HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #48

August / September 1995

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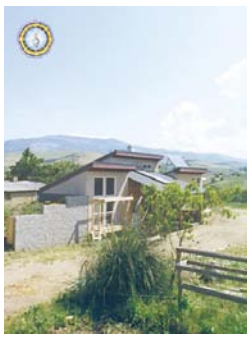
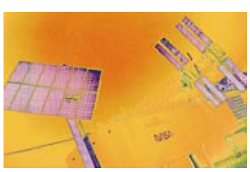
Features





Fundamentals

GoPower

Homebrew

Cover: Risa Buck's home in Ashland, Oregon and it's solar-powered and off-grid. Photo by Richard Perez

Things that Work!

Columns

Regulars

Access and Info

Access Data

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Recycled Paper

Recyclable Paper

Cartoon by Harry Martin, colorized by Richard Perez

When Godzilla is done wrecking havoc on the grid, you can be sure he goes home to a renewable energy system at night.

Ever since he flamed the powerlines feeding his home in 1955, Gozilla has enjoyed reliable, clean renewable sources of energy.

If a large prehistoric lizard can figure it out, then what's our excuse for clinging to out-dated power sources? Mother Nature is alot like Godzilla—reliable, and direct. So next time the grid goes out at your house, remember that Godzilla is probably watching it all go down on his solar-powered TV.

Richard Perez and Harry Martin for the Home Power Crew

People

Clare Bell
Risa Buck
Sam Coleman
Jerome Cordeiro
Michael Hackleman
Kathleen Jarschke-Schultze
Stan Krute
Don Loweburg
Kelly Madding
Bob Maynard
Harry Martin
Steve McCrea
Ruth McDougall
Kurt Nelson
Karen Perez
Richard Perez
Shari Prange
Bob-O Schultze
Jerry Solobay
Peter Talbot
Larry Weingarten
Suzanne Weingarten
Michael Welch
Mark Whitaker
John Wiles
Donna Worden

" Think about it…"

"Most of the shadows of this life are caused by standing in one's own sunshine."

—Ralph Waldo Emerson

energy depot
four color
full page
on film

NOTE: STRIPOUT
THE SAN DIEGO ADDRESS!

this is page 5

Above: Risa Buck's home is solared-powered and off of the grid in downtown Ashland, Oregon.

Just Say No!

Risa Buck

I am blessed by being able to live on a small parcel of land that can accommodate an accessory structure addition and the good fortune to have secured a loan to make my dream come true.

Changing Values

Developing the way I wanted to live took a more sustainable direction during my six years in Davis, California, where I lived in a 5-person vegetarian cooperative. Our front and back yards utilized many permaculture concepts: composting, the use of drought-tolerant native plants, diversity in vegetables, flowers, and seed collecting from our organic garden.

But it was my relationships with the people I lived with and those in my community that exposed me to a link I was unaware was missing. I lacked knowledge of the connection of me, the human, to my impact upon my surroundings.

Once upon a time, I believed organic farming was a marketing ploy. It had never occurred to me that the "conventional agricultural industry" was poisoning much more than the food I ate. I had never been exposed to information that enabled me, nor was I on my own able, to connect the dots.

My awakening began with the pleasures and necessity of eating. It then traveled full circle to affect every aspect of living. What I consume, where it comes from, how it was created, what the *costs* are (human, environmental, economical, political, and spiritual), are factors that matter to me. It is not always practical to honor these ideals. Money and time are unfortunately important considerations. No one ever said that the road to conscientious consuming would be easy.

So, all kinds of new, incredible information and understanding has come to me and been integrated over the years. Talking to people, attending the Ecological Farming Conference for some years, volunteering for the Committee for Sustainable Agriculture and the California Action Network, and a little bit of reading helped shape my idea of what a dream home might look like if one took an ecological approach to building a home.

I built my house the way I did because it expresses (in part) the way I want to be in the world. The amount I impact my environment/community matters. Building my house the way I did took my convictions and materialized them into a 3 dimensional form that I can share with others. Taking to heart what I have learned in the last ten years made it impossible for me to build a house any other way.

Obstacles

There were numerous obstacles that were overcome: all the usual financial frustrations most home builders encounter and then there were more.... When I began this project, my greatest asset was enthusiasm. Perseverance saw me through my second tri-mester. And I think endorphins carried me to the finish line at the end of the ninth month when I got my C of O (Certificate of Occupancy).

Part of my point here is that I did not come into this project with an extensive background in carpentry, architecture or technical knowledge about alternative technology. I even lacked a basic understanding of how a conventional home is constructed and operates. Well, those days of blissful ignorance are gone. The more I learned, the more I wanted to do things efficiently and sustainably. Finding reliable resources (in written and human form) presented a major challenge. After some detours and poor choices, I found, with delight, that Southern Oregon has seasoned professionals (see Access at the end of this article).

I knew that there were many homes in Southern Oregon that had incorporated solar power in varying degrees, but the City of Ashland had never officially granted occupancy to a home that chose not to hook up at all to the electrical grid. When I submitted my plans to the City of Ashland, they included a passive solar designed home with photovoltaic modules for electricity, Copper Cricket (solar heat exchanger for hot water), north-facing cinder block wall bermed for mass (keep it cool in summer, retain heat in winter), and a masonry stove. There didn't appear to be any problems with the plans, and a number of people who work for the city were encouraging.

A major obstacle loomed when the chief building inspector informed me that the Oregon Building Statutes dictated that I hook up to the city's electrical grid. At one point, I had resigned my ideal and figured I would just do both, hook up to the grid and equip my house with sufficient off-grid capacity. After some more thinking, I insisted that I be provided, in written form (a photocopy), with the building code that dictated mandatory electrical hook-up within city limits. I also asked for the chief building inspector's interpretation of that code. I said that having that information in writing would help me understand and accept his decision.

Time went on ... and I continued to repeat my request. Time was running out.

In the middle of all this, the inspector requested that I provide him a list of the PV equipment I had purchased plus a diagram of how the system would be installed. Much to my dismay, I learned AFTER purchasing all the PV equipment that it ALL must be UL listed (approved by Underwriters Laboratory or other sanctioned testing lab to UL specifications). The only acceptable purchase was my batteries. So, I began the process all over again. OUCH!

The second time around, I made certain I asked every possible question. In retrospect, I see I had made an incorrect assumption. I thought that my regular communication with the city would have revealed any small print that my inexperience would have been unaware of.

WHEW!

Well, I was just about down to the wire (no pun intended), and I got a call from the chief building inspector informing me that my perseverance had paid

Below: Risa and her dog, Ahlyo, on the roof with the seven PV modules that provide their home with electricity.

off and I would indeed be able to be totally off the grid. A big sigh of relief and a major hooray resounded throughout the Rogue Valley.

The Best Picture

Perhaps living totally off the grid is not practical or feasible for the average household. The ultimate system, it seems, would be to hook up to the grid and have other renewable energy source(s), without batteries and install a two-way meter. When the sun is shining or the wind is blowing, the meter would run backwards and the home would be credited for the renewable energy it produces. When clean renewable energy is not available, the meter would run forward and the home would be billed by the utility as usual.

There are two reasons I did not choose the utility intertied scenario. Number 1: two-way metering is not yet available in my area. Number 2: I felt that getting the city to approve a totally off-the-grid house for the first time would do more for the movement toward clean renewable energy sources. Being off of the grid would stretch the City of Ashland's continuum of acceptance and general awareness in alternative housing and development.

Plans for the Future

A major personal and community hurdle was cleared when the City of Ashland approved my home for occupancy. The coming seasons will be a time to adjust to the technology in place. It is already apparent that my water heating system needs a supplemental source during sunless periods in the weather. This possibility was anticipated and propane is accessible to the water tank. The Myson "tankless hot water heater" will be the likely choice.

Once I get a computer, I may need a small wind generator to keep the batteries charged during low seasonal sun shining times. This site is conducive to generating electricity from the wind, particularly during the winter months. The wind tends to blow when the sun does not shine.

In the not-too-distant future, I hope to install a composting toilet and be able to hear, simultaneously, the applause from the City for my greywater system!

I planted seven fruit trees, plus kiwi, grape and berries, that will, in time, be part of a lush, tasty and sustainable landscape.

In the fall, Tom Ward and I will be organizing a workshop to build a 3,000 gallon ferro-cement tank to collect roof rainwater for irrigation. If you are interested in attending, please call (503) 482-6164 to reserve a spot. I anticipate an ongoing relationship with the City of Ashland to help promote sustainable development, education on alternative energy, and to develop incentives for people wanting to retrofit existing homes as renters or homeowners and for eco-sensitive new development. I intend to create a slide show and booklet of some sort to equip individuals on "How to Build a Sustainable House in an Urban Setting." If you are aware of any grants or funding to support these projects, please contact me c/o HOME POWER or at my phone number listed above. In the near future, I hope to have an e-mail address.

I look forward to the day when my home blends into a landscape of rooftops functionally decorated with solar panels and wind generators, working together with local utility companies. This has been an incredible process that is possible, IF you can imagine, and then believe, that it could be so.

Risa Buck's RE System Costs

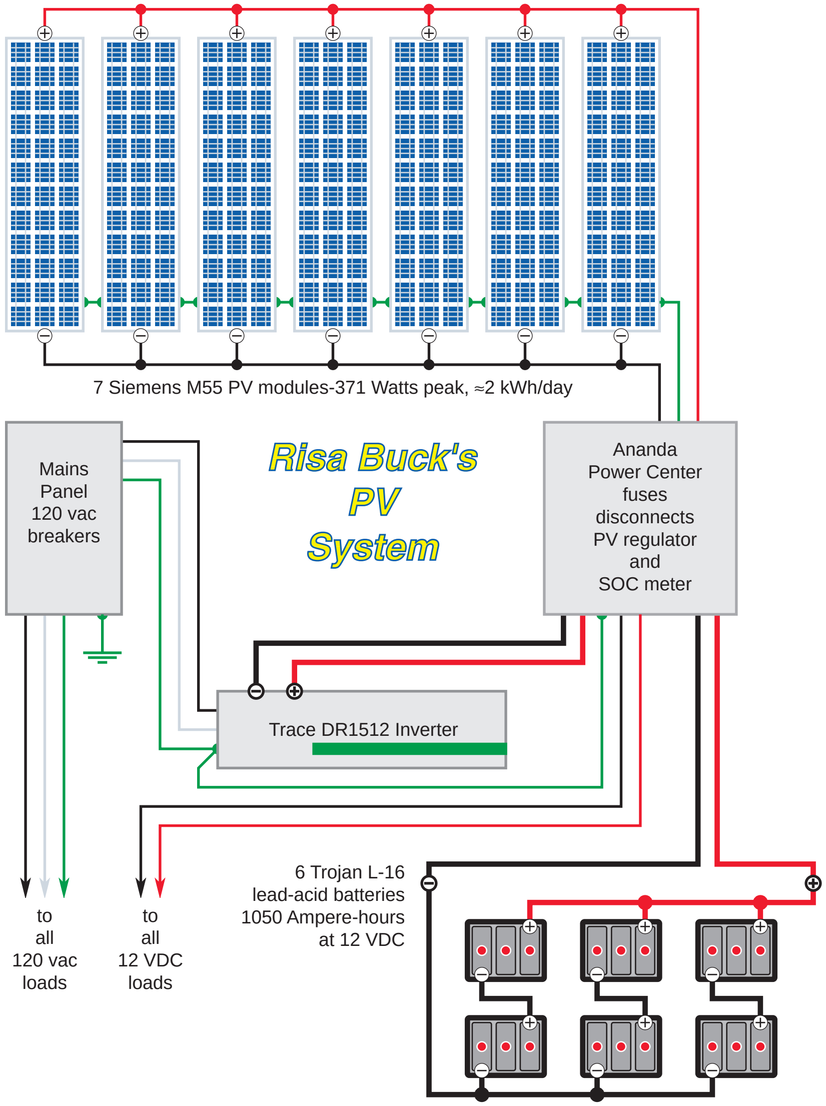
No.	*Item Description*	*Item Cost*	*%*
7	Siemens M55 PV modules	$2,303	40%
1	Ananda Power Center	$1,385	24%
1	Trace DR1512 inverter	$849	15%
6	Used Interstate I-16 batteries	$700	12%
1	Rack for PV modules	$200	3%
1	TriMetric meter	$169	3%
1	DuraPulse battery conditioner	$169	3%
	total	$5,775	

Other Non-electrical Stuff

Masonry stove	$6,100	48%
Copper Cricket solar DHW	$2,600	20%
Battery/Inverter shed	$2,600	20%
Danby propane frig/freezer	$1,049	8%
Peerless propane cook stove	$359	3%
total	$12,708	

Above: Risa' house viewed from the southeast.

Above: the back of the PV array showing the wiring and mounting rack.



Above: the power shed

Above: the inverter and safety stuff

Above: the batteries in tubs

Above: the DuraPulse conditioner

Above: Jerome installed the system

Designing Risa Buck's PV System

Bob Maynard, Energy Outfitters

Risa and I began discussing her new home and power system long after construction had begun. She told me she had already purchased some used equipment, including a Trace 2012 inverter, six L-16 batteries, and an SCI controller and monitor. In addition, solar panels had been purchased via mail order. At this point in the project, no one had done a comprehensive load profile or system design to meet Code requirements. We sat down and went to work!

Risa's load profile showed that the components already acquired weren't too far off from meeting her needs, but due to Electrical Code requirements, UL Listing (or equivalent) was needed on the system components. The older inverter, controller and monitor did not meet this requirement, nor did the new PV modules.

I sized her stand-alone system based on my knowledge of a typical Ashland, Oregon winter. With no backup electrical source, this was a necessity. Risa's efficient lifestyle allowed me to do this without creating an unrealistic (and unaffordable!) system.

After choosing the components required to fulfill Risa's needs, as well as the inspector's, her used equipment was sold; her new PV panels were returned to the mail order source and they exchanged them (with extra cost) for Siemens M-55s.

Fortunately, appliances for the home had not been purchased yet. We chose a 24" pilot-less Peerless Premier LP range and a Danby LP refrigerator with carbon monoxide alarm. This being an airtight, new home, coupled with the fact that gas refrigerators are not vented to the outside, reflects the importance of CO protection. A 12 Volt DC ceiling fan was chosen for its low watt-hour consumption compared to conventional 120 vac fans.

My last concern was the six used batteries. Their history was unknown as to age and previous use (or abuse). We decided to use them, with the knowledge that we might have to re-evaluate them after the system was put into service. Mainline Electric's new pulse device is being used, and to date, the batteries are performing well.

My message to all new, potential users of a renewable energy system is this—before you start buying components, retain the services of a qualified system designer. Check their references, then provide them with quality information so a properly sized and designed system will result.

Installing Risa Buck's System

Jerome Cordeiro, Mainline Electric

The primary concern when wiring to satisfy local electrical inspectors is safety. As an electrical contractor, I find it most amazing that many equipment manufacturers in the solar industry have little concern for system integrity and safety. In the state of Oregon, all electrical equipment must be UL approved or approved by the State electrical inspectors office. There are some exceptions.

Whenever electrical inspectors see exposed wiring, rubber cord, romex, or electrical fittings used improperly or even plumbing fittings used in an electrical installation, they know they should try to be tactful in their explanation, or simply red tag the installation and walk away.

Exposed wiring below eight feet is usually not allowed. It should at least be protected by a wooden barrier, sheetrock, conduit, etc. Rubber cord is only allowed with portable equipment, or temporary installations. If you plan on packing your inverter from building to building or plan on leaving soon, your inspector may insist on permanent wiring. Permanent wiring means conduit or flex over conductors for all exposed wiring. To make conduit wiring possible, inverter manufacturers should always include a termination box as standard equipment. Charge controllers should have a wiring area large enough to connect conduit and be UL approved. Solar panel junction boxes should be large enough to allow at least two 7/8" knock outs for standard 1/2" flex fittings. It is difficult to find a single strand wire able to withstand UV rays and be durable for years. I use #10 XHHW wire, but I would prefer to run the solar panel wiring in inexpensive liquid tight flexible nonmetallic conduit, generically speaking, plastic flex.

For the inspector, I installed plastic flex over the solar panel wires and cut a small hole at the bottom of the flex loops to drain any moisture since I could not install connectors in the junction box. I could not buy a wiring junction box for the Trace inverter, so I had one fabricated. In most installations, I find it best to use a 4" x 4" or 6" x 6" wireway for interconnect wiring. It makes the installation neat and most of all, accessible for future changes. It is also very simple, saving installation time. All conduit runs are short conduit nipples from the equipment straight into the wireway. Large battery cables run easily from the batteries straight to the disconnect, then passes easily to the inverter junction box.

Since the batteries in this installation were used, the voltages varied after being charged. Specific gravity was between 1.200 to 1.245. I installed the DuraPulse unit, and after three weeks all cell voltages were within .1 Volt and the specific gravity returned to 1.270 in all cells.

When installing a system be sure you label all breakers and disconnects. Protect your wire with the proper fuses or circuit breakers. Grounding is important for lightning protection and safety. A good practice is to oversize rather than undersize low voltage wiring and use the proper termination methods because we do not want to loose that expensive PV power.

All the inspectors that I know are pretty decent people. They will remind you that their job is not to teach you how to wire, but they will usually give you good hints if you smile and are nice to them.

Above: Risa's living room.

Above: While Ahlyo lives in a solar-powered home, what he really appreciates is chilling out in his very own wading pool.

Above & below: Risa's kitchen

Above: Risa's bedroom

Above: the earthbermed north wall

Above: the mansonry heater.

Above: the hot water tank with solar loop.

The City of Ashland's Point of View

Kelly Madding
City of Ashland Associate Planner

The City of Ashland, Oregon, issues many certificates of occupancy (a statement that all inspections have been completed and the home can be occupied) a year. Yet the certificate of occupancy issued to Risa Buck on March 17, 1995 was cause for celebration. She had accomplished a feat never before performed in Ashland, she had built a house that derived its electricity from the sun, instead of the grid. Her unique house and the sometimes rigorous building permit process was finished.

When she walked through the door with her project we here at the City jumped on a steep learning elevator. The three main points of the learning curve come to mind:

1) We realized that, and this may be a gross generalization considering only one person has accomplished this within the City limits, the people interested in building this way are "hands-on" kind of people. Risa wanted to be there through every step of the process. And as it turned out her tenacity was necessary; necessary when her first electrician did not promote her wishes and she had to step into the process herself and necessary to keep asking the right questions until she got answers. And finally she heard the answer she'd been waiting for "Yes, you can build your house off of the grid." This answer came only after she provided the necessary information to our building department, an interpretation from the State of Oregon Chief Electrical Inspector, and that interpretation was affirmed by the City's Building Official.

It must be noted that building departments are typically very busy and ours is no different. The building department has to balance individual needs with the needs of the many. Permits still need to be reviewed and inspections need to be performed daily. The building department is best suited to approve plans created by licensed professionals. Because it is unlikely that the building departments' load will get lighter, the building official has this advice, "find the licensed professional you are most comfortable with and work closely with them."

2) The City learned that we don't have any information, in a handout format, that we can give to people who are interested in pursuing this path.

3) We learned that this project has had the effect of a small stone being tossed into a pool of water, it has had a rippling effect. The ripples have gone out to the City's Administration, Conservation, Planning, and Electric Departments. All those connected with the project, except the building department, felt the waves.

And all of those not directly connected to the building department learned some things as well. We learned that our building codes are derived from local, state, and federal law. They require energy equipment to be listed and labeled from an approved testing agency. One of the most common listing agencies for electrical equipment is Underwriter's Laboratory (UL). However there are other approved testing companies and checking with your local building official will let you know who and where they are. Also if the structure you are building is of a residential nature (a house) your equipment needs to be listed and labeled for residential use—commercial use is not acceptable. We learned that the Building Official can interpret codes. For example the codes are written with the assumption that houses connect to the grid yet the code does not specifically say that a home is required to be connected. The Building Official was able to make the determination that the house needed to be electrically designed as if it were going to be connected to the grid. So Risa has electric outlets all over her house prepared to emit electricity from the grid but emitting it from the sun instead.

Again I would like to emphasize that this has been a learning experience for the City. Our goal now is to make sure the next person who walks through the door with the desire to build or retrofit a home using alternative energy will be greeted with a warm handshake and informational handouts. In addition the City is sponsoring a solar workshop on July 29, 1995 from 9:00 am to 12:00 pm in the City Council Chambers. For more information contact Dick Wanderscheid at 503-488-5306. The Conservation Manager has also initiated discussions with the Electric Department to determine the feasibility of allowing reverse metering. The Electric Department is listening which is fabulous considering that the City of Ashland sells electricity to its residents.

Finally, I would like to thank Risa for her tenacity and humor through the City's process. As anyone who has paved the way knows, the road can be initially rocky. Hopefully the next person that walks down this path will have an easier journey. We at the City of Ashland hope to make the road as smooth as possible as we all continue on the alternative energy learning path.

Editorial Comments on Risa Buck's System

Richard Perez

Our coverage of Risa Buck's system is different from any system saga we have ever published in Home Power. Usually system articles are written by a single person—the same person that designed, installed, and uses the RE system. Here we have four different people writing their particular perspectives on Risa's system.

First, Risa herself describes why she decided to go off grid inside the City of Ashland, Oregon. Risa has a dream of how a house should be built and powered. Her home reflects her concern for our planet and everything living on it. She dreamed the dream and then carried it into reality.

Second, Bob Maynard of Energy Outfitters describes the design process involved with Risa's system. He knows the importance of UL listed components in "downtown" systems. If your dream system is going to be given electrical inspection, then be sure that all the components are acceptable to the local building codes before buying them.

Third, Jerome Cordeiro of Mainline Electric stresses installing the proper components in the proper fashion—downtown systems must pass NEC wiring standards. Jerome is an electrical contractor and regularly deals with inspectors. His comments are invaluable for anyone who needs to meet the NEC and have their RE system pass electrical inspection. Be advised different locations interpret the NEC differently. Check the codes in your area before beginning the system's design.

And finally, Kelley Madding describes the learning process involved for the City of Ashland. No one had ever wanted to go off grid in Ashland before. Her comments show that responsive local governments and utilities can peacefully coexist with user-owned, renewable energy systems.

During the last ten years, small scale RE systems have captured the off-of-the-grid market. Few consider using an engine generator as a prime power source anymore. Instead photovoltaics, wind generators, and microhydros provide cost effective electricity from renewable and natural sources. In the particular case of Risa Buck, she said, "No" to the local utility and went off gird. While the unincorporated areas around Ashland, Oregon abound with many off grid RE systems, no one had ever refused Ashland's municipal utility before.

Small scale RE systems are now being installed on grid—the next frontier is utility intertied systems. The hardware used is the same, the intent is the same, but the problems faced are different. Here the problems are legal, sociological, and political. Many small cities, such as Ashland, have municipal utilities. The majority of these small municipal utilities don't actually generate any electricity. Instead they buy power from larger utilities who make it using nonrenewable and polluting energy sources such as coal, natural gas, and nuclear. The same is true of most rural electric coops. These small utilities should welcome independent RE input to their grid. Questions such are NEC compliance, billing rates for the RE power placed on grid, and liability/insurance are paramount.

It's pioneers like Risa, Bob, Jerome, and Kelly who are putting renewable energy in places where it has never been before. Risa's system is a concert played by a quartet of electrical wizards. Four folks, each with their own specialty, working together to make Risa's dream come true.

Access

Risa Buck, c/o Home Power, PO Box 520, Ashland, OR 97520 • or via phone direct at 503-482-6164

I would like to thank the following professionals for their help on my solar home.

Jerome Cordeiro of Mainline Electric (503-770-0220) did the code-approved PV system installation.

Tim & Geoff Dawson of Solar Collection, Inc. (503-535-5364) installed the Copper Cricket solar hot water system.

Dennis De Bey of Ashland Forge (503-482-9568) built the custom PV rack.

Very special thanks to Les Langmeyer (503-482-3512) was my architect and building designer.

Bob & Golda Maynard of Energy Outfitters (1-800-GO-SOLAR) designed the photovoltaic system.

Jamie Paiken of Firestone Masonry (503-482-4379) installed the masonry heater, the foundation, and the cider wall.

Greg Sprague (503-482-8189) was my plumbing contractor.

Joe Tobiasson of Tobiasson Excavation (503-482-7554) did the earth moving for the home's berms and foundation.

Extra special thanks to Scott Vasak of Vasak Construction (503-858-3845 • Pager: 503-858-3845 • 503-865-4318) was my general contractor.

Dick Wandershceid, City of Ashland, • 503-488-5306

Tom Ward, Permaculture Designer & Wildcrafter • 503-488-3198

PHOTOCOMM

full page bled top, bottom, right
8.25 wide
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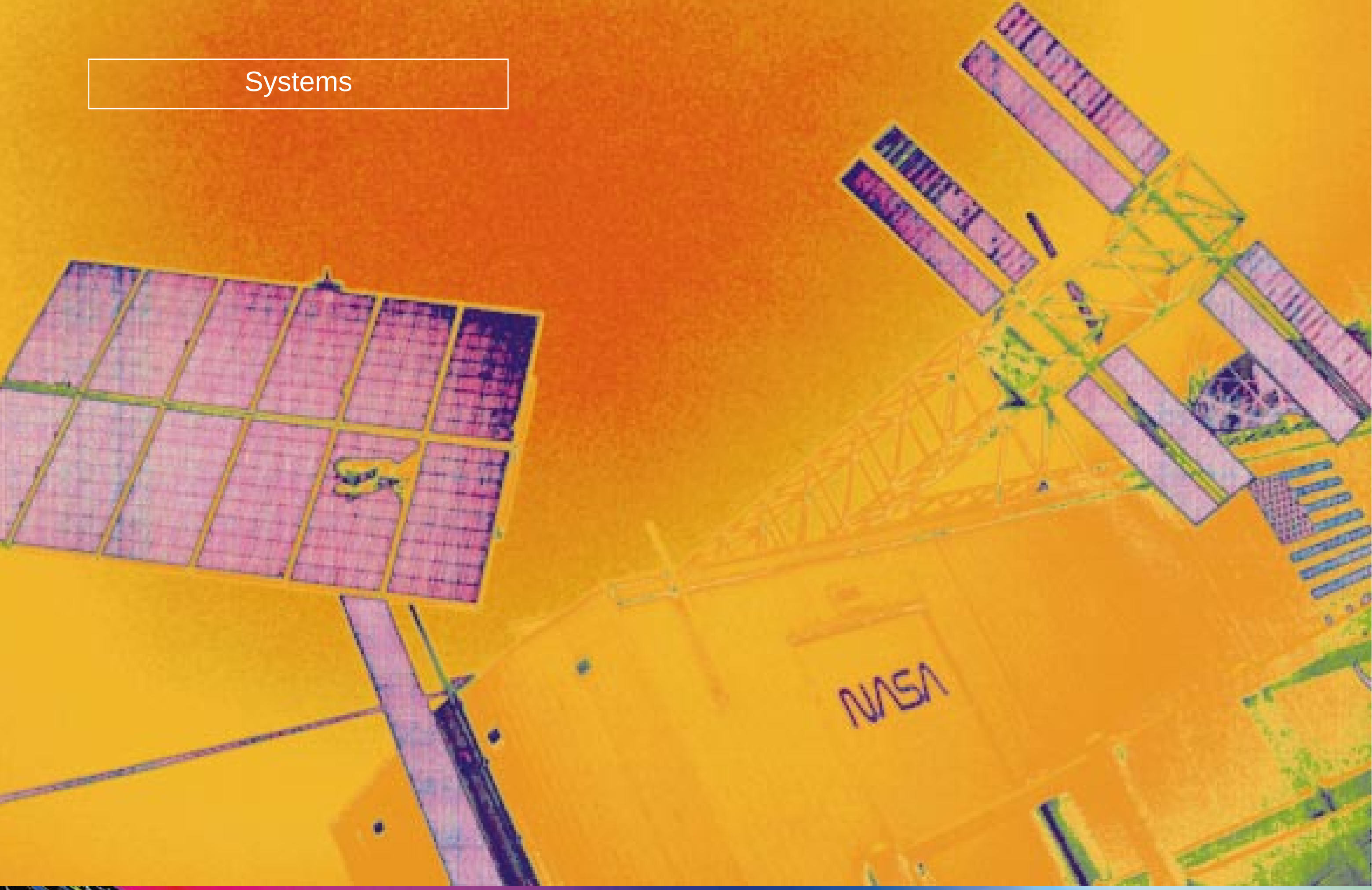
four color on negative

This is page 15



Space Station Quest

Kurt Nelson

Two years ago, I was contacted by Sharon Ryan of the Wausau School District, Wausau, Wisconsin. Sharon is project director of Dream Flight Wausau, a school program developed to increase student interest (and test scores) in math and the sciences. The first phase of their program had recently been completed—the conversion of an old school bus into a space shuttle look-alike, complete with 'rocket engines' that blast clouds of CO_2 during 'lift-offs.' The bus was a great mobile classroom and really sparked student interest. A small building adjacent to the Rib Mountain Elementary School was turned into a Space Sciences Center and Mission Control. The program was so successful that they wanted to add Space Station Quest, a mock space station made out of a 10 ft. by 60 ft. mobile home.

