

# Walking the Talk

**Michael Welch**

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## Energy Group Gets Solarized

Redwood Alliance (RA) is a community-based social and environmental organization whose main focus is advocacy and education to promote safe and efficient energy use and development.



Twenty-four Shell Solar, 130-watt solar-electric modules provide energy for several businesses in this building in Arcata, California.

Integrating the panels into the building design offered the perfect opportunity to showcase the system to the public.

Founded in 1978 in Arcata, California, RA's original goal was to stop the reopening of the Humboldt Bay Nuclear Power Plant near Eureka. After that success, RA's focus shifted to working on the safe storage of the old, irradiated nuclear fuel that is still on site there, and the eventual decommissioning of the plant.

But RA, where I work as a volunteer, found that being anti-nuclear was not enough—we needed to show that safe, effective, sustainable alternatives to nuclear energy existed. On that front, RA began advocating for and educating about renewable energy (RE). Dozens of workshops, energy fairs, public meetings, and other forms of community publicity have helped put Arcata on the RE map.

Since the early '90s, one of the goals of RA has been to generate our own electricity using solar energy and to demonstrate the technology to the community. This is a very difficult accomplishment for a grassroots nonprofit on a tight budget, and in the situation of being a renter. But in the last couple of years, several circumstances came together to finally achieve this goal.

### *System Starts*

Several times over the last fifteen years, we had attempted the task, and each time were foiled either by lack of equipment or by an unfavorable landlord. Getting donations was very tough because lots of deserving nonprofits and projects are out there, and after awhile we became pretty discouraged.



**This state-of-the-art installation provides clean, renewable energy and serves as a fantastic demonstration system for the public to see firsthand.**

## **PV System Tenants**

Besides generating electricity for RA, two other offices housed on the second floor of the building also benefit from the solar-electric system installation.

Like RA, Center for Environmental Economic Development (CEED) is a nonprofit organization. For more than ten years, CEED has worked as a catalyst for environmentally sustainable community development. CEED's work in sustainability is divided into seven project areas, including RE and Climate Change, Green Building and Sustainable Tourism, and Sustainable Materials and Zero Waste.

Visual Tattoo (VT) is the first known solar-powered tattoo parlor in the world. In February 2005, VT artists Dean Shubert and Brian Kaneko designed a special tattoo to commemorate the solarization of the business. The solar-electric system supplies energy for area lighting and task lighting, and the electricity for needles, which each draw about 100 watts. (What's a tattoo customer's least favorite word? "Whoops!")

Then we moved to a building with a landlord who loved the idea of solar energy. We decided to try anew and began putting out feelers about getting equipment donations, or obtaining equipment at a substantially reduced price.

After spending more than a year working with various PV manufacturers with no luck, we were again on the verge of giving up. Then we heard that Shell Solar, which had recently purchased Siemens Solar, had some modules with the former company's name on them—and they were willing to give them to our organization. We received a wonderful donation of forty-eight, 130-watt modules.

### *Designing a Showcase System*

With the all-important module donation in hand, we knew we were most of the way home. We could now figure out what kind of system we wanted and start designing it. First, though, we worked on improving our energy efficiency, adding task lighting for each desk in the office, replacing standard fluorescent fixtures with energy efficient T-8 fluorescent lighting throughout the building, and swapping out a CRT computer monitor with a low-power ViewSonic LCD display.

We wanted to showcase both batteryless and battery-based grid-intertie systems in this demonstration system. An off-grid system uses nearly identical components to

