EMMVEE

Your Partner for Solar Energy
Since 1992

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Greetings

D.V. Manjunatha
Founder and Managing Director of EMMVEE

Dear Ladies and Gentlemen,

Thank you for your interest in EMMVEE. This brochure seeks to provide an overview of EMMVEE: Our production, product components, history and services. Since EMMVEE's inception in 1992, the company has developed various expertises in Solar Water Heating Systems, Photovoltaics and Toughened Glass. Thus we created a multifaceted brochure to present you all relevant details related to EMMVEE's various business segments and offer you a glance into our company philosophy. What are our areas of expertise? What are EMMVEE's special features? Our top priorities are quality and service. In order to ensure long-lasting product efficiency, EMMVEE has developed long-term business relationships with renowned component manufacturers and place great emphasis on innovative quality management. With the help of our 650 employees in locations across the world and various suppliers, EMMVEE is able to stand out through excellent customer service. Friendly and accessible support team at EMMVEE assist the customers and offer solutions to all queries.

For company or any product related enquiry please contact our EMMVEE team.

We hope you will enjoy our company brochure.

Sincerely,

D. V. Manjunatha

EMMVEE
Solar products from Bengaluru to the world

EMMVEE is a company of over 650 well trained and highly motivated employees in India, Germany, Italy, France, Singapore and the United Kingdom. We only use carefully selected highly qualitative components from internationally renowned manufacturers to produce modules and systems of outstanding quality, high yield, long life and attractive design. Let's take a look at EMMVEE's business:

EMMVEE is a developer and manufacturer of high performance solar thermal systems as well as mono- and polycrystalline modules in Bengaluru, the Silicon Valley of India. We offer various solar water heating systems, photovoltaic modules and solutions. EMMVEE has more than 650 well trained and highly motivated employees all over the world working in the segments of photovoltaics, solar thermal systems and glass production.

In the year 1992, Mr. D.V. Manjunatha founded the company EMMVEE in Bengaluru, India. Starting its activities in the solar water heater production with sales and marketing office in India, EMMVEE Solar Systems Pvt. Ltd., since 2008 a JV with SolarCAP A/S enmark, has grown to be the largest manufacturer of solar water heating systems in India and probably in Asia. Our eco-friendly products shall not only go a long way in helping global efforts in conserving the environment but also helps customers in reducing their electricity bills thereby generating additional savings. EMMVEE is continuously working on introducing new age technologies in both manufacturing process and management practices.

As early as 2007, EMMVEE started to manufacturing mono- and polycrystalline modules which are suitable for on-grid and off-grid applications. Today, EMMVEE has prominent market share in the PV industry across India and Europe, in countries like Germany, Italy, France and United Kingdom.

In India, EMMVEE specializes in distributing photovoltaic modules for on- and off-grid applications as well as standard and customized photovoltaic systems for stand alone and especially roof top applications.

EMMVEE utilizes only the best components to reach the highest degree of efficiency and reliability. We have achieved a further increase in effectiveness as the first company by using a special patterned surface glass which


EMMVEE in India


EMMVEE in Italy

EMMVEE in Germany

D.V. Manjunatha
Founder of EMMVEE

reflects the incident light multiple times onto the cells (light trap effect) and increases the efficiency at least 3% compared to a flat glass. The Institute for Solar Energy Research Hameln in Germany documented the efficiency gain (page 20). These glasses show a low level of contamination from dirt particles and other objects, resulting in high yield when compared to modules with flat glasses.

EMMVEE is completely transparent about its production and suppliers. All relevant information can be found on our website. Stringent incoming goods inspection of all raw materials as well as a comprehensive quality management system in production and stringent final inspection ensure a consistent high quality level. EMMVEE modules are certified to the standards of IEC61215 Ed. II, IEC61730 and IEC61701 by TÜV Rheinland (German technical inspection agency). The annual TÜV inspections and approval of our production facilites are proof of our high quality standard. All our TÜV certified modules meet European and international requirements. Selected modules also receive US certification from Underwriters Laboratories, UK certification from MCS and Australian registration from Clean Energy Council.

EMMVEE Solar has already installed over 400 000 domestic and industrial systems under the brand name 'Solarizer', 'SolarizerPlus' and 'Solarizer Supreme' amounting to a total capacity of around 500 000 m^2 across India which includes prestigious clients like ETA Properties, TTD Tirupathi, Jayadeva Hospital, JSS institutions.

All our produced photovoltaic modules and systems have been successfully connected and generate high yield to our customers worldwide.

State-of-the-art Production
EMMVEE Photovoltaic Modules

EMMVEE produces high quality photovoltaic modules using the latest and best machinery. Skilled staff operate 3S and Somont machines assisted by sophisticated and highly calibrated machines. Since its foundation, EMMVEE has grown into an international company with 650 employees. Today, EMMVEE manufactures solar thermal systems and photovoltaic modules at two locations in Bengaluru.

The production capacity for our on-grid module has reached a capacity of 135 MW with the most modern production line in India.

The production takes place in a very clean and dust-free environment. Each staff member wears head and mouth covers and special clothing to minimize dirt. The three production lines from 3S are absolutely high-tech from Switzerland offering precision at the same time as speed.

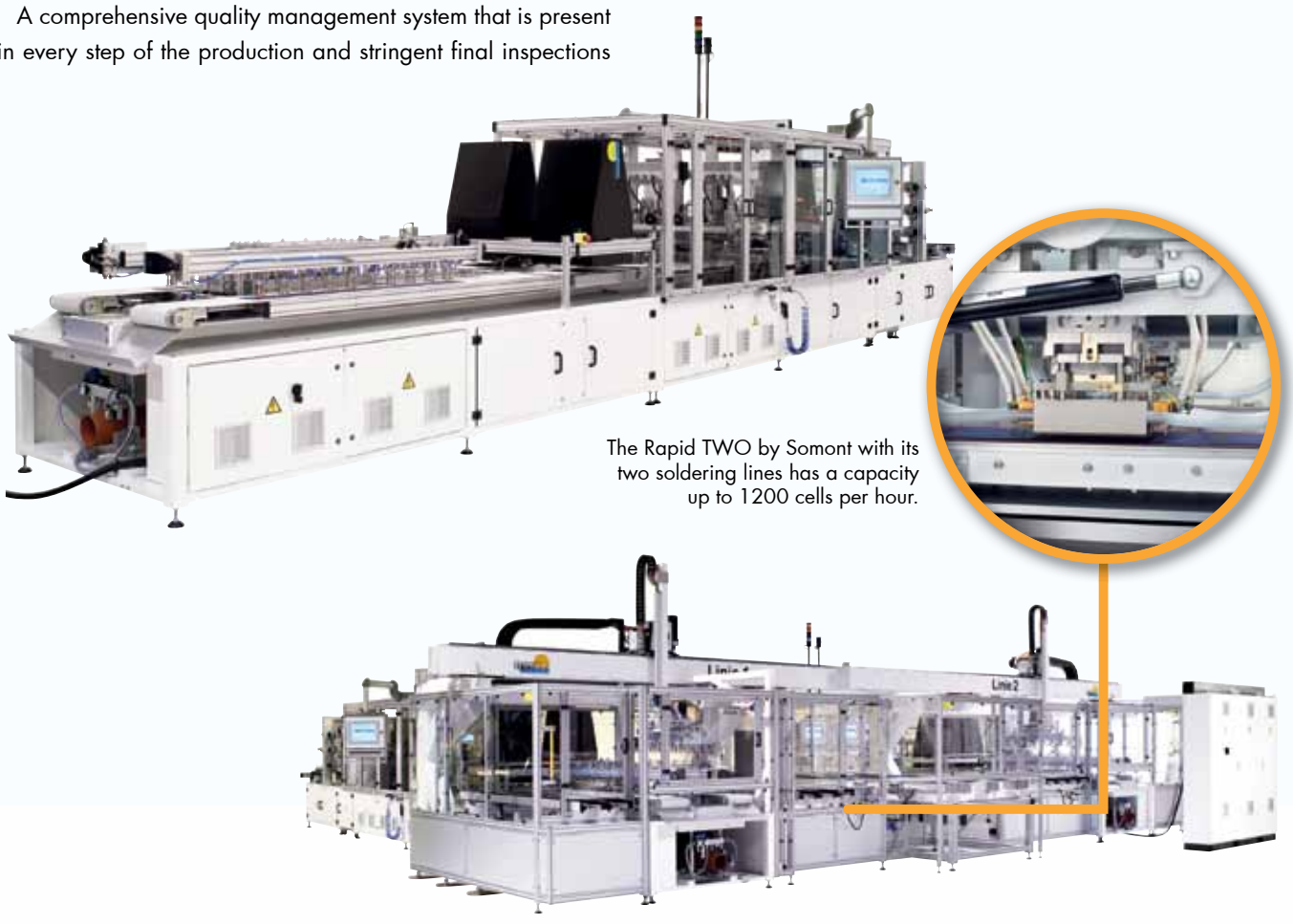
The Rapid TWO soldering lines reach a capacity of 1200 cells per hour. Our most recent line, The Rapid Four was added at end of 2010, which reached a capacity of 2400 cells per hour. The solar cells get checked by the machines and are safely put into strings (up to 2000mm) using the soft touch soldering technique for a perfect soldering process. The strings are then connected and laminated.

A comprehensive quality management system that is present in every step of the production and stringent final inspections ensure consistent high quality levels. Our qualified specialist staff and engineers perform additional work to achieve optimum production quality in addition to the automatic production process.

After the lamination process, the module is sorted and tested under standard test conditions with the Pasan flasher.

The final touch is giving by a laser engraving on the frame of the module with an individual serial number before getting packed and distributed worldwide.

Our off-grid modules are being produced automatically on Spire soldering line as far as the production process does permit. For smaller modules using cut cells, our well-trained staff will process with highly precise manual soldering.



The Rapid TWO by Somont with its two soldering lines has a capacity up to 1200 cells per hour.

Impressions of the production in Bengaluru:
EMMVEE photovoltaic modules have to fulfil high quality requirements. Technical perfection, state-of-the-art machinery and stringent quality control in a clean environment are the foundation of our module's efficiency. All EMMVEE modules are manufactured on 3S/Somont machinery.

EMMVEE Solar Water Heating Systems

EMMVEE is continuously working on introducing new technologies in both manufacturing process and management practices. EMMVEE has become the specialist in enamel-coated tanks. EMMVEE is the pioneer and the only manufacturer of glass enamel coated tanks of sizes of 100 to 3000 liters for solar water heating systems in India. The additional layer of glass enamel on the steel layer not only increases the strength and the lifetime of the tank but as well the resistivity against corrosion and guarantees a highly hygienic water quality for a long time

EMMVEE Solar Systems Pvt. Ltd., an ISO 9001:2008 & 14001:2004 certified company was established in the year 1992 in Bengaluru, India and is a manufacturer of solar thermal products such as solar water heaters (widely known as Solarizer), solar dryers and solar pool heating systems.

EMMVEE Solar Systems Pvt. Ltd., since 2007 a JV with SolarCAP A/S Denmark, has grown to be the largest manufacturer of Solar Water Heating Systems in India and probably in Asia. EMMVEE's latest 120000 sq. ft. state-of-the-art production is in operation since June 2009 on a 21 acre plot at Dabaspet, near Bengaluru.

Collector Leak Test

Collector Flange Brazing

Flat Plate Collector

EMMVEE has a semi-automated production centre for manufacturing solar collectors. An online quality monitoring process at each stage of the production ensures the highest quality of the collector.

The production process can be listed as follow:

- Brazing the fins with header tubes
- Leak and pressure test on fin assembly
- Assembly of fin assembly with aluminium box
- Rock wool insertion at bottom and sides of the box
- Back sheet assembly and assembly of glass with EPDM rubber

Tank

The in-house manufacturing of the tanks is done using sophisticated machineries like auto controlled hydraulic press, auto linear and circumferential welding machineries along with online quality procedures. Each tank is subjected to leak test and pressure test before it proceeds to the enamel coating section.

Collector Glass Handling Equipment

Enamel coating

The tanks which pass the quality tests are then subjected to enamel coating. Here, the tank's inner surface is chemically washed and rinsed with water through a 7 stage process the tank is then dried using hot air. Once the inside of the tank thoroughly dries, enamel is flooded inside the tank and it is rotated to achieve uniform coating thickness. A thin layer of enamel is also coated on the outer surface of the tank to prevent the corrosion. On completion of the flooding process, tank is again dried by using hot air and fired at 870° C to ensure proper bonding of the enamel with base material.

These tanks are further subjected to leak and pressure test after fixing the gasket, backup heater and anode.

Insulation

Enamel coated tanks are insulated with a high density insulation material to prevent heat loss. Uniform thickness of the insulation material is maintained by using auto controlled machines and fixtures.

Final quality inspection and documentation

Before packing, these insulated tanks are subjected to a final quality inspection.

Collector Back Sheet Assembly

Enamel Coating Plant

EMMVEE Toughened Glass

EMMVEE Toughening facility is equipped with TAMGLASS, technology and market leader of safety glass machines from Finland. EMMVEE Toughened Glass is catering the solar thermal and photovoltaic in-house production as well as to sectors like construction, architecture, furniture and engineering industry in Bengaluru.

Solar Water Heating Systems

EMMVEE has established an in-house production facility to manufacture tray collectors which meets the international standards. This type of flat plate collector is made with single body structure with a unique glass locking mechanism. The advantages of this type of collector over normal collector are the higher efficiency and the elegant look.

