Rethinking The Good Life

Christine Parra

Redwood Alliance's *Take Your Bedroom Off the Grid* workshop crew '99. This year—grid intertie. Author Christine Parra is on the lower right.

It had been a long, dark New York winter. Each morning, sleepy commuters, *Wall Street Journals* in hand, roused themselves from their morning naps as the train pulled into Grand Central Station. And each night, the Metro-North commuter train between New York and Connecticut made its trip back. I was one in an army of trench-coated, newspaper-carrying businesspeople. The spring day had been much like any other except that, in place of a newspaper, I held an issue of *Home Power* in my hand.

I had picked up a copy during a Solar Energy International workshop in Colorado the previous summer, and have subscribed ever since. I was tired of the *Journal,* which was so ubiquitous on the trains and in offices. I realized that there was more to life than constant earning and unbridled consumption, but couldn't identify it.

The Good Life?

I had made a model life: the executive house in the suburbs on 2.5 acres of land, sport utility vehicle, car, etc. There was, however, little connection with the seasons, no letup in the pressure to pay the huge monthly mortgage, little time for peace and reflection, extracurricular activities, or relationships. The illusion of wealth was accompanied by a severely impoverished quality of life.

But in this issue of *Home Power (HP22,* p. 26), I read about a group of people at Humboldt State University (HSU) who were making hydrogen from the sun and using it in a fuel cell. Something in the article struck me: these people were developing a technology that would make a clean, domestic hydrogen economy possible. I was inspired to move to California and study engineering.

I became a graduate student in Environmental Resources Engineering (ERE) at Humboldt State University in the fall of 1992. By the spring semester, I had enough background to complete basic tasks at the Schatz solar hydrogen facility as a volunteer. By the end of the 1993 spring semester, I was working as a paid employee at the Schatz lab, which I continued to do throughout my student years. After two more years of statistics, engineering, and design courses, as well

as calculus, physics, and chemistry prerequisites, I wrote a thesis and graduated with a Master's Degree in ERE.

Hydrogen Research

Peter Lehman and his colleague Charles Chamberlin direct the Schatz Energy Research Center, which is funded by a generous grant from Dr. L. W. Schatz, a retired businessman and self-made millionaire. The center has produced the only solar hydrogen fuel cell facility in the world, as well as America's first fuel cell powered car. The center's staff consists of a talented bunch of fifteen like-minded engineers and scientists, mostly graduates of the HSU Engineering program.

Those of us who work at the Schatz Energy Research Center acquired design, fabrication, and operating experience in solar electrolysis, fuel cells, integrated power systems, and programming. My own activities have included photovoltaic (PV) and fuel cell system design, marketing and economic analysis, budgeting, teaching, and even hands-on involvement with the hardware. Our projects have ranged in size from small, local initiatives to multimillion dollar, government-funded programs.

Take Your Bedroom off the Grid

In my eagerness to become more familiar with the hardware for small PV systems, this past May I attended a *Take Your Bedroom off the Grid* workshop. This weekend workshop was hosted by Redwood Alliance and taught by Johnny Weiss of Solar Energy International. Sharice Low and Chane Binderup of Redwood Alliance did an excellent job of organizing the workshop. Bob-O Schultze of Electron Connection and Joe Schwartz from *Home Power* rode herd on the installation portion and shared their expertise.

Johnny Weiss, Solar Missionary, is a master of RE education and instructor of many of SEI's workshops. Experience him if you can.

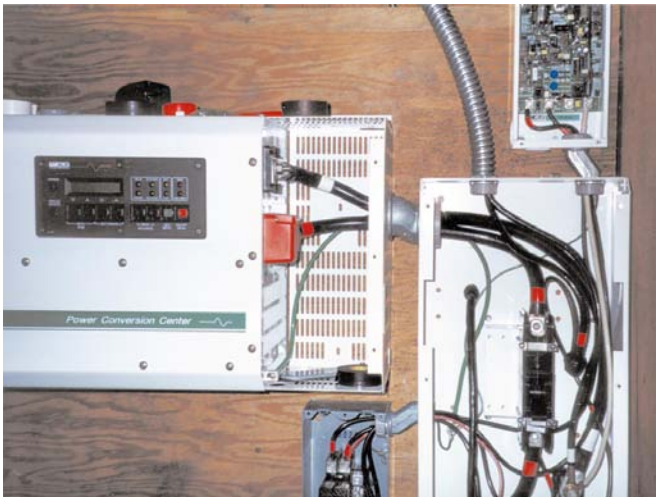
Jay Peltz of Alternative Energy Engineering helps students get their hands on renewable energy equipment.

