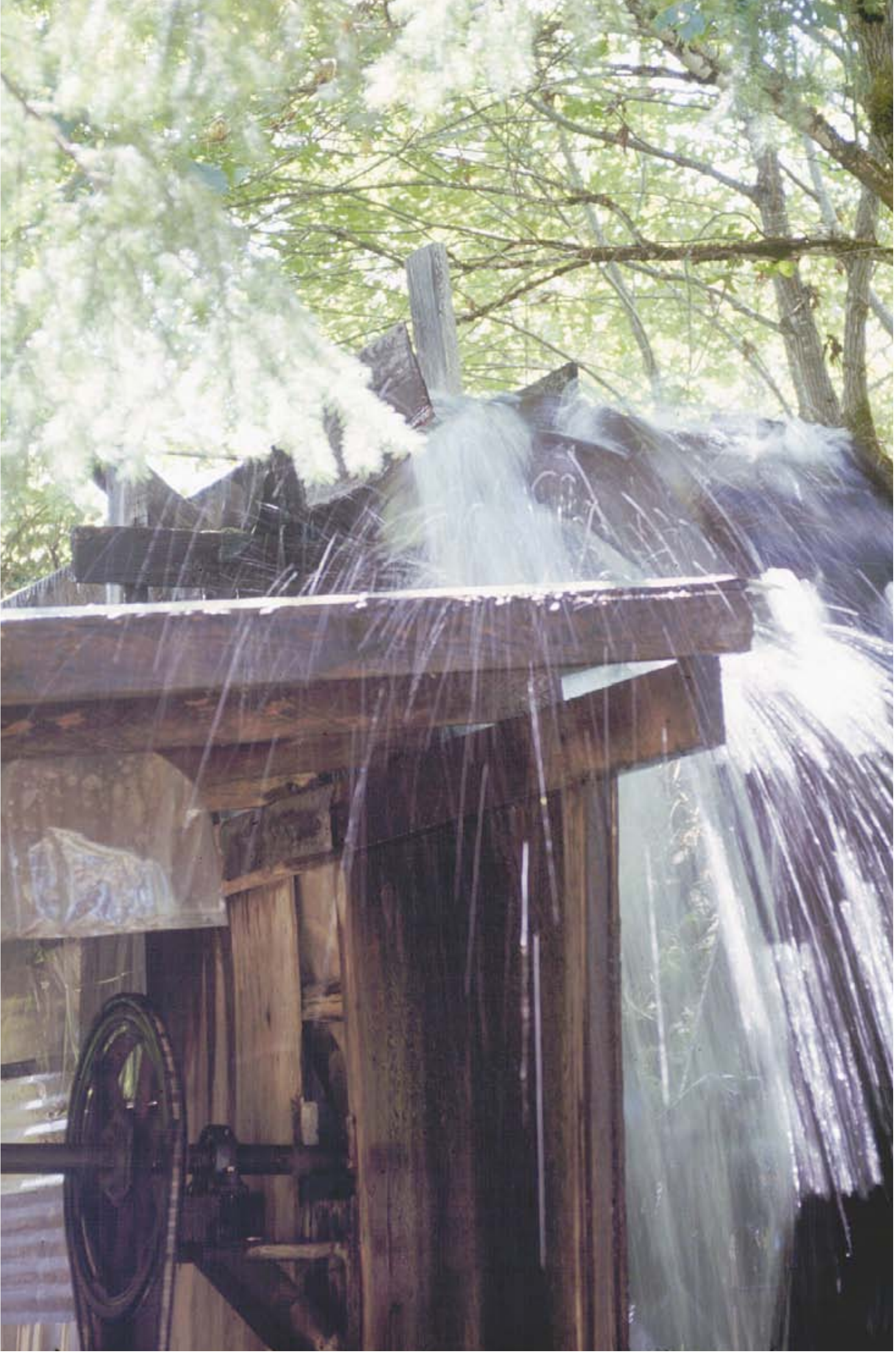
Let us hope that the sun, even though captured, will be free to the peoples of the world.

G. Don Graham

(sent by Jack Thompson)

SOLEC
camera ready on negative
full page
bleed top, right, & bottom

PAGE 5



Above: A thirteen foot diameter overshot hydro wheel makes 2,000 watts of electric power. Photo by Richard Perez

Handmade Hydro Homestead

Bob-O Schultze

In 1975, Matt and Roseanne Olson's diesel generator died. Faced with an expensive repair, Matt figured this was as good a time as any to build the hydroplant which he'd been collecting parts for over the past four years. With the help of his good neighbor and friend, Rod Ward, he set to work building a temporary fix for his generator problems. Eighteen years later, that "temporary" fix is still producing clean, renewable electricity. The old diesel plant has long since been traded for spare parts.

Location is Everything

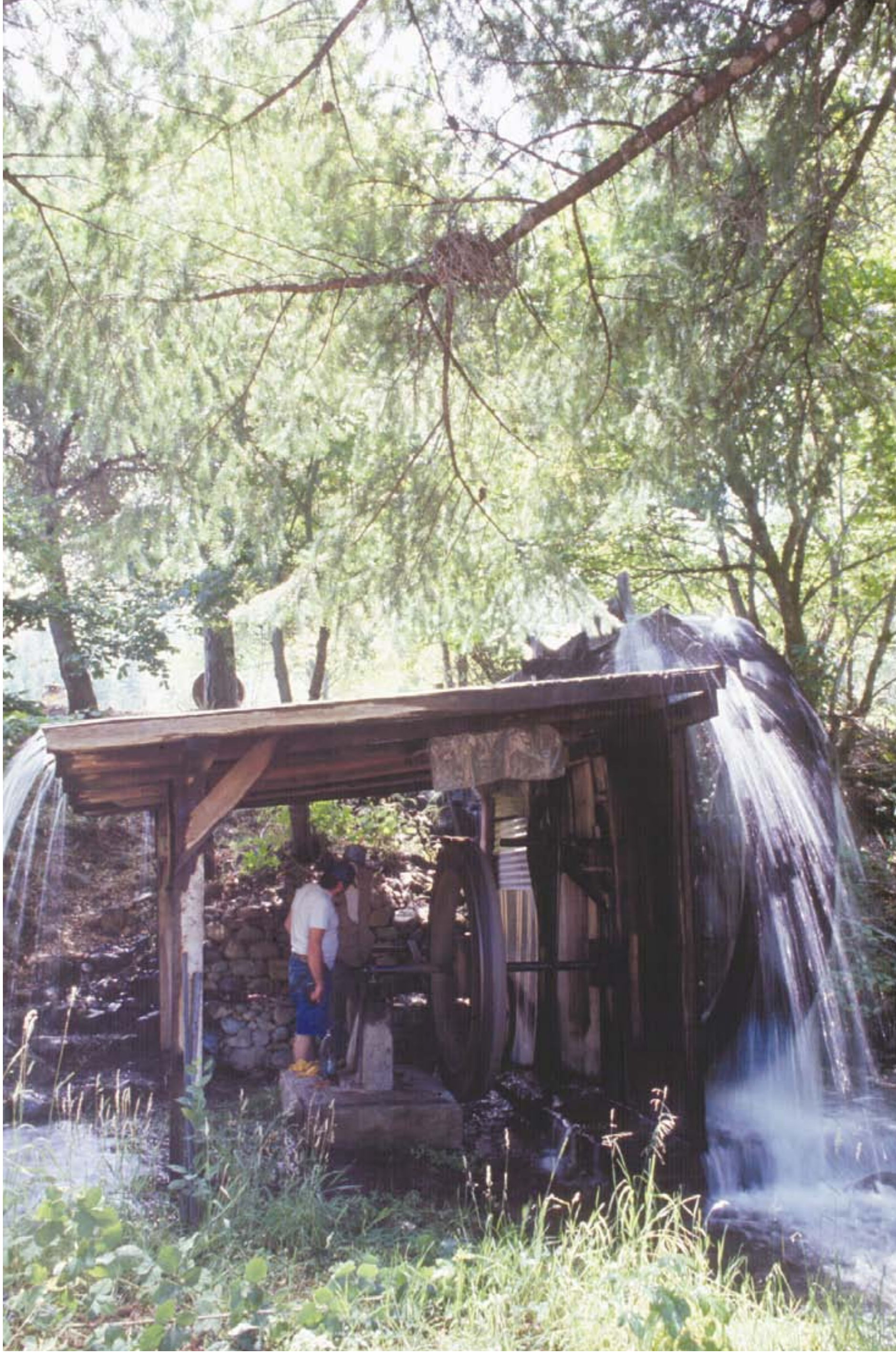
Matt and Rosie live at the confluence of Methodist Creek and the Salmon River in Northern California. Their homesite lies in the western part of the Klamath National Forest. This river corridor is still very scenic and colorful, despite placer mining before and during the 1930s, the ravages of two major fires, and extensive road building and timber cutting by the Forest Service over the past 30 years. The beauty of the Salmon River Country is due in no small part to reclamation by folks like the Olsons and small-scale miners along the river who have adopted an attitude of stewardship and living with the land rather than from it.

This country is a dandy place for low-impact microhydro because of the many creeks and springs which feed the Salmon River. The nearest electric utility lines are 23 miles away through one of the steepest, most picturesque river canyons in California. Even if the locals wanted utility power — which they don't — and even if the utility was willing to provide it — which *they* aren't — the cost and visual impact to the area would be prohibitive. So it's a case of using what Mother Nature provides on-site and learning to live on her terms. Not a bad philosophy for all of us.

It's the Water

It takes a fair amount of water to run an overshot wheel. Matt & Rosie's hydro and irrigation water comes from a recycled mining ditch which flows along the back edge of their property. A weir, that is, an adjustable gate, at the intake from Methodist Creek determines the flow into the main ditch which feeds the ram pump, flood irrigation check ditches, and, finally, the overshot wheel itself. This weir restriction serves two functions. First, it keeps out the anadromous fish which use Methodist Creek as a spawning ground. The existence of large redds, or spawning beds, at and above the intake attest to its low impact. Second, the weir limits the flow of water into the ditch during high water periods which would cause erosion of the ditch banks and overspeeding of the wheel.

All along the ditch, trees, bushes, and a giant thicket of blackberry vines drink their share of the water. How much do they take? "About 500 watts/hour worth during a hot summer's afternoon," according to Matt who can watch the power drop as the temperature climbs. "The plants, grass, and especially Rosie's flower garden come first where the water is concerned," said Matt. "In low water years we may have to shut the wheel down for up to three months because they get priority." After the water leaves the wheel, it flows down through an overgrown mining tailrace and into the Salmon River, none the worse for wear.



Above: Bob-O Schultze (left) and Matt Olson (right) examine the power transmission for the hydro. Photo by Richard Perez

Recycle, Reuse, Rebuild

Nearly every part of Matt & Rosie's hydroplant has been reincarnated after dying as something else. The hub and main shaft of the 13 foot diameter overshot were part of a 24 inch Pelton wheel with the cups removed. The one inch steel rods radiating from the hub came from a scrap metal pile. The floor of the buckets and the 18 inch x 12 inch deep buckets themselves were painstakingly cut from an old dump truck body and individually welded into place. Most of the pulleys, sprockets, and jack shafts for the speed multiplier gear train were bartered or scrounged from deceased mining and farming machinery. About the only things purchased new were the bearings for the main and jack shafts and the V belts. In 1975, those items cost approximately $250. To replace them all at today's prices would run about $550.

The 1800 rpm 2.6 kiloWatt Kurz-Root ac generator came out of a 1940s military portable GenSet. Matt replaces the brushes about twice yearly and trues the commutator and slip rings every couple of years. He tells a great story about filling a missing commutator insulator with JB Weld™, which turns out to be nonconductive, and turning it down on a lathe. "That was over a year ago, and the dang thing still runs great."

The Hydroplant

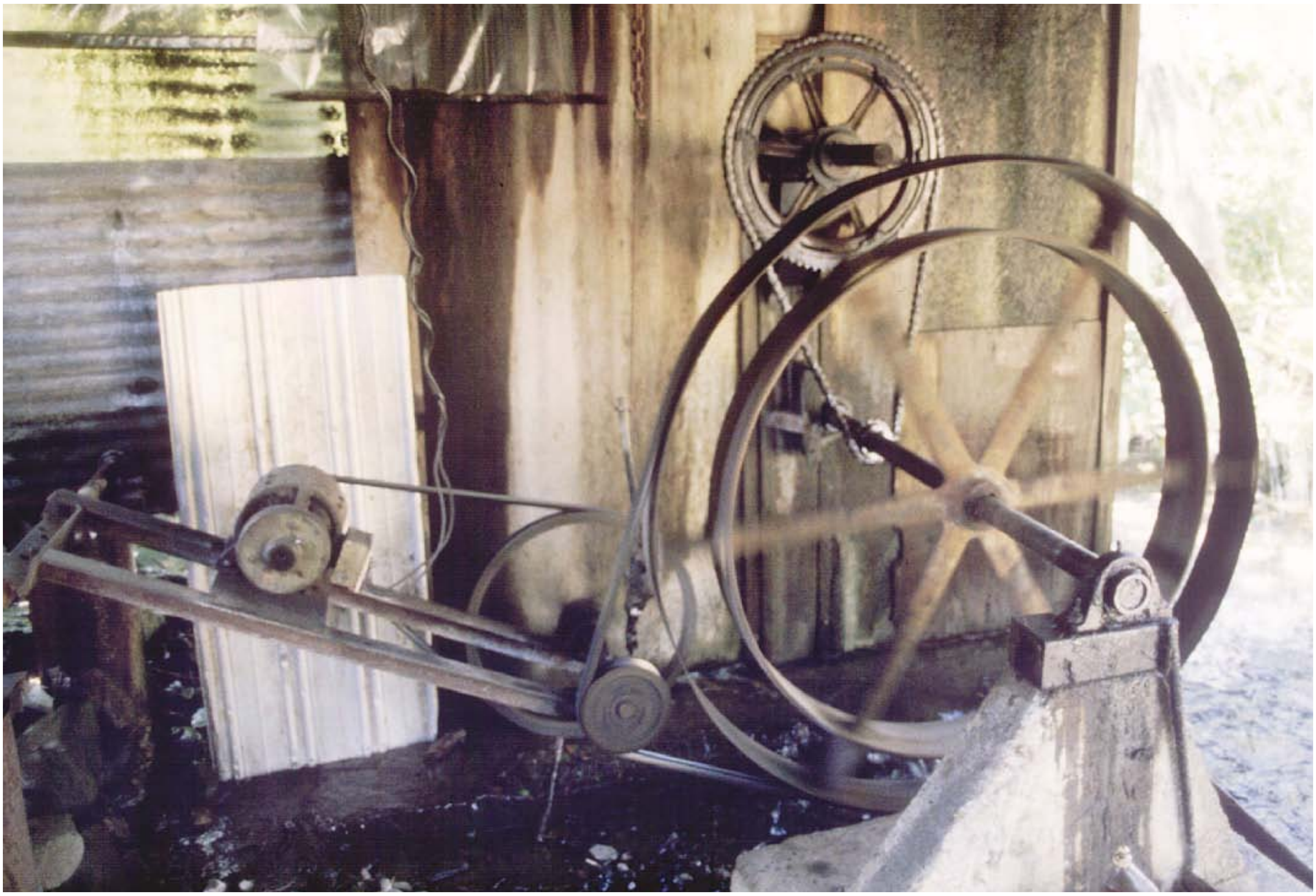
The total head of the Olsons' hydro system is about 14 feet. This includes the pitch on the wooden chute which acts as a nozzle and the 13 foot diameter wheel itself. At full output, the Olsons' hydro system produces 2,500 watts (2.5 kiloWatts) of 120 volt, 60 Hz ac power. This hydro produces a whooping 40 kiloWatt-hours daily.

The wheel uses one cubic foot per second (cfs) of water, and turns at 12 rpm while under load. Through a system of jack shafts that would do Rube Goldberg proud, the speed is increased to approximately 2000 rpm. Maintenance consists of greasing all the bearings weekly and knocking some of the ice build-up off the wheel during the coldest part of the winter.

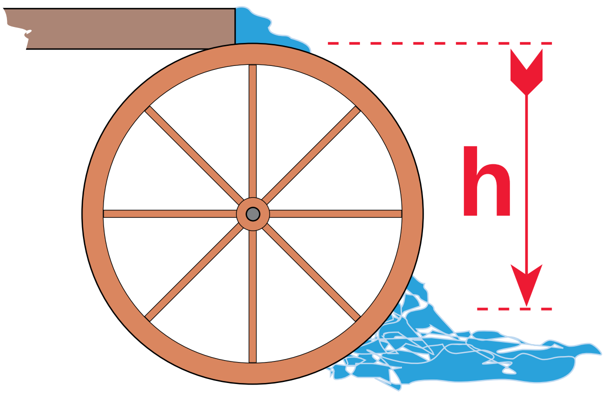
Living with an ac Hydroplant

There are no batteries, inverter, or controls that we normally associate with a stand-alone renewable energy system. It's rolling thunder and you have to use what you produce — one way or another. Increasing the wattage loading past the generator's output will cause low voltage brownouts and lower than 60 Hz power frequency. Decreasing the load on the generator will cause the wheel to spin faster, subjecting all the appliances and lights to a high voltage and frequency condition.

Below: The power transmission increases the low speed (12 rpm) of the overshot water wheel to high speed (≈2000 rpm) at the electric generator. The wheel is coupled to the uppermost shaft in the photo. Here a chain drive is used to transfer the power to the next shaft at a higher speed. In all, four shafts are used to speed up the water wheel's power output by about 160 times for electric power generation. Photo by Richard Perez



the physics of falling water



Above: Matt and Rosie's hydro powered homestead. Not only does falling water provide the electricity, but it also drives a ram pump to pump water for the house and gardens. Note the lights burning in the living room during the middle of the day. This is a typical practice in 120 vac 60 cycle hydro systems.

Below: The flume delivers about one cubic foot of water to the wheel every second. Photos by Richard Perez

Gravity powers the overshot water wheel. The water falls and as it falls it does what physicists call work because its mass is accelerated by the pull of gravity. The overshot water wheel converts the energy of the water's falling mass into mechanical power at the wheel's axle. The amount of power available for conversion depends on two factors: the amount of water per second flowing over the wheel, and the vertical distance that the water falls. Here's the equation.

$$P = \frac{W\ h}{0.7376}$$

where:

P = the available power in watts

W = the weight (in pounds) of water flowing over the wheel per second. A gallon of water weighs about eight pounds. A cubic foot of water weighs about 64 pounds.

h = the distance (in feet) that the water falls. Most overshot wheels only capture the water for 120° of their rotation. With 120° rotation, h is equal to 1.5 times the wheel's radius.

The 0.7376 is a fudge factor to make the Power unit come out as watts rather than foot-pounds per second.

From the equation, two facts are obvious to every hydromaniac — the more water flowing over the wheel per second the better, and the longer distance that the water falls the better. These two factors, flow and head, determine the power potential of all hydros regardless of type.

Above: Matt Olson.

Matt and Rosie use the simplest form of manual load management. They leave the lights on. Rosie jokingly says, “I’ve had friends who don’t know about the system come to the house and tell us ‘That must have been a hell of a party last night for you to go to bed and leave all the lights on!’ ” They also keep an eagle eye on the voltage and frequency meters mounted in the kitchen between the sink and the refrigerator. “We just always glance at it as we go by, it’s not even something we think about anymore,” according to Rosie. What better place for metering than the highest traffic area in the house? It’s a great place to install the system instrumentation in any RE powered home.

This kind of load management would be very difficult — even dangerous — with a high rpm impulse wheel system like a Pelton, but the overshot wheel turns at only 12 rpm. Consequently, it takes a while to change the rpm of the generator, and hence change the voltage and frequency, one way or the other. Time enough to turn an appliance on and some lights off without a mad dash for the switch.

Hydro-power Appliances

Matt and Rosie’s system powers all the electrical appliances they need. Like most folks powered by hydro, they were vague about their power consumption. When your concern is keeping the hydro’s constant power output under control, things like lights burning all night are common. Matt and Rosie power lighting, a satellite TV system with color TV, Matt’s machine shop full of power tools, and a slew of kitchen appliances. Cooking and water heating is fueled by propane.

Using Water to get Water

Rather than using electricity to run a pump for the house water, Matt and Rosie use a 40 year old Rife™ ram pump. The Rife is fed through a 2 inch diameter pipeline dropping about 20 feet from the ditch into another ancient mining tailrace. They’ve been using the Rife continuously for the past 24 *years*!

The ram pumps against a large pressure tank which also feeds a couple of sprinklers for the lawn during the summer and an open overflow line in winter. Matt figures that the Rife produces about 10–15 gpm. By keeping track of the amount of water being used continually, they can maintain about 25–30 psi of pressure in the tank. Plenty for most household uses.

Matt has modified the captive air tank on the ram pump by adding a couple of small petcocks. These valves make the weekly chore of draining the water and re-establishing the air “cushion” in the pump just a five minute job. The only other maintenance Matt has performed during the ram pump’s 24 year tenure is

Below: Rosie Olson visits in her beautiful garden.

Above: This Rife™ hydraulic ram pump has been pumping the Olson's water for the last 24 years.

replacing the rubber seals and gaskets "every five years or so." After buying the first set of replacement gaskets, Matt has been making his own out of a section of discarded rubber conveyor belt.

Conclusion

It wasn't all that long ago when the Olson's lifestyle and philosophy of recycling, rebuilding, and reusing was considered pretty backward. Today, most of us have caught on to the three "Rs" in one way or another, and it turns out the Olsons are pretty forward after all.

Access

Matt and Roseanne Olson, Methodist Creek, Forks of Salmon, CA 96031

Author: Bob-O Schultze, Electron Connection, POB 203, Hornbrook, CA 96044 • 916-475-3401 voice or FAX

PV in the City

Burke O'Neal
& Ben Fiore

Above: Burke and Ben reaching for the sun.

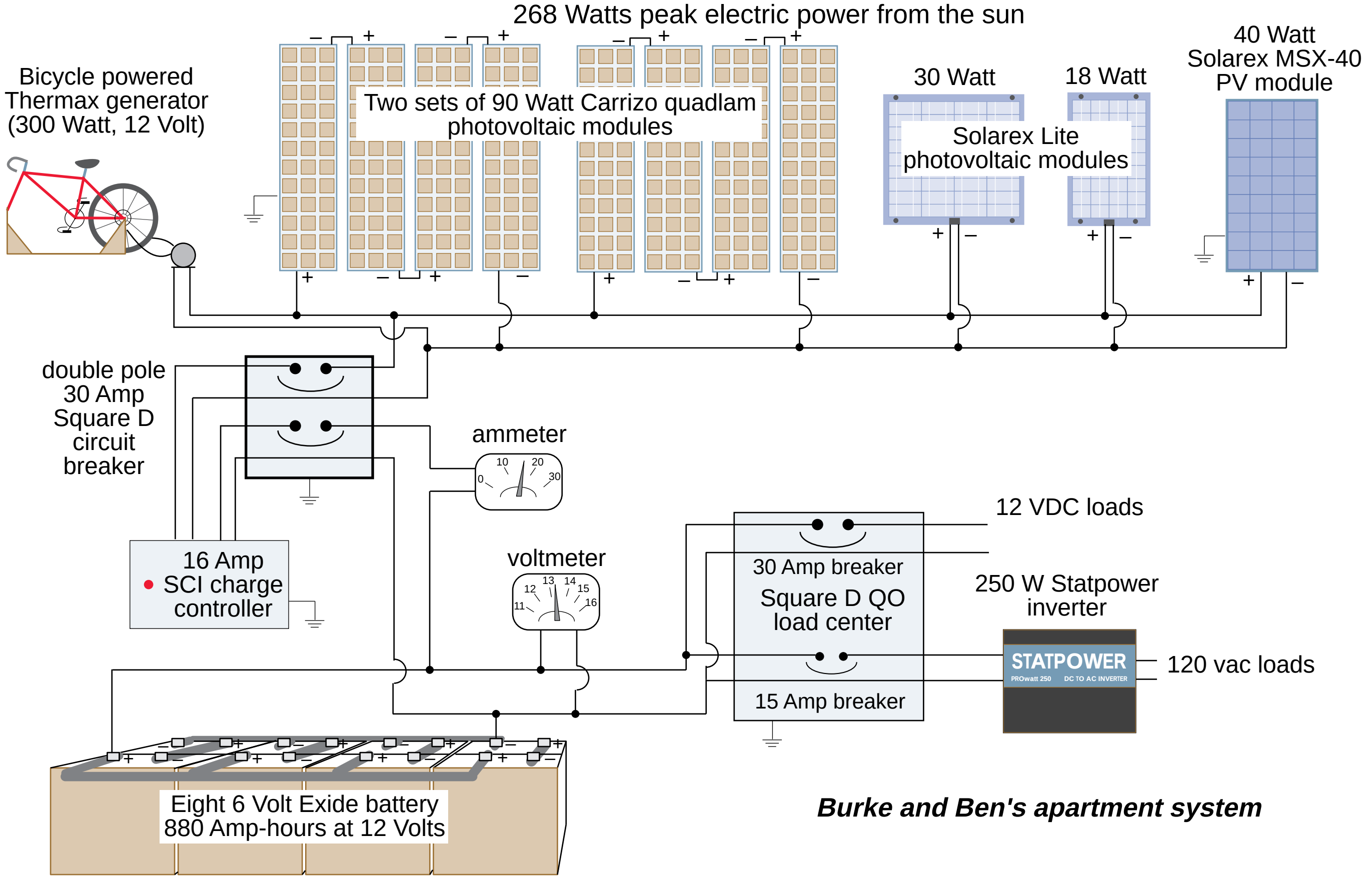
Our fascination with energy can be traced to our childhood — we have known each other since we were three. Inspired by President Jimmy Carter's sweater-wearing speeches, I was always sneaking over to the thermostat and trying to turn it down. Ben built a solar town for his fourth grade science fair and won a blue ribbon with it. I give yearly presentations to fourth graders on pollution and different forms of energy. Last summer we took our solar message to the Lollapalooza festival where we enticed the progressive rock nation with our solar-powered boom box. In this article, we will describe the operation of our present photovoltaic energy system.

Both of us are undergraduates in Mechanical Engineering at the University of Wisconsin, Madison. As our interest in alternative energy grew, we began amassing the equipment for the photovoltaic power system we presently use. When we moved out of our old neighborhood and into a downtown apartment, we decided we would get most of our electricity from the sun. It wasn't an easy task. First of all we encountered a lot of resistance from our landlady. After placing an ARCO QuadLam module outside our front south facing window, we got a message on our answering machine. "I want you to remove those solar panels instantaneously. I don't like them one bit. My building looks like student housing." But later she agreed that we could put them on the roof as long as we promised not to create any permanent damage.

We did a lot of research and reading about the electric code and realized it would be impossible to meet all electrical code requirements unless we altered the apartment significantly. We installed UL listed circuit breakers and clad the DC run into the apartment and the wires connecting the controls in conduit. We also installed a grounding rod to reduce damage in case lightning strikes near the panels.

The PV panels

Our photovoltaic (PV) system consists of two sets of 90 Watt ARCO QuadLams, 18 Watt and 30 Watt unbreakable Solarex panels, and a 40 Watt Solarex MSX-40 surplus module. With the exception of the unbreakable modules, the modules are mounted on the



Burke and Ben's apartment system

roof of our two story apartment building. The unbreakable panels rest on our awning, allowing easy removal to take to the beach, UCS (Union of Concerned Scientists) information tables, or PV demonstrations and speeches as well as for instant snow removal. The panels on the roof are wired for 12 Volts DC necessitating two 50 foot runs of #10 gauge Romex to the batteries. The section running through the window and to our control system is clad in conduit. A piece of scrap Styrofoam was cut to allow the conduit to pass through the window; the window closes onto the foam. The frames of the solar panels are all grounded to an eight foot copper pole sunk into the ground on the side of the apartment.

Batteries

The control board and battery box lie in one corner of our living room. We have eight 6 Volt, 220 Amp-hour Exide golf cart batteries configured for 12 Volts — a total of 880 Amp-hours capacity. We decided not to ground the negative terminal of the battery. The battery box is constructed of ½ inch wafer board, and the bottom is lined with fiberglass food trays. All seams in the box are sealed with silicone rubber. Several holes were drilled near the bottom of the box to permit air to enter. It is vented with a 4 inch diameter dryer hose out a window. We cut out a piece of scrap Styrofoam that allows the dryer hose to go through; again the window closes tight onto the foam. At night and on cloudy days we plug the hole to prevent heat loss.

Control panel

All our controls are mounted on a ½ inch plywood board in front of the battery box. The positive wire from the solar electric panels runs into one side of a double pole 30 Amp square D circuit breaker and then to a steel enclosure containing an SCI charge controller. An ammeter and voltmeter are located in the cover. The power then flows through the other half of the 30 Amp breaker and into the batteries. Coming out of the batteries, the wire runs through a 30 Amp breaker connected to a 250 watt Statpower and a 15 Amp breaker connected to our DC loads. The DC loads are wired with Romex and located close to the battery box in our living room. The ac loads are distributed throughout the whole apartment connected with extension cords.

DC refrigeration

During the warm months we use a super insulated 36 quart, 12 Volt thermoelectric cooler. (The super insulation is four inches of polystyrene for an additional

R-26 insulation.) We retrofitted the cooler with a homemade digital thermostat using Radio Shack parts and some assistance from Engineering Technical Services at the university. When the refrigerator is running it consumes about 48 Watts. However, with the thermostat it only cycles on about half the time, and even less at night when no one opens it.

This unit is our largest summertime load so it is reserved for about three days per week use, depending on the weather. We are both vegetarian so refrigeration isn't a big priority. We can get fresh vegetables at a whole food grocery about a block from us, and dried beans, pasta, grains, and rice don't need refrigeration. The unit works OK for items such as beverages and foods that that are already chilled. However it takes a very long time to cool down warm leftovers and would probably not be safe for cooling down cooked meats. It is also less efficient than a Sun Frost refrigerator which neither of us could presently afford. (Someday, though!) I hope by then compressor type refrigerators will no longer contain CFCs (ChloroFluoroCarbons).

For the winter we feel we have the best refrigerator an environmentalist could ask for. This is simply a two foot high, three foot across and three foot deep box insulated to R-13 designed to set in our window. About one fifth of the unit projects outside. A small, 1.4 W DC brushless fan blow the cold outside air through the box when the temperature in the box rises above the temperature we set the thermostat to. If the thermostat is set for 33°F, for example, and the temperature outside is 40°, the fan will circulate air, keeping the temperature at 40°. If the temperature outside is below 33°, the fan will stop running as soon as the refrigerator temperature drops to 33°, thus stopping the forced air circulation and preventing our food from freezing. We use the same digital thermostat that is used for the summer refrigerator.

Two 3 inch diameter plastic dryer hoses about two feet long lead from the back of the box allowing air to enter and exit. This serves a dual purpose. First of all it prevents water from getting in. It also serves to prevent too much outside air from circulating when the fan is not running, which would cause

Above: Burke on friendly terms with the landlady of their apartment building. The Solarex Lite photovoltaic modules mark the awning of Burke and Ben's apartment in Madison, Wisconsin.

Below: Ben sends 6 Amps of DC current into the battery via a Thermax 300 Watt, 12 VDC generator (and gets some exercise while he's at it).

Ben & Burke's Daily Energy Consumption

12 VDC Appliances	*Watts*	*Hrs/day*	*W-hrs/ day*	*%*
Refrigerator (summer)	48	24	246.9	34.6%
Halogen light	20	6	120.0	16.8%
Cordless phone	2.4	24	57.6	8.1%
CD boombox	7	6	42.0	5.9%
Answering machine	1.6	24	38.4	5.4%
Cold box fan (winter)	1.4	8	11.2	1.6%
5 inch color TV	12	0.5	6.0	0.8%
		Subtotal	522.1	73.2%
12 vac Appliances	*Watts*	*Hrs/day*	*W-h/d*	*%*
c. fluorescent lights (2)	27	3	162.0	22.7%
c. fluorescent light	27	1	27.0	3.8%
fluorescent light	9	0.25	2.3	0.3%
		Subtotal	191.3	26.8%
		Total	713.3	

freezing if it were very cold out. Dryer vent flapper valves could be used to facilitate this.

We have found since we installed the unit last October, there are not many winter days where the temperature rose above forty. I don't think there were any in December, January and February. The months when this unit is most useful coincide with those in which we get the least sun! This unit uses so little electricity compared to the summer 'fridge that we can enjoy refrigeration throughout the cold winter months. A unit like this could still be useful in addition to other refrigeration. It could be used to keep beverages, some fruit, or whatever you frequently use during the day. Thus this would reduce the amount of times you have to open the high power refrigerator and reduce the times the compressor must come on. Even a Sun Frost uses a lot of power compared to this.

Ben & Burke's System Cost

Equipment	*Cost*	*%*
Two 90 W ARCO QuadLam PVs	$850	32.3%
18 W & 30 W Solarex Lite PVs	$480	18.2%
Eight 6 V 220A-h Exide batteries	$400	15.2%
40 W Solarex MSX-40 PV module	$200	7.6%
200 w Statpower inverter	$200	7.6%
300 W 12 VDC Thermax generator	$180	6.8%
48 W 12 VDC Thermoelectric refrig.	$100	3.8%
wiring & battery cables	$100	3.8%
disconnects, fuses, meters	$65	2.5%
8 Amp SCI charge controller	$60	2.3%
Total	$2,635	

Other Appliances

Our stove uses gas and our heat comes from a central oil burner used to heat the whole complex. We hope to build a solar oven to reduce our gas dependence. Even though we don't pay for hot water, we have installed a water saving shower head. All of our lights are compact fluorescents, except for one 12 Volt DC halogen light. Because of our inverter's limited power range, we can't run a conventional vacuum cleaner. We use a push broom we picked up at a garage sale for a dollar for regular cleaning and when we have surplus power we use a hand held Hoover vacuum. We use utility grid power to provide power when we allow the PV panels to equalize the batteries. Also some "essentials" like toasters and slide projectors use too many watts for our inverter. The grid also serves as a backup when extended cloudy weather or extended VCR, ac stereo or lighting use drains our batteries. Our TV runs on DC electricity and uses only 15 Watts. We aren't big TV watchers.

Utility bills

Our average electric energy bill since we finished installing our current system in July 1992 has been less than a dollar. Our lowest monthly electric bill of 35 cents was in August, with a close second of 38 cents in October. January, February, and March's electric bills have been less than 40 cents. Unfortunately Madison Gas and Electric charges us a $3.50 hook up charge no matter how little energy we use. Overall the winter has been a lot better than we expected. The ARCO QuadLam PV modules seem to provide about twice the maximum current in the winter than the summer. This is mostly due to the lowered temperature which allows them to operate more efficiently.

We have a 300 Watt Thermax generator coupled to a 12 speed bicycle on a homemade frame. This would reduce our need for grid power further, but we have generally been more lazy than we anticipated when the unit was built.

Conclusion

Installing the photovoltaic energy system we have in our apartment has been very rewarding. We have learned a lot about solar technology, electric wiring and electrical code. And of course there is nothing in the world like getting your energy from the sun! We hope our society will soon follow the examples of the people in this magazine and implement a policy of safer, less polluting and more localized energy systems.

Access

Burke O'Neal & Ben Fiore, 414 S. Brearley, Madison, WI 53703 • 608-251-8971

Above: The Piyasena family on the day of the installation with the SUNTEC installation crew.

From Darkness to Light with the Power of the Sun

Lalith Gunaratne

"We've brought a gift for you," said Gunaratne Bandara, the agricultural field officer, to a 14-year-old girl, Dayani, who had just returned home from the village school. She was impatient to find what the gift was.

"A SUNTEC," he answered to her excited query. Over the radio Dayani had heard of SUNTEC, the generic name for solar power in Sri Lanka, and she knew it was the latest way of generating electricity from the sun.

Piyasena and Soma, the parents of Dayani and four younger children, own a simple home in a remote village called Deniya in the deep south of Sri Lanka. The family owns two acres of wet land where rice is cultivated. They also grow bananas on a quarter acre of dry land. Their annual income is about $2000 U.S. per year, which affords them a relatively comfortable life. Being situated in a distant region has deprived this family of government-provided grid electricity. Even if the power lines came near their home, its thatched roof disqualifies the house from getting electric power due to safety regulations. The only source of power they have is kerosene, which is used to light a few lamps.

The dangers of kerosene use are well known. Often, from careless handling of lamps, village homes are burned down, causing death and destruction. So, when Piyasena was chosen by the area agricultural field officer to get a Suntec solar electric system as a demonstrator for the village, he could not contain his excitement. Like a little child when given a toy, he jumped for joy and ran off to inform his wife.

That afternoon, the news had spread that Piyasena's house was getting a SUNTEC. This became an event for the village. The neighbors had all gathered in the usual community spirit to share the happiness with the Piyasena family, and Soma cooked a feast for all. By the evening, the system was installed and — like magic — the lights were switched on. Piyasena and family had a happy glow on their faces as they entertained their guests to food and drinks. The neighbors commented on how the usual dark surroundings had been lit by Piyasena's home. They also pondered with awe, how the sun had given them electricity.

From that evening, Piyasena could operate a few fluorescent lamps and even power his radio, which had previously operated with costly dry cell batteries. The system also produces sufficient power to run a small black-and-white television set which he plans to purchase in the near future.

How we in the city take the switch on the wall so much for granted! Imagine living without electric power.

Two billion people around the world grope around in the dark after sunset. They have no access to power because they are too far away from the city. Often, they are the backbone of many developing world agricultural economies. Yet, they are left behind due to the high cost of drawing power lines to their areas.

Solar power is fast becoming a way of solving the immediate energy problems of the rural masses of the developing world. The ease of installation, maintenance and use of solar systems along with its environmentally benign nature, make PVs very appropriate. Another advantage is that the systems are modular, so when Piyasena wants to increase his available power, he can simply add on solar modules.

Solar power — already powering a few thousand homes in Sri Lanka — is poised to play a significant role in rural electrification as more and more people are opting for it.

Piyasena always viewed the sun with reverence. He knew that the sun is the single most important source of energy — the lifeline to everything that has ever inhabited the earth. So, the almighty sun's providing the little energy he needs only strengthens his veneration. As sure as the rising sun, it has brought him light by night.

Access

Lalith Gunaratne, Joint Managing Director, Power & Sun (Pvt) Ltd., 338 T.B. Jayah Mawatha, Colombo 10, Sri Lanka • 686307 • FAX 575599

Born in Sri Lanka, Lalith Gunaratne resided in Canada until 1984. Then, he with two other Sri Lankan born Canadians, Pradip Jayewardene and Viren Perera, moved to Sri Lanka with the idea of applying solar technology to serve the rural population. About 70% of Sri Lankans do not have access to power. After much research, the three founded Power & Sun, which is the only manufacturer of PV modules (SUNTEC) and system components in Sri Lanka.

Dear Home Power,

We are a small company meeting the electricity needs of rural Sri Lankans living away from the government's electricity grid. We manufacture and sell SUNTEC brand solar PV modules and balance of systems.

You must certainly be aware of the battles one has to fight to introduce a new technology such as solar power, especially, to a commercial market. The battle is even tougher when one has to compete with local politicians who keep promising rural people grid power for votes. In most cases, there is no hope of actually giving power, as most rural homes are too far from the grid. We are only now convincing these politicians that solar PV is a viable alternative. After all, when the government endorses the use of solar power, it will be more readily accepted by the market.

So, we continue to work away at commercializing the use of solar power, as opposed to working with aid (hand-out) projects which have given solar power a bad name the world over. The responsibility for the system's purchase, operation and maintenance should lie in the hands of the user. The government should assist only, by way of endorsing the use of solar power and establishing effective finance schemes for users. We have seen a few thousand homes in Sri Lanka accepting and paying for solar power providing they know for sure the main line grid will not come their way.

Globally, a lot needs to be done yet to increase the awareness of solar power, its uses and benefits. Therefore, we solar people have to stick together and work to make solar power a globally accepted source of power for not only remote applications, but for mainstream uses as well.

…and the bottom line. We must strive to bring our costs down too and we can achieve that through economies of scale.

The happy faces of people who are otherwise left to grope in the dark at night alone is reward enough. Well partly….

All the very best. Sincerely yours,

Lalith Gunaratne

Above: Solar cookers ready to shine in HP's Solar Cooking Contest. Photos by Richard Perez

A Kitchen in the Sun

Therese Peffer

We've all heard the saying about too many cooks in the kitchen. But what happens when you move your kitchen into the sun? You get a myriad of solar cooker designs, great food, and lots of fun in the sun. We found this out recently at Home Power's 2nd Annual Solar Cooking Contest.

Last February, we offered a challenge to our readers: design and build a simple, cheap, and easy to use solar cooker that works well. The rules were simple: the cooker had to cook, meaning it should boil water. The cooker should use common tools and materials appropriate to your area. Durability and easy duplication would score high points.

And our readers responded. We received twelve cooker designs for the contest. Of these twelve, three contestants sent their cookers. Two cookers arrived at the contest with their designers. We built three designs for a total of eight entries in the contest. (We built the designs appropriate to the contest — original designs that were easy to duplicate with complete instructions).

The day of the contest

Saturday, July 31, dawned clear and bright — a beautiful day for the cooking contest. By nine am, solar cookers covered a fair portion of Camp Creek campground. Besides the eight contestants, we had eleven other solar ovens smiling at the sun. Jim Shoemaker from Redding brought his cardboard and foil Sun Star type cooker. The Solar Man himself, Phil Wilcox, brought two solar ovens. One small commercial cooker, a Sunspot, could easily fit into a backpack; the other design was part of a U.S. Air Force survival pack in the '50s! Yes, solar cooking has been around for awhile. We also had four Sun Ovens, a Sun Chef, and three other homemade models cooking ribs, peach cobbler and other tasty goodies.

By ten o'clock, we placed a cup of pre-soaked pinto beans and a cup of rice in each of the contesting cookers. One result of having this number of solar cooks — you get an incredible variety of cookers! Each cooker reflected the designer's carefully spent time, creativity and imagination; no two were alike. Walking around the cookers, you could hear how the cookers sparked the imagination of all those who came. We looked, appreciated, and used other's creations as a stepping stone for our own solar cooker dreams.

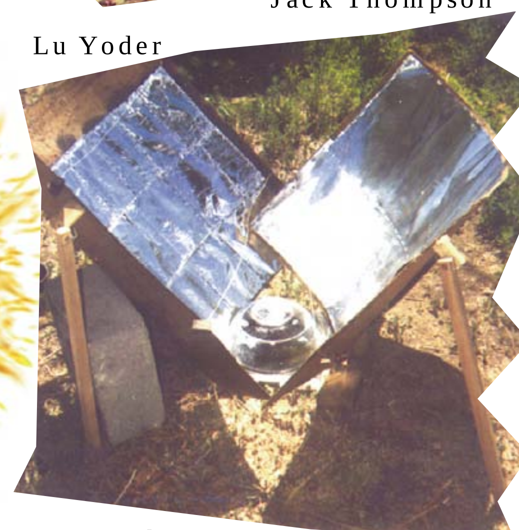
Dan Freeman

David Baty & Cody Brewer

Jack Thompson

Bohuslav Brudik

Lu Yoder



Jay Campbell

Peter Pearl

Rodrigo Carpio

The Contestants

Unfortunately, we don't have the space to fully cover the designs for every cooker. What will have to suffice is a brief description, photographs and the designer's name and address (at the end of the article). So take a close look at the photos and be inspired by the ingenuity of the designers! Keep in mind next year's contest.... As with last year's contest, the first place cooker design is described in full.

The parabolic cookers added a new dimension to the contest — they really cook! Two cookers used parabolic dishes to reflect and focus the sun's energy onto a cooking pot.

Jack Thompson from San Diego, California sent a design that used a cardboard-ribbed foil-covered parabolic dish. A galvanized pipe frame held the dish and cooking pot. Kathleen and Bob-O built this cooker from Jack's plans and "rib" template.

The other parabolic design arrived with David Baty and Cody Brewer, who hail from Berkeley, California. Their cooker consists of a four foot diameter sand & cement dish that rests in an old car tire. They used aluminum flashing for the reflective interior. David and Cody had already impressed us the day before by making espresso in their parabolic cooker. On contest day, their rice and beans kept boiling over and needed additional water a few times. Both parabolic cookers cooked the rice and beans to perfection in less than two hours. This left plenty of sun time for a solar cooker first for all of us at the contest — solar popped popcorn!

Lu Yoder from Albuquerque, New Mexico sent a simple design that used two 2 foot by 3 foot cylindrical concentrators. His plans called for a flexible substrate such as hard plastic, thin plywood or masonite covered with a reflective material, such as polished aluminum cans. The panels were curved to concentrate the sun's energy on a cooking pot that sat on an insulated box on the ground. We made the cooker with masonite and aluminum litho sheets from our local newspaper.

Dan Freeman sent his cooker from his home in Peoria, Arizona. Dan's creative portable design used aluminized bubble pack material (similar to Reflectix) as both reflector and insulation. This material was velcroed to a folding aluminum frame. His cooking box sported a unique curved parabolic-section shape.

