Solar-Electric Awnings

Form Meets Function

Sandy Woodthorpe

Northeast Ohio receives an average of four peak sun hours daily. That might not seem like much to those of you living in the Sunbelt, but it's enough sunshine for solar electricity to work in Cleveland. In fact, two solar-electric awnings that a group of us Ohio solar-energy enthusiasts installed last summer are generating electricity for a small architectural firm. And we are busily planning more projects to demonstrate that solar electricity is a viable alternative to coal- and nuclear-generated electricity.

Above: Architect Bill Doty and RE systems designer Erika Weliczko under the solar-electric awnings at the south corner of the Doty & Miller office.

Below: Structural engineer Ed Gallagher and Bill Doty display one of the custom mounts.

The awning system was Green Energy Ohio's (GEO) first workshop project. This article describes the system, as well as how we used the project to turn one July weekend into a fun, educational, and publicity (and electricity!) generating event. The installation drew more than twenty participants from central and northeast Ohio, as well as Michigan, and was a big success.

Seed of an Idea

Our workshop and installation grew from an idea conceived by Bill Doty, solar energy advocate and partner of Doty & Miller Architects. In 2002, he applied for matching grant funds from the Ohio Department of Development's Office of Energy Efficiency to help finance a small, grid-intertied system at his firm's office building in Bedford, just south of Cleveland. Bill included an educational component—a workshop—in his proposal for the Energy Loan Fund (ELF) grant. The purpose of the workshop was to help promote solar energy to the community, provide a learning opportunity for budding solar-electric installers, and keep costs within budget. The total project cost was US$20,250. The ELF grant Bill received covered 50 percent of the cost; he matched it with US$10,125.

The project was promising right from the start. Doty & Miller is a 27-year-old firm, well known in the region for its commitment to using "green" design and materials. The firm's offices are located in a beautifully renovated 1930s-era U.S. Post Office building that showcases the firm's sustainable design expertise. Green construction materials were used for the flooring, walls, windows, paint, and trim. The heating, cooling, and ventilation system, as well as kitchen appliances, office equipment, and lighting were selected for their high efficiency ratings.

Doty & Miller Architects renovated this former post office to modern-day efficiency standards.

The Seed Is Planted

At the time funds were approved for his system, Bill was hosting meetings for the GEO's solar committee. This group of about ten volunteers was organizing GEO's annual tour of solar homes and businesses, held each October in conjunction with the American Solar Energy Society's National Solar Tour. When Bill happily informed the committee that money was on the way to install a solar-electric system, the members saw the potential for a high-profile renewable energy demonstration project. Doty & Miller's reputation for sustainable design, the firm's civic involvement, and the building's location in a recently revitalized part of town were elements for success.

In the past, GEO offered numerous seminars that provided overviews of various renewable energy technologies. The solar committee wanted to take learning to the next level by giving workshop participants hands-on installation experience.

A Showcase System

Because of the demonstration nature of this project, Bill felt it was essential that the solar-electric panels be visible from the street, rather than hidden on the roof. He liked the idea of a solar-electric awning system for its aesthetic appeal and also because it combines active solar energy generation with passive shading of the building's windows during the summer.

With the Doty & Miller building, system designer Erika Weliczko had to take into account two different sun exposures—one on the southeast side and the other on the southwest side—

Custom-made mounting brackets provide a stable platform for the PV arrays.

Workshop participant Jason Moore wires the panels.

and figure out how to deal with shading from nearby trees. Ultimately, she designed the system with two separate PV arrays—a southeast-facing array optimized for 9 AM to 2 PM, and a southwest-facing array optimized for 11 AM to 3 PM. Each array feeds DC electricity to a dedicated inverter that, in turn, outputs grid-synchronous AC electricity.

The next challenge was designing the support framework (mounting racks) for the solar-electric panels. Rather than ordering stock mounts and retrofitting them to form the awnings, Bill favored custom designing the framework. After calculating combined solar-electric panel weights, the optimum angle for capturing solar energy, weatherability, strength, and aesthetics, Doty & Miller's structural engineer Ed Gallagher came up with a design that used stock aluminum angle material, cut to size and bolted together.