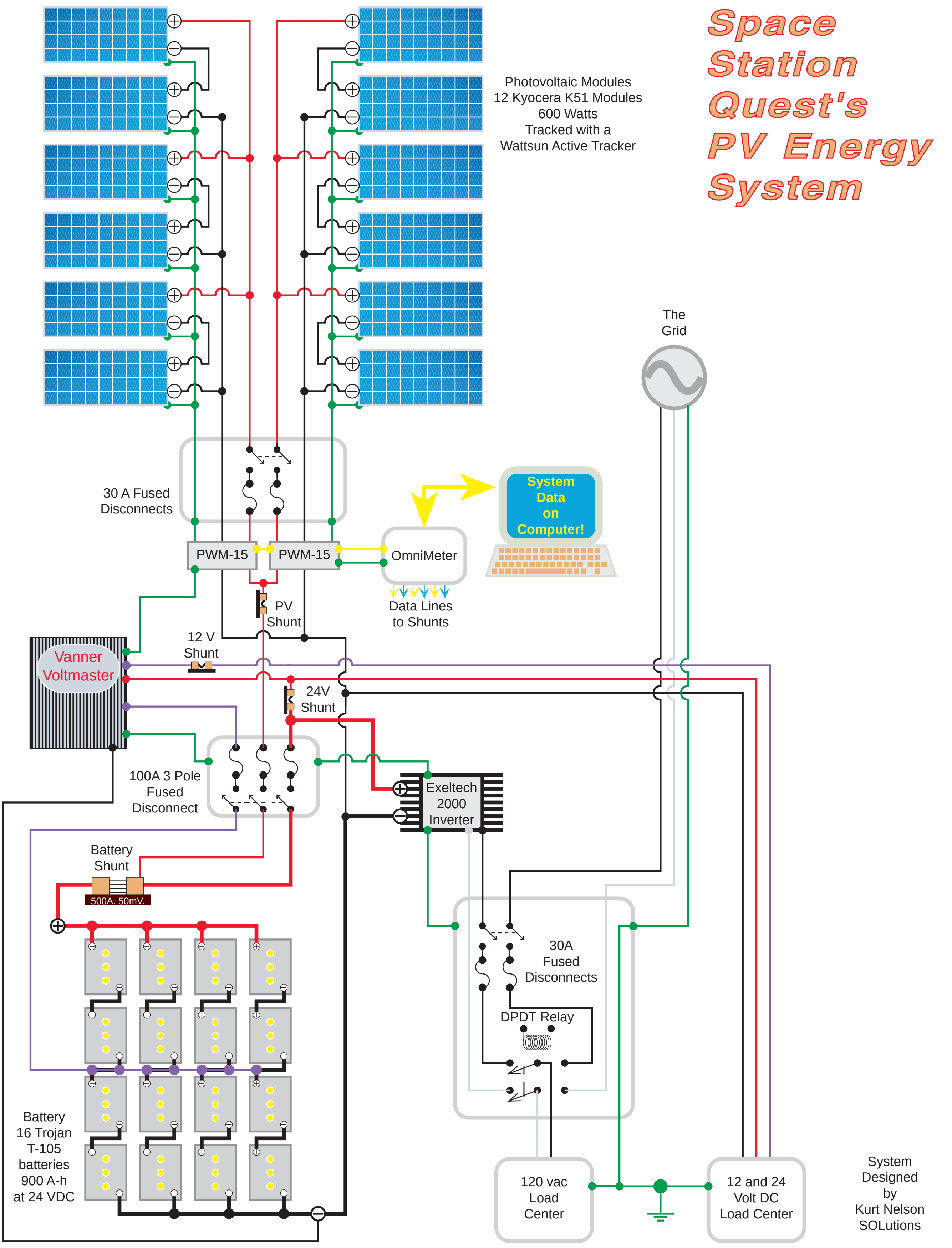
Sharon called me because they wanted Quest to be solar-powered, and she had heard that I had worked on the Midwest Renewable Energy Association's model home project. It seemed like a great idea to me—after all, it was NASA that did a lot of the early development of photovoltaics. Actually, the school district had already started on the project and they had mounted a fake PV array on the shell of the space station. I wanted to see *real* photovoltaics on the space station as much as they did and agreed to donate my time to the project. I also said that I would contact my suppliers for equipment donations or 'at cost' deals. Sharon told me that they had approximately eight thousand dollars budgeted for the PV system and I wanted to see that money go a long way. After doing some load profile work, and based on their budget, I decided to design a PV/utility hybrid system. It was a fun system to design, as the main function of the system was education!

The whole space station is one incredible educational experience. One computer is dedicated to an OmniMeter which monitors the solar electric system. A second computer has up to eight Personal Science Laboratory programs running and is a CD ROM resource link. There are twelve other study stations along the interior of Quest at which students study such things as the effects of gravity on fluids, spectrum analysis, molecular studies, optics and light refraction, and chemistry. There is even a hydroponic garden and a small robotic arm! Students also train for the program prior to coming on board. Their preparation can include a complete physical exam, weightlessness training in a swimming pool, some flight time in small aircraft, and communications training on radio equipment. Last year, students actually made radio contact with a Cosmonaut who was in orbit 250 miles above them.

The PV System

The system consists of twelve Kyocera 51 watt photovoltaic modules mounted on a dual-axis Wattsun tracker. The array is divided into two, six-panel arrays, as I wanted to utilize Pulse Width Modulated (PWM) technology in the charge controller and have a charge divert option. At that time, Sun Selector, maker of the OmniMeter, only manufactured a 15 Ampere PWM charge controller that had a divert option. They have since added larger PWM charge controllers to their line that include charge divert. The sensor leads from the OmniMeter, which regulates the charge controllers, are paralleled to both PWM-15 charge controllers. The tracker sits atop a 21 foot, 8 inch, Schedule 40 well pipe that has a four-foot stub of 3 inch pipe at the top. The bottom five feet of the mast is underground. When I had finished digging the footing hole, I drove two 8 foot copper-clad ground rods into the bottom of the

Above: Fourteen learning stations inside the Quest.
Below: Computer Station One is wired to the OmniMeter which logs and displays PV system data


Space Station Quest's PV Energy System
Photovoltaic Modules
12 Kyocera K51 Modules
600 Watts
Tracked with a
Wattsun Active Tracker
The Grid
30 A Fused Disconnects
PWM-15
PWM-15
OmniMeter
System Data on Computer!
Data Lines to Shunts
PV Shunt
12 V Shunt
24V Shunt
Vanner Voltmaster
100A 3 Pole Fused Disconnect
Exeltech 2000 Inverter
Battery Shunt
500A. 50mV.
30A Fused Disconnects
DPDT Relay
Battery
16 Trojan
T-105
batteries
900 A-h
at 24 VDC
120 vac Load Center
12 and 24 Volt DC Load Center
System Designed by Kurt Nelson SOLutions

hole at slight outward angles. A single run of number six stranded ground wire was then run from the top of the mast, down the inside to both ground rods, out of the hole and into the space station for system grounding. The hole was then filled with three yards of concrete. I also made sure that the utility service to the station was properly grounded. We were going to share a common ground and I didn't want to ground them through our equipment.

Before I explain more about the system, I must back up a bit and explain some of the planning that dictated system design. I proposed a system that had almost every 'load' controlled from the space station's Master Control Panel. It allows all the loads on the space station to be individually switched between solar and 'auxiliary' (utility), as well as off. This makes it possible to monitor individual loads on the OmniMeter and Omni-linked computer. The control panel consists primarily of 12 double pole, double throw switches (with center off) and is entirely low voltage DC. Each switch's corresponding circuit is wired through two 25 amp double pole, double throw contactors located in the relay panel 40 feet away. A lot of extra relays and wiring was involved, but it was all in the name of education.

The control panel also houses a battery meter, environmental controls (thermostat), remote inverter switch, panel fuses, lots of LED indicator lights, and the manual tracker controls. The manual tracker control was an option that Ron Corio at Array Technologies was kind enough to provide. It gives students the ability to switch the tracker out of auto and manually move the array to any position by toggling two little 'joy sticks'. They can then study the effect this has on the performance of the PV array and graph it on the computer.

The main system voltage is 24 VDC, and a 24 Volt, 2000 watt Exeltech inverter provides all of the solar 'house' current. The battery consists of 16 Trojan T-105, 225 Ampere-hour, six Volt batteries wired in series/parallel to provide 900 Ampere-hours at 24 VDC. The top of the battery box has heavy plexiglas™ panels that allow the students to view the inside of the vented battery box.

We actually ended up with four separate voltages on board: 120 vac utility power, 120 vac

Above: The power center with the plexiglass-covered, battery box below

Below left: The master control panel

Below right: Students at work with the robot arm and computer station two.

inverter power, 24 VDC for the main system voltage and robotic arm, and 12 VDC. Upon learning just how much sensitive radio equipment might be involved, including a satellite dish and Ham radio Packet transmitters, I got nervous. Not being too familiar with Exeltech's pure sine-wave performance, I thought it would be better to run the communications loads, all of which could run on 12 VDC, directly off the battery in hopes of filtering out any noise on the line. In hindsight, powering these loads off 12 VDC was probably not necessary. Not only is the Exeltech *really pure*, but a lot of inverter noise is normally picked up from the background, not just on the lines. I have observed this by switching the Omni Link computer program into the 'scope' mode, which in effect makes the OmniMeter an oscilloscope. So the radio equipment could have run off standard power supplies with 120 vac input from the inverter or utility. Nonetheless, I installed a Vanner Voltmaster to deal with the 12 Volt loads (there is also a small 12 Volt water pump), and it has performed flawlessly. We have not experienced any communications problems associated with the inverter.

All of the DC loads on board are supplied through a 100 Amp Siemens load center which is protected by a 100 Ampere 'T' class fuse. I brought the +12 VDC to one leg of the load center and the + 24 VDC to the other, with the whole system having a common negative and ground. I have never figured out if this meets code, but any standard ac load center also has more than one voltage in it, 110 and 220 vac. The main drawback of this DC load center is that you have to be sure you are plugging a given circuit into the correct panel slot, as they alternate 12 and 24 VDC.

The system has been up and running for a few months now. I feel confident saying that, at least from an educational aspect, the OmniMeter is the heart of the system. All four channels are utilized. Channel one is the main battery channel, channel two monitors PV input, channel three is 24 VDC, and channel four is the 12 VDC loads. The OmniMeter and Omni Link computer program are great! They are not only excellent instrumentation for the overall PV system, but are a wonderful 'turn-key' educational package. They allowed me to program lots of high current, low voltage, and low capacity alarms into the system. When the computer brings in an alarm, the students are instructed to figure out what caused the alarm and take action to correct the problem, such as switching loads over to auxiliary power.

I also was involved in writing the curriculum for the solar. There are plans to bring junior high school students into the program later, however at this time 5th and 6th graders are the only students using the Space Station. Each student spends a total of 20 minutes at each learning station inside Quest. At the Omni-linked computer, the children fill out a system log and then read data logs which graph the amount of energy used by the robotic arm and the radio transmitter. They can also overlay two data logs and graphically compare the effects of such things as PV current on battery voltage. The curriculum will expand as more students of varied age groups are included in the program. This is sure to happen, as Sharon is already receiving inquiries from schools around the state wanting to schedule field trips.

All in all, the project has been a great success, and my involvement very rewarding. My only regret is that I am moving away to Wisconsin's remote north woods—a move to an area with greater demand for working solar systems and great wind potential along the south shore of Lake Superior. Mickey Wurl-Koth, of Solar Spectrum, has agreed to inherit the project and will provide support and maintenance from his Tomahawk home.

Finally, I mentioned earlier that I had agreed to contact my suppliers to ask for support. I would like to thank Ron Corio at Array Technologies, Gary Chemelewski at Exeltech, and all the good folks at Alternative Energy Engineering. A special thanks goes out to Joe Bobier at Sun Selector/Bobier Electronics. Projects such as this only happen when everyone gets on board, and when they do, the sky is the limit.

"Tell me and I forget.
Teach me and I remember.
Involve me and I learn."
Benjamin Franklin

Access

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Sharon Ryan, Dream Flight Wausau/Wausau School District, 415 Seymour Street, Wausau, WI 54403

SIEMENS

full page bled

four color on negatives

This is page 21

Above: Mark Whitaker's home in downtown Portland, Oregon. Note the two PVs on the roof and the utility powerline.

Portland PV Power

Mark Whitaker

I have been interested in solar electricity since I was a teenager. I remember dreaming of a cabin in the woods with solar panels on the roof and a woodstove for heat. This was in the late seventies and early eighties, when Mother Earth News was a big fat publication crammed full of do-it-yourself articles and classified ads for cheap land. It wasn't until the nineties that my dream started to become real, at least in part.

I picked up my first issue of Home Power - #22 - at the Oregon Country Fair in 1991, and at the same time I got a catalog from Alternative Energy Engineering of Garberville, California. I was amazed to see how many people were already living this dream of mine, and how easy it seemed. In 1993, I visited some friends in Humboldt County and saw their off-grid home, and also visited Arcata's Renewable Energy Fair and AEE's store in Garberville. I finally realized that a small photovoltaic system was within my reach.

In January 1994, I took a week-long class in solar design taught by Johnny Weiss of Solar Energy International. The class culminated in the installation of a 225 Watt photovoltaic system at the shop of Mr. Sun, a Portland solar water and pool heating dealer. After this, I decided that I was ready, and, in February, when AEE had a sale on some 53 Watt Solec PV panels, I took the plunge and bought two. These are 36 cell panels that make 3.1 peak amps each at 17.1 peak volts

The Loads

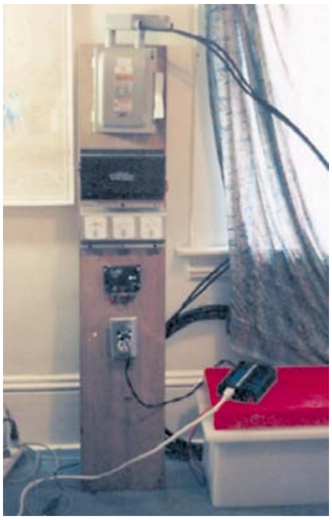
My intent was to put together a small system that could power my computer, a couple of lights and possibly my stereo. Since I live in the city presently, and am grid connected, this would give me a chance to live with the system for awhile and get to know its limitations (and my own!) before having to rely on such a system for all my electrical needs.

My computer is a Toshiba laptop that uses only about 50 watts, and I bought a Canon BJ-200 printer specifically because of its small size and low power draw: only about 15 watts or so. I have one 50 watt, 120 vac halogen light and one 13 watt, 120 vac compact fluorescent in my office. My stereo draws about 25 to 75 watts at 120 vac. Also plugged into the system is an old Zenith shortwave receiver.

Other Equipment

Now that I had almost $600 invested in PV panels, the pressure was on! Next came the inverter, and I chose a Statpower PROwatt 250. It had plenty of room to run the computer, a light and the stereo all at once, it was small and portable, and it was cheap.

The other major components of the system were, of course, batteries and a charge controller. The batteries are two Trojan T-105 deep cycle, six Volt batteries wired in series, for 220 AH at a nominal 12 Volts. I also purchased a heavy duty, corrosion resistant box for them. Originally I had planned to make one of plywood, but this plastic box seemed to be superior to anything that I really had in mind. The charge controller is a Steca Midi 8 Amp unit that has a function that allows the controller to charge the batteries to a lower voltage (13.7 V) when the battery was not used heavily the night before. When the battery was used heavily (down to 12.4 V), then the controller charges to a higher voltage (14.5 V). The manufacturer calls this “gassing regulation” and AEE recommends them highly. The Steca Midi also has a low-voltage disconnect.



Other necessary ingredients included a set of analog meters for system voltage, array amps and load amps; a 12 Volt fuse box; a 30 Amp, 2 pole fused disconnect; and lots of copper wire. I used #10 AWG type TC outdoor wire to connect the panels together and to a junction box near the roof. From the junction box to the disconnect inside, I used #4 AWG USE wire. All the rest was wired with #10 AWG primary wire, except to connect the batteries, which was done with #4 AWG cable.

Above: two PV modules make 100 Watts of power.

The Process

Now I had to install this pile of expensive equipment so that it worked. I mounted the disconnect, the fuse box, the meters and the charge controller together on a 1 X 10 board. I connected everything according to a combination of the diagrams that came with the charge controller and the general purpose diagrams in the AEE catalog. All connections were soldered and taped. The cigarette lighter plug on the inverter was removed and a normal household socket and plug were specially wired for the inverter to plug into. The neutral was used for positive and the ground was used for negative. This way, if the inverter is accidentally plugged into a 120 vac outlet, it won’t be damaged (Assuming, of course, that the 120 vac socket is wired properly. So far as I know, this is not a code-approved way to do this. *Editor’s note: Mark is right. This inverter’s installation does not conform to the NEC.*) The cigarette plug was kept and adapted to take a regular household plug, so I can still use the inverter in a car if need be.

The system was ready in time to go to Portland’s 2nd Annual IN-POWER Energy Fair in July and powered the Oregon Conservancy Foundation’s sponsor booth. We ran a notebook computer which was used to add names and addresses to the OCF mailing list. Oddly enough, besides the system for the music and the stage, mine was the only complete, working PV system there.

Mark Whitaker's System Cost

#	Component	Cost	%
2	Solec S-53 PV panels, 6.2 A @ 17.1 V	$580	49.1%
2	Trojan T-105 6V batteries (220 Ah)	$133	11.3%
1	Statpower PROwatt 250 inverter	$130	11.0%
	Wiring, plugs, connectors	$90	7.6%
1	Steca Midi 8A charge controller	$69	5.8%
	Meters: 10-16 VDC, two 0-10 ADC	$62	5.2%
1	Battery box	$59	5.0%
1	Fuse box for DC loads	$36	3.0%
1	Fused disconnect 3 wire, 2 pole (30 A)	$23	1.9%
	Total system cost	$1,182	

Problems

But alas, things were not perfect. Since the loads are handled through the LVD on the charge controller rather than directly from the battery, I couldn't put the array meter between the controller and the battery. It went instead between the controller and the array. This meant that when the batteries were full and the controller short-circuited the panels, the meter would read as if amps were still flowing from the array to the battery. Not true!

This was easily remedied however, by bypassing the LVD and taking the loads straight from the battery. The array meter was then moved to the other "side" of the charge controller where it only registers the amps that are actually going to the battery. Since the "control center" for the system is right next to my desk, I can keep an eye on things and I don't need the LVD.

Also, I discovered that my stereo amp doesn't really like modified-sine wave power, as it persisted in producing an annoying hum whenever powered by the inverter. The digital tuner was apparently not fond of the inverter either and promptly mixed up or lost all the pre-set stations. Fortunately, these problems went away with a return to sine wave, grid power.

The third problem really had nothing to do with the system itself. Before I could mount the panels on the roof of my house, I had to replace the roof. During the summer, I had been dragging everything outside during the day to charge, then bringing it in to use in the evening. Obviously this couldn't go on for long, and in September I finally re-roofed the house. It was October, however, before I mustered up the courage to drive screws through my beautiful new roof and mount the panels. On November 13, the whole thing was finally hooked up and running, and I moved one step closer to the dream of my teenage years.

Next Time

As could be expected, I have a few ideas about things I would do differently if I were starting a project like this again. Mainly, I would buy a bigger charge controller and bigger ammeters. The 8 Ampere controller leaves no room for expansion. In fact, I have a Siemens 35 Watt PV panel for my boat that I would like to use at home right now, but the controller won't handle it. I should have bought a controller big enough to handle at least two to three times as many panels as I initially bought. Also, I don't see the need for a low voltage disconnect in this sytem. Since I will someday need to be able to run my stereo off this system, too, I will eventually be purchasing a small sine wave inverter. Additionally, I would like to make some nice DC halogen lights so I wouldn't have to have the inverter on just for light.

Aside from these minor points, I am extremely satisfied with the start I have made. I have a functional system that can be expanded, that meets a few of my basic needs, and that cost less than $1200. And, along the way, I became a solar dealer as well.

Access

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Radar Electric, 704 SE Washington, Portland, OR 97214 • 503-232-2404 (inverters, electronic tools and parts).

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Things that Work!

Things that Work!
tested by *Home Power*

Trace Engineering's SW4024 Inverter

Richard Perez and Bob-O Schultze

Every once in awhile a product comes along that revolutionizes a whole industry. The SW4024 power inverter is such a product. Powerful, compatible, efficient, stand alone or grid intertie, this machine has it all. With 4,000 Watts of sine wave output power, a built-in 120 Amp battery charger, automatic generator starting, and load diversion circuitry plus much more, this device will tie it all together and do more to mainstream the use of renewable energy than anything we've seen so far.

Inverters 101

For newcomers to *Home Power*, an inverter is a device which changes DC power stored in a battery to standard household 120/240 vac electricity. Most renewable energy charging sources (PVs, microhydro, and wind) generate DC which is stored in batteries. Nearly all lighting, appliances, motors, etc., are designed to eat ac power, so it takes an inverter to make the switch from battery-stored DC to standard house power (120 vac, 60 Hz).

The Name Game

Inverters come in two basic flavors, square wave and sine wave. That sounds simple enough, but it ain't. Most inverters sold today produce a modified square waveform. The marketing spin doctors tend to call it modified-sine or quasi-sine wave. Whatever, it all looks the same on an oscilloscope. Most ac devices will digest this waveform OK, but there are some notable exceptions. Devices such as laser printers, which use triacs and/or silicon controlled rectifiers, fry and die when fed mod-sine power. Motors and power supplies usually run warmer and less efficiently on mod-sine power. Some things, like fans, amplifiers, and cheap fluorescent lights, give off an audible buzz on mod-sine wave power. On the plus side, mod-sine inverters make the conversion from DC to ac very efficiently. They are relatively inexpensive, and many of the electrical devices we use every day work fine on them.

To have the term sine wave applied to inverters at all is unique. Sine wave is usually used to describe a waveform produced by a rotary generator. In an inverter, direct current (DC) is switched back and forth to produce alternating current (ac). Then it is transformed, filtered, stepped, whatever, to get it to an acceptable output waveform. This is not a trivial process! Much wizardry goes on in a sine wave inverter. The more processing, the cleaner and quieter the output, but the lower the efficiency of the conversion. No free lunch, eh? The goal becomes to produce a waveform that is acceptable to all loads without sacrificing too much power into the conversion process.

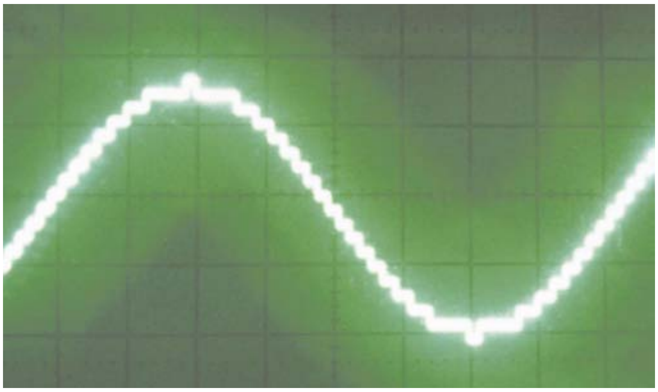
The SW4024 Waveform

Trace calls their waveform a "stepped approximation of a sine wave." I call it the "Mayan temple" waveform. Check out the photo. It's the damnedest thing I ever saw. And it changes! Trace varies the number of steps per cycle between 34 and 52 depending on battery voltage and/or load. Low input voltage or a large load increases the number of steps. More steps mean a closer approximation to a sinusoidal waveform.

We can discuss the theories and relevance of sine waveforms until the cows come home, but the goal is the same: a waveform that is acceptable to all loads without sacrificing too much power into the conversion process. Put simply, if all loads will digest the inverter's waveform as well as they do a sinusoidal wave, who cares what it looks like? They gotta eat it, not me.

Packaging and Manuals

Trace has always packaged their machines as if each one had to go "there and back again." The SW4024 is a BIG machine. It measures 21"W x 15"H x 9"D and weighs in at a whopping 105 pounds (48 kg). Packaging such a behemoth to go around the world is no small thing. Trace started out using the molded foam technique that works well with their smaller inverters. After a few too many dings and crushed battery terminal covers, they switched to two flexible foam cradles which support the machine from all sides and keep it suspended in its heavy cardboard shipping



Above: The 4024's waveform on the scope

box. The whole shebang is put into another close-fitting heavy cardboard box with cutouts for hand grips and is stapled closed. Short of a jousting contest with forklifts or practice for the caber toss, we think the 4024 will arrive safely.

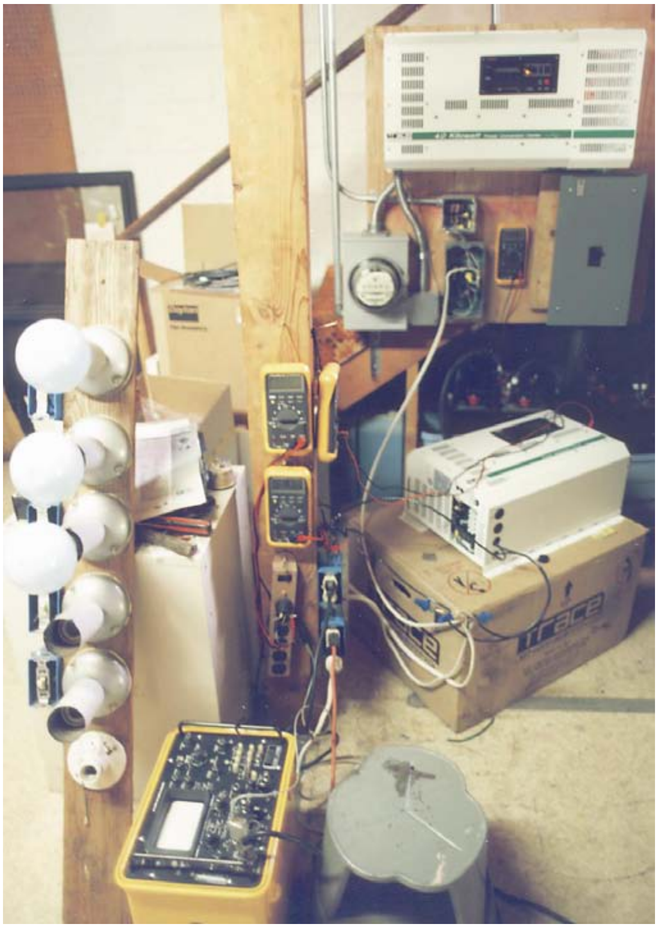
In the past, Trace owner's manuals have been top notch. We were happy to see this tradition continue with the SW4024, with only a few flaws. The section on battery recommendations seems to have been taken directly from the 2500 Series manual without any updates as to sources of supply. The newer SW4024s are compatible with alkaline batteries. Also, the section dealing with automatic generator starting and stopping needed far more explanation than was given. The manual for the inverter we tested was Version Two. By the time you read this, Version Three should be shipping. It speaks to some of the SW4024 improvements made in the past few months.

The manual runs forty-eight 8-1/2" x 11" pages plus two fold out diagrams and a five page addendum of warranty and registration information. None of it is fluff. This is a very serious machine. There are so many features and user adjustable parameters it takes a computer-like, menu-driven, LCD control panel just to display them all. The manual does an excellent job of explaining the operation. It starts right off with important safety instructions. Read these first. This is a machine to be reckoned with.

The manual then goes into an overview and an explanation of the modes of operation, including inverter, battery charger, UPS, and generator or utility interactive mode. The manual proceeds to explain the control panel and its functions. Following that is the discussion of batteries. Finally, on to the actual installation instructions.

While the owner's manual is written in plain English with a minimum of technical jargon, its job is to try and explain a very complex and powerful piece of

Above: The Trace SW4024 inverter



Above: Our testing jig for the Trace SW4024. We had to build an entire 120 vac distribution setup in order to test this inverter at full power (4000 watts). The 4024 on the wall is powering Bob-O's house, while the 4024 on the floor is undergoing testing. Note the Fluke 87s (hanging on the beam) and the oscilloscope (sitting on the floor).

equipment. Read it *before* you unpack the inverter. If it makes you nervous or gives you a headache, the manual has probably done its job. Think about hiring an RE electrician to help you out.

SW4024 Specifications & Features
The SW4024 is packed with features. So many, in fact, that we haven't heard of anyone using all of them in one application. The following is a brief description and synopsis of the main ones:

• It's a 4,000 Watt sine wave inverter. Continuous. And then some. It has a published idle draw of 16 Watts (we measured 14 W) and a search mode where the inverter powers itself down to one Watt while sending out pulses until a load is detected.

• It's a three-stage battery charger. Adjustable charge rate from 0 to 120 Amps DC. Adjustable bulk charge voltage, bulk done amps, float voltage, battery temperature compensation, and max charge time.

• It's an uninterruptible power supply (UPS). If the grid (or generator) goes down, it's on line in 32 milliseconds or less.

• It's a utility interactive synchronous inverter. If you have excess power from your RE sources or stored battery power, it will synchronize to the grid waveform and sell back power. The battery voltage sell point and maximum sell current are adjustable.

• It's a peak load shaving inverter. It has an onboard clock which can be set to power your loads during peak energy consumption times and recharge the batteries off peak when grid electricity is cheaper.

• It provides generator support. Should your generator need assistance starting a large load, it will switch from charging to inverting mode, synchronize with the generator waveform, and give up to 10 kW extra starting boost. The generator support voltage and maximum current support are adjustable.

• It provides a run and a cranking relay to automatically start and stop your generator based on battery voltage.

• It has separate and interactive inputs for utility and generator support sources.

• It has three independent voltage controlled relays which can be used for load diversion, alarms, whatever. Both the relay trip voltage and the change state voltage (hysteresis) are adjustable.

Control Panel
The control panel sets the inverter's operating parameters using an LCD display and eight pushbuttons. One of the buttons is dedicated to turning the machine on/off or into charger mode. This button is colored red for easy identification. A green button switches an automatically starting generator on or off. Two buttons scroll backward or forward through 15 general menu headings. Two others scroll backward or forward through the items under each of the menu headings. The remaining two buttons set the programmable parameters of the menu items.There are 47 user-adjustable settings, 9 metering functions, and 8 diagnostic readings to indicate errors which would cause the machine to shut down. All accessible via the control panel. Whew!

In addition to the LCD display, there are eight LED indicators showing whether the machine is inverting, charging (bulk or float), selling power, has a malfunction, or has grid or generator power present on its inputs.

The control panel also has an adjustment for the LCD contrast for better visibility in different light conditions and an Oops! button which resets all parameters to factory defaults in case you've really got your knickers in a knot.