We were thrilled to receive an international entry. Rodrigo Carpio from Cuenca, Ecuador sent beautifully detailed designs in Spanish for his rugged, but surprisingly lightweight box type cooker. Bill Battagin and I built the cardboard and plywood cooker from Rodrigo's design. The cooker walls consisted of 2x2 wood frames covered with cardboard and then wrapped in foil — light, sturdy insulation. We screwed the walls together to form a box, and finished the outside with ¼ inch plywood. The plans called for the walls to lie inside the box for storage — in storage mode, the cooker was only half the height! We didn't have the materials to finish the box with aluminum sheeting as per plans, so we painted the outside instead. Quite a weatherproof design. The wide flat interior of this box cooker is especially suited for climates near the equator.

From Las Vegas, Nevada came a cooker designed by Bohuslav Brudik. This clever design used a store-bought rectangular bamboo basket, insulated with cotton batting and rags and covered with cardboard painted black. Bohuslav used plexigass for glazing and fashioned reflectors from flattened honey cans supported by dowels. Simple and worked great!

Peter Pearl drove from Bisbee, Arizona to share his solar cooker design and other great ideas. His compact solar cooker had a black beveled steel interior in a small wooden box with a single polished reflector.

And finally, Jay Campbell, who won first place in last year's contest, sent another original cooker from Albuquerque, New Mexico. He designed the cooker using a washtub, insulated with straw, with a box interior. Jay made foldable reflectors of foil-covered masonite. The cheery green cover added to the festive atmosphere at the contest.

The envelope please...

Now the toughest job of all. Six judges walked around the cookers to judge the performance, buildability, ruggedness and beauty of design of each entry (see sidebar for details). Anita Jarmann, Sherri Reiman, Selina S-Wilcox, Karen Perez, Kathleen Jarschke-Schultze, and Dan Lepinski spent a few hours studying the cookers, sampling their fares, and marking numbers on their detailed sheets. Most cookers had no problem with the rice, but the beans presented a challenge. We decided the point system would allow impartial judging. (After sampling the espresso, Karen was a bit biased towards the cement parabolic cooker. As it is, that cooker now resides at HP Central. If you want your own too, see directions on page 34 this issue.)

When the judging was finished and the numbers tallied, we had our winners. Cookers were ranked by total number of points from all judges. Jay Campbell won a Solarex MSX-60 photovoltaic panel for first place with his washtub design. Peter Pearl will be installing a PowerStar 200 watt inverter for winning second place. David Baty and Cody Brewer shared the solar/dynamo radio for winning third place with their cement parabolic cooker. Finally, time to eat rice, beans, salsa, guacamole, hot dogs, ribs, peach cobbler....

Judging the Cookers

Each judge carried a judging sheet for each of the eight contestants. The cookers were given points in four categories: Performance, Buildability, Ruggedness, and Beauty of Design. The four categories in turn consisted of two to five subcategories, worth 15 to 25 points.

Performance of the cooker included how well it cooked, high temperature reached, ease of use, and ease of set-up. Each subcategory here was worth up to 25 points for a total of 100 points for this category.

Elements of buildability consisted of clarity of instructions, easy of assembly, imaginative use of materials, amount of tools needed for construction, and common skills needed for assembly. The subcategories here were worth up to 15 points each, a total of 75 points.

In the ruggedness category, points were given for portability, wind resistance, site preparation needed and moisture resistance. Up to 20 points each were allotted for these subcategories for a total of 80 points.

And finally, beauty of design included physical appearance of the cooker and originality of design, worth up to 25 points each — 50 points total. The most points possible from each judge was 305.

While sometimes it can be difficult to assign numbers to different qualities, we think it allows for easy and fair judging since all the cookers were judged in the same fashion. The details of the judging are provided for those of you interested in entering the contest next year. And, (ahem) we've asked Jay to be a judge next year….

And now as promised, are the details of the winning design by Jay Campbell.

The Winning Design — the Navahorno

This year, I chose to work with a developing country right in my own back yard. I designed and built a solar oven based on the needs, foods and materials common to the Navajo Nation. This stunning land spreads across 24,000 square miles of New Mexico, Arizona and Utah, and is home to more than 175,000 people. Of the 500+ tribes in the United States, the Navajo tribe is the largest, and their landholdings the most extensive. They were chosen for this project not for their size, however, but for their need.

Despite the beauty of the land, life on the reservation is hard. Much of the tribe has never been on the grid, so

The Winning Cooker!

Jay Campbell, Albuquerque, NM

the concept of going off it is meaningless. Wood and propane supply the primary sources of household energy. The climate and terrain of the Navajos are typical of many tribes in the area. The air is dry, vegetation is sparse and the sun shines brightly. Wood is not available in many areas, so it is hauled in from the distant mountains. The tribal government has been promoting solar electricity for some time now, funding small systems at remote sites, and encouraging members to utilize this abundant resource. They will play a key role in the promotion of this oven.

This project would have been impossible without many consultations with JoAnn Willie, a lifelong resident of the rural Navajo land. She is also a graduate student in Mechanical Engineering at the University of New Mexico. Her combination of skills was invaluable in the development, testing and promotion of this oven. The information she gave on materials, foods, cookware and eating habits was all blended into this design, and its ultimate success is hers to enjoy.

The Oven

The oven is built around several common items in rural Navajo life. The outer box consists of a two foot diameter galvanized washtub, commonly used for washing kids, clothes and produce. When they no longer hold water, they are used to feed animals, store wood, and haul whatever needs hauling. These are truly a ubiquitous item in daily living. They are common, abundant, durable and used ones can be found for next to nothing.

Materials and Tools for Jay's Navahorno

Materials	*Tools*
One 2 foot diameter washtub	wood saw
One 15 in. x 15 in. 1/8 in. glass	measuring tape
One 4 ft. x 4 ft. Masonite	paintbrush
One 4 ft. x 4 ft. 3/8 in. plywood	hammer
6.5 ft. old garden hose	razor knife
1/10 bale straw	C clamps
Two small hinges with screws	

also leather strips, white glue, 3/4 in. nails, and aluminum foil

The insulation used is straw. The dry land doesn't provide sufficient grass for grazing, so hay, alfalfa and straw are widely used for fodder. This oven requires about 1⁄10 of a bale of straw, costing about a quarter.

The inner box is sized around the most common types of cookware — enameled steel stew pots. The volume is large enough to feed a family of six. All other materials are made from commonly available items, down to using leather for hinges and weatherstripping. A piece of garden hose, split lengthwise, is used to seal the inner and outer boxes together.

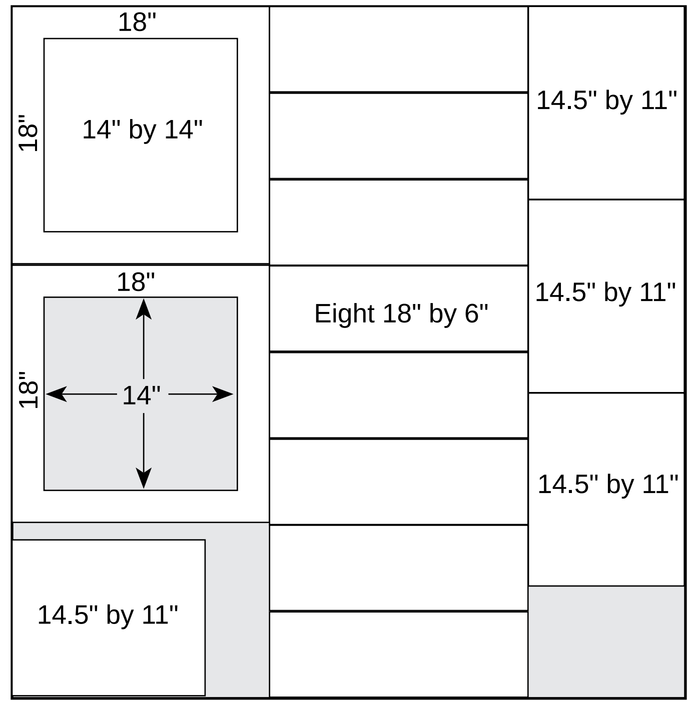
The collapsible reflectors reduce storage space requirements when not in use. The exposed surfaces are either painted or galvanized, helping to assure a long life. For outdoor storage, however, a cover would be recommended. A door on top swings open for access to the hot section. The reflectors are mounted securely to the door, and have withstood winds of up to 30 mph. The leatherwork is oiled, to protect it from the elements. The colors of this oven represent something the Navajos are world famous for — their turquoise and silver jewelry.

A set of cardboard risers is included to size the cooking space for the cookware. The appropriate riser is placed into the oven, and then covered with a black cardboard square. This way, the food can be raised to the hottest part of the oven, regardless of the cookware.

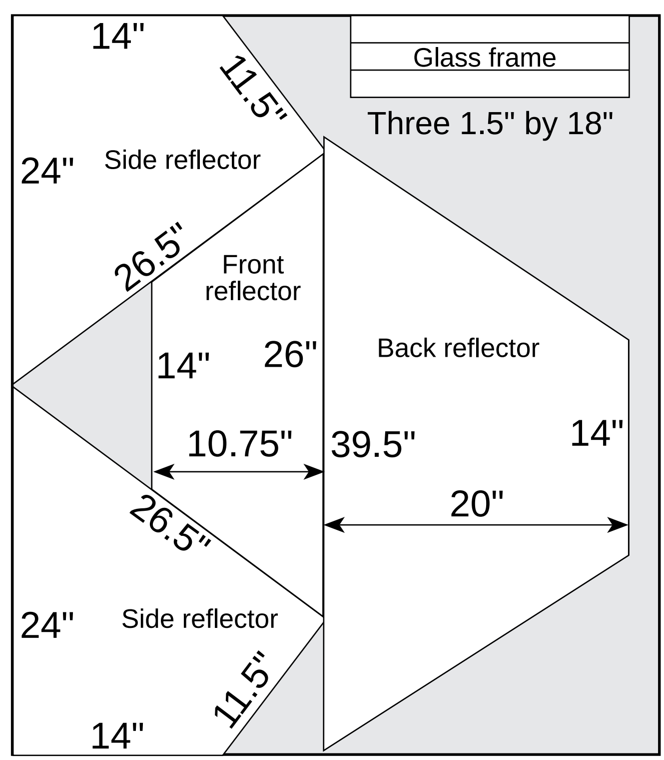
The highest temperature achieved was 330°F (165°C). The time required to boil one liter of 20°C water was 56 minutes at this elevation (about 6000 feet). The total cost as built is $10.83, assuming a used washtub. A new one would add about $10 to that price. About 6 hours was spent on the actual construction; this could be reduced significantly for any future copies.

Construction
Gather tools and materials. Measure and cut wooden pieces (right). Put together the inner box, top, glass frame, and reflectors, then assemble these together.

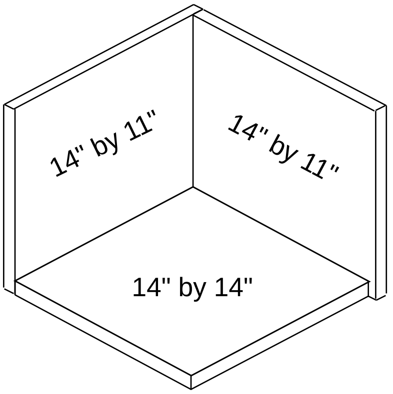
Cut the following out of plywood:



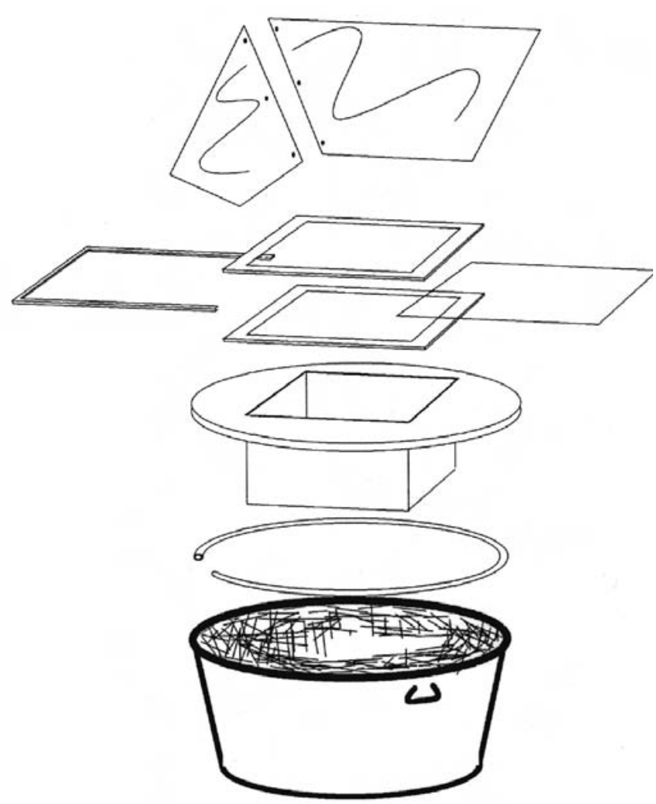
Cut reflectors and glass frame pieces from Masonite:



Inner Box
Nail the four sides (11 inch by 14.5 inch) to the edge of the 14 inch square, overlapping the corners as shown top right. Glue joints before nailing together. Cover both the inside and outside of box with aluminum foil, using a 1:1 glue to water mixture and spread with a paintbrush.

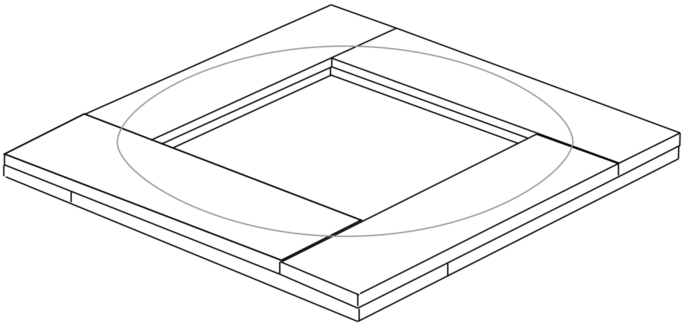


Two sides of the inner box glued and nailed to the bottom.
Note overlapping corners.



Top

Turn the inner box upside down. Stack the eight 18 inch by 6 inch strips snugly around the box (below). Once fitted, glue and nail the strips together. When the glue has dried, nail the box to the top from the inside.



Now set the inner box/top upside down. Place the washtub over it, and center it. Draw a circle around the edge of the washtub. Next, cut a slit in the whole length of garden hose. Nail the garden hose to the top, just inside the circle you just drew. Use one nail every 4–5 inches to assure a strong joint. Once the glue has dried, trim off the excess wood beyond the hose/seal.

Glass Frame

Set the piece of glass on one of the 18 inch squares. Place three 1 inch by 15 inch masonite strips around the glass, snug, but not so tight that the glass is locked into place. Set the other 18 inch square on top. Glue and nail these together. The glass should slide in and out of the frame like a drawer, so it can be replaced.

Reflectors

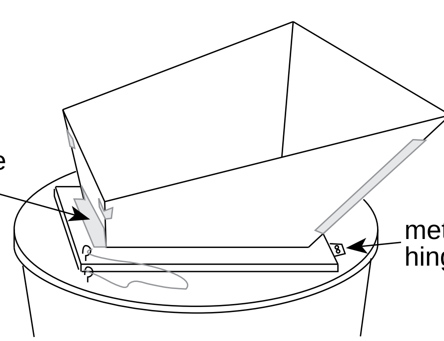
Cover the reflectors with aluminum foil. Once dry, trim the foil back to the edge of the masonite. Align the large reflector and a side reflector (see top right). Cover one side of a leather strip with glue and clamp along the edge of the two reflectors. Repeat with the other side reflector. Align the small front reflector to the edge of the window. Glue a piece of leather to the back of this reflector and the window frame, as a hinge.

The Final Assembly

Use the two metal hinges to attach the glass frame (opposite side from the front reflector) to the top. Glue strips of leather on the top, where the frame rests. This seals the box from the wind. It should fit snugly and make a continuous ring around the glass. Attach an eye hook to a corner of the frame and another eyehook to the top. Hook a sturdy string through both eye hooks. Now when you open the cooker lid to get to the food, the string holds the frame and reflector.

Use

This oven works similar to most multiple reflector ovens. Food is prepared and placed into the oven, using the appropriate riser to keep the food at the top of the oven. Dark enameled steel cookware (the standard in the area) works extremely well in this oven, but a variety of glass and aluminum has also been used. The oven can be left unattended for long periods, but stays hottest if it is turned every hour or so. The round base and handles makes turning it easy. Like most solar



Above: Note the deep interior of the washtub cooker. Different sized cardboard inserts (bottom right) can be added to raise shallow cooking pans to the warmest part of the oven. The inserts are covered with a 14 inch square of cardboard painted black.

ovens, cooking times are about double those of a conventional oven. Foods which require a long, slow simmer are especially well suited to solar cooking.

Traditional Navajo meals include green chile stew, mutton stew, roast meats, breads and corn mush. A gallon of stew will cook up nicely in an afternoon, as will a few quarts of beans. Cornbread has been baked in this model in about 40 minutes. When the food is ready, the reflectors are folded together. The door swings open and the food can be removed. If desired, the pot can be covered with a couple of towels, and left inside the oven. This way it will retain its heat for quite some time, and even keep on cooking.

Alternatives

The main alternative design tested was with galvanized sheet metal reflectors. The dimensions and overall performance were essentially the same as the model submitted. The increased durability comes at a higher financial cost, and it didn't seem worth it. The masonite reflectors are good enough, and last long enough that occasional replacement would still be cheaper.

Better insulation could be used, but only if it were free or very cheap. The multiple radiant barriers (foil and sheet metal) provide much of the thermal protection, and the straw is only a defense against conduction.

Conclusions

This oven will cook many of the staple foods used in the Navajo Nation. It can be built easily by individuals, or produced in quantities by a small shop, using only basic hand tools.The investment in materials will repay itself in about a month, and continue paying dividends for years to come. The climate in the region will allow its use for over 200 days per year, which can make this a primary, rather than secondary, means of cooking.

Although specifically designed around the materials and foods of the Navajo, it is suitable for use over a wide region. Promotional efforts have begun in New Mexico, and show a strong amount of interest.

Calling all Cooks

Thanks, Jay, and all those who entered or participated in our contest this year. The more cooks that move their kitchen into the sun, the better the broth will be! More people entered the contest this year. We saw a wider variety of cookers from a greater number of people, reflecting their creativity, ingenuity, and love of solar-cooked food. The solar spark catches and spreads to even more people, so put on your thinking caps and start dreaming of your ideal cooker. If you don't know how to use some tools, find someone who does (and make him cookies for a job well done). Build a cooker. Cook your meals without fuel, and keep your kitchen cool in the summer. Enjoy some solar-cooked food (and win a PV module next year).

Access

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Tower Economics 101

Mick Sagrillo

Wind generators live on tall towers. And for good reason. Their “fuel” is way up there. As we’ll see, the quality of your wind resource improves radically with height.

Physics

The power available to the rotor (that is, the spinning blades) of a wind generator is defined by the equation:

$$P = \frac{1}{2}d \times A \times V^3$$

where P is the power at the rotor, d is the density of the air, A is the swept area of the rotor, and V is the velocity of the wind.

We can increase the power available to the rotor of a wind generator three ways — by increasing any variable in the power equation: d, A or V. Each variable in the power equation has its own effect on the power available to the rotor. Let’s look at why these factors influence the power equation, and what our options are.

Density (d)

Wind generator blades spin because air molecules are moving past them. The more molecules we can move past the blades, the faster the blades will spin, and the more electricity the wind system will produce.

Density refers to the number of molecules in a given volume of air. Air is more dense in winter than in the summer. Therefore, a wind generator will produce more power in winter than in summer at the same wind speed. However, density of air is one variable that we can’t do anything about.

Swept area (A)

Area of the rotor is included in the power equation because the rotor is, in essence, the collecting device for the wind generator. The rotor “captures” the power in the molecules that are moving past it. It makes sense that the larger the collecting device (that is, the rotor), the more electricity we can produce.

Increasing rotor area is not as simple as putting bigger blades on a wind generator. Many a manufacturer has learned this lesson the hard way. The swept area of the rotor is defined by the equation: $A = \pi r^2$

Because we square the radius (which is the length of one blade), doubling the diameter of the rotor has the effect of quadrupling the swept area. For example, let’s increase the rotor diameter of a wind generator from 10 feet to 20 feet. The 10 foot rotor has a radius, or blade length of 5 feet. Squared, this becomes 25 square feet. Multiplied by π, and we get a swept area of 78.5 sq. ft. If we double the rotor diameter to 20 feet, the radius becomes 10 feet. Squared, this is 100 sq. ft. Multiplied by π, we get 314 sq. ft.!

At first glance, this appears to be a very easy way to increase the amount of energy that a wind generator can capture. And it is. But by increasing the swept area to the tune of 400%, we have also increased all of the stresses on the wind system by that same 400% at any given wind speed. In order to compensate for this change and have our wind system survive, we must make all of the mechanical components 400% stronger. While this can be done, obviously this approach is going to get very expensive very quickly.

Velocity Velocity Velocity

Increasing wind velocity increases the number of air molecules passing the rotor, so increasing wind speed will also have an effect on the power output of the wind system. But because velocity is cubed in the power equation, wind speed is the one variable that has the greatest impact on the power equation.

As an example, let’s take a look at what happens when we double the wind speed for a given wind generator. At 5 mph, the V^3 part of the power equation is 125 units of something (5 x 5 x 5) that is multiplied by density and swept area. Doubling the wind speed to 10 mph gives us 1000 units to multiply by density and swept area (10 x 10 x 10). This is an 800% increase in power output from the same wind generator!

From all of this we can conclude that we can get the biggest bang for our buck with our wind generator, not by fiddling with air density or increasing swept area, but by somehow increasing the speed of the air that the rotor sees. (For a more in-depth discussion of this topic, read “Wind Generator Tower Height” in *HP* #21.)

Fluid Dynamics

Like water, air is a fluid. We can learn some lessons about how the air moves by sitting on a stream bank and watching the water go by.

If we throw a twig into a stream near its center, we will see that twig move rather rapidly downstream, depending on how fast the current is flowing. If we throw another twig in the water near the stream’s bank, we'll observe the twig move rather lazily downstream. Why is this?

Near its edge, the stream is slowed down because of friction between the bank and the water. As we move towards the center of the stream, the effect of the bank's friction diminishes. The laminar flow of the water moving over water allows the stream to pick up speed.

The same thing occurs with air masses as they pass over the surface of the earth. The face of the earth itself, as well as its vegetation, significantly reduce the speed at which the air can flow over the earth's surface. This is called ground drag. As you move away from the earth's surface, ground drag decreases and the laminar flow of air increases. Expressed another way, increased height means greater wind speeds.

Turbulence
Let's go back to the stream. Our twig is still cruising along down the center of the stream. Up ahead, however, is a stump sticking straight up out of the water. Watch what happens.

As the twig approaches the stump in the stream, it slows down considerably as water piles up in front of this obstacle. The twig almost comes to a stop, but then passes slowly around the stump. Now behind the stump, the twig slowly spins around and around, until it gradually moves back into the swift flowing stream.

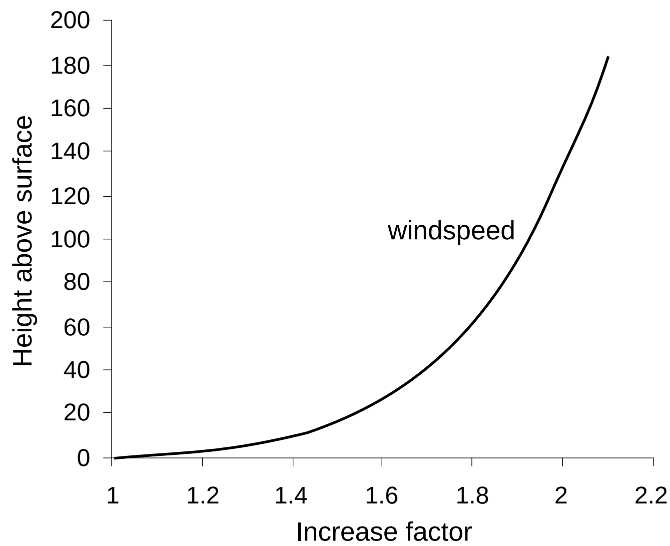
What we have witnessed is fluid turbulence. The same thing will happen with our wind generator if it is sited too close to trees or buildings. Turbulent air robs our wind generator of the energy available in laminar flowing air. The quality of our "fuel" has depreciated!

The obvious difference between the twig and a wind generator is that the stationary wind generator cannot escape the effect of turbulence on it as the moving twig did. Which brings us to a *major* rule of thumb: Wind generators *must* be sited *at least* 30 feet above anything within 500 feet.

Picture this
Graph 1 (above right) depicts the increase in wind speed as a function of height above the earth's surface (actually above a relatively frictionless surface, such as a body of water.)

Wind speed increases significantly at first, but then the rate of increase begins to diminish with height. An example will clarify what this graph is telling us.

Let's assume that we measure the wind speed with a hand-held meter at shoulder height, 5 feet above the ground. Our measurement is 10 mph. How fast is the wind blowing at 100 feet above the ground?

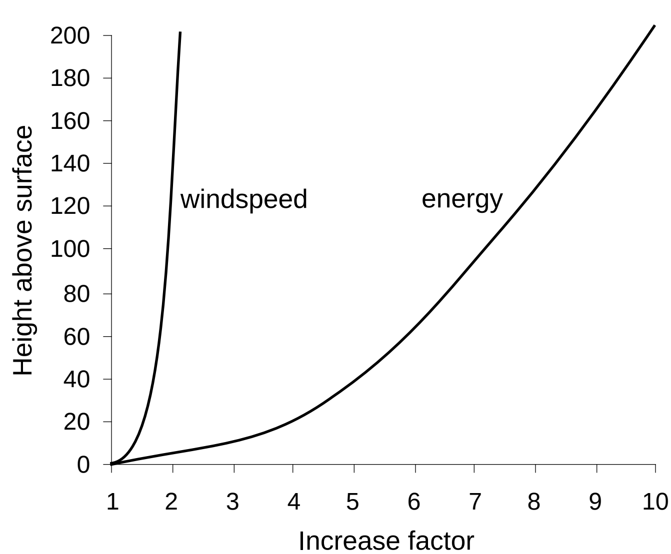


Graph 1

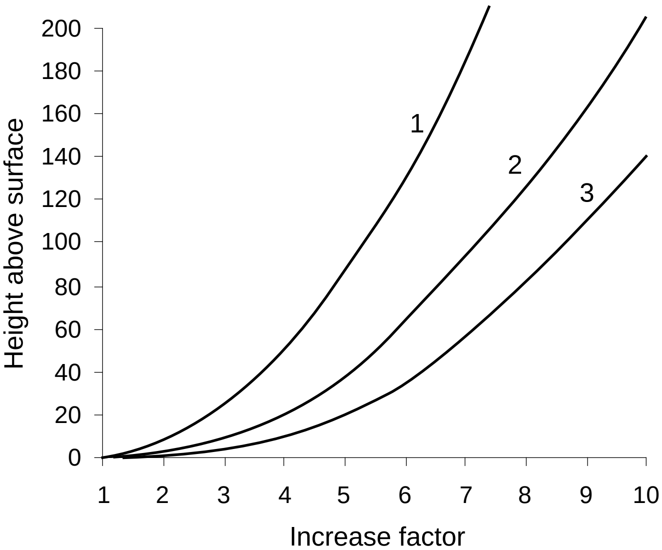
Reading Graph 1, at 5 feet the increase factor is about 1.25. If we divide 10 mph by 1.25, we get a wind speed of 8 mph at ground level. At 100 feet, the increase factor is about 1.93. If we multiply 8 mph by 1.93, we find that the wind is blowing at 15.8 mph at 100 feet. That's a significant increase!

How significant, you ask. Remember that the power available to a wind generator rotor is a function of the cube of the wind velocity. Graph 2 below illustrates the increase in power available to the rotor as a function of height above relatively open ground. (The "windspeed" curve is the same one depicted in Graph 1 only compressed.)

Remember that this graph only depicts increase in power over relatively open ground, such as that



Graph 2



Graph 3

covered by crops like corn or wheat. When we look at power increases over other types of surfaces, we get different results (see Graph 3 above).

In Graph 3, curve 1 represents power increases over open water. Curve 2 represents power increases over low vegetation growth, like corn or wheat. And curve 3 represents power increases over taller vegetation, such as trees. All three curves reveal significant gains over ground level with increasing heights.

Note that the rate of increase of wind speed (and therefore, power) as a function of height decreases with surface vegetation. This makes sense when you think about it. Tall towers are much more important if your installation is surrounded by trees. The tree line is, in effect, your "ground line".

The Plot Thickens

Let's go back to our example used with Graph 1. We determined that at 100 feet, the wind speed would be 15.5 mph. If we cube 15.5 (as though we were going to plug the numbers into the power equation), we get the number 3724. Half of this is 1862, the cube root of which is 12.3 mph. In other words, there is only half as much power in a 12.3 mph wind as there is in a 15.5 mph wind.

If we divide 12.3 by 8 mph, the wind at "ground 0", we get an increase factor of 1.54. Going back to Graph 1, this corresponds to a tower height of about 25 feet. We can generate the same amount of power by installing one wind generator at 100 feet or two identical wind generators on their own 25 foot towers.

For Example

Let's assume, for simplicity's sake, that we need a very small system, say a 500 watt Windseeker. We determine our power requirements, and come up with two options: installing one wind generator on a 100 foot tower, or two identical systems using 25 foot towers. Both systems will be installed on two inch guyed water pipe as per the owner's manual. Both systems also include the price of the anchors, guy cables, miscellaneous fittings, and tower wiring. Batteries and inverter have not been included, as they are the same for either system. Here's what it would cost:

Cost Breakdown

Equipment	*100' tower*	*25' tower*
wind generator	$900.00	$900.00
2" pipe for tower ($2.50/ft)	$250.00	$62.50
guy cable ($0.10/ft)	$68.00	$11.00
anchors ($10 ea)	$40.00	$40.00
miscellaneous fittings	$40.00	$10.00
wiring	$40.00	$10.00
Total per system	$1,338.00	$1,033.50
Grand total	$1,338.00	$2,067.00
Cost per watt	$2.68	$4.13

Remember we need two complete systems on 25 foot towers to produce as much power as one system on a 100 foot tower.

Lessons Learned

What does this all mean? We can draw some general conclusions based on the data presented.

- Turbulence and ground drag reduce wind velocity.
- Turbulence and ground drag are minimized with height.
- The rate at which wind speed increases with height is a function of surface vegetation, ground roughness, and buildings around the wind installation.
- The top of these obstacles is the effective ground line for the wind system.
- The higher we go above the effective ground line at our site, the more power our wind installation will produce.

In the next article, we'll examine the cost effectiveness of incremental tower heights.

Access

Mick Sagrillo plots power curves at Lake Michigan Wind & Sun, E3971 Bluebird Rd., Forestville, WI 54213 • 414-837-2267

Graphs adapted from "Planning a Wind Powered Generating System," by Enertech Corp., 1977.

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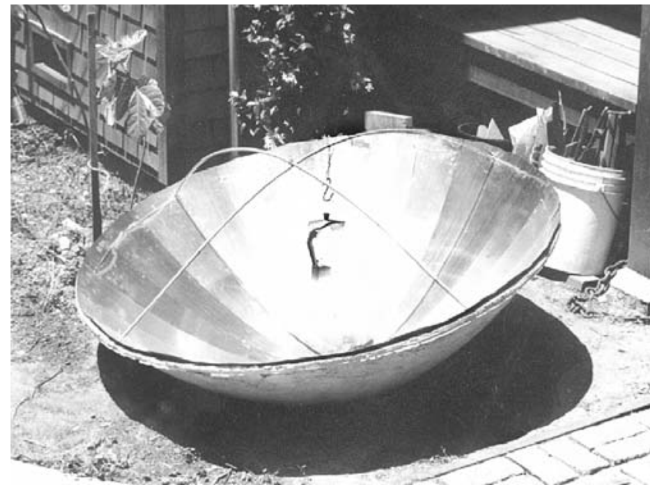
Construction Notes for the

Berkeley Thermonuclear Paraboloid

David Baty



Above: A Thermonuclear Paraboloid making espresso in Berkeley, California.

Build a low tech, high performance parabolic type solar cooker for about $20! This solar cooker is based on the shape of another parabolic cooker, the SK 12, developed by the State Technical College in Altötting, Germany (*HP*#31, p. 65). Our design uses a fundamentally different type of construction and permits using a variety of construction materials. The use of a structural composite shell in lieu of the SK 12's skeletal frame dramatically reduces material costs and simplifies construction.

The Design

A flexible design that allows a variety of materials lets you use stuff that is easy to find, and lets you build to your budget. You can build a functional cooker for next to nothing in material costs. Spending more money initially (up to $20) can result in a cooker which is more durable, easier to build, and more easily repaired.

These are construction notes rather than a rigid set of step by step instructions. I want to encourage you to think about the building process, and, if necessary, to adapt construction techniques to the available tools and materials. Different possibilities are suggested along the way.

The building process is fairly labor intensive for building only one cooker. However, one virtue of this building process is that not only is the finished composite shell (or "dish" as I call it below) the body of a cooker, but it will also serve as a form on which to make another dish. Thus one dish can be the form for another dish. This design is perfect for a cottage industry.

The Pattern

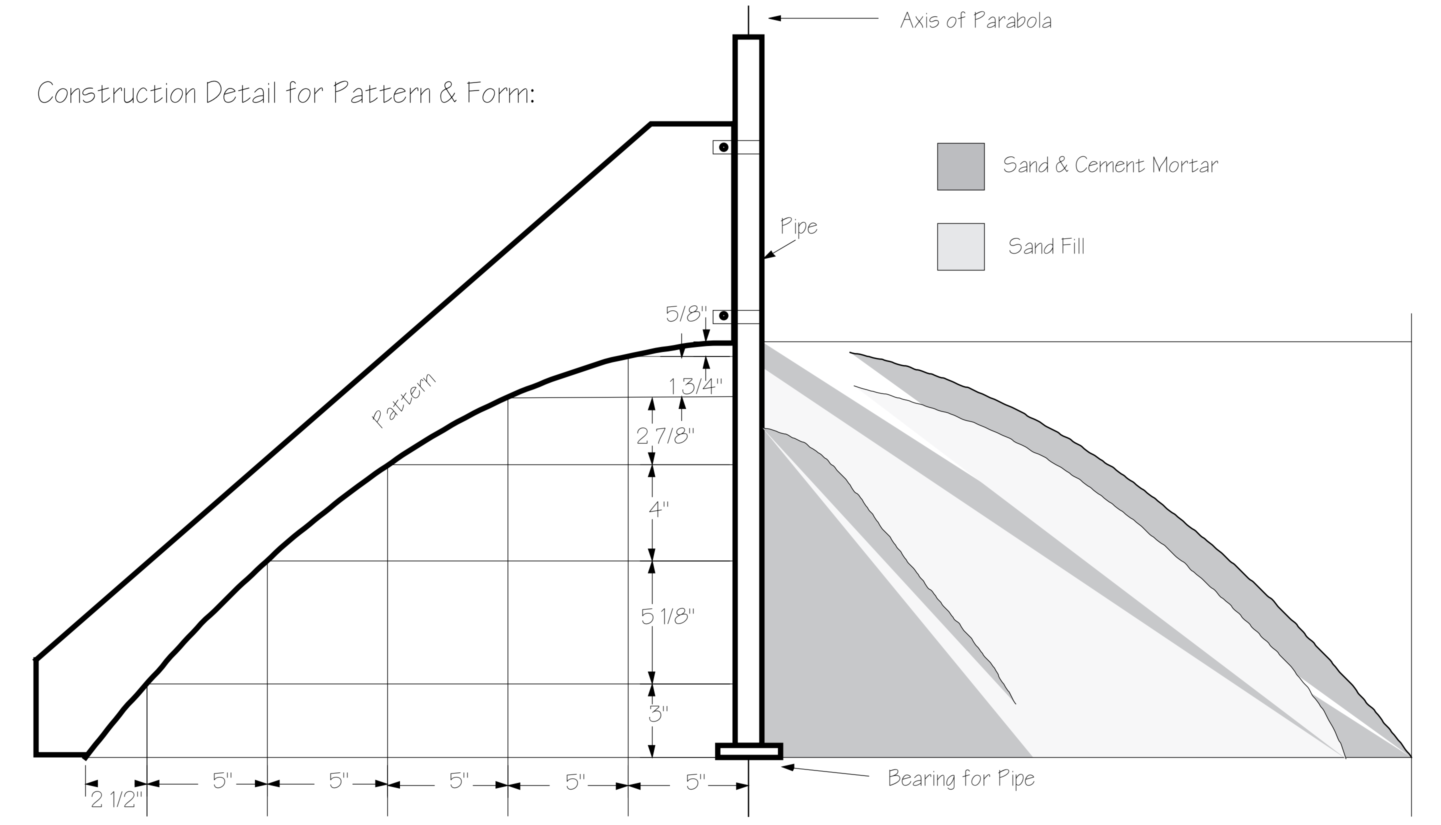
The essence of this design is a simple wood or metal pattern which can create and re-create the parabolic cone. The parabolic cone is the inside face of the finished parabolic cooker.

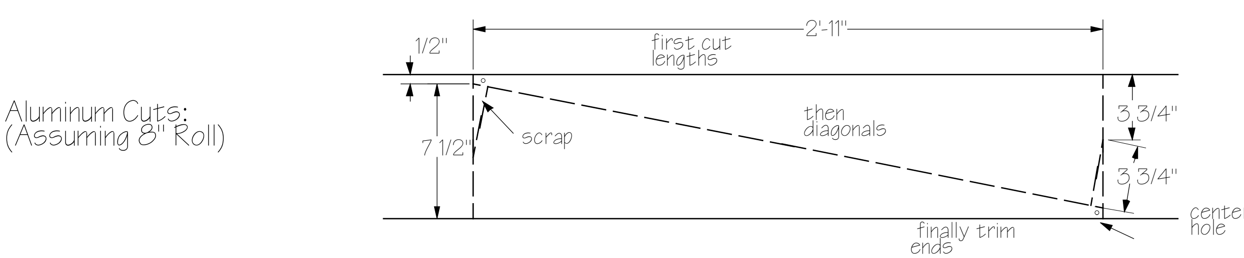
The desired shape of the pattern is shown on the Construction Detail for Pattern & Form. This shape can be transferred to any reasonably stiff material — wood (probably easiest), metal, or plastic. The resulting pattern is attached to a 30 inch or longer piece of pipe, dowel, or other round stock to use as a vertical bar. I used an unthreaded piece of ¾ inch pipe. This bar sits on a bearing of some hard material — almost anything: a scrap of metal, glass, tile, a rock….

The pattern is clamped onto the bar in such a way that its location on the bar can be moved up or down. My pattern was a piece of wood, attached to my pipe with two pieces of plumbing strap and two machine bolts. Any village handyman should be able to cobble together a functional equivalent from whatever wood, metal, wire, and/or vines are locally available.

The Form

The first step in building the form is to create a pivot around which the bar and pattern can rotate. This pivot is no more than a pile of mortar (sand and cement mixed approximately 4:1) piled up around the bar a foot or so high. The bar should be sitting on the bearing, pretty close to vertical. Rotate the bar slightly once or twice before the mortar hardens and the cement sticks to the bar. Let the cement set at least overnight.





After making this mortar bearing I piled sand (almost anything could be used as a filler here) over the pile of mortar. There was 1½ to 2 inches of space between the sand and where the pattern could rotate.

I made the finished surface of the form using more mortar (sand and cement 4:1) and rotating the pattern to trim excess mortar from the pile. This procedure may feel like a labor intensive mess until you begin using the pattern. It is easy to generate a precise shape using the pattern to trim and smooth the layer of mortar that is the finished surface of the form. The surface of the form doesn't need to be exact, but since this form can be used to create more parabolic dishes, it's worth taking the time to get it as nice as you can. Let the finished form harden at least overnight.

The Dish

I was familiar working with mortar and impatient to see how well this technique would work for creating a thin composite shell. So I decided to make the first dish of ferro-cement with two layers of chicken wire and mortar (sand and cement 3:1).

I removed the pattern from the bar and covered the form with a very thin (0.27 mil) piece of plastic sheet to prevent the dish from sticking to the form. Regular plastic wrap, wax paper, etc. would work as well. Above the plastic wrap I laid approximately two layers of light weight chicken wire. The wire will lay quite close to the form if you make a few radial cuts in the wire towards the edge of the dish and tighten the chicken wire at the center by twisting loops. Extra wire towards the edge of the dish is probably a good idea for strength.

When the wire was pretty close to the surface of the form, I reattached the pattern to the bar. The pattern was approximately ¾ inch above the form. By rotating the pattern above the form I could see where the wire needed to be worked closer to the form. I didn't mind if the pattern touched the wire but I wanted the pattern to move easily around the form.

Above: After the form is done, Cody Brewer constructs a parabolic cooker.

When the pattern would swing fairly easily around the form without hanging up on the wire, I mixed a somewhat cement rich mortar — about 3 parts sand to 1 part cement. I then used the pattern to shape a ⅝ inch to ¾ inch thick shell the same way I'd used it to create the form. When making the dish I had a little trouble with wayward chicken wire and I wished I'd spent a little more time with the wire before applying the mortar.

After the dish is formed, a number of small holes are poked in the still soft mortar about an inch and a half from the rim. These holes are evenly spaced and correspond to the number of aluminum reflector pieces used. In this case I needed 28 holes a little less than 6 inches apart. The holes allow a piece of wire to lace the ends of the reflector pieces to the rim of the dish. These holes can be made with a nail or small stick. Finally, I covered the dish with more plastic wrap, shaded it, and let the cement cure for about 4 days.

To remove the dish from the form I made several small wooden wedges and gently tapped them between the edge of the dish and the form. The dish came loose easily. Two people were able to lift it off and turn it upright. The finished dish weighs about 100 pounds, easily moved by two people. Adjusting its orientation to the sun takes one person. The dish feels stable and shows no sign of being troubled by animals or children. Since it is made of cement it will not rot or burn.

This dish requires nothing fancy in the way of a mount or support. A shallow hole in the ground works nicely. We used an old car tire at the contest. Point the cooker toward the sun by pulling up on one edge of the dish.

The Reflector

The reflector material is sheet aluminum 0.010–0.020 inches thick. This material is commonly available, at least in the U.S., as aluminum roof flashing in rolls of various widths by 50 feet long. One roll weighs about three pounds and provides more than enough material for one cooker. The cost of the reflector material is about two thirds of the cost of the whole cooker.

One could build this cooker using aluminum foil, reflectorized mylar, or flattened aluminum cans for less money. However, this initial savings will likely involve a sacrifice of performance, durability, repairability, and ease of construction. Given the moderate cost, durability, ease of working, ability to conform to an efficient parabolic curve, and ease of repair it would be hard to beat this aluminum flashing. Initially cheap is often not ultimately cheap.

The aluminum is easily cut with a sharp knife and straight edge. Make two or three firm passes with the knife and the scored aluminum readily bends and breaks along the scored line.

The number of reflector strips must correspond to the number of holes previously cast in the dish. The reflector could be made of various width strips depending on the availability of aluminum. The wider the strip the less cutting of aluminum, but the more the shape of the reflector will depart from the desired parabolic shape. The design of this cooker is based upon the use of an eight inch wide aluminum roll. Twenty-eight reflector pieces are required to easily cover the interior of the dish. The aluminum is cut (see p. 35) to minimize waste.

After the reflector pieces are cut, punch or drill a hole near the narrow end. Stack all of the pieces up, drill a small hole near the narrow end and drop a small machine bolt through the hole. This assembly of reflector pieces can be secured to the inside face of the dish by placing the bolt in the center hole of the dish. Secure the bolt in place with a nut and washer(s) on the outside. Leave the nut loose enough to allow the reflector pieces to be fanned out evenly around the dish so that the entire inside surface of the dish is covered. This same arrangement can be accomplished with punch (nail, sharp stick) and short length of wire or string, as locally available.

The outer edges of the reflector are simply laced to edge of the dish. Overlap two adjacent reflector pieces over one of the holes cast in the rim of the dish. The hole in the dish is used as a guide to punch or drill the hole in the reflector pieces. A piece of wire is threaded through these holes and in and out the other holes around the dish. Separate wires could be used at each overlap of the reflector pieces, but using one wire laced around the entire dish gives a nicer appearance.

The Pot Support

The pot support keeps the cooking pot at the focus of the parabolic cone regardless of the angle of the cooker, and provides an easy way to aim the cooker at the sun. This support is simply a couple of slender pieces of wood or metal about 60 inches long. These are sprung across the rim of the cooker at right angles to one another, wired or tied together where they cross.

If the cooker is tilted, one of these cross pieces should be oriented so that it runs from the high point to the low point of the dish. This cross piece will provide a support from which to hang a cooking pot at the focus of the parabola. The other cross piece stabilizes the first piece against movement from side to side. The shadow of the intersection of these pieces on the center of the parabola indicates when the cooker is aimed directly at the sun.

Above: David Baty and Cody Brewer at the 1993 Home Power Solar Cooker Contest.

Use

The theoretical focal length is 11 inches, a point safely inside the parabolic curve. The focus of this parabola is soft; it concentrates the sun's energy to a hot spot, but not a dangerously hot point. This spot is easily located with one's hand when the cooker is aimed at the sun. It is also useful to learn how the focal point changes when the cooker is no longer aimed directly at the sun. I imagine that learning to cook on a parabolic type cooker would be analogous to cooking over a fire. The cooker must be tended from time to time to maintain heat by reorienting to the sun, just as a fire must be fed more fuel to maintain heat. Within both the cooker and a fire there are naturally hotter and cooler areas, and both heat sources if left untended will gradually cool off.

