



DARREN BOUTON, PACIFIC ENERGY CENTER

Bringing Light to Low-Income Communities

What better way to help families lower their electric bills than with solar power systems installed by volunteers eager for experience?

By Tim Sears, P.E.

Too often grid-connected solar power has been seen as a luxury affordable only to the well-off. Those hardest hit by rising electricity costs have been unable to afford the up-front installation costs, and typically have not had the time, resources and information required to make an informed choice about solar. Yet it's just these people who can most benefit from solar power. In California, affordable-housing owners are eligible for rebates on photovoltaic systems on these homes or apartments. What better way to help them take advantage of the rebates than by matching them with individuals eager to gain experience installing the systems?

It was just this goal that led to the creation of the Solar Affordable Housing Program. By providing free installation, access to low-interest financing and assistance with rebates, permitting and utility agreements, the program is bringing solar to a new set of homeowners. As the program's first installation demonstrates, solar power has the potential to dramatically lower the monthly electric bills of working class people — and create strong new advocates for the technology.

Assembling the Partners

Building this system was as much about bringing together the right parties as connecting the right wires. The project, a 1.6-kilowatt photovoltaic (PV) system on the San Carlos, Calif., home of Bob and Lorraine Murphy, was the first installation of GRID Alternatives' Solar Affordable Housing Program. The program recruits and trains volunteer teams of environmentally and socially concerned Bay Area community members who are also interested in gaining valuable solar electric training, to provide system installation on the homes of income-qualified families. Skills development/job training for system recipients is also an integral component of the Solar Affordable Housing Program. The program provides low-income members of the community with training in solar electric installation, and gives individuals the opportunity to network with and be mentored by GRID Alternatives' licensed solar contractor partners. As a 501(c)(3), nonprofit organization, GRID Alternatives relies on individual donations and grants to cover costs to run the program. For this installation, the Peninsula Community Foundation was the primary funder.

In addition to bringing solar power to working-class homes, the Solar Affordable Housing Program provides low-income people with training in solar electric installation.

The volunteers for this two-day installation were approximately 25 students from a weeklong course in PV design and installation offered by Solar Energy International (SEI), Carbon-dale, Colo. Through the course, students learned everything from the physics behind the photovoltaic effect to National Electric Code wire-sizing regulations. Mike Fairbanks from Stockton, Calif.-based Power Independence Electric (PIE) volunteered his time to oversee the installation, and PIE provided the warrantee for free. Solar Depot Inc., Petaluma, Calif., provided the solar panels and other major equipment at a discounted price. This cost, along with the permitting fees, was paid for by a combination of a grant from the city of San Carlos and a rebate from the California Energy Commission's (CEC's) Emerging Renewables Program. For future Solar Affordable Housing Program projects, GRID Alternatives will help the homeowners finance this cost with a low-interest loan, resulting in immediate savings with no out-of-pocket costs for the homeowner.

The most important partner, however, was the Murphy family, who bravely volunteered their house as the first site for a new program. GRID Alternatives identified the Murphy family through the city of San Carlos' home-rehabilitation program. The Murphys were the ideal first clients. Bob Murphy participated in the SEI training course and helped to install the system, and he, his wife Lorraine and their two sons have all become true ambassadors for solar.

Designing a System to Fit the Murphys' Needs

Because improving a home's energy efficiency is almost always the most cost-effective means of reducing the utility bill, the first thing GRID Alternatives' staff did was check to see if there were any low-cost efficiency improvements to be made. The Murphys were ahead of the game, having already replaced all of their incandescent light bulbs with compact fluorescent lamps, insulated their water heater and hot water pipes and weather-stripped doors and windows.

To size the PV system, our team at GRID Alternatives studied 12 months of electricity bills. Because California's net-metering laws will allow customers to "zero out" their annual electric bills but do not require utilities to pay clients for any electricity they produce over and above their annual usage, we initially selected a 2.4-kilowatt (kW) system. This size system would offset approximately 90 percent of the Murphys' annual electricity costs.

Our staff contacted several solar equipment suppliers for bids on the panels, inverters, racking and disconnects. After comparing the bids on a dollar-per-AC-watt basis, we selected the low-cost supplier.

The next step was getting up on the roof and taking measurements to see if the system we had selected would fit. As it turned out, the roof was not large enough for a 2.4-kW system, so after reviewing the available products, we selected a system comprised of 12 BP Solar 160-watt (W) panels and a Sunny Boy 1800-W inverter from SMA America. When the temperature effects on panel efficiency and inverter losses are considered, this system is rated at 1.6 kW.

Installing the System to Last

Finally, installation day arrived. On March 19, two GRID Alternatives staff members, 25 SEI students, two SEI instructors and the licensed solar contractor all converged on the San Carlos home.

The morning orientation included a review of safety procedures, an overview of the system design and individual components, and a discussion of the plan for the day's work. Volunteers were divided into two groups: One group focused on the inverter installation, and the other group worked primarily on the roof doing the racking assembly and panel installation. SEI instructors coordinated the installation, while the licensed solar contractor provided oversight and GRID Alternatives' staff provided logistical support.

