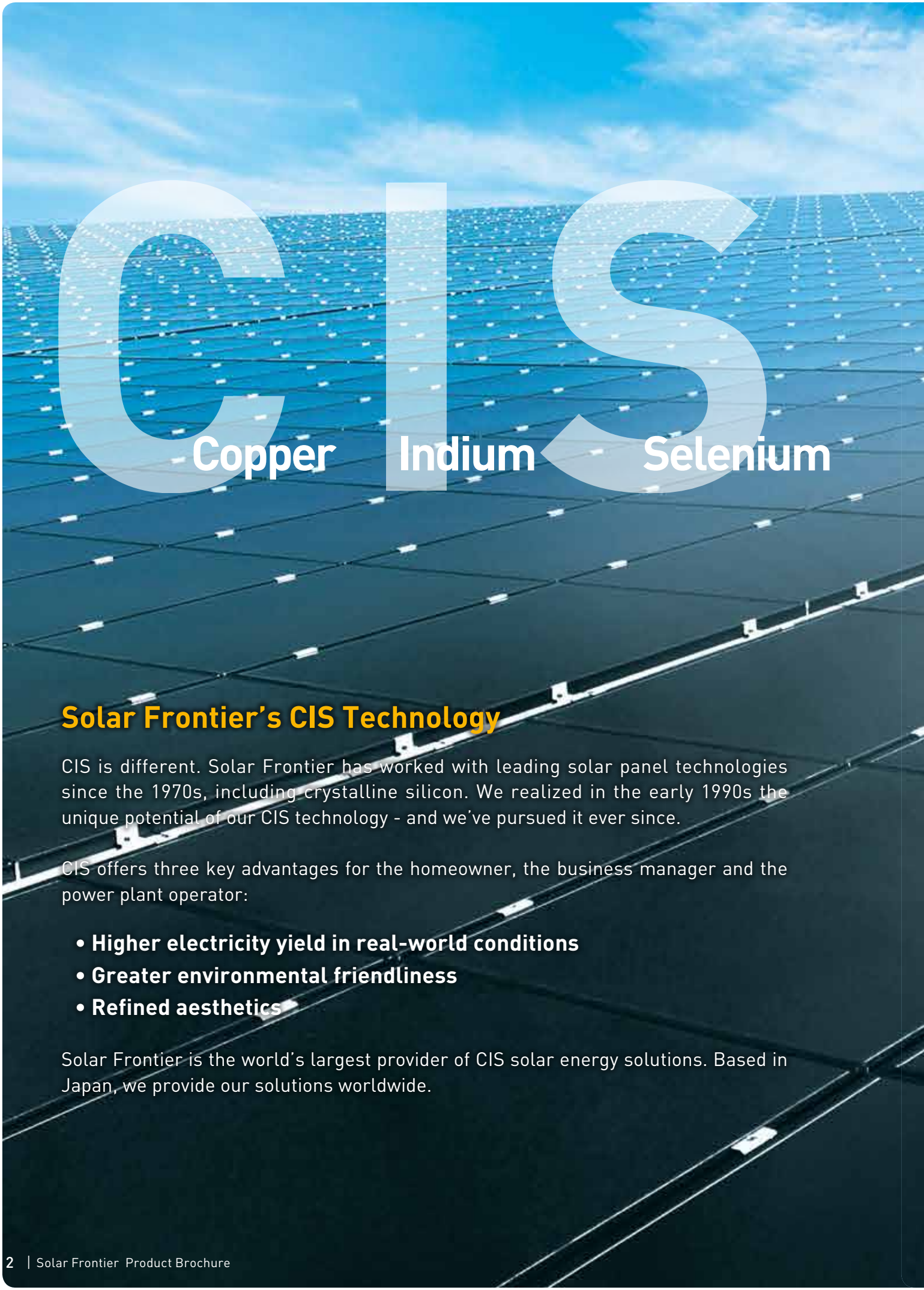
SOLAR FRONTIER

Product Brochure

Solar Frontier K.K.



Solar Frontier's CIS Technology

CIS is different. Solar Frontier has worked with leading solar panel technologies since the 1970s, including crystalline silicon. We realized in the early 1990s the unique potential of our CIS technology - and we've pursued it ever since.