The main goal of the workshop was to show people how to take advantage of the modularity of PV systems. You can start slowly and gradually increase the size of the system as more cash becomes available. This article contains ideas from the course that might help you with your PV system design. These ideas might also help you design some other parts of your life.

Independence & Conservation

Renewable energy systems are dependable, quiet, and clean. They make independence possible, and encourage conservation by making you aware of your use of resources. With RE systems, you have a limited amount of energy available for consumption. You have no choice but to be in touch with natural cycles. You can't have a small PV system and be careless or inattentive. You have to be thoughtful about your activities.

Are we ready to apply these ideas to other parts of our lives too? To figure out the difference between true needs and desires? To understand the difference between standard of living and quality of life? To stop chasing material goods to achieve happiness? To apply technology thoughtfully? To look at how we produce (in largely mechanistic, repetitive, specialized jobs) and consume (often in programmed and isolating ways with destructive results)? Are we ready to change? To earn less, use less, and have a greater connection with the natural world? Maybe—you can decide for yourself, based on the following points covered in the course.



Demystifying RE installation is one main workshop objective.

Know Your Resource and Determine Your Load

You really haven't started a PV design until you've found out how much solar energy is available to you and how much energy you need for your lifestyle. This is called determination of resource and load profile.

The resource is pretty much set. The larger question is how you decide to use what is available and how much you want to pay for certain conveniences. Remember, it's costing us all the time we work during our lives to earn the money we need for our lifestyles. It pays to consider resource versus load.

Don't Make More, Use Less

It turns out that using less is easier than making more. As you're designing your renewable energy system, you'll find that you pay quite dearly for small conveniences. This doesn't mean that you shouldn't make your system large enough to make you and your family comfortable. But it pays to think twice about each habit.

Have you ever calculated how much money it takes to satisfy your minimum needs? Or calculated the actual cost of certain habits (let's be fair—dollar cost to you as well as impact on the planet)? Have you tried measuring that cost in hours at work or in stress?

Here's a secret that I've discovered since exiting the rat race: if I consume less, then I need to buy less and I need to earn less money to buy it. In addition, I have a smaller impact on the world. Or, taken one step further, if I consume just enough to satisfy my spiritual and physical needs (as opposed to my media-fabricated desires), then I spend less time earning and more time hiking, dancing, and playing music.

This is the difference between "quality of life" and "standard of living." Which makes me happier: to be doing things each day that I enjoy and learn from, or to have as many material goods as I can accumulate in a lifetime?

Remember also that the goal of maximum convenience can cause amazing amounts of inefficiency and some

A Small Residential PV System

In Redwood Alliance's *Take Your Bedroom off the Grid* workshop, we had the opportunity to get some hands-on experience with multimeters, batteries, and photovoltaic panels (PVs). On the last day, we installed a system at the house of two renewable energy enthusiasts, Elias Elias and Gretchen Ziegler.

The couple had attended the *Take Your Bedroom off the Grid* workshop two years ago and had wished for their own system ever since. By the time the course participants arrived on site, most of the preparation work had been completed and the system was ready to be installed. Participants had the opportunity to attach the panels to the rack, wire them together, and mount the rack on the roof. We also connected the charge controller, inverter, and batteries, and then the E-Meter—the user interface.

