



Borosil

SMART SOLAR GLASS

FOR

SMART AND SOLAR CITIES

302 KVA Rooftop installation at 80000 sqft warehouse of Borosil Group company at Bharuch, Gujarat





- Glass is widely used in today's world almost in every aspect of life. Glass inert and special types of glass have been developed which are thermal shock resistant, scratch resistant etc.
- Soda Lime glass is a widely used glass which is having Soda and Lime as its constituent as its name suggests. Commonly found glass windows, glass bottles, lamp shades etc are made of soda lime glass.
- Typically Sodalime glass is made from a recipe of raw materials such as sand, dolomite, limestone, feldspar and refining agents such as sodium sulphate and carbon
- Pre weighed batches of the raw materials is fed into a melting furnace continuously to convert the raw materials into molten glass at temperatures exceeding 1550 deg C. The molten glass is then converted into sheets by various technologies.
- The technologies such as the PPG process, Float process, Rolled glass forming process, coldburn process etc. convert the molten glass into sheet of glass and the formed sheets are termed as Float glass, Sheet glass, textured glass etc based process and some properties of the product.

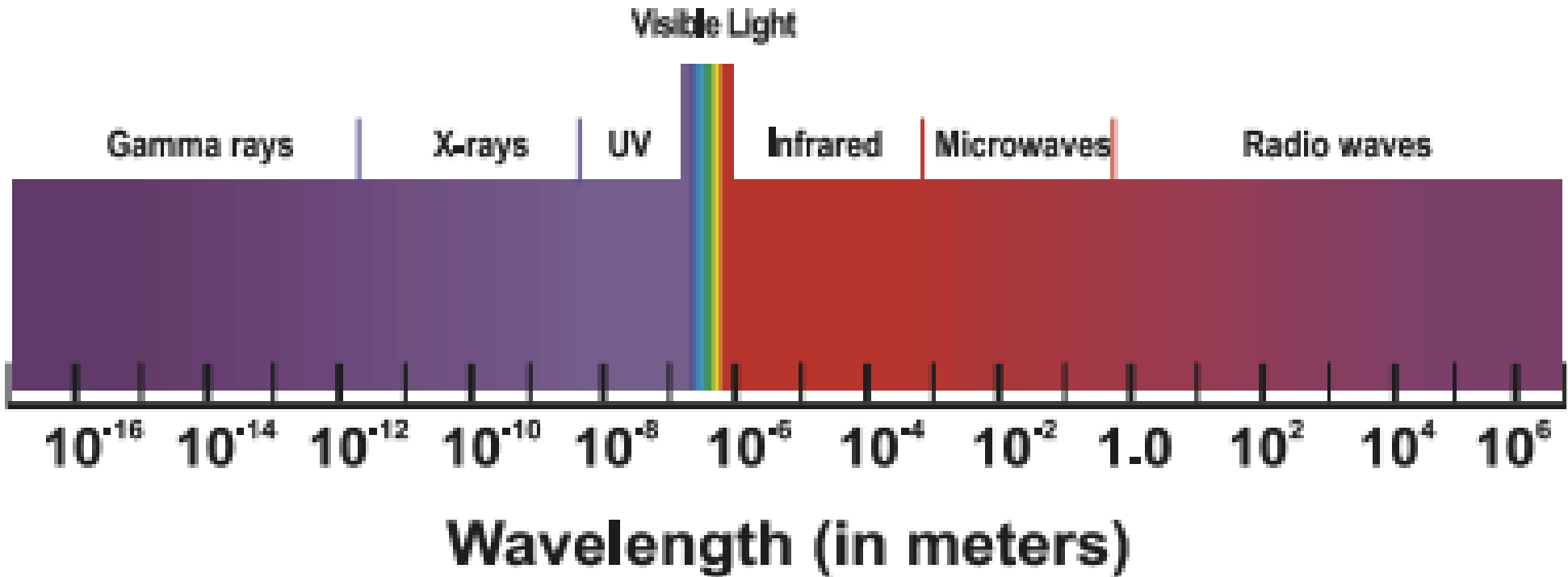
The Sunlight seen by us is the Visible spectrum which is a small fraction of The total Electromagnetic spectrum in the universe.