## Tech Specs

### System Overview

**Type:** Battery-based, grid-tie PV

**Location:** Arcata, CA

**Solar resource:** 4.4 average daily peak sun-hours

**Production:** 320 AC KWH per month

**Utility electricity offset:** 100 percent

### Photovoltaics

**Modules:** 24 Shell Solar SP130-PC, 130 W STC, 33 Vmp, 24 VDC nominal

**Array:** Eight, three-module series strings, 3,120 W STC total, 99 Vmp, 72 VDC nominal

**Array combiner box:** OutBack PSPV, 15 A breakers

**Array disconnect:** OutBack PSDC, 60 A breaker

**Array installation:** Direct Power & Water LPRGM mounts installed on SSW-facing balcony, 50-degree tilt

### Energy Storage

**Batteries:** Twelve Concorde PVX-1080T, 12 VDC nominal, 108 AH at 24-hour rate, sealed AGM

**Battery bank:** 48 VDC nominal, 324 AH total

**Battery/inverter disconnect:** 175 A breaker

### Balance of System

**Charge controller:** OutBack MX60, 60 A, MPPT, 72 VDC nominal input voltage, 48 nominal output voltage

**Inverter:** OutBack GVFX3648, 3,600 W, 48 VDC nominal input, 120 VAC output

**System performance metering:** GE CL200 KWH meter, WinVerter PC software, OutBack Mate



**The installation crew mounts photovoltaic panels on the second floor balcony.**

to install two separate systems—one for each meter—so that we would not be overpowered and give away too much excess energy to the utility. California's net billing law allows us to annualize PV production versus energy consumed. So summertime's higher production can make up for fewer watt-hours produced during the winter season. The effect of this is that the customer is paid at retail price for all power produced, up to the amount consumed over a year, and any excess energy produced is "donated" to the utility. For our 6,240 watts of solar panels, having two meters on this building created a perfect situation in matching our electricity production with our electricity consumption.

### The Process

We decided to start with the battery-based system, to be attached to the meter for the upper floor, which houses RA and two other businesses.

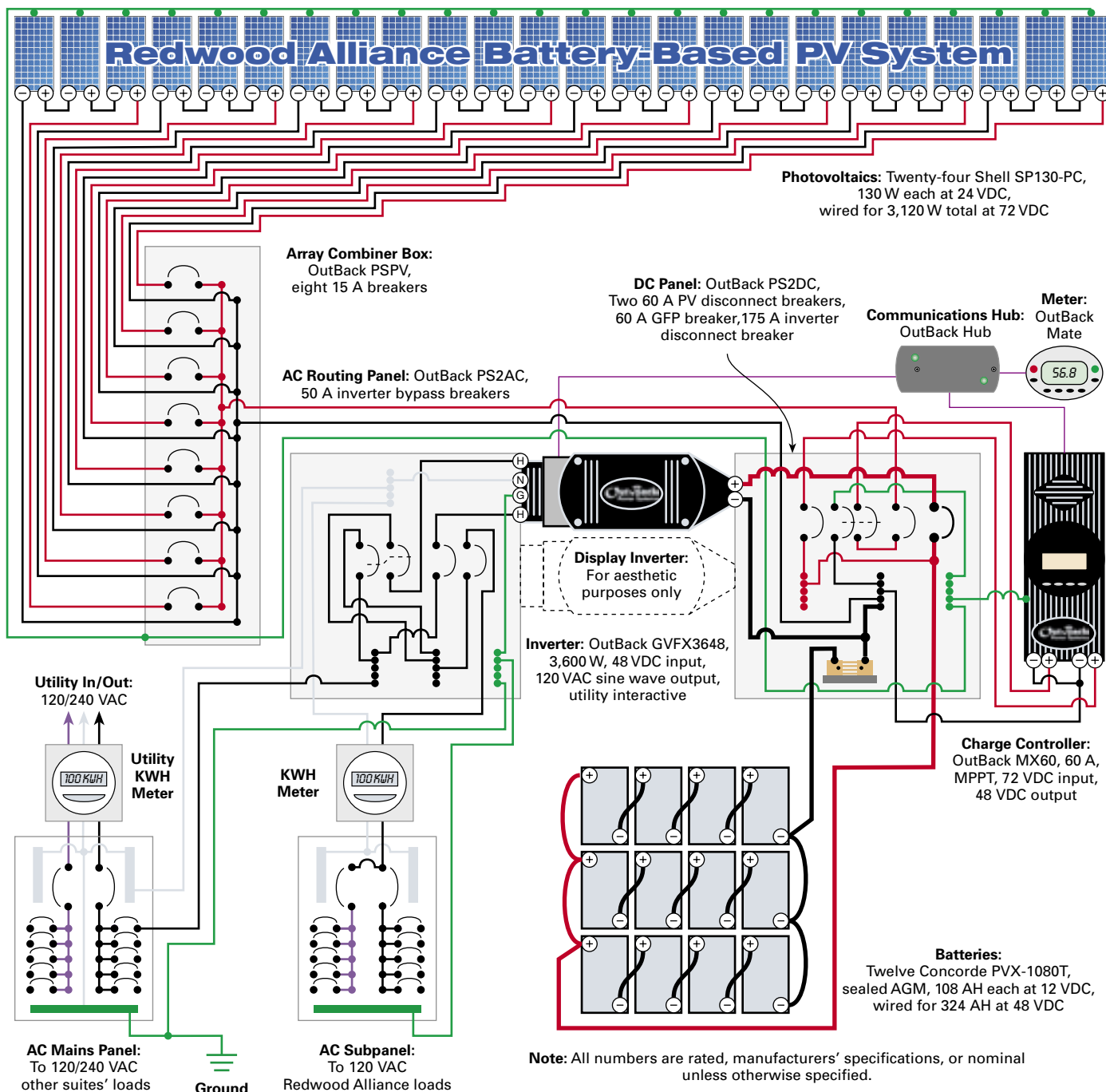
But before we could start, we needed to begin the application process to reserve our state rebate, which would cover costs for equipment and labor that would not be donated. Although we were working with OutBack Power Systems to source equipment, their inverters were not yet approved under the rebate program. Instead, we substituted a different, approved inverter for application purposes. Once a rebate application is approved, it is permissible to switch to other approved equipment, and we kept crossing our fingers that the inverters we selected would qualify before we needed to start the installation.

