



HOME POWER

THE HANDS-ON JOURNAL OF HOME-MADE POWER

ISSUE #83

June / July 2001

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**Solar Electricity:
Finally Cost
Effective On-Grid**

**Classic Off-Grid
Solar in Oregon**

**Passive Cooling-
Part 2**

**Build Your Own
Voltage Monitor**

**Toyota Prius
Test Drive**



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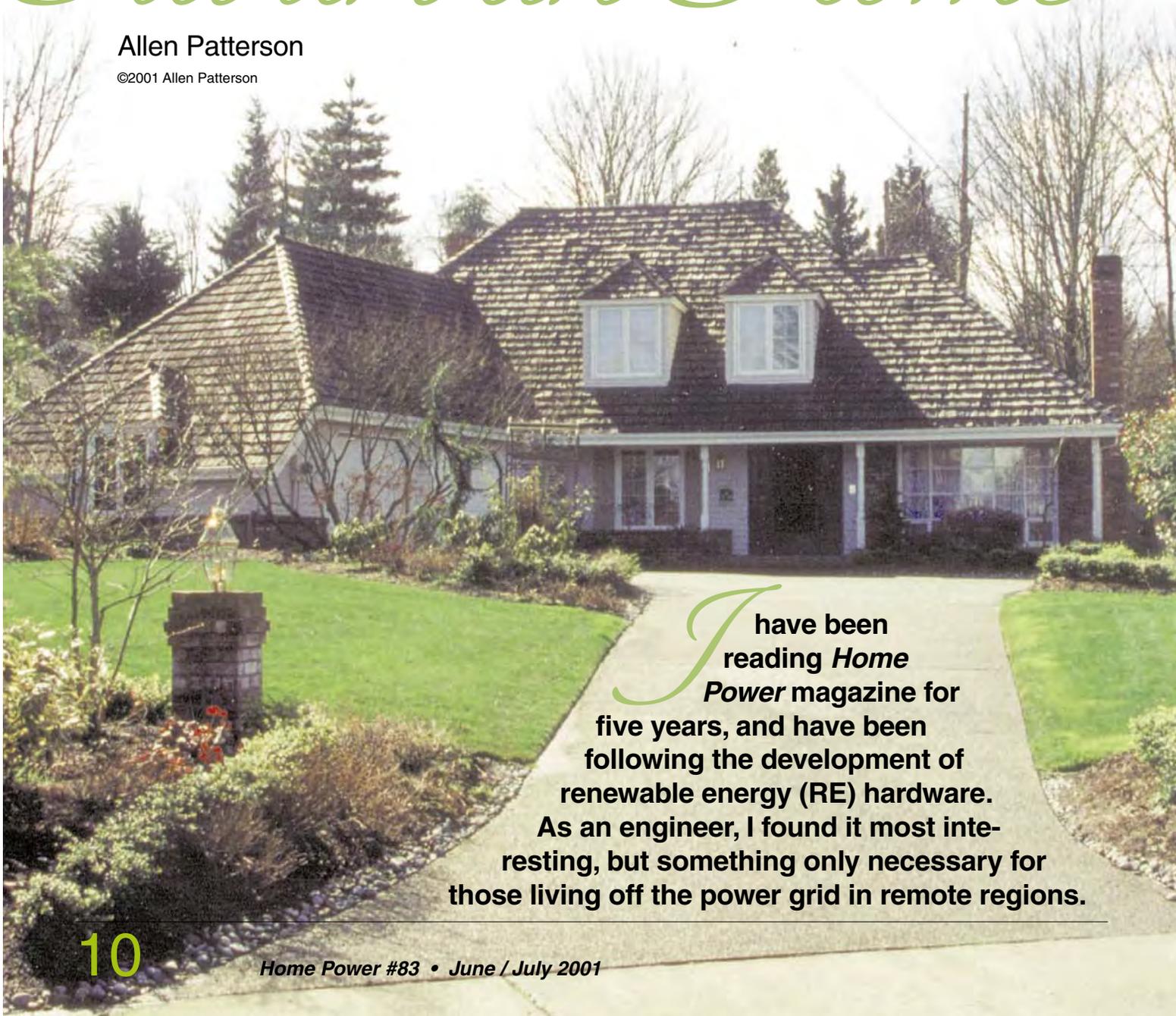
GoPower

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M. Tariq Iqbal built a beautiful electric trike to grant advanced mobility to his aging father, and he did it with the limited resources available in Pakistan.