The cooker develops temperatures high enough for frying food. Popcorn and espresso are now culinary events that are quite easily done in a solar cooker. One can cook more than a single dish of beans and rice during the course of a day. We have used it to boil a quart of water in about 12 minutes. One parabolic cooker has the potential of doing the same amount of cooking as several box type cookers. Higher temperatures allow more types of cooking techniques. A parabolic cooker can be used to purify drinking water, heat bath water, etc. During less than ideal weather a parabolic cooker is more likely than a box cooker to have the solar gain required to cook a meal.

The Future

Cody Brewer and I have been experimenting with this cooker for just a little over two months and have experimented with different materials for the dish and construction details. We are planning to do a "production run" of 20–50 dishes to refine construction techniques for building these cookers in non-industrialized areas. We encourage anyone interested in the cooker, particularly its production, to contact us.

Access

Author: David Baty, 2929 M.L.King Way, Berkeley, CA 94703 • 510-848-5951.

A version of these construction notes and full sized blueprint of the pattern are available for $5 postage paid at the above address.

Using Magnetic Fields to Change Voltages

Chris Greacen

At the turn of the century a battle raged over whether the country would be run on alternating current (ac) electricity, or direct current (DC) electricity. Thomas Edison was the big proponent of DC electricity. The eccentric inventor Nikola Tesla, backed by George Westinghouse, was sure the future lay with ac electricity. When the dust cleared, the utilities chose ac electricity. The determining factor was that ac electricity can easily be changed from one voltage to another using transformers. This meant that power could be produced at a voltage convenient for the power plant (hundreds of volts), transported great distances at a higher voltage (hundreds of thousands of volts), and eventually reduced to lower, safer voltages for use in homes and businesses.

Historically, homes powered by renewable energy were 12 Volt homes. Energy was produced, stored, and used as 12 Volt DC. We're finding, though, that renewable energy systems can be cheaper and more flexible if we play some of the voltage transforming games which the utilities have long been doing on a grand scale. This allows power producers (solar, wind and hydro) to harvest Nature's energy offerings efficiently. It allows low-loss transportation, and convenient and safe storage and use.

Technology has progressed since the days of Tesla and Edison. Nowadays it's possible to "transform" DC electricity from one voltage to another using DC to DC converters. These circuits are more complex than ac transformers, because they contain an oscillator and switching circuitry. But properly designed, DC to DC converters can be smaller, more flexible, while just as efficient as the best transformers. PowerStar and Statpower inverters and Todd chargers are common renewable energy equipment which use DC to DC converters in places which had previously been the exclusive territory of 60 Hertz ac transformers. Bobier Linear Current Boosters and Solarjack pump controllers are DC to DC converters which "transform" the power from photovoltaics to better match the current and voltage needs of DC electric motors.

How Does This Stuff Really Work?

Let's get into the nitty gritty, starting with how transformers work. My last article (*Home Power* #35, page 77) discussed magnetic fields created by electrical current, and electrical current made by changing magnetic fields. Here's a recap of the two laws of physics at work.

Ampere's Law: *When current flows in a wire it creates a magnetic field wrapping around the wire.*

The "right hand rule" predicts the direction of the magnetic field: point the right thumb in the direction of

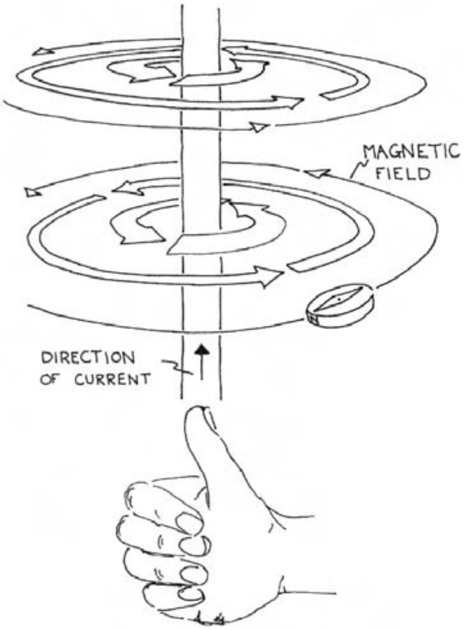


Figure 1: the right hand rule.

the current, and the fingers wrap around in the direction of the magnetic field.

If you wrap the wire into a coil, a current flowing in the wire creates a magnetic field (stronger than one made by a straight wire) inside the coil. A coil of wire like this is called an inductor.

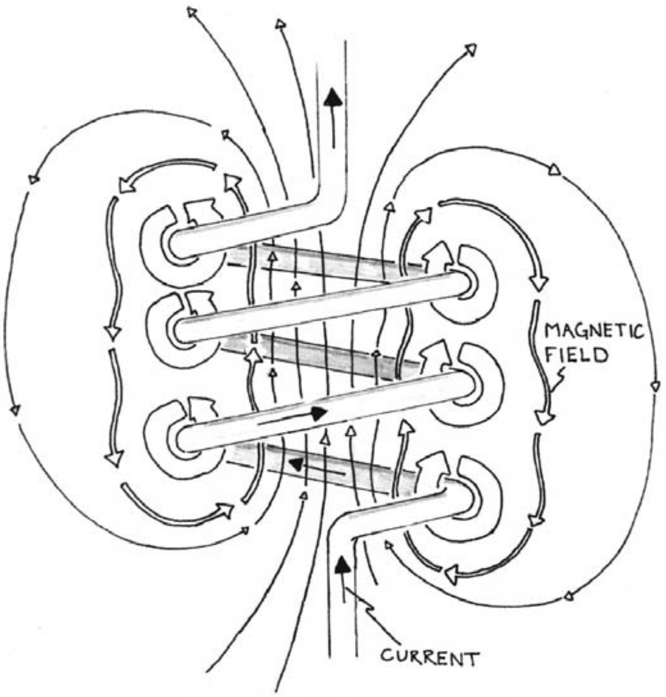


Figure 2: Magnetic Fields in an inductor.

The more turns of wire, the greater the magnetic field. If you stick a hunk of iron inside the coil the magnetic field can increase thousands of times.

To convince yourself Ampere's law is for real, make an electromagnet. Wrap a small (22 gauge to 26 gauge) wire 100 or more times around a big nail. Connect the wire ends to the positive and negative sides of a flashlight battery. Pick up washers, small bolts. Try more wire wraps, or another battery in series. (Note: this experiment is pretty hard on batteries)

Faraday's Law: *A changing magnetic field produces a voltage in a nearby wire.*

The current (if any) which flows as a result of this voltage will be in the direction such that the magnetic field it produces will counteract the original magnetic field change. If this sounds confusing, read on, it will make more sense as we look at how a transformer works.

Transformers

Figure 3 shows a simple transformer. The "primary" winding (on the left hand side) is where you put in the ac electricity you want to "transform". You attach the load to the "secondary" winding (right hand side). A soft iron ring magnetically couples the primary and secondary. In this picture the primary winding has 15 turns, and the secondary has three. This was easy to draw, but let's pretend they have 150 and 30 turns respectively, as a real transformer might.

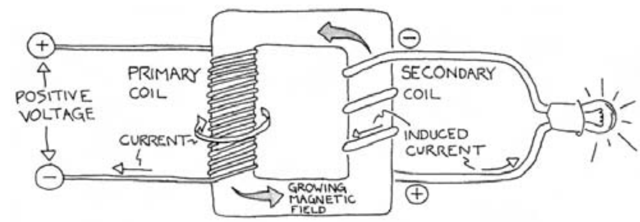


Figure 3

Imagine applying direct current (not ac) to the primary. The current flowing through the primary coil creates a magnetic field (pointing downward in the picture). This magnetic field travels through the iron core (counterclockwise) and inside the loops of the secondary coil. For the instant that the magnetic field grows from zero to its full strength, it induces a voltage in the secondary coil, and the bulb lights for a moment. But the instant the magnetic field stops growing (when the primary current reaches a steady state — Figure 4), the bulb goes out (secondary current is zero).

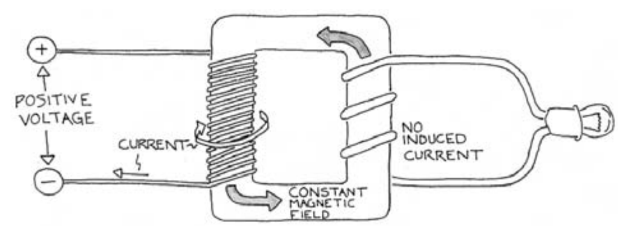


Figure 4

Now disconnect the direct current to the primary (Figure 5). Current stops flowing in the primary, and therefore the magnetic field dies away. This decreasing magnetic field momentarily induces a current in the secondary the opposite direction as before. Again the bulb lights for a moment. The important thing to keep in mind is that current only flows in the secondary when current in the primary is changing (growing or shrinking).

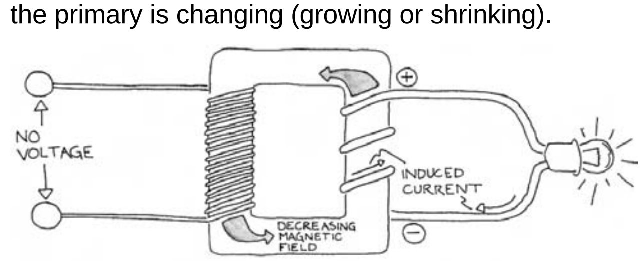


Figure 5

Connect the primary wires up so that positive and negative are switched from what they were at first (Figure 6). The current in the primary goes the other direction now, and therefore so does magnetic field. You could say the magnetic field decreased from zero to some negative value. Again a changing magnetic field induces a current in the secondary, and the bulb glows.

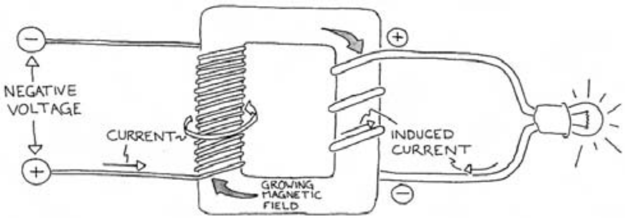


Figure 6

It was the changes in the DC voltage that induced current in the primary. But ac (alternating current) is always changing. For example America's 120 vac sloshes from +165 volts to -165 volts sixty times a second. An ac voltage applied to the primary, creates an ac voltage on the secondary. For a perfect transformer, the voltage of the primary divided by the voltage of the secondary is equal to the number of turns in the primary divided by the number of turns in the secondary.

$$V_p/V_S = N_p/N_S$$

where V and N refer to voltage and number of turns, and the subscripts p and s refer to the primary and secondary coils. If you fed the transformer (Figure 3) 15 volts ac, you'd see 3 volts ac on the secondary, since

(150 turns/ 30 turns) = 5 = (15 volts ac/ 3 volts ac).

A transformer like this, with less secondary turns than primary turns ($Ns < Np$) is called a step-down transformer. What would happen if you exchanged the primary and the secondary? You would get a step-up transformer. If you plug 15 volts ac into the side with 30 coils, you'd see 15 volts ac x (150 / 30) = 75 volts ac.

And that's all there is to it. The transformers in inverters, and in wall cubes (the things that you plug in the wall to power small 9 Volt or 6 Volt appliances), and big utility transformers you see on power poles — all of them work pretty much the same way.

DC to DC Converters

Doing the transforming thing for DC is more difficult. The problem is that you can only get energy out of magnetic fields if they're changing. And you can't make changing magnetic fields with DC. You could take DC, and chop it up into ac, and then run it through a transformer to change its voltage, and rectify it back to DC. Indeed, this is sometimes done. But in addition to something that chops electricity, this approach requires a transformer (two coils of wire), and a full wave rectifier (four diodes), and filtering capacitors. A "switching" DC to DC converter is an elegant, efficient solution. It requires, in addition to a "chopper", only one coil of wire (an inductor), and a single diode, and (usually) a couple of capacitors for filtering. They come in three flavors: Buck, Boost, and Inverting.

The Klüge Firefighting Buck Converter.

Dr. Klüge and his duck friends are on fire duty, putting out boat fires. The fireboat they've constructed has a tank of water on a high platform. This is great for making a high pressure spray of water, but it only lasts for a short time — until the tank runs out. Is there a way they can use the water in the tank to pump some ocean water so they can get more water (but at a lower pressure) for fighting fires?

The Dr. Klüge solution: use a turbine attached to a flywheel, a check valve, and a valve that can be quickly opened and closed by a dedicated duck. When the duck's valve is open wide, water from the tank flows out through the hose, spinning up the turbine and the flywheel as it goes. Then the duck closes the valve. The flywheel keeps the turbine spinning, now strongly sucking water up from the check valve to the ocean. When the turbine slows down, the duck opens his valve again to speed it up. Now the water coming out the hose for the fire is the water from the tank plus the pumped water from the ocean.

Buck Converters

Buck converters change DC electricity from a higher voltage to a lower voltage. They're the most common DC to DC converter in the renewable energy world. Linear Current Boosters and other pump controllers are buck converters. They work a lot like Dr. Klüge's fire boat. A coil of wire (an inductor) plays the role of the flywheel and turbine. A diode is the check valve to the ocean, and the "duck valve" is an oscillator and a power transistor — usually a FET. (For more on components, see the Basic Electricity articles in *HP*#32, #34, #35).

Let's start with the circuit off: no currents flowing and no magnetic fields. When the transistor is turned on, current starts to flow from the higher voltage supply, through the inductor, to the load. The increasing current stores up energy as a magnetic field in the inductor. When the transistor turns off, the energy stored in the inductor works to keep pulling current — but from where? Up from the diode from ground! Eventually the energy stored in the inductor is expended pumping this current up through the diode. Then the transistor turns on again, bringing current from the higher voltage source, charging up the inductor.

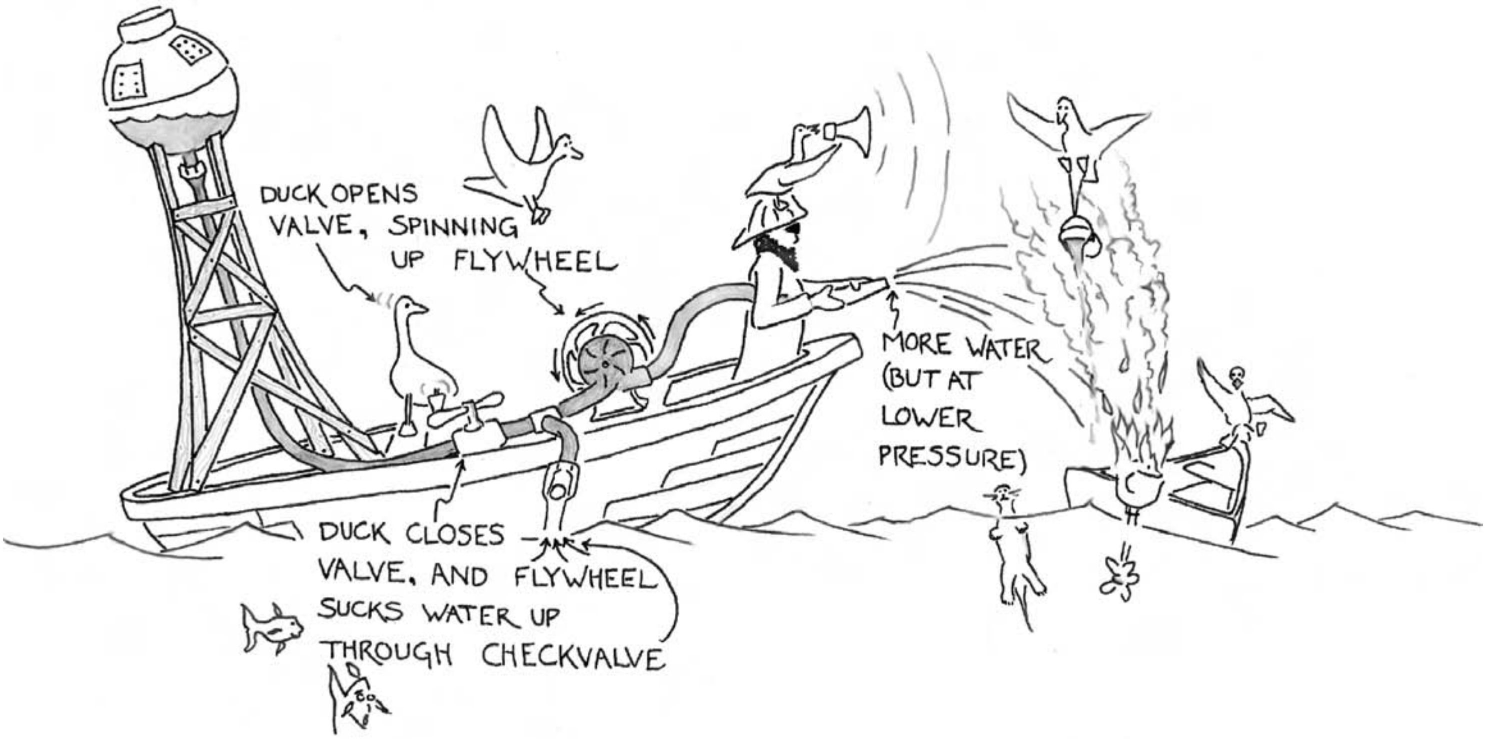


Figure 7: Dr. Klüge's fireboat does with water what a buck converter does with electricity.

Is this rigorous enough for you? I can explain it without talking about "energy" if you want. When the transistor turns on, increasing current in the inductor builds an increasing magnetic field which, in turn, induces a voltage opposing the increasing current. When the transistor is turned off, the current through the inductor is no longer increasing — it's decreasing, and the magnetic field begins to decrease. The inductor's decreasing magnetic field drops the voltage at point X to –0.6 Volts, and current flows up through the diode, through the inductor, and out to the load. (If the diode weren't there, the voltage at X would drop well below –0.6 Volts.) The collapsing magnetic field provides the voltage "rise" across the inductor to pump current to the load. Finally, the transistor turns on again, repeating the cycle. Capacitors on both sides of the DC converter absorb voltage ripples caused by this somewhat jerky process. See the Home Brew in this issue for a simple buck regulator you can build to efficiently provide up to 3 Amps at 12 Volts DC from any 14 to 40 Volt source.

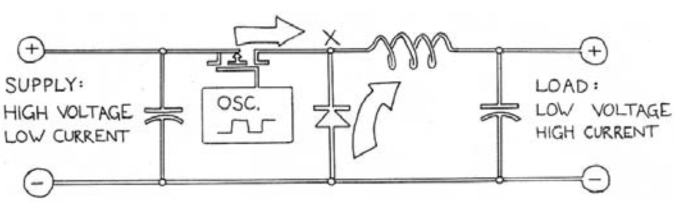


Figure 8: Buck converter

Boost Converter

Rearrange the transistor, inductor, and diode, and you get a boost converter: low voltage/high current in — high voltage/low current out. Have you ever looked at how a hydraulic ram pump works, using a lot of water falling a short distance to pump a small amount of water higher? (See *HP*#28, page 11 for a diagram) A boost converter is the ram pump's closest electrical cousin. The transistor to ground entices increasing current to flow through the inductor. Then the transistor is switched off, and the current (driven by the inductor's collapsing magnetic field) has no place to go except out the diode to the higher voltage load.

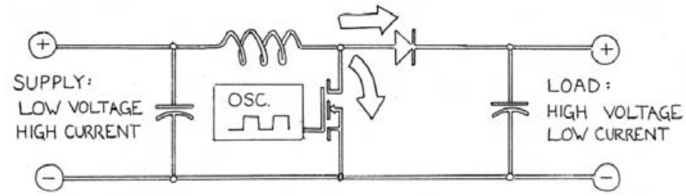


Figure 9: Boost converter.

Inverting Buck/Boost Converter

There's one last rearrangement of the inductor, transistor, and diode, making an inverting converter. Put in some positive DC voltage and you get out a negative DC voltage. When the transistor is turned on, an increasing current flows through the inductor to ground, building up the inductor's magnetic field. When the transistor is turned off, the inductor's collapsing magnetic field sucks current through the diode, dropping the voltage of the load below ground.

Inverting converters are versatile: the magnitude of the output voltage can be greater or less than the input voltage depending on the frequency and duty cycle of the oscillator. But they require greater currents through the transistor than do the buck or boost circuits above. This means bigger, more expensive transistors.

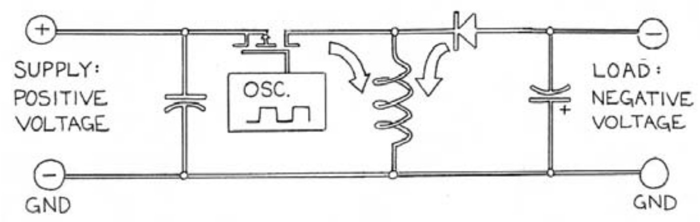


Figure 10: Inverting converter.

Access

Author, Experimenter, and Artist: Chris Greacen, Rt 1 Box 2335B, Lopez Island, WA 98261. Thanks to Anne Brandon, Beaverton, OR, for the idea of the plumbing inductor.

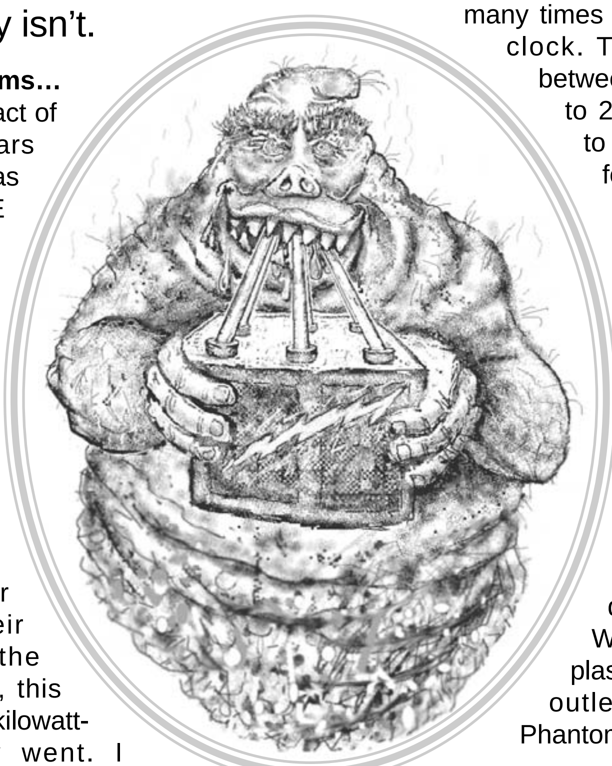
Phantom Loads

Richard Perez

Just because the switch says "OFF" doesn't mean a device is not consuming electric power. Many modern appliances contain clocks, memories, remote controls, microprocessors, and instant-on features that consume electricity whenever they are plugged in. That's 24 hours a day, 7 days a week…. While these Phantom Loads are often small, their power consumption really adds up. Some Phantom Loads are easy to spot — clocks and and timers have displays. Other Phantom Loads are truly hidden: the appliance seems off when it is switched off, but it really isn't.

My introduction to the phantoms…

I first became aware of the impact of phantom loads about five years ago. At the time I was working as an installing dealer of RE systems. I had a call from a customer complaining that his brand new batteries weren't working. Immediately after installation, the family went on vacation for three weeks and returned to fully discharged batteries. I made a service call to the site and investigated. After questioning, it was apparent that the family had mistakenly left their inverter up and operating during their vacation. But since all the appliances were switched off, this couldn't explain where the two kilowatt-hours of daily PV energy went. I questioned the family further, "Did you add any new appliances to the system?" "Yes," they replied, "we bought two new TV sets and a new stove with electronic ignition." And the hunt was on!



While the two 21-inch color TVs looked great, both were equipped with remote controls and "instant-on" picture tubes. A quick measurement determined that each TV was consuming 28 watts even when switched off. Most of this power was keeping the filaments in the picture tube warm 24 hours a day. A quick go with the calculator gave us a total inoperative TV power consumption of 1300 watt-hours daily. Measurement of the stove showed that the power supply driving the electronic ignition was operating 24 hours a day and consuming 14 watts. So the stove was consuming about 330 watt-hours daily, even when no one was cooking. Since all these appliances were powered via an inverter, the actual power consumption was even higher due to inverter inefficiency. I figured that the two TVs and the stove were consuming about 1,900 watt-hours of power daily. And they weren't even being used!

Obvious Phantom Loads

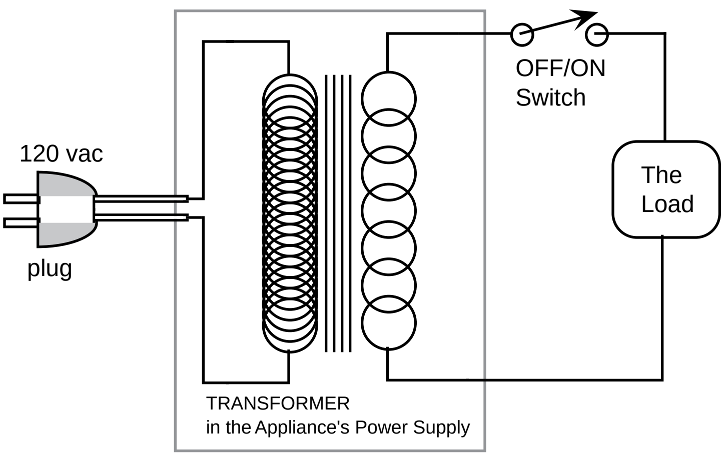
Consider a clock. Many microwave ovens, washing machines, stoves, VCRs, and other appliances contain a clock or timer. The electronic clock/timer and its display consume very little (≈0.5 Watts). However, there is a power supply in the appliance that converts 120 vac into low voltage DC for the clock/timer. This power supply is very inefficient at low power, consuming many times the power actually used by the clock. This power supply consumes between 4 and 8 Watts or about 100 to 200 Watt-hours daily — enough to run a compact fluorescent light for about ten hours.

Sneaky Phantom Loads

Some Phantom Loads appear to be truly OFF when switched off. There are no lights or indicators showing power consumption, but the device is still using electricity. Offenders in this category include instant-on TVs, stereos, VCRs, computers, calculators, computer printers, satellite TV systems, and any device powered by a "wall cube". Wall cubes are power supplies in plastic boxes that plug into 120 vac outlets. Let's visit a few of these Phantoms where they lurk.

The Primary is Alive!

Many 120 vac appliances contain power supplies. These convert 120 vac, either inverter or grid produced, into low voltage DC for the appliance's electronics. On some appliances the ON & OFF switch is placed on the secondary (low voltage side) of the supply's transformer. The primary is not switched and is always connected to the 120 vac source. See the diagram below.



The inverter or commercial power grid sees the primary of the transformer as a constant load. Power consumption on these devices may run between 50 to over 200 Watt-hours daily.

Filters and Line Conditioners
Many 120 vac business appliances like computers, printers, typewriters, FAX machines, and copy machines use small filters on their power input. These filters serve a useful purpose — protecting the device from overvoltage, surges, noise and other electric trash that may wander onto the grid supplied electrical lines. Unfortunately, most of these filters are wired in ahead of the power switch, and are online all the time. They consume power from the inverter — about 8 to 40 Watt-hours daily. True power conditioners like ferroresonant line conditioners made by Sola, LineTamer, and many others can also be Phantom Loads. For example if a 500 watt power conditioner is used to filter inverter power for a computer system, then the filter will consume about 250 watts even if the computer system is unplugged from the filter.

Wall Cubes
These small black boxes are really Phantom Loads. Wall cubes are actually small power supplies. Consider the case of a telephone answering machine powered by a wall cube. The wall cube is plugged into an electrical outlet and feeds the answering machine via a low voltage power cord. The ON/OFF switch is located on the answering machine itself. Even if the answering machine is turned OFF, the wall cube still consumes electricity. This is electrically the same as having a power switch on the transformer's secondary — the primary is alive all the time. A wall cube uses 20 to 50% of its rated power even when its device is switched off.

Dealing with Phantom Loads
Unplug the appliance! This works for sure because it is disconnected from its power source. However, constantly plugging and unplugging is a pain and wears out the plug and socket quickly. Just about every hardware or discount store sells extension cords with multiple female plugs that are *switched* on the plug strip. They sell for $4 to $8. When the plug strip is switched OFF, all the appliances plugged into the strip are disconnected from the 120 vac power source.

We use these plug strips for all phantom loads. Here on Agate Flat, we have many SL Waber (Model EP7S, costing $5.99 at the local discount house), seven outlet, plug strips with neon indicator lights. The neon indicator glows when the plug strip is turned ON and supplying power to all the phantom loads connected to it. We have all our computer equipment, all remote controlled electronics (TV & VCR) and many wall cube powered devices plugged into these strips. I don't mind feeding these appliances when they are actually operating, but I don't want them wasting power and flattening our batteries when they are supposed to be OFF.

Selecting Appliances that are NOT Phantom Loads
Any appliance with a built-in electronic clock or timer is a constant and obvious phantom load. If you want a clock, then buy a clock, not a microwave or VCR. Avoid appliances with electronic memories unless these memories are kept alive by small batteries within the device.

In many cases all appliances of a particular type are phantom loads. VCRs, for example, all contain clocks and timers that are alive even if their displays are not lit. All appliances using wall cube power supplies are phantom loads. Every piece of electronic office equipment is a micro phantom load because of its filtration. Here the switched plug strip comes to our rescue.

The Bounty on Phantom Loads
If you live on the commercial grid, you're paying an average of 7.75¢ per kilowatt-hour for electricity. A small phantom load of 4 watts costs you about $2.70 yearly.

If you make your own electricity, then the savings situation is even better. Site produced power costs much more, about 60¢ per kilowatt-hour. The 4 watt phantom load costs home power producers about $21 per year. The plug strip pays for itself in less than 4 months. And we get to use our power elsewhere.

The bottom line for an individual phantom load tells only part of the story. Sure we can save some money by disconnecting phantom loads. We can also save resources for use elsewhere. We can also eliminate the pollution produced by the power going down the throats of phantom loads.

Regardless of the electrical power source, phantom loads waste energy because they don't do anything in return for their power consumption. While in the individual sense, these phantom loads are small, in the collective sense, we're wasting enormous amounts of electricity.

ENERGY CONSUMPTION IN PHANTOM LOAD APPLIANCES

The Small Picture — 1 household

The Big Picture — 93,347,000 households

Quan	*Phantom Load Appliance*	*Watts*	*Watt-hrs. per day*	*% Equipped*	*millions of KWH per year*
1	Instant-on TV	28	672	80%	18,317
1	Video Cassette Recorder	14	336	70%	8,014
1	Microwave Oven w/clock	8	192	60%	3,925
2	Wall Cube Power Supply	5	240	90%	7,359
1	Stereo w/remote control	8	192	50%	3,271
1	Electronic Ignition Stove	14	336	20%	2,290
	Totals	77	1968	*Total*	43,176

Let's do a little calculator speculation about phantom loads. A homestead powered by PV or wind can face between 1 to 2 kilowatt-hours of extra energy consumption from phantom loads. That's roughly equivalent to the energy produced by four to eight photovoltaic modules at a cost of around $350 each. Add also extra batteries to power the phantom loads at night. When you're making your own electricity, phantom loads are the enemy! Break out the plug strips and launch a direct frontal attack!

On a more serious, grid-connected note, our nation wastes about 43 billion kilowatt-hours of energy on phantom loads yearly. The spread sheet above shows how this was calculated. This is enough electrical energy to totally provide the countries of Greece, Peru, and Vietnam for one year. When I consider that this energy does nothing but waste power and produce pollution, I am ashamed.

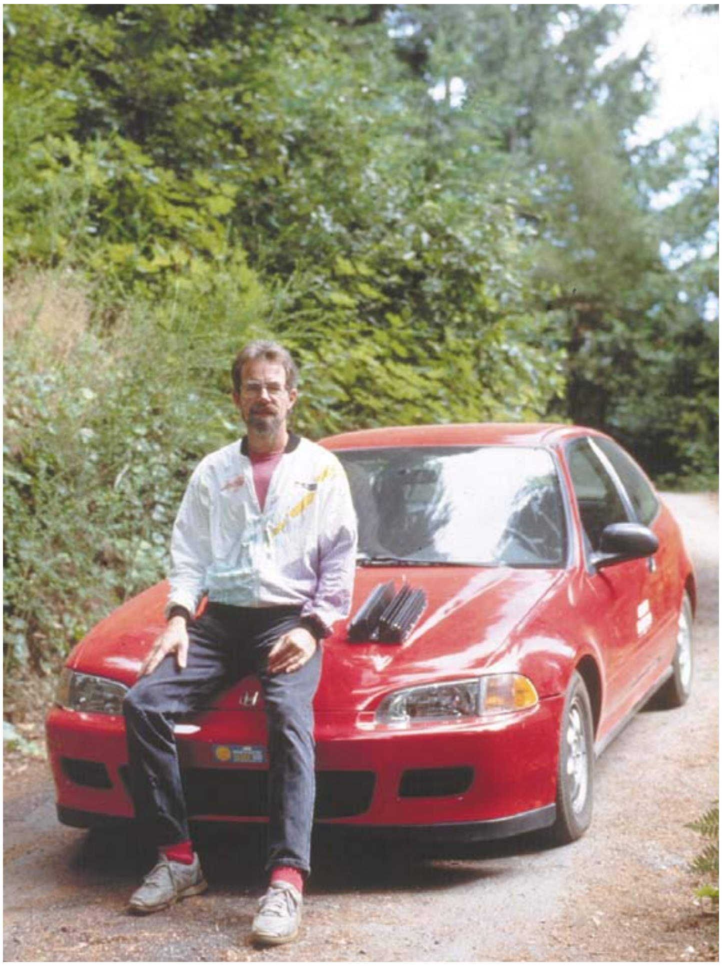
Access

Author: Richard Perez, c/o Home Power, POB 520, Ashland, OR 97520 • 916-475-3179

Artist and renderer of the Phantom Load Demon: Stan (the pixelating pinhead) Krute, c/o Home Power, POB 520, Ashland, OR 97520

The Silent Revolution

Michael Hackleman



Almost two decades ago I discovered a wonderful machine. I was busy plowing through new and old technologies — full of windmachines, solar panels, biogas containers, and waterwheels. One of the things I found was a way that I could make a car plug into a windmachine. A car that could run on the wind energy I was generating on my farm. It was the electric car. I wrote a book on what I found. And I went on with my journey, other discoveries, other books, other fields.

Years later, I came back to electric vehicles (EVs) Like a parent looking for a lost child in the blankets, I was surprised a little that the EV hadn't taken off by itself. It was such good technology. A natural for the planet. Something that fixed a lot of problems with such a low-tech solution. Its silence shouts its efficiency. It works well even without transistors! As basic propulsion beyond human power, it was good.

In my workshops, I sometimes tell the story about my first wild ride on an electric. It was a runaway. The modified golfcart didn't *act* like one at all! Up to then, the technology had been bridled, held back. It was better than it looked at first glance. With me, it has survived the test of time.

When I started looking for more information on EVs, I found it. Written material buried deep in the library system, one hundred years old. The discovery was intense. So, I had no problem identifying with Richard Orawiec's passion in "Relaunching the *Esther*". Electric vehicles have proven themselves in many applications over time. Electric cars, electric buses, and electric trains offer some of the most benevolent technologies — all ready for us to use. "And the plug for it is in the sky!" says Richard, standing on an electric boat.

Driving an electric car daily has taught me some humility. I feel more thoughtful of the way I use transportation. I don't just mindlessly power myself about. I plan trips. As a Solar Eagle teammember (see "Racing Solar Panel Design"), I grew to appreciate how little energy it takes to move ourselves about. I discovered that EVs weren't the handicap I thought they would be. It's true that knowing how much electricity I have on board is a challenge. And yet — it's not. Again, I'm *thinking* about it.

Another discovery is something that electrics have that engines won't until they're screaming. Low-end torque. With utmost efficiency and quiet elegance, you can beat almost any other car off the line at the traffic light. Indulging yourself or not, it's nice to know that you *can* do it.

I felt something this past year that I haven't felt before, relative to EVs. A feeling of success. Electrics are going to make it. They have some distance to go. A lot of refinement. Rick Proctor's "Catching the Dream" is proof that many are accepting the challenge. Education is important. Mingling with professionals, even competitors, maintains perspective, as indicated in “The REDI Report.” Listening to the voice of experience, as with Shari Prange’s “Electric Car Speed Control Systems,” assures the driving public that EVs are safe and reliable.

Driving an electric has taught me about addiction. If your day doesn’t happen without a car, then you’re dependent on it. Willfully engaging in a transportation system that kills 50,000 people in the U.S. each year in accidents alone, is either crazy or addictive behavior. Which one is yours?

It’s a scary time. Changes abound. Breathe! I believe the saying that fear is excitement without breath. Part of the belief system with GoPower is that non-abusive transportation is possible. Electric transportation (not necessarily cars) is a piece of the puzzle. Electricity is magic. It’s a nice way to move energy. Like my words on a screen. The print you read. Positively electric.

GoPower is for *you*. When you’re ready to do something relative to transportation, I want to help make it happen. As Michael Leeds says, “If you want *your* dreams to come true, help make *other* people’s dreams come true.” If you *are* already doing something, share it with GoPower’s readers. I want pictures and words. You don’t have to be a good writer. Don’t worry; I’ll make you look good. If you describe also what did *not* work, you warn others of the pitfall. Effort *is* important. Ask questions. Suggest answers. The future belongs to all of us.

Access

Author: Michael Hackleman, c/o Home Power, POB 520, Ashland, OR 97520

A note on the photo on page 49:

This is a commercially available, electric commuter vehicle made by Doran. See ad index for access.

Above: The Solar Eagle tastes its first solar energy on the CSULA track.

Racing Solar Panel Design: Part Four

Michael Hackleman

While publishing *Alternative Transportation News*, I began a series on designing and fabricating the solar panel for the Solar Eagle, a world-class solar race car. In 1990, the Solar Eagle placed 4th of 32 cars in the transcontinental Sunrayce USA, and 10th of 42 cars in the transcontinental World Solar Challenge in Australia. Although this was, therefore, a highly competitive design, there *are* more similarities in various solar panel designs than differences between them. This series, then, was intended to reveal design and construction techniques that would apply to a scratchbuilt solar panel for mobile or stationary applications.

In the first of my articles on Racing Solar Panel Design (*ATN,* Jun/Aug 91), I toured the design issues, the constraints due to panel shape and size, and the method we selected to string cells in series-parallel configurations. In the second article (ATN, Sep/Oct 91), I detailed the actual module construction: interconnect options, soldering, applying the glazing, light testing, and soldering the sub-strings. In the third article (*ATN,* Nov-Dec 91), I covered module design, construction issues, assembly, mass production, carriers, attachment to the substrate, and vacuum bonding. (These three back issues are available from Home Power.)

This is the fourth and final article in the Racing Solar Panel Design series: finishing, testing, and racing the Solar Eagle panel. The process picks up at the point where the modules have been assembled on the substrate and the bonding agent has dried.

Module interconnection
Once all of the modules had been bonded to the substrate, the array team began the process of connecting them together electrically. Typically, there were two terminating strips to each module to handle the end-of-row junctions. These were pinned in place

overlapping the adjacent module's terminators. Individual modules were connected with others by soldering. In the wide portion of the center panel, there were many "center" terminators to join. These continued the rows of cells all the way across the width of the panel. These terminators were also bent into position and soldered.

As strings were completed, they were tested with a voltmeter under ambient light conditions to ensure that the connections had indeed been made, and that the V_{OC} (voltage, open circuit) was approximately the correct value. Once the interconnection of modules was complete, the solar array was cleaned of any adhesive that had leaked out from under the cells.

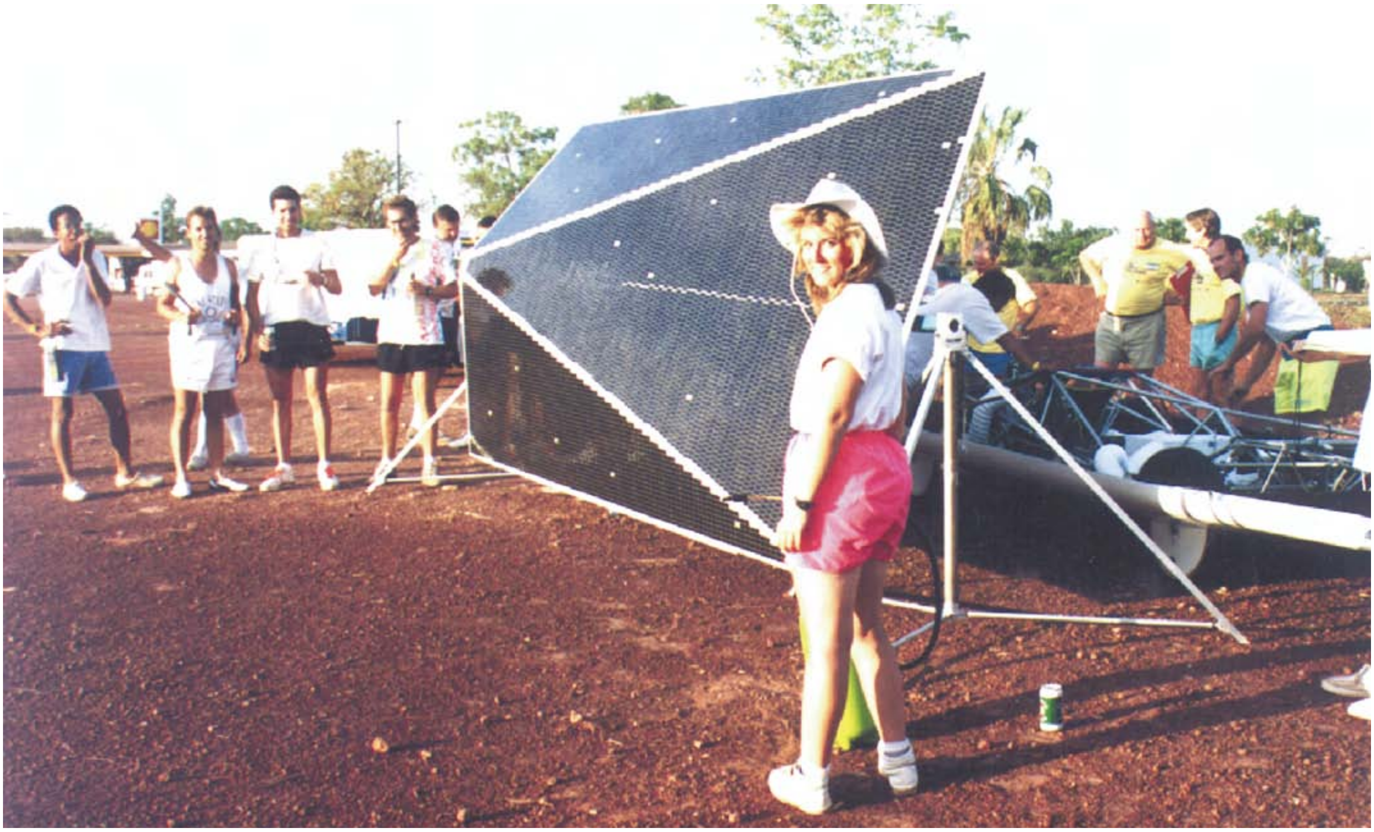
Actually, a substantial amount of adhesive had pushed out from under the cells. Partway through the bonding process, I was shocked to discover that most of the solar cells that had been bonded to the substrate had "dished". Dishing occurs when the center of the solar cells bonds closer to the substrate than the edges of the cell. This is partially due to the soldered interconnect under each cell. I hadn't noticed this with panels built at Spectrolab. Admittedly, none of the cells had cracked, but I did have nightmares about what would happen when the panel got hot or was subjected to road shock. Nevertheless, we continued the bonding process, and completed the panel. Fortunately, no cells were lost because of this effect. Subsequently, however, I discovered that a vital ingredient was missing from our adhesive recipe — microballoons. This acts like both a filler and a thickener. It would have prevented most of the dishing and kept a larger percentage of the adhesive under the cell, too.

Bypass Diodes

Bypass diodes were added to each of the solar strings. A bypass diode is wired in parallel with a portion of a string of series cells to provide a current path around them in the event a cell becomes resistive or open. This way, a string can supply power at *reduced* voltage rather than *no* power. To ease the fabrication effort, our design put diodes across *rows* of cells. Diodes, then, bypassed as few as fifteen and as many as forty seven cells. A more standard procedure is to install bypass diodes across a specific number of cells throughout a string. However, since we could not find any reason *not* to do it, we opted for this irregular procedure. It clearly simplified our assembly process!

To simplify the testing procedure and to help with any subsequent troubleshooting effort, all of the bypass diodes were mounted on small pieces of perforated

Below: Solar Eagle teammembers orient the PV panel for a quick recharge at the end of a race day.



Above: Richard Benevides connects a wire from a bypass diode to a terminator strip on the PV panel.

Above: Michael Hackleman routes wires from the diode boards on the back of the PV panel.

circuit board. These boards contained as many as ten diodes and were mounted underneath the substrate surface, facing out, for access from under the panel. Each diode was soldered to the next diode on these boards; the finished product represented a string of diodes wired in series. From each of these soldered connections, a wire of the correct length ran to a hole drilled close to a terminator (an *end* or *center* of a cell row) on the modules. The end of this #22 size wire was stripped, tinned, pushed through the hole, bent over, and soldered to the terminator. Additional wires were added to connect the diode boards together, as needed. These wires and the diode boards themselves were fixed in position with Kapton tape. The tape was transparent enough to allow us to inspect the wiring and diode polarity without ripping off the tape — a real plus.

