

Install A Solar- Electric Roof

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Nailing down the PV shingles is similar to installing regular composition shingles.

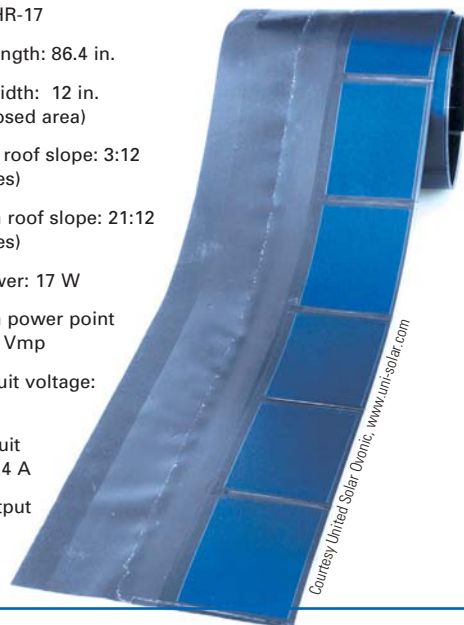
Building-integrated photovoltaic (BIPV) systems integrate solar-electric materials into a building's exterior skin. Residential BIPV roofing options include PV shingles or tiles, and PV laminates on metal roofing. PV shingles are one BIPV option for homeowners, converting roofing into a source of electricity.

Homeowners concerned about aesthetics can choose PV shingles for new construction or for re-roofing existing homes. PV shingles meet the needs of homeowners in locations that otherwise restrict the installation of solar-electric modules, satellite dishes, and antennas. Another advantage is saving money. A homeowner will save on conventional roofing materials, PV mounting frames, and hardware—and, of course, energy too.

United Solar Ovonic's PV shingles use flexible thin-film solar cells of amorphous silicon on a 5-mil (0.0127 mm) stainless steel substrate. They are encapsulated in a weather-resistant polymer, and blend into the roofing pattern of conventional fiberglass or asphalt shingles. The shingles carry a 20-year warranty on electrical output, and are rated to withstand 80 mph (36 m/s) winds. The PV shingle is nailed in place with common roofing nails over 30-pound felt underlayment.

Uni-Solar PV Shingle Specs

- Model: SHR-17
- Shingle length: 86.4 in.
- Shingle width: 12 in. (5 in. exposed area)
- Minimum roof slope: 3:12 (15 degrees)
- Maximum roof slope: 21:12 (60 degrees)
- Rated power: 17 W
- Maximum power point voltage: 9 Vmp
- Open-circuit voltage: 13 Voc
- Short-circuit current: 2.4 A
- Power output warranty: 20 year



Installing PV shingles on a hip roof can be complicated, requiring some advance planning.



Below: Wiring leads on the back of a PV shingle.



Courtesy United Solar Ovonic, www.uni-solar.com

Several courses of PV shingles seamlessly integrate into a typical composition roof.

Planning & Layout

A lot of pre-installation planning is required to assure a clean and code-compliant PV shingle project. When installing on new construction, planning your PV system with the architect during the building design stage is critical. When installing on existing buildings, care must be taken to examine the roof structure, paying close attention to construction type, spacing of framing members, and working space in the attic. You must carefully consider the roof areas and dimensions of the roof sections.

Installing PV shingles on simple gable roofs is the most common installation. Each horizontal course of shingles is offset from the course below it by half a tab, or 3¹/₂ inches (9 cm)—this is standard shingle roofing practice. When you're done installing the PV shingles, you have two vertical columns of wires 3¹/₂ inches apart, which are routed through two parallel raceways under the roof deck between the rafters. A hip-roof installation takes on a trapezoid shape, with a single line of wires that cross rafter spaces and can easily hit rafters or blocking, and interrupt the required continuous raceway.

The high DC input voltage of grid-tied inverters calls for 30 to 40 shingles wired in series. This may require 100 to 120

square feet (9–11 m²) of unshaded roof area for one series string. A 1 KW array of solar shingles is approximately 60 shingles and 180 square feet (17 m²). The efficiency of the shingle is about half that of a crystalline module. This means that the roof area needed for a 1 KW PV shingle array is approximately twice that of a crystalline array.

Installing PV Shingles

PV shingles are installed on sloped roofs that have at least a 3:12 pitch, to provide adequate weather protection. Allow for about five courses of conventional shingles at the eave and peak to allow for the working clearances required by the *National Electrical Code*.

