Deck Mounting a Photovoltaic System

With the right design, installation is straightforward and payback time is shorter than ever

by Conrad Geyser

My company has been installing rooftop solar equipment since the 1970s, when the words "solar panel" meant solar hot water, and photovoltaic modules — now commonplace in both residential and commercial settings — were found mostly on satellites, being far too expensive for most earthly projects.

But PV costs have come down to earth. The grid-connected systems we install today typically cost around $4.30 a watt, or about what the PV modules alone cost six years ago. For a 9-kw system like the one shown in this article, that brings the gross cost to $39,000 or so, and municipal, state, and federal incentives may cut the out-of-pocket cost by half or even more (see "SRECS and Tax Credits," next page).

Estimating system output. We use a free solar calculator called PVWatts to develop an accurate preconstruction estimate of a proposed system's output. It's designed for grid-connected systems and is available from the National Renewable Energy Laboratory at nrel.gov/rredc/pvwatts/grid.html. Using it is a matter of plugging in the system parameters and the location and letting the program run. But because this will give you the expected annual power production on a hypothetical site with full sun throughout the day — and many installations experience partial shading at some point during the solar day — that initial figure has to be de-rated to account for site-specific conditions.

To perform that fine-tuning, we use a solar site-assessment tool called the Solar Pathfinder (solarpathfinder.com). It's a reliable and relatively simple-to-use analog device that lets us factor in local shading from trees and other obstructions. Although more sophisticated — and costly — electronic site-assessment calculators are now available, we've had such good results with our current approach we see no need to change. By the time we've crunched all the numbers, our estimate usually comes in within 5% of the actual production of the installed system — typically on the low side, since we want our customers to be pleased at getting a little more power than expected (rather than the other way around).

Cost and payback. With a kitchen or bath remodel, value is subjective. That's not the case with a PV installation. Our clients tend to be environmentally aware and concerned about issues like global climate change, but at the end of the day their decisions are based on payback expectations measurable in dollars and cents.

To help with those decisions, we provide homeowners with a document that lays out the upfront cost of the system, factors in available incentives and the value of the power produced, and calculates its expected payback time. Most of the systems we install will pay for themselves in five years or less.

Roofing matters. It's important to make sure existing roof shingles have lots of life remaining before covering them with a solar array. We might consider mounting panels on a 10-year-old roof, but if the material is older than that it's a good idea to reroof first. We've removed a lot of solar-thermal and PV systems to permit reroofing before reinstalling them afterward, and this isn't something you want to do more often than you have to.

Interestingly, the roofing beneath the solar array is almost always in vastly better shape than areas exposed to sun, wind, and weather. Unfortunately, unless a house has been designed with available module dimensions in mind, it's seldom possible to extend the life of an entire roof plane by covering it with panels from eaves to ridge. More often than not, obstructions like dormers and partially shaded areas limit the available roof area to some fraction of its overall area.

The project pictured on these pages is typical in that respect. The following photos offer a step-by-step look at how the key details in this installation went together.

SRECs and Tax Credits

The most obvious financial benefit to a net-metered PV installation is its effect on the electric bill: Every kilowatt-hour the system generates is one less kilowatt-hour the homeowner has to pay for. But other credits and incentives can make residential PV an even better deal. In our area, there are three major sources of funding available to residential PV customers:

• SRECs, or solar renewable energy credits, are available in states that require utilities to provide a certain percentage of their power from renewables. In most cases, it's simpler for the utilities to buy that renewable power from third-party producers — including homeowners and businesses with grid-connected PV systems — than it is to produce it themselves.

One SREC is equal to 1,000 kwh of electricity, or one megawatt-hour — roughly the amount that a typical 10-kw PV system will generate in a month. Once the system's revenue-grade meter — which tracks the total system production over the life of the PV system — logs 1,000 kwh of production, the owner is credited with one SREC. Normally these are sold through a solar aggregator, which buys the credits from small producers and resells them to utilities. The value of an SREC varies from state to state and in response to supply and demand, but the going rate in Massachusetts is now around $200 each.