Blocking Diodes

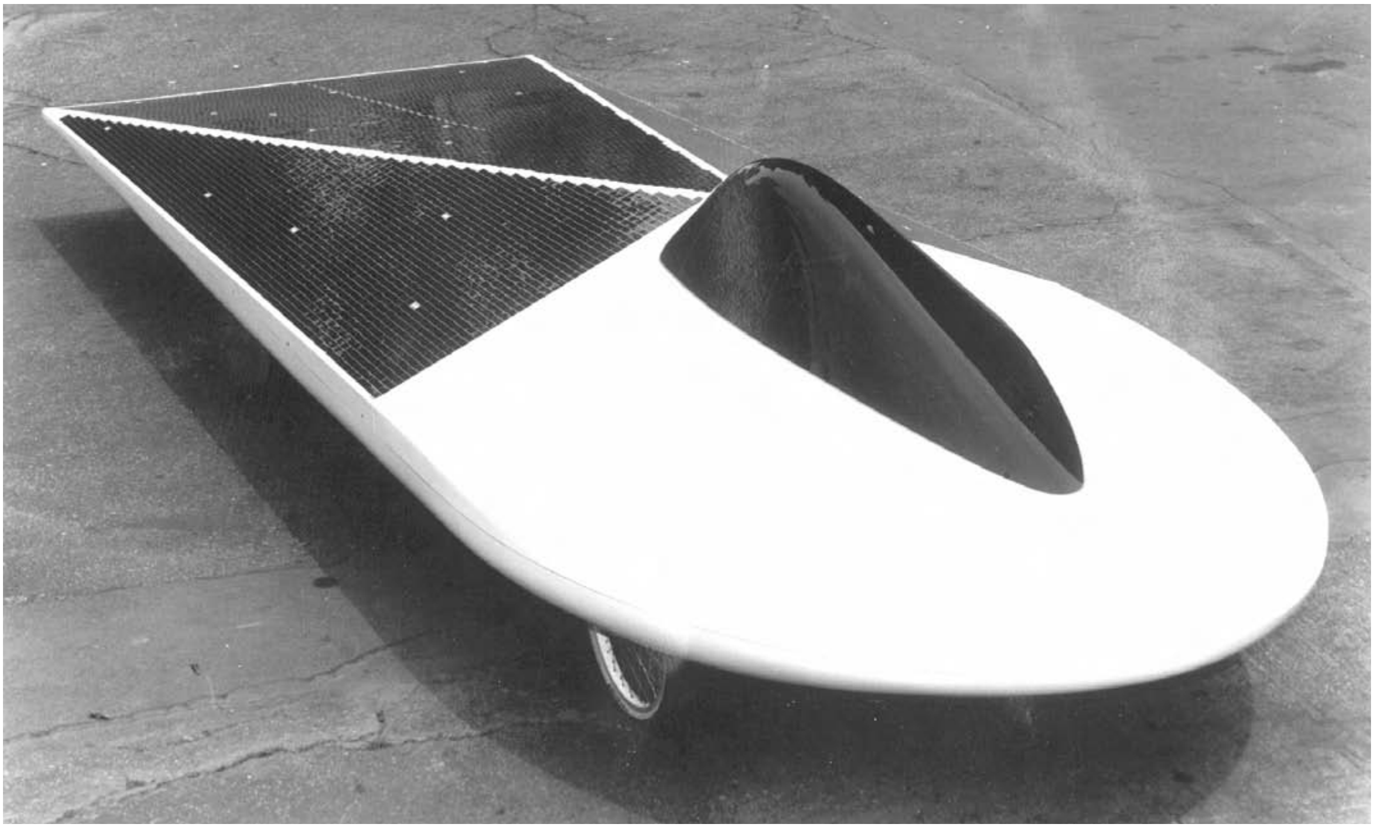
Larger wires (#16) were also inserted through holes drilled in the substrate near the junctions of the solar strings. Both positive and negative leads were soldered to each end of the strings and run to the frontmost section of the panel. These were identified and labeled with a string number, and terminated in separate, perforated circuit boards.

The negative leads from all strings ended in one board. While it would have been possible to tie all of the negative leads of the strings directly together and save some wire, we elected to run *both* the positive and negative wires from each string forward for several reasons. The major one was to preserve *isolation* of the strings from one another. This helped considerably with troubleshooting, as there were several clever ways that the team managed to miswire diode boards and strings. It was difficult enough to sort out the anomalies even with the isolation of the strings from one another! Also, the individual wires helped us to isolate the inputs (pos and neg) of the three PPTs (Peak Power Trackers) from each other for fine tuning and troubleshooting.

Each positive lead from a 432-cell string was terminated in a blocking diode. A blocking diode permits parallel wiring of strings on a panel without incurring the risk of a damaged string dragging down adjacent strings. There were twenty of these 432-cell strings on the panel and, thus, twenty blocking diodes. These were mounted together on one board. We selected Unitrode JANTXV diodes (600 PIV, 1 A) to isolate the strings from one another.

At this point, the panel was taken outside, mounted on its stand, and left to sit in the sun. Without positive air movement over the panel, it quickly heated up. Both Voc and Vpp (voltage, peak power) measurements were then taken. The panel was realigned as we took readings of each facet of the three sections. A resistive load was fashioned so that we could observe the voltage and current of the strings as we varied the load resistance manually.

Our first readings were a disappointment. Despite all of our efforts, all of the strings seemed to be reading much too low, and there was a considerable variation in string output. I recall that we initially read a paltry 700 Watts of power! Low readings of a solar string when compared with others in the same section led to further checks and we quickly isolated faulty wiring, reversed diode boards, and the like. These were corrected and the readings improved. A few weeks later, the Solar Eagle was taken for a test run in the San Joaquin Valley and the readings improved even more. Even on a sunny day, the smog in the Los Angeles basin was robbing the panel of as much as 15% of its power!



The Umbilical Cable

The Solar Eagle's panel was connected with the rest of the vehicle via a connector and a long length of cable. When finished, it had the look of an umbilical cord. This cable was composed of a number of wires, most of which carried power from the three panel sections to each of their respective PPTs mounted just behind the driver in the chassis. To keep line losses to a minimum, the wire sizes were large, and each wire carried only the current from several strings. These were ganged at the terminal boards at the panel head, and at the connector pins. This way, if any wire in the cable was severed or if a pin failed, paralleled wires would safely route the power around the fault and onward to the PPTs.

Each PPT (peak power tracker) was a special low-weight version of the (Maximizer) commercial unit and was rated for 1,200 watts. In the Solar Eagle, one of the PPTs handled almost 450–500 Watts of power, while each of the other two PPTs carried only half of that amount.

The connector cable also routed some low-voltage power from the panel to various loads in the racing chassis — fans, lights, etc. These cells filled up leftover spaces on each of the substrates that was too small to accommodate enough cells to form one of the twenty 432-cell strings.

Conformal Coating

Once the panel had been tested, a conformal coating was applied. Industrial syringes were used to apply adhesive (essentially the same one used under the cells) around the cells, like grout on a tile floor. Once and for all, this sealed the panel, preventing any water from getting under a cell to short it out or corrode it. This was a laborious effort that I only observed, since it was at this point that I left the project — to start the magazine *Alternative Transportation News*.

How Did it All Work?

Following each of the two races, the 1990 GM Sunrayce and the 1990 World Solar Challenge, I talked with Solar Eagle team members. During this whole time, no cells broke, chipped, cracked, or opened up due to shock, heat, rocks, mishandling, or rain. If they had, a replacement technique designed and perfected by Richard Benevides (one of the array's builders) was ready to go. But — it was not required.

In retrospect, there are only two changes I would make to the way the Solar Eagle panel was done. One was to add the aforementioned microballoons to the adhesive solution that bonded the cells to the substrate. At least, this would have minimized dishing. It might have saved cleaning adhesive off all those cells, too. It also might have eliminated the task of adding a conformal coating.

Another change I'd make is to hold to a smaller tolerance at the angular edge of the panel's facets. (That's the big white V in the panel.) We worried about getting the edges of the cells in the modules too close to a curved joint along the angled edges of the array's facets. We did not custom fit the solar modules to the panel substrate. Rather, construction of the array substrate and the modules occurred simultaneously. We were running out of time. The modules had to be ready to bond to the substrate as soon as it was done.

I was way too optimistic about the amount of power our panel would produce for the number and quality of cells involved. Consequently, while we were careful, we were also somewhat conservative. Anyway, it looks like we could have squeezed another 90–180 cells onto each of the three panel surfaces. Coupled with the cells (used as fill) that were wired for 12 VDC loads, the additional cells might have resulted in a 10–14% gain in the panel's output power. Of course, that's 20/20 hindsight! No one on the team had ever built a panel before. When you've got a couple of hundred thousand dollars in a prototype, you must be somewhat conservative or risk a major goof.

Still, as ignorant as we were to begin with, I'm amazed that things turned out as well as they did. It was an *enormous* task. Anyone who worked on the project was virtually a slave to the process and effort. The project consumed more than a year of my life, and I know that it took me almost a year to recover. It's been said that building a solar car is once-in-a-lifetime experience. Let me translate that! I learned a lot, I'm glad that I did it, but I'm not likely to do it again!

This information aims to ease the way of others that may walk this path. Good luck!

Access

Michael Hackleman, c/o Home Power, POB 520, Ashland, OR 97520

Above: Michigan State's HEV at the Dearborn Proving Ground.

Catching the Dream!

Rick Proctor

For a hundred years electric vehicles have been the dream of eccentrics, futurists, and the backyard hobbyist. The mainstream auto industry, in spite of huge capital resources, has been repeatedly thwarted by foot dragging and the perception of unsolvable technical problems. The experimenters see it as a worthy challenge and, perhaps, that "big" chance to hit it rich. There are more electric automobiles on the road today built by amateurs than by the big three, and the number is growing rapidly.

Government, big business, educators, and experimenters normally do not mix well but this spring was an exception. The Department of Energy's Center for Transportation Research participated in four electric vehicle (EV) events: The Phoenix 500, the Atlanta Clean Air Gran Prix, the American Tour de Sol, and the Ford HEV challenge. There were two major goals in the competitions. First, to encourage and support high school and university teams to develop EV technology. Second, to gather performance data on a wide range of EVs. It is for this latter reason that George Ettenhiem, a private consultant in charge of the Ford HEV Challenge hotline, approached Cruising Equipment to provide battery instrumentation for the event.

The rules required an Amp-hour or kiloWatt-hour meter to be installed on each vehicle. Electrical power consumption was a major part of scoring the efficiency event. Ford, thus far, had been unable to locate a satisfactory and affordable meter.

Our experience with Ford-sized companies has not been great. Lots of questions, contracts, proposals, purchasing procedures, slow pay, and red tape is the best to be expected. We sent a proposal to the team leader for Technical Specifications, Bob Page, for a unit built on our production platform. Finally, we got word, "Yes, they wanted to use our meters." We were handed off to Bob Larsen and Nicole Hill at Argonne's Center for Transportation Research. They were responsible for the instrumentation in all of the aforementioned events. By the time everything was signed, we had six weeks to develop and deliver a new product for the first event.

Developing a new product is like a bungee jump for techie nerds. Shortening the time line is like raising the tower. You hitch up, jump in, work like hell, and pray everything works out at the end. Late nights, long hours, luck, and Andre's Pizza fueled the project. Thanks to the special effort of our staff, Rick Young, Dave Daniels-Lee, and Steve Kahle, we met the ship date.

The Phoenix 500 Race

The first event of the season was the third annual Phoenix 500 sponsored by the Solar and Electric Racing Association (SERA). Nearly 70 EVs were entered in eight classes. There were 25 vehicles in the student electric conversion class alone. Eleven of the vehicles had received $5,000 worth of equipment and grants from the Arizona Public Service Co. and General Electric. The rest of the teams were primarily self sponsored.

I arrived the day before the event started and began checking the installations of meters. Easily one third of the meters were installed wrong. However, only one unit had been rendered inoperable. Not bad considering these were experimental vehicles wired by high school students.

The Phoenix 500 is a bit of an odd venue for a student competition. The D.O.E. supports education and research, not racing. To ensure an exciting event, SERA and D.O.E. compromised. SERA and the general public got a 25 lap heat race and D.O.E. got its one hour paced event at 50 mph for data purposes (see table next page).

Analyzing this data is very difficult. Vehicles ranged from a 1965 Corvair to a 1988 Ford Tempo. Drive systems are difficult to compare because aerodynamics, rolling resistance, vehicle weights, and battery charging methods are not constants. Even starting position was a factor. Competitors were instructed to keep a five car length interval behind the vehicle in front of them at a 50 mph paced speed, and could not pass. This resulted in rubber banding. So, current consumption varied in relation to vehicle position in the line of cars as drivers slowed or accelerated to maintain the pace. Page High School car #22 won the event, squeezing 13.0 kW-hrs from their battery, 30% more than their nearest competitor.

Below: Wayne State at the Dearborn Proving Ground. Photo courtesy of Ford Motor Co.

Another entry, Chapparral in car #18, a bright yellow 1965 Corvair, placed fifth. Following a disappointing 11 laps in the heat race the previous day, General Electric technicians found that the reverse winding on the motor was energized continuously. Once corrected, the Corvair achieved the highest energy economy with 4.82 mi/kWh and the highest Mass Energy Economy with a rating of 31.3. The Mass Energy Economy (M.E.E.) equals the mass of the vehicle times the distance traveled divided by the amount of energy required. This scalar indicator of performance requires that the batteries be fully charged before the test and then completely discharged under identical conditions for each vehicle. Calculating it for Chapparral:

$$\text{M.E.E.} = \frac{\text{distance x mass}}{\text{work}} =$$

$$\frac{(43 \text{ miles}) \frac{1609 \text{ meters}}{\text{mile}} (3273 \text{ pounds}) \frac{4.45 \text{ Newtons}}{\text{pound}}}{(8.93 \text{ kW-hrs}) \frac{3600 \text{ sec}}{\text{hour}} \frac{1000 \text{ Watts}}{\text{kW}}}$$

M.E.E = 31.3

Cruising Equipment had instrumentation in other cars at Phoenix, including several of the "pro" competitors. We also helped "crew" in the Hackleman/Schless pit, sharing their Open Lightweight win, and their Class A stock defeat. Their electric wheel-barrow, built by Bob Schneevies, should be sold in hardware stores world wide!

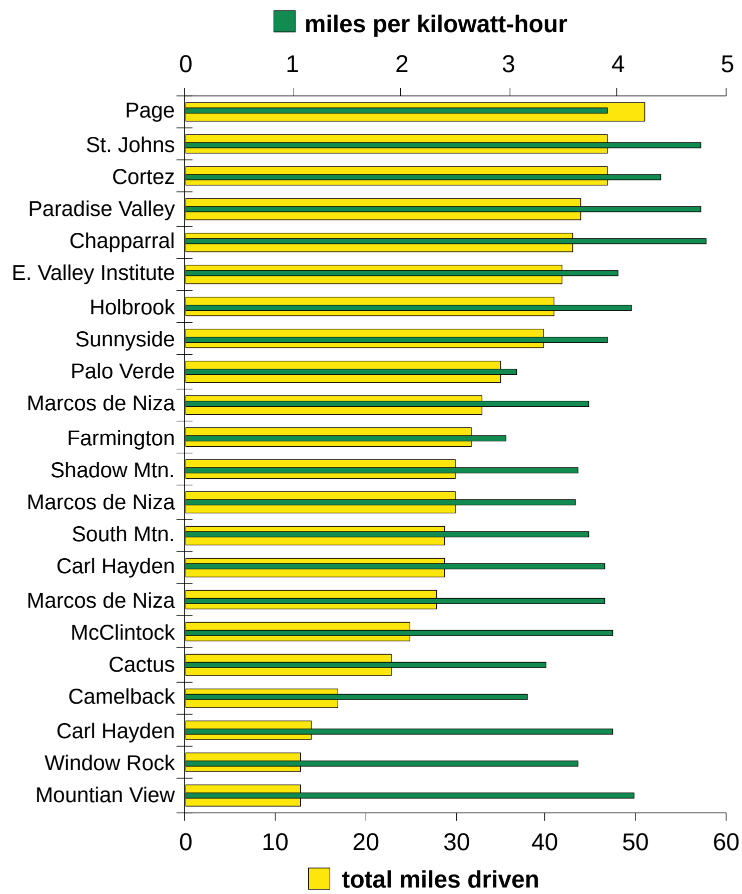
An unusual entry came with Ed Rannberg of Eyeball Engineering. His Silent Eagle was a *very* fast, modified gravity racer built in about 3 weeks, untested before the race. In the first heat race, a tire rubbing against the underbody blew out, and the car hit the wall. The driver's wife was more shaken than the driver, and the car was bent. A replacement driver was recruited. In the last lap of the race, the Silent Eagle was clocked at 65 mph. At Bonneville Salt Flats this summer, Ed will attempt to set the under-500-kg class world speed record. They hope to go over 125 mph!

The main event at Phoenix is the two-hour Class A Electric Stock Car race. It was a duel between the Salt River Project car #90 driven by Indy driver Tom Sneva and the Solectria Force car #93, using Nicad batteries and the Solectria ac drive, driven by James Worden. Worden stuck to Sneva's tail and waited until he ran out of battery. Fifteen minutes from the end of the

Energy Consumption Data — Phoenix 500, March 5-7, 1993

School	*Year & Model*	*mi.*	*kWhr Used*	*miles/ kWhr*	*Wt. lbs.*	*MEE*
Page	1984 Ford Escort	51	13.00	3.92	3231	25.2
St. Johns	NA	47	9.85	4.77	2949	28.0
Cortez	1982 Ford	47	10.64	4.42	3127	27.5
Paradise Valley	1988 Ford Tempo	44	9.19	4.79	3236	30.8
Chapparral	1965 Corvair	43	8.93	4.82	3273	31.4
E. Valley Inst.	1979 Chevy Luv	42	10.45	4.02	3274	26.2
Holbrook	1988 Ford Festiva	41	9.89	4.15	3021	24.9
Sunnyside	1978 Chevy Luv	40	10.21	3.92	3388	26.4
Palo Verde	1981 Ford Courier	35	11.39	3.07	3353	20.5
Marcos de Niza	1974 Ford Courier	33	8.80	3.75	3335	24.9
Farmington	1976 Datsun 280-Z	32	10.75	2.98	3251	19.3
Shadow Mtn.	1979 Chevette	30	8.21	3.65	2888	21.0
Marcos de Niza	1979 Datsun P.U.	30	8.27	3.63	3206	23.2
South Mtn.	1981 Chevy Citation	29	7.76	3.74	3152	23.4
Carl Hayden	1979 VW Dasher	29	7.44	3.90	2982	23.1
Marcos de Niza	1985 Chevy S-10	28	7.20	3.89	3492	27.0
McClintock	1980 Ford Mustang	25	6.31	3.96	2924	23.1
Cactus	1974 Datsun	23	6.88	3.34	3287	21.9
Camelback	1985 Chevy S-10	17	5.37	3.17	3635	22.9
Carl Hayden	1978 Toyota	14	3.54	3.95	3225	25.4
Window Rock	1983 Ford Escort	13	3.56	3.65	3114	22.6
Mountain View	1984 Chevy	13	3.12	4.17	2973	24.7
	Averages	32	8.22	3.89	3196	24.7

Data collected with Cruising Equipment Co. Kilowatt-Hour+ Meter.
Data prepared by Rick Proctor. Sorted by overall placement.



race, Sneva slowed and pulled into the pits for a rapid recharge. The Solectria car went 120 miles in less than two hours including two 60 mph victory laps.

The Ford HEV Challenge

The Ford HEV Challenge, held June 1–5, was absolutely unique. Ford, the D.O.E., and the Society of Automotive Engineers co-sponsored the event. Its stated goal: "...to establish a relationship that is mutually beneficial to all parties involved. The Organizers have an opportunity to gain graduates who are knowledgeable, capable, and confident. The universities and students gain an education that goes beyond the classroom. The students can utilize their classroom skills on a real world problem ... there are no answers in the back of the book."

Hybrid Electric Vehicles (HEVs) are able to operate as a Zero Emission Vehicle (ZEV) by using battery power alone. An Auxiliary Power Unit (APU) helps extend the vehicle's range when outside the city. This technology acknowledges that internal combustion engines are most efficient and generate the least pollution when running at highway speeds. In the stop-and-go of city traffic, however, the energy efficiency and zero emission qualities of the electric are preferred.

Two classes of vehicles competed in the 5 day HEV challenge: those that were built from the ground up (12 entries) and those that were converted Ford Escort Wagons (18 entries). Despite the fierce competition in the eleven categories scored, teams shared tools, information, and spare parts.

It seems as if every possible solution to designing an HEV was explored by these thirty Universities. Vehicles with DC motors were better represented than ones with ac motors. Battery voltages varied from 72 V to 394 V. The APU engines varied from a 250 cc Honda to the stock Ford Escort. Some systems ran in series (the APU powers the wheels through the electric motor) and others ran in parallel (the electric motor and the APU can supply power simultaneously). The level of workmanship varied from wire art to snakes.

Ford HEV Challenge June1-5, 1993 Summary Data

Ground Up Class

car #	*School*	*ZEV mi.*	*kWhr Used*	*mi./ kWhr*	*MEE*	*Electric Motor*	*Bat-tery*	*VDC*	*HEV mi.*	*gal. used*	*mi./ gal.*	*APU*	*HP*	*Wt. lbs.*	*Cost $ U.S.*
42	Cornell Univ.	50.8	9.9	5.1	26.2	18hp AC/42hp DC	L/A	120	132	7.2	18.5	Brig. & Strat	18	2552	32,307
30	Univ. of Cal, Davis	53.4	10.2	5.2	24.7	43hp DC/PM	NiCd	195	136	3.1	44.0	570 cc B&S	20	2364	34,404
55	Michigan State Univ.	36.8	7.4	5.0	32.4	15hp AC/Squirrel	NiMH	300	166	4.4	37.6	1L Geo	50	3266	78,889
33	Univ. of Tennessee	44.8	6.1	7.3	39.8	25hp DC/PM	L/A	180	124	4.1	30.3	624cc Kohler	20	2726	51,003
1	Lawrence Tech.	24.4	7.8	3.1	22.8	20hp/Ind	L/A	240	146	5.6	26.0	1L Geo	55	3647	41,880
56	Univ. of Cal, Santa Barbara	30.8	8.2	3.8	23.3	AC/Ind	L/A	144	170	9.1	18.8	1L Geo	52	3096	28,051
31	Univ. of ID/WA State	31.4				135hp AC/Ind	L/A	336	158	5.1	30.8	624cc Kohler	20	4382	75,171
3	Univ. of Tulsa	DNQ				15hp AC/Ind	L/A	264				359cc Honda	12	3847	52,603
223	Cal Poly, Pomona	20.8	5.1	4.1	22.7	60hp DC/WF	L/A	120	41	2.1	19.3	1L Geo	16	2759	23,114
101	Cal Poly, San Luis Obispo	15.6	3.4	4.6	25.1	28hp AC/Ind	L/A	120	42	4.4	9.6	1L Geo	49	2703	33,120
	Averages	34.3	7.3	4.8	27.1				124	5.0	26.1		31	3134	45,054

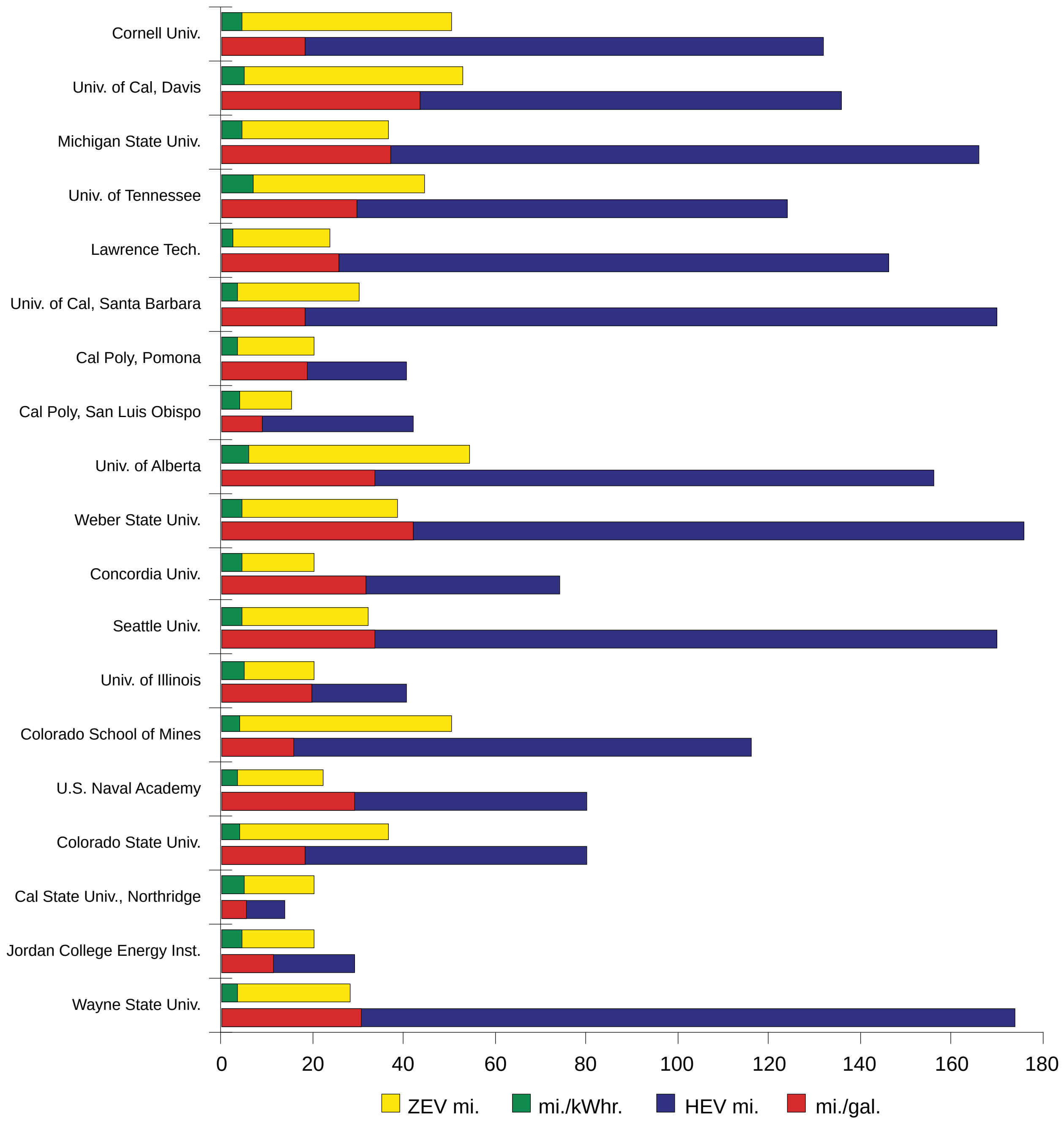
Conversion Class

car #	*School*	*ZEV mi.*	*kWhr Used*	*mi./ kWhr*	*MEE*	*Electric Motor*	*Bat-tery*	*VDC*	*HEV mi.*	*gal. used*	*mi. /gal.*	*APU*	*HP*	*Wt. lbs.*	*Cost $ U.S.*
8	Univ. of Alberta	54.8	8.9	6.2	44.7	2-16hp DC/PM	NiCd	170	156	4.6	34.0	1L Geo	55	3609	40,277
6	Weber State Univ.	38.8	7.5	5.1	39.2	60hp DC	L/A	72	176	4.1	42.6	1.9L Stock	100	3812	20,331
66	Concordia Univ.	20.8	4.4	4.8	35.3	N/A	L/A	144	74	2.3	32.0	480cc B&S	16	3692	30,200
0	Seattle Univ.	32.8	6.9	4.7	36.0	43hp DC/PM	L/A	192	170	5.0	33.8	1L Geo	52	3791	44,702
88	Univ. of Illinois	20.8	3.9	5.3	38.6	25hp AC/Ind	L/A	336	41	2.0	20.2	620cc Kaw.	23	3631	39,561
35	West Virginia Univ.	20.8				19hp DC/SW	L/A	96	29	0.4	69.0	620cc Kaw.	24	3651	38,459
10	Colorado School of Mines	50.8	11.0	4.6	33.0	40hp DC	NiCd	120	116	7.2	16.2	620cc Kaw.	19	3568	28,377
96	U.S. Naval Academy	22.8	5.8	3.9	29.7	21hp DC/WF	L/A	120	80	2.7	29.8	B&S	18	3794	26,525
4	Colorado State Univ.	36.8	8.5	4.4	33.1	45hp DC/PM	L/A	180	80	4.3	18.7	620cc Kaw.	22	3805	44,461
86	Cal State Univ., Northridge	20.8	4.0	5.2	34.4	20hp DC/PM	L/A	120	14	2.4	6.0	250cc Kaw.	30	3290	33,566
100	Stanford Univ.	20.8	5.6	3.7	27.3	75hp AC/Ind	NiCd	108	19			250cc Honda	23	3668	40,828
110	Univ. of Wisconsin	20.8				100hp AC/Ind	L/A	394	4			624cc Kohler	20	3805	61,904
77	Jordan College Energy Inst.	20.8	4.4	4.7	35.3	N/A	L/A	120	30	2.5	11.7	500cc Kaw.	57	3744	28,119
99	Wayne State Univ.	28.8	7.0	4.1	33.7	2-32hp DC/ShW	L/A	240	174	5.6	31.2	1.9L Stock	100	4084	24,522
11	Pennsylvania State Univ.	13.0				N/A	L/A	144	186	6.8	27.5	1L Geo	49	4345	47,615
	Averages	28.3	6.5	4.7	35.0				90	3.8	28.7		41	3753	36,630

kWhr Data collected with Cruising Equipment Co. Kilowatt-Hour+ Meter

Data prepared by Rick Proctor supplied by Ford. Sorted by overall placement.

Ford HEV Challenge Mileage and Efficiency Data



The first three days consisted of safety inspections, technical reports, engineering design evaluations, oral presentations, acceleration events, emission tests, and hundreds of hours of trouble-shooting and repair. Those teams that were the best prepared gained the early lead. The University of Alberta, the first conversion to pass technical inspections and qualify, eventually won their class.

The range event, held on the fourth day, was the first event we actually collected data on energy consumption. First, each vehicle completed 20.8 miles in the ZEV mode at the Dearborn Proving Ground at 40–55 mph speeds. Switching to HEV mode, the vehicles covered 80 miles over public roads to the Michigan International Speedway. Another 20 miles in the ZEV mode finished the qualifying run. Additional ZEV miles (worth 1.75 HEV miles in the scoring formula) and HEV miles were optional until the 5 hour time limit expired.

A Buck's Worth

The University of Alberta won the range event in the conversion class by traveling 54.8 miles as a ZEV and

Above: The winning Cornell HEV. Photo courtesy of Ford Motor Co.

156.4 miles as a HEV. The energy economy figures were impressive with only 8.85 kWh of battery and 4.6 gallons of fuel consumed. That's 6.2 miles per kilowatt hour and 34 miles per gallon! Assuming $0.08 per kilowatt-hour, a charge efficiency of 85%, and charger efficiency of 90%, the cost of the electricity amounts to $0.92. That means a buck's worth of electricity would take this car about 60 miles. At $1.15 per gallon of gasoline, a buck's worth of gasoline would take this car about 29 miles. It is hard to escape the fact that electricity makes sense.

The University of California, Davis won the range event for the ground up class, travelling 53.4 miles as a ZEV and 136.4 miles as an HEV. Consuming 10.22 kWh of battery power and 3.1 gallons of gas, a buck of electricity buys 50 miles whereas the same buck buys gas for 38 miles.

The *average* energy economy for both ground up and converted cars was 4.7 miles per kilowatt-hour and 25.6 miles per gallon. Thus, in an average vehicle, a dollar takes you 22 miles on gas and 45 miles on electricity.

The last day was the Commuter challenge, a stop-and-go event that simulated urban driving. The event consisted of two sessions of ten laps each around a 1.1 mile track. No straight-away was longer than ⅓ mile. There were 5 or 6 stop signs per lap, and turns of greater than 90 degrees, including hairpin and S curves, were included. The first session would be five laps of HEV mode and five laps of ZEV mode. The second session reversed this, calling for five laps of ZEV and five laps of HEV. Scoring would be based on the lowest elapsed time. Cornell won the ground up class with a time of 27.5 minutes and Alberta won the conversion class with a time of 29.27 minutes.

Cornell consumed 3.49 kWhrs in the 11 miles of ZEV operation in the Commuter challenge, or 3.15 miles per kWhr. A dollar, then, would get this vehicle 30 miles in city. The University of Alberta consumed 3.22 kWhrs during their 11 miles of ZEV operation, or 3.41 miles per kWhr. A dollar of electricity here gave 33 city miles. This is better than almost all production internal combustion vehicles.

Closing Notes

The event closed with an award banquet for eight hundred people, and included short speeches and awards of checks and plaques. I presented the "gag" awards. Colored phasing tape for the "Reverse Polarity" awards, Troll dolls with fluorescent hair for the "Best Gremlin" awards, and the "Toasted Processor" award for the first and only team to successfully destroy every part on one of our circuit boards (application of over 300 volts to the ground bus). Two Ph.D.s graciously accepted the blackened circuit board.

Partying lasted until nearly dawn. The students, faculty, the Ford Team Concept crew, the D.O.E. crew, and I talked cars. Absent were words like horse power or burning rubber. Instead, key words were miles per kilowatt-hour, range, and M.E.E. factors. These young men and women had caught a dream and turned it into reality. The largest population of HEVs in the world sat outside. Collectively they had driven 3,201 miles in competition in two days. In the future they will own electric vehicles because they will be designing them.

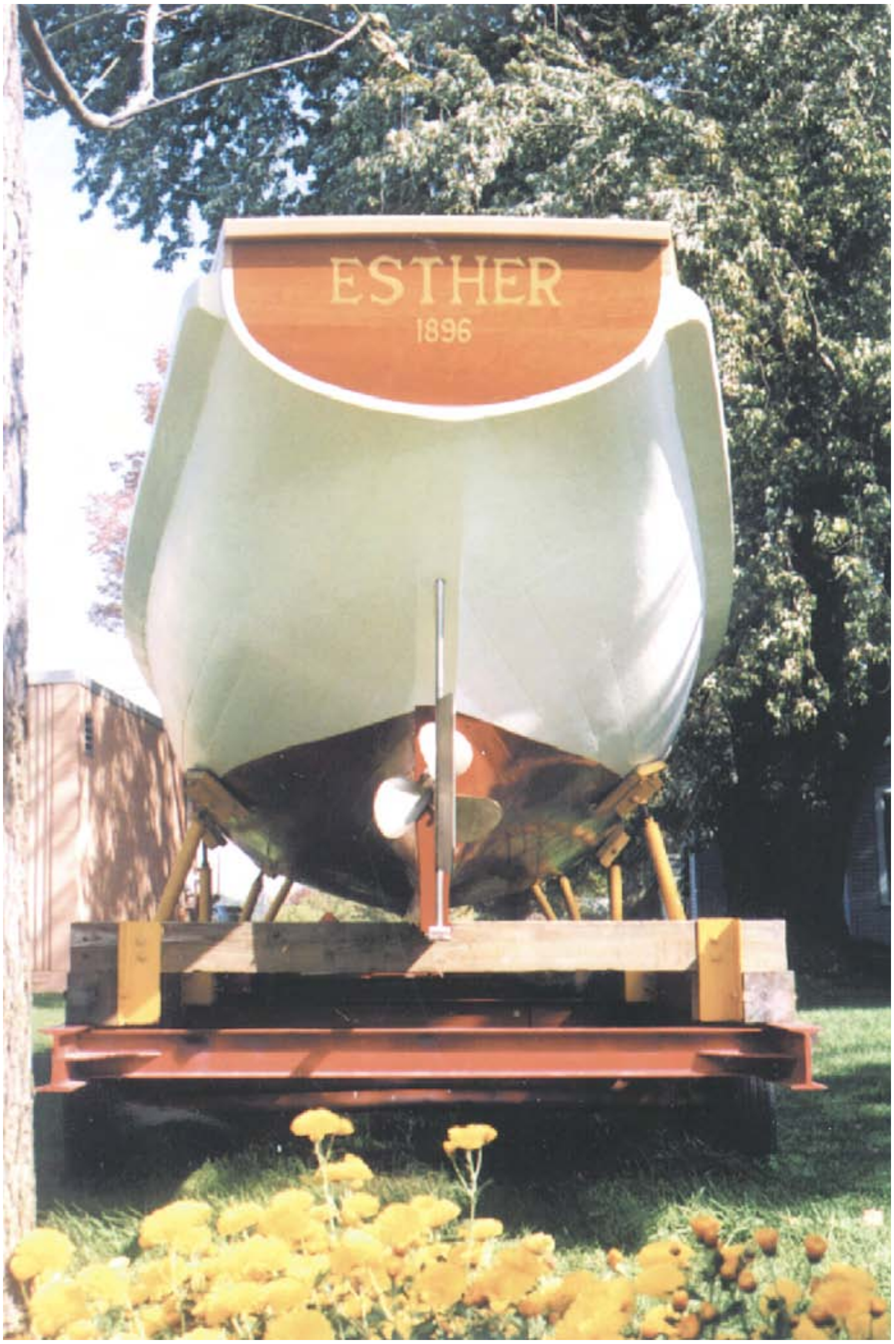
Access
Rick Proctor, Cruising Equipment, 6315 Seaview Ave. NW, Seattle, WA 98107 • 206-782-8100

Relaunching the *Esther*

Richard Orawiec and LeRoy Wolins

*The date is October 16, 1992. Live at 5, a Grand Rapids TV station news team, has traveled to Saugatuck, a historic Michigan port and resort. On the hoist at the Tower Harbour Marine dock is a launch. Its propulsion system is an electric motor and it is powered by batteries. It is not a prototype. It's a piece of history. It was **designed** to be electric powered. Soon it will celebrate it's 100th anniversary.*

Right now, the launch is going back into the water. Tom Van Howe tells the story to tens of thousands of viewers through a satellite uplink, interviewing Bruce Herron and the two of us when he is able. Also present is R.J. Petersen and his son, Matt, who have loaned facilities and helped us immeasurably these years as we've struggled to restore this ship. It is the Esther. *She takes to the water gracefully — as she once did, without nearly so much fanfare, nearly 100 years ago.*



Some 250,000 spectators watch as President Grover Cleveland pushes a button. The World's Columbian Exposition in Chicago begins. It is a time of celebration — of the anniversary of Columbus' find and America's emergence as a world power and technological leader. The date is May 1, 1893.

There were many important events at the Exposition to attract the crowds. Few of them, however, were as popular as the boat rides being offered on the canals, lakes, and on the Grand Basin itself, a lagoon half a mile long and 250 feet wide. Special attention is given to a special fleet of 55 launches. Each is 36 feet long. They are built specifically for passenger service. All are equipped with the latest mechanical marvel — battery-powered electric motors.

Subsequently, the front page of the Nov. 1893 issue of *Scientific American* devoted its front page to the ELCO craft:

"No electrical feature at the World's Columbian Exposition was entered upon with more uncertainty than the introduction of electric launches on the lagoons. Up to this time, such launches had not been made use of in this country except in an experimental way. In spite of these uncertainties, however, the launches were among the first electrical features that were ready. And they have fulfilled their requirements during the entire period that the Exposition has been open. With gratifying results. They have carried over one million passengers. They have earned $314,000.

"The launches were in constant use from 12–14 hours per day on a single charge. The greatest test was on Chicago day when the fifty electric boats made a total of 623 trips, each 3 miles in duration. Six of these boats averaged fifty miles each — another twenty of them averaged over forty miles — carrying 40 people per trip.

"The batteries are of 150 Ampere hours' [sic] capacity. Each boat has 66 cells. These are arranged in three groups of 22 cells, or two groups of 33 cells each for propulsion. One lever alongside the steering wheel selects four speeds forward and two backward."

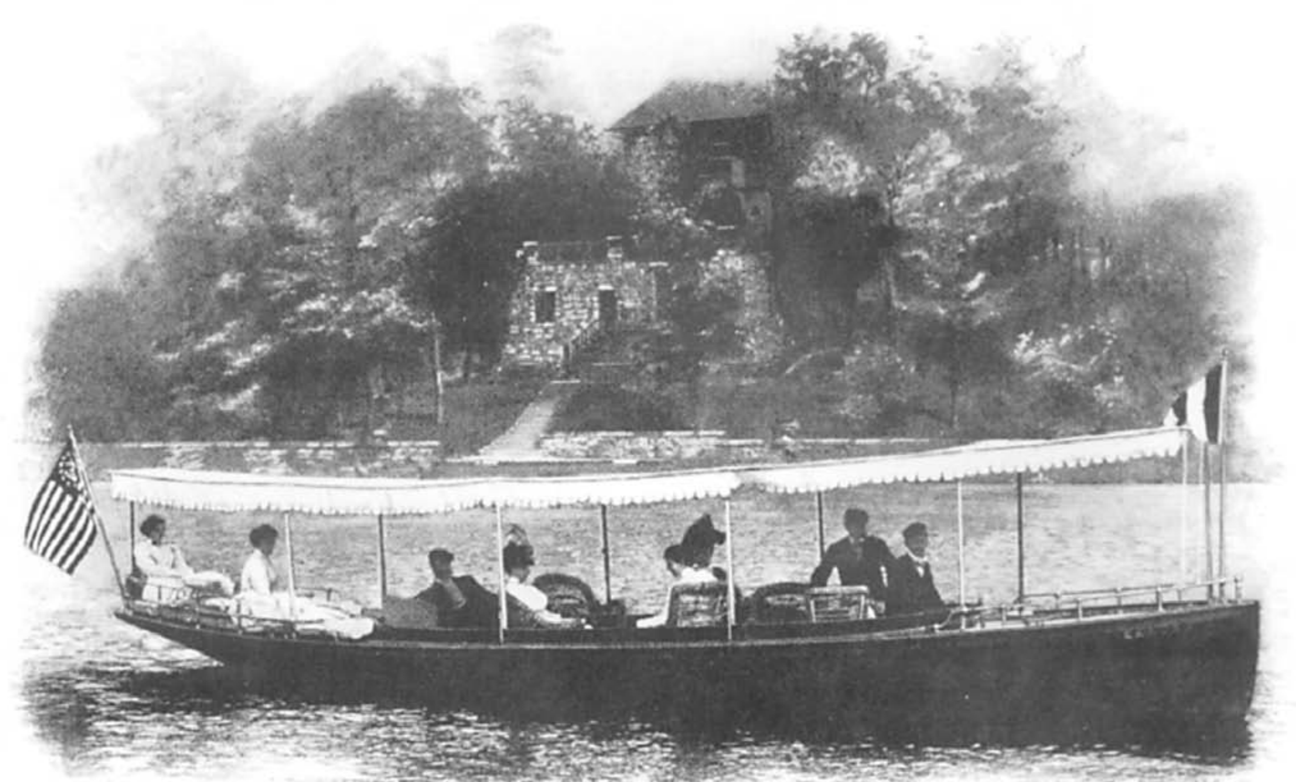
A tour with the fleet

The success of ELCO launches at the Exposition encouraged the Navy to use them as gigs for its major warships. This was unusual, since most launches of that period were powered by steam — and generally faster than the electric ones. Yet, when charged off the battleships or at dockside — the Pearl Street Power Station in New York was opened by Edison in 1882 — the electrics represented instant torque with no fuss or muss. No head of steam to build, no wait. And no problem with reliability, as with the engines of the day.

One of the many 36-foot electric launches delivered to the Brooklyn Navy Yard in 1896 was the Esther. It appears to have been the one used by Admiral Sims as a private gig. It served with Teddy Roosevelt's Great White Fleet.

In 1897, Leopold Rice purchased the Electro Dynamic Company (later to become General Dynamics Corp.). William Swanson writes in his history, *Launches and Yachts*, "Rice was fascinated by electricity and electrical gadgets. In 1888, he acquired the patent rights to Clement Payan's "chloride accumulator" battery — the electric battery as we know it today. Rice established the Electric Storage Battery Co. (later to become Exide) in Philadelphia. By 1897, Rice had achieved a monopoly on all storage battery manufacturing. He founded the Electric Vehicle Company, too. Soon, a fleet of more than 100 electric taxi cabs operated in the city of New York. Remember, it's 1897!

Below: *Esther* as she looked in 1896. Reprinted from the 1902 ELCO catalog



Above: Richard Orawiec removes the Chrysler inline eight remarking, “Beam this INFernal thing outta here….”
Below: Bruce Heron, left, and Richard Orawiec check the Sovonics PV panel and GNB battery that power *Esther*’s bilge pump.

Above: Eighty years after *Esther*’s electric motor was removed, the rotational electron star drive is re-installed.

Honorably Discharged

In 1903, the Navy sold the ELCO launch to the Reverend Alexander Dowie. Dowie was a wealthy fundamentalist preacher. He named the launch *Esther*, after a daughter who died from burns caused by an alcohol lamp. From the oldest book in the bible, *Esther* means “star” in Persian.

