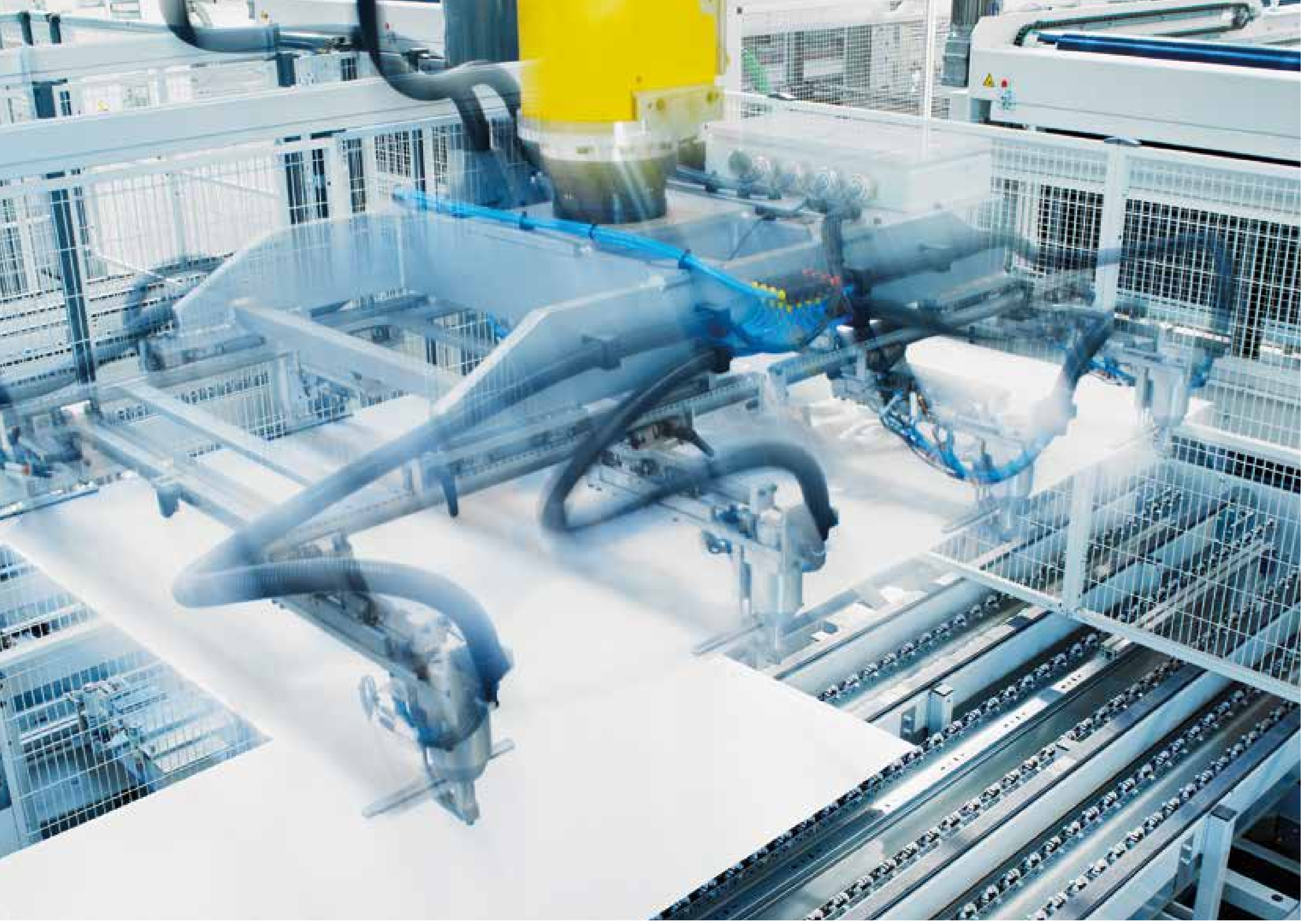
Tech-technology explained

Solar modules

solar fabrik

Creating a Powerful Future



Functionality and structure of a solar cell

The basic function of a solar cell is simple: sunlight is converted into electricity. The process can be explained in more detail as follows.

Solar cells usually consist of several layers of silicon. Silicon is a solid material with a crystalline arrangement of the smallest particles, which is why it is also referred to as monocrystalline or polycrystalline solar modules. The silicon layers are also deliberately contaminated with foreign substances such as phosphorus or boron. This results in a surplus or deficit of electrons in the different layers.

Sunlight consists of photons. When sunlight hits the cell, the photons transfer energy to the electrons and activate them. They begin to move between the layers and equalise the differences in charge. This creates a voltage and thus an electric current. This process is known as the photoelectric effect. The cell structure can differ depending on the technology. The most common technologies on the market are P-Type and N-Type technology.

Solar Fact

A solar cell also consists of several layers to capture the „complete" sunlight.

This is because sunlight is made up of spectral colours (red, yellow, green, blue and purple). These colours have different wavelengths. This means that when the light hits the surface of the cell, it reaches layers of different depths within the cell.

Cell technologies

Monocrystalline cells

In today's solar industry, monocrystalline solar cells are produced almost exclusively. They have proven themselves in terms of efficiency, appearance and function and have established themselves on the market. Solar Fabrik also uses only monocrystalline solar cells. Monocrystalline cells are combined with other technologies such as P-type, N-type and bifacial cells. Monocrystalline means that the cell is made from a single silicon crystal. This is the difference to polycrystalline solar cells, which are made from several silicon crystals.

Advantages of monocrystalline

Monocrystalline solar cells have a high degree of efficiency due to their cell structure. This means that they can convert more solar energy into electrical energy in relation to the amount of sunlight they receive than other cells.