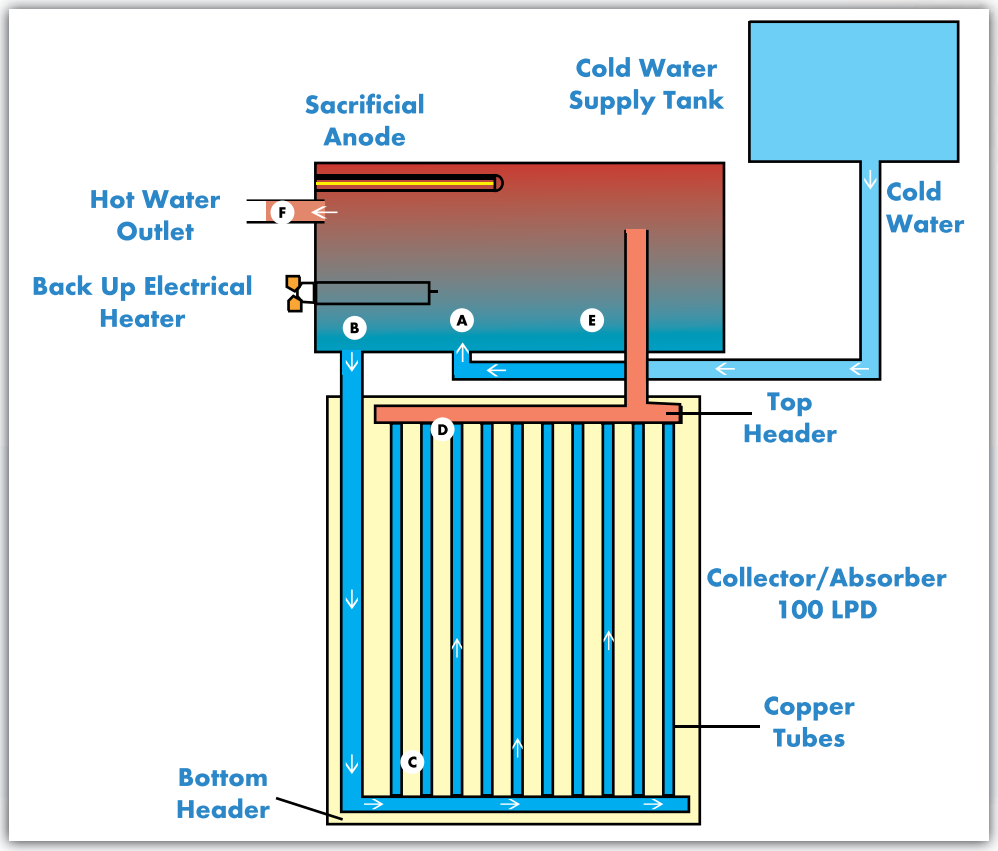
Basic Working Principle of Solar Water Heating system

As shown in the diagram, by gravity flow, water from the cold water tank enters the solar tank at point A and fills it up. The cold water from the solar tank in turn flows via point B in the bottom header pipe of the absorber and into the copper tubes at point C, until all the absorber tubes and the header at the top of the absorber are full.

When the sun rises to a certain level, its energy, which falls on the absorber fins and tubes, begins heating the water contained therein. The heated water being lighter than the cold water rises and via the top header pipe (point D) of the absorber, flows into the top of the solar tank through point E. The more cold water from the solar flows into the absorber tubes, gets heated and rises to the top, and so on. This process is called as 'Thermosyphon Process'. This process continues until the temperature of the water in the solar tank and the absorber equalizes. Now the solar tank is full of hot water.
(Note:- Average temperature is 60 degree centigrade at the end of 7-8 hours of bright sunshine.)

Further when the hot water is drawn from the solar tank outlet (point F) to the utilities point, cold water enters into the solar tank and takes its place at point A, thus lowering the overall temperature of the hot temperature between the water in the solar tank and the absorber tubes, the thermosyphon process starts once again, as explained earlier.

The diagram also shows the back up electrical heater (to be used during cloudy days) and the sacrificial anode rod in the solar tank to prevent galvanic corrosion (but not scale formation), if the hardness of the water quality is less than 140 ppm, thereby ensuring effective working for longer time.



Pressurised System

The basic working principle of solar water heating remains the same. A pressure pump is used to pump cold water from the source into the Solarizer tank.

This type of water heating system is used when

- The level of the overhead tank (The original cold water source) is at low level.
- High pressure hot water flow is required for various uses like shower panels, jet shower, telephone shower.
- The number of hot water points are more than normal.

System for Multi-Storied Buildings

The solar water heating system installed for multi-storied buildings, process industries, apartment complexes, hospitals, hotels works on the same basic principle, but is specifically designed to meet rigorous requirement of such conditions.

Such installations have multiple hot water outlets at different levels of the building. It is important that all outlets should dispense hot water as soon as the taps are opened, and also minimize the wastage of cold water.

To achieve this, a special device called the Electronics Control Unit is installed within the hot water plumbing lines. During the process of heating, if the temperature of the water goes below 30° C, the Electronics Control Unit (auto temperature controller) switches on the pump immediately. The pump then pumps out the cold water accumulated within the tube and fins, thereby allowing immediate flow of water.

The advantages of this system are

- Cold water wastage is not there.
- Hot water is readily available on the turn of the tap.
- Electricity is saved because wastage of cold water is minimized, thus saving precious resources.

Heat Exchanger

This type of Solar water heating system is used when the original cold water (from the source) contains chemical contents and is therefore hard water.

Thermal fluid (Distilled water) is filled through make-up tank to the outer tank shell. In turn, this fluid gets circulated through the solar fins and tubes and goes back into the top of the outer tank. This fluid acts as a heat transfer media and prevents clogging of the copper tubes due to chemical contents in the original water source.

The inner tank gets filled with cold water from the original cold water source. Since the inner tank is immersed within the outer tank, the heat gets transferred to the inner tank through the conducted and convection method and the water in the inner tank gets heated up and available for hot water utility.

Forced Circulation

If the capacity of hot water requirement is more than 4000 upto 100000 LPD, the water requires additional force to push the hot water collected in the solar collector.

The DTC (Differential Temperature Controller) senses the inlet and outlet temperature of the water. If the thermal difference is more than 10^0C, the DTC switches on the pump and the hot water in the collector is forced to flow into the storage tank.

This system requires continuous supply of electricity for the motor to operate.

Fixed Circulation

This system is used in process industries where in the hot water requirement is between 4000-100000 LPD at a fixed hot water temperature or when the collectors and the tanks are placed at different places.

In this system, cold water flows into the collectors and waits till it gets heated up to the set temperature.

Solarizer Products

Our current product portfolio includes

Solarizer

Hot water storage tank

Material of Storage Tank	Stainless Steel 304
Insulation	PUF - Thickness: 50mm
Outer cladding	Stainless Steel 430
Inter connecting pipe	High pressure steam hose
	with both side 1" BSP swivel nut
Working pressure	Atmospheric: 1kgf/cm

Collector

Absorber material	Electro grade copper with 99.9%
Absorber coating	Selectively coated black chrome on copper to withstand temperatures up to 300^{0}C
Riser	Copper tube: 12.5mm +/- 0.5mm
Header	Copper tube: 25.4mm +/- 0.5mm
Bonding - header & riser	Copper brazing
Bonding fin & riser tube	Ultrasonic welding
Back insulation	Rockwool: 48kg/m^3 density
Side insulation	PUF - Thickness: 25mm; 38kg/m^3 density
Collector box	Extruded aluminium L 2050mm x B 1040mm x H 100mm +/- 0.2mm
Collector back sheet	Aluminium steel - Thickness 0.71+/-0.08mm
Collector stand	Mild steel structure with Polyester Powder coating
Glazing	Toughened glass - Thickness: 4mm
Retainer angle for glass	Extruded aluminium angle with Polyester Powder coating
Beading for glass	EPDM rubber
Absorber area	2m^2+/-0.1m^2/collector
Heat transfer media	Water
Collector area	2.132m^2
Number of fins	9
Maximum working pressure	10kgf/cm^2
Dimension of collector	L 2050 x B 1040 x H 100 mm

Warranty

Collector	1 Year
Tank	1 Year
Electrical Backup	1 Year
Glass	No Warranty

Solarizer Plus

Hot water storage tank

Material of storage tank	Glass enamel coated steel
Insulation	CFC free PUF - Thickness: 50mm
Outer cladding	Pre-coated steel
Inter connecting hose pipe	Aluminium Composite
Safety valve	Pressure valve
Electrical backup heater	2kW per 100 LPD to 300 LPD
	(with Thermostat)
Working pressure	6 kgf/cm^2
Anode	Aluminium

Collector

Absorber material	Electro grade copper with 99.9%
Absorber coating	Selectively coated black chrome on copper to withstand temperatures up to 300^{0}C
	Absorptivity: 0.95 +/- 0.02 - Emissivity: 0.12 +/- 0.02
Riser	Copper: 12.5mm +/- 0.5mm - Thickness: 0.71mm
Header	Copper: 25.4mm +/- 0.5mm - Thickness: 0.71mm
Bonding - header & riser	Copper brazing
Bonding fin & riser tube	Ultrasonic welding
Back insulation	Rockwool: 48kg/m^3 density - Thickness: 50mm
Side Insulation	CFC free PUF - Thickness: 25mm
Collector box	Extruded aluminium L 2050mm x B 1040mm x H 100mm +/- 0.2mm
Collector back sheet	Aluminium 2000mm
Glazing	Toughened glass - Thickness: 4mm
Retainer angle for glass	Extruded aluminium: 25mm x 11.5mm +/- 2mm
Beading for glass	EPDM rubber
Absorber area	2m^2 +/-0.1m^2/collector
Weight of collector (dry)	45kg
Collector area	2.132m^2
Number of fins	9
Maximum working pressure	5kgf/cm^2
Dimension of collector	L 2050 x B 1040 x H 100 mm

Warranty

Collector	1 Year
Tank	5 Year
Electrical Backup	1 Year
Glass	No Warranty

Solarizer Supreme

Hot water storage tank

Material of storage tank	Glass enamel coated steel
Insulation	CFC free PUF - Thickness: 50mm
Outer cladding	Pre-coated steel
Inter connecting hose pipe	Stainless steel flexible UV
	resistant insulation
Safety valve	Pressure valve
Electrical backup heater	2kW per 100 LPD to 300 LPD
	(with Thermostat)
Working pressure	6kgf/cm^2
Anode	Magnesium

Collector

Absorber material	Electro grade copper with 99.9%
Absorber coating	Selectively coated black chrome on copper to withstand temperatures up to 300^0 C
	Absorptivity: 0.95 +/- 0.02 - Emissivity: 0.12 +/- 0.02
Riser	Copper: 12.5mm +/- 0.5mm - Thickness: 0.71mm
Header	Copper: 25.4mm +/- 0.5mm - Thickness: 0.71mm
Bonding - header & riser	Copper brazing
Bonding fin & riser tube	Ultrasonic welding
Back insulation	Rockwool: 48kg/m^3 density - Thickness: 50mm
Side insulation	Rockwool - Thickness: 25mm
Collector box	Extruded aluminium L 2050mm x B 1040mm x H 100mm +/- 0.2mm
Collector back sheet	Aluminium
Glazing	Toughened glass - Thickness: 3.2mm with low iron; Transmissivity>92%
Retainer angle for glass	Extruded aluminium: 24.3mm x 17mm +/- 2mm
Beading for glass	EPDM rubber
Absorber area	2m^2 +/-0.1 m^2/collector
Weight of collector (dry)	42kg
Collector area	2.132m^2
Number of fins	9
Maximum working pressure	10kgf/cm^2
Dimension of collector	L 2050 x B 1040 x H 100 mm

Warranty

Collector	1 Year
Tank	5 Year
Electrical Backup	1 Year
Glass	No Warranty

Photovoltaic Modules

EMMVEE manufactures monocrystalline and polycrystalline high-performance modules in the performance range between 180 Wp and 300 Wp. All EMMVEE components are subject to a continuous process of optimisation and very stringent quality checks in order to ensure a high level of quality.

EMMVEE uses only first-class components, which are all acquired from renowned manufacturers, predominantly from Germany. The poly- and monocrystalline solar cells of German manufacturers Bosch and Q-Cells have a 3-bus-bar technology for higher output. The soldering process is fully-automatic on state-of-the-art technology and machines from 3S/Somont. The EVA foils made by Solutia Solar and the back sheets made by Krempel are long-lasting and durable. EMMVEE modules are protected with a solid 50mm anodized aluminum frame and a 4mm thick front glass with a special surface pattern made by Saint-Gobain Solar Glass. The front glass is extremely transparent and designed in such a way that the modules optimally capture the light of the sun. EMMVEE offers 3 different types of glass: plain glass, Albarino S as well as Albarino P (pyramidal pattern) and Albarino G (wave-shaped pattern) which increase the radiation quantity incident on the cell and subsequently the energy yield. The junction boxes made by Spelsberg and Lumberg have 3 by pass diodes with a high current carrying capability and temperature regulation.

The solar cables and connector plugs made by Multi-Contact and Lumberg are durable, resistant to high temperatures and harsh weather conditions.

The modules are certified according to the standards IEC 61215 Ed. 2 and IEC 61730, and stand out due to their great quality, high yield, long life and attractive designs. The measurement tolerance of the modules in relation to nominal performance under standard test conditions is ± 3 percent. The modules have a performance tolerance of ± 2.5 Wp, for example from 242.5 to 247.5 Wp in the 245 Wp performance class.

EMMVEE modules are designed for a maximum system voltage of 1000 V DC and an operating temperature range from -40°C to +85°C. The maximum surface load capacity is at 550 kg/m^2. The modules have passed the hail impact test with ice balls in diameter of 24 mm and impact speed of 83 km/h.

EMMVEE manufactures high-quality OEM solar modules for its customers (OEM=Original Equipment Manufacturer). This provides several advantages to the customer. They may determine the performance class of the modules, the cell size and the cell material. Our in-house glass manufacturing division EMMVEE TUF TM - Toughened Glass - also offers the option of selecting different dimensions and front glasses for the solar module, which means creating a real unicum.

The high flexibility of our production processes allows for delivery optimisation based on demands. To guarantee the high quality and long life cycle of OEM products, EMMVEE uses only first-class components, which are purchased predominantly from German manufacturers. Our suppliers are leading companies in their sectors and have many years of experience in photovoltaics.

All EMMVEE products are subject to a continuous process of optimisation and very stringent quality checks in order to ensure this high level of quality in the future as well.

Until now, EMMVEE's product range comprised 10 different photovoltaic modules. With the Intersolar 2011, EMMVEE introduces a new system of 4 module types (Black Pearl, Diamond, Sapphire and Crystal) as well as a tailor-made module corresponding to the customer's needs (Custom). Please find further information about the components used in our PV modules and our module categories on the following pages. Datasheets and technical information can be found on our website www.emmvee.com

Photovoltaic Module Components

The Cell

EMMVEE modules are made of mono- or polycrystalline solar cells from the companies Bosch, Gintech and Q-Cells. The cells consist of either mono- or polycrystalline silicon. The raw material used is silicon dioxide of either quartzite gravel or crushed quartz. Because the silicon is not pure in its natural state, it is refined and purified.