The custom-designed and fabricated aluminum awning that supports the solar-electric panels consists of a series of triangles constructed out of lightweight, 3- by 3-inch, aluminum angle. Before the workshop, the mounts were pre-drilled and bolted together to form triangles using stainless steel bolts with stainless steel nylon locknuts. Next, the triangles were drilled and mounted to the building on previously installed, threaded epoxy stud anchors. After the mounts were fastened to the building, aluminum box beam rails were attached to them horizontally. With the rack and horizontal rails in place, the solar-electric panels were then fastened to the rails using UniRac low-profile mounting clips.

Tech Specs

System Overview

Type: Batteryless, grid-tie PV

Location: Bedford, Ohio

Solar resource: 3.9 average daily peak sun-hours

Production: About 300 AC KWH per month

Utility electricity offset: About 4 percent (due to significant HVAC loads)

Photovoltaics

Modules: 28 Kyocera KC-120, 120 W STC, 16.9 Vmp

Array: Two, 14-module series strings, 1,680 W STC each, 236.6 Vmp, 3,360 W STC total

DC array disconnect: Square D HU361

Array installation: Custom mounts installed on SE- and SW-facing facades, 45-degree tilt

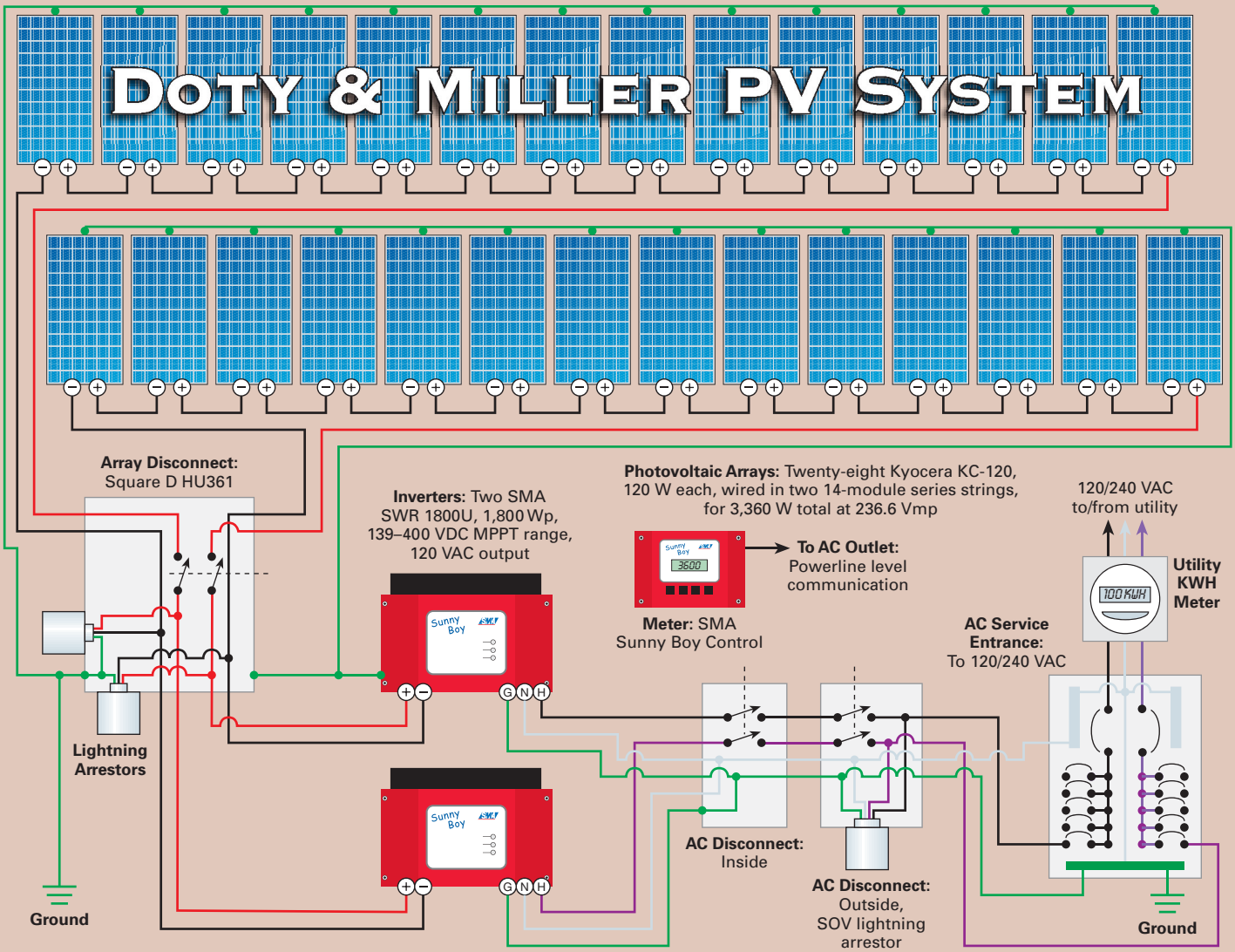
AC disconnect: GE TG3221

Balance of System

Inverters: Two, SMA SWR 1800U, 1,800 Wp, 139–400 VDC MPPT range, 120 VAC output

System performance metering: Sunny Boy Control

Installing the photovoltaic panels—participants were provided with hard hats and gloves, and given a briefing on safety before beginning the hands-on portion of the workshop.



Locating the balance of system components in the vestibule lets visitors see how they function.

System Components

At 15,000 square feet (1,394 m^2) of office space, the Doty & Miller building has significant loads due to office equipment, and space heating and cooling. To stay within their limited budget for this demonstration project, a relatively small PV system, which meets approximately 4 percent of their electricity needs, was designed and installed. Since the building's critical electrical loads, including the security system and building controls, already had battery backup and the local utility grid rarely experiences outages, a batteryless inverter system was chosen.

Each awning consists of fourteen Kyocera KC-120 (120 W) panels wired in series, feeding its own Sunny Boy 1800U inverter. The peak output rating for each awning is 1,680 W.

Workshop Design

The GEO solar committee agreed that registration would be higher if people did not need to lose standard work time to participate. After much discussion, we finally decided on a single weekend workshop. Once we defined our objectives, the workshop scope, registration logistics, project workflow, and many of the other planning details fell into place quickly.

After deciding on three to four hours for the morning lecture session, we tried to gauge the amount of time each activity would take during the hands-on portion. We figured that groups of four to five people could work simultaneously on each aspect of the installation. Each group would have access to a workshop volunteer for consultation and supervision.