Renewable Energy & Conservation in a Suburban Home

Allen Patterson

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I have been reading *Home Power* magazine for five years, and have been following the development of renewable energy (RE) hardware. As an engineer, I found it most interesting, but something only necessary for those living off the power grid in remote regions.

In the last two years, I slowly became aware of an impending power crunch. Power deregulation was being touted as the new way to reduce consumers' energy bills. California deregulated one side of the equation and left the other side regulated, and energy conservation seemed to have a very low priority. To me, this looked like a formula for disaster.

Modern Home

In December of 1999, I bought a fourteen-year-old home that had all the modern features. I wanted to add an RE system, using the south-facing roof for the PV array, and the oversized garage to contain the batteries and associated electronics. In July of 2000, I began the search for a qualified, experienced, and knowledgeable contractor.

I wound up contracting with Planetary Systems from Ennis, Montana. I explained to owner Bill von Brethorst that I was looking for blackout and brownout protection, and that I was concerned about possible rate increases. Little did I know! My home had a new chef's kitchen with two ovens, standard incandescent lighting, and all the normal appliances. I also wanted to be able to operate my amateur radio station (KC7SYR) in the event of an emergency. This all added up to a lot of energy.

I sent Bill digital pictures of my house showing the roof, location of the gas meter (for connection to the generator), and garage. He designed the complete system, and sent back specifications and pricing. We signed a contract on October 31, 2000, and equipment began arriving over the next six weeks.

Power Package

Planetary Systems' "Power Package" (patent pending) is a state-of-the-art system. It encompasses all of the advantages of previous renewable energy systems, without the inherent downsides of learning about and adjusting to new and highly technical equipment.



Sixteen AstroPower PV modules, for a total of 1,920 rated watts, are mounted on the south-facing roof above the greenhouse.

Utility input capability is up to 40 amps at 120/240 VAC, or 9,600 watts. Generator input is up to 30 amps at 120/240 VAC, or 7,200 watts. And PV input is up to 120 amps at 24 VDC, or 2,880 watts. Power Package output on the AC side is up to 60 amps at 120/240 VAC, or 14,400 watts maximum. DC output is available at 24 VDC up to 30 amps, or 720 watts.

The system arrived in two modules—a battery module and a control module. The control module, which

Author Allen Patterson keeps tabs on his RE system with digital metering.



Grid Intertied Photovoltaics

includes the Trace inverters, disconnects, charge controllers, grounding, and wiring, is completely assembled and tested when it arrives. This eliminates not only a good portion of the labor, but also a great deal of the frustration.

Planetary Systems personnel were on site mainly to help install the solar-electric panels on the back roof. With the Power Package, only a couple days of work were needed to install this relatively large system.

The rear (south) side of the house is focused on solar collection, with PV panels, a greenhouse, and garden beds.



The preliminary work was done by a local electrician. It included changing the house panel board configuration so that there would be a main utility panel and a house subpanel. This means that the selected utility-only house loads are isolated, and that the sell-back feature of the Power Package would feed a utility-only power panel, per Trace recommendations.

The Trace manual recommends setting up a subpanel for all circuits that you want to run with the RE system.

In our system, we ended up with only the two electric ovens, hot tub, and yard lights remaining on the main grid panel. Everything else was shifted to the subpanel. This gave us a system that can sell back power, import power from the utility grid, and still maintain the house power reliably, whether or not the utility is available.

The AC system setup uses plug-in connectors and flexible UL-listed cords. The electrician wired an input circuit from the utility, an input circuit from the generator, and an output circuit to the house main panel. These went to a junction box on the wall, and connected to the cords in the Power Package that were labeled for each use.

Each cord is mechanically coded, so wrong cords cannot be plugged into each other. A bypass mechanism is also built in, so that the inverter output to the house panel may be plugged into the utility supply, thus bypassing the inverter system. Each cord is "dead front" meaning no live parts are exposed. (The end with voltage is the female end, and the end that has no voltage is the male end.)