The Raw Material

To create **monocrystalline silicon**, high-purity silicon is melted. It is then allowed to solidify very slowly in contact with a single crystal "seed" dipped into the molten silicon. The seed crystal rotates and grows as it is withdrawn, forming a cylindrical ingot or "boule" of extremely pure silicon. From the boule, silicon wafers are sliced with a square or semi-square profile and a thickness of 0.16 to 0.20 mm. **Polycrystalline silicon** involves a casting process. After the silicon has been melted, it is directly cast into a mold and allowed to solidify into an ingot. The cooling rate determines the final size of crystals in the ingot and the distribution of impurities.

The Production

The manufacturing process is fully automated. After an intensive quality control check regarding geometry, size, thickness and resistivity as well as for cracks and scratches, the wafers undergo a cleaning. The wafer is then treated and etched with an acid to create a special surface texture that improves the light absorption and accommodate all incident solar radiation to increase the energy yield. The silicon wafer is doped with boron, but a semiconductor homojunction is formed by diffusing phosphorus (an n-type dopant) into the top surface of the boron doped (p-type) Si wafer to make it capable of conducting electricity. The edges are isolated with a chemical process for avoiding short-circuits in the p-n junction. The silicon disks are then provided with an anti-reflective coating of silicon nitride to reduce the amount of sunlight lost and increase yield. Although the coating can vary in thickness and colour, the blue variant possess the best optical characteristics: less light is reflected back and more light is absorbed. The blue variant appears darker when the coating is thinner. Screen-printed contacts are applied to the front and rear of the cell, with the front contact pattern specially designed to allow maximum light exposure of the Si material with minimum electrical (resistive) losses in the cell. Back printing makes the "back surface field" which is an optical and electrical mirror. In the firing process, the passivation of the recombination areas within the cell takes place. The last step is checking and sorting the cells according to efficiency, optical quality and colour.

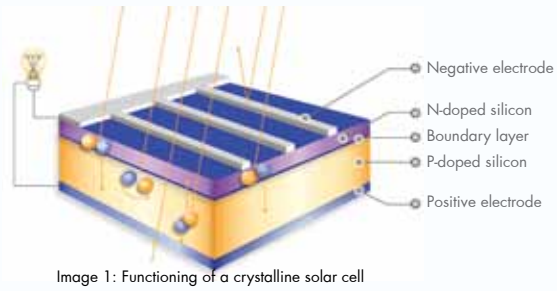


Image 1: Functioning of a crystalline solar cell

The Photovoltaic Effect

By doping the silicon with substances such as phosphorus and boron, (called "n-type" and "p-type"), entirely different electrical properties are introduced into the silicon creating semi-conductive material. In the middle is the p-n junction that produces the necessary internal electric field, the depletion region. When light hits the solar cell, the imbalance created between the positive and negative poles enable the electrons to flow – producing electricity. A single silicon solar cell produces an open-circuit voltage of about 0.5 volt.

Module Efficiency

Solar cells made from monocrystalline silicon currently have efficiency up to 18.4%, whereas polycrystalline cells reach up to 17.4% color of cells blue.

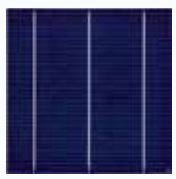


Image 2: Polycrystalline silicon solar cell manufactured by Q-Cells (Source: Q-Cells)


Image 3: Monocrystalline silicon solar cell manufactured by Bosch (Source: Bosch)


Image 4: Polycrystalline silicon solar cell manufactured by Gintech (Source: Gintech)

The Embedding Foil

Solar cells are extremely delicate. Then again, they are mounted on a roof or land and exposed to harsh weather conditions. Nevertheless, they are expected to have extremely long life-spans of more than two and a half decades. As a result, all solar cells used for EMMVEE's modules are protected with an embedding foil or encapsulant and sealed in an airtight laminate. A front glass specially developed for photovoltaic modules acts as an additional protector.

The Embedding Material

Between the glass and the back side, solar cells are embedded with specific materials. Two of the most common materials are ethylene-vinyl-acetate (EVA) and polyvinyl-butiral (PVB). Thermoplastic polyurethane (TPU), ionomer, polyacrylic resin, Teflon and silicone is also used. All used solar cells are preferentially wrapped in an encapsulation EVA foil type VISTASOLAR® by Solutia Solar or EVA from STR. The solar cell is first placed between two layers of EVA foil. The front glass and back sheet are added and during the deairing process, laminated and sealed by use of heat up to 150 °C under vacuum. The EVA melts during this process enclosing the solar cell from all sides. The hardening takes place during the fast-cure process with a lamination time of only less than 8 minutes with our latest Excel laminator from Meyer Burger 3S. The laminator recipe that attains a very high degree of cross-linking is made in-house by EMMVEE engineers. The EVA embedding process stands out due to high transmission, as well as resistance against heat and salt water enhancing durability and lifetime. During process control, every batch is tested for its laminating quality through a delamination test as well as a laminating check.

The Back Sheet

The back-side of the module is usually a compound foil made of polymer and fluoropolymer films. EMMVEE modules are assembled with Tedlar®-PVF- and Kynar®-PVDF-foils manufactured by Krempel, which demonstrate excellent mechanical, electrical and chemical properties, durability, as well as resistance against moisture, weather conditions and UV radiation. Effectively, the foil is one of the reasons for a long service life of the PV module. Krempel's goal is to provide back sheet laminates with outstanding durability of 25+ years.

The main component of the back sheet is the PET foil (polyester-core foil). Its function is to provide protection, resistance against moisture, and electrical insulation. The two fluoropolymer films (Tedlar® or Kynar®) laminated to both sides of the core film, are characterized by a high UV resistance and protect the enclosed synthetic components against short wave UV radiation. This kind of radiation might quickly destroy synthetic material due to photochemical decomposition. The multiple component adhesive used in the production of the laminate is manufactured solely by Krempel. The surface coating is also part of a special Krempel technology development to form a

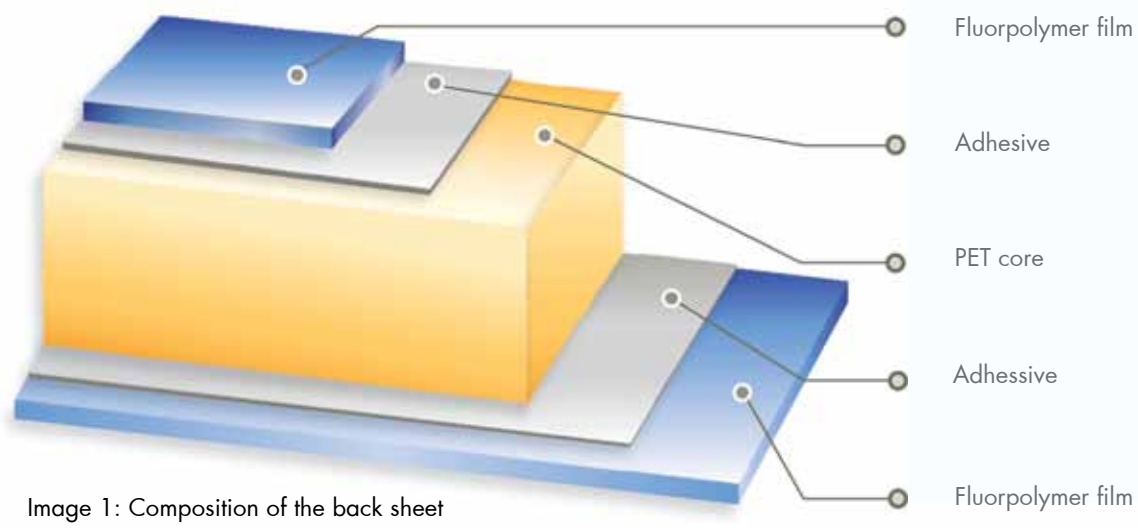


Image 1: Composition of the back sheet

dependable and compatible bond between the back sheet and all embedding materials such as EVA, PVB and TPU. The entire manufacturing process as well as the final back sheet product is monitored continuously for quality checks. The different foils are produced with an uniform thickness ranging from 300 mm to 360 mm and a maximum system voltage of 1000 V. Another important factor is the peel strength of the foil, which indicates the amount of force that needs to be applied to peel off the foil from the EVA layer underneath. The EVA peel strength of more than 4 N/mm is the same for all foil types. Latest developments show that it is important to consider the back sheet's resistance against ammonia which is crucial for the application of PV modules on roofs of buildings used for animal husbandry and farming with ammonia emission. The back sheet is available in white, black and transparent colour. The back sheet producer Isovolta and Toyal were added as new partners in our portfolio. EMMVEE has been a customer of Krempel in Vaihingen since 2006. The KREMPEL-GROUP is a leading global system supplier established in the world of progressive materials. The electrical insulations, composites, base materials and special laminates put this group of companies amongst the leaders world-wide. There are over 950 employees in the production facilities
operating in Germany, England, and Poland as well as China.

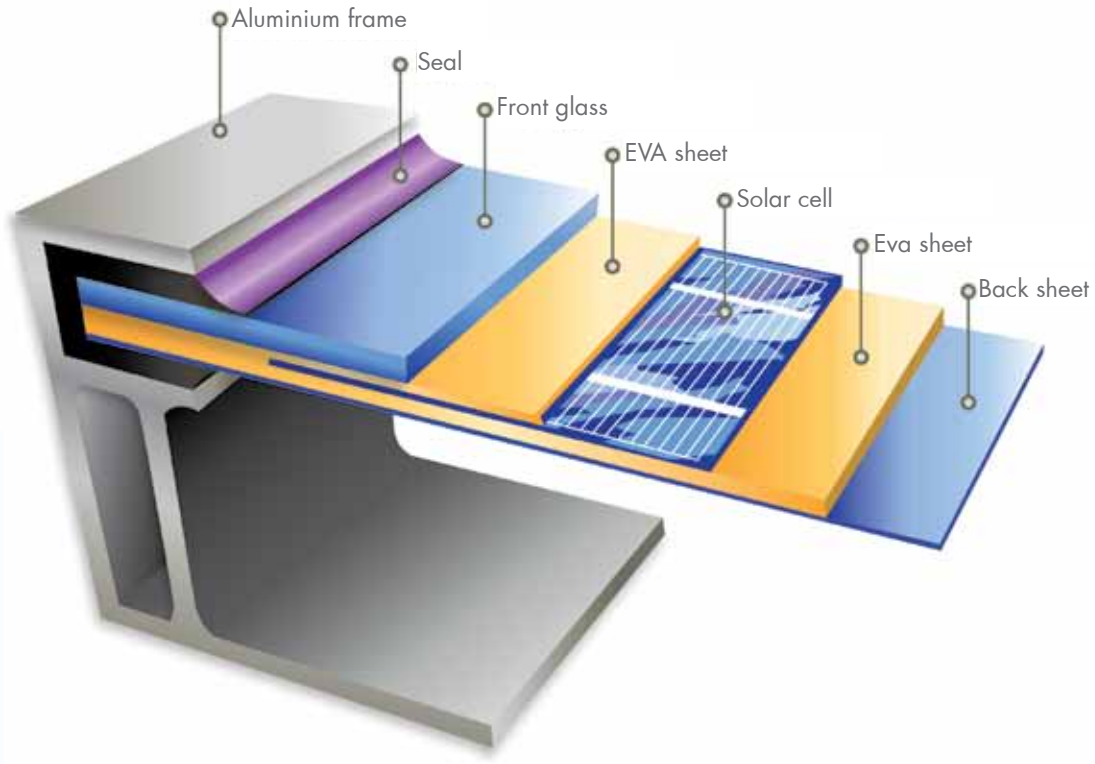


Image 2: Structure of a photovoltaic module

The Glass

The distinctive feature of EMMVEE modules is the use of Albarino P and G front glass by Saint-Gobain Solar. The optimised surface pattern of the glass allows an increased light input into the module, resulting in an increase in yield of at least 3 % per year.

The solar cells of EMMVEE modules are covered with a hardened solar glass panel on the front. On one hand, the front glass has to protect the module from environmental influences, including UV radiation. On the other hand, it should be as transparent as possible and designed in such a way that the modules optimally capture the light of the low lying sun in these latitudes so that any radiation caught will not be released again, if possible. EMMVEE was the first manufacturer of front glass to use a special surface pattern.

Saint-Gobain Solar, a long-term partner of EMMVEE, is based in Mannheim and manufactures Securit® Albarino P and Securit® Albarino G glasses. The glass is deep extruded, extra white cast glass developed specially for photovoltaic modules. It has low iron oxide content, providing especially favourable absorption characteristics. Albarino P front glass has a pyramidal pattern with the edges and corners blended. Albarino G front glass has a wavy structure. Both surface patterns act as light traps. Part of the radiation is reflected in such a way that it again impinges on the surface, i.e. part of the radiation which (with plain glass) is normally lost to the environment is reflected back onto the solar cell. This increases the radiation quantity incident on the cell and subsequently the energy yield.

Saint-Gobain Solar states an increase in energy yield thanks to energy transmission of three per cent annually compared with Saint-Gobain Solar's unpatterned glass. With an angle of incidence of 70 degrees to the normal line an increase in yield of as much as 10 % can be expected. A study conducted by ISFH Institut für Solarenergieforschung Hameln (Institute for Solar Energy Research Hameln, in Germany) shows that with patterned front glass an increase in yield of four per cent can be expected as an annual average. Accordingly, the efficiency gain of photovoltaic modules with specially patterned front glass over conventional plain front glass is highest in the morning and evening hours. As a result, photovoltaic modules with structured front glass are especially favourable for locations with low angles of incidence, e.g. building integrated installations (BIPV) or systems with East-West orientation.