It took almost a year to line up the rest of what we needed and design the system around that equipment, giving OutBack plenty of time to complete their certification

a battery-based grid-tied setup, so for demonstration purposes, our battery-based system covers both applications. Even though Arcata does not experience frequent or prolonged utility outages, we are surrounded by areas that do, and surrounded by areas with no utility service at all. Demonstrating a system for the off-grid community was important to us. And as we eventually found out during a recent outage, it is very nice to be able to keep working right through a blackout. We would be able demonstrate either type of system—on grid or off grid—with a flip of the switch that controls the utility connection.

Two utility services with separate KWH meters, one for each floor, serve the building we rent space in. We wanted





and ETL-listing processes. Batteries are not covered under the rebate program, and just as we were about to purchase some at a huge expense, Concorde Battery Corp. donated twelve Sun Xtender sealed batteries perfect for our indoor installation. OutBack donated an MX60 charge controller, a Mate remote monitor and control, and a PSR battery rack, and gave us the normal discounts they give all nonprofits on the rest of the equipment we needed.

Since this was a demonstration system, we really wanted to show off the modules. A south-facing balcony runs the entire length of our building on the second floor. It was the perfect place to show off PV panels since it is visible to a major street and a well-used sidewalk. We approached

the City of Arcata's design review committee with our proposal, but they really didn't like the idea of PV modules just hanging off the building. They wanted the array to look more like a conventional awning, and even asked for triangular side covers, ornamental mount legs, and cute awning skirts. We talked them out of the custom legs by assuring them that the support system would be hidden entirely behind the modules, but agreed to their other ministrations to keep the project moving forward. After the array was installed, they agreed that it looked great without the previously required embellishments.