The system's modular containment design is extremely easy to maintain. It's much better than traditional systems with components mounted all over the garage walls, allowing access by unauthorized people. Dust and particulate matter normal to any garage is also kept out of the equipment.

Initially, the system operated as an interactive system without sell-back,



The main grid panel and subpanel with the automatic transfer switches for the ovens, below.



Solar array 40 amp breakers and Trace PVGFI-2 ground fault interrupter.

providing power to the house and purchasing off-peak power from the grid to charge the batteries. Once the system was inspected, both by the local electrical inspector and by Puget Sound Energy, a contract for sell-back was initiated and signed.

A ten-minute phone call to Planetary Systems was all it took to walk through the Trace inverter programming and initiate the sell-back feature of the system, which

has been operating in that mode ever since. The simplicity of the design makes it easy to operate this high-tech system.

Hungry Kitchen in a Smart Home

My kitchen has two electric ovens, one with gas burners and one with an attached microwave. I wanted to be able to get power to both when off the grid, but only enough to run the gas igniters on one oven and the

Planetary System's packaged electronics module provides drag and drop convenience.



The battery module provides vented containment for the twelve IBE lead-acid cells.



Grid Intertied Photovoltaics

Patterson Loads*

Unit	Watts
Hi-Fi	300
Furnace	223
Freezer	218
Refrigerator	204
Projection TV	192
Small TV	48
Total	1,185

* Other than lighting

microwave on the second oven. The electric ovens would be much too power-hungry to operate off-grid.

Two Todd Engineering automatic transfer switches were added to the design to switch the ovens from the grid panel (30 amp breakers) to the subpanel, using ten amp breakers with a twenty-second delay. This provides enough power for the igniters and microwave, but the breakers trip if the main electric ovens are used.

My home utilizes Smarthome technology for lighting, HVAC, entertainment, and security alarms. It uses a JDS Technologies Stargate computer with X-10 technology to control loads when off the grid. X-10 is a standard technology used by many manufacturers to send control signals over a home's wiring. The control signal is sent when the sine wave is at the zero crossing. The communication between the two Trace SW4024 inverters in the solar-electric system did not interfere with the zero crossing technology.

Appliances & Lighting

After the solar-electric system was installed, I began to look at where my power was being used. I added "Power Planners" to our fairly new refrigerator and freezer, furnace, clothes washer, and attic fan. These

The 8,500 watt Kohler backup generator runs on natural gas.



Generator, utility power, and main output breakers.

