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SULFURCELL

SOLAR CONSTRUCTION WITH SULFURCELL:
NEW SOLUTIONS WITH STYLE

Thin-film solar modules based on CIS semiconductors

SOLAR CONSTRUCTION
SUSTAINABILITY
TECHNOLOGY

Dear Reader,

We are living in truly exciting times: the energy market is experiencing more movement than ever before, extreme price fluctuations in the commodity markets and the climate change are presenting us with entirely new challenges, and alternatives to fossil fuels are becoming more important than ever before. Photovoltaics – the generation of electricity from sunlight – is the energy source of the future. This is because photovoltaics provides answers to urgent questions that are concerning industry and society: How can environmentally friendly energy production be combined with the trend to ecological construction? How can the apparently conflicting interests of functionality, aesthetics and cost effectiveness be reconciled in deploying renewable energy? And in such a dynamic market, how do you find proven products that combine innovation and quality at an affordable price? This is exactly where Sulfurcell provides convincing solutions. As one of the leading producers of thin-film solar modules based on CIS semiconductors, Sulfurcell represents the cutting edge of solar technology. On the following pages, I invite you to find out for yourself about the future of photovoltaics.

Sulfurcell launched its first solar modules onto the market back in 2005 and since then has been able to attract numerous users. The excellent reputations of our specialist dealers – IBC SOLAR, Krannich and Energiebau – reflect the perfected quality proven over many years. However, we are not resting on our laurels but continue to develop our products on a daily basis, turning our vision of a future based on solar energy into reality. Our solar power solutions based on CIS semiconductors show vast potential for development – and not just in terms of their efficiency.

Our progress is also creating a stir at the international level. Renowned technology investors, such as Intel Capital and the BEU funds supported by Gaz de France Suez and Vattenfall Europe, have provided us with growth financing amounting to 85 million euros in 2008. We used this capital to considerably expand our production capacities and to commence mass production. Above all, however, we are bridging the gap between sustainable energy production and attractive solar architecture. We are leading by example with our new production plant and energy self-sufficient administration building in Berlin. But why not simply take a look for yourself?

Kind regards,

Dr. Nikolaus Meyer,
CEO and founder of
SULFURCELL Solartechnik GmbH

Sulfurcell's management team: Dr. Axel Neisser, Martin Beck, Henrik Krüpper (CSO), Dr. Nikolaus Meyer (CEO), Dr. Rüdiger Stroh (COO), Birgit Grüner, Ulfert Rühle

GROWTH THROUGH INNOVATION

SULFURCELL Solartechnik GmbH

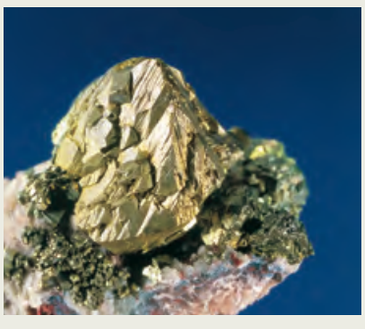
Sulfurcell develops and produces high-quality thin-film solar modules for generating photovoltaic energy. The Berlin company specializes in the family of materials used for chalcopyrite-type semiconductors, which includes copper indium sulfide and copper indium gallium selenide – "CIS semiconductors" for short. Chalcopyrite is a naturally occurring mineral and belongs to the sulfide class of minerals. Sulfurcell's power to innovate is based on these semiconductors – hence the name of the mineral class was incorporated into the company name.

Sulfurcell is a spin-off company from Berlin's distinguished Hahn-Meitner Institute (now called the Helmholtz Centre Berlin for Materials and Energy), which is Europe's largest research establishment for thin-film photovoltaics. The company triumphed in transferring its pioneering research activities into industrial applications, whereby commercial modules have been produced and sold since 2005. Sulfurcell's customers have quickly come to appreciate the new product and its advantages. Trust has grown over the years and Sulfurcell modules are being increasingly deployed in solar power systems and applications. In October 2009, the new headquarters (3000 m²) and production plant (17,000 m²) were completed in which it is planned to produce solar modules amounting to 35 megawatts each year.

Solar modules based on CIS semiconductors provide considerable scope for development. In the past Sulfurcell has constantly improved the material and has patented its innovations. Whereas in 2005 the efficiency of the first solar modules was still less than 5 %, by 2008 they had already achieved an efficiency of 8 %. Laboratory results have shown that the potential is still far from exhausted. Today, solar cells produced from CIS semiconductors already reach efficiency levels of 20 % under laboratory conditions, which is more than all the other materials used for thin-film solar modules. Sulfurcell is therefore making major investments in developing CIS semiconductors.

Sulfurcell's team is working towards its technological goals with expertise and passion. The more than fifty technologists at Sulfurcell include scientists with many years of CIS experience, engineers from the semiconductor and electronic industries as well as specialists for solar building design. We are passionate about making solar energy more attractive through innovation.

With its cutting edge, technically sophisticated products, Sulfurcell fully lives up to the traditional "Made in Germany" seal of quality: the company offers products that are distinguished by their long-term stability, attractive price/performance ratio and aesthetic excellence. The solar modules can therefore be applied as visible building features and are already deployed like conventional building materials. Sulfurcell has thus achieved a new dimension in building design: economic, sustainable and aesthetically excellent.



Taking its lead from Mother Nature
Sulfurcell uses CIS semiconductors based on the natural mineral chalcopyrite (Photo: Lapis/ Christian Weise Verlag, Munich).

GROWTH THROUGH INNOVATION

How it all began

The seeds to Sulfurcell's success were sewn when the company was founded in July 2001 by Nikolaus Meyer – now the company's Chief Executive Officer – together with colleagues from the Hahn-Meitner Institute. The company's founders seized the opportunity to apply the latest research on thin-film technology to solar modules in industrial production. That was the beginning of the success story, which continues today.

The production line commenced operations in 2004. One year later Sulfurcell presented the first prototype.

Production and commercial marketing of the modules began soon after in 2005. Since joining the market, the Berlin company has considerably expanded its production capacities. 75,000 solar modules were already sold and installed by the beginning of 2010. This makes Sulfurcell one the world's three most important manufacturers of CIS semiconductors. The company has also won several awards for its groundbreaking research and product development – including the 2006 Innovation Award Berlin-Brandenburg.

» Sulfurcell is a promising young company with very innovative technology. Thanks to the extensive technological know-how of its staff and the ambitious expansion plan, we can expect Sulfurcell to become a major German photovoltaic manufacturer in the coming years. As such Sulfurcell is helping to ensure that Germany remains one of the world leaders in photovoltaics in future, too. «

Gerhard Stryi-Hipp, Fraunhofer Institute for Solar Energy Systems ISE, Head of Energy Policy, Member of the Supervisory Board of Sulfurcell Solartechnik GmbH

The Supervisory Board of Sulfurcell Solartechnik GmbH (left to right)

Raoul Arvengas, **Gaz de France Suez, Paris**
Gerhard Stryi-Hipp, **Fraunhofer Institute for Solar Energy Systems, Freiburg**
Kalman Kaufman (Chairman), **entrepreneur, Tel Aviv**
Dr. Stefan Beyer, **Ventegis Capital, Berlin**
Alex Betts, **Climate Change Capital, London**
Heiko von Dewitz (Observer), **Intel Capital, Munich**
Christof Sagasser (no photo), **Vattenfall Europe, Berlin**

From pilot project to mass production

The company's technical expertise and strong development as well as the growing global demand for solar modules convinced renowned financial investors to provide Sulfurcell with 85 million euros in July 2008 to finance the company's continued growth. The group of investors and partners includes high-caliber stakeholders from the industry itself: the Californian chip manufacturer Intel invested via Intel Capital (Santa Clara); Climate Change Capital (London) is one of the leading investment banking groups investing in clean energies and low carbon companies; the Berliner Energie Umweltfonds is funded by Germany's third-largest energy company, Vattenfall Europe, and the German branch of France's leading energy group Gaz de France Suez; Ventegis Capital (Berlin), Demeter (Paris), Zouk (London), AIG (Zürich), Bankinvest (Copenhagen), Engelbert Giesen (Berlin) and Masdar Clean Tech Fund (Abu Dhabi) all invested as well.

