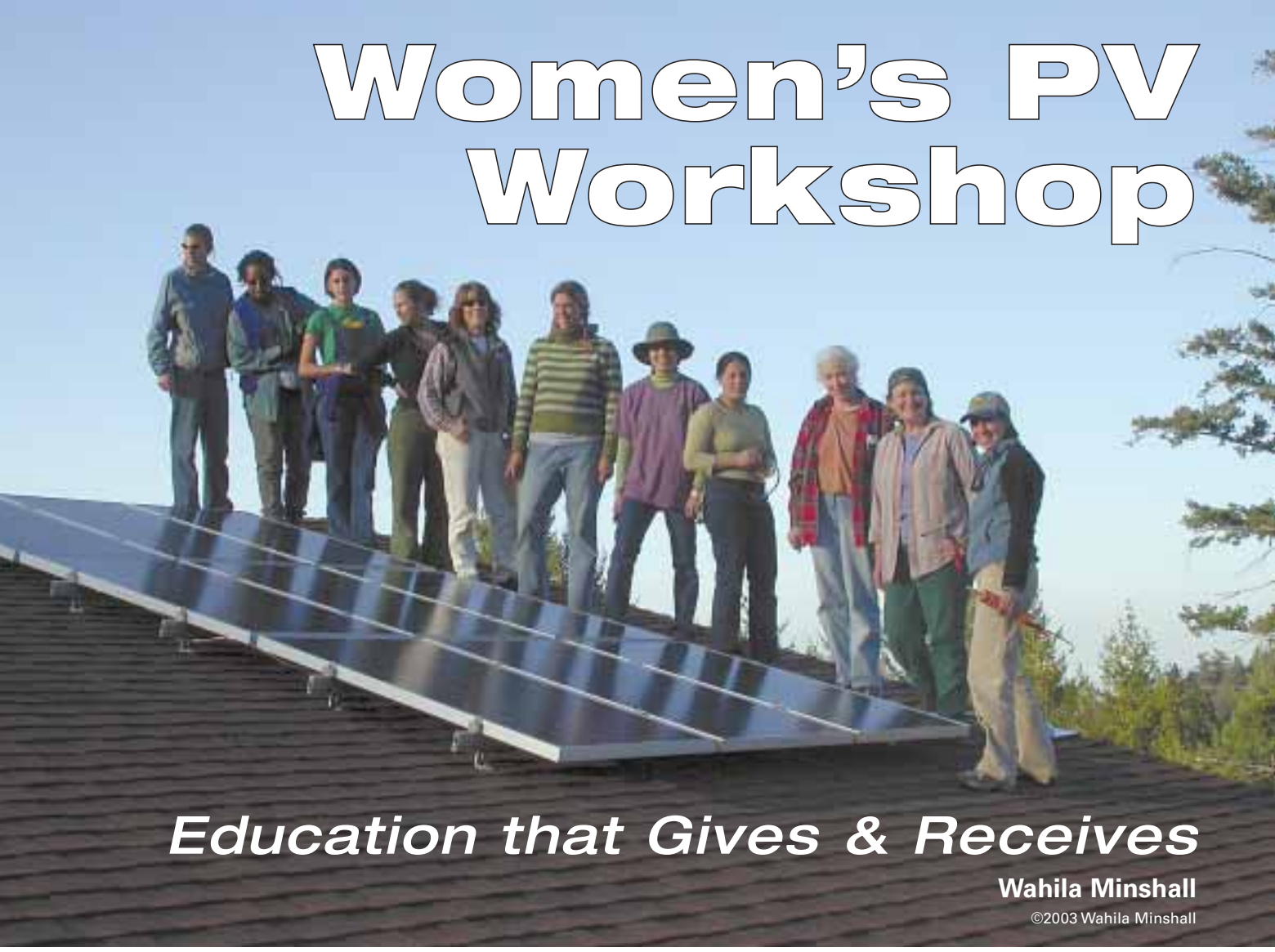
Women's PV Workshop



Education that Gives & Receives

Wahila Minshall

Instructor Justine Sanchez, bottom right, and the array installation crew line up behind the finished array as the sun sets.

On a clear, sunny day in March 2003, a group of women were outside a California environmental science school talking shop—and that isn't short for shopping. Discussing everything from conduit bending to system voltage, these 25 women were at Walden West Center in Saratoga, California, installing a 1.5 KW solar-electric system.

Walden West is an outdoor environmental science school in the Saratoga hills that hosts week-long science programs for 5,000 to 7,000 students each year. The women, who came from all across the U.S., had just finished four days of classroom sessions in Santa Cruz, California, as part of a women-only PV Design and Installation workshop offered by Solar Energy International (SEI).