Dowie died in 1907. The electric power plant was pulled from *Esther* in 1909. Thereafter, *Esther* received a long series of INFernal combustion engines and the launch became a ferry. With some superstructure changes, the wooden-hulled *Esther* changed roles again. She became a tugboat. She enjoyed a record fifty-year service. For a time during the 1970’s, she was on display at a maritime museum in South Haven. Then, she was abandoned.

Found Again

Rescue came in 1988 at the hand of Bruce Herron of Blue Star Woodwork. Herron was looking for an old boat to restore — and a home for one of his steam engines. It was at this point that we joined the project. When we realized *Esther*’s history, we knew it was time

Above: *Esther* awaits her re-launch in Saugatuck.

to turn back the clock. To restore the electric propulsion — and power it with non-polluting sunlight. We knew we wanted to do it. We didn't know how.

Help came from R.J. and Matt Petersen at Tower Harbour Marine. They provided the longterm storage and workspace we would need. *Esther* was stripped. We replaced her keel, stem, and stern with new oak. *Esther* even spent one summer on display near the Petersen's *S.S. Keewatin*, a well known floating museum and restaurant. We used solar modules, batteries and an inverter to power our tools. About this time, the IRS awarded our Good Ship *Esther* Foundation its tax exempt status.

Esther's hydrodynamics

Esther has a displacement hull, designed for entry and exit from the water. Imagine flipping the hull over, upside down, and sitting it on axles. You'd be looking at an electric car with good aerodynamics. The master shipbuilder had his own version of a personal computer to help as he sighted down his thumb from 20 paces at *Esther*. It was quite a lesson to learn what our forefathers knew — how to shape a renewable resource, trees, into a hull that moved quickly and easily through the water.

The original power plant (electric motor) in *Esther* was probably 6 horsepower (hp). The 1902 launches had a "radius of action" of up to 80 miles with maximum (long-range option) batteries.

The New Powerplant

Esther's new power plant will be essentially the same as the one used in 1896. A pulse modulation controller will be substituted for the mechanical control relays. The original launch had the motor midship. Ours will be positioned over the shaft with a sprocket and chain reduction. We have a 5 hp Baldor electric motor, rated 48 V and 2200 rpm. Its amp-hour curve suggests that, at 1250 rpm, it will drive *Esther* through the water at 5 knots at a discharge rate of 40 Amps.

Five "strings" of four PV modules (48 Volts at 50 Watts) will fit easily on the launch roof. This photovoltaic canopy will generate 250 Watts of peak power toward the propulsion effort. A tracking array would work best dockside, trimmed underway to maintain a low-profile.

The only way for us to know for sure what prop will work best is to complete *Esther*, do shakedown cruises, and fine-tune the system. Prop diameter and pitch, motor rpm, load, cruising speed — all will be balanced to an optimal solution.

Toward this end, we contacted Joe Fleming, a marine engineer who has experience with the ELCO craft, about *Esther*'s system. We received this reply:

"Cruise speed on the ELCO boats is 5 to 5.5 knots. I enclose the boat-horsepower-speed curve for a hull similar to *Esther's* hull. I'd recommend a 15/11 prop (15 inches diameter, 11 pitch). It will want to turn at 1000 rpm.

"The system will use 20 amps for each horsepower the propeller will want. Horsepower is determined by multiplying volts x amps x system efficiency. Figure 80% efficiency. Divide the product by (the conversion factor of) 750 watts, which equals one horsepower. Thus, 48 volts x 20 amps x 80% efficiency — divided by 750 watts equals 1.024 horsepower.

"[I recommend during trials that you] put a voltmeter and ammeter on the batteries. Steady your speed at 40 amps draw. That should be 2 horsepower. (Note the speed.)

"Twelve 8D-type batteries (12 V, 220 A-h), wired in three strings of four batteries will give you 48 volts at 660 A-h. At a 40-amp rate, *Esther* should go 660/40, or 16.5 hours. Converting knots to speed, that's 5.7 mph for 16.5 hours, or a 94 mile range."

[Editor's note: 94 miles represents a 100% discharge. A better service life will result from only 50% DOD, or depth of discharge. This still gives a 47 mile range — with a safe 100% reserve. Also, 8D batteries are too heavy. Choose another type. MH]

A Bold Plan

The purpose of this project is to further demonstrate the feasibility of solar electric transportation. We propose to bring "history" out of the museums and back to life. In this spirit, we wrote a letter on March 19, 1993. In part:

"Dear President Bill Clinton

"One hundred years ago, 55 electric-powered boats carried over one million passengers at the 1893 Chicago World's Fair. In November, 1893, Scientific American front-paged their success. The U.S. Navy was impressed enough to adopt this model as Captain's gig on every major ship in the fleet. These gigs, in their mother ships, circulated throughout the globe in Ted Roosevelt's Great White Fleet. Our Foundation is named for the *Esther*, delivered to the Navy by the Electric Launch Co. (ELCO) at the Brooklyn Navy yard in 1896.

"The foundation is prepared to donate the *Esther* to the US Navy for your use as a Presidential yacht. The restored hull has been relaunched ... and [we'd like to] sail it to the East Coast on an educational voyage for delivery to the Navy and you."

We received this reply, in part:

"We sincerely appreciate your generous offer to donate the *Esther.* However, the Navy does not have a program that maintains a vessel for use as a Presidential Yacht. Given *Esther*'s interesting history, you may consider extending your offer to the Smithsonian Institution. You may contact them at ..." — Gregory R. Nowak, Director, White House Liaison Office, Office of the Secretary of the Navy

Where do we go from here?

The Good Ship *Esther* Foundation is still not done. If there's anyone out there that will help us, we ask them to contact us. We could use it. We have appealed to a variety of manufacturers, including PV manufacturers, for hardware and support. Not much response. We don't feel most of them realize what we have here, in *Esther*. Maybe this article will help make it clearer. We'll keep you informed of our progress.

Access

LeRoy Wolins is a founder and long time member of Veterans for Peace. Effort expended in turning a former warship into a solar peace ship is his way of beating swords into plowshares. POB 255, Pullman, MI, 49450 • 616-236-5880.

Richard Orawiec lives in an off-grid home, is a Michigan licensed contractor, and installs solar systems. POB 255, Pullman, MI 49450 • 616-236-6179

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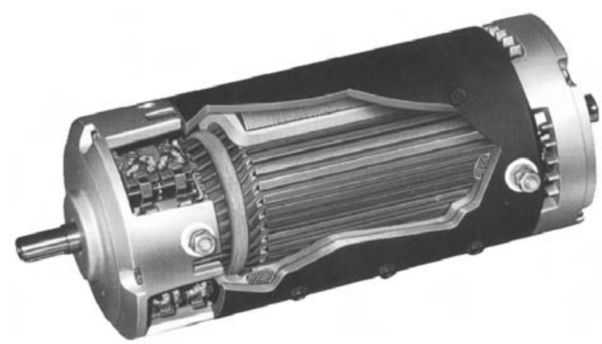
The Good Ship *Esther* Foundation is a Michigan corporation with a tax exempt status. Write: POB 265, Pullman, MI 49450



Marine Electric Propulsion

Michael Hackleman

I first learned about the Good Ship Esther *Project when Richard Orawiec approached me following one of my workshops at the Midwest Renewable Energy Fair (June 1993). Richard had a story to tell me, pausing now and then to hand me a videotape, letters from government officials, and photos of the* Esther *in various states of restoration.*

Richard gave me a copy of Launches and Yachts *by William Swanson. For the most part, this is a reprint of the original 1902 catalog for ELCO (the Electric Launch Company). I wrote to Swanson, asking permission to reproduce some of its drawings in this article. I took this opportunity to engage Swanson in a technical discussion of refitting the* Esther *with today's technology. The sidebar below, arranged by topic, is a summation of his detailed reply.*

Bill Swanson has supplied many useful "rules of thumb" here that should help evolve the updated propulsion system for *Esther*, or any other electric boat, for that matter. About most of these matters, I find myself in complete agreement with him. I have these reservations about these topics: voltage and safety, 6 V vs. 12 V batteries, volts vs. capacity, controller type, and solar-charging.

Voltage, Battery Capacity
The "below 50 Volts" rule undoubtedly stems from safety issues. High voltage and water don't mix. Low voltage reduces the shock hazard.

The original specifications sheet says that the ELCO 36 foot launch had 44 cells in its battery pack. The

Refitting the Esther with Today's Technology

I wouldn't spend two minutes trying to duplicate the original specs of *Esther*. Everything has changed — motor efficiencies, battery capacities, new technologies (mainly chopper pulse regulator). Start from scratch.

Propeller Size and Pitch
Generally in a displacement boat like *Esther*, you want the largest possible propeller that will fit in the aperture (cutout). So, measure the maximum possible clearance, and subtract about two inches. That will be the maximum diameter of the prop. Consult a naval architecture manual and cross reference prop diameter and engine rpm on the nomograph to see what the prop pitch should be. Then, go to a prop manufacturer and tell them you want a prop with those dimensions. For example, an 18/15 prop is 18 inches in diameter and has a pitch of 15 inches.

The rpm will be in the hundreds, not thousands. For a big prop, the lower the rpm, the better. Low rpm means less "slip" (loss of efficiency), less cavitation (air bubbles), and generally less wear-and-tear.

A three-blade prop is the safe, sane choice. A two-blade would be too little in surface area, and a four-blade is good only if you've got the dollars. It doesn't have to be anything fancy or "high tech". Get quotes from Michigan Wheel, Federal, and maybe one or two other prop manufacturers for making the prop .

The prop must be bronze. *Esther* will have too many electrolysis problems with an aluminum prop. A thrust bearing must be installed. Consult a thrust bearing manufacturer for size and installation.

Displacement Hulls, powerplants, controls
I'd say an electric motor in the 5–7 horsepower range is about right. Unlike cars, displacement boats have a very low "maximum" speed, so that even if you put, say, a 100 hp motor in *Esther*, you're still only going to get the same performance as a 10 hp motor. It's a different story for planing powerboat hulls. Expect to pay as high as $100 per horsepower over the counter.

All powerplant calculations should be at 75–80% of maximum speed. Use this formula: 1.2 x square root of waterline length (in feet) = maximum speed of *Esther*. Now, multiply this number by 0.8 (80%) to get your "cruising" speed. "Cruise" is the speed you'll use in ANY calculations involving motor rpm, battery capacity, etc.

Esther should use a "chopper" (motor control) system. It'll deliver 20–50% more operating time.

Battery Voltage and Capacity
I believe there is a U.S. Coast Guard boatbuilding

Scientific American article says that 66 cells were used in the launches at the Exposition, at 150 A-h capacity each. The article said that the speed controller arranged them in three packs of 22 or two packs of 33. This implies system voltages ranging 40–80 Volts, with battery capacities at 300–450 A-h.

I recommend the use of 6 V batteries instead of 12 V batteries for *Esther*'s pack. It is true that 12 V batteries are the fastest, most space-conserving means of reaching high voltages. However, a 12 V battery has proportionately higher internal resistance, delivering fewer watts per pound of battery, than a 6 V one. That is, the 12 V battery

Above: solar powered tools help with the reconstruction of *Esther.*

regulation somewhere that differentiates systems above 50 Volts and those below. If I were you, I'd do whatever was necessary to keep *Esther's* system at a maximum of 48 Volts. Above 50 Volts, you have a ton of specification requirements. Below 50, you're golden.

A whole mess of batteries can be wired in either series or parallel. You can come up with any voltage (and capacity) you want. There's no real advantage to 6 Volt batteries when your operational choices are in 12 Volt increments: 12, 24, 36, or 48.

Batteries in Boats
There are five issues when using batteries in a marine environment: type, cost, weight, maintenance, and replacement.

Nicad, sodium-sulphur, lithium, all that future high-tech stuff, gel cells, maintenance-free — it's all hooey. Someday, maybe, one or more of the above may work. But not right now, today. There's only one option here: the bread-and-butter, garden variety, lead-acid deep cycle battery.

In the "real world", you're interested in dollars per Amp-hour ($ per A-h). Pick the cheapest, but reasonably reliable name-brand of battery. At current prices, anything more than about 75–80 cents per A-h of capacity (in a 12 V) is wasted money. There's really not too much to choose from — nor does there need to be.

If a single human being can't reasonably lift the damn battery in and out of its slot in the boat, the battery is too big. If this means you have to design in forty small (group 24 or 27) batteries instead of six monster batteries, so be it.

Batteries will need maintenance. Sealed batteries aren't required. If the boat is going to be upside down (or even 90 degrees over) for any period of time (say, oh, three seconds), you've got much bigger troubles than electrolyte slopping around. What you've got basically is irreversible sinking!

Finally, the batteries need to be easily replaced. If your battery isn't sold at Sears, K-Mart, or your local car battery store, it's not worth whatever other advantages it may have.

Solar Charging
Electric boats use energy at the rate of 50 to 100 Amps per hour. A solar charging system that supplies a small fraction of this is just an expensive toy. A month of sunlight for an hour's running time is not currently practical.

Access
William C. Swanson. Author, *Launches and Yachts: the 1902 ELCO Catalog*, Swanson Marine Enterprises, 829 Copley Ave, Waldorf, MD 20602 • 301-843-1367

sacrifices energy density for power density. In high rpm motor applications with limited space (like cars), this is justified.

However, *Esther*'s system has different requirements. As Swanson points out, a big prop wants low rpm. Low rpm and low voltage are a good match.

Let's assume *Esther* is outfitted with a 48 Volt system. Using marine deep-cycle batteries, we get 48 V with eight standard 6 V batteries, each 220 A-h in capacity. At 60 pounds each, eight batteries yield 480 pounds.

This is the *minimum* size of pack. *Esther* originally had much more capacity than this. If we double the pack size (described above) to 16 batteries, putting the two packs in parallel with each other, the 48 Volt pack's capacity will increase to 440 A-h .

Speed and Motor Control

Swanson's claim for the efficiency of the electronic controller is generally accepted. It gives infinite speed selection and corrects any mismatch between batteries and motor. However, there's merit in a control technique like *Esther*'s original system: voltage selection. Voltage selection is an inexpensive, low-tech motor control technique that arranges the batteries in various combinations of series and parallel wirings. This is too jerky for use with a road vehicle. In a boat, the prop "slips" much better than do tires on a road surface.

The simplest system would use a DPDT (double pole, double throw) copper knife switch. This is easily wired to supply two speeds — 24 Volts or 48 Volts to the motor — in a single throw. A second DPDT knife switch would add an extra speed — 12 Volts. A third DPDT switch can handle motor reversing.

A hefty knife switch is relatively safe at low voltage and easily handles hundreds of amps of current. The addition of a 12 Volt contactor and a pushbutton (in the shift lever) would enable the operator to momentarily power down the system, change the voltage selection (up or down), and re-engage — eliminating any current arcing at the knife switches. Shifting down provides a braking effect, too.

The primary drawback to this low cost, low-tech control technique is that it *does* reduce speed control options to a few steps. And, if it's not coupled through linkage to one main control level, it's not safe and probably won't get approved. For good reason: Electricity and water works for eels and hydrogen generators — not humans. Under the right conditions, as little as two Volts or one tenth of an amp can kill you. Do it safe or don't do it.

Finally, it is true that a PV canopy on *Esther* will generate power at a fraction of that consumed, even at cruise speeds. And that power will come expensively. Twenty modules represents a $6K investment. The good news is that as little as two days of sun will power *Esther* more than an hour at cruise speed. As Richard Orawiec has commented, "The plug for this thing is there," pointing toward the sky.

Access

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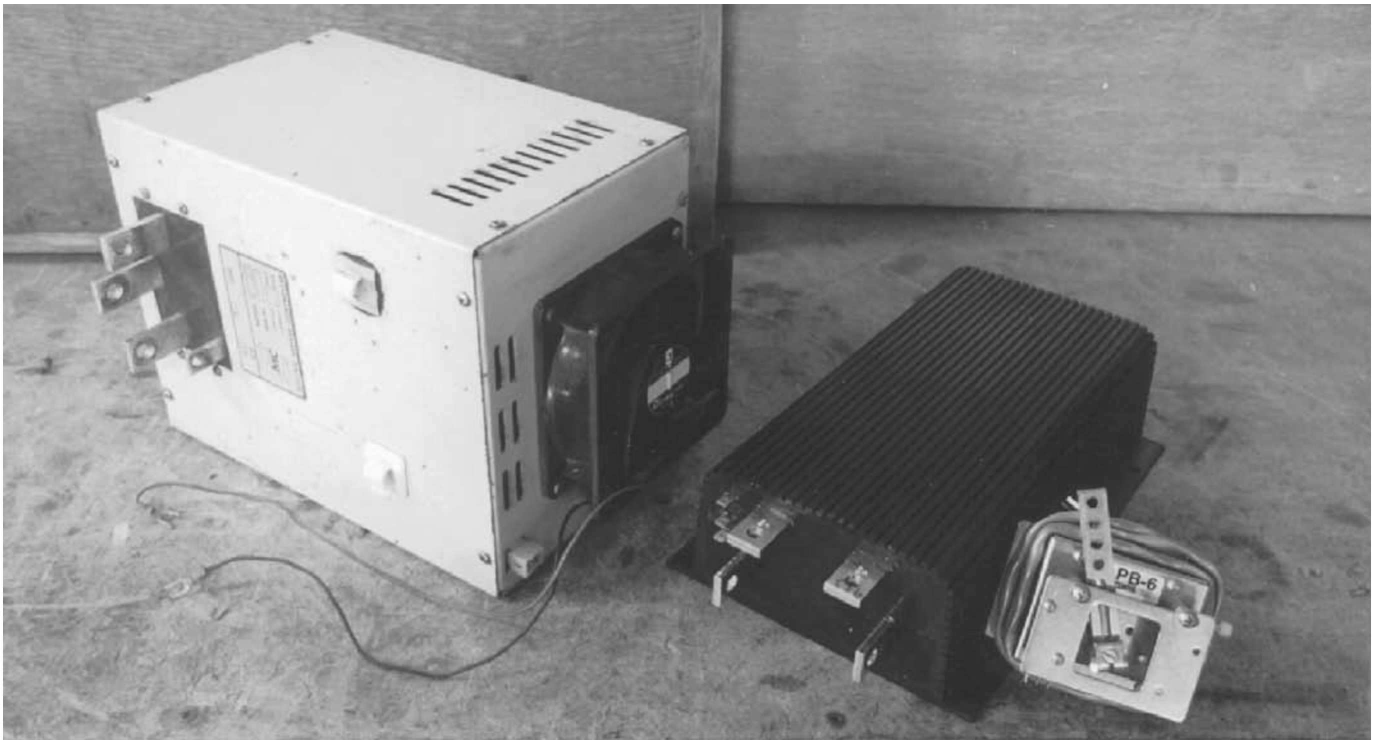

Above: Electric car controller evolution: on the left is an early transistorized PWM controller; on the right is a modern MOSFET PWM controller and potbox. Photo by Shari Prange

Electric Car Speed Control Systems

Shari Prange

The controller is to the electric car what the carburetor is to the gas car. It meters out the "fuel" to the motor according to the demand, as signalled by the throttle pedal.

Controllers have advanced more than any other part of the electric car over the years. The most primitive system involved series-parallel switching. In this method, the batteries could be run in two configurations: all wired together in series for full battery pack voltage, or split into two equal half-packs connected in parallel. This system had two speeds, which combined with the manual transmission to yield a confusing set of choices. It had complex wiring and required flipping some type of switch as well as shifting gears. Series-parallel switching provided little speed control, and performance was jerky.

A second type of controller used resistors. This type could have several speeds. In low speeds, the unneeded energy from the batteries was burned off as heat by banks of resistors. As each bank of resistors was eliminated from the loop, more energy made it to the motor and speed increased. As you can guess, this system was extremely inefficient, because the batteries were essentially always at full-throttle, but most of the energy was siphoned off and wasted. Resistor type controllers were also a terrible fire hazard.

SCR controlling

An enormous improvement was the Silicon Controlled Rectifier (SCR) controller. It controlled speed by rapidly turning the battery voltage on and off by means of a silicon controlled rectifier. This type of controller is called a "chopper". The power is actually full on or full off at any given moment, but the pulses happen very rapidly, so the effect is an averaging out of the power.

The SCR controller simplified the wiring and gave a smoother and more complete range of speeds. However, the controller still lost efficiency through heat, and required a bypass contactor to achieve full throttle.

The SCR controller was both frequency and pulse width modulated. At higher speeds, it functioned by varying the duration of the "on" part of the cycle — the pulse width — while holding the frequency constant. At lower speeds, however, it also needed to vary the number of times — the frequency — that it turned on and off each second. This ranged from about 0.02 kHz (kiloHertz, or thousand cycles per second) to about 0.4 kHz. This frequency range is audible as a growling sound.

Unfortunately, the SCR controllers had some efficiency losses, and they tended to be worst right in the middle of the performance range where most real life driving is done.

PWM controller
The next step in the evolution of the controller was the transistorized pulse width modulated (PWM) chopper. When this type of controller was introduced by Frank Willey, and then further developed by Curtis PMC, it quickly dominated the electric vehicle market.

The transistorized PWM controller varied speed by varying only the pulse width, operating at a constant 2 kHz frequency. This was much higher than that of the SCR, and reduced noise to a slight whistle.

The transistorized PWM controller was smaller, lighter, quieter, smoother, more efficient, more reliable, and simpler to install than the SCR controller. Later models came in sealed weatherproof aluminum cases with extruded heatsink fins.

Since then, the PWM has evolved again. The Darlington transistors inside it have been replaced with MOSFETs (metal oxide semiconductor field effect transistors). The result is a more streamlined package without the heatsink fins, a broader range of input voltages, and a higher frequency of operation (15 kHz), making it virtually silent.

The choice
A PWM controller is the best choice, (preferably the MOSFET version) but an SCR controller is acceptable. In fact, SCR controllers are still used on very large motor applications, such as diesel/electric trains and electric transit trains. If you have an SCR unit, you will need to accomodate its larger bulk. Since its contactors and components are all exposed, this controller should have some kind of weatherproof enclosure, while still allowing cooling airflow.

Resistor and series-parallel battery systems are not acceptable for high power applications such as EVs.

Installing the controller
The controller should be mounted with its terminals as convenient to the motor terminals as space permits. On the PWM controller, the terminals can face in any direction except straight up. In that position, it is possible for moisture to collect and seep along the terminals into the controller and create a short circuit.

Temperature
Temperature control is the most critical factor for controller performance. If the controller position does not achieve good airflow in its installed position, duct air to the back of the plate from elsewhere. For a high performance race car, or a car with a rigorous duty cycle including long steep hills, use a finned heatsink plate.

The MOSFET PWM controller heatsinks through its bottom, and must be mounted on an aluminum plate measuring 12 inches by 12 inches by 1/4 inch minimum. The plate need not be square, so long as it has an equivalent quantity of aluminum in it. Coat the bottom of the controller completely and evenly with heatsink grease before mounting it on the plate. This plate needs to be positioned in the airflow for cooling.

One of our customers installed his controller vertically on standoffs on the firewall behind the driver's seat of a Porsche 914. The bottom inch of the plate extended under the car into the airstream. In motion, this caught the air and funnelled it up between the plate and the firewall, providing very effective cooling.

AC controllers
All of these controller apply to DC motor systems. The ac motor has an entirely different controller. An ac controller needs to be, in effect, three DC controllers synchronized together. For this reason, it is also very expensive and bulky, and not generally used by hobbyists.

Potbox
The other part of the speed control system is the potbox or potentiometer (variable resistor). This is the unit that connects to the throttle pedal. It is typically a 0–5 kiloOhm (kΩ) unit much like a dimmer knob on a light switch. Depending on how much the throttle is depressed, it sends a resistance signal ranging from 0–5 kΩ to the controller. The controller interprets this signal and varies the duration of the energy pulses proportionately.

The potbox must be mounted rigidly to be effective. Adjusting the throttle linkage is one of the trickiest and most critical operations for good performance. If the potbox does not achieve full "on", the car will never have full performance.

If it does not achieve full “off” position, there are other problems. The PMC potbox has a high-pedal lockout safety feature. This means that the controller will not operate if you try to start the car with a partially depressed throttle. This protects against an abrupt and unexpected lurch if the car is turned on with the throttle accidentally depressed. However, if the potbox cannot return to the full “off” position, the car can’t be started.

The potbox lever arm has several holes spaced along it for the throttle linkage, to allow different travel distances. If none of the existing holes works for your throttle, you can build an extension for the arm and add more holes.

Incidentally, the PMC potbox contains one of many emergency disconnects that should be in the system. It is a microswitch that functions as a “deadman” switch. Any time the throttle is released, the microswitch opens the main contactor, shutting off all power to the system.

The three main qualities to look for in an electric vehicle speed control are efficiency, performance, and safety. If you choose a good system and install it carefully, you’ll never need to think about it again.

Access

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REDI: Renewable Energy Development Invitational Willits, CA August 1993

Michael Hackleman

As those who attended will recall the Solar Energy Exposition & Rally (SEER) in 1992 was a big success for the alternative energy movement. However, it basically fried everyone that headed it, most of whom made no money (or lost some) in the effort. Planning for SEER '94 is underway and it promises to be bigger and better. Unwilling to skip a year, the SEER staff opted this year to put on an event. The result was the Renewable Energy Development Invitational, or REDI. This conference featured speakers and workshops for professionals in the field. With Keith Rutledge and Kathy Maples at the helm, REDI was a solid show.

I've seen the behind-the scenes work the SEER folks have put out for the past two years, so I made an early commitment to attend and help. It seemed a shame to let the year go by without a *west* coast gathering. REDI seemed like the perfect window — and I obviously wasn't alone in the thought.

First, though, let me help put the past 12 months in perspective. Much has been happening throughout the country. About this time last year, the three-day L.A. Electric Grad Prix moved clean-air vehicles through more than 100 miles of the smoggiest area in the country. Kudos to Peter Hackes and Becky Murray for a first-try winner. The EV Symposium sponsored by NESEA in Boston (Nov '92), under the guidance of Nancy Hazard and Robert Wills, was a superbly executed conference, and there's every reason to expect the same this year. (See Happenings for details.) Ernie and Carol Holden's SERA-run 3rd annual Phoenix Solar & Electric 500 was bigger, better, and safer. The '93 Midwest Renewable Energy Fair, with Julie Weier's team, has become a formidable event. Even in the rain, exhibits and workshops were packed. I missed out on the '93 Tour de Sol U.S.A. , but I heard it was also great.

I also attended a few utility and industry sponsored events, which shall go nameless. Here, everyone seems preoccupied with the idea of showing that "they're doing something". All of the information feels biased towards the status quo, excluding too many good technologies. The information, then, feels outdated, irrelevant, or only politically correct.

Okay, we're back at REDI. The first decision attendees had to make was: energy or transportation. What I saw of the former sessions looked lively and well attended. I chaired a number of transportation meetings, and the same was also true. Altogether, it was invigorating to get updates on many of the emerging technologies, and to hear societal and economic issues discussed along with technological ones.

When it was time for some fresh air, a diverse variety of vehicles and technologies greeted the eye curbside. A surprisingly nimble City-el was put through its paces by many people. It felt safer to drive than it looks. Hmmm. European styles always seem to hide their toughness and crashworthiness. Bill Worf is setting up dealerships to make this 700 pound vehicle available in the U.S. Ruth MacDougall revealed a plan to put a hundred of these well designed vehicles into the hands of SMUD customers in Sacramento. I drove the City-el and liked it a lot. Its silence was uncanny. The City-el is a time-proven design. If you're going electric, check it out.

Other good prototypes and conversions were there to look over. One was Michael Leed's Speedster. Starting life as the Solar Mule, a zesty 3-wheeler that ran well in the Phoenix 500 in 1992, the Speedster is a good example of what happens when you think "light". The 4.5 horsepower Advanced DC motor cranks out 12 hp during acceleration. Applied to 650 pounds of vehicle, it's a smooth launch that surprises onlookers.

John Takes from Burkhardt Turbines showed off a 3-wheel runabout that mixes a MGA (two wheel) front end with a Yamaha 360 cc dirt bike rear end — engine, transmission, cradle and swing arm. It's a no-nonsense, workhorse vehicle that demonstrates the merit of using complete subassemblies from the right vehicles to achieve goals quickly. The series-parallel contactors were a bit jerky for the novice, but I expect things will improve.

Peter Talbert from Ft. Bragg showed off a hybrid electric-HPV. It sports a BlueSky shell (Mark Murphy kit body design) wrapped around a robust frame (built by Jan Hellsund — see *ATN*, Jun/Aug 91). Peter is offering a production version of the frame. After some more tuning and road time, this will be a neat marriage.

George Buono (Solar George to Willits' folk) brought down his immaculately crafted electric vehicle. Half of its sturdy 1100 pounds is battery pack. With twin Solectria drives at work, it's a sweet vehicle, well engineered and smooth to drive and ride, with regenerative braking. As Phil Jergenson says, "It's a sensible design." A few weeks before REDI, George lost a lifetime's work when his uninsured solar workshop was destroyed by fire. I'm glad he decided to attend REDI.

Steven Heckeroth also showed up with his latest conversion, driving 43 miles over from his homestead. The route includes the Fort Bragg to Willits road, and its significant uphill and downhill grades. Steven is gaining recognition for his solar home designs, and is setting up to do custom EV conversions.

REDI happened and then it was time to leave. I returned with the HP crew to visit the magazine's offices, meet scores of cats, stare at Mt. Shasta in the distance, breathe in stars and — you know, do other business things.

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Michael Hackleman, c/o Home Power, POB 520, Ashland, OR 97520

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Must either bust or advertise."
Sir Thomas Lipton — 1870

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Efficient 12 Volt Power from Higher Voltages:

A Simple Buck Regulator

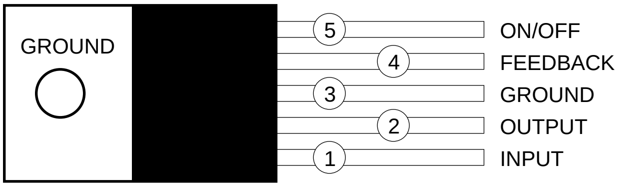
Chris Greacen

Hey, you folks with 24 Volt (or higher) systems out there! Do you ever want to run small 12 Volt appliances off your battery bank?

It used to be you had three choices: (1) tap into 12 Volts of your battery bank, (2) use a Vanner Voltmaster battery equalizer (24 Volt systems only), or (3) use a linear regulator. The first choice leads to an unbalanced battery. The second choice keeps the battery balanced, but costs — a ten Ampere Voltmaster retails for $216. The third choice wastes energy by "burning off" excess voltage as heat.

Buck Regulator on a Chip

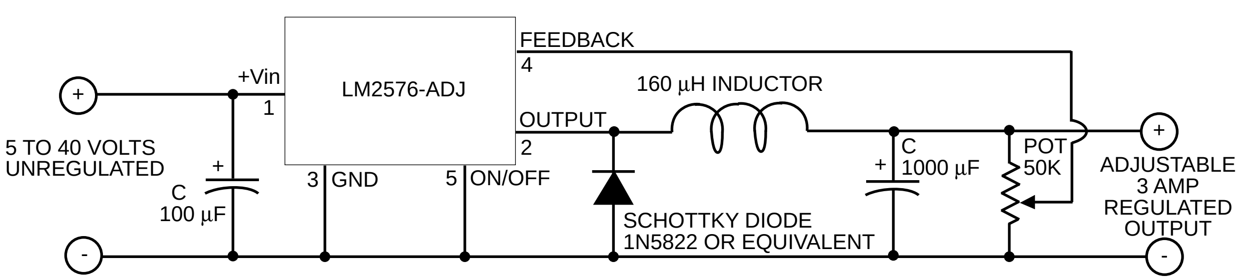
Now you've got a fourth choice. National Semiconductor's LM2576-XX series are "buck regulators on a chip". You provide an inductor, a Schottky diode, and a couple of capacitors, and you've got an efficient buck converter. Put in anywhere from 14

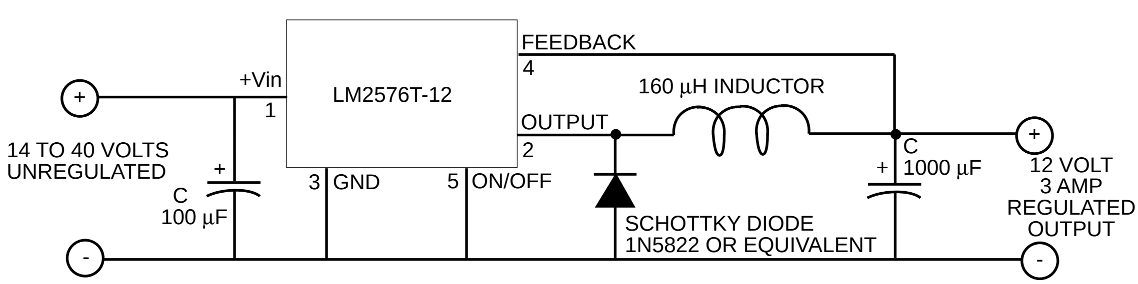


to 40 Volts (60 Volts on the high voltage LM2576HV-XX), and you get more current out (up to three Amperes) at a regulated lower voltage. As well as the 12 Volt output version (LM2576-12), the chips are available in 3.3 volts, 5.0 Volts, 15 Volts, and an adjustable 1.23V to 37V version (LM2576-ADJ).

For the basics on how buck converters work, see "Using Magnetic Fields to Change Voltages" on page 40 in this issue. In this circuit, Pin 4 on the LM2576-12 senses the output voltage, and any time it falls below 12 Volts, the chip allows current to pass from pin 1 to pin 2. Current from pin 2 passes through the inductor, building up its magnetic field, and arrives at the output, raising the output voltage. When the voltage rises above the 12 Volt threshold, pin 2 is shut off, and the inductor's collapsing magnetic field induces current through the Schottky Diode, supplying the output. The capacitors provide filter input and output to within ±3% of 12 Volts.

The chip contains internal frequency compensation, current limit protection, and thermal shutdown. It works great! I used the circuit to power a PowerStar POW200 inverter from a 24 Volt battery pack. Using a variety of ac powered loads from the inverter, and taking data with a recording Fluke 87 DMM, I measured efficiencies from 82% (239 mA output), to 93% (980 mA output). At





1.7 Amperes output the efficiency was 87%. To test the thermal shut-down and overcurrent protection, I powered a 60 Watt ac incandescent bulb through the inverter. This meant my 3 Ampere buck converter was supplying 5.0 Amperes DC! The light turned on (a little dim) and ran for 15 seconds before shutting down. Ten seconds later, it fired up again for another 15 seconds. No damage to the chip. Efficiency out here: 79%.

When you build the circuit, keep wire leads short. Since the switcher operates at 52 kHz, I wouldn't recommend using it to power radio equipment which operates near this band. But I noticed no interference on a FM (~100 MHz) radio powered by the regulator/inverter.

Access

Author: Chris Greacen, Rt. 1 Box 2335B, Lopez, WA 98261 • 206-468-2838. Thanks to Dave Gardner at Advanced Electronics (see advertiser's index) for turning me onto this chip.

Parts: Finding components for these circuits isn't easy. DigiKey has the LM2575T-5.0 which is a 1 Ampere, 5 Volt version of the chip. It sells for $6.55. For most folks this won't do. National Semiconductor was not able to recommend any other retailer of these chips on a piece by piece basis, and big distributers sell in lots of 45. But National Semiconductor says they will accommodate individual customers building prototype circuits. What this means is they'll send you one if you ask nicely and use words like "sample", "engineer" and "prototype". Their support center is 1-800-272-9959. If you're interested in this stuff, their "1993 Power IC's Databook" is excellent.

Schottky diodes are available from DigiKey • 1-800-DIGI-KEY. Their PBYR745PH-ND is good for 7.5 A, and costs $1.29. Also you might try All Electronics • 800-826-5432. Hosfelt Electronics, 2700 Sunset Boulevard, Steubenville, OH 43952 • 614-264-6464 has a 160 µH inductor for a buck, part number 18-123.

I'll build you one of these circuits, and put it in a nice little box, for $75. Tell me your input and output voltage choice. Or I'll send you all the parts, including the box, for $60. Allow six weeks for delivery.

Federal Energy Subsidies & The Societal Costs of Energy

Michael Welch

Some time ago, I presented a poster session at an energy conference at Humboldt State University that showed the advantage that the oil, gas, coal and nuclear industries received as a result of government subsidies. The session was very well received, but what amazed me the most was how little otherwise astute individuals knew about how much the energy they used truly cost them.

This column will concentrate on two facets of the issue: government subsidies and the more enigmatic hidden (societal) costs of energy, which can certainly be considered a subsidy. Basically, there are two schools of thought in the renewable energy world on government energy subsidies. First, there are those that believe that all subsidies should be removed, and that, as a result, a free-market economy will then pick and choose between available energy production methods to end up with only those energy sources that can stand on their own two feet. On the other end of the continuum, there are those that believe that we should encourage the Federal government to allocate as much money as possible to solar and other renewable energy resources (including increased efficiency) in the hopes that these funds will help renewables more quickly catch up to where the conventional energy sources are.

Many folks that are thinking seriously about this are somewhere in the middle. They realize it is overly idealistic to believe that our politicians would ever end subsidies that have been in place to a significant degree for many decades. They also realize that the very same reason will prevent large enough renewables subsidies to adequately even out the playing fields. By my way of thinking, a subsidy has merit, regardless of opposing technologies' subsidies, if it encourages new development which is considered desirable for our society, but would not get a good start on its own.

A logical, practical implementation of these beliefs would be to work hard to decrease the subsidies for less favorable technologies and then to work even harder toward leveling the playing field by increasing the subsidies for renewables and energy efficiency. At this point in time, it would not make sense to consider having equal or no subsidies as a level playing field. Infrastructure decisions and other investments have long been based on past subsidies, and these market effects could linger for decades after the subsidy itself is eliminated.

According to The Alliance To Save Energy's recent report *Federal Energy Subsidies: Energy, Environmental and Fiscal Impacts*, "The historical pattern of federal subsidies for energy ... refutes the notion that there is a free market in energy. If this damaging pattern is not broken, the United States may fail to achieve its energy, environmental, fiscal, and economic goals." The report is based on 1989 figures, the most recent year for which complete and reliable data could be obtained. According to the report, 58% ($21 billion) of all energy related subsidies directly promotes the use of fossil fuels and 30% ($11 billion) is earmarked for nuclear, while energy efficiency receives only 3% and emerging renewable sources account for only 2%.

The report points out that our energy subsidy pattern is damaging in several areas. First, it represented a heavy tilt toward conventional energy supply and away from energy efficiency. It is becoming increasingly apparent that efficiency and conservation are the cheapest and most environmentally effective means of meeting our future energy needs. Second, it favors mature energy resources like fossil fuels, nuclear fission and hydroelectric that should already be able to stand the test of the market over emerging technologies that could truly use a boost to get going. Third, it represents poor environmental policy because it strongly favors polluting and environmentally risky technologies over safer energy sources. And last, this subsidy pattern can be translated to lower energy bills for consumers (at least in the short run). But if you add on any associated tax burdens to the public, the heavily subsidized technologies end up being pricier in the long run. The artificially inexpensive energy rates could ultimately discourage the development of new technologies which may prove to be cheaper.

Other Costs of Energy

And then, there are the hidden, or societal costs of energy. *WARNING: THESE FIGURES ARE STAGGERING, & MAY INDUCE LIGHTHEADEDNESS IN THE FAINT OF HEART* ... or at least really tick you off. Though hard to specifically identify and just as hard to put in financial terms, these hidden costs include damage to the environment, environmental illness as the direct result of pollution from energy industry activities, economic and employment effects, damage to our country's buildings and infrastructure as a result of acid rain, and the costs of military efforts to protect U.S. control of the world's oil supplies. Thanks to the American Solar Energy Society's (ASES) 1989 Roundtable, Michael Nicklas has made an excellent stab at these annual figures (the ranges indicate the difference between various information sources researched). See table below.

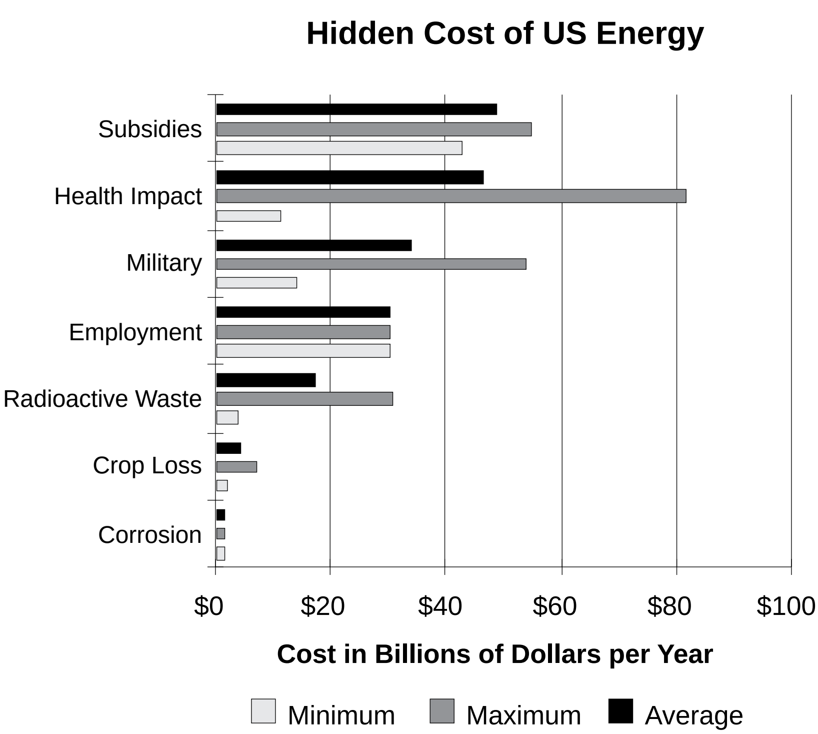
When you add in the range of estimated annual government subsidies for energy at $43.3–$55.2 billion, that means that the total costs of energy that most of society does not know about ranges from $109.2–$258 billion, an absolutely staggering figure. This figure comes to over $1000 per U.S. citizen per year!

According to Nicklas, our free market economy would operate best when both the buyer and the seller have complete knowledge of which choice will benefit them the most. Obviously, when most of us make our energy choices, we are thinking of our immediate out of pocket expense. Who stops to consider when they pay their utility bill, that sulfur dioxide from coal burning plants cost Americans $82 billion per year, or that farmers are suffering $7.5 billion per year in crop damage, or that it will cost us $31 billion per year to deal with nuke plant decommissioning and radioactive waste? If the true costs of energy were more closely associated with our individual energy needs, the best long-term solutions would more likely result in increased energy efficiency, conservation, and, of course, renewable energy use.

Another report, *The Going Rate: What it Really Costs to Drive* published by the World Resources Institute (WRI), concentrates on the hidden and subsidized costs of our motor vehicle transportation system. According to the report, "Motorists today do not directly pay anything close to the full costs of their driving decisions .... The net effect is to make driving seem cheaper than it really is and to encourage the excessive use of automobiles and trucks." According to the WRI report, the hidden and subsidized costs of driving are at least $300 billion per year.

When you figure that Americans drive two trillion miles per year, this comes to an additional 15 cents per mile, average cost. If you estimate that the average mileage on an American owned vehicle is 20 miles per gallon, that means that our society is paying an additional $3 for every gallon of vehicle fuel consumed.

Let me ask you, what would your driving decisions be like if gasoline prices at the pump were to be increased by $3 per gallon? Mass transportation, bicycling, and even just staying at home would begin to look much more attractive. So, when you go out and buy your remote energy system or your electric vehicle or your bicycle instead of paying the energy industry for their standard fare, you can feel good about your decision for more reasons than just becoming energy independent. You can truly justify your decision based on realistic economic figures, as long as you consider more than just your immediate out of pocket expenses. The only problem with this analysis is that you and I are still paying big bucks for others' less sound decisions.



How many energy lobbyists does it take...

I don't know the exact number, but they were all in Washington this spring, and their mission was accomplished. President Clinton's proposed BTU energy tax appears to have gone by the wayside. His proposed tax, while raising $70 billion for deficit reduction, looked meager when compared to the energy costs outlined above. The way I hear it, the special interest lobbyists came out of the woodwork to stand up for the "rights" of the oil and transportation industry. When combined with Republican efforts to discredit the Democrat President with their inflated "tax & spend" rhetoric, the BTU tax plan didn't stand a chance.

The answers to our woes in Washington are becoming clearer and clearer every year: We've got to get rid of the lobbyists and reform campaign financing. With money and influence-peddling out of the way, our government could finally get back to work for the good of us all. It does look, however, like there could be an energy tax in our future, albeit somewhat smaller than that proposed by Clinton. A transportation tax has been proposed which will raise Federal transportation fuels taxes from 14.1 cents per gallon to 21.4 cents. The whole point for the President is to use these taxes to decrease the deficit.

Access

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continued from page 4

I have nothing against the utilities using sunshine to make power. In fact, for the good of our environment, the sooner the utilities go solar the better. I see PV modules on the roof of virtually every building, all contributing power to a nationwide solar electric grid.

The big question is who owns these PV modules, and more specifically who owns the electric power that these modules make? Will the energy companies hold on to their power monopoly, or will electric power become something we commonly own? By analogy consider the following: you live in a cold climate where vegetables, shipped from a distant place, are only available at supermarkets. Someone invents a greenhouse that allows local vegetable production. Imagine inviting the supermarket to come to your homestead, erect a greenhouse, grow a garden, then sell you the vegetables.

