CRUISING EQUIPMENT / HEART INTERFACE

full page

four color

on negatives

This is page 1

HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

Issue #62 December 1997 / January 1998

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The switch to renewables from fossils can be costly and time consuming but the owners of Elk Lake Resort have made the commitment. William von Brethorst took on the task of cleaning up a power system that had a 150 kilowatt diesel generator!

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Access and Info

Access Data

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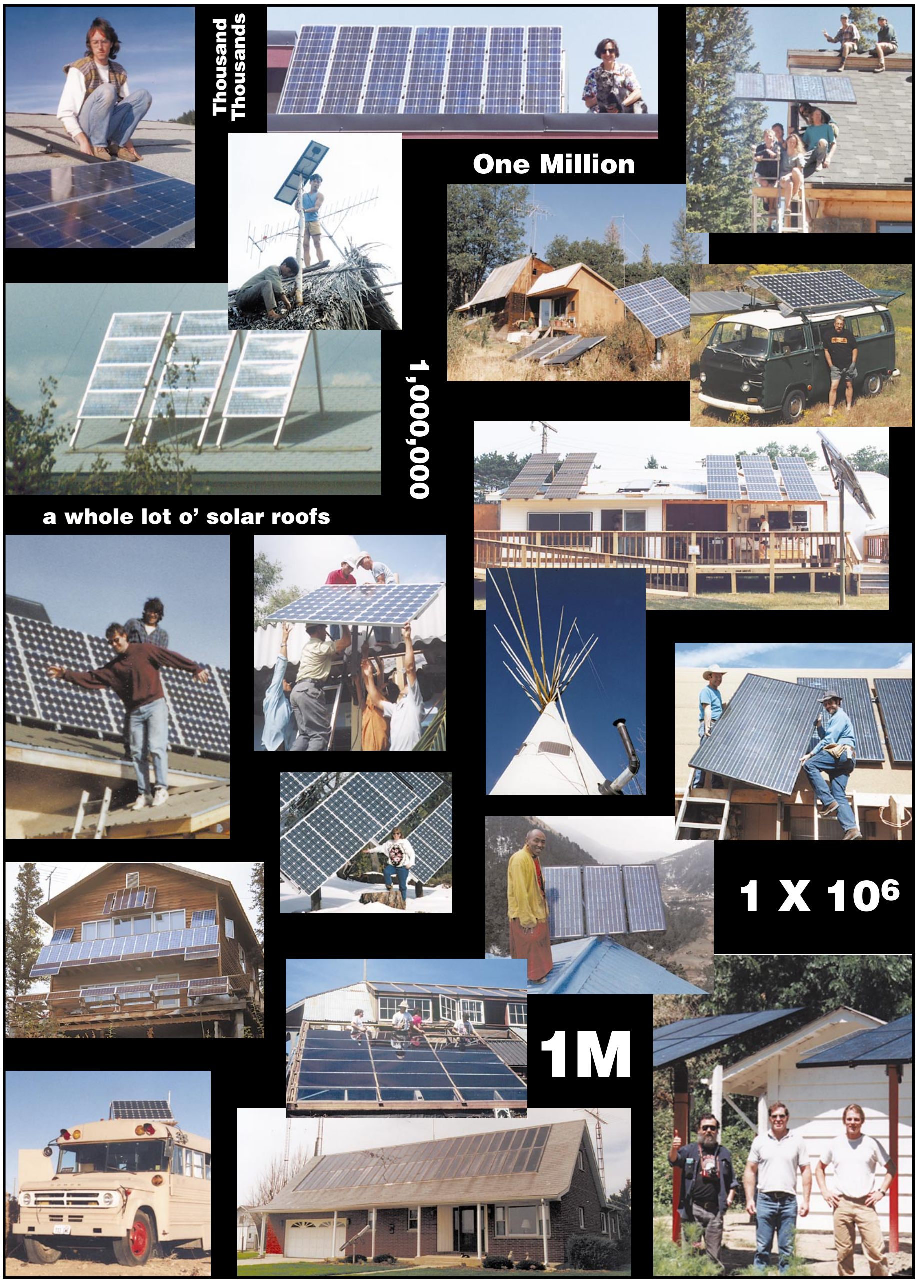

A million solar roofs...

After what seemed like a million solar goofs, the federal government is finally figuring it out. President Clinton says we need a million solar roofs. He's right, but a little on the low and slow side. We need hundreds of millions of solar electric systems worldwide, and we needed them yesterday.

President Clinton has figured out what thousands of *Home Power* readers have known for decades. Solar energy works and is the key to our energy future. It is the solution to energy related pollution. It makes us energy independent and frees us to live wherever we wish.

Perhaps the first of the new million solar roofs should be on the White House.

The HP Crew

People

Marina Baird
William von Brethorst
Mike Brown
Drake Chamberlin
Sam Coleman
Skip Goebel
Chris Greacen
Kathleen Jarschke-Schultze
Michael Klemen
Stan Krute
Don Kulha
Don Loweburg
Karen Perez
Richard Perez
Shari Prange
Benjamin Root
Bob-O Schultze
Laurie Stone
Michael Welch
John Wiles
William C. Williams
Myna Wilson

" Think about it..."

"The making of a million solar roofs begins with a single module."

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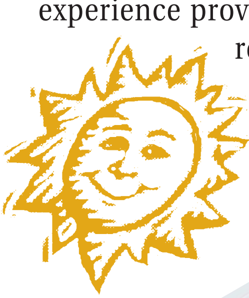

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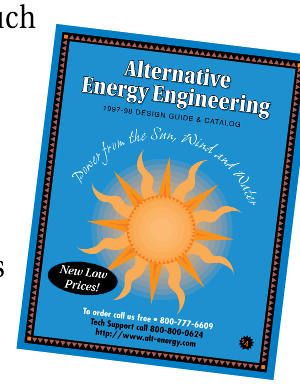

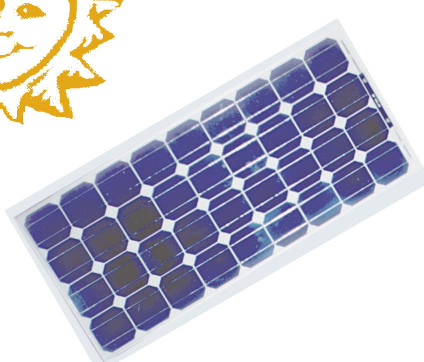

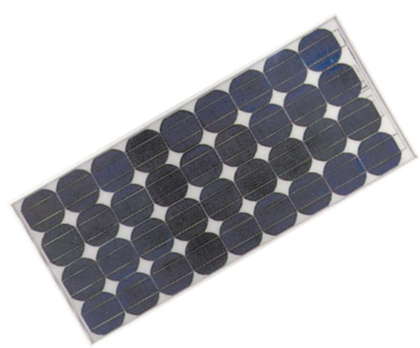

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ASTROPOWER AP7105
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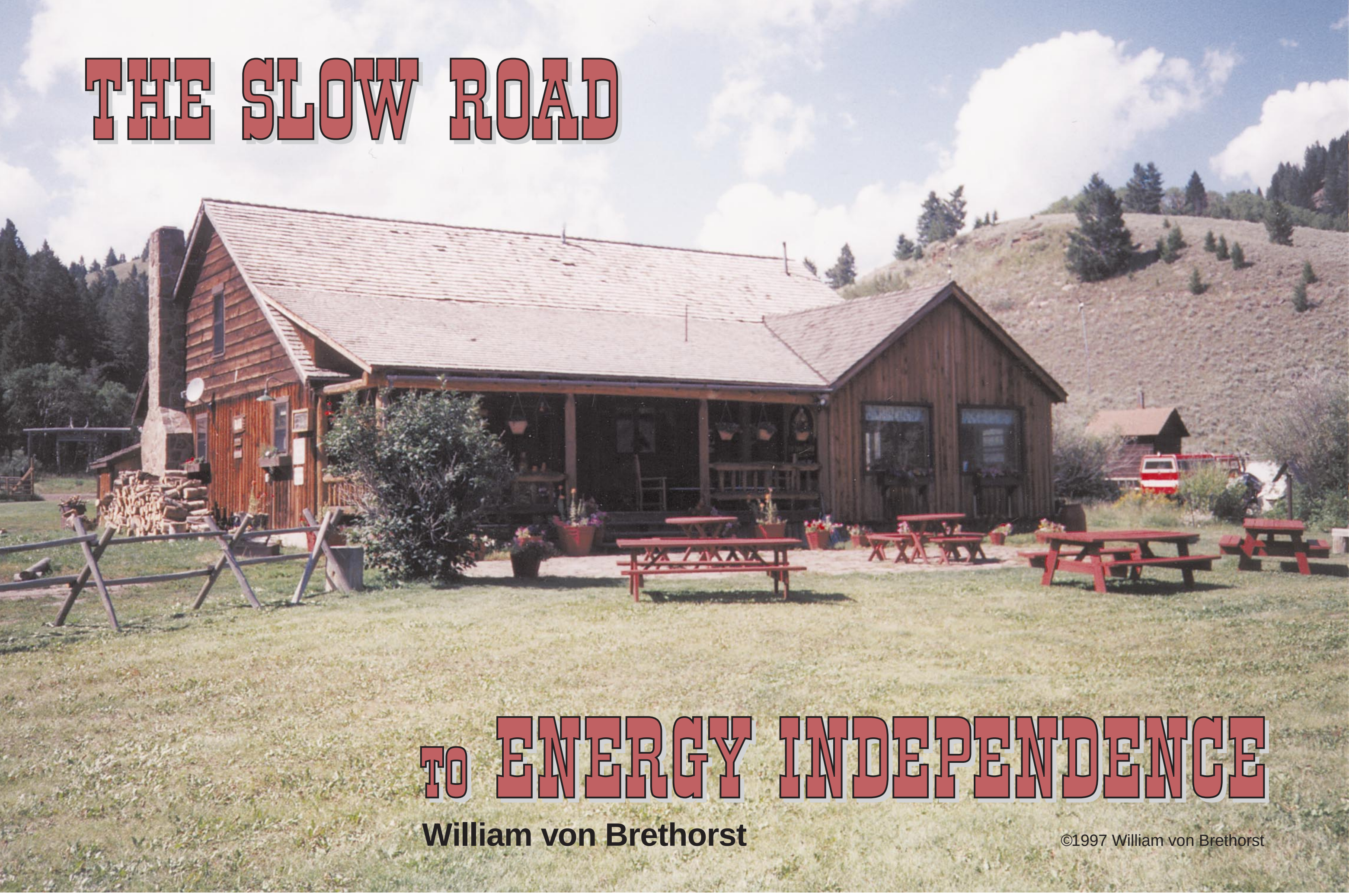
THE SLOW ROAD TO ENERGY INDEPENDENCE



William von Brethorst

Elk Lake is in Montana near the Red Rocks National Wildlife Refuge just outside of Yellowstone National Park. Elk Lake Resort consists of a lodge and seven cabins with fishing and other recreational activities as permitted by the National Forest Service. The area is very remote and isolated, accessible only by a dirt and gravel road in the summer and snowmobile in the winter.

The solitude and grandeur of the place is overwhelming. First homesteaded in the 1860's, the existing lodge is over 90 years old and the cabins were built in the 1930's for some of the first tourists to the area. The lodge had a pelton wheel generator at one time, the remnants of which still lie in a shed. No one seems to know all of the history through the past eight owners. But in 1992, the owner at the time decided (with some prompting from the Forest Service) to stop using the 150 kw Caterpillar diesel generator as much and reduce the size of the fuel storage tank. The tank was about 10,000 gallons and above ground, so the Forest Service worried about spills and leaks. But even with less fuel and generator use the property still needed electrical power for much of the day.

The Story Starts

The resort serves meals, has cabin lodging, and quite a few visitors. Refrigeration, water pressure, lights, and other amenities were required. I was asked to provide an estimate to get this done. In 1993, when I first surveyed the electrical usage, there were many old, standard freezers, a 3/4 hp well pump, a large reach-in cooler, an ice machine, washers and electric dryers, and a few refrigerators. The total of these were about 20 kw with over 40 kw in surge loads.

Most wiring was an old style known as Knob & Tube, unacceptable in today's electrical code. To complicate matters further, the wiring was only single phase while operating from a three phase generator. The generator was seriously unbalanced. Some of the wiring was unserviceable and needed to be replaced. After some design time and some back and forth consultation, I recommended the following course:

1. Replace or repair wiring needing it over the next year.

2. Relocate service panels and rewire to balance the generator load better.
3. Redistribute the loads, add efficient refrigeration and freezer capacity using Sun Frost refrigerators and freezers, and change lighting to compact fluorescent.
4. Add a renewable energy package including:

   Two Trace 2624/SB inverters stacked for 5000 watts at 120 vac

   Trace 2500 inverter for the well pump with Trace T-220 transformer for 220 vac

   Twelve IBE industrial batteries rated 1292 Ampere-hours at 20 hour rate, 2 VDC each for 24 VDC

   Todd PS-260 transfer switch to disconnect inverter load while charging

   Twelve solar panels at 60 Watts with two Trace C-30 controllers

   Two Winco Tri-fuel 9000 watt generators for charging and lodge loads

   Todd TS-50 transfer switch to move well pump load to genset when running.

Below: Wayne Scofield behind the bar with a Vestfrost fridge, one of nine refrigeration units at the resort.

Above: The main dining room at the lodge.

The plan was that when the load was reduced by changing the refrigerators to much more efficient Sun Frost units and by using compact fluorescent lighting, the main generator run time would be greatly reduced. The only remaining loads would be the electric dryer and some refrigerators which would run only when the generator was on.

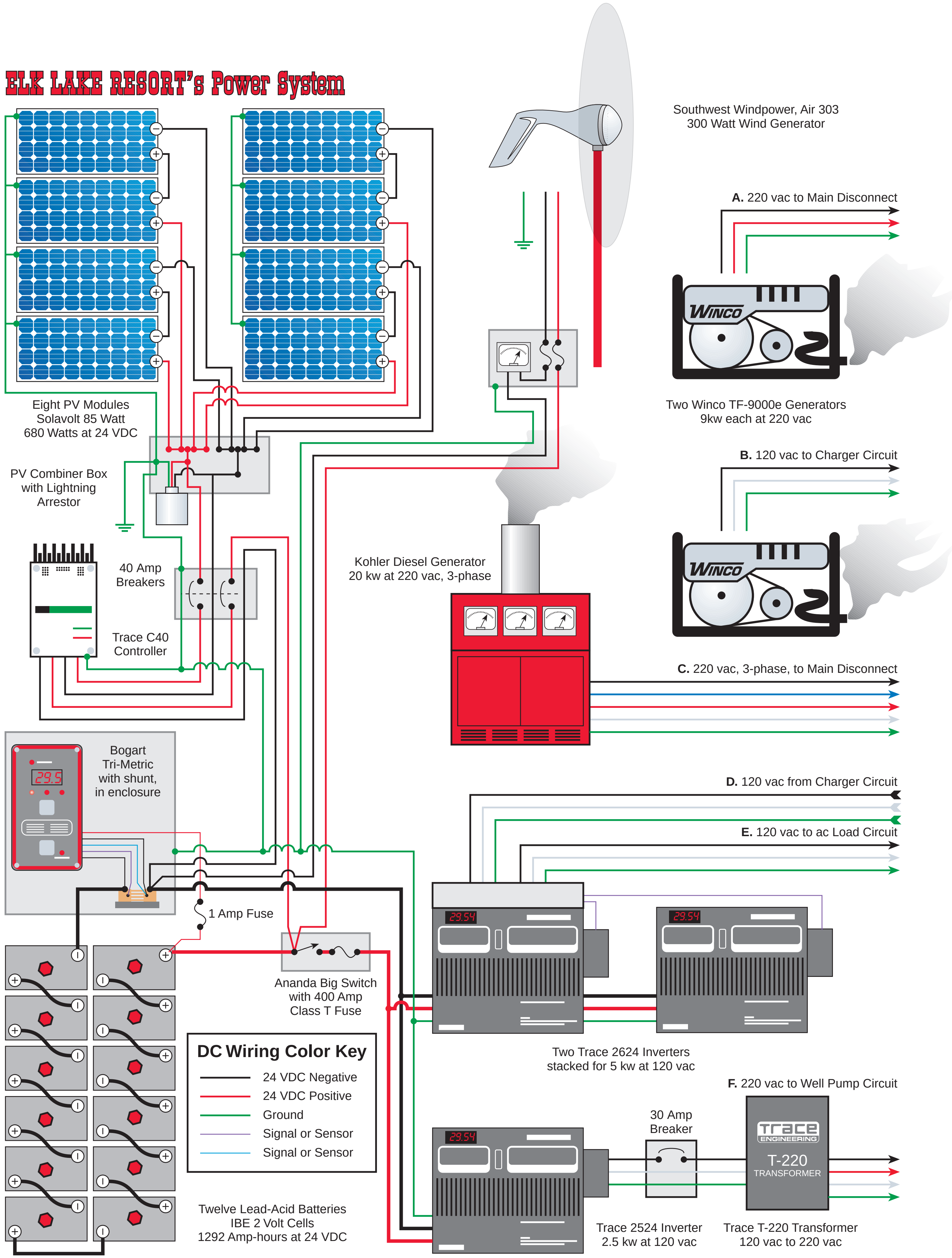
Change in Plans

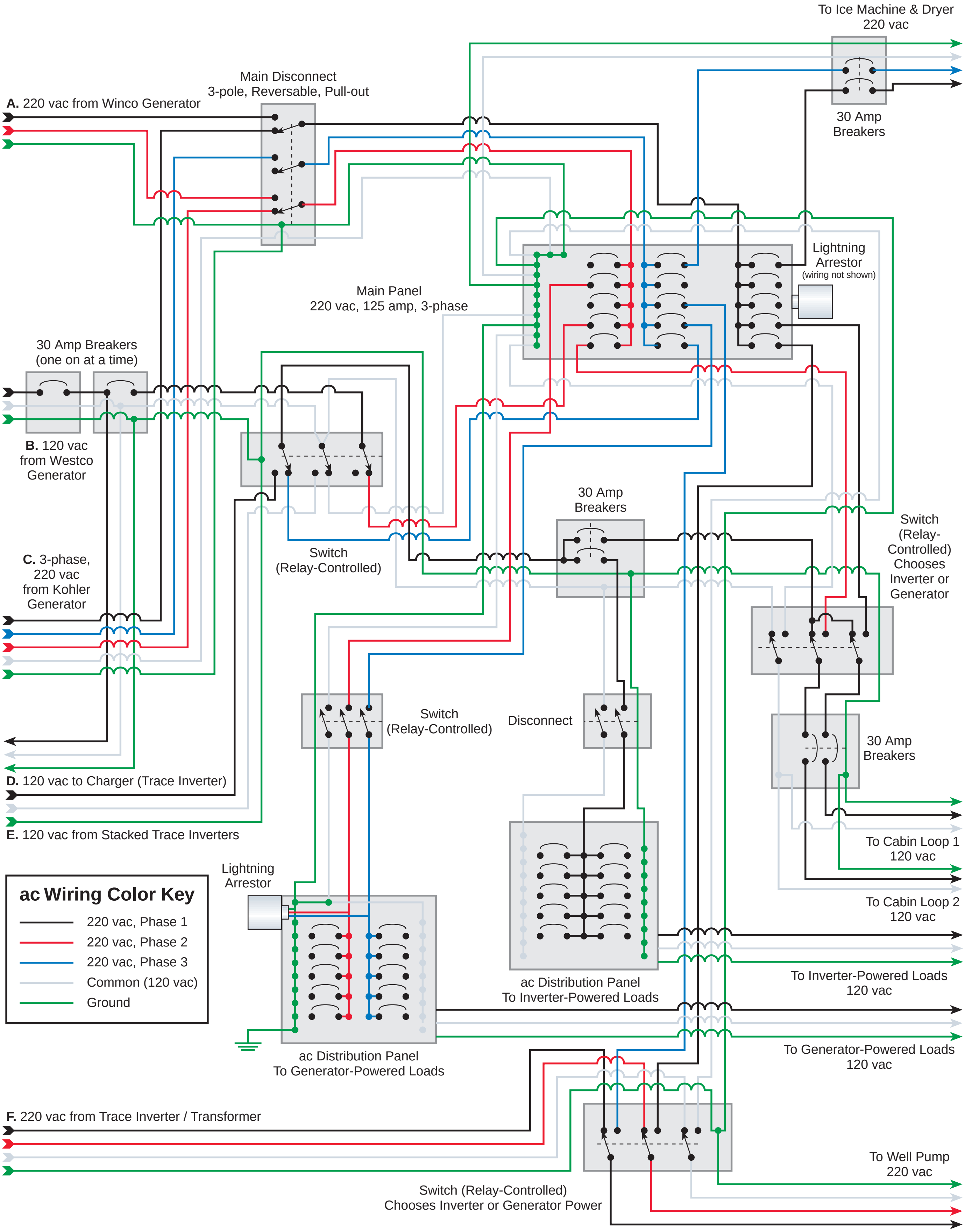
As with all plans, things changed and budgets were constrained. The resulting system consisted only of the inverters, battery system, the Winco generators, four Arco 16/2000 panels, a Trace C-30, no Sun Frost fridges or freezers, and only a few compact fluorescents. The Sun Frost units were to come in the next year as the budget allowed.

A redesign was done so the Winco generators would be used when fewer people were at the lodge. The loads would be shifted to reduce the main large generator to 5 to 8 hours daily and the inverters were to provide power for the well pump at night as well as a few lights. A circuit was added to re-distribute the well pump load using another Todd TS-50 transfer switch to disconnect the well pump from the inverter and run from the main generator. These systems were finally installed in July of 1993 by my friend, master electrician Skip Chisholm. Skip also rewired to bring the place up to a reasonable level of safety and efficiency.

Several things kept the entire plan from being enacted. The large fuel tank was reduced to about 500 gallons but the Caterpillar diesel quit working. It was removed

ELK LAKE RESORT's Power System



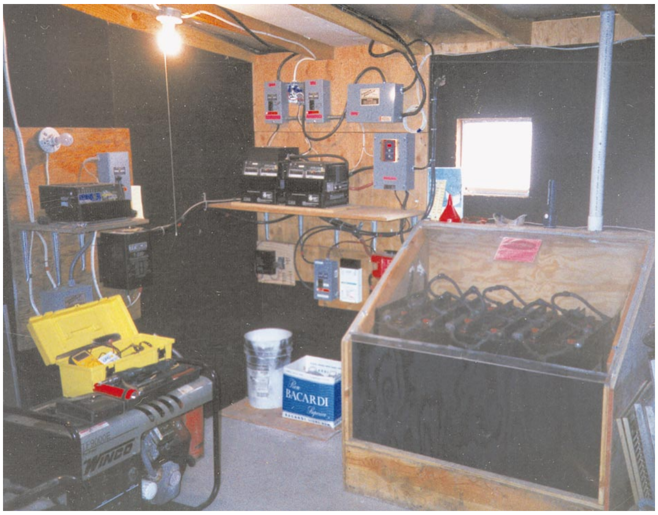

To Ice Machine & Dryer
220 vac
Main Disconnect
3-pole, Reversable, Pull-out
A. 220 vac from Winco Generator
30 Amp
Breakers
Lightning
Arrestor
(wiring not shown)
Main Panel
220 vac, 125 amp, 3-phase
30 Amp Breakers
(one on at a time)
B. 120 vac
from Westco
Generator
30 Amp
Breakers
Switch
(Relay-Controlled)
Switch
(Relay-
Controlled)
Chooses
Inverter or
Generator
C. 3-phase,
220 vac
from Kohler
Generator
Switch
(Relay-Controlled)
Disconnect
30 Amp
Breakers
D. 120 vac to Charger (Trace Inverter)
E. 120 vac from Stacked Trace Inverters
To Cabin Loop 1
120 vac
To Cabin Loop 2
120 vac
ac Wiring Color Key
220 vac, Phase 1
220 vac, Phase 2
220 vac, Phase 3
Common (120 vac)
Ground
Lightning
Arrestor
ac Distribution Panel
To Inverter-Powered Loads
To Inverter-Powered Loads
120 vac
ac Distribution Panel
To Generator-Powered Loads
To Generator-Powered Loads
120 vac
F. 220 vac from Trace Inverter / Transformer
To Well Pump
220 vac
Switch (Relay-Controlled)
Chooses Inverter or Generator Power

Above: More refrigeration, Vestfrost freezers, and 220 vac electric dryer.

and replaced with a 15,000 watt Detroit Diesel. Unfortunately, the load was not changed, so during the next few winters the Winco generators were called on to perform much more duty than intended. They had problems, as did the new Detroit Diesel. Several large propane tanks were added to switch electrical heating loads to propane.

Power Factor
A noteworthy factor is that running on a generator is not like running on utility power or an inverter. Many large commercial generators of 7.5 kw and up operate at 0.8 power factor, while utility and inverter power is at 1.0 or unity. Power factor affects the way loads operate even more than whether they operate on sine or modified

Below: Three Trace inverters, and the other DC components inside the power shed.



Elk Lake Resort Original Loads -1993

				Runs on:	
Load	*Volts*	*Amps*	*Watts*	*Gen*	*Inv*
Large Freezer-Original	120	8.50	1020	x	
Chest freezer	120	6.90	828	x	
Upright Freezer	120	8.90	1068	x	
Other freezer	120	7.90	948	x	
Bar Fridge	120	9.02	1082	x	
Bar Ice Maker	120	3.40	408	x	
Back Room Fridge	120	8.80	1056	x	
Reach-in Cooler	120	6.90	828	x	
Outdoor Walk-in Cooler	120	3.90	468	x	
Dryer	240	20.20	4848	x	
Washer-I	120	5.60	672	x	
Washer-2	120	4.90	588	x	
2nd dryer	240	20.20	4848	x	
Kitchen Fan	120	1.20	144	x	
Microwave	120	10.10	1212		x
Kitchen Lights	120	6.00	720		x
Great Room Lights	120	4.00	480		x
Dining Lights	120	6.00	720		x
Bathroom-Lodge	120	0.84	101		x
Bar Lights	120	2.00	240		x
Kitchen Equip.	120	1.50	180		x
Backroom Lights	120	3.00	360		x
Outside Lights	120	2.00	240		x
Signs	120	1.00	120		x
Misc. Bar Equip.	120	1.00	120		x
Stereo/TV	120	0.30	36		x
Satellite Dish	120	0.70	84		x
Cabins-Lights	120	5.00	600		x
Cabins-Outlets	120	8.00	960		x
Other Misc. Loads	120	2.00	240		x
Well Pump	240	8.40	2016	x	x
Power Shed Lights	120	1.68	202	x	
Misc. Outlets	120	1.00	120		x
Ranch House	120	1.00	120		x
		Total	27677		

It is important to note that, when running, the generator carries the majority of the load, though the inverter does have some resident parasitic loads.

sinewave power. This is especially true of things such as washers and microwaves. A 1200 watt microwave operating on utility power can deliver full power. The same unit on a generator with an 0.8 power factor can deliver only 80%. If running on a modified sinewave inverter, it can deliver about 85% of effective power. If the generator operates with an unbalanced load, the voltage regulator cannot maintain voltage under startup loads and the voltage drops. The same applies to battery charging using the Trace inverters which are an inductive load much like a motor. Further, unlike an inverter which has a reservoir of power in the batteries, a generator is limited to its nameplate rating. If exceeded, the voltage will drop and appliances can fail more quickly.

In the past few years Skip and I made several trips to the resort, upgrading the system and adding more automatic switches to provide more evenly distributed loading and more services.

In 1996, the lodge was purchased by a group from Idaho Falls including the Schofields: Wayne, Nancy, his

Elk Lake Resort New Loads - 1997

			Watts	
Load	*Volts*	*Amps*	*Gen*	*Inv*
Whirlpool Freezer-New	120	10.20	1224	
Vestfrost Freezer	120	1.80	216	
Vestfrost Freezer	120	1.80		216
Vestfrost Freezer	120	1.80	216	
Bar Fridge-Vestfrost	120	1.20		144
Main Ice Maker	240	6.60	1584	
Back Room Fridge	120	8.80	1056	
Reach-in Cooler	120	6.90	828	
Outdoor Walk-in Cooler	120	3.90	468	
Dryer	240	20.20	4848	
Washer-1	120	5.60	672	
Washer-2	120	4.90	588	
Kitchen Fan	120	1.20	144	
Microwave	120	10.10		1212
Kitchen Lights	120	0.80		96
Great Room Lights	120	4.00		480
Dining Lights	120	6.00	720	
Bathroom-Lodge	120	0.10		12
Bar Lights	120	0.12		14
Kitchen Equipment	120	1.50		180
Backroom Lights	120	3.00	360	
Outside Lights	120	2.00		240
Misc. Bar Equip.	120	1.00		120
Stereo/TV	120	0.30		36
Satellite Dish	120	0.70		84
Cabins-Lights	120	3.00		360
Cabins-Outlets	120	8.00		960
Other Misc. Loads	120	2.00		240
Well Pump	240	8.40		2016
Power Shed lights	120	1.68		202
Misc. Outlets	120	1.00		120
Ranch House	120	1.00		120
		Totals	12924	6852

Note: when running, the generator carries all the above loads, but not all loads are on at once, though possible.

Above: Eight Solavolt 85 Watt modules on the roof of the power shed.

brother John, and his wife Fran. They realized immediately that the system needed a tune-up. Skip and I made a trip to check the system out. We found that the old problem loads had not been replaced and had increased, and that the IBE battery bank had been deeply discharged practically every night for the last three years, regularly hitting 23.5 Volts. For any other battery, this would be murder.

A Battery Miracle

After a series of equalizing sessions we had the batteries looking a little better. They would not go above 27 Volts and the hydrometer was reading 1.100 on most cells. We decided to try something I had been using for a while on very low batteries. It is a product from Unival Corp. in Pleasantville, New York, and is supposed to bring back a dead battery without side effects. We added three ounces of this red cocktail to

Right: Power source switching station for choosing between generators or inverters.

Elk Lake Resort System Costs

Original System - 1993

Item	*#*	*Cost @*	*Total*
Winco TF-9000e	2	$1,850	$3,700
IBE Industrial Cell 1250 Ah	12	$303	$3,636
Trace 2624 Inverter	2	$1,400	$2,800
Trace 2524 Inverter	1	$1,100	$1,100
Arco 16/2000 Panels	4	$150	$600
Installation and Wiring	1	$600	$600
APT 400a Saf-T Switch	1	$369	$369
Trace T-220 Transformer	1	$275	$275
Stacking Option	1	$250	$250
Todd PS-260	1	$126	$126
Trace C-30	1	$99	$99
Cables-Set 410	1	$96	$96
Breakers-2p/3Oa	2	$48	$96
Todd TS-50	1	$85	$85
Panel Rack	1	$40	$40
		Subtotal	$13,872

Additional Equipment - 1996

Item	*#*	*Cost @*	*Total*
Solavolt 85 Watt Modules	8	$435	$3,480
Installation	1	$800	$800
Air-303 Wind Genny	1	$499	$499
Module Rack	2	$85	$170
Trace C-40 Controller	1	$158	$158
Tower	1	$125	$125
Cables-Set 4/0	1	$96	$96
Disconnects	2	$36	$72
Cable and Wire	1	$50	$50
		Subtotal	$5,450

Freezer/Fridge Additions & System Rewiring - 1997

Item	*#*	*Cost @*	*Total*
Vestfrost Freezer	3	$675	$2,025
Vestfrost Fridge	1	$900	$900
Installation and Misc.	1	$800	$800
Wiring and Cable	1	$350	$350
Delivery	1	$135	$135
New 3-phase Main Panel	1	$125	$125
New 1-phase Indoor Panel	1	$85	$85
		Subtotal	$4,420

Projected Additions - 1997

Item	*#*	*Cost @*	*Total*
Trace SW-4024 Inverter	1	$3,195	$3,195
Installation and Misc.	1	$400	$400
Delivery	1	$55	$55
Trade-in inverters	-1	$800	($800)
Subtotal		*Subtotal*	$2,850
		Total Project Cost	$26,592

each cell and, after waiting a few hours, began equalizing again. Within three hours, the batteries were slowly boiling and reached 30.5 Volts. With regular charging this system shows almost new performance and reads 1.258 to 1.267 on the hydrometer one hour after finishing charging (at 67° F).

The new owners were convinced that some serious work was needed to keep from having 3000 lb. of dead batteries or a big generator repair bill. A plan was devised to add some new components or systems every year and change out some old loads. Beginning in late 1996, the first serious solar charging was added with eight Solavolt 85 Watt modules and a Trace C-40 controller replacing the Arco 16-2000 and Trace C-30 setup. An Air-303 wind generator was added to help in the spring and winter when winds are very reliable and sun can be rare. A Kohler 20 kw generator had been added in 1994 after the demise of the Detroit Diesel unit and we hastened to advise the rearrangement of all circuits to balance the loads on this generator. Early in 1997, new circuits were added to balance some of the load and compact fluorescent lights were installed.

Finally, in August of 1997, most of the old freezers and fridges were replaced by a Vestfrost fridge in the bar and 3 Vestfrost freezers in the back room. There are still 2 conventional freezers and the large reach-in cooler left, but the remaining freezers are operated on generator only and are used mainly during the summer and fall. The overall generator load was reduced by 60% simply by changing from conventional equipment to low energy appliances. Most important, the surge load was drastically reduced. Before, surges of over 100 amps on one leg (240 vac) of the three phase generator were common. Now, even when the dryer is operating, the total load does not exceed 8000 watts per phase and is balanced between the three electrical legs of the generator. Fuel consumption should drop and batteries always get charged because there

Right: Resort owners Nancy and Wayne Schofield in front of their power shed.

is more voltage available to the Trace battery chargers. The Vestfrost fridge and one freezer are wired into a circuit fed only by the Trace inverter stack. They have timers which turn off the units at night for four hours, which does not seem to hurt the cooling capacity.

Four years after the original suggestions for a renewable energy system and low energy appliances, the vision is becoming a reality due mainly to forward thinking owners with an eye on the future, not just the bottom line. This may be a lesson for us all. A dollar spent on renewable energy in today's energy market may be worth much more in a future where every drop of energy may be as precious as clean water is today.

What's Left

We still have to deal with the large reach-in cooler, an electric dryer and ice maker with hefty energy appetites, a couple of washers, and a large brand new Whirlpool freezer in the back room for meats. The owners are committed to dealing with these and changing the inverters to a Trace 4000 watt sinewave to improve load efficiency. The generator is still essential for battery charging and backup power, as it should be for most renewable energy systems. But no longer is it the prime source it once was, and should it fail the remaining Winco 9000 watt backup generator could get them through till repairs are made.

It has been stimulating dealing with this project over the past four years, and has provided some parallels between the world in general and this small remote microcosm of people and energy demands. We all deal with the same issues of money, budgets, and bottom lines versus what would be done if our national emphasis was on energy use reduction as it is in Europe and other places. If real progress is to be made in the 21st century we must reduce our dependence on dinosaur fuels and invest time and money in new technologies that are safe, effective, and, most important, efficient. Centralized power and distribution are as wasteful and ancient now as is the iron mass core rotating in a magnetic field as first devised by Nicholas Tesla over 150 years ago.

Access

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System Owners: Wayne, Nancy, John, and Fran Schofield, Elk Lake Resort, West Yellowstone, MT 406-276-3282

Electrician: Skip Chisholm (Mr. Electricity), PO Box 594, Victor, MT 59875 • 406-642-3100

BP SOLAR

Two page spread covering
pages 14 and 15

four color

on negatives
this is page 14

BP SOLAR

Two page spread covering
pages 14 and 15

four color

on negatives
this is page 15

Amazon Power

Debbie Tewa

Donna Fischer

Laurie Stone

Technology, electricity, and power tools have traditionally been part of the male world. The renewable energy field is no different. If women have come so far in the past century, why are there still so few women in the renewable energy industry?

There are many reasons which vary from country to country. Yet everywhere, social, political, and economic factors influence the work people do. In most countries only a small percentage of women enter the science and technology fields. The barriers that women must overcome to enter the PV industry are diverse. The following four women have shown it is not impossible to overcome the gender barrier and enter the PV field.

There are resources available for women who want to get involved in non-traditional fields such as photovoltaics. Some are listed at the end of this article. There is also a lot of support from women already in the field. There are women working in every aspect of renewable energy, from education to training to research. The women highlighted are examples of the many helping to bring renewable energy to people who need it.

Self Sufficiency on the Hopi Reservation — Debbie Tewa

Debbie Tewa is the project director of the Hopi Solar Electric Enterprise, a project of the Hopi Foundation. The Hopi Foundation was started in 1984 to meet the community's needs. One of their largest projects, the Hopi Solar Electric Enterprise or "Native Sun," helps make solar electricity accessible to people on the Hopi Reservation and the neighboring Navajo Reservation.

Respect for traditional values and a distrust of outside agencies keep many Native Americans off the grid. Yet

Women and PV

Seela John Sainyeye

Marlene Brown

many Native Americans now want access to the modern conveniences that electricity can provide. Not only do PV panels use a traditional source of energy, but they also eliminate any need for an outside power company with its intrusive poles and distribution lines.

Debbie had been working as a commercial electrician in 1987 when she received a call from the Hopi Foundation asking if she would like to attend a photovoltaic training workshop. Debbie and four other Hopis were selected to attend Solar Energy International's (SEI) PV workshop. In 1991, she began working with Native Sun installing PV systems on the Hopi Reservation.

