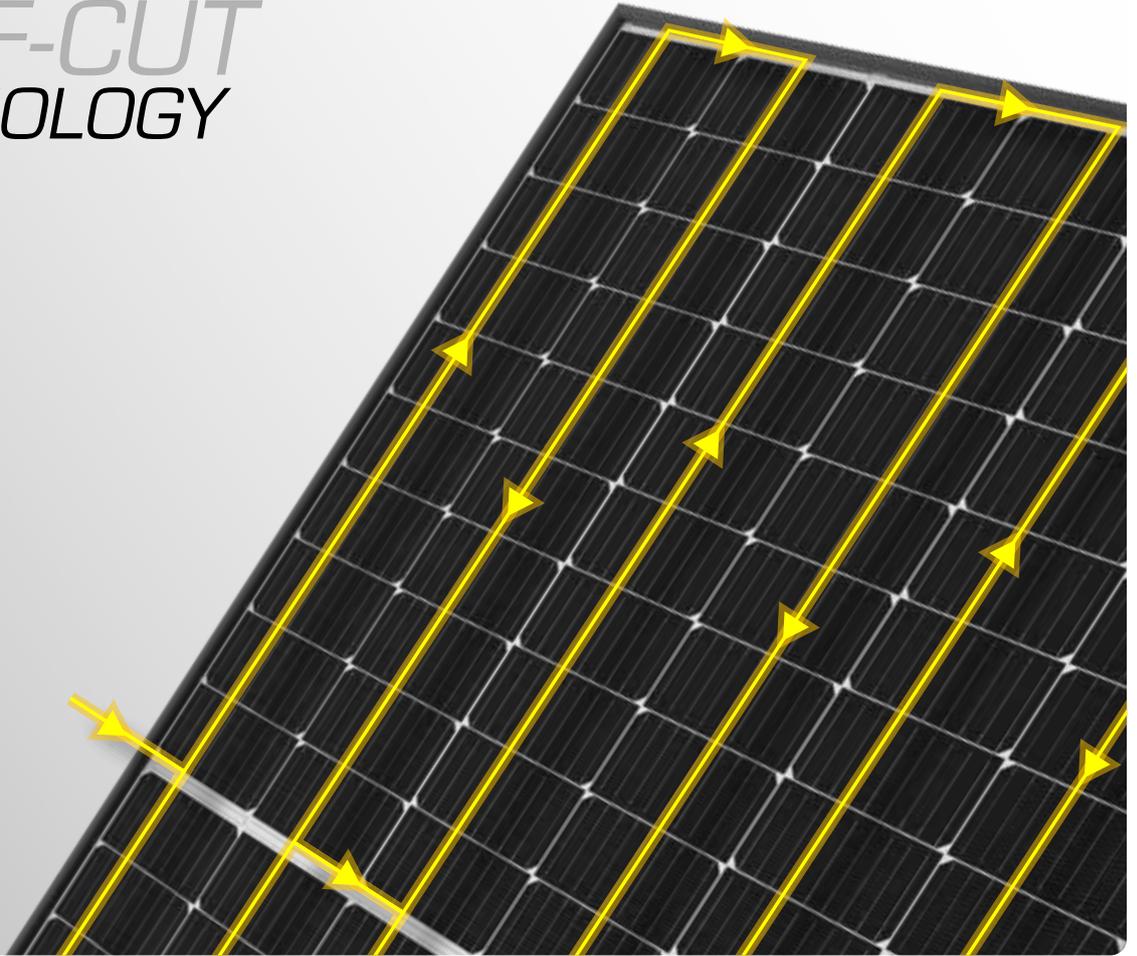




Solar Modules

HALF-CUT TECHNOLOGY



Solar module technology

- The benefits of half-cell modules in detail

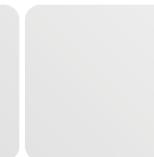
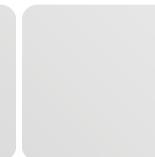
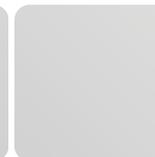
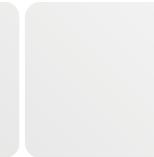
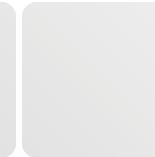
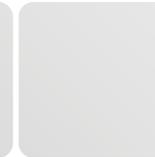
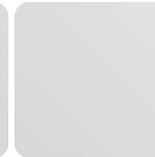
