

## Photovoltaic (PV) Roofing Products – Are They Reliable?

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### **Introduction**

The Wisconsin Solar Use Network (WisconSUN) promotes the mainstream use of photovoltaic (PV) systems. By mainstream, we mean PV located in an urban environment, where land is expensive, and PV systems must be aesthetically pleasing. Given this objective, WisconSUN envisions that portions of the building shell (i.e., rooftops, facades, and windows) of our homes, shops and offices will be composed of PV modules and generating solar electric power.

Initially, WisconSUN is focusing on PV roofing products. Currently there are three PV roofing products readily available in the US market.

1. UniSolar PV Shingles
2. UniSolar PV Standing-Seam Metal Roofing Panels
3. Atlantis PV Roofing Slates (called SunSlates)

The UniSolar modules use an amorphous solar cell (a thin-film PV material). The Atlantis modules use a mono-crystalline silicon, polycrystalline or amorphous silica cell.



Photo 1 Installing UniSolar PV Shingles

There have been four technical concerns with PV roofing products:

1. Degradation of the amorphous silica material and PV output over time
2. Delamination of the flexible module substrate and cover (used both with PV shingles and standing seam PV roofing)
3. Shorts at the electrical connections between each module
4. Roof leakage caused by wiring penetrations

We discuss each of these concerns below.

### **Capacity Degradation**

The pre-1997 UniSolar modules used two, three-layer cells of PV material (this is known as a dual-junction solar cell). These dual-junction cells experienced power output that degraded with time (typically 20% of their rated capacity), a phenomenon known as photo-degradation. The output of all PV materials degrades gradually with time but the dual-junction amorphous cells degrade more rapidly than crystalline cells. For example, an eight-year-old dual-junction amorphous UniSolar system being tested at the National Renewable Energy Laboratory (NREL) is now producing 20% less power than its rated capacity<sup>1</sup>. This is, however, better than single-junction amorphous cells from the 1980s, which exhibited output reductions of about 30%.

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<sup>1</sup> In 1995 Home Power Magazine reported that their UniSolar module was operating above its rated output. The module is operated in a hot climate and not ventilated; amorphous silica cells perform slightly better at increased temperatures. An amorphous silica cell's operating temperature (~40 to 60°C) is usually greater than the temperature used to rate the power output of modules (25 °C), hence the higher reported output.

In 1997 UniSolar introduced a new PV product line fabricated with a new amorphous silica solar cell. The new cell has improved conversion efficiency (power output), long-term performance (due to reduced photo-degradation), and durability. The new UniSolar product line uses a triple junction amorphous solar cell. The triple-junction cell uses three, three-layer cells of PV material, each tuned to a specific spectrum of sunlight<sup>2</sup>. This has improved the modules' efficiency. In addition, each of the three amorphous silica layers is thinner than in the past; the thinner the amorphous silica layer the less photo-degradation is experienced. Thus, power-output degradation has been significantly reduced, improving long-term performance.



The new UniSolar triple-junction module's degradation is anticipated to be about 10% over a 20-year period. To date, NREL has not seen any power degradation in their triple-junction test module. In cold climates output will decline slightly in the winter. But in general, the amorphous silica modules are less temperature-sensitive over all temperature ranges than crystalline silica modules. The conversion efficiency of amorphous silica solar cells actually improves slightly in warmer temperatures. Crystalline silica cell's conversion efficiency, conversely, degrades with warmer temperatures<sup>3</sup>.

Photo 2 Installing Atlantis Energy's PV Shingles

UniSolar has a 20-year limited warranty for their products<sup>4</sup>. UniSolar guarantees that output degradation will not exceed 20% of the module's rated capacity for 20 years. The rated power output of a UniSolar module is based on an estimate of the module's stabilized long-term performance. Thus, it is common that a UniSolar module's output will be somewhat higher than its rated capacity for the first several months of operation.

### ***Delamination of Module Materials***

Older UniSolar PV roofing had problems with moisture entering the module and causing delamination of the module. The new UniSolar modules have wider seals around the edges and sit on a substrate that does not wick moisture. To date, delamination has not been a problem with the new UniSolar PV modules. The UniSolar 20-year warranty also covers module delamination; if a UniSolar module delaminates and its output declines by more than 20% of its rated power, then UniSolar's 20-year warranty covers it.

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<sup>2</sup> The top cell is tuned to blue light, the middle cell to green and yellow light, and the bottom cell to orange, red and near infrared light.

<sup>3</sup> Thus it is better not to vent the backs of amorphous silica cells; rather, let them get warm in the summer sun.

<sup>4</sup> The warranty covers the replacement of the module but does not cover other costs or items (such as lost output and labor).

## **Electrical Shorts**

Individual PV roof modules have the following peak outputs: 17 watts for a PV shingle<sup>5</sup>, 12.2 watts for a crystalline SunSlate, and 64 or 128 watts for a standing seam panel. Thus, systems of 1 to 2 kW will require many electrical connections. To date, electrical shorts have not been a significant problem if the modules were properly installed.



Photo 3 Installing UniSolar standing seam PV roofing

Mechanical installation of PV roofing products are performed by conventional roofers using standard installation practices. Electrical installation is quite straight forward, allowing a qualified electrician or PV system installer to easily install the system. The Atlantis Energy SunSlates use plugs designed in Switzerland that provide quick and easy module interconnection and protect the connection from the elements. In all cases, with proper installation techniques, electrical shorts between modules should not be a concern.

## **Roof Penetrations for Wiring**

Roof penetrations are only needed for the UniSolar PV shingles. For the Atlantis SunSlates, wires are run out the gable ends of the roof. For the UniSolar standing seam metal roofing, the wires are



Photo 4 Installing Atlantis Energy's SunSlates

run either beneath the ridge cap or under the roof's overhang. To minimize the potential for leakage with the PV shingles, they are designed to form a double weatherproof layer upon installation, like conventional shingles. At the overlap between each shingle an adhesive seal forms a water and weather-tight bond between the consecutive layers.

## **For More Information**

### **Evaluations of the UniSolar Products**

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<sup>5</sup> About 7 feet long