This Electromagnetic spectrum consists of the gamma rays, x-rays, and radio waves in addition to the visible light.

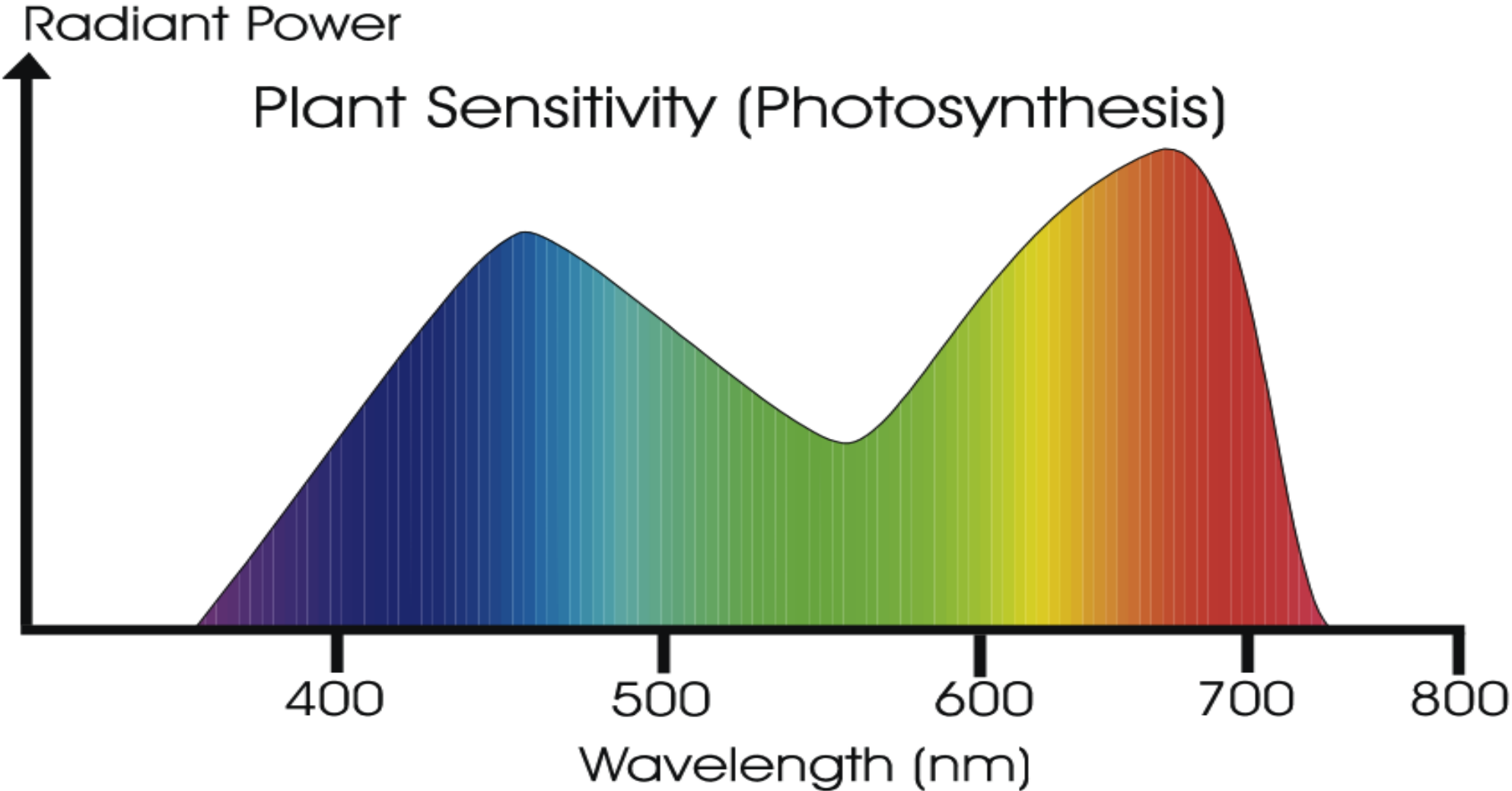
Violet colored light rays at about 380 nm (nanometers) are the shortest wavelengths that humans can perceive in appreciable amounts, and red light wavelengths at about 720 nm are the longest.