Since Debbie became involved with photovoltaics she has not encountered any gender problems. Unlike when she was working as a commercial electrician, Debbie feels that the PV industry is more accepting of women.

Debbie and her colleagues at Native Sun have installed over 320 PV systems. But they do not only install systems, they also educate people. According to Debbie, education is key to the Native Sun philosophy. Besides educating the users and owners of the systems she installs, Debbie travels around to schools and summer camps teaching Hopi children and teenagers about solar energy.

Debbie's most satisfying work is working with the Hopi people and making their lives better. By making PV electricity accessible she is helping people become self-sufficient. When people eventually pay off their systems and own their own electric company, it is very empowering. Debbie also serves as a role model for the young girls on the Hopi reservation by showing them that they do not need to be limited by their gender.

Debbie's advice to other women who want to get involved in the renewable energy field is, "Just get in there and do it." She advises women not to let PV technology intimidate them. "Sometimes it may be hard, but it's like life. If you decide that's what you want to do, you just have to do it."

Amazon Power — Donna Fischer

Donna Fischer has always been interested in helping the planet in any way she could. She never thought she could get involved in renewable energy technology because she had no experience. However, after she learned electrical skills, it seemed a much more accessible goal.

In 1988, as a single mom, Donna started an apprenticeship with an electrician. Having no previous electrical experience she ended up doing a lot of the grunt work. During that time, she also worked as an apprentice to a PV installer where she also did mostly "no-brainer" stuff. After a couple years of apprenticing she went to school to learn more of the technical part of electricity. She eventually took some hands-on photovoltaic workshops at SEI and, in 1993, started her own PV dealership in New Mexico called Amazon Power Company.

For Donna, the most important part of her work has been her personal growth. Moving from no technical knowledge of electricity to learning the skills and being able to apply them to help people has been very satisfying. She can see that bringing electricity to isolated people makes a big difference in their lives.

Donna finds most people in the renewable energy industry more supportive of women than in other technical fields. In the traditional fields, Donna felt more like an intruder. "Being an electrical apprentice is hard for anyone, and it was compounded by being female." Yet she feels that there are many people in renewables who respect her because she stuck with it.

That tenacity is what Donna thinks was the key to her success. When she first started doing electrical work there were a lot of people who didn't think a single mother with no technical skills could do it. But Donna was too stubborn to let them have the satisfaction of being right. She wants to encourage women to "just go for it in the best way you can, and don't give up." Donna's persistence resulted in Amazon Power Company.

Bringing Light to the Masai — Seela John Sainyeye

Seela John Sainyeye works for an organization in Tanzania called the Orkonerei Integrated Pastoralist Survival Program (OIPSP). It was started in 1991 in Tanzania to improve the quality of life for the Masai. OIPSP has six branches: environment, education, communication, health, human rights, and women. One of the projects in the environmental program is the solar project.

The solar project was started to demonstrate, evaluate, and make available affordable solar lighting systems for the Masai. The project coordinators are also researching and implementing solar lantern technologies to bring light to people who can't afford complete solar systems.

70% of the Masai women in Seela's community are illiterate. The need to improve women's lives by bringing them electricity was the main reason that Seela became involved with photovoltaics. Before photovoltaics came to Seela's community the only source of light was fire. Seela saw PV as a non-polluting energy source that could greatly help her people.

Seela's first and one of her most rewarding PV installations was powering a vaccine refrigerator for a health clinic. She helped out the other technicians at the clinic before she had any PV training. After that installation she decided to learn more about PV, so she attended a training workshop at KARADEA, a solar training facility in Kagera, Tanzania. Since the training program Seela has helped install 25 PV systems, mostly for lighting.

OIPSP has four solar technicians and Seela is the only woman. The only gender problem she encounters is that Masai women have a lot of responsibilities in the home. Many times she cannot leave her house to do an installation because she has to take care of her child or perform other household chores.

However, she says that more women in Tanzania are becoming interested in PV. OIPSP had a PV training workshop last April and six women attended. OIPSP has also started a day care center to make it easier for women to get involved in programs like the solar project. Seela tells women who want to learn more about PV electricity to come by OIPSP's office, look at the equipment, and start reading about the technology. "And if they can't read," she says, "we will explain it to them."

Making a Difference — Marlene Brown

Marlene Brown first became involved with renewable energy because she wanted to make a difference. She took a course in college called Energy Systems which exposed her to PV technology and piqued her interest. She did energy conservation work for awhile and, in 1989, attended a one year course offered by the founders of SEI to learn more about photovoltaic technology.

Since then Marlene has worked with the Solar Electric Light Fund (SELF) doing PV work internationally and Sandia National Laboratory doing research. Although Marlene finds her research work fascinating, her most satisfying work has been her international work. Marlene is the project manager for SELF's Vietnam Project (see HP #50). She spent four months in

Vietnam training technicians and users, and installing PV systems for rural electrification. She also spent two weeks doing a rural electrification project in the Solomon Islands. She finds this work so satisfying because “you can actually see it changing people’s lives.”

At Sandia National Labs, Marlene works in the PV Research lab. Although very different from actually being in the field and installing systems, she thoroughly enjoys her research. She is on the cutting edge of new technology for the PV industry.

Marlene is also currently a graduate student in electrical engineering. Being one of the few women grad students in her field and one of the only women in the PV Research Lab at Sandia has not been easy. She feels the more technical a woman gets, the more challenges she faces because of her sex. Marlene feels she needs to work harder than most men in her field to prove that a woman can do just as good a job. Marlene has encountered problems on all levels because of her gender. “The more you move into the men’s field, the more you tread on their traditional roles, the more you have to prove yourself.”

She concedes that it is not easy for women to enter technical fields because they don’t initially get respect. Yet her advice to women who want to get into the PV industry is “Go for it and stick with it. Follow your heart, follow your dreams. You never know where you’ll end up, but it will always pay off. Knowledge is a wonderful thing.”

Overcoming the Gender Barrier

The reasons there are few women in the PV field are diverse. In developing countries, working outside of the home may not be an option for women who have many domestic responsibilities. In the United States, a woman may be faced with the challenge of working harder in a traditionally male field to prove that she is competent. Even women who overcome these barriers and enter the PV industry still face challenges working in a male dominated field.

The separation of skills by gender starts at an early age. The education system has been a large factor in women’s exclusion from technology. Subjects that children study in school are strongly linked to a person’s gender. Many young girls are not encouraged to take scientific and technical subjects while boys often are. Girls are often discouraged from taking technical classes. In many developing countries the education system can be even harsher for girls, with only boys being allowed to go past the primary grades. Half of the world’s women continue to be deprived of higher education.

This discrimination in education systems affects people later in life. Due to women’s lack of participation and training in technology, they have not been in an equal position to compete with men for technology employment. Women may also be restricted in choice of jobs due to family and domestic responsibilities. Intimidation is an added factor to overcome when joining a traditionally male field.

PV technology can greatly improve the lives of women. Photovoltaics can ease women’s burdens by bringing lights to rural homes, electricity to health clinics, and water pumping systems to rural villages. And as the PV industry grows, more and more women will have access to this technology. Yet women need more than just access, they also need to participate in the development of these technologies as well as exercise control over their applications.

Technology is never neutral, and renewable energy technologies are no different. Men and women have different sets of skills, knowledge, and priorities. This means that women have something distinct to offer when they become involved in technologies. In the developing world, women spend more time in the home and with the family than the men do. Therefore, they may be aware of different needs that photovoltaic electricity can fulfill. In the developed world, women are more often the educators and are more likely to pass their knowledge of renewable energy on to young children. Throughout the world, women who are involved with photovoltaics can be role models for young girls who would like to get involved in technical fields.

I strongly encourage any woman who has an interest in renewable energy technologies to pursue her dream. These four women are only a few examples of the many women working with photovoltaics. Yet for every Debbie Tewa in the PV field, there are hundreds more women who have not been able to enter traditionally male dominated fields. However, just as renewable energy technologies have a lot to offer women, women have a lot to offer to the renewable energy field.

Access

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Marlene Brown, Sandia National Laboratories, Box 5800, Mailstop 0752, Albuquerque, NM 87185 E-mail: marlene@unm.edu.

Resources for Women in Technology:
In March of 1998, SEI will conduct a Women's PV Design & Installation Workshop in Tucson, AZ.

Advocates for Women in Science, Engineering and Mathematics, Oregon Graduate Institute of Science & Technology, PO Box 91000, Portland, OR 97291-1000
503-690-1261 • E-Mail: awsem@admin.ogi.edu
Web: www.wwide.com/awsem

Society of Women Engineers, 120 Wall St. 11th floor, New York, NY 10005-3902 • 212-509-9577
E-Mail: hq@swe.org • Web: www.swe.org

Dr. Barbara Farhar, Women In Sustainable Energy Development, NREL, 1617 Cole Blvd., Golden, CO 80401-3000 • 303-384-7376

Wider Opportunities for Women, 815 15th St. NW Suite 916, Washington, DC 20005 • 202-638-3143
E-Mail: wowinfo@w-o-w.org

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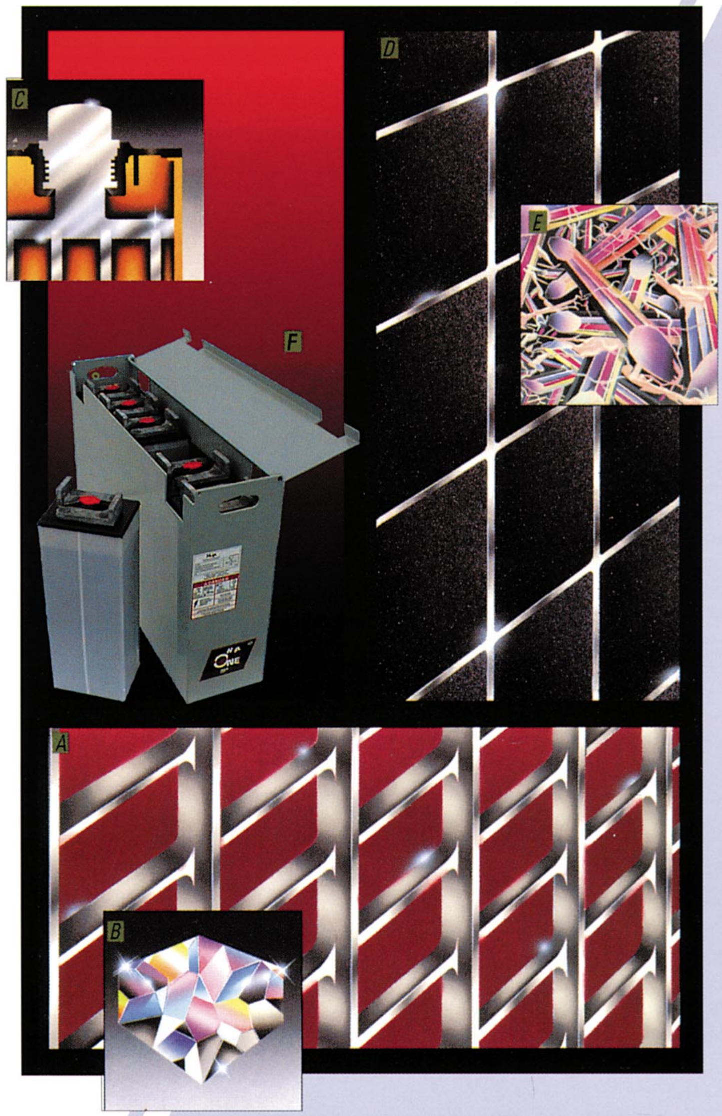

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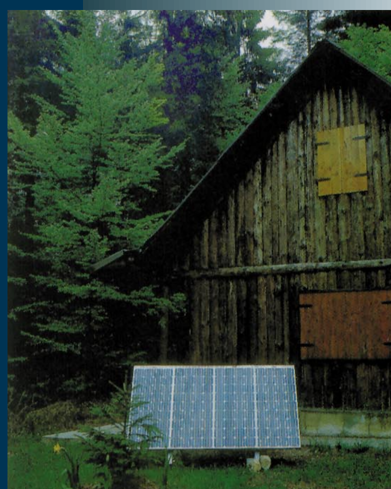

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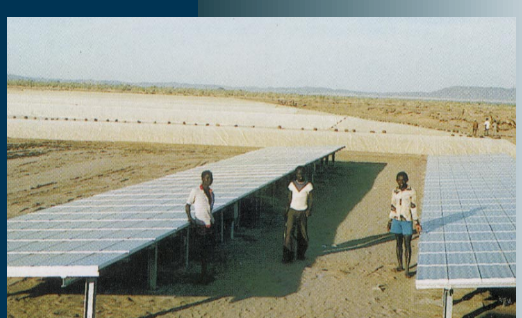

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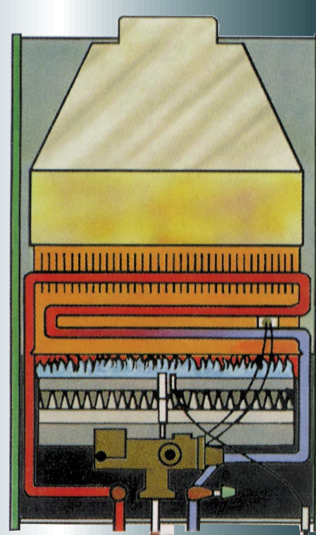

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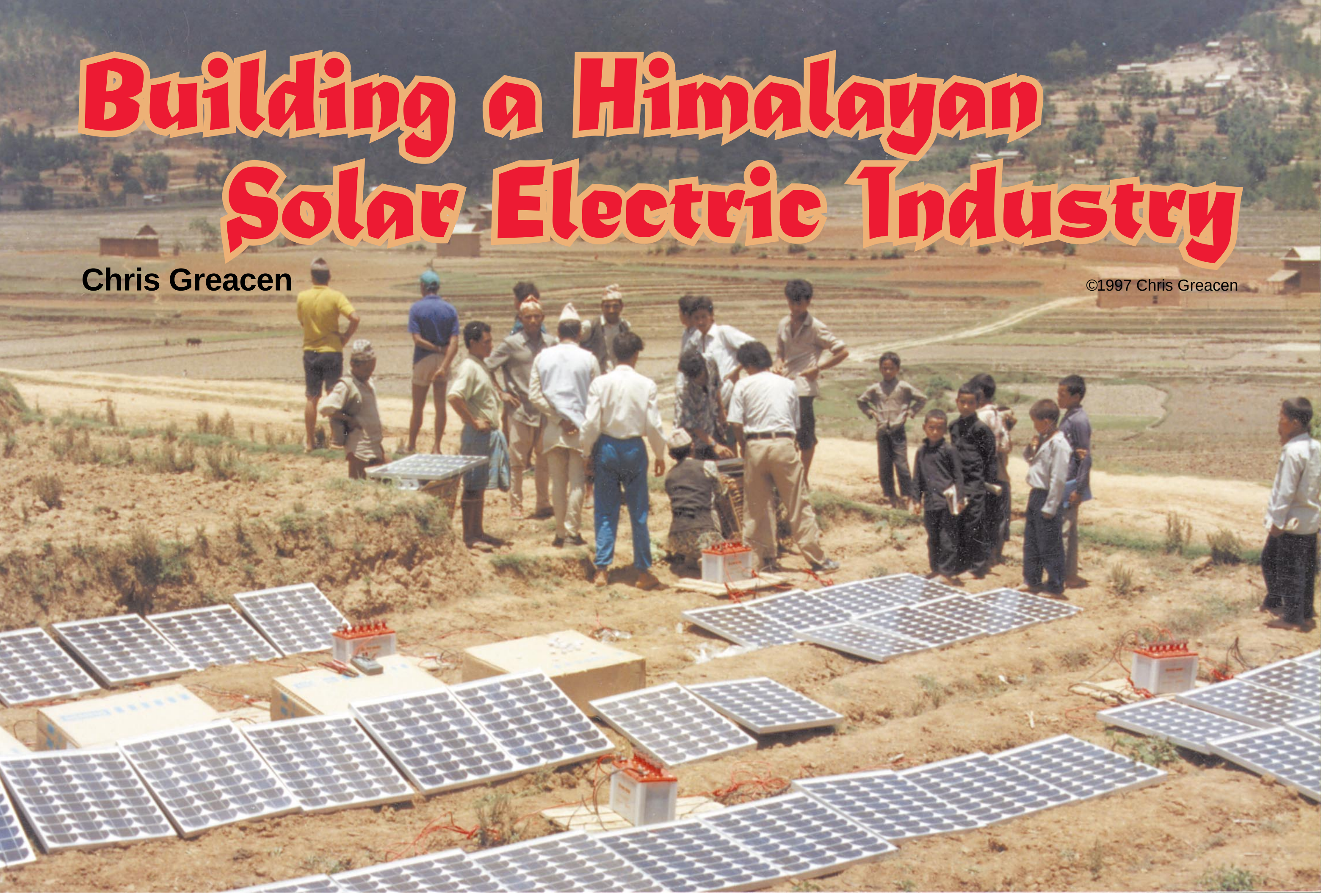
Building a Himalayan Solar Electric Industry

Chris Greacen



Above: Siemens PC2-JF panels soak up the sun in a field at Bhakunde village. This was Lotus Energy's first village installation and batteries were brought to the site dry. At the site, acid was added, and each battery was given its initial charge using ten 36 Watt Siemens PV panels in parallel. It took three days to charge forty batteries! Now Lotus Energy adds the acid and charges batteries in their factory in Kathmandu. Photo: Yogi Kayastha.

Five years ago Adam Friedensohn and Jeevan Goff (formerly JR Goff) left the US and came to Nepal with the dream of starting a business providing solar electricity to remote villagers. Eighteen million of Nepal's twenty million people have no electricity. They want electrical power to replace kerosene for lights at night and perhaps to power a radio or TV to hear news from the outside world. Electrification by utility line extension is a distant dream, made difficult and expensive by Nepal's rough mountainous terrain. For many villagers, photovoltaic (PV) or micro-hydro offers the best hope for household electrification.

Jeevan and Adam started their solar village electrification efforts with only one laptop computer and very little cash. Their business plan was based on the following:

Cost of extending the electric grid in Nepal: $30,000 to $60,000 per kilometer. Cost of a 35 Watt stand-alone solar photovoltaic (PV) system: $600. How many households could be electrified with solar for the price of a kilometer line extension? Answer: 50 to 100 for the cost of the line extension alone! With these numbers in hand, they figured it was worth risking several years of their lives to find out if they had a business. Today their company, Lotus Energy, has a staff of over 50 and a three-story office/factory in Kathmandu. The business includes a manufacturing division that makes MOSFET-based charge controllers and 12 Volt DC compact fluorescent ballasts.

They have installed over 1000 solar electric systems and components in rural Nepal, mostly for home lighting, but also for solar pumping and powering remote medical clinics, development project offices, and Tibetan Buddhist monasteries. They train and employ Nepalese for all the jobs in the company, including electronics design and prototyping, system installation and repair, sales, and marketing.

Above: Often, components must be carried by foot to remote villages. Lotus Energy technician Lekhnath Aryal helps customer Mr. Chakra Dwoj Lama of Kamere village, Kanpur, pack a complete solar electric system into a doko (traditional bamboo basket) to be carried to his village. Photo: Yogi Kayastha.

Typical Village Solar Electric System

Lotus Energy mainly sells small 36 Watt PV systems for village lighting. Fortunately, many traditional Nepali village homes have similar floor plans. Downstairs is a cooking area and a room for animals at night. Upstairs are one or two 500 square foot bedrooms. This similarity means that Lotus can create and sell standardized solar electric systems, including pre-cut wire lengths. This makes the solar electric systems easier to build, repair, and finance. Each village household system is powered by a single 36 Watt Siemens (New model number is: SP36) PC2-JF PV module. This module provides several hours of power to three compact fluorescent lights and a black and white, 12 Volt DC television.

Charge Controller

Lotus Energy's 10 Amp MOSFET based controller regulates the battery and loads. Lotus Energy designed the package with international symbols so that even an illiterate person can operate the system. The shunting-type controller has two low voltage disconnect (LVD) modes to prevent the battery from discharging too deeply. This feature is essential since batteries that are frequently run until they are "flat" will last only a fraction as long as those that are moderately discharged. The first LVD (usually set at 11.5 Volts) triggers a blinking red light and shuts off power to the loads, but will allow the villager to turn on the power for two more minutes if the controller's "ON" button is pressed. This allows users a few more minutes of light to put away things for the night.

The second LVD (usually set at 11.0 Volts) is not as generous. At this low-battery voltage, lights are out. Period. The power is allowed to be turned on to the loads when the battery's voltage has climbed above 12.0 Volts. The load controller also has built-in 12 Amp over-current protection, triggered by measuring the voltage drop across the controller's (50 Amp rated) MOSFET. Electricity from the solar panel is stored in a 70 Amp hour 12 Volt deep-cycle battery manufactured by a company called Industrial Batteries Ltd. in Bangladesh. The battery has tubular positive plates for long life and recombination caps to reduce the amount of water that escapes from the cells. Each system is provided with one liter of distilled water, enough to last for several years.

Compact Fluorescent Ballast

For home solar electric systems, reliable, efficient lighting is essential. Unfortunately, most 12 Volt compact fluorescent light ballasts have poorly designed starting circuits that lead to premature bulb failure. Lotus Energy designed and produces their own high efficiency electronic ballast for four-pin Phillips "PL" bulbs that appears to last for several years of frequent cycling. The ballast uses a special heating circuit that warms the tube for about half a second before starting. A 20 kHz, filtered, bipolar transistor-driven sinewave generating circuit drives the bulb. The ballast is around 80% efficient.

The circuits that Lotus makes are easily serviceable in the factory. Lotus makes the housing of the SYSCON 10 Amp controller and the fluorescent light ballast out of durable fiberglass and the back plate from sheet aluminum. Circuit boards for the controller and ballast are printed in-house using silk-screen, then stuffed, soldered, and tested by Lotus employees.

Tending the Seeds

Well built solar electric systems are crucial for the long-term success of solar village electrification. In developing countries there are a number of challenges

Above: Lotus Energy technicians Bharat Dhakal, Deepak Humagain, and Navaraj Thapa unload PV panels from a tractor-pulled cart in Asrang village, Gorkha district. Photo: Yogi Kayastha.

that renewable energy companies face that have little to do with engineering. They're policy problems and financing problems. How will the systems be paid for? Nepalese villagers have very little cash. While a solar electric system may pay for itself in the long term, in the short term even a small system can cost more than a year's wages. How will they be maintained? Solar electricity requires little maintenance compared to, say, a gasoline generator. But batteries need distilled water, electrical contacts need to be kept clean, and bulbs need replacing. Often this maintenance isn't intuitive to villagers. But if it's not done, then the system may die a premature death.

These are issues that many renewable energy development projects ignore entirely, by dropping a foreign technology in an exotic, needy area, taking photos, writing up an impressive report for the donor organization, and leaving. It all looks good on paper, but often six months or a year later, all that's left in the village is a pile of expensive junk, and a growing bad name for renewable energy (and "development projects").

To address how to pay for village PV systems, Lotus Energy worked with the Nepalese government and Nepalese banks to put in place a program called LEVEL-UP, the "Lotus Energy Village Electrification and Lighting Utility Program." The Nepalese government provides a 50% subsidy for solar electric systems available through the Agricultural Development Bank of Nepal (ADB/N). ADB/N offers the same subsidy to village micro-hydro systems, but for the past several years this subsidy has not been fully claimed. Traditional grid extension electrification is also subsidized, as is kerosene and other fuels.

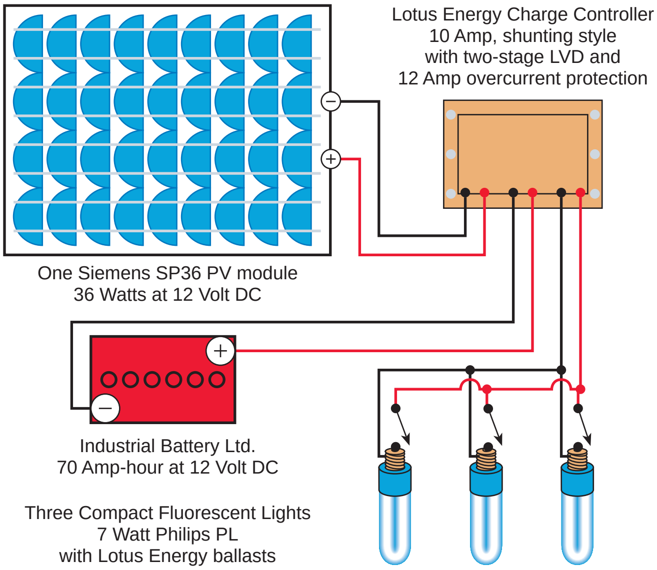
To cover the remaining unsubsidized costs, Lotus Energy worked with ADB/N to create a revolving loan fund. Villagers pay 5,000 rupees (about US $100) down-payment, and pay the remaining 10,000 rupees at 16% interest to the local branch of ADB/N. The bank pays Lotus in batches of 50 systems. Via a combination of subsidy and long-term loan, the villagers finally have what they have long been promised by politicians, but never got: electricity in their homes.

The First Round of LEVEL-UP Installations

After an extensive survey, Lotus Energy chose the Kabhre district in central Nepal to be the first site for LEVEL-UP. The area was within a day's travel of Kathmandu (facilitating easy monitoring of the project) and had adequate sunlight. In some villages, mountains cast substantial shadows both in the morning and late afternoon hours. Lotus Energy installed a sample system at the health clinic with the help of a local 12 year old boy. After explaining the operation and maintenance of the system to the selected caretaker they left the system in the responsible hands of the village chief.

The villagers of Kabhre used the system every night for a few months. When Lotus Energy returned villagers lined up to buy systems for their homes. Lotus decided to offer 40 systems for the first round. Once the banking paperwork was completed for these systems, Lotus

Below: Transportation to villages during the rainy monsoon season is very difficult. This truck carrying 10 solar electric systems (as well as bags of rice and people) is stuck up to its axles. Photo: Bhumi Baral.



Energy returned and installed them all within a week or two. They began on Earth Day just before the monsoon rains started. The roads wash out every year at that time, so Lotus technicians could not return until a few months later. During monsoon, sunlight hours are at their lowest, only four sun-hours per day average. When Lotus Energy returned after monsoon, the villagers were happy with their systems and said they rarely saw the system controller's low-battery indicator light come on. They used three compact fluorescent lights for three to four hours a night. They also connected their cassette radios and stopped buying the flashlight batteries that used to litter the countryside.

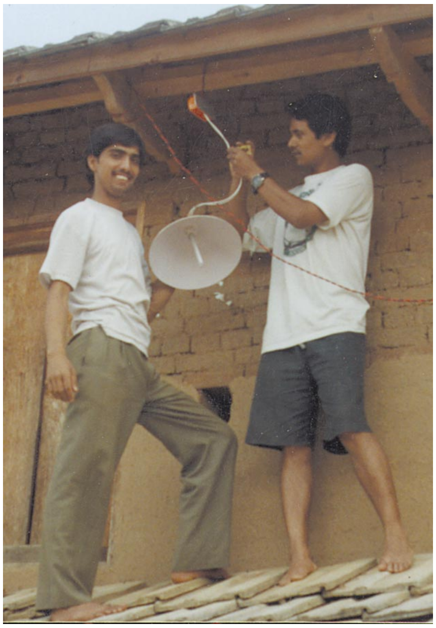
At the end of monsoon there were over 200 more villagers waiting for their chance to buy systems. Lotus has since done similar projects in several other districts. In each, a local person is trained and hired to maintain the systems. This maintenance person ensures that the systems are operated properly, and that the batteries have sufficient water. He also installs new wiring, lights, and responds to warranty claims. The PV panel is warranted for ten years, the electronics for two years, and the battery has a three year pro-rated warranty. For an area with extreme transportation difficulties, this kind of network of local repairmen / promoters is crucial for the success of a renewable energy electrification program.

Making Money, Saving Money

Many of the villages in which Lotus Energy works have resident thanka painters. Thankas are a beautiful intricate type of Tantric Buddhist painting. The artists earned their income from painting thankas and selling them in the capital city, Kathmandu. Previously they complained about the smoke, soot and noise from the Petro-max ("Coleman" mantle type) lanterns and about how much money and time they spent buying kerosene. The light from the Petro-max was of a poor quality. Now with solar systems they have clean, bright light and much more cash in their hands (about 500 Nepali Rupees extra or $10 per month). They can paint later into the night and sell more paintings!

Tailors and weavers in the village are able to continue working later into the night and make more money. Store owners can stay open later. Women are happy not to have to wake up and struggle with kerosene lanterns for half an hour in the dark before their families wake up. They have more time for other things and can

Left: Installing the PV panel is the most dangerous part of the installation in typical Nepali village homes. Here Lotus Energy technician Ramji Khanal installs a PV panel on the roof of a three-story house in Bohre village. Photo: Dharmendra Maharjan.



Right: Lighting is the biggest demand on village solar electric systems. Here Bhumi Baral and Yogi Kayastha install a 7 Watt CFL outdoor lighting fixture and Lotus Energy 12 Volt electronic ballast under the eve of a house in Bhakunde village. Photo: Nanda Raj Lama.

The village, or the house… that is the question

There are two different perspectives on renewable energy rural electrification. One school of thought believes that village scale power production is the best option. Because of low cost, comparatively low-tech manufacturing requirements, and economies of scale, micro hydroelectricity is most commonly chosen. Village micro-hydro plants are installed by a number of companies in Nepal, often using Nepalese-manufactured turbines and controllers. Projects usually involve working closely with a village to develop a managerial system, maintain the installation, collect fees from villagers, and address conflicts that arise when villagers don't pay. Equipment usually consists of Pelton or cross-flow turbines powering induction or synchronous generators. These generators vary in size from 100 Watts up to hundreds of kilowatts. Electronic load controllers (ELCs) keep the voltage regulated by diverting excess electricity into resistive heating loads when households aren't using the hydro's full capacity (in the middle of the night, for example). In some installations there is no ELC, and the hydro plant is manually regulated by a man with a hand on the water valve, and his eye on the voltmeter! In the past 20 years, some 300 micro-hydroelectric systems have been installed in Nepal. Another 1,000 produce mechanical power for grain milling and hulling or oil expelling.

A second school of thought focuses on decentralized home-based systems. This is the area where Lotus Energy has worked so far. It turned out to be much more difficult than expected to get an entire village to organize and follow through with hydroelectric projects. By contrast, household scale PV systems seem to be doing well. With stand-alone PV, each household gets its own system, each its own responsibility, and it alone enjoys the benefits. There's no social problem or headache! On the other hand, with individual systems, there's less opportunity for the village to work together on a common goal. In practice there is plenty of need for both PV and small hydro in Nepal, and the best technology for electrification depends on local geography and the goals and aspirations of villagers.

EV Public Transportation in Kathmandu

What else is Lotus Energy working on? They have opened up an electric vehicle company called EVCO which has several three-wheeled vehicles running on fixed routes that can take 9 passengers each. The vehicles run on two battery exchanges per day, which occur at a central station in Kathmandu. Lotus Energy's aim is to replace 2,000 three-wheeled diesel "Vikrams" with non-polluting electric vehicles.

Typical System Cost

#	*Description*	*Cost US $*	*Cost Nepali Rupees*	*%*
1	Siemens 36 W 12 V Module	$293	16682	50%
1	70 Ah 12 V Battery	$114	6498	19%
3	7 W Compact Fluorescent Light	$63	3534	11%
1	Misc. Installation Materials	$54	3078	9%
1	10 A Controller	$42	2375	7%
1	PV Mount	$25	1425	4%
	Totals	$591	33592	100%

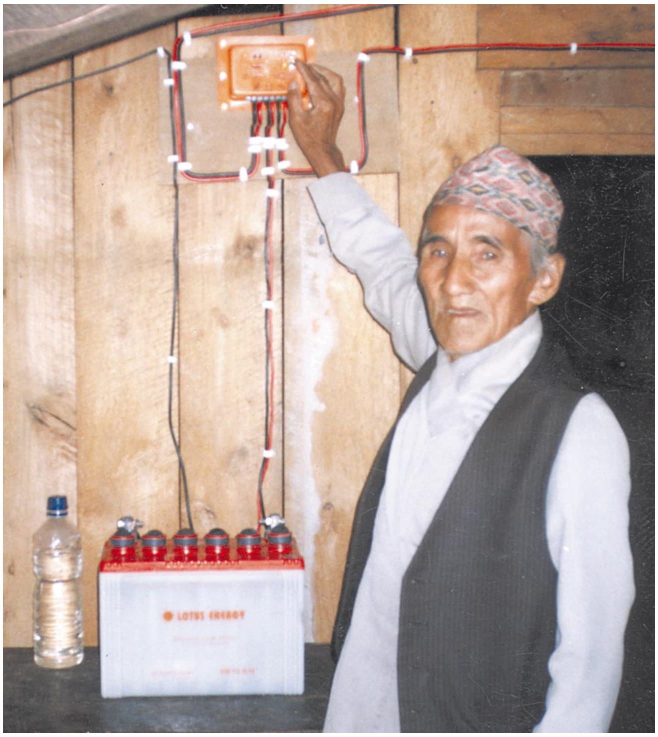
handle food without it smelling like kerosene. In homes with solar electric lights, headaches and eye irritations caused by dim light, soot, and fumes from kerosene lamps are a thing of the past. Best of all, children are better able to see at night to study. This is especially important during busy agricultural times when work in the fields consumes all the daylight hours.

A Brighter Life

Life in the Himalayas is extremely rugged. The villagers wake before the sun rises to get ready for the field work of the day. Women are faced with many hours of grueling work just to bring enough water to their homes for cooking and washing. This water supply requirement is an issue that Lotus Energy hopes to address in some communities in the coming year. Remote village electricity requirements are too small to attract the Nepal Electricity Authority (NEA) who could never justify running lines to these areas for only a few pennies a month. The NEA has a hard enough time as it is collecting the small amounts from remote areas since the villagers are never home in the daytime when the bill collectors come by.

The systems Lotus Energy provides can't solve all the villagers' energy problems. They can't cook with solar PV, and in many areas forests are being cut down for fuel wood much more quickly than they can grow back. Villagers cannot operate heavy machinery or water pumps using PV, except in a few cases with larger systems installed by Lotus Energy, and they still have to mill their rice with diesel engines every year.

What the systems can offer is to cut back significantly on their imported non-renewable kerosene use for lighting, the costs and risks of kerosene, and the time spent carrying kerosene (usually on their backs) from the cities. The systems may reduce the number of disposable mercury-containing flashlight batteries littered all over the countryside. Radio and TV, powered by the solar electricity, provides valuable information and entertainment, though it also introduces "culture pollution" of urban pop-culture. Finally, solar powered



Above: Hom Prasad Thoklehang, an elder from Ektin village (Panchthar District), presses the "ON" button of the system controller for his new solar electric system. Notice the bottle of distilled water and the recombination caps supplied with the battery. Photo: Ramu Khatri.

radio-telephone systems provide crucial emergency communications in many remote areas. All of these make life in the villages a little easier, cleaner, safer, and brighter.

Access

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Help a Himalayan Buddhist Monastery have Solar Light

Lotus Energy has recently opened up a new program called "Himalayan Lotus Lights". The program offers solar PV lighting systems to Buddhist monasteries and retreat centres throughout the remote Himalayas.

Contact: lotuslights@lotusnrg.com.np for further details.

Wind Speed Data and its Application to Wind Generated Power

Michael Klemen

Wind speed data is not a very good tool to use in measuring the wind resource available for a wind-powered generator unless the wind speed data was taken with that particular purpose in mind. Wind speed is measured by an anemometer. As the anemometer spins in the wind, it generates pulses of voltage. The anemometer is typically connected to an analog device which counts the number of pulses over a certain time period. This time period is of vital concern to the person recording wind speed data to estimate the wind resource available for a wind driven generator.

Response Time

In order to estimate the wind available for a wind generator, the resource needs to be measured in the same time frame that the wind generator can respond to the wind (response time). The data often taken by these analog devices will record the average wind speed every 15 minutes. This means that the device counts pulses for 15 minutes, then records the number of pulses for those 15 minutes. The number of pulses can then be converted to a wind speed. The problem with this data is that the response of a wind generator to the wind speed is much faster than a 15 minute delay. A wind generator will often respond to a wind gust in a matter of seconds.

Averaging Time vs. Recording Time

Before things get too confusing, it is important to distinguish the difference between the time interval used to acquire the data and the time interval used to average the data. The time interval used to acquire data should be on the order of the response time of the wind generator. In other words, the data should be acquired every couple seconds at worst. The time interval used to average the data should also be the same as the time interval for acquiring data. If we take data every two seconds, but don't use a two second average, we have lost some important details in our data.

Gusting Power

The difference between averaging data at ten second intervals and fifteen minute intervals seems to be kind of trivial. For the sake of knowing at what speed the wind is blowing, it is a very trivial difference. For the sake of trying to figure out how much power a wind generator will produce, it isn't. The reason this difference is NOT trivial is because the amount of power available in the wind is not linearly proportional to velocity, it is proportional to the velocity cubed:

$$P = \rho AV^3$$

where

P = power available
ρ = air density (primarily a function of temperature)
A = swept area of a wind generator's blades
V = velocity of the wind

This formula is a formula for the amount of power available in the wind. It is *not* a formula for the amount of power available from a wind generator. More variables would be needed to account for the performance of the wind turbine blades, friction, and other things. What is of far more importance is that every time the wind speed doubles there is an eight-fold increase in the amount of power available in the wind. This is critical because every wind gust is important in calculating how much power a wind generator can produce. If wind speed data doesn't record every gust it won't be an accurate tool to use to figure out how much power a wind generator can produce.