Green Energy Ohio workshop participants expanded their own knowledge and helped expose the community to renewable energy with this high-visibility PV system.

Our workshop registration form asked participants to indicate their electrical experience level, any related certifications, and their reasons for attending. This helped Erika design the instruction to fit the students, as well as provide what they needed to know to work on the Doty & Miller project.

As it turned out, participant skill and knowledge levels varied. All indicated that they believed energy independence to be important for the future of America. Many said they were considering solar electricity for their own homes. A few attended to learn and have fun working on a "green" project. Several professional electricians, including two members of the International Brotherhood of Electrical Workers union, came to learn more about solar electricity and expand their expertise.

Two major learning objectives were important—to provide sufficient information about solar energy relevant to the Doty & Miller project and to give participants hands-on installation experience.

Workshop time was split into a morning classroom session and an afternoon hands-on installation session. The Saturday morning instruction featured a crash course in the fundamentals of solar electricity. Using the specifics of the Doty & Miller project, major topics included power and energy, budget considerations, electricity costs, solar-electric panel ratings, component selection, wire sizing, safety, resources, and system configuration comparisons.

After spending all morning sitting inside, participants were eager to get outside and start working with the real thing. Toward the end of the first afternoon, participants returned to the classroom for a debriefing with a question-and-answer period. Then, they were given a preview of the important installation elements that were scheduled for completion on Sunday.

The class was divided into four rotating work groups. While one group was mounting the inverters and disconnects, another was cutting pieces of flexible, weather-tight conduit for the panel-to-panel connections and assembling wires with spade terminals for installation between the panels. A third group was up on the scaffolding. Other participants were running conduit from an external junction box to the inside equipment and pulling the necessary wiring. Everyone had the opportunity to climb up on the scaffolding and get their hands in a wiring junction box on the back of a solar-electric panel, or work with the inverter electrical connection, as well as do some wire stripping or learn how to heat PVC conduit so it could be bent.

The combination workshop–installation undertaking proved successful, in large part, because of the collective talents, skills, and experience of the committee and volunteers. So far, the workshop–installation combo has gained us publicity in three magazines—*Home Power, Properties,* and *Solar Today.* Online, the project is described at the Green Energy Ohio Web site and Department of Energy's Million Solar Roofs Web site.