From poring over the building's blueprints, we could not be certain that our balcony would handle the extra

## Battery-Based System Costs

Item	List or Street Price (US\$)
24 Shell Solar SP130-PC modules	\$14,229
OutBack GVFX3648 inverter	2,345
Miscellaneous wire, conduit, electrical	2,265
12 Concorde PVX-1080T sealed batteries	2,100
Labor, PV system installation	1,763
DP&W LPRGM6-SQ roof mounts	1,568
Labor, AC electrical site preparation	1,145
Engineering for balcony installation	875
OutBack MX60 charge controller	649
OutBack PSR battery rack	649
Lumber, steel & carpentry for balcony reinforcement	512
OutBack PS2DC with 175 A breaker	385
OutBack PS2AC with 50 A bypass breakers	385
OutBack display inverter, no innards, with covers	329
Permits & documentation	306
OutBack Mate system display & controller	295
Cables for batteries & inverter, 2/0	198
OutBack HUB4 communications manager	195
Miscellaneous hardware	161
OutBack PSPV array combiner box	139
Scaffold & tool rental	131
OutBack OBDC-GFP/2 ground fault protection	129
OutBack PS2MP power system mounting plate	129
8 OutBack OBPV-15 breakers for combiner, 15 A	96
OutBack PSR-SK battery rack shelf kit	89
OutBack PSR-SZ4 battery rack seismic kit	89
3 OutBack PSR-SCT battery rack trays	87
OutBack PSR-HDT battery rack HD top	79
2 OutBack OBDC-60 breakers for controller, 60 A	58
Square D DU221RB utility disconnect	48
Cutler-Hammer 2-100 breaker	46
Cutler-Hammer 8-16 load center, 125 A	41
<b>Total</b>	<b>\$31,515</b>

weight of the PV system cantilevered from it, and we were not sure what kind of extra wind loads the system might create. The blueprints showed that the balcony wall was attached to the walkway merely with Simpson Strong-Tie clips, though none of that could be seen through the stucco. Visual inspection showed the 4 by 6 posts were strictly ornamental, and not able to support anything.

Our engineer calculated that the potential for wind loads would be minimal compared to the weight problems. The 24 modules and their rack would add about 1,300 pounds (590 kg) to the balcony structure, some of which would be levering downward from several feet out and applying lots of outward torque to the balcony wall. We made some suggestions to the engineer, who calculated them out and approved our solution of adding thick, steel reinforcement plates to both sides of the balcony posts, attaching them to the heavy glue-lams top and bottom, and then adding 2 by 10 Douglas fir top plates to the balcony wall, running 24 feet in unbroken lengths between the posts. The new top plates would keep the array mounts in line, the posts would keep the top plates from moving outward, and the steel plates would tie it all to the building. With a system design, stamped engineering, and an OK from the City's design reviewers, we finally got our permits.

### Construction Ready

We ordered the steel plates and specialty lumber, and started construction. The local Blue Lake Rancheria tribal authority's head of construction, Bruce Ryan, oversaw the crucial balcony reinforcement. Next, our installer Roger and his crew, along with our volunteers, went to work mounting the PV subarrays. It turned out that eight subarrays of three modules (72 V nominal) in series would be a great match for a single MX60 controller (converting to 48 V nominal for the battery bank) with the 3,600-watt OutBack GVFX3648 inverter, and perfect for the length of our balcony. The balcony has just enough room left at one end for the future sign touting the system, and a little empty space on the other end where, ironically, a utility pole would have shaded the end of the array each midafternoon.

After some deliberation, we decided that looks were as important as performance for this demonstration system and set the module tilt at 50 degrees instead of at 40 degrees, which is optimal for our latitude. Hopefully, this will help folks with concerns about the aesthetics of a PV system accept this technology.

Next, we needed to figure out how to best show off the electrical equipment and the bank of batteries. We wanted a very clean-looking installation, so we decided to go with the OutBack PS2 power system rack. For a simple and neat installation, this system combines all the inverter-related components onto a backing board, including the charge controller, the inverter, both AC and DC disconnect enclosures with breakers, the OutBack Mate communications-display module, and the OutBack Hub (which allows the Mate, inverter, and controller to interact). The PS2 system is capable of handling two inverters and charge controllers, for double the size of our system.