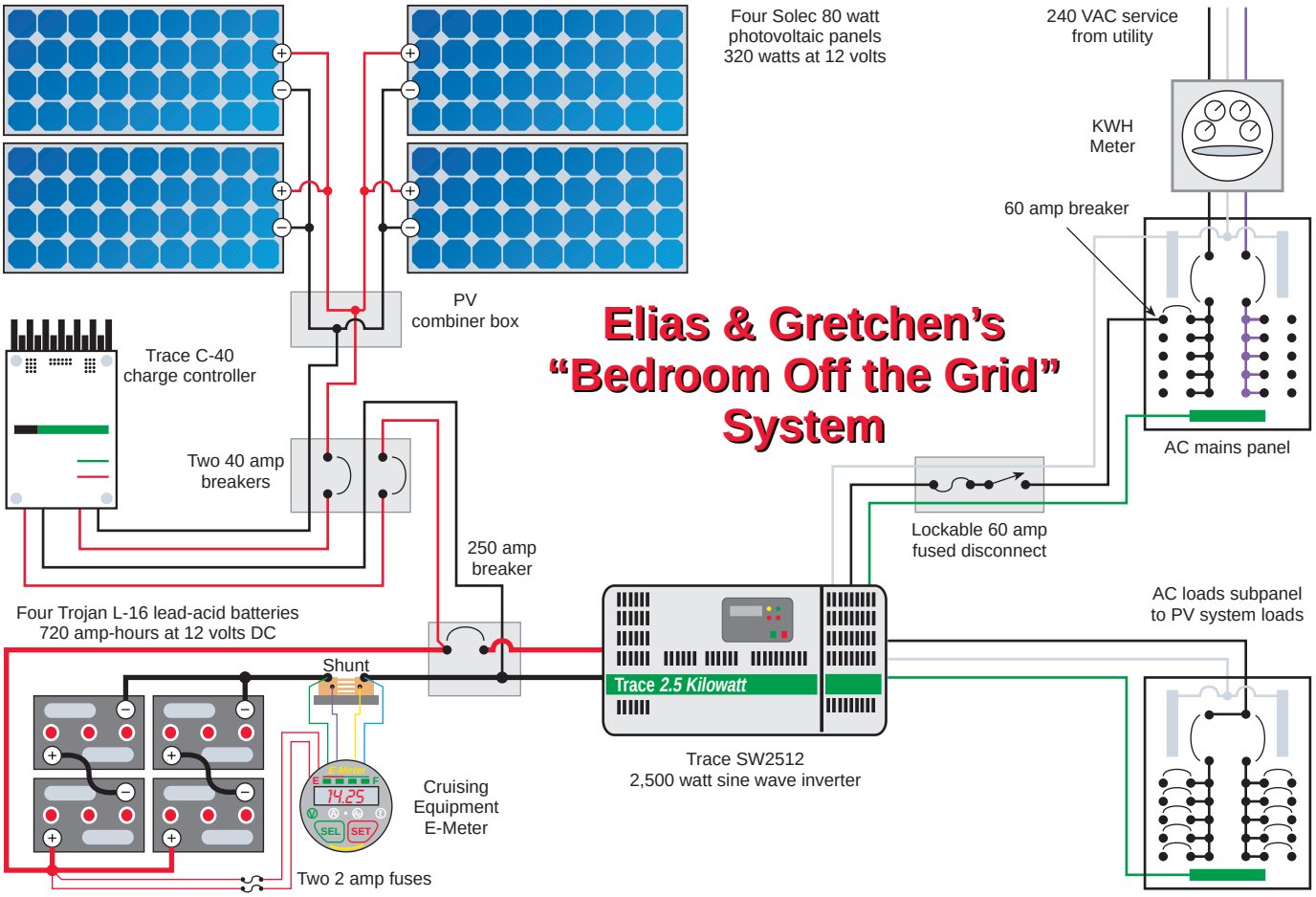
The system contains four Solec 80 watt modules (as many as the owners could afford) and four 6 volt Trojan L-16 batteries wired in two series pairs for a capacity of 700 amp-hours at 12 volts.

Gretchen and Elias wanted to be able to add more PVs later, and to tie the system to the grid, so they needed a synchronous inverter. They decided on a Trace 2.5 KW unit, which allows for expansion and puts out power clean enough for the grid. The system also contains a Trace charge controller and an E-Meter, which displays system current and voltage, as well as amp-hours left in the batteries. Balance of system components include breakers, shunts, cables, connection boxes, and miscellaneous hardware and conduit.

What's the Cost?

The total retail cost of the system was US$7,211 (see the cost table). In the somewhat cloudy climate of Arcata, which gets an average of about 4.4 peak sun hours a day, the system will provide 1,200 watt-hours of energy on an average day (68.9 W x 4 modules x 4.4 peak sun hours per day). Note that I've derated the power output of the modules to PVUSA test specs.

Homeowners installing PV systems in sunnier climates will have higher output due to greater insolation, so the



Elias & Gretchen's "Bedroom Off the Grid" System

system life cycle cost will be lower. The cost per KWH for a system installed in the desert would be 68 percent of the price of a PV system installed in Arcata, because there would be as many as 6.5 peak sun hours per day.