PV System Costs

Item	Cost (US$)
28 Kyocera 120 W panels	$12,320
2 Sunny Boy 1800U inverters	3,400
Custom aluminum frames	2,000
Sunny Boy Control	700
Scaffolding rental	500
Design & consultation	300
Misc. electrical, hardware, etc.	250
Permits & fees	200
DC disconnect	150
4 Lightning arrestors	112
4 Internal mounting clips	104
Hardware for frames	100
2 AC disconnects	84
2 External mounting clips	30
Installation labor donated ($7,600 value)	0
Total	$20,250
Ohio Office of Energy Efficiency matching grant	- $10,125
Out-of-Pocket Cost	$10,125

To consolidate system components and reduce cost, only one DC disconnect was installed on this system. Flipping the DC disconnect lever effectively shuts down both awnings by opening both the southeast and southwest array circuits. The same is true for the AC disconnect located near the inverters, as well as the external lockable AC disconnect. Electrical storms are common in northeast Ohio, so as an extra precaution, each awning has a lightning arrestor installed on both DC and AC sides of the inverter.

Solar-Electric Success

Volunteers and GEO committee members completed the installation in a weekend workshop led by Erika (see "Workshop Design"). And so far, says Bill, "The system is doing very well—even generating some electricity under cloudy conditions."

The Doty & Miller building was a featured attraction on the 2004 Green Energy Ohio–American Solar Energy Society tour. "Many [of our visitors] didn't realize that solar-electric systems could be so attractive," says Bill. "In fact, many people commented on how cool it looks. The awning and component panel provide an excellent demonstration of renewable energy—colorful, technically interesting, and aesthetically unique. The awning shows how a building can benefit from both active solar-electricity generation and passive shading."

"The system is great for public education and awareness," says Bill. "We located the controls in the rear entrance vestibule, so people who tour the building can easily see how the system is laid out and understand how it works. Eventually, we'll also add informative labeling of the components, much like the ones we have in the building to explain its energy efficiency measures."

Recently, they added a software program that allows them to track the system's output. This output will be integrated into their newly upgraded building automation and controls program. Both will be incorporated into a Web-based control system, which they can access via the Internet. This capability will give them the opportunity to monitor and adjust their operating systems online, as well as collect data on the solar-electric system's performance.

"Doty & Miller believes that renewables are the future," says Bill. "It's just not 'talk' to us—we are truly committed. Installing this small system on our building provides visitors and clients alike with tangible evidence of that commitment."

Access

Sandy Woodthorpe, Technical & Marketing Communications • 440-639-0819 • iwrite4you@earthlink.net • www.writeon4you.com

Bill Doty, Doty & Miller Architects, 600 Broadway Ave., Bedford, OH 44146 • 440-399-4100 • Fax: 440-399-4111 • wdoty@dotyandmiller.com • www.dotyandmiller.com

Green Energy Ohio, 7870 Olentangy River Rd., Ste. 209, Columbus, OH 43235 • 866-GREEN-OH or 614-985-6131 • Fax: 614-888-9716 • geo@greenenergyohio.com • www.greenenergyohio.org

Erika M. Weliczko, REpower Solutions, PO Box 91992, Cleveland, OH 44101 • 216-402-4458 • erika@repowersolutions.com • www.repowersolutions.com

Kyocera Solar Inc., 7812 E. Acoma Dr., Scottsdale, AZ 85260 • 800-223-9580 or 480-948-8003 • Fax: 480-483-6431 • info@kyocerasolar.com • www.kyocerasolar.com • PV panels

SMA America Inc., 12438 Loma Rica Dr., Unit C, Grass Valley, CA 95945 • 530-273-4895 • Fax: 530-274-7271 • info@sma-america.com • www.sma-america.com • Inverter

Square D/Schneider Electric, 1415 S. Roselle Rd., Palatine, IL 60067• 888-778-2733 or 847-397-2600 • Fax: 847-925-7207 • www.squared.com • Square D breaker

UniRac Inc., 3201 University Boulevard SE, Ste. 110, Albuquerque, NM 87106 • 505-242-6411 • Fax: 505-242-6412 • info@unirac.com • www.unirac.com • Rack mounting system