To best display the system, we decided to put the power system in our office space. Our biggest concern was that noise from the variable-speed fans in the inverter and charge controller would disturb our work. The fans go on and off individually, and vary in speed as the amount of heat to be dissipated fluctuates. Clearly, these components do not belong in living or work spaces where noise is a concern,

but for our demonstration purposes, having the equipment front and center was critical. Now that the system has been up and running for several months, it is a hair louder than we expected, but still within acceptable limits. Our office mate hasn't complained at all.

A floor-to-ceiling stub wall, built next to our windows and viewable from the balcony, houses the OutBack PSR battery rack below the PS2 system. Conduit was run through an open space behind the wall and into holes punched in the backside of the electrical equipment—not one piece of conduit is visible from the wall front. Finally, to polish the look of the system, we purchased an OutBack FX display inverter, sans guts, to fill the empty spot in the PS2MP mounting plate.

We wired and installed the power panel components using the color-coded wiring diagrams that accompanied the PS2DC and PS2AC boxes, though I don't recommend this for most end-users. Even the internal wires were provided, the right size and cut to length. Normally, all the wiring for these units is done at the wholesale level by trained system integrators. Our components came directly from OutBack, so we did not have that advantage.

I had insisted on hiding all of the wire and conduit for the PS2 installation, and I wanted the battery racking and cabling to also be as neat as possible. I ordered precise cable lengths for the twelve Concorde batteries. I made all the cable ends and battery terminals perfectly flat to increase contact area. Instead of covering the batteries with the opaque front that comes with the battery rack, we used clear Plexiglas.

Brant Electric installed our utility disconnects and put in an AC subpanel so that the battery backup would provide power only to our office out of the three businesses on the utility service. Finally, Roger and his crew put in a performance KWH meter on the backside of the stub wall, completed the wiring between the PV combiner box and the DC disconnects, and then hooked up our new AC subpanel to the inverter panel's AC disconnects.

With everything in place, Roger set up the inverter and controller. Later, he complained to me, "Why do inverter manufacturers make this so hard? Why can't the menus be more descriptive, and not so deeply nested?"

Really, all he needed to do was set the nominal battery voltage, set the system to "sell," and have the system give the batteries an initial charge. It wasn't so difficult, but the settings also allow for the finest of tuning, which can involve using a deep and complex system of setup menus.

Working with OutBack tech support, I decided that the only fine-tuning our system needed was to turn off the inverter's charger so that the grid would never be called upon to charge the batteries. Our relatively large solar-charging source enables us to quickly make up for any outages that cause us to dip into our battery backup.

### Up & Running

With the system installed and paperwork filed, our utility, Pacific Gas and Electric Co. (PG&E), came out and installed a new, digital KWH meter, which reads in both directions.



**Installer Ben Scurfield assembles the OutBack PS2 power panel. The second inverter case is for display only.**

The utility representative inspected the system, and then we went upstairs to turn it on. With the system operating, we went downstairs again to see the utility meter running backwards. Success!

Long before, we knew it would work just fine, as PG&E allows pre-approval operation of the system for testing purposes. We were careful not to "test" it too much, as we did not want the meter reading to show a surplus from the last time it was read. We had heard horror stories from folks who had run their systems too much before PG&E's inspection, and got caught in some kind of corporate, bureaucratic maze. We quit "testing" just in time to show only a small, positive amount of KWH used for that month.

PG&E's interconnection approval came the day before the National Solar Tour—on September 30, 2004. RA participated in the tour, which is coordinated in communities nationwide. We had quite a few folks come through our office that day, and I have kept in touch with some of them. At least two of them have ordered systems of their own. One is almost identical to our battery-based intertie system because they live in a rural area that is last on the list for repair when there are extensive storm-related outages. The other system will be a batteryless system in the heart of Arcata, proving that the Redwood Alliance demonstration center is already doing its job. Once RA's second system is up and running, we plan on scheduling a dedication ceremony and solar-electric celebration for the community.

### Number-Crunching

After a year in operation, we know that the system is making much more energy than our suite consumes, even in the winter. And it looks like we can count on the system averaging as much as *all* the suites are using, making the annual net usage equal zero.