Let's look at a simplistic example, comparing 15 minute averaged data and data averaged on a 5 minute interval. We will assume for this example that the ρ A term is a constant. For the 15 minute period let's say the average wind speed was 10 mph. This means that there are 10^3, or 1000 power units available in that wind. There are a lot of ways to get a 10 mph average wind speed for 15 minutes. Let's consider the ridiculous for a moment, and break this data down into 3 different data points of 5 minutes each. If the wind was completely still for 10 of those 15 minutes, we can still get a 10 mph average wind speed for 15 minutes if the wind speed was 30 mph during one 5 minute segment. Now, for the 5 minute intervals that had no wind speed, there is no power available. For the 5 minute interval where the wind speed is 30 mph, we have 30^3, or 27,000 power units. This makes the 1,000 power units look trivial. We could break down the 15 minute data into smaller pieces of, let's say, 1 minute in length and exaggerate this important problem in wind speed data even more, but this example was probably sufficient to raise one's curiosity.

My Data Acquisition System

I have been taking data for over one year on a site in west-central Wisconsin. This data agrees with my theory that the time interval for taking data is VERY important when considering the feasibility of a wind generator. My tower is 50 feet tall with an open field to the north and west (our prevailing winds). I am using an analog anemometer like described above, with one exception. Since I do computer programming (and enjoy data acquisition) I plugged the anemometer into the data acquisition board in my PC, which converts the analog voltage of the anemometer into digital form. My data acquisition board is a Data Translation DT2838, which is capable of taking data on eight input signals at a speed of 260,000 samples per second (which is much faster than I need for this application). My data acquisition computer is a Dell 386 running at 25 MHz, with a 300 MB hard drive and 4 MB of RAM.

I was anxious to start taking data to compare the problems with the 15 minute data to the real-life wind generator scenario I presented above. I started taking and recording data at 1 minute intervals 24 hours a day since December 8, 1995. Each daily data file required 93 KB of storage on the hard drive.

When I was at the Midwest Renewable Energy Fair last year, I asked Mick Sagrillo of Lake Michigan Wind and Sun how long it really takes a wind machine to respond to a gust of wind. His answer was that a small machine can respond in a split second, and a bigger machine like the Jacobs 10 kW will take maybe a couple of seconds. This got me thinking about my data and how inaccurate it would be for the 1 minute intervals I was using. I re-wrote my program to take and record data at 10 second intervals. From the 10 second data I could put six data points together to get a 1 minute average. I could also put 80 data points together to build a 15 minute average wind speed. Then I could compare their respective results. My 10 second data begins July 1, 1996. The data file for each day requires about 530 KB of storage on my hard drive.

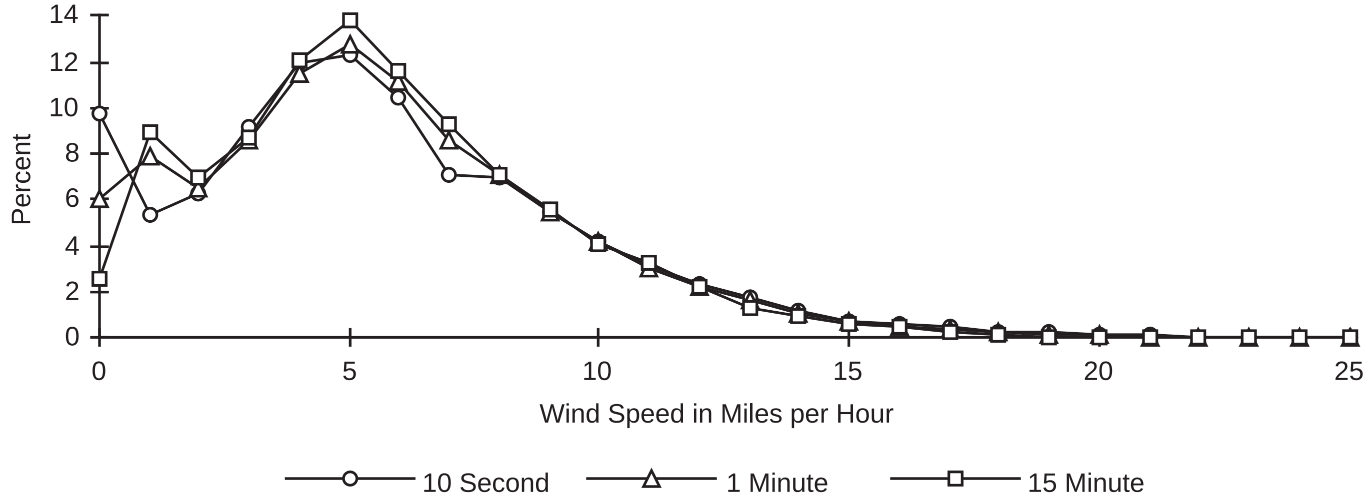
Anemometer Resolution

I chose to take and record 10 second data rather than a shorter time period due to the resolution of the anemometer. The signal generated by my anemometer is a sine wave. I am simply counting the pulses during the 10 second interval. If I was using a faster computer, I might try to distinguish where the data starts on the sine wave, and where the data ends, thereby increasing available resolution. By taking data at 10 second intervals, I am guaranteed a resolution of 0.17 mph, as compared to 0.28 mph for a 6 second interval. As the time interval gets smaller, the resolution of the wind speed gets worse. Since I wanted to compare the differences for actual wind generators, I needed to maintain resolution and accuracy. If a 6 second interval gives me 0.28 mph resolution, that means for the worst case scenario I would only have three data points for some 1 mph increments. For example, I would put 2.27, 2.55, and 2.83 mph in the 2 mph increment. I didn't find that to be acceptable, so I opted for the 10 second data with a resolution of 0.17 mph.

The Results

Next, I interpolated the power curve for various wind machines. My choice was almost completely random. My parents had talked about putting up a wind

Figure 1—Wind Speed Distribution since 1 July 1996



machine, and I thought the Jacobs 10 kW would be a realistic choice for them. (To be more honest, I was intrigued by the flatness of the power curve when the wind machine starts to govern.) I also decided that I needed to compare more affordable machines like the Whisper 3000 and 1000. I tabulated the number of data points at each 1 mph increment for each day, and subsequently for the entire period of data acquisition (for the 10 second, 1 minute, and 15 minute data). Next, I plugged that wind speed distribution into the power curves for the various wind machines. I came up with some rather interesting results. The wind speed distribution curve came out as expected. In Figure 1, the 15 minute data shows a larger distribution of lower velocity wind than the 10 second data. Conversely, the 10 second data shows higher wind speeds than the 15 minute data (which is where we get more power from a wind generator).

I can now plug the wind speed distribution into the power formula to get a reasonable look at the difference between taking the data at 15 minute or 10 second intervals. (For those of you who may not catch the difference between power and energy, power [kW] is instantaneous energy [kWh]. So, when I plug the distribution into the power formula, I get energy because the distribution happened over time.) In Figure 2, there are two curves for each data interval. The first curve is for the energy available at the given wind speed. The second curve is the sum of all energy for each data interval (10 second data, 1 minute data, and 15 minute data). I summed up the energy available only for wind speeds of 7 mph or above (this is where many wind generators will start to generate power). It is easy to see that there is more wind energy available if we account for the increased energy due to gusting (by using 10 second data).

The 15 minute average wind speed doesn't accurately reflect the energy available in the wind. The question that now arises is: "Is this available wind energy really going to give an increase in performance for a real wind generator?" Next, I took this data and plugged it into the power curves for the Jacobs 10 kW, Whisper 1 KW, and 3 kW. The results were not surprising (Table 1).

Noticing Some Differences

There are a couple of questions about the data which have logical explanations. The reason each of the wind machines has a different response to the data lies in the power curve for the given wind machine. The Jacobs 10 kW machine has a gearbox and additional friction as compared to the Whisper wind generators. It is also important to bear in mind that I read the output from each wind machine from a graph to put it into digital form. There is bound to be some error in doing this as compared to having the precise numbers from the manufacturer of the wind machine. Thus, when comparing the theoretical (energy units) percent increase to that of the stated wind generator, there is bound to be some discrepancy. In the case of the Whisper machines, it is noticeable, but marginal.

There is one more thing I should mention with regard to renewable energy systems. The days that had relatively little output from the wind generator benefitted most from this analysis. On a day that averaged 2 or 3 mph, the 15 minute data might have suggested that we would have generated 0 to 5 kWh (with the Jacobs 10 kW machine), whereas the 10 second data indicated that we would have generated 100 to 300% more power.

Figure 2—Available Wind Energy using data since 1 July 1996

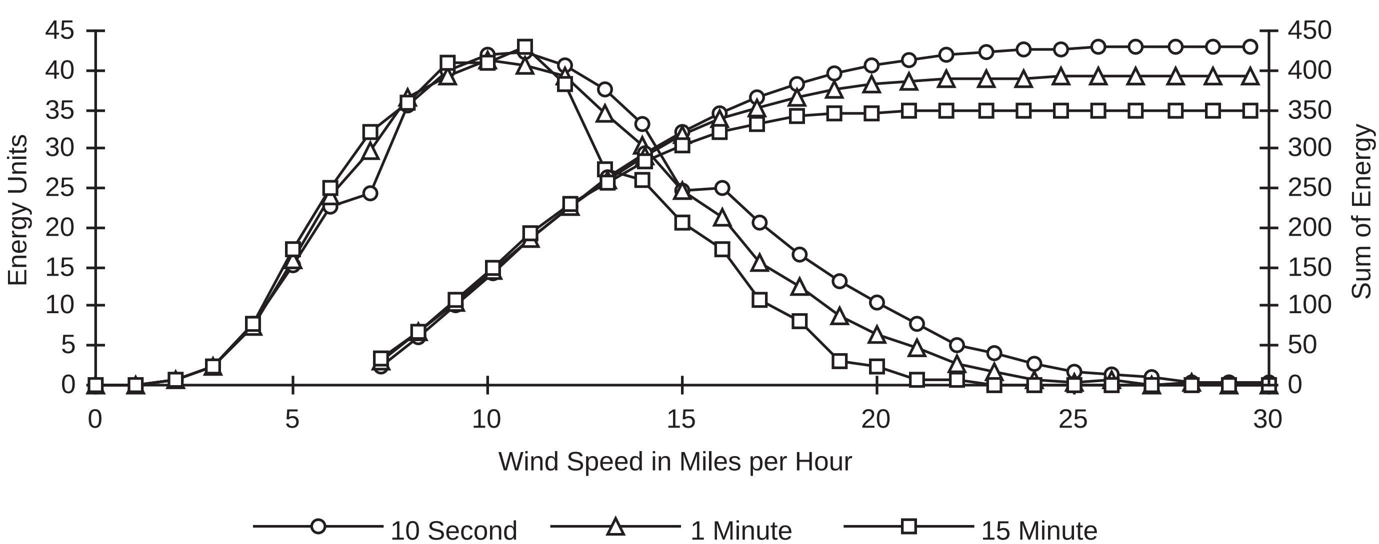


Table 1: Energy Produced

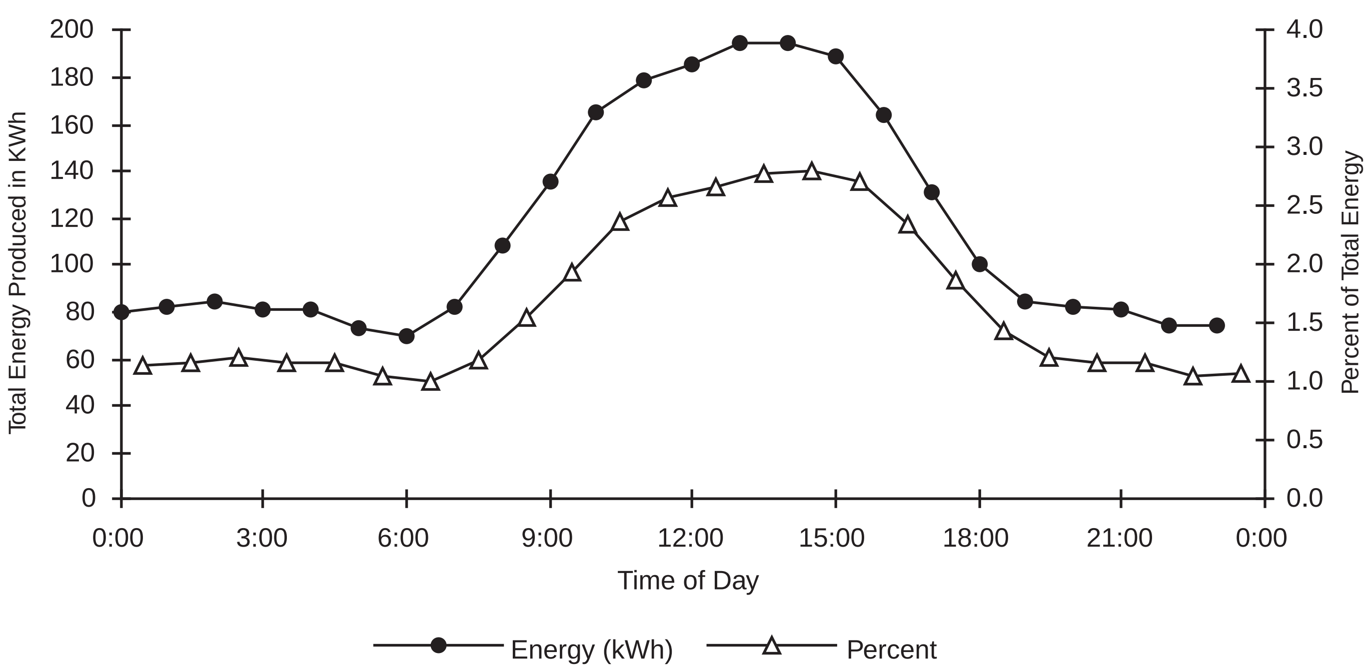
Wind Generator Make/Model	*10 Second Data*	*1 Minute Data*	*15 Minute Data*	*Percent of Power Increase* from 15 Min to 1 Min Data	*from 15 Min to 10 Sec Data*	*from 1 Min to 10 Sec Data*
Jacobs 10 kW	2070.40 kWh	1948.92 kWh	1799.88 kWh	8.28%	15.03%	6.23%
Whisper 3 kW	595.08 kWh	545.29 kWh	480.86 kWh	13.40%	23.75%	9.13%
Whisper 1 kW	196.04 kWh	179.52 kWh	157.93 kWh	13.67%	24.13%	9.20%
Theoretical	430.82	392.19	347.97	12.70%	23.80%	9.85%

Is 25% More Power More Affordable?
The fact remains that we see a 15 to 25% increase in energy output from wind generators by looking at the wind speed from the generator's response time rather than 15 minute data. For any renewable energy system, that kind of increase in output is significant. Maybe if you have seen local data, such an increase in energy output would make a renewable energy system more affordable. I would like to remind you that this data was taken at our site. These increases in energy are only increases over the energy expected from the 15 minute average wind speed data. Our tower is 50 feet high. By raising our tower, I would expect that the fluctuations in the wind speed will be smaller, thus reducing the amount of gain possible over the indicated data. But, also by raising the tower, I expect our average wind speed to pick up, increasing the energy output of a wind generator. Your site and output will vary from this data.

Utility Intertie?
I was curious how much a utility might benefit from connecting a large wind generator to the grid. I know that utilities do not like peak load times because the electrical generation plants must be designed for them. Since I recorded the time of each data point taken, I re-analyzed the data with respect to the time of day. In Figure 3, I plotted the percent of total energy produced (with a 10 kW Jacobs) with respect to the time of day to see if a wind turbine at our site would produce power when the utility wished it had more power.

The results are self-explanatory and understandable. Winds are caused by ambient pressure differentials, which are caused by the uneven heating of the earth's surfaces by the sun. I would have expected to see a reasonable amount of wind during the day, during utility peak times.

Figure 3—Total Energy Produced and Hourly Percent of Total Energy since 1 July 1996



What's Next?

Preliminary results from my sister's Whisper 4500 indicate that 10 second data increments are quite insufficient for that particular wind machine. During 6 days of monitoring, I found that the wind machine output was able to change very significantly during 10 seconds. One data point I found jumped from 1501 watts to 3144 watts output. This is about a 110% increase in 10 seconds. Likewise, the output decreased from 4350 watts to 2590 watts, a 40% drop in output. I would like to install an anemometer at her site, comparing the wind speed from the anemometer with the output from the wind machine (to verify the power curve). I will also reduce the time increment from 10 seconds to something markedly smaller. In order to get reasonable resolution from an anemometer, I will be forced to find the phase of the cycle of the anemometer rather than just counting the pulses I get. This may tax the 386 computer a little, and I may have to move my data acquisition board into my 486, and heaven forbid, use the 386 at home!

If you have any questions about wind power, data acquisition systems, programming, or about my data in particular, please feel free to write.

Access

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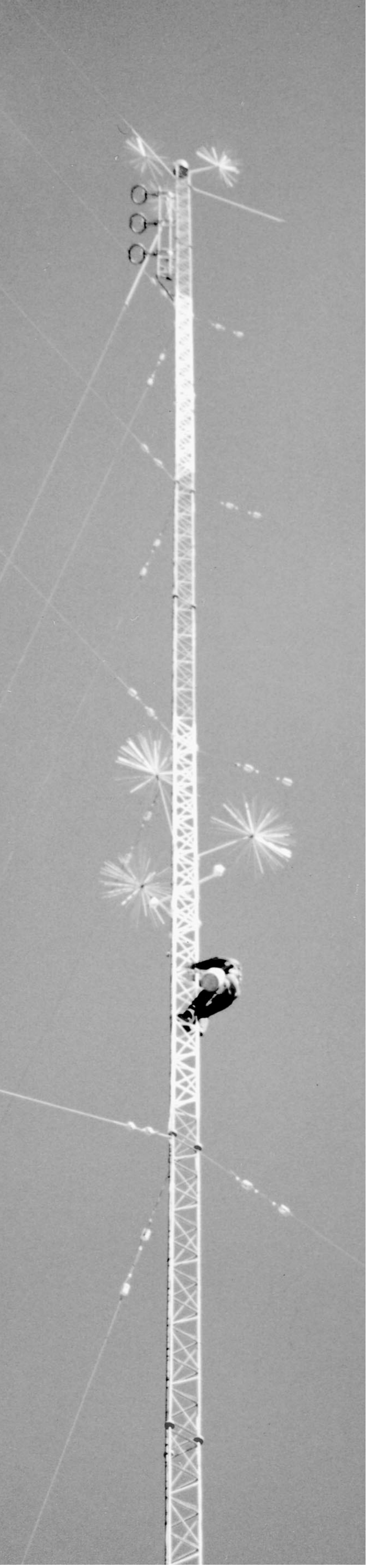

Tower Safety and Lightning Prevention

William C. Williams

I read Dan Whitehead's article about living with wind machines (HP #57) with great interest. There are, however, some safety issues that I feel need to be addressed. This is not meant to be a criticism, I'm writing this to share my expertise.

I have been a tower rigger (Steeplejack) for close to 25 years and I have climbed over 725 miles (one way) on towers. I have worked atop a 2,380 foot tower. At those heights you start climbing at about midnight to be at the top by sun up.

I have also seen nineteen people die on towers. Eleven of those fell out of their safety belts and two fell while climbing. Actually one fell and the other guy tried to catch the first. The impact severed the second man's lanyard (stressed to over 1,500 pounds). Recently in Texas, three men were killed when a 1,520 foot tall tower collapsed while they were working on it.

The point is, tower work is not place for minimum safety. The following are some things that you may want to be aware of.

1. Safety belts are often recommended. But, safety belts are not OSHA accepted and are subject to failure. Safety belts lost their OSHA blessing in 1995. Full body harnesses have never, to my knowledge, slipped when properly maintained and worn. Harnesses also provide an opportunity to assume a sitting position, taking weight off your legs. Fatigue is your number one enemy on towers.

2. Tennis shoes are inappropriate on a tower. Paragraph 25.G.06 of the Occupational Safety and Health Industrial Guidelines manual recommends that soft sole shoes and shoes that offer minimal ankle support never be worn on towers. The reason is that tired or sore feet are a distraction and compromise safety.

3. Always inspect the tower on the way up, not on the way down. Should there be a hardware problem, it needs to be addressed before your weight adds to the tower's total load.

4. When climbing, always keep three points in contact with the tower. Never move more than one hand or one foot at any instant. When a person is moving up or down a tower it tends to bounce. This bouncing causes the tower members to be stressed in directions it was not designed for. Take an active role in minimizing the bouncing, even on guyed towers.

5. While working on the tower, always do the task in your mind before you begin with your hands. Think it out thoroughly before beginning.

Left: Willaim C. Williams on a 300 foot, three bay, FM transmitter antenna tower. Note the Static Discharge Arrays (SDAs) at the tower's top and at mid tower.

Above: The author harnessed and ready to climb.

6. A very important team member is the safety person on the ground. This person's only responsibility is to stay in visual contact with the tower climber. Don't go to the bathroom, answer the telephone, or anything else. Should the climber get into trouble the safety person needs to be alert enough to get help immediately, nothing else.

7. When you tie yourself off on a tower, you should "foul" or wrap your laniard around a tower leg so that the lanyard cannot slide down the tower.

I have heard many complaints about the price of safety harnesses. While safety belts start at about $40, OSHA harnesses range in price from $80 to $170. I use a modified parachute harness. It may be slightly uncomfortable walking on the ground in it but that virtually disappears when climbing. It affords me the opportunity to secure myself in more positions than a regular harness and feels more secure than any other safety hardware. I have even been able to take a nap on the tower while in the harness. The really attractive part is the fact that you cannot fall out of it. I get the harnesses for $85 each plus shipping. Most places will not sell a parachute harness for climbing purposes. My supplier manufactures harnesses and is a Master Rigger by trade. Please don't buy from a military surplus store unless you don't value life very much.

Rope is also an issue for riggers. Twisted rope will untwist and spin any hoisting load. Double braid line is the best.

The ground crew should never be any closer to the tower base than 25% of the tower height (100 foot tower = 25 feet from the base) and always set up so the ground crew is working upwind. The safety person should be about 50% away so they don't fall victim to neck fatigue.

In the American Radio Relay League's Antenna Handbook there is a potentially serious flaw in their gin pole instructions. Under no circumstances should the haul rope pass over the gin pole and tower. The haul rope should pass over the head shiv and down through the gin pole, down the side of the tower, and through a base pulley attached to a tower leg close to the ground so that the lifting force is applied close to the ground. That way the hauling action does not shake, move, or bend the tower, allowing the load to be lifted high, wide, and handsome.

If for some reason you need to have more than one person on a tower at a time, don't bunch them together on one leg, as on the cover of HP #42. That is a definite no no. If the top person should have slipped or dropped something, they would have taken the others with him. I know, I have seen it happen and it was not a pretty sight.

Radios for communication on towers is a good idea. However, I found that VOX circuits can be triggered by wind and breathing noises. I use a pair of audionic radios with the microphone in the earpiece and backed up by a pair of Motorola HT600 UHF FM radios.

A safety meeting before a climb is necessary. Discuss and rehearse the tasks so that the ground crew knows what will happen and what will be expected of them. Work out hand signals before any work begins.

Remember: work safely,
it's your responsibility.

I hope this information is useful to readers and helps keep someone alive. A major reason to follow industry safety guidelines is to protect yourself and others. A very recent situation was brought to my attention that readily reflects this. An electronics worker was installing an antenna atop a 150 foot tower when he dropped a 9/16 inch nut. The nut was blown into the tower striking a cross member at about the 45 foot level and ricocheted across the street breaking a large picture window in a house some 260 feet from the tower. Since the worker was wearing a safety belt and not a harness, his insurance company denied the claim and refused to defend him in the subsequent lawsuit.

Lightning Prevention

There are various approaches to lightning protection. Mick Abraham did quite well in discussing surge and EMP protection in HP #55. But I prefer prevention methodology.

Having worked on radio towers since 1969 and serving 16 years with the broadcast industry, I have installed quite a number of systems based upon many schemes. The following is a little of what I have learned.

1. Lightning rods were originally designed to be struck, thus controlling the lightning's path.

2. Lightning can strike the same place twice. I have been on a tower when it was struck twice.

3. Towers are seldom struck at the top. Most strikes occur between the 20% and 85% levels.

When dealing with lightning it helps to consider a few of the basics of lightning physics. First, lightning is the result of an imbalance of electrical charges, the ground being negatively charged as a result of the atmosphere becoming positively charged due to turbulent air or storm activity. A lightning strike occurs when these two charges become great enough to overcome the resistance of the air separating the two. This is called the dielectric breakdown voltage, and is usually millions of volts. Second, we know that static electricity is best conducted by what is known as "skin effect," the tendency for a small electric charge to travel on the surface of a conductor rather than through its core.

We have seen with artificial lightning that the arcs originate from spikes or points on whatever conductor is used for controlling or manipulating the arcs.

The presently accepted lightning prevention scheme theoretically works something like this: A bunch of long, pointy conductors, known as Static Discharge Arrays (SDA) attract the electrostatic charges in the air and conducts them to ground. This bleeding off of the static charge from the air is known as deionizing. The object is to deionize the air long before the dielectric breakdown voltage is reached, thus increasing the resistance of the air near the deionizer as compared to air farther away, hence lessening the chance of lightning being attracted to the tower.

In practice, SDAs are typically mounted at the tower's top and near the 60% level with the goal of creating a column of deionized air. This charge must be bled off rapidly. The grounding system becomes very important in lightning prevention. Not only is it important for it to be highly conductive but it must cover a great surface area as well. The greater the area of stabilized air, the better.

In the broadcast application, copper ribbons three to four inches thick are used. In many non-broadcast applications copper water pipe or tubing one inch or larger in diameter is used. The ends of the tubing are flattened and soldered closed and a hole is drilled in one flat and bolted to the tower leg. Care is taken to avoid kinks, sharp bends, or acute angles. These pipes are buried horizontally below the frost line and extend outward from the tower a distance equal to the tower height. Each radial is then terminated with a ground rod plus more ground rods driven at intervals and bonded to each radial. The spacing of the ground rods plus the number and spacing of radials is determined by the conductivity of the soil.

An important consideration in the design of SDAs is the total surface area and greatest number of sharp points. In the broadcast application, the length can become important. They must be a length that will not interfere with the radiated signal, neither re-radiating nor attenuating the signal.

The result of this system is the creation of an "umbrella" of protection extending from the top of the tower to the ends of the ground radials. The tower in the photo shows my favorite SDAs installed on a 300 foot AM/FM broadcast tower. This tower had over 200 burns from lightning strikes in the thirteen years prior to the installation of the system. In the three years since I painted the tower, it has been struck only once.

To apply this technology to a homestead requires one to modify the hardware somewhat. The problems are primarily in mounting the SDAs and placing a good, well-spaced ground radial system.

Yes, ground radials are necessary. In many applications an SDA can be mounted on windmills or wind generators or antenna masts (unipole) or tower. One of the most unique and aesthetically benign applications is at a friend's place in Colorado. Almost 200 copper plated spikes were brazed to the windmill's (water pumper) tail, gear box cover, and blade tips. Oddly enough the bearings, though well greased, are able to conduct. The ground radials are bonded to both the tower legs and well casing. The house sits within the radius of the radials and is also well grounded. The ground radials consist of thirty-six 50 foot runs of #14 bare copper with ground rods at 10 foot intervals plus a "halo" that runs in an arc around the immediate yard and parking area. There is also a 30 foot flag pole in the front yard with an SDA and tied to the ground radials.

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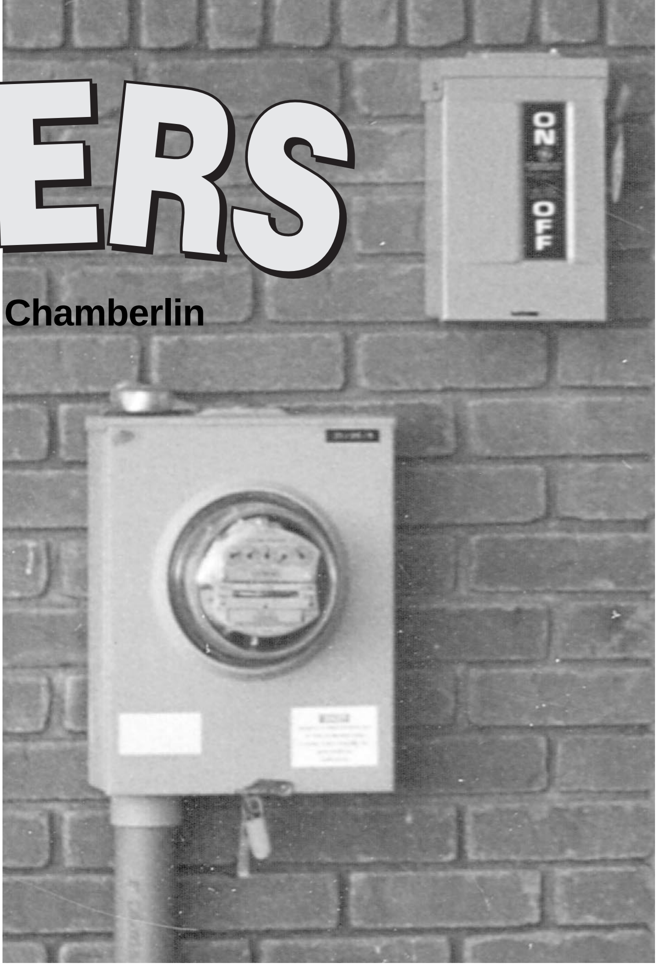
Grid Intertied INVERTERS

Drake Chamberlin



Systems that utilize an inverter and also connect with the utility grid raise important issues. These are still relatively new code and safety issues. They have come about mainly through the widespread use of the Trace “grid interactive” inverters. The National Electrical Code® (NEC) rules governing these systems are not always well understood.

Since inverters can be connected in different ways for various applications, different installation methods are required.

When the inverter can supply electricity to the grid, potential hazards are introduced. (For rules on interconnected electric power production sources, see Article 705 of the NEC.) Trace SW Series inverters can supply energy to the grid when connected in the standard manner. User programmable parameters allow the inverter’s functions to be set. When in “Sell” mode the inverter will supply power to the utility network. (Optional wiring methods allow for a hookup where this back feed is not possible.)

Another application is a grid supplied inverter used as a backup system. In a premise with such an “uninterruptible power supply” (UPS), selected circuits always stay hot. Power to the building cannot be totally switched off by the utility disconnect. These optional standby systems have their own safety requirements. (For rules on optional standby systems, see Article 702 of the NEC.)

Service Disconnects for Inverters
A service disconnect is the switch that turns off electrical service to a premise. The power can be supplied by a utility or an alternative power system.

A switch must be located next to an inverter that supplies any load. This switch is the disconnect for the inverter as a power source. It usually consists of an enclosed circuit breaker.

Where power is supplied by more than one source, a plaque must be posted at the service disconnect for each power source. Each plaque must give the location of all other service disconnects. (For details see section 230-2(b) of the National Electrical Code.)

Feeding the Grid
In many cases, home generated power is supplied to an electrical utility. During peak solar or wind generation

Figure 1: Breakers for branch circuits inside service disconnect enclosure.

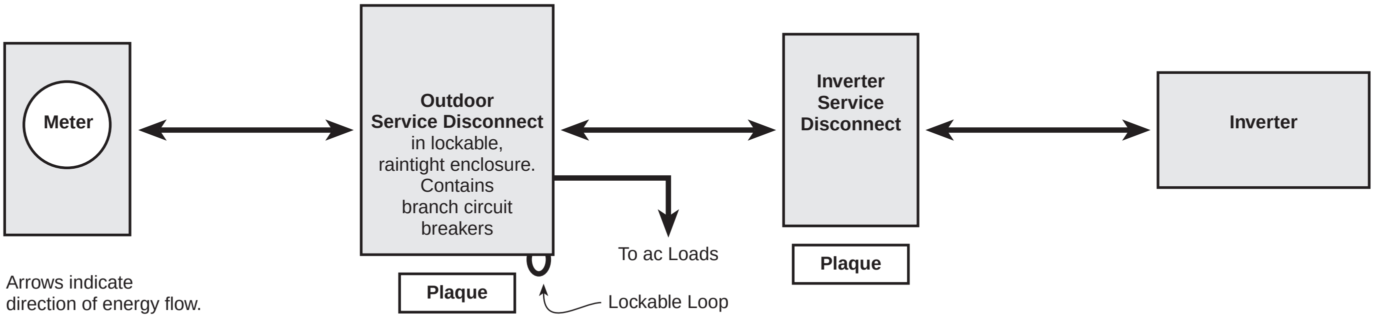
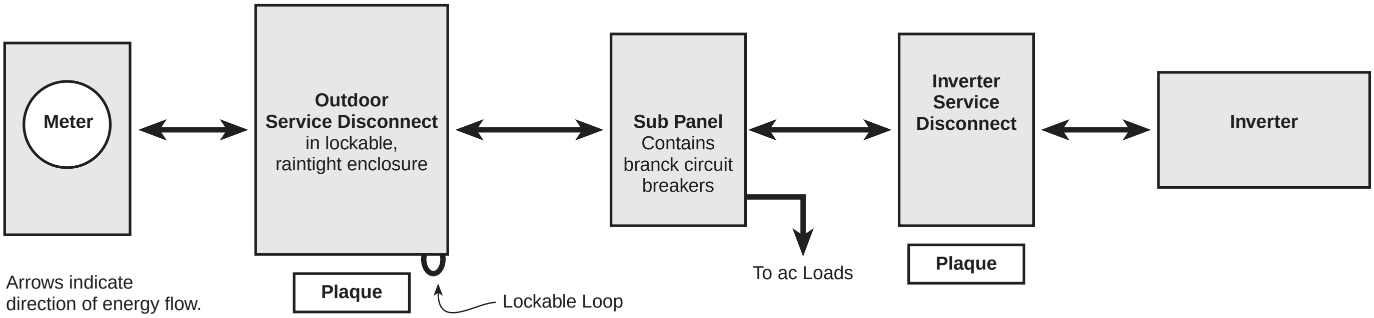


Figure 2: Breakers for branch circuits in separate enclosure from service disconnect. Inverter connects to sub panel.



periods, excess power is sold. When more electricity is being consumed than generated the grid will supply the deficit. The electric company can be used in place of a battery bank.

It is essential that these grid interactive inverters shut down automatically when utility power is lost. Since the inverter feeds the grid the utility wiring could be energized by an inverter. Back feed through a transformer could easily energize a power line to an extremely high voltage. California's PG&E has tested the Trace 4000 Series inverters and found that they shut down reliably.

Before energizing a system that supplies power to the grid the local utility must be contacted. Requirements from different utilities vary. Some utilities will allow the use of one meter for both selling and buying power. The meter turns backward when selling. Other areas will require two meters. The utility may also require a written contract.

Utilities often require equipment installed that will allow them to lock out a system that supplies energy to the grid. This ensures that all possibility of back feed can be mechanically eliminated. This second line of defense is needed to protect utility line workers when the utility power is off.

How to Provide a Lockout

The requirements for providing lockouts vary with the utility. Always check with your local representative to see how the utility wants it set up. Often, service disconnect enclosures include a means for attaching a paddle lock. These enclosures are typically of rain tight design and may or may not include branch circuit breakers. See figures 1 and 2.

If the utility will allow a lockable enclosure as a lockout, no additional equipment needs to be installed. The power company can switch off the main breaker and lock the enclosure. This will effectively isolate the inverter from the utility grid.

When a Separate Switch is Required

In some situations, the utility service disconnect may not be allowed as an inverter lockout. It may be necessary to install a separate switch. Usually it won't be necessary for this switch to disconnect the large service conductors. Only the inverter needs to be disconnected.

Inverter power merges with grid power through a smaller wire, leading to a breaker panel. This wire will usually connect to a circuit breaker. This breaker will be located either in the service disconnect enclosure or a sub panel.

Figure 3: Grid interactive system where a separate utility lockout is required. Buying and selling power.

