



UNI-SOLAR®

Bekaert ECD Solar Systems LLC

BUILDINGS & PHOTOVOLTAICS GRID-CONNECTED PV-SYSTEMS

Unique Photovoltaic Technology based on:

- Shingles
- Metal Roofing
- Framed Power Modules

UNI-SOLAR® ROOFING SYSTEMS

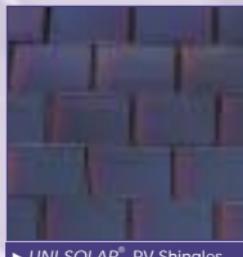
The leader in Thin-Film Silicon Photovoltaics, Bekaert ECD Solar Systems LLC, offers a revolutionary line of products for the built environment (grid-connected applications). Unlike other photovoltaic technologies that use heavy, framed, glass-encapsulated modules, UNI-SOLAR® framed PV-modules are unbreakable and lightweight. But the real superiority of UNI-SOLAR® products only becomes apparent in the UNI-

SOLAR® roofing products for Building Integrated Photovoltaics (BIPV). These architecturally attractive, roof integrated photovoltaic products emulate conventional roofing materials in design, construction, function and installation. UNI-SOLAR® products are cost-effective design options for creating sustainable and energy self-sufficient buildings.

Three different UNI-SOLAR® product families are available for use in combination with buildings in grid-connected PV-systems:



► UNI-SOLAR® PV-Metal Roofing Panel



► UNI-SOLAR® PV-Shingles



► UNI-SOLAR® Framed Power Modules

UNI-SOLAR® PRODUCT ADVANTAGES

- Solar panels are structurally and aesthetically integrated roofing elements (exception: framed power modules)
- Cost-effective installation through easy and fast fixing of large area roofing elements
- Standard installation techniques (standing seam metal roofing, shingles)
- No support structures needed for metal roofing and shingles
- Compatible with all traditional roof decks (direct installation on substructures of wood, steel, concrete or insulation board)
- No back-ventilation of solar panels necessary (panels can be placed directly on insulation material)
- Easy replacement of roof panels during renovation (roof is accessible for maintenance)
- Design freedom: custom-made metal panels available
- Ridge to eave coverage possible (homogeneous uni-coloured surface)
- Architecturally pleasing products with modern look
- Wind and waterproof roof
- Suitable both for renovation and for new buildings
- Unique UNI-SOLAR® Triple Junction Thin Film Silicon Solar Cells
- Higher energy output especially under non ideal orientations towards the sun (e.g. façades, nearly flat roofs) due to higher sensitivity to low light levels and to diffuse light
- Extremely shadow tolerant
- 20 Year limited warranty on power output



Simple installation and a perfect match with asphalt shingles and slates

UNI-SOLAR® PV shingles permit roofs of commercial and residential buildings to evolve from mere protection from the weather to a source of electric power. The flexible, thin-film solar cell shingle perfectly blends into a roofing pattern of traditional asphalt shingles or natural and fibre cement slates, making them also suitable for historical buildings.

- ▶ Direct nailing on substructure
- ▶ Easy to transport and to install
- ▶ No support structures needed
- ▶ Extremely lightweight
- ▶ Available in rolls of 12 interconnected solar cells
- ▶ Dummies available for filling edges
- ▶ Easy retrofit installation on top of existing asphalt shingles
- ▶ Suitable for historical buildings covered with natural slates (e.g. churches)



METAL ROOFING (SSR)

A combination of architectural styling with the structural performance and durability of Al-Zn coated (Aluzinc® or Galvalume®) steel.



1

Aesthetically-pleasing, solar metal roofing panels are integrated into the roof just like conventional standing seam metal panels. Solar electrical power is collected through electrical terminations located on top or on the bottom of the panel. No deck penetrations are required.

- ▶ For residential, commercial and public buildings
- ▶ For renovation and new buildings
- ▶ Suitable for very low slopes ($\geq 5^\circ$)
- ▶ Modern architectural look
- ▶ Large design freedom (panel length, width, curvature).
- ▶ Al-Zn coated steel can be pre-painted to better match the building colors



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Designed for ease of installation, these solar panels can be directly installed on (existing) wooden, concrete, or steel beams, avoiding the need for special support structures. System design and installation are made based on user needs.