The fresh capital has been spent on constructing a new production plant in Berlin-Adlershof and on research. The new factory will increase Sulfurcell's production capacity to 35 megawatts (MW) initially. The second phase will see capacity rise to 75 MW. The leap to mass production has been achieved.

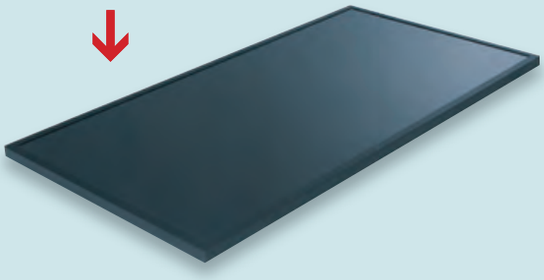
The staff – the most important capital

Our company's success is essentially due to our 200 members of staff (as of May 2010). Highly qualified technologists, technicians and production staff ensure that Sulfurcell and its products continuously develop. A lean administration and sales team ensure that everything runs smoothly and supports our partners and customers with competent advice and assistance. What motivates them all is a passion for pioneering solar solutions. An enthusiasm for technology and good teamwork unite them. Together they help shape the future of Sulfurcell. That is a good basis for more growth in the coming years. To facilitate this growth, Sulfurcell is planning to double the number of employees, by hiring additional engineers and scientists in particular. This is because Sulfurcell will need highly qualified colleagues to maintain its ability to innovate and grow in future.

CHALLENGES AND GOALS

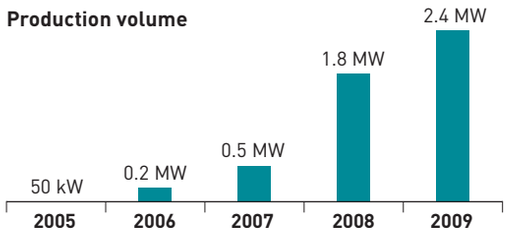
PHASE 1: 2003-2005
UPSCALING

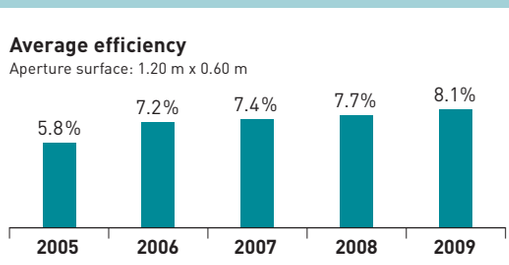
2003
Laboratory module from the Hahn-Meitner Institute (5 cm x 5 cm)

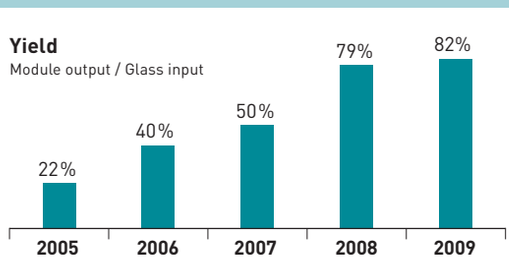


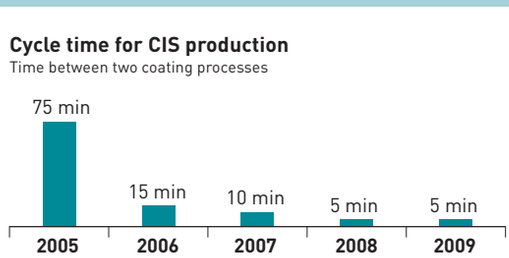
2005
First solar module from Sulfurcell (125 cm x 65 cm)

PHASE 2: 2005-2009
INDUSTRIALIZATION









SUSTAINABILITY IN ACTION

Sulfurcell's new production center

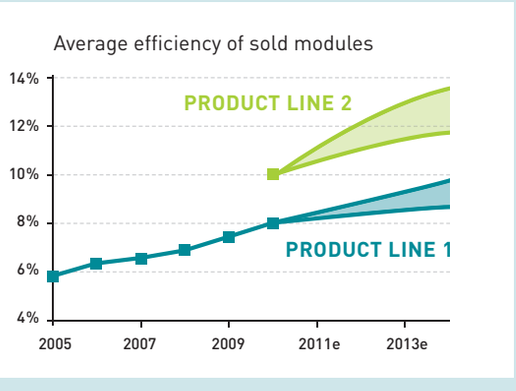
Sulfurcell also bases its corporate decision-making on sustainability factors. Correspondingly, the company was one of the first signatories of the "Berlin Climate Alliance" at the end of 2008. Together with the city of Berlin and twelve other renowned firms, Sulfurcell is actively committed to reducing CO_2 emissions in Berlin: the aim is a decrease of more than 40% from 1990 to 2020. This is because for the staff and management, climate protection goes hand in hand with corporate responsibility. They have contributed by expanding Sulfurcell's production capacities in Berlin-Adlershof.

The annual production rate there is being increased to 35 megawatts. After all, every kilowatt-hour of electricity generated in a photovoltaic installation is a step in the right direction. This is why solar modules were also used for the new administration building and production plant. Large-scale solar power systems supply the new building with energy. 700 modules on the facade and a 300 kW roof-mounted system will provide renewable energy for the production operation. The administration building is 100% energy self-sufficient.

PHASE 3: FROM 2008
COST REDUCTION AND GRID PARITY

Mass production

Continual improvement of technology



☑ 75 MW expansion launched

☑ 2008 Development projects defined, financed and launched

Sulfurcell's headquarters

SOLAR CONSTRUCTION: ROOF INTEGRATION

Sulfurcell sets trends for building the future

Whether for residential buildings, public buildings or commercial properties: the desire to combine renewable energy generation, energy-efficient construction and attractive architecture is becoming increasingly important. Sulfurcell manages to unite all these elements in its own unique way: by means of solar modules which can be integrated into facades and roofs. Therein lies the future of construction. That is solar construction.

Fitters, trade professionals and architects value the anthracite-colored Sulfurcell modules with the fine pinstripes. Thanks to their compact form, they can be made to fit all sorts of building surfaces perfectly, and the solar modules give roofs the same harmonious structure as conventional roof tiles. This is what sets Sulfurcell modules apart – not just from crystalline silicon modules, which are undesirable for solar construction because of their chess board-like appearance, but also from other thin-film modules which are mostly uneven and brownish or purple. Sulfurcell guarantees excellent quality and offers solar modules with an even dark surface. Many of our partners describe our modules as the most attractive solar modules on the market.