Metering Functions
The SW4024 control panel has an ac ammeter and both 120 vac and 24 VDC voltmeters. The ammeters display inverter amps (– while inverting, + while recharging), input amps either from grid or generator, and load amps passing from the inverter to the loads. The rms ac voltmeters indicate the inverter ac output voltage, and grid or generator input voltages. The DC voltmeters show actual battery voltage, and temperature compensated battery voltage if the included temperature sensor is used.

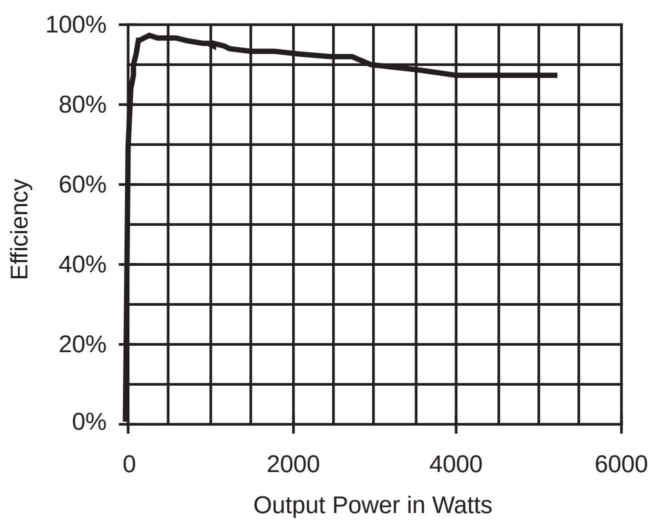
The Test Bench
We tested the SW4024 using four Fluke 87 DMMs and a Hewlett-Packard AN/USM 339 dual trace oscilloscope. The Flukes have a DC accuracy rating of 0.1%. The scope was used to view the waveform and the current phase. *Home Power* had never tested an inverter this big. Even after rummaging through two households, we could only come up with 3850 Watts of resistive loads!

In order to measure the inverter's input current, we used a Fluke 87 measuring the voltage drop across a 500 Ampere, 50 mV shunt. The Fluke measuring DC input voltage was connected at the inverter's input terminals. Output current was measured across a 100 Ampere, 100 mV shunt.

We used Bob-O's main battery (twelve Trojan L-16s—1050 Ampere-hours at 24 VDC) to power the inverter. Even with this much stored energy, we had to wait for a sunny day with wind to come up with enough power to really twist the Trace's tail. This is a really big inverter and feeding it requires lots of watts! We set up the test jig in the basement, and testing lasted for over five hours. We had to stop testing periodically to let the battery recover and recharge.

We measured the inverter's no-load power consumption at 13.31 Watts (0.5 Amperes at 26.61 Volts DC). We then proceeded to add loads from 25 watts to 5236 watts. The Trace SW4024's efficiency was over 90% from 95 watts to 2748 watts. We measured 87% efficiency at a full 4000 watts out of the inverter. For a sine wave inverter, this is very high efficiency.

Trace SW4024 Inverter Efficiency



Both the rms and peak output voltages of the Trace were very stable. We measured a low rms voltage of 118.5 and a high of 121.9 vac rms. The peak voltage of the Trace's waveform varied from 161 to 172 vac peak. This degree of stability is better than the utility grid delivers to most homes.

Performance
The power efficiency chart speaks for itself. Our overload tests showed us this machine really has lots of snort. After loading up the 4024 with our 3850 Watts of resistive loads long enough to bring on one of the internal cooling fans, we started a 1/2 HP split-phase grinder. With the grinder and the other loads running, we started a 1/2 HP air compressor. Finally, with all of that going, we started a 7–1/4" Skilsaw. The Trace still had more to give, but our 250 Ampere input circuit breaker popped off at 274 Amps input!

We didn't have the capability at the test site to adequately test the charger features, but data observed from other SW4024 installations indicates it will do as specified at around 75% efficiency (117 vac in to 24 VDC out). This is a big improvement over the Trace 2500 Series chargers which run at about 55%–60% efficiency.

Here are some comments from other SW4024 users.

"The table saw starts much faster, even with the electric water heater on."

"Wall cubes don't buzz (some cheap compact fluorescents still do)."

"The three general purpose relays are great! I have simply been plugging/unplugging the electric water heater (dump load which also serves a useful function). Now I can use one of the relays to control a power relay."

"I like being able to use power tools while someone else is microwaving without dumping the computer."

Warts, or, *Ya Can't Please Everybody...*
The lowest search threshold is 16 Watts. We'd like to see it a little lower. Over the years, many of us have trained ourselves to eliminate all phantom loads and replace our energy sucking incandescent lighting with low wattage compact fluorescents. I've heard of folks having to insert a phantom in a circuit just so their favorite 7 or 11 Watt CF reading light will stay lit.

The pushbuttons on the control panel sometimes don't make contact and you need to punch them a few times to change the display. The menu items under the menu headings are not necessarily grouped intuitively. We'd like to see two copies of a control panel flow chart, one with the manual and one loose to tack up on the wall next to the machine until you can find your way around.

While the SW4024 is pretty quiet on its power output, the inverter itself emits a very audible hum, especially at high output power. For most applications and installations this should be no problem at all, but if you have to live or work in close proximity to the inverter, then the noise will be irritating.

The stickem on the battery temperature sensor needs some help. It's come unstuck from the sides of several battery banks I've seen.

If this sounds pretty picky, it is! We had to hustle to come up with these! Given the incredible versatility of the SW4024, these are pretty minor flaws.

This and That
The SW4024 is also available in a 48 VDC input version. It also comes in a 3kW, 234 vac, 50 Hz export version, the SW3024E. Trace plans to release a 2500 watt, 12 VDC model by this fall. Options for either the 4024 or the 4048 include a conduit ready enclosure for

the DC input cables, a series interface cable and a full function remote display. Everything else is built in. There is a stacking interface that allows two 4024s to operate together. The warranty is two years.

The Trace 4024 is gaining acceptance by utilities. It has been approved by Pacific Gas & Electric for utility intertie in Northern California. The Trace SW4024 is ETL certified to UL® spec. 1741 (residential service), so there will be no problems with installations on grid.

Conclusions

The Trace SW4024 is an incredible device. It is the missing link between small-scale renewable energy and America's utility grid. It makes a wonderful, stand-alone inverter for those off of the grid. The retail cost of the SW4024 is $2980. This is very inexpensive (75¢ per watt) for a sine wave inverter. Our testing was rigorous, and the 4024 met Trace's specifications.It works well and is affordable. Great work, Trace!

Access

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Things that Work!

Things that Work!
tested by *Home Power*

Statpower's TrueCharge™ Battery Charger

Tested by Richard Perez

Battery chargers haven't changed much in thirty years. These 120 vac-powered battery chargers mostly use large transformers and have minimal regulation. Statpower's new series of TrueCharge™ battery chargers is radically different. Gone is the large transformer—replaced with a modern high-frequency switching power supply. Gone is the simplistic control of just voltage regulation—replaced with three-stage, computer-controlled battery recharging.

Statpower TrueCharge™20 Specifications and Features

This 20 Ampere (continuous) battery charger is powered by conventional house current or generator power. It will accept 60 Hz input from 90 to 135 vac rms (240 vac, 50 Hz models are available). It is designed for all types of lead-acid batteries—from flooded "wet" cells to sealed "gel" cells. Output voltage range is 13.8 to 14.8 VDC with float voltage ranging from 13.2 to 14.0 VDC. There is a user-initiated equalization function which defeats the voltage limits and allows a controlled overcharge of the battery. Efficiency of the charger is rated at 85%. The TrueCharge™ battery charger will recharge either one or two different batteries.

The TrueCharge™20's modern 75 kHz switching power supply technology offers users several distinct advantages. One is small size—the TrueCharge™ measures 11.5 inches (29 cm) by 6 inches (15.25 cm) by 2.75 inches (7 cm) and weighs only 5.5 pounds (2.5 kg). Another is totally silent operation—the TrueCharge™ is totally quiet both to the ear and to radios. Using switching power technology allows this charger to be easily and efficiently controlled for "smarter" recharging.

Statpower uses a three-stage, recharge scheme for their computer-controlled TrueCharge™ models. The first stage is known as "bulk charge" and replaces about 75% of the energy withdrawn from the battery. During bulk charge, the TrueCharge™ delivers its maximum rated current. After the battery has undergone the bulk charge, it is ready for the second stage called "absorption charge." During absorption charge, the battery is held at near-gassing voltage and the charging current is steadily decreased. This minimizes water loss. When the absorption charge is finished, the battery enters the third stage of recharge—"float charge." During float charge, the battery is held at a full state of charge and at a reduced voltage level. The battery can be left under charge in float mode continuously without damage. A fourth stage of recharging is also available for equalization charges. Here, all voltage limits are defeated and the battery is overcharged and allowed to gas extensively.

Shipping Carton & Documentation

The Statpower TrueCharge™20 arrived here on Agate Flat, Oregon in fine shape via UPS. The shipping carton was more than adequate—it is stout enough for air dropping into the Alaskan bush. The documentation provided by Statpower is outstanding. The 34 page manual is clear, complete and concise. I can only wish that all RE equipment came with docs this good!

Test System
I tested the Statpower TrueCharge™20 at our home and office on Agate Flat. This charger is the 20 Ampere model, but 5, 10 and 40 Amp models are also available. I powered the charger from either of our two sine wave inverters (Exeltech 1 kW and Dynamote 2.3 kW). I charged a variety of lead-acid batteries with the Statpower TrueCharge™20. I recharged five 65 Ampere-hour, 12 VDC sealed recombinant lead-acid batteries and two 100 Ampere-hour, 12 VDC flooded lead-acid batteries in our electric tractor. We use the sealed batteries because they are portable and easily transported to energy fairs.

Our PV/wind system here on Agate Flat is large. I often find myself treating our system like we were plugged into the grid. We generate and use between six and thirteen kiloWatt-hours per day (mostly consumed by *Home Power's* computers). Our system is oversized to provide the necessary reliability during the winter. During the spring, summer and fall months, we often have a substantial surplus of power. We use this surplus power to pump water, to refill smaller, more portable, batteries and to recharge the electric tractor. The Statpower TrueCharge™20 is the only charger efficient enough to even consider powering from our main PV/wind system. I installed the Statpower TrueCharge™20 on 24 March 1995 and it has been in intermittent service since then.

Charger Installation
Installation was fairly straight-forward thanks to the great manual. I do, however, wish that Statpower supplied a cord and plug for the charger's 117 vac input. Instead there is a small junction box on top of the charger, and the user must supply the wiring and connect it to 117 vac either via junction box or with a plug. This is a result of the charger's Canadian CSA (UL spec. 1236) listing.

Since the charger only puts out 20 Amps max, I wired it to the batteries with 10 gauge copper wire. The wiring connectors on the charger's low voltage output are adequate, but could be more robust.

Charger Performance
Operation is user transparent. Just set the switches for the appropriate battery type (flooded or gel) and battery temperature (cold, warm, or hot). The rest is totally automatic.

The TrueCharge™ takes a moment to begin charging—the computer is sensing the battery's voltage and takes about five seconds to initiate charging. As the battery fills, the charge rate gradually decreases until the battery reaches float mode. I left the sealed recombinant batteries under continuous charge for ten days without damaging the cells. These cells are cased in plastic and tend to bulge about the middle if recharged too rapidly. I then proceeded to recharge the electric tractor's batteries (flooded cells). The TrueCharge™ refilled both with ease and more quickly than I expected based on recharging with a 60 Hz transformer-based charger.

As a *coup de gràce*, I charged two different batteries at the same time. The charger merely divided its power between the batteries, giving each what was required at that point in their state of charge. I have never before had a battery charger that was a "set it and forget it" unit. The TrueCharge™ is truly automated and capable of minding the recharging process all by itself.

Conclusions
The TrueCharge™ is an outstanding battery charger. It is highly intelligent, automated and efficient. Retail price for the 20 Amp model I tested is $389.95. While this may seem expensive, I consider it in line with performance, efficiency, and quality of this Statpower charger. The TrueCharge™ is the only charger efficient enough to consider operating from our main RE system. Thumbs Up, Statpower!

Access
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Things that Work!

Things that Work!
tested by *Home Power*

Heliotrope's CC120E PV Charge Controller

Tested by Richard Perez

The CC120E is unique. No other photovoltaic regulator handles 120 Amperes of current, is user selectable for either 12 or 24 VDC operation, and uses the best method of regulation—Pulse Width Modulation (PWM). After eighteen months of extensive testing at *Home Power*, the CC120E still meets Heliotrope's specifications and flawlessly continues to do its job—preventing our PV arrays from overcharging our battery.

Photovoltaic Regulators

PV regulators come in many sizes, from those which will handle just a single module, to those which will regulate large arrays of many modules. The Heliotrope CC120E is the largest single unit PV regulator that I know of. It will regulate an array of around 40 (at 12 VDC) to 80 (at 24 VDC) average-sized PV modules. Regulation at these high power levels demands impeccable engineering and flawless execution. Anything less than perfect will quickly fry and die.

Just as PV regulators come in many sizes, they also use differing regulation techniques. Three regulation techniques in common usage are "hi-low," shunt, and pulse width modulation (PWM). Lets look at hi-low first. The hi-low regulator allows the battery to rise to a high voltage set point, then disconnects the PV array completely from the battery. When the battery voltage falls to the low set point, the regulator reconnects the PV array once again to the battery.

Shunt type regulators work by diverting some or all of the PV array's current into a load (usually a resistor).

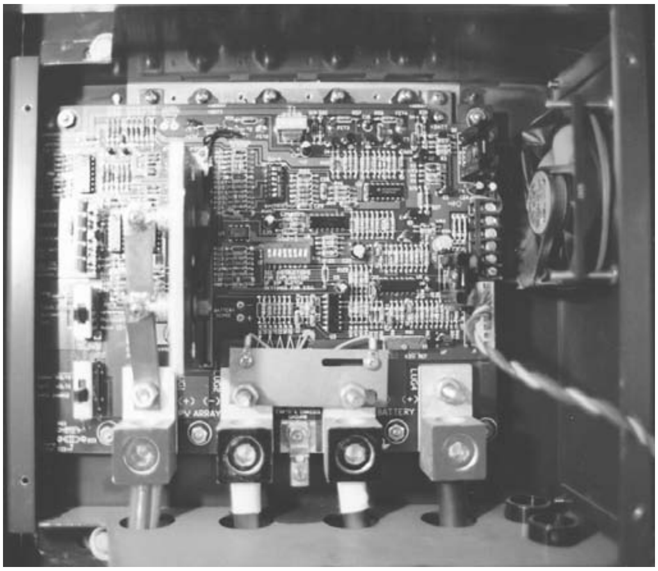
Above: The CC120E with its cover on. Note the huge heatsink that keeps the CC120E cool.

Shunt regulators work best at lower current levels (under 100 Amperes) and when the power source cannot withstand being unloaded (such as a wind generator or microhydro turbine). Photovoltaics are not damaged by being unloaded, i.e. disconnected from their load (the battery).

PWM regulators work by rapidly disconnecting and reconnecting the array so that the voltage output from the controller is a user-set constant. This type of control didn't exist before the invention of the super-efficient, high-powered, MOSFET transistor. PVs don't mind being open-circuited; all that happens is that the array voltage rises to its open circuit level. When the PWM regulator reconnects the array to the battery, the array's available current once again flows into the battery. The frequency of the disconnect and reconnect cycle is quick—500 to 2000 times per second. The duty cycle (i.e. connect duration versus disconnect duration) is varied to produce a regulated, constant voltage at the controller's output. This PWM charge control technique was judged to be the most effective in a six-month Sandia National Labs test of eight different types of PV controllers. I have noticed, on my own, that batteries fed with PWM type controllers get fuller faster and live longer. In short, the PWM type regulator is an ideal controller for PV systems.

The CC120E

This regulator will control, using PWM, 120 Amperes of current from a photovoltaic array. Its voltage regulation level can be set from 13.5 to 16.5 in 12 VDC systems, and 27.0 to 33.0 in 24 VDC systems. This wide range in regulation set points makes the CC120E suitable for use on either lead-acid or alkaline (Ni-Cd or Ni-Fe) batteries. This controller incorporates a battery temperature sensor, remote battery voltage sensing, and a complete digital meter that displays array current, array voltage, and battery voltage. The meter's



Above: A close-up look inside the CC120E.
Note the massive connectors at the bottom, and the cooling fan on the right.

function is switch-selected from the front of the regulator's case. The voltage regulation set point is selected via an eight pin DIP switch inside the controller. There is also a user-selectable equalization switch on the front of the control that allows overcharging the battery. Also located on the front panel are five LED status lights that indicate charging, charged, over temperature, low battery voltage, and low voltage disconnect operation (optional). One unique feature of the CC120E is that the user can select and change the control's operating voltage from 12 to 24 VDC with the flip of a single DIP switch. This makes it great when you upgrade your system from 12 to 24 Volts because you don't have to replace the controller.

In fact, the CC120E will conduct the same amount of current at 24 VDC that it conducts at 12 VDC—120 Amperes. So the CC120E can handle about 2 kW of PV power in 12 Volt systems and almost 4 kW of PV power in 24 Volt systems. That's a pile of power to attempt to control….

Shipping Carton and Documentation
Heliotrope packages all their equipment well, and the CC120E was no exception. The heavily packaged CC120E weighed in at about 40 pounds and arrived here undamaged via UPS.

The documentation is short and to the point. It gives you all the required information for installing the control in a safe and effective fashion. The docs even include great tables for choosing the right wire gauge size for the PV array to CC120E wiring.

Test System and Installation
We installed the CC120E in our office/home system here at Agate Flat, Oregon. This system has grown over the years as *Home Power's* office and our home have expanded. Currently we cycle between six and thirteen kiloWatt-hours of energy daily. Our PV array is a motley collection of over 50 modules, over 1/3 of which ride around on trackers. All of these modules are collected in four different circuits. Each circuit is fed into the power room via a pair of 0 gauge copper cables. The current from all these PVs adds up to between 80 and 130 Amperes depending on battery voltage, solar insolation, and air temperature. It is not unusual to see over 142 Amperes peak current during cold days.

Our system stores power in a large battery—1500 Ampere-hours at 12 Volts DC. This battery is composed of 150 NIFE, HIP-10, nickel-cadmium cells and stores about 18 kiloWatt-hours of energy. While our battery only stores enough energy to run *Home Power* for three days, we are never out of electricity. In combination with the large PV array, we also use a 1000 Watt wind generator and conserve electricity during extended cloudy periods.

The CC120E is easy to install because Heliotrope is one of the few charge controller makers who provide decent-sized connectors. The CC120E has four large 250 CFM lugs that easily swallow cable bigger than 0000 gauge. These monster lugs use Allen screws and you can really get huge cables securely connected. Try doing this with a screw driver….

We mounted the CC120E to the wall above our Ananda Power Center. We used steel angle iron to hold the controller about 1.5 inches from the wall. This allows essential air circulation behind the controller to keep it cool. Since the Ananda Power Center bolts right up to our battery via copper bus bar, round-trip wiring loss from the CC120E to the battery is just about zero, so we didn't use the remote battery voltage sensor. It took less than 15 minutes to install the CC120E. We installed it in November of 1993 and it's still on line right now.

CC120E Performance
When a controller works well, there is not much to say. The CC120E does its job just like Heliotrope General said it would. I know semiconductor electronics and appreciate

just how big of a job regulation of over 120 Amps of current is. The CC120E is as stable as sunrise.

I vary the voltage set point seasonally to match our energy production. I set the voltage up during the winter (16.0 VDC for our Ni-Cd battery) and down (15.3 VDC) during the summer. This always assures a full battery without overcharging and excessive water loss during the sunny summer months.

Our PV array has daily pushed the CC120E to its design specification limits. On hot summer days the temperature of our power room has peaked at 88°F (we use a recording thermometer). The CC120E still does its job, except it gets warmer. We have not seen the CC120E shut itself off due to over temperature. We get severe thunderstorms here in the summer. While I've often worried about the CC120E being destroyed by lightning induced transients, this has not happened.

All in all, the CC120E is a really boring machine. All it does, repeatedly and reliably, is what it is supposed to do. And that's enough.

Conclusions & Flowers

Heliotrope General's CC120E is the ideal controller for 100 Ampere+ PV systems. It is reliable, precise, and backed by the best limited warranty in the business—ten years! We have pushed it to its limits on a daily basis and it has not failed us. The engineering and quality built into this control are outstanding and worth every penny of its $689 retail price (includes heatsink).

I have a word on Heliotrope General and its products. I bought my first Heliotrope control in 1987 (a 20 Amp controller). We soon outgrew this control and replaced it with a 60 Amp version also made by Heliotrope. The 20 Amp model was used in a variety of portable applications (as in "beat up plenty on the road") and now lives on the remote end of our radiotelephone system. We eventually outgrew our 60 Amp Heliotrope and traded it off to our neighbor, Steve Brogatti, who still uses it. See HP#13 for a TtW! review of Heliotrope's CC20 and HP#8 for a review of Heliotrope's CC60. Heliotrope has been around for over fifteen years and has made reliable products backed by the best warranty in the business. I trust Sam Dawson and the Heliotrope Crew to regulate all the solar power we can make.

Access

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How We Got Into Hot Water

Larry & Suzanne Weingarten

In the beginning there was cold water—and people didn't bathe much. They masked body odor with perfumes and oils or just went around smelly. Even as recently as the turn of the century, running hot water was a luxury. It was available only to those who were well off. In the United States today, a personal supply of hot water is thought of as a necessity, right up there with food and shelter. (Just try going without it.)

Over time, people have heated water in a great many ways. A brief look at some of these methods can give perspective, and you will see how some of these older and now unused techniques could have application today.

Above: This water-back/range boiler has been working since the early 1920s.

From Stove to Storage Tank

When wood and coal were the prevalent fuels, water was usually heated in a pot over the fire or in a kettle over the cook stove. Some stoves had a reservoir lined with tin, copper or porcelain. This would be filled with water for heating. Heating enough water for a bath was a time-consuming ordeal. Much of Saturday was spent getting cleaned up for church on Sunday.

Later, when running water came indoors, a chamber or pipe loop called a water-back (or a water-front) was installed in the fire box of the stove. Heated water would move by convection through this chamber to a storage tank. (For reasons which can only be guessed at, these tanks were called range boilers, even though it was the stove which did the heating.) Some of these old systems are still operating today out there. The oldest water-back/range boiler we've seen still hooked up and in use dates back to the early 1920s.

A variation of the stove/storage tank idea was the "scuttle-a-day" heater which used coal. This was a small cast-iron device. Short and squat, with a rounded top, it looks more like Star Wars' R2-D2 than a water heater. Hooked up to a storage tank in the same way as the water-back, it used one scuttle (bucket) of coal per day to keep the water hot — more or less. Using the scuttle-a-day eliminated the need to fire up the kitchen stove when hot water was needed. It saved fuel and avoided turning the house into a sauna during hot weather. This heater had damper controls to adjust the rate of burning, but fully automatic water heating was yet to come.

Another interesting type of heater was the side-arm. It usually had a gas burner placed underneath a copper coil. These were "holstered" in a cast-iron shell. Water would be heated in the coil, and then convection would drive the heated water to a storage tank, just as it did in the water-back and scuttle-a-day coal burner.

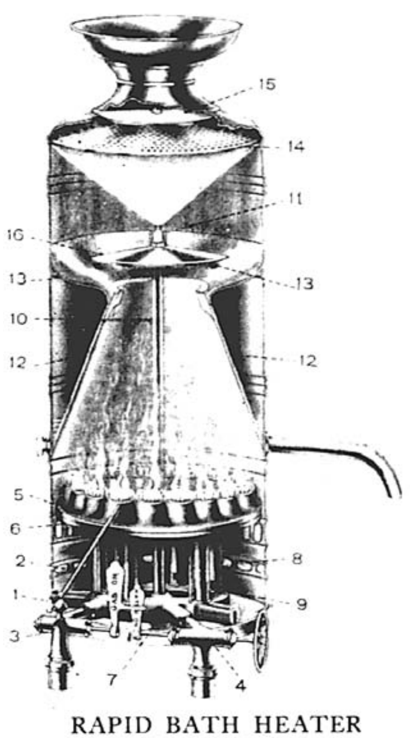
Originally, side-arm heaters simply had a gas valve which was operated by hand. The gas was lit with a match when you wanted a bath. Forgetting to shut it off when done with the bath "triggered" a potentially explosive situation. Later, automatic controls and safeties were developed which made the side-arm heaters easier to live with. One advantage of the side-arm heater was that if its storage tank rusted out, you could simply replace that one component. You'd transfer the burner and other pieces to your new tank, keeping costs down. Planned obsolescence had not yet become a way of life.

It's interesting to note that one of the most efficient water heaters available today, the Marathon, is an updated side-arm heater. One of the main reasons it is so efficient is that the burner is separated from the storage tank. Because there is no flue running up through the stored hot water, standby heat loss from the tank is greatly reduced.

Hot Water in an Instant

Up until the 1890s, all forms of water heating both heated and stored the water. Kerosene, gasoline, and a variety of gases have been used to heat water. Some gases, such as acetylene and producers gas, could even be made on site. With the advent of high-energy liquid and gaseous fuels, instantaneous heating became possible. These fuels were much easier to regulate automatically than wood or coal.

The bath heater was one of the first instantaneous types. We find one variety particularly interesting (see illustration). Once a pilot was lit, turning on the water would also turn on the gas burner. Water flowed up



1. Pilot Light Valve
2. Pilot Light Tube.
3. Gas Valve.
4. Water Valve.
5. Burner Plate (upper).
6. Burner Plate (lower).
7. Gas Chamber.
8. Retort Tubes.
9. Gas Nipples.
10. Stand Pipe.
11. Sprayer.
12. Center Cone.
13. Truncated Cone.
14. Perforated Plate.
15. Solid Baffle Plate.
16. Water Shed.

RAPID BATH HEATER
Sectional View Showing Operation

through a pipe to a sprinkler inside the top of the unit. As water sprayed out through the combustion gases, it collected heat (and combustion by-products). From there the water cascaded over metal that was being heated by a flame, collecting more heat. The water then traveled around to a spigot and into the tub.

Ad copy in Sweet's Catalog (1906) boasted that this method utilized "92 heat units out of a possible 100, a feat never before accomplished in heater construction." This heater was extremely efficient, though it did result in slightly tainted bath water. (Perhaps the somewhat acidic water cleaned better!) Today, the most efficient furnaces and boilers also condense flue gases.

As the Century Turned

At present, four or five manufacturers produce most of the water heaters in the United States. In the early part of this century, there were over one-hundred-fifty manufacturers. Many types of heaters were competing for business. The two major camps were automatic instantaneous and automatic storage heaters. You already know which prevailed.

It may have to do with how people bathe. For many reasons, precise temperature control has always been difficult with instantaneous heaters. That didn't matter when filling a tub, which is what most everybody used to do. As toes tested the water, hot or cold was added until the bather was satisfied. When the "rain bath" or shower became more common, if the water temperature fluctuated, it was noticed — and not much appreciated. Tank-type heaters seemed to gain in popularity around this time.

Galvanized steel tanks were common, but longer-lasting copper, bronze and monel (similar to stainless steel) were available, also. Performance was improved dramatically when insulation was added to the tank. (Surprise! What seems obvious to us now was innovation then.) Like the side-arm heater, some of the early tank-type heaters were designed so you could replace just the tank and re-use the rest of the components, even the insulation.

Because tankless heaters could produce hot water as soon as the pilot was lit, we imagine tank-type heater makers felt at a competitive disadvantage. They came up with some innovative ways of getting hot water from a tank within a few minutes after heating had begun.

One method placed a coil of pipe in the combustion chamber. Water was fed into the coil from the bottom of the heater. A tube ran from the coil up the flue and connected to the hot outlet pipe. Water was heated in the coil almost immediately; it could either be used right then or go to storage.

Another method wrapped a jacket about an inch away from and completely around the flue, surrounding it inside the tank. This jacket was open both top and bottom, creating a rising current of heated water. Like the previous method, hot water — although limited in quantity — was almost instantly available for use.

These tank heaters still took just as long as ever to heat their entire contents, but they could provide small amounts of hot water quickly for chores. That meant the heater could be turned on briefly and then kept off most of the time, greatly cutting standby heat losses.

Early Solar

Solar water heating started catching on around the turn of the century. Originally there were batch heaters, now called internal collector and storage (ICS) units. These heaters had one or more tanks placed behind glass, in an enclosed box. They are very simple, with no moving parts and little risk of freeze damage. Their main drawback is substantial overnight heat loss.

Thermosyphon systems were an improvement. This method placed the tank above the collector and used convection to move heated water into the tank (just like the side-arm heater). One manufacturer was Day and Night, so called because their heaters provided hot water both day and night. Their insulated tanks kept stored water hot after the sun went down, and that was a solar first.

The company suffered when unusually cold weather caused freeze damage to many of their collectors. Their remedy was to install a heat exchanger between the tank and collector and fill the collector with alcohol and water. (We personally feel that was one of the most elegantly simple and efficient solar systems ever devised.)

A second problem occurred as solar tanks aged and began to leak. A major cause of leaks then, as now, was using different metals together in water. When metals are mixed in this way, one of them always corrodes to protect the other. One metal turns bodyguard to the more “noble” metal, and it sacrifices itself. Thus, steel rusts away to protect copper. When these metals were used together, plumbing corroded and holes developed. Water leaked out and caused havoc. Today, plastic-lined steel nipples and dielectric unions can be used effectively to separate the metals and prevent this problem.

These solar tanks were usually installed in attics, up under the peak (so thermosyphoning with the roof-mounted solar panels could work). When tanks leaked, it was always a major headache. Even if they had not been packed in boxes with cork bits all around, access to attic tanks was difficult. Replacement would have been a nightmare, and it was probably seldom attempted. Instead, tanks or their plumbing failed, houses flooded, and solar developed a black eye. (If only solar system owners had been informed about galvanic corrosion and the use of sacrificial anodes to protect their tanks!)