In addition, monocrystalline solar cells are very durable and robust, as they are made from a single crystal and have no breakage points.

Monocrystalline solar half cells also satisfy at high temperatures, as they have a low drop in performance at high temperatures.

Bifacial cells

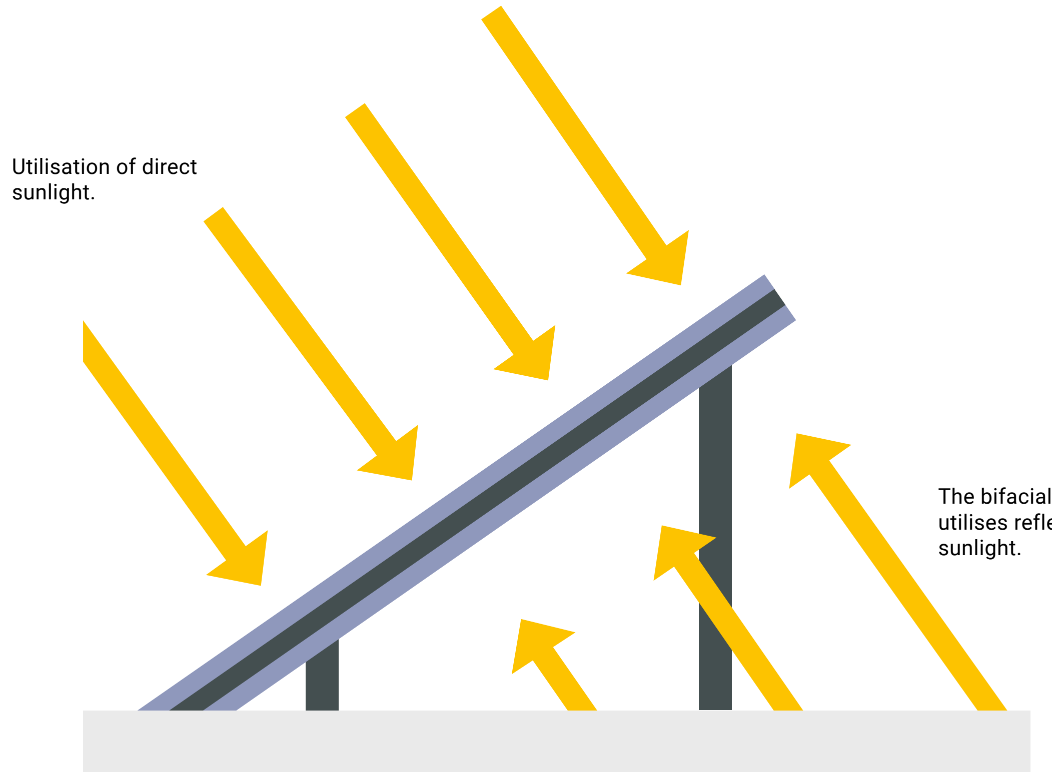
Monocrystalline cells can also be bifacial at the same time. Bifacial cells, also known as double-sided cells, absorb reflected light on the back of the cell in addition to direct sunlight. This reflectivity is also known as the albedo effect. In combination with a rear glass instead of a rear film, bifacial cells are becoming increasingly popular. The double glazing on the front and back of the module allows sunlight to shine through between the cells and be reflected from the ground to the underside of the cell. In addition, light that hits the ground next to the module can also be absorbed on the back of the cell.

Advantages of bifacial

The technology is ideal for flat roofs and ground-mounted systems, allowing energy generation on both sides to be optimally utilised. Solar Fabrik modules can generate up to 30% higher yields.

Bifacial cells can also better absorb diffuse light and sunlight in the twilight. In the morning and evening, the angle of the incident light is flatter, which leads to optimum reflection on the back of the cell.

In addition, bifacial cells have a longer service life as they are optimally protected by the double glazing.