Most SEI courses culminate in an actual installation, providing students with the hands-on training needed to truly understand PV system operation and installation. The PV system at Walden West began its life by educating future renewable energy workers and advocates. And since it is installed as part of an environmental education program, it will go on to teach tens of thousands of children about the benefits and practicality of solar electricity.

Collaborative Effort

The installation was accomplished through a collaborative effort between Walden West Center, Solar Energy International, Rahus Institute, and Akeena Solar. Walden West received a Flex Your Power grant from the state of California for the project, but that money didn't cover the full US$14,000 cost of the system and installation. Tor Allen, Director of Solar Schoolhouse, a program of the Rahus Institute, brought the funding situation to my attention.

Akeena Solar, which has two SEI graduates on staff, had already agreed to guarantee a local installation for the hands-on portion of the March 2003 SEI workshop. Akeena Solar's president, Barry Cinnamon, then offered to donate the remaining equipment for the project. Everyone involved was thrilled with this solution.

"As a parent, I want to do everything I can to help break our country's dependence on fossil fuel energy sources, both foreign and domestic. My kids go to Walden West in the summer, and they have a terrific outdoor education program," said Cinnamon. "By helping fund

Installing the conduit run from the PVs to the inverter.

Instructor Carol Weis (in red baseball cap) oversees the construction of the complicated junction box, affectionately dubbed the "artificial heart."

Educating Women PV Installers

Colorado-based Solar Energy International (SEI) is one of the nation's foremost educators for renewable energy installers and green builders. They offer classroom and laboratory work, complemented by case studies, field tours, and professional installations with real equipment in real settings.

Six years ago, SEI began to offer some courses for women only, to encourage more women to enter this traditionally male-dominated field by providing a less intimidating atmosphere for learning. These courses have been extremely successful, greatly increasing the number of women attending SEI workshops and drawing in women of all ages from all walks of life. Some come because they are thinking of installing their own systems, some because they are looking to make a career in the field, and others to further their knowledge of the field in which they are already employed.

SEI's women-only workshops allow women to talk about this very technical subject in language that they are comfortable with. As a result, a lot more questions are asked, and an inspiring amount of networking goes on.

I was a workshop participant in the first SEI women-only course to be offered in Santa Cruz. I was pursuing a career in the solar-electric field and felt that the hands-on aspect of the SEI course and SEI's good reputation for training renewable energy workers would make me ultimately more employable. This proved to be true when I interviewed with Akeena Solar. The fact that I could work as an auxiliary installer when needed tipped the scales in my favor, and I was hired as their marketing manager.

the installation, we will be able to communicate the clean energy benefits of solar electricity to thousands of students, and promote the transition from fossil fuels to clean renewable energy. Akeena Solar's philosophy is simple: we believe that producing clean electricity directly from the sun is the right thing to do for our environment and economy."

The Walden West system was an ideal installation for the SEI students for a variety of reasons. The site offered plenty of space for this large group of women to work. The installation offered some unique challenges, but was small enough to be completed in the two days allotted. To top it off, Walden West offered to feed and house the SEI students during the workshop, helping to defray their expenses.

System

The system consists of an SMA 2500U-SBD, 208 volt Sunny Boy inverter with display, and nine Sharp NE-Q5E2U 165 watt modules. When more funds become available, this system can expand to sixteen modules.

Technical Specifications

System Overview

Type: Batteryless grid-intertied

Location: Saratoga, California

Production: 190 AC KWH per month average

Utility KWH cost: US$0.23 per KWH

Percentage offset by PV system: 3.3 percent

Photovoltaics

Manufacturer and model: Sharp NE-Q5E2U

Number of modules: 9

Module STC wattage: 165 W

Module nominal voltage: 24 V

Array STC wattage: 1,485 W

Array nominal voltage: 216 VDC

Array disconnect: 30 amp Square D general duty safety switch

Array installation: Roof-mounted using UniRac SMR-Solar Mount Rails; orientation, 164 degrees magnetic = 180 true south or dead on true south; 18 degree tilt angle

Inverter

Manufacturer and model: SMA Sunny Boy 2500

Maximum DC input voltage: 600 V

MPPT voltage window: 180 VDC min, 550 VDC max

Nominal AC output voltage: 208 V (three-phase service)

System Performance Metering

Equipment: Sunny Boy display & additional AC KWH meter

Kate Latham and Cecily Cahill mount a rooftop junction box.

Because the building's commercial electrical service was 208 volts AC, we were not able to use the standard 240 volt model of the Sunny Boy. Note that the lower output voltage of the 208 V inverter means that the maximum AC output is 400 watts less than the standard 2,500 watts, and the maximum DC input it can handle is sixteen (instead of eighteen) modules at this location.