Sulfurcell's solar modules are ideal for large agricultural or industrial buildings. They blend in with the natural landscape and enhance the roof – not just visually but also economically, for having a solar power system on

Sulfurcell modules blend in with the natural landscape – including on agricultural buildings

the roof makes use of surface areas that would otherwise lie idle. If, on the other hand, they are covered in modules, they can make money – all the more if the roof is optimally angled to the sun, the installation is as simple as possible and the costs of the solar modules themselves are kept to a minimum. Hence, the advantages of Sulfurcell modules are very clear – for they are easy to install and offer excellent value for money. The special system solutions of Sulfurcell's specialized dealers are partly responsible for this. Customers benefit from the solar system's extremely high profitability and enjoy a module technology that is environmentally friendly, innovative and high-quality.

Sulfurcell's roof-integrated modules replace roof tiles and protect the house from weathering. They also cover the house's energy requirements and give the building an attractive modern appearance.

Solar facade on a building belonging to the Rückgrat company in Donaueschingen, Germany (architect: Günter Limberger)

SOLAR CONSTRUCTION: FACADE INTEGRATION

Solar construction means using solar modules like conventional building materials and replacing passive construction materials. The modules thus fulfill two functions – providing the building shell and generating energy. Furthermore, the solar application is even more economical as it saves on the costs for tiles or facade panels. Sulfurcell's product range offers ideal construction elements for every part of a building. The production hall of the company Heuchemer in Miehlen (Taunus) is just one example of a facade-integrated PV array. Sulfurcell modules adorn the facade of this building, replacing passive construction materials. Moreover, Sulfurcell is applying a similar solution to its new company headquarters (see image on p. 9). Conventional mounting systems can be used as well and, in conjunction with Sulfurcell modules, achieve a more elegant appearance. The building illustrated on this page demonstrates the use of Sulfurcell's frameless modules, which have been installed on the AluTec mounting system from CreoTecc. This turns the solar module into an architectural highlight and enhances the building, something that is usually only possible with expensive special glass or natural stone panels.

Facade-integrated modules on an industrial building belonging to the Heuchemer company in Miehlen, Germany (design: Goldbeck Bau)

Facade cladding with solar modules providing solar control on a building belonging to the Max Fuss company in Berlin

The solar facade of the Ferdinand Braun Institute for High Frequency Technology in Berlin

Sulfurcell has set new standards in solar architecture with the solar facade of the Ferdinand Braun Institute for High Frequency Technology (FBH) in Berlin. Sulfurcell accompanied the project from the planning to the installation as a competent partner. The shiny black wall is about 640 square meters in size (8 by 80 meters) and has a peak capacity of about 39 kilowatts. Dresden-based architect Christian Matzke designed the elegant, curved solar wall as part of extensive new construction and conversion measures to the FBH. The facade was installed by Dachland GmbH. With this impressive facade, Sulfurcell demonstrates what is possible in solar architecture.

PHOTOVOLTAICS OF THE FUTURE

Sulfurcell produces thin-film solar modules based on semiconductors from the CIS family

In recent years the number of photovoltaic absorber materials has grown and grown. The conventional crystalline silicon modules have been joined by thin-film solar modules, which bring benefits for many applications. The thin-film technologies include solar modules made of CIS semiconductors, like the ones Sulfurcell has been producing for years. The Berlin company helped to research and develop this groundbreaking photovoltaic technology and patented it.

Thin-film technology based on CIS semiconductors differs from other solar modules in that it is environmentally friendly from the very outset, i.e., no high-temperature processes have to be applied in production, so the energy consumption is low and is recaptured during the first operating year via the sunlight used. Toxic process gases and chlorine chemicals are spared. But most important of all, the production of the modules uses natural resources sparingly: the glass is coated with a razor-thin layer of semiconducting material which converts sunlight into electricity. It is thinner than a hair, and a hundred times thinner than the silicon wafers used for conventional modules. The few concerns that the element indium, as is present in CIS semiconductors, was too scarce to be used for mass production have been scientifically refuted.[1] Indium exists in sufficient quantities in the Earth's crust and is even found more often than silver.

Sulfurcell is working hard to enhance its technological edge. To this end, it collaborates with leading research institutes such as the Helmholtz-Zentrum Berlin and the University of Oldenburg. Under laboratory conditions CIS semiconductors already reach the highest degree of efficiency of all the materials used for thin-film modules.

CIS technology, a competitive comparison

Polycrystalline silicon module

CIS module from Sulfurcell

	Semiconductor material
Modules (wafers)	**Polycrystalline silicon**
Thin-film	**CIS** $CuInS_2$, $Cu(In,Ga)Se_2$, $Cu(In,Ga)(S,Se)_2$
	Cadmium telluride CdTe
	Amorphous/ microcrystalline silicon a-Si/µ-Si

[1] See "Indium: Geology, Mineralogy, and Economics" by Ulrich Schwarz-Schampera and Peter M. Herzig, Springer, Berlin (2002).

[2] Solar efficiency tables, Progress in Photovoltaics, Vol. 15, 425-430 (2007)

Sulfurcell is the most important industrial partner for the Helmholtz Centre Berlin in the field of CIS solar cells. Its team managed to develop a reliable and attractive photovoltaic product based on entrepreneurial vision and scientific expertise. The company's technology roadmap is very convincing and will enable the company to continuously increase the efficiency of its thin-film solar modules.

Professor Hans-Werner Schock, Helmholtz Centre Berlin for Materials and Energy

The aim is to exploit this potential on an industrial scale. Thanks to the material's modification possibilities, the module capacity can be constantly improved: the elements – indium, gallium, sulfur and selenium – can be combined with each other in various ways. In addition, alternative manufacturing processes open up a whole range of options with which our technologists can work innovatively. It is these optimization possibilities that will make it possible for CIS semiconductors to achieve the same efficiency as today's polycrystalline silicon solar modules in the long term. And at the same time they have considerable cost benefits compared to polycrystalline silicon solar modules: the amount of expensive semiconductor material required in production sinks dramatically – instead of 500 grams of silicon per square meter, just five grams of CIS are used. CIS semiconductors also avoid the multi-layer production process required for conventional modules and cut two thirds of the production steps.

Maximum efficiency (Lab records[2])	Advantages	Disadvantages
20.3%	— Solution when space available is limited but high capacity is required	— Higher costs and energy consumption in production — Not attractive for solar construction — Power loss with high operating temperatures
19.5%	— High efficiency and potential to reduce costs — Environmentally friendly technology — Most attractive appearance, ideal for solar construction	— Production volume still low
16.5%	— Low production costs	— Low acceptance for application in or on buildings
11.7%	— High availability thanks to large production volumes — Can also be used in watches and calculators	— Low efficiency potential — Energy yield falls in the first operating years — Module format and electrical design often awkward

GENERATING ELECTRICITY FROM GLASS

The production of Sulfurcell modules

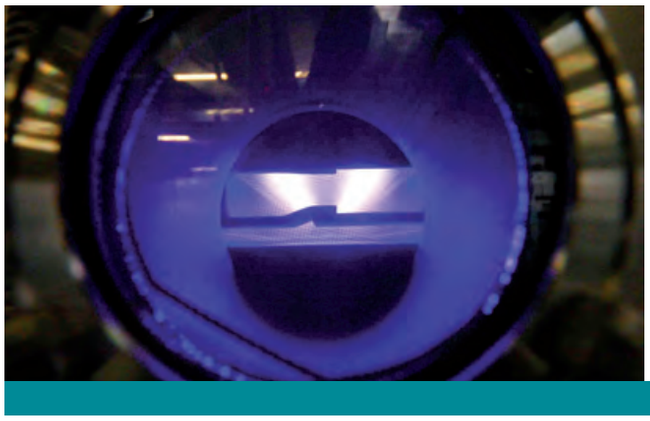
On the surface the production of CIS solar modules is simple, yet it is technologically complex. The source material for Sulfurcell solar modules is simple window glass. The glass is coated with thin layers of metals and semiconductors, which make up the CIS solar cells.