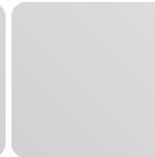
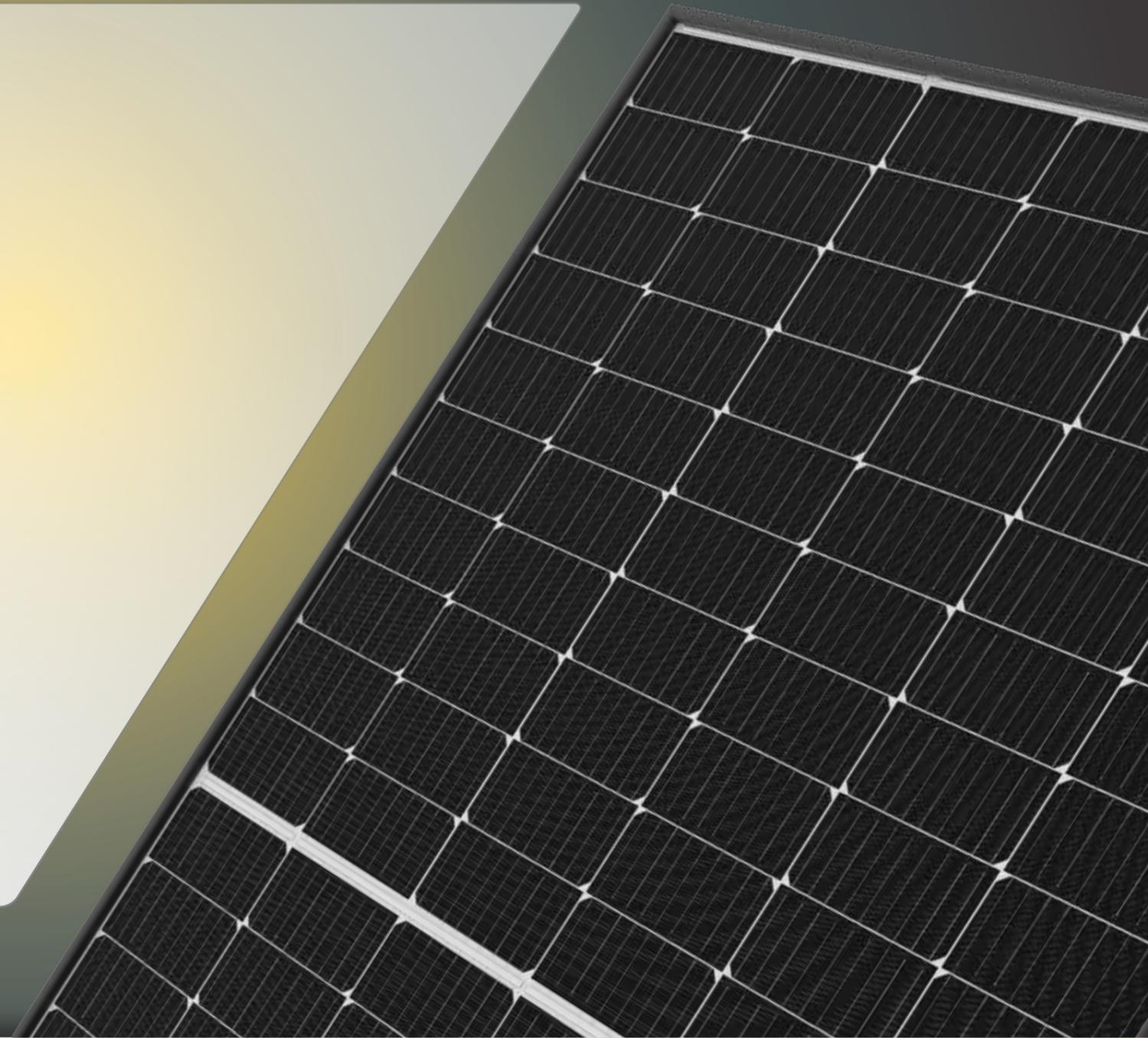




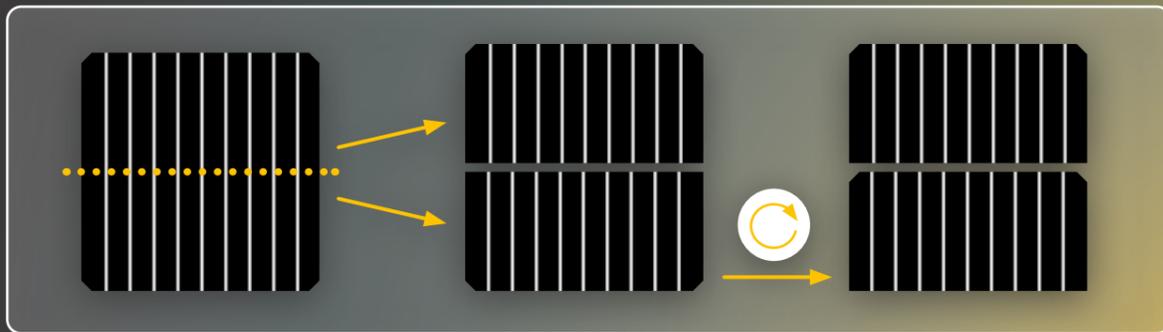
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HALF-CUT SOLAR CELLS - THE TECHNOLOGY IN DETAIL

Higher performance and more reliability through cell division



Solar modules with halved solar cells are called half-cell modules or half-cut solar modules. This generation of solar cells has advanced properties.

The Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE) found that solar modules with half-cell technology achieve on average 2-3% more performance than full-cell modules with the same input cell.

Half-cell modules are thus significantly more powerful than modules with conventional full cells, even though they are made of the same material.

In contrast to the usual full cell, the current flowing through half cells is reduced due to their reduced size. The division of the solar cells halves the current intensity per solar cell.

The power loss of solar cells can be precisely calculated with a mathematical formula.

(The power losses of a half-cell module are reduced by a factor of four, since the power loss is calculated as the product of the line resistance and the current intensity squared)

The formula thus demonstrably confirms the most important benefit of half-cut technology - the lower loss of power compared to full solar cells.

Less power loss increases the efficiency of the solar module and the module achieves higher solar yields.

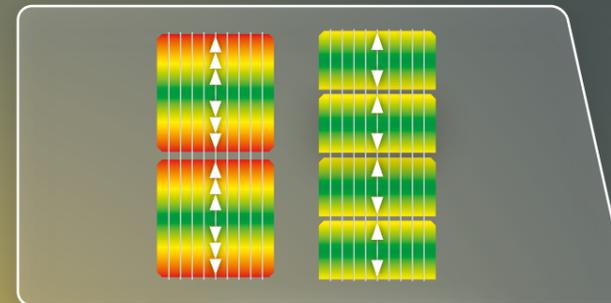
HALF-CUT CELL TECHNOLOGY

The essential benefits at a glance:

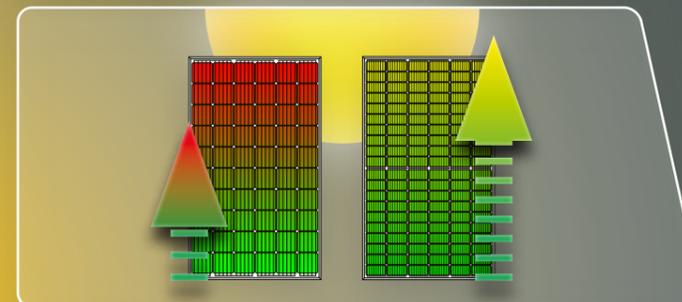
- ✓ Lower power loss
- ✓ Higher efficiency & fill factor
- ✓ Optimised temperature behaviour
- ✓ Increased energy yield

$$P_v = R \times I^2$$

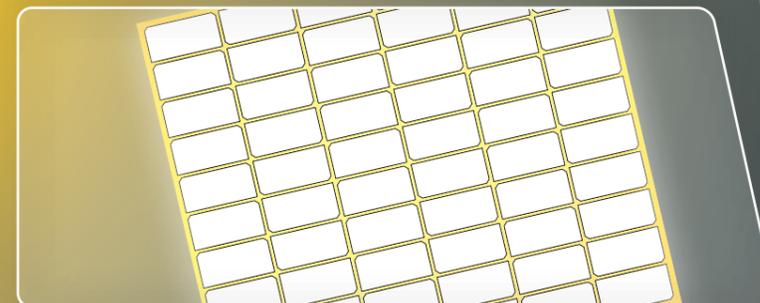
P_v = power dissipation, R = line resistance in ohms, I = current intensity



TEMPERATURE BEHAVIOUR OF THE SOLAR CELL:
Half-cut cells have an optimised temperature behaviour. The heat loss at the cell connector is considerably reduced as they have only half the working current. This reduces the operating temperature accordingly and improves the reliability of the module as well as the energy yield.



TEMPERATURE BEHAVIOUR OF THE SOLAR MODULE:
The halved current intensity inside the whole module allows an improved temperature coefficient. Half-cell modules can therefore achieve higher performance at high temperatures or in strong sunlight.



CELL INTERSPACES:
With half-cell modules, additional space is created between the cells. This amplifies reflections within the laminate and thus increases the use of light in the cell.

MULTIBUSBAR TECHNOLOGY:

Half-cut cells with additional Multibusbar (MBB) technology further increase the efficiency of the cell. They achieve another 2-2.5% more performance and offer maximum reliability. (MBB means that a solar cell is equipped with 9, 12 or 16 busbars instead of 4, 5 or 6)

The increase in performance of multibusbar cells is achieved both by the "shortened transport paths" between the individual busbars and by the highly reflective, shape-optimised wire structure. The optimised wire design features reduced shading, improved light scattering on the cell surface and lower series resistance.