Elias and Gretchen completed all of the documentation necessary to sell power back to the grid. According to Assembly Bill 1755, any California consumer of electricity and owner of a system less than 10 KW in size may sell as much power back to the utility as s/he consumes. The utility company must pay the market rate for the power. You run your meter backwards, a concept called net metering.

This makes possible a minimum monthly electric bill of five dollars. As described above, the system will produce about 1.2 KWH per day. Pacific Gas & Electric (PG&E) charges 13.321 cents per KWH to residential consumers of electricity in Arcata, California. So the total gain of net metering for Elias and Gretchen's system will be about 16 cents per day, or about US$59 per year.

Subsidy & Credits

Elias and Gretchen also decided to take advantage of the California Emerging Renewables Buydown Program. The California Energy Commission (CEC) offers rebates of up to US$3 per watt or 50 percent of the system purchase price (whichever is less) to those who install PV or wind systems. The applicant must derate the PV modules slightly (based on PVUSA tests) and account for inverter inefficiency. Qualified equipment must be used (see list on CEC Web site).

The allowed power rating per module turned out to be 68.9 W for the Solec 80 W modules and the allowed Trace inverter efficiency was 90 percent. At the current offering of US$3 per watt, this produced a rebate of US$744 (68.9 W x 4 modules x 90% x US$3/W).

Finally, there is a 10 percent investment tax credit available from the federal government for solar electric, solar heating/cooling, or geothermal electric power equipment (use Form 3468 and report the answer on Form 1040, line 47). Keep in mind that you have to reduce the basis of the property by the amount of other

The fun part—puttin' panels on the roof.

questionable system design. Think about convenience first and you wind up dragging oil from the Persian Gulf in order to drive your car six miles down the road to the school or store.

Our Resources Are Not Infinite

With a renewable system, you buy a bucket of energy. You no longer behave as if you were connected to an infinite grid. If I behave as though all resources were limitless, my behavior is not sustainable. Well—face it—we're not connected to an infinite supply of anything. But this is not actually bad news. A change in consciousness can lead to enjoying living with less.

Do you remember from childhood what life was like when time was infinite? A change in consciousness could produce uncluttered minds and houses, more freedom, independence, and time. Such a shift is akin to the form of medicine that uses pleasure to cure addictions—life feels so good that after a while you forget about what you had to give up.

Not Every Technofix Is Useful

Just because you can do it doesn't mean it's a good idea. Elegance and simplicity are often more valuable than incorporating a lot of expensive, highly developed technofixes in your system—and in your life.

Consider this: my partner and I recently went to buy a refrigerator for our new house. The store offered a dizzying variety of options: 18 to 30 cubic feet (0.5–0.8 m^3); with an external or internal icemaker or without any icemaker; with the freezer on the bottom, side, or top; highly efficient or not efficient at all; and black, white, or stainless steel.

What is it that made me wish for the largest, top-of-the-line model? Did I think to ask, "What are my exact requirements and how much of a refrigerator do I truly need?" It's easy for me to say that California's gasoline prices are too high. But rarely do I take offense at a salesperson's suggestion that I "deserve only the best," even though it'll cost me (and the environment) dearly. What if "the best" is not the biggest, most expensive, or most advanced, but just what fills my specific need?

There's No Substitute for Common Sense

If you're about to put in a PV system, know your site. Go there, live there if you can, get to know when and where the sun rises on the property at different times of the year and understand when you'll need the most power. Keep in mind that no two renewable energy systems will be completely alike, because all sites are different and all load profiles are different. There's no

subsidies (such as the US$744 from the CEC). In the case of our two homeowners, this credit is equal to US$647 [10% x 7,211 x (1-744/7,211)]. This slightly convoluted way of calculating the credit can be found on the IRS Form 3468 and in its instructions.

Compare the Cost

We know that it's not fair to compare renewable energy to fossil fuel energy economically. Fossil fuels carry a political cost, economic risk, and high government subsidy. The technologies that allow us to use fossil fuels are highly developed and have had many years to become less expensive. The extraction and burning of fossil fuels produces emissions that affect our health as well as the quality or our air, water, soil, and climate.