The famous mnemonic for the visible spectrum is VIBGYR. At the far end of the visible spectrum is UV (Ultra Violet) and the other end is the IR(Infra Red)

The Electromagnetic Spectrum



- The basic function of solar glass is to transmit as much solar energy as possible while protecting the solar cell and the entire grid which produces and channelizes electricity.
- Solar glass is used in applications such as Photovoltaic modules, Solar thermal water heaters and Green houses
- Solar glass has high transmission compared to the commercially manufactured architectural glass
- The Solar Spectrum used for each of these applications is different. For Green houses, typically a spectral range of 300 to 780 is desired as the plants respond well in this spectral range and the photosynthesis is superior resulting in high growth of plants and hence the yield.
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- For Photovoltaic modules, the relevant spectral range is 380 to 1100 nm as the photocells do not respond to solar radiation beyond this spectral range.
- The Solar water heaters are based on thermal energy from the sun and hence they use the entire spectral range of Solar radiation upto 2500 nm
- Solar glass has high transmission compared to the commercially manufactured architectural glass in all these ranges for all three applications.
- The high transmission of Solar glass is mainly attributable to its low iron content. Iron absorbs solar radiation and hence reduces the transmission. The commercial glass appears green due to its high iron content.
- Solar glass appears white or yellowish white as it has very little iron content

What Makes the Solar glass Smart??



- The Solar Glass is smart when it is able to overcome the various problems of normal Solar Glass.
- As Solar Glass is used for generating energy which is supposed to be non polluting and environment friendly, it does not make sense when toxic elements such as Antimony are present in it. Antimony has a limit of 6 parts per billion in drinking water by USEPA.
- End of life considerations for modules made with glass having antimony are complicated
- Recently Mumbai High court, has banned the use of PET bottles in medicines as these bottles contain antimony
- GBL is the first and only company in the world to manufacture totally toxin free Solar glass.
- Secondly the glass is smart enough to take care of movement of Sun in the sky and give high transmission even when the sun is at a steep angle. This is called Incident angle modifier and SPF has measured the same and has found that GBL glass has higher transmission



- Thirdly, the smart solar glass takes care of light Induced Degradation.
- The Sun's radiation causes chemical reaction in the glass and makes the transmission to reduce over a period of time. However the glass composition is designed to take care of this and hence it is able to overcome this problem and infact GBL glass gives a marginally higher transmission after exposure to sunlight rather than a reduction faced by other Solar glasses.
- Fourthly, the smart solar glass takes care of Potential Induced Degradation caused by migration of Sodium ions from the glass into the cell when the module made of Solar glass is installed in a solar farm where the voltages are 1000v and above causing damage of the modules or reduction in power output.
- PICON , Germany has tested modules made of Solar Glass from five different manufacturers and has found that the Solar glass from GBL shows no degradation at all after rigourous tests.
- GBL has achieved this by suitably tweaking its Solar glass chemical composition.
- Further this is also the reason for high chemical durability of this Solar glass