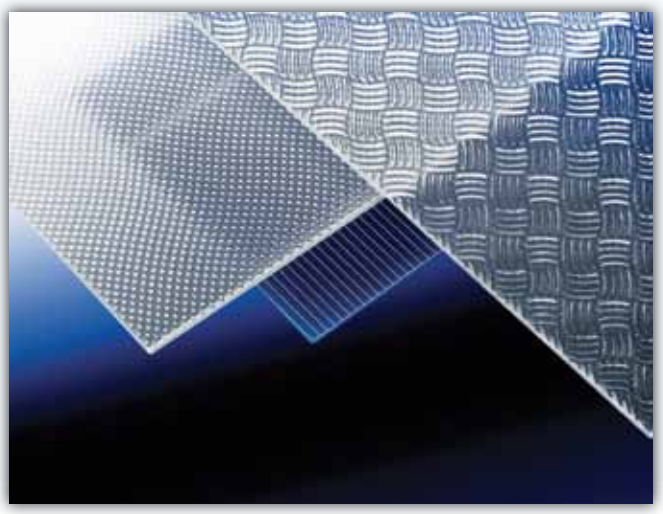


Image 1: Pyramidal and wavy structure of Securit® Albarino P and G for PV modules (Source: Saint-Gobain Solar)

Cleaning

The edges and corners of the pattern are blended so that dirt and dust particles do not deposit but are flushed away by rain. On the Albarino P glass the dirt particles gather in one place – the lowest point in the pyramidal depression – and the major part of the surface remains free from contaminants. The optical properties are unchanged; however, the angle of installation should not be less than 10 degrees.

The accumulation of dirt particles is more easily discharged by wind or rain than e.g. a large number of small particles on plain glass. This is because the flow velocity of rain water is higher around the blended pyramidal edges, similar to a lump of rock in a river bed in which case the water flows around the sides more quickly. Modules with Albarino P and G glass require very little maintenance.

Production

Cast glass can be produced with a small energy input.Special rolls impart their pattern into the molten glass which flows from the melting end. As the rolls are cooled, the glass solidifies when passing the rolls and the glass surface retains the structure. A precisely adjusted online detector system recognizes nickel sulphide inclusions from the production process even in patterned glass. This is important as such inclusions may result in glass fracture. The glass is then cut, the edges machined and the glass hardened.

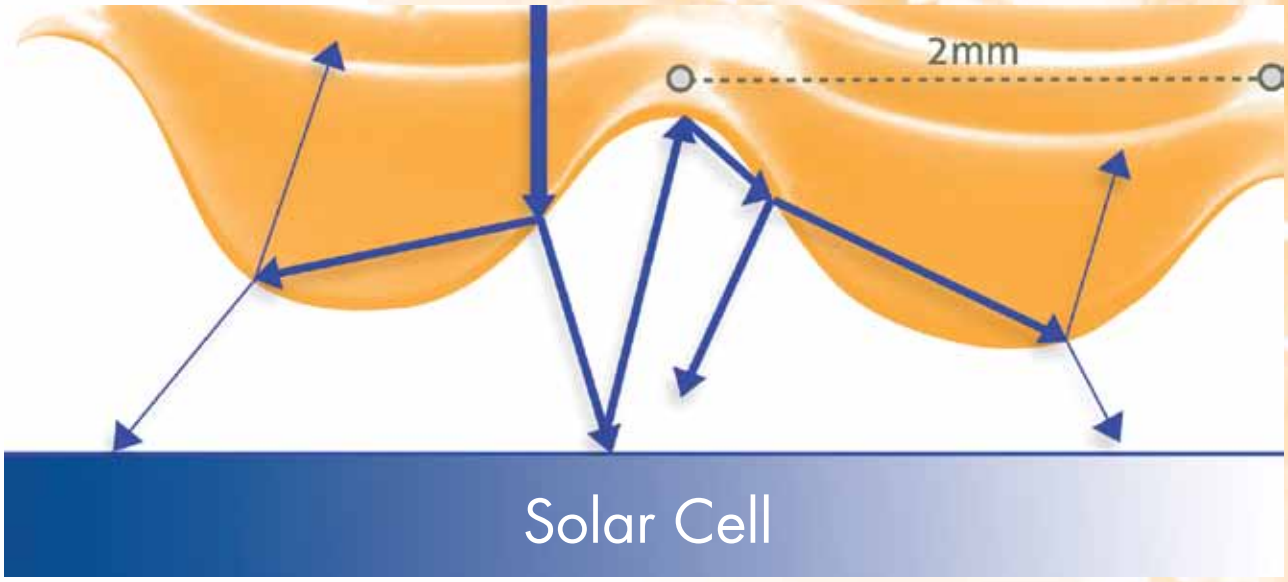
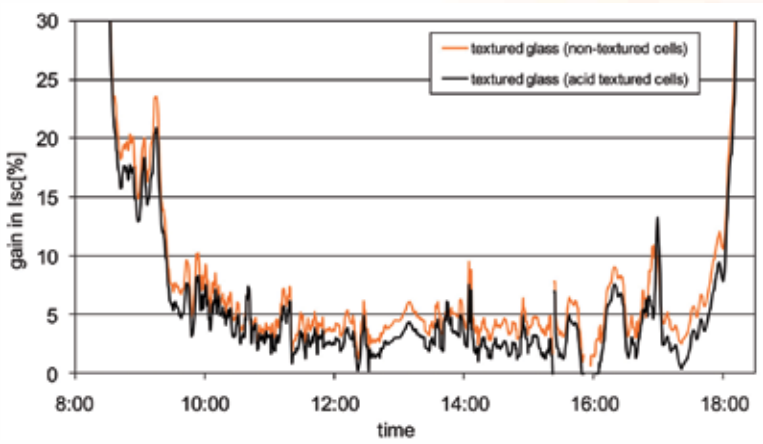
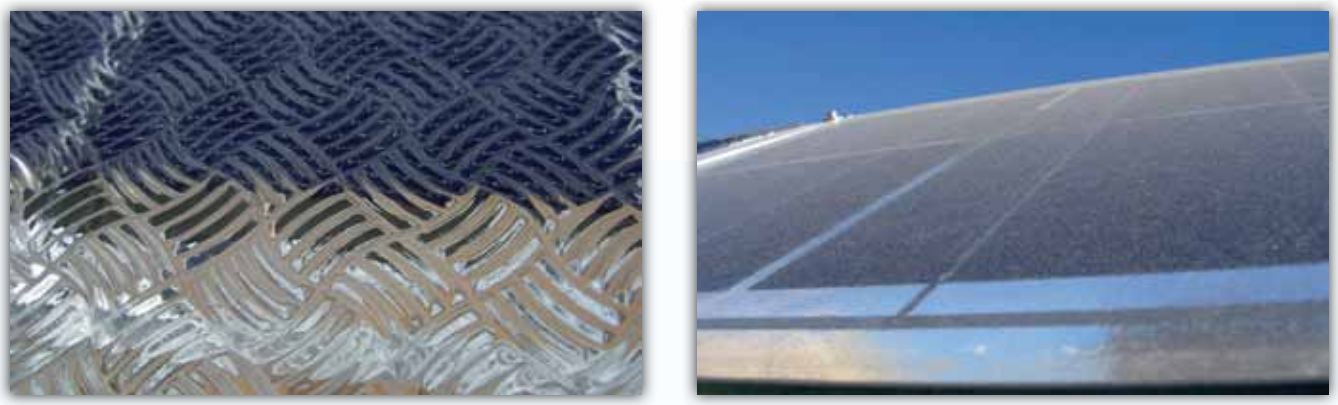


Image 2: Illustration of the light trap effect



A typical probe during a day at the location Herzogenrath/Germany
(Source: Saint-Gobain)



Comparison of dirt accumulation for modules with structured front glass (left) vs. flat glass (right) under dusty conditions in Almunia/Spain after nine months without rain (Source: Saint-Gobain)

The Junction Box

Photovoltaic modules have a junction box at the back side. Their purpose is to transport all produced electricity to the inverter. Since photovoltaic modules are mounted outside and exposed to various weather conditions, it is important to have a high quality durable product. All EMMVEE modules have a junction box by Spelsberg or Lumberg.

The back sheet has a small opening for the electrical connection cables to stick out. The junction box is then attached to that spot consisting of four clamps for the connection of the strings, three bypass diodes and two clamps for the module connection cable. The bonding of the strings and connection cable is done with a screwless clamp technique. The junction box is applied on the back sheet of the solar module with silicon glue or double-sided adhesive.

The Casing

The junction box has a waterproof and dustproof casing made of polycarbonate (Spelsberg) or polyphenyle ether (Lumberg). This material is durable, impact resistant, and rigid. The casing is resistant to weather and radiation and is also a good isolator against electrical current. The junction box is compliant with IP 65 standards of IEC 60529 and safety class II. The junction box cannot be opened or modified for safety purposes. The temperature range varies from - 40 °C to +85 °C (IEC61215). For pressure compensation every casing has sintered metal plates.

The Diodes

Obstructions such as trees, buildings, antennas, soiling (such as leaves) and bird droppings that become the source of minute and partial shading of the modules will cause a noticeable decrease in system output. In order to prevent damage on shaded cells and reduce further output loss of non-shaded cells, the bypass diodes are installed in parallel with modules to allow current to pass around a shaded area of a module.

The junction box of EMMVEE modules includes three bypass diodes with each individual diode protecting 16 to 24 cells.Schottky diodes are used as bypass diodes. When a module becomes shaded its bypass diode becomes “forward biased” generating heat. To prevent overheating the diodes have a space between them to allow for heat dissipation. The diodes can be exchanged and replaced, even though they are extremely durable. The most common reason for a diode to fail is overvoltage due to installation errors or lightning strikes.

The Cables and Plugs

All EMMVEE modules are equipped with connection cables as well as polarized and scoop proof plugs for easy installation. The cable cross section is 4 mm^2 and the cable is 1000 mm long. The conductor is made of fine-wired tinned copper and the insulation of halogen-free polyolefins. The plug in connectors are MC4 and LC4.

Quality Assurance

The junction boxes by Spelsberg and Lumberg are certified according to TÜV and UL standards to fulfil all quality requirements. Quality testing includes fire-, dust-, weather- and water-proofing. Every diode is subject to a complete fully-automatic inspection to check for diode performance and functioning, clamping of the cable, torque of the cable screws and the pressure compensation elements. Every junction box has a unique serial and production number.

Image 1: The junction box LC4-JC made by Lumberg (Source: Lumberg)

Image 2: The junction box PV 1410-2 made by Spelsberg (Source: Spelsberg)

Module Portfolio

New On-grid modules

Black Pearl
- 60 monocrystalline solar cells with 3 bus bars made by Bosch
- Performance classes from 250 to 260 Wp
- Efficiency of up to 15.2 %
- Front glass 4 mm Albarino P
- Black frame 50 mm

Diamond
- 60 monocrystalline solar cells with 3 bus bars made by Bosch
- Performance classes from 240 to 250 Wp
- Efficiency of up to 15.2 %
- Front glass 4 mm Albarino P
- Frame 50 mm

Diamond
- 60 polycrystalline solar cells with 3 bus bars made by Q-Cells
- Performance classes from 230 to 240 Wp
- Efficiency of up to 14.6 %
- Front glass 4 mm Albarino P
- Frame 50 mm

Sapphire
- 60 polycrystalline solar cells with 3 bus bars made by Gintech
- Performance classes from 230 to 240 Wp
- Efficiency of up to 14.6 %
- Front glass 4 mm Albarino P
- Frame 50 mm

Crystal
- 60 polycrystalline solar cells with 3 bus bars made by Gintech
- Performance classes from 230 to 240 Wp
- Efficiency of up to 14.6 %
- Front glass 3.2 mm flat glass
- Frame 50 mm

Custom
- 48, 60 or 72 poly or monocrystalline solar cells, different dimensions
- Front glass 3.2 mm or 4 mm flat glass, Albarino P or Albarino G
- Frame 50 mm in silver or black and frame less modules
- Back Sheet in white, black or transparent color

3S MODULTEC MODULE SOLUTIONS

lumberg

KREMPEL GROUP

ENERGIZED BY Q.CELLS

BRUKER-SPALECK SPEZIALDRÄHTE

EMMVEE photovoltaics

BOSCH

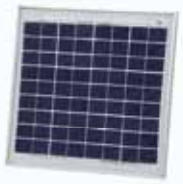
Solutia

els spelsberg

SAINT-GOBAIN SOLAR

Multi-Contact MC STÄUBLI GROUP

Off-Grid modules and systems



ES 10-20 P36
- 36 polycrystalline solar cells
- Performance classes from 10 to 20 Wp
- Efficiency of up to 11.2 %
- Front glass 3.2 mm flat glass
- Frame 35 mm

Home Lighting System (DC & AC)
- DC Models 20 to 80 Wp
- Charge Controller 5 to 10 A
- AC Models 100 to 1000 Wp
- Solar Inverter/PCU 12 V/600 VA to 48 V/2000 VA

ES 25-125 P36
- 36 polycrystalline solar cells
- Performance classes from 25 to 125 Wp
- Efficiency of up to 13.3 %
- Front glass 3.2 mm flat glass
- Frame 35 mm

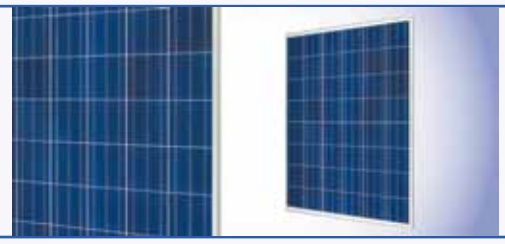
Solar Street Lighting System
- CFL Systems 75 Wp, 120 Wp (11 W SL, 22 W SL & DL)
- LED Systems 37 to 200 Wp (DC 9 W to DC 50 W)

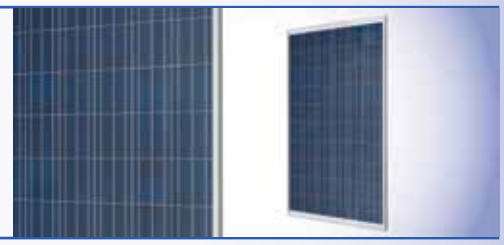
ES 125-150 P72
- 72 polycrystalline solar cells
- Performance classes from 125 to 150 Wp
- Efficiency of up to 13.3 %
- Front glass 3.2 mm flat glass
- Frame 35 mm

Solar Water Pumping System
- Submersible Pump 900 to 1800 Wp
- Surface Pump 900 and 1800 Wp

Standard and customized photovoltaic systems for stand-alone and on-grid applications

EMMVEE Photovoltaic Power Pvt. Ltd. is accredited as channel partner under JNNSM subsidy scheme for roof top stand-alone and on-grid PV systems from size of 1kW upto 100kW