Under the Public Utilities Regulation Policies Act of 1979 (PURPA '79), the federal government ruled that utilities must buy renewable energy from any producer. To us average type folks, PURPA '79 means that if we put up PVs, a wind generator, or a hydro, our local utility must purchase our RE-produced power. While PURPA '79 doesn't make it easy for us, as independent RE producers, to contribute our energy to the grid, it is very specific that we own this RE power and that the utility must purchase it from us.

Solar energy puts you in utility's traditional role of power producer and demotes their role to power broker.

Nowhere in the utilities' marketing of solar energy, do I see recognition of our legal right to own our particular piece of the sun. I am here to tell you what the utilities don't tell you. You can own your own electric power, and even sell your surplus energy back to them. If you are off-grid, you can own your own electric system for a fraction of the utility's lease cost.

Utilities are businesses. They make decisions based on their interests. It is not in their interest to have you own the power producing system and contribute this energy to their grid. This puts you in utility's traditional role of power producer and demotes their role to power broker. From the utility's standpoint this is a bad business move. From your perspective, as an RE producer, owning the energy offers you security and freedom. Instead of paying retail prices for power, you own your own. If the system is large enough to produce a surplus, then you should get a check from the utility.

The word is out. Owning your own renewable energy system is like growing your own food. Just one more necessity of life that is secure and under your control rather than subject to the decisions of others. Energy is now something that can be home grown.

"Who owns the sun"

Well, you do, of course. Federal law, common law, and just plain good sense all tell us that. This question must be repeatedly asked so that we are all aware that we do indeed own the sun. By way of helping us to forget who owns the sun, the powers that now control power offer us a number of tempting solar scenarios. Take a look…

Utility scale solar power plants

These represent the utilities' traditional approach to electricity — build a huge plant, make lots of power, and ship it on wires to wherever they can sell it. The main problem with this approach is the democratic and distributed nature of sunshine. All anyone gets is one kilowatt per square meter and that's it. Solar energy is diffusely offered everywhere and awkward to centralize. The main attraction of utility scale PV projects is that they allow the utilities to keep their traditional role as producers in the style to which they have become accustomed.

The utility's PVs on everybody's roof

In this scenario the utility installs their PV array on your roof. Here you buy their power which is produced on your roof. This scenario is actually being practiced by a major utility and this utility charges more for the solar energy than for its regular electricity. This "PV for Yuppies" program (as it's known inside the utility) is actually being successful because so many folks want to help our environment. There are three advantages for the utility in having their modules on your roof — no real estate cost, no additional transmission wiring, and they get to keep you for a customer. The disadvantage for the user is that you are still a power consumer with a monthly power bill.

There are legal questions surrounding the utility owning the PV array located on a roof that you own. Consider fire, storm damage, lightning damage, and other real life disasters. Who is responsible for what aspects of the system? New types of insurance and law will have to be written to insulate the utility from the homeowner and vice versa.

Your PVs on your roof
This scenario reflects the real ownership of the sun. You own the PVs on your roof and the power that they make. This scenario is legal (PURPA '79) and is being practiced by hundreds of grid connected RE systems. This scenario is not promoted publicly by most utilities because it is not in their own interest. As long as the RE producer meets rigid technical requirements, the system can be insured and legal requirements are clear cut.

I would like to suggest the following financial arrangement between the utility and any independent RE producer — all RE systems producing under 50 kiloWatts should receive net billing. This means equal payment for power produced or consumed.

Power bills without the wires
Utilities are entering markets which they have never serviced before. One such market is off-grid home power systems. Several utilities are considering leasing, and one is actually now leasing, stand-alone PV systems to off-grid homes.

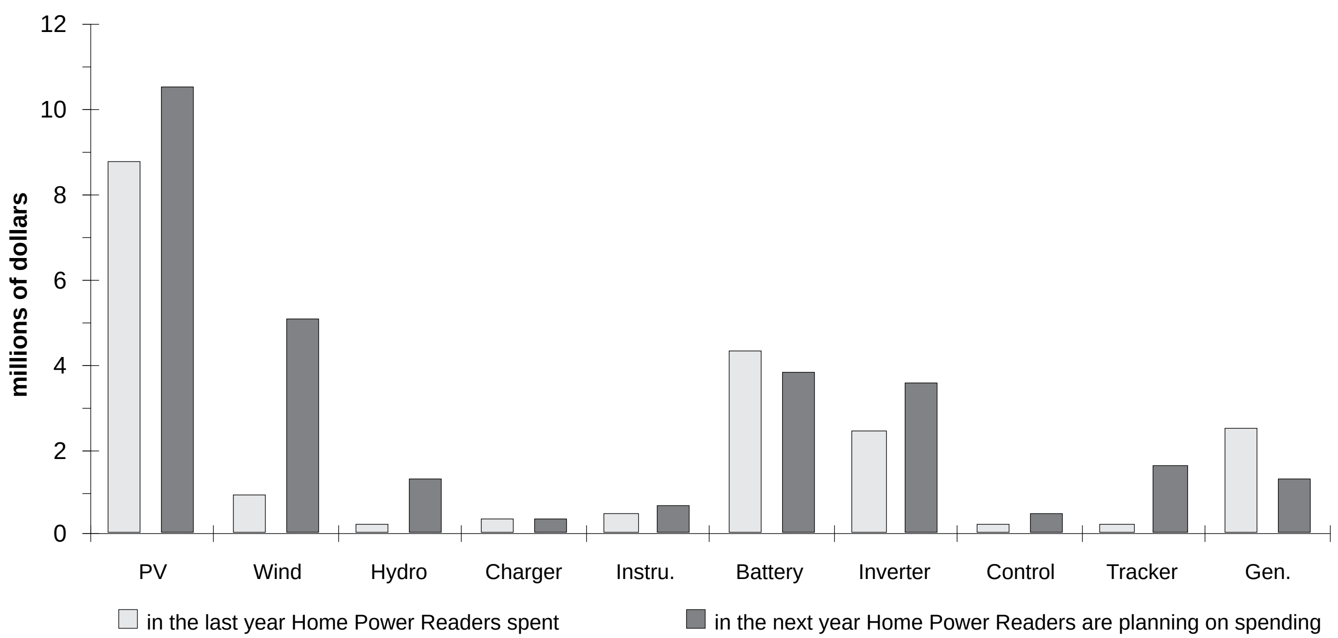
Utilities lack the expertise and experience to enter the off-grid market. I recently attended an RE conference and asked representatives of two major California utilities how many off-grid ratepayers they had. Both representatives answered none. By definition, off-grid means not connected to the utility's wires. This is a market that is radically different from any that utilities have ever serviced. Here there are design and customer interface skills that will take years for the utilities to master.

Utilities actually lack the legal ability to enter any PV market. Legally, public utilities are hampered from using solar energy by two factors. One, a utility cannot easily raise its rates. This limits their use of utility owned PV on their grid because they cannot show it to be cost effective. Two, a utility is prohibited from using its publicly granted monopoly to unfairly compete with other industries. This limits their competition with established, off-grid RE businesses.

The off-grid market is already effectively serviced by over 1,000 companies nationwide. These are the people who developed solar energy and made off-grid living a working reality. They have the experience of over 50,000 installations nationwide. Ten years ago the utilities laughed when we told them that small scale RE systems were more cost effective than either line extensions or running a generator all the time. Over the years, these small companies have pioneered home power systems until they represent a sizable and rapidly growing market. The chart below shows the volumn of off-grid home power business that we can track through our subscriber's database. I think that these figure represent less than 30% of the actual off-grid renewable energy market.

Utilities are trying to hold on to their energy production monopoly. The PUCs rule that the utilities can't buy PV because it's not yet cost effective to put solar on their grid. They can, however, lease PV systems to off-grid homes where it is clearly cost effective. Except for the legal wrinkle that there is this growing industry which is already servicing the off-grid market.

The off-grid market serviced by renewable energy dealers



Watching all this high-powered wrangling over sunshine and the utilities courting the RE industry has been fascinating. If utilities can't legally enter the off-grid market, then they can gradually buy its companies, and then run it their way. Which means the utility owns the power and we buy it — business as usual. Some off-grid RE companies are suffering from money-induced myopia. Some distributors and wholesalers think that the off-grid market will benefit from utility participation. "Come into my parlor," said the spider to the fly….

Energy Loan Sharking

Utilities want to offer financing to the RE community. While it's plainly clear that the utilities have the money, it is also clear that the financing they are talking about is for leasing a system, not buying one. For a specific example, Idaho Power is offering to lease a full sized, off-grid, home PV system for about $1,000 down and $300 per month for five years. Over a five year period the user would pay about $18,000 for power and end up owning nothing. If the same Idaho customer were to buy the system from an independent RE dealer, it would cost about $10,000 installed. At the end of five years, the owner still has a system that will continue to make power for at least another fifteen years.

Utility financing has only one tempting feature — it is the only offer we have. Currently almost all banks and lending institutions are too conservative and slow to realize an RE system's value. This is slowly changing, with some banks, like those in Willits, California, now offering financing for RE systems in off-grid homes.

Our solar future

There are few doubts that the 21st century will end up solar powered. After over 23 years of life off the grid, I know solar works. An industry doing over 100 million dollars in business yearly knows that solar works. Recent maneuvering by energy utilities shows they now know solar works.

If you've made it this far in the longest editorial I have ever written, then you are interested in energy. Insist on your right to own your portion of the sun. If you are a utility person, then please see that the times are changing. What was a power owned by few is now a power offered freely to all. Please be graceful during these times of change. Your role in our solar future is that of storage and distribution. Production has been moved to the big nuke 93 million miles from here.

Within the next decade we will make the decisions affecting our energy future. Not the least of these is, "Who owns the sun?"

Access

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A personal note

From this editorial you may gather that I am no fan of energy monopolies. I have a long memory. I remember watching Science Fiction Theater on TV in 1955. The show was sponsored by our local utility. I remember Redi-Kilowatt telling me about the coming age of clean, safe, nuclear power that would be too cheap to meter. I remember Three Mile Island. I remember WPPS. I remember the Gulf War. Clean, safe nuclear power has *arrived, via the Sun. The energy monopoly dinosaurs have not yet realized that the climate has changed.*

There is something about concentrated wealth that brings out the worst in humans. Solar energy can redistribute our energy wealth. This removes one of life's essential items from our list of things to fight over.

What grass roots RE dealers need is a nationwide organization that represents their interest and the interests of the off-grid market they serve. I offer Home Power Magazine's services in aiding the birth of such an organization. I suggest that a Renewable Energy Association (REA?) could greatly benefit us all. We are currently dealing with issues a case at a time. An organization could pool our experiences and resources. If you are in the home power RE business, then please contact us at Home Power.

The Gridman Cometh

Bob-O Schultze

Southern California Edison (SCE) has proposed a three year, 2000 kiloWatt (peak), pilot program to provide photovoltaic (PV) generated electricity to users in their service territory where line extensions are "uneconomical". How will this affect the development of the Renewable Energy market? Read on....

The Scenario

Some of the details of the plan are still sketchy, but as it stands now, a potential off-grid customer will be handed a list of "approved" contractors. These contractors will pick from a list of "standardized" systems based (presumably) on the user's needs, site, and budget. The user will be allowed to choose whichever of these approved vendors he/she prefers and enter into a contract with the utility agreeing to purchase power from the system for 15 years with the option to buy the system outright at any time for its prorated value. The utility will then hire the chosen contractor to provide/install the system. The utility will send the user a monthly bill. Yet to be determined is who pays for insurance, liability, maintenance, and costs of back-up generators and fuel.

A Disclaimer...

I am a licensed contractor who owns and operates a Renewable Energy design/installation business in California. As such, I have some definite opinions and ideas about this proposal and the whole concept of utilities entering the off-grid market. While it's my intention to give a fair analysis and report on this situation from an end-user's point of view (I live on and with PVs too), well...I am what I am. If you disagree with my reporting, please consider the sources — both yours and mine. Fair enough?

Meet the Players

• The Utility: SCE is a stockholder-owned corporation. Their service area is some 50,000 square miles of southern California. They are currently involved in a joint venture with Texas Instruments to develop (and market) a new type of PV module.

• The California PV Industry: Consisting of PV and BOS (balance of system) component manufacturers and distributors, local system designers and dealers, and system installers. Many of the manufacturers and distributors and a few of the dealer/installers are represented by Cal SEIA, the California chapter of the Solar Energy Industries Association. Of the 110 members in Cal SEIA, only 15 are involved with PVs, with the rest doing solar thermal or some other solar work. Of the 15, only three members are dealer/installers, whereas the Home Power "In Biz" database lists over 120 PV dealers in California.

• The California Public Utilities Commission: The CPUC is charged with regulation of the large electricity and gas utilities. Any expansion or change in the way they provide services to ratepayers must be submitted to and approved by the PUC.

• The California Energy Commission: The Energy Technology Development office of the CEC has taken an active role in sponsoring meetings between Cal SEIA, the Utilities, and the PUC. It also has a role in the PV4U (PV for Utilities) Working Group. While the CEC has no direct involvement with the outcome of the proposed project, it is charged with tracking and assisting energy technology development.

Pros or Cons?

The utilities paint a rosy picture explaining how their entrance into the off-grid market will benefit us all by advancing the use of PVs. Let's take a hard look.

SCE will finance the PV installations and lease the facility to the consumer for a monthly fee. The monthly cost will be much higher (kilowatt for kilowatt) than for a grid-connected home. However, it will allow remote homeowners access to solar electricity without having to come up with the price of the system at the time of purchase. The user could purchase the system from SCE at any time.

• Users will pay more for power from a SCE system than they would from a system bought outright from a reputable vendor. If the user decides to "buy-out" the system from SCE at some future date, the purchase price will be based on the prorated life of the system components added to the total cost of installation. The portion of the monthly charges that went to kW-hr consumption, system maintenance, accelerated depreciation, and financing will be gone.

• The utility owns the installation. Part of the monthly charges will include periodic and preventative maintenance performed by the contractor. You didn't think they'd let you maintain *their* system, did you?

Installation will be done to accepted electrical standards and performed by licensed and presumably experienced installers. The PVs and BOS components will be standardized and approved by an accepted testing laboratory.

• Most installations are done by qualified and experienced contractors now. Moreover, these small contractors are sensitive to and have a much better understanding of their customer's needs and lifestyles. A system is carefully tailored to a particular customer. Large contracting corporations are sure to get on the approved list, especially those having "good old boy" status from previous grid-connected business dealing with the utilities. The unsuspecting remote homeowner will then be faced with a smooth-talking, commission motivated salesman with marginal or no off-grid experience, who will "design" their PV system for them.

• To qualify for the approved or "blessed" list, a vendor/contractor will likely have to carry higher insurance coverage and bonding than they do now. SCE contracts and requirements will add additional paperwork and related expenses to the contractor. These expenses will be passed on as higher installation costs.

• As grid provided off-grid systems are "standardized", PV and BOS manufacturers will rush to get on the blessed list by providing acceptable and, more importantly, cheaply produced goods. Are these going to be the best quality? Will they continue to be produced — as nearly all are now — by American hands? New products will more likely be tested by a testing laboratory, *and* the utility, rather than the market — us, seasoned users. The testing criteria for test laboratories is based around the fire safety aspects of the equipment. For example, UL listing on an inverter tells you it's not a fire hazard, but it doesn't even consider the quality of the power produced by the inverter. Consider that this UL listing will take the manufacturer a year to get and may cost $5000–$10,000. This will increase the development time and expense of new products, and limit small businesses from producing new products.

If orders for PV modules increase dramatically, the price of modules will decrease overall. That decrease will benefit other PV users as well.

• If the utilities were to order 10 times the 2000 kW goal of the proposed project, the PV manufacturers would be inclined to invest in more production facilities. At this point, it's doubtful that SCE will find off-grid customers for even half the project goal in their service area.

A Few Other Potential Problems

• Small dealer/installers will be unable to compete with the distributors who also sell and install on a retail level. As these smaller, low-overhead vendors are eliminated and competition is reduced *within* the PV industry, prices to the end user will rise.

• The utilities have huge advertising, marketing, and legal departments in place. They have "name" recognition and public trust — after all, they've held a legal monopoly in their service area for decades. In the case of expansion into the solar energy market, the CPUC regulations specifically state that, "The commission shall deny the authorization sought if it finds that the proposed program will restrict competition or restrict growth in the solar energy industry or unfairly employ in a manner which would restrict competition in the market for solar energy systems..." Can we rely on an overworked and underfunded PUC to enforce the anti-restriction of competition and growth of solar energy statutes?

• Some of the utilities in California have demonstrated a penchant toward favoritism in choosing their suppliers and contractors. Favoritism is a widespread industry concern. At a recent meeting between the RE industry and a utility, favoritism ranked 5th of the 22 voiced concerns about the utility entering the RE market. A practice like this will restrict competition and eventually cause higher prices to the end user. Why should entrance into the remote home market change this?

• Traditional lending institutions who are just now testing the financial waters in the remote PV market may back away due to competition from utility financed systems.

And so...

It was bound to happen. The giant power utilities have discovered the reliability and cost-effectiveness of using photovoltaics as a viable alternative to line extensions to remote homes. The utilities are not interested in using PVs for grid-connected homes. Never mind the environmental benefits — it's just too costly to fly it past the stockholders at this point. But there are dollars to be made in them thar hills.

Now, after decades of virtually refusing to service the remote market and watching government and small businesses shoulder the burdens of developing the technologies and filling the void, they want in. They want into a well established, already serviced decentralized off-grid market. And we have a choice. Perhaps we should — just say no.

Access

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Cables and Currents

John Wiles

In the early days (before NEC awareness), PV systems were wired with any wire that was at hand. Little attention was paid to the quality of the wire, its current carrying capability, or how it was connected. Experience with 12 years of large and small PV installations and the test of time along with help from the local electrical inspector has shown us better ways. Now, conductor types, ampacities, and terminals are a hot topic in the back rooms of most PV distributors, dealers, and installers. Conductor selection and ratings in various PV applications are the topic of this Code Corner.

Module Wiring

Rigid and flexible nonmetallic and metallic conduit can be used with modules having the appropriate conduit fittings on the junction boxes. If conduit is not required by a local code, Section 690-31 of the 1993 National Electrical Code (NEC) permits the use of single-conductor cable that is identified as sunlight resistant for PV module interconnections. Underground Feeder (Type UF), Service Entrance (Type SE), and Underground Service Entrance (Type USE) cables are allowed for module interconnects. Most UF cables are made with PVC insulation. Problems have been identified with PVC insulation when used in direct-current circuits where moisture is present. Under these conditions, the insulation dissolves. It is unknown whether PV module wiring in wet climates provides the conditions necessary for PVC insulation failure. It might be wise to use USE or SE cables in locations where the cables are in contact with standing water. Furthermore, although passing the Underwriters Laboratories (UL) standards for sunlight resistance, UF cable has shown signs of deterioration after only four years in hot, sunlight-exposed installations.

USE and SE cable are generally not marked sunlight resistant, but they have passed the sunlight resistance tests and most inspectors are familiar with the use of these cables outdoors in exposed locations. If the USE or SE cable has cross-linked polyethylene (marked XLPE or XLP) and is further marked RHW and RHH or RHW-2, it is one of the best, commonly available cables. Standard USE cable has only a 75°C insulation when wet. The RHW designation indicates rubber 75°C insulation for use in wet conditions, and the RHH indicates a rubber insulation, when dry, with a 90°C insulation. The new RHW-2 and USE-2 designations indicate insulation with a 90°C rating even when wet. SE cable has a slight advantage in that it has flame resistant additives that USE does not have. The Underwriters Laboratories label (UL) will ensure that the cable meets the highest quality standards and will be the most durable product.

Section 400-7(a)(10) allows the use of flexible cables to connect moving parts. Tracking flat-plate and concentrating PV modules are moving parts and these cables could be used. Types W and G are recognized by the NEC as flexible cables. Types SEO, SEOO, and the like usually have the necessary sunlight and weather resistance. These flexible cables are not allowed when connecting fixed arrays.

This wiring method using exposed, single-conductor cable is only allowed for module connections. At some point near the modules, the wiring method must be changed to one of the other methods meeting the requirements of the NEC. The exposed, single-conductor cables could be routed to a weather head and into conduit and then into the building and to the PV Disconnect Switch. Another alternative is to route the single-conductor cables to a junction box where the cables can be spliced to a jacketed, multiple-conductor cable like NM (Romex) or UF (Underground Feeder). These jacketed cables would then be installed with the required physical protection, and routed to the disconnect switch. NM cable, of course, can only be installed in indoor locations, while the UF cable has sunlight resistance and, with appropriate protection from physical damage, can be installed in outdoor locations.

Tray Cable (TC) comes in two or more conductor cables and is generally marked sunlight resistant, but some inspectors object to its use based on the NEC requirement in Section 340-4 to have it mechanically supported by a cable tray or other means. Also, Section 340-5 prohibits the use of tray cable as open cable on brackets or cleats. Tray Cable requires special calculations for current-carrying capacity (ampacity); the NEC must be consulted carefully when using this cable.

Temperature Derating
Because the PV modules are in the sunlight, they get significantly hotter than the surrounding air temperatures. Ambient air temperatures in some parts of the country may be as high as 45°C (113°F). The backs of the modules, the module junction boxes, and other nearby areas where the conductors must operate can have temperatures as high as 65°C to 75°C. The ampacity of the cables used to connect the modules must be derated for these higher temperatures.

Most installations should use an ambient temperature of 65°C to derate the conductors. In hot locations, with no ventilation provided for the back of the modules (e.g. mounted directly on a roof), a 75°C temperature should be used in the temperature derating calculations. In less sunny, cooler sections of the country, maximum module temperatures might be lower.

An Example
In a particular installation, it has been decided to use number 10 AWG conductors because of the size of the module terminals. Single conductor number 10 AWG USE-2 cable has been ordered with XLPE, RHW-2, and UL markings which indicate a 90°C temperature rating. The modules are mounted on a rack on a brown shingled roof, but for esthetic reasons, the spacing between the modules and the roof is only two inches. The wiring is to be in free air (not in conduit) so Table 310-17 in the NEC may be used. Since the 90°C module terminal rating matches the USE-2/RHH wire temperature rating of 90°C, the cable can be operated at the maximum temperature for which it was rated. In Table 310-17, Number 10 AWG cable with 90°C insulation has an ampacity (current carrying capacity) of 55 Amps at ambient temperatures of 30°C. A footnote to the table notes that number 10 AWG conductors may not have an overcurrent device rated at more than 30 Amps. Because the modules have little ventilation space and the roof is brown, the area between the modules and the roof and in the module junction boxes can be expected to be as high as 75°C on hot, sunny days. The ampacity of the conductor must be derated for this temperature which is the ambient temperature in which the conductors operate. Ampacity Correction Factors are presented in the lower section of Table 310-17. For conductors rated at 90°C, the derating factor is 0.41 yielding a number 10 AWG cable with a derated ampacity of 22.6 Amps (55 x 0.41).

Furthermore, Section 690-8 requires that a 25% safety factor be used when sizing the conductors so that they will not be operated continuously at more than 80% of the rated ampacity. This calculation indicates that the maximum short-circuit current that this conductor can handle is 18.1 Amps (22.6/1.25). The sum of all short-circuit currents for all of the modules connected in parallel on this number 10 AWG USE-2 cable should not exceed 18.1 Amps.

If the modules were spaced six or more inches from the roof, the maximum operating temperature would drop to about 65°C on hot, sunny days. In this case, a derating factor of 0.58 is given which, when multiplied by the 55 Amp rating of the cable at 30°C, gives a derated ampacity of 31.9 Amps (55 x 0.58). After the 25% safety factor is applied, the maximum short-circuit current that can be carried by this cable is 25.5 Amps (31.9/1.25).

Interior Wiring
All interior wiring of DC PV source circuits and DC and ac load circuits must comply with all aspects of the NEC. The cables for DC circuits are similar in most cases to that required for ac circuits. In some cases a larger size conductor is used to reduce voltage drop in DC circuits, but the installer must ascertain that switches and outlets have terminals that will take the larger conductors.

Battery and Inverter Cables
Large conductors such as the 2/0–4/0 AWG cables used to connect batteries and inverters are very stiff if made with building wire such as THHN or USE with 19 strands of copper. The inspector may require the use of such cable because the NEC requires it to be used in fixed installations and the inspector frequently sees electricians using these stiff cables in standard ac power installations. The NEC also requires that space be allocated for wire bending and connection areas when installing equipment using these large cables. Use of these cables requires the proper tools, available from electrical supply houses, to deal with the stiffness.

Most PV installers use either battery cable (controlled by SAE Standards) or welding cable for the larger cables. These cables have numerous small strands that provide a degree of flexibility not found in the more rigid building cables. Stand-alone inverters and large battery cells are being manufactured with flexible cables attached, but these products are generally designed for mobile applications or industrial applications which do not fall under the NEC. The flexibility makes for ease of installation, but the NEC does not make definite provisions for their use in fixed installations. If the flexible cables are used, they should be UL Listed, acid resistant, and installed in conduit. Flexible, Type W single-conductor cables are available and identified for extra hard usage. UL Listed, flexible welding cable is also available, but is not recognized in the NEC for this use.

There are restrictions in Section 400-8 that prohibit these flexible cables from being run through walls or being attached to building surfaces. Section 400-10 of the NEC also requires that strain relief be used wherever flexible cables are connected. This would indicate that if the inspector approves their use, it will most likely be for short runs to a nearby junction box where the flexible cables are connected to a standard, stiff cable. A proposal will be submitted for the 1996 NEC that permits this particular use of flexible cables in an otherwise fixed installation.

Manufacturers of inverters are starting to deliver products with the necessary conduit fittings that will allow the use of the more rigid standard building cables. Underwriters Laboratories is addressing the cable and cable termination requirements as they develop standards for the inverters and battery systems used in residential and commercial PV systems falling under the NEC.

High-Current Cables

The inverter-to-battery cables should be sized based on the inverter continuous power rating at the lowest battery voltage. More and more systems are being installed with large inverters, backup generators, and auxiliary battery chargers. Deep-well pumps filling large storage tanks present a significant load especially when other DC and ac loads are being used simultaneously. If the inverter has the ability to deliver continuous power, and a generator, micro hydro, or the PV array can hold the batteries above the low voltage disconnect point, then that exact situation can and will occur. For example, the 85% efficient inverter is rated at 2000 Watts on a 12 Volt system with a low voltage disconnect of 10.5 Volts, the input current under full power is 2000/.85/10.5 = 224 Amps. The 25% safety factor increases this to 280 Amps and Table 310-16 of the NEC indicates that 250 MCM cable (one size larger than 4/0) in conduit should be used.

Summary

Cables and equipment that meet the requirements established by the NEC are available and can be used for PV installations. Ampacity calculations that are related to high-temperature PV installations are required. In some cases, waivers by the electrical inspector may be required. In other instances, new (to the PV installer) installation techniques may have to be used to deal with the existing, required cables.

Access

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National Electrical Code - 1993, National Fire Protection Association, Batterymarch Park, Quincy, MA 02269

Underwriters Laboratories, 333 Pfingsten Road, Northbrook, IL 60062

NESEA
camera ready
3.65 inches wide
by 4.85 inches high

ELECTRIC AUTO ASSN.
OF CALIF.
camera ready
3.1 inches wide
by 5.1 inches high
LEAVE BORDER
AROUND AD

Small Packages

Therese Peffer

My mom always told me that good things come in small packages. I believe her. Just look at flowers, seeds, Gary Larson cartoons, (and transistors, for you electronic folks out there).... My latest fascination with things in small packages has been small batteries. If you think about it, those AA or D batteries allow you to power your flashlight, radio, or camera, or whatever you choose, wherever you want.

In the last issue, I discussed charging small rechargeable nickel cadmium (nicad) batteries with small solar electric (photovoltaic or PV) modules. And I've been wondering which cells are the best to use. I use mostly AA cells, so I decided I would buy a bunch of cells (mostly nicad but a few nickel metal hydride) from different manufacturers and test them. Another "good" thing about testing these small packages of energy: I'm reviewing quite a bit of basic electricity!

I got more than I bargained for! So far I have 30 cells from 7 manufacturers (and more en route). See below.

Name	*Capacity*	*Type*	*Recommended Charge*	*bought from*
SAFT industrial nicad (Mexico)	500 mAh	S	50 mA for 14 hours	Sunelco Inc
Panasonic P272 nicad (Japan)	600 mAh	R	60 mA for 15 hours 600 mA for 1.5 hours	DigiKey Corp.
Golden Power nicad KR700AA	700 mAh	R	70 mA for 14–16 hours 210 mA for 4–5 hours 700 mA for 1–1.5 hours	Real Goods
Millenium nicad (Gates Energy Products)	750 mAh	R	can be charged in one hour, no information	Crutchfield (also 7th Generation)
Radio Shack Hi-capacity nicad (China)	850 mAh	S	85 mA for 14 hours	local Radio Shack
Gold Peak Sylva Charge nicad (China)	850 mAh	S	85 mA for 14 hours	C. Crane Company
Harding Energy NiMH nickel metal hydride	1100 mAh	S	125 mA for 16 hours	Progressive Power

*S = Standard charge, R = Rapid charge

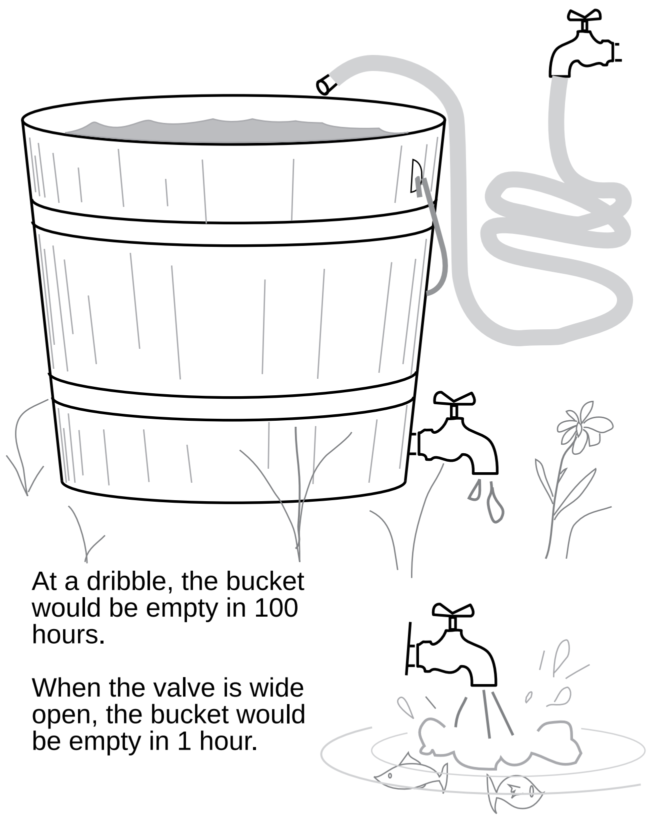
To Recharge or not to Recharge?

Why use rechargeable batteries? First, there's the waste involved with one-time use batteries. Sure they're small, but they've got to go somewhere when you're done with them. I did not have much luck in finding a place to recycle non-rechargeable cells. David from Chemical Waste Management suggested calling the local city council to find out about household hazardous waste programs. Kinsbursky Bros. of Anaheim, California (see Access) is currently undergoing a pilot program to recycle non-rechargeable cells. They currently have all the dry cells they need, and don't know when or if they will be accepting more cells in the future. Some disturbing info sent from Mark Rabinowitz, "Ordinary use-once batteries require 50 times more power to manufacture than the battery stores."

Yes, rechargeable batteries contain toxins too, but most claim 500–1000 charges! And now the nickel metal hydride (NiMH) rechargeables have hit the market; NiMHs last longer than the nicad cells and don't have the toxic cadmium. Two companies, Real Goods and Millenium, guarantee the nicads they sell for life; should a cell fail, they will replace it. Real Goods also has a recycling program for small rechargeable nicads bought from them. Rechargeable batteries are initially more expensive and have less capacity (½ to ⅔ the capacity of throw-aways), but in the long run you're saving money, resources, and energy.

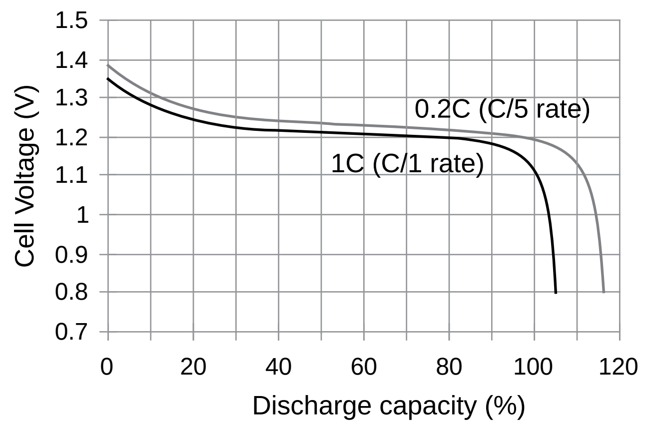
What do *you* look for in batteries? I want AA cells with high capacity, that can be rapid charged (in 1–5 hours), will last for many cycles of charging and discharging, and well, that aren't too expensive. Standard charge cells, (cells that can be charged in 14–16 hours) might be fine depending on the cost and reliability. Other people might want cells to withstand high temperature or heavy discharge. You can find small rechargeable cells in many flavors.

How will I test these 30 AA cells? Basically, I'll be charging and discharging these cells to see if they indeed have the capacity that they are supposed to. As I develop my test for these cells, I'm understanding more about battery capacity, charge rates, and yes, even Ohm's law. First let's discuss capacity and charging.



At a dribble, the bucket would be empty in 100 hours.

When the valve is wide open, the bucket would be empty in 1 hour.



Above: Nicad cell voltage drops as it is discharged.

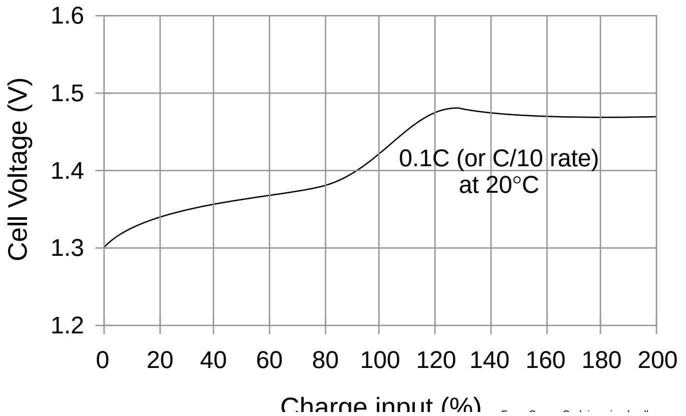
Batteries and Buckets
Battery capacity is measured in Ampere-hours at a particular charge/discharge rate (called C rate). I used to find C rates really confusing, so let's find an analogy. Richard often compares a battery to a bucket — you fill it up, use it, and refill it. The bigger the capacity, the more a bucket (or battery) will hold. Now, to talk about charge rates, let's take our bucket and add a valve or hosebib to the bottom. Suppose we turn the valve so a fair dribble of water runs out (obviously watering plants — we won't waste it). And this dribble is such that the bucket is empty in 100 hours. You can imagine a certain rate of water flowing through the valve. If we take the capacity (C) and divide by the time to empty the bucket, we get a rate of C/100. But suppose we turn on the valve some more, so that the bucket is empty in 20 hours. Then the rate would be C/20. Or we could turn the valve wide open and empty the bucket in 1 hour — a C/1 rate.

But a battery is not exactly like a bucket. When the battery reaches its discharge cutoff voltage, that's it. The battery cannot be discharged any further. The discharge cutoff voltage for small sintered plate nicad cells is 1 Volt. The amount a battery can deliver (its true capacity) depends on the rate of discharge (how fast the electrons are moving out of the "valve"). A capacity figure (100 Amp-hours) is followed by a C rate to tell you what the capacity is when the battery is discharged at that rate or slower. Most deep-cycle batteries used in home power systems are rated at about C/8 to C/20 rate. The capacity of most small cells (for my AA cell shootout, 500 milliAmp-hours to 1100 mA-h) is rated at a C/5 rate. If a battery is "emptied" at a faster rate than its C rating, it will have less capacity than its capacity rating. (See nicad voltage vs. discharge graph above). For example, if I discharge a 500 milliAmp-hour AA cell in 4 hours (a C/4 rate), I will get less than 500 mA-h. I imagine that the electrons are moving so fast, they spend energy bumping into each other instead of getting out. (Note: sometimes you'll see the C rate expressed as a decimal rather than a fraction, i.e., 0.1C for C/10).

A C rate can express the charge rate as well as the discharge rate. Imagine filling up our bucket with a hose that has a similar valve. We can turn the valve on to a dribble that will fill the bucket in 100 hours (a C/100 rate). Or we open the valve more to fill the bucket in 20 hours (a C/20 rate).

A C rate is useful to describe batteries of different capacities. Let's take our bucket and borrow Dr. Klüge's Incredible Shrinking Bucket Machine to reduce our bucket and valve 50 times. If the original bucket was equivalent to the 220 Amp-hour battery in my system, the shrunk bucket is like a 4.4 Amp-hour D cell. We turn the valve again to a fair dribble so the bucket is empty in 100 hours. You can imagine the amount of water dribbling through the valve is much less than the original bucket. Because both the valve and bucket are 50 times smaller than the original bucket, the *rate* — C/100 — is the same.

How do we know how far to turn the valve to empty or fill the bucket in a certain number of hours? We need to know the capacity and the amount of water leaving/entering the bucket. Use the same idea for batteries: we need to know the capacity and the amount of current leaving or entering the battery. The battery in



Above: Nicad cell voltage climbs as it is charged.

my system holds 220 Amp-hours; a high capacity D cell holds 4.4 Amp-hours. If we want to discharge (empty) the D cell at a C/5 rate, we divide the capacity (C) by the number of hours to get the current.

$$\frac{\textbf{C}\text{apacity (in Ampere-hours)}}{\text{hours}} = \text{current (in Amperes)}$$

We would draw 880 milliAmps for 5 hours (4.4 A-h/5 hours) to empty the battery. Or we could fill (charge) the batteries at a C/20 rate. So 220 Amp-hours/20 hours equals 11 Amps of current for my system. For a D cell, we'd need to use a current of 220 milliAmperes (4.4 Amp-hours/20 hours).

But, again, a battery is not exactly like a bucket. We can work the math and predict when the battery *should* be full by figuring a constant current for so many hours. But no battery is ideal. For larger lead-acid and nicad batteries, we can skirt the issue and look at the voltage to tell us when the batteries are full. But for small nicad cells, the voltage difference between full and empty is in tenths of a volt. (See nicad voltage vs. charge above). So we use the capacity and charge rate to figure a constant current for a certain number of hours, then add more time to make sure the cells are full. How much more? I've heard anywhere from 15% to 50%. For example, the Panasonic AA cells hold 600 mAmp-hours, and like a standard charge of 60 mAmps for 15 hours (60 mAmps times 15 hours is 900 mAmp-hours — a 50% overcharge). Usually the manufacturer gives a recommended charge — so many milliAmps current for so many hours.

Beginning the test

For my test, I have cells with capacities of 500 mA-h to 1100 mA-h. Some can be rapid charged in 1.5 hours, others require 14–16 hours. All the cells came uncharged, so the first step in using rechargeable cells is to fill them up and discharge them several times. I wouldn't know this except for reading some of the instructions that came with the cells. This deserves a digression.

Charging Tips for Nicads

Confused on how to charge your nickel cadmium and nickel metal hydride cells? Here are some tips:

- Nickel Cadmium (nicad) cells and Nickel Metal Hydride (NiMH) cells are usually sold uncharged. They must be charged and discharged several times before they reach full capacity. This appears to be more a problem with new NiMHs than new nicads.
- Nicads can be overcharged, yes, even by the sun, although this is more difficult to do with the smaller panels. Read any literature that comes with the cells and read the label on the cells carefully for recommended charge rate and amount of time needed to charge.
- Observe the correct polarity (+ vs.–) when inserting your cell in the holder.
- Discharge the nicad cells fully at least most of the time. "Fully" means that the flashlight is dim, or the tape is slow, or the voltage is about 1 Volt. Do not over discharge. The infamous memory effect (wherein the cells "remember" the partial capacity as their full capacity) is caused by repeated (dozens) of partial discharges. Richard has a classic "memory effect" story: folks at KTVL TV station where he worked used rechargeable D cells in video camera lightbelts. They would recharge the cells after every shoot. Although the cells were not discharged fully, the camera people did not want to get caught with dying cells in the middle of a roll of film. The cells would only last six months or so. If the cells are discharged fully every few cycles, your cells will retain their full capacity. (See Q&A this issue for more on this.) NiMH cells have no memory effect.
- These cells lose their charge over time. With nicads, the self-discharge rate is fairly slow. Cells that have sat around for a month will need to be topped off before use. With NiMHs, the self-discharge rate is much faster. After a month, NiMHs may need a full charge again.
- Test the voltage of your cells regularly. Sometimes one cell will be less charged than another, and this can cause problems. During the charge or discharge cycles, the cell will give up its charge to other cells. The bad cell can actually reverse polarity, which ruins it eventually.
- Clean the contacts on your cells, cell holders and/or charger a few times a year. These parts can oxidize and a thin film develops which lessens the electrical connection. C. Crane suggest using the eraser on a common yellow pencil to clean contacts because of its abrasive particles.
- C. Crane also recommends the slower the charge rate the better for the longest cell life. Yes, this includes rapid charge cells.
- Some of the higher capacity cells are too large in diameter to fit in some appliances (MiniMag flashlights, for example). Check that your new cells fit your appliances before you start using the cells.

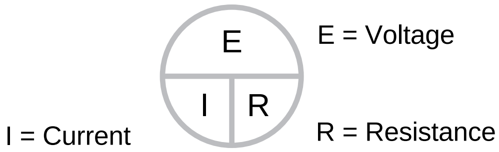
Some of the cells I bought came without any instructions! Both C. Crane and Real Goods sent charging information, and Brian from Sunelco gave me instructions over the phone when I bought the cells. Three cells (Golden Power, Radio Shack, Gold Peak) have the capacity and recommended charge rate right on the label; the other cells did not. In fact, the capacity of the Millenium cells was not listed on the cell, packaging, or even in the Crutchfield catalog where I bought them! The package states that the cells can be charged in one hour, but I need to know at what current!

I think the assumption is that you don't need to know this information, especially if you use a commercial ac plug-in charger. I have heard that many people return rechargeable cells because they tried charging them (often with solar) and found the cells didn't work or didn't last very long. I am requesting more technical specs from the original cell manufacturers. See sidebar previous page for some tips I garnered from the instructions I did receive.

I've started by charging the cells, eight at a time, with three 12 Volt, 50 milliAmp Kyocera Jetski photovoltaic modules. The Saft cells take 15 hours, the nickel metal hydride will take 33 hours. I've been discharging them using a 10 Watt, 10 Ohm (Ω) power resistor. More basics here. What the heck is a power resistor, and why did I choose 10 Ω resistance?

Ohm's Law Revisited

I've never met Mr. Ohm, but I've sure been using his "law" a lot. Ohm found a relationship between current (I), voltage (E), and resistance (R) which is I = E/R. (Current is expressed in Amperes, Voltage in Volts and Resistance in Ohms.) When I was studying for my amateur radio license, the book used a trick to help memorize this relationship:

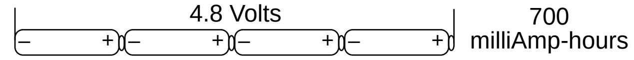


If you know two variables and want to know the third, cover the unknown quantity with paper or your finger. If the two variables showing are side by side, multiply them to get the third. If one variable is over the other, then divide.

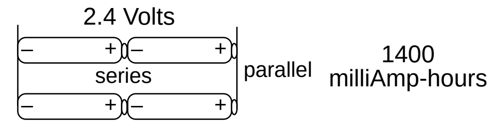
So let's use Ohm's Law: I wanted to discharge four AA cells that are rated at 700 milli-Amp-hours. I have them in a four cell holder (from Radio Shack). The 4 cells are connected in series, that is, the positive button of one cell is electrically connected to the flat negative end of another (see diagram top right).

One AA cell:

Four AA cells in series:



Four AA cells in series-parallel:



When charged, each nicad cell has a voltage of about 1.4 Volts (NiMHs about 1.5 Volts), but during the discharge, the voltage drops to about 1.2 Volts (check out the discharge graph pg. 98). When cells are connected in series, the voltage across all four cells is added. So for my voltage figure for Ohm's law, I get 4.8 Volts (4 times 1.2 Volts).

What about the current? Since the cells are in series, I know that the current drawn through each one will be the same (Kirchhoff's law. Note that if the cells were in parallel as shown above, the current now has two paths to travel and may not be the same through each cell). I know the capacity of each cell is 700 mA-h; since the cells are in series, the capacity of the whole four cell pack is 700 mA-h. I want to discharge the pack in about an hour or two (I don't care if I get the whole capacity or not. My concern for these first few cycles is discharging the batteries so I can charge them again.) So, if I discharge the cells in an hour, I should draw 700 mA (700 mA-h/1 h); for two hours I should draw 350 mA current (700 mA-h/2 h).

Now I have a voltage figure and a current figure — time to use Ohm's Law. I divide the voltage by the current to get the resistance I should use. If I want to discharge the cells in one hour, I should use about a 6.9 Ω resistor (4.8 V/0.7 A); for a two hour discharge, I should use a 13.7 Ω resistor (4.8 V/0.35 A). We have a 10 Ω resistor, so I will use that.

