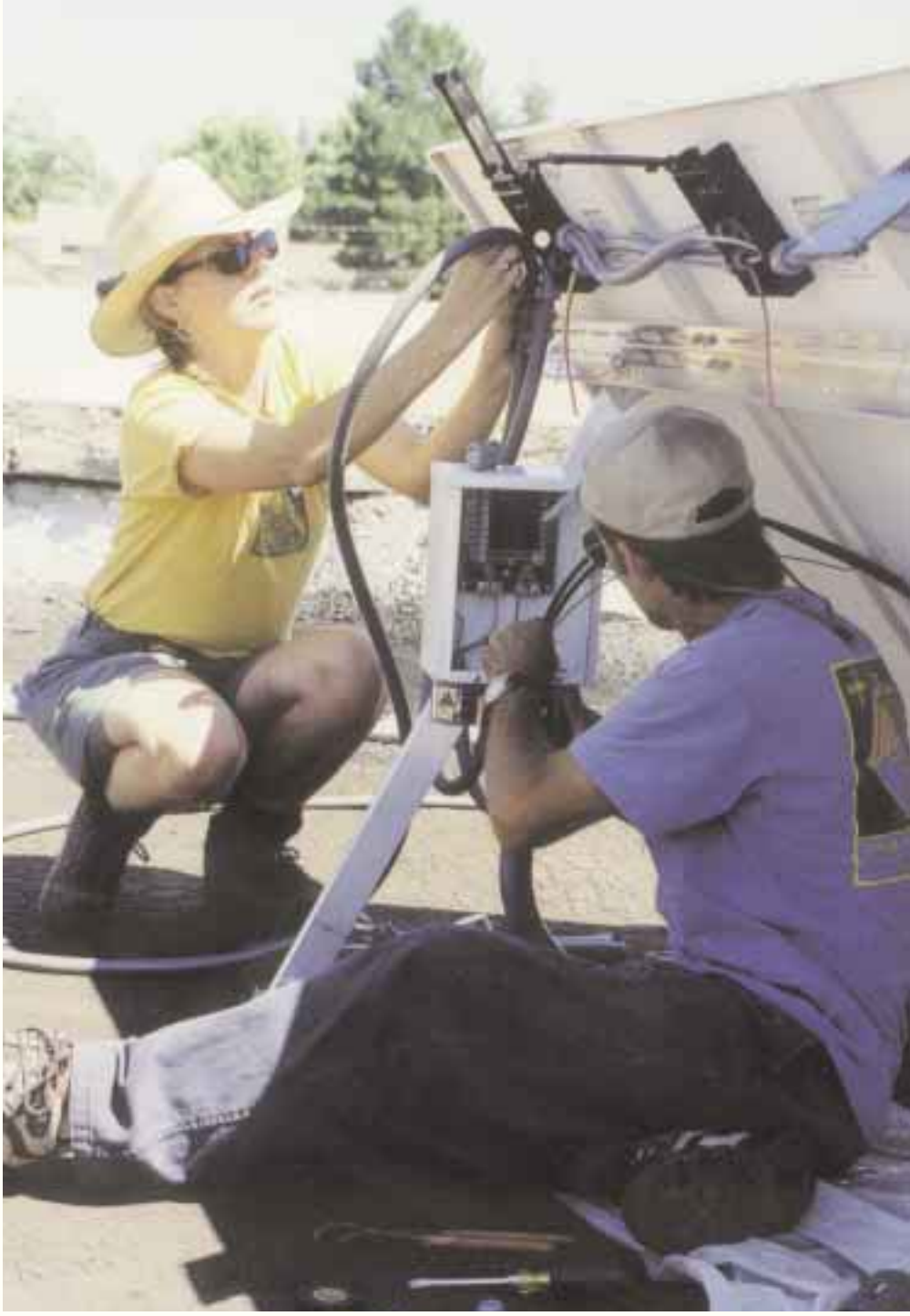
Take That Office Off the Grid

SolWest Prefair Workshop 2001

Richard Perez,
with Joe Schwartz



Workshop participants Anna Delocis and Chris Worcester wire the PV combiner box on the roof of EORenew's office in John Day, Oregon.