At this time, gas was becoming more widely available, and its price was very attractive. Utility companies even got into the business of selling water heaters (free bath towels included) to build demand for their product. Solar was not able to compete against low gas prices or the freedom from involvement that abundant utility energy offered. Solar water heating slowly disappeared.

Tank Evolution

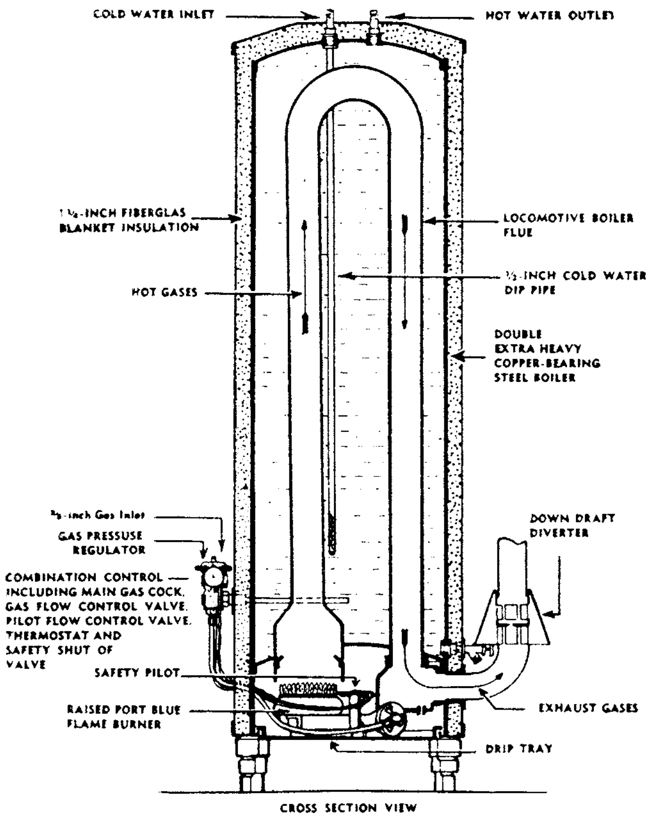
In the meantime, tank-type heaters had become dominant. Various methods and energy sources existed, but electric and gas tank-type heaters took over the lions’ share of the market. Tank building technology was changing, and some interesting things happened. As gas prices started going up, attempts were made to make tanks more efficient.

One such tank was the “U” tube heater. It’s enlightening to compare it to present-day heaters. Modern gas heaters have a flue, usually a 3 or 4 inch diameter pipe running from the combustion chamber right up through the center of the tank. This flue vents combustion fumes. However, it also acts like a chimney, and heated air is constantly flowing up and out. This is all lost heat.

In the “U” tube heater (see illustration), the flue went up, inside the tank, until it got near the top. Then it made a 180° turn and headed back down. It exited near the bottom and connected to an external vent pipe. This inverted U created a heat trap. It would vent only when the burner fired and so lost much less heat. Also, since the U doubled the surface area of the pipe inside the tank, more heat was captured by the water. It was very efficient.

Another design variation was the slow-recovery heater. It fired at 5 or 10 thousand BTUs per hour instead of the 30 to 40 thousand BTUs modern or “fast-recovery” heaters burn. Therefore, the flue’s outlet could be smaller. This resulted in more efficient capture of heat during combustion and less heat loss during standby periods.

Another change in manufacturing was the advent of glass lining. This glass coating is similar to ceramic glazing. Baked onto the inside of a steel tank, it provides a very good defense against rusting. Because



"U" Tube Water Heater

Used by permission of the copyright holder, American Gas Association.

a perfect process for glass lining tanks has yet to be developed, sacrificial anode rods are used to protect the steel at any "holidays" or imperfections in the lining.

This system worked so well that manufacturers eventually stopped making tanks of expensive metals such as copper and monel. Instead, their better tanks were made of extra-heavy steel lined with a double coating of glass. With such good protection and thick steel, a tank could last decades after its anode was used up. In fact, we recently ran across a 42-year-old heater that is still in good condition.

As the business of making and selling water heaters grew ever more competitive, ways were found to cut costs. Tank quality began to deteriorate as tanks were made of thinner steel and double glass lining was no longer offered. Metal drains were replaced with plastic.

Experience has shown us that modern tanks are more delicate than their predecessors, but with maintenance, their service lives can be greatly extended. More expensive tanks today may have a second anode, or they may have a plastic lining or be entirely plastic to prevent corrosion. Still, glass-lined units make up the great majority of tanks in service and sold today.

Safety and Energy Upgrades

Efforts have been ongoing to make water heaters safer. The results have been so successful that at one point, it was suggested we didn't need to install relief valves any more because tanks had quit blowing up! Tanks do explode less often today, precisely because relief valves DO get installed and because heaters have better controls.

Manufacturers have also been fine-tuning heaters for better energy performance to meet stringent federal energy codes. This has pros and cons. Yes, plastic drain valves lose less heat than brass ones, but very often they simply don't work. Yes, some small amount of heat is lost through an anode's exposed hex head. However, proposals to insulate and cover the hex head may do more damage than good. Unless they specify that access to the anode remain, anode replacement and water heater maintenance will become much more difficult.

One area which is likely to get even more attention in the future of water heating is conservation. Once the heaters themselves have been tweaked for every BTU of performance, it will make sense to zero in on the antiquated distribution systems where many of those BTUs are being lost. Other areas for improvement include heat recovery and reducing consumption of hot water.

Because they work so well, water heaters are generally the least thought-about piece of equipment in most homes. But it's useful to take the time to understand them, learn a little about their past, and guess at their future. That way we're in a good position to do what's needed to get the best performance and longest life from our water heating systems. It's the best way to stay in hot water!

Access

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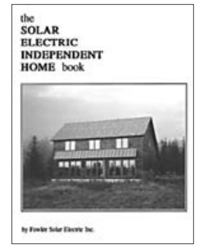
Recommended: *A GOLDEN THREAD: 2500 Years of Solar Architecture and Technology,* Ken Butti and John Perlin. Currently out of print, but check in used bookstores or library. Revised edition is in the works and will be published by MIT Press.



the
SOLAR
ELECTRIC
INDEPENDENT
HOME book

A Voltage Maximizing 50 mA Ni-Cd Battery Charger

Peter Talbot

Picture this. You are camping miles from anywhere on a remote stretch of beach and about to make that all important radio check on your marine VHF. You key the transmitter only to find the low battery indicator signal — trouble. Without a spare battery pack your only backup is an odd assortment of flashlights, a small solar panel, and a gel cell. Rather awkward power sources to jury rig to your expensive radio, and you'd rather not fry your nickel-cadmium pack with an unregulated charge.

The same situation has happened to me more than once whether I'm in the car, on a climbing expedition or out in my kayak. There is often a source of DC charging current available, but my electronic gadgets have anywhere from 1 to 9 AA Ni-Cds for power, and I prefer to charge at a C/10 rate or 50 mA to prolong the life of these rather expensive battery packs.

The Advantage Of A Low Voltage Drop Charger

Often the only power source available for charging my higher voltage Ni-Cd packs is a car battery at its resting voltage, or a deep-cycle battery connected to one or more solar panels. As charging the radio pack at a C/10 rate usually takes all night, the charging source may be at less than its optimal voltage. What I needed was a regulator that would current-limit to 50 mA, yet minimal voltage drop, less than a volt if I was to charge a 9.6 Volt battery from a 12.8 Volt source. A 9.6 Volt Ni-Cd will reach close to 12 Volts at full charge. Similar regulators can be constructed using the popular LM78XX series of fixed voltage regulators or the LM317 adjustable type. These regulators are excellent at voltage control in small power supplies and can be configured as current limiters. But they suffer from low efficiency, and more importantly, produce at least a 1.6 Volt drop to operate as a voltage regulator and up to 3 Volts to current-limit to 50mA. I measured an LM317 regulator and got the following results: minimum input voltage 15.56, output current 47 mA, and output voltage 12.8.

Lowering the input voltage caused the output current flowing into the battery pack to drop off sharply. That voltage difference between my radio battery and the charging source would be lost to a conventional regulator and tricky to current-limit with just a series resistor. In any case, I would need to carry a selection of resistors and check the charging current with a meter as the battery approached full charge.

The various PWM "pulsar" circuits, while making excellent chargers in the workshop, develop a larger voltage drop across the circuit and require a certain minimum input voltage to operate the internal electronics.

A Simple Solution

Figure 1 shows the circuit of a simple and inexpensive current limiter which drops only 0.8 of a Volt across its active element, while maintaining an output current of close to 50 mA. It can be connected to any voltage source greater that the battery to be charged, up to 24 Volts, and will charge at a rate compatible with a C/10 rate for AA Ni-Cd batteries. Figure 2 shows my measured data from charging a 9.6 Volt Ni-Cd battery in a marine VHF radio. Figure 3 shows the data for 2 AA cells from my Walkman. The input voltage was varied over a range to simulate almost any potential power source, and the tables show the change in charging current.

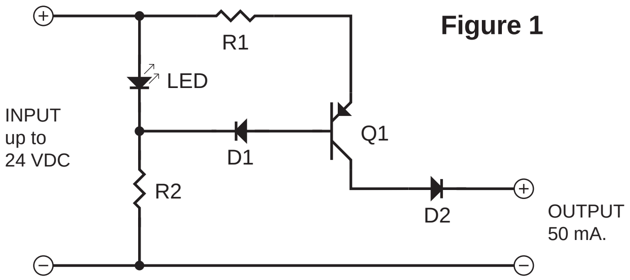


Figure 1

Actual charging current can be set by changing the R1 Ω resistor value. I tried a 10 Ω unit and found the charging current increased to 55 mA. I ended up with a 12 Ω in parallel with 51 Ω to optimize the current for my battery packs. Remember the formula for calculating resistors in parallel: (R1 x R2) / (R1 + R2) or 1 / ((1/R1) + (1/R2) + (1/RN)).

Theory of Operation

The regulator is able to limit current due to the gain or amplification characteristics of the transistor. By establishing a fixed current flow through the base of the transistors, a larger fixed current can flow out of the collector pin and to a load, in our case the battery pack. With no load connected, the LED is extinguished. In this case, the 0.7 Volt drop across the transistor, together with that of diode D1 and a small drop over R1, is slightly less than the 1.7 Volts needed to turn on the LED. In other words, the series combination of R1, Q1 and D1 short out the LED. With no load connected, the input current would be around 5 mA assuming an input of 12 Volts.

Figure 2

V in	*V out*	*I out (mA.)*
9.5	9.6	0
10.0	9.6	12
10.5	9.8	30
11.0	10.0	45
11.5	10.4	46
12.0	10.5	46
12.5	10.5	47
13.0	10.5	47
13.5	10.6	48
14.0	10.6	48
14.5	10.6	49
15.0	10.6	50

Figure 3

V in	*I out (mA)*
5	41
6	44
7	45
8	48
9	50
10	52
11	54
12	54
13	55
14	56
15	57

With the battery connected to the output, the situation changes. Now, input current flows through Q1 to the load, with a small fraction of this current flowing through D1 and R2 to forward bias the transistor. The LED turns on, as the voltage drop over R1 is now upwards of 0.6 Volts, which together with the drop over D1 and Q1's junction is now greater than needed to turn on the LED.

Not only does the LED serve as a charge indicator, but it also aids in linearizing the charge current if the input voltage increases. The voltage drop over the LED remains reasonably constant while the current flowing through it can vary as the input voltage changes. This holds the bias on the transistor to a fixed level.

Building the Circuit

Almost any construction technique can be used to assemble the charger. It generates little if any heat, but it is still wise to fuse the input. Shorting the output will have no damaging effect once the unit has been tested and the output current checked to be close to 50 mA, with the input voltage run up to 24 Volts.

In order to take advantage of this circuit's low voltage drop, it is possible to bypass the reverse current flow diode D2, thus eliminating an additional 0.7 Volts between input and output. In any case, the reverse current flow is only 3–4 mA without the diode and is only a concern when the input supply is disconnected while the battery under charge is left connected.

One note of caution, this circuit is a current limiter and not a voltage regulator. The open circuit output will be very close to that of the input voltage, so do not connect voltage sensitive electronics directly to the output unless an appropriate battery is also connected.

Parts list for building the charger.

R1 — 10 to 12 Ω, 1 Watt carbon resistor
R2 — 3900 Ω, 1/4 Watt carbon resistor
D1 — 1N914 silicon switching diode
D2 — 1N4001 silicon diode
Q1 — PNP transistor, T0220 case, RCA 2N6107 or equivalent
LED — red, 1.8 Volt drop at 10 mA

If you prefer, a complete unit, fully tested and built on a small PC board, complete with instructions, is available for $20 (see Access).

Access

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GoPower

Big Fun!

Michael Hackleman

The only REAL competition for photovoltaic arrays.

(Right) Standford Ovshinski will be a keynote speaker at REDI in August.

(Far Right) Nature has her own salvage rights on abandoned machinery.

My photos still hadn't been processed when Richard wrote up the Earth Day event in Arcata in the last issue of HP. So—I've included a few that I particularly like. Earth Day is also my birthday, so it felt like I was attending a party arranged just for me.

I've gotta tell you a funny story. I was listed as a keynote speaker. (No, that's not the funny story!) The PA system was wired up to a solar array. When it came my turn to babble about something, I asked to have the microphone powered by the HEC (human energy converter). All the pedal positions quickly filled up. When I asked them to "rev it up" to see what it'd do, the inverter tripped out (and the PA died). The source overloaded the machinery! Big fun. Better than a cake anyday.

Kelly Larson takes time out from assembling the fair's solar array to take her daughter, Emilly for a spin on Todd King's electric motorcycle.

Co-director M. "Mo" McHolland gives the HP crew a tour of Humboldt State University's Campus Center for Appropriate Technology.

Returning to the HP site, I observed a little friendly competition going on at the solar array. That wrapped up the roll of film!

A preview of this issue's GoPower

Okay, let's clean up the office here. First, Clare Bell,writer/novelist/EV owner and builder/racecar driver shares her adventures in shopping cart racing in *Wildcat One*. Next, I relate some personal experiences in testdriving Ely Schless' latest creation in *A Spin on the Power Bike*. Shari Prange continues with the detail an EV owner must give to *Electric Vehicle Charging and Maintenance.* The last article, *A Visit to a Lead Recycling Plant*, from Steve McCrea, came in with a flood of mail, phone, fax, and email on a related topic. A preliminary report of a study conducted by Carnegie-Mellon on the impact of EVs on the environment seemed unusually harsh on emissions from lead mining, manufacturing, and recycling in connection with electric vehicles. So, a sidebar,

prepared by HP crewmember Donna Worden highlights some of the responses, from sources, such as the Union of Concerned Scientists, California Air Resources Board, SMUD and others. It all makes for, an interesting read. We've also gotten a report about who *funded* the "study." Of course – the damage is already done. (More on this next issue!)

REDI Conference '95
For the transportation side of REDI (Renewable Energy Development Institute), I'm happy to announce that Stanford Ovshinski (President of Ovonics, the manufacturer of the nickel-metal hydride battery) and Steve McCrea (author of *Why Wait for Detroit!*) will be keynote speakers. Other exciting events, people, and machinery are in the works. REDI is shaping up nicely.

Machinery Recycling
Oh, yeah, on the way back from Arcata, the HP Crew made its traditional stop at the Indian Creek Cafe (Happy Camp, CA). While everyone perused the 32-page menu, I walked back along the road to snap a picture of nature at work. Who says machinery can't be composted!

Gotten any Cat Faxes?
Everybody knows that the HP office abounds with cats. We figure a cougar got a mess of them a month ago. Well, there's ten kittens ready to take their place, two of them HVK's (high-velocity kittens). They can now work the fax. And I'm wrapping this one up before they get on my keyboard!

The Saga of Shopping Cart Racing

WILDCAT ONE

Clare Bell

Clare Bell on Wildcat One between heats.

Photo by Richard Rahders

"First of Three Parts"

What has two motors, two batteries and can scream around a pylon cone or lug logs up a hillside? Wildcat One, a built-from-the-ground-up cheapo EV (electric vehicle) that uses a modular drivetrain simple enough for backyard builders and fast enough to power a shopping cart racer. (Shopping cart racer? Patience, all will be revealed.)

Wildcat, or "Fang," as I have dubbed the prototype, is configured just like a garden tractor or an earthmover. This little EV is articulated with a pulling drive unit and a trailer. It uses Group 27 marine starting batteries. Trailer and tractor are coupled with a pin hitch. Hitch location is not just a tag-on afterthought, but a part of the vehicle's designed-in stability at speed. The link also adjusts to accommodate the driver's leg length.

Look Ma, No Controller, No Gears!

The most unusual part of Wildcat's design is the use of dual footpedals that control drive motors on each wheel. The tractor is actually made up of two identical (though mirror-imaged) independent subassemblies. Each subassembly has a footpedal with a toe-switch accelerator and a heel brake. Instead of varying motor speed via an electronic controller or changing drivetrain speed with a gearbox, Wildcat uses two V-belts that are driving pulleys. The footpedal and motor assembly are mounted on a pivot shaft. Toe pressure not only closes the motor contact but also tensions the V-belt, changing the amount of slippage against the pulleys. Belt slippage is what gives this simple mechanical transmission its infinitely variable characteristic.

This gives performance equivalent to a vehicle equipped with a gearbox and controller without the expense of either! Bob Schneeveis, of SnoWhite fame, came up with this nifty little design. Wildcat's drivetrain is self-contained and modular. It doesn't have to go on the vehicle described here. With a little engineering ingenuity, it could bolt onto anything.

Driver Interface

Driving this EV is fairly simple once you get used to its unusual design. In fact, it is in some ways simpler than driving a stick-shift car or motorbike. The tricky bit is learning to use the footpedal controls in combination with hand steering.

To turn, you just push with one foot or the other. The toe-switches are quite stiff, so that you can exert enough force on the footpedal to turn the vehicle without actuating either motor. This gives you a nice, sweeping, shallow turn. You can also do tighter, powered turns by driving the outside motor while braking the inside one. This requires some coordination, but once mastered, it gives unbelievable cornering capability. I can make Fang do donuts and pivot on the inside drive wheel. But that comes later. Hey, we haven't got the thing built yet!.

The Idea Trail

You may be wondering what sort of strange and wonderful path led to this admittedly odd little vehicle. I sometimes wonder myself, since what I ended up with was radically different from the original concept. Actually, it was not so much a continuous path as a series of rebounds off reality, spinouts, collisions and recoveries.

It began, as many projects do, with a need. A friend of mine has mobility problems due to diabetic complications. He needed a four-wheel "motivator" type mobility cart. However, after seeing the prices on these specialty EVs ($2-5K new and not much less used), I decided to build something. Subsequently, the "need" was satisfied by a rental cart. Then, a new sport started up, and my desire to participate radically reshaped the original design into a racer.

Shopping Cart Racing?

You've heard of barstool racing? Lawnmower racing? Belt-sander racing? Well, here's the newest version of mobile craziness and trash sport with an EV twist—shopping cart racing.

It all began in a warehouse not so long ago and not so far away. In Alameda, California, to be exact, in the warehouse where Jim McGreen assembles his Zap! electric bikes. Zap! uses only part of the floor space; the rest is occupied by creative souls doing various and sundry structural and decorative modifications to boats, old cars, bicycles, etc.

In short, there was a high concentration of skill, inventiveness and off-the-wall attitude which was intensified when Bob Schneeveis brought over his electric racing wheelbarrow. Add to the brew some nighttime madness, welding equipment, tools, motors and bicycle parts. Into this volatile mixture wandered a few battered shopping carts, probably abducted and then abandoned by homeless folk. These otherwise unpromising items were the spark that ignited the mixture. When the smoke cleared, a new kind of vehicle emerged—the human- or electric-powered shopping cart.

As soon as the warehouse wildfolk had built two of these contraptions, the question arose as to which was faster. They competed first among themselves, but

Monterey entry in rear-wheel drift. Photo by Alec Rayle

outside challenges soon arose. The Alameda warehousers took on the personas of pirates and dubbed themselves the Clement Street Jolly Rogers.

Yes, There ARE Rules

The races take place inside the aforementioned warehouse, the track being an oval defined by two cones set seventy feet apart. The contests are short and fast, three (or four at most) laps, and are run as elimination series with two vehicles competing at a time. The one that emerges at the top of the heap wins the coveted "Golden Caster."

The rules are:

•***Chassis***. The racer must begin as a shopping cart and be recognizably derived from same. Sticking a shopping cart basket on the back of an electric go-kart is not kosher. However, building a go-kart-like vehicle from shopping cart parts is perfectly OK.

•***Motive power***. Must be electric or human or a combination of both. No infernal combustion engines!

•***Braking***. It has to be able to stop. How this is done is not specified, but the vehicle must be able to bring itself from a suicidal forward hurtle to some semblance of stationary stability. Driver, major parts and wheels must still be attached, and no foreign objects, alive or otherwise, may decorate the front.

•***Casters***. Two of the original shopping cart casters must remain on the vehicle and touch the ground at some point during its run. These can be trailer wheels, wheelie wheels, etc.

There had been a fifth rule that involved the ability to carry a bag of groceries, but that one was quickly abandoned as competition heated up.

Mad Dog leads until one of his skid-arounds turns into a spinout. Toes-down on Fang's footpedals, I pull back on the wheel to lift the casters and run only on the drive wheels to maximize speed.

A prime unwritten rule is that vehicles should be built out of "found materials." Throwing money at such a project is a faux pas of the greatest magnitude and contrary to the spirit of the sport. Those who commit such sins shall be greeted with derision and a barrage of stale marshmallows (the stale ones sting!) from the Tank's on-board cannon.

(Despite the above, I suggest that the original shopping cart be procured as legally as possible. Junked ones, with the nameplates broken off or rusted over, are fair game. Carts that inhabit grocery store parking lots are off-limits, as are ones being used by homeless folk.)

The rules were designed to minimize restrictions and encourage the most ingenuity. They work. I have seen more diversity and creativity in the present population of shopping cart racers than you would find in the whole of Detroit.

Despite the craziness, participants do pay attention to safety. Vehicles have roll bars, cages, padding, impact bumpers and other types of driver protection. Drivers must wear helmets. Many also wear gloves, jackets, motorcycle leathers and even motocross gear. Before any racing begins, however, everyone (including spectators) stands, raises their right hand and chants The Litany. To paraphrase:

"Shopping cart racing … is inherently dangerous … Someone could get hurt … including me … Therefore, I acknowledge this risk … and I will take it upon myself … to ensure that I stay safe."

This is the same sort of disclaimer used in most competitive motorsports and any potentially dangerous spectator sport.

Competing for the Golden Caster

With formalities over, the race begins. Gentlepersons, hit your contactors!

Running against me is "Mad Dog" Jimmy Kirkpatrick and "11:53," his killer go-kart. I line up "Fang" at the center cone opposite "Mad Dog." (This 180° separation minimizes the chances of collision.) Racemaster Nancy Cadigan gives the count and both vehicles launch across the concrete floor. Mad Dog throws his vehicle around his first corner cone, spinning the kart's racing slicks to skid the rear end. Fang can corner well, but I haven't quite mastered her yet and I run wide. Her casters bump and bang over rough concrete at the edge of the track.

Mad Dog leads until one of his skid-arounds turns into a spinout. Toes-down on Fang's footpedals, I pull back on the wheel to lift the casters and run only on the drive wheels to maximize speed. Tight around the corner — too tight. Fang veers over the center line and nearly passes to the wrong side of the center cone.

Mad Dog gets his twin-motor, rear-wheel-drive terror uncrossed and puts on a burst of speed. Fang makes a good tight turn around the last cone and rockets on the straight-away with casters lifted, but Mad Dog is ahead when the checkered flag drops.

Well, Fang "ran a good race", but Jimmy K. and his "11:53" are Golden Caster material. Besides, I'm still learning how to handle my vehicle.

Photo by Alec Raylce

Bob Schneeveis and his electric wheelbarrow.

Photo by Richard Rahders

L to R: Racemaster Nancy Cadigan, Otmar Ebenhoech, Clare Bell, (unknown), and Jimmy Kirkpatrick

Recipe for a Golden Caster Winner

Tight turning, acceleration, stability and controllability are the key requirements. In the beginning, wild creativity tended to overwhelm functionality. The first vehicles were ingenious but clumsy, depending on the driver's ability to compensate for various idiosyncrasies and recover from upsets. The winner in these early races was the one who could merely keep his/her cart on the course.

Vehicle names reflect the nature and evolution of the sport. ".001," the very first of the breed, was based on a stock shopping cart, but the vehicles soon diversified into go-karts, bicycle/shopping cart hybrids, articulators (Fang) and others. Mad Dog bet a fellow Jolly Roger that he could complete his entry before midnight. He did it with a few minutes to spare, so his racer became "11:53." One has merely to eyeball this contraption to realize that only after nights of profound study of subjects such as couch-warming and beer-chugging could 11:53 have been created. Another racer, "The Dislocator," refers to the state of its creator's elbow after an attempt at "pushing the envelope" (it doesn't push very far in these things).

Having helped to inspire the sport, Bob Schneeveis, along with some members of his SnoWhite pit crew, decided to offer the Jolly Rogers some competition. He built a murderously powerful beast that has to be steered by standing up on a trailer and has a tendency to buck off its driver when entering corners. Being Bob, he added a pair of stuffed toy rabbits animated by a kiddy-car pedal mechanism to the back of his trailer, so that the rabbits do what comes naturally. The faster the vehicle goes, the faster the rabbits. Thus was born "Humping Bunnies," now ably piloted by Otmar Ebenhoech (in full motocross gear plus paid-up health insurance). This combo wrested the Golden Caster away from the Jolly Rogers and still holds it. However, Bob has a hard time keeping his bunnies — the Jolly Rogers take them hostage.

Next issue: *Building a Shopping Cart Racer*

Access

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"Fang" (left), and "The Dislocator"(right) await drivers

Photos by Clare Bell

The last issue of your Home Power Subscription is printed in plain English on your mailing label. You don't have to be afloat in Viet Nam to read it…

Thanks to Marlene Brown (Superwoman who helped install over 100 PV systems in 3 months in Viet Nam) for this wonderful photo of a Vietnamese police officer checking his label on the Mekong River in Tien Giang province.

A Spin on the Power Bike

Michael Hackleman

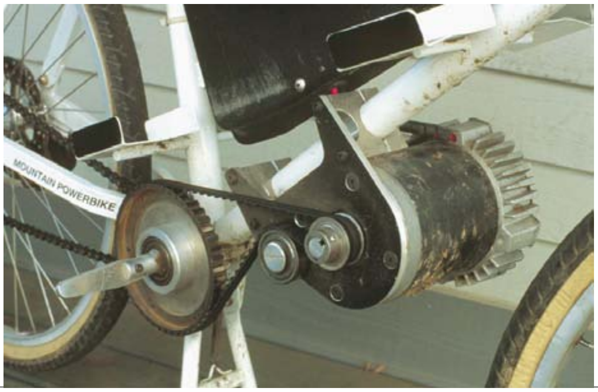
When I drive a vehicle, I like it that I run out of courage before I run out of performance. That's what it's like to test drive the PowerBike. Off the line like a startled cat. Momentum recharges the battery pack everytime you use the brake, with a braking force that you control. *Maximum* will pitch you over the handlebars!

Ely takes the grade on Eagle Mill Road outside Ashland, Oregon.

Photos by Michael Hackleman

I'm no stranger to the NoPed series of machines that Ely Schless has developed. I have thoroughly enjoyed driving *all* of them. Still, I've never liked the idea of adding 100 pounds of machinery to a bicycle. I got over that notion just a few minutes into the test drive of the PowerBike by adding, "...except when it can go this fast." Thirty-one miles per hour on level ground on a bicycle is *fast.* Any feeling of heaviness in the machine at *rest* evaporates at *speed* and is replaced by blissful momentum. It's nice to know there's some help available in keeping the PowerBike on the ground. This machine has a propensity to fly.

I don't mind going fast if I know I can stop. With so much acceleration, speed, and weight, the PowerBike is operating beyond the capacity of stock rim brakes. So, front and rear, it has disc brakes. They work great but, believe it or not, they're the *backup* system. The primary system is *regenerative* braking, a feature that is built into the prototype of a new controller from Curtis PMC. Ely got a "beta" (a "see if you can blow this up") unit. This is a long-awaited unit for low voltage (12-48 VDC) operation of 1-2 horsepower permanent magnet motors. (Alas, it won't work with *series* motors.)



A gearbelt transfers motor power to a jackshaft, and on to the rear wheel via a chain.

A center module houses controller and charger. Sealed batteries are wired into two fast-exchange saddlepacks.

In the tradition of the NoPed series, the PowerBike has simple controls. There are no shift levers and switches. *Everything* is on the handgrip throttle. A separate switch disables the throttle, but it's there mostly to avoid accidental launches of the vehicle.

On the Road

What happens at the throttle? Let's take a test drive. Hopping on, it's reassuring to feel the suspension "work", fore and aft. Footrests are mounted where the footpedals used to attach to the bike frame. The shaft doubles as part of the drivetrain (see photo). My knees are a comfortable fit against the battery saddlepacks.I ease the throttle on. With narry a whisper or whine, the PowerBike moves away from a stop. It seems like you can increase the rate of acceleration *forever*, it's got so much potential. It *is* possible to spin the tires *and* to jump teeth on the motor drivebelt. If you've an urge to impress someone, use just one-half throttle. Remember, to anybody watching you, you're on a bicycle with saddlepacks. It's no big deal to get noticed on this thing. People can't *wait* to ask about it!