CIS offers three key advantages for the homeowner, the business manager and the power plant operator:

- **Higher electricity yield in real-world conditions**
- **Greater environmental friendliness**
- **Refined aesthetics**

Solar Frontier is the world's largest provider of CIS solar energy solutions. Based in Japan, we provide our solutions worldwide.

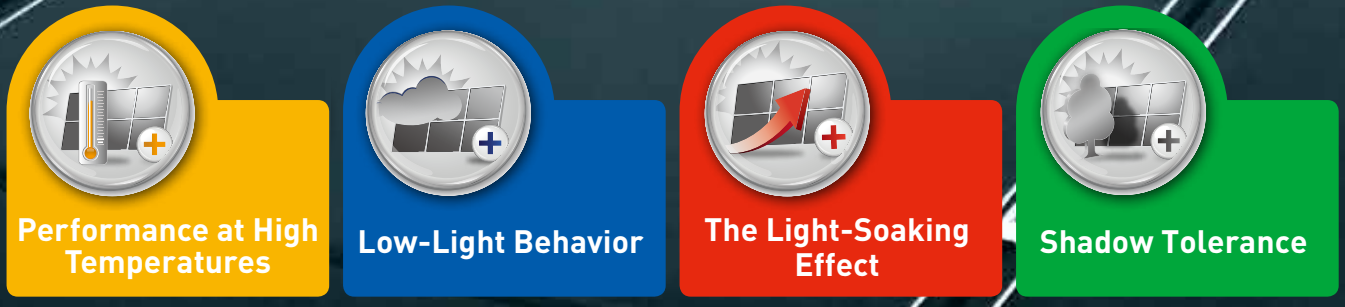
Why do real-world conditions matter?

If you could select the criteria for the ideal system, you would choose an installation facing south with a tilt angle best suited to the direction of the sun. The environs would be absolutely free of shade and the air would be clear and devoid of impurities – whether dirt, dust, fog or smog. The weather would always be cold and sunny, bringing out the highest possible energy yields.

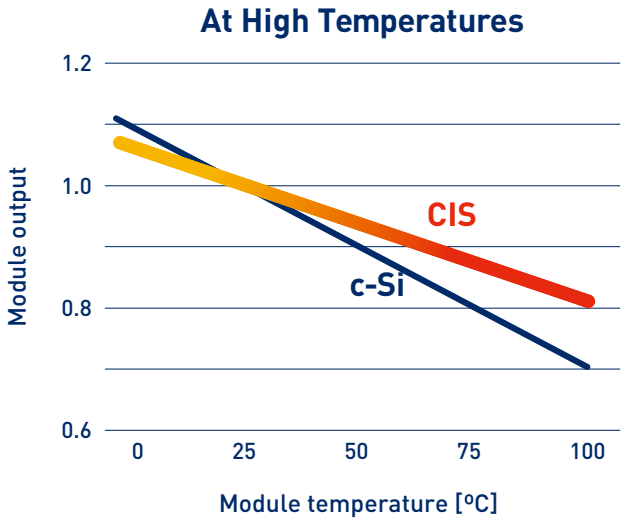
But in the real world, this very rarely happens. Roofs have different orientations. Temperatures climb to extremes – especially in deserts. Trees, chimneys, buildings and even clouds cast shadows. Humidity, lighting conditions and a myriad of other climatic conditions fluctuate between environments. Every one of these factors can impact the energy yield of a solar power system.

CIS advantages in real-world conditions

CIS is suited to dealing with real-world conditions, resulting in higher energy yield. This makes our technology different.