This year's pre-SolWest workshop snatched the office of the nonprofit Eastern Oregon Renewable Energies Association (EORenew) from the gaping maw of the local grid. That's right, the EORenew office is now on a steady diet of sunshine. And sixteen workshop attendees made it happen.

The Concept

EORenew director Jennifer Barker wanted the office to walk the talk. The EORenew office is located in downtown John Day, Oregon, and was grid-powered. We wanted to do a workshop that would teach a small group the basics of solar electricity, and also completely solar power the EORenew office.

We began planning for this workshop during July of 2000. Jennifer would do the local groundwork and solicit donations of the equipment. Joe Schwartz and I would design the system, teach the two-day workshop, and oversee the installation.

Jennifer did a thorough energy audit of her office's appliances. Joe and I ran this estimate through *Home Power's* Energy Master spreadsheet, and generated the load table you see printed below. With an estimated average daily usage of only 763 watt-hours, putting Jennifer's office on solar electricity was a snap.

Jennifer worked overtime securing donations for this project. After Joe and I did the system design, Jennifer had a specific wish list for hardware. In most cases, we received a donation of our first choice of components. I want to thank the following companies that donated their RE gear to this project—Exeltech for the inverter, Matrix Solar Technologies for the Photowatt PV modules, RV Power Products for the MPPT PV controller and remote, Solar Depot for the Dynasty AGM batteries, Southwest Solar for the evaporative cooler, UniRac for the PV mounting racks, and Xantrex for instrumentation and combiner box.

Electron Connection and Schott Applied Power donated safety gear, circuit breakers, and enclosures to the project. *Home Power* donated our time, along with conduit, wire, battery/inverter cables, and small hardware. Dennis Voigt, a local electrician, rewired the AC circuits and installed the transfer switch at a reduced charge. The cost table shows the retail dollar value of all the equipment we used in this system.

The Lesson Plan

This year's class was a heavily mixed group of sixteen people. Some were experienced enough with solar electricity to have taught the class, while others had never heard of Ohm's law. We tried to accommodate all, with classroom sessions on system design, component selection, how PVs work, wiring, batteries, inverters, and safety gear.

Joe and I like to do hands-on experiments at these classes. This year we put one of the PV modules out into the sun and plotted a current versus voltage (IV) curve on it. The class got to see first hand the effect of heat on a PV panel's power output.

SolWest Office Loads

Item	*Watts*	*Hours/ Day*	*Days/ Week*	*WH/ Day*	*Percent*
Inverter standby	10	24	7	240.00	31.5%
Solar Chill cooler	80	7	3	240.00	31.5%
Computer system	125	2	3	107.14	14.0%
Fax standby	4	24	7	96.00	12.6%
Lighting	128	1	3	54.86	7.2%
Answering machine	1	24	7	24.00	3.2%
Fax transmit	20	0.1	3	0.86	0.1%
			Total	762.86	

Co-instructor Joe Schwartz explains the finished power wall in the EORenew office closet.

We also ran a series of tests on various inverters using a Fluke 43 power quality analyzer. Several of the students were alarmed when viewing the over 40 percent total harmonic distortion (THD) of their portable modified square wave inverters.

All in all, we had about eight hours of classroom sessions. Joe was great at collecting RE equipment literature, and each student had a huge pile of materials to study after the workshop. But the real thrust here was to take Jennifer's office off the grid.

The Installation

We split up into teams. This was necessary because the PVs were to be installed on the roof, and the remainder of the system in a small closet in Jennifer's office. The office is small, with only enough room for six or eight people. The closet is even smaller, with only enough room for one person at a time.

One group headed to the roof with PV racks, drills, and wiring supplies. Another went to work in the closet installing the inverter, charge controller, and breaker panels. A third crew broke out the monster crimpers, torch, lugs, and cables. They began making up the battery and inverter cables—with flame soldered connectors and shrink tubing, no less.

Rack 'em and stack 'em—Sixteen students learned about photovoltaics while helping to install the system.