- ▶ Easy installation
- ▶ No roof penetrations through roof skin necessary
- ▶ No back-ventilation of solar panels necessary
- ▶ High power ratings per roofing element (64 Wp-256 Wp)
- ▶ Durable: Aluzinc® or Galvalume® coating on steel panels
- ▶ Environmentally friendly (100 % recyclable)



2

POWER MODULES (US)

Standard rigid modules with durable aluminium frame for easy fixing on mounting structures on flat and sloped roofs.

- ▶ Unbreakable (no glass)
- ▶ Retrofit installation on top of roof tiles or flat roofs
- ▶ Power Ratings: 116, 64, 42, 32 Watts
- ▶ Lacquered Galvalume®-steel backing plate provides stiffness
- ▶ Anodised Aluminium Frame
- ▶ Weather Resistant Junction Box
- ▶ Multi-Contact (MC)-Junction Box with MC-connectors optional



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The unique Triple Junction solar cells provide extra power under low light conditions, under diffuse light and during warm weather, resulting in a 10-20 % higher yearly energy production per purchased kWp compared to all crystalline silicon technologies



2



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- ▶ For residential, commercial and public buildings
- ▶ UNI-SOLAR® Triple Junction Thin Film Silicon technology
- ▶ High sensitivity for diffuse and low light levels
- ▶ Low temperature coefficient
- ▶ More energy production per purchased kWp than crystalline silicon technologies
- ▶ Bypass diodes per cell for shadow tolerance
- ▶ Twenty Year Limited Warranty
- ▶ CE-compatible; JRC-Ispra CEI/IEC 61646/CEC-701 Certificates; UL-listed.

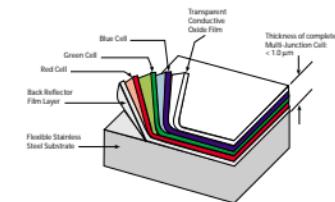


Triple Junction
Technology

Technology

All UNI-SOLAR® PV products use the unique Triple Junction solar cells of United Solar System Corp. This proprietary Triple Junction technology provides unprecedented levels of efficiency for thin film silicon solar cells. Each cell is composed of three semiconductor junctions stacked on top of each other. The bottom cell absorbs the red light, the middle cell the green/yellow light and the top cell absorbs the blue light. This spectrum splitting capability is the key to higher efficiencies and higher energy output, especially at lower irradiation levels and under diffuse light. The cells are produced in a roll-to-roll vacuum deposition process on a continuous roll of stainless

steel sheet, employing only a fraction of the materials and energy of the production of standard crystalline silicon solar cells. The result is a unique, flexible, lightweight



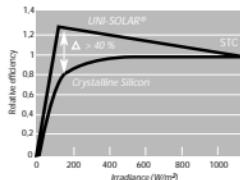
cell. The solar cells are encapsulated in UV-stabilised and weather-resistant polymers. The polymer encapsulation includes EVA and the

fluoropolymer TEFZEL® (a DuPont film) on the front side. The laminated solar cells are bonded to conventional roofing panels or fabricated into flexible roofing shingles. The resulting modules are exceptionally durable. By-pass diodes are connected across each cell, allowing the modules to produce power even when partially shaded. Each module (except SHR-17) has either a weather resistant junction box, designed to accept 12.7 mm conduits or a Multi-Contact (MC) junction box with MC-cables and connectors. These modules are appropriate for all applications from simple single module requirements to high voltage grid-connected applications.