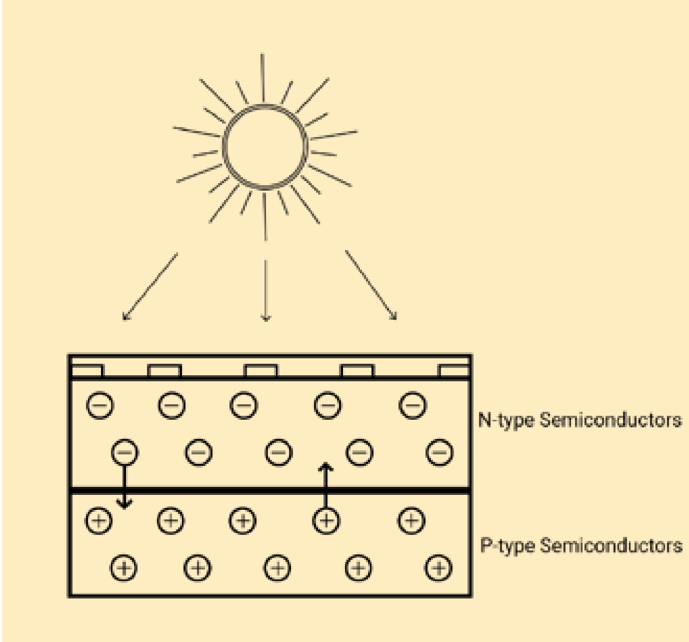


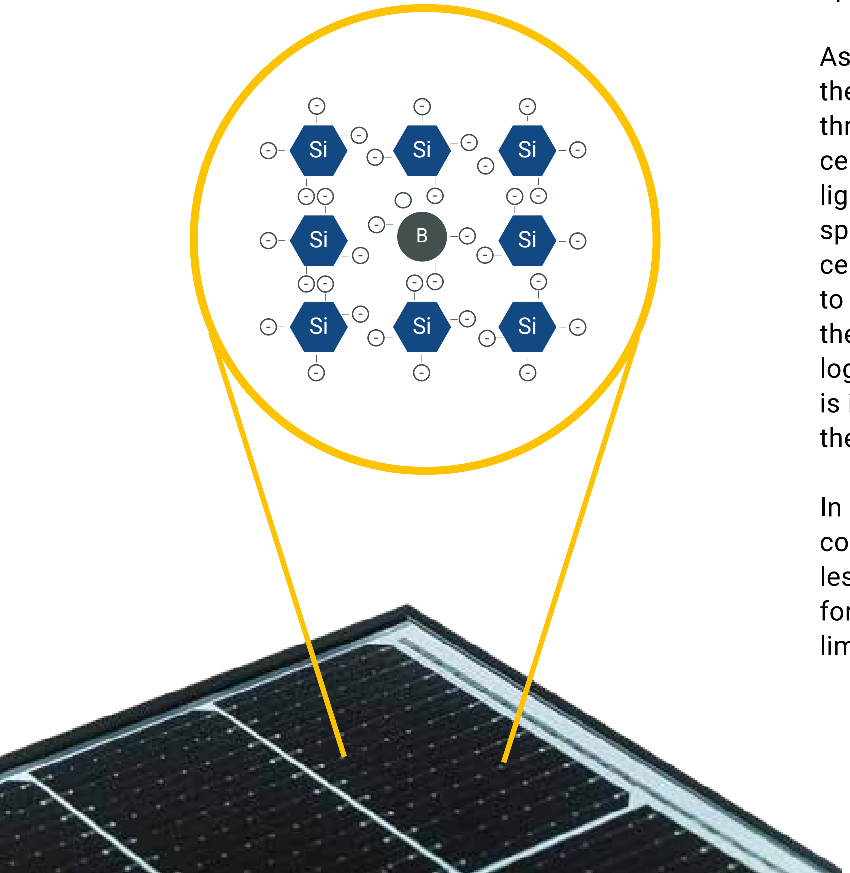
P-Type Cell -> PERC

The term „PERC“ means Passivated Emitter and Rear Cell. The technology utilises the backside passivation process. This means that there is an additional layer on the back of the cell. Here, the translucent light is partially reflected back into the cell and is therefore not completely lost. However, not every cell with P-type technology is a PERC cell. Solar Fabrik P-type cells combine both cell properties.

A P-type cell consists of two silicon layers. The layers are doped by adding the additives. The number of electrons in the additives determines the doping of the layer.
In a P-type cell, the bottom layer is doped with boron. As boron has one electron less than silicon, the layer is positively doped. This is where the technology gets its name, the „P“ stands for positive.

The upper layer consists of pure silicon and is negatively doped in combination with the positive base layer. This difference in charge is equalised by the electrons when exposed to light and an electric current is generated (see Cell function).





Advantages of P-Type

The P-Type PERC cell technology also offers a number of advantages. The biggest advantage is that the hours of sunshine in the morning and evening can be optimally utilised.

As sunlight consists of different spectral colours and therefore also wavelengths, some of the light can pass through the cell without generating energy. The PERC cell counteracts this problem with its backsheet. Red light has a very long wavelength compared to the other spectral colours. The red light is reflected back into the cell through the backsheet and can therefore contribute to power generation. As there is often a lot of red light in the morning and evening during twilight, this cell technology scores highly. For this reason, P-Type technology is ideal for roofs with an east-west orientation, allowing the greatest energy potential to be utilised.

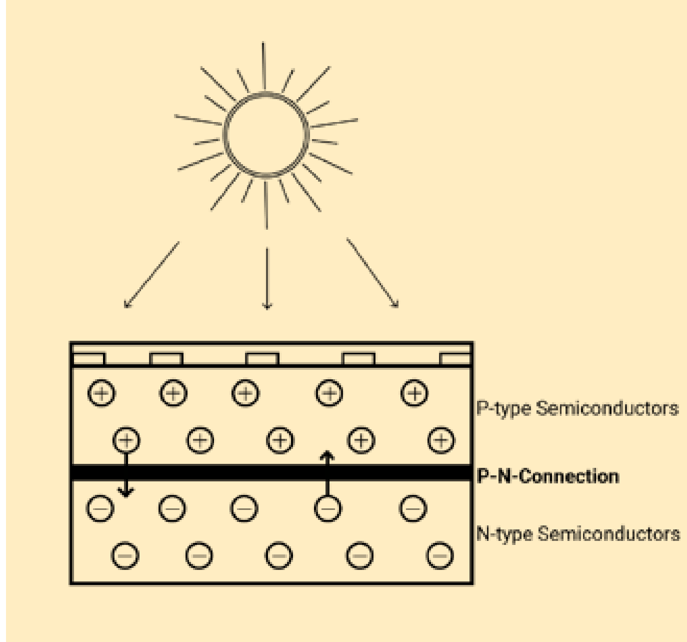
In addition, the manufacturing effort and the associated costs for this technology are comparatively low. Modules with P-Type cells are therefore particularly suitable for residential and commercial applications with a limited budget.