However, most consumers will compare the cost of grid power to the cost of power from a home PV system. So, let's see if the net metering, California rebate, and federal tax credit made the price of the PV system power competitive with that of grid power. This is accomplished by a life cycle cost analysis. I won't show the details here, but here are some highlights:

	With Batteries	*Without Batteries*
System Cost	$7,211	$6,231
CEC rebate	-$744	-$744
Federal investment tax credit	-$647	-$559
Net upfront cost	$5,820	$4,928

For the analysis, I assumed that there was a positive cash flow from net metering of US$59/year (described above), a 25-year life of the system, battery bank replacement every eight years (for the scenario that includes batteries), a discount rate of 5.5 percent, an

System Costs

Item	*Cost (US$)*
Trace SW2512 inverter	$2,445.00
Four Solec modules, 80 watt	$1,796.00
Four Trojan L-16 batteries	$792.00
Two Seas universal rack, 6 module	$460.00
Trace DC250 breaker	$275.00
E-Meter with shunt	$198.00
Trace C40 charge controller	$145.00
Misc. hardware and conduit	$115.68
A.E.E. SWCB conduit box	$85.00
Two #4/0 inverter-battery cables, 8 foot	$74.00
#6 wire, 230 feet	$64.40
AC subpanel	$53.15
#2 wire, 67 feet	$36.85
Four #2/0 battery interconnect cables	$32.00
Combiner block for PV	$22.25
Grid disconnect with box	$20.42
6 by 6 by 4 inch rain-tight box	$20.00
2-circuit breaker box	$17.50
E-Meter wire, 20 feet	$15.40
Two 50 amp DC breakers	$13.90
Shipping for rack	$12.00
Twelve Carflex fittings	$11.88
60 amp AC breaker	$11.25
6 by 6 by 4 inch elect. box	$8.20
Labor donated	$0.00
Total	$6,724.88
Sales tax	$487.55
Grand Total	$7,212.43

Elias and Gretchen are proud parents of a grid-intertied photovoltaic system which produces clean energy.

easy answer, and only your thoughtfulness can give you the system that's right for you.

In our own lives, there's nobody to tell us when we're wasting our hard-won resources of time and money. The average American spends about fifteen hours a week in front of the TV, and makes numerous purchases that may only meet the criterion of immediate gratification.

We're In This Together

PVs come from corporations. Pick your favorite polluting, government-subsidized, fossil fuel company. And I hope that these corporations make money at their PV production. Because that's how change will happen—when we make it profitable to do the things that have a smaller impact on the environment.

inflation rate of 3 percent, an interest rate of 2.5 percent, and a salvage value of the panels of 10 percent of cost. I used the Sandia Labs method for computing life cycle cost.

Based on these assumptions, the life cycle cost was US$0.93 per KWH for the system with batteries and US$0.31 per KWH for the system that did not have batteries. In the desert, the cost is US$0.21 per KWH for the system, excluding batteries. These prices can be compared to the PG&E price of US$0.13.

Note that I've done the analysis with batteries and without them. Many consumers who are connected to the grid may elect not to include batteries in their systems. Some people like batteries because they allow the system to provide power when the grid is down. I would recommend careful consideration because such a convenience carries a hefty cost.

One of the main points brought out in the workshop was that batteries are the most common cause of problems in PV systems. In addition, they are expensive and bad for the environment. Using the grid to store PV electricity is easier if you are already connected anyway (especially if you wish to provide only a portion of your power with PVs). As shown in the analysis, the batteries nearly triple the system lifetime cost, even when you assume a very long battery lifetime.

Gretchen and Elias were fortunate enough to be able to fund their whole system. But the great thing about PV systems is that they can be simple or complex, small or large. An investment of $50 a month can be the beginning of clean electricity for an entire family—and a cleaner environment for everyone. It's our choice.

No matter what ideals we hold, most people need and wish for similar things in life: satisfaction of human needs for food, clothing, and shelter; a sense of belonging, love, personal growth, and play; and connection with the natural world. When we work together and lead thoughtfully examined lives, we can meet our own needs without jeopardizing the ability of others (present and future) to meet their own needs.

Newton said that "a system will remain in equilibrium until a net force acts upon it." Renewable energy can be the net force that acts upon our collective consciousness in favor of change. Living with renewable energy is a great way to make us aware of everything else that we consume. It renews our respect for each other and our reverence for our planet.

Access

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