Higher outdoor performance

UNI-SOLAR® products perform better than all their crystalline silicon and other thin film counterparts under non-ideal orientations and under real outdoor conditions and under real outdoor conditions (higher kWh energy production per kWp purchased). This enhanced performance, up to 20% higher, can be attributed to the higher sensitivity for low light conditions and for diffuse light, better performance at high temperatures and improved shadow tolerance of UNI-SOLAR® products. All solar modules are sold with their peak power performance (Wp) tested under laboratory conditions (STC): i.e. under a very high and direct irradiation (1000 W/m²), a module temperature of 25° C, and only one type of solar spectrum (AM1.5: mainly direct irradiation). Under real outdoor conditions, this peak power is seldom achieved, since module temperature usually is more in the range of 40–60°C under illumination (especially true for modules that are building integrated), the hours of 1000 W/m² irradiation is only about 1 % of

total sun-hours and the spectral content of the solar spectrum changes continuously with varying climatic conditions. Diffuse light dominates when the sky is clouded



or during mornings and evenings. In Northern and Central Europe, the majority of solar irradiation comes from diffuse light (more than 50 % of all solar irradiation), and even in Madrid, the diffuse part is, on average, still 33 %. Outdoor testing has shown that UNI-SOLAR® PV-products perform 40 % better at low light conditions (40–100 W/m²), than all present crystalline technologies. In Northern and Central European climates, where low light

conditions and diffuse light prevail, this results in 10–20 % higher yearly energy output per Wp purchased power for UNI-SOLAR® products compared to all crystalline (and other thin film) technologies. In warm, southern climates such as in Southern Europe, performance and yearly energy harvest is also 20 % higher, in this case due to the better temperature behaviour.

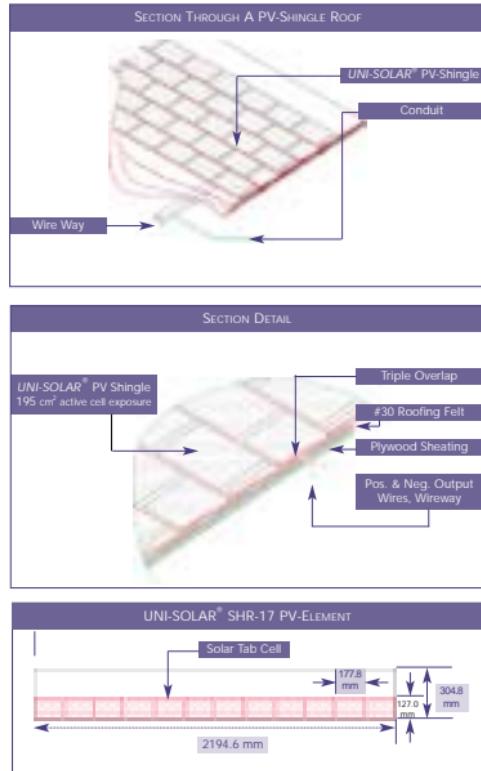
QUALITY ASSURANCE - PROVEN RELIABILITY

UNI-SOLAR®- modules comply with the following qualification tests (CEI/IEC 61646 certificate):

- Thermal Cycling
- Humidity-Freeze Test
- Damp Heat Test
- UV Test
- Wet Insulation Test
- Mechanical Load Test
- Hail Impact Test
- Robustness of Terminations Test

Product: **UNI-SOLAR® SHR-17**

- Appearance: the surface is textured to blend and complement the granular surface of the surrounding conventional shingles
- Shingle roll size: 2194.6 mm x 304.8 mm; 12 interconnected cells per roll (cell size: 127.0 mm x 177.8 mm)
- Electrical connections: two 300 mm long lead wires exiting from the bottom side of each shingle roll
- Installation: nailed in place using common roofing nails on conventional roof decking over a #30 (0.44 kg/m²) felt-underlayment or over a vapour barrier film. Applied in consecutive overlapping layers. An EVA-strip on the back of each SHR-17 element secures additional fixation to the underlaying SHR-17 element (upon heating with a hot air blower). Lead wires on back side of the head-lap pass through the roof deck to allow wiring connections to be made in the sub-roof space
- Wind load: independently tested up to 96 km/hour
- Weight per shingle element: 2.1 kg (installed weight: 7.5 kg/m²)
- Suitable roof slopes: 15° - 85°
- Maximum system voltage 600 V
- System: typical systems range from 1 kWp to 15 kWp