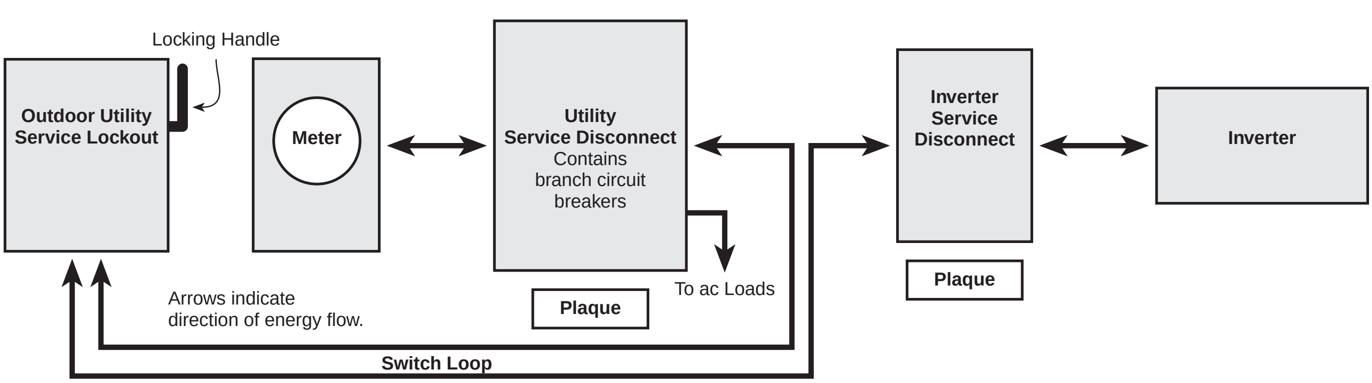
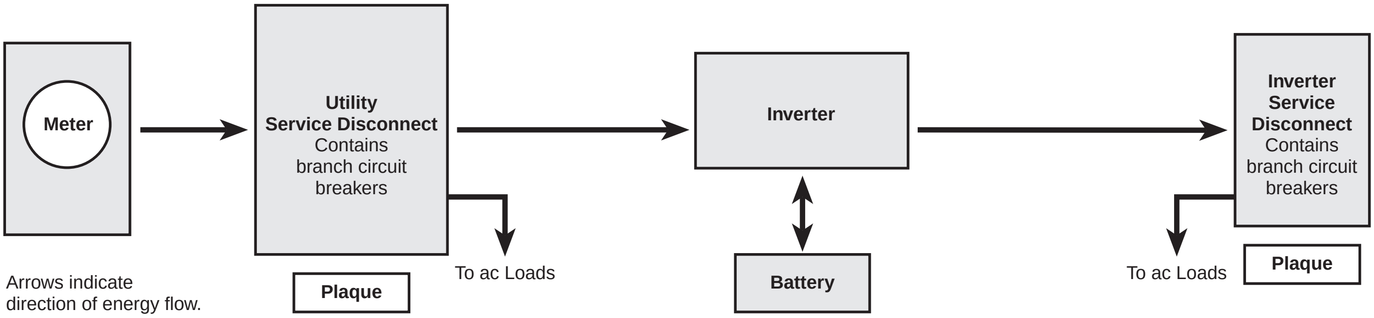


Figure 4: Inverter used for backup power (UPS).



On Line Inverters

The following terms are used in the article.

Grid: The network of utility wiring including all equipment required for distribution of electrical power.

Grid interactive inverter: An inverter that can both deliver power to the grid and receive power from it. Power received is often used for battery charging. The Trace 4000 Series inverters can be set up to be grid interactive. With these inverters, power is purchased and sold through the same wire.

UPS: An uninterruptible power supply. This is also referred to as a standby system or a backup system. It can be an emergency or an optional standby. Such a system is used to support electrical loads when utility power is down.

NEC: The National Electrical Code®, printed by the National Fire Protection Association. The Code contains the set of rules with which electrical wiring in the United States must comply.

Premise: A location where electrical power is delivered. It can be a factory, house, sign, water pumping location, etc.

Load: An end use device consuming electrical energy. It can be a light bulb, electric heater, toaster, etc.

Service Disconnect: The switch that turns off the electrical service to a premise.

Branch Circuit: The wiring between the final circuit breaker and the load to be served.

Enclosure: A containment for electrical equipment. It is often a box made of metal or plastic that has been listed by an agency such as UL, as suitable for its purpose.

An inverter lockout can consist of a switch disconnecting this wire. See figure 3. This will allow the use of economical equipment. A lockable disconnect rated at 30 to 60 amps will usually be sufficient.

Uninterruptible Power Supply

UPS are used in systems where essential loads must function during power outages. In normal operation, utility power will supply the UPS loads through the inverter's transfer switch. When utility power fails the inverter takes over.

In an emergency situation all power to a premise may need to be turned off. The problem is that even if the power is turned off at the utility service disconnect, the UPS loads will not de-energize. If fire fighters were to switch off the service disconnect, they could still encounter hot circuits.

The solution to this is to have a separate service disconnect for the UPS. This disconnect must be located next to the inverter. Plaques must be located by both the inverter and the utility disconnects and are especially important in a UPS application. See figure 4.

The Bottom Line

There are a few basic rules to remember when using an inverter in conjunction with the grid. All power sources must be protected by service disconnects. Plaques must be posted at all utility and inverter service disconnects.

When an inverter can sell power back to the grid, the utility gets involved. This is because the inverter is functioning as a utility power generator. The system owner becomes a partner in the supply of power to the utility network. The inverter must shut down automatically when the utility power goes out.

As a fail-safe, an inverter lockout is usually required by the utility. It may isolate either the entire electrical system or just the inverter.

When an inverter is used for a UPS a plaque must be located by the utility service disconnect, telling the location of the backup power source. A plaque must also be located by the inverter disconnect, telling the location of the utility service disconnect.

Conclusion
Advances in inverter use and technology have created new issues to be dealt with. Both safety needs and code requirements must be satisfied. A primary concern is that all wiring may be readily de-energized in an emergency. This applies to both the premise electrical system and the utility grid.

Disclaimer
The information contained in this article is based upon experience, code study, and correspondence with the Engineering Department of the National Fire Protection Association (publisher of the NEC). The issues dealt with here are not eligible for a Formal Interpretation by the NEC. However, a staff opinion was offered in response to my request for a Formal Interpretation. Much of the above information is based on my interpretation of that opinion.

Interpretation of the code is the responsibility of the authority having jurisdiction. In other words, the requirements are what the inspector says they are. Before connecting an inverter to utility power, get plans approved by local authorities.

Besides meeting the NEC requirements, it is also essential to get utility approval of designs when selling power.

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Steam Power

An Introduction

Skip Goebel

Human beings have a habit of continually seeking ways to improve their condition. Sometimes, they go full circle in their quest for comfort and revert back to the basics. In the realm of alternative energy, steam can be considered “basic.” It may not be the best or cheapest thing available but it certainly works. Fortunately, all the technology has been discovered, proven, and documented. When we are tired of all the other energy sources being absorbed into “the system” many self-sufficient folks will try their hand at steam.

What is Steam?

Steam is a gas, not a water vapor. It is clear, tasteless, and odorless, so if you can see it then that is actually only water vapor and not capable of doing any work. It takes a given amount of heat added to water under a given amount of pressure to convert from water to steam.

A simple and safe experiment to observe water and steam is to “can” some water. Put an oven thermometer in a canning jar with a small amount of water. Using a pressure cooker, evacuate all the air and seal the lid. Gently heat the water and notice at what temperature the water boils. Watch the volume changes closely. Then with the water around 120°, have some fun by putting an ice cube on top and watching the water continue to boil all the way down to about 60°. You’ll get an idea of how water changes states at different pressures and temperatures.

Steam System Sizing

The first step in a steam system, as with any system, is planning. First, determine your needs or task. Then work back to your source of power and then to your fuel source. It all ties together in a full circle and you can go around and around making refinements until you have a system that is suited to your needs.

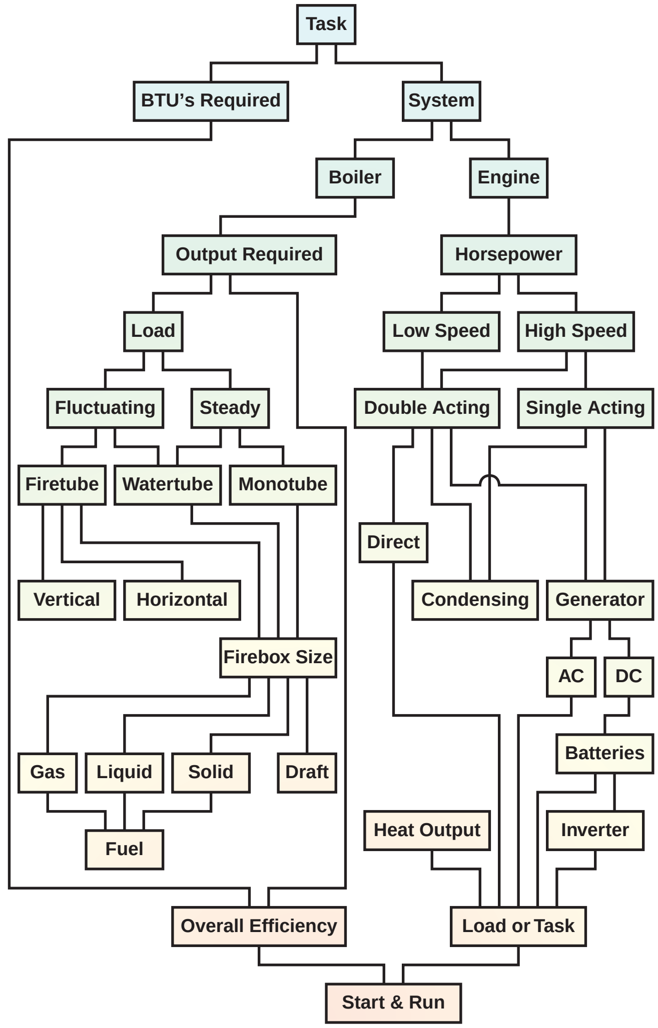
The best tool there is to plan this way is a flow chart. The flow chart will give you a visual representation of what you are trying to accomplish and you can see how one aspect relates to another. The idea is to break down the entire system into as many individual elements as possible to determine what they require and how they relate to each other.

You can follow our example flow chart and make changes to suit to your needs. Starting at the top is the task, or actual needs. Determine exactly what you are going to do: pump water, generate electricity, or even power a 30 foot boat. In this example, we will make 1000 watts of electricity in one hour. What ever you choose to do, you should know that there is a fixed set of values to move mass or create energy. In fact, energy is often considered a measurable force in the movement of mass. The key words here are horsepower, torque, foot pounds, watts, btus, etc. Steam is an excellent way to take potential energy or raw resources and convert them to kinetic energy, or "energy in motion."

Energy Required
This leads to the next planning phase which is energy required. Looking at the illustration, we can learn some values and apply them to our application. Since we will be using steam, we will be creating a difference in heat values. The most common way to measure this is the btu, (British Thermal Unit). It is the amount of heat needed to raise one pound of water 1° Fahrenheit, with no time value. In mechanical form this translates to lifting 778 pounds of mass one foot. Also, 42.44 btus in one minute equals 1 horsepower at 100% efficiency.

I mention that because no system ever comes close to 100% efficiency. A good starting point is around 10%. We will benchmark our initial system plan for 10%. Since we wanted to make 1000 watts for one hour we will need enough btus for 10,000 watts. One watt equals 3.412 btus so we will need about 34,120 btus (3.412 x 1000 x 10). Look at the fuel values chart to determine how much fuel you will need. We will use wood for our example so we divide 34,120 by 6,000 (cheap Ozark wood) and we get 5.68 lbs. Please note

System Design Flow Chart & Interrelationships



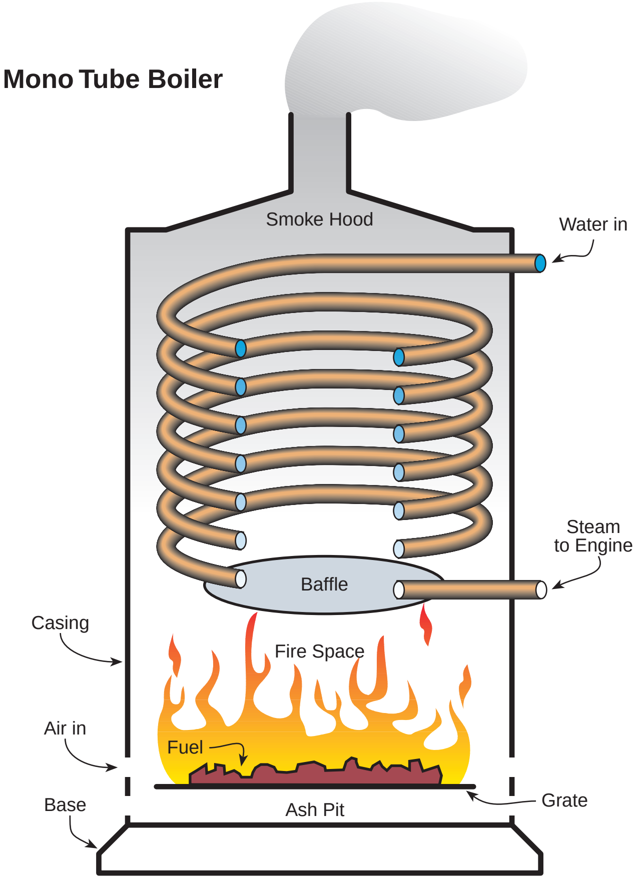
that this figure does not take into account warming up the system, shutdowns, or idle time. More on that later.

From here, we could follow the flow chart in two directions, costs / source of fuel or system. I'll start with the system. In our steam system, the two main categories are Boiler and Engine. Let's start with sizing the engine first.

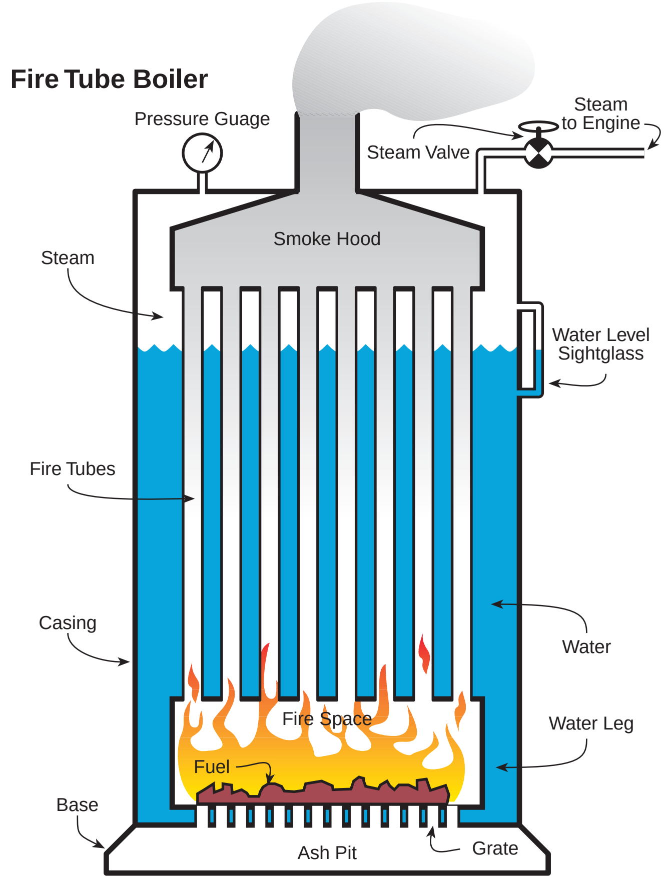
Engine
If you are used to typical horsepower ratings such as the way manufacturers rate gas engines, you're in for a shock here. A safe bet is to figure one steam horsepower equals 3 gas engine horsepower. The truth is that one horsepower equals raising 33,000 pounds one foot in one minute or 550 pounds one foot in one second. Period. That's why we call steam "honest horsepower."

Generally speaking, 750 watts equals one horsepower so 1000 watts is roughly 1.34 horsepower. In real life you are going to need at least 2 or more horsepower as

Below: A steam-powered lathe.



Mono tube boilers consist of a series of coils of small diameter tubing connected such that water and steam travel through one long tube. Water and gasses move in opposite directions, known as contra-flow, so that the coolest water comes in to contact with the coolest gasses first. These boilers are the safest and most efficient of all designs, however they require the greatest skill to operate due to their small water reserves and sensitivity to changing fuel and load conditions.



Vertical Fire Tube Boilers are popular where horizontal space is limited. They are the easiest boiler type to construct. 50% to 70% of the heat energy is captured by radiance therefore a water leg often completely jackets the firebox. Combustion space is usually small requiring smaller pieces of fuel. A forced draft system is often utilized to combust greater amounts of fuel. Note that while they are not detailed in these diagrams, SAFETY VALVES ARE A MUST!

there are inefficiencies in all generators. So, how do you figure the horsepower of a steam engine? The standard horsepower formula in reciprocating (piston) steam engines is called PLAN. That stands for multiplying together:

P = pressure (average or mean)

L = length of stroke in feet

A = surface area of the piston in inches

N = number of revolutions per minute (rpm)

Our example engine has a 2 inch piston and a 3 inch stroke running at 1000 rpm and a 100 pound average or “mean” pressure. The area of piston (A) = πr^2 = 3.14 x 1 x 1 = 3.14 square inches. The stroke (L) is 3 inches so converting to feet = 3 / 12 = .25 ft. The pressure (P) is 100 and the rpm (N) is 1000 so 100 x .25 x 3.14 x 1000 = 2.37 hp. 2.37 horsepower gives us a little extra hedge room and will suit our needs.

You can also find the torque by dividing the stroke in half and dividing by 12. Then multiply the pressure times the area of the piston times your stroke figure. 3 / 2 = 1.5, 1.5 / 12 = .125. So 3.14 x 100 x .125 = 39.25 ft. lbs. of torque.

Cogeneration

Now that we have an engine size, what is it going to do and how is it going to do it? What else can we do with the steam? Making both electricity and hot water are perfect examples for us to utilize here. In operations of less than 10 kw it is more practical to make DC instead of ac electricity because standard ac requires exactly 60 cps making engine speed critical. With DC we can work the engine hard for a brief time, storing the power, and go about our business for the day. Utilizing the exhaust steam gives us 55,000 to 60,000 btus to heat water with.

There is an abundance of low speed generators. Instead of using gears or belts we can direct connect to the engine, enhancing system reliability. Also, the regulators are small and efficient or even built in making a more compact power plant. For water heating, a 10 to 12 foot length of 1/2 inch copper tubing placed inside a water tank will work as a heat exchanger.

Some Quick Tips

Use an automotive in-line solenoid fuel pump to extract the condensate. It will maintain a small vacuum, adding power and efficiency. Use a windshield wiper gear motor direct-connected to a small high pressure pump to supply water to the boiler. Make a small, open tank called a "hotwell" to collect the condensate and provide a supply for the feed pump. A common float valve can be used as a bypass to regulate the system, but more on that later. Finally, check out the local battery company and ask if they have some phone company change-out batteries. A bargain might be found there.

You'll notice that on our flowchart the task is at the beginning and the end. We go from point 'a' to point 'b', so to speak, and work the details out in between. Also notice that you can connect each box or segment to any other box and see the relationship each has to the other. Study this to avoid expensive surprises later on.

Back to the System

We have our engine or work (or kinetic energy if you will) all figured out. Now we have to take potential energy (fuel) and convert it (reaction) and then transmit it (using steam) from the reactor to the engine. We call the apparatus that handles this a boiler. When your neighbor asks, "What is that?" Tell them, "That is my rapid oxidation reduction reaction hydro-morphosis energy transmission reactor." That will keep him a few feet away.

Safety Lecture

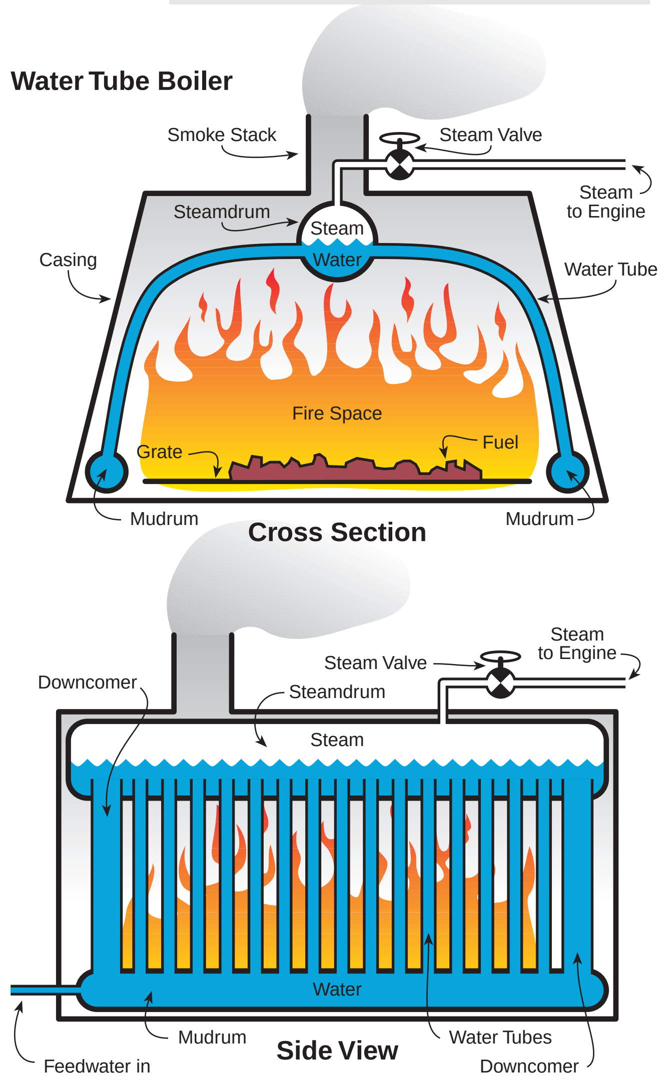
In round numbers, there is a stick of dynamite in a gallon of water. How close do you want to get? Steam, when superheated, is an invisible, super-radiant gas. It can burn to the bone. You can walk into a cloud of invisible superheated steam, take one breath and destroy your lungs. It takes about 3 minutes to die and there is nothing you can do about it. Period. If you think you are going to do this inside your house, send the kids to live with grandma, sell your Arizona swampland, and please put me in your will.

Boilers

Boilers are basically of either the pressure vessel or the mono-tube type. Solar should be put in a class by itself because most boilers are built around the chamber where combustion occurs.

Of the pressure vessel types, we generally classify them as fire-tube (combustion gases pass through tubes surrounded by water) or water-tube (combustion gases surrounded by water filled tubes). The generating section is where the water is close to the fire. Anywhere else the combustion gases transferring heat are usually known as ancillary sections and are where steam may be superheated, feed water preheated, or even the incoming combustion air heated.

Water Tube Boiler



Water Tube boilers usually have smaller diameter tubing than Fire Tube boilers and are therefore lighter. The relatively high amount of surface exposure for a small amount of water allows these types of boilers to come up to temperature more quickly, but limits residual capacity.

A boiler giving a steady steam supply with less fluctuations is determined by the amount of water it holds. Heat stored in the water is called latent heat. This is the left over energy that can still turn the water to steam after the fire out.

A fire-tube boiler generally holds the most water. It is known for steady steaming, ability to supply upon sudden demand, and also is the most dangerous! For the novice, this type of boiler has no place in the homestead so no more discussion on this one.

Safer, but still dangerous, is the water-tube boiler. They consist of a smaller pressure vessel that sits above the fire and has lots of small tubes attached that extend down and around the fire. Natural convection in the water makes it circulate thereby allowing the cold water to flow downward and warming water to travel upwards to release its steam in the main vessel. This boiler is the

Steam Table

lbs. Gauge (Absolute)	° F	Heat (BTUs) Water > 32	Steam > 32	Latent Heat (BTUs)	Volume of Steam (cu. ft.)	Weight in lbs. of Steam per cu.ft.
-14 (.7)	90	58.0	1099.0	1041.0	470.00	0.0021
-10 (4.7)	155	125.0	1128.0	1003.0	85.00	0.0125
-4 (10.7)	196	164.0	1144.0	980.0	36.00	0.0280
0 (14.7)	212	180.0	1150.4	970.4	26.79	0.0373
5.3 (20)	228	196.1	1156.2	960.0	20.08	0.0498
10.3 (25)	240	208.4	1160.4	952.0	16.30	0.0614
15.3 (30)	250	218.8	1163.9	945.1	13.74	0.0728
20.3 (35)	259	227.9	1166.8	938.9	11.89	0.0841
30.3 (45)	275	243.4	1171.6	928.2	9.39	0.1065
40.3 (55)	287	256.3	1175.4	919.0	7.78	0.1285
50.3 (65)	298	267.5	1178.5	911.0	6.65	0.1503
60.3 (75)	308	277.4	1181.1	903.7	5.81	0.1721
70.3 (85)	316	286.3	1183.4	897.1	5.16	0.1937
80.3 (95)	324	294.5	1185.4	890.9	4.65	0.2151
91.3 (106)	332	302.7	1187.4	884.7	4.19	0.2336
99.3 (114)	338	309.0	1189.0	880.0	3.90	0.2500
125.3 (140)	353	324.6	1192.2	867.6	3.22	0.3107
151.3 (166)	367	338.7	1195.1	856.4	2.74	0.3654
175.3 (190)	378	350.4	1197.3	846.9	2.41	0.4157
200.3 (215)	388	361.4	1199.2	837.9	2.14	0.4680
255.3 (270)	408	382.5	1202.6	820.1	1.72	0.5820
305.3 (320)	423	399.1	1204.9	805.8	1.46	0.7080
355.3 (370)	437	414.0	1206.8	792.8	1.26	0.7910
435.3 (450)	457	435.0	1209.0	774.0	1.04	0.9600
485.3 (500)	467	448.0	1210.0	762.0	0.93	1.0800
1047 (1062)	550	542.0	1200.0	658.0	0.42	2.3600
2250 (2265)	650	670.0	1111.0	441.0	0.16	6.2000

most commonly used today and can be seen in everything from power plants to ships and heating boilers. The size of these boilers is usually determined by the combustion chamber. The combustion chamber is determined by the size and type of fuel. More on this later.

The safest and most efficient type of boiler is the mono-tube boiler. Just as the name implies, it is a continuous coil of tubing with water forced in one end and steam out the other. Typical examples are steam cleaners. Many spas use the same configuration to heat water. So do tankless domestic water heaters.

With no vessel to explode, mono-tubes can only burst at a joint or seam. This is still dangerous, but the damage is limited to the release of heat. I strongly advocate these boilers for beginners. They are inexpensive and, for the homesteader making DC electricity, they suit the purpose ideally.

While it is possible to admit water on one end and get steam out the other, it is customary to have some sort of a chamber at the end to allow the steam and water vapor to separate. This also gives a small amount of residual power to smooth out fluctuations. In general, the more residual you have the less sensitive your control system will have to be.

Boiler Size
How do we determine the size of our boiler? In round numbers, figure about one square foot of grate area per horsepower when burning wood under a light draft. Other fuels may produce more heat. Regardless of the fuel, it takes a certain amount of air to burn efficiently. The more air you add the more fuel you can burn. But as the reaction speeds up the temperatures go up and that may not be all that desirable. Nitrogen will start to oxidize and so will other things. Not only does this create poisonous gases but it is also wasted energy. We want to heat the water, not the air.

A long, gentle, white and orange flame is the most desirable. The flame requires space and time to occur, so give a couple of feet of space between the fuel and the water surfaces. A solid fuel will require more space than a liquid or gas fuel and, with all fuels, combustion space is determined by the amount of fuel and air being joined at a given moment. Better put, forcing more air to the fuel makes a smaller, more intense flame.

A good rule: for every square foot of grate surface add a foot of combustion space. And remember, “Flame shall not touch metal!” It quenches the flame and makes poisonous carbon monoxide.

Another round number to remember is when using wood, figure that 8 to 10 square feet of heating surface produces one horsepower. One boiler horsepower is equated to evaporating 35 to 40 pounds of water into steam in one hour. A hotter fire requires less surface to transfer the heat but we will use wood for our example.

Our engine was fairly efficient for it’s size and produced 2 horsepower while consuming 70 pounds of steam (not steam pressure, but the weight of water converted to steam and run through the engine) in one hour. We need to determine the size of the combustion area and the amount of heat transfer area required to evaporate the water.

Build Your Own!
We are going to coil a length of pipe and stuff it inside a casing where the fire will be. 1/2 inch black iron pipe (never use galvanized in a boiler!) has about a 2 inch circumference. So, for every inch of pipe length, we have 2 square inches. There are 144 square inches to the square foot and we need about 16 square feet of surface (2 horsepower). 144 x 16 = 2204 square inches. Since every inch of pipe gives us 2 square inches, 2204 / 2 = 1102 inches or about 92 feet of pipe length. If it is coiled at 12 inches diameter, you would need about 30 turns. That coil would be about 2 1/2 feet long and too long so we would probably need 2 coils; one smaller diameter and fitting inside the larger coil.

Steam Engines

For other than rockets and catapults, steam power is usually converted into a rotary motion. This is broken down into two classifications, turbine and reciprocating.

Turbines

Two types of turbines are in use today, impulse and reaction. There are often combinations of the two types and several variations such as Parsons and Terry for impulse, and dozens of reaction types including centripetal, like turbo-chargers.

An impulse turbine extracts energy by accelerating the steam in a nozzle and aiming it at a curved blade. The steam changes directions passing the kinetic energy to the blade. Theoretically, the blade would move at half the velocity of the steam. Since that is impossible, most turbines have several sets of blades (stages) to allow the steam to change directions each time.

A reaction turbine works by allowing the nozzles ejecting steam to be fixed on the rotating wheel. Generally, this is done in many stages. The blades in these turbines are shaped so the steam enters a small end and exits through a larger end. In doing so, the steam accelerates a little bit each time. These types of turbines are very efficient, but because the steam must keep expanding until its volume is quite large, they are relegated to applications with plenty of area.

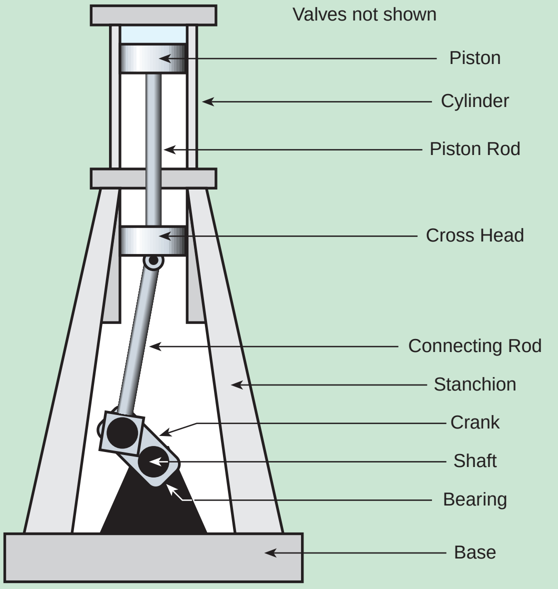
For any turbine to efficiently use steam, it requires that it be a size that allows for the expansion. A pound of steam wants to occupy 27 cubic feet at atmospheric pressure. Most small turbines consume 40 to 80 pounds of steam per horsepower. This inefficiency comes from the lack of physical space to allow all that steam to properly expand, doing its work.

Worth mentioning are rotary vane motors that can run on steam and Tesla designs, which use fluid viscosity and centripetal force. Unfortunately, even though they are practical, the efficiencies of these types of motors are too low to be in common use.

Reciprocating

Reciprocating engines are the method of choice in applications of steam up to 100 horsepower. They take a metered amount of steam and allow it to expand, driving a piston in a cylinder. The piston is connected to a crank which turns a shaft. At common pressures enormous torque can be achieved delivering a lot of power from a small, practical engine.

Vertical or "Marine" Configuration



Vertical configuration is used where horizontal space is limited, e.g. boats and cars. Side thrust created by angular moment between the crank and piston is taken up by the crosshead. This configuration, almost exclusive to steam engines, allows the piston to be thin, light, and to not touch the cylinder walls. This design is key to steam engine longevity. Flywheels (not shown) on vertical steam engines are usually small due to space restrictions.

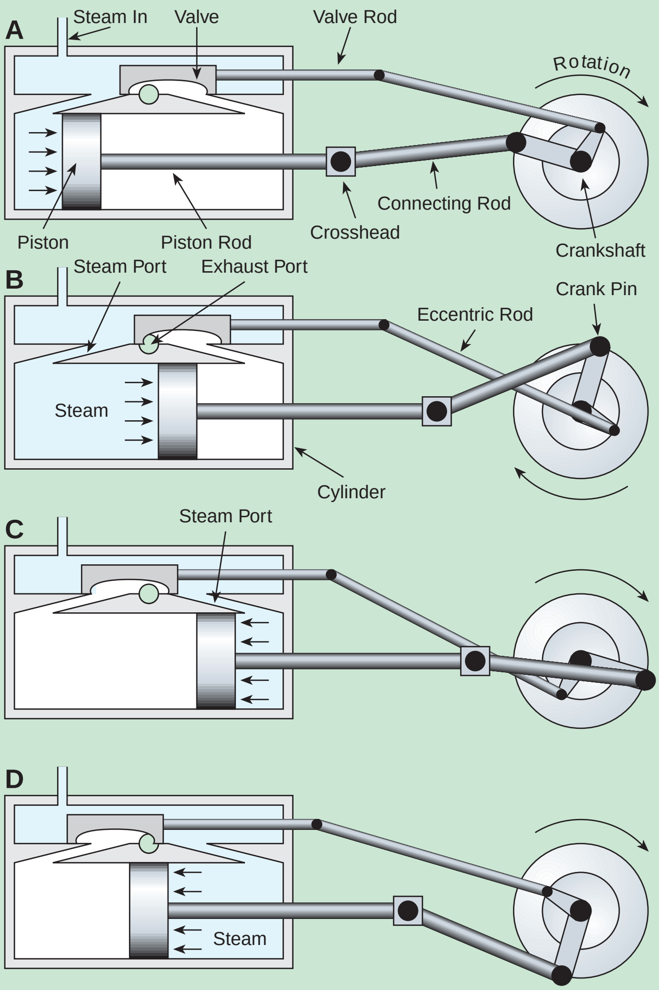
The Mike Brown engine is of this type. A lot of torque means a slow, silent, and even a direct connection to the task. There is no need for high rpm, multiple gears, and their resulting noise.

Reciprocating, or piston, engines are easy to build. Their slow speed and simple design increases longevity. Tour an old refinery or even a food processing plant and you may find piston engines still in operation after 50 years of use!

There are at least two major manufacturers of steam engines in the U.S. Unfortunately, steam engines are expensive due to a limited market. Until recently, small engines could be afforded only on a hobby or research basis. That has changed with the production manufacturing of the Mike Brown engine. Reliable power, parts, and support are now available at a practical price.

In a reciprocating engine, the front port is exposed to steam chest pressure allowing the steam to enter the cylinder and start to drive the piston. The valve then starts to travel forward and will soon cut off the steam admission from the front port and expose the rear port. The piston will continue on to the end of its

Motion & Timing of a Double Acting Steam Engine



Valve action in relation to piston action is shown. Steam chest is filled with high pressure steam at all times. A valve admits the steam into the cylinder through ports in the cylinder wall. The same valve allows steam to escape through a center exhaust port. Since steam force is used on both sides of the piston the engine is called "Double Action." This design allows very low rpms and high torque. Action is as follows:

A. The left port is open allowing steam chest pressure into the left side of the cylinder which pushes the piston towards the right.

B.. The valve is starting to travel left and will soon cut off steam through the left port. The piston will continue to the end of its stroke due to flywheel momentum.

C. The valve has traveled fully left exposing the right port to pressurized steam.The piston will be driven towards the left. The left side of the cylinder is now exposed to the exhaust port allowing old steam to vent.

D. As the piston continues its stroke the valve again begins moving towards the right. It will soon close the right port and open the left port driving the system towards the condition in diagram A.

stroke at the rear of the cylinder. The valve traveled forward, exposing the rear port to the pressurized steam and allowed steam to enter the backside of the piston which will drive it back again. The valve then moves back in the original direction as the piston continues forward. The valve will soon cover the rear port and expose the front port to begin the process all over again.

It is important to study the timing of the eccentric, which drives the valve back and forth, and its relation to the crank journal which is connected to the piston rod via the crosshead.

"Single acting" engines operate by admitting steam to only one side of a piston. The other side of the piston is exposed to a much lower atmospheric pressure. They produce power for only 50% of the revolution. This is desirable if construction needs to be inexpensive or a light valve train is needed for higher speed engines.

When maximum power is required in as small a power plant as possible, an engine may be designed to receive steam on both sides of the piston. This is known as "double acting." Both sides of the cylinder are sealed from the atmosphere and a valve system is used to admit and exhaust steam during alternate periods of the stroke. This is the type of engine seen in the drawing and that of the Mike Brown engine. They provide low rpm with high torque. Locomotives, autos, and marine engines use this and, if they have another eccentric that is 180° opposite, they can reverse crankshaft direction simply by switching one eccentric to the other.

The engine alternately admits and exhausts steam through a pair of ports cast into the cylinder. The ports are opened and closed by a valve that slides back and forth over them.

There are many shapes of valves but the one seen in the drawing is known as a D valve. The valve has the high pressure steam on the outside of it and exhausts the steam through the center which is constantly exposed to a port leading to the outside of the cylinder. Note how the outside and inside edges of the valve work back and forth across the cylinder ports.

Due to the thermal reduction of steam as it expands, it is not feasible to expand it by more than four or five times in one cylinder. In order to get more work from a given amount of steam, it is a common practice to exhaust the steam from one cylinder into another larger cylinder. This process is called compounding. Even though the steam is at a lower than initial pressure as it enters the second cylinder, the area of the piston is much larger than the initial cylinder and can provide the same amount of power. Sometimes this is done in 3, 4, or even 5 stages.

Since 2 horsepower will require 2 square feet of grate surface, we can use a round grate of about 19 inches diameter. Just to be safe we'll place our pipe coils 3 feet above the grate. We need to put all this in a casing and it just so happens that a 40 gallon water heater tank fits these dimensions roughly. We cut the tank in half, make holes for a door, air, and exhaust and we're in business.