When you back off the throttle, the brakes come on. *Regenerative* brakes. The further you back off, the more braking effect. Let go of the throttle, and you could get pitched over the handlebars! Still, this is *so* intuitive to use, it feels like the way throttle and brakes should be—on *one* pedal. In this case, a handthrottle. Within a few blocks, I realized I had as much braking as I would ever *need*—and more than I've ever *had* before relative to the weight of machine.

Exciting is the word that best fits the roadtest. I enjoyed the speed, talking with folks when I came to a stop, and the relaxing excursions through the countryside. The silence contributed greatly to my enjoyment.

PowerBike comes off the line first *and* stays that way up to 25 mph. Whether weaving through stopped or slow-moving cars, or changing lanes, the necessary speed, acceleration, and braking is there aplenty.

Sorry, I can't be too specific about many design features of the PowerBike. Ely has a sensational vehicle here, and has plans for limited production. I can say that the motor controller AND charger reside inside the center module, the Scott-Doran motor is rated at 1 HP, and the saddlepacks can be exchanged with a duplicate set (freshly charged) in 30 seconds time. Or the PowerBike plugs into the nearest receptacle.

Access:

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Ely Schless, 503-488-8226

MORNING STAR
b/w
3.4 wide
4.5 high

Electric Vehicle Charging & Maintenance

Shari Prange

An electric vehicle requires very little care when compared with an internal combustion vehicle. However, developing good charging and maintenance habits from the beginning will help you get the best performance out of your car.

Charging Facilities

Pay careful attention to the instructions that come with your charger. They may specify the gauge and length of cord to be used. If you use a cord that is too light or too long, it will get hot. This heat is wasted energy that is not going into your batteries. It is also a fire hazard.

If possible, install a dedicated circuit breaker for your charging station. This will maximize the amount of current flowing into the batteries. It will also minimize the possibility of throwing the breaker because your teenager plugged in her boombox and her hair drier on the same circuit while you were charging.

You may prefer to turn on the charger with a switch, rather than just plugging it in. You could wire the charging outlet with a switch beside it. If your circuit box is conveniently placed, you could turn the charger on and off there.

Opportunity Charging

Lead-acid batteries do not have a charging "memory" problem like flashlight NiCds, so there is no need to fully discharge them before recharging. In fact, these batteries do not like to sit in a discharged state for long. For this reason, it's a good idea to charge your car at every convenient opportunity. For instance, if you only drive ten miles a day, charge it every night anyway, rather than once or twice a week.

If you have the ability to charge during the day at work, do so. Many employers are surprisingly receptive to this idea, and even enthusiastic. It's a very inexpensive way for them to support a clean form of transportation.

Driving the same route from day to day, you will notice better performance, range, and longevity from your car if you charge it every day instead of every few days.

An added advantage is that you always have the greatest possible range available to use. Waiting for several days to recharge your car, until it is nearly empty, is like passing gas stations until the you're down to your last gallon. Some day, you're going to come up short.

Charging Temperature

Batteries accept and release their energy better if they are warm. For this reason, enclosing them in boxes and parking inside a garage are recommended. The process of charging and discharging the batteries also creates heat inside the batteries.

This is another argument in favor of opportunity charging. If you plug in the car right after you park it, the batteries are still warm from being driven and will accept a charge better. If you wait several hours, the charge will not be as effective.

This also means that you will see some seasonal variations in the car's performance. It will be more lively and have a longer range in the warm summer months. In cold climates, anything you can do to maintain battery warmth will help. This is the same reason diesel truckers in cold climates use special heating pads around their batteries and plug them into parking outlets for block heaters.

For safety, always leave on the battery caps when charging.

Turning Off The Charger

Of course, you should be using a commercial charger with a tapered charge and all the proper safety features. Leaving the car plugged in at the finish charge level is not recommended long-term. A few hours won't hurt. You don't need to get up in the middle of the night to turn off the charger when the car has finished charging.

A Dormant Car

If the car has been sitting unused for several days, there will be a slight decrease in range and performance, even if it was fully charged before it was parked. You might want to put it on the charger at the finish charge level for an hour before using it, just to perk it up a little.

An even better technique (if it's convenient) is to drive the car hard for a short quick run, then put it on the charger to "top it off." This will get the batteries warmed

Above: It takes a solar array about the size of a household roof to charge an electric passenger car. **Photo by Shari Prange**

and awake and counteract the effects of sitting dormant.

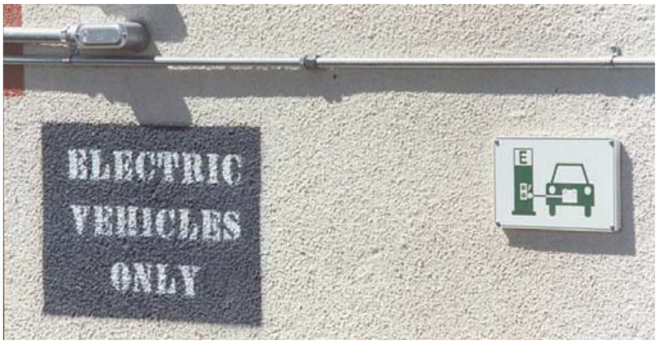
If the car will be dormant for several weeks, it should be charged periodically to keep the batteries healthy. A constant trickle charge is not recommended, since anything more than milliamps will harm the batteries. Instead, about once a month plug in the car and let it go through a normal charge cycle.

Replacing Batteries
If a battery fails in the first year or two of life, there is probably some pro-rated warranty on it, and you can simply replace it. If you are getting well into the third or fourth year, you should consider replacing the whole pack. The failure may be only the first of many as the batteries reach the end of their lifespan. Mixing new and old batteries is not good. The new ones will accept a charge faster and will begin to gas before the old ones are fully charged. This will shorten the life of the new batteries.

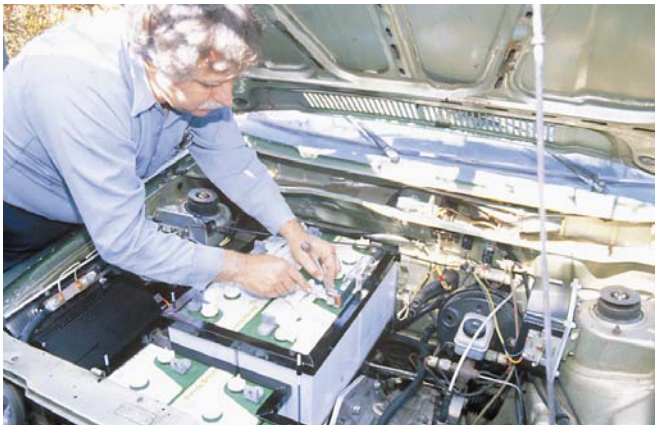
If you do add one or two batteries, there is a technique for equalizing them with the rest of the pack. Put the new batteries in place without wiring them into the string. Using a hydrometer, check the specific gravity on the new batteries. Charge the old batteries until their specific gravity matches the new ones. Then wire the new ones into the circuit and finish charging them all together.

Battery Maintenance
Once a month, inspect your batteries. Be sure the terminal connections are clean and tight. Loose or corroded connections will generate resistance and heat, wasting energy and possibly melting a battery post.

Painting the contact surface between the battery post and the interconnect with an anti-corrosion compound (such as Noalox) will prevent corrosion. You can paint the same compound on the outside of the post and connection as well.



Above: In the near future, electric vehicles will have more reserved parking spaces with charging outlets.
Photo by Shari Prange


Above: Keep the electrical connections on the batteries tight and bright. **Photo by Shari Prange**

Another option is covering the connection with a rubber cap. This prevents corrosion by protecting the post from acid deposits. It also serves as an electrical insulation over the contact.

Be sure the battery tops are clean and dry. A thin film of moisture, dirt, or acid on the battery top can form a conductive path to the chassis that will trip your charger's ground fault interrupter.

Periodically washing the battery tops with clean water, then wiping them clean and dry, will clear away any traces of acid.

Every other month, check the electrolyte level and add water as needed. If the level is below the tops of the plates, add enough water to cover the plates by 1/8" before charging, and check the fluid level more often in the future. Otherwise, add water after the batteries have been charged, to a level 1/4" below the fill neck.

Distilled water is best, but any drinkable water that does not have a high mineral content will do. Avoid metal containers for the battery water.

Mechanical Maintenance
The most important single maintenance check for optimum performance is tire pressure. Check it weekly until you are sure you have no slow leaks, then check it monthly. This should be done when the car has been resting for some time and the tires are cold.

Check your brakes every six months until you learn how fast they are wearing. Depending on your terrain and driving style, you may find you actually use your brakes less often than before.

No Free Lunch
There is no such thing as a "maintenance-free" vehicle. Many diesels became electrics because their owners thought "diesel" meant never having to say "service," and they were wrong. But an electric car comes pretty darn close. If you take care of it, it will take care of you.

Access
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A Visit To A Lead Recycling Factory

Steve McCrea

In 1991, I visited one of the best-run lead smelters and recycling facilities operating in the U.S: Sanders Lead Co. in Troy, Alabama.

Smokestack emissions are tracked on a computer, which reports daily highs and average emissions.

Roy Baggett, the environmental manager, spent over an hour describing the recycling process and then took me on a two-hour tour of the facility. Some highlights:

The training facility. The company trains both new and old staff in new regulations and environmental controls with workshops and videos that explain plant procedures and types of chemicals encountered.

Handling of previous solid and liquid wastes. The manager admitted that when he first came to Sanders, there had been improper past handling practices of lead-contaminated wastes. “That was before people understood about how dangerous lead can be if it reaches the water supply,” he explained. He showed me large areas of the Sanders property where the groundwater is tested regularly to ensure that pumps are keeping the tainted soil from spreading off the company’s property. Double-lined catchments hold wastewater, and a water treatment plant treats battery electrolyte and other liquids to meet federal and state clean-water standards. In another arena, air leaving the smelter is as clean as or *cleaner* than air entering the furnace. Large bags capture nearly all the airborne lead particles that manage to get around baffles and other flow-control devices.

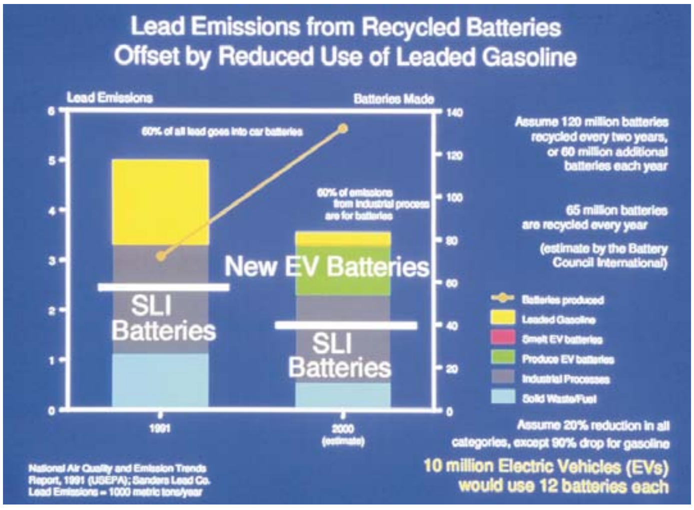
Handling of hazardous wastes generated now. Each of the 12 million batteries recycled each year (80% from gas cars) at the Sanders smelter contains about half a pound of hazardous waste. It is fixated and stabilized before being buried in a managed landfill off the site. Most of the recycled batteries weigh about 35 pounds. 420 million pounds of potential landfill is compacted to recycled lead, treated water and about 6 million pounds of landfilled waste—a 99% reduction.

The Emissions Report

After my guided tour of the Sanders facility, I traveled 50 miles north and inspected the emission permits in Montgomery at the Alabama Department of Environmental Management. According to records at ADEM, the Troy smelter is permitted to emit up to 5.82 pounds of lead per hour through stacks #1 and #5 (the other stacks are for steam and are segregated from the lead smelting air flow). The total *actually* emitted during a test on June 1990 was 0.12 pounds per hour (stack #1) and 0.29 pounds per hour (stack #5), or 0.4 pounds of lead per hour. That works out to be roughly 3,500 pounds of lead per year. The ratio of airborne lead emissions to total battery inflow is 1:120,000, based on a ratio of 3,500 to 420 million pounds (estimated weight of 12 million batteries). In other words, one battery in 120,000 gets vaporized (not 1 in 50, as the recent Carnegie-Mellon study claims).

There had been a smelting plant in Leeds, Alabama, a facility older than Sanders. It had difficulty meeting some of the airborne emission targets. It has since closed. Roy remarked, “If you can’t clean up your pollution, it just doesn’t pay to stay in business.”

“Our future depends on proper management of waste streams and to reclaim them makes sense,” Roy added. Shelves at Sanders display products made 100% from recycled battery plastic and lead. Companies that purchase from Sanders include:



Editor's Note

As we went to press, the HP office was flooded with faxes, phone calls, and mail regarding the publication of a Carnegie Mellon "study" (*Science*, Vol 268, pp 993-995) that forecasts extremely negative environmental impacts from the commercialization of electric vehicles. The *New York Times* used this report as a basis for an article on May 9, 1995, "Electric Cars Called Perilous to Environment." Lead *does* pose a health hazard to human beings and it is important to look at this issue. However, informed agencies are crying foul on this report and are looking more closely at who funded this study. Below, I have included comments from the many letters sent to Carnegie-Mellon, the *New York Times*, and *Science* magazine, among them ones from California Air Resources Board (the agency responsible for the 2% ZEV mandate), Union of Concerned Scientists, Sacramento Municipal Utility District (a leader in EV usage), and other watchdog groups. Look for an article in HP next issue. *Michael Hackleman*

The interior of a lead-smelting plant.

On-site training keeps Sanders' employees informed on good management practices.

Responses:

"One of the study's major flaws was the fact its numerical analysis focused on the total amount of lead that might be discharged into the environment, without distinguishing between airborne particles—the most toxic form—and solid waste at smelting plants, called slag, which can easily be managed so there is little danger of human exposure. Simply looking at the pounds or tons of lead put into the environment strikes me as an incredibly blunt, if not clumsy, approach."—Don Ryan, Executive Director, *Alliance to End Childhood Lead Poisoning*, a national non-profit group

"Lead is the most recycled material used today. About 97% of the lead-acid batteries currently in use will be recycled to make new batteries. Studies show that recycling of lead is an environmentally safe procedure and poses no threat to the surrounding community."—Ruth McDougall, *Sacramento Municipal Utility District*

"In new battery manufacturing plants, lead emissions...will be limited by US Environmental Protection Agency regulations to an amount one-hundredth as great as the study assumed." —*The Boston Globe*

"The conclusions (of the Carnegie-Mellon piece) are misleading and overstated. Human exposure to lead, even if you had a substantial increase in use of batteries, is not going to be a problem."—Daniel Sperling, Director, *Institute for Transportation Studies*, University of California, Davis

"They (the Carnegie-Mellon authors) have really gone out of their way, for whatever reason, to really make electric cars look bad. For example, figures given in the study for an 'available technology' car overstate the weight of the batteries by a factor of three, and underestimate the energy those batteries can store by half."—Ronald Hwang, a Senior Analyst with the *Union of Concerned Scientists*

"The study grossly overestimates the number of EVs expected to be on the road in the next decade. One of the study's key findings is premised on EVs making up 5% of the national car fleet (10 million EVs). California, Massachusetts and New York's zero-emission vehicle programs will put approximately 50,000 vehicles on the road in 1998 and just 500,000 by the year 2003. Cleaner, more efficient battery technologies, nickel-metal hydride, lithium polymer, and composite flywheels, are already favored by some manufacturers and are likely to enter the market by the year 2000. The bigger the market for EVs, the bigger the incentive for improved batteries."—Michelle Robinson, *Union of Concerned Scientists*' Transportation Program

"Carnegie Mellon University has received money from petroleum and auto interests to support a consortium that funded the controversial study regarding the potential environmental effects of lead-acid batteries".—*Science: Journal of the American Association for the Advancement of Science*

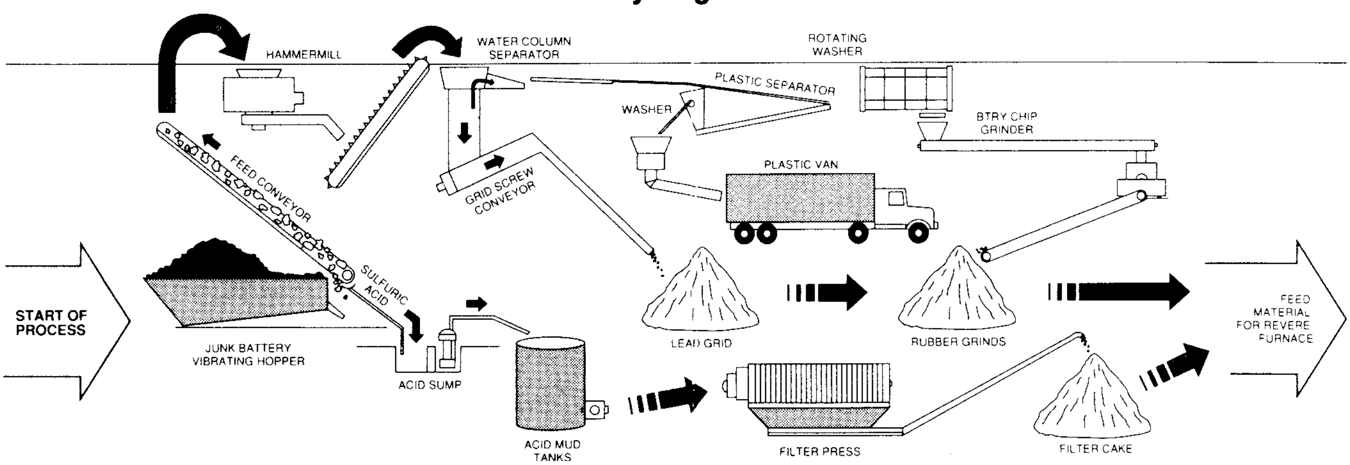
"The Carnegie Mellon study overestimates lead emission rates by ***a factor of 44*** for primary smelting, ***400*** for battery manufacturing, and ***1000*** for secondary smelting."—Tom Cackette, Chief Deputy Executive Officer, *California Air Resources Board*

"As illustrated by this small sampling of reactions, the Carnegie-Mellon study was based on bad assumptions, old data, and biased representations. Therefore, the conclusions reached are highly suspect. It is unfortunate that a document ripe with mathematical errors and inconsistencies was given such a national forum and attention."—Patrick Kennedy, *Sacramento Municipal Utility District*

"A gasoline vehicle with a flooded lead-acid battery would never be allowed to be commercialized in today's strict regulatory environment. Yet there are 49 million gasoline cars, each with a lead-acid battery." [There are an additional 139 million vehicles (trucks, buses, motorcycles, etc.) in the U.S., each with a lead-acid battery.]—Ruth McDougall, *Sacramento Municipal Utility District*.

(Quotes compiled by Ruth McDougall & Donna Worden)

The Recycling Process



•Lead & plastic: Johnson Controls and GNB Battery.
•Lead only: Crown Battery and Douglas Battery.
•Plastic only: Ford Products.

Access

Steve McCrae, Editor, *Why Wait For Detroit? Drive An Electric Car Today!* 2314 Desota Drive, Fort Lauderdale, FL 33301-1567 • 305-463-0158 • Fax 305-462-4423

EH Pechan & Associates, 3500 Westgate Dr. # 103, Durham NC 27707 • 919-493-3144 • Fax 919-493-3182, contractor to EPA on lead emission data.

Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources, AP-42, published by the EPA. Special thanks to Randy Strait and T. Allan Dean.

National Air Quality and Emissions Trends Report, 1991, EPA

USA Today, Nov. 13, 1991, “Used Motor Oil Called Key Lead Source”

Crawl Space Fit for a King

Jerry Solobay

After two years of designing, my wife and I were finally ready to start building our dream home. The two years seemed an appropriate length of time required as this was the first time we had ever built a house. The challenge was to build a tasteful, functional and inexpensive house on a narrow and steeply sloped mountain cliff edge 300 feet above the Fraser River in British Columbia, Canada.

In order to get enough space for a 30 foot wide house we had to drill and blast back into the rock face behind the future house site. This left the rear of the house buried over fifteen feet below the back elevation grade while the front (cliff face) was just level with the foundation footings. Needless to say, it took a lot of concrete (103 tons) and rebar to complete the foundation that ended up fifteen feet high in the rear and just six inches high in the the front. We planned on using the standard practice of insulating the inside of the concrete walls with fiberglass or rigid foam insulation. The two methods are basically the same and only vary in the thickness of the stud cavity required and cost. The fiberglass requires a 2 x 6 stud cavity to get R–20 and the rigid foam needs only 4.0”. Since this insulating wall takes up useable living space, we opted for the thinner rigid foam wall which, of course, is the more expensive option.

Once the foundation was complete we could see we had a major back fill requirement to fill the gap between the tall foundation wall and the blasted rock face. The problem was we had tons of chunky shot rock and dirt mixed together which was not acceptable to place against the concrete wall. The natural solution would be to truck the bad fill away and then buy and haul good fill in. This did not fit in with our idea of inexpensive nor would the budget allow for such unexpected costs to occur so soon in the building process.

The solution came while looking for exterior doors. The standard steel exterior door is constructed by taking a wood frame and covering it with a skin of sheet metal. This metal sandwich with wood borders is then filled with a foam insulation which expands to fill the cavity and then hardens to make a very stiff and warp free door. We discovered that all the doors were made solid, without any openings, and that window and hardware holes were cut out after the foam hardened. This led us to ask the question, what happens to the large cut outs made in French doors that are currently so popular? A few weeks and many phone calls resulted in the name of a manager at a brand new door factory that was just a half hour away from our site. He informed us that the cut outs were just bulky garbage that he has a hard time getting rid of and that we could take as much as we could carry.

You can imagine our delight—free armour-plated insulation that we could place against the outside of the foundation wall. Surely the steel covered foam would take the brunt of any rocks that hit the wall during the back fill and we would now have free insulation on the outside instead of expensive space-robbing insulation on the inside. We rented a trailer and headed out to the door factory that very weekend. We found the panels stacked on skids and tied with steel strapping. There were 54 panels per skid and each panel was 5’ 4” by 1’ 8” by 1.75” and weighed about 18 pounds. We cut off the strapping and hand loaded the panels one by one. They were sharp edged and very dusty because of the routing process used to cut them out.

When we got back to the site we put on dust masks before we started to unload. After about ten minutes we were abruptly stopped by the arrival of two police cars. It appeared the block watch program in our rural area was functioning well as we were informed that there was a report of suspicious activity (unloading the trailer) by masked persons unknown. After a few minutes of laughter and recording of our driver's licenses we were back to work.

The moment of truth came when we finished the first row along the bottom wall. I rolled the biggest rock I could move over the cliff's edge so that it crashed into the door panels. The result was a big noise, a pierced steel panel skin with a 1/2 inch dent and a minor crack in the foam. This was quite acceptable as no self-respecting excavator operator would ever back fill as carelessly as I did in my test.

Of course, now that the back filling problem was solved we started to think of all that free insulation. I called the door salesman and asked him the R value for a door panel. He told me it was R–13.4 for the 1.75" thick panels. I thought if we put two panels against the foundation walls, we would have R–26.8, which is 30% better than the standard fiberglass insulation in the 2 x 6 stud cavity! We went insulation crazy. R–26.8 on all exterior concrete walls and around the footings too!! R–13.4 under the crawl space skim cost, R–26.8 and R–40.2 under the kitchen and living room floor slabs. We also put a triple layer (R–40.2) along the very bottom row of the 15 ft wall just in case the back filling was a little rough.

We found the best way to hold the heavy panels against the concrete was to use a generous glob of silicone in the two upper corners and let each row set over night before doing the next row. The concrete had already been tarred over for water proofing, so the high spots had to be scraped smooth as the steel skin would not sit flat if there were any bumps on the wall.

The backfilling was blissfully uneventful. When it came to insulating the wood framed part of the house, we used a contractor. It is a very competitive business and we got a firm price quote for fiberglass insulation and vapor barrier supplied and installed for the same price that would just cover the cost of buying the insulation if we did it ourselves.

We explained that no insulation was required on any of the concrete surfaces and the contractor's only request was that we remove materials, ladders, tools and boxes from all of the floor areas as they worked best in a flat open space. We agreed to clean up and stored everything in the crawl space which is a 375 square foot area, four feet high, tucked in the bottom corner of the 15 foot concrete foundation wall.

The contractor was scheduled to start on a Monday, so I went out to check his progress that night. I was amazed to see they were almost finished. As I checked out their work, I noticed that the folding chair I had used to block the entrance to the crawl space was gone. I looked in the crawl space and was shocked to see that all the neatly piled supplies we has stored there had been tossed around like a hurricane had passed through. As I surveyed the mess, I discovered what had happened and I started to laugh. The wood floor over the crawl pace is not fastened to the concrete walls, instead it sits on a 2 x 6 pony wall that rests on the concrete footings. When the workers looked into the crawl space they saw the 2 x 6 stud cavities and went into insulating autopilot. They had probably has a few choice words for whomever piled everything against the walls they thought they had to insulate. They felt quite justified in moving everything out of their work area in the fastest and easiest way they could.

So we now has a crawl space that had three layers of door panel insulation, ten inches of concrete wall water proofed on the outside and five 1/2 inches of fiberglass insulation, vapor barriered on the inside. This gave us a total R value of:

3 times R–13.4 for the door panels = R–40.2
10 inches of concrete = R–1.1
5.5 inches of fiberglass = R–20.0
Total insulation R value = R–61.3

We sleep well at night knowing our super-insulated home was not only cost effective to insulate but will also save money on yearly heating costs. We figured the cost to buy the equivalent amount of rigid foam insulation would have been about $2,500. Also we were environmentally friendly by using materials that would have ended up in some land fill and we have reduced the energy crunch by lowering our need for heating energy for years to come.

In hindsight we did not believe how much time we would spend on our free insulation. We made about half a dozen trips and hand loaded, unloaded, cut and laid down or glued up over 550 panels which adds up to just under five tons! We spent over two weeks of our labor doing this but there is a strange comfort in having the warmest and driest unheated crawl space on the mountain.

Access

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PV Commercialization in the Era of Restructuring:

The IPP Program

Don Loweburg

Throughout the United States, the utilities are changing the way in which they use Photovoltaics (PV). With some of these changes come serious anti- competitive consequences that can and should be avoided because there are better ways to commercialize PV.

During the last 10 years, utilities have done R&D photovoltaic demonstration projects almost exclusively using central grid-connected power plants. In the last year and a half, however, utilities have shifted their strategy and launched efforts to place utility owned PV generation directly on customers' premises. Both offgrid and ongrid programs employing this approach are well underway. Some of the current programs are being partially subsidized by Department of Energy (DOE) funding as part of a national program to commercialize PV. This program has been named "Project TEAM UP." These programs differ significantly from earlier ones in that they are implemented at the customer site, the point of load.

Customer sited, utility owned generation has serious anti-competitive consequences. Photovoltaic generation, being a modular mass produced technology, offers the utility customer the opportunity to self-generate and bypass the utility. Customer abilities to compete with the utilities are diminished by utility access to significant Federal subsidies, specifically DOE TEAM UP grants. These subsidies, coupled with the advantages enjoyed by regulated monopolies, will erect competitive barriers. In turn, this will foreclose the eventual development of a mass market of PV end-users producing electricity in competition with the utilities. In fact, this utility bypass market is already served by competitive PV service companies in all states of the nation.

A successful commercialization program for PV would stimulate end-user purchases and through free market mechanisms build and further develop the PV service infrastructure already in place.

A commercialization program promoting end-user purchases of PV would include five essential elements. These are the following: (1) Defining and determining the value of dispersed generation and "unbundled services"; (2) Net Periodic Metering for utility customers; (3) Establishing incentives for end-user purchases of PV generation; (4) Limiting Investor Owned Utility (IOU) monopoly abuse; and (5) Developing recognized technical standards for equipment and installation practices. Each of the above elements requires some explanation.

First, the term "unbundling" denotes separating the functions of generation, energy efficiency, coordination and system control, and transmission and distribution. As utilities become restructured, determining the value of these functions becomes important. Dispersed generation, including customer self-generation, has Demand Side Management (DSM) and Transmission and Distribution (T&D) benefits. In addition, dispersed generation coupled with storage capability would offer power dispatchability. By accounting for these values accurately, self-generation becomes economically more attractive.

Furthermore, self-generation with PV has other values not yet economically quantified. Of significant economic value is the possibility of power backup in the event of utility outage or failure. Small businesses, home offices, computer BBSes and locations providing critical medical support could all benefit. In addition, another value of PV generation is demonstrated by the Sacramento Municipal Utility District's (SMUD) "Green Pricing." SMUD has a PV Pioneer Program in which over 200 customers elect to pay a surcharge every month to have PV generation mounted on their rooftops. Yet more difficult to quantify economically, but significant, is a widely expressed desire by many Americans for energy independence. Thus, one element in a successful PV commercialization plan would be to explicitly evaluate and communicate these benefits and value adders to the consumer.

Second, Net Periodic Metering (Net Metering) describes a method of interconnection between a self-generator and the utility. In essence, the arrangement allows electricity to flow in both directions through a single meter. When a self-generator has an excess of power, the meter reading goes down. When the customer needs power, the reading goes up. In this way only the net power used is accounted. There are a couple of basic restrictions generally imposed in this arrangement. For example, the producer is not in the business of selling power to the utility. Also, the generating capacity is limited, usually in the range of kilowatts of generation. These restrictions limit any unfair impacts on the utility and the utility ratepayers. This arrangement can best be understood as a loan of power. As such, it is fair. The utility has use of the power during peak need periods, especially mid-day summertime, while the self-generator can use the grid as an electricity bank, retrieving power at night or at other times of need. In this way, the customer-producer reduces the PV system cost by eliminating or reducing the requirements for battery storage. Finally, it has been demonstrated that net metering materially increases the economic incentive for a homeowner to install PV. If net metering were available nationally, a huge potential market for the commercialization of end-user PV would be created.