RightHand Engineering donated their WinVerter software to us, which monitors both the inverter and the

charge controller, and gives us a ballpark view of how the system is running. This software gives me the ability to monitor the system from my computer.

Compared to older battery-based, grid-tie inverter designs, the OutBack GVFX3648 inverter has a very high conversion efficiency. For example, WinVerter was showing an array output of 2,730 watts. The only loads are 132 W for a computer and a monitor, so the available output is 2,598 W. Yet the output to the grid has been showing 2,268 W, which indicates an efficiency of about 87 percent. We are quite pleased with these results.

Some modern batteryless inverters achieve peak efficiencies of about 95 percent. This difference in efficiency, the additional cost of the equipment for handling batteries, and the cost of the batteries and their eventual replacement are strong arguments in favor of batteryless systems—unless the security of backup power is necessary. Our second PV system is now demonstrating a batteryless system, with a Xantrex GT3.0 inverter attached to the other 24 Shell Solar modules we have. Stay tuned for this story.

Eventually, RA hopes to have an extensive data collection system that will monitor individual offices' consumption, as well as graphically display a full range of data for both PV systems.

## Keeping the Good Energy Going

Part of our process included applying for California's rebate program for both of our PV systems. The rebates will cover all of our system expenses. When our rebate arrives, we will offer a portion of it as matching grants to the other businesses in the building, so that they can have funds for installing energy efficiency measures too. PG&E also has awarded us a generous grant to our general fund, some of which will go to energy efficiency measures, and some of which we may use to remove the power pole that shades the east end of the balcony.

Finally, after nearly 30 years of energy activism, Redwood Alliance can take pride in where its energy comes from. Instead of sucking up Diablo Canyon's nuclear-created electricity, or damming rivers, or burning fossil fuels, we've taken our energy matters into our own hands, and we will be cranking out a few extra watt-hours onto the grid for other folks to use.

## Access

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Alternative Energy Engineering, PO Box 339, Redway, CA 95560 • 888-840-7191 or 707-923-2277 • Fax: 707-923-3009 • info@alt-energy.com • www.alt-energy.com • Battery cables, great advice

Bruce Ryan, Blue Lake Rancheria, PO Box 428, Blue Lake, CA 95525 • 707-668-5615 • www.allianceofcatribes.org/bluelake.htm • Balcony reinforcement

Peter Brant, Brant Electric, PO Box 66, Arcata, CA 95518 • 707-822-3256 • Fax: 707-826-1180 • pbrant@foggy.net • Electrical contractor

Center for Environmental Economic Development, PO Box 4167, Arcata, CA 95518 • 707-822-8347 • Fax: 707-822-4457 • ceed@humboldt1.com • www.ceedweb.org

Concorde Battery Corp., 2009 San Bernardino Rd., West Covina, CA 91790 • 800-757-0303 or 626-813-1234 • Fax: 626-813-1235 • skipkoss@aol.com • www.concordebattery.com • AGM Sun Xtender batteries

Direct Power & Water Corp., 4000-B Vassar Dr. NE, Albuquerque, NM 87107 • 800-260-3792 or 505-889-3585 • Fax: 505-889-3548 • jrandall@directpower.com • www.directpower.com • PV mounts

OutBack Power Systems, 19009 62nd Ave. NE, Arlington, WA 98223 • 360-435-6030 • Fax: 360-435-6019 • sales@outbackpower.com • www.outbackpower.com • PS2 power system components, battery rack & PV combiner box

RightHand Engineering LLC, 19310 226th Ave. NE, Woodinville, WA 98077 • Phone/Fax: 425-844-1291 • info@righthandeng.com • www.righthandeng.com • WinVerter software

Roger, The Little House, 1527 Buttermilk Ln., Arcata, CA 95521 • Message only: 707-826-9901 • Solar contractor

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Shell Solar Industries, 4650 Adohr Ln., Camarillo, CA 93011 • 800-272-6765 or 805-482-6800 • Fax: 805-388-6395 • solarsales@shellsolar.com • www.shellsolar.com • PVs

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