Other Details
Now we add feed pumps and connect everything together with copper tubing using flare fittings only. But, we're not quite done. There are some important details you need to know. All fittings have to be steam rated, meaning no rubber seats in the valves, etc. Most importantly: add a safety valve! Steam safety valves are expensive and simply a fact of life. Sooner or later, you will have more steam than can be contained and it needs an uninterrupted passage to the atmosphere. A safety valve will release steam at a pre-set pressure and seal again automatically when the pressure drops to a safe level. If you think you can get by without one, forget this article and go buy a diesel generator.

Another thing that you can't overlook is the amount of heat needed to come up to operating speed and what is lost in the cool-down period. Earlier we determined that we needed 5.68 pounds of good dry wood per hour to make 1000 watts. First we'll need to bring about 10 pounds of water and about 100 pounds of steel to 350°. That means an additional 12,000 to 15,000 btus or about 3 pounds of wood. Another 2 or 3 pounds of wood energy can be figured as lost for the cool-down. Go out and chop at least 10 pounds of good wood.

Once you have everything mathematically correct, start calculating your losses to determine your overall efficiencies. This segment ties into everything and where one change is made, everything else will be affected. I call this the "headache phase." For example, we might discover storage losses in the batteries or inefficiencies in our generator. Believe me, there is always something so grab a few extra sticks of wood.

You can start to see the relation between each individual element of your design flowchart and where the most practical modifications can be applied. Many a fun night can be spent with the feet near the woodstove and a calculator by the recliner as you dream up your system.

System Cost
Dollar and "sense" wise, a person could assemble a system like this for less than $2000. That's not cheap, but it puts it within sight of other energy sources.

Don't just go out and start building a system just because you have the facilities to do so. Do everyone within a hundred yards of yourself a big favor and get yourself educated in steam first! The best and most fun way to get educated about steam is to attend a steam engine show. There are almost 5,000 shows across the nation. Steam has its own fraternity of dedicated individuals. Many like to restore old machines and show them off. The shows are very family oriented with lots of stuff for kids. They can best be described as a blend of Mad Max and Lake Woebegone. You'll see more NRA belt buckles and Grateful Dead t-shirts than anywhere else. Steamers are an eccentric folk.

Chances are you live close to a steam club, you can find one in a show directory, or ask your local tractor dealer or model shop where they are. Also, the Internet is loaded with steam. Type "Live Steam" into your favorite web searcher and see what happens. Just remember that steam is it's own fraternity and anyone with an imagination is welcome!

Access
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Sources
Live Steam Magazine (premier steam hobby magazine), PO Box 629 Traverse City, MI 49685

Steamboating Magazine (mostly small steam launches and engineering), RT 1, Box 262, Middlebourne, WV 26149

Iron Men Album (old steam tractors, etc., large classified section), PO Box 328, Lancaster, PA 17608

Steam & Gas Show Directory (lists all the shows, a "must have"), PO Box 328, Lancaster, PA 17608

Steam Automobile Club Association, 1680 Dartmouth, Deerfield, IL 60015

Tiny Power Steam Engines, PO Box 1605, Branson, MO 65616 • 417-334-2655

Known Values
231 cu. inches in one gallon of water

One gallon of water weighs 8.34 pounds

One pound of water occupies 27.7 cu. inches or 0.016 cu. feet

One cu. ft. holds 7.48 gallons or 62.39 lbs of water

1 btu = 1 lb. water raised 1° Fahrenheit = 778 ft. lbs. (778 lbs. lifted 1 ft.)

42.44 btus a minute = 1 horsepower at 100% efficiency

1 horsepower = 33,000 lbs. lifted 1 ft. in one minute = 550 lbs. lifted 1 ft. in one second = 750 watts electrical energy (746 true)

1 kw (1000 watts) = 1.34 hp

1 watt = 2654.5 foot lbs of energy

Watt hours can be found by determining load x hours. Example: a 100 watt light bulb on for 12 hours = 1200 watt hours

One kw (1000 watts) for one hr = 3412 btus, or 1 watt hour = 3.412 btus

One pound of water requires 970.4 btus added to water at 212° to convert to 212° steam (at atmospheric pressure, or 14.7 lbs absolute)

One pound of water at atmospheric pressure (14.7 lbs. gauge) converted to steam will occupy 26.8 cu ft., at 100 lbs gauge 4.43 cu. ft., and in a 29.4 in. vacuum 1208 cu. ft.

Water boils at 100 degrees at 28 inches vacuum, and at 327.8 degrees at 100 lbs. (absolute)

Steam at 100 psi (saturated) will gain 14% volume with 100° superheat

To Determine Steam Horsepower (constant)
Use the following formula: P.L.A.N. / 33,000 where P = pressure (mean), L = length of stroke in ft., A = Area in sq. in., and N = rpm

(P x L x A x N) / 33,000 = constant horsepower

To Determine Pony Brake Horsepower (common): (2 x π x T x N) / 33,000, where T= torque and N = rpm

To Determine Boiler Horsepower divide the pounds of water evaporated into steam in one hour by 34.5

To Determine Grate Area for Solid Fuel in Light Draft, 1 square ft. per hp. If you double the air with forced draft then reduce by half (Note that air also requires some heat to be brought to the ignition temperature of the fuel.)

Condensers require about 1 sq. ft. of cooling surface per horsepower using 60° water

Engine Efficiency may be determined by measuring the amount of condensate from the exhaust in one hour and dividing it by the constant horsepower. For example: an engine gives 200 lbs of water (condensate) while producing a constant 5 horsepower or 200 / 5 = 40 lbs per horsepower hour. About 3 lbs per horsepower / hour is 100% efficiency

Cutoff or valve timing is termed in percent of stroke. Admission of steam is stopped at determined points in the piston stroke allowing steam to expand in the cylinder. The average pressure in the cylinder is the "mean" pressure.

HEAT Lightning

Shari Prange

Above: Formula Lightnings at the 1996 Cleveland Electric Formula Classic.

For many people, the concept of a race car is epitomized by the cars that race in the Indianapolis 500: low, open-wheeled formula cars built for speed. The electric equivalent of the Indy car is the University Spec car. But while Indy cars fill the air with their thunder, these cars are pure heat lightning, flashy but silent.

In The Beginning

The concept was born in the early days of the Phoenix race, when it was the Solar/Electric 500 at Phoenix International Raceway. Electric car racing was, for the first time, moving onto the same major tracks used by conventional race cars. Race organizer Ernie Holden designed the Formula Lightning, the first production electric racing chassis of its kind in the country.

The car was aimed primarily at universities, which were already involved with solar racers and interested in electric car engineering projects. Initially, the car did a few demo appearances, and the first three Lightnings ran in the "Open" class at the Solar/Electric 500.

In 1994, the first actual Formula Lightning event was run in Ohio, sponsored by Cleveland Electric Illuminating, the local utility. The event even attracted some mainstream media coverage, something which had always been in short supply for electrics.

Evolution

Over the next few years, various changes took place. The Solar/Electric 500 moved from Phoenix International Raceway, a one-mile oval track, to Firebird Raceway, a Phoenix road course. The administration of the event passed from the Solar Electric Racing Association (SERA) to Electric Vehicle Technology Competitions (EVTC) under Mike Shaw's direction, and the event name changed to the APS Electrics.

During this time, sixteen Formula Lightnings were built and sold. Most went to universities, but Carl Hayden High School also acquired one, and at least one became a corporate demo vehicle. However, Ernie Holden's health was deteriorating, forcing him to reduce his involvement with the cars, and finally to bow out altogether. (He passed away in the spring of 1997.)

EVTC now had a University Class Spec series, with three to four events a year. They raced at various tracks around the country, including Phoenix, Cleveland, Connecticut, North Carolina, and Indianapolis Raceway Park. However, there would be no more Formula Lightnings built. What to do to keep the series alive?

The Next Generation

In response, EVTC designed their own chassis for production, the US-1. This chassis was patterned after Indy Light cars, the “farm team” for Indy 500 cars. A conscious effort was made to examine the shortcomings of the Formula Lightning design and improve on it.

The Formula Lightning suffered from a mid-course change. It was originally designed to top out at about 2,300 lbs. in racing trim. However, after the chassis was designed, Ernie took a look at the existing open-wheel electric class in Europe. The Federation Internationale de l’Automobile (FIA) rules for these events give a maximum vehicle weight of 2,750 lbs. Ernie changed the limits on Formula Lightnings to match, in the hope that there might be some crossover between the two series.

The teams, of course, quickly took advantage of the new rules to add batteries. Immediately after that, the cars started to have problems and breakdowns. While street cars are designed to be very forgiving, race cars are optimized within narrow margin. The extra weight added stresses for which the chassis had not been designed.

In order to correct this problem, the teams were limited to 400 volts, which effectively limited the battery pack weight as well. Also, over the course of the first several races, various parts of the Formula Lightnings were strengthened and redesigned to eliminate these breakdowns.

In contrast, the US-1 reverted to the original, lighter weight limitations. Other changes included a shorter wheel base and tread width, and more streamlined body.

The Shape Of Things To Come

The first three production US-1 chassis are now in progress. The University Spec series will now allow both Formula Lightnings and US-1 chassis to compete together. Although there are differences in the sizes and weights of the two kinds of vehicles, EVTC has worked the formulae so that they will be comparable in performance.

The series is intended specifically for universities. High schools, corporations, or private individuals may buy the chassis and race them in open classes, but not in the series. The purpose is to encourage engineering students to refine and improve electric vehicle technology.

This goal also underlies the semi-spec nature of the rules. The chassis is defined by the manufacturer, and is not open to alteration by the teams, but the electric drive system is wide open, except for the 400 volt limit on Lightnings. Any type of motor or control system can be used, and any kind of battery is fair game. This focuses the team’s research and design efforts on the drive system, and relieves them from having to “reinvent the wheel” on chassis issues.

Play It Safe

The only constraints are issues of safety. These rules specify that the batteries must be approved for safety and must be completely enclosed, and all normal rules regarding roll cages, helmets, driving suits, and so forth apply. Drivers must have SCCA (Sports Car Club Of America) national level racing licenses, or other professional racing licenses. For this reason, many teams bring in “hired gun” drivers, unless they have a team member or alumnus who holds a license.

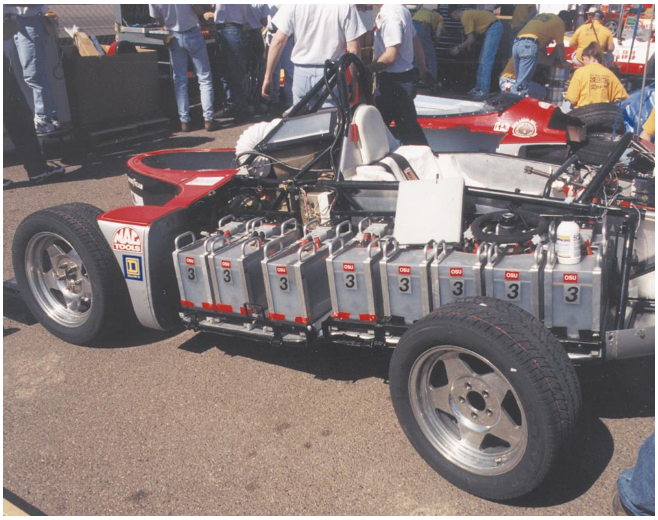
Apparently the safety rules and chassis design work. One Lightning hit the wall at racing speeds. In another incident, two cars bumped wheels, and one drove over the other. In both cases, the drivers were unhurt, the cars were repairable, and there were none of the spectacular fireworks that pessimists predict for EV crashes.

The Race

The University Spec series runs on both oval and road tracks, just like the Championship Auto Racing Teams (CART) in conventional racing. Track lengths vary, but the races are approximately 30 miles long, however many laps that requires.

The race begins with a flying start behind a pace car. Lap speeds are in the mid 80 mph range. Pit stops are allowed, and most teams make one stop for a quick battery change. This is still accomplished primarily by human muscle power, but the teams have refined the

Below: This Ohio State car uses Optima batteries in parallel. Each pair is in its own box, with lifting handles.



process down to about 15 seconds. The key is well-rehearsed procedures and battery connections designed for quick release and reconnection.

A few cars may stop more than once, and a few may not stop at all. These last are generally using nickel cadmium batteries. Quick-charging in the pits would be allowed, but the teams have not found it an option worth pursuing.

Nuts and Volts

Most of the teams so far run AC drive systems, with a typical pack voltage around 336 volts. Some may go as high as 372 volts, but the motors won't accept more than 410 volts, or less than 240 volts. These motors and the controllers come from a range of manufacturers, including Uniq Mobility, AC Propulsion, and Delphi.

A few cars run DC systems. They typically run two parallel battery strings of 192 Volts each.

Both direct drive and transmissions are used. The best system seems to be a two-speed transmission to give maximum power both on the fast straights and in the slower turns.

Both ac and DC teams favor Optima Red Top batteries. Because they are sealed, they are safer, require less maintenance, and can be mounted in various orientations. They are also light weight. Perhaps most important to racers is that they can release their energy quickly for racing speed, acceleration, and maneuvering.

Price Tag

A University Spec chassis costs $19,500. Completing the chassis and adding the drive system and batteries, will bring the cost to around $35,000. As with solar race cars, university teams are in a position to generate donations and grants, and may receive support from suppliers in the form of discounted or donated components or batteries.

A Class By Itself

The University Spec cars are similar to familiar conventional race cars in appearance and in the kind of tracks where they race. Unlike conventional race cars, however, they are the creations of engineering students, and as such are both classrooms and laboratories on wheels. While their competition is exciting to watch, their biggest contribution to electric vehicles is yet to come, when the engineers and ideas that originate on these teams make their ways into the designs of the cars we will someday be driving.

Access

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EV Tech Talk

Mike Brown

Last issue we started to figure out why an EV was not working. We began with the auxiliary battery, checked both battery packs for open fuses or interconnects, and checked the cables that connect the two packs. We stopped at the point where we had nominal battery pack voltage and we were about to hook up to a component such as a circuit breaker, main cut-off switch, or the main contactor.

Note: the control system checks that follow are based on the early PMC 21 and 25 controllers and the late style 1221 and 1231 controllers, as these are the most widely used systems. For other controllers, the voltage checks at many points will be the same. Measurements specific to PMC controllers will be noted.

For more detailed explanations of controllers and safety disconnects see Home Power issues #37 and #38.

If you have confirmed nominal battery pack voltage across the most positive and most negative terminals of the battery pack, you need to start checking individual components in sequence.

We will start at the circuit breaker or main cut-off switch, which every EV should have in the positive leg of the high voltage system. First make sure the circuit breaker is closed. If it was open, reset it and see if the EV works. Then determine why it was open: did some one flip it open, or did a fault further down the line make it do its job?

If the circuit breaker is closed but the car still doesn't work, you need to check out the breaker itself. With the negative lead of the volt meter connected to the most negative battery terminal, touch the positive probe to the battery side terminal of the circuit breaker. (A purpose-built extra long jumper wire might be necessary for the negative lead if the breaker is located in the driver's compartment.) You should get nominal battery pack voltage.

Now move the probe to the other terminal of the breaker. Again, you should have nominal battery pack voltage. I have never seen a circuit breaker fail open, but it is a good idea to check for voltage on both sides just to have proof of continuity. The same checks apply to manual cut-off switches. I have seen failures when switches were used beyond their ratings.

Next we go back under the hood to check the main contactor. The first check is for voltage between the battery pack's most negative terminal and the battery positive terminal of the contactor. Again, you should have nominal battery pack voltage. If you don't, check the cable between the breaker and the contactor.

At this point the EV's two electrical systems come together. The main contactor is a large switch that is closed by a magnetic coil powered by the EV's auxiliary battery. When the switch is closed, the battery pack is connected to the controller. The failure modes of a contactor are simply that it won't close or once closed, it won't open. Failure to open is usually caused by the contact points welding together. This happened a lot in the early days of EVs when the contactors used were less robust surplus parts and were opened under load. Modern control systems, in which all switching is done in the unloaded state and the contactors are sized to suit EVs, have just about eliminated this failure mode.

The other failure mode, not closing, gets more complicated. As mentioned above the contactor is closed by a magnetic coil powered by the EV's auxiliary battery, and there are several places between the auxiliary battery and the contactor where a failure can occur. WARNING: BEFORE PROCEEDING WITH THE TEST, BE SURE THE TRANSMISSION IS IN NEUTRAL AND THE PARKING BRAKE IS ON! IF POSSIBLE, JACK THE DRIVE WHEELS UP OFF THE GROUND. UNINTENTIONAL ACCELERATION HURTS.

Since we checked the auxiliary battery earlier, the next thing to check is the 12 Volt path from the auxiliary battery to the main contactor. There are two possible paths. The earlier controllers used a three-wire potbox with no microswitch. In these systems, the main contactor closes when the key is turned on and stays closed as long as the key is on. Some people ignore the manufacturer's instructions and wire the later style controllers the same way, eliminating the microswitch.

So first check your system for a three-wire potbox or a potbox microswitch with no wires on it. If your system fits either of the above descriptions, turn the key on and see if the contactor closes. If it doesn't, take your voltmeter and, with the negative probe on a good chassis ground, touch the positive terminal of the contactor's coil with the positive probe. You should see at least 12 Volts.

If you don't, check the wiring between the switch and the contactor, the switch itself, and the wire between the auxiliary battery and the switch, including any fuses. If you get 12 Volts up to the positive coil terminal, check for continuity between the negative coil terminal and its ground wire. If you get a good ground, then the contactor coil has failed.

If you have a late style controller with a two-wire potbox, with wires on the microswitch, you have one more component to check out before you get to the main contactor. The potbox microswitch is a three-pole switch in which the path between the two outer poles is open when the potbox lever is in the off position. When the accelerator pedal is pressed and the lever is pulled off its stop, the microswitch closes the path between the two outer terminals. The microswitch is in the circuit between the keyswitch and the main contactor, and acts as a "deadman switch" by opening the high voltage circuit between the battery pack and the controller when the accelerator pedal is released.

Check the microswitch for 12 Volts at both the input side and output sides with the potbox lever off the stop far enough to actuate the switch. If there is not 12 Volts at the input side, check the auxiliary battery-keyswitch-microswitch circuit to determine why. If there is 12 Volt in but nothing out, the microswitch is faulty and should be replaced.

With the contactor closed, check to see if you get nominal battery pack voltage at the controller side terminal of the main contactor, just to check the contacts.

Again, with the main contactor closed, touch the appropriate probes of the volt meter to the B+ and B- terminals of the controller. You should get nominal battery pack voltage. If you get no voltage, check the cables that attach the B+ terminal to the contactor and the B- terminal to the battery pack.

The controller needs two other inputs to function, so if you have battery pack nominal voltage to the B+ and B- terminals and still no action, we need to check the other inputs. We talked earlier about whether the potbox had two or three wires, and whether it had a microswitch. We have covered the microswitch, so it is time to talk about these wires.

Note: the following paragraphs are specific to the PMC 21, 25, 1221, and 1231 controllers.

The controller is told how much voltage to send to the motor by a 0 to 5K ohm signal from the potbox, determined by the lever position, which is controlled by the accelerator pedal. This signal is sent by three wires in an early control system and two wires in a late system.

The early controllers (21 and 25) had three small potbox terminals on the end of the controller. The white wire attached to the top terminal, the black wire attached to the middle terminal, and a green or red wire attached to the bottom terminal. After checking that the these wires are still attached to the controller, remove them and hook the probes of your voltmeter (set in ohm meter mode) to the white and black wires. With the potbox lever in the full off position, the reading should be from 0 to 50 ohms. With the potbox arm in the full on position, the reading should be 4.5 to 5.5K ohms. If either of these numbers is off, the potbox is defective and must be replaced.

The late controllers (1221 and 1231) also have three small terminals on the end of the controller. The top terminal is for the key switch input (KSI) voltage, which will be discussed later. The middle and bottom terminals are for potbox input. The black and white wires from the two-wire potbox can go to either of these two terminals. Again, after checking that they were attached to the controller, remove them and hook up the ohm meter. The readings for full off and full on should be the same as the early potbox. Again, if the numbers are off replace the potbox.

In the early controllers, the voltage to run the logic circuit of the controller was tapped from the traction battery positive terminal internally. On the late controllers, this traction battery positive voltage must be supplied to the top or key switch input terminal mentioned above. This is another "deadman switch" to ensure that the controller shuts off when the accelerator pedal is released.

There are a couple of ways to supply this signal. The folks that ignore the potbox microswitch usually run a small gauge jumper wire from the large B+ terminal to the small KSI terminal so the KSI signal is turned on with the key and stays on as long as the key is on, defeating yet another safety feature.

The factory recommended method uses a small key switch relay controlled by the potbox microswitch, which closes the relay at the same time the main contactor is closed, and supplies battery pack positive voltage to the KSI terminal.

Whichever method is used on your car, a voltmeter connected to the B- terminal of the controller and the KSI wire at the terminal must have a reading between 8 Volts and nominal battery pack voltage. If there is no signal, check the wiring and the relay.

If you have battery pack nominal voltage at the B+, B-, and KSI terminals of the controller, and a 0 to 5K ohm signal to the potbox terminals, and still no action from the motor it's time for the final controller output test.

With the key on, touch the positive probe of the voltmeter to the B+ terminal and the negative probe to the M- terminal. Move the potbox lever while watching the voltmeter. The voltage should go from 0 Volts to battery pack voltage as the lever is moved toward full on. If there is no reading, the controller is defective and should be sent to the manufacturer for repair.

If you have output from the controller and the motor still doesn't turn, check the motor-to-controller cables for continuity and good connections.

Most of the motor failures I have seen have been catastrophic and gave plenty of loud smelly evidence, but worn out brushes could be a cause of failure so they are the last item to be checked. If the brushes look good then the motor should be taken out and checked out by a motor shop.

In closing I would like to emphasize the procedure I used. Start at the beginning, check out the system step by step, building each step on known facts. Don't do random checks based on guesswork. Also note that the largest part of the check out procedure was the part that led up to checking the controller, which was the first part blamed.

What about the person who called me with the dead EV in the first place? He turned out to have a bad connection at the potbox microswitch.

I would like to hear from Home Power readers with EV questions, problems, or comments. I am open to just about any topic. I need to know what you want to read.

Access

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Above: Will the sun come out?

Solar Sprint Racing

Don Kulha

Solar Sprint racing takes many forms. The Junior Solar Sprint (JSS) rules are posted at the SprintWeb site. They foster competition because everyone follows the same rules. Various locales have modified the rules. In Hawaii there are separate classes for belt and gear drive cars. In Maryland they require the racer to carry a 12 ounce aluminum can. Tracks might be shorter or longer than the regulation 65 feet. For our Senior Solar Sprint (SSS) races, we've adopted the JSS rules as a standard.

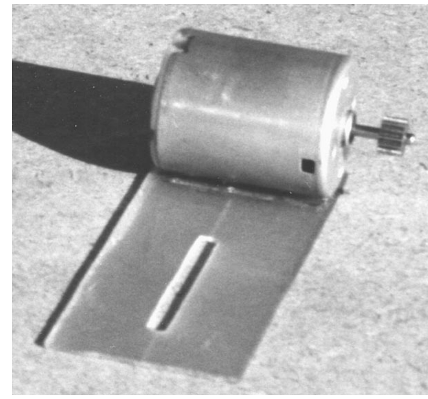
For any Solar Sprint to take place there needs to be a host. While schools usually conduct JSS races, they are also sponsored by merchants, local community groups, and clubs. The Education office at the National Renewable Energy Laboratory (NREL) helps hosts with information. They show how to stage races and find groups currently involved in the program. Individuals can promote the sport in their area by proposing it to schools. Individuals can find local businesses to supply kits or to conduct the event. They can also help a team construct and build their entry. Schools sometimes operate on tight budgets and need community sponsorship.

National JSS Race

There was a National JSS race held in Dallas, Texas on August 6 at The Science Place. Six regional JSS winners raced for the national title. K'NEX sponsored the event as a marketing kickoff for their new line of solar-powered construction kits. The kids had a great time, competing for $1,000 in prize money and a Hard Rock Cafe bomber jacket. The winner was Yohana DeLeon, a young woman from Berkeley, California. Her entry ran the 65 foot course in an astounding 5.47 seconds. I understand that it used a variable rate transmission. Great job, Yohana!

Construction Notes

The chassis is the base on which the rest of your racer is built. It must be sturdy, lightweight, and provide attachment points for the motor, axles,

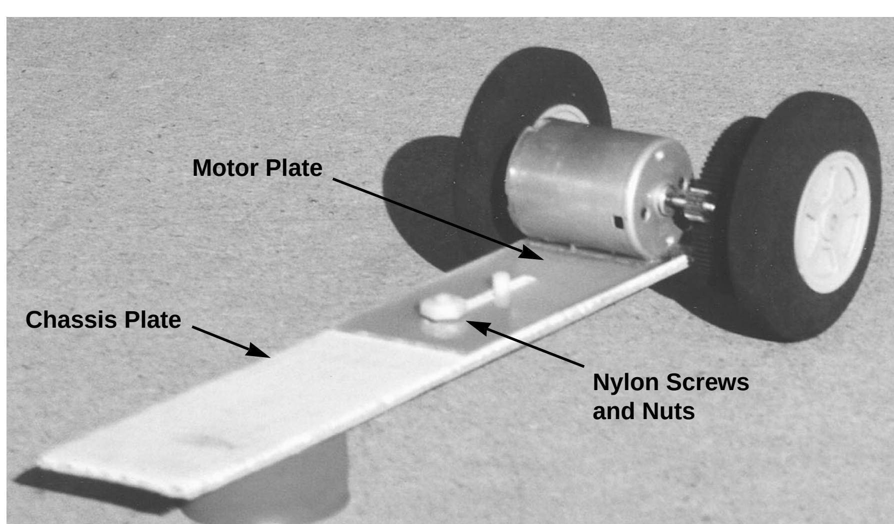


Above: Motor epoxied to slotted fiberglass mounting plate.

line guide(s), and PV panel. The choice of chassis material is open. Foam board, balsa, cardboard, plastic and composite materials are a few possibilities. A chassis is required because the rules state you cannot attach wheels or axles directly to the PV panel. A good test for this is removing the PV panel from your racer and powering it from a battery instead. I've done this for testing, and it's handy on cloudy days.

The chassis geometry also establishes the relative locations of your wheels. If the axles aren't parallel, then the racer will try to turn away from the guide line. This creates friction and reduces speed. Wheel alignment is important too. If the wheels don't run parallel, then they will scrub their way running down the track. We aren't dealing with much power in the first place, so we don't want to waste any.

Below: Slotted motor plate allows for gear or belt adjustment.



Draw your design accurately and to scale on paper. This allows you to check the relationship of the parts and avoid interference problems. One set of gears I considered using would have resulted in the axle hitting the motor—not good! You can also use the drawing as a construction guide to keep everything aligned. Measure diagonally the distance from the front axle's end on one side, to the rear axle's end on the opposite side. Compare the results on both sides, and you can tell if your chassis is square. It's less painful to discover mistakes on paper than after you've built the car.

I've noted more problems with racers following the guide line than in any other area. They bind up on the guide wire, rub on it, and even flip over it. The specification for guide line height is 1 cm ± 0.5 cm (a quarter inch plus or minus an eight inch). Problem is that this requires a 65 foot long area to be flat within a quarter of an inch. Your guide should handle a line lying on the ground or being 3/4 inch off the track. The optimal guide minimizes line friction while maintaining tight directional control. I'm using a pivoting front guide extended forward following line elevation. I also use a fixed rear guide that forms a slot 0.06 inch wide by 0.5 inch high. Having front and rear guides on your chassis aids stability at the cost of friction. They can also save you from being blown off the track by a strong wind. Ideally the centerline of your guide(s) will coincide with the thrust from your drive wheel(s), i.e., centered between them.

Variable Rate Transmissions

I received an interesting note from Jeff Alleman, a researcher at NREL who volunteers his time to help with JSS. Jeff writes, "The fastest transmission is a variable rate transmission. The simplest explanation is think of how a cassette tape rewinds. The empty reel can put a large amount of torque on the full reel and when the small reel starts to fill the speed of the full reel is increased. This applied to a car makes it very fast (California car). My cars use this method." Good information here. Thanks Jeff.

Access

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NREL Education Office, Event host technical assistance, 1-800-NEW-ENGY. Builder and Host info at: www.nrel.gov/business/education/SprintWeb

Solar Sprint kits: Pitsco, 1-800-835-0686
Web: www.pitsco.com

Some Parts Suppliers on the World Wide Web

Sheldon's Hobbies:
www.btown.com/sheldon.html

Tower Hobbies :
www.towerhobbies.com/index.html

Kimborough Racing Products (R/C racing gears): kimbrough-products.com

Aerospace Composite Products:
www.acp-composites.com

Minutia

John Wiles

Sponsored By The Photovoltaic Systems Assistance Center Sandia National Laboratories

Understanding and applying the minutia of the National Electrical Code(NEC) has been the primary reason that for the last 100 years, the United States has had one of the safest electrical power systems in the world. Since PV systems are electrical power systems and must be safe, we (the people involved in all phases of PV system manufacture, design, and installation) must strive for complete understanding of the NEC.

While the NEC is not as clearly worded as some would like, there is a wealth of information contained in the various chapters—information that applies to PV systems just as it does other electrical systems. Ignoring this information or maintaining that it does not apply to PV systems dooms us to repeat the mistakes that led to the various sections of the code being developed in the first place. The PV industry, in it's relative infancy, cannot afford to make mistakes. A fire or electrical problem that damages property or causes loss of life in a highly visible PV system will attract the attention of the insurance industry. Such attention may be more than the PV Industry can stand. We must work together to understand and apply the various codes and standards to prevent this from happening. I welcome the dialog that the Code Corner Columns generate.

In 1990, there were PV installers who were not putting fuses or disconnects between the batteries and the inverters on PV systems, even though the NEC and common sense required them. Fortunately, the word has reached most in the PV industry that the NEC represents a minimum set of safety requirements and that fuses and disconnects are good ideas that don't result in significant performance penalties.

Feedback

In response to the letters that appeared in Home Power 61 (Code Curveballs) and other letters, e-mail, and telephone calls concerning the Code Corner Column in Home Power 60, I would like to address some of the details that are involved in understanding and applying the NEC to achieve safe PV systems. The information presented below is obtained from the NEC, the NEC Handbook, and various UL and IEEE Standards. The NEC Handbook is published by the National Fire Protection Association and is written by the electrical engineers at NFPA who are responsible for editing the NEC and making formal interpretations of it. The appeal process for differences in interpretation between electrical inspectors and the PV installer ends at the NFPA if the differences cannot be resolved at a lower level. Local codes supplement the NEC and may impose different requirements.

Cable Ampacities and Temperature Deratings

The Insulated Cable Engineers Association (ICEA) in conjunction with Underwriters Laboratories (UL) and the Institute of Electrical and Electronic Engineers (IEEE) have developed detailed cable standards (e.g. ICEA T 22-294 on testing cables in wet locations). If the cables are built to the published standards, tested and listed to those standards, and installed in accordance with the appropriate codes, they are designed to last at least 20-years. An important aspect of conductor life is the insulation temperature. If the insulation temperature is allowed to increase above the design specification, then the life of that insulation will be reduced and the cable may fail unexpectedly.

PV Module Cable Sizes

Most PV modules less than 100 watts in size have terminals or lugs that can accept cables in the range of number 14–8 AWG. Some modules come with number 16–10 AWG conductors that are attached as pigtails. Contrary to the opinion that no one would use cables that are too small to meet code because they don't want to waste valuable PV power, I have worked with several large PV module manufacturers and PV systems integrators that were trying to use cables as small as number 18 AWG to save money on copper costs and connectors. In large (50–100 kW) PV arrays, there is a lot of wiring and the costs mount up rapidly if oversized cable is used.

The NEC requires that cables be sized based on the ampacity of the cable because it is amperage that causes cables to overheat and overcurrent devices to trip. Voltage drop, important in RE systems, is not directly addressed in the NEC except as a non-directive Fine Print Note. I have found that after the proper temperature deratings have been applied to the ampacity of a PV module cable, the voltage drop for the minimum size code-compliant cable is usually acceptable. Of course, voltage drop should always be checked. When dealing with the cables that can be connected to the 100 watt and smaller modules, the number 12 and 10 AWG cables are most common.

Temperature Derating Cable

Ampacities start with the conductor material, the insulation material, the number of cables in close proximity, the installation method, and the ambient temperature in the vicinity of the cable. NEC Tables 310-16 and 310-17 give the starting points for the ampacities and these values are further modified by a series of footnotes and other restrictions. An engineer can also make detailed ampacity calculations (real arcane minutia) and not use the tables in the NEC.

For example, a number 10 AWG conductor may have insulation rated at 90°C and may be installed in a conduit. Table 310-16 of the NEC gives data that infers that if the current in the conductor is at or below 40 amps (the ampacity) and the ambient temperature around the conductor is 30°C, then the temperature of the insulation will go no higher than the 90°C rating.

If the ambient temperature around the conduit is 40°C, then the temperature derating factor of 0.91 reduces the maximum allowable current to 40 x 0.91 = 36.4 amps. Currents at this level coupled with an ambient temperature of 40°C allow the insulation temperature to remain at or below 90°C.

If the conductor is connected to a PV module (by connecting it to terminals in the PV module junction box), the conductor can be exposed to temperatures of 70°C and higher. Temperatures in PV junction boxes have been measured as high as 73–80°C when the ambient temperature has been 40°C (104°F) and the solar irradiance at 1050 watts/meter squared (W/m2). It should be noted that in many portions of the country ambient temperatures can exceed 104°F and irradiance, on clear days, is usually above 1050 W/m2 for several hours. Modules mounted close to dark roofs with little air circulation can be exposed to temperatures higher than the ambient temperature of the surrounding air.

At the 70°C temperature, the ampacity derating factor for the conductor rated at 90°C is 0.58 which limits the ampacity of the number 10 AWG cable in conduit to 23.2 amps (0.58 x 40). If the current in the cable exceeds 23.2 amps under these conditions, then the insulation may be exposed to temperatures higher than the rated 90°C which will shorten the life of the cable. Keeping the current at or below 23.2 amps allows the insulation temperature to remain at or below 90°C and the cable will meet longevity specifications.

In a similar manner, cables with insulations rated 60°C and 75°C can also have their ampacities derated for temperatures higher than 30°C.

It is generally assumed that if a cable with a 90°C insulation is operated at a current that is equal to the rated ampacity of the same size cable with a 60°C insulation, then the insulation will remain at or below 60°C. For example, the ampacity of a number 10 AWG cable with 60°C insulation is 30 amps at 30°C (compared to the 40 amps of the number 10 AWG cable with 90°C insulation). If the 90°C insulated cable is operated in conduit at 30 amps, it is assumed that its insulation temperature will be 60°C or lower. While this assumption is generally made, it has not been extensively verified through tests. The insulation materials, thickness, and thermal conductivity on 60°C cables can be quite different than the same factors in 90°C cables.

However, it should be noted that ambient temperature also affects the 90°C conductors being operated at 60°C. If we take a 90°C rated, number 10 AWG conductor and operate it at 30 amps in an ambient temperature of 40°C, the insulation temperature will probably exceed 60°C. Table 310-16 shows a temperature derating factor of 0.82 for 60°C conductors operating in 36-40°C ambient temperatures. The derated ampacity now becomes 0.82 x 30 = 24.6 amps. If operated under these conditions at 30 amps, the insulation temperature would probably exceed 60°C. Some installers have suggested that the temperature derate factor be only 0.91 (the number associated with the 90°C conductor actually used), but there is no general agreement on this from the people that wrote this section of the NEC. Some think that the non-linear nature of the heat transfer equations (See NEC Section 310-15(b) and Appendix B) suggests that the higher derate factor associated with the 60°C cables be used.

There is some question about the value of the ambient temperature that should be used to derate the ampacity of conductors that are in conduit which is exposed to sunlight. The NEC, in earlier editions, had solar-gain tables to assist in calculating this temperature. These were removed for unknown reasons several years ago. However, most people know that it is unwise to touch a steel or gray plastic pipe that has been sitting in the sunlight on a hot day. The external and internal temperatures of such conduits are considerably hotter than the ambient temperatures of the surrounding air. Solar water heaters work well because of solar gain. However, the NEC requires that only the ambient temperatures be used in the ampacity derating calculations. This might indicate that PV installers be somewhat conservative when using conduits and cables exposed to sunlight.

A Test

I ran an informal test on a new, two-foot piece of 3/4 inch flexible non-metallic conduit. This conduit had a shiny, somewhat reflective surface and had not turned brown or chalky gray as these conduits do when exposed to sunlight and the weather. I inserted two number 10 AWG THWN-2 conductors and a thermocouple probe into the conduit. I partially blocked the open ends of the conduit to simulate the restricted air flow in a longer piece of conduit. I connected the thermocouple to a digital thermometer and placed the conduit in a shady area. It was a bright, clear afternoon and there was no wind. The solar irradiance was about 925 W/m2. The temperature of the ambient air was 30.5°C (87°F). This also was the temperature inside the conduit when the conduit was in the shade.

I then placed the conduit in the sunlight away from any other structure or body that might reflect sunlight or heat onto it. Within 30 minutes, the internal temperature of the conduit was 58.5°C (137°F). This represents a 38°C rise in conduit temperature above the surrounding ambient air temperature due to solar gain alone.