In order to apply these layers to the glass, a process called sputtering is used. This process has been used successfully for decades for coating large-scale architectural glass, and it is known for its high energy efficiency. Today virtually all panes in industrial construction go through a sputter system at least once in order to be layered with sun or heat protection. Sulfurcell has put the experience gained by the glass industry to good use: it uses sputtering to coat the glass, which makes the module coating extremely even. This is the basis of the homogenous design, and it is what makes the subsequent products so attractive.

To produce the centerpiece of the solar module, the CIS semiconductor, several elements have to be combined. Sulfurcell does this by exposing sputtered layers of copper, indium and gallium to sulfur or selenium vapor and heating them to 500 degrees Celsius. The Sulfurcell engineers set great store by developing a quick – and thus productive and energy-conserving – process for this. In 2006 the panels had to be heated for more than 15 minutes, but today this has been reduced to just two minutes – an achievement unparalleled by competitors.

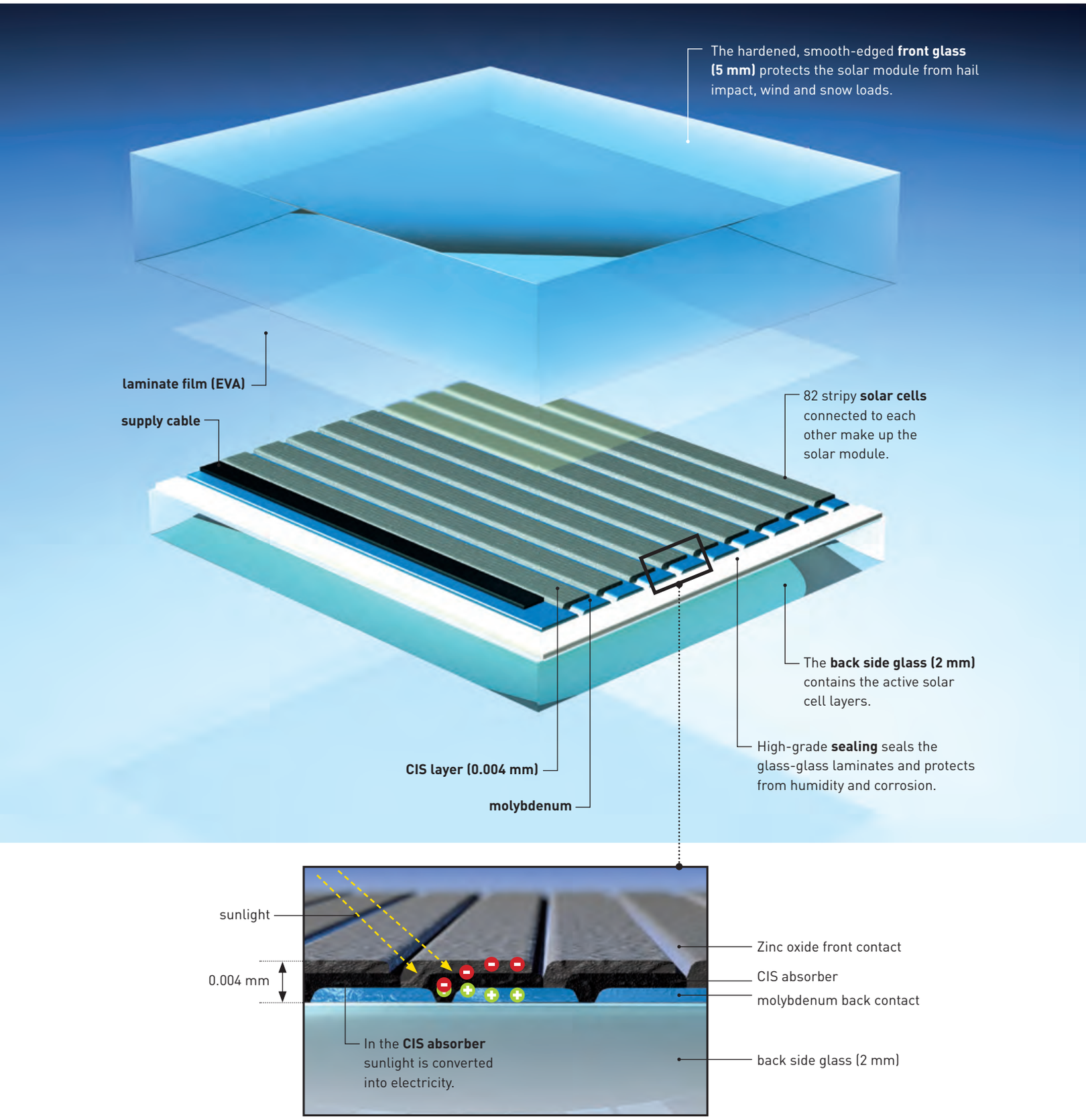
In the case of solar modules the glass has to be more than just 'stained' – after all, the layers have to perform an electric function. That's where the real challenge of producing CIS solar module lies. The layers applied may not be contaminated. They have to stick to each other and be combined electrically – and their properties have to be kept constant from glass pane to glass pane, week to week. Thus, before the commencement of mass production in 2008 the company carried out pilot production operations for three years, all the while optimizing all processes and workflows. When it came to the selection of the technology, initially a simple CIS process was chosen that used only copper, indium and sulfur. With this basic process the company quickly managed to achieve good efficiency levels and stable production. As a result, at the end of 2005, Sulfurcell was one of the first providers to launch CIS solar modules onto the market. Sulfurcell will now continue to develop itself technologically by building on its tried-and-tested basic production technology and by implementing even more complex processes. It already has the scientifically verified formulas for high efficiency – and with its valuable production experience, Sulfurcell will be able to apply them successfully to future production.

Plasma during the sputter coating of glass



A glimpse of Sulfurcell's mass production

Solar modules from Sulfurcell: Method of functioning and quality features



ECONOMIC, SUSTAINABLE, AESTHETIC

- Qualified, IEC EN 61646
- Safety tested, IEC EN 61730
- Periodic Inspection

Quality: highest standards guaranteed

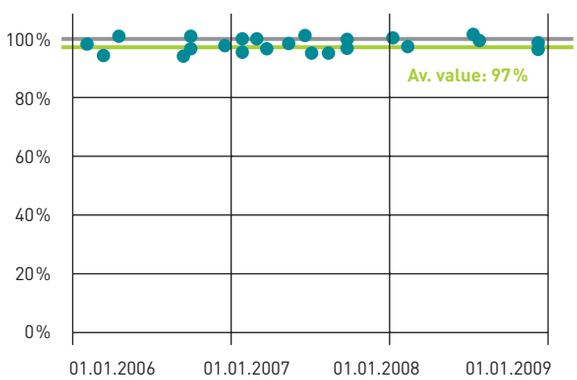
Sulfurcell sets itself high standards. Quality begins in production, which we organize according to ISO standard 9000/9001, and continues right through to the final product. Customers of Sulfurcell enjoy products that last. In order to guarantee this longevity, the solar modules are tested externally and internally regularly. And they pass these tests with flying colors: the prestigious TÜV Rheinland (Rhineland Technical Inspection Agency) has certified all three Sulfurcell solar modules according to the quality standards IEC EN 61646 and IEC EN 61730.