The PV shingle is installed like a conventional three-tab or dimensional shingle. Plan the shingle layout so the wires fall between the rafters to make the wiring connections easier. Nail the shingles to the roof with conventional roofing nails. The positive and negative bus bars, encapsulated in the shingles, run in the area 1¹/₂ inches (38 mm) above the cells, so follow the nailing instructions that come with the shingles.

Making the wiring connections and containing the series string wiring in conduit is a complicated and time-consuming task. Each shingle requires a hole to be drilled through the



Drilling the wiring holes before nailing the PV shingles.

plywood roof sheathing so the wires can be inserted and then connected to the other shingles to complete the array wiring. United Solar provides a cardboard template to help installers mark the locations for the wires. The template has to be placed very accurately so that the holes for the wires will be precise and shingles are properly placed for even exposure and to avoid shading other cells or pinching the wires. Snap chalk lines up the roof to provide guidelines for the template.

Since wiring connections need to be accessible, shingles should not be installed on overhangs, or other sections of roof where there is no access to the wiring below the roof deck. You cannot cut a PV shingle, so make sure you will have adequate area for the shingle length and the multiple series wiring connections of the low-voltage shingles.

Since 1998, my company has followed United Solar's recommendations, and has used a plastic surface raceway like Panduit for series string wiring and connections. The base strip of the Panduit is drilled to match the holes in

the roof and secured to the underside of the roof deck with $\frac{3}{8}$ -inch screws. We use a $\frac{7}{8}$ -inch drill bit to make our holes in the roof, and a band saw, miter saw, or hacksaw to cut $\frac{1}{2}$ -inch-long pieces of $\frac{1}{2}$ -inch PVC conduit. The PVC pieces are inserted into the holes in the roof before securing the Panduit. Another raceway option is manufactured by Wiremold. The G4000 raceway product is steel, and UL listed for use up to 600 volts.

Wiring PV shingles can be tedious work—requiring more than 60 connections for each rated kilowatt of PV array, many times in less-than-ideal conditions. Use a good crimping tool and weather-resistant butt connectors to make reliable, long-term connections. Give the wires a good tug and measure the open circuit voltage as you go to ensure good connections. Parts for the plastic surface-mount wire raceway include snap-together inside corners, outside corners, 90-degree base and cover pieces, and junction boxes. Terminate the module interconnect wiring in a J-box, and run THHN-2 or THWN-2 in metallic conduit, or run armored cable to the combiner box, disconnect switch, and inverter.

Solar-Electric Roofing

PV shingles are just one option for installing a solar-electric system on your home, and they have their advantages and disadvantages. On the downside, wiring PV shingle systems

Making series connections in the raceway.



Code Issue

United Solar Ovonix received UL approval in 1998 to use plastic raceway, mounted below the roof deck, as a junction box for their PV shingles. Section 690.14 of the 2005 *National Electrical Code* requires that PV source circuit and output circuit wires run in *metallic* conduit from the point that the wires penetrate the roof to the first readily accessible disconnecting means. In some jurisdictions, this requirement may prohibit long runs of PV source and output circuits inside a building before reaching the code-required PV disconnect.

The best approach to installing PV shingles is still under discussion. The skilled professionals who continue to develop better techniques to install PV shingles, as well as the other renewable energy technologies, are helping to standardize the industry and encourage satisfaction and ownership of solar energy systems.



PV shingles seamlessly blend into this home's rooftop, merging form with function.

is definitely more complicated than module installations, with lots of connections for these low-voltage shingles. And thin-film roof shingles are about half as efficient as crystalline PV modules, so you need more roof space for the same output. But for energy efficient homes with good southern roof exposure, this is not generally a serious limitation.

Chief among the advantages of PV shingles are that they blend in with the existing structure. Another advantage is that the cost of your roofing material and your electrical generating equipment is rolled into one product, so you don't need to purchase separate roofing, modules, and racking equipment. PV racking can be a significant cost of a system, and the labor to assemble and install it is another cost. You also have no exposed roof penetrations with a shingle installation, while with most module racking systems, you have multiple penetrations.

If you want your solar-electric system to blend in with your home's exterior, you should consider BIPV options. Then you can smile whenever the sun shines, knowing that your roof is not only keeping you dry, it's also providing your electricity.

Access

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Panduit • www.panduit.com • Plastic raceway

United Solar Ovonic • 800-843-3892 or 248-475-0100 • www.uni-solar.com • PV shingles

Wiremold • 800-621-0049 • www.wiremold.com • G4000 raceway

"Roof-Integrated PV: From Sunbeam to Standing Seam," William Ball, *HP105* • Solar-electric laminates for metal roofing