System Details

The PVs are installed on a fixed UniRac mount that is through-bolted to 2 by 6 blocking that was added inside, between the rafters. The individual Photowatt PW1000, 90 watt modules have 72 cells and can be configured for either 12 or 24 VDC. We wired the modules for 24 VDC. A positive and negative lead from each module was run to a Trace TCB10 combiner box using #10 (5.3 mm^2) THHN-2 copper wire in flexible, nonmetallic conduit.

Each module is protected with a 15 amp series fuse in the positive lead. The total rated output of the array is 360 watts at 24 VDC. But after we ran the IV curve on the modules, it was obvious that high ambient temperatures would decrease array output by as much as 20 percent.

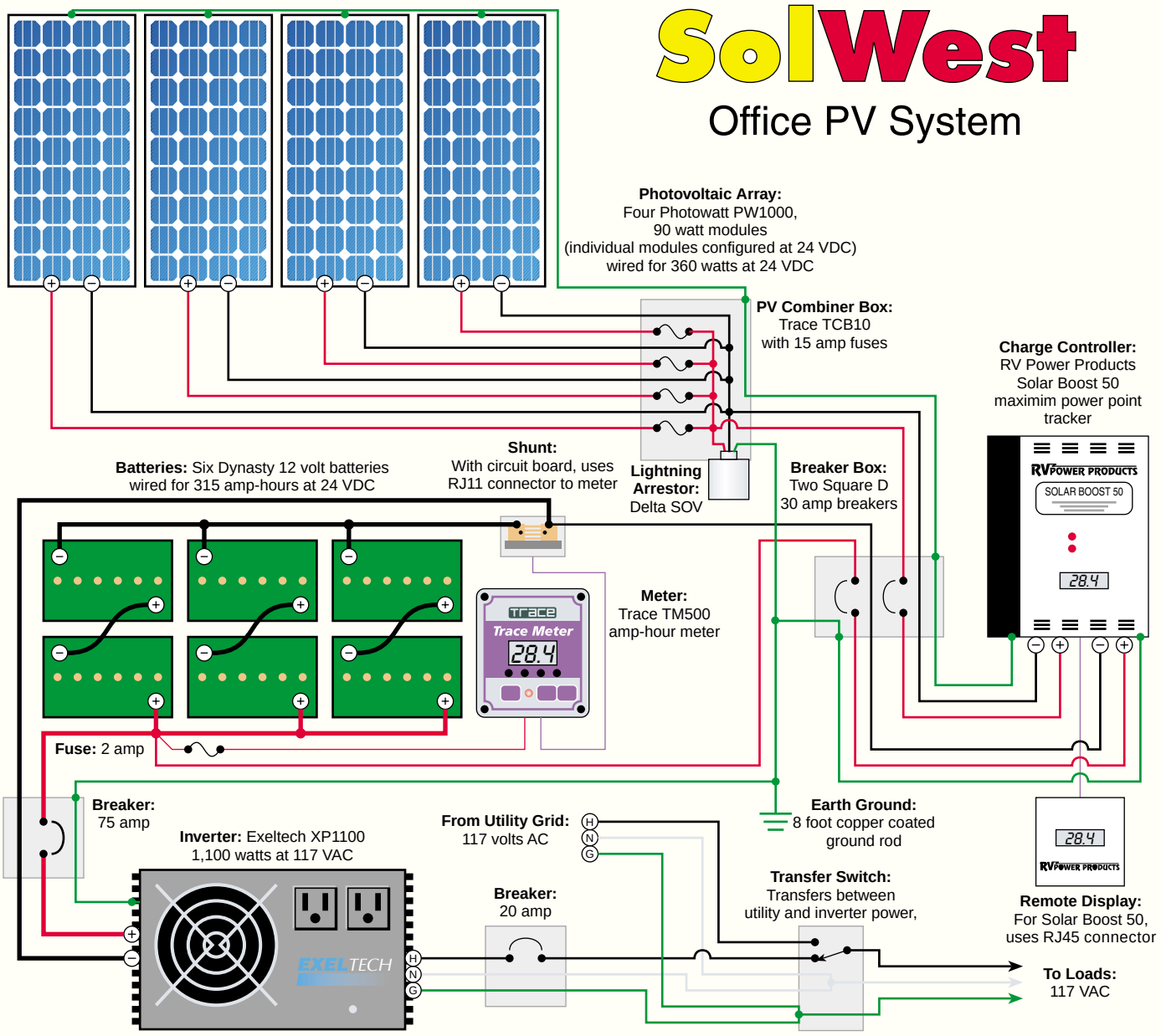
We ran 30 feet (9 m) of #2 (33 mm^2) THHN copper wire in PVC conduit between the combiner box and a two-circuit, Square D, QO breaker box located in the closet. A 30 amp, DC-rated breaker protects the wire run from overcurrent, and provides a means for disconnect. PV output is then routed to a Solar Boost 50 (SB50) maximum power point (MPPT) charge controller. Both the charge controller and wire run were oversized to allow for future expansion. The output of the SB50 is run through a second, 30 amp, DC-rated breaker and then to the batteries.