Our products are also continuously tested in our own laboratory – where they undergo accelerated life-time tests. During these tests they are subjected to high levels of humidity and extreme temperature fluctuations.

The tests also simulate the strain of strong winds, large quantities of snow and hailstorms. We also check the long-term resistance of our modules to UV radiation and test each module for its high-voltage stability. The power of each individual module is precisely measured using class A sun simulators and these results are made available to the customer.

But Sulfurcell's solar modules don't just pass the tests under laboratory conditions, they also prevail in real-life longevity tests. The data from the test equipment provide important information on how to maximize the energy yields during the permanent operations and make it possible to measure the actual energy yields of a solar application. The endurance tests have proven what

Module power after accelerated ageing
(1 000 hrs, 85°C, 85% rel. humidity)



Accelerated life-time tests simulate the performance of the modules after twenty years. Sulfurcell's modules still achieve 97 % of their original capacity in the damp-heat test, more than the 95 % required by the TÜV. The graphic shows test results from modules from three production years.

Sulfurcell's climate chamber for accelerated module ageing

the physics tell us: that CIS semiconductors solar modules do not lose 10 to 20 % of their capacity in the first operating year, like thin-film amorphous silicon solar modules. Rather, the yield properties of the Sulfurcell solar modules are much more similar to conventional polycrystalline silicon modules – yet they are markedly superior in warm, sunny countries.

Sulfurcell also demonstrates how the capacity of a photovoltaic installation can be maximized with the choice of the right system components. Thus in its installation guide, Sulfurcell provides information on how a solar power system should be electrically installed. This ensures that the inverters and assembly system are matched to our modules.

Installation: quick and painless

Sulfurcell modules are just 0.8 square meters in size, which means a good roof coverage is possible and the distances to dormer windows and ridges can be kept low. The fitters appreciate the light weight and the format of the modules and can transport and assemble them without any elaborate tools. The modules can be assembled both horizontally and vertically, have long connecting cables and plugs that comply with established international standards. Their low VOC and the high admissible system voltage make long strings possible and reduce the amount of wiring required. In short, they give the fitter the flexibility needed to meet the specific needs of each individual project.

Sulfurcell's bending test for frameless modules

Microscopic quality inspection during production

TECHNICAL BACKGROUND

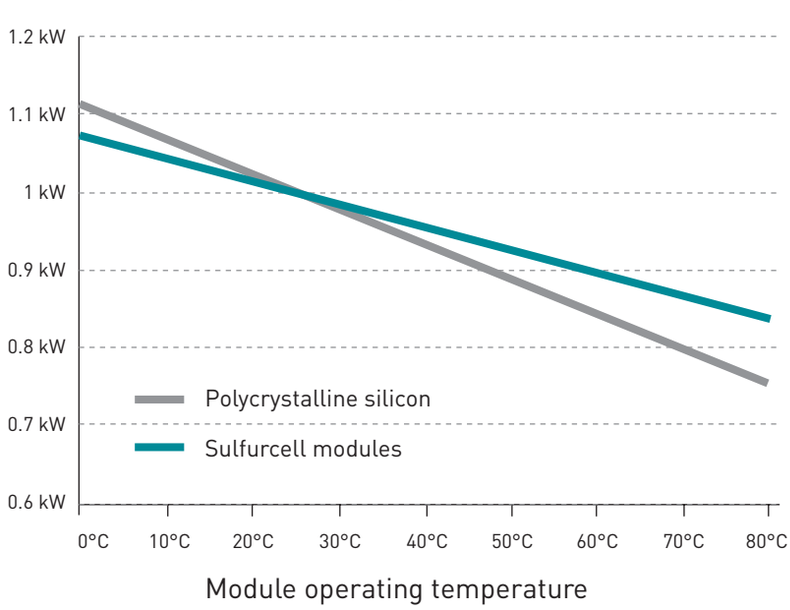
Efficiency, energy yield and profitability

The **efficiency** of a solar module reveals what proportion of the sunlight is converted into electrical power and what electrical power can be gained from a certain surface area. Solar modules are priced according to their output (measured in **watts** [W]). With regard to their efficiency, solar power systems only differ from one other in terms of the surface area that a solar installation with a certain output covers. Modules with a lower efficiency are usually cheaper per watt than those with a higher efficiency. Hence, if there is enough space or if the investment sum has to be kept low, low-cost solar modules with a low efficiency should be used. However, if space is limited and the output has to be maximized, a higher efficiency is required and the price per watt will be higher too. Thus, higher efficiency often means lower profitability and a greater investment, but is more compact. So the efficiency level is just one of many quality criteria, but does not indicate the **price/performance ratio**.

In 2008 Sulfurcell sold solar modules which had an efficiency of up to 7.5%, and higher efficiency rates are expected in 2009 and 2010. The space needed for a Sulfurcell installation is about two thirds more than for a typical polycrystalline silicon solar module. But Sulfurcell's customers know that Sulfurcell makes modules that are much more cost-effective than crystalline silicon products of a comparable quality per watt of electrical output. In terms of the surface area of a roof, the savings factor is even greater: in this regard the Sulfurcell installation is up to 50% more cost-effective than an installation with silicon modules. So if a roof is to be completely covered with solar modules, Sulfurcell modules lower the investment and the loans required considerably.

The annual **energy yield** – measured in kilowatt-hours per year (kWh/a) – is not determined solely by the efficiency, for this depends on the illumination conditions and the

1 **Actual output of 1 kWp solar power systems**
(with perpendicular sunlight, AM 1.5, 1 000 W/m²)



1 Sulfurcell's solar modules are more "tolerant" of heat than crystalline silicon modules and are therefore particularly suitable for southern latitudes.

2 The monthly appraisal of the energy yields proves the consistent performance of Sulfurcell modules and their strong performance in warm summer months.

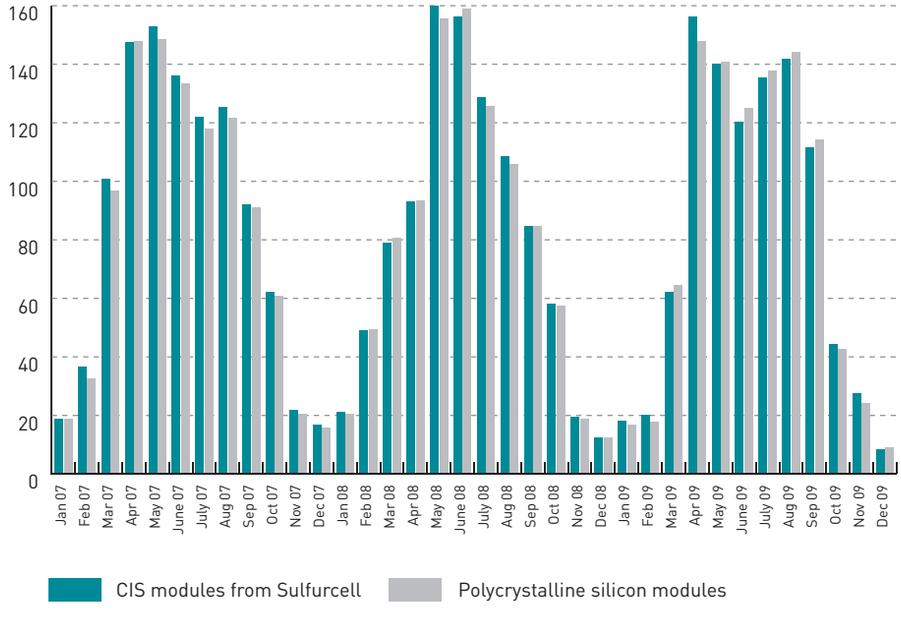
3 The energy yield from Sulfurcell's modules is just as stable and as high as for polycrystalline silicon modules. In contrast to amorphous silicon, the capacity of Sulfurcell modules does not decrease in the second operating year.