Power Resistors

Can I use just any kind of resistor? Radio Shack sells all kinds.... Let's look at this discharge scene. I could have stuck the cells in my flashlight and just left the light on, but a few cycles would have burnt the bulb. If I run the same power through a resistor, I get heat instead of light. How much heat? I know two equations for power: P = E I, or $P = I^2R$, so I get about 2.3 Watts of heat. I need a resistor that can dissipate this much heat. Richard recommended that I use a power resistor with twice the power rating that I figured I needed. We didn't have any 5 Watt, 10 Ω power resistors, so I used what we did have, a 10 Watt, 10 Ω power resistor.

The Test Procedure: the Voltage Divider

I knew that testing two dozen different AA cells wasn't going to be easy. Here at Home Power Central, we have quite a few tools at hand to help. One tool is Remote Measurement Systems data logger, the ADC-1 Data Acquisition and Control (see HP #34, pg 76). Another tool is our Macintosh PowerBook 160 computer. The other tools (sigh) are in the toolbox under the electronics work bench.

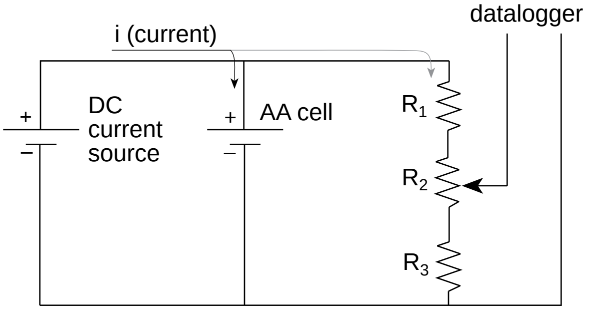
The Big Picture

Basically, we'll have an old but reliable Hewlett Packard DC current supply charging the cells, eight at a time, and the data logger will read the analog current and voltage of each cell and feed this as a digital signal to the computer. We will charge and discharge the cells at different rates. Then we will absorb the many numbers compiled with the computer to compare the cells' performance to their specs. Does that Radio Shack high capacity AA cell really hold 850 milliAmp-hours? Stay tuned!

Planning the test procedure presented a small challenge to my beginner's mind. One problem: our analog to digital data logger cannot read large voltages; its range is ± 400 milliVolts DC. For the current we'll use a shunt. But somehow we have to translate the 1.0 to 1.4 Volts of each cell to a quantity that the data logger can accept. Richard suggested a voltage divider to perform this task. He and the Wizard designed this voltage divider; I just try to understand it. So here goes — see schematic above.

Only one cell is shown for simplicity. The cells will be charged in series. Total resistance ($R_1 + R_2 + R_3$) = 100 kΩ. R_3 = 10 kΩ and $R_1 + R_2$ = 90 kΩ. Since we found a 88.7 kΩ resistor (as R_1), we use a 0 to 2 kΩ potentiometer (as R_2) to achieve 90 kΩ.

Say we charge this cell with 50 mA at 1.5 V. Since the cell is in parallel with the resistors, the voltage through each branch (cell and resistors) is also 1.5 V. The amount of current that flows through each branch depends on the resistance of each. The resistance of the data logger is very large, 1 MΩ; the resistance of the battery is very low. Most of the current flows through the battery because the cell poses much less resistance than the 100 kΩ resistors.



How much current is flowing through the resistors? The total current is equal to the current through the cell plus the current through the resistors. Going back to Ohm's Law, the current through the resistors is equal to the Voltage drop across the resistors divided by the total resistance:

$$i_r = \frac{E_r}{R_r} = \frac{1.5\text{ Volts}}{100\text{ k}\Omega} = 15\ \mu\text{A or } 15 \times 10^{-6}\text{ Amps}$$

We get 15 µA current through the resistors — quite a small amount. The rest of the current (50 mA – 0.015 mA = 49.985 mA) charges the cell. The total resistance was chosen to maximize the amount of current through the cell.

What is the voltage drop across each resistor? The total voltage across all resistors is 1.5 V as stated above. By Kirchhoff's Law, we know that the current travelling through all resistors is the same. So we get:

$$E_{r_{total}} = 1.5\text{ Volts} = i(R_1 + R_2) + iR_3$$

The voltage through R1 + R2 and R3 is:

$$E_{r_{1+2}} = i(R_1 + R_2) = (15 \times 10^{-6}\text{ Amps})(90\text{ k}\Omega) = 1.35\text{ Volts}$$

$$E_{r_3} = iR_3 = (15 \times 10^{-6}\text{ Amps})(10\text{ k}\Omega) = 0.15\text{ Volts}$$

Voila! We have solved our problem with a 9:1 voltage divider! The voltage across all three resistors is 1.5 V, but the voltage across R_3 is 0.15 V — one tenth the voltage. This is within the range of our data logger. We can set up the data logger to read the voltage across R_3. It is an easy matter for the PowerBook computer to multiply by ten to get the actual voltage. Wish it were that easy for a human to compare all these numbers....

On with the test

This initial method of charging with solar over a few days and then discharging with a power resistor works for a few cycles with my 30 cells. But for the test, I want something more efficient and reliable. Sounds like a job for a computer! For the gory details, see sidebar.

Hey, Readers! If any of you have had experience (good or bad) with rechargeable batteries or chargers, please let me know! In the meantime, I'll be testing away....

Access

Therese Peffer finally received her no-code technician Amateur radio license, KB7WRP and is testing cells at Home Power, POB 520, Ashland, OR 97520

Recycling batteries:

Nicad (incl. rechargeable sintered plate cells), NiFe batteries: (you pay $0.24–0.26/ pound) Inmetco, 245 Portersville Road, Route 488, Elwood City, PA 16117 • 412-758-5515

Zinc carbon, silver, nicads, pocket and sintered plate: you pay $0.60/pound, 500 pound minimum. Also lead-acid batteries. Maybe someday, small non-rechargeables. Kinsbursky Bros., 1314 North Lemon St., Anaheim, CA 92801 • 714-738-851

Mercury, silver, and sintered plate nicad cells (alkaline, carbon zinc, and zinc air accepted, but currently placed in double-lined landfill. Wait on these). Only in bulk shipments (55 pounds), and only with a contract, and you pay a fee, so get your community together! Mercury Refining Company, 1218 Central Ave., Albany, NY 12205 • 518-459-0820

HAPPENINGS

INTERNATIONAL
AUSTRALIA
Solar '93 — The annual meeting of the Australian and New Zealand Solar Energy Society will be held in Fremantle, Western Australia December 1-4, 1993. Bridging gaps between research, development and markets. Although a national conference, the society is always pleased to welcome overseas visitors, both to participate actively and observe. The range of subjects covered by the annual meetings — this is the 31st — is wide indeed. The areas of interest range from remote area or village power systems to new trends in demand management, education and training, and low energy architecture. Australia and New Zealand are fortunate in having not only a substantial research base but some significant renewable energy industries, many based in Perth. Delegates will not only be able to meet the researchers and company people, but will be able to participate in site visits. We are delighted to bring you four guest speakers of international standing — Doug Balcomb, David Bellamy, Amory Lovins, and Carl Weinberg. Located right on the coast, Fremantle is the perfect place to be in December. For more information contact: Dr. Bill Parker, ANZSES, Box 175, N Perth 6006, Western Australia

A Centre for Applications of Solar Energy (CASE) in Perth Australia has been proposed under the auspices of the United Nations Industrial Development Organization (UNIDO). An invitation to participate has been offered for research, manufacturing, marketing, financing, aid, government, and policy organizations. For more information contact UNIDO, Technology Promotion Development Division, POB 300, A-1400 Vienna Austria, FAX Int+43 1 230-7355 or The Executive Officer, Perth CASE, POB 7234 Cloisters Square, Perth, Western Australia Fax Int + 619-327-5481

CANADA
SW Alberta Renewable Energy Initiative Information Centre–This group provides Canadians with information and workshops on renewable energy. For more information contact Mary Ellen Jones, Information Centre Manager at POB 2068, Pincher Creek, Alberta, Canada T0K 1W0

NATIONAL
Independent Home Tour — National Energy Awareness Month will have a special attraction this year. On Saturday, Oct. 16, 1993 from 10 AM to 3 PM (local time) more than two hundred people across America who live in energy independent homes, powered by sun, wind, water or grid-intertie systems, will open their homes to the public so that others interested in energy independence may have first-hand experience in seeing renewable energy in use.The goal of this project is to give as many people as possible an "up close and personal" look at the lifestyle that is possible with today's renewable energy technologies. The National Tour of Independent Homes is a unique event, designed to satisfy the curiosity of anyone who accepts the premise of energy independence, but who has never experienced it in the flesh! Tour logistics are being coordinated by Real Goods Trading Co. Although Real Goods is physically coordinating the Tour, the event is being handled as an industry-wide, non-commercial effort. People interested in visiting an energy independent home in their area may call 800-762-7325 or write Karen Hensley at Real Goods, 966 Mazzoni St., Ukiah, CA 95482-3471

Electric Vehicle Safety Survey: In order to establish meaningful standards, the Electric Vehicle Industry Assoc. is seeking data on the safety of EVs already in actual use. Anyone who has had any experience with EV accidents is invited to share their information. The survey takes 10 minutes to complete. Final data will be made available for publication. To participate, contact Shari Prange, Electro Automotive, POB 1113, Felton, CA 95018-1113 • 408-429-1989

Elfin Permaculture is holding a number of workshops ranging from one day to three weeks in locations around the U.S. and Canada. Contact Cynthia Hemenway, 7781 Lenox Ave., Jacksonville, FL 32221

The Conservation and Renewable Energy Inquiry and Referral Service (CAREIRS) is a national service, funded by the U.S. Department of Energy, that provides the general public and educators with free information on renewable energy and energy conservation. They also maintain a referral network of approximately 500 organizations that provide more technical information. CAREIRS is interested in organizations that can benefit from being part of their monthly mailing list. The mailings are most useful to organizations who have direct contact with the public. For more information contact CAREIRS, POB 8900, Silver Springs, MD 20907, or call 800-523-2929

HOME ENERGY MAGAZINE is offering a free Directory of Energy-Related Graduate Programs in U.S. Universities. Over 60 programs in the fields of energy, resources, the environment, and development. This directory was produced by the Energy Foundation, with the cooperation of Student Pugwash USA, a national educational, non-profit organization. The free directory is available via book, IBM 3.5" disk, IBM 5.25" disk, Macintosh disk, (please specify MS Word 5.0, Filemaker Pro (Mac) or delimited ASCII). Contact Home Energy Magazine, 2124 Kittredge St #95, Berkeley, CA 94704

FREE NATURAL GAS VEHICLE MAGAZINE Send SASE to Frank Rowe Circulation, NGV Magazine, 1410 Grant St Ste A-201, Denver, CO 80203, 303-863-0521, FAX 303-863-0918

EV NETWORK - Ken Koch will search his file of 2,000 customers and let you know if there's an EV owner near you. Send him an SASE: 12531 Breezy Way, Orange, CA 92669

Papers are currently being accepted for Solar '94, featuring the American Solar Energy Society Annual Conference & the National Passive Solar Conference. Paper presentations will be made in conference Technical Sessions, June 27-30, 1994 in San Jose, CA. Presentations should be 10 to 15 minutes with audience interaction. Anyone with special knowledge in some aspect of the solar energy field is encouraged to submit a paper for consideration by the technical Program review committee. Abstracts are due November 15, 1993. Contact American Solar Energy Society, 2400 Central Ave G-1, Boulder, CO 80301, 303-443-3130, Fax 303-443-3212

ALABAMA
THE ALABAMA ENERGY EXTENSION SERVICE is offering free energy consultation and literature on a wide variety of energy related topics. Contact: Alabama Energy Extension Service, The University of Alabama , Box 870201, Tuscaloosa, AL 35487 or 1-800-452-5901 (AL only) or 205-348-4523

ARKANSAS/MISSOURI
OZARK RENEWABLE ENERGY ASSOC. (OREA) is dedicated to providing RE enthusiasts regional connections and promoting the use of alternative energy in the Ozarks. OREA is working on a Networking Directory which is meant to be a vehicle for getting interested folks in touch with each other. For more info about OREA and a Directory Questionaire send SASE to Julie Courtney at RT3 Box 4305, Reed Spring, MO 65737, 417-338-8688

ARIZONA
The Common Ground Project of Prescott College will hold its Second Annual National Conference October 15-17, 1993. The theme will be “Environmental Entrepreneuring: People, Jobs and the Environment”. The goal of the Common Ground Project is to bring the interests of business and the environment together. For more information contact Sue Ellinger or Derk Janssen, 602-776-5109 or 776-5123

CALIFORNIA
North San Francisco Bay Chapter of the Electric Auto Assoc. (EAA) holds meetings on the second Saturday of each month at the PG&E Business Center, 111 Stony Cir, Santa Rosa, CA from 9:30 AM–Noon. For information on the EAA and the chapter nearest you, send an SASE to 1249 Lane St, Belmont, CA 94002, or call 415-591-6698 (10 to 5 on weekdays).

The American Hydrogen Association’s Silicon Valley Chapter is now offering access to a bulletin board system with information on solar cells, hydrolyzers, gensets, windmills, hydropower, ocean thermal energy, converters (OTRCs), bio ponds, thermal cracking and other means of converting solar energy in Hydrogen. Learn about technologies for transporting hydrogen by pipeline, storage of hydrogen as a liquid, a gas, and a hydride, combustion of hydrogen with air and by catalytic burning and how hydrogen is electrochemically combusted to produce electricity within fuel cells. Contact: The American Hydrogen Association-Silicon Valley Chapter Headquarters, 1401 Pointe Claire Ct., Sunnyvale, CA 94087, BBS@408-738-4014 Voice@408-235-1177

COLORADO
The Renewable Energy Education Program (REEP) will be held at Solar Energy International (SEI). One to two week workshops are for owner-builders, people seeking careers as solar professionals, and people who want to do work in developing countries. The “hands-on, how-to” workshops offered September through November include PV, passive solar, wind, micro-hydro, solar cooking, food drying, and more. For a detailed description of REEP, costs and scholarship information, write SEI, POB 715, Carbondale, CO 81623-0715 • 303-963-8855

Solar Energy International (SEI) is presenting an expanded course on wind power beginning October 25. The two week course consists of one week of design and one week of a hands-on full scale working installation in the Colorado mountains. This exciting workshop will be taught by guest instructor Mick Sagrillo of Lake Michigan Wind & Sun. The cost of the workshop is $400 per week. Scholarships and work/study programs are available on a limited basis. For more information, write SEI, POB 715, Carbondale, CO 81623-0715 • 303-963-8855

SEI will hold a workshop for Decision Makers in Non-Governmental Organizations, United Nations Agencies and Funding Organizations involved in international development. A two day workshop on “Renewable Energy for Sustainable Development” is being offered in New Jersey on Sept. 30th and Oct. 1st, and again in Washington, DC on Oct. 4th and 5th. The workshop will provide participants with the how-to experience in solar, wind and micro-hydro power. Decision makers will be able to choose renewable energy technologies with confidence for their development programs. For a workshop agenda and more information please call SEIs New Jersey office at 908-876-4677

CONNECTICUT
On April 10-12, 1994, a broad coalition of industry, environmental and trade organizations will convene RENEW’94, a watershed conference focused on bringing the production and use of renewable energy into the mainstream for the northeastern USA and accelerating the development of the renewable energy industry within this region. The Northeast Sustainable Energy Association, organizer of RENEW’94 invites exhibitors of products and services to participate. For more information contact, NESEA, 23 Ames St, Greenfield, MA 01301, 413-774-6051, Fax 413-774-6053

MAINE
Hands-On Workshops will include: solar air heating, solar water heating, solar cookers and ovens, solar electric home, passive architecture, greenhouses and sun spaces, and the immensely popular photovoltaics workshop. The fee for each of these workshops is $25.00, which includes lunch. For information on sites and dates contact Richard Komp, Maine Solar Energy Assoc., RFD Box 751, Addison, ME 04606 • 207-497-2204

MICHIGAN
Northwoods Energy Alternatives is offering workshops. Currently the last scheduled workshop of 1993 is Stand Alone Hybrid Systems - October 16th, 9AM-5PM. People are encouraged to suggest additional topics of interest. Workshop fees are based on a sliding scale of $20-$50...you determine what you can pay. Off grid home tours are

regularly offered. For more info contact Maggie or John, Northwoods Energy Alternatives, POB 288, Lake Leelanu, MI 49653, or call 616-256-9262 or 616-256-8868

NEVADA
Solar Electric Classes in Nevada taught at remote solar home site. Maximum of four students for more personal attention. Two day classes on weekdays & weekends upon request, minimum of 2 students. Class will be full of Technical info, product evaluation, sizing systems etc. Students will build a solar system $75 per person. Call 702-645-6571 or write Solar Advantage, 4410 N. Rancho Dr #148, Las Vegas, NV 89130

NEW YORK
On October 15-16, 1993 The New York Solar Coalition will be sponsoring its second annual energy conference with special attention given to renewables and the environment, energy and architecture, state of the art technology, financial and marketing strategies, & energy and transportation. For further information call Jim Hurt at 212-861-0100, fax 212-861-0101

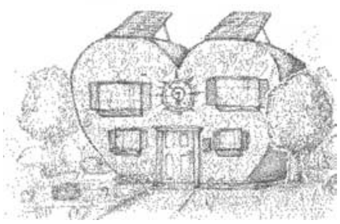
OREGON
The Appropriate Technology Group is a grassroots and hands-on group formed to explore how to educate, demonstrate projects, provide a community resource for designers and builders, do experimental projects involving energy, transportation, sewage, hazardous and solid waste , etc., etc. The group meets once a month in Portland, Oregon. For more information call 503-232-9329 (evenings).

Oregon SunWorks "93 Sustainable Homes: Sustainable Community; A three day conference October 15-17, 1993 merging the best ideas of the 70's with state-of-the-art-technology of the 90's; energy professionals, exhibitors, electric car rally, solar chile cook-off, speakers, workshops, solar home tours and a kids camp.The event will be held at the Two World Trade Center, Portland Oregon. Presented by the Solar Energy Association of Oregon. For more information call 503-224-7867

TEXAS
Texas Renewable '93 will be held November 5-7 1993 in Austin, Texas. This is the combined annual meetings of the Texas Solar Energy Society and the Texas Renewable Energy Industries Association. Workshops, tours of Austin solar sites, state agency renewable energy activity/policy updates, project reports from utilities, community and non-profit groups, and private industry, business development sessions and speakers. For more information contact, Russell E Smith, 512-345-5446

WASHINGTON
Building with Value '93: A Resource-Efficient Construction Conference and Trade Show will be held on November 12-13, 1993 at the Washington State Convention and Trade Center. For the "greater" building industry. Practical workshops, expert talks, roundtables, and a "green" product exhibit will show how you can build structures that save energy, protect the environment, and vitalize the economy. For more information contact Kathleen O'Brien, POB 10705, Bainbridge Island, WA 98110, 206-842-8995 or the Sustainable Building Collaborative, 815 SE Clatsop, Portland, OR 503-234-6931.

Home & Heart



Kathleen Jarschke-Schultze

Have you ever wanted to vacation in some remote beautiful place but couldn't afford the prices of lodging and restaurant meals every night? What about leaving your own house and RE system unattended? Maybe there is an answer.

Trading Places

One of the morning news shows had a segment about people who trade houses for a week or two to have the comforts of home when they travel. There is a quarterly publication where you pay $35 to be listed with a picture of your home and your access information. When you contact someone or they contact you the trade is all worked out between yourselves. There is no middleman or agent.

The people interviewed had traded homes all over the U.S. and one couple even traded with some students who had an apartment in Paris. This sent our imaginations soaring. Bob-O and I love to travel, but who can afford it? Most of the money spent on a vacation is on lodging and food. We could trade with someone in Seattle and visit the museums, we could trade with someone in Colorado and climb mountains, or... Our speculation was endless.

Of course reality set in. How could we leave our house and system in the hands of someone uninitiated to RE living? Have you ever noticed how when you visit someone who lives on the grid, or they visit you, you seem to spend a lot of time walking around turning off lights and TVs in rooms people have left? The thought was sobering.

Bright Idea

The compact fluorescent bulb came on over our heads! Why not trade with other RE home owners? Most people who live on RE are beyond the power lines; usually in some beautiful, remote place. RE users are spread across the planet. Wow, what a concept! The outback of Australia, the beaches of the Carribean, skiing in Vermont, solar cooking in Baja California. Our enthusiasm was off and running again.

Now, what have we got to offer on our side of the trade? Well, we live one hour away from a ski resort in one direction and one and a half hours from another to the south. We are forty-five minutes from the world famous Ashland Shakespeare Festival. It takes about ten minutes to drive to a lake where you can fish, water ski or windsurf. There is excellent birdwatching in our area. If you think about it there are always some really nice features to your area. That's why you live there.

Rookie RE

We expanded on this line of thinking. Sure remote homes have their unique attractions, but what if you had cabin fever and wanted to go to a city and go to a different movie every night.

On the flip side what if you lived in the city and dreamed of an RE home in the boonies? Wouldn't you like to try the lifestyle on for size and see if it fit your ideal? Wonder what it is like to live with wind power, or hydro, or solar or a combination of all three? This could be your chance. What are the attractions of where you live?

Teachtext

You would need to make a folder or, better yet, a folder and a video of your particular system. Since each RE system is as unique as its owners this would be *de rigueur* for a trade situation. You would need lists of all the equipment, troubleshooting, idiosyncrasies — the whole shot. Then, depending on the time of year, there are the other duties that come with country living. How to care for animals, wood stoves, gardens, waterlines, etc. It's all part of the big picture.

Mi Casa, Tu Casa

It could all work. People all over the world are doing it now. We are just suggesting a twist on an already established form. Why shouldn't we also benefit from our dreams and ideals? I have spoken to a few people about this idea, testing the hydro so to speak. People, on and off grid, have responded enthusiastically to the idea. I would really like to hear from people interested in this medium of exchange. Possibly to start a newsletter with listings and guidelines for trading homes for vacations.

Fire Safe

On a different front I was talking to Michael Blend, a remote RE home owner, the other day. We were discussing the difficulty in getting fire insurance for your home when you are miles from official fire protection. This can be a very hard thing to find. No insurance company wants to take the risk and unfortunately, they don't have to.

At one time Bob-O and I considered organizing a neighborhood volunteer Fire and Rescue squad thereby having official fire protection much closer. We figured this would help us and our neighbors get insurance or maybe lower the rates for those lucky enough to be covered already. The squad was never formed as all our neighbors have insurance and thousands of gallons of water storage already. This would be everyone's individual fire protection, if needed.

After I had told Michael of my experiences with fire insurance he said he would look further into the options. He called back a few days later and left a message that he had obtained fire insurance from Cal Farm through the Farm Bureau. They are set up to work with people in rural areas. Check your phone book for local access.

Access

Author: Kathleen Jarschke-Schultze, c/o Home Power Magazine, POB 520, Ashland, OR 97520

Good Books

Solar Cooking Naturally

written by Virginia Heather Gurley

reviewed by Kathleen Jarschke-Schultze

One of the first things a new solar cook asks me is, “Are there any solar cookbooks?” Here is a new addition to the too few books available. Ms. Gurley hits on all aspects of solar cooking.

The book itself is a well constructed 94 pages. Along with the usual chapter headings Ms. Gurley also takes on “Advantages of Solar Cooking”, “Solar Cookers: a Global Solution”, “Cooking Tips”, and “Starter Recipes”.

Ms. Gurley has been cooking for her family and friends for the past 15 years. She is also an elementary Montessori teacher and uses solar cookers to provide hot lunches for her students. She has chosen the Kerr-Cole Eco-Cooker II as the cooker to test and time all the recipes in the book. Of course, she explains, any solar cooker may be used, and even your conventional oven set at 325°F, to cook any of these meals.

Everything I cooked from the book came out well and was complemented on by the test eaters. I especially liked the variety of recipes. From baby teething sticks and Tofu cheesecake to stuffed duck the dishes are all intriguing. All the recipes are made with natural whole foods. Ms. Gurley has presented a good selection that was enjoyable to choose from. With the “Starter Recipes” she guides the new solar cook gently into the advanced until they are hooked. She has a whole chapter on pie crusts, something that can be scary for the rookie solar cook.

I found her glossary of ingredients useful. It helps to know the language of the art you are practicing. Her two Appendixes, “Organizations Promoting Solar Cooking” and “Solar Cooker Resources” are inspiring reading and cover the world in their scope.

This is a great little cookbook, whether you are just starting to cook with the sun or if you are an old hand at sol food. I really like it.

Access

You can get your own copy of *Solar Cooking Naturally* from SunLightWorks, PO Box 3386, Sedona, AZ 86340 • 602-282-1344. The price is $10.

Reviewed by Kathleen Jarschke-Schultze, c/o Home Power, POB 520, Ashland, OR 97520 • 916-475-0830

the Wizard speaks…

Resources or: *More for Less*

As the population rises and the environmental questions become more acute, the way in which we use our resources becomes more important. There are four areas of consideration related to this situation. These are efficiency, conservation, renewable resources, and recycling.

Efficiency
Efficiency is an easy concept. It is the ratio of the output to input. If we use resources more efficiently, we can get more output for the same input. If we are very efficient, we can get more output for less input.

Conservation
Conservation goes hand in hand with efficiency. It basically relates to not wasting resources. If resources are not wasted than we have more while using less. If you don't need it, don't use it, and then it will be available for another purpose.

Renewable Resources
Renewable resources are those which can be used without reducing their future availability. Renewable resources can be used continually as long as the replacement level is not exceeded. This replacement level is different for different resources. By using renewable resources wisely, we can produce more with less impact on the environment.

Recycling
Recycling is the most important element of this scheme. Nature recycles all its resources. We should do the same. If we are able to approach 100% recycling, the impact we make on the environment would be reduced considerably. This would mean changing the economic paradigm to include a recycling feedback loop. This feedback loop would process *all* waste products for reuse. In this way we could produce much more while still having less of an impact on the environment.

Finally a necessary adjunct to the above program is world-wide birth control. If the human population of the planet is not limited, all efforts could fail. To preserve the biosphere, population control will sooner or later become a necessity.

Writing for Home Power Magazine

Want to share your story? Home Power specializes in hands-on, practical information about small scale renewable energy production and use. We try to present technical material in an easy to understand and easy to use format.

Informational Content
Please include all the details! Be specific! Write from your direct experience — Home Power is hands-on! We like articles to be detailed enough so that a reader can actually apply the information. Please include full access data for equipment mentioned in your article.

Article Style and Length
Home Power articles can be between 500 and 6,000 words. Length depends what you have to say. Say it in as few words as possible. We prefer simple declarative sentences that are short and to the point. Use sub-headings generously to organize your information. We highly recommend writing from within an outline. Check out articles printed in Home Power.

Editing
We reserve the right to edit all articles for accuracy, length, and basic English. We will do the minimum editing possible. We get over two times more articles submitted than we can print. The most useful, specific and organized get printed first.

Photographs
The photos you see in Home Power are done digitally. We use a 35 mm slide scanner and a 8.5 inch by 14 inch flatbed scanner. We can work best from a color slide (color positive transparency). We can also work with virtually all 35 mm film formats (color and B/W negatives) and color or B/W prints.

Line Art
We can redraw your rough sketches via computer. We can generate tables, and graphs from your rough data.

Article Form
We would love your article on a 3.5 inch computer diskette. Or put it on the Home Power bulletin board (707-822-8640), addressed as e-mail to Richard Perez. We can, and often do, work from typewritten doubled spaced manuscripts. If you don't have access to either a computer or typewriter or other fancy hardware, then please print in ink. The quality of your info and experience counts, not the cost of your equipment.

We use Macintosh computers. We can also read TEXT files on 3.5 inch IBM disks. Format all Mac or IBM word processor files as ASCII "TEXT". Format all computer graphics in EPS format. Use the Helvetica 10 point font for all text embedded within graphics. If you want more specific info on computer submissions, then call Richard at 916-475-3179.

Want your material returned?
Please include a stamped, self-addressed, return envelope that is big enough for your stuff. Otherwise your material will not be returned.

Copyrighting
If you request it, we will copyright your work in your name. Otherwise we will copyright the information in Home Power's name. The copyright on your material is yours for the asking.

Got any questions?
Give us a call. This saves everyone's time.

Access
Home Power Magazine, POB 520, Ashland, OR 97520 • 916-475-3179 phone and FAX

Letters to Home Power

Too Shy

Letter to Home Power Readers: For all of you Home Power readers that were not fortunate enough to partake in the "Irish weather" at the Energy Fair this June, we have some news to relay to you. (Richard & Karen were too shy to mention much of this in the article on the Energy Fair).

On Friday, June 18, at our annual awards ceremony, Richard and Karen Perez and *Home Power Magazine* received the "Renewable Energy Promotion Excellence Award." This award was presented in recognition of their leadership in the promotion and support of renewable energy.

Home Power was instrumental in the birth and development of the Midwest Renewable Energy Fair. They have enthusiastically supported us throughout our four year history and for that we are forever grateful. We look forward each year to working with the Home Power crew and seeing their smiling faces at the Fair (in any type of weather!).

If anyone in the renewable field is more deserving of this award, we have yet to find them. Thank you Karen and Richard and the Home Power crew for all of your enlightening work.

Submitted by Julie Weier, Executive Director, MREA on behalf of the Board of Director's, MREA, 116 Cross St., Amherst, WI 54406 • 715-824-5166

Aw shucks. Mick Sagrillo made us print this — thank you, Julie. — Therese

Access Correction

In the Wizard Speaks column of HP#36, you printed some incorrect information. The Nate BBS phone number is not in service.

There is a Space Sciences BBS at 805-294-0154. It carries a zipped text file called FREENRG3.ZIP. This BBS is free to all users, and I downloaded this file, and others, without any problem. FREENRG3 contains text and pictures about powering a load with a battery, without discharging the battery. This is mostly theory, and I don't think the average person could build such a device based on this paper. I guess it's fun reading though.

I think either you, or the Wizard, should check your facts before publishing incorrect information.

I am looking forward to GoPower!, and enjoy articles about electric cars, etc. All the major articles were interesting and well written, I'd say it was your best issue to date.

Gary Gallup (address withheld by request)

Just Plain Folk

As your readers understand, *Home Power* is the non-industry source for us "plain folk". Democracy in a free-market requires educated consumers. Your hardware evaluations (i.e., HP#36's comparison of inverters) are found virtually nowhere else. They keep the industry accountable to its users and for this alone HP is invaluable.

Environmental concerns such as questions of paper and ink are particularly of interest to the HP readership. I've rejected other periodicals because their ecological cost/value didn't justify my subscription. Those are in the library.

However, Karen's explanation of the new format is quite adequate. The quality of the printed graphics in issue #14 required imagination to fill the voids left by their fuzziness. In issue #36 you can read medium-sized print on the equipment labels. Scanned images, the Wind Baron ad pg 73 or truck photo pg 91, are still vague though no crucial info is lost. If the more professional look brings you advertising, a more assured existence, and a widening of the circle of renewable users...then it's a good trade...not selling out. I trust you'll continue to make further eco-ethical choices as they become available. At 112 pages instead of 55, HP is more than twice the value. Please sign me up for another two years.

Bill Dorsett, 1715 Leavenworth, Manhattan, KS 66502

Hey Bill, thanks for the flowers and the assurances. The production crew (which is a fancy name for Karen, Therese and I) got tired of bargain basement printers turning our hard work into mud. We are very pleased and excited to increase the "baud rate" of Home Power. Our new printer (St. Croix Press) is as concerned about communications as we are. Check out the color photos in this issue. All (including the cover and page 49) are scanned and processed here at Home Power using only solar and wind sourced energy. Just another example of home business, advanced technology, and solar power making the impossible possible.

As far as keeping the industry honest, we do our level best. Fortunately, the weasel to angel ratio is very low in the off-grid RE industry because until recently there was no big money to be made. As more folks claim *their share of the sun this will change. We will continue to do our best as consumer watchdogs. — Richard Perez*

Mexican Wonder Batteries

This is in response to John Rogers' article "Solar Pioneers in Central America" in HP#34. For years I heard rumors from customers and travelers regarding Mexican automotive batteries and their tolerance for deep cycling. I mean people running them down repeatedly until the lights were dim (over discharging) and batteries still lasting a few years. Car batteries as we know them in the U.S. will never tolerate more than 20 deep cycles, if that. I didn't believe these stories, until the fact was confirmed to me by a competent PV dealer in Mexico, whose customers use car batteries. Here's my theory: Car batteries made in the U.S. are built to perform in sub-zero temperatures. The plates are many (and thus thin) to gain large surface area. This increases their cranking amp capacity, enough to compensate for sluggish chemistry and hard-to-crank engines in winter. Mexican batteries are not made for a cold weather market. It is simpler to manufacture them reliably with the "old fashioned" thick plate design. Plate thickness is the most significant difference between deep cycle and engine-starting batteries.

It takes advanced technology to make a thin-plate battery that will hold up on rough roads. I suspect that a country that only recently began to make its own batteries may use newer imported technology to make thin-plate batteries; they are smaller and cheaper per cranking-amp. The Mexicans have been making batteries for decades. Their homegrown industry uses lower-tech methods, necessitating the production of thicker plates which, incidentally, tolerate deep cycling.

We need to know how to identify old-fashioned "de-facto" deep cycle batteries. The least we can do is look down the filler holes and compare plate thickness visually. Is anyone out there familiar with battery manufacturing on the international scene?

Windy Dankoff, PVSS, POB 548, Santa Cruz, NM 87567 • 505-351-2100

Hello, Windy, and thanks for the info. Plate thickness and plate density are, indeed, critical factors affecting a lead-acid cell's lifetime under deep cycle service. Interestingly enough, Karen and I visited a MAC SA battery plant in Colombia, South America and saw car batteries being made with the same thick, high-density plates. Maybe in some case these folks are making better deep cycle batteries cheaper than us gringos.

Home Power has many international readers. How about some reports about batteries that are not made in the USA? — Richard Perez

Wanna Work!

It was good to see you and your team at the Midwest Renewable Energy Fair again this summer. Many thanks to Richard for another breathtakingly incisive and understandable work — this time on inverters! Good to see you all get an award, too, although I suspect many in the audience are not really aware of the extent of your commitment and contributions over the years.

I talked to Therese Peffer at your booth briefly (she noted my Berkeley sweat shirt) about some kind of space in *Home Power* to help graduating students and perhaps others make connections with job opportunities in home power businesses. She asked that I put this thought in a letter. I have had several students in the last five years that have formed a real dedication to the home power effort. One graduated this past year, another ran a small business of his own on the side for a few years while a student. In these and other cases, I have offered the advertising in *Home Power* as a source of contacts for possible jobs.

A better mechanism for connecting dedicated young souls with jobs prospects would, however, be awfully nice. Would it be possible to start a section, perhaps back with the letters from readers, where people wanting to work in home power could identify themselves and give a very short summary of their skills/interests? Would it even be possible to offer prospective employers a little space to describe job openings? If this could be done at low or no cost to students at least, it seems like it might help a great deal in bringing dedicated workers together with worthwhile work! (I would suspect that a fair number of students would even be interested in subsistence or no-pay summer or year-long internships, with home power businesses where they would be in a position to learn something and get a start.)

You all are clearly in closer touch with the need (or lack of need) for such a service than I am. If such a thing is possible, though, I know there are folks here who would much appreciated it.

Thanks, and keep up the good work. I suspect that you're developing a far larger cheering section than you ever really could have imagined!

Cordially, Jesse S. Tatum, Assistant Professor, Science Technology & Society, Michigan Technology University, 1400 Townsend Dr, Houghton, MI 49931

Thanks, Jesse, that's a great idea. Okay, readers, help us out here. Does anyone know of a renewable energy job board in existence (sounds like a great application for a computer bulletin board system)? If we're not repeating someone else's work and if there is enough *interest, we'll find some space for renewable energy related jobs wanted and needed. (We reserve the right to edit though). Go Bears! — Therese*

I think that a networking service connecting folks who want to work in the renewable energy industry with companies needing people is a great idea. Here at Home Power we get maybe four job applications a month, and we just publish info about really doing it. I am willing to dedicate a regular space in Home Power's *printed pages to networking for companies and people looking for work in the RE field. Let's get going. Companies wanting employees send us your requirements! Individuals seeking work and hopefully careers in renewable energy, send us your qualifications! We'll do our best to help make connections. — Richard Perez*

Low Head Hydro

I read in a recent issue of *Home Power* about someone interested in generating electricity from a river with little head. The letter asked if it was possible to submerge a propeller/generator as might have been used on sailboats to recharge batteries.

While visiting Miami, Florida this week I stopped by Crook and Crook Marine Supply, near Shell Lumber, and asked about such a device. Crook and Crook sells photovoltaic panels to recharge batteries on sailboats, but the store manager had never heard of the propeller-driven generator you mentioned and Crook and Crook does not carry it. The manager did, however, direct me to talk to one of the Crook and Crook employees that owns a sailboat and has a lot of sailing experience. This employee had heard of the device and said they are no longer used much on sailboats since windmills are now used. He said the propeller-driven generator is still available, from other stores (not Crook and Crook), and he estimated it would cost about $500. Most importantly, he said those devices require that water pass the device at a speed of at least five mph. That's a very swift current, and most low-head rivers probably flow much slower than five mph.

Sailboats now use windmills to recharge batteries. There are two brands of windmills used on Florida sailboats — one kind uses internal brakes to protect the windmill from high winds, and is not very reliable. The other brand uses external brakes and is much better and totally reliable. "Don't let the home-made look of the windmill with the external brake fool you — it's much better," says the experienced sailor at Crook and Crook.

Every sailboat I've seen in recent years has a windmill. Go to any anchorage, such as the bay northwest of the golf course in Marathon, Florida, and you'll see dozens of sailboats anchored with their small windmills spinning. Carlos Portela, POB 1373, Poway, CA 92074

Puddy Power

What an excellent mag. Can't wait to get my first people friendly issue. I always thought this area of AE was for physicists, scientists and other brains like my husband. But you guys explain things beautifully, give me ideas and make things fun. One thing I've come up with on my own is KTU — (Kitty Thermal Units). I have about ten on the bed every nite. An electric blanket uses 177 watts. My ten cats use one can of food per day plus dry food. Probably not a great savings, but when one starts purring they all start and it's like having the "magic fingers" machine in bed. They are really warmer than the electric blanket but it's very welcome up here at 4000 feet in Klamath Falls, Oregon. One other advantage is that you don't have to plug it in and wherever you sit for a while they seem to gather. Why, yesterday I only had three KTUs on the easy chair and was quite comfortable. Joking aside, thanks for a great mag.

Sincerely, Nancy Shinn, RR 1 Box 344W, Bonanza, OR 97623

Hello, Nancy, it is wonderful to meet another friend of felines. There are some nights when Karen and I have had trouble turning over in bed because of the weight of a dozen of more KTUs. Our furry friends surely radiate much more warmth to this home than they adsorb. Renewable energies come in many forms…. — Richard Perez

Home Business

Enjoyed your article on home business and thought we'd add our two cents' worth. Very down-to-earth, common-sense advice, especially the part about just starting whatever you're going to be doing right in your own home. We did that ten years ago when we began our publishing business, and it took up a corner of the bedroom. Now it takes up more than half the house, and we've added on considerably during that time!

Running your own business allows so much more flexibility and diversity in your day, especially a mail-order based business such as ours. If none of us feels like working on a given day we simply pack a picnic and go fishing. Sounds great, huh? But the hard reality is that we're more likely to be at our computers into the wee hours of the morning, trying to get an article edited "just right" for the next issue. It's a plain fact of life that after working frantically all afternoon filling orders we're usually rushing off to the post office ten minutes before they close for the day. Our kids know that when we're on deadline they fix the meals, or nobody eats. They sigh in resignation when the phone rings — we've been known to spend five hours on the phone with business associates across the country. But we can also leave home for two or three weeks at a time to travel around, and we often do.

When people ask us about home business we advise them to find something they believe wholeheartedly in and want to promote and support. For us that has been home schooling, and it quite literally consumes our lives. But we absolutely love the interaction with these devoted, loving, resourceful, committed, caring people who chose home education for their children, and that interaction sustained us through several lean years getting established. We knew that our most valuable asset — our reputation for reliable information and caring service — would one day support our family, and so it does.

We looked forward to your article on putting together a business plan. We've never had one, we just kinda "flew by the seat of our pants," so to speak. Lotsa good ideas that worked, lotsa bad ones that didn't pan out. So it goes in life, eh?

Mark and Helen Hegener, Home Education Press, POB 1083, Tonasket, WA 98855 • 509-486-1351

I salute you, Mark and Helen. I can add nothing to your perfect summation of survival with a home business.— Richard Perez

Microwave

I work every day on rural electric, water, and heating, either building new systems or making service calls. I have a long list of things that don't work. Your magazine works!

Having been a printer I enjoyed the articles on your printing changes and the improvement is great. I think good products can only result from *informed* decisions and your publication has brought AE products into the daylight.

In reference to two articles in issue #35, as far as I know all radiation including light and radio follows the Inverse Square Law: intensity diminishes in direct proportion to the square of the distance. The intensity at 2 inches (from the source) will be half as much as at 1.4 inches and twice as much as at 2.8 inches and four times as much as 4 inches away. Sound familiar? Get your favorite adjustable camera and look at the f stops: f11 is twice as much light as f16 but half that of f8. The unit of measurement is not important whether inches, feet, or meters but it must be from the *source* which is not necessarily the *door* of the microwave. The f stop scale should give you a good idea of how fast energy diminishes when close to the source and how much staying power it has over distances.

I am looking for a Line Loss program to run on my PC. Something that would cover a wide range of ac/DC applications and wire sizes to 1000 MCM. If someone could point me in the right direction I have an older XT with 5.25 HD floppy input to hard disk.

Also what measurable effect does a twisted pair have on DC power transmission?

Thanks Again, Mike Doig, POB 597, Big Sur, CA 93920

Hello, Mike. All radiated energy does in fact obey the inverse square law. Sorry I can't help you with that particular disk format, but I'm sure some reader can…. When you speak of effects on a twisted DC power transmission cable, there are in fact several. First is that any low frequency (below 7 kHz) ac magnetic fields are reduced by a factor of about twenty. This is true of all conductors regardless of whether they are carrying DC or ac current. Many people think that just because a power cable is connected to a battery it carries a constant DC current and therefore has no alternating current magnetic fields. This is not true for DC cables feeding any inverter or any electric motor — both big current consumers. In these cases, the amount of current being carried by the conductor changes radically and rapidly. Such conductors are surrounded by heavy low frequency (<100 Hz) ac magnetic fields. We've measured motor and inverter conductors at over 1000 milliGauss at a distance of one foot. These are the very same types of fields being linked to health problems. Check out the index in Home Power #36 under Electromagnetic Fields, you'll find a wealth of interesting info about our research into the beasties. — Richard Perez

"Plugs" & Glow Bars

My new house is 1/2 mile from the last power and phone lines. My next door neighbor is a 26,000 acre private game preserve, and 10 miles or so of trees on essentially unbuildable land in the other direction. I run 16 Hoxans feeding 20 Trojan T105 batteries, a 2524 Trace, and various other bells & whistles from the helpful folks at Fowler Solar Electric. Refrigeration is a Sun Frost RF12. The phone was an 800 MHz SMR business radio system, until cellular came to the area last year, now it's cellular. The whole system works pretty well so far. We've been living on the site for a couple of years, and last winter was the first winter in the house. The main problem I now have is that in the winter, my heat is produced by heating 300 gallons of water in an outdoor wood boiler and pumping the water through the concrete basement. The circulator runs more than I thought it would; nearly constantly, so I have to run the generator any time I have more than one day without sun. Maybe next winter, I'll add a woodstove to the inside of the house. The house is a post & beam super-insulated styrofoam sandwich panel design, with R-36 in the walls & R-45 in the ceiling. Maybe someday, I'll get a chance to tell you all more about it, with pics.

Anyway, I had to tell you about what a lifesaver issue #35 was. I just finished installing a new built-in GE LP gas stove. When I was adjusting the burners and saw the infamous glow bars, I knew I was in trouble. When we bought the stove we made it clear what our needs were. At that time, we were so concerned about the draw of the clock and digital front panel that I installed a switch before the stove's ac outlet, so we could turn it off when the stove was not actually in use. The salesman never mentioned glow bars, or we certainly never would have bought the stove.

I immediately called the dealer (Sears), and they said they'd take it back, but that they knew of no other built-in stove that didn't have glow plugs. That night, my wonderful Home Power came & I saw the letter from Renee Thompson. Thank you so much Renee! I called Peerless Premier's 800 number (800-858-5844) & they are sending me info on the stoves. They said they've gotten *lots* of calls from the mention in Home Power. I also called GE to see if there was any modification I could do to make the glow bar go off once the burner lights, as I *really* do not want to have to pull out a built-in stove and put in another. They said "no way". I asked them to please pass on to their product planning people how, even outside my particular circumstances, terribly inefficient it is to have a gas oven that draws 400–500 watts of electricity. That whole concept is the craziest idea I ever heard of!