The battery bank is made up of six, 12 VDC, 105 amp-hour, Dynasty sealed batteries. Pairs of batteries were wired in series using #2/0 (67 mm^2) welding cable for 24 VDC. Then the three pairs were wired in parallel for a total battery capacity of 315 amp-hours at 24 VDC.

The Exeltech XP1100, 24 VDC inverter is connected to the battery bank using #2 (33 mm^2) welding cable. The positive leg is run through a 75 amp, DC-rated Heinemann breaker. The inverter's AC output is hardwired to a 20 amp AC breaker and then to a 20 amp transfer switch. The switch allows Jennifer to manually transfer the office circuit over to the grid when the batteries are discharged to a 50 percent state of charge (SOC), and allows the system to be operated without a battery charger. The reality is that the total office electrical load is small in comparison to the PV system output. The office will most likely never be on the grid again!

A Solar Boost remote display and a Trace TM500 amp-hour meter provide Jennifer with system information without having to get up from her desk. And a 24 VDC Solar Chill evaporative cooler keeps the office at a

Four Photowatt PW1000, 90 watt modules, in the relentless Eastern Oregon sun, should easily meet the office loads .



comfortable temperature during those hot Eastern Oregon summer days.

Training Realism at Its Best—or Worst

During the last classroom session, I delivered my standard battery safety rap. Now, Joe and I had been discussing buying all the battery safety gear (baking soda, gloves, eye protection, fire extinguisher, etc.) before the install. We'd use it as props during the workshop and leave it with Jennifer after the install was done. Well, we forgot to do this, so we were unprotected for the all too real training session that was to follow—the exploding battery.

Joe and I like doing experiments at these events, but up till now we have stopped short of exploding a battery and dealing with the mess. As fate—and our carelessness—would have it, explode a battery we did.

The battery bank is located on the floor of the closet. Joe had made a very nice plywood top for the batteries, but this wasn't installed since we were working on the batteries and their connections. The students had thrown multiple layers of plastic over the tops of the batteries. This made me slightly nervous, since hardware was continually being dropped on top of this plastic, not to mention the occasional tool. But all seemed well.

What I didn't know was that there was a disconnected series battery cable lurking beneath all that plastic. Someone must have kicked this loose cable, and it

SolWest Office Costs

Item	*Cost (US$)*
4 Photowatt PW1000, 90 W PV modules	$1,920
6 Dynasty batteries, Group 27	1,020
Exeltech XP1100 inverter	830
RV Power Products SB50 controller	389
UniRac PV mounting rack	265
Trace TM500 amp-hour meter	245
Trace TCB10 combiner box	229
SB50 charge controller remote	219
Inverter/battery disconnect, 70 amp	129
9 Battery/inverter cables, 2/0 CU	90
Wire, conduit, fittings (estimate)	60
2 Square D fused disconnects/enclosures	60
Delta SOV lightning arrestor	45
AC transfer switch	10
Total	$5,511

made contact with one of the 12 V batteries in the 24 VDC pack. The entire 24 V pack discharged very quickly into a single 12 V battery.