I have no doubt whatsoever that if the ambient temperature had been a few degrees higher and/or the irradiance had been nearer the peak noon-time value of 1075+ W/m2, the internal temperature of the conduit would have exceeded the 60°C wet rating. As the conduit ages, the color changes will result in even more solar energy being absorbed. Keep in mind that these temperatures were measured with no current flowing in the conductors that were inserted in the conduit. With aged conduit (non-reflective or darkened), current flowing in conductors, high ambient temperatures (40°C), and expected daily normal insolation values (>1000 W/m2), I would expect the internal temperatures of this type of conduit to exceed even the 80°C dry rating when exposed to sunlight.

Installations

Flexible conduit is exposed to sunlight in many PV installations. In some installations, there are gaps between the modules and sets of modules that allow sunlight to shine on the conduit. The conduit is also routed to junction boxes and down the poles of trackers exposing these sections to sunlight.

So What, I'm in the Shade

If the conduit is installed behind the modules, it appears that there would not be any direct solar heating. However, we must keep in mind that the back of module temperature and the j-box temperatures can be in the 60–80°C range when the ambient temperatures are at 40°C. If the conduit touches the back of the module or the conduit fitting is connected to the j-box, then the conduit and the fitting on the end may be exposed to temperatures above the rated value. The NEC does require that good mechanical connections be made when attaching the conduit fitting to the PV j-box. The code also requires that the conduit be well supported within 12 inches of the j-box and at not more than 3-feet intervals elsewhere along the maximum allowable six-foot length [NEC Section 351-27]. These mechanical constraints indicate that there is a possibility that one or more points on the conduit or fittings will be at temperatures higher than 60°C due to just thermal conductivity and convection in the shade without direct solar heating.

Wet Locations

All exposed, outdoor electrical installations are considered wet locations. Wet-rated conductors (types THWN-2, RHW-2, and XHHW-2 for 90°C wet ratings) must be used in conduits installed in outdoor locations. The conduits may not be used at the higher dry temperature ratings when used outdoors. This is fully explained in the NEC Handbook in Article 100 under the definitions of "location." Conduits attached to PV modules are in outdoor, wet locations. The NEC and the NEC Handbook are very clear on the point that outdoor exposed conduits frequently have water in them from wind-driven rain and condensation. The assumption is that they may have water in them at any time, even when the sun is and has been shining brightly. I have personally seen professionally-installed PV systems that had water in the module junction boxes and array-wiring conduits days after any rain. NEC instructions for installing conduit point to the requirement to install it in a manner that will minimize the collection of water. The NEC and the NEC Handbook mention sloping it downward at all points and making provisions for drains at low points [NEC Sections 100A., 225-22, and 230-53]. Of course, no one knows how to make it drain—do we leave the fittings loose (a definite no-no), or do we drill holes in it (another no-no)? These requirements indicate that the conduits in PV systems must be used at their wet temperature rating of 60°C.

Some flexible, non-metallic conduits have a 70°C wet rating (Kaf-Tech brand), but I believe that even this temperature may be exceeded in many installations. The Carlon brand flexible non-metallic conduit has three-piece end fittings that are rated at 107°C (but the conduit is still rated at 60°C wet, 80°C dry). The cheaper Carlon one-piece fittings are only rated at 60°C (presumably wet or dry).

Flexible Nonmetallic Conduit—Can We Use It?

Maybe. Although I have not experienced mechanical failures of the conduit connectors coming loose from the conduit, I do have one report of such a failure to the extent that the installer will not use this product . While this report may be a simple problem of mismatched components or improper installation, it may also be due to a product being operated beyond its ratings.

As Bob-O Schultze and Redwood Kardon pointed out in their letter in Home Power 61, if we use 90°C, wet-rated cables and keep the current in the cable below the ampacity of a 60°C insulated cable (derated for any elevated ambient temperature), we can operate with the flexible non-metallic conduit. As shown above, the current in a number 10 AWG cable in a 40°C ambient temperature must be kept below 24.6 amps. While we can accomplish this, it appears that we cannot keep the temperature of the conduit due to sunlight heating from exceeding the 60°C wet rating. Conduit heated by sunlight to 60°C, plus additional conduit heating due to conductors operating at 60°C indicates to me that flexible, non-metallic electrical conduit should not be used in PV installations. To do so would violate the provisions of the National Electrical Code.

In moderate to cold climates (maximum ambient temperatures below 30°C (86°F)), with proper temperature deratings of the conductors, high-temperature fittings, careful mounting, and good ventilation to the backs of the modules, it may be possible to keep the conduit temperature below 60°C and not violate the provisions of the NEC in Section 351-23(b).

What Happens if I Do Use It?

If the flexible conduit is installed where the 60°C temperature limitation is exceeded, the effects will probably not be dramatic. The combination of moisture and temperature may result in some, none, or all of the following: conduit and conductor insulation deteriorating faster than specified, conduit separating from the fittings, or conduits deforming causing conductors to operated at even higher temperatures with possible accelerated insulation failures. The deterioration of the conduit and insulation are related to chemical changes in the compounds that make them up. Many chemical reactions are accelerated by a factor of two for every 10°C increase in temperature. The increased temperatures are the main cause for the shortened lives of cable insulation and conduits. Heat can also soften the conduit and insulation making them more subject to mechanical abuse and failure.

Other Options

Manufacturers like Heyco and T&B produce high-temperature tubing that is sunlight and moisture resistant. Unfortunately, it is only a recognized product and is not listed as a flexible non-metallic conduit. I will continue to search for a suitable product. Ideas from others are welcome and will be included in this column when appropriate.

I have heard about (from an IBEW member), but not seen, expansion joints that are used for rigid electrical PVC conduit. These gasketed, water-tight slip joints would make it easier to install rigid PVC conduit. They are available from Graybar and probably other suppliers.

Single-conductor USE-2 or Tray Cable (type TC) in the two-conductor version looks better and better all the time where conduit is not required.

Summary

We install PV systems with PV modules that will be producing energy day-in-and-day-out for 25 years or more. We install other balance of systems components that we hope will be equally long lived. I see no reason to use a product like flexible non-metallic conduit beyond its ratings. To do so only invites system failures and possibly worse.

We all would like to see PV become a real player in the energy supply of the United States and the world. The Department of Energy's Million Roofs Program (250,000 for PV, 750,000 for Solar Hot water) will be another addition to the hundreds of thousands of stand-alone residential systems already operational. As the number of PV installations approaches a million or more in all forms, we must be ready to address and deal with the failures that might happen once in 10,000 installations. Those one hundred failures may be prevented if we all carefully study and apply the minutia of the NEC.

Next issue I will address some more of the code and performance issues as they apply to the use of fuses, circuit breakers, and diodes to protect PV modules. Dave Katz made some very good points in Home Power #61 and I would like to elaborate on them.

Questions or Comments? If you have questions about the NEC or the implementation of PV systems following the requirements of the NEC, feel free to call, fax, email, or write me at the location below. Sandia National Laboratories sponsors my activities in this area as a support function to the PV Industry. This work was supported by the United States Department of Energy under Contract DE-AC04-94AL8500. Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy.

Access

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Bob-O Schultze (aka the Wrench)

A "Wrench" is someone who is actually involved in the installation of RE systems. In other words, them what's doin' as opposed to them what's talkin'. IPP members, folks that have installed their own systems to Code, and many others are mostly wrenches. The time has come for us to share our experiences and views about the National Electric Code (NEC®), electrical inspectors, installation techniques, and the RE installation business in general.

Let's get one thing straight. This Wrench is not anti-NEC. As a working electrician, I use it nearly every day. I am not ashamed to say that I've learned more about the correct way to do my job from reading the NEC than I have from any other single source.

The NEC and You

The NEC is a codified record of wiring techniques whose purpose, in the authors' words, is the "practical safeguarding of persons and property from hazards arising from the use of electricity." The key word there is "practical." The NEC can not protect anyone or anything from poor workmanship or the improper use of electricity by the end user. Perhaps this is why, in spite of 100 years of NEC rule making, electrical fires are still one of the leading causes of property loss. You can't protect people from themselves. Neither should you attempt to regulate or codify emerging technologies. We can certainly build on and use existing techniques where they apply, but some leeway is necessary in order for learning to take place. Stifling the learning process by attempting to enforce the letter of the Code in new or untested situations goes beyond the Code's scope or intent.

The NEC itself recognizes this in Article 90-1(b). "This Code contains provisions considered necessary for safety. Compliance therewith and proper maintenance will result in an installation essentially free from hazard but not necessarily efficient, convenient, or adequate for good service or future expansion of electrical use." While the authors apparently intended that "adequate for … future expansion of electrical use" to mean the addition of a second garage, I believe it applies to situations where new electrical generating technologies and methods are used as well. If it doesn't, then 90-2(b)(5) applies to any RE installation not actually on or in a building intended for uses other than as a shelter for the generation equipment. In plain American, 90-2(b)(5) says that if you are an electric utility, the NEC does not apply to your generation facilities. It doesn't say public utility, just utility. Reading strictly the letter of the article, one can easily interpret the words to apply to a private utility with a customer base of one: you. Is that the intent of the NEC? I don't believe so, but therein lies the difference between Code Corner's ideas and the rest of us. Mr. Wiles seems not to grasp that where the letter of the NEC is inadequate or unclear in a new situation, the intent of the words take precedence over the words themselves.

Liquidtight Conduit in Wet Locations

Mr. Wiles, in Code Corner, puts forth the argument that because the sheltered underside of PV modules is considered by the NEC to be a "Wet Location," the 60°C Wet rating of the nonmetallic flexible conduit (nfc) applies and the "conduits may not be used at the higher dry temperature ratings when used outdoors." He builds an impressive hypothetical scenario around that statement. It's wrong. Let's take a look at the facts.

The Carlon Electrical Products data sheet on their Carflex® brand liquidtight conduit states the following:

- *UL listed for outdoor use.*
- *Suitable for use at conduit temperatures of 80°C dry, 60°C Wet and 60°C oil resistant as required by section 15-6 of ANSI/NFPA 79-1985 and UL 1660.*

Liquidtight flexible conduits, metallic and nonmetallic, in contrast to rigid PVC conduit and electrical nonmetallic tubing, does not have wire temperature limitations. Any temperature rated wire (for example, 90°C wire) can be used as long as the temperature conditions marked on the conduit are not exceeded. UL listed conduits that are not marked are limited to maximum temperatures of 60° wet or dry.

It seems very clear to me. Conduit temperature means conduit temperature, not conduit location. Of course, this Wrench is not an expert, just a working electrician trying to do the right thing. By the way, I found this data sheet at my local electrical wholesaler. It's there for the asking.

Mr. Wiles writes that he's seen professionally installed PV systems with water in the J-boxes and array-wiring conduits days after any rain. While we Wrenches don't doubt this, we do question the workmanlike manner of the installation and the quality of the PV J-box design. We wonder if Mr. Wiles has seen any nice, clean, dry installations as well? Well installed liquidtight conduit does not leak. Hence the name, "Liquidtight!" Shall we try to formulate policy based on poor workmanship or module design? Neither is covered by the NEC nor can they be. If there are any indicators here, they are that one should use good equipment and hire competent installers.

The Test vs the Test
The Code Corner test procedure for determining the temperature inside of a piece of fnc is flawed. Granted it was an "informal test," but is it scientific? Still, I felt the need to test the premise, so I did a little test of my own. Regretfully, it's mid-October here in the Northwest and temperatures aren't high enough to give us really meaningful hot weather data. On the other hand, the data I did get was significant as to the relationships between temperatures taken at various places in, out, and around the fnc. Here it is, draw your own conclusions.

Methodology
I performed the testing on a actual working PV system with current flowing in the wires during the test. The test jig was ten Siemens PC4JF modules on a dual axis Wattsun tracker. The array wiring and the fnc interconnects are approximately two years old. There were a total of three 10 AWG wires inside the 1/2 inch (trade size) fnc. All of the wires carried between 4.1 and 4.4 Amps at 26 to 28VDC depending on the time of day and household uses.

I used a Fluke 87 DMM, Wavetek TC-253 Temperature/Voltage converter, and an assortment of Wavetek Type K temperature probes. One probe was placed inside the fnc approximately one inch from the module J-box, which I reckoned to be as close to as hot as it gets. Other probes measured ambient air temperature both in the sun and the shade, the temperature on the PV module's back, and the temperature on the outside of the fnc at the point where the sun shined on it through a 3/8 inch crack between modules. I could not measure direct sun on the fnc elsewhere, because the system was designed so that all the rest of the conduit is shaded at all times.

Data points were taken each hour starting two hours before solar noon and ending three hours after. The day was clear and bright with no clouds. The wind speed varied between 0 and 1.5 meters per second. All temperature measurements are in °C.

Results
See for yourself. For me, the interesting measurements are those taken inside the fnc in relation to the back of the PV, and the relationship between the interior and exterior fnc temperatures. In the PV / interior fnc relationship, the warmer the PV got the greater the difference in temperature between it and the inside of the fnc became. This would seem to indicate that the fnc has an insulating effect on the wires within, protecting them somewhat from high PV temperatures rather than the other way around. The temperature on the exterior of the fnc, while absorbing some radiation from the sun and increasing in temperature, seemed to have little effect on the interior fnc temperature.

Conclusions
Very few, really. There isn't enough data in either test to form a conclusion. Neither this test or Mr. Wiles' test is based on the scientific method. There are far too many vagaries and no controls of any kind. It is not good science. About all I can say in defense of my testing is that it attempts, at least, to simulate a real world RE situation using generally accepted test equipment and techniques.

Temperature and Carflex® conduit on a working PV array

Date: 18 October 97 *WX: Clear, Bright* *All temperature measurements °C* *Wind: 0-1.5 meters/second*

Time (Solar)	*Amb./Shade*	*Amb./Sun*	*Carflex/IN*	*Carflex/Out*	*Back of PV*
Minus 2 Hrs	16.5	18.5	34.4	19.8	34.7
Minus 1 Hrs	18.8	21.8	35.2	21.8	36.1
Solar Noon	19.5	23.0	35.2	24.0	36.5
Noon +1	20.7	24.8	36.5	24.5	38.4
Noon +2	22.0	29.7	37.8	32.0	44.0
Noon +3	23.3	25.3	35.9	31.3	43.3

I am not going to try to draw a conclusion. You can give the tests whatever value or discount you want. Mr. Wiles, on the other hand, seems to have made up his mind and is making recommendations based only on his single informal test. Is this wise?

Mr. Wiles and the 1999 NEC
I counted 67 proposed changes to Section 690 of the NEC. Of those Mr Wiles submitted 59. Of those, 55 were accepted either outright or in principle. Of the eight other submissions, only two were accepted! I'm very concerned that one person's opinion carries so much weight at the NEC, especially given Mr. Wiles' lack of homework on this fnc issue. In future Wrench Realities columns we will take a hard look at some of the proposed changes that affect RE.

Want to see what's coming at you in 1999? Point your web browser at http://roproc.nfpa.org/nec/. All the proposed changes are there in pdf format. You can download them and view them with Adobe Acrobat Reader®. The reader is available online from lots of places including Home Power at www.homepower.com.

Calling All Wrenches
Look, here's the deal. By myself, this Wrench can easily be dismissed as just another California nutcase. Together, sharing our experience and techniques, we can have real influence. We're the RE electricians, technicians, end users, and enthusiasts. We're the folks who are working toward RE replacing the power generating sources which are polluting our air, fouling our water, and emitting cancer-causing radiation. What we're not doing is burying RE under a morass of contrived, unreasonable restrictions. These restrictions keep RE beyond the reach of the common person and in control of groups like Sandia, the electric utilities, and the Department of Energy.

Think about this. In the absence of any real-world examples, an inspector, even the ones who think for themselves and follow a logical path, will apply the Code Corner doctrine by default. Let's give them another choice! A different and practical way to look at RE installations. The time is now. The place is here. We can hang together or (if these unreasonably restrictive Code interpretations continue for much longer), starve separately. What do you say?

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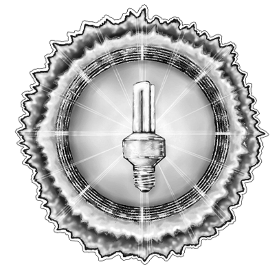
Web: www.snowcrest.net/econnect

Home Power's Business



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

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California's PV Purchase Incentives

Don Loweburg

Beginning early in 1998 California grid connected households will be eligible for PV system rebates. The program is a result of California State legislation (AB 1890 and SB 90) passed last year that restructures the electric utilities. IPP has participated along with members of the California PV Alliance and the State Energy Commission in a series of meetings crafting the PV incentive program. Though not completely final, these are the program's main points.

Eligible residential and commercial customers must be served by one of California's Investor Owned Utilities (IOU). Participants must purchase a PV system that will be sited on the customer premises and be connected to the customer's side of the meter. The system can be grid interactive or stand-alone with batteries. Residential systems must be 10 kW or less.

The program will last for five years, 1998-2002. Approximately 30 million incentive dollars will be available for residential PV system buy-down. For each year a block of money will be available. If the block for a specific year is used up, then the program pauses until the next block is due. If a block is under subscribed, the remainder is moved to the next year.

Here is how it will work. A customer and seller decide on a system and price. A form is filled in listing the major components (there will be a list of approved components), the cost of the system, and then is signed by the parties. The form is submitted to the California Energy Commission (CEC) and will be approved if the system meets technical specs.

The amount will be based on system ac output wattage. During year one the incentive payment is $3 per ac watt, declining in subsequent years. Once a reservation is made, the system must be installed within six months. Upon installation and documentation indicating code compliance (a signed inspection by appropriate building authorities) and utility connection (an old bill), a check for the amount of the reservation will be sent to the seller of the system. The seller will have already passed the value of the incentive to the customer in the form of reduced system price. By discounting the retail price of the system, the customer avoids sales tax on the incentive amount.

Net metering in Arkansas?

New IPP member Donald Long, from Arkansas wants to establish net metering in that state. I have forwarded to him the name and addresses of other Arkansan IPP'ers. Hopefully this is the beginning of an action group in that state. Any readers from Arkansas please contact Donald (see access) and work to make this happen. Perhaps President Clinton should take some interest in his home state having net metering given his promotion of the Million Solar Roofs project. (He does read Home Power, doesn't he?)

Net metering will soon to be available in 20 states. That's good news and we need to continue pressing this important grid access issue in all states. There is also effort to make net metering part of a national utility restructuring law. Solar Energy Industry Association (SEIA) and Public Citizen are working on this.

Some lessons learned.

Net metering must not be diluted or eliminated by restructuring activities. Beware of restructuring laws that may affect net metering, such as what happened in Maine or the "departing load" fiasco attempted by Edison in this state (see last issue).

Some things we learned in California: Net metering laws must be accompanied by interconnection policies that are appropriate to the small microprocessor controlled systems being installed today. Enforcement of those standards must reside with building inspectors, as is the norm for other building codes and practices. Utility control of interconnection standards is unacceptable. See Tom Starr's comments in IPP #60. Simplified interconnections standards are essential if citizens are expected to comply. A PV industry leader from Southern California told me (off the record) that he had documented over 14 "renegade" grid connected systems in Southern California. Since almost all non-time-of-use kWh meters are bi-directional and synchronizing inverters are available off the shelf, there is nothing stopping a person from just doing what they want. Understand, I'm not recommending this. It's just a fact of life that if people are faced with cumbersome bureaucracy, they may ignore it! A revised version of the Model Net Metering legislation that reflects the above refinements is available from CALSEIA or from IPP

PV Value?

Not long ago I got a packet from Solarex describing their PV Value program. In the presentation, Solarex solicited retail partners to market packaged PV systems. The wholesale pricing was very attractive, reflecting a $1 per watt ac buy-down using federal TEAM UP dollars. I was pleased to know TEAM UP dollars would be benefitting end users rather than regulated monopolies as has been the rule. When I called for more information I found much had changed. I was told the program had stopped accepting partners. I asked who some of the West Coast partners were and was told that there was only one. It turns out the only partner is the Photovoltaic Services Network (PSN). PSN is itself funded by TEAM UP! PSN's mission is to support rural utilities to implement PV. Looks like Solarex's PV Value has abandoned the end user market for the utility market in this turnaround.

Million Solar Roofs (MSR)

The MSR Implementation Plan and a table of Net Metering States are available at the SEIA web site. This national program, due to start in early 1998, has the goal of one million solar roofs to be installed by 2010. (See Power Politics, page 86) The MSR Implementation Plan posted at the SEIA web site states, "The Million Solar Roofs program will provide a package of incentives to residential and commercial consumers to make the purchase of qualifying photovoltaic and solar thermal systems more affordable." The incentive package will consist of:

1) Federal cost-share grants to states or localities to provide buy-downs to reduce the costs of PV. Buy-downs could take the form of consumer rebates; a kilowatt hour-based production payment for photovoltaic produced electricity, or some other mechanism. The details of the amount of the buy-downs and the number of years they will be available are to be established over the next few months.

2) Low cost loans to finance purchase of photovoltaic and solar thermal systems with the goal to provide easy access to 20-year loans at 5% interest.

3) A national registry to recognize consumers who participate in this important effort.

4) Federal agencies will do their part by aggressively procuring solar energy systems for use in government buildings.

The Implementation Plan cites the California Solar Fund model as the kind of roof top incentive program that would be acceptable to Million Solar Roofs. The plan goes on and explains what solar energy systems qualify for Million Solar Roofs. "Photovoltaic and solar thermal systems that provide energy to buildings, are located on the customer's premises, and meet size and standards requirements can qualify for Million Solar Roofs. Examples of solar energy systems that could qualify include roof mounted photovoltaic or solar water heating systems, photovoltaic shingle systems, photovoltaic curtain wall systems, solar pool heating systems, and transpired solar air heating systems. Systems that do not qualify for Million Solar Roofs include solar systems that are not located at the customers premises, or passive solar applications."

Maine Update

Last issue we reported that net metering was in trouble in Maine. Language in the State's restructuring law revoked power purchase contracts, including net metering. Utilities in fact stopped signing net metering agreements on authority of the new law. IPP member Bill Lord and others active in Maine renewable energy policy have initiated emergency legislation designed to correct this mistake. The State Governor has also been contacted by Thomas Thompson of North East Solar Energy Association (NESEA). The letter encourages the Governor to sign the emergency bill restoring net metering. Thank you.

More on Distributed Generation (DG)

Hopefully by now most readers of Home Power are aware of the issues involved with DG. I and others have detailed arguments against regulated utilities owning DG. The California Public Utilities Commission's Office of Ratepayers Advocates (ORA) has issued a position paper, co-signed by IPP and nine other parties consisting of energy marketers, manufacturers and a major energy supplier that argues against IOU ownership of DG. You are encouraged to read this paper, available from IPP for the asking. IPP has taken the position that if retail competition is actually going to happen, then DG must be fully competitive and that means no Investor Owned Utility DG.

The author notes that, other than in this magazine and within the CPUC, the whole conversation around IOU participation in DG seems stifled if not suppressed. Yet this very important topic needs to be at the forefront of all restructuring plans and it needs to be fully developed. The issue must be pressed nationally. The conversation must move beyond the pages of Home Power magazine and be a part of every state restructuring plan and any national restructuring plan. The silence to date is like that 900 pound gorilla sitting in the living room that no one talks about!

Module Output Ratings

Most Home Power readers already know that the listed or rated wattage output of a PV module is almost never realized in actual field use. Currently manufacturers base wattage output on “STC”. STC rating measures the power output at a cell temperature equal to average room temperature, about 70° F. Under most field conditions, the cell temperature is much higher than room temperature. In most cases the cells operate hot. Due to the physics of silicon cells, high temperature reduces power output. Many have argued that ratings should reflect real life performance, not idealized lab or room temperature conditions. Most people would support this position. The question is, what other conditions should be used? How hot should the rating temperature be?

The California PV Alliance, as part of the design process for the California State PV Incentive program, has voted to use a rating system developed by PVUSA. The PVUSA rating is based on real life cell temperature and also makes an adjustment for inverter loss. The PVUSA rating then is closer to the real world ac output wattage of a PV system.

More About PVUSA

PVUSA, a facility first established about 10 years ago to test utility scale PV, is now operated by Sacramento Municipal Utility District under a contract with the California Energy Commission. During earlier years the projects tested were large central PV arrays coupled to large inverters feeding directly into the grid. Today, with the demise of the large central utility model and the advent of roof-top customer sited PV operating as DG, PVUSA is undergoing change. Four roof top scale PV systems have been built. These kW sized systems use residential sized inverters and serve as models for the grid connected, net metered systems that will be installed under MSR and the California PV program in the coming years. Not only will the facility host public tours for those wishing to see operating PV systems, it will also be used to conduct training for PV professionals and members of the building trades. Early this year a training workshop for building inspectors is scheduled. Other projects in the works are to develop several sites using Building Integrated PV.

Happy Birthday

IPP is three years old. We incorporated on September 30, 1994. Our initial membership of 20 has grown to a national total of 175 members. Our purpose remains the same: develop and promote end user PV applications as a competitive alternative to utility generation. Then, we rallied to oppose utility ownership of customer sited PV. Now, we rally against regulated utility ownership of DG. The names have changed but the game’s the same.

Access

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You Can Help Solar Home Financing!

Marina Baird

Okay....you've found your ideal property. Nice trees, plenty of water, and excellent building sites. There's only one problem, it's off the grid. The utility company tells you it will cost thousands of dollars to bring power to the property, or worse, it's not available at all.

Or, how about this... you've found your dream home, secluded, nice area, everything you've always wanted. One problem, it's off the grid and powered by a generator and a solar system. Who's going to finance this with a reasonable interest rate? Can you even get conventional financing?

These are examples of the difficulties typically encountered by Off-Grid loan seekers.

Federal loan programs such as FANNIE MAE and FREDDIE MAC offer the lowest rates and 30 year terms for home loans, but in order to qualify for these types of loans homes must meet certain guidelines. In the lending industry there is a common misunderstanding about the acceptability of "private power systems" for these federal loan programs and often the lender will tell an applicant that private power systems simply "do not qualify" for these loans. This is absolutely NOT TRUE. In fact there are currently nationwide lenders making secondary market loans on homes with private power.

One such lender, very familiar with the difficulties of obtaining conventional financing for unconventional homes is Keith Rutledge, loan officer with the Bank of Willits, a leading lending institution in the area of off-grid home financing. In addition to loan officer, Keith is the president of Renewable Energy Development Institute (REDI), also based in Willits, California.

Off-Grid Home Mortgage Loans

Renewable Energy Development Institute, with a grant from the utility and solar energy industry, is hard at work developing the Off-Grid Home Mortgage Loans (OHM Loans) project. They are currently seeking to clarify these lending issues through a two pronged approach. First by compiling a list of lenders currently offering financing for homes with private power for publication on the Internet, on disk, and in print. Secondly by working with the federal loan programs such as FANNIE MAE to inform lenders of the acceptability of private power systems which meet certain market criteria. The Renewable Energy Development Institute, working together with the Solar Energy Industries Association, the Utility Photovoltaic Group and the Switzer Environmental Fund of the San Francisco Foundation, is surveying lenders, solar businesses and private power homeowners to compile as complete a list as possible of these existing lenders.

If you or anyone you know has financed an off-grid home you can enter the lender into a nationwide database by contacting REDI at the toll-free numbers below and leaving the name of the lender, location and contact information. By doing so you will make it easier for the next off-grid homeowner to find financing. Who knows, it may even be you!

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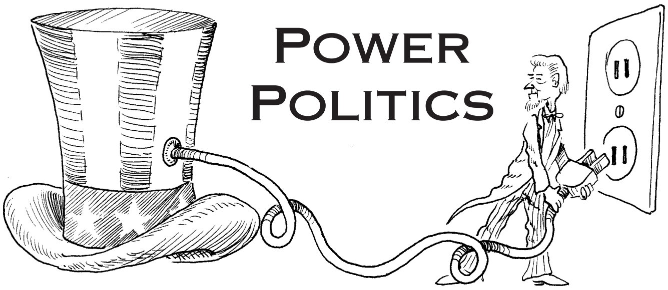
You can call or fax REDI toll-free at 888-646-REDI (7334), or by postal mail at 383 South Main Street #234, Willits, CA 95490
or by Email: REDI@pacific.net



Million Solar Roofs Initiative

Michael Welch

"Capturing the sun's warmth can help us to turn down the Earth's temperature."—President Clinton
"By putting solar cells on the roof, we're going to send solar sales through the roof."—Energy Secretary Federico Peña

Thus began last June a new Federal initiative to increase the use of solar energy across the nation. The Clinton Administration wants to put a million solar energy systems onto the rooftops of American homes and businesses by the year 2010.

It is important to note that this initiative does not create any new funding for solar energy, but rather relies on "leveraging existing resources to promote solar energy sales and working with local communities and other groups to find ways to rapidly expand the use of solar technology." The underlying goal of the initiative is one that Home Power readers have heard about many times in the last few years: to bring about reduction in prices of solar technologies and to encourage more investment in module production facilities.

Actually, Clinton had requested a significant increase for the FY1998 budget over the 1997 budget and was hoping that those monies would help the Roofs Initiative. When all the legislative wrangling was over with, renewables and energy efficiency combined have a 10% increase over the 1997 budget. While better than last year, the '98 budget of $924 million was still quite a ways below the $1.1 billion allocated in 1995. The 1998 renewables increase was 7.5%, increasing from about $266 to $302 million.

In the past it appeared that government interest in energy was focused more in the areas of efficiency, conservation, and solar heating. But an interesting point of this new initiative is that the focus is on PV, although solar hot water systems are included in the Million Roofs goal.

Interagency Working Group

The first step of the Roofs Initiative deals with the leveraging of existing resources. The administration felt it was important to identify all the Federal programs that could be brought on board. A task force is set up to work within the various agencies to identify those programs and how to maximize them to make the initiative successful. The administration gave examples of already existing programs that can help the initiative:

- 1994 Executive Order 12902 called for the accelerated purchase of solar energy systems for federal buildings. The U.S. government owns more buildings than any entity in the world, and is the largest consumer of electricity. Through the initiative, the Feds hope that more and more of their $3 billion annual electricity bill will be offset by solar, and they have 500,000 rooftops to do it on.

- Federal grants can be focused on the goals of the initiative instead of going to other projects. "Strategic technology" programs within the EPA and Departments of Commerce, Defense, and Energy can be used to "buy down" the costs of solar energy.

- Eight Federal lending programs from the Small Business Administration, the Department of Agriculture, the Department of Housing and Urban Development, and other housing agencies can be tapped to make solar energy more affordable.

According to Energy Secretary Peña, "We can marshal these resources in creative and effective ways... The Department of Energy will take a leadership role to make sure that happens."

Increasing Momentum

A second aspect of the Million Solar Roofs Initiative is to increase the already building momentum for the use of solar energy in the U.S. Doing so will be an environmental boon to the nation. It is estimated that the initiative will reduce pollution by the equivalent of what is now produced by 850,000 cars annually and generate the same amount of electricity as three to five coal-fired power plants.

Until recently, the idea of decreasing pollution and greenhouse gases has been unpopular in business circles because people felt it would reduce jobs and shut down industry. But the Roofs Initiative can help offset that fear by spurring growth in newer and cleaner industries and even create 70,000 new jobs. Huge companies like Ford and BP are publicly recognizing the global warming problem.

VCR Syndrome

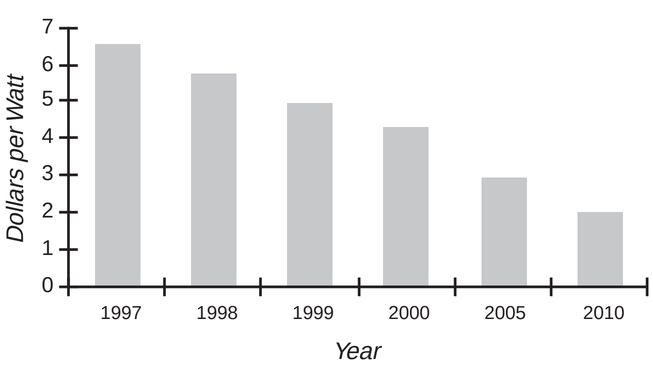
Scott Sklar of the Solar Energy Industries Association (SEIA) is 100% behind the initiative, and even participated in Secretary Peña's news conference this summer. He points out that it is important for jobs in the U.S. to maintain leadership in the multi-billion dollar global markets for solar energy. Sklar feels that the Roofs Initiative will help avoid "falling into a replay of what we call 'VCR Syndrome,'" reference to what happened when video recording equipment manufacturing was lost to overseas companies.

Sklar also succinctly pointed out that, "driving pollution control through technology and pollution prevention will be far more effective and acceptable to the public than command and control."

$2 per Watt!

The benchmark goals of the Roofs Initiative are interesting. They predict that an average PV system size will increase from 1 kW to 4 kW, that the installed cost of these systems will plummet to $2 per Watt, and that the energy cost of PV will be down to 7.7 cents per kWh; all by the year 2010.

Predicted PV Installed Cost



If solar power gets that cheap, and it likely will, then I feel that the amount of pollution savings and the number of participatory households could both be significantly increased over the initiative's goals. How? Simply. I see little mention of community education in any of the info on the initiative. It is the answer.

We already know that people want to use renewable energy and that they would choose it instead of the polluting technologies if they could afford it. In just over ten years, the technologies will be affordable. But if we were to embark on major educational campaigns designed to get folks used to the idea of rooftop PV, then a lot more than a million people could be ready to install when it becomes affordable. When PV hits $2 per Watt, folks will be lining up at their local hardware stores to buy it ... but only if they are knowledgable will they be ready.

Program Drivers

The Million Roofs Initiative is nothing more than an enabler. The point is to maximize resources already available to finally end up with the community impact it seeks. The "others" that it enables are the PV / solar hot water industry, builders and developers, energy providers, local and state agencies, and finally, nongovernment organizations.

This is where the rest of us can come in to make the initiative goals a reality or even improve upon them. We need to spread the word on the program and encourage our utilities and governments to find creative ways of taking advantage of it. As part of another step not specifically outlined by the program, we need to begin educating the public about their role and what they can do to be ready for their solar future.

Mobile Chernobyl

As we go to print, the Nuclear Waste Policy Act of 1997 (H.R. 1270) is on its way to the House floor for a vote. The bill would establish an "interim" high-level nuclear waste storage facility at Yucca Mountain in Nevada. It's called Mobile Chernobyl, because it would cause a mass exodus of high level nuclear waste from nearly every nuclear power plant in the nation. 43 states are on these transportation routes, and each would suffer increased risk of a nuclear accident on their highways.

Due to citizen concerns and the State of Nevada fighting it tooth and nail, the final nuclear waste repository that has long been under construction and scrutiny has not yet been readied to receive those wastes. This new bill would circumvent that process and make the Yucca Mountain area a place where the waste could be stored until such time as a permanent repository is completed. Many people believe that there will never be a permanent repository, and if that is the case the Yucca Mountain interim facility would become a de facto permanent storage area.

Nevada Congressional Republicans challenge the idea that the site is temporary but point out that if it really is, the transportation hazards are not warranted. H.R. 1270 also exempts the nuclear waste program from most environmental laws. In spite of strong opposition to the bill from both the House Resources Committee and the floor of the House, it has enough support to make environmental groups nervous. The Clinton Administration vows to veto the bill if it passes.

Radioactive Frying Pans

According to a press release by the Nuclear Information Referral Service (NIRS), the U.S. government is now converting old radioactive machinery left over from nuclear bomb factories into everyday items that will expose the public, unknowingly and repeatedly, to radiation. The Department of Energy (DOE) has just signed on to a precedent-setting contract with private companies including BNFL, a subsidiary of British Nuclear Fuels Ltd., that guarantees the company a profit on sales of the contaminated metal to the marketplace.

Once stripped from the radioactive buildings, the radioactive metal will be transported to privately owned, state-licensed companies who will process and sell it on the open market. The scrap could be used for cars, I-beams of buildings, or anything made with stainless steel. BNFL already has plans for a contract with a company that makes nickel metal hydride batteries which could end up in items such as scooters, cars, computers, and toys.

As atomic reactors and weapons factories close, decommissioning begins. There is imminent danger that radioactive metal will be released into circulation. The amount of contaminated metal entering the marketplace is on the verge of a dramatic, exponential increase.

Of course, I'm sure the levels of radioactivity will be within allowable limits. Just ask the nuclear industry officials that get to influence the very rules that govern them.

Access

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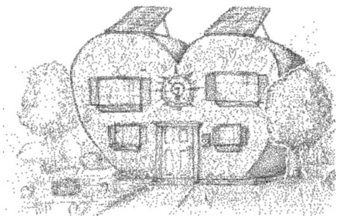
Home & Heart



Kathleen Jarschke-Schultze

There has been some response to my last column on the effects of RE living on relationships, new or old, beginning or ending. Some of my friends have implored me not to use their current scenario to illustrate my points. I will honor their wishes on this point.

Remote Relationships—Part Deux
As I said in the last issue Bob-O and I met through the mail. I was not the first woman he ever wrote to from his mountain cabin. In Mother Earth News, July 1976, issue #40, in the personal ads is his first attempt at contacting a lifemate through the post. It's a great ad, but I personally would never have answered an ad in a magazine. I am much too cynical for that.

Apparently about 150 women were not too cynical and answered his ad. He told me it was really difficult to keep up any kind of meaningful correspondence on that level. He first received four replies. He wrote back. The next week he got five more replies, plus answers to the first three letters he replied to. The next week he got ten new letters and six replies to his letters. Soon he was unable to respond to all the letters and could barely keep an ongoing correspondence with the few he had begun.