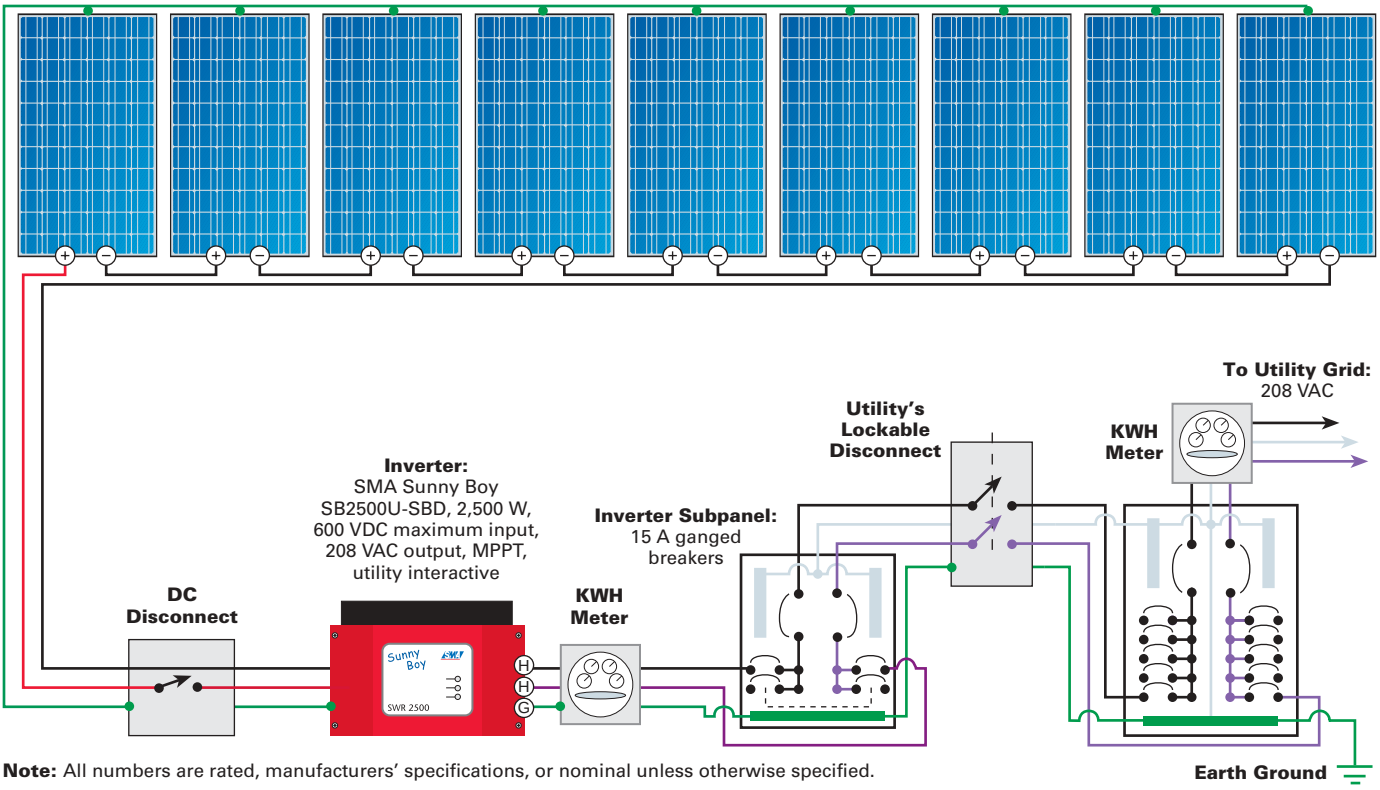
The system was installed in an accessible, outdoor classroom area, making the wiring a bit tricky to prevent vandalism and accidents. It was important to install the inverter and external AC display meter in a place that was visible to the students. It was also important to install the DC disconnect in a secure location inside a locked electrical closet.

The solution was to construct a custom junction box, so that conduit could securely pass through a concrete block wall. It was the most complicated part of the system, and was at the heart of the installation. We affectionately dubbed the junction box "the artificial heart" because of all the DC and AC lines going in and out. We clearly labeled the wiring inside this junction box to meet *National Electric Code (NEC)* requirements, since both AC and DC wiring runs through the box.

The DC line ran from the array to the junction box, through the wall to the array disconnect inside the electrical closet, and then back out through the wall via the junction box and into the inverter. The AC line went out of the inverter through the junction box and to the AC display meter, back through the junction box, and through the wall to the 208 volt AC service panel. The inverter was installed about 7 feet (2.1 m) above ground level to minimize the likelihood of tampering by students or others.

EMT conduit was used on all exposed wiring. A fairly long conduit run down the roof and across the face of the building under the eaves required some complicated bends. This gave plenty of opportunity for learning the art of conduit bending. A rooftop junction box was used for the transition from USE-2 wire from the modules to the THWN-2 wire used inside the conduit.