ES-190 P48 Q

ES-230 P60 Q

Electrical Data at 1000 W/m², 25°C and AM 1,5 (STC in accordance with EN 60904-3)

Rated Power at STC [1]	180 Wp	185 Wp	190 Wp	195 Wp[2]	220 Wp	225 Wp	230 Wp	235 Wp	240 Wp[2]
Module Efficiency at STC [3]	13,6 %	13,9 %	14,3 %	14,7 %	13,0 %	13,3 %	13,6 %	13,9 %	14,2 %
Cell Efficiency	16,1 %	16,4 %	16,7 %	17,0 %	15,8 %	16,1 %	16,4 %	16,7 %	17,0 %
STC Open-Circuit Voltage Voc	28,99 V	29,26 V	29,49 V	29,78 V	35,93 V	36,31 V	36,60 V	36,92 V	37,23 V
Short-Circuit Current Isc	8,01 A	8,15 A	8,31 A	8,44 A	8,08 A	8,18 A	8,30 A	8,40 A	8,51 A
Rated Voltage Vmpp	23,38 V	23,60 V	23,78 V	24,02 V	28,99 V	29,30 V	29,53 V	29,79 V	30,04 V
Rated Current Impp	7,70 A	7,84 A	7,99 A	8,12 A	7,59 A	7,68 A	7,79 A	7,89 A	7,99 A

Electrical Data at 800 W/m², NOCT, 1m/s wind speed and AM 1,5

Rated Power Pmax	145,8 W	149,9 W	153,9 W	158,0 W	178,2 W	182,3 W	186,3 W	190,4 W	194,4 W
Open-Circuit Voltage Voc	28,72 V	28,99 V	29,21 V	29,50 V	35,59V	35,97 V	36,25 V	36,57 V	36,88 V
Short-Circuit Current Isc	6,43 A	6,55 A	6,68 A	6,78 A	6,49 A	6,57 A	6,66 A	6,75 A	6,84 A
Rated Voltage Vmpp	23,46 V	23,68 V	23,86 V	24,11 V	29,09 V	29,40 V	29,63 V	29,90 V	30,15 V
Rated Current Impp	6,22 A	6,33 A	6,45 A	6,56 A	6,13 A	6,20 A	6,29 A	6,37 A	6,45 A

Thermal Data

Temperature Coefficient Open-Circuit Voltage	- 0,36 % / K	- 0,36 %/K
Temperature Coefficient Short-Circuit Current	+ 0,06 % / K	+ 0,06 %/K
Temperature Coefficient Rated Power	- 0,43 % / K	- 0,43 %/K
NOCT (Normal Operating Cell Temperature)	47 °C ± 2K	47 °C ± 2K

Mechanical Data

Cell Type	48 polycrystalline, 3 Bus-Bar	60 polycrystalline, 3 Bus-Bar
Cell Size	156 mm x 156 mm	156 mm x 156 mm
Cell Manufacturer	Q- Cells, Germany	Q-Cells, Germany
Dimensions: Length x Width	1340 mm x 991 mm	1691 mm x 1002 mm
Frame Thickness	50 mm anodized aluminum	50 mm anodized aluminum
Weight	20 kg	23,5 kg
Front Glass	4 mm Albarino G	4 mm Albarino P
Embedding	EVA (Solutia Solar)	EVA (Solutia Solar)
Back Sheet	TPT Tedlar®/ Polyester /Tedlar® (Krempel)	TPT Tedlar®/Polyester/Tedlar® (Krempel)
	KPK Kynar®/ Polyester /Kynar® (Krempel)	KPK Kynar®/Polyester/Kynar® (Krempel)
Junction Box	Spelsberg/Lumberg with 3 bypass diodes	Spelsberg/Lumberg with 3 bypass diodes
Cables and Plugs	MC4/LC4	MC4/LC4

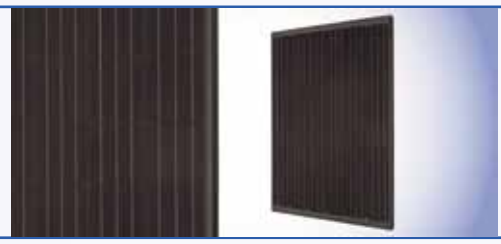
Permissible operating conditions

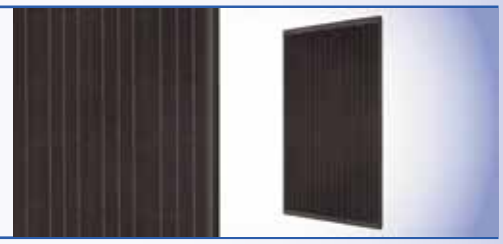
Operating Temperature Range	-40°C to 85°C	-40°C to 85°C
Max. System Voltage	1000 V DC	1000 V DC
Max. Reverse Current	15 A	15 A
Maximum Surface Load Capacity	5400 Pa or 550 kg /m²	5400 Pa or 550 kg /m²
Resistance Against Hail	Maximum diameter of 24 mm with impact speed of 83 km/h	Maximum diameter of 24 mm with impact speed of 83 km/h
Protection Class	II	II

Warranty and Certificates

Product Warranty	10 years	10 years
Performance Warranty	90 % up to 10 years	90 % up to 10 years
	80 % up to 25 years	80 % up to 25 years
Certification	IEC 61215 Ed. 2 & IEC 61730 TÜV Rheinland; MCS-accredited; ISO 9001 & ISO 14001	IEC 61215 Ed. 2 & IEC 61730 TÜV Rheinland; IEC 61701; UL 1703; MCS-accredited; ISO 9001 & ISO 14001

[1] The measurement tolerance of the nominal yield is ± 3 %. The modules delivered are sorted in a range of ± 2.5 Wp.
[2] Available in limited amounts upon request.
[3] At low irradiation (200 W/m², 25° at AM 1,5), minimum efficiency at STC is 97 %.
Subject to errors and technical modifications within the scope of product improvement.
For more details, see Installation Manual.





	ES-190 M48 B Black Pearl				ES-230 M60 B Black Pearl			
Electrical Data at 1000 W/m², 25°C and AM 1,5 (STC in accordance with EN 60904-3)								
Rated Power at STC [1]	195 Wp	200 Wp	205 Wp	210 Wp[2]	240 Wp	245 Wp	250 Wp	255 Wp[2]
Module Efficiency at STC [3]	14,7 %	15,1 %	15,4 %	15,8 %	14,2 %	14,5 %	14,8 %	15,1 %
Cell Efficiency	17,4 %	17,7 %	18,0 %	18,3 %	17,4 %	17,7 %	18,0 %	18,3 %
STC Open-Circuit Voltage Voc	29,50 V	29,81 V	30,10 V	30,40 V	36,90 V	37,12 V	37,32 V	37,53 V
Short-Circuit Current Isc	8,48 A	8,61 A	8,73 A	8,86 A	8,32 A	8,44 A	8,57 A	8,69 A
Rated Voltage Vmpp	24,38 V	24,64 V	24,88 V	25,12 V	30,00 V	30,18 V	30,34 V	30,51 V
Rated Current Impp	8,00 A	8,12 A	8,24 A	8,36 A	8,00 A	8,12 A	8,24 A	8,36 A
Electrical Data at 800 W/m², NOCT, 1m/s wind speed and AM 1,5								
Rated Power Pmax	158,0 W	162,0 W	166,1 W	170,1 W	194,4 W	198,5 W	202,5 W	206,6 W
Open-Circuit Voltage Voc	29,22 V	29,53 V	29,82 V	30,11 V	36,55 V	36,77 V	36,97 V	37,17 V
Short-Circuit Current Isc	6,81 A	6,91 A	7,02 A	7,12 A	6,68 A	6,78 A	6,88 A	6,98 A
Rated Voltage Vmpp	24,47 V	24,73 V	24,97 V	25,21 V	30,11 V	30,29 V	30,45 V	30,62 V
Rated Current Impp	6,46 A	6,56 A	6,65 A	6,75 A	6,46 A	6,56 A	6,65 A	6,75 A
Thermal Data								
Temperature Coefficient Open-Circuit Voltage	- 0,36 %/K				- 0,36 %/K			
Temperature Coefficient Short-Circuit Current	+ 0,02 %/K				+ 0,02 %/K			
Temperature Coefficient Rated Power	- 0,47 %/K				- 0,47 %/K			
NOCT (Normal Operating Cell Temperature)	48 °C ± 2K				48 °C ± 2K			
Mechanical Data								
Cell Type	48 monocrystalline, pseudo-square, 3 Bus-Bar				60 monocrystalline, pseudo-square, 3 Bus-Bar			
Cell Size	156 mm x 156 mm				156 mm x 156 mm			
Cell Manufacturer	Bosch, Germany				Bosch, Germany			
Dimensions: Length x Width	1340 mm x 991 mm				1691 mm x 1002 mm			
Frame Thickness	50 mm anodized aluminum				50 mm anodized aluminum			
Weight	20,0 kg				23,5 kg			
Front Glass	4 mm Albarino G				4 mm Albarino P			
Embedding	EVA (Solutia Solar)				EVA (Solutia Solar)			
Back Sheet	TPT Tedlar®/Polyester/Tedlar® (Krempel)				TPT Tedlar®/ Polyester /Tedlar® (Krempel)			
	KPK Kynar®/Polyester/Kynar® (Krempel)				KPK Kynar®/ Polyester /Kynar® (Krempel)			
Junction Box	Spelsberg/Lumberg with 3 bypass diodes				Spelsberg/Lumberg with 3 bypass diodes			
Cables and Plugs	MC4/LC4				MC4/LC4			
Permissible operating conditions								
Operating Temperature Range	-40°C to 85°C				-40°C to 85°C			
Max. System Voltage	1000 V DC				1000 V DC			
Max. Reverse Current	15 A				15 A			
Maximum Surface Load Capacity	5400 Pa or 550 kg /m²				5400 Pa or 550 kg /m²			
Resistance Against Hail	Maximum diameter of 24 mm with impact speed of 83 km/h				Maximum diameter of 24 mm with impact speed of 83 km/h			
Protection Class	II				II			
Warranty and Certificates								
Product Warranty	10 years				10 years			
Performance Warranty	90 % up to 10 years				90 % up to 10 years			
	80 % up to 25 years				80 % up to 25 years			
Certification	IEC 61215 Ed. 2 & IEC 61730 TÜV Rheinland; MCS-accredited; ISO 9001 & ISO 14001				IEC 61215 Ed. 2 & IEC 61730 TÜV Rheinland; MCS-accredited; ISO 9001 & ISO 14001			

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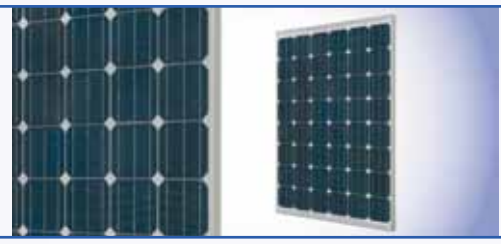
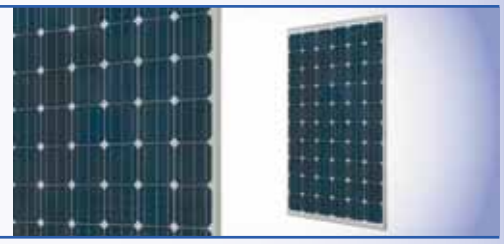




ES-190 M48 B

ES-230 M60 B

Electrical Data at 1000 W/m², 25°C and AM 1,5 (STC in accordance with EN 60904-3)

Rated Power at STC [1]	195 Wp	200 Wp	205 Wp	210 Wp[2]	240 Wp	245 Wp	250 Wp	255 Wp[2]
Module Efficiency at STC [3]	14,7 %	15,1 %	15,4 %	15,8 %	14,2 %	14,5 %	14,8 %	15,1 %
Cell Efficiency	17,4 %	17,7 %	18,0 %	18,3 %	17,4 %	17,7 %	18,0 %	18,3 %
STC Open-Circuit Voltage Voc	29,50 V	29,81 V	30,10 V	30,40 V	36,90 V	37,12 V	37,32 V	37,53 V
Short-Circuit Current Isc	8,48 A	8,61 A	8,73 A	8,86 A	8,32 A	8,44 A	8,57 A	8,69 A
Rated Voltage Vmpp	24,38 V	24,64 V	24,88 V	25,12 V	30,00 V	30,18 V	30,34 V	30,51 V
Rated Current Impp	8,00 A	8,12 A	8,24 A	8,36 A	8,00 A	8,12 A	8,24 A	8,36 A

Electrical Data at 800 W/m², NOCT, 1m/s wind speed and AM 1,5

Rated Power Pmax	158,0 W	162,0 W	166,1 W	170,1 W	194,4 W	198,5 W	202,5 W	206,6 W
Open-Circuit Voltage Voc	29,22 V	29,53 V	29,82 V	30,11 V	36,55 V	36,77 V	36,97 V	37,17 V
Short-Circuit Current Isc	6,81 A	6,91 A	7,02 A	7,12 A	6,68 A	6,78 A	6,88 A	6,98 A
Rated Voltage Vmpp	24,47 V	24,73 V	24,97 V	25,21 V	30,11 V	30,29 V	30,45 V	30,62 V
Rated Current Impp	6,46 A	6,56 A	6,65 A	6,75 A	6,24 A	6,56 A	6,55 A	6,75 A

Thermal Data

Temperature Coefficient Open-Circuit Voltage	- 0,36 %/K	- 0,36 %/K
Temperature Coefficient Short-Circuit Current	+ 0,02 %/K	+ 0,02 %/K
Temperature Coefficient Rated Power	- 0,47 %/K	- 0,47 %/K
NOCT (Normal Operating Cell Temperature)	48 °C ± 2K	48 °C ± 2K

Mechanical Data

Cell Type	48 monocrystalline, pseudo-square, 3 Bus-Bar	60 monocrystalline, pseudo-square, 3 Bus-Bar
Cell Size	156 mm x 156 mm	156 mm x 156 mm
Cell Manufacturer	Bosch, Germany	Bosch, Germany
Dimensions: Length x Width	1340 mm x 991 mm	1691 mm x 1002 mm
Frame Thickness	50 mm anodized aluminum	50 mm anodized aluminum
Weight	20,0 kg	23,50 kg
Front Glass	4 mm Albarino G	4 mm Albarino P
Embedding	EVA (Solutia Solar)	EVA (Solutia Solar)
Back Sheet	TPT Tedlar®/Polyester/Tedlar® (Krempel)	TPT Tedlar®/ Polyester /Tedlar® (Krempel)
	KPK Kynar®/Polyester/Kynar® (Krempel)	KPK Kynar®/ Polyester /Kynar® (Krempel)
Junction Box	Spelsberg/Lumberg with 3 bypass diodes	Spelsberg/Lumberg with 3 bypass diodes
Cables and Plugs	MC4/LC4	MC4/LC4

Permissible operating conditions

Operating Temperature Range	-40°C to 85°C	-40°C to 85°C
Max. System Voltage	1000 V DC	1000 V DC
Max. Reverse Current	15 A	15 A
Maximum Surface Load Capacity	5400 Pa or 550 kg /m²	5400 Pa or 550 kg /m²
Resistance Against Hail	Maximum diameter of 24 mm with impact speed of 83 km/h	Maximum diameter of 24 mm with impact speed of 83 km/h
Protection Class	II	II

Warranty and Certificates

Product Warranty	10 years	10 years
Performance Warranty	90 % up to 10 years	90 % up to 10 years
	80 % up to 25 years	80 % up to 25 years
Certification	IEC 61215 Ed. 2 & IEC 61730 TÜV Rheinland; MCS-accredited; ISO 9001 & ISO 14001	IEC 61215 Ed. 2 & IEC 61730 TÜV Rheinland; MCS-accredited; ISO 9001 & ISO 14001

[1] The measurement tolerance of the nominal yield is ± 3 %. The modules delivered are sorted in a range of ± 2.5 Wp.
[2] Available in limited amounts upon request.
[3] At low irradiation (200 W/m², 25° at AM 1,5), minimum efficiency at STC is 97 %.
Subject to errors and technical modifications within the scope of product improvement.
For more details, see Installation Manual.