Third, government sponsored incentives would stimulate consumer purchases of PV. For example, one program with almost no cost to the national treasury would be to require that PV equipment be included in qualifying mortgages under Freddie Mac and Fannie Mae loan guaranty programs. If the Federal Government explicitly qualified PV systems under its loan programs, local lenders would consider these loans as less of a risk and homeowners could cover the cost of the PV system in their home mortgage. PV equipment standards are equal to those applied to appliances and equipment such as pumps, air conditioning, refrigerators and other items, all routinely folded into a home mortgage. Therefore, PV should be a part of the mortgage package as well.

Another government incentive that could significantly accelerate the commercialization of PV would be the creation of a fund to provide low interest loans to qualified homeowners purchasing PV systems. By helping with the interest rate on the loan, the government would be effectively leveraging taxpayer money. For example, instead of giving away over one hundred million dollars to the utilities, as planned in Project TEAM UP, the same money could generate over two billion dollars worth of low interest loans for the purchase of PV systems. Ironically, the United States Government is currently funding projects in other countries that help individual families purchase PV systems. For example, in South Africa the DOE is supporting PV in this way. According to a press release from Renewable Energy for African Development (READ), "The multimillion dollar first phase in South Africa will include the establishment of a credit facility to allow consumers to purchase up to 4,000 photovoltaic home power systems in rural areas." Modest incentives structured to benefit the electricity consumer can significantly accelerate the commercialization of PV.

Fourth, the utilities can play a role in the commercialization of PV and they can do this without abusing their monopoly privilege. Of course, PV generation located on utility property poses no problems and should be encouraged. In addition, utility owned PV placed on leased sites may also be acceptable. Another appropriate role for the utilities would be financing the purchase of PV by homeowners. In fact, Southern California Edison (SCE), in its experimental offgrid PV program, is doing this through a lease-to-buy program. As their offgrid program is refined, it may serve as a model for utility grid-connected PV programs.

However, utility ownership of customer sited PV systems at this time can not be allowed because it is anti-competitive and is a blatant abuse of the utilities monopoly status. Consumer groups like California based Toward Utility Rate Normalization (TURN) and Utility Action Consumers Network (UCAN) and others support this conclusion. To illustrate, let us imagine some years in the future when PV system prices have dropped and many people are purchasing them to either reduce or eliminate their utility bills. One could conclude that PV power has become competitive with utility power. At that time, then, there would not be anti-competitive concerns if utilities wanted to place their PV on customer rooftops. But the undisputed present reality is that most homeowners cannot afford to purchase PV systems. Utilities, enjoying the benefit of being regulated monopolies, can purchase PV. Doing so and placing the PV on customer rooftops is anti-competitive. Government subsidies, to the extent they are acceptable at all, should be used to level the playing field, not tip it further to the disadvantage of the taxpaying consumer of electricity, as Project TEAM UP does.

Fifth, for widespread commercialization to proceed, residential PV systems must comply with national and local electrical codes. One of the most effective ways for this to be accomplished is for the equipment itself to be certified by recognized testing laboratories such as UL and ETL. Local inspecting authorities almost universally accept these standards. Recognizing this fact, major PV equipment manufacturers are now seeking and receiving certification.

Similarly, installation practices must also meet electrical code requirements in addition to the specialized requirements of good PV design. Ongoing training within the PV industry is ensuring electrical code compliance. In fact, many PV installers are electrical contractors and this soon will be the norm. The commercialization of PV depends on continued equipment certification and an expanding infrastructure of trained and qualified service providers.

PV has been described as being on the verge of commercialization. Like a large stone perched on a hilltop, it won't roll downhill on its own until nudged over the edge. The measures outlined here can do that. Further, they are directed toward the appropriate market, the end-user.

Maybe more than anything else, the commercialization of PV hinges on the nature of the technology itself and human nature. From the perspective of human nature, things happen because people want them to happen. Neither early automobiles nor personal computers were cost effective when initially available in the market. Yet enough people bought them to make it happen. And like the personal computer, PV is an enabling technology. It can change the way things are done.

CA PV4U June '95 Meeting
In what constituted a last minute cliff hanger, Southern California Edison chose to announce an ongrid PV Advice Letter (AL) that includes no utility ownership of rooftop PV systems on customers premises. As outlined, the filing would be for five years and pass all DOE or other subsidies along to the customer to help buy down the system cost. It will keep competitive bidding on Edison leased systems and add a contractor's customer option (in this scenario a customer and contractor may establish a relationship, then go to Edison for financing. At IPP's suggestion, a voice consensus determined there was no opposition to the SCE filing as outlined, though Mike DeAngelis of the California Energy Commission insisted on distributing a ballot at a later time.

Jim Kemp of Enron Corporation, a large unregulated energy company, went into considerable detail attempting to convince all the attendees that they (Enron) were the ones to be worried about, not the poor hamstrung utilities (all that nasty regulation, you know). Enron is promising $2/watt thin film PVs in 2 years. This got everyone's attention, but we've heard similar claims before. Time will tell.

I took the initiative and suggested to DeAngelis and a couple of other attendees that the Collaborative continue to meet and focus on some specific projects like developing financing opportunities and PV infrastructure development. These activities would be consistent with the purpose of accelerating the commercialization of PV and serve all segments of the industry. My goal here is to make the collabs more independent of the Utility PhotoVoltaic Group (UPVG) and less focussed on serving utility interests.

IPP plans to be present at REDI in August and present our PV Commercialization Plan at that time.

Access
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Code Corner

Example Systems Stand-Alone Hybrid System

John Wiles

This Code Corner will continue the series of examples on the selection of the wiring, overcurrent devices, and disconnects for various types of PV systems. These designs will meet the requirements of the National Electrical Code (NEC). These are examples only and should not be used to define the requirements for any particular system. No information will be presented on sizing the PV array. The array sizes and the loads are used only for illustration. Calculations for a specific system should be accomplished using the methods presented in previous issues of Home Power. The example in this Code Corner will cover a complex residential hybrid PV system with a backup generator.

The system described below and the calculations shown are presented as examples only. The calculations for conductor sizes and the ratings of overcurrent devices are based on the requirements of the 1993 NEC and on UL Standard 1703 which requires specific instructions in the installation manuals of UL-Listed PV modules. Local codes and site-specific variations in irradiance, temperature, and module mounting as well as other installation particularities dictate that these examples should not be used without further refinement. Tables 310-16 and 310-17 from the NEC provide the ampacity data and temperature derating factors.

Medium Sized Residential Hybrid System
Array Size: 40, 12-volt, 53-watt modules
Isc = 3.4 amps, Voc = 21.7 volts
Batteries: 1000 amp-hours at 24 volts
Generator: 6 kW, 240-volt ac
Loads: 15 amps DC and 4000-watt inverter,
efficiency = .85

Description
The 40 modules (2120 watts) are mounted on the roof in subarrays consisting of eight modules mounted on a custom single-axis tracker. The eight modules are wired in series and parallel for this 24-volt system. Five source circuits are routed to a custom power center. Single-conductor cables are used from the modules to roof-mounted junction boxes for each source circuit. From the junction boxes, UF sheathed cable is run to the main power center.

Blocking diodes are not used to minimize voltage drops in the system.

A prototype array ground-fault detector /array disabler provides experimental compliance with the requirements of NEC Section 690-5.

The charge controller is a relay type. Diversion loads are used to keep the batteries operating below 90% state of charge. The batteries are fully charged once a week.

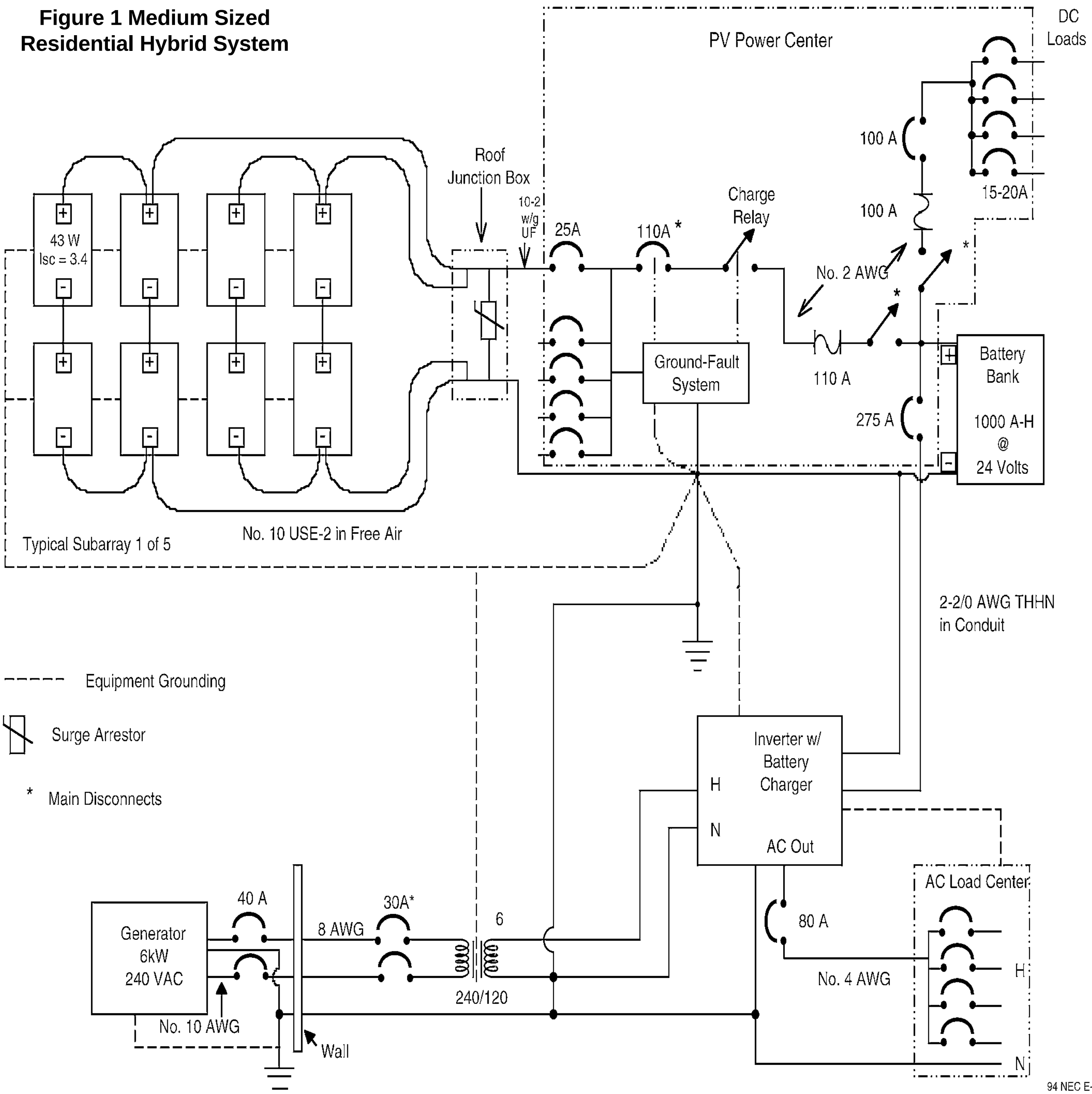
DC loads consist of a refrigerator, a freezer, several telephone devices, and two fluorescent lamps. Peak current is 15 amps.

The 4000-watt sine-wave inverter supplies the rest of the house.

The 6-kW natural gas fueled, engine-driven generator provides back-up power and battery charging through the inverter. The 120/240-volt output of the generator is fed through a 6 kVA isolation transformer to step it down to 120 volts to deliver full power to the inverter and the house. Figure 1 presents the details.

Calculations
The subarray short-circuit current is 13.6 amps (4 x 3.4).
UL 125 percent: 1.25 x 13.6 = 17 amps
NEC 125 percent: 1.25 x 17 = 21.25 amps
The temperature derating factor for USE-2 cable at 61-70°C is 0.58.
The ampacity of number 10 AWG USE-2 cable in free air at 70°C is 31.9 amps (55 x 0.58).

Figure 1 Medium Sized Residential Hybrid System



The temperature derating factor for UF cable at 36-40°C is 0.82.

The ampacity of number 10-2 w/gnd UF cable at 40°C is 24.6 amps (30 x 0.82). Since the UF cable insulation is rated at 60°C, no further temperature calculations are required when this cable is connected to circuit breakers rated for use with 75°C conductors.

The source-circuit circuit breakers are rated at 25 amps.

The PV array short-circuit current is 68 amps (5 x 13.6).
UL 125 percent: 1.25 x 68 = 85 amps
NEC 125 percent: 1.25 x 85 = 106 amps

A 110-amp circuit breaker is used for the main PV disconnect after the five source circuits are combined.

A 110-amp RK-5 current-limiting fuse is used in the charge circuits of the power center, which are wired with number 2 AWG THHN (170 amps with 75°C insulation) conductors.

The DC-load circuits are wired with number 10-2 w/gnd NM cable (30 amps) and are protected with 20- or 30-amp circuit breakers. A 100-amp RK-5 fuse protects these discharge circuits from excess current from short circuits involving the batteries.

Inverter
The inverter can produce 4000 watts ac at 22 volts with an efficiency of 85 percent.

The inverter input current ampacity requirements are 267 amps ((4000 / 22 / 0.85) x 1.25).

Two 2/0 AWG USE-2 cables are paralleled in conduit between the inverter and the batteries. The ampacity of this cable (rated with 75°C insulation) at 30°C is 280 amps (175 x 2 x 0.80). The 0.80 derating factor is required because there are four cables in the conduit.

A 275-amp circuit breaker with a 25,000-amp interrupt rating is used between the battery and the inverter. Current-limiting fusing is not required in this circuit because there are no circuit elements that need protection from high short-circuit currents.

The output of the inverter can deliver 4000 watts ac (33 amps) in the inverting mode. It can also pass up to 60 amps through the inverter from the generator while in the battery charging mode.

Ampacity requirements, ac output: 60 x 1.25 = 75 amps This reflects the NEC requirement that all circuits not be operated continuously at more than 80% of rating.

The inverter is connected to the ac load center with number 4 AWG THHN cable in conduit, which has an ampacity of 85 amps when used at 30°C with 75°C overcurrent devices. An 80-amp circuit breaker is used near the inverter to provide a disconnect function and the overcurrent protection for this cable.

Generator
The 6-kW, 240-volt generator has internal circuit breakers rated at 27 amps (6500-watt peak rating). The NEC requires that the output conductors between the generator and the first field-installed overcurrent device be rated at least 115 percent of the nameplate rating ((6000 / 240) x 1.15 = 28.75 amps). Since the generator is connected through a receptacle outlet, a number 10-4 AWG SOW portable cord (30 amps) is run to a NEMA 3R exterior circuit breaker housing. This circuit breaker is rated at 40 amps and provides overcurrent protection for the number 8 AWG THHN conductors to the transformer. These conductors have an ampacity of 44 amps (50 x 0.88) at 40°C (75°C insulation rating). The circuit breaker also provides an exterior disconnect for the generator. Since the isolation transformer isolates the generator conductors from the system electrical ground, the neutral of the generator is grounded at the exterior disconnect.

A 30-amp circuit breaker is mounted near the PV power center in the ac line between the generator and the transformer. This circuit breaker serves as the ac disconnect for the generator and is grouped with the other disconnects in the system.

The output of the transformer is 120 volts. Using the rating of the generator, the ampacity of this cable must be 62.5 amps ((6000 / 120) x 1.25). A number 6 AWG THHN conductor was used, which has an ampacity of 65 amps at 30°C (75°C insulation rating).

Grounding
The module and DC-load equipment grounds must be number 10 AWG conductors. Additional lightning protection will be afforded if a number 6 AWG or larger conductor is run from the array frames to ground. The inverter equipment ground must be a number 4 AWG conductor. This size is based on the 275-300 amp overcurrent device between the battery and the inverter. The grounding electrode conductor must be 2-2/0 AWG or a 500 kcmil conductor.

The system uses two ground rods to provide additional surge protection and to minimize radio frequency interference. The ground rods are spaced ten feet apart and are bonded together with a number 2/0 USE cable.

DC Voltage Ratings
All DC circuits should have a voltage rating of at least 55 volts (1.25 x 2 x 22).

Summary
The calculations used in these examples are based on UL and NEC requirements. While there is some leeway in the selection of cable types, overcurrent devices, and disconnects, only DC-rated devices should be used. Oversizing the cables will lower voltage drop and increase performance, particularly where long cable runs are involved.

In Home Power Magazine Number 49, the changes in the 1996 National Electrical Code will be discussed and how they impact the installation of PV systems.

Access
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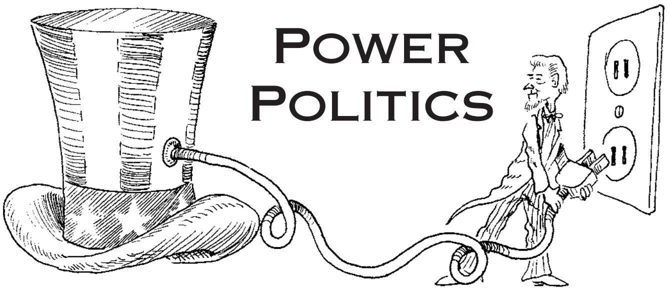

Season of Change

Michael Welch

I figured I should tone things down a little from last issue's column lest Home Power staff be overrun with criticism for my tongue-in-cheek comments about electro-lobotomizing politicians. So far, there haven't been any. Maybe folks liked the idea and accepted it as a workable solution.

But definitely, our government is running amok, and we need to do something about it. The question is, "What?"

Many people have mistaken the Republican "Contract on America" (COA) as doing something about the problems in Washington, DC. Lest anyone get the wrong impression, here, I don't give Democrats much greater credit, and I certainly think there is a lot of room for improvement in those programs that actually are good for the country. We've got a big problem with the status quo, and neither party in power is doing a good job. It never fails to amaze me how gullible voters can be. I guess we just wanna believe, and I guess we find it easiest to believe the candidate with the most and best TV ads.

Back to the COA. What *is not* being attacked by the COA should be. For example, the largest drain on taxpayers is corporate welfare in its various forms. To be true to the philosophy, COA would put an end to it. Real campaign and lobby reform would be at the top of any responsible democracy supporter's list.

But what *is* being attacked by the COA are the very things that only a government can take care of. Like the environment. What else will take care of it? Certainly not the corporations that constantly sink millions of dollars into gaining the right to exploit resources and pollute our fragile planet.

Like our workers. In the last couple of decades, corporations have once again become stronger than the supporters of worker rights. What else but the government is strong enough to protect us from unsafe working conditions and protect our need to organize effectively? Unfortunate, but true.

Like our poor and disabled. There are only so many resources. As the rich get richer, the poor get poorer relative to an acceptable standard of living. It becomes almost impossible for someone to pull out of this situation, because there is only so much to go around, and the rich and powerful are constantly asserting their power to grab it up.

And really, that's what this "Contract on America" is about, shifting more power, natural resources and financial wealth to the corporations and the rich. It is *not* about getting government off of taxpayers' backs, although that's a major stated goal of Republican voters and politicians.

It *is* a successful effort to motivate an identified and readily obtainable minority block of voters while discouraging and disenfranchising opposition voters. Second, it is an effort to concentrate corporate and wealthy individual's support in the hands of the radical right politicians. In exchange, they give away the health and well-being of the planet and its inhabitants. A stroke of political genius, I believe. Divide, tip the scales, and conquer. The Democrats are salivating because they didn't think of it first.

So, what's this got to do with energy? Everything. The most influential corporations in the world have to do with energy. The automotive industry does not want to give us clean vehicles, because it will cost them more money on the short term.

The fossil fuel and nuclear industries would like nothing better than to see the demise of renewable energy, or at best are hedging bets with some minor investment in solar. At the same time, they are pounding the pavement looking for tax breaks to help keep the playing field tilted toward them.

And then, there's major energy consumers like the mining, chemical and wood product corporations. This list also includes the oil companies (refineries) and automobile manufacturers. These corporations only care about cheap power as a way to increase profits, and are willing to exert their influence to get it.

This ads up to a massive assault on a safe and clean energy future, and helps keep the price of home scale renewable energy high compared to the other choices.

Back to the question of what to do about our government run amok. There is only one way that we will get a fair shot at a renewable energy future from our government. It is the same way that practically every other government problem can be fixed: Change the way our politicians are accessed by ending the buying of candidates and by eliminating the one-sided influence of corporate lobbying.

Only these things will produce the real change needed to give people back their government. Until then, all our efforts are a matter of sticking our fingers in the dike. Don't get me wrong, we need to keep a lot of fingers in that dike until we can make real change transpire.

Veto Power

Fortunately for us, President Clinton is starting to show some mettle. He wasn't very good at getting some of the things he promised in his campaign. Early on, he seemed afraid to go against Congress, even though the Republican majority was constantly on his case.

But, he vetoed the COA recision bill which would have significantly reduced renewables and energy efficiency funds. I wish that all such subsidies could be axed, but without getting rid of those for competing unclean and unsafe energy technologies, we really need ones dedicated to helping renewable energy.

I think we can count on him to react the same way in dealing with assaults on clean water and clean air laws, both of which should help a renewable energy future.

Net Billing (say, how much do those nets cost, anyway?)

Apparently, they cost too much. Steven Bragg of Tucson was kind enough to send me some information on the local utility (Tucson Electric Power) and its willingness to provide net billing for grid-connected home power producers. Even though there is no state mandated program, the utility offers such an option. But according to Steve, no one has been willing to take them up on it. It is still too expensive for most, specially with PV, and only those with magnanimous tendencies will make the plunge. A check with the Tuscon Electric Power Company showed that they now have one residential customer taking advantage of the net billing option, and that system has not produced more than the home uses.

By itself, net billing won't do much good. Other incentives on top of it will be the ones to make a difference. We need good loan programs, rate-based incentives, and tax-breaks to level the field. And we need to work harder to make politicians and sympathetic business people understand this.

As hard as it is to work with politicians, and as hard as it is to work against big business, we must continue to do just that. California's Senate Bill 656 (full text available on the Home Power BBS) is a good start for that state. Even though the state's utilities managed to make it a mere shell of its original self, it still holds some incentive.

It was a battle that shouldn't have had to happen. Even in a bill that started out thin, utilities still managed to get wind and small hydro deleted (leaving only PV), managed to decrease system size to a maximum of 10 kW, managed to significantly decrease the installable number of net billing systems to a mere one tenth of one percent of each utility's peak electricity demand forecast for 1996, and managed to add provisions giving the utilities an out when the eventual utility deregulation occurs.

Nevertheless, this bill will probably pass in its present form this summer, and that will be better than what we had before. Californians need to make ensure that and then move on to the next goal. The rest of us can do the same in each state.

Deregulation Fallout

It looks like some of the negative effects of retail electric deregulation are going to happen before the restructuring even takes place. PG&E is the largest utility in California, the state that seems to be taking the lead on deregulation. They have long been known for the excellent service they provide through their electric transmission (no, that is not a car part) system and the workers that maintain it.

But they see the writing on the wall. Deregulation will likely put an end to the utility getting paid a guaranteed profit on the amount of money it spends on its transmission system. So, they are already practicing "downsizing", the preferred corporate method of cutting costs to increase profits. An ad was recently placed by employees fearful of losing their jobs. It claims that one of PG&E's maintenance divisions will be cut by at least 50% with the remainder of the employees being relocated further away from the communities they have been serving. Without a corresponding decrease in rates, of course.

It certainly remains to be seen how widespread these layoffs will be, but they certainly do not bode well for quality of transmission service.

Is that bad in the long run? Hmmmm... the resulting customer dissatisfaction could add incentive to join the home power movement! If quality of service goes down for grid consumers, then it will be up to us to educate the them about the joys and reliability of making our own electricity. I don't know about you, but the ONLY time my PV/battery system goes down is when I want it to.

When this downsizing comes to pass, and you find yourself explaining your reliable home power systems to friends, please do it with compassion. Remember, they may have just lost a freezer full of veggies and missed seeing the latest episode of "Home Improvement".

Another bit of fallout in the California dereg scene is what the utilities want to do with their "uneconomic investments", or "stranded assets". These are both fancy words for nuke plants. The California Public Utility Commission (CPUC) is on the verge of giving nuclear utilities a tremendous bailout in the form of accelerated recovery of costs.

That means that ratepayers would pay much more for the nuke plants for just a few years, instead of over the entire life of the plant. In the case of the San Onofre Nuclear Generating Station (SONGS), the public would be forced to pay an estimated $5.2 billion (yes, that was a b in front of that illion) above market prices for electricity over the 8 year bailout period. Certainly it seems fair that the public should pay a share of the costs to close these uneconomic assets, but why the heck should they have to pay for the utilities' poor choice to build such an expensive plant in the first place.

Competition is the wave of the future. The CPUC is the body that started deregulation so that the free market could take over in setting the cost of electricity, and now they are trying to change the rules. If the utilities make poor business decisions, it should not be up to us to bail them out. That isn't how open market competition works.

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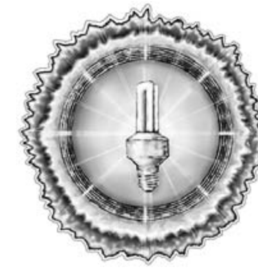
For more info on California utility deregulation, contact the Center for Energy Efficiency and Renewable Technologies (CEERT), 1100 11th St. Suite 311, Sacramento, CA 95814, (916)442-7785

For more info on the national deregulation scene, contact the Union of Concerned Scientists, Climate Change and Energy Program, 1616 P St. NW Suite 310, Washington, DC 20036, (202)332-0900

Home Power's Business



"The man who on his trade relies
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Sir Thomas Lipton — 1870

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916–475–3179 Advertising and Editorial

Kathleen Jarschke-Schultze

For years now we have not owned an electric toaster. We had been using a round cast iron griddle. It worked okay, nothing to write home about though. If the bread wasn't exactly flat, the edges would be very well done and the center would be barely toasted. Then my friend, Red, showed me a better way.

Red and Grayce

The end of our driveway (townside) ends in a campground. Through the years, we have met many of the campers who return each year. One friend of ours, Nora, had us over for dinner one summer evening. I made a solar baked carrot cake, with cream cheese frosting, for dessert. Red and Grayce Oster also came to dinner that day. Red really was impressed with the solar cake.

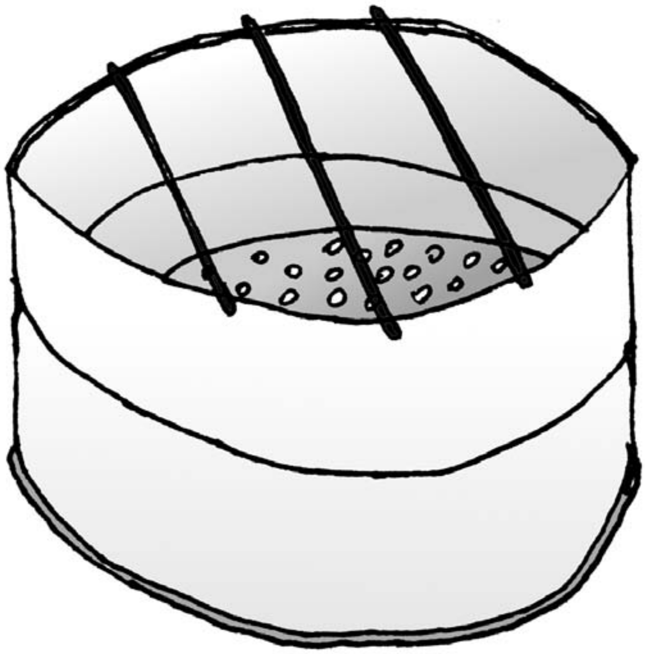
A couple of days later, Bob-O and I brought Red and Grayce up to our house to see the RE system. They had never seen anything like it. Red, however, noticed that although I had most of the appliances an on grid kitchen uses, there was no toaster. He offered to make me a toaster if I would bake him another solar carrot cake. Turned out to be one of the best trades I've made.

Recycle, Reuse, Reinvent

This toaster design came about because Red and Grayce are retired and travel in their trailer a great deal. Red figured it out for Grayce to use in the tiny trailer kitchen on the gas range top.

First you need a 5 lb. coffee can. Use the coffee or transfer it to another container till you can use it up. Measure up the side three and a half inches, then mark the circumference on the can. Cut on that line. Use pliers and bend a one-eighth inch lip down inside the can, all the way around. There should be no sharp edges on the top of the can when you are done.

Take a hammer and nail and make three holes on each side of the top, directly across from each other. See drawing. They should be approximately one and a half inches apart. Turn the can upside down and use the nail to make holes all over the bottom. I counted the holes on mine and there are 104 holes.



Find a metal coat hanger or a length of brass welding rod and cut it so you end up with three pieces that reach over the can by one half to three quarter inches. Use pliers or needle nose to bend the ends of that wire into the holes on the top rim of the can. Crimp the ends so the wire does not shift or jiggle. You want them tight across the top of the can.

Now you need to place the can on the burner and burn off the paint. Be sure to open the doors and windows when you do this to avoid the fumes. You could set it on a barbeque outside and achieve the same result. I put mine into our wood stove. I placed it on top of a piece of wood that was burning on the bottom. You don't want to melt or warp it so be careful if you use this method.

Toasting

Place the toaster on top of your gas burner. Turn the flame on medium. It takes a while for the toaster to warm up so the toast pieces cook progressively faster. You can toast two pieces at once. If you want all your toast to stay warm while the rest toasts, stack it directly on top of the cooking toast.

You have to pay attention with this toaster. Don't answer the phone, check your battery water level or whatever. Just make toast. Meditate on the good even brownness, the heady aroma and the kudos you'll get from your family for performing this miracle and enjoy.