4 The warmer the place, the greater the benefits of Sulfurcell modules. In Greece, a 5% greater yield has been measured compared to crystalline silicon modules.

operating temperature of the solar modules as well. The solar industry has therefore defined **standard test conditions** in which the efficiency is determined. The manufacturers also derive the **rated power** of a solar module (measured in **watt-peak** [Wp]) as indicated on the data sheets from these laboratory tests and base the module price on it. Standard test conditions, for example 25°C operating temperature and midsummer-strength (1000 W/m²) perpendicular sunlight, occur rarely in real-life operations and are, at best, conceivable on cold summer days. In summer solar modules typically work at temperatures of 50 to 80°C and the efficiency falls. The **temperature coefficient** refers to the fall in capacity per degree Celsius. This is another strength of the Sulfurcell solar modules: their good temperature coefficient makes them ideal for warmer regions (e. g. in southern Europe) and manifests itself in a higher energy yield per watt-peak. Thus, depending on where they are installed, Sulfurcell solar modules can achieve annual yields that are 4 to 8 percent higher than that of crystalline silicon modules.

Last but not least, the annual energy yields per watt-peak depend on the system technology and the solar radiation. Maximum yields can be reached when the best possible installation locations and angles are found, the right inverters are fitted to the modules, and the installation is connected and installed professionally. Sulfurcell works together with reputable dealers who have this expertise and have installed thousands of applications. They provide on-site advice and help the user to get the most out of Sulfurcell's modules.

2 **Annual energy yield of 1 kW solar power systems**
Berlin (roof-mounted)

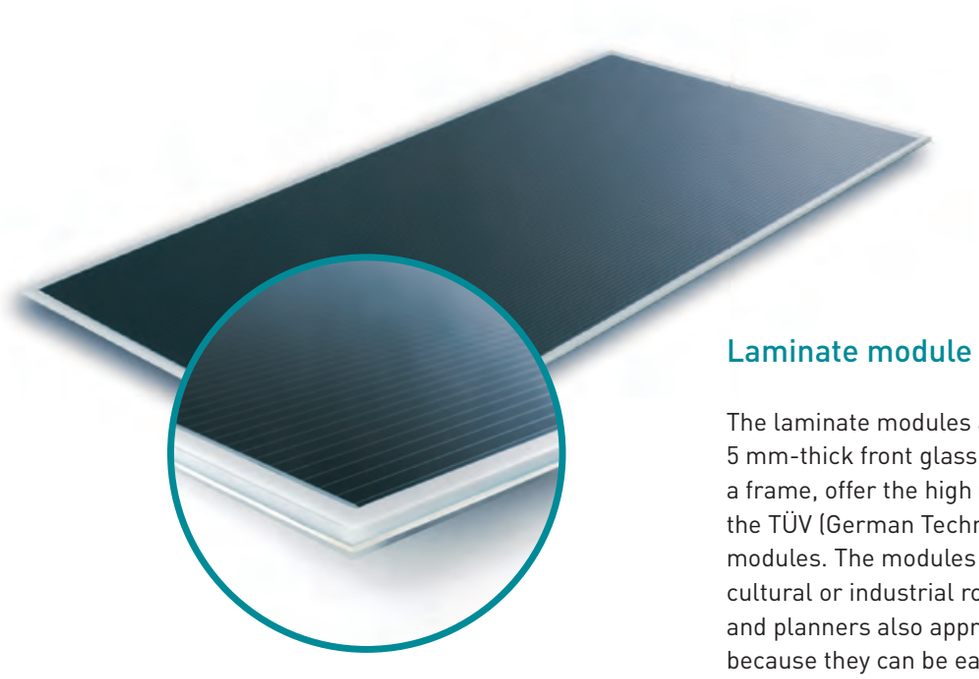


3 **Annual energy yield**
1 kW solar power systems
Berlin (roof-mounted)

4 **Annual energy yield 2008**
1 kW solar power systems
Berlin/Trikala

MODELS AND APPLICATION POSSIBILITIES

With a virtually black main surface area and light conducting paths, the Sulfurcell modules can be described as "anthracite with pinstripes" and are among the most visually attractive solar modules on the market. This makes them particularly suitable for integrating into roofs or facades. Sulfurcell designs its solar modules in such a way that they can be easily used as building materials. Countless projects are the definitive proof that Sulfurcell is a preferred partner for architects and building contractors and can fulfill the highest design and structural engineering requirements.



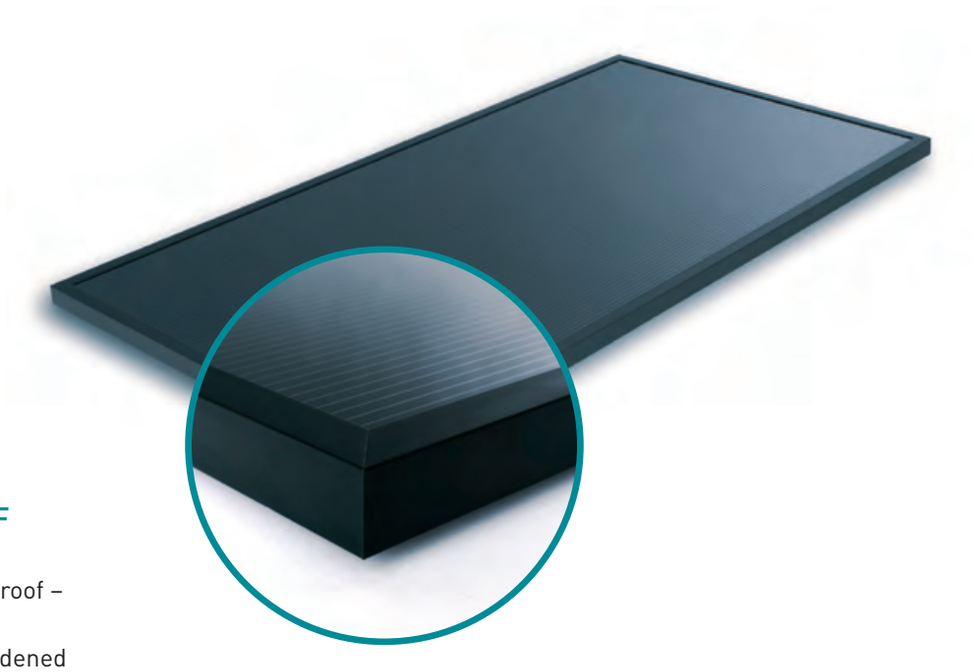
Laminate module type SCG-HV-L

The laminate modules are furnished with a hardened, 5 mm-thick front glass and therefore, even without a frame, offer the high mechanical stability required by the TÜV (German Technical Inspection Agency) for solar modules. The modules are the best option for large agricultural or industrial roofs. But construction engineers and planners also appreciate the laminate modules because they can be easily integrated into standard buildings and glass constructions. They are also ideal for roofs with a low tilt angle (of up to two degrees), since water and dirt can run off easily.