Catalina Power Plant, 82.5 MW,
USA - EDF Renewable Energy



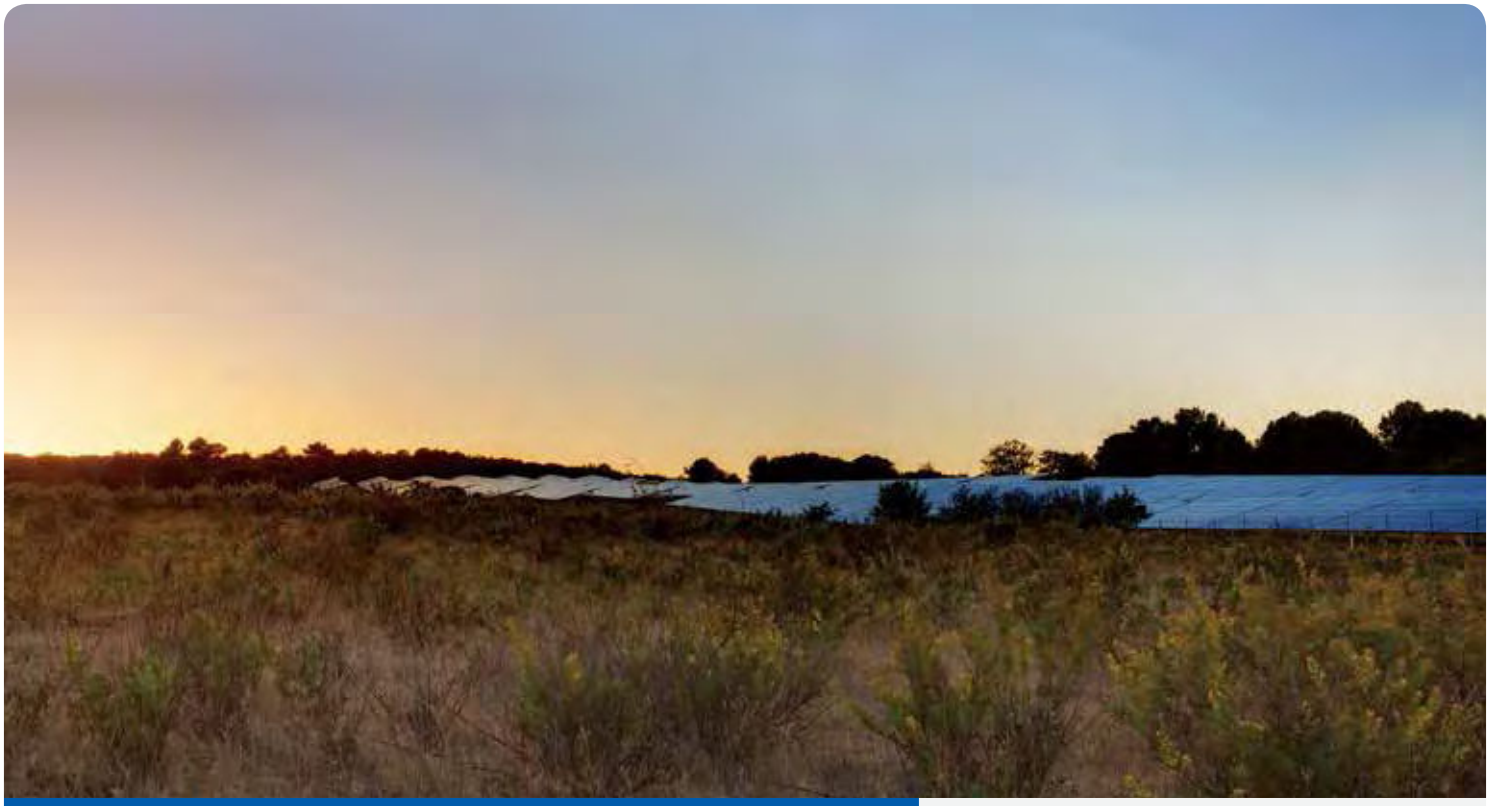
Performance at High Temperatures

CIS delivers high yields – even in desert heat.

All solar panels are affected by heat. Some technologies are just better at handling heat than others.

CIS modules have an advantage over crystalline silicon panels at higher temperatures. This advantage is especially relevant because modules operate at a higher temperature than ambient temperature. The effect of heat is measured by a module's "temperature coefficient", which is the rate at which power output decreases as temperature increases. Solar Frontier's CIS modules have a lower temperature coefficient than crystalline silicon modules, resulting in lower energy production losses at high temperatures.

When every kilowatt-hour of electricity generated affects your return on investment, this can make a big difference.