Caveat

Don't toast buttered bread. Don't even toast the bottom of buttered bread. Don't toast last night's left over garlic bread. The absolutely last thing you want to do is get butter or oil into the bottom of the can. That is unless you want to test your smoke alarms out. If you do get butter on the toaster, use very hot water and dish soap to wash the toaster. Then immediately put it on a medium burner to dry it out and to make sure you've got all the butter off.

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Kathleen Jarschke-Schultze is enjoying toast whenever she likes at her home in northern-most California, c/o Home Power Magazine, PO Box 520, Ashland, OR 97520 • 916-475-0830 • Internet e-mail: kathleen.jarschke-schultze@homepower.org or kjs@snowcrest.net

HAPPENINGS

AFRICA
The 1995 ISES "In Search of the Sun" Conference, "The World Solar Energy Exhibition" and the finish of a solar car race is scheduled for September, 11–15, 1995 in Harare, Zimbabwe. For exhibitor and attendance info contact Peter Armstrong, exhibitor director, In Search of the Sun, PO Box 2851, Harare, Zimbabwe; Phone: (263-4) 730707, Telex: 0907 (26623 ZW), Fax: (263-4) 730700, e-mail: xcarelse@zimbix.uz.zw

CANADA
The Canadian Wind Energy Association will host a workshop presented by Paul Gipe, author of "Wind Energy Comes of Age" and "Wind Power for Home & Business." The workshop includes a copy of Gipe's, "Wind Power for Home & Business," a 414-page book describing how homeowners, farmers, and businesses can determine for themselves if wind energy makes economic and environmental sense. The workshop includes numerous slides (diapositives) of wind turbines used in a variety of applications throughout North America and Europe. For more information contact Cindy Bourns; Canadian Wind Energy Association; 100, 3553 31st NW; Calgary, Alberta T2L 2K7; phone: 800 9 CanWEA (in Canada), +403 289 7713 (outside Canada); fax; +403 282 1238.

The 2nd World Hydrogen Summit in Montreal, September 28–October 1, 1995 will be presented by The International Council on Cooperation & Development of Hydrogen and include "Hydrogen & Ecology '95 Workshop." The exhibit portion will be part of the largest business show in Canada, with more than 30,000 visitors. For exhibitor and attendance info contact Hydrogen Industry Council, 1800 McGill College Ave #2610, Montreal, Qc Canada H3A 3J6; 514-288-5139, Fax: 514-843-6079.

Environment and Energy Conference of Ontario, October 31 - November 2, 1995 at the Metro Toronto Convention Centre, will also include the Annual Conference of the Solar Energy Society of Canada. Papers/abstracts/presenters are requested on a wide spectrum of topics including sustainable transportation, agriculture, chemistry, business. Ask for complete info from Roger Scott 416-323-5879 or Kirsten Mania 416-323-4675; or write: 1995 EECO, Ministry of Environment and Energy, 11th Floor, 135 St. Clair Ave. W, Toronto, ON M4V 1P5, Canada; Fax: 416-323-4322.

The "Alberta Sustainable House" is now open for public viewing every Saturday 1:00-4:00 PM free of charge. The first of its kind in Canada, the project emphasizes cold-climate state-of-the-art features/products based on the founding principles of occupant health, environmental foresight, resource conservation, AE, recycling, low embodied energy, self-sufficiency, and appropriate technology. Already in place: R17 window, multi-purpose masonry heater, solar hot water, greywater heat exchangers, LED and electroluminescent lighting, solar cookers, and others. Under development: hydrogen fuel cells, Stirling co-generator, Tesla bladeless steam turbine, and others. Contact: Jorg Ostrowski, Autonomous & Sustainable Housing Inc/Alternative & Conservation Energies Inc, 9211 Scurfield Dr NW, Calgary Alberta T3L 1V9, Canada; 403-239-1882, Fax: 403-547-2671.

The Institute for Bioregional Studies was founded to demonstrate and teach recent ecologically-oriented, scientific, social and technological achievements that move us toward ecological, healthy, interdependent and self-reliant communities. For more info: IBS, 449 University Ave, Charlottetown, Prince Edward Island C1A 8K3, Canada; 902-892-9578.

FRANCE
13th European Photovoltaic Solar Energy Conference and Exhibition, Nice, France, 23–27 October 1995. For more info contact Dr. H Ossenbrink, EC-Joint Research Centre, European Solar Test Installations/ESTI, 1-21020 Ispra (VA), Italy; Phone: 39-332-789 172, Fax: 39-332-785 561 or 39-332-789 268. For proceedings of the 12th Conference write: H.S. Stephens & Assoc, Pavenham Rd, Felmersham, Bedford MK43 7EX, England.

IRELAND
The Irish Wind Energy Association will host a workshop presented By Paul Gipe, author of "Wind Power for Home & Business." (see listing under Canada for details). For more information contact Sheila Layden; Irish Wind Energy Association; Arigna Fuels; Carrick on Shannon; Ireland; phone: +353 78 46002; fax: +353 78 46016.

MONACO
Born from its traditions of autosports and a beautiful environment, the first Monte-Carlo Rendezvous of Electric Vehicles will occur October 19-22. The Salon portion will bring together manufacturers, distributors, dealers and servicers of EVs with press, schools, municipalities, etc. The Rallye portion will feature sports/entertainment personalities and leading EV drivers for a media-filled event of the latest technologies. To participate, drive or exhibit, contact: Sylvie Boutinot, Editions & Promotions Internationales, 11, Boulevard Albert-I-ER™, Phone: 92-16-03-76, Fax: 93-15-03-13

NATIONAL
Electric Vehicle Challenge 1996, The Charge Across America is planned for June 16-28, 1996 and will run from Washington, DC to Los Angeles. Entered vehicles will take 13 days to travel over 2700 miles. Within the run, special events will take place in Indianapolis IN, Tulsa OK, and Phoenix AZ. Entry registration closes January 15, 1996. For info, contact EVC Headquarters, 12 Cedars, Freeman, MO 64746; 816-899-5511, Fax: 816-899-5430.

Energy info on the Internet can now be accessed via the Energy Efficiency and Renewable Energy Network (EREN), a multimedia WWW server developed by the DOE. Check it out at http://www.eren.doe.gov or contact: Energy Efficiency and Renewable Energy Clearinghouse, POB 3048, Merrifield, VA 22116; 800-363-3732; e-mail: ENERGYINFO@delphi.com

"Learning to be Water Wise and Energy Efficient"curriculum with materials for classrooms and home schools is now available from National Energy Foundation, 5225 Wiley Post Way #170, Salt Lake City, UT 84116; 801-539-1405, Fax: 801-539-1451.

American Hydrogen Association Bulletin Board System: Solar Hydrogen BBS, 415-494-3116, 1200–14,400 baud V.32bis. V.42bis 8N1; also, Prosperity without Pollution: AHA Tempe BBS 602-894-8403.

Energy Efficiency and Renewable Energy Clearinghouse (EREC) is offering info for people who would like to cut their energy bills at home or business: free fact sheet-"Cooling Your Home Naturally (FS186)". Contact EREC: Phone: 800-DOE-EREC (363-3732); mail: EREC, PO Box 3048, Merrifield, VA 22116; e-mail: energyinfo@delphi.com; TDD: 800-273-2957; BBS: 800-273-2955.

ARKANSAS
Sun Life is now conducting "Third Saturday Seminars" on inexpensive building techniques. Their focus is to teach home building from materials that can last a thousand years and cost less than conventional wood-framing. These are hands-on, all-day workshops. Contact Loren at PO Box 453, Hot Springs, AR 71902.

ARIZONA
The State of Arizona is now offering a tax credit for installation of all types of solar energy systems. A solar technician certified by the Arizona Department of Commerce must be on each job site. For info contact ARI SEIA; 602-258-3422.

Electric/Solar Boat Races will run September 16, 1995 at Lyman Lake State Park near St. Johns (features camping, Indian Petroglyphs). Included are Battery Marathon, Solar Marathon, Hobby Level, and Circle races. The Electric Boat Racing Association (EBRA) is not holding a race this year and supports this one. For rule book/info contact Mike Loomis, American Hydrogen Association, 216 S Clark Dr #103, Tempe AZ 85281, 602-921-0433 or 602-839-1771, Fax 602-967-6601, BBS 602-894-8403.

CALIFORNIA
Offline Independent Energy Systems Workshop: Designing Your Home PV Power System for Beginners—Sunday October 22, 1995. The class will begin with a tour and discussion of our own PV system, which includes water pumping and telecommunications. We will then develop the following topics: basic systems types, determining power needs, the PV array, the battery, and inverters. We will discuss how it's all put together such as any special wiring needs, code requirements and safety, instrumentation and controls. We will also look at how to LIVE with PV in relation to appliances, computers, and entertainment equipment, attitude and awareness. The workshop will be held at the Offline home/office about an hour from Fresno, California in the Central Sierra. Cost is $35 per person or $45 for two together, For further information, reservations and directions, please call, write, or e-mail Don and Cynthia Loweburg, Offline Independent Energy Systems, PO Box 231, North Fork, CA 93643, 209-877-7080. internet ofln@aol.com

Siemens Photovoltaic Training Workshop, intensive five-day seminar, will be held October 16–20. For more info contact Cindy Vernon, Siemens Training Department, 4650 Adohr Lane, Camarillo, CA 93010; 805-388-6585, Fax 805-388-6395.

Electric Vehicle Workshops will be given in Fort Bragg, September 23-24 and November 18-19. Topics covered include design, components, maintenance, safety, and many others. Contact Burkhardt Turbines, 1258 N Main St, #B2B, Ft Bragg, CA 95437; 707-961-0459.

Renewable Energy Development Institute-REDI Conference '95: PVs and EVs-California Leads the Way, August 11–13. Three main topics: Utility Deregulation-financing, effects on RE, and REDI '93 follow-up; EV Marketplace-fleet operators meet EV manufacturers, financing, and insurance; National Labs-National Technology Transfer Center and Federal Lab Consortium will provide info on the range of tech advancements of over 750 national laboratories (such as NREL, Argonne, Sandia, Lawrence Livermore) and potential commercial applications. Contact REDI, 733 S Main St #234, Willits, CA 95490; 707-459-1256, Fax 707-459-0366.

California Air Resources Board (CARB) is doing "routine, continuous review" of the 1998 ZEV mandate (2% of cars sold must be EVs) and holds forums, usually at their Mobile Source Division, Annex IV, in El Monte. Dates and subjects: August 9-Hybrid Issues (revised treatment under the regs); September 13-Fleet Issues; September 28-Board Hearing (proposals for "LEV regulatory clean-up items"); October 11-Technology Review (focus on batteries, incl. staff and industry presentations); November 8-Benefits and Costs of EVs (incl. staff presentations). Contact: Air Resources Board, 2020 L St, Sacramento, CA 95814; 916-332-5840.

COLORADO

'95 Jade Mountain/Denver Electric Vehicle Council Electrathon Challenge Schedule: Electrathon Challenge '95 events will be held the third Sunday of the month. Vehicle inspection will begin at noon with competition starting at 1:00 pm. The future is electric! Join the fun at the next Electrathon. August 27th and September 24th locations to be announced. For more information call Bill Williams 303-449-6601 or write DEVC, 2940 13th St, Boulder, CO 80304

Wind Power Workshop, August 14-25, Carbondale. The first week combines classroom instruction with actual set-up of residential-sized wind generators. The second week will be spent installing a complete residential system. Other workshops for '95, Micro-Hydroelectric Power, August 28-September 8; Photovoltaic Design & Installation, September 11–22; Advanced Photovoltaics, September 25-October 6; Solar Home Design, October 9–27; Straw-bale, Adobe & Rammed Earth Building, Weekends in October. Contact Solar Energy International, PO Box 715, Carbondale, CO 81623, Phone 303-963-8855, Fax 303-963-8866.

The 6th Crestone Energy Fair, Labor Day Weekend, September 2nd and 3rd, 1995, Crestone Town Park, Free to the public. A gathering of solar advocates, experts, and novices for a weekend of solar technology, fun, music, food, council and a tour of solar homes. This is a self organizing solar potluck and camp. Come and enjoy. Booth fee — 1 item donation to the Green Goods Raffle. Turtle Island, PO Box 222, Crestone, CO 81131.

Solar Energy International (SEI) is offering workshops on the practical use of solar, wind, and water power. The 1995 Renewable Energy Education Program (REEP) features one and two week workshops: Solar Home Design , Environmental Building Technology, PV Design & Installation, Advanced PV, Solar Cooking & Biofuels, Micro-Hydroelectric Systems, and Wind Power. Guest speakers and professional instructors will teach the design of state-of-the-art solar homes that are self-reliant, energy efficient, healthy to live in, and earth-friendly. Participants will learn the knowledge and skills to build energy-independent homes with solar, wind, and water power. The series is for owner-builders, industry technicians, business owners, career seekers, and those working in developing countries. The workshops may be taken individually or as part of a program. The cost is $400 per week. Scholarships and work/study programs are available on a limited basis. Contact: Solar Energy International, PO Box 715, Carbondale, CO 81623 or call 303-963-8855.

Visit the new National Wind Technology Center operated by the National Renewable Energy Laboratory, just outside of Golden. Facilities assist wind turbine designers and manufacturers with development and fine-tuning and include computer modeling and test pads. Call in advance, 303-384-6900, Fax 303-384-6901.

INDIANA

Formula Lightning Championship electric car races at Indianapolis' IRP on

August 17 will be televised nationally by ESPN on the "Thursday Night Thunder" program.

IOWA

4th Annual Iowa Renewable Energy Expo & Alternate Fuel Vehicle Showcase will fill Hawkeye Downs in Cedar Rapids, September 9-10, and feature large- and small-scale wind; solar thermal and PV; conservation for home and farm; energy-efficient/solar architecture; vehicles that run on electric, solar, soy diesel, natural gas and hydrogen power; practical electrical workshops; contests and workshops for teacher and kids; and forums for discussing utility, legislative, scientific and grass roots issues. As well, there will be entertainment, food, demonstrations and much more! For more information, to participate or to join the association, contact: Iowa Renewable Energy Assn., 611 Second St. SE, Dyersville, IA 52040 (Tom Snyder), 319-875-8772; or Stan Eilers 319-365-7314 (Cedar Rapids); or Tom Deves 319-556-4765 (Dubuque).

MASSACHUSETTS

The Seventh Annual Sustainable Transportation and S/EV95 (Solar & Electric Vehicle) Symposium, Boston, MA, November 13-15, 1995 (exact location to be announced) will bring together a broad coalition of transportation planners, electric and hybrid electric industry representatives, business people, policy makers, ands engineers to foster the growth of a viable electric vehicle industry, and the development of a sustainable transportation vision for the nation. In-depth workshops, concurrently held sessions and an extensive trade show have made the event the major electric vehicle conference in the United States. For more information contact: NESEA, 50 Miles St, Greenfield, MA 01301, 413-774-6051, fax 413-774-6053.

MICHIGAN

Cedar Valley Workshops and Seminars. Traverse City. MI will be holding a week-long workshop on photovoltaics August 13–19. For more information contact Dr, Conrad Heins, 215 E. Muskegon St., Cedar Springs MI, Phone (616) 696–0603.

MISSOURI

Join the Modern Pioneer Workshops at Ozark Flock 'N' Fiber Farm, August 26-27 and September 16-17. Topics: Make Your Own Solar Oven and Solar Dryer, Alternative Lighting, Saving Seeds and others. $90 for first person and $65 for each additional in a group. Includes meals and camping (call if you don't have a tent-they can help). Route 2 Box 337, Salem, MO 65560; 314-729-3081.

NEW YORK

The New York State Electric Auto Association (NYSEAA) is dedicated to sharing current electric vehicle technology. Monthly meetings, for date and location call Joan at 716-889-9516

OHIO

Solar electric classes taught at rural alternative powered home with utility backup. Maximum of 12 students. Must advance register. $30 fee per person, $35 per couple, lunch provided. Class will be full of technical info, system sizing, NEC compliance, etc. Students will see equipment in use. Dates: Aug. 12, Sept. 9, Oct. 14, Nov. 11, & Dec. 9. All classes held from 10 AM to 2 PM on Saturday.. Call 419-368-4252 or write Solar Creations, 2189 SR 511 S, Perrysville, OH 44864-9537.

The Great Lakes Electric Auto Association's mission is to contribute to the freeing of the US automobile market from dependency on petroleum through advancements in electric and hybrid/electric technology. For more information contact, Larry Dussault, GLEAA, 568 Braxton Pl E, Westerville, OH 43081-3019, 800-GLEAA-44 or 614-899-6263, Fax 614-899-1717. Internet address: DUSSAULT@delphi.com

OREGON

Build a 3,000-gallon ferro-cement tank, hands-on workshop in Ashland, September 22-24. Call now to reserve a spot, 503-482-6164.

The Lost Valley Educational Center is an intentional community and learning center devoted to developing the skills and awareness that will create a sustainable lifestyle. They are offering various low-cost workshops covering everything from low-cost underground housing to building solar ovens. For more information call or write Lost Valley Educational Center, 81868 Lost Valley Ln, Dexter, OR 97341, 503-937-3351

Aprovecho Research Center has three internship openings for Fall term. Interns study organic gardening, sustainable forestry and appropriate technology. Help bring in the seasons crop, do some horse logging, finish testing a new solar thermal pump, desalinator, solar dehydrator and solar refrigerator. Cost is $500 per month, includes room and board, classes 8:30 to 5:30 daily. Contact Aprovecho at 80574 Hazelton Rd., Cottage Grove, OR 97424 or call (503) 942-8198.

TENNESSEE

A Solar Fair with booths and demos will be held September 22nd in Legislative Plaza, Nashville, in conjunction with the 5th Annual Harvest Festival. For information, contact: The 5th Annual Harvest Festival, Box 259, Summertown, TN 38483, Phone 615-964-2590.

VERMONT

Yestermorrow Design/Build School offers hands-on experience in affordable, natural homes that are real, lasting and beautiful. "Everything you need to build your own home is in your own backyard...join others whose mailboxes are filled with letters just from friends." Courses include: Solar Design (Aug 5-6), Stone Masonry (Aug 26-27), Straw Bale/Adobe (Aug 27-Sep 2), Home Design (Sep 10-16), Green Commercial (Oct 15-21), woodworking/furniture courses, others. Yestermorrow Design/Build School, RR1 Box 97-5, Warren, VT 05674; 802-496-5545; Fax: 802-496-5540.

VIRGINIA

Seminars at Bear Mountain Outdoor School include Active Solar Design, September 15-17. Contact Bear Mountain Outdoor School, US 50, Hightown, VA 24444, Phone 703-468-2700.

WASHINGTON

GreenFire Institute offers resources and info on staw bale construction including Build-a-Complete-Home Course, 7 weekends August-October, Whidbey Island. Contact the Institute at 1509 Queen Anne Ave N #606, Seattle, WA 98109; Tel/Fax: 206-284-7470, e-mail: pegrobs@aol.com

The Seattle Electric Vehicle Association presents “Gasless in Seattle”, this summers cleanest automotive event, Saturday, August 26, 1995, 11 am to 6 pm. Bring your banners, your card tables, chairs, hand-outs, etc.—Participate—help educate. For more information on this event or to join the Association call Steven Lough 206-524-1351, Olof Sundin 206-634-0263, or Victor Munoz 206-632-2994.

the Wizard speaks…

Dimension

The concept of dimension arises from the perception of separation between events. We are most familiar with the normal three dimensions of space and one of time. Modern theorists say there may be anywhere from ten to as many as thirty or more dimensions.

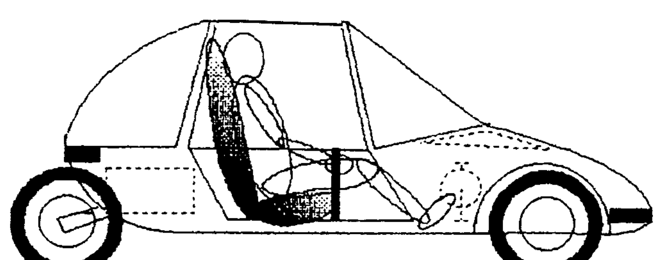
Maxwell, in the original form of his famous equations, was the first to point out the potential existence of dimensions other than the normal three of space and one of time. The newest theory is that of Richard Hoagland and his associates. It is based on the hyper-geometry of the tetrahedron.

The basic question is whether these higher dimensions are space-like or time-like. If a higher dimension is space-like, there are many universes of different origin separated by intervals of that space-like dimension. If a higher dimension is time-like, there is a single universe whose probability levels are separated by intervals of that time-like dimension.

The higher dimensions probably consist of both types, giving the meta-multiverse a very interesting and ever-changing landscape.

Cycle Car

lightweight — electric motor
three wheels — human-assisted hybrid
protected from rain and street grime
...a new way to get around



For a free 16-page brochure, write to Omni-HPV, Box 96, Albion, CA 95410 or fax your address to 707-937-0603. *The first 400 respondents also receive "My Mom Drives An Electric Car," a 20-page book that introduces the young people in your life to battery-powered transportation.*

Free new "electronic" newsletter. Eco-Tourist Journal, dedicated to promoting environmental, cultural, and offbeat destinations. Send your e-mail address to: altfuel@bcfreenet.seflin.lib.fl.us

Writing for *Home Power* Magazine

Home Power is a user's technical journal. We specialize in hands-on, practical information about small scale renewable energy (RE) systems. We try to present technical material in an easy to understand and easy to use format. Here are some guidelines for getting your RE experiences printed in *Home Power.*

Informational Content
Please include all the details! Be specific! We are less interested in general information, than in specific information. Write from your direct experience—*Home Power* is hands-on! We like our articles to be detailed enough so that a reader can actually apply the information. Please include full access data for the makers of equipment mentioned in your article. *Home Power* readers are doers. They want access data for the devices and products you mention in your article.

Article Style and Length
Home Power articles can be between 350 and 6,000 words. Length depends on what you have to say. Say it in as few words as possible. We prefer simple declarative sentences that are short (less than fifteen words) and to the point. We like the generous use of Sub-Headings to organize the information. We highly recommend writing from within an outline. Check out articles printed in Home Power. After you've studied a few, you will get the feeling of our style. Please send a double spaced, typewritten copy if possible. If not, please print.

Editing
We reserve the right to edit all articles for accuracy, length, and basic English. We will try to do the minimum editing possible. You can help by keeping your sentences short and simple. We get over three times more articles submitted than we can print. The most useful, specific, and organized get printed first.

Photographs
We can work from any photographic print, slide, or negative. All color reproduction is best done from a well exposed photo.

Line Art
We can work from your camera-ready art. We can also scan your art into our computers, or redraw it via computer. We usually redraw art from the author's rough sketches. We can generate Tables, Charts, and Graphs from your data.

Got a Computer?
We would like your article's text on 3.5 inch computer disk if possible. This not only saves time, but also reduces typos. We use Macintosh computers. Please format all word processor files in "TEXT" format. We can also read text files on 3.5 inch IBM disks (720 KB, 800 KB, or 1.4 MB). Please format the IBM word processor files as ASCII TEXT. Format all Mac graphics in the EPS format. Use the Helvetica 10 point font for all text embedded within graphics.

You can send your article via modem to either the HPBBS at 707-822-8640 or via Internet. HPBBS address is: richard perez • Internet address is: richard.perez@homepower.org

Want your material returned?
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Got any questions?
Give us a call. This saves everyone's time.

Home Power Magazine

PO Box 520, Ashland, OR 97520 USA

916-475-3179

Internet Email via: richard.perez@homepower.org

Air Conditioners on PV?

Dear Home Power, Thanks for the great magazine. I have several questions.

First — As I've learned more about renewable energy systems, I've become interested in their potential here in southeast Texas. In our area, most folks (including me) use lots of electricity for home central air conditioning because of sustained high temperatures and very high humidity. From reading HP, I have learned that such sustained high power requirements and high peaking power needs may severely challenge a modestly priced RE system. Would you say that central air conditioning loads create worst-case scenarios for modest RE systems? Any suggestions?

For now, I would like to know of a method or instrument that I could use to measure my power loads on a "real-time" basis. I would like to produce hourly, daily, monthly, or yearly load graphs easily via computer so that I can size my RE system correctly. Also, is there an instrument that will produce "real-time" kilowatt-hour information?

Second — I'm confused about the environmental impact of lead-acid batteries used in RE systems. From one source, I read that they cannot be recycled easily, could create long-term pollution concerns, and are the weak link (environmentally) of renewable energy. On the other hand, I heard a battery expert say that new RE batteries are 100% recyclable. I would appreciate your opinion on this issue. Shouldn't recyclability be an integral part of a system design especially when systems are installed in third-world locations? Can the car battery industry assist in recycling RE batteries?

For future stories, here are items I'd like to hear more about: 1) Midway Labs' improved concentrating arrays using new, more efficient solar cells; 2) the Electrosource battery — its applications, costs, recyclability, and projected availability; 3) any information on highly efficient "photoactive" molecules such as the ones being worked with at Argonne National Labs which might be used to create 70%-efficient solar cells.

Thanks again. Eric Voss, Sugar Land, TX

Hello, Eric. I don't think that air conditioning is the "worst case" load for an RE system because the air conditioning is usually operating when the sun is shining. Most RE systems are photovoltaic. Consider electric heating on a cold winter's night. Any sized load can be powered by renewable energy—it's just a matter of system size and cost. Let's look at central air conditioning as an example of a large load.

Central home air conditioners on PV

Ton Size	*BTU per hr.*	*Run kW*	*kWh per day*	*# of PVs*	*PV System Cost*
2.0	26400	2.34	18.72	36	$25,611
2.5	32000	2.93	23.40	45	$30,514
3.0	38000	3.51	28.08	53	$35,417
4.0	50000	5.85	46.80	89	$55,029

The above spreadsheet assumes that an efficient home central air conditioner is used (thanks to Jerome at Mainline Electric for the central home air conditioner consumption data). Usually a 2 ton unit will handle the average, well insulated, 2000 sq. ft. home. The spreadsheet also assumes that the central air operates eight hours daily (1/3 duty cycle). Local temperatures, humidity, and the degree of home insulation will greatly affect the central air's duty cycle. I specified Siemens PC4JF PV modules at retail price of $550 each, but at that quantity of panels any dealer will cut a discount. I also assumed seven hours of sun daily because we are talking a summertime load here. Included in the cost is a pair of Trace 4024 inverters which are interfaced with the local utility. I did not include batteries in the cost. As you can see the cost is large.

What the spreadsheet does show is what happens when the central air is not operating. Then the home has a substantial energy surplus that can be sold back to the local utility. Depending on the home's other loads, this huge array could possibly make all the power used by the home on an annual basis.

Before even considering putting central air on PV, look at the home's thermal characteristics. Is the home's insulation at least R19? Does the home have an attic venting system? Are the windows shaded during the summer? Do the doors and windows seal tightly or do they leak air? Every dollar spent on tightening up the building's thermal envelope will save three dollars in PV and inverters. Less cooling load means a smaller air conditioner operating at a lower duty cycle—hence less energy used—hence fewer PVs—hence cheaper system.

On the subject on instrumentation, you need one of Joe Bobier's OmniMeters (304-485-7150). See the article on page 18 of this issue for a description of an OmniMeter at work. The OmniMeter interfaces with any PC (sadly not Macs yet) and not only measures and datalogs, but also displays real time graphs of system operation. The unit will also function as a smart control (i.e., turn off the air conditioning when energy is low, etc.). For 120/240 vac kWh instrumentation, the common kWh meter used by utilities is cheap and accurate.

On lead-acid battery recycling, see Steve McCrea's article on page 64 of this issue. The lead-acid battery industry in America has an outstanding reputation for recycling their products. Chances are that the lead in your car's battery has ridden around in at least two vehicles before yours. Over 90% of lead-acid batteries are recycled. The same companies that *make car batteries also make the industrial deep-cycle types used in home power systems.*

On future articles on future technologies, we are keeping our eyes on a number of new products. The Midway concentrator PV are no longer a new product, they have long passed the “prototype” stage. We are going to visit Midway in Chicago after MREF, so expect an article soon. As for the Electrosource battery and the new lepton PV, both these devices are very much prototypes and we won’t have our hands on them for a while. Please realize that there are lots of publications covering “pie-in-the-sky”. We cover “pie-on-the-plate”. Richard Perez

Hello Folks,
I am writing to touch bases on my opinion of your magazine and more importantly, your announced price increase. The magazine is appreciated by me. I think it is the best one available currently on the RE issues. I think you are getting too politically green, but that is my opinion, and probably for the most part politics should be left out of technical publications. RE will survive no matter who pollutes or what political party is controlling us Americans. People are left to be in charge of the planet including animals. We should be humane and sensible, but I believe we do have priority.

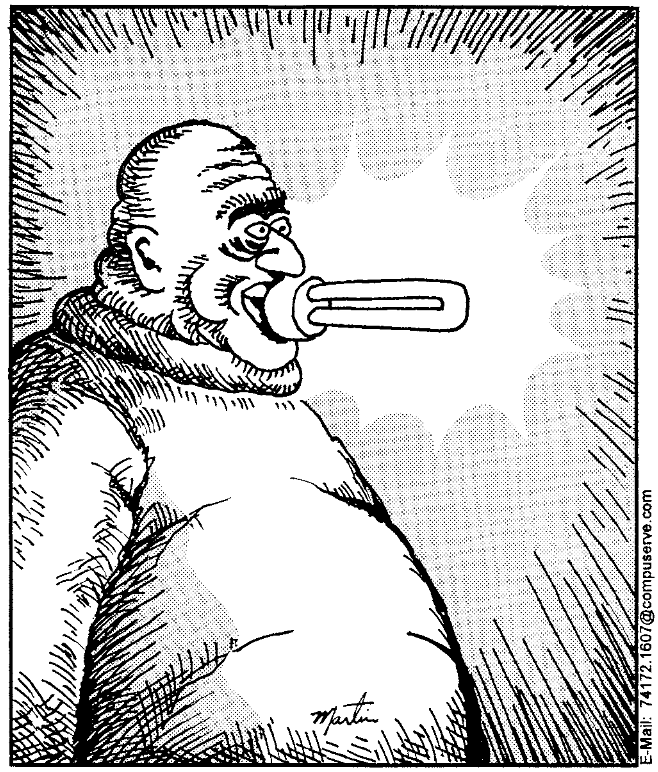
As to the large price increase, I cannot understand! I do not think I will renew at the present rate. What happens to the income generated from 25% of the pages being advertising? Why haven’t advertising rates gone up as subscription has gotten bigger? Seems the more people exposed to the ads make the ad worth more, but the price is still the same as when the magazine was FREE. Same with MicroAds. I don’t know the present circulation, but surely it has increased as your awareness has. Somehow, it seems an increase from free, to $10, to $15, now to $22.50 to the subscriber is way out of proportion to no increase to the advertiser for the same time. Am I wrong? Perhaps I’m missing something. (Incidentally, I was never a free subscriber and missed most of the first 10.)