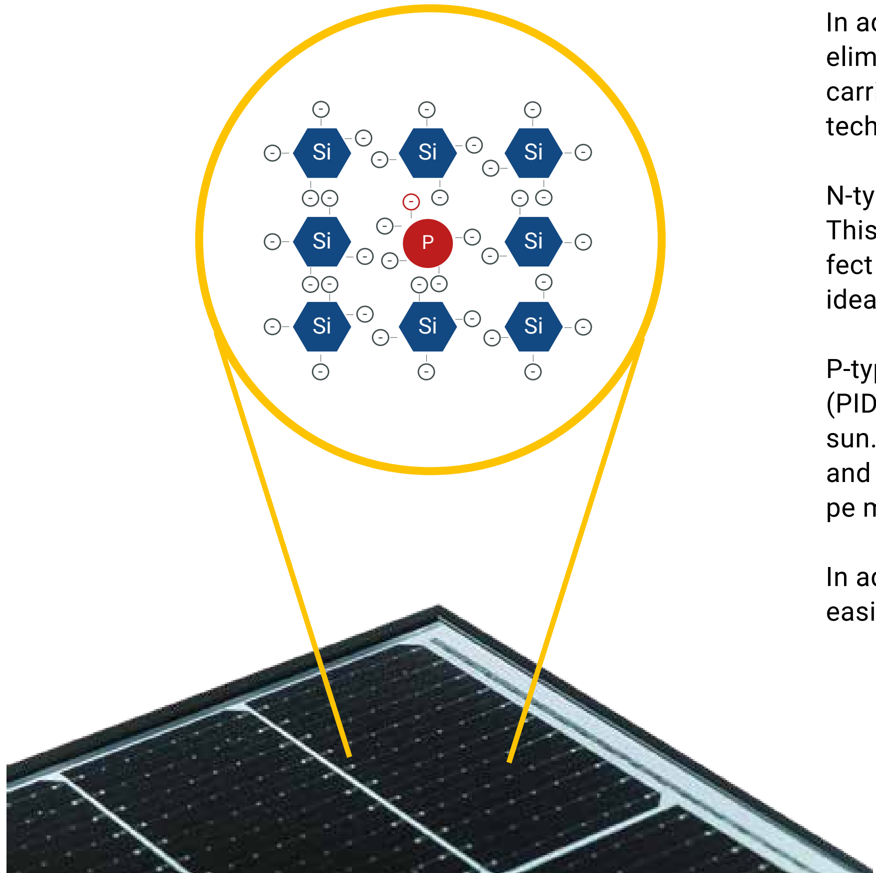
N-Type Cell -> TOPCon

The term „TOPCon“ stands for Tunnel Oxide Passivated Contact. As the name describes, the silicon layer is not in direct contact with the connection contacts. This prevents recombination of the charge carriers in order to avoid a loss of performance. On the back of the solar cell there is a tunnel oxide layer and a thin, negatively conducting silicon oxide layer. This layer passivates the surface, but allows a low resistance to the current flow. It should also be mentioned here that not every cell with N-type technology is a TOPCon cell.

Like the P-type cell, an N-type cell also consists of two silicon layers. The difference lies in the arrangement of the layers. In the N-type cell, the bottom layer is negatively doped by the addition of phosphorus, as phosphorus has one more electron than silicon.

The upper layer also consists of pure silicon and is positively doped due to the resulting charge difference. When exposed to light, the electrons are activated and move between the layers. A P-N-connection is formed between the layers. Electric current is also generated here.





Advantages of N-type

Due to the N-type layer arrangement, charge separation can also take place on the back of the cell and thus higher efficiencies can be achieved.

In addition, the doping with phosphorus eliminates the risk of a boron-oxygen complex. A longer carrier service life can be guaranteed than with P-type technology.

N-type modules have a lower temperature coefficient. This means that higher temperatures have less of an effect on module performance. The modules are therefore ideally suited for regions with high temperatures.

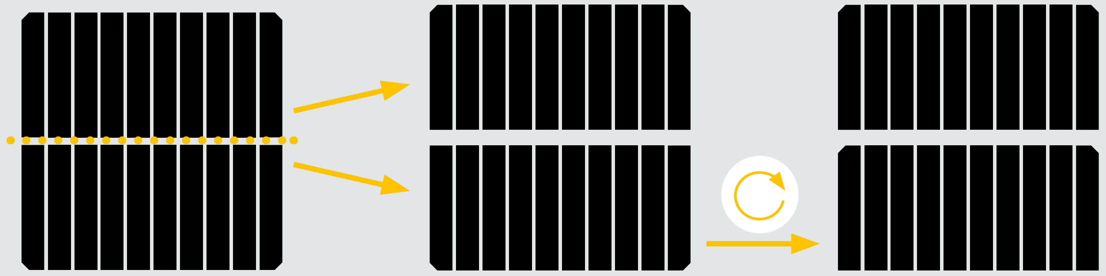
P-type cells often suffer from light-induced degradation (PID) when the modules first come into contact with the sun. This is caused by a chemical reaction in the cell and leads to an initial degradation in performance. N-type modules are not susceptible to PID.

In addition, existing production lines for PERC cells can easily be upgraded to produce TOPCon cells.

Solar module structure

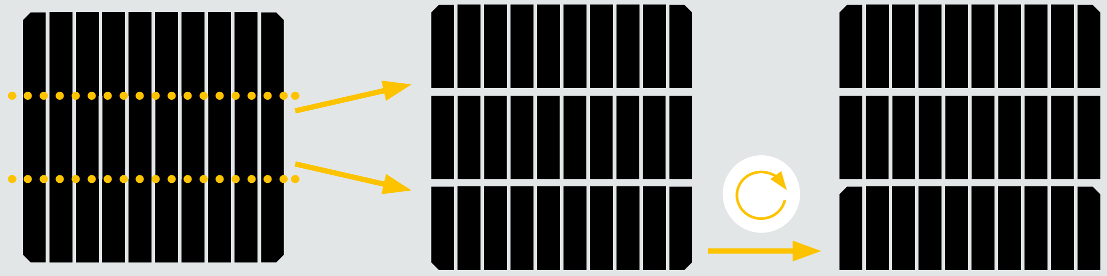
Halfcut Solar cells

By dividing the cells into two halves, modules can guarantee a continuous electricity yield even when there is shade. This leads to an overall higher performance and efficiency of solar modules.