Sulfurcell has optimised the costs for this model. It has been possible to dispense with the expensive aluminium frame since Sulfurcell modules are smaller than conventional silicon modules. This way they have a far higher inherent stability and can withstand pressures and strains in the long term. Aluminum is only necessary for the solar installation's substructure, which reduces the consumption of this energy-intensive material by 30 %. The laminate module manages to combine an extremely impressive maximum profitability with the conservation of resources.

Sulfurcell's laminate modules boast another advantage too: Sulfurcell supplies its laminate modules in cardboard sleeves. They protect the module during installation and function as a buffer in case the module is struck. The cardboard sleeves are not removed until after the installation process is complete – so Sulfurcell combines the benefits of frameless modules with simple and safe installation.

Cardboard sleeves protect Sulfurcell's laminate modules during transport and installation



Framed module type SCG-HV-F

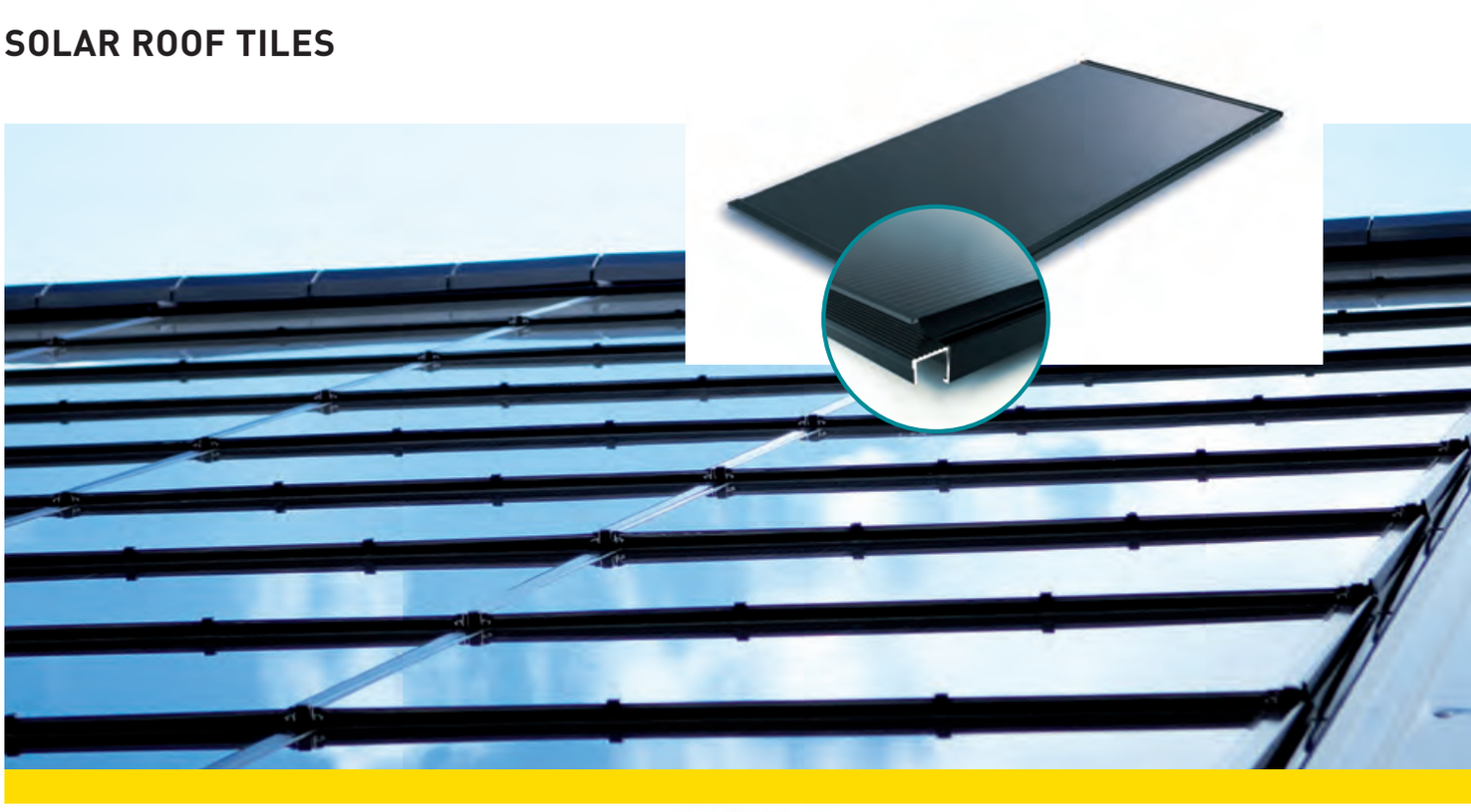
Whether as a facade element or on the roof – our framed module is always suitable. Thanks to the aluminum frame and hardened front panel, they are so robust they can even be used in areas with heavy snowfall (snow load zone 3). The modules are particularly simple to install since the frame protects the glass from being damaged. This means they can be installed in places that are difficult to access or on mounts, which wouldn't be possible with frameless modules.

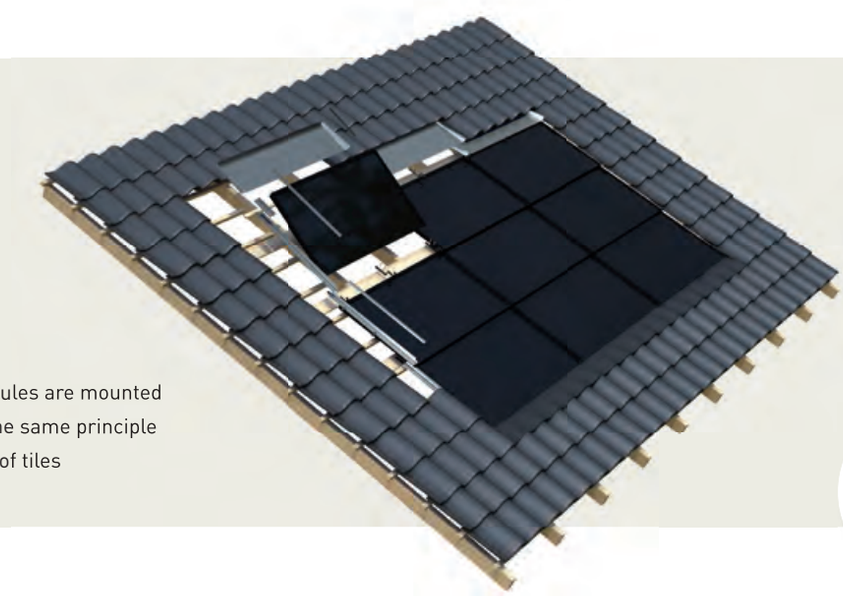
ECOLOGY: GREEN TECHNOLOGY

Sulfurcell sees itself as a pioneer in the fight against climate change. That means our manufacturing processes have to meet the highest ecological standards as well. And they do so demonstrably: with thin-film technology a comparably small amount of resource material is used and little energy is consumed in production. Thanks to the high yields of CIS technology, there is also a dynamic amortization period of one year – half the amortization period for crystalline silicon modules.