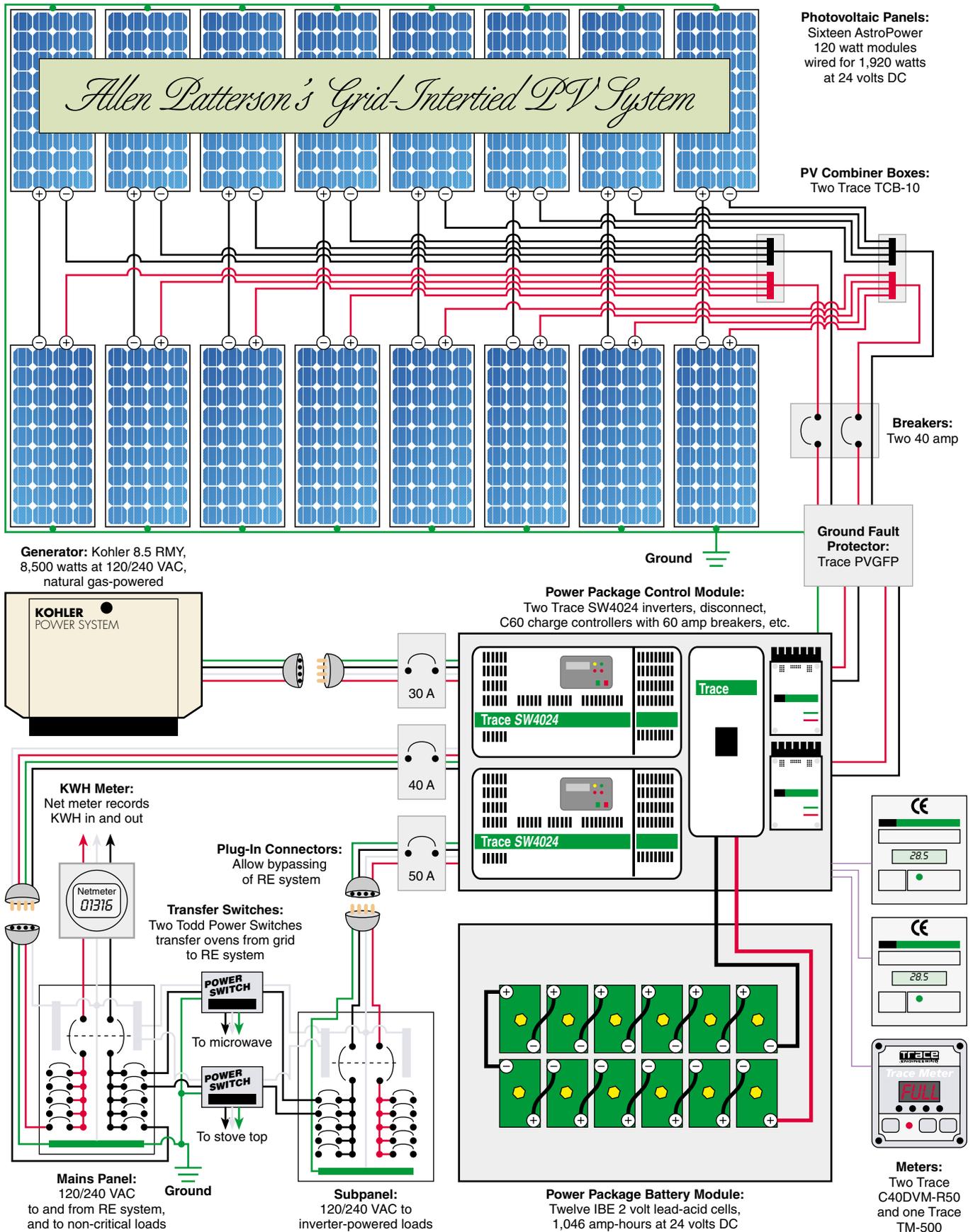
devices are made by EnergySmart, an Arizona company. There is some disagreement about the effectiveness of these units in some situations, but they did seem to result in a drop in energy use in my home.

Next I looked at lighting, which is a major load in most homes. I wanted to keep bright lighting available throughout the house, and still reduce the load as much as possible.

My in-house lighting total was 4,550 watts. Out of that, 790 watts would need to stay with incandescents. They were in bathrooms and the dining room, and the fixtures were not easily retrofitted with compact fluorescents. But 3,760 watts could be changed to dimmable compact fluorescent lights compatible with my X-10 Smarthome control system. These lights were used frequently, so significant savings was realized by replacing these with 713 watts of compact fluorescents—a 3,047 watt savings!

Power Savings: Incandescent vs. Compact Fluorescent Lighting

Area	Incandescent (Watts)	Fluorescent (Watts)	Savings (Watts)	Percent Savings
Den	650	111	539	82.9%
Bedrooms	1,040	182	858	82.5%
Kitchen	600	115	485	80.8%
Hallways	600	115	485	80.8%
Garage	600	129	471	78.5%
Library	270	61	209	77.4%
Total	3,760	713	3,047	81.0%



Phantom Loads & Always-On Loads

Item	Watts	WH per Day
Home telephone system	24	576
Computer, router, and hub	57	1,368
Satellite receiver	31	744
Small TV sets (4 watts each)	12	288
Projection TV	16	384
Furnace	13	312
Microwave & electric oven	17	408
Gas-top & electric oven	27	648
Battery chargers in shop	18	432
Other home battery chargers	45	1,080
<i>Total</i>	260	6,240
<i>Total KWH per day</i>		6.24

Phantoms

After dealing with lighting efficiency, I estimated close to 500 watts of phantom loads that I had to hunt down. I figured that I could reduce this significantly. See the table for the present state of my phantom load battle. The phantom loads add up, and they are hard to find.

I plan to put X-10 appliance modules in selected outlets for the battery chargers and have them automatically switch on for eight hours each week. The oven phantom loads are for the display and control electronics. There is not much I can do about them without changing ovens, which I don't plan to do.