He actually met a few of the women but did not find THE one. One woman fell in love with the mountains though and became a fire lookout. She still works and lives in the woods.

The Beer Tree is a tree across the road from the post office and store with a picnic table under it. One friend, John, told me that whenever the locals were hanging out at the Beer Tree and they saw some pretty woman jump out of the back of a pick-up with her backpack and sleeping bag, having hitch hiked, the guys would run over and introduce them selves. "Hi, I'm Bob-O John" and "I'm Bob-O Bill". He told me some of the women never made it to Bob-O's cabin at all. Of course I thanked him for that.

Bon Chance
We had a friend who was looking for a mate and wanted Bob-O to write the letters for him. I vetoed that. It smacked too much of Cyrano. The friend did join the Sierra Club singles and wrote to several women. One woman came to the Salmon River to meet him and spend time there. She liked the hiking and the river. She didn't mind the outhouse very much. She would up-turn a cereal bowl over the butter dish (which he never bothered to do).

The third night she was there she woke him up at 2:00 am. She had a horrible headache. Nothing would do but that he drive her to a hospital 3 1/2 hours away. Fine. So they got ready to go. She brought all her things to the car. They proceeded to drive. Ten minutes later she was snoring on the seat beside him. He drove to the coast and woke her up. Her headache was miraculously gone but since they were close to where she had parked her car would he just drop her off there. So long, good-bye. And he never heard from her again.

Dope Opera of Life
There certainly is no right or wrong way to meet life mates. Bob-O and I have worked out a theory where you get to make the small decisions in your life. Like what you are going to wear or where you are going to work or live, but big things like who you are going to love are already in the cards. Destiny, fate, kismet.

In terms of relationships, reality rivals TV dope operas. Anything and everything does happen. In a remote setting this carries different possibilities than urban or metropolitan living. Fewer people, fewer choices. Cabin fever is a real thing. If you are contemplating a remote life be sure you can take the solitude. Solitude is good, loneliness is not.

Renewables?
What does this have to do with renewable energy? Not a lot. But sometimes to live a certain lifestyle you must place yourself in a different setting. More often than not RE means remote. That is going to change in years to come as RE becomes accessible to more people. This is just food for thought.

Freezing
I have a freezer. It is a Sun Frost F-10. So far it is great. I will be writing in more detail next time after I have had a chance to use it for a while and Bob-O has had time to get some test data on it. It is in the basement, which stays cool or cold all the time. This is the first Sun Frost freezer reviewed in Home Power so I have to get the data first.

Cold Nights, Hot Tub
Bob-O and I picked up an old redwood hot tub for cheap. It is just the tub part, no heater or filter or anything. We are in the process of setting it up and figuring out a solar heating set up for it. I checked out all the books I could from the library on hot tubs and we have decided on the deck structure. It looks like we will

have a Thermomax solar heater and a propane flash heater for back up.

Now that the leaves are turning and the trees along the creek have stopped taking in water we have our hydro power back. This is always a great feeling because this time of year is when the wind stops. It is getting cold outside. We have our fire wood in and have had to light a fire in the mornings and evenings lately. That hot tub is going to be great if we can pull it off before it snows.

Access

Kathleen Jarschke-Schultze is enjoying the changing leaves that are falling at her home in Northernmost California, c/o Home Power Magazine, PO Box 520, Ashland, OR 97520 • 530-475-0830
E-Mail: kathleen.jarschke-schultze@homepower.org
or: kjs@snowcrest.net

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17. I certify that the statements made by me above are correct and complete. Karen L. Perez, Publisher and Managing Editor 9/18/97.

HAPPENINGS

AUSTRALIA
The World Solar Challenge is now a biennial event and will run October 18–27, 1998. It is the premier solar car race in the world and contributes vital research and development towards the quest for sustainable future transportation. New: Entry Competition open to school and tertiary entrants. Free entry to the first school and tertiary teams to register. Contact: Ray Wieland, Event Manager, level 7 178 N Terrace, Adelaide 5000, South Australia • +61 8 8303 2021
E-mail: wsc@saugov.sa.gov.au
Web: www.wsc.org.au

CANADA
The “Alberta Sustainable House” is open for public viewing every Saturday 1:00-4:00 PM free of charge. The project emphasizes cold-climate 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 windows, multi-purpose masonry heater, solar hot water, greywater heat exchangers, LED and electro-luminescent 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 info: IBS, 449 University Ave, Charlottetown, Prince Edward Island C1A 8K3, Canada • 902-892-9578.

Electric Vehicle Society of Canada, Toronto Chapter—whose purpose is to promote EVs in order to reduce the terrible environmental impacts of conventional automobiles (and have some fun at the same time!) are a group of enthusiasts, inventors, Sunday mechanics and environmentalists from every walk of life who share the belief that EVs are a viable alternative. Meetings on the 3rd Thursday of each month, September through June. New Members welcome! Contact: Howard Hutt, 21 Barritt Rd, Scarborough, Ontario, M1R 3S5 Canada • Phone/Fax: 416-755-4324

Renewable Energy Technologies in Cold Climates ‘98, incorporating the 24th Annual Conference of the Solar Energy Society of Canada Inc. A forum for the exchange of information, research and development for renewable energies in areas with cold or extreme climates. For more information contact: RETCCC’98, c/o Solar Energy Society of Canada Inc., 116 Lisgar St Ste 702, Ottawa, Ontario, Canada K2P 0C2 • 613-234-7004 • Fax: 613-234-2988
E-Mail: RETCCC.98@simpatico.ca

UNITED KINGDOM
Weekend Workshops! Build a wind generator, PV, water heating system or any alternative technology project. Work with others of varying ability in a well equipped workshop. By Robert Keyes GW4IED, of Keystone Systems. Held in Newport close to the M4 J25, Saturday 12-6, Sunday 9-4 with hotel & B/B close by, hard standing suitable for caravans available on site. Through 1997. Contact:Tel/Fax: 01633 280958.

NATIONAL
Sandia’s new WWW address is www.sandia.gov/pv and they have added new material and organized it to make material easier to find. It includes “Stand-Alone Photovoltaic Systems: A Handbook of Recommended Design Practices,” “Working Safely with PV,” and balance-of-system technical briefs which provide information about battery and inverter testing.

Solar Energy & Systems, a college credit course by Mojave Community College. Covers fundamentals of RE for the home owner or small village. Taught on the Internet using the latest technology. Weekly assignments for students to review various text books, videos, WWW pages, a weekly chat room, and email questions and answers from students. Tuition $100 plus $10 registration. Contact Don Timpson, 800-678-3992

DOE Online Energy Info Resources—Information on energy efficiency or renewable energy technologies. The Energy Efficiency and Renewable Energy Clearinghouse (EREC) BBS Online Service offers users free access to text files, share and freeware programs and utilities, and a free publication ordering system. Accessible via the Web: erecbbs.nciinc.com • Modem: 800-273-2955. The Energy Efficiency and Renewable Energy Network (EREN) is accessible on the Web at www.eren.doe.gov and provides links to hundreds of government and private internet sites. EREN also offers an “Ask an Energy Expert” online form that allows users to E-mail their questions directly to specialists at EREC. For more information: 800-363-3732.

American Hydrogen Association, national headquarters, 216 South Clark Dr. #103, Tempe, AZ 85281 • 602-921-0433 • Fax: 602-967-6601 • E-Mail: aha@getnet.com • ”Prosperity Without Pollution” Web: www.getnet.com/charity/aha

Energy Efficiency and Renewable Energy Clearinghouse (EREC) offers free info: Small Wind Energy Systems for the Homeowner (FS135) Reviews system requirements, site determination, and costs of residential wind turbines. Also; The New Earth-Sheltered Houses (FS120), Photovoltaics: Basic Design Principles and Components (FS231), Cooling Your Home Naturally (FS186), Automatic and Programmable Thermostats (FS215). Contact EREC: PO Box 3048, Merrifield, VA 22116 • 800-363-3732 • E-Mail: energyinfo@delphi.com • TDD: 800-273-2957 • Modem: 800-273-2955 • Web: www.eren.doe.gov

American Wind Energy Association World Wide Web: www.igc.apc.org/awea. Obtain information about the US wind energy industry, AWEA membership, small turbine use, and much more.

The Federal Trade Commission is offering free pamphlets on: Buying An Energy-Smart Appliance, the EnergyGuide to Major Home Appliances, and the EnergyGuide to Home Heating and Cooling. Write to: EnergyGuide, The Federal Trade Commission, Room 130, 6th St and Pennsylvania Ave NW, Washington, DC 20580 • 202-326-2222 TTY: 202-9326-2502. The full text of these and more than 160 other consumer and business publication are available • Web: www.ftc.gov

The Surface Solar Energy data set, derived from satellite observations and produced by the Atmospheric Sciences Division of NASA Langley Research Center is now available. The data set contains site specific insolation values with monthly fluctuations, three hourly cloud fraction, and additional useful data. Text files, color plots and contour plots on a global scale are also available. Web: eosweb.larc.nasa.gov/DATDOCS/Surface_Solar_Energy.html

The Interstate Renewable Energy Council (IREC), in cooperation with the SEIA and Sandia National Lab has a handbook to guide state and local government procurement officials and other users in the specification and purchase of renewable energy technologies. Information on biomass, photovoltaics, solar domestic water and pool heating, and small wind systems. Technology specs about equipment, photographs and vendor contact info. Contains information on simple methods for estimating the pollution benefits of RE systems. Send $15 ppd USA to Interstate Renewable Energy Council Distribution Center, c/o ASES, 2400 Central Ave Ste G-1, Boulder, CO 80301 (make checks to ASES).

SOUTHEAST US
The Self-reliance Institute of Northeast Alabama is seeking others in the southeast interested in alternative energy, earth sheltered construction, and other self-reliant topics. Contact SINA, Route 2 Box 185A1, Centre, AL 35960 • E-Mail: cevans@peop.tdsnet.com.

ARIZONA
Power to the Parks, Phoenix, AZ, Feb. 2-7, 1998. A special workshop focusing on RE to meet park service needs. $500, Contact SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • FAX: 970-963-8866 • E-mail: sei@solarenergy.org

Women's PV Design & Installation Workshop, March 2-7, 1998, Tucson, AZ. Help power the Cooper Environmental Science Camp cabins. $500. Contact SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • FAX: 970-963-8866 • E-mail: sei@solarenergy.org

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

CALIFORNIA
Convert It Workshop, a hands on EV conversion workshop, January 19-22, 1998, Felton, CA. Contact 408-429-1989 • Web: www.elctroauto.com

Windpower '98, April 27 to May 1, 1998, Bakersfield, CA. Contact: AWEA, 122 C St. NW, 4th Floor, Washington, DC 20001 • 202-383-2500 • Web: www.igc.apc.org/awea

Lead Acid Battery Workshop, Feb. 20-21, 1998, Los Angeles, CA. Limit: 20 persons. Contact SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • FAX: 970-963-8866 E-mail: sei@solarenergy.org

Siemens Solar Industries offers two levels of PV training: Basic PV Technology Self-Study Course (continuously available), and the Comprehensive Photovoltaic System Design Seminar (call for 1998 seminar dates). Instructor Mark Mrohs, Manager of Training for Siemens Solar. The Self Study program includes our 500-page Training Manual and 9 hours of video lessons and applications, with exercises and examples throughout. The System Design Seminar is a 5-day intensive mixture of lecture, hands-on assembly, labs, and team system design problem solving. Completion of the Self Study program ($500 plus shipping and tax) is a prerequisite for the System Design Seminar ($1000). Contact: Siemens Solar Training Department, 805-388-6568 • Fax: 805-388-6395 • E-Mail: cvernon@solarpv.com • Web: www.solarpv.com

Rising Sun Energy Center presents ongoing Solar Energy Classes including electricity, water heating, cooking, and a kids' day. Contact for schedule and info: PO Box 2874, Santa Cruz, CA 95063 • 408-423-8749
E-Mail: sunrise@cruzio.com
Web: www.cruzio.com/~solar

Institute for Solar Living offers ongoing workshops on a variety of subjects. Call Real Goods, 800-762-7325.

COLORADO
Solar Energy International (SEI) offers hands-on workshops on the practical use of solar, wind, and water power. The Renewable Energy Education Program (REEP) features one and two week sessions, PV Design & Installation, Advanced PV, Wind Power, Micro-hydro, Solar Cooking, Solar Home Design, Cob & Natural Building, Straw-Bale Construction and Adobe/Rammed Earth. Experienced instructors and industry representatives. Learn in classroom, laboratory and through field work. For owner-builders, industry technicians, business owners, career seekers, and international development workers. The workshops may be taken individually or as a comprehensive program. $450 per week. SEI is a non-profit educational organization dedicated to furthering the practical use of RE technology. Contact: SEI, PO Box 715, Carbondale, CO 81623 • 970-963-8855 • Fax: 970-963-8866 E-Mail: sei@solarenergy.org

National Wind Technology Center operated by the National Renewable Energy Laboratory, just outside of Golden, CO. The 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.

FLORIDA
14th International Electric Vehicle Symposium, December 15–17, Walt Disney World, Orlando, FL. Contact: Pan Turner, EVS-14 Symposium Manager, c/o First Option, 15 N Ellsworth Ave Ste 202, San Mateo, CA 94401 • 415-548-0311 • Fax: 415-548-9764 • E-Mail: firstopt@aol.com

SOLTECH, IREC, AND UPVG annual meeting, April 25-30, 1998, Coronado Springs Hotel, Orlando FL. Contact: Sharon Wilson, SEIA, • 202-383-2620

IOWA
Iowa Renewable Energy Association board meetings are held the second Saturday of every month at 9:00 am, at Cooper's Mill Restaurant (Village Inn Motel) in Cedar Rapids. Everyone is welcome. Time and place of meeting may change so call I-Renew for updated information. Contact: I-Renew, PO Box 2132, Iowa City, IA 52244 • 319-338-3200 • Fax: 319-351-2338
E-Mail: irenew@igc.apc.org

MASSACHUSETTS
NESEA is converting its headquarters into a showcase of environmentally responsive building. Members are converting a historic railroad hub into a working demonstration of a healthy, daylit, office building flanked by a park which celebrates transportation history while demonstrating principles of urban ecology. Opportunities for involvement: Saturdays at NESEA: A volunteer program through which construction novices learn green building tricks of the trades working with professionals. Major transformations of the building and park will be undertaken as "barn-raisings." Contact: NESEA, 50 Miles St, Greenfield, MA 01301 • 413-774-6051 Fax: 413-774-6053

NEW MEXICO
Solar 98: Renewable Energy for the Americas, June 13-18, 1998, Albuquerque, NM. Featuring the ASES, ASME, and AIA conferences for RE. Contact: ASES, 2400 Central Ave., #G-1, Boulder, CO 80301 • 303-443-3130 • Fax: 303-443-3212 • E-Mail: ases@ases.org • Web: www.ases.org/solar

OREGON
APROVECHO RESEARCH CENTER is a non-profit educational institute on forty acres nestled in the forest of Oregon. Internship programs March 1, June 1, and September 1. Also, a six week winter internship in Baja, Mexico which focuses on studying and researching appropriate technology applications, learning Spanish, teaching in a grade school, and working in fruit orchards and gardens. Contact: Internship Coordinator, Aprovecho Research Center, 80574 Hazelton Rd., Cottage Grove, OR 97424 • 541-942-8198.

TEXAS
SEASUN, El Paso Solar Energy Association has a new web site: www.epsea.org

VERMONT
Free PV Workshops for beginners wanting to see working systems and for experienced off-grid people looking to share information and to see new, or different ways of solving problems. By David Palumbo of Independent Power & Light, first Saturday of most months. Interest will determine topics: site selection, PV modules, batteries, safety, charge controllers, inverters, DC lighting, balance of system components, system monitoring and maintenance, water topics, snow topics, ponds, living in cold climates, living with our woods, heating with wood, and root cellars. Free, so bring your own lunch and coffee. Contact: David Palumbo, RR1 Box 3054, Hyde Park, VT 05655 • Voice/Fax: 802-888-7194 • E-Mail: indeppower@aol.com

WASHINGTON
GreenFire Institute is offering workshops and information on straw bale construction. Contact: GreenFire, 1509 Queen Anne Ave #606, Seattle, WA 98109 • 206-284-7470
Fax: 206-284-2816
Web: www.balewolf.com
E-Mail: wilbur@balewolf.com

WASHINGTON, DC
Utility PV Experience, Conference and Exhibition will share experience of energy service providers engaged in introducing solar electricity to customers. Contact: Erin O'Donnell, Utility Photovoltaic Group, 1800 M Street, NW, Suite 300, Washington, DC 20036 • 202-857-0898 • Fax: 202-223-5537
E-Mail: eodonnell@ttcorp.com

WISCONSIN
Midwest Renewable Energy Association Workshops. Call MREA for cost, locations, instructors and further workshop descriptions. See our ad in this issue. Membership and participation in the MREA are open and welcome to all. Significant others may attend for 1/2 price. Contact: MREA, PO Box 249, Amherst, WI 54406
715-824-5166 • Fax: 715-824-5399

the Wizard speaks…

Space

Space is empty. This has been the mainstream concept of space since the start of the twentieth century. Today, however, space is beginning to be seen and conceived of as a non-empty medium. Experimental and theoretical considerations have led to new concepts of space. Space is now seen as a sea of potential energy, a liquid or gaseous medium, and in some cases a flexible plastic-like medium.

Quantum Mechanics has produced the concept of space as a sea of potential. Certain “free energy” experiments indicate a liquid or gaseous nature, while Relativistic, Quantum Mechanical, and other considerations point at a flexible plastic-like medium.

Lately, it has occurred to me that all these notions of space could be reconciled in the concept of a granular medium. This medium would consist of very, very small positive and negative charges. These particles would be many magnitudes smaller in both size and charge than the smallest known particles of today. Perhaps as much as a trillion trillion times smaller. The internal dynamics of this type of medium, and its interactions with the fields produced by normal matter, could account for all the material fields and processes we know of today. It could also explain the results of the many anomalous results in many present day experiments.

OOPS!
Dear Richard, I think you folks made a mistake on page 4 the picture of the wind generator belongs to Cam Anders of Webster N.Y. I work with Cam and he was disappointed about the mistake. Just thought I would let you know. By the way I love the magazine. Kyle Klaver

Hello Kyle and Cam. Hat in hand and head bowed, we apologize for the glaring typo. We accidentally used the city name in place of Cam's last name. By the way, Cam, how's about fixing us up with a system article on your great looking installation? Michael Welch

Super-Efficient Washer
Dear Home Power; As I to prepare to go off grid in a few years, I continue to look for new stuff with low energy consumption. I'd like to make Home Power readers aware of another possible choice in washers / dryers.

Maytag has a washer and a dryer called "Neptune," the washer being the horizontal drum type. They claim big reductions in water use and greater water extraction during spin which reduces drying requirements. They told me the washer uses 0.8 kWh average per load and the gas dryer averages 15 kWh plus 0.11 therms per load. Pricey yes, but at the so-called "average" of 9 loads per week; at my present electric rate I would literally pay for the whole washing machine in electricity NOT used in about 11 years. Do your own numbers; get your own questions answered; and make your own comparisons. They have legendary reliability and a petty good warranty, too.

If you are interested, check out http://neptune.maytag.com. Just for the record; I am NOT in ANY way associated with Maytag. R.C. Morris, Jr, Pennellville, NY • rcmjr@axess.net

120 VDC Systems
Dear Editor, Lights on! to the letter in HP#60 talking about 120 Volt DC. All the old ships up until the 50's used 120 Volt DC. I first observed these systems on the Liberty Ship; "Jerimia O'Brien," that I sailed on as it came out of mothballs to become a museum now in San Francisco.

Later, I ran a 120 Volt DC steam-powered system and became spoiled on it. This system started out as a steam engine turning overhead line shafts in a woodshop at the "Engler Block," a crafts mall in Branson, Missouri. I ran this shop for a few years on steam, then put a large induction motor on the line. Since I had to find something to do with the steam, I took a 1 1/2 horse DC conveyor belt motor rated at 115 Volt (bought for $5) and grounded the field. Voltage varies with the rpm and load in this type of setup but DC appliances are very forgiving. Actually, you need less voltage than normally required for ac appliances as you are getting the full amount of amperage 100% of the time. I found that all brush motors run well and incandescents dig DC. Halogen bulbs are the most tolerant (72-130 VDC), variable speed motors, and high speed motors such as vacuum motors are happy with DC. I kept the voltages below 110 and things didn't get hot. Ac-rated switches don't last long due to arcing, but are cheap. Blade type or mercury switches are great, but expensive.

I know there are plenty of ways to improve this setup but I lived with the minor inconveniences. Just before the shop was dismantled, I put ten 12 Volt old car batteries in series on the line along with diodes from an old welder before and after the battery pack. A large capacitor from an old motor placed across the line reduced the arcing in the switches and quieted the motors (especially the sidewalk blower). They really improved the system by giving me surge capabilities and smoothing out the voltages. I had just gotten a line on 20 Exide glass case 6 Volt 220 Amp hour batteries that were surplus from the phone company and a high voltage oscillator when the shop had to be closed down.

It is of special note that with DC, you can have 2 oscillators 180° out of phase and double the voltage! That's what car stereos do. I think you can take 3 oscillators and make 3 phase also. Anyways, all this was one of the better moments of my life and would recommend high voltage DC to folks who need serious power or live in communal situations. Skip Goebel, Branson, MO 146942@msn.com

Biomass in Indonesia
Dear Richard: My partner and I are assisting in designing a trial project in Kalimantan, Indonesia for the creation of a small gasifier power generation unit to use the scrap wood and jungle clearing waste that is currently being burned and causing so much smoke throughout the region (you may have heard in the news recently). We are not engineers, more like greasy social workers who like the thrill of battling mosquitos and the roar of crude power and flickering 25 watt bulbs. But both myself and my partner, Mr. Ridwan Dobson, have a general or lay background in mechanics, engines, etc., and we generated the idea based on general reading on the subject and its clear applicability to Kalimantan. There are several factors:

1. Availability of wood and other bio-waste in great quantity.

2. Transport of liquid fuels is very costly and raises upriver costs of fuels three times the base cost.

3. Burning wastes because of their 'useless' nature causes tremendous smoke and sometimes unwanted forest fires.

4. Power is needed in remote regions but not yet available.

5. Sale of waste wood for power generation could be a source of income for local people.

6. The government is taking our idea seriously.

Is there a generic design available for the home builder? If we were wanting to design and build our own in the future can you give us a lead on some kind of commercial link to produce someone's gasifiers here in Indonesia? I look forward to your reply. Regards, Luke Comey, Djakarta, Indonesia E-Mail: imronc@centrin.net.id

Hello Luke, We've run about six articles on gasifiers and methane over the last ten years. The best source is our Solar 2 CD-ROM which indexes all methane info, even in the Letters and Q&A columns. I know of no commercial units made local to you or in the USA for that matter. Let's see if our readers can directly supply you this info. While I understand the abundance of biomass in developing nations, I deplore the additional carbon dioxide its combustion makes. Consider solar electric for lights at night. See pages 24 through 29 in this issue. Richard Perez

Magnetically Speaking

Issue #60 featured an informative article by Donna Wildearth describing how she and her husband designed their solar heated and powered home.

I don't believe it was clearly stated that for optimum solar performance magnetic variation in your area should be taken into account. For those unfamiliar with this, simply put, what your compass says is south ain't necessarily so. In my neck of the woods, true south is 17 degrees or so east of magnetic south., in most of California it's around 13 degrees east of indicated south.

While I agree with Donna that generally speaking 15 degrees or so either way will not make a huge difference in solar performance, if a person is not aware of the anomaly and lives in a high variation area it could result in a greater than anticipated dislocation from true south.

Further, if you have the opportunity to layout your new solar assisted house as your choose, why not get it right on? The simplest way is to go down to your local airstrip or ask a local private pilot "Hey, what's our magnetic variation around here?" He or she should be able to tell you.

For your amusement, the enclosed picture is my micro-mini PV/thermal system. Idaho's highest peak, 12,662 foot Mount Borah is in the background. It really was nice listening to music while taking a hot shower after the climb! Besides a CD player, other loads are a couple of "Osram" Halogen lights.

While hiking that day, I left the radio playing in hopes of keeping nearby bovine from lunching on my bird (it worked), and the 5 Watt Solarex panel provided enough power for more music plus lights that night, the 17 Amp gel cell battery still having plenty of starting capacity the next morning. The 2 1/2 gallon "Sun Shower" water heater is four years old and used a lot during the summer, hot water being good for getting bugs off the home built tracker's windshield. Magnetically correctly yours, Tom Simko, Inkom, Idaho

Code Counterpoint

Dear Editor: There has been considerable controversy concerning National Electrical Code® interpretations by John Wiles. Two articles that appeared in HP #61 challenge points raised in the HP #60 "Code Corner." I would like to add a couple of points.

About temperature ratings of wiring methods. Traditionally, using equipment with the ability to tolerate 90˚C does not require that the system operate at that temperature. For instance, Square D equipment is listed for use with 90˚C wiring. This allows appropriate wiring to be operated at 90˚C. This does not require a 90˚C system, it only allows it. Up until several years ago, Type TW wire, rated at 60˚C, was the industry standard. It was not at all uncommon to connect this wire to Square D equipment. Today, TW wire has been mostly replaced by THHN. This wire is rated for 90˚C, but is often operated at lower temperatures.

The only times it is necessary to use wiring methods rated for 90˚C is when a "combination of ambient temperatures and conductor temperatures are in excess" of the ratings of lower temperature methods. The operating temperature of conductors is determined by the current in the wire, the ambient temperature, and the number of current carrying conductors in a conduit.

No competent PV installation designer would operate a wire at an amperage that would cause it to run hot. Wiring is usually sized to minimize voltage drop, which will also prevent heat buildup. In practice, most PV wiring will operate at close to the ambient temperature.

It shouldn't be necessary to use 90˚C wiring methods with solar modules, unless rare conditions of extreme heat are encountered. While it is useful for modules to be able to handle any temperatures that any installation could possibly encounter, the 90˚C rating of the module should not automatically require 90˚C wiring and conduit.

About fuses and blocking diodes. In the "Code Corner" article of Home Power #60, potential module failures were simulated. Mr. Wiles showed how such failures could be prevented by the use of module fuses and blocking diodes. Unfortunately both of these methods would compromise the system. Blocking diodes waste precious wattage. Module fuses would make for difficult system maintenance and added installation expense.

In one scenario "hundreds of amps" of reverse current from the batteries was described flowing through a single cell, causing "catastrophic" conditions. In another case, 100 Amps of reverse current caused solder bonds to melt within a module. Neither of these situations should develop in a properly installed system. The over current protection for an array would open the circuit before the amperage reached the above mentioned ratings. The array fuse or circuit breaker is usually rated at 60 Amps or less. If reverse current flow conditions are in fact causing problems, an easier solution is available. Arrays can be broken down into sub arrays and fused at the power center.

Solar electric systems have quite a bit of history to draw lessons from. New requirements should be dictated by reference to real problems, not imagined possibilities.

It is an unfortunate fact that no technology is 100% safe. Modern electrical systems have good track records for safety. The potential hazards of PV systems tend to be less catastrophic than those that can be introduced by connection to a utility power line.

As photovoltaic systems continue to evolve, we need to decide what is technically necessary for safe installations. It is the hands on PV workers that come in contact with the actual system issues that need to be addressed. It is imperative for us to find ways to work with the NEC to aid in the adoption appropriate rules. I would like to hear from any of you who share this view. Drake Chamberlin, Nederland, CO • E-Mail: solar@eagle-access.net

More Code Counterpoint
Richard, In regards to our Indian Creek Nature Center PV workshop last month, the Code Corner article on page 74 in HP61 is sure caused some stirring in the bushes here in Iowa. According to Square D, which is so kindly supplying the conduit among many other items, there is no difference on the rating of the two (metallic vs nonmetallic) when damp. The temp rating drops to 60° for both. We changed our outside runs from 6 modules to run in the metallic conduit at the last minute to meet code per John's article, but according to our suppliers there is no difference. Any thoughts?

Also you folks might enjoy the last minute humor(?) of IES (the local IOU). All they wanted from us was to include a redundant switch after the Trace inverter. As of today they claim they will not hook this project up to grid unless they get to install a second meter, pay 2 cents to the center and sell ALL back at their rate (they claim 15 cents). Iowa, as you know, is net metering. They said they would have to check into it! Later. Tom Snyder, IRENEW • E-Mail: tsnyder@mwci.net

Hello Tom and welcome to Code Wars. We all have questions about how safe is safe enough. And then there's passing the electrical inspection to consider. Stay tuned, the debate is bound to be, at least, interesting.... Richard Perez

Greywater and Solar Space Cooling
Dear Home Power, I have a request, I hope you can provide information or point me in the right direction.

1. Looking for information on designing a grey water system to provide toilet flush water and to water plants.

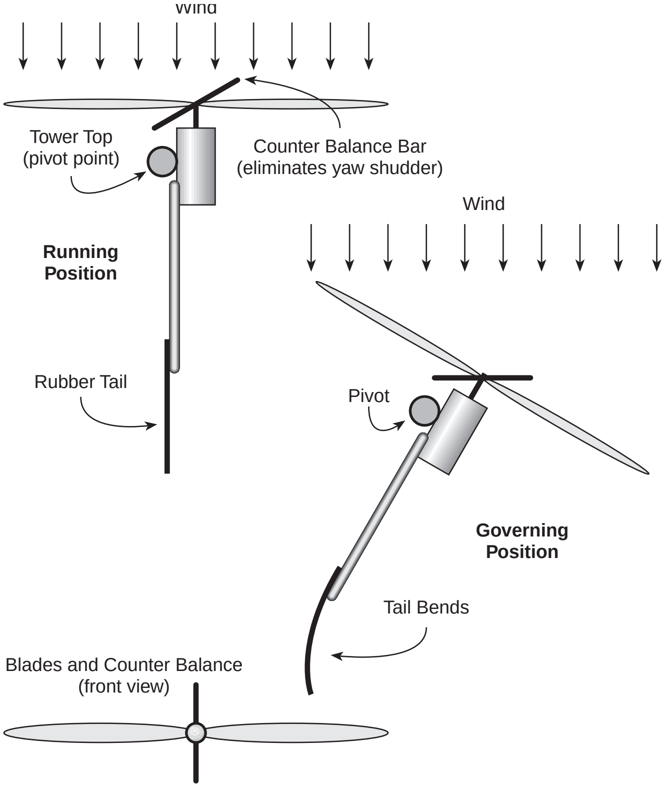
2. Looking for information on new techniques of cooling, especially in the tropical zone. Is there something with crystals or foam, using PV?

Looking forward to hearing from you. Thanks! Devorath Elcock, Virgin Islands Energy Office, St. Croix, USVI

Hello Devorath. The fellow to talk to about greywater processing and use is Art Ludwig, Oasis Designs, 5 San Marcos Trout Club, Santa Barbara, CA 93105 • 805-967-9956 Fax: 805-967-3229. When it comes to space cooling in hot, humid locations the only really effective solution is air conditioning. In terms of solar thermal air conditioning, the Singapore International Airport is air conditioned by thousands of Thermomax solar thermal collectors driving an absorption cycle refrigeration system. In terms of solar electric air conditioning, look into ground coupled heat pumps. We use a swamp cooler here, but our summer time humidity is around 20%, not the over 80% you must get in the Carribean. Richard Perez

Wincharger
Issue #60 , even better than ever, thanks for being there!

On Carl Martin's Wincharger, a swinging tail governor can't work unless the generator is set off center. I've seen dozens of Winchargers, and never saw one with an offset generator to be able to swing out of the wind.



On my three home built generators, built in 1991 and still going strong, the 6 foot rotors are off set from the pivot, the tail cane is made of flexible stiff rubber (old conveyer belt bed material). It just flexes in strong winds, while the generator swings out of the wind (see drawing).

On EDTA treatment of batteries. I have six golf cart batteries. They all showed diminished performance proportional to their age. The one purchased in 91 would go up to 16 Volts, with hydrometer readings of 1.250. The younger ones a little better. I treated then with EDTA as per instructions. Within 2 hours, and only a few amps of solar power, they were cooking and actually very warm with reaction to the EDTA solution added. Within a couple of days, amazing, the voltage dropped from 15–16 Volts, batteries gassing, down to a normal 12.5 Volts plus, with hydrometer readings up to 1.280 plus.

After two months since treatment the batteries behave as new. I hope the performance stays. I'll let you know. Three RV/boat batteries bought in '91, used to power my electric boat three months in summer and kept charged in a warm shop in winter, showed no improvement with EDTA treatment.

Issue #60, page 4, Love It! For a while there I thought you'd all became capitalists, selling expensive equipment, in a shiny magazine to well heeled yuppies who happen to be a bit distant from the grid. Thanks Richard Perez!

Sushi is also my favorite food. Keep nori, Botan rice, sugar & vinegar handy always, sushi anytime—homemade! It'll get you by. Roll your own. Lov ya all, Alex, Krakow, Wisconsin

Flywheel Automobiles
Dear Mr. Perez, The following Internet Web Sites are a good jumping off point for information about flywheel Power for hybrid vehicles.

http://www.hev.doe.gov/general/calc.html

http://www.calstart.or/usflywheel

http://www.hev.doe.gov/components/fly_phys.html

http://www.calstart.org/new./pngv/pngv-0220.html

http://www.llnl.gov/Ipandc/opportunities93/10-transportation

Articles in the October Scientific American give a good summary of advances or the present state of the art for flywheel autos. Earlier information gleaned from the Project at Langley Air Force Base indicates that substantial problems exist where the primary propulsion is via flywheel. Langley estimates indicate a flywheel of about 160 lbs rotating at 60,000 rpm in a very low pressure Hydrogen or Helium atmosphere and suspended on magnetic levitation bearings would be required for a medium sized auto for approximately 300 miles prior to re-spinning the flywheel. They have not been able to fabricate an adequate flywheel material that does not self destruct at substantially less than the required 60,000 rpm.

In the Langley design it is supposed that the flywheel would be integrally fabricated with a dynamo that would either be used as an electric motor to spin the flywheel up to the required speed, or by changing the external circuitry be used as a generator to provide the electrical power for traction motor(s).

There is a "containment" problem for the flywheel in the event of a catastrophic accident wherein the flywheel becomes detached. At full rotational speed, such a freed flywheel would have enough stored energy to travel more than a 1,000 miles at high speed. There is also the "Precession" problem caused by the rotation of the earth that is going to require very sophisticated gimbals to correct.

There were flywheel powered buses operating in Switzerland with flywheels allegedly made of stone and about 6,000 lbs rotating at less than 600 rpm. A pantograph on the roof would raise to make contact with electrical outlets at various stops along the bus route. It was said that the bus could be propelled by the flywheel between power-pickups for approximately 6 miles.

More recent investigations are oriented toward the "Hybrid" type of vehicle, where a small engine provides the power to operate in normal conditions and the flywheel provides the energy for acceleration or to climb hills.

Other "Hybrid" concepts of small horsepower constant speed gasoline engines coupled to standard batteries are close to introduction major automotive manufacturers. Toyota announced a proposed production rate of approximately 1,000 vehicles per month. It is touted as having a range of 60 miles per gallon.

Other stored energy vehicles have been proposed utilizing High Energy Storage Batteries, such as Sodium/Sulfur or Lithium/Lithium Hydride. Both of these systems have certain safety hazards because of the extremely high temperatures required, the possible exposure of the occupants to the molten metals in the cells, or the possibility of severe explosions in the event of a crash where the highly reactive molten metals came in contact with rain water. I have a feeling that the High Energy Battery Car would not have "HAVE A NICE DAY" for a motto or slogan. In any event, Have A Nice Day. William C. Farrell, New Milford, CT • E-Mail: u11216@snet.com

Appropriate Energy for Developing Nations
STEADI, Inc. is a non-profit organization helping third world rural communities with low cost systems such as: treadle pumps for irrigation, solar cookers, intensive food growing systems, "fiber-crete" that uses reeds, straw, palm leaves, etc. bonded with Portland cement to make light weight containers, aluminum foil backing for aluminum foil solar cooker reflectors and rot-proof, fire-proof roofing components. We would like to exchange information with others working on really low cost alternative systems of all kinds. With your agreement your system could be posted on our web page to serve village development workers. Anyone who wants to participate in this program to help hungry and depressed communities is very welcome.

If there is anyone in Bellingham, WA who has back copies of Home Power who would let us consult these back copies it would be much appreciated. Bob Luitweiler, Bellingham, WA 360-714-1043 • E-Mail: gentil@steadi.org

Do We Really Need Load Analysis?
Dear Home Power, Richard Perez's article, "What to Expect from your RE Dealer," has some excellent advice, especially concerning the advantages of having a dealer install equipment. However, I disagree with his statements concerning load analysis.

Richard writes, "Many systems are purchased without ever doing a load analysis. Anyone who does this is wasting money and bound to be disappointed with their system." I have never done a load analysis, and neither have any of my friends who live in photovoltaic homes. But we are all delighted with our systems.

Richard scares readers, who think there is some magic to load analysis. He makes this step sound essential and mysterious; it isn't. When you get right down to it, there is nothing wrong with the method of "Buy what you can afford; you can always improve it later." Let me explain my logic.

All of us, when you get right down to it, would love to have a few more PV panels. That's just the way it is. This is because winters are darker than summers. This factor may not be as much of an issue in Arizona as Vermont; but the principal still applies.