In addition, the finer wiring on the cell increases the mechanical load capacity and reduces the formation of micro-cracks in the material in the long term.

MULTIBUSBAR



HALF-CUT SOLAR MODULE - THE SUPERSTRUCTURE

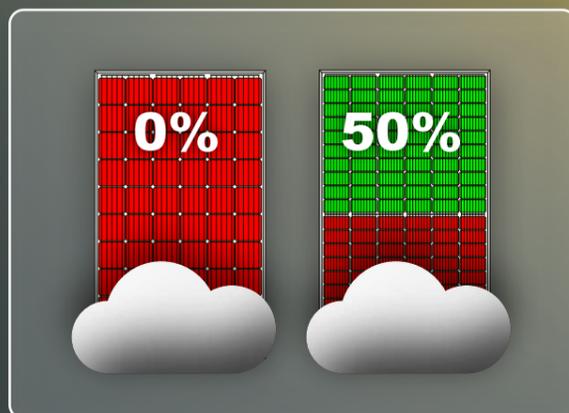
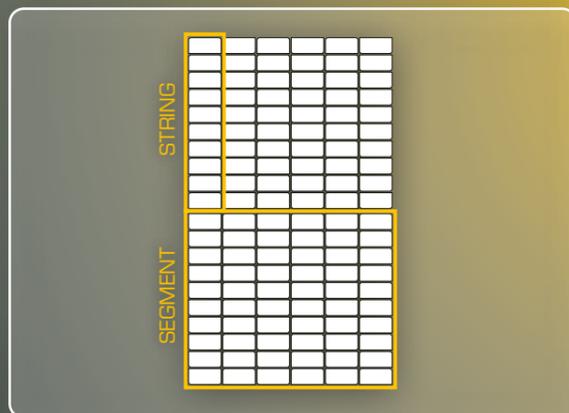
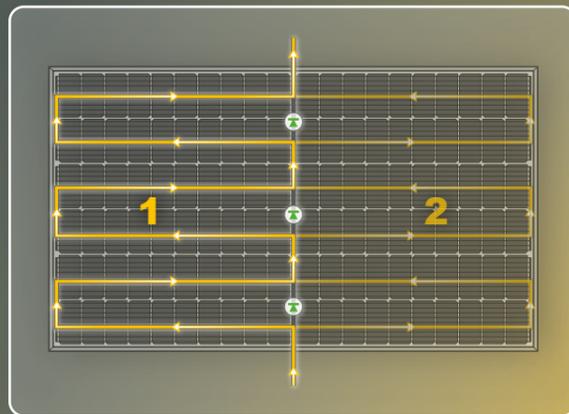
Clever design for increased yield with shadow effect

Half-cut solar modules are not only characterised by the use of advanced half cells. Another striking feature is the separate connection of the individual half cells into two separate current paths. For this purpose the half cells of a segment are interconnected in series in six strings. The two segments are then connected to each other in the middle using a parallel connection.

This construction method has the particular benefit that the shading behaviour changes fundamentally. Photovoltaic modules with regular full-cell interconnection produce no more electricity even with slight shading of some solar cells!

Half-cell modules, on the other hand, can still produce electricity. The unshaded half of the module continues to generate yields due to its clever design. With an upright installation, this means that even with partial shading in the morning or evening, a remaining performance of 50% can still be expected.

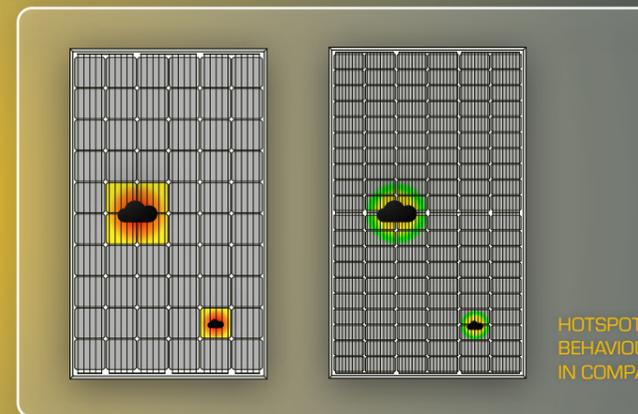
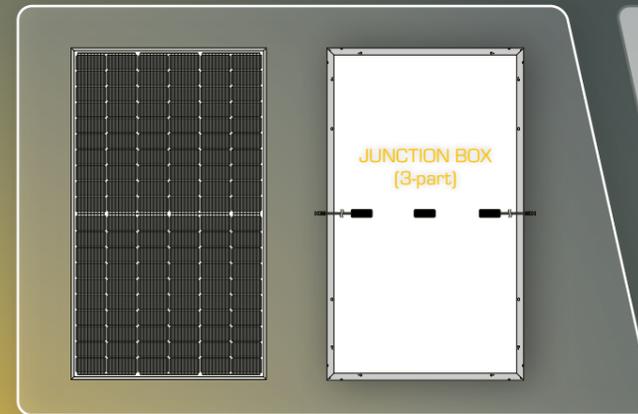
The 50% increase in output, with partial shading, is made possible by the two independent current paths. These are efficiently interconnected in the middle of the module by free-wheeling or bypass diodes.