Long-Term Tests for EMMVEE Modules

EMMVEE leaves nothing to chance. To ensure highest possible output and a profitable solar power plant, our modules are not only subject to our own quality and performance inspections, but also undergo tests of independent renowned institutions.

In co-operation with the University of Albstadt-Sigmaringen in Germany EMMVEE has put its modules through a long-term test to measure performance and output. Nine EMMVEE modules (three with flat glass, one with pyramidal structured glass, one with wavy structured glass) are analyzed alongside 53 modules from other manufacturers to compare their electrical data under various outdoor weather conditions. The results can be found at the University's Photovoltaic-Website: http://141.87.12.119/photovol. A test report including the yield overview for 2010 is available from EMMVEE Photovoltaics.

The Institute for Solar Energy Research Hameln GmbH (ISFH) has examined the change in efficiency and yield as a function of the angle of insolation when using structured front glass instead of conventional non-textured plain glass.

EMMVEE were the first users of Saint-Gobain Solar's Albarino innovative front glass with a special surface pattern. The Albarino P and G glass consists of deeply textured, extra white cast glass and have been specially developed for photovoltaic modules by Saint-Gobain Glass (SGG) in Mannheim.

For the purpose of the study by ISFH, mini modules comprising nine solar cells were built using glass with wavy or pyramidal structure as well as corresponding reference modules using non-textured front glass.

The tests were conducted using different intensities of insolation (1000W, 400W,150W) with the panels inclined at angles of 0°, 20°, 40°, 60° and 80° to determine their change in efficiency compared to the reference module with non-textured front glass. With the angle of incidence increasing, a larger increase of efficiency was recorded on the modules with structured surface glass compared to those with non-textured plain glass, independently of the intensity of insolation. The largest increase was found with an angle of incidence of 80° (Image 1).

Based on the measurements collected and using standard weather data, the electrical energy generated by the modules over one entire year was calculated for the site of Passau. The study showed an increase in yield of 5.4 % ± 0.5 % as an annual average for the wavy front glass, and an increase in yield of 4.1 % ± 0.5 % as an annual average for the pyramidal front glass[1]. The chart in Image 2 illustrates the interrelationship between the increase in yield and the angle of installation of the module. The reference module with plain glass showed the maximum yield of 100 % at an inclination angle of 30° . The study also revealed the following: At an inclination angle of only 10° , EMMVEE modules are close to producing 100 % output. At an inclination angle of 30° , EMMVEE modules reach their maximum yield and produce more than 100 %[2].

The theory was then put into practice. EMMVEE modules with Albarino P- and G-glass were installed at multiple sites throughout Europe, and the practical results not only confirmed but also exceeded the test results. Hence, EMMVEE modules have proven to hold their ground. The front glasses Albarino P and G are high-grade innovative products that demonstrate increased energy transmission due to minimal absorption in the glass when compared to non-textured plain glass. Photovoltaic modules with structured front glass are especially favourable for locations with low angles of incidence, e.g. systems with East-West orientation or building integrated installations (BIPV). Another feature of the Albarino P and G glass is its low level of contamination. The rounded structures result in a higher flow speed of rainwater: Dirt and dust particles are flushed directly off the glass and cannot deposit in the patterns. The ISFH is a non-profit organization and 'associated institute' of the Leibniz University Hannover. The institute is offering scientific services to the industry and other research institutions in the fields of solar thermal and photovoltaics.

1 Inclined at an optimum angle of 30° from the horizontal line and facing directly south. The additional yield refers to the plain glass reference module. Please note that the test results are for anisotropic glass. This implies that the additional yield also depends on the azimuth of the sun so that a slightly deviating yield increase can be observed.

2 The study is available from EMMVEE upon request.

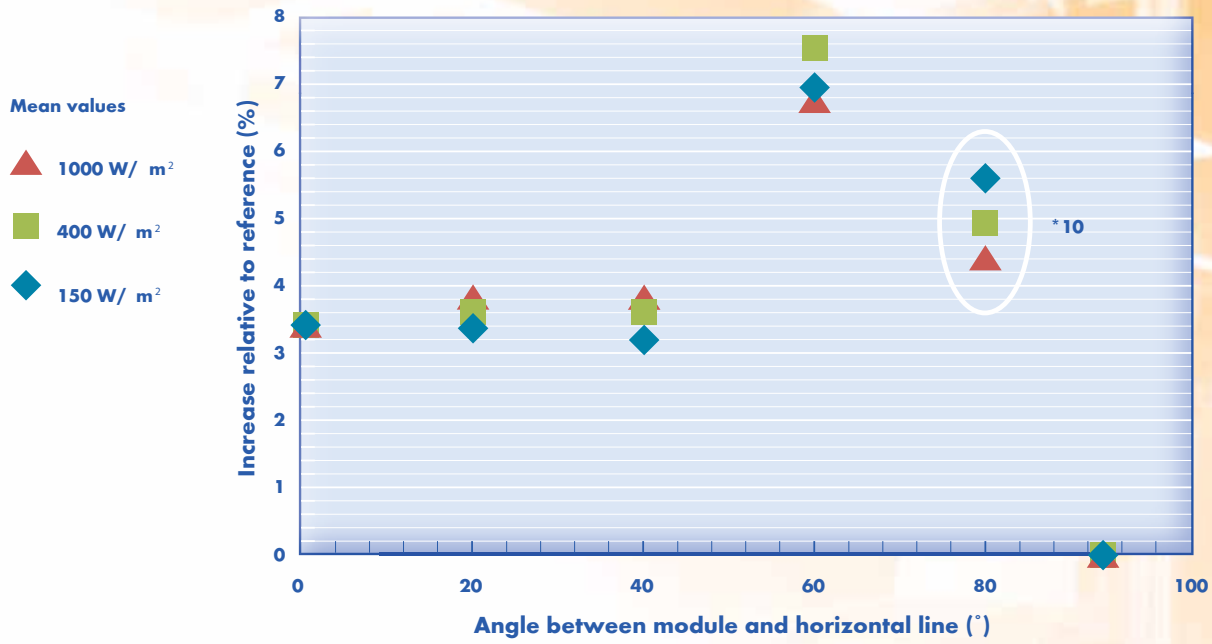


Image 1 : Efficiency increase - wavy glass (source: ISFH study)

Module yield relatively to the yield of the reference glass module at optimum angle and south facing direction

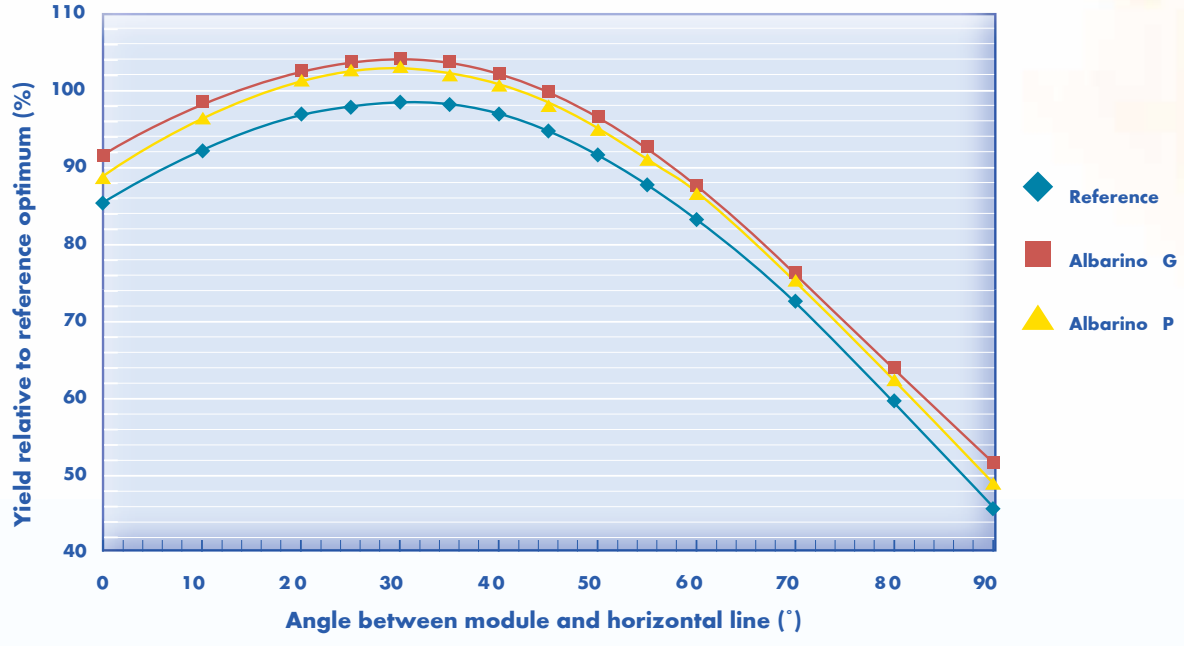


Image 2: Comparison of energy yields for various front glass types, depending on the angle of incidence (Source: ISFH study)

Quality Management

Module manufacturers usually provide a 25-year performance warranty. Photovoltaic modules as well as its components are subject to multiple tests in order to ensure stability and long-life performance.

One of the most important Technical Inspection Associations is the Technische Überwachungsverein (TÜV). Die TÜV Rheinland Group is a leading provider of technical services worldwide. Founded in 1872 and headquartered in Cologne, the group employs more than 13,800 people in 490 locations in 61 countries. All EMMVEE products are TÜV Rheinland tested and certified.

Certification Standards for Photovoltaic Modules

Crystalline silicon terrestrial photovoltaic (PV) modules are tested for design qualification and type approval according to standards IEC 61215, currently the most important certificate. The standards are a combination of measurements and tests for withstanding manifold environmental stresses. They determine the type of testing site and laboratory, the testing procedure and the test criteria to receive the TÜV certificate.

The object of the test sequence IEC61215 is to determine the electrical and thermal characteristics of the module, and to show that the module is capable of withstanding prolonged exposure under harsh climate conditions. There are three groups of stress testing: UV, outdoor and mechanical. UV-test and outdoor measuring determines the negative impact of sunlight while the mechanical tests measure the impact of hail, snow and wind loads. Environmental chambers simulate extreme weather conditions. First, the module has to resist 1000 hours of humidity heat-tests at 85 degree Celsius and 85 % humidity. Then, under the humidity-frost-test the module has to endure ten sudden drops in temperature ranging from +85 degree Celsius to -40 degree Celsius at a humidity level of 85 %.

The module will qualify and receive the certificate according to IEC 61215 if it has passed all tests and did not display any visual damages or a decrease in performance levels and isolation characteristics. The TÜV test mark is not only the sign of quality for crystalline PV modules, but also the basis for financial funding or feed-in-tariffs in many countries.

Less known but equally important is the standard IEC 61730, which stands for photovoltaic module safety qualification – Part 1: Requirements for construction and Part 2: Requirements for testing. The IEC 61730 describes the requirements for photovoltaic (PV) modules in order to provide safe electrical and mechanical operation during their expected lifetime. Specific topics are provided to assess the prevention of electrical shock, fire hazards, and personal injury due to mechanical and environmental stresses. Additionally selected modules have also received the certification according to IEC 61701 (Resistance against Saltwater Mist Corrosion).

A market entry in the United States of America requires a PV module to be certified by the Underwriters Laboratories (UL). The Underwriters Laboratories were established in 1894 as the trusted resource for product safety certification and compliance solutions in the USA. Their headquarters are in Northbrook, Illinois. UL evaluates not just the product, but also whether the manufacturing process complies with the relevant standard. The standard similar to the IEC mark is UL 1703.

A market entry in the United Kingdom requires MCS accreditation (Microgeneration Certification Scheme). The independent scheme certifies microgeneration products and installers in accordance with consistent standards through institutions such as British Board of Agrément on the basis of the IEC standards, as well as inspection of production facilities and manufacturing process.