Triplecut Solar cells

The solar cells can also be cut into three parts. This enables a further increase in output and also increases the advantages in terms of shading.



Solar modules with halved solar cells are known as half cell modules or halfcut 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 an average of 2 - 3 % more output than full cell modules with the same input cell. Half cell modules are therefore significantly more powerful than modules with conventional full cells, even though they are made of the same material.

In contrast to conventional full cells, the current flowing through half cells is reduced due to their smaller size. The division of the solar cells halves the current per solar cell. The power loss of solar cells can be calculated precisely using a mathematical formula. (The power loss of a half-cell module is reduced by a factor of four, as the power loss is calculated from the product of the line resistance and the current strength squared). The formula thus demonstrably confirms the most important advantage of halfcut technology - the lower power loss compared to full solar cells.

Lower power losses increase the efficiency of the solar module and the module achieves higher solar yields.

Halfcut cell technology

The essential benefits at a glance:

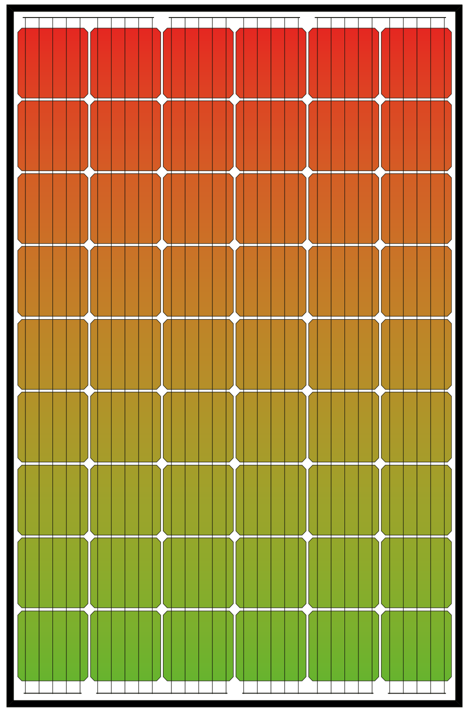
+ Lower power loss
+ Higher efficiency & fill factor
+ Optimised temperature behaviour
+ Increased energy yield

The formula $Pv = R \times I^2$

Pv = power dissipation
R = line resistance in ohm
I = current intensity

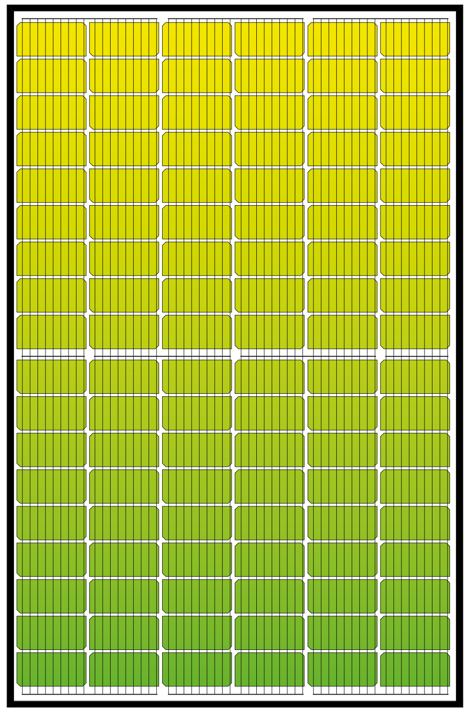
Temperature behaviour of solar cells

Halfcut cells have optimised temperature behaviour. The heat loss at the cell connector is significantly reduced as they only have half the operating current. This reduces the operating temperature accordingly and improves the reliability of the module as well as the energy yield.



Temperature behaviour of solar module

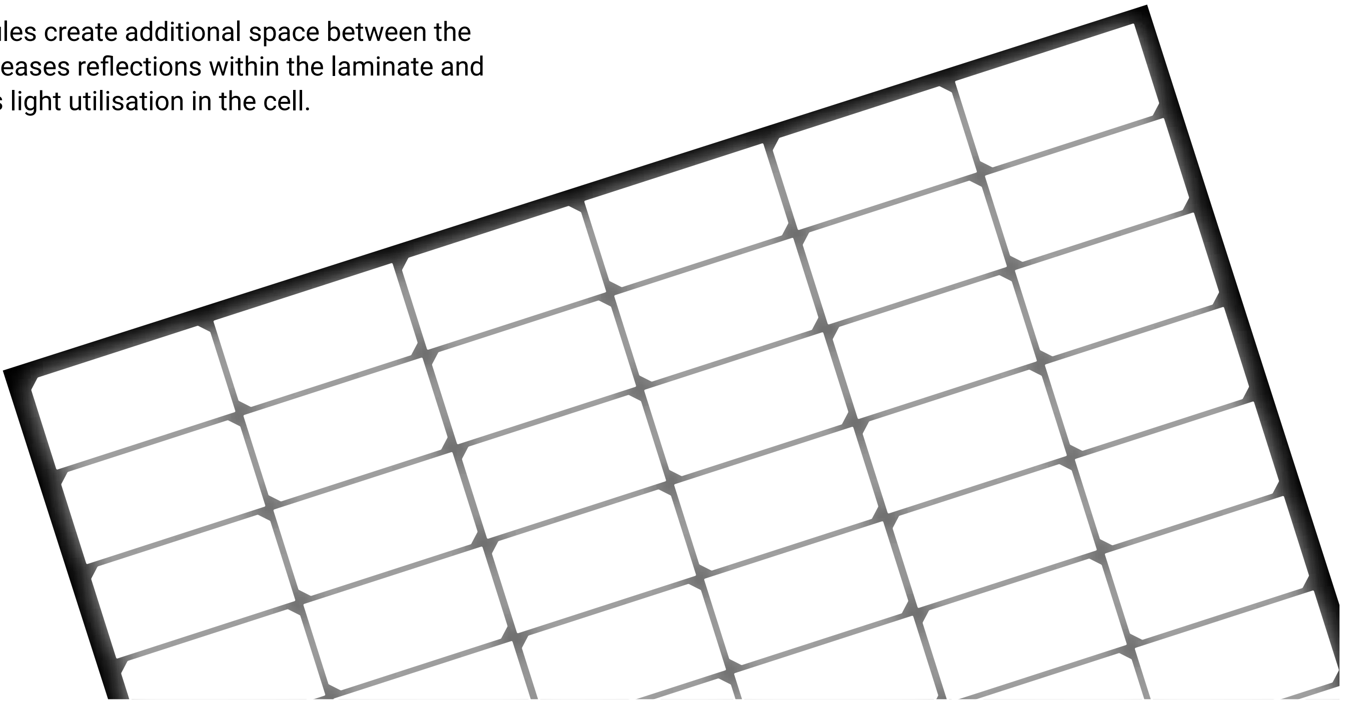
The halved current inside the entire module enables a better temperature coefficient. Half cell and third cell modules can therefore achieve significantly better performance at high temperatures or in strong sunlight.