Bessan Power Plant, 4.19 MW,
France - Belectric France

Low-Light Behavior

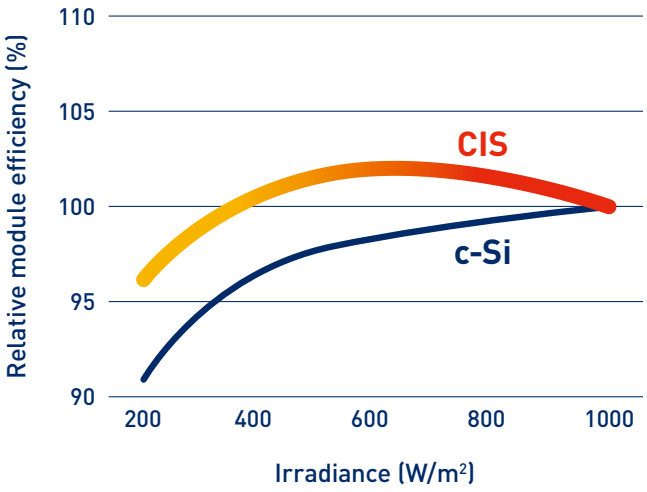
Sunrise, sunset and under cloud cover – CIS is better suited.

Mornings, evenings, fog, diffused light, overcast skies – the sun isn't always shining in full force. These conditions are one area where Solar Frontier's CIS modules outperform competitors.

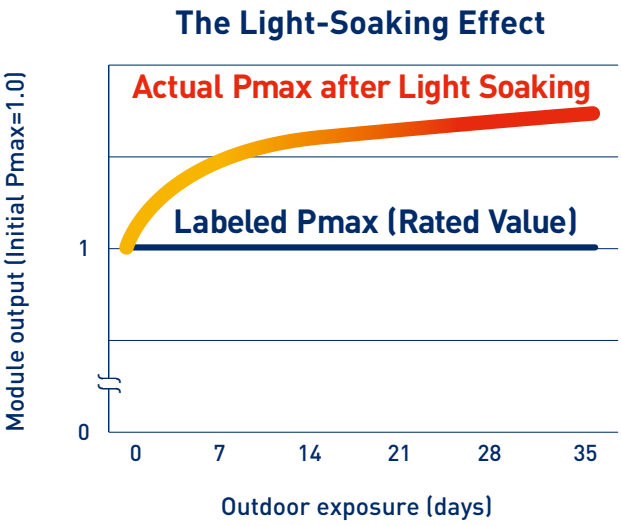
CIS modules effectively have access to longer "working hours", enabling them to deliver more energy than crystalline silicon modules. More sensitive to lower intensities of light, they start generating electricity from earlier in the morning to later in the evening. CIS modules are also better at converting diffused light caused by cloudy conditions and moisture in the air.

These advantages enable Solar Frontier's CIS modules to also generate more electricity in less than ideal conditions, such as when facing east, west and north, or when installed flat.

In Low-Light Conditions



Windhoek Chicken Farm, 69.6 kW, Namibia - HopSol



The Light-Soaking Effect

CIS modules react to sunlight, increasing their power output.

After exposure to light, CIS modules undergo a phenomenon called the light-soaking effect during the first few days of operation. This increases their actual power rating compared to their initial labelled value. You could even say that they've "warmed up" for the job.

Once CIS modules have undergone the light-soaking effect, they will then continue to perform at a higher power rating before degrading over time like other solar panels. This is one of the reasons that CIS modules can generate higher energy yield – or kilowatt-hours per kilowatt-peak – than crystalline silicon panels.

* Impact of light soaking effect can vary

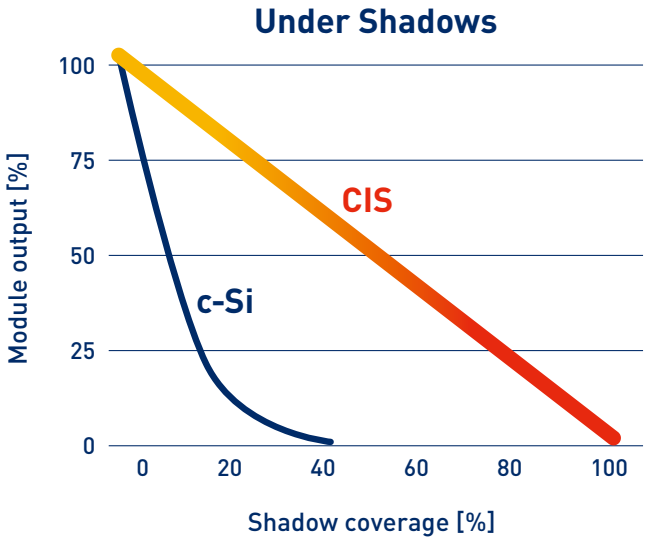
Graefelfing, 12 kWp, Germany - EFA Institut