For the roof team, the first step was laying out the Roof Trac mounting system from Professional Solar Products. For residential roof-mounted solar installations, the panel racking must be attached to the roof, which usually means penetrating the roofing material. Installers used Fast Jack standoffs from Professional

Economic Analysis of the Murphys' Photovoltaic System

Major Equipment Cost (panels, inverter, disconnects, mounting hardware)	\$8,767
Other Costs (permits, wire, conduit, miscellaneous materials)	\$676
Gross Cost	\$9,443
Rebate ¹	\$5,075
Net Cost	\$4,368
Estimated Additional Cost at year 15 to replace inverter	\$1,600
Annual Energy Production ²	2,700 kWh/year
System Life	30 years
Total Saving Over Life of System ³	\$14,200
Internal Rate of Return	8.2%
Estimated Reduction in Carbon Dioxide Emissions Over Life of System ⁴	46.7 tons

¹ Rebate of \$3.20 per watt from the California Energy Commission (CEC) for grid-tied solar electric systems installed in California based on system rating of 1,586 watts.

² Based on estimate of 1,700 sun-hours per year.

³ Assuming electric rate of \$0.12 per kilowatt-hour, with a 3 percent annual electricity price escalation factor and a 0.5 percent annual system efficiency-degradation factor.

⁴ Based on 1.2 pounds of carbon dioxide per kilowatt-hour from CEC's Clean Power Estimator tool.

Solar Products to ensure that these penetrations would not leak for the 30-plus-year life of the solar electric system. These standoffs allowed each penetration area to be completely covered with a rain-tight Oatey flashing. In addition, the team used Sika's Sikaflex sealant to seal all possible leakage points.

When solar panels are wired together in series, even one bad panel can reduce the output of the entire string. To avoid that problem, the team tested each panel with a volt-amp meter to make sure they all met the voltage specifications. The panels were wired together in two series strings of six panels, and these two strings were combined in parallel inside a weatherproof junction box. To ensure good electrical contacts throughout the life of the system, the team used insulated electrical wire connectors for these connections, rather than the ubiquitous wire nuts that are often used. As shown in the diagram on p. 26, the panels were wired together using the MC connectors that came with each BP panel. For extra insurance, each connection was sealed with a heat shrink sleeve.

Above all, our primary concerns for this installation were safety

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and quality. No accidents or injuries occurred, and the finished system looks professional and performs as well or better than expected.

Quantifying the Results

The Murphys' solar electric system provides free electricity whenever the sun is shining, reducing their average monthly electricity bill approximately 58 percent. The Murphys routinely visit the side of the house to watch the meter run backwards and track how much power the system is producing. A digital readout on the inverter monitors a range of outputs: output power, solar generator voltage, total produced energy since commissioning, total operating hours since commissioning, energy produced that day, and system operating mode.

Based on initial data, the system output appears to be slightly higher than anticipated. GRID Alternatives will collect pre- and post-installation utility bill data and use the logging capability of the system's inverter to determine the Murphys' actual savings. The table on p. 25 summarizes the system costs, estimated energy savings and emissions reductions.

Although the installation went smoothly, we learned a few lessons that will help on future installations.

First, because of the scheduling constraints of this project (the SEI class was scheduled before the client was even selected), the equipment had to be ordered prior to receiving the rebate confirmation from the California Energy Commission. That meant that if the CEC rejected the rebate reservation, GRID Alternatives would have had to come up with the rebate amount. In this case everything worked out, but in the future, we will not schedule the installation nor order the equipment until the CEC sends a rebate confirmation letter.

Another lesson learned was the importance of coordinating with the neighbors. Although most of the neighbors were supportive, one neighbor was upset about the aesthetics of the system and the potential for glare. He was also upset about the volunteers' cars parked on the street. In order to address the neighbor's concerns, GRID Alternatives' staff spent significant time listening to his concerns and dispelling some misconceptions about solar power. In the end, the quality of the finished installation and the fact that his concerns were acknowledged worked to quell his disapproval.

In the future, we can avoid some of these issues by havin]g a community meeting or posting fliers explaining the Solar Affordable Housing Program, describing what will happen during the installation and providing neighbors with an opportunity to voice concerns beforehand.

Based on our experience with witnessing 25 volunteers learning how to install solar, we recognized that it would be difficult for one GRID Alternatives staff member and a solar contractor partner to effectively manage so many volunteers without the SEI instructors. So for future program installations, the number of volunteers will be kept between five and 10. Having fewer volun-

teers will mean each volunteer gets more hands-on practice, and fewer people will mean less disruption for the neighbors.

Flipping the Switch

To celebrate the successful installation of the Murphys' system and recognize the critical roles our partners played in this project, a "Flip-the-Switch" celebration was held April 21. Several city and county officials, representatives of nonprofit housing and environmental organizations and the local press attended the

event, enjoying "sunshine cookies" baked with electricity produced by the sun. For the grand finale, the Murphys, with the assistance of representatives from the city of San Carlos, Solar Depot and GRID Alternatives, flipped a six-foot-tall ceremonial light switch. Articles on the event appeared in three local news publications.

Partly due to the success of this pilot installation, GRID Alternatives has received partial funding to run the Solar Affordable Housing Program in San Mateo County, San Francisco and Pleasanton, Calif. GRID Alternatives has completed one additional system installation on a Habitat for Humanity home in San Francisco, and plans between 30 and 40 installations over the next 15 months. We at GRID Alternatives look forward to bringing the benefits of clean, affordable solar power to the low-income families who are most affected by high electricity prices. ●

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Diagram of the Murphys' Grid-Tied PV System