Most PV homes have generators. This is the ugly secret of alternative electricity; people don't like to talk about it. A generator is how we get through the winter. Generator availability is much more important than load analysis. Need more power? Pull the cord. Want to be free of a generator? Buy more panels, wind generators, and batteries. But remember, you're not going to make it through December in Vermont on alternative energy, no matter what you do (unless you have a good hydro site).

Anyone contemplating living in a PV home is going to need the personality to monitor gauges. When they say you are using more electricity than you're making, you've got to turn off some lights, don't do the laundry, or use a clothesline, not the dryer. If a homeowner has the expectation that they won't have to monitor electrical usage, they shouldn't live in a PV home. This is how we all live as we save money for more panels.

Technology changes. You can be as scientific as you want about load analysis, but the fact is that all of the technology has changed. The accepted wisdom has changed on DC usage; on inverter usage; on preferred DC voltage; on many issues. Even if you cross your T's and dot your I's right now with a perfect load analysis, your system is going to change, because the technology is going to change.

So what do I advise? Learn as much as you can, buy the best system you can afford now, don't worry too much about load analysis, get the most efficient appliances available, conserve usage to match your system, and have a generator for winter. Be prepared to change your system as your needs evolve and the technology changes.

There's nothing wrong with package systems. Sellers describe typical packages, and the appliances you can expect such a system to power. There's not a lot of mystery to load analysis. Sincerely, Martin Holladay, Sheffield, VT • E-Mail: holladay@kingcon.com

Hi, Martin; excellent points. I guess that being info nerds makes us err on the side of wanting such an analysis. My own system is set up mostly like you suggest, except that before I bought my inverter I wanted to make sure that it would properly handle the loads that my PV array size would eventually grow into. Also, I was lucky enough to find a huge, used battery bank more than big enough for any future growth. But many folks are interested in finding out in advance what their system size SHOULD be. The number one question we get here at Home Power is, "My home is x,000 square feet. How much would it take for us to satisfy our energy requirements?" Gradually growing up with a system is very different than purchasing and using one that the owner expects to meet their energy needs. Michael Welch

Hydrogen Embrittlement of Metals

Dear Mr Perez, As usual, you and your magazine have brightened my day. I have had the marvelous experience of witnessing the miraculous growth of Home Power Magazine from a gnarly black and white on reprocessed newsprint to the glamorous full color slick twaddledoo that it has become. I am continuously amazed that you have avoided the common trap of growing the magazine into an esoteric diversion into unintelligible technobabble that would leave the common dirt farmers, among us, in the dust.

Re: (page 106 Issue #61) hydrogen embrittlement of metals. Common high pressure storage bottles are first used for Nitrogen storage when they are new. After substantial life and abuse these flasks are downgraded to use storing Oxygen, then Carbon Dioxide and or Argon or Helium. When these flasks are about 25 to 30 years old they are again downgraded into Hydrogen storage.

It is not unusual to examine the hydrostatic testing dates (hammered into the metal) and find Hydrogen flasks with an original date around the end of World War One, or 75 to 85 years.

These flasks are "drawn" from a red hot billet of steel. All of the valve mechanisms are of bronze or brass with appropriate shutoff seals and packing at the shafts. It is my opinion that the storage of Hydrogen in a steel container does not present a hazard due to Hydrogen Embrittlement.

Typically, Hydrogen Embrittlement occurs when the gas is present at a time when the metal itself is red hot or worse. Caution must be exercised during most welding operations or in "Hydrogen Furnace Stress Relief" operations.

Recent attempts at obtaining Hydrogen storage at the grain boundaries of carborized granular metal (see Mercedes Benz hydrogen storage for motor vehicles) utilize a very sophisticated Alphatizing of the particles and grain boundaries to effect the production of this cohesive storage technique for extremely low pressure storage of Hydrogen.

Probably the most significant factor concerning the use of Hydrogen is the danger presented when the concentration (in air or an oxygen bearing atmosphere) of Hydrogen is very low (it gets very nasty at around 0.5% concentration, as any submariner can testify).

Little known fact. If using a typical Plumber's Solder Pot atop a flame heater, do not use a piece of galvanized sheet metal to skim the slag from the top of the solder surface !!!!! The introduction of very small amounts of Zinc, from the galvanized metal, will totally screw up the solder while your back is turned, in the dark of night some time down the pike. If I live long enough (now 74) I will write to you concerning the cleanup and performance of old Fork Truck Traction Batteries of the Nickel Iron or Nickel Cadmium variety. You will find them laying all over the place at the Fork Truck repair depot, and nobody wants them. They should be pretty cheap. Probably the greatest problem has to do with the spent Electrolyte in a good, clean and safe manner. I remain, a happy camper and pleased reader. William C. Farrell, New Milford, CT • E-Mail: u11216@SNET.COM

Home Power in Boulder
Dear Richard, I'd like to connect with folks in the Boulder, Colorado area who are interested in renewable resources for home power. My particular interests are solar and wind power. I'm just beginning to design a new home that will be powered by renewable resources, and I'm looking for land in the area just south of El Dorado Springs. Donna M. Auguste, PO Box 17280, Boulder, CO 80308 • 303-823-9619 • E-Mail: auguste@freshtech.com

Straw Bale in Manitoba
Dear Editor, I am planning a straw bale, RE building in the Winnipeg, Manitoba, Canada area with the purpose being a headquarters and showcase for living and working in an eco-friendly manner. Any persons or organizations interested in being a part of the planning, construction, and occupation of this 'environment', please contact us. The emphasis of this project will be on community involvement. This is a non-profit venture, an experiment on what can be done with community participation, little capital, and clever utilization of scrounged resources. Lane & Deborah Robinson, #5, 293 Provencher Blvd., Winnipeg, MB Canada R2H 0G6 • 204-231-4962
E-Mail: lane@total.net

One Room Do-It-Yourselfer
I live in the city on the coast of Southern California and was considering taking one room off the grid (more of a hobby than anything else). The article in issue #60, "Take Your Bedroom Off the Grid," got me real interested. Being able to switch back onto the grid as needed also helped sell me on the idea. Redwood Alliance sent me their materials on this, it appeared more technical than I expected, but my interest was undiminished. I planned to go to their next seminar and I figured on a budget of $2,500 for a room with two lights, TV and VCR should cover it.

The article in issue #61 "What to Expect from your RE Dealer" helped me take a hard look on what needed to be done. I did not want to spend hundreds of dollars on specialized tools, and the level headed analysis provided by the article helped me make what I think is the right decision, which is to let a professional do the work.

I want to thank HP for giving me a realistic outlook on this. My next step is to visit all the web sites listed in the ads, making sure to mention HP. Bruce G. Schweitzer, Santa Ana, California • E-Mail: BSchwei227@aol.com

Hi Bruce, lots of folks requested RA's info packets, many more than we could provide. It really gave us an indication of how much interest there is in the "little bit at a time" strategy. Hope to see you at the next workshop, but 600 miles is a long way to travel, so may I suggest contacting a local RE non-profit in your area to see if they have an interest in conducting such a workshop. RA would be happy to work with you and them. Michael Welch

From the Ukraine
I am writing to you from Ukraine, former part of USSR, now it is independence state. I find your article in Countryside Magazine. My friends sent me there magazine because we do not receive any American magazine or newspaper in our city.

We live in Chervonograd with 100,000 inhabitants. A lot of people here very interested about small scale solar, wind or hydro-electric electricity. Why? Because 80% inhabitants live in apartments and almost everybody has small garden and orchard in suburb. We call these gardens by not interpretable word "dacha." Some people live there all spring, summer and autumn. People have tiny houses there. People that have job are going to dachas after work and every weekend. It is not rest but hard work for family to survive. People have not any electricity in dachas but they very need it for watering. Also people in villages very need electricity.

We also need information about small tillers. People have money for small cheap tillers that can till one acre or 1/2 acre per one day and small electricity for one home. Maybe some US corporations or firms would like to open for themselves our huge market in Ukraine. We have not these things in our shops. I was in USA and I know English and I, with pleasure, will help Americans. I am electric engineer and I work in a coal mine. I have own home and garden and fruit orchard.

We have hard currency now in Ukraine. I would appreciate if you will decide to print this letter in your magazine with my address. I will be very glad to receive your Home Power Magazine. Alex Korsoun, Lvivska obl, Chervonograd, Molodishna 6/1, Ukraine 292210

Deregulation in Illinois
Our state is restructuring the electric utilities. If renewable energy is to have a better place in Illinois, we as a group need to speak out. I was able to testify at the Orlando Park public hearing October 9, and was the only person speaking up for renewable energy out of about 30 or 40 people testifying. For now Com-Ed is the sweetheart of the Illinois Senate. From what I can see, it appears that Com-Ed will get most of what it wants. They want their stranded assets covered on the uneconomical nuclear power plants. This is going to be several billion dollars.

A lot is going to happen in the months of October and November. I don't know when it is going to be voted on or when things will become finalized. One thing for certain is that we as a group are not speaking out. The democratic process works best if we voice our opinions. If we want renewable energy and energy efficiency to get support, we in Illinois need to write our congressman, call them, or visit them in their office and speak up for our needs. Call Senator Mahar, and ask for renewable energy and energy efficiency to be strengthened. Where does the bill stand now and how would he plan to change it for the better?

At present there are three million for energy efficiency and five million for renewable energy. I asked Senator Mahar on the phone if there would be any chance of strengthening the bill. He didn't see where he could get the money to do so. Then I talked with his staff person about what the money could be spent on. She (Jo Johnson) said it could be spent for research and development and could possibly also be spent on installations of renewable energy systems. When I presented the information to John Thompson (an environmental advocate), he said the amount of money is so small that only the big organizations will get it and there will be nothing left for us little people. He also added that in the future, if this program is popular, larger amounts can be allocated. Bill Mahar did also mention that he was willing to work with renewables in the future.

The Senator sponsoring the bill is: William Mahar, 14700 Ravinia, Orland Park, IL 60462 • 708-349-1400 • Fax: 708-403-9212.

If there is any way I can help please contact me. Jeff Green, 102 S Maple, Frankfort, Illinois • 815-469-5334 • E-Mail: jeff_green@msn.com

Hi Jeff, thanks for the update. Restructuring in Illinois seems to be going much the same way as in other states. The public knows so little about it that they are not being very effective in influencing the way things will be finalized. Hey everybody, this is a wake-up call. If you don't get active in your state, you could end up paying billions in bail-out money for your nuke plants while giving renewables, conservation, energy efficiency, and programs for low-income households the collective shaft. Michael Welch

I'd like to put my two cents in here. Restructuring America's utilities reminds me of chumming the waters in the movie "Jaws." The Sharks (and for the last hundred years it has been apparent who you are, darlings) gather. As long as we put our energy future in the hands of those who want to rent us sunshine, we deserve what we get—another century of energy slavery. Go Solar. Own your own RE system, and if possible sell your excess to others at a reasonable rate. We RE users know where the energy comes from, and its up to us to to inform those enslaved by utilities. Richard Perez

The Big Step

It's time to renew my subscription to HP. Please send future issues to my new Off Grid address!!

My wife and I are building our new home this summer. We have 260 Watts of PV, Trace DR 2424, and eight golf cart batteries. This system powers all our tools, including a table saw and small air compressor. Last year we built a workshop (same location) using a gasoline powered generator. It worked but the solar is so much more pleasant to use.When we move into the new house (living in a solar powered RV now) we plan to expand the system to include a Whisper 600 wind generator.

The house has an earth sheltered 1st floor, lots of south facing glass, and a post and beam 2nd floor loft. We will have wood heat but hope to shorten our burning season with the help of solar heat. We picked up a used H2O panel at the MREA Fair to work with an on-demand water heater.

Thanks for all the great info. Keep up the good work! I don't know if we would have taken the big step off grid without your magazine for inspiration. Brian Riley, Beallsville, Ohio

Brian: OK then, if you may not have done it without us, then you could repay the favor by writing it up and submitting a systems article. We rely on our readers to also be our writers. Congratulations on your new RE home. The Crew

Down-Home Home Power,

I like the solid technical yet "Down-Home", funky, avoid the consumer excess, practical/philosophical orientation. Don't hesitate to keep it out there. Like Solar Age Magazine in its first few years '76 – '81. Because of you I have a Staber (and from earlier, a Sun Frost...etc.).

Enclosed is a photo of one of our many Phoenix installations from this summer. This one is on the West Coast Trail. Later this month Hot Springs Cave. Then back to the Charlottes, etc. My genuine congratulations on your fine work. Michael Kerfoot, Sunergy Systems, Ltd, Cremona AB, Canada

More "PV Pump Retrofit"

We have received a terrific response to our PV Pump Retrofit article in HP61, which shows how we adapted our 48V SunRise Submersible Solar Pump to a 24V home power system. Many folks have asked us to duplicate this system. However, the solution shown in the article fit one particular case and may not fit yours. One of these options may work better for you:

Option 1: You can install a 48V system for your home, instead of 24V. Use an inverter such as the Trace SW series in 48V form instead. Run the pump as a normal DC load. This is simpler and less expensive, as no transfer switching or pump controller is required.

Option 2: You can run the pump from a 24V battery system, if your water needs are modest.

Option 3: If you have a 12V system consisting of at least 4 PV modules, you can adapt the method used in the article by using a 12V relay with an appropriate switching pattern.

Option 4: If your pump is a long distance from your power system, you can put a PV subarray on a portable rack. During the summer leave the portable array at the well to run a simple, array-direct system. During the winter (when you need less water but need more energy for the house) fill up your storage tank and then move the array to the house.

Option 5: Use the SunRise to both lift water from your well and supply pressure. This requires running it from your battery system. We have a detailed article on designing such a system in HP#38.

Option 6: If you have a shallow water source you can consider using a surface pump instead of a submersible. They are less expensive, and can pressurize at a greater volume.

Option 7: If you have a well casing of at least 6 inch inside diameter with an ac pump in it, you may be able to fit both pumps in the well, keeping the ac as a backup!

There are many ways to configure a solar pumping system. No single solution fits the wide range of water sources, sites, and power system variables.

Windy Dankoff, Dankoff Solar Products, Santa Fe, NM • 505-820-6611 • E-Mail: pumps@danksolar.com

Nuclear Problems
Enclosed is an interesting and scary article on nuclear reactors that are 100 miles west of me. These Canadian (CANDU) reactor systems were once touted as being the best in the world and have been sold worldwide. These reactors near Toronto are plagued with safety problems that will cost $Billions to fix.

Note: Ontario hydro rates have been frozen by the government at about 10¢ a kWh for at least two more years. Then we're fair game to any increases.

Ontario Hydro Technologies (Research division for Renewable/Conservation) was dropped about six months ago due to funding cutbacks and they stated "Renewables were not feasible."

I'm on grid, use about 20 kWh/day average. now compared to 34 kWh four years ago. Added solar DHW and compact fluorescents to achieve this. Your mag is great. Keep up the good work. Paul Bailey, Bloomfield ON, Canada

Thanks for the article, Paul. Like any other nuke plant, the manufacturers and owners really like to make their technology look good. The announcement of the closure of several Canadian reactors took the anti-nuke movement by surprise. It wasn't the problems that surprised us, just the admission that things are amiss. Keep up the movement toward energy efficiency and conservation, it is just as important, and the precursor to, being off the nuclear-fed grid. Michael Welch

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 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 more interested in specific information than in general information. Write from your direct experience—*Home Power* is hands-on! Articles must be detailed enough so that our readers can actually use the information.

Article Style and Length
Home Power articles can be between 350 and 5,000 words. Length depends on what you have to say. Say it in as few words as possible. We prefer simple declarative sentences which 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. System articles must contain a schematic drawing showing all wiring, a load table, and a cost table. Please send a double spaced, typewritten or printed copy if possible. If not, please print.

Written Release
If you are writing about someone else's system or project, we require a written release from the owner or other principal before we can consider printing the article. This will help us respect the privacy rights of individuals. Please call us for a form for this purpose.

Editing
We reserve the right to edit all articles for accuracy, length, content, 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 published first.

Photographs
We can work from any photographic print, slide, or negative. We prefer 4 inch by 6 inch color prints which have no fingerprints or scratches. Do not write on the back of your photographs. Please provide a caption and photo credit for each photo.

Line Art
We can work from your camera-ready art. We can scan your art into our computers.

We can redraw your art in our computer. We usually redraw art from the author's rough sketches. If you wish to submit a computer file of a schematic or other line art, please call or E-Mail us first.

Got a Computer?
Send us your article's text on 3.5 inch computer floppy diskette, either Mac or IBM format. We can also read ZIP disks (either Mac or IBM), and Magneto-Optical disks (128 MB, 230 MB, 1.2 GB and 1.3 GB all Mac only). This not only saves time, but also reduces typos. Please also send a hard copy printout of your article. Save all word processor files in "TEXT" or "ASCII TEXT" format. This means removing all word processor formatting and graphics. Use your "Save As Text" option from within your word processor. Please don't just rename the file as "text" because it will still include unreadable (at least to us) word processor formatting.

You can send your article via modem either to the *Home Power* BBS at 707-822-8640 or via Internet, as an enclosed ASCII TEXT file. On our BBS, address the message with the enclosed file to: Richard Perez. The E-Mail address is: richard.perez@homepower.org .

It is wise to telephone or E-Mail ahead of electronic file submission. This is particularly true concerning graphics files. There are many, many, many ducks and they all need to be in a row....

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

Access
Richard Perez, c/o *Home Power* Magazine,
PO Box 520, Ashland, OR 97520 USA
Voice Telephone: 916-475-3179 (during West Coast USA business hours, otherwise you will get an answering machine)
FAX: 916-475-0836 (24 hours a day)
Internet E-Mail: richard.perez@homepower.org

Ozonal Notes

Karen and Richard Perez

Karen and I are really pleased to be running this Ozonal Notes column as a regular feature once again. We need to be able to ask you, our readers, questions. While Karen and I manage the day to day operation of *Home Power*, this is really your magazine, not ours. As usual there is lots to talk about. While Ozonal Notes issues are not strictly technical, they do affect the flow of information through these pages.

The Great Paper Search

Unfortunately the PC30 grade #4 paper (30% postconsumer, elemental chlorine free) we have been using is no longer available. The small family-owned mill sold to a large conglomerate that won't special run the paper any more. We use around 82,000 pounds of paper a year for the interior of *Home Power*. That sounds like a lot but isn't enough for the larger paper mills to consider running special paper for us.

I am amazed with the trouble we are having coming up with a comparable paper here in the US. I've managed to find a 30% postconsumer, 100% recycled, totally chlorine free paper from Dancing Tree in Berkeley which we can afford. But—ain't there always a "but"—it is only made in a matt finish. Since the paper does not have much of a coating, the ink holdout is not as good as a gloss. What that means is that the photos would look muddy and a lot the detail would be lost.

Dancing Tree also has a beautiful grade #2 gloss paper that is 25% postconsumer, chlorine free, but it's too rich for us. I've also checked into kenaf and hemp paper: No coated stock, rather short supplies, and very expensive.

I'm waiting for paper samples from a European mill. In Europe they make high postconsumer, chlorine free, gloss or silk finish stocks for reasonable prices. Our concern is the embodied energy of bringing the paper across the Atlantic.

So for the next issue or two we will be using a 10% postconsumer, elemental chlorine free paper, grade #3 house paper from our printer while the search continues.

If anyone has any other leads I would love to hear from you. Karen Perez, on the great paper search….

Should Home Power Allow Advertisers to Print Prices?

We have been getting complaints from some of our advertisers that *Home Power* is fostering cut-throat competition by allowing advertisers to include prices. They are asking Karen and I to change that policy. They claim that publishing prices harms the renewable energy industry in general and their business in particular.

Since the beginning of *Home Power*, we have published prices of products and services for two reasons. First, have you ever purchased a product and/or service without knowing what it cost? The price is the essential bottom line in any business transaction. If our readers are going to use RE, then they need access to the equipment. This means buying and properly installing the gear. When this happens, both the buyer and the seller are well aware of the cost involved. Our original concept was that not printing prices just slowed down the flow of commerce, generally causing needless work and expense for both buyer and seller.

The second reason is that we believe in the free flow of info. We don't want to pass editorial judgement over our advertisers. We monitor all the advertisers you see in *Home Power*. We will not allow advertisements by those we know to be dishonest or have demonstrated high levels of customer dissatisfaction. Beyond this, we want HP advertisers to be able to freely communicate with you, their customers.

Competition is an essential ingredient in any business. Advertising is the leading edge of that competition. We feel that you, the consumer, should decide what is a good deal. See my article in HP#61, page 40 on the subject of using and choosing a renewable energy dealer.

Once again we ask you, our readers, to help us with a tough decision. Should *Home Power* continue to allow advertisers to print prices?

Code Wars

Many of you have noticed the ongoing debate between John Wiles of Code Corner and the "Wrenches," as some installing RE dealers and contractors call themselves. We have printed National Electric Code® info on safe systems since the first Code Corner article in HP #13 (Oct/Nov 1989). Lately the Wrenches have complained that NEC nit-picking on RE system details is slowing down the process of development and increasing installation costs for no good reason. Since everyone wants to be safe and pass electrical inspection, we will continue to foster this debate. We need NEC standards and we need them to be functional and realistic. This requires information input from both sides. While this debate may seem esoteric to many, standards dictated by the National Electric Code effect everyone.

Ham radio at MREF 1998

We are helping coordinate an RE-powered Amateur Radio Special Event Station at next year's Midwest Renewable Energy Fair. We have the support of Hams and the American Radio Relay League (ARRL). Here is a list of the Hams who have volunteered to date. We are publishing this list so all on it, and other new volunteers can contact each other directly and work out all the details. Those hams wishing to participate, but without Internet E-Mail, should contact Richard Perez (N7BCR) via phone or snail mail.

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Electronic *Home Power*

We are continuing to distribute the electronic edition *Home Power* magazine on the Internet for free from our web site at: www.homepower.com

Home Power's major objective is the dissemination of RE information. To this end we are delirious to see this info go global without either the dead trees or the help and vagaries of postal services. We are still giving it away because we haven't yet been able to put a price on it. Our research indicates that the major cost component in selling you an electronic edition of *Home Power* is processing the order. It is the bookkeeping and the credit card charges which are more expensive than anything else. We have already done all the editorial work to produce the issue. We are going to keep it free for now because it is the cheapest option for all of us. We realize that downloaders of the electronic edition bring their own effort into this info exchange. You have your time, your phone time, and your investment in computer stuff. We are willing to match your effort by giving you *Home Power* for free. May the info flow….

The electronic edition is in Adobe Acrobat Portable Document Format (PDF). If you do not yet have the Acrobat Reader for your computer (Win/Mac/Unix), then use the link on our web site to download it directly from Adobe. There is no charge, the Acrobat Reader is free.

The latest issue of *Home Power* is about 5 MB in PDF. Most folks report download times on the order of one hour. We also have the file broken up into smaller segments to make it easier for those with iffy Internet connections.

Many Thanks!

I want to thank all the HP readers who have responded to my recent questions about RVs and hot water plumbing. You folks are great! I have not responded to everyone personally, so please accept our thanks in this form.

Bath/Green House Series of Articles

We ran out of space for this article in this issue, so be looking for the beginning of this series next issue.

High Intensity White LEDs

Many of you have written asking where to get the hi-intensity white LEDs. Call Nichia Corp. at 717-285-2323

Access

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Q&A

Solar Water Pumping—pumps & pipes

Having taken a course on PV water pumping, I was somewhat consternated by the advise I am receiving from a local well driller and others about what not to do when it comes to solar electric water pumping.

The well driller says that $700 DC solar pumps are "not that reliable." He explains that sandy conditions prevalent in our area accelerate wear on these pumps to the extent that they must be pulled up every 8 to 12 months for servicing and repair. He also made the general comment that the technology and engineering on these pumps does not seem to be well settled yet. He also said it seemed difficult to obtain replacement parts because designs of these pumps kept changing. His recommendation was to use a conventional 1/2 or 1/3 horse ac pump off of a larger Trace inverter.

What is the real scoop? I do not want to pull the pump every 8 to 12 months. On the other hand, isn't it dreadfully inefficient to go through an inverter using an ac pump rather than using a PV direct DC pump? I intend to use at least 2000 gallons of water storage and run a pressurizing pump between the storage and the house, so I don't need the larger pump to pressurize water direct from the well to faucet.

This same well driller, as well as others, has specifically said to not use flexible plastic pipe, but rather to use galvanized pipe. Two reasons they gave were 1) the plastic pipe could not hold up to the wear and tear (from pulsating hammering?) as well as the metal pipe; and 2) if I need to pull the pump, the metal pipe would not break as would the plastic pipe. My understanding of DC diaphragm pumps is that they do "pulsate." It is inherent in their design. Nevertheless, if coupled securely to the pump, plastic pipe is better able to absorb this pulsing than is a metal pipe with its numerous couplings that could come apart. As for pulling the pump, it is also my understanding that a pump should always be hung from a safety rope—one should not rely upon pulling the pump using pipe. Please tell me if my understandings are correct.

Thanks for your time and response. Bob Clark, Omak, Washington

Hello Bob. Your well driller is partially right. The $700 DC solar pumps use a diaphragm to pump water. This diaphragm is flexible and wears out after around 2,000 hours of operation. If the system pumps water six hours a day, then this amounts to about a year before the diaphragm fails. These diaphragms are not among the common items you will find at your local pump supply house. They must be special ordered. In some cases, installing the new diaphragm in a pump requires special tools. While these pumps are super efficient, they do require regular maintenance. Many installing dealers I know keep a spare diaphragm pump around for their customers. When a pump fails, they put the loaner pump down the well while the defective pump is being repaired. This assures their customers of a continuous water supply.

We found all this out when we used diaphragm style DC pumps in our well. We powered the pump using two 60 Watt Solarex PV modules on a Zomeworks tracker. It would pump about one gallon per minute all day long. The first pump lasted about a year and the second one lasted about eight months. In both cases the diaphragm wore out. I wanted a pump which was more reliable and required less maintenance. I went to our local well service and had them build one designed for low power consumption.

Our new well pump is a multi-stage rotary type made by Gould and is powered by a one-third horsepower, 117 vac, Franklin electric motor. This pump has been down the well for over three years now with no trouble. It delivers five gallons per minute to our two 1,350 gallon storage tanks which gravity feed water to all our faucets. We mostly use the Trace SW2512 sine wave inverter to power the pump which draws about 8 amperes at 117 vac. I just wait until our main PV/Wind system has a power surplus, then switch on the pump and let it run for a few hours. I think we get better service from having the PVs on our main system, rather than having them dedicated to the DC pump. In the winter, when our water needs are much lower, the modules contribute to the main system rather than uselessly languishing about at the well head.

We discovered an interesting fact about using an inverter to pump water with a 117 vac pump. Our well pump delivered 30% more water per unit time when powered by a sine wave inverter over a variety of modified sine wave inverters. DC power input into all the various inverters was about the same. Big electric motors are designed for and like sine wave electricity. They run more efficiently, faster, cooler, and will probably last longer than on modified sine wave electricity.

Is our current 120 vac well pumping regime more efficient than the low voltage diaphragm pump system it replaced? Well, if you look at gallons pumped per input watt, then no, the diaphragm pumping system is almost twice as efficient as the 117 vac well pumping system. If you consider that we only pump water when our main RE system has surplus power, then yes, the 120 vac *pumping system is far more efficient because we would have refused the surplus energy if we didn't use it to pump water. If for some reason our main system batteries are low, then we can start our engine/generator and pump water directly powered by it. I like the 117 vac pumping setup far better. Best of all I like not having to haul the pump out of the well once a year.*

Our 117 vac well pump is located some 250 feet down the well on plastic pipe. No problems. All well pumps, regardless of type, need to have a safety line suspending them in the well. This line prevents the pipe from having to support the pump and makes it impossible to drop the pump into the well in the event of pipe/wire failure.

I had the pump service remove the anti-drain back valve from the pump. This means that the dedicated pipe line between the pump and our storage tanks drains back into the well when the pump is not active. This gives a lower electrical starting surge for the pump's motor and lower starting shock to the pump's pipes. It also prevents the well-to-tank pipe from freezing because the only time it contains water is when we are actively pumping. This does waste a miniscule amount of energy since it takes the pump about two minutes to fill the pipe between the well and the storage tanks. Obviously, the well water enters our tanks at their tops.

We laid separate pipes for recharging and discharging our water tanks. The pipe between the well head and the tanks goes only one place: to the tanks. We have two tanks. Tank One feeds only the house and bath house. Tank Two feeds everything else. Both these discharge lines are separate pipes. This way we can space out irrigation in the summer and still have water in the house. Well water is pumped into the top of Tank One and when Tank One is full, the overflow goes into Tank Two.

Water pumping is highly site and need specific. What works for us here at Funky Mountain Institute may be needlessly expensive overkill for others. While we like our water system, it may not supply enough for huge gardens or watering large quantities of livestock. The one major lesson we learned is: If you are going to use a low voltage diaphragm style pump, then have a spare on hand and learn to replace it yourself. Richard Perez

Inverter Design Question Answered

You had a gentleman in Kenya requesting info on inverters, design and construction. I am an electrical engineer with 20 years experience in RF power engineering. About 5 years ago with the shrinkage in the aerospace industry, I decided it would be useful to bone up on inverters, as a possible entry into a commercial job.

For a long time I could not find ANY books on the subject, but finally came across the book *Power Supplies, Switching Regulators, Inverters and Converters* by Irving Gottlieb, published by TAB Books, now part of McGraw Hill. Professor Gottlieb, who teaches electrical engineering at UC Santa Barbara, comes close to a Forest Mims style with solid material, and lots of detailed schematics and parts lists. Dr. Gottlieb's other five books are on similar topics and and worth getting copies of (some may be out of print, but I saw that the *Power Supplies…* book has recently been reissued.) Philip Pesavento
E-Mail: ppesavento@sara.com

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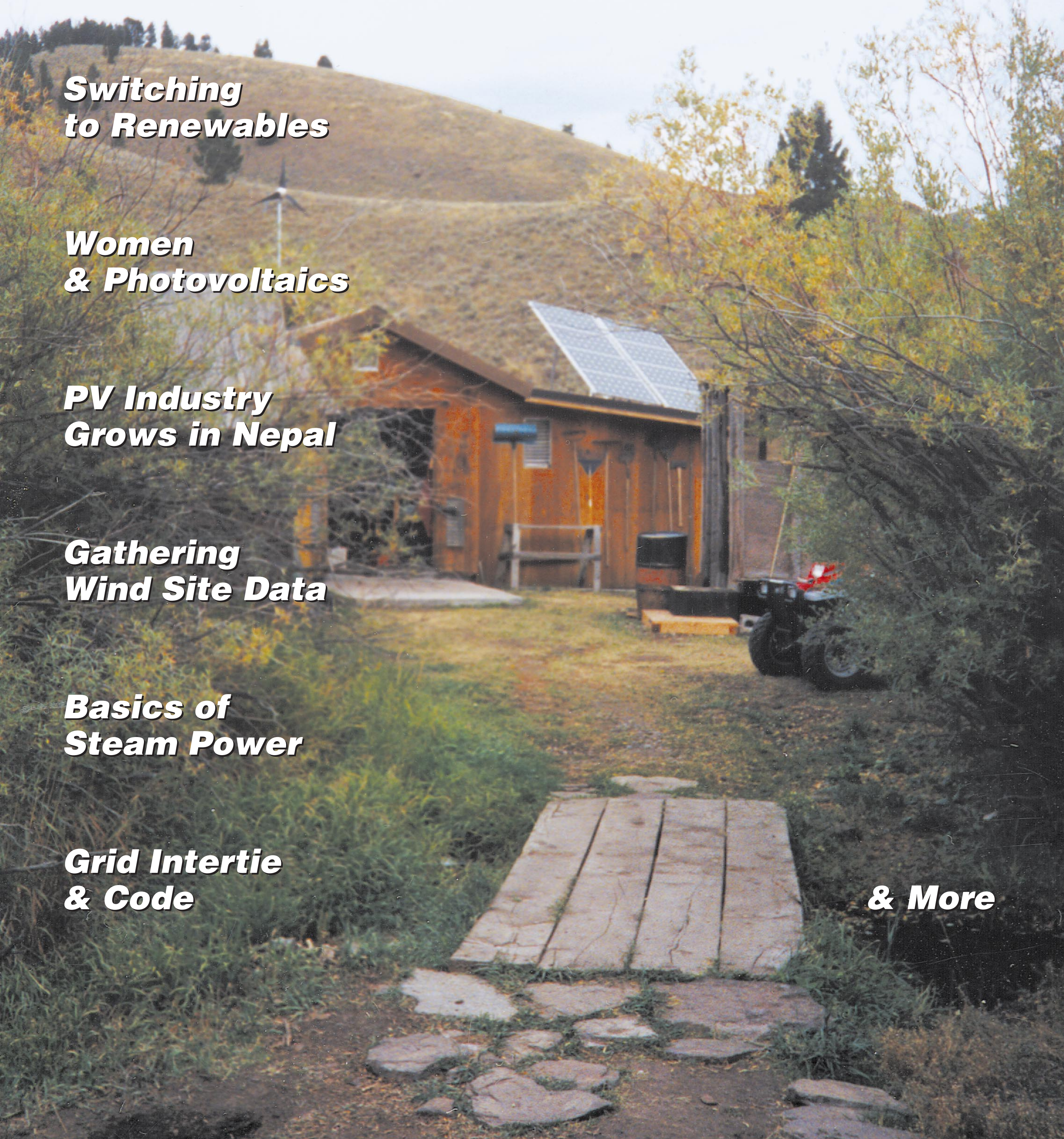

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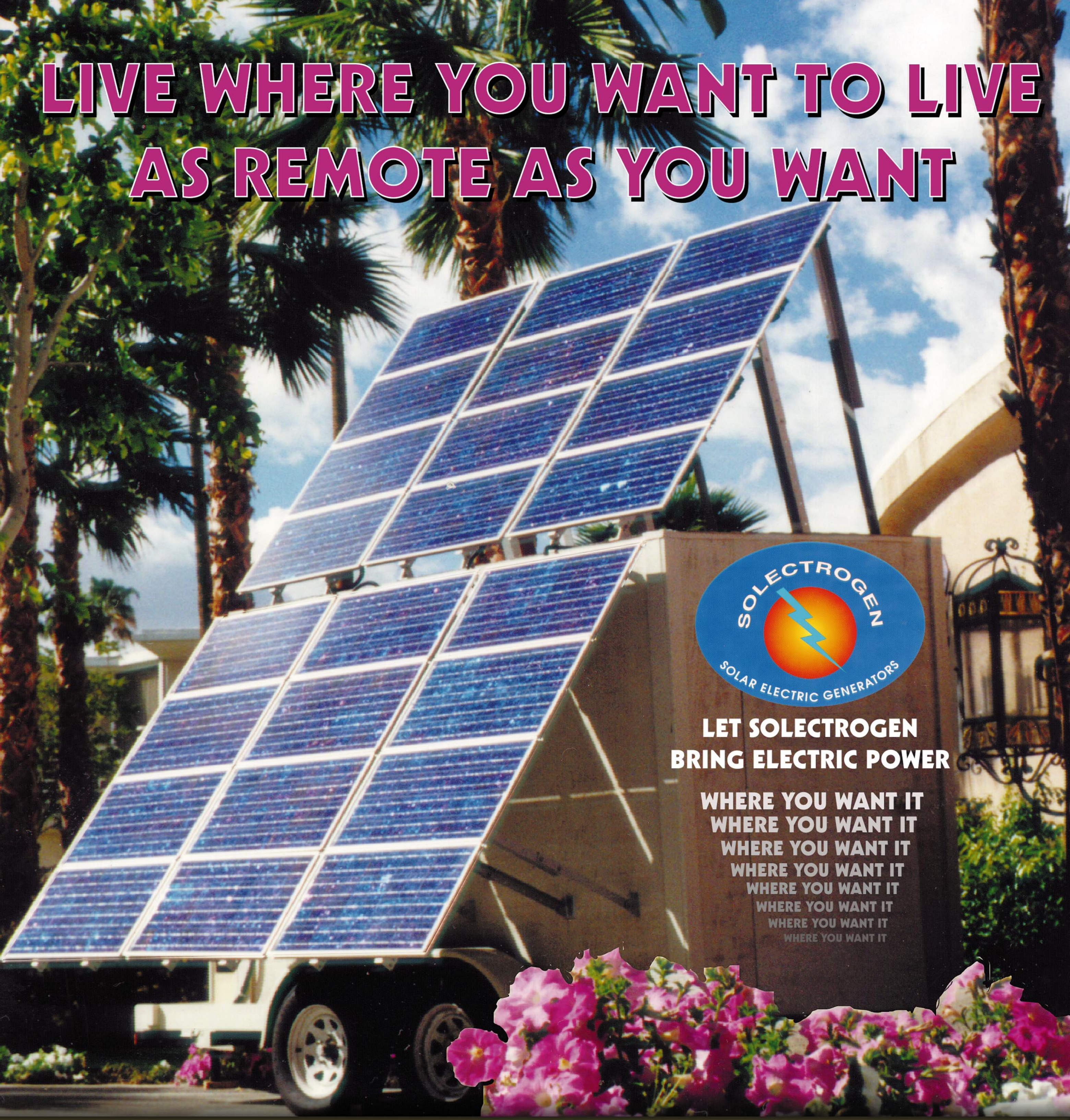

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