• The federal tax credit on a solar system is equal to 30% of the gross cost of the qualifying system. Unlike a tax deduction that reduces the homeowner's taxable income, this is a direct tax credit that is subtracted from his or her tax bill.

• State and municipal incentives may also come into play. For example, residential PV systems in Massachusetts are eligible for a 15% state income tax rebate, and customers of some utilities are eligible for additional rebates of $0.40 to $0.85 per watt toward system installation.

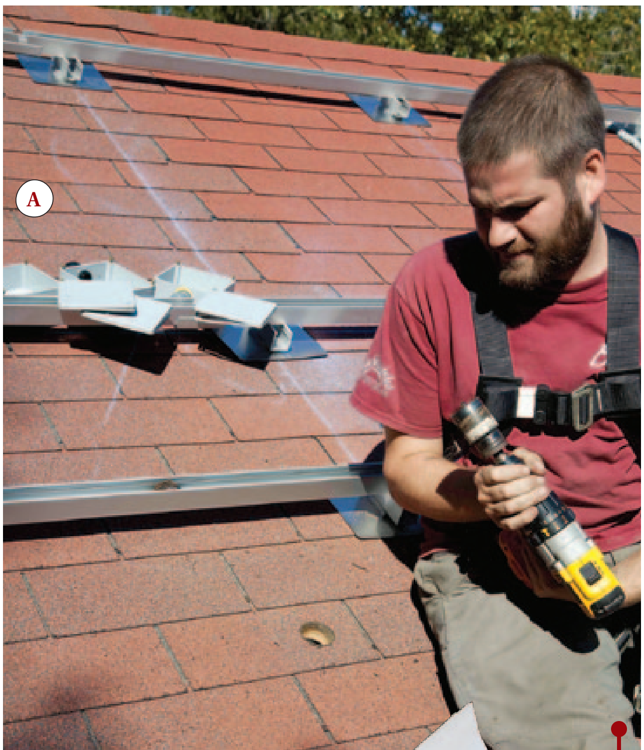
1. The author uses the Solar Pathfinder site-assessment tool at left to evaluate the effect of local shading on a PV array. For optimum power output, the angle of a fixed photovoltaic array should equal the local latitude — about 42 degrees at this Massachusetts site. While the existing roof wasn't a perfect match, it was close enough: PV panels are now cheap enough that it's more cost-effective to install a larger array directly on the roof than to incur the additional cost of angled mounting brackets.

2. After snapping lines marking the position of the rafters, the installer lays out the first extruded-aluminum mounting rails, which will be fastened to each rafter with a 5⁄16-inch hot-dipped lag screw (A). The rails are held off the roof at each connection by a short spacer or "mounting foot" cut from extra railing material (B, C). A manufactured aluminum flashing tab (D) is slipped under the shingle above; its rubber grommet forms a weatherproof seal around the lag.

3. Where required, rail sections are joined between mounting feet with splice fittings that allow for necessary thermal expansion and contraction. The fittings add enough flexibility to allow the rails to conform to minor irregularities in the roof plane.

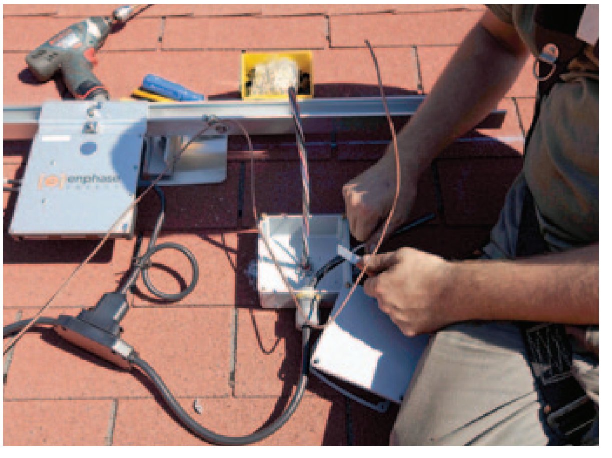
Deck Mounting a Photovoltaic System

4. Intermodule clips are slipped into tracks as each rail is installed. The clips fit between adjacent modules, securing them to the rails and ensuring a consistent edge-to-edge spacing. Slightly different fittings are installed at the end of each rail.