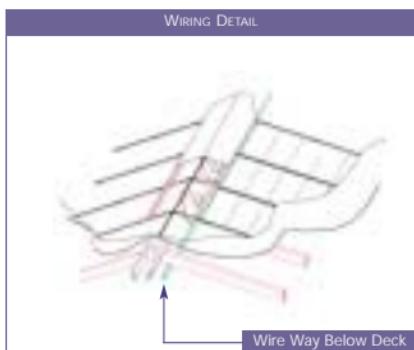
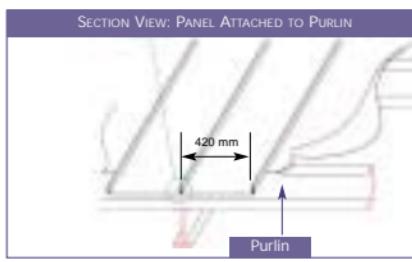
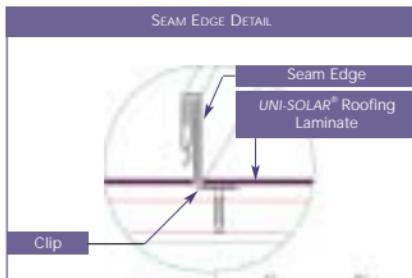
Photos: courtesy of Ulifex

SPECIFICATION & INSTALLATION

Product: **UNI-SOLAR® SSR-64 or SSR-128 and other custom made structural standing seam roofing panels**



- ▶ Metal Panel: 0.78 mm thick steel (S51GD or S280GD) with 185 g/m² Aluzinc®/Galvalume® coating (Al-Zn-Si, 55-43.5-1.5 by wt %) on both sides
- ▶ Finishing: unlacquered or lacquered with polyurethane/poly-amide (PU/PA); various colours on request
- ▶ Panel width (in situ): 420 mm standard width, but variable upon special request (405 mm minimum);
- ▶ Panel length: customer specified;
 - for 64 Wp panels minimum length is 2.924 m;
 - for 128 Wp panels minimum length is 5.562 m;
 - for 192 Wp panels minimum length is 8.486 m;
 - for 256 Wp panels minimum length is 11.124 m;
 - maximum panel length: 12 m
- ▶ Span width: about 500 mm
- ▶ Roof slope: minimum 5° (8 %)
- ▶ Minimum radius of curvature for curved steel panels: 1.2 m
- ▶ Applicable on: plywood frame, metal deck, rigid board insulation, metal framing, fibre-cement plates and concrete substructures
- ▶ Electrical connections: standard top termination (can be hidden and protected by ridge cap). Bottom termination on special request. Terminals end in a Junction Box.
- ▶ Maximum system voltage 600 V
- ▶ Systems: typical systems range from 3 kWp to 100kWp.



ELECTRICAL SPECIFICATIONS

UNI-SOLAR®

PRODUCT	SHR-17	SSR-64	SSR-128	SSR-192	SSR-256	US-116	US-64	US-42	US-32
Rated Power (W)	17	64	128	192	256	116	64	42	32
Operating Voltage V_{MPPT} (V)	9.0	16.5	33.0	49.5 ^c	66.0 ^c	30.0	16.5	16.5	16.5
Operating Current I_{MPPT} (A)	1.9	3.9	3.9	3.9 ^c	3.9 ^c	3.9	3.9	2.5	1.9
Open circuit Voltage V_{OC} (V)	13.0	23.8	47.6	71.4 ^c	95.2 ^c	43.3	23.8	23.8	23.8
Open Circuit Voltage V_{OC} at -10°C and 1250 W/m ² (V)	14.8	27.1	54.2	81.3 ^c	108.4 ^c	49.3	27.1	27.1	27.1
Short Circuit Current I_{SC} (A)	2.35	4.80	4.80	4.80 ^c	4.80 ^c	4.80	4.80	3.17	2.40
Short Circuit Current I_{SC} at -75°C and 1250 W/m ² (A)	3.07	6.30	6.30	6.30 ^c	6.30 ^c	6.30	6.30	4.20	3.10
Series fuse rating (A)	4.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0	4.0
Minimum blocking diode (A)	4.0	8.0	8.0	8.0	8.0	8.0	8.0	6.0	4.0
Dimensions (mm)	304.0 ^a x 2194.6	420.0 ^b x 2924.0 ^b	420.0 ^b x 556.2 ^b	420.0 ^b x 8486.0 ^b	420.0 ^b x 11124.0 ^b	762.0 x 2444.8	741.2 x 1366.1	741.2 x 928.3	328.7 x 1366.1
Weight (kgs/m ²)	7.5 ^d	9.8	9.8	9.8	9.8	< 9.0	9.06	9.11	9.18
Area (m ²)	0.28	1.22	2.32	3.55	4.65	1.86	1.12	0.69	0.52

a ► Shingle width including head-lap. In situ, exposed shingle width = 127 mm.