Brian Meyette, RR2 Box 579A, Cornish, NH 03745

Hello, Brian. Thanks for amplifying our experience with the glow bars. Off-grid renewable energy systems have special appliance criteria. What may be considered super efficient on the grid may turn out to be a battery sucking son of a Phantom Load. In our case, I should have been able to spot the problem from the stove's 120 vac power cord. I should have asked myself why a propane range need such a heavy 120 vac power cord. I didn't and I trucked the stove all the way home and installed it before I got the bad news. If your gas stove comes with an electric cord, then investigate very carefully how much electricity the stove requires. — Richard Perez

Solar Stills

After playing with solar distillers for the last couple of months, it was good to see an article in Home Power. ("Clean Water from the Sun" by Laurie Stone, HP #36.) I can concur that insulating the tank improves efficiency a great deal. My current design uses two inch foam board insulation and produces close to a gallon per day using a 2 x 4 foot collector (about five liters per square meter). The foam board also adds structural rigidity to the 'still. Blue foam is probably the strongest, but I couldn't find any locally with the right thickness so I am using black board with a rating of R-18.

Your readers should know, however, that not all types of plastic are suitable for solar still construction. The second unit I built used sheets of 3/32 inch ABS plastic. This material was a nice opaque black color and had a textured surface — perfect for the application, or so I thought. The first problem was that the plastic began to buckle and warp after a few weeks of operation. Even the PVC tubing used as the pickup trough was curling up in the heat. (Much of the damage occurred when a reflector was added on a particularly warm July day, generating temperatures high enough to produce scalding steam).

The second problem was even worse: The ABS was out-gassing and contaminating the distilled water. Passing the product through an activated charcoal filter removed the plastic taste, but this is obviously the wrong approach. I re-built the entire unit, replacing all of the plastic. The tank was constructed of printed circuit board material (sheets of fiberglass plated with copper) painted with selective black paint, and copper pipe was used for the pickup trough. (At the surplus outlet where I bought it, the PC board material was actually cheaper than the ABS.) It's only been in operation a couple of days now, but I don't anticipate any more melt-downs.

There's an interesting phenomenon that has repeated itself with all the stills I've built: their efficiency starts out very low and then increases over the course of a couple of week's water production. I attribute this to contaminants on the glass causing drops of condensed water to fall prematurely back into the tank rather than running down to the pickup. After a while, these contaminants get scrubbed off by the operation of the still and efficiency rises to its maximum.

Eric Williams WD6CMU, 5860 Clinton Ave., Richmond, CA 94805

DC over ac

One possible advantage of DC over ac may be with regard to the possible potential of the hazardous effects of electromagnetic field radiation. While scientists are still trying to decide if such radiation is a biological hazard, it would seem that we might want to keep this in mind.

I am thinking primarily in regard to electric motors and potential increases of their use for transportation. Are there any disadvantages to DC motors as compared to ac motors?

Most of the ac motors in my home (blender, refrigerator, etc.) radiate between 6 and 8 milligauss of magnetic radiation. While I have no DC motors readily available, my understanding is that DC current produces no magnetic radiation.

Dan Baright, 281 N Jackson Apt #9, Lebanon, MO 65536

Sorry, Dan , but all motors produce ac magnetic fields. Brush type DC motors consume more current at some points in their rotational cycle than at others. In regards to the low frequency EM fields in electric vehicles, we have measured less than five milliGauss average in a Voltsrabbit converted by Mike and Shari at Electro Automotive (see Ad Index for access). — Richard Perez

More on Lightning Protection

Per our phone conversation on lightning, I received the back issues you referred me to and find they were quite good. I can add very little. One point not covered is the importance of not having any sharp bends in the grounding path. The large amperage in the conductor with its associated fields forms a one-turn motor. The electromotive forces will tend to straighten the conductor unless it is suitably restrained.

An example is the attachment of lightning diverter strips to an airplane's nose radome. These strips are bolted to the plastic radome at approximately six inch intervals. Where the strips are grounded to the airplane structure, the lightning path makes an abrupt 90 degree turn. In lightning laboratory tests the strips were torn off the surface locally to form a gentle curve at the point of grounding. The fix was to double the attachments locally.

More to the point for your applications. Do not attach a lightning conductor to a ground rod with a 90 degree fitting, use an axial connection to prevent a strike from breaking the connection. Since the initial wave front of lightning is very steep (megaHertz), lightning in addition to being a direct current acts as an alternating current. Each change of direction restrained or not acts as an impedance in the total path to ground. The whole point of lightning grounding is to provide a minimum path so it is chosen over other possible routes.

Gordon K. Greene, 6565 E Beach Rd, Port Angeles, WA 98362

Good advice, Gordon and thanks for sharing it. Lightning is best conducted to ground via a straight path. Here basic physics and the high rate of current change per unit time favor a straight path. — Richard Perez

Resistant?

I really like Kathleen's "Home & Heart" column. My favorite articles are the bio's of RE in action and how people transformed their lives & lifestyles. Keep up the great "work" you're doing. It's so great to read a magazine that reads like we talk. Why is it that with every trip I make to the Southwest (AZ, NM — you know the sun states!?) I am continually appalled at the lack of solar energy applications? Flying over Phoenix yielded so few PV cells or collectors viewed on roof tops. Am I not looking in the right places or are the SW people (on the whole) resistant to RE???

Joan Lucero, 13525 SE Marsh Rd, Sandy, OR 97055

Hi, Joan. Thanks for your comments. I don't know about solar hot water and photovoltaics in the Southwest, but I have a sense that solar cooking is big! The vast majority of the entrants for our solar cooking contests hailed from the Southwest. I'd be overjoyed to see that solar cooking happened say, in Minnesota, too. Come to think of it, we have quite a few readers in the Southwest, and I know there's a few active solar citizens' groups down there. It may take a few years until solar hits the mainstream. — Therese Peffer

In Retrospect

I have been a subscriber since issue 21. Your magazine has been the most informative and helpful tool that I have found. I only wish that I had discovered it before I began installing my system. Well, I was not too far along and didn't make too many mistakes, but I know in retrospect that I would have done things differently with the knowledge gained from *HP*.

I have a remote cabin in northern New Hampshire (about 70 miles south of the Canadian border) that is used about once a month for four or five days. Since I am not in full-time residence, I am in a very different situation than most of the people and systems that you write about. I enjoy reading about systems large and small as something can be learned from each article. But I particularly like the articles about small systems as they tend to relate more to my situation. I don't believe that you have addressed the part-time PV user. Solutions that are practical and economical for the full-time resident are not always solutions for someone like me. For example, I cannot justify the cost of a Sun Frost refrigerator or even a Servel that would be used only about a month each year. I enjoyed Therese Peffer's articles on her small system as her system has more relevant to my situation. But she did not mention refrigeration.

I have solved most of the problems (or am on the way to solving) with plumbing, water supply, heating, etc. Refrigeration is the major unsolved problem. We have for years used an icebox (1930's vintage) picked up at an auction for 15 bucks. I replaced the insulation and door seals. It does an adequate job but has its drawbacks. Years ago we had a local ice house and could fill the box for fifty cents (the same amount of ice costs about 10 bucks today). When the ice house went out of business I began to make block ice in a recycled refrigerator crisper pan in my freezer at home. I can take enough ice in two large coolers for three or four days in summer; then we have to purchase ice for the remainder of our stay. The coolers take up a lot of space in my small wagon and it is not convenient.

In my situation would it be practical to purchase a small inverter and a small (about 3–4 cubic foot) refrigerator? Perhaps at a cost of about $500. What size inverter would I need? I also wonder about the time it would take to get the temperature down to operational temp. if the frig was shut off between stays, and what this initial energy requirement would be versus running the 'frig continuously all summer.

Finally, as to the new look for HP. I was subscriber to Mother Earth for many years until it went YUPPY and I was concerned that HP might go the same way with glitzy ads and trivial articles. At this writing I am pleased to say that I think that you have made a good compromise. The articles are down to earth and as helpful as always and the mag has become more attractive. Keep up the good work.

Richard A Kenyon, 37 Danielson Pike, Foster, RI 02825

Hello. Richard. Thanks for the feedback. I would use a small Sun Frost refrigerator in your application. Turn it on when you're there and off when you're not (leave the door open when the reefer is off). I would expect a small Sun Frost (4 cubic feet) to consume the energy produced by a couple of modules or less. Why use an inverter when these super-efficient refrigerators are cheaper and more efficient at 12 or 24 VDC. If you add the cost of the inverter, the additional PV power, the additional battery storage, and the added inefficiency of a standard, small 120 vac reefer, then the $1000 price tag for the Sun Frost is really less expensive— Richard Perez

Via Auckland

Your new format looks great, enough of the negative. The information you have published over the years has helped people all around the world, people who without this information would probably still be using candles and kero lanterns and/or running their generators 18 hours a day.

I have been involved with AE here in New Zealand for 7 years. The industry is alive and well here in New Zealand. We have only a small population but there are many people living off the grid (utility). Power has been supplied in many cases by generator sets. Now many of these sets have an inverter/charger and battery pack. Running costs are reduced and there is available a 24 hour power supply without the noise of a generator thumping away all day and half the night.

Solar and wind together as a hybrid works well down here. There are also quite a few stand alone solar systems up and running also. We have a local wind generator manufacturer working hard to provide a machine that can stand our hellish winds. This is a good test ground for wind generator survival testing. We have had trouble with U.S. manufactured wind generators down here. They work well but have trouble surviving the hellish winds that prevail in the coastal regions of this country.

Looking forward to reading your test results of tracking versus fixed arrays.

Graeme McIntosh, POB 27-277, Mount Roskill, Auckland, New Zealand

Thanks, Graeme, for the words about RE in New Zealand. We have many readers from down under. We are still conducting testing on trackers, and PVs. Look for an article soon. — Richard Perez

Possibilities

First and foremost, enclosed is a check for a 2nd class subscription renewal. I'm looking forward to another year's entertainment!

I wanted to extend a sincere "Good Job!" to the *Home Power* crew for putting together a diverse and interesting magazine. As an electrical engineer who has worked in power electronics for a half dozen years, it's not the technical information I enjoy so much as the inspiration and "imagining the possibilities."

When I look at the exploding technology around us — CD players, PCs, right down to computer controlled washing machines — I see applications that have taken off due to consumer demand. If only we could get that interest in alternative energy! The technology is there. The interest isn't. A PV system is so much less elaborate than a modern TV set, yet PV systems and components lag far behind in utilizing existing technology. Some examples: Peak power point tracking. DC to DC converters. Embedded computer control. Yes, there is some use of these, but not much. *Home Power* magazine helps me keep my hopes up that someday our society will see the sun as energy, not just light.

Also kudos for Chris for trying to make the ugly understandable, via Dr. Kluge. It's not an easy task, as I can attest!

Finally, a concern, that reviewers for Home Power are careful not to "slant" the facts. An example a recent review of a DC electric heating pad. Yes, I'm sure it's nice. I'm sure it produces far less electro-magnetic fields. But the article made a big deal of the power it used versus an ac model, without mentioning a size difference. Ac and DC resistance are equally efficient, and the article implied otherwise. The pure merits of the pad reviewed were sufficient for a "thumbs up". I'm disconcerted the review wasn't as clear as it might have been.

The new magazine format looks fine. Good job in making an informed decision.

Time to get off my soap box.

Eric Richardson, 4200 Spanish Bit NE, A301, Albuquerque, NM 87111

Sorry that the article on the heating pad (HP#29, page 58) was misleading. You are correct — ac and DC resistive heating are equally efficient. The point that I was trying to make was that the heating pad had much lower EMF and that the amount of heat produced was sufficient. Guess it boils down to the thermostat ! — Karen Perez

Hi Eric, thanks for the comments. Chris' articles have helped me immensely. Time for me to get on my soap box — why do you think there's not a wide interest in solar? I think part of the problem is public perception. At the REDI conference I was surprised to hear the architects from SMUD remark that they had to change the name of the passive solar design guidelines from "solar" to "natural". The term solar would actually dissuade people from that design! Solar was sure given a bad name fifteen years ago. Part of the answer, for me, is education. Tell people, they forget. But immerse them in a solar-hot shower and stuff them full of solar cooked cake, and maybe we'll get somewhere. — Therese Peffer

Sailing Does Count

Your magazine looks awesome! I hope you can maintain the human touch which has made HP stand out from all the magazines I know.

I just finished a 10 month cruise from the west coast to the east coast on "Longhope". Carved 3 new wind generator props and lost the propeller from my towable generator for Hamilton Ferris. 5,600 solar miles — sailing counts doesn't it?

Bill Oldfield, POB 1536, Blowing Rock, NC 28605

Not only does sailing count, Bill, I wish I'd have gone with you! If applying RE at a homestead is a walk in the park, then doing it afloat is climbing Mt. Whitney! Write us an article about how your RE systems worked on the cruise. — Richard Perez

Big Wind

I visited a real honest to goodness wind farm located in Central Massachusetts. The farm consists of eight 40 kW Enertech three bladed down-wind, wind machines. WOW!!!

One quarter of a mile down the hill from where they are located, on the other side of a stand of trees that were located between me and the machines, the sound emanating from them was as loud as a mosquito.

They do make quite a bit of racket though when standing right under them. I learned about the wind farm from an environmentalist who was opposed to a plan by U Mass, Amherst to install an 80 foot tall, 250 kW two bladed down-wind ESI machine atop a local ski resort. The environmentalist claimed big noise would be heard far away from this machine. Doesn't appear to be the case.

By the way, U Mass has reactivated their old "Wind furnace" house. The same one seen in Don Macier's "Wind Power for the Homeowner" book, now out of print. U Mass currently has about eight old ARCO 1 foot x 3 inch mods at 1 amp atop this house on the roof. Mounted vertically on the south wall are three or four, 4 x 2 MOR FLO air heating panels. Each has a small fan. Next to the PV modules up on the roof is mounted a rack of SUN FAMILY solar domestic hot water panels. These are integrated storage type of panels that drain back at night. Even though there is an evacuated tube to insulate the tank, these panels lose mucho heat to the night sky in this climate.

These U Mass guys have a PV module from pre-ARCO Solar. Solar Technology International! The ASME student section at U Mass Amherst is also working on a solar car for this year's Mexican Solar Car Race.

Keep up the good work.

James Mell, Wilbraham, MA

The Good, The Bad and....

I consider my copies of *Home Power* "almost sacred"...which is why I won't cut so much as even a coupon or subscription order blank. Hence, my renewal is a photocopy. This is the way I felt about Mother Earth back in the early days when they were so poor that they printed like a small town newspaper — but every issue was a gold mine of information. My early copies are now almost beyond price because they are complete and *not* chopped up. Years later Mother went "slick", became so rich and famous that she had an office a few blocks from Wall Street, and her new city-slicker owners lost touch with the land...It is my opinion that

that is when Mother became *so* slick and fluffy that she no longer had room for substance. That's when I quit subscribing. A few years later Mother claimed to have "regained her senses" and contacted all the old-time subscribers and quite literally pleaded with us to "try one more time". So I sent in my money, got my copies, observed (in my opinion) that little had improved, and dropped her like a hot potato. Although I see a similar sequence of events happening to the production of *Home Power*, the "substance content" is actually improving and it appears Karen and Richard have all good intentions of NOT letting "progress" corrupt their fantastic magazine...time will tell.

Dave Kemmer, Oronoco, NM

Stick with us, Dave, Karen and I are dedicated to getting the word about RE out to where it will do the most good. HP's *new face lift is our attempt to put the same info into a nationally palatable package. Stay tuned to see if it works! — Richard Perez*

The Ugly

Aaaah! Among the deluge of glossy-paper magazines I always enjoy receiving *Home Power* on its newsprint paper. With the change in format to glossy paper it will cost me 3 cents/pound to dispose of *Home Power* — as much as I hate to admit it I don't save all the issues.

Keep the quality articles and information but bring back the newsprint.

Lise Kowaski & Selby Jones, Worcester, VT

Well, Lise, no chance of the muddy ole' newsprint back. Coated paper for recycling is actually in short demand right now in some places. Encourage your local recyclers to get off their butts and give you a break on coated stock. A back issue of Home Power will cost you about 1.5¢ to recycle. We've heard of our early issues changing hand for $50. So instead of recycling your HP *immediately, wait two or three years and you'll be able to sell it for more than it cost. — Richard Perez*

Building an electric-assist HPV

Great article in HP#33. Seems criminal to crush the Honda after such a fine conversion and successful racing. Oh, well. Maybe Honda will reconsider? (Or keep it for themselves?)

I plan to convert an Easy Racers "Tour Easy" recumbent bicycle to include electric-assist power. (½ hp motor max) After that, my wife and I are planning to build an EV.

Tom & Tess Danaher, Sebastopol, CA (707-874-1156)

Hi Tom. Many people have asked about the Honda. American Honda is *considering donating the Honda to me. I will remove the electrics if it has to go back. Let* HP *know how things go with your HPV electric-assist project. I can't think of a more practical platform for sane transport. Actually, you can probably get sufficient help from a ⅛th hp motor, since most PM (permanent magnet) and all DC motors will deliver several multiples of their continuous hp rating for short periods. There's a big difference between an electric HPV and a HPV with electric assist. Remember, PM motors also offer easy regenerative and dynamic braking capabilities. Good luck. — Michael Hackleman*

Keeping your Electric Warm

I enjoyed your article in Feb/Mar issue of *Home Power* magazine. I am converting a '87 Honda Civic wagon, 2WD and will have a bit more room than your Honda VX to play with. Gross vehicle weight rating is 3,010 pounds.

The car will be used mainly for my commute back and forth to work, 14 miles one way. There are 4 miles of stop and go, and 10 miles of 3-lane, 60 mph highway on flat Ohio roads.

Do I need 20 batteries like on your VX? Will the 20 hp DC motor accelerate my wagon safely onto the highway onramp? If I use the gas tank area for batteries, I will need to lay them on their sides. Will the sealed gel cell (i.e., Prevailer) type battery work in this application? Will there be room for a small heater (gas-fired) type under the hood? Ohio winters are cold!

Joseph Fulford, U.S. Navy

Dear Joseph, Ten 12 Volt batteries in my Honda VX gives me a bit more than 30 miles range — 5 miles stop and go, 15 miles freeway cruise, and 10 miles up and down some serious hills. The figures go up 80% by doubling the size of pack. Both figures represent complete discharge; use 50% of these values for good battery service life. The big Advanced DC motor (9 inch, 20 hp) is necessary to pull the hills at speed, and ensure onramp performance for your vehicle's weight range.

I wouldn't recommend gel cells for an electric just yet. Discharge currents of 300 Amps would hurt most gel cell types. I know that you don't have much room. My rear battery box is sheet steel welded together, slipped through a rectangular hole cut in the body, welded all around. It ties into the rear wheel suspension supports, so it's quite solid. Steel bars bolted across the top of the steel battery box will keep the batteries in place in a rollover or big collision. These support for the lexan covers (showtime) or rear plywood deck and rug (normal life).

Standard household electric floor heaters (or equivalent) will keep the car's interior toasty for cold weather use. Many of these will operate directly off a

120 VDC battery pack without modification. Full ON, this will affect your range by only 5%. A better scheme is to use a timer, and allow the heater to connect directly to the incoming 120 vac to your charger. This way, the heater turns ON before you operate your car. It's so nice to get into a warm car on a cold morning! Both Solar Car Corporation and Solectria offer heater/air conditioning units for EVs.

There are several ways for keeping your batteries warm. You'll need both insulation and an electric heating pad/wires. Allow room for this when you design your battery cradles or boxes. Wire them to work off your pack directly (DC when mobile) or when you're plugged in (ac while parked).

Try to set up worksite recharging. That way, you leave work with warm batteries and a warm cab. This avoids any potential freeze-damage to your batteries sitting partially discharged at work, particularly in cold weather. At home, garage the EV to minimize the amount of pack heating needed. — Michael Hackleman

EVs are No Joke

I am currently converting a 1981 Volkswagen Rabbit using the Electro Automotive Voltsrabbit kit. I have just started taking the car apart in anticipation of the arrival of the kit.

To my surprise and delight, I am receiving tremendous interest and encouragement with fewer and fewer extension cord jokes. I think the general population concedes that a change is needed.

R. W. McConchie, Oak Harbor, WA

Dear R.W., I hope that you'll send me photos and a story on your conversion using the kit. In California, we call that "sharing the experience".

Nowadays, as you've discovered, I find little ridicule from anyone over the subject of EVs. Curiosity is a better description. Surprise, once I've answered their questions. And, finally, envy, that I am able to change my way of getting around. When you do a good job of making an EV, people can see how simple it is, and it encourages them. It's important that they feel like it's something they can do for themselves. Until they're available on the showroom floor at reasonable prices, a conversion is one of the few ways to get an EV. — Michael Hackleman

Motorized Bicycles

I'm interested in motorized bicycles or light vehicles of bicycle type construction. Living in the flat central valley, it's easy to pipe dream designs that would boost cruising speed and not worry about uphill weight penalties. I'm favoring a trailer design where a power module connects to an unmodified bicycle and pushes it, constant torque, on and off control. I'm hoping to access appropriate parts, people, and plans for all types of alternative transportation.

Roger Madison, 124 Russell St., Winters, CA 95694 • 916-795-2555

Dear Roger, Good ideas. I've included your phone number so that interested readers have a way of reaching you directly.

Low weight is critical to performance in all electric vehicles. It is more important than aerodynamics. Stop and go driving, and hillclimbing ability gets easier (lower hp) with low weight. Scratchbuilt-EVs, like the Leeds Speedster, are proof enough of that. One half of its 600 pound curb weight is battery weight. Talk about a visceral experience! Of course, the Speedster uses motorcycle technology.

Bicycle technology seems strong enough for curb weights up to about 50–75 PPW (pounds per wheel) as a two-wheeled EV. Or 40–50 PPW as a three wheeler. Watch out! Even rims with a high number of spokes will bend or collapse on sharp turns at speed. — Michael Hackleman

Ideal EV Site

Since we only have 30 miles of paved road in the country, it's not out of EV range.

M. Trevor, Marshall Islands.

Dear Michael, Most islands are natural places to convert to electric propulsion. Not only is the range not an issue, it's often helpful to the economy to stop the import of fuel. It's unfortunate that someone doesn't crunch the numbers to see how well solar, wind, and biomass can be in these areas. Of course, it isn't easy. As a utility, you have to supply power on demand, and the uncertainties of experimental systems feel as useful as a greenhorn in a stampede. — Michael Hackleman

Q&A

Lighting

Does anyone have a simple economical solution to powering up fluorescent lamps during brownout periods?

Promptly, each evening our grid power of 240 volts, 50 cycles falls below what's required to fire these lamps. Our solution has been to switch on early those lamps necessary for essential lighting — what a waste! Perhaps some form of electronic ballast/starter is available?

Thanks and keep up the good work. John W Roach, POB 4, Chiang Dao, Chiang Mai, Thailand

Hello, John. Use switching type ballasts instead of magnetic coil/capacitor ballasts. The "electronic" switching ballasts will start at very low voltages and can be purchased for long tube fluorescents as well as built-into compact fluorescents. We like the Osram brand and they are available in 240 volts, 50 Hz. models. — Richard Perez

Nicads & Inverters

I need some help and advice on inverters and I thought you may be able to help me out. I am currently using a Trace 2012 inverter on nicad batteries that are being charged by six Solarex MSX60s. However, the inverter shuts off before the batteries get fully charged because their voltage is too high. After putting in a charge controller, I can keep the inverter running but can't fill up the batteries. What can I do? I want to get a bigger inverter, but I can't find any that won't shut down because of high voltage. Are there any inverters that will handle the higher nicad voltage. I would consider going 24 VDC and removing one cell if that is the only way to go. Any advice or information would be greatly appreciated. Todd M Tollefsrud, RR1 Box 107, Sugar Grove, MN 55974

Hello, Todd. There are two solutions. One, buy an inverter which is compatible with the cycle voltage variations of alkaline cells. We are now using two such inverters: the Exeltech 1000 watt (high voltage cutout at 17.5 VDC!) and the Dynamote 2300 watt. Both are sine wave models and will operate in the 16 VDC range. Both these inverters work well with our nicad battery (ten series connected cells making a nominal 12 VDC). In the world of modified sine wave inverters, PowerStar and Dimensions Unlimited both make models which operate at 16 VDC or higher. The second solution is to move your system voltage to 24 VDC and use 19 series connected alkaline cells. This brings the cycle voltage profile into the same window as a 24 VDC lead-acid system. You are not alone in this problem. Many of us are applying equipment like inverters in alkaline systems when the device was originally designed to operate in a lead-acid system. — Richard Perez

Sintered Plate Nicads

I've read the *Complete Battery Book* and a shorter article of efficient nicad battery use, and I've profited well from your information. While I think I've grasped most of the characteristics of nicad cells, I am still a bit confused about how sintered nicad cells die.

With proper use, sintered nicad cells are supposed to last about 1000 charge cycles. What happens after that? As I understand it, you can damage one of these little guys in the following ways:

1. If the cell is overcharged at a high current rate (say C/5 or faster), overheating can result in venting or explosion. Result: permanent destruction of cell.

2. After numerous charge cycles, dendrites form and cause internal shorting, preventing the attainment of a full or even partial charge. This problem can be successfully treated by zapping.

3. The memory effect characteristics of a sintered nicad cell can reduce its ability to take a full charge. The problem is both treatable and avoidable through proper battery management.

4. The frequent, complete discharge of a cell, or storage of the cell in a discharge state is supposed to be harmful. I'm not sure what the consequences of this practice are.

Is the 1000 charge life span governed solely by dendrite formation, and if so, does successful zapping allow an indeterminate afterlife? If dendrites aren't the end, what is? Does physical construction of the nicad cell eventually deteriorate, as the lead plates will in an automotive battery?

Thank you very much for your help. I hope the *Complete Battery Book* is available again someday, as it is an excellent work. David J DeLaurant, 1505 N Lafayette, Fresno, CA 93728

Thanks for the encouragement, David. I'm working on the revised edition. In terms of the actual cause of sintered plate demise, my money is on improper cycling. If the cell is overcharged to the point of venting, then water is lost from within the cell. Eventually the cell dries out. Repeated minor ventings will dry a cell out in as few as fifty cycles. If cells are to be charged at greater than C/10, then they must be monitored to prevent overcharging.

Dendrite formation is an "old age" problem for sintered plate nicads. After fifty or more cycles, the powdered active materials grow dendrite "whiskers". This is a natural and unavoidable consequence of the electrostatic fields surrounding the chemical bonding that takes place during charging and discharging. Eventually the dendrites penetrate the separator between the anode and the cathode. Here they form a high resistance short circuit within the cell. The cell's voltage drops during both the charge and discharge cycles. The cell's self-discharge rate increases radically. The best defense against dendrites is regular recharging using high current pulses (≈5C) with a very low duty cycle (<5%). (See HP#30 for nicad pulsar homebrew)

Regular complete discharges will not harm the sintered plate cell. This is what they are designed to do. What will harm them is overdischarging resulting in polarity reversal. This is easily possible if the cells are being discharged as a battery. Storage is best done with the cell fully charged. Nicads like regular use. Prolonged storage results in decreased cell lifetime and capacity.

As to why sintered plate nicads die? Well, one or more of the above problems eventually gets them. There are millions of cells out there. They are all getting used differently. My best bet is repeated overcharging resulting in venting which dries the cell out. — Richard Perez

Series Strings

I enjoyed visiting with you at Amherst about the drain down nicad conditioner. Plans are found in *Popular Electronics,* May 1993, page 31. Input is DC. Resistor changes are shown to accommodate 2–8 cells nicad packs. Parts & PC boards are available from Peripheral Products, 813-835-8088.

We're planning to put the generator in our stand alone machine shop on reduced hours. Eventually for backup in a pinch. The new system will have to start and run 3 hp, for sure, and probably 5 hp motors. A 120 VDC battery bank has been suggested. Nicads are my preference. Would stringing 100 reconditioned nicads together run a major risk of having a low capacity cell reduce the capacity of the whole string? Would 5 strings of 20 cells actually give me more battery capacity? Br. John Carr, SJ, St. Francis Mission, Rosebud Reservation, Box 499, St Francis, SD 57572

Well, John, every battery is at the mercy of Kirchhoff's Law. In any series circuit, the current is limited by the highest resistance element in the series string. In the case of series connected cells, the capacity of the resulting battery is limited by the weakest cell. The more cells in series, the more a bad cell will affect the capacity of the resulting battery. This is true of all battery technologies, not just nicads. The success of any battery using 100 series elements will rest on the quality and uniformity of the cells. If you were using brand new cells, then I'd say go for it, but with reconditioned cells, you'd better stick with as few series elements within the battery as possible. This allows you to shuffle the cells into configurations of similar capacity cells. Our battery here at Home Power consists of 150 reconditioned HIP-10 Nife nicad cells. We use ten series cells to get 12 VDC and then parallel 15 of these ten series cell strings. Loss of a single cell causes a loss of 6.6% of the battery's capacity. — Richard Perez

Battery Venting

I recently attended the Midwest Renewable Energy Fair in Amherst, Wisconsin, in particular a workshop on batteries by Robert Wills. He mentioned the necessity of ventilating a battery room, which he said you solved by installing a device which would activate a fan when the battery began gassing at a particular voltage.

I have a similar problem. I was unable and unwilling to install a vertical vent through the roof, but had to settle with a 7 foot horizontal duct pipe. I realize that ventilation of a battery room would be adversely effected by the horizontal run. A voltage activated fan be ideal for my situation. Could you please explain how you did this? Also, is there any danger of the fan igniting the hydrogen? Wolfgang Weiss, RR 3, Perry Sound, Ontario P2A 2W9, Canada

Hi, Wolfgang. Use a sparkless fan. Almost all the DC "muffin" type fans are brushless and sparkless. We use two in our battery room. Use the circuit in Home Power #33, page 80 to switch the fan(s) on at the appropriate voltage. — Richard Perez

Metering

I have read and reread the article on Cruising Equipment's Amp-Hour +2 in HP#26 trying to figure how it would fit into my solar system on my 5th wheel trailer. I am sure just how it works and if it would tell me what I want to know.

I understand, from the article, I probably would use the Amp-Hour +, not the Amp-Hour +2.

My system is composed of four panels (two ARCO M75 and one ARCO M53). My lead-in wires are four #10 stranded wires hooked-up with two on one pair of panels and two on the other. They are hooked-up to a Cave Creek Power Guard charge controller and then four Dynasty 105 Amp-hr deep cycle sealed gel batteries through the four #10 wires twisted together to make one + (pos) and one -(neg) to the batteries. The positive goes on the + (pos) on battery #1 and the negative is hooked to the -(neg) on battery #4.

I have a Heart 1200 W inverter to supply 120 V for the coffee maker, vacuum, sweeper, toaster, and whatever else I might want to use on 120 V.

That basically is my system. I monitor the electric supply by a little Equus digital voltmeter and Amp-Volt meter in the controller. I have looked at those meters many, many times trying to guess how much juice I had left or available. It is my understanding that is four 105 Amp-hr batteries, at full charge have 200+ Amps and 0.75 Volts available. When I add up the amp consumption for a 24 hour period, it comes to nowhere near the 200 Amps available, but that 0.75 Volt will be almost gone, or 12.20 or 12.25 Volts indicated in the batteries. My original supplier (Solar Electric of Cave Creek, Arizona) says I should not pull my batteries below 12.25 Volts.

I am not an electrician and understand only the very basics of electricity. I have not been able to understand how that 0.75 of a volt can carry all those 200 Amps of power.

My big question is would the Amp-Hour meter help me to determine how much of my batteries I have used and how much I have left? Also, the pictures of the meter show the #100, how would it register the 400 plus amps in the four batteries. How long are the wires to connect the meter to the batteries; I would require at least 15 feet one way to connect the meter to the batteries and have it where I could monitor it. One last question, is it simple enough to hook-up, or would I be wise to seek out help from a professional? Lyndon Granat, 3870 G 1/4 Rd, Palisade, CO 81526

Hello, Lyndon. Assessing battery state of charge with a voltmeter is difficult. Your best bet is an ampere-hour meter. Installation is relatively easy and the meter can be physically located up to 30 feet from the battery. If you aren't familiar with wiring, then get some help. — Richard Perez

Car Heaters

Lately, I've seen PV powered car fans to keep cars cool. Do you know of any PV powered car heaters and/or de-frosters? I've got a VW Rabbit. It has always achieved 40–50 mpg, but it's not exactly a sauna during winter. John Nienstaedt, 717 East A St, Iron Mountain, MI 49801

Hello, John. Running a fan is very different from electric heating. The amount of energy involved is at least ten times greater. A car's roof has more than enough space for a PV module large enough to run a fan, and even keep the car's battery at peak charge. Resistance heating of the vehicle would require between 500 and 1000 watts of power and would require a PV array much larger than the roof. Sorry, but look elsewhere to warm up that Rabbit. Try contacting Mike and Shari at Electro Automotive (see ad index). They convert VW Rabbits to electric and are sure to have run into the heater problem before. — Richard Perez

In the Desert

Here in the desert my PV system runs more efficiently in the winter when it is cooler. I have ten old 33 Watt ARCO panels and I believe with the extra hours of sun, and the general brightness, that I get much more power than expected. I have four 6 V deep cycle batteries — tall ones. I run lights, TV, VCR, rock cutting machinery, small kitchen appliances and a Norcold chest refrigerator/freezer of about 2 sq. ft. capacity with two inches of hard foam glued to it. In hot weather I run a 20 watt fan 12 hours a day with a couple of misters clipped on to it to cool an area about 20 degrees which is none too cool when it gets to 115° F to 120°F. In this heat my batteries show on the meter about 14.5 V at day's end and 13.5 V in the morning in summer with the refrigeration keeping ice frozen. In the winter if it is sunny with a nice breeze I have to turn the refrigerator colder to keep the batteries from overcharging. When that happens the inverter won't go on until I run a 900 Watt 12 V blow dryer until the inverter kicks in.

I have to keep things simple since I have to do it all myself and I really don't understand a lot of this very well. I also have to finish building the house. I have a couple of questions. My Norcold is ac/DC but it kept burning out cig plug outlets on the DC so I run it on ac. I guess I could wire the DC cord into the wiring to the battery bank, but the cord is wide and flat and looks like it has 3 wires in it. How do I know which is which and where to put them?

I use a variety of efficient fluorescents. A Phillips PL-5 takes 9 watts and will not turn on the inverter. An Osram Dulux 11 watt with reflector will turn it on but a "Feit" SL18, 18 watt that sells locally for $6 will not turn it on. Why? Is the 11 watt using more start up power?

I have a motion sensor security light in my unfinished bathroom by running the wire out of a vent hole and putting a small PV on the roof. I really like the light coming on automatically when I walk into the room and want to have that feature in the finished house. I have 120 vac wiring but will put in 12 V wiring too. What kind of sensor could I use for this? They have small 120 vac ones that control non-fluorescents for about $20 but I don't want something that would run the inverter all the time. I saw 12 V infrared sensors for security systems at Radio Shack for $60. Is there a better option, and could I run a compact fluorescent off these? I would also like some kind of dim night light to come on in the halls — the best I can think of is a 7 watt 12 V malibu blub since I don't want to use a lot of watts for a dim light. Even the 5 watt Phillips puts off a lot of heat, unwelcome in this weather if left on in a room. Would #10 wire be OK or should it be stranded? Pat Weissleader, Desert Hot Springs, CA

Hi, Pat. Have someone who is experienced with electrical stuff help you wire the Norcold frig. A techie with a meter can identify the polarity and purpose of the wires easily and quickly. Without this knowledge and the instrument, you are flying blind and risk damaging the frig from reverse polarity. These type of refrigerators/freezers draw about 20 Amperes at 12 VDC. It is a rare cigar lighter plug that doesn't melt down at this current level. Hardwire the frig to your load center or DC distribution buss. Use heavy wire, big connectors, and/or solder.

On the compact fluorescents, the problem isn't really startup power. The Osram uses a high frequency switcher ballast that will trigger the inverter out of sleep mode. The other two fluorescents use magnetic coil/capacitor ballasts that will not wake up the inverter. In my experience, the Osram is actually more efficient than the other two and an all around better light.

I seriously suggest that you operate your home exclusively via 120 vac. I have wired many homes for 12 VDC including my own. Most of these systems now only use DC to power the frig and radio gear (RT and such like). Inverters are now very efficient at very low wattage levels. Consider the efficiency of a PowerStar UPG1300 is greater than 97% at less than 20 watts output. Wiring is much easier, cheaper, and passes inspection quickly at 120 vac. In my experience every home eventually collects one appliance that will keep the inverter running all night. The money you save on specialized appliances (like the motion sensor) will pay for an efficient all-night inverter.

With regards to wire, the length of the circuit is a critical factor for specifying wire gauge. Without the amount of wire in the circuit, it is impossible to spec the gauge. Whether it is stranded or solid makes no difference to the gauge size.— Richard Perez

Re-wire?

I just purchased a "monster module" of ARCO M52 Laminates. I wired the modules per your diagram in HP#27 — four sets of four — series-parallel but, my open circuit voltage/short circuit current at noon in July (in central California) is 25 Volts, 22 Amps. Am I wasting my power if it goes into a 12 Volt SCI charger (30 Amp max)? Should I re-wire the panels to get 18 Volts at higher amperage, say five panels in parallel, three sets in series (one panel left over out of 16)?

I plan on adding a wind generator of about 600–100 Watts next year. I also have four ARCO 36 cell (round) panels and four more of the ARCO M51 Laminates (not framed yet). Please advise me on the best set-up for my panels. What would be the best type of controller for a 12 Volt battery system to utilize the power of the panels that I have.

P.S. My M52 Lams are Bronze blems but they seem to put out much more than advertised (5 Amps, 6 Volts, short circuit current/open circuit). J Williams Oliver, 14701 Grizzley Hill Rd, Nevada City, CA 95959

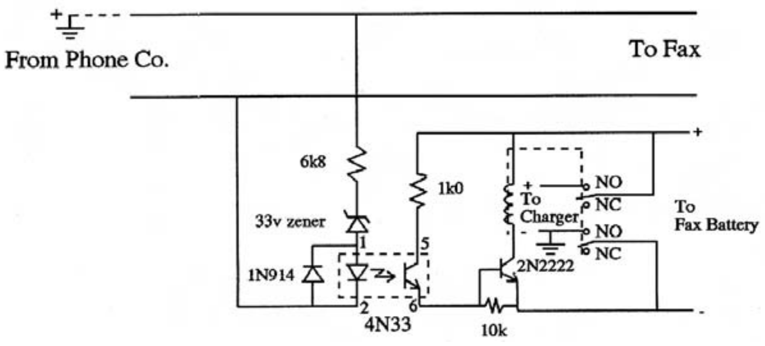
Hello J. Stick with four M52s in a series string. Open circuit voltage and short circuit current are very different from voltage and current at the module's maximum power point. Check out the hot weather PV tests in HP#24. Three M52s in series will barely be able to 25% recharge a 12 volt battery on a hot day. Your array should easily be within spec for your charge controller. If you suspect that the controller is a bottleneck, then measure the voltage drop across the control when it is passing full current. If the control uses a relay for final switching, then the voltage drop should be less than 0.2 VDC. If the control uses a transistor and series diode, then the voltage drop should be about 0.75 to 1.2 VDC. More voltage loss than this across the controller, and something has gone south.

I would assemble all the modules into a 12 VDC nominal array. The modules are too dissimilar to use as a high voltage array with LCB downconversion. Use four Lams in a series string and wire everything else in parallel. I'd recommend a PWM type charge controller. We've been hearing much good feedback from owners of the recycled modules. Seems like the utilities should have hung on to them…. — Richard Perez

Fax Fix

I was reading HP #35 Q & A when I came across your reply to Ludo van Helsding about the earth loop problem on Fax machines. I am a Datacomm Engineer and was very surprised to hear that the line is earthed inside the Fax. Modem manufacturers go to some trouble to ensure complete isolation between line and equipment, i.e., line transformers, relays and opto-isolators.

There are several options to solve this problem, 1) as you suggested, a separate unearthed power supply. 2) disconnect the link between the phone line and the equipment earth. This may sound drastic but it is how every modem I have ever seen is wired, including U.S. built modems. This assumes that the Fax uses the transformer etc. listed above and that the earth link is not required for the Fax to operate. On the machine I looked at, there was a place where a jumper could be installed which would connect the B leg to the mains earth. The jumper was, of course, not installed. This



would be my first choice. 3) use a Line Isolation Unit, usually used when connecting unapproved equipment to a phone line. This should float the line from the phone company. The LIU regenerates the DC from the line for the Fax and the ring current. Unfortunately these are usually mains powered which won't help Ludo. 4) use the circuit shown to right.

This circuit requires that the grounded leg (the "B" leg) of the phone line is connected to the grounded input of the Fax machine and that there is no difference in voltage between the two. There was no difference between them at my home where the circuit was tested. But there was a 1.5 volt difference on our company PABX which stopped the ring signal which will, of course, stop the Fax answering and the line voltage dropping to trigger the circuit. The circuit will also operate when a phone or other device on the line goes off hook. This is necessary, as the requirement here is to keep the line isolated from ground whenever the line is in use.

The circuit monitors the voltage on the phone line. When the Phone/Fax is On-Hook the 50 V flows through the 6.8 kΩ current resistor, the 33 V zener diode into the opto-isolator, this switches on the photo transistor switching the external transistor which energizes the relay connecting the Fax battery to its charging source, e.g., a grounded battery pack. The relay must switch both leads to the battery to float it and must be heavy enough to handle the charging current.

When the Fax goes Off-Hook the voltage on the line drops to much less than that required to make the zener diode conduct, this switches off the relay which floats the Fax battery from the rest of the pack allowing the Fax to work normally. When the Fax goes back on-hook the voltage goes back to 50V and the relay is re-energised recharging the battery. Note, the relay draws current only when the charging source is present, so doesn't load the Fax battery while the Fax is in use.

The circuit could be modified by moving the base of the 2N2222 to pin 5 of the optocoupler (the collector) and changing the values of the resistors and reversing the connections on the relay. This would mean the Fax battery would power the relay and by adjusting the resistor values the relay would drop out automatically when the Fax battery voltage got too low. If this happened while the Fax was in use the data being sent/received would be corrupted from the line until the battery was recharged.

There are several deficiencies in this circuit, 1) It requires ensuring the polarity of the line and the Fax are correct and also the monitor circuit (the last could be overcome by passing the voltage through a bridge rectifier before going to the rest of the circuit.) 2) It puts a continuous load on the phone line, but only about 2 mA with the 6.8 kΩ resistor. 3) Theoretically any circuit connected to a phone line should be approved by the appropriate authorities. As long as the connections to the opto-isolator are kept as far apart as possible (i.e., keep pins 1 & 2 away from 5 & 6) the isolator will retain its 3500 V isolation. The idea here was to make the circuit as simple as possible. I hope that all this babble hasn't masked this. This circuit could also be used to switch on a light when answering the phone at night.

I have sketched a more complicated circuit which should work if this circuit doesn't. Simply, it floats the battery as soon as it sees ring circuit and then holds the relay until it sees the line voltage go back to 50 V. It has not been tested and may need some modification to work correctly. I hope the simple circuit will work in the majority of cases. I have also designed and built modems which use the current from the line to power the modem. They generally draw less current from the line and equipment, but that's another story.

Now to change the subject completely, can you give me an address for Advanced DC Motors as used by Michael Hackleman in his Honda Civic. Also, on Beyond 2000 sometime ago I saw a piece on a group in the U.S. building houses using old car tires filled with earth and straw. This concept appealed to me, have you heard of the method, maybe readers are aware of it? I am interested in feedback. I guess that's enough for now, I hope the circuit is of use to you, and other readers, it will be cheaper than another PV panel. Justin Southam,17a Pimlico Pl., Newlands, Wellington 6004, New Zealand

Hi, Justin. See page 69 this issue for Advanced DC's address. Try Michael Reynolds of Solar Survival Architecture, POB 1041, Taos, NM 87571 • 505-758-9870 — Therese

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HYDRO POWER PLANT Trace Inverter 2624 SB Burkhardt Turbine 4 Nozzle #12 — 6 Volt Batteries 24 Volt operation plus acc. Total System $4000 or OBO T. Mason Box 491 Arcata CA 95521

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POWER2GO DC-AC INVERTER Ideal Emergency Power Source. 140w Continuous 200w 2min 400w Peak ONLY $84.95 1yr Warranty C.O.D., M.O. Free Shipping in U.S. SASE for Info A.C.S. POB 42161-H Phoenix, AZ 85080; 24hr Phone/Fax 602-780-4717

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BATTERIES: 2 Volt 200 A.H. at 8 Hr Rate $45.00 ea + S.H.; 2 Volt 3300 A.H. at 8 Hr Rate $300.00 ea + S.H.; 2 Volt 1450 A.H. Gell Cell 200 ea + S & H Cell Energy Inc. 1-800-321-0714

PRECISION ELECTROMECHANICAL ENGINEERING — Call Charlie Bright at 206/ 630-8580 For Help with your hardware.

FOR SALE: FOUR ARCO ASI 16-2000 solar panels, 33 watts, 12" X 48" each panel, set of 4 — $630.00 + freight. Call Don Levonian at (703) 966-1545 7-4 pm or (703) 992-4710 After 5 pm.

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I WOULD APPRECIATE HEARING from people with Bowli or other non-electric composting toilets. Do they work well? Thanks. Charles McAlister, Box 64, Hasty, AR 72640

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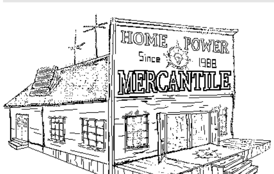

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