Sulfurcell solar modules are environmentally friendly and can be disposed of as household rubbish at the end of their life cycle according to the current statutory regulations. Nevertheless, Sulfurcell has developed a return system for solar modules so that the recyclable materials – especially glass and aluminum – are reintegrated into the cycle of materials. As such Sulfurcell is a founding member of the PV Cycle Association, which is developing a return and recycling program for the solar industry.
www.pvcycle.org

SOLAR ROOF TILES





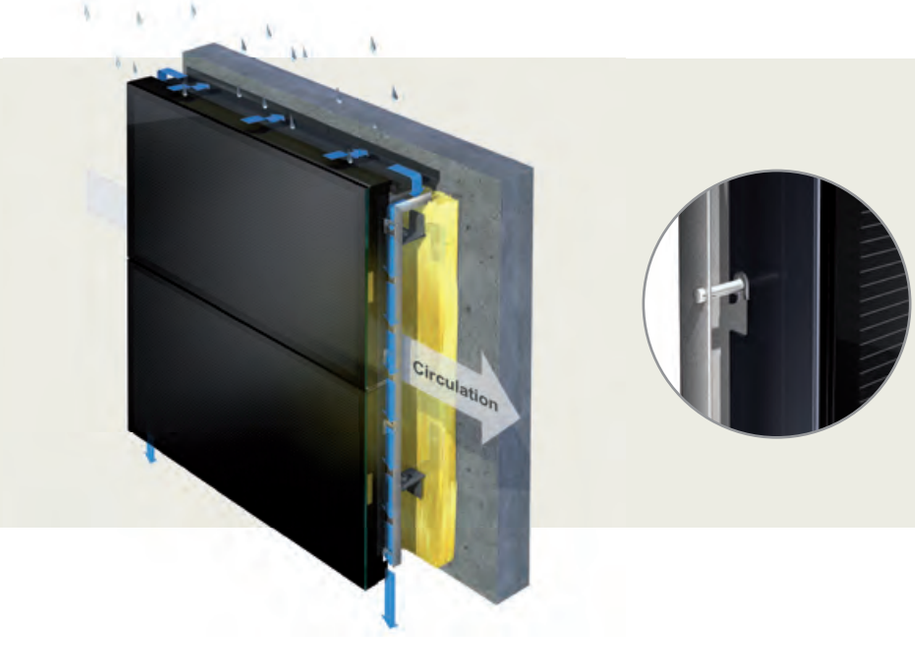
Roof-integrated modules are mounted like shingles using the same principle used for installing roof tiles

Roof-integrated module type SCG-HV-RI

The roof-integrated module offers new possibilities in solar construction. The modules are installed quickly and easily on the roof battens like tiles, thus saving on tile costs. The use of these modules saves construction costs of about 20 – 30 €/m². The use of black SOLRIF frames, tried and tested in the industry and made by the company Schweizer Metallbau, makes them easier to install, gives the roof a homogenous and aesthetically pleasing appearance and offers excellent design possibilities. But most important of all, the installation is simpler than with other roof integration solutions: French specialists from the consultancy firm Cythelia compared various roof-integrated solar systems in 2008 as part of an extensive market study. Their investigations revealed Solrif-based solutions as the test winner.

Sulfurcell's system partners assist the user with the layout or roof finish of the solar installation. Custom-fit sheets provide a perfect roof finish so that patchwork solutions can be avoided.

SOLAR FACADE CASSETTES

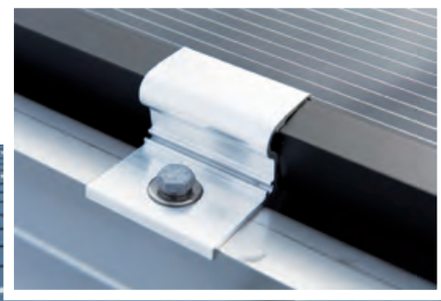


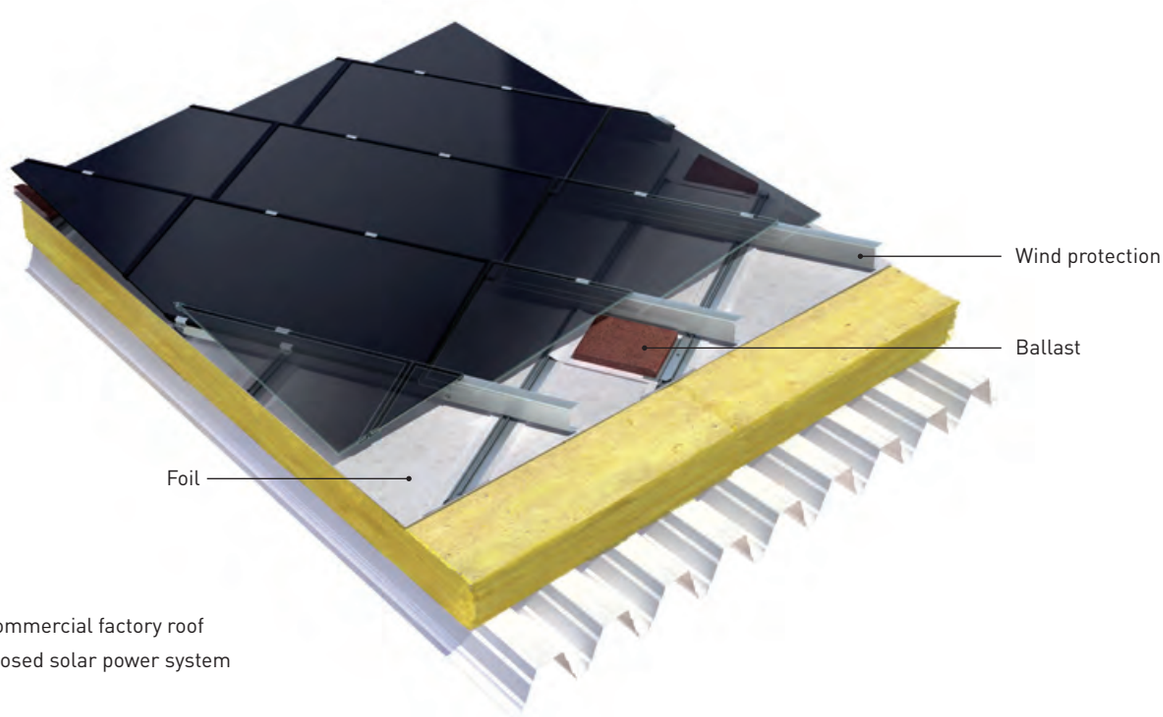
The rear ventilation prevents interstitial condensation and cools the solar modules

In industrial construction it is common to use facade cassettes because they provide weather-proof cover for insulation and discharge rainwater in a controlled manner. They are made of sheet metal and are mounted onto the facade. Sulfurcell has developed a technology for giving these facade cassettes a further advantage and enhancing them visually, too. Sulfurcell offers cassettes that contain a laminate module on the surface.

In contrast to other facade-integrated solar systems, this way frameless modules can be used for the facade. This converts the sheet metal facade into an elegant glass facade which also generates electricity for the offices behind. This new technology is being applied for the first time to Sulfurcell's new company building in Berlin, where it can also be viewed.

WEIGHT-OPTIMIZED SOLAR POWER SYSTEMS FOR COMMERCIAL FLAT ROOFS





Structure of a commercial factory roof with a superimposed solar power system

It is often not possible to install conventional solar power systems on large-scale flat roofs because the solar power systems weigh too much or there are no suitable means for fixing them. Sulfurcell's flat roof solution offers an intelligent response: the system is weight- and wind load-optimized and only has a load of 19 kg per m² (plus ballast). The particularly low-profile installation reduces the surface exposed to wind, while additional wind protection panels reduce the suction even more, enabling the solar power system to be mounted without the need for fixings that penetrate the roof. The low-profile installation also minimizes shading from the modules, enabling the module rows to be placed closely together. This thus enables a minimum output of 55 kW to be installed per 1000 m² of surface area.