5. The modules will be grouped in two separate "strings," so only two roof penetrations are required for the entire 38-module array. A waterproof plastic junction box at each penetration is carefully sealed to the shingles with silicone to prevent leaks (A). Two parallel runs of metal-clad cable conduct power from the rooftop array to the service entrance (B). Adhesive stickers identifying the cable as a photovoltaic power source will be attached to the cable at regular intervals, as required by code (C).

6. Each 245-watt PV module is given its own microinverter, which converts the DC output to AC and continuously adjusts the output for maximum wattage. The microinverters also enhance safety by shutting off the flow of power in case of a local outage on the grid. After manufactured module interconnection cables are laid out on the roof (above), a locking waterproof plug at each microinverter is snapped into the adjacent cable fitting, and the cable is connected to the metal-clad cable and module ground wires at the junction box (right).



7. At about 65 inches by 40 inches and 42 pounds, individual modules are easily handled by one worker (far left). Each panel's DC output passes through a pair of wire leads on the back (left).

8. Starting at one end of the mounting rails, workers move modules into position and connect their positive and negative leads to the microinverter input fittings (A). Cables are zip-tied to the rails or module frames as needed to prevent them from rubbing against the shingles or trapping debris (B). Another set of mounting clips is positioned against the outside edge of the module frame, and the sequence is repeated for the next module (C).

9. At the service entrance, the metal-clad cables from the array can just be seen here entering the subpanel at top center. Because the power from the panels has already been converted to AC and synchronized with the grid at each microinverter, there's no need for a large synchronous inverter between the PV subpanel and main breaker box at far left. The utility-grade meter at center tracks the array's power production. The additional box to the right of the meter will contain a data acquisition system, or DAS, which will automatically track production of solar renewable energy credits (SRECs) and send that information to a third-party meter reader.

Trade Restrictions

Installing a photovoltaic system spans a couple of different trades and professions, including roofing, carpentry, and engineering. Most of the remaining work is electrical, and state regulations often dictate who's allowed to do what. In California, for example — where the residential PV industry is well-established — state-licensed solar installers are allowed to do much if not all of a residential installation, including wiring runs.

The situation in Massachusetts, where we work, is more chaotic and less installer-friendly. Thanks to the influence of the electrical worker's union, only licensed electricians are permitted to handle or install any solar components, including racking or any other part that may be used for grounding. This increases costs and doesn't necessarily result in better or safer installations. In fact, because electricians may not be trained in the structural and roofing aspects of an installation, the electrician-only rule may lower the quality of some work. Recently, my company and several others had to take the Board of State Electrical Examiners to court in order to block its attempt to prevent us from contracting this work that we've always done.

There's reason to hope that the state will eventually adopt a more practical licensing system unique to PV installations, although proposed legislation on the subject has been blocked for the past four years.

10. A second meter on the outside wall registers the homeowner's net power use, spinning forward or backward depending on whether the home is drawing power from the grid or supplying it. If more power is produced than used, there's no electric bill that month. A utility-required emergency shutoff switch allows utility workers to confirm that the panels are offline when needed.

11. Layout of the 9.3-kw array (two additional PV modules lie on the far side of the larger gable dormer at right) was based on a thorough shading analysis of the site. Because the structure faces southwest, it receives full sun relatively early in the day for much of the year, but is subject to some late-afternoon shade. (Several trees to the west of the array were later removed to eliminate some shading.)

***Conrad Geyser** is the principal of Cotuit Solar in Cotuit, Mass.*