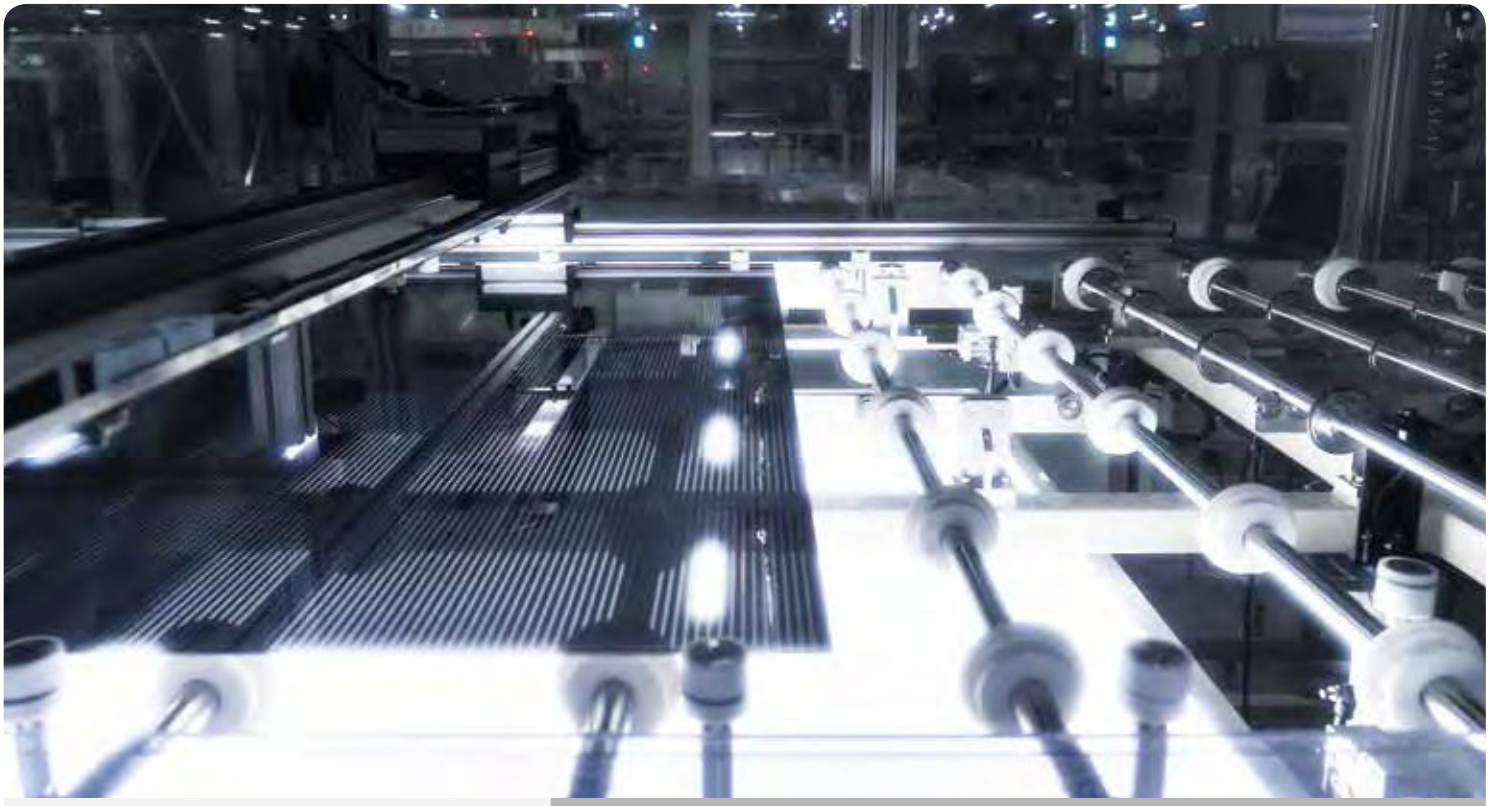
Shadow Tolerance

Even under partial shading from neighboring objects, CIS performs.