HALF-CUT MODULAR CONSTRUCTION

The essential benefits at a glance:

- ✓ 50% more output power with partial shading of the PV module
- ✓ 3-part junction box with optimised temperature behaviour during energy transfer
- ✓ Reduced hotspot temperatures
- ✓ Increased reliability



MODULE CONNECTION:

A 3-part junction box on the rear of the module dissipates the energy gained. The multi-part component transfers less heat to the cells below than one-part junction boxes.

HOTSPOT BEHAVIOUR:

The unique construction method gives the half-cut solar module its unmistakable appearance and reduces the occurrence of undesirable "hotspots".

In practical operation, partial shading of smaller areas can increase the local temperature of the solar cells concerned, since the current of the producing cells is, for physical reasons, conducted through these cells.

These so-called "hotspots" can cause irreversible deterioration of the module performance over a long period of time.

Since the string current of half-cell modules is half that of full-cell modules, the hotspot temperature can be reduced significantly. Experimental tests have shown that this reduction can be 10-20°C, which confirms the reliability of a half-cut module.

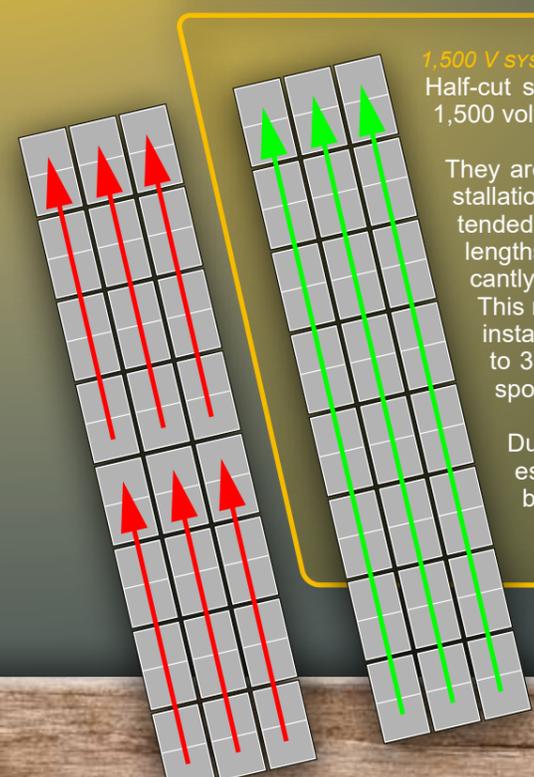
1,500 V SYSTEM VOLTAGE:

Half-cut solar modules with a electricity of 1,500 volts bring further benefits.

They are the perfect solution for project installations, as module strings can be extended by 50%. Parallel connections, cable lengths and cross sections can be significantly reduced.

This results in a lower material requirement and the costs for components and installation are reduced. The system balance (BOS) is thus reduced by up to 33%. Prerequisites for this include certified junction boxes and the corresponding module back sheet.

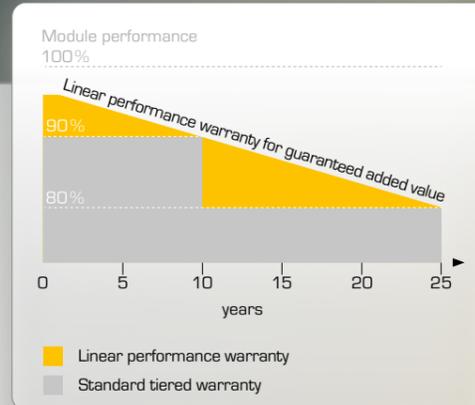
Due to the higher voltage, in combination with the lower currents, power losses are further reduced. Lower degradation and higher reliability are further benefits, which have a positive effect on the entire plant.