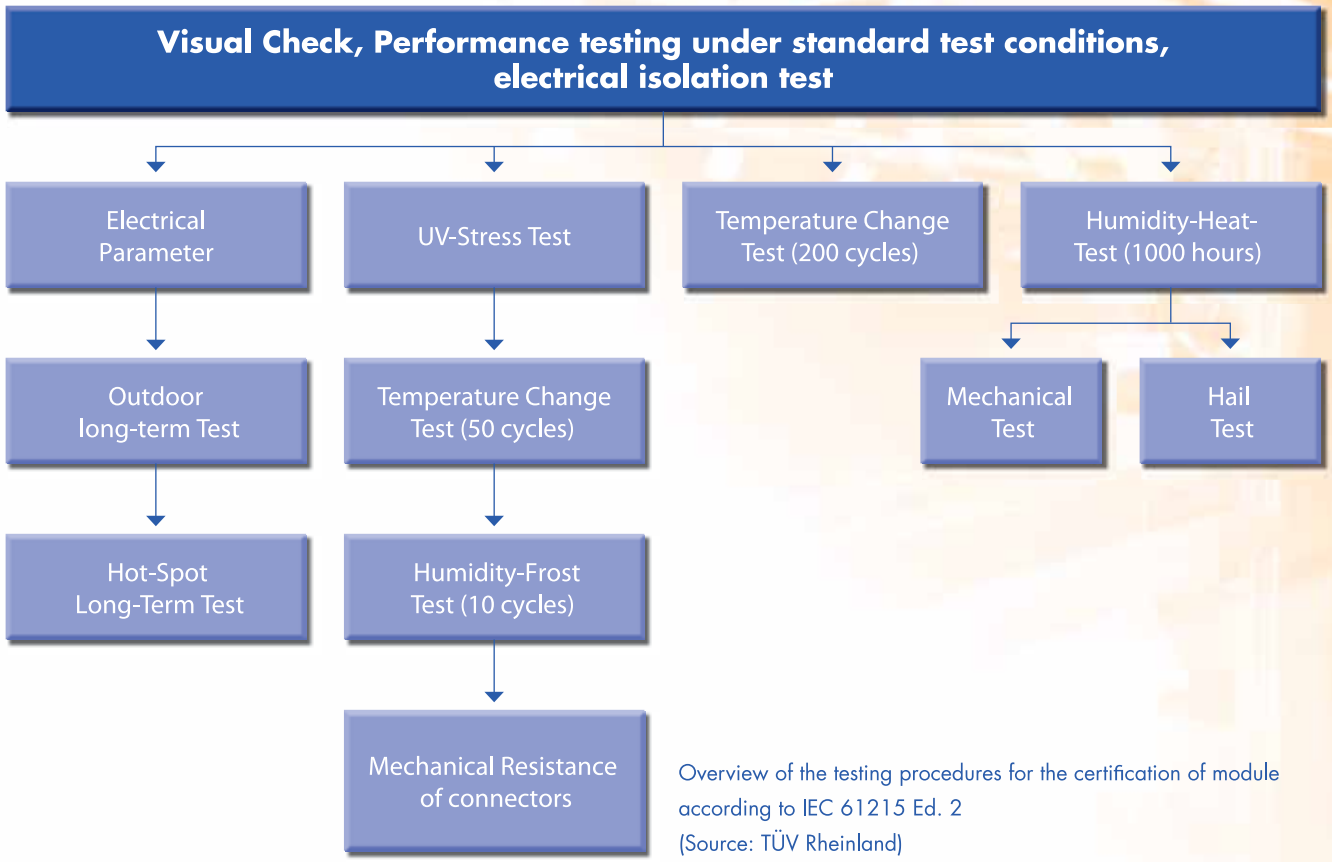
A market entry in Australia requires compliance to AS/NZS5033 Photovoltaic Installations. The Clean Energy Council maintains the database and website listing of AS5033 compliant PV modules. Module testing must be performed by a test laboratory approved to test PV modules to these standards under the IECEE CB scheme (CBTL). The certification must be issued by a National Certifying Body (NCB) associated with that laboratory, who are accredited to certify PV module testing under the IECEE CB Scheme

Official TÜV-certification logo for EMMVEE Diamond Modules

Official UL-certification logo for photovoltaic modules

Official MCS accreditation logo for photovoltaic modules

Official CEC accreditation logo for photovoltaic modules



Overview of the testing procedures for the certification of module according to IEC 61215 Ed. 2
(Source: TÜV Rheinland)

EMMVEE's Quality Control

The components used for the manufacturing of EMMVEE modules are mainly supplied by German manufacturers and fulfil highest quality requirements. The cell manufacturer Q-Cells is TÜV certified according to DIN EN ISO 9001 and DIN EN ISO 14001. Front glasses Albarino P and G made by Saint-Gobain according to DIN EN 572-5 Certification. The junction boxes made by Spelsberg and Lumberg as well as the cables and plugs come with a TÜV and UL certificate. The company Krempel guarantees a long-life performance and high product quality for its back sheet according with standard ISO/TS 16949. In addition, the company Bruker-Spaleck guarantees its cell- and string connectors are certified according to ISO/TS 16949.

Incoming Goods Control

Stringent incoming goods inspections of all raw materials used ensure that all components fulfil EMMVEE's quality requirements. First, the raw materials are registered using a detailed technical documentation process and then stored in accordance with the manufacturers' storage and handling guides. EMMVEE does not use materials which do not fulfil its quality standards or which have exceeded their lifespan.

Mechanical load test for photovoltaic modules at the testing laboratory TÜV Rheinland in Cologne (Source: TÜV Rheinland)

Methods of Production Quality Management

In order to ensure highest production quality, we take a close look at the following production process parameters:

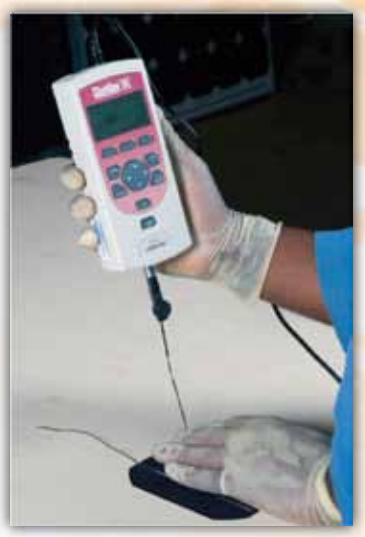
- The soldering temperature of the cell connectors is constant with a maximum deviation of ± 1 degree Celsius.
- Camera-detector systems are able to locate even the smallest fractures and damages, as well as misalignment of busbars.
- Every batch is examined for the quality of its laminate using delamination trials and laminate control checks.
- The tightness of the soldering joints between the cell and cell connector is inspected 5 times a day and checked after every change in production process parameters.
- To ensure accurate performance measuring under standard test conditions (flasher-test) we use calibrated and TÜV certified reference modules.
- Every module receives its unique serial number which is imprinted into the aluminum frame with a laser.

Final Inspections

Before a module is packed, it undergoes a final inspection. A visual inspection looks at serial number and product label, examines the module surface for possible bubbles, bumps, finger prints or other contamination, and checks all clamps and cables inside the junction box. The final electrical inspection includes testing for high-voltage grounding, performance measuring under standard test conditions (flasher-test) and the determination of the dark I-V curve.

Product and Performance Warranty

Our modules come with a 5 or 10 years product warranty (subject to warranty terms). Moreover, we warranty a yield of 90 percent of the minimum output power identified within the first 10 years and of 80 percent within the first 25 years from commissioning.



Pull test for the cell and string connectors during quality control at EMMVEE production facilities in Bengaluru, India

PASAN-flash generator-sun simulator of performance class A for measuring the output under standard test conditions at EMMVEE production facilities in Bengaluru, India

Module breakage test at the testing laboratory TÜV Rheinland in Cologne (Source: TÜV Rheinland)

EMMVEE - Quality Certificate

Module certification according to IEC 61215 Ed. 2 , IEC 61730 safety certification and IEC 61701 resistance against salt mist corrosion by TÜV Rheinland
Module certification according to UL 1703
MCS and Clean Energy Council accreditation
Quality Management System according to ISO 9001:2008
Environmental Management System according to ISO 14001:2004

Tips and Tricks for Mounting and Maintenance

Please note: This section provides an overview of the various applications for EMMVEE modules. Working on a PV system requires specialized knowledge and should only be attempted by qualified professionals. An up-to-date version of this installation manual can also be found at www.emmvee.com. Failure to follow these instructions may result in bodily injury or damage to property.

Site Selection

Photovoltaic modules can be roof mounted on a flat or sloping roof or ground mounted free-standing. Please ensure that the roof construction is suitable for a PV system installation. Avoid obstructions such as trees, buildings and antennas or soiling such as leaves and bird droppings because even small and partial shading of the modules will cause reduced system output. The module should be facing true south in northern latitudes and true north in southern latitudes for best power production. The ideal inclination for Central Europe is at 30 degrees. The ideal inclination is steeper for installations in Northern Europe and flatter for installations in Southern Europe. The minimum inclination should be 15 degrees to result in a higher flow speed of rainwater and flush off dirt and dust particles.

Mechanical Installation

Modules can be mounted in either a horizontal or vertical orientation. When installing vertically, the module clamp of the junction box has to point downward. The support module mounting structure, clamps, nuts and bolts must comply with all customary norms. EMMVEE recommends leaving a space of 20 mm between two modules considering linear thermal expansion of the module frames. Provide adequate ventilation under a module for cooling (100 mm minimum air space between module and mounting surface) and to allow any condensation or moisture to dissipate. The roof installation of solar modules may affect the fire proofing of the house construction. Please leave a space between the modules of 150 mm every 3 to 5 meters to allow access of fire fighting personnel in the event of a building fire. It is also possible to install the fireman's switch in the immediate vicinity of the PV module in the DC current line. EMMVEE solar modules can be mounted on the rails using pre-drilled mounting holes which are located at the back of the module frame or using module clamps. You will find further information for mounting and installation in our manual. Site-specific loads such as wind and snow need to be taken into consideration to ensure that this weight loading is not exceeded.

Electrical Installation

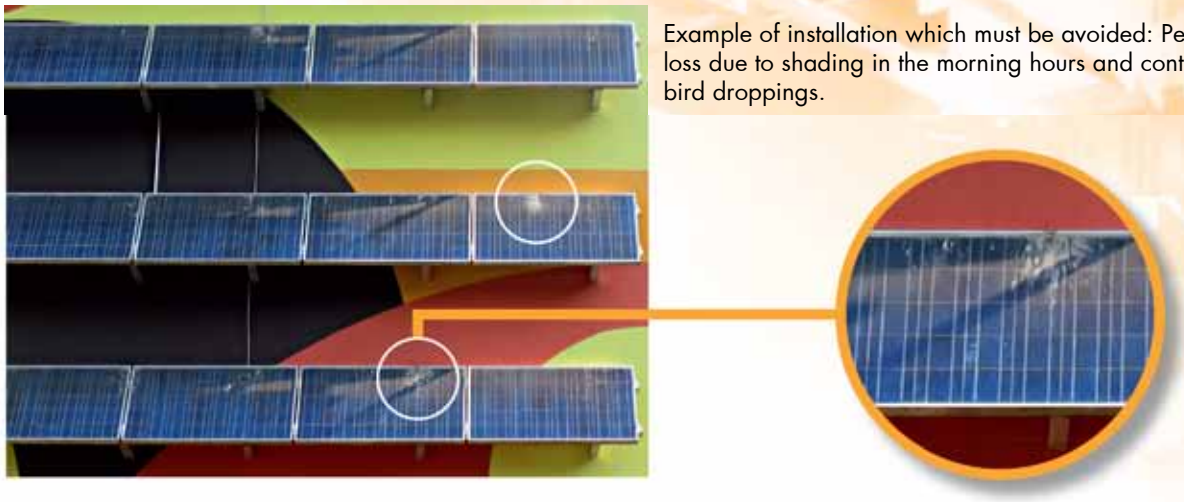
Several modules can be connected in series or in parallel to form a PV array with a specific current and voltage. Your inverter will determine if modules are connected in series or parallel. If modules are connected in series, the total voltage is equal to the sum of individual voltages. If modules are connected parallel, the total current is equal to the sum of individual currents. To connect the maximum amount of modules in series, make sure that the open circuit voltage multiplied by the number of modules in series is not higher than the maximum system voltage at the lowest temperature. If the modules are to be connected together in series they should have the same amperage. If they are to be connected in parallel they should have the same voltage. EMMVEE modules delivered are sorted in a range of ± 2.5 Wp, e.g. 242.5 to 247.5 Wp in the performance class 245 Wp. Solar modules connected in series which do not have identical properties or which experience different conditions from one another will cause mismatch losses. It will lower the output of the entire PV module down to 1 %. To reduce mismatch losses to approx. 0.2 % it is crucial to sort all modules according to similar MPP amperage using the results from the flash test.

Maintenance and Cleaning

Solar modules, unlike all other power plants, require little maintenance. They do not shift and the user does not need to refill or replace anything. But they have to be monitored and inspected for performance, damages and cleaning. The inverter's functioning should be checked on a daily basis to guarantee flawless performance. We deem it advisable to record the PV systems' output in a log. In view of the tilt angle of the PV modules (>15), normal rainfall is sufficient to keep the module glass surface clean. Snow will also usually slide of the module. Cleaning of the surface is recommended once at the end of the winter season. Do not use high pressure water spray or chemicals to clean the module. Under no circumstances should dirt be scraped or rubbed off the modules, as this can cause micro scratches on the surface of the modules and reduce the transparency of the module glass. In order to ensure proper operation, please check all wiring connections, condition of the insulation and mechanical connections once every year and report any problems immediately. All cleaning and maintenance operations are to be done by a trained person only.

General Dangers and Safety Advice

Please pay close attention to the characteristics of the photovoltaic system:



Example of installation which must be avoided: Performance loss due to shading in the morning hours and contamination of bird droppings.

• PV modules generate DC electrical energy when exposed to sunlight or other light sources and cannot be turned off.
• Photovoltaic systems generate direct-current electrical energy with high voltage. When disconnecting wires connected to a photovoltaic module that is exposed to sunlight, e.g. clamps, plugs or when measuring electric currents with an ampere meter, a potentially lethal electrical arc can occur which will not self extinguish. Danger of death from electric shock through risk of arcing when in contact with electrically active parts of the module. Please read the instructions in our manual carefully.

Quality Advice

Only use solar modules that are certified through renowned certification bodies like TÜV, VDE or UL to guarantee the solar system will last for 20 years. It is crucial to process components of high quality from renowned manufacturers. Every module is invariably as strong as its weakest component. EMMVEE always uses brand-name components from prominent manufacturers. Always seek professional advice and leave it up to an expert to install a solar system.

Environmental Compatibility, Waste Disposal and Recycling

At EMMVEE, environmental protection is an integral part of the company policy. Hence, we support the implementation of the REACH-regulation and are equipped to adapt our products to the RoHS-conformity in accordance with the RoHS-guideline.