Think about shading caused by nearby objects such as trees, buildings and neighboring arrays. Under such conditions, crystalline silicon modules would quickly stop working. If only the shorter side of a CIS module is covered by shading, however, the uncovered part will continue to produce electricity normally.

As a result, project designers can even choose to move arrays closer together - even if this causes partial shading to neighboring arrays. By doing this, higher power density can be achieved in limited spaces.





CIS production at 900 MW Kunitomi Plant, Japan

Quality & Reliability

CIS modules are built for long-term performance in actual operating conditions.

Reliability is paramount. Your solar modules need to perform for the duration of their warranty period, if not longer.

We ensure reliability and standardization in technology. Our CIS modules are manufactured using fully automated lines in Japan based on strict quality-control protocols. Our lines have also been tried and tested since we began production in 2007, and are periodically technically audited by independent third parties such as Black & Veatch.

And at the module level, our technology has passed multiple additional durability tests.

Quality Highlights

Resistance to salt mist corrosion

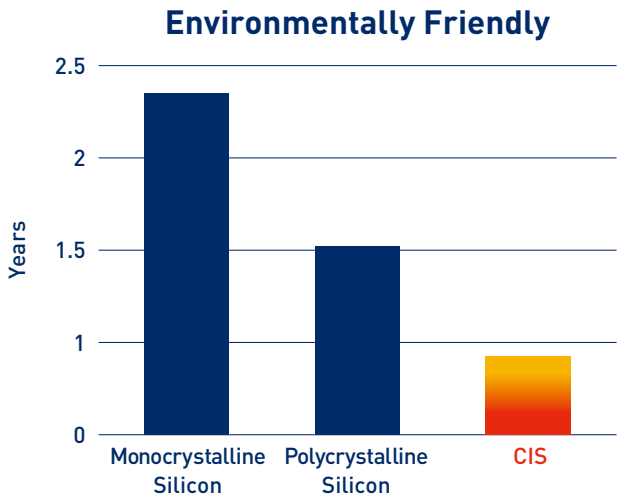
Resistance to ammonia corrosion

Resistance to PID

No hotspots

No microcracks

Robust glass/glass/back sheet



Environmentally Friendly

CIS has no special recycling requirements and requires less energy to produce.

In the solar panel industry, we use a metric called Energy Payback Time (EPT). This measures the time for a module to generate the same amount of energy as required to manufacture it. CIS modules require 60% less energy to produce than crystalline silicon panels.

Our modules are also cadmium and lead-free, and have no special recycling requirements. We are certified as compliant with the European Union's Restriction of Hazardous Substances (RoHS) regulations.

Aesthetically Refined

CIS can be integrated into natural surroundings or used for visual enhancement.

Solar Frontier CIS modules have a black module surface and a black aluminum frame. The color comes from our proprietary production process. Only two silver busbars are visible on the edge of the module. On top of this, our modules use anti-reflective glass - for aesthetics, safety and efficiency.

Bibbiena Facade Installation, 63 kW, Italy - Baraclit

Product Technical Data

STC Characteristics [1]		SF145-S	SF150-S	SF155-S	SF160-S	SF165-S	SF170-S
Nominal power	*Pmax*	145 W	150 W	155 W	160 W	165 W	170 W
Factory binning				+5W/0W			
Module efficiency	*%*	11.8 %	12.2 %	12.6 %	13.0 %	13.4 %	13.8 %
Open circuit voltage	*Voc*	107.0 V	108.0 V	109.0 V	110.0 V	110.0 V	112.0 V
Short circuit current	*Isc*	2.20 A	2.20 A	2.20 A	2.20 A	2.20 A	2.20 A
Voltage at nominal power	*Vmpp*	81.0 V	81.5 V	82.5 V	84.0 V	85.5 V	87.5 V
Current at nominal power	*Impp*	1.80 A	1.85 A	1.88 A	1.91 A	1.93 A	1.95 A

[1] The nominal power of SF PV modules indicates the power generated under Standard Test Conditions (module temperature: 25°C, air mass 1.5, solar irradiance 1000 W/m2). Photovoltaic modules may produce more current and/or voltage under actual operating conditions than in Standard Test Conditions. The electrical characteristics are within ±10% of the indicated Isc and Voc values under STC.
The power output stated on the label is measured at the plant after module preconditioning. The values of Isc and Voc marked on modules shall be multiplied by a factor of 1.25 to determine component voltage ratings, conductor ampacities, overcurrent device ratings, and size of controls connected to the module output.