MONO S2 - Half-cut

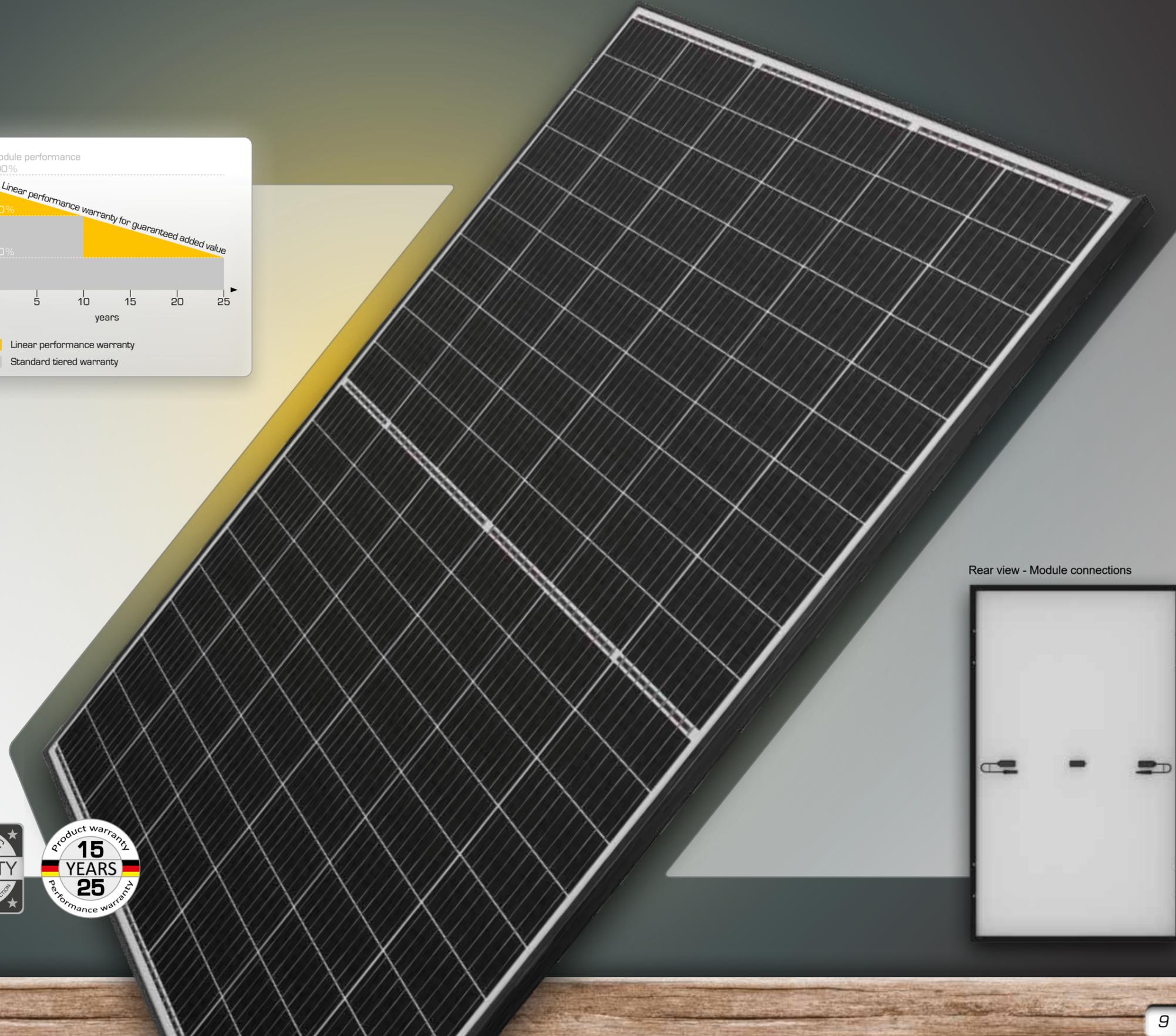
345 W

- ✓ Solar module with 120 half cells
- ✓ Multibusbar-technology
- ✓ Highly transparent self-cleaning glass
- ✓ Resistant to environmental influences:
Passed salt mist & ammonia test
- ✓ German warranty



TECHNICAL SPECIFICATIONS:

Cell size:	158.75 x 79.375 mm
Module size:	1684 x 1002 x 35 mm
Module weight:	about 19.2 kg
Module frame:	Anodized aluminium alloy
Glass cover:	3.2 mm
Max. system voltage:	1500 V
Reverse current capacity:	15 A
Junction box:	Protection class IP68
Module connection:	MC4 compatible
Cable cross section:	4.0 mm ²
Cable length:	(+) ≥ 1200 mm, (-) ≥ 1200 mm
Snow loading:	5400 Pa = ^ 550 kg/m ²
Hail resistance:	25 mm iceball with velocity of 23 m/s