Energy flow

Intercellular spaces

Half cell modules create additional space between the cells. This increases reflections within the laminate and thus increases light utilisation in the cell.

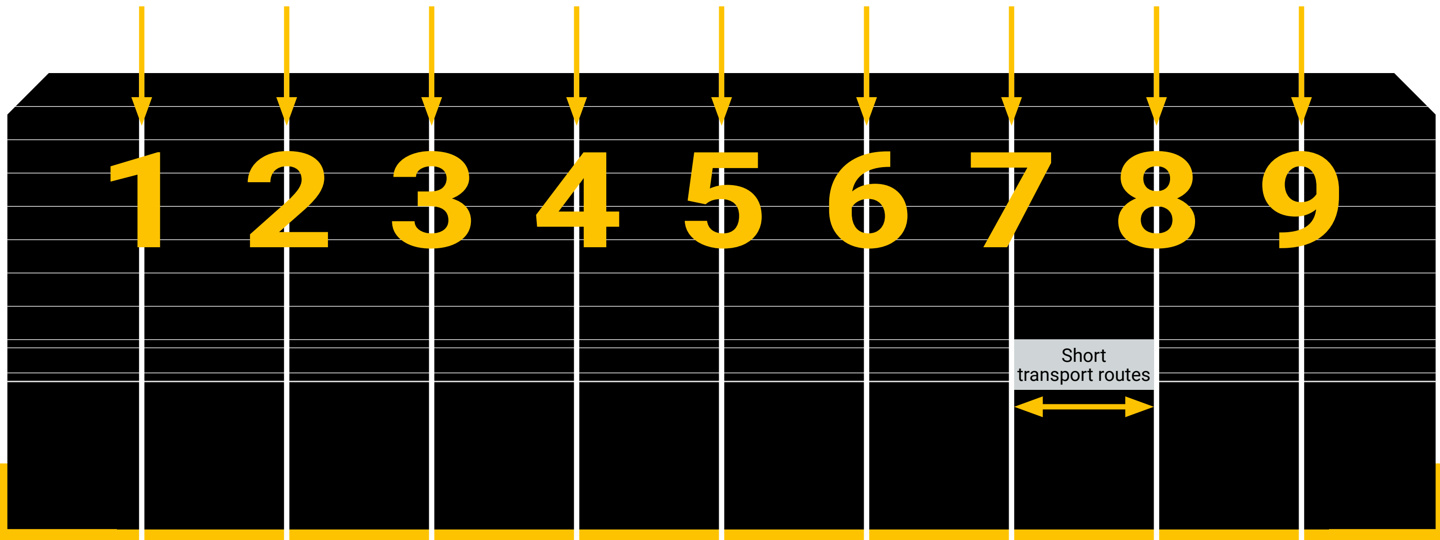


Multibusbar technology

Halfcut 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.



Yield increase

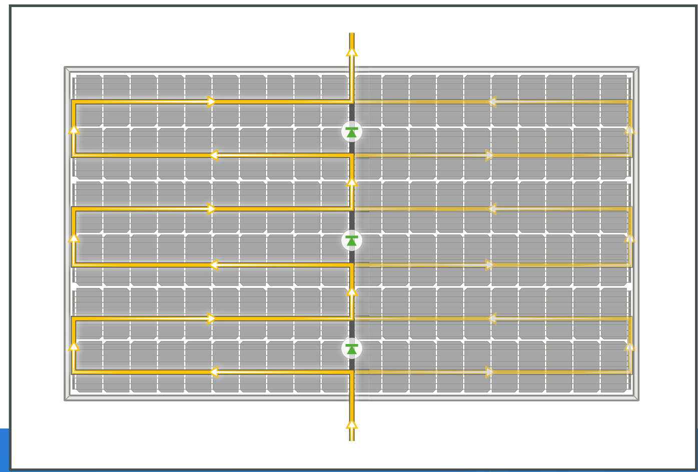
Clever design for increased yield with shadow effect