NOCT Characteristics [2]		SF145-S	SF150-S	SF155-S	SF160-S	SF165-S	SF170-S
NOCT power	*Pmax*	108 W	111 W	115 W	119 W	123 W	126 W
Open circuit voltage	*Voc*	97.4 V	98.3 V	99.2 V	100.0 V	100.0 V	102.0 V
Short circuit current	*Isc*	1.76 A	1.76 A	1.76 A	1.76 A	1.76 A	1.76 A
Voltage at NOCT power	*Vmpp*	76.0 V	76.4 V	77.4 V	78.8 V	80.2 V	82.1 V
Current at NOCT power	*Impp*	1.43 A	1.47 A	1.49 A	1.51 A	1.53 A	1.55 A

[2] Values measured under Nominal Operating Cell Temperature Conditions "NOCT" defined by IEC norm (Module operating temperature at 800 W/m² irradiance, 20°C air temperature and 1 m/s wind speed)

Thermal Characteristics		
NOCT		47 °C
Temperature coefficient of Isc	α	+0.01 %/K
Temperature coefficient of Voc	β	−0.30 %/K
Temperature coefficient of Pmax	δ	−0.31 %/K

Characteristics for System Design	
Maximum system voltage	1,000 V DC
Limiting reverse current	7 A
Temperature range	−40°C to +85°C
Application class (IEC 61730)	Class A
Fire rating (IEC 61730)	Class C
Safety class (IEC 61140)	II

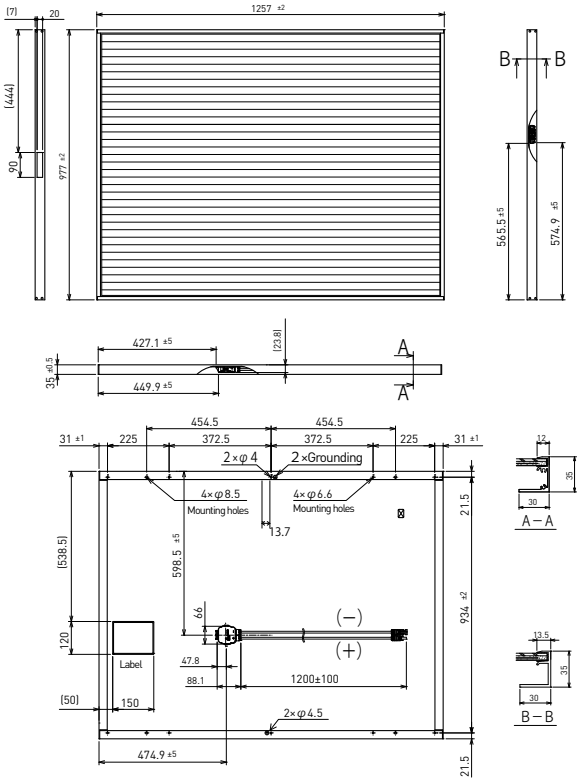
• The sum of Voc for modules in series must not exceed the maximum system voltage of the module under any condition, this includes at low temperature.
• Reverse current applied to the modules should not exceed 7A under any circumstances.

Mechanical Characteristics	
Dimensions (L x W x H)	1,257 x 977 x 35 mm
Weight	20 kg (16.3 kg/m²)
Snow & wind load (IEC 61646)	2,400 Pa

Materials and Components	
Cell type	CIS (cadmium free) on glass substrate
Front cover	3.2 mm clear tempered glass
Encapsulant	EVA
Back sheet	Weatherproof plastic film
Frame	Black anodized aluminum alloy
Edge sealant	Butyl rubber
Junction box	Protection rating: IP67 (with bypass diode)
Adhesive	Silicone
Cables (length/cross section)	2 x 1,200 mm/2.5m² 14AWG (halogen free)
Connectors	MC4 compatible (waterproof, locking type)