Additionally, my Stargate system will automatically turn off certain loads in the event of a power grid failure, such as the instant water heater. The one gallon (3.8 l) instant water heater in my kitchen is a very nice device. It is not on very often, but when it is, it draws 660 watts. In normal operation, the Stargate system turns it off every night, and back on at 6 AM.

We have a mixture of incandescent and fluorescent lighting on the same X-10 dimmer circuit. As I push the dimming switch, the incandescent lights dim faster than the fluorescent lights. So I can easily dump much of the high incandescent load, and still have a majority of the fluorescent lighting on. If I continue to push the dimming switch, the fluorescents will continue to dim until they are completely off.

Utility & State are Cooperative

I was very pleased with the cooperation, encouragement, and enlightened attitude of the state of Washington and Puget Sound Energy regarding my renewable energy system. I dealt with Shannon McCormick, Program Manager for Energy Efficiency Services for Puget Sound Energy, who helped me obtain a contract for net metering.

Net metering is the law in Washington state, and the state feels that it is a win-win situation. By reducing the need for costly new combustion turbines, they can better serve a growing customer base. It also reduces their need to seek rate increases.

Renewable Insurance

This has been an interesting and rewarding project for me. As I dove into all the details, I became keenly aware of all the energy I was needlessly wasting—just like the majority of the population. My biggest load was lighting, which I reduced by over 81 percent just by changing to fluorescent lighting wherever possible. The savings was over 3,000 watts! I should have done this a long time ago.

My friends and family are slowly becoming educated about renewable energy. At first they questioned the wisdom of this kind of expenditure. But now they hear of major concerns for our area of the country—shortages of hydro power and natural gas, and the very real potential of brownouts and blackouts. This new awareness already has them buying Power Planners and fluorescent lights, which helps in energy conservation.

My system is working flawlessly. It's a little early in the game to have much hard data, but here's what I know so far: I use between 10 and 20 KWH per day depending upon how much the furnace, washer, dryer, and hot tub are used. This is a lot, but I started out with a traditional suburban house. I see now that if I were starting from scratch, I could do much, much better. Bill at Planetary Systems says that he runs a comfortable home on 3.5 KWH per day.

If the sun is out for five hours, and the array is producing 1,000 watts of solar power, it will provide for my needs during the daytime, and sell about 1 KWH back to the utility (when I keep my usage down to the

Patterson System Costs

Item	Cost (US\$)
Power Package model #2DS1, includes:	\$12,824
2 Trace SW4024 inverters	
2 Trace C60 charge controllers	
12 IBE 85N-21, 2 V, 1,046 AH batteries	
2 #PV120-8 solar packages, includes:	10,670
16 AstroPower 120 watt modules	
Trace PVGFP ground fault protector	
2 Trace TCB-10 array combiners	
Kohler 8.5RMY propane generator	4,544
Installation	3,065
<i>Total</i>	\$31,103



The utility meter records both incoming and outgoing kilowatt-hours.

Shannon McCormick of Puget Sound Energy gives the RE system the OK for intertie.



10 KWH level). During the summer, with longer days and more intense sun, I should be able to almost cover my needs around the clock. I don't have much data yet, but I plan to aggressively collect and analyze my data, and use it to improve my system.

I run a business out of my home, and I need to have the assurance that I will have electricity available at all times. Also, in the event of any disaster, I will have power for my ham shack for emergency communications. My renewable energy system is my insurance policy.

Access

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Puget Sound Energy, Shannon McCormick, PO Box 90868, Bellevue, WA 98009 • Energy Efficiency Hotline: 800-562-1482 or 425-454-2000 energyefficiency@puget.com • www.pse.com

R&I Electrical Contractors Inc., Ioane Aufai, 16202 89th Ave. NW, Stanwood, WA 98292 • 360-652-3623 Fax: 360-652-8228 • Electrician

Kelson Distributors, 13000 Bel-Red Rd., Bellevue, WA 98005 • 800-223-3808 or 425-453-1199 Fax: 425-453-1043 • Dimmable fluorescent lights

Smarthome.com, Inc., 17171 Daimler St., Irvine, CA 92614 • 800-SMART-HOME or 949-221-9200

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