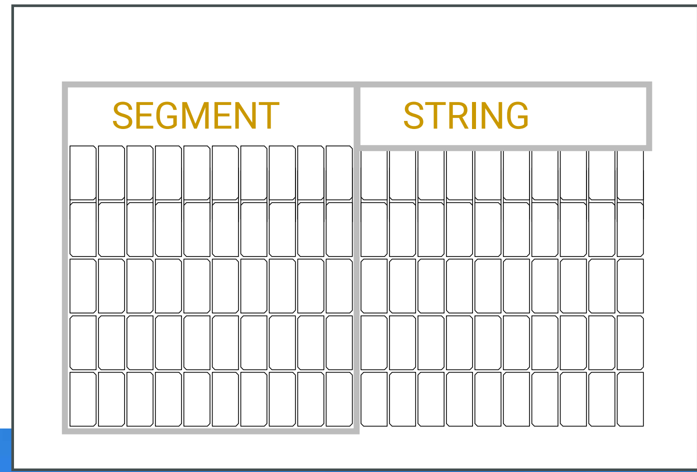
Halfcut solar modules are not only characterised by the use of advanced half cells. Another striking feature is the separate connection of the individual half cells into two separate current paths. For this purpose the half cells of a segment are interconnected in series in six strings. The two segments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

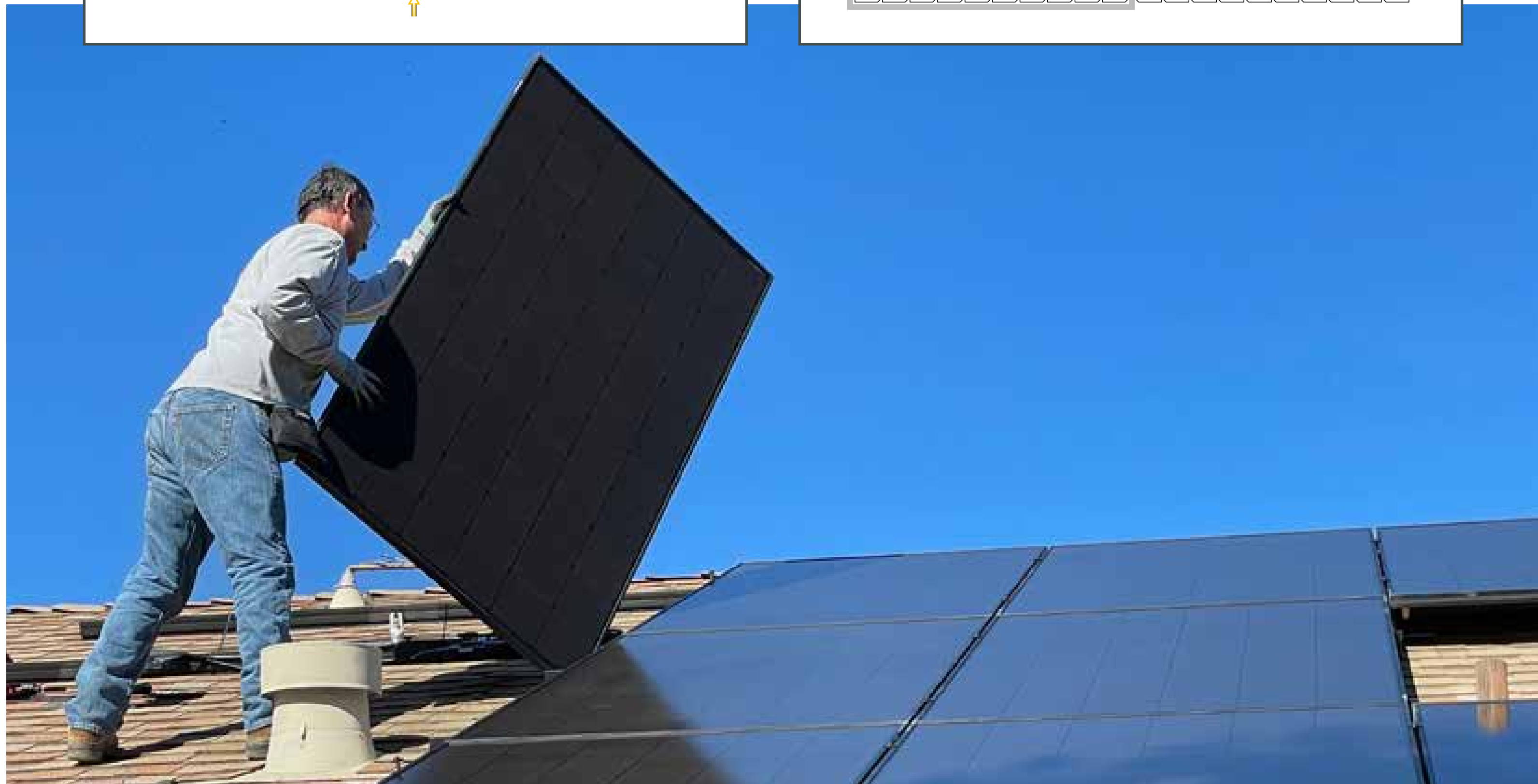
This construction method has the particular benefit that the shading behaviour changes fundamentally. Photovoltaic modules with regular full cell interconnection produce no more electricity even with slight shading of some solar cells!

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 freewheeling or bypass diodes.