Photovoltaics: Nine Sharp NE-Q5E2U, 165 W each, wired for 1,485 W total at 216 VDC



Note: All numbers are rated, manufacturers' specifications, or nominal unless otherwise specified.

UniRac rails were secured to the composition shingle roof using aluminum L-brackets and lag bolts attached to the underlying rafters, which were 4 feet (1.2 m) on center. For ease of lifting, the women carried the modules up to the roof one at a time, instead of installing the modules on the rack on the ground. The modules were then mounted in a three by three panel array on the rails using top mount clips.

By 4:30 PM on the last day of the workshop, most of the pieces of the system were in place. But the sun was about to set beyond the western hills, so we had to pick up the pace. We worked madly to get all the modules aligned and finally secured, wiring completed, junction boxes closed, and final safety checks made.

Just before the sun went down, we began to commission the inverter. After about five minutes of system initialization, the system fired up with minutes to spare. A cheer went up as the AC meter started to spin backwards slowly and the inverter's display indicated that we were producing several hundred watts of solar electricity. The group was delighted to see that they had accurately applied the principles they had learned in the workshop.

Educating Consumers & Children

Walden West Center recognizes how critical it is to teach children about renewable energy. Spokesperson Richard Reid said, "Our children will experience a huge transition in how energy is produced in their lifetimes. An important goal of this school is to educate these students so that they will understand, embrace, and encourage this change."

Real-World Output

In terms of real-world system output and savings, Akeena Solar relies on a fairly conservative model of system performance. Total rated DC output of 1,485 watts (nine modules, each producing 165 watts DC) is reduced by 11 percent for PVUSA rating factors, 4 percent for low irradiance conditions, 7 percent for annualized panel soiling, 14 percent for inverter/MPPT efficiency and wire losses, and 3 percent for orientation/tilt factors.

After applying these factors in succession, the end result is that we expect the actual AC output to be about 66 percent of the PV's rated output. When we multiply this output by 5.5 hours of peak sun per day and 365 days per year, annual energy output for the Walden West system is about 2,000 KWH per year.

In reality, the vast majority of our customers see actual outputs that exceed our conservative initial estimates. In the 30 days that the system has been running at Walden West, it has already produced 190 KWH, which is about 15 percent ahead of what our modeled performance predicted for that time frame.

SEI's women-only PV workshop takes a break for a group picture.

With this installation, the school will develop and implement a new curriculum unit on solar electricity to add to the solar thermal unit they already have. The students will conduct a weekly study on how much electricity is generated. They will then calculate the number of 100 watt bulbs that could be powered for an hour with this much electricity. Rahus' Solar Schoolhouse program has provided portable solar labs that allow the students to experiment with operating motors, lights, and water pumps with PVs. They will experiment with the effects of shading and orientation.

Rahus has conducted staff training workshops and complementary hands-on activities with the Walden West staff over the last six months. Lessons are being piloted this school year. "It is exciting because the kids will actually be able to see the electric meter spinning backwards. It is a great place for them to learn, and we'll save energy but also show them how we are saving energy for California," Anita Parsons, Walden West co-director said.

The school has upgraded all the lighting systems to reduce its electricity needs. They are using a combination of fluorescents with electronic T8 ballasts and high-pressure sodium lamps. In addition, they have a large solar thermal system for heating the swimming pool, and plan to install a solar domestic hot water system to supply the shower rooms.

The new PV system will provide Walden West with more than 2,000 kilowatt-hours of clean electricity per year. This will enable Walden West to eliminate the release of 60 tons of CO_2 over the 30-year life of the equipment and save US$600 annually on their utility bill.

Powering the Future

Walden West hopes to soon add the additional seven modules needed to fully power the Sunny Boy 2500. The school also has a new main building in the planning stage, and has included in the specs a PV system sized to provide all the electricity for this new structure.

Though these systems serve both to offset educational costs and to educate electricity consumers and future decision makers, due to the large upfront cost of photovoltaic systems, very few of them have been installed in schools. Many of the children who are educated about solar electricity here at Walden West will go on to educate their parents and others. This will help support a cultural switch to greater use of residentially produced renewable energy. In the words of one 6th grade student who was at Walden West during the installation, "You can make electricity from the sun? That is so cool!"

Walden West Center System Costs

Item	Cost (US$)
9 Sharp NE-Q5E2U PV modules	$6,156
Balance of system components	3,744
SMA 2500U Sunny Boy inverter	2,569
Design & engineering	1,516
Total	$13,985
California buydown rebate	-4,921
Flex Your Power grant	-5,000
Akeena Solar contribution	-4,000
Walden West Bottom Line	$64

Access

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