The REACH-regulation requests manufacturers and importers of chemical substances to register the substances they use at the European Chemicals Agency. According to chemical regulations photovoltaic modules fall into the product category. Product substances are only to be registered if these substances are, in accordance with the regulation, released while using the product. This is not the case for crystalline photovoltaic modules. Therefore, the substances in the modules do not have to be registered.

The RoHS-guideline stipulates that the use of lead, mercury, cadmium, hexavalent chrome, polybrominated biphenyl (PBB) and polybrominated diphenylether (PBDE) in certain electrical and electronic products is prohibited. Currently, photovoltaic modules are not affected by the RoHS-guideline. However, EMMVEE is trying to adapt all products to the RoHS-conformity and already almost exclusively uses components that correspond to the RoHS-guideline. Notably, the EMMVEE photovoltaic modules do not contain any cadmium.

A large proportion of the components used in photovoltaic modules is recyclable. A conventional silicium module consists, corresponding to its weight, to 63 percent of glass, to 22 percent of aluminium and to 7.5 percent of EVA foil. The silicon solar cells and the receptacle account for 4 or respectively 1.2 percent of the total weight. Notably the glass and aluminium frame have a high yield and can almost be 100 percent recyclable. The wafer material of the silicon solar cells is also of particular value as it can be retrieved as a raw material and be reused to produce PV modules. In addition small amounts of copper are accrued.

References
Photovoltaic Systems

Reference 1

Location	Cortemaggiore, Piacenza (Italy)
Commissioning	2010
Performance	1 MW
Module type	ES- 200 M60 (230 W)
Glass type	Albarino P
No. of modules	4347
Inverter Type	REFUSOL 20K (50x)
Roof Orientation	0° South
Roof Inclication	30°
Installer	Codam S.r.l

Reference 2

Location	Pandino, Cremona (Italy)
Commissioning	2008
Performance	49.5 kW
Module type	ES- 170 M72 (180 W)
Glass type	Albarino P
No. of modules	275
Roof Orientation	60° south-west
Roof Inclication	6°
Installer	Savex S.r.l
Yield 2009	1040 kWh/kWp
Yield 2010	1017 kWh/kWp

Reference 3

Location	Varese, Lombardy (Italy)
Commissioning	2009
Installed Capacity	36.11 kW
Module type	ES- 230 P60 (230 W)
Glass type	Albarino P
No. of modules	157
Inverter Type	Fronius IG 40 (7x)
Roof Orientation	South and north 10°
Installer	KeyNRG S.r.l.
Yield 2010	1036 kWh/kWp and 899 kWh/kWp

Reference 4

Location	Fareham, Hampshire (UK)
Commissioning	2011
Performance	4kWp
Module type	ES 230 M60 Black Pearl
Glass type	Albarino P
No. of modules	16
Roof Orientation	0° south
Roof Inclication	6°
Inverter Type	SMA Sunnyboy
Installer	Your Generation

Reference 5

Location	Etoges, Champagne 51 (France)
Commissioning	2010
Performance	117.03 kW
Module type	ES-200 P60 (235 W)
Glass type	Albarino P
No. of modules	498
Installer	Capthelios

Reference 6

Location	Tebн , Vysoina (Czech Republic)
Commissioning	2009
Performance	4.09kWp
Module type	ES 200 M60 (235W)
Glass type	Albarino P
No. of modules	18
Roof Inclication	356°
Inverter Type	Fronius IG 40
Installer	Novatrix s.r.o.

Reference 7

Location	Schrozberg, Baden-Wuettemberg(Germany)
Commissioning	2009
Performance	99,36 kW
Module type	ES-200 P60 (230 W)
Glass type	Albarino P and G
No. of modules	432
Inverter Type	SMA SMC 10000 TL-10(9x)
Installer	EWB Elektroservice GmbH

Reference 8

Location	Ratshausen, Wuerttemberg (Germany)
Commissioning	2010
Performance	456.56 kW
Module type	ES-200 P60 (230 and 235W)
Glass type	Albarino P
No. of modules	1965
Inverter Type	Power One PVI 10.0 (32x),
	PVI 4.2 (1x), PVI 3.6 (5x),
	PVI 3.0 (5x)
Roof Orientation	25° South-west
Roof Inclication	15° and 20°
Installer	Heinrich Trick Baukonzept GmbH

Reference 9

Location	Nandha village, Bhiwani, Haryana, India
Date of connection	28 of June 2011
Performance	1 MWp
Module type	ES- 230P60
Glass type	Flat Glass
Installation type	Ground Mounted
Applications	Solar Grid tied Power Plant
	2nd 1MW power plant under JNNSM scheme
No. of modules	4.370
Installer	C & S Electric Limited

Reference 10

Location	Ramanashree California Resorts
	Bangalore, Karnataka, India
Commissioning	2011
Installed Capacity	75 kW
Module type	ES- 250 M60
Glass type	Flat Glass, Saint Gobain
Installation type	Roof Top
No. of modules	300
Applications	Local grid
Installer	Emmvee Photovoltaic Power Pvt. Ltd.

Reference 11

Location	BSNL, Bhubaneswar, Orissa India
Commissioning	2011
Installed Capacity	15.1 kWp = 10kWp (Solar) + 5.1 kWp (Wind)
Module type	ES- 250M60
Glass type	Albarino P
Installation type	Hybrid (Solar+Wind)
No. of modules	40
Applications	Telecom Solutions
	Base Transceiver Stations (BTS)
Installer	Emmvee Photovoltaic Power Pvt. Ltd.

Reference 12

Location	ETA Star, Bengaluru, Karnataka, India
Commissioning	2010
Installed Capacity	13.82kWp
Module type	ES- 175 P72
Glass type	Flat Glass
Installation type	Rooftop
No. of modules	79
Applications	Home Lighting
Installer	Emmvee Photovoltaic Power Pvt. Ltd.

References
Solar Water Heating Systems

ETA Constructions, K'taka & TN - 100000 LPD

Aliens Developers, Andhra Pradesh - 70000 LPD

Suvidha, Karnataka - 20000 LPD

Reva Institutions, Karnataka - 28000 LPD

Isha Foundation, Tamil Nadu - 40000 LPD

JSS, Karnataka - 80500 LPD

Father Muller, Karnataka - 65000 LPD

Baptist Hospital, Karnataka - 9500 LPD

Fountain Hotel, Maharashtra - 30000 LPD

ABM Hotel, Tamil Nadu - 3000 LPD

Larsen & Toubro, Karnataka - 1500 LPD

Accenture, K'taka, AP & TN - 20000 LPD

EMMVEE Solar Systems Pvt Ltd is accredited channel partner under JNNSM Solar Water Heaters subsidy scheme

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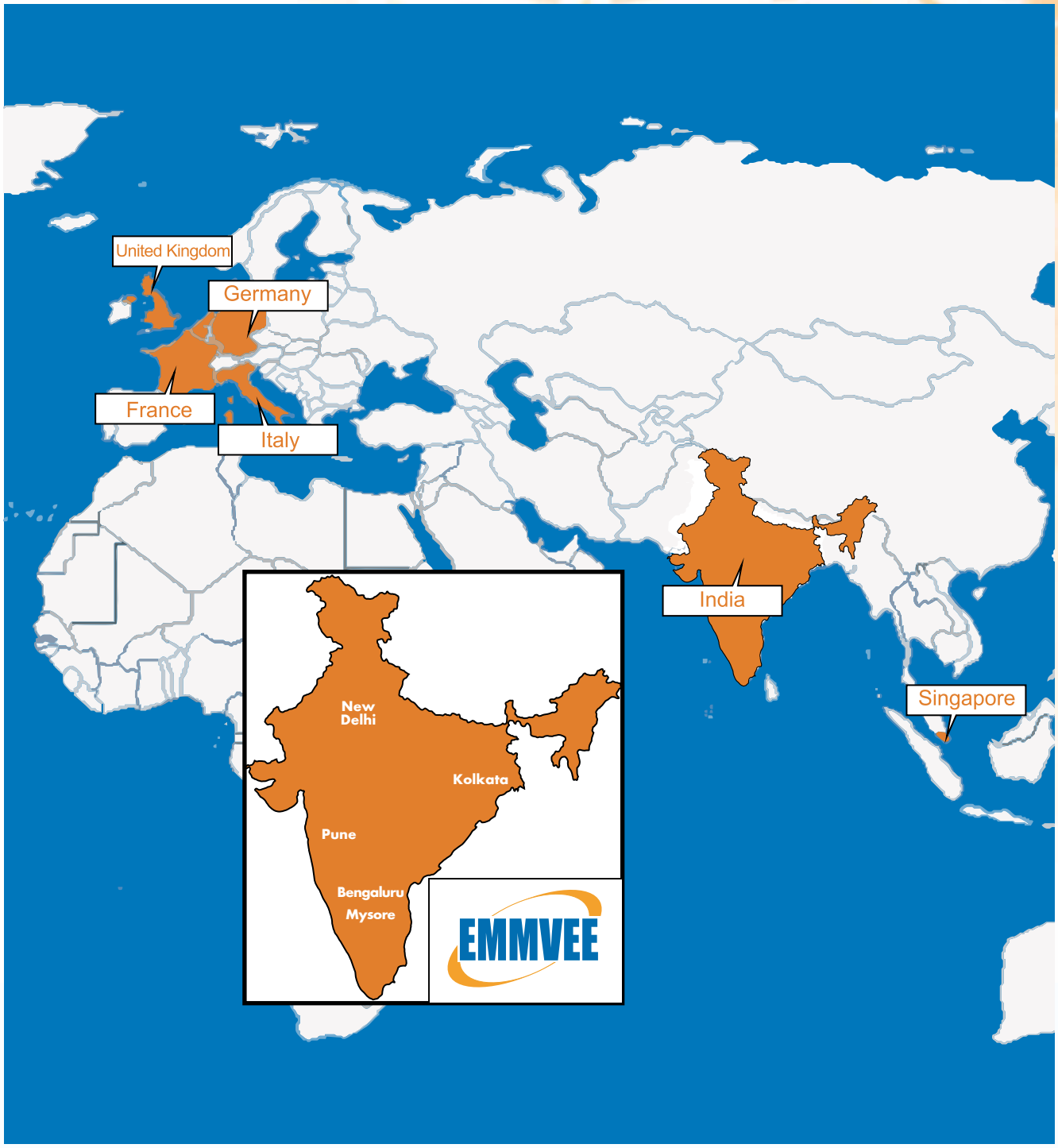
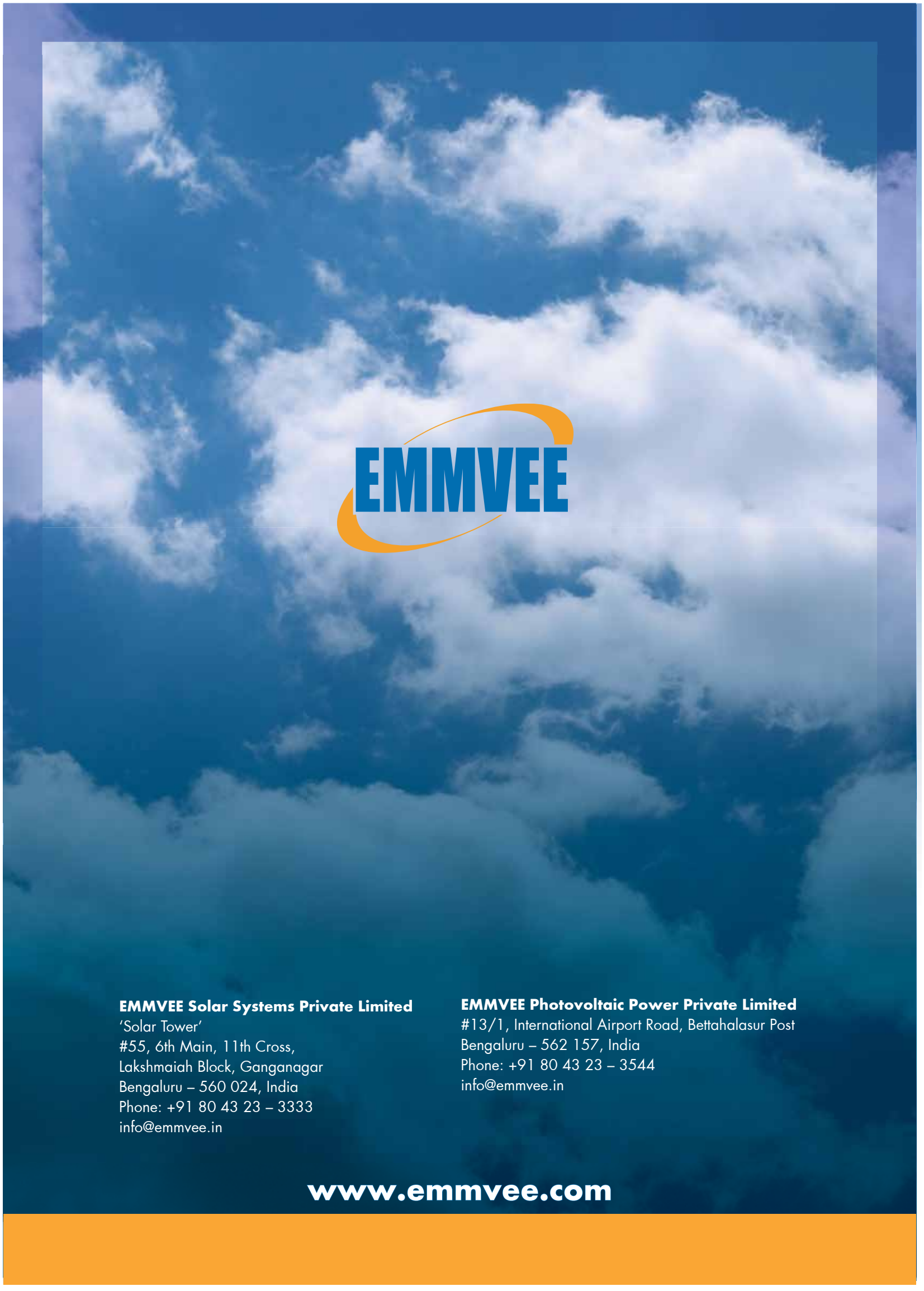
Our Presence





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