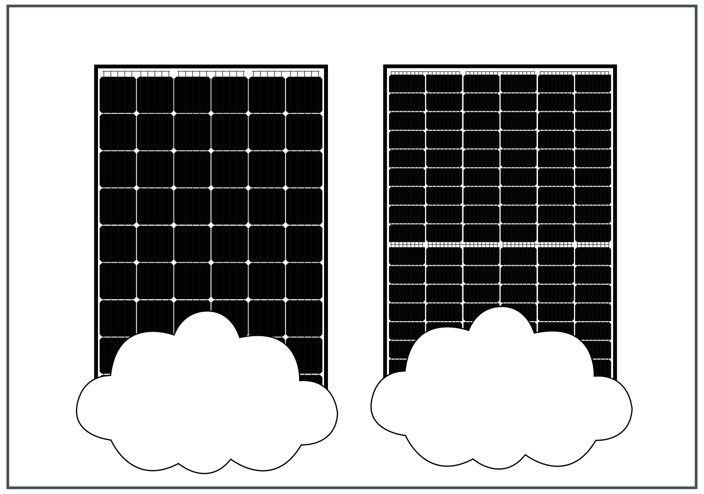


Many advantages

Halfcut modular construction

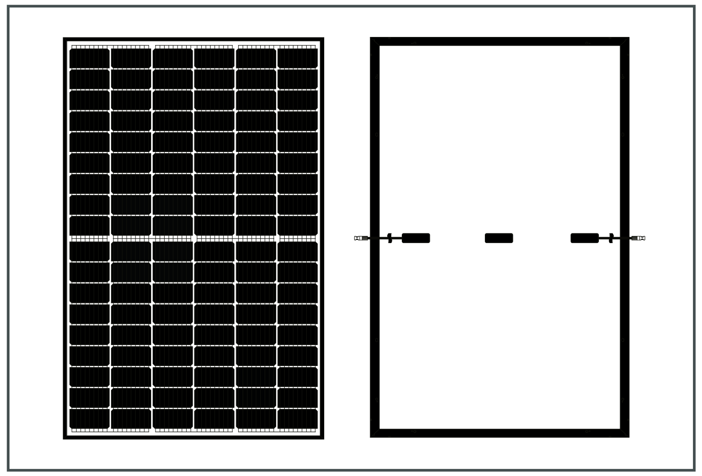
The essential benefits at a glance:

+ 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
+ Increased energy yield



Module connection

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

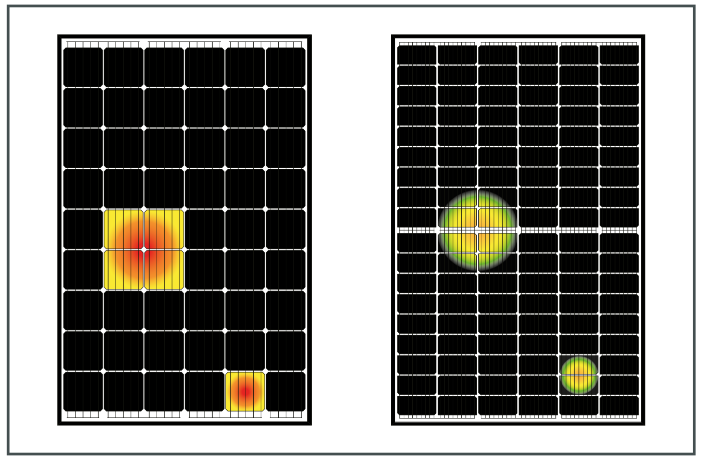


Hotspot behaviour

The unique construction method gives the halfcut 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 halfcut module.



Reduce power losses

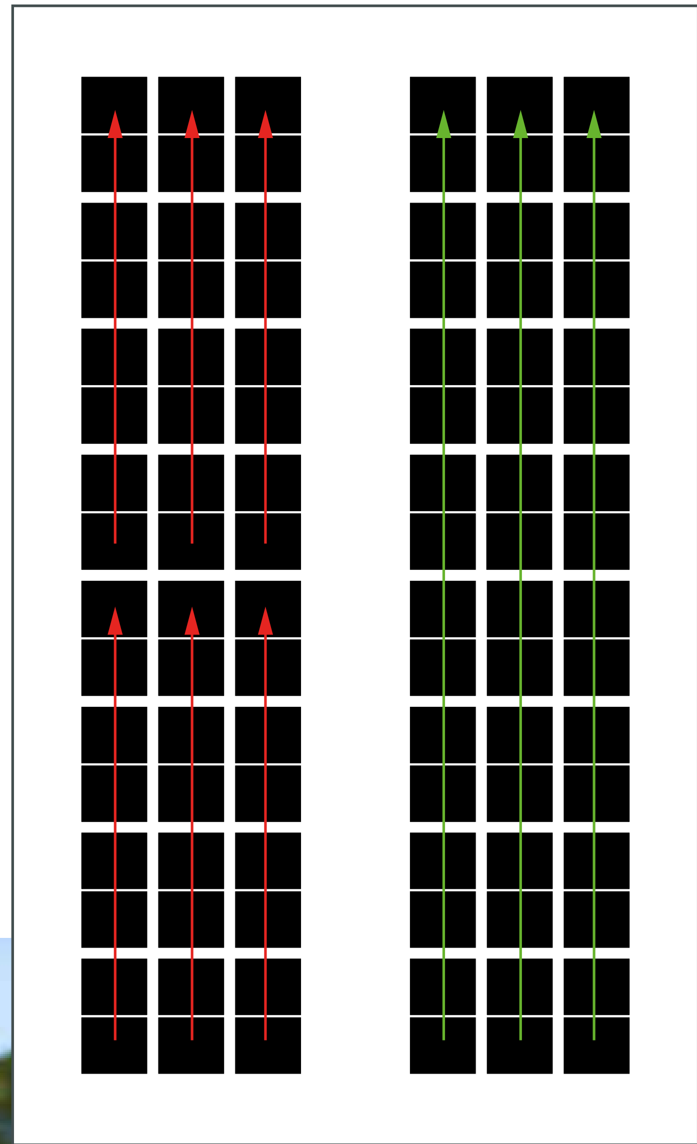
1,500 V system voltage

Halfcut 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.



Solar Fabrik GmbH
Hermann-Niggemann-Str. 7–9, 63846 Laufach, Germany
info@solar-fabrik.de, +49 (0)6093 20770-0