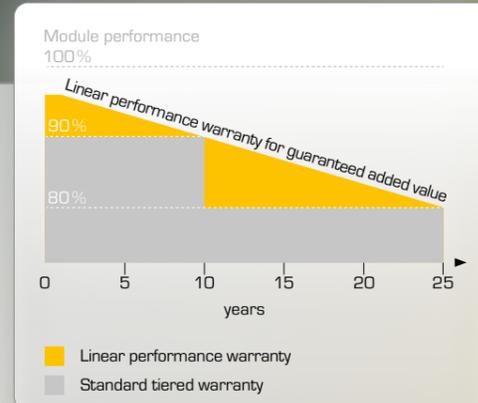
Rear view - Module connections



Mono S3 - Half-cut

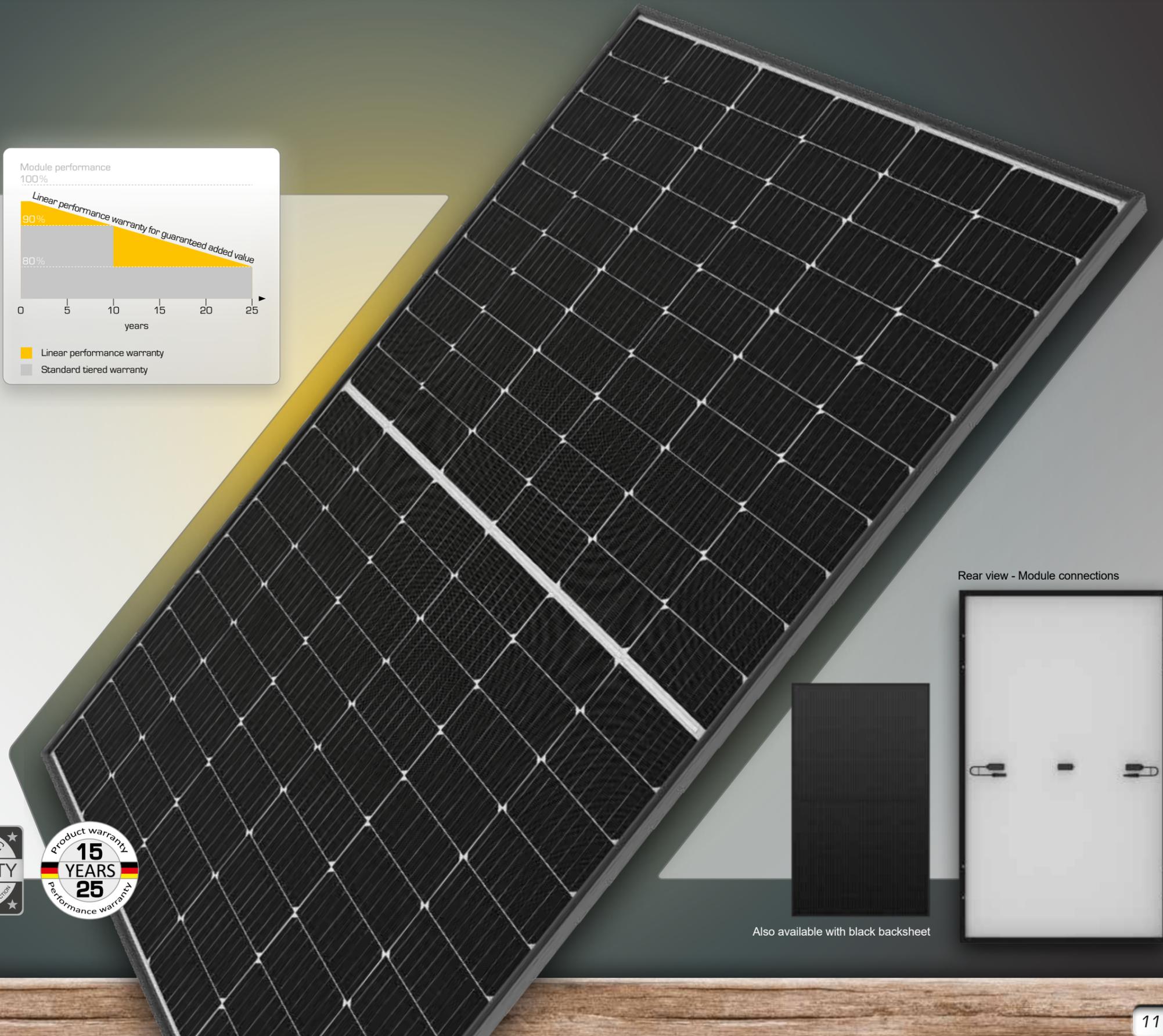
360 W • 365 W • 370 W • 375 W • 380 W

- ✓ Solar module with 120 half cells
- ✓ Multibusbar-technology
- ✓ Highly transparent self-cleaning glass
- ✓ Resistant to environmental influences:
 - Passed salt mist & ammonia test
- ✓ German warranty