Standing 6 feet in front of the battery, I could see, underneath the translucent plastic layers, one of the batteries spurting gas and flame. I was closest to the batteries, since the hissing and foul smell had scared the students back from the closet. I could see that the layers of plastic covering the batteries had caught fire. My first reaction was to stop the fire from spreading by grabbing the flaming plastic and pulling it from atop the battery pack. No sooner had I done this than the battery exploded.

Fortunately, I was the only one even mildly injured. The acid spray put pin holes in my clothes, I got minor burns on my hand from the flaming plastic, and a permanent acid pit on my right cheek to remind me to never be so silly again.

All of a sudden, we needed all that safety gear that we'd discussed in class, but had forgotten to buy. Emergency expeditions were dispatched to secure baking soda, rubber gloves, and a plastic bucket to contain the demolished battery. Fortunately the AGM batteries don't contain very much sulfuric acid, and we successfully cleaned up the mess in less than two hours.

The ultimate responsibility for this accident lies with me. I should have made sure that the batteries were removed before anyone worked above them. I will be eternally grateful that I was the only one injured, and I will certainly be more careful around batteries in the future. While this was an entirely real and exciting learning experience for all involved, I don't plan to repeat it at future workshops.

Off the Grid!

We brought EORenew's system online at 9:30 AM on Saturday July 28, 2001. Solar energy streamed from the rooftop PV array and began charging the batteries. The inverter fed clean electricity to the office loads. Just one day earlier, the office had been powered predominantly by electricity generated by the hydroelectric dams that choke the Columbia River, and coal-fired plants that mar the western landscape, not to mention the atmosphere. But from now on, the office will be powered by the sun.

EORenew has gone solar-electric, and has a great educational tool as well. On Sunday during the fair, Joe and two of the workshop participants led a tour of EORenew's new office system. They walked into the office and flipped on the lights that were now running on solar energy. Together they described how they had installed the system and how it functioned. Another PV system was up and running. And another great group of folks are spreading the word about the power of the sun.

Access

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800-886-4683 or 817-595-4969 • Fax: 817-595-1290
info@exeltech.com • www.exeltech.com • XP1100 inverter

Matrix Solar Technologies • 877-2MATRIX
Fax: 505-833-0400 • marketing@matrixsolar.com
www.matrixsolar.com • Photowatt PV panels

RV Power Products, 1058 Monterey Vista Way, Encinitas, CA 92024 • 800-493-7877 or 760-944-8882
Fax: 760-634-8193 • info@rvpowerproducts.com
www.rvpowerproducts.com • Solar Boost 50 charge controller

Solar Depot, 61 Paul Dr., San Rafael, CA 94903
800-822-4041 or 415-499-1333 • Fax: 415-499-0316
staff@solardepot.com • www.solardepot.com • Dynasty batteries

Southwest Solar, 5085 S. Melpomene Way, Tucson, AZ 85747 • Phone/Fax: 520-885-7925 cuningham@dakotacom.net www.southwest-solar.com • Solar Chill evaporative cooler

UniRac, Inc., 2300 Buena Vista Dr. SE, Suite 134, Albuquerque, NM 87106 • 505-242-6411 Fax: 505-242-6412 • tracker200@unirac.com www.unirac.com • Solar panel racks

Xantrex Technology, Inc., Distributed Residential and Commercial Markets, 5916 195th St. NE, Arlington, WA 98223 • 360-435-8826 • Fax: 360-435-2229 inverters@traceengineering.com • www.xantrex.com Amp-hour meter, combiner box, array grounding

Electron Connection, PO Box 203, Hornbrook, CA 96044 • 800-945-7587 • Fax: 530-475-3401 econnect@snowcrest.net www.electronconnection.com • Heinemann 75A breaker

Schott Applied Power Corp., PO Box 339, Redway, CA 95560 • 800-777-6609 or 707-923-2277 • Fax: 707-923-3009 • info@solarelectric.com • www.solarelectric.com Enclosures for Trace products

Dennis Voigt, B&D Electric, Inc., PO Box 678, Prairie City, OR 97869 • 541-820-4144 • Wiring of AC circuits