Packaging	
Packaging material	cardboard free – reusable corner pieces
Modules per pallet	25
Pallets per container	36

MODULE DRAWING

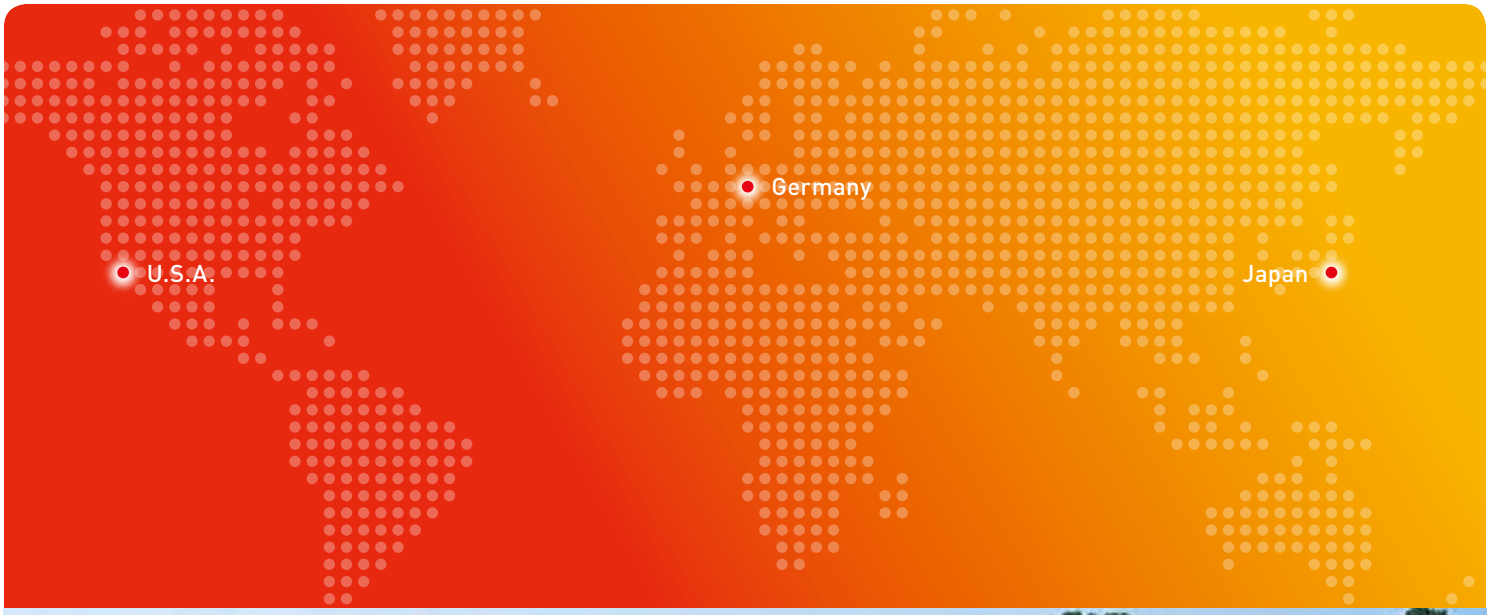


Unit:mm

CERTIFICATES

IEC 61646: Design qualification and type approval
IEC 61730: Photovoltaic module safety qualification
IEC 61701: Salt mist corrosion testing
IEC 62716: Ammonia corrosion testing

ID 0000023497 www.tuv.com



Solar Frontier - at a glance

Solar Frontier is:

- The world's largest CIS solar energy solutions provider
- From Japan and active worldwide

We build on:

- Over 35 years in photovoltaics
- Over 3 GW global shipments

We do:

- R&D
- CIS module manufacturing
- Total system solutions

We offer:

- CIS thin-film modules
- Solar energy systems for homeowners, businesses and power plant owners

We support:

- Industry professionals: project developers, EPCs, financiers, installers and distributors
- End-users: residential, commercial and utility

Contact:

Daiba Frontier Building
2-3-2 Daiba, Minato-ku
Tokyo 135-8074
Japan

Tel: **+81 3 5531 5626**

Or contact your vendor:

More information available on our website:

www.solar-frontier.com

Solar Frontier K.K.
2016.06

SOLAR FRONTIER