TECHNICAL SPECIFICATIONS:

Cell size:	166 x 83 mm
Module size:	1755 x 1038 x 35 mm
Module weight:	about 19.5 kg
Module frame:	Anodized aluminium alloy
Glass cover:	3.2 mm
Max. system voltage:	1500 V
Reverse current capacity:	20 A
Junction box:	Protection class IP68
Module connection:	MC4 compatible
Cable cross section:	4.0 mm ²
Cable length:	(+) ≥ 1200 mm, (-) ≥ 1200 mm
Snow loading:	5400 Pa = ^ 550 kg/m ²
Hail resistance:	25 mm iceball with velocity of 23 m/s



Rear view - Module connections



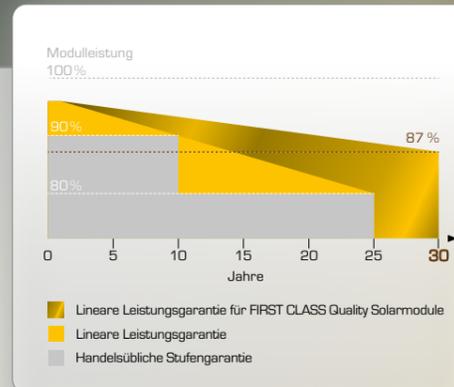
Also available with black backsheet



Mono S3 Innovation - Half-cut

360 W • 365 W

- ✓ Solar module with 120 half cells
- ✓ Bifacial cells - up to 30% higher energy yield *
- ✓ Multibusbar-technology
- ✓ Highly transparent self-cleaning glass
- ✓ Resistant to environmental influences:
Passed salt mist & ammonia test
- ✓ German warranty



TECHNICAL SPECIFICATIONS:

Cell size:	166 x 83 mm
Module size:	1755 x 1038 x 35 mm
Module weight:	about 24.0 kg
Module frame:	Anodized aluminium alloy
Glass cover:	Frontside/Backside: 2 mm/2 mm
Max. system voltage:	1500 V
Reverse current capacity:	25 A
Junction box:	Protection class IP68
Module connection:	MC4 compatible
Cable cross section:	4.0 mm ²
Cable length:	(+) ≥ 1200 mm, (-) ≥ 1200 mm
Snow loading:	5400 Pa = ^ 550 kg/m ²
Hail resistance:	25 mm iceball with velocity of 23 m/s



DOUBLE-GLASS MODULE

BIFACIAL HALFCUT TECHNOLOGY

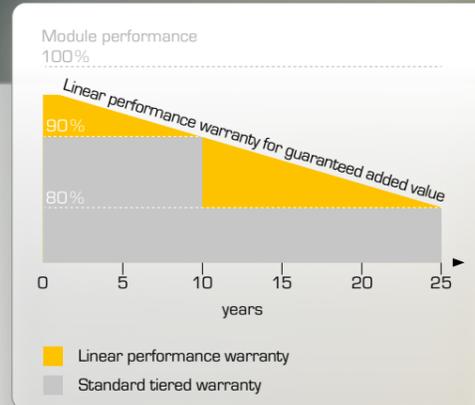
* The Mono S3 Innovation has a higher energy yield under optimal radiation conditions due to its bifaciality. Depending on the degree of ground reflection (so-called albedo effect), the cells located at the back are illuminated with diffuse light, so that yields can also be achieved through the back of the module.



MONO S4 - Half-cut

395 W • 400 W • 405 W • 410 W

- ✓ Solar module with 108 half cells
- ✓ Multibusbar-technology
- ✓ Highly transparent self-cleaning glass
- ✓ Resistant to environmental influences:
 - Passed salt mist & ammonia test
- ✓ German warranty



TECHNICAL SPECIFICATIONS:

Cell size:	182 x 91 mm
Module size:	1724 x 1134 x 30/35 mm
Module weight:	about 21.5 kg
Module frame:	Anodized aluminium alloy
Glass cover:	3.2 mm
Max. system voltage:	1500 V
Reverse current capacity:	25 A
Junction box:	Protection class IP67
Module connection:	MC4 compatible
Cable cross section:	4.0 mm ²
Cable length:	(+) ≥ 1200 mm, (-) ≥ 1200 mm
Snow loading:	5400 Pa = [^] 550 kg/m ²
Hail resistance:	25 mm iceball with velocity of 23 m/s



Rear view - Module connections





Solar Modules



Solar Fabrik GmbH

Hermann-Niggemann-Str. 7
63846 Laufach
Germany

Phone: +49 (0) 6093 20770-0
Fax: +49 (0) 6093 20770-99

Mail: info@solar-factory.com
Web: www.solar-fabrik.de