I am glad my subscription is paid through #56, but I don’t see renewing at such a high price. It doesn’t compete with any other magazines I take. I just think you need to reconsider. Surely I’ll not be the only one to respond similarly. A Concerned Subscriber, John Parsons, Burr Oak, KS

Hello, John. Let’s see if I can shed some light on Home Power’s recent price increase and our green politics. Let’s try the politics first.

Karen and I are refugees from the Haight Ashbury during the Viet Nam war era. My personal politics were decidedly pink before they got green. During Home Power’s first four years, we didn’t utter a political word in print. My attitude was the same as yours—politics don’t belong in technical publications.

Over time, I slowly realized that political factors, not technical factors, were limiting the growth of renewable energy. The obstacle is a legal and political structure which favors large scale, nonrenewable energy sources. After all, it’s difficult to sell, regulate and tax the sun and wind.



Uncle Fester discovers the fluorescent bulb

Our political articles are bound to please some and alarm others. This is after all politics. The only stickier subject to discuss is religion. Our political articles are less than 3% of our content. I urge you to consider the ideas presented in these articles. I also solicit coherent information from different political points of view. I don’t care if you politics are red, white, blue, or green. If you have political information that relates to energy, then it will be considered for publication in these pages.

Home Power’s recent increase in subscription price was primarily due to an increase in paper cost. See Karen’s article on this in HP#46, page 70. You indeed measured Home Power’s advertising content accurately—we are about 25% ads. We are a second class publication registered with the US Post Office. This means we can have up to 75% ads and still have second class mailing rights. Most second class magazines (and that’s everybody from Road &Track to Time Magazine) have an ad content greater than 50%. The revenue we gain from our advertising just about, on a good issue, pays for its printing, and even sometimes, mailing that issue. We print about 21,000 copies of Home Power each issue. About 9,000 of these go to paying subscribers around the world. Another 9,000 are shipped out for sale on newsstands world-wide. The remainder we sell eventually as back issues. We are law-abiding corporate and private American taxpayers. About 35% of our earnings go to the various local, state and federal taxes. We, the Home Power Crew, earn our living from your subscriptions. Our yearly subscription rate is far below any other publication offering high quality technical information. I am sincerely sorry that *you feel we are too expensive now. We wouldn't have raised our price if we had any other choice. Richard Perez*

Energy Independence Spreads!
I am so glad I found your magazine and discovered other people who are interested in becoming independent from the centralized energy bureaucracies. Especially, I was intrigued to read about individuals who were able to become more energy-independent on a modest budget. Photovoltaics, wind generation, and electric vehicles are all subjects in which I am interested.

Furthermore, I felt your explanation regarding Home Power's subscription-rate increase was both informative and quite conscientious. Recently, I have been concerned about the rising costs of books and magazines but I was glad to learn that this trend reflected an increase in the value of a scarce resource such as paper. Also, I appreciate the fact that you do not send out renewal notices. Your concern for the environment combined with a hands-on knowledge of renewable energy technologies are two of the reasons I've decided to subscribe to Home Power. Sincerely yours, Ford LaCrosse, Grapevine, TX

Paper Praise
I'm saving every issue so that I can implement all this stuff when I get out of college. Thanks for helping me from becoming a mindless consumer, and keep up the great work! P.S.—Your magazine remains a great value despite the increase in price; I am fully willing to pay more for paper that is made in an environmentally-responsible manner. Will Orton, Santa Cruz, CA

Thanks for the flowers, Will. Our paper is as environmentally friendly as Karen can find. Our interior is printed on Pentair PC30 gloss made by Niagara of Wisconsin Paper Corp. This is paper is 50% recycled (30% post-consumer) and no chlorine is used to make it. Niagara was the first (mid 1960s) paper mill to go no chlorine inside USA. Our cover is printed on Recovery Gloss made by S.D. Warren Paper Co. It is 50% recycled (10% post-consumer) paper. Kudos go to our printer, St. Croix in New Richmond, Wisconsin for being ready and able to use these papers. Richard Perez

Fellow Greenhouse Gas Busters!
Two comments about the latest issue of HP, #46. High praise to the Nekolas of Chicago for proving that RE can be "urbanized." I've long maintained that if we all continue to seek our "little house in the wilderness" to plop an RE system together, it'll be not too long before no "wild" areas will exist.

Which brings me to my second concern. The sustainable use of shrinking rural land in the US concerns me. Though I can't begrudge the Kingmans for locating away from San Jose off the grid, I found myself asking, isn't this a subtle variation on urban sprawl? Please keep the land in mind, and focus on revitalizing urban areas with RE, rather than chopping up the remote rural land even more than we already do. Mike Mangan, Durand, WI

Hi, Mike. I agree. We are continually making more people, but we aren't making any land. I wouldn't worry about everyone moving to the country. After 25 years of country living, I can tell you that not everyone likes it. Towns and cities grew for a reason—most folks like living more closely together. We are doing our level best to bring RE downtown. The problems aren't PV, they are politics.

As energy, communications, and transportation become decentralized, expect more "urban sprawl." It's going to take more than just RE to revitalize deeply urban areas. I don't know of anyone who is in love with deep city living. What we need are two things: for all to tread as gently as possible on our planet, and for all of us to make less babies. If we do this, then we, and our planet, will survive and prosper. Richard Perez

No Net Billing in New Hampshire
We've been with you since HP#1—you are still right on target. Thanks so much for all your work. New Hampshire does NOT have net metering, of this I'm sure. Seabrook has the power company running scared—rates are so high that Big Industry is considering co-generation and asking for "open-grid" legislation to "shop" for cheaper power out of state. This legislation would open the power market to alternative generators but probably bankrupt the NE utilities. Tough choice considering it's their fault — they built Seabrook. Oh well. I'll forward any news. Sincerely, Dwight & Karen Swisher, East Alstead, NH

Hi, Dwight and Karen. I think nukes are a dead issue. Ever since WPPS defaulted on their bond, Wall Street is not interested in any more nuke projects. I would seem to me that RE input would be welcomed by floundering utilities. RE is locally produced, locally owned, and has no decommissioning costs. We can dream of the day when the utilities figure it out…. Richard Perez

Safety First!
Please renew my subscription and send a gift subscription to my friend, address below. He is interested in building an electric car. I'm interested in electric cars, boats and some solar water heating for my heating system in my home.

I particularly enjoy the articles on appropriate technology for less-developed countries. Please tell Dennis Ramsay [cover story, HP#45] that death isn't the only thing that can happen if you fall off a roof. You can end up crippled, in constant pain and a burden on your relatives or the government and unable to do the things that you enjoy. It happened to me. A fellow as resourceful as he is can certainly hustle a climbing harness in Nepal. Installing PVs, solar water heating and windspinners almost always carries the risk of falls. Please show proper fall protection techniques as part of the information in these articles. Thank you. Sincerely, Phil Crabtree, Seattle, WA

Your right, Phil, we have been lax in showing fall protection. If anyone is on a roof or up a tower, then a life line is a necessity. When I used to install systems I used mountaineering gear as you suggested. A 150 foot length of 9/6" goldline, a belay seat and chest harness, two Jumars (rope climbing gizmos) and a few carabineers are all that's needed. This amounts to less that ten pounds of stuff and costs under $250, which is cheaper than a trip to the hospital. Richard Perez

New York State RE Metering
In NYS [New York State], RE producers must have 2 meters-

ratchet type to sell back to grid. (NYS Public Service Dept, 3 Empire State Plaza, Albany, NY 12223, 518-474-7080, fax 7146) I feel we should approach the EPA about this because the grid is actually the perfect battery when single-meter-counting, power in and power out equally, is used. Think of the reduced size of battery systems if PSD in NYS overturns their rule. We need thousands of RE producers in NYS, and the grid does too. If we have a compatible, friendly grid, everyone benefits. And the environment would benefit if each home had 4 batteries instead of 24. Hi to all at HP. Keep it coming! Edwin L. Falk, Lyons Falls, NY

You've got the right idea, Erwin. I too see the future of RE as small distributed systems all contributing to a central grid. The reduction in batteries is only one of many advantages. It will probably take several years for utilities and PUCs to catch up with RE technologies and gracefully accept our energies. Richard Perez

EV Info Sharing

Enclosed is my $22.50 for my next year's subscription. As I've grown to admire the constantly evolving and maturing format; congratulations on the exceptional journal you've created. I have my back issues carefully coveted in my library to show to students and clients, and I feel that anyone serious about being self-sufficient should get a subscription. It sure got my attention when the mailing label changed from a number to "This is your LAST issue." NO WAY. It really is great not to get those duns in the mail like some other magazines send out.

Thank you for the notices on my Third Saturday Building Classes. I'm getting responses from Canada to Texas and though it takes a while for attendance to build, every class but February had good attendance. I'll keep teaching as long as people are interested in learning. The May class, I'll be building a root cellar out of ferro-cement and hope to do the whole project in a day or two. Your assistance in the "Happenings" promotions is greatly appreciated.

Michael Hackleman's GoPower is where I zip to when I get the mag, to see what hot new rods are out there quietly buzzing around. This month he sounds somewhat despondent in his Odds n' Ends article. And where is some info on that Solar Bicycle?! Michael, if your projects are still sitting in a file, why not throw them out for a brain storming session and material source search? With the minds reading this publication, I'd think you'd be able to get some great input. I'd love to work on the All Terrain EV. I'm getting ready to build on top of a steep mountain and don't want to cut a road up there. A small path will work fine to carry my building materials up there. You could assign a value to input of ideas or materials and create a joint project that was owned by its creators. Think positively. Lots of us are very creative and also very well-connected to resources. You might be surprised! Thanks again for your wonderful work. Loren Impson, Mt. Ida, AR

Thank you, Loren, for the kudos. I've still got the "when-is-this-book-project-going-to-be-done?" blues, but it IS getting done, although I feel like I'm racing a snail. The solar bicycle? It's a C. Michael Lewis photo of a Tour de Sol entry (Switzerland). Please realize that much of artwork I try to share with HP readers is classified as "imagery". It's suppose to tease you, please you, inspire you into doing something similar, and light the psychic fire. If I don't include technical detail, it's usually because I don't have it, and probably can't track it down. When I first saw that slide, I looked at it with a magnifying lens, and gleaned what I could from what I could see. That's the way it is. It's a better process than trying to recall any detail from cool machines that simply whiz by me somewhere in time! As for sharing my files with HP readers, there's some merit in that. However, for the last 1-1/2 years I've been distilling that info into the BOOK. I'm taking a break from layout to answer this letter at the HP offices. My favorite fantasy is that, with the release of the book (The New Electric Vehicles), everyone interested in propelling anything with electricity is going to go into ecstasy for at least a year, and I'll get a vacation. As well, I expect the book to blow holes in the sails (sales?) of naysaying writers, automakers, and oil companies with its seventy (70) examples of electric vehicles done RIGHT. While I want to immediately write letters to the editors of newspapers and magazines printing "EV fluff", I channel that energy instead into the copy, imagery, and substance of the book. So, patience please. Just a few more months and I'm gonna blow your socks off. Ask Richard Perez. He's the only one that's seen it all on the computer screen. Michael Hackleman

Welder Power

Great magazine, very informative, more detail and hard facts. Useable info, not just general info like other mags. Question. I have a DC welder that produces 400 Amps at 40 Volts at 3500 rpm, 60% duty cycle. With a diesel power plant, would it be feasible to use this unit for home power generation or as a backup unit? I have several other gas-powered units as well, with ac power available, but they are not fuel-efficient. I would like to see an article on this subject. Thank you. Alex Clement, Averill Park, NY

Well Alex, I'd recommend not using an engine as the prime power source. My dissatisfaction with engines comes from over twenty years of running our generators and watching all the other generators in the neighborhood. Engine generator operation is only efficient if you also use the engine's waste heat. Engines are complex devices with many moving parts—they require high levels of maintenance. They are noisy, smelly, and use non renewable fuel sources. Generators are fine back up power sources, but expensive prime movers. Having said my piece on engines, I'll now get off my soap box.

You can use your welder to recharge your batteries. Most welders are adjustable, so it's a matter of feeding the proper amount of current to the battery. The fastest recharge amperage rate is C/10 (the battery's capacity in Ampere-hours divided by ten). Insert a shunt into one of the welder's output leads so you can measure current. Battery recharging is a 100% duty cycle condition, but your welder is rated at 60% duty cycle. Your welder is rated at 16 kW, so derate it to about 8 kW for continuous battery charging. Since your welder is so large, be sure to keep the recharging current at or below below the C/10 rate. You have enough power in the welder to really overcharge even a very large battery. Recharging with the welder provides no voltage regulation, *so watch the battery's voltage with a voltmeter. A fully recharged lead-acid cell will reach about 2.55 VDC while under charge at C/10 and at a temperature of 78°F. Multiply this 2.55 VDC by the number of series cells in you battery. For example, a 12 Volt battery has six series connected lead-acid cells. When is this 12 Volt battery reaches 15.3 VDC (2.55 X 6) while under C/10 charge, then it is fully recharged. Richard Perez*

Surveying for PV and Wind

Here is my renewal for another year, at this point all I can do physically to vote for your continued growth and excellent work. You have been and still are the best, and I continue to refer to you in discussions about AE.

I do have a question or suggestion for an article—or if I missed it, tell me what issue—regarding how to get started with actual power generation. Specifically, how to go about site analysis as to what type of instruments are best suited and economically practical to determine which resource to pursue. Example: would a Davis Instruments weather station connected with the weather link computer hookup be a good investment for wind, and then what about solar panels? Bottom line question: how can I know if my site is suitable for solar and wind power situation without the expense of buying both and putting them up, only to find the site not good for either or both? Thank you. Ruth Nymeyer, Lynden, WA

Hello Ruth. Home Power#21 contains a basic article about site evaluation for solar, wind and hydro.

The weather station you mentioned can assess your wind power potential if you locate the anemometer probe correctly. The probe should be at the site and altitude of the proposed wind generator. Mounting the anemometer probe ten feet above your roof won't work. Locate the probe where the actual wind tower is going to be and at the proposed height of the tower. Trade Winds makes a good, inexpensive recording anemometer (called an odometer) for less than $200. See HP#22 page 53 for a review of this odometer. HP#26 and HP#28 also contain info on wind measuring instruments. After much discussion with Mick Sagrillo and other wind maniacs, we've decided that the best way to access wind potential is to install a small wind generator. Install this small genny at the same height you are planning to install the larger machine. HP#40 and #41 contain wind siting articles by Mick Sagrillo.

When it comes to siting solar devices like PV modules and hot water collectors, the Solar Pathfinder is the tool for the job. It cost less than $200 and it works. See HP#16 page 44 for a review of the Solar Pathfinder. See the ad index in this issue for current access data on the Solar Pathfinder. While the Solar Pathfinder allows exact siting of solar devices, it cannot predict your solar insolation—cloudy or overcast days. I checked our Home Power Subscriber's Database for some local info for you. Within about 100 miles of you there are 72 RE installations. PVs lead the way with 55 systems, while there are 12 wind generators and 5 hydros. It sounds to me like the sun shines and the wind blows in your neighborhood. Check with your local airports and NOAA for their version of solar insolation and wind speed data. Richard Perez

Electric Catamaran

I am in the process of having the design completed for a 57' catamaran (sailboat). It was originally planned to have two 50 HP diesel engines to power it, as well as a 20 kW generator. After doing some reading, I have been considering using two electric motors for propulsion.

This vessel would have a speed of about 10 knots under power. I would like to get as much information as possible before I make a decision about using electric power for my main propulsion. Could you please help by sending as much technical information as possible about how to calculate the needed horsepower, the best available motors to use, and the motor controllers.

I have read some books on this subject as it pertains to automobile conversions, so I am not completely ignorant on the subject, but I do need a lot more information. Any help you can provide will be greatly appreciated. Thank you for your time and cooperation. Sincerely, Jon Rosenthal, Newtown, Connecticut

Hi, Jon. An electric catamaran? Good idea. First, check out HP#37 (pg 64-72). This is an article on restoring the Esther and similar watercraft with three different voices addressing the subject. Next, get in touch with Stephenson Projects in the Del Mar area (near San Diego, CA). Pete and Mike Stephenson have built a bunch of catamarans. Their experiences were described in an article in the last issue (#5) of ATN (Alternative Transportation News). These are available from HP (see ad, this issue). ALL of the aforementioned material is integrated into my soon-to-be-released book on EVs, too. If your application is larger, substitute the larger powertrains found in bigger EVs. I've assembled several tables and charts of the EVs described in the book with this "scaling" process in mind. Coupled with numerous rules of thumb, this information should act as a template for projects of any scope. Good luck. Michael Hackleman

EV Education

I am an eighth grade student at an American high school in northern Italy. My English teacher has just assigned a Career-Search paper. I am supposed to pick a career field that interests me and then read about it, write letters, and conduct interviews to find the answers to all my questions.

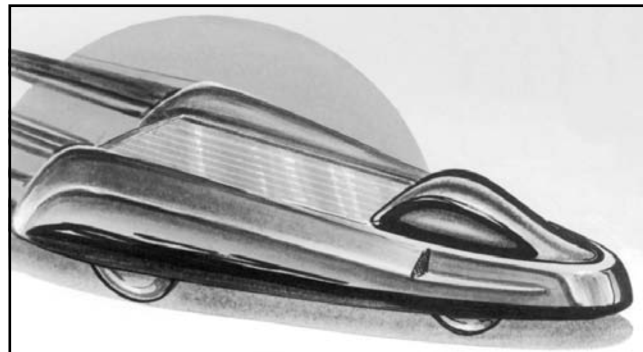
Over the years I've paid close attention to cars, so I chose the career of Electric Car Engineering. Since cars fascinate me so much, I decided I'd enjoy designing one myself. I would like to know, what should I be doing in high school to prepare myself, how many years of college does it take, what qualifications should I have, and what types of things should I know how to do with a computer to design an automobile? If you would like, I will send you a copy of my completed paper when I'm done. Thank you for your time. Sincerely yours, Christian Valencia, APO AE 39603

Hi, Christian. An Electric Car Engineer? Good idea. Hmmm. I would suggest attending a school that has built a solar car. Or a school that has a vehicle program that you can influence into doing an EV project. Build your own vehicle, such as an Electrathon racer, to gain more experience. During the summertime, hang out with individuals and teams doing *similar stuff. Education coupled with experience is the key. It's helpful to learn CAD programs, but the tool does not make the thing–people do. Michael Hackleman.*

EV Economics

I am also interested in the challenge of finding a solution to the pollution that our cars cause. I am a high school senior and we have been reading and thinking about what the future might be. I wonder if you could answer two questions for me? 1. Is it true that the large electric companies are mainly interested in getting a share of the automotive fuel market? 2. Is it true that once electric cars become common, the electric companies might use that fact to justify building new nuclear power plants? Yours truly, George Price, Santa Clara, California

George, I'm happy to hear seniors talking about transportation. The electric utilities sell electricity, so they are definitely interested in the idea of fueling cars with electricity. Since some utilities derive their electricity from sustainable energy sources (solar, wind, and hydro), this is a welcome energy supplier for EV advocates. Will it mean more nuclear power plants? I consider that unlikely. US utility companies took a bath with nuclear power already, and most are unlikely to repeat the scenario, despite newer technology since the REAL issues of nuclear power have not been addressed, much less solved. Fortunately, most EV charging will occur overnight, when the power is cheaper and more available. Something like 30 million EVs can be absorbed on the grid overnight in the US with no new power plants. Where EVs are daytime charged, the ideal power plant is one using solar energy (daytime) and natural gas (night and poor weather). While the oil companies have tried to make the solar power plant look expensive and complicated, in its California powerplants, LUZ showed the technology to be simple, inexpensive to build and maintain, and environmentally-benign. Using ten-year old technology, one solar power plant 80 miles square would power the entire United States of America. When it comes to energy politics, look at who controls it or owns the sources, and all becomes clear. Michael Hackleman.



Q&A

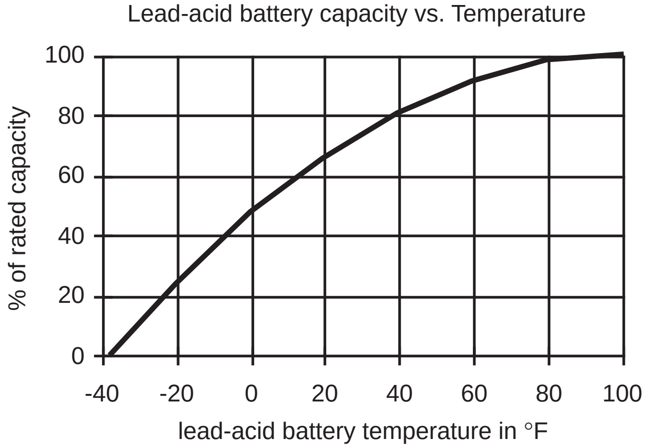
Cold Batteries

I just read your article on batteries in HP #47. Toward the end you give the optimal operating temperature range as 40-110° F. Do you have any words of advice, wisdom, caution for those of us who have our PV installation at a remote site where the batteries will be exposed to long periods of sub-zero (-20 F in northern WI isn't uncommon). Is there enough for a whole article on sites like this that are also unattended for weeks at a time. Many thanks for whatever you can come up with. John Surber

Well, John, the picture is pretty grim for very cold lead-acid cells. First they will suffer an apparent capacity loss when chilled down below 20°F. If the cells are discharged, then the electrolyte becomes water and freezes at 32°F. So the first thing is to keep lead-acid cells as fully charged as possible during very cold periods. If the cells are fully charged, then the electrolyte is rich in sulfuric acid and won't freeze until below –50°F.

The bottom line is keep lead-acid cells as warm as possible and as fully recharged as possible. See HP#40 page 6 for an article by Chris LaForge about installing power sheds in Maine. He buried the battery in an underground enclosure to keep it from freezing. He added a shed above the enclosure to house the inverter, instruments and controls. He mounted the PVs on the roof of the shed and shipped all the power to the house as 120 vac from the inverter. Passive solar heat could also be added to the power shed.

Lead-acid battery capacity vs. Temperature



Oversizing the system's battery is a good idea in cold climates. Your particular situation with no occupancy during the cold periods is actually beneficial for the battery. With no one home using power, the PVs will keep the batteries completely recharged and they won't freeze. Richard Perez

Inverter Problems

I have been reading your magazine since about issue #6 and have enjoyed it very much. My wife and daughter know when my Home Power arrives they will not be able to get my attention until I have at least scanned it from cover to cover.

We live in a small town outside Redding, Ca. The local power company wants $40,000 to bring power to our property. For that price we decided we could put in a pretty nice solar system and not have an electric bill.

We started with a small system and have been adding to it for about 3 years now. We now have a 4 panel system that runs the pump in our well (1500 ft. away), a 2 panel system that pumps water out of a 1500 gal. tank to a pressure tank, and a 12 panel system to supply power to the house. This brings me to my problem.

We have a Trace SW4024 and 8 Trojan L16s, and an Onan 6500 generator. The Trace inverter is wired to start and stop the generator when needed. It will start the generator with no problem. The problem is it cannot stop it. I have it set to start at 23.6 Volts and it should stop when the batteries reach "Float."

I have talked to both Trace and Onan. They both say they do not know the other's system and cannot help me. So I thought I would go to the experts — Home Power!

I feel that the problem is that the Trace sends a signal to ground the generator, but on an Onan you have to hold the ground down until it stops completely or it will restart. I feel the system is OK since I hear the switch click in the inverter. And I cannot shut down the generator manually unless the batteries are at float or I turn the generator control in the inverter to "off." The generator is a NHEFA26100K, if you need that. It has been converted to run on propane.

I would appreciate any help you or your readers could give me. I am sure I am not the only one out here that has a Trace SW4024 and an Onan 6500. Thank you. Steve Barbich, Oak Run, CA

Steve, Without providing a wiring diagram of how you have the generator wired into the inverter or the Serial # of your SW4024, it's hard to say for sure what's going on. The start/stop relay is affected not only by the battery Voltage, the bulk charge Voltage, and the bulk done Amps, but by the generator run time setting AND the quiet time setting. Assuming you have no conflict there (and that's alot to assume!), you probably have an early model of the Trace. Before Serial # 1360 or so, relay #7 was available only in normally open (NO) to ground mode. When the inverter computer gave the start signal to the relay, it closed, then reopened when the charge parameters were met. In your case, that setup is worthless. I don't think your Onan needs a start signal (other than to crank the starter) Wiring into #7 on the older machines would actually prevent your generator from starting! On all 4024s shipped after January 1995, #7 relay can be wired either NO or NC. The manual tells you absolutely squat about this, an omission that will be addressed in Version #3.

If you have an earlier machine, you can use one of the auxiliary relays (#9,10,or 11) to shut your Onan down. I'd set one up to close at whatever battery voltage you'd like to get to with the genny and open somewhere above the setting for generator start up. Set enough hysteresis so the relay will hold closed long enough to shut the Onan down. Try 4.0 V for starters. Unfortunately, those relays operate only on voltage, *so you won't be able to hold at bulk voltage during the absorption stage of charging or equalize charge without defeating the relay. Bob-O Schultze*

EV Safety and Battery Pollution

HP #42 was the first issue I received. On page 48 were pictures of a fragile electric vehicle. More fragile vehicles were in other issues so I concluded that EVs were TOO DANGEROUS. Those kinds of articles should be eliminated from your magazine. But #45 p.42 showed that EVs are viable.

On May 20, 1995 I heard on the BBC that in this week's journal "Science," it said that EVs produce 60x as much lead as gasoline cars do. Francis McMichael (of Carnegie-Mellon University in Pittsburgh) said that even though EVs have zero emissions from a tailpipe, there is quite high environmental emissions of lead (smelting, refining) compared to lead gasoline. 7 kilograms of lead per person per year were used during peak of led gasoline. 5 kilograms are used now. If 2% of vehicles were powered by lead batteries, double the per capita demand for lead would result. He said a substitute for lead would be a set of $20,000 nickel-cadmium batteries which perhaps would be more of a problem than lead.

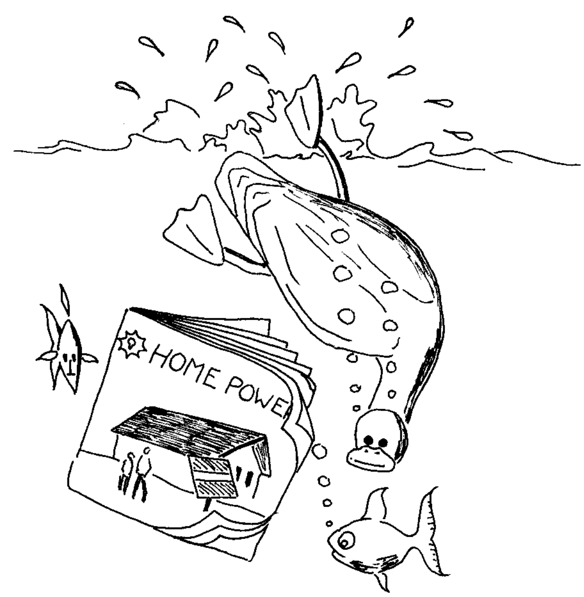
He never mentioned another kind: How about nickel-iron-alkaline (Edison) batteries? You mentioned nickel-iron twice in #46 (Edison?). It has much less weight than a lead battery. The light weight and durability of its cells is due to use of steel in its plates and containers. The electrolyte, caustic potash, does not attack steel, does not freeze solid. The active materials do not shed and therefore there is no sediment. Typical life is 10 years in industrial trucks. Also used in isolated power plants, railway-car lighting. In 1971, they were made by the Nickel-Alkaline Division of the Electric Storage Battery Company. Where are Edison batteries made?

I have a set of "Automobile Engineering" books, published in 1920 that have a section on electric automobiles. It tells of the same features as used today: as set of batteries, electric motor, controller. I have a good SLR camera to copy pictures if you would be interested. Regan Castevens, Sparta, North Carolina

Thanks for the note, Regan. I WOULD be interested in the old photos. Please shoot the pictures and send them on. Black and white film, slow speed (ASA100 or slower), gentle light on the pages, and leave a little space around pictures to minimize optical distortion.

The Carnegie-Mellon report has generated a lot of response. I'm not sure the researchers can backpaddle fast enough, or dodge the shots from just about every direction (see pg 65, this issue) on their errors, poor assumptions, old data, etc. More on this in the next issue of HP.

I don't know of any EVs using nickel-iron batteries. They just don't have the energy OR power density needed for electric propulsion. The hot new battery for EVs is nickel metal hydride. Twice the energy density of lead-acid batteries, cold weather operation, twice the cycle life, recyclable, and non-toxic materials. And, most importantly, they're time-tested. Unfortunately, the production volume for the next few years is already committed to automakers and the expense is going to be intolerably high. So, expect to use lead-acids for a while. And, I would recommend, enjoy them. Applied correctly, they're very, very good. Small, lightweight vehicles may appear fragile, but—so is the planet! We need to lighten up on the way we get around—if we want our children to be able to enjoy the world, too. Michael Hackleman.



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