b ► In situ panel width (including mounting clip width). Actual panel width 418 mm.

c ► Valid only for the two separate PV-laminates connected in series.

► Voltage and current may vary, if the two PV-laminates are interconnected differently.

d ► In situ weight including three layer overlap

e ► Minimum panel length. Actual panel length on customer's request.

Electrical specifications (+/- 10 %) are based on measurements performed at standard test conditions of 1000 W/m² irradiance, Air Mass 1.5 and Cell Temperature of 25°C after longterm stabilisation. Performance may vary up to 10 % from rated power due to low temperature operation, spectral and related effects.

During initial 8-10 weeks of operation, UNI-SOLAR® PV-products have higher electrical output than rated output. The output power may be higher by 15 %, the operating voltage may be higher by 11 % and the operating current may be higher by 4 %. In some applications, this initial power bonus must be considered when sizing power system components such as wiring, inverters and switchgear.

Inverters for UNI-SOLAR® PV-Products.

BESS EUROPE advises only to use inverters with a galvanic separation between AC and DC side (i.e. inverters having a transformer). The maximum open circuit voltage V_{OC} at -10°C and 1250 W/m² irradiation per module should be used as the design voltage to calculate string voltage(s) fed into the inverter(s). It is further recommended to take into account the higher power output of UNI-SOLAR® PV-modules during initial 8 - 10 weeks of operation of the system.

In order to harvest as much as possible from the DC-energy generated by the UNI-SOLAR® PV-modules as AC-energy, inverters should have a fairly constant efficiency curve with respect to incoming solar energy. European Conversion Efficiency of the inverter should be typically higher than or equal to 94 %. And more importantly, the inverter should still have a fairly high conversion efficiency, also for very weak irradiation levels as low as 40 W/m² (corresponds to 4 % of rated DC-power of the modules). Several inverters on the market simply do not switch on before at least 10 % of the rated DC-power of the string to which they are connected, is reached.

Positive results have been reached with the following types of inverters: Fronius (whole range), SMA (whole range, except the SunnyBoy 2000), ASP. This list is of course far from exhaustive.

Supply of complete turn-key UNI-SOLAR® PV-Systems.

For large projects (min. size 20 kWp), BESS EUROPE offers complete UNI-SOLAR® PV-Systems including: system design and engineering, inverters, DC-cabling, support structures (in case of rigid framed panels) or Aluzinc® steel metal roofing, mechanical installation of the PV-system (metal roof installation if applicable) and electrical installation of the PV-system.



Bekaert ECD Solar Systems LLC



CORPORATE PROFILE

Energy Conversion Devices, Inc. (ECD), with corporate offices in Michigan, USA and N.V. Bekaert S.A. (Bekaert), with group headquarters in Belgium, Europe, two of the world's most respected high technology companies, formed a strategic alliance in April 2000 to meet the growing demand for UNI-SOLAR® products. The ECD-Bekaert alliance works through two companies: United Solar Systems Corp. (United Solar) and Bekaert ECD Solar Systems LLC (Bekaert ECD). United Solar is a joint venture between ECD and Bekaert. Bekaert ECD is a joint venture between Bekaert and United Solar.

United Solar develops and manufactures the Triple Junction solar cells for the UNI-SOLAR® brand of solar panels and systems. Bekaert ECD assembles and sells UNI-SOLAR® products through its world-wide distribution network. In Europe, UNI-SOLAR® products are sold by Bekaert ECD Solar Systems Europe N.V. (BESS EUROPE).

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Triple Junction
Technology