Applications of Solar glass in Smart and Solar cities - Rooftop

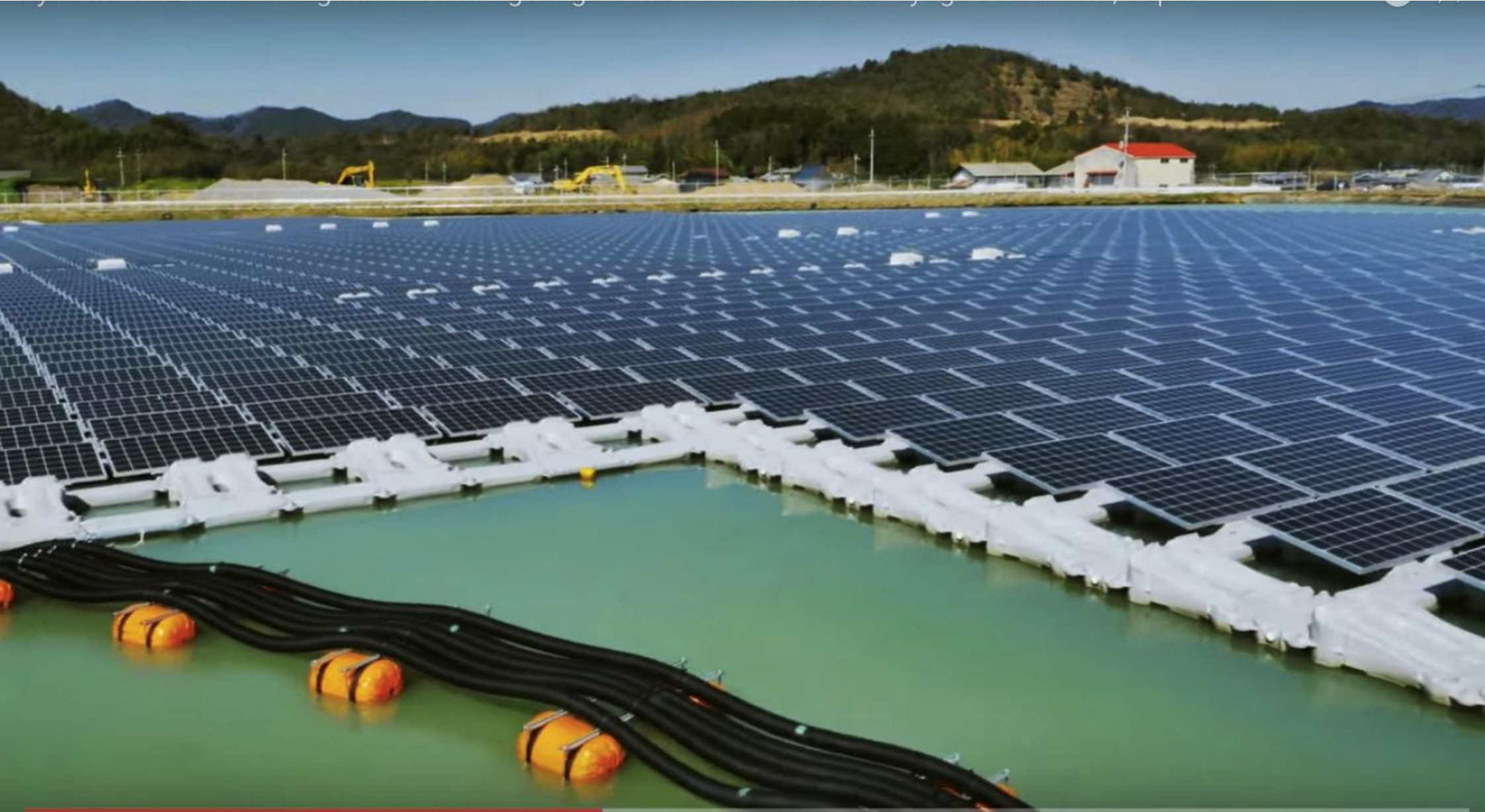


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- Rooftop presents its own unique challenges
- The roof area is always a constraint and one needs to have high efficiency modules made with high output solar cells and high transmission solar glass to generate maximum power output in a given limited roof area.
- GBL is in the process of procuring a tempering line from LISEC, Austria which will enable it to make 2mm fully tempered Solar glass which will be the first in India and also one of the very few around the world with Solar glass manufacturers.
- This low thickness high transmission glass modules will have high efficiency of the modules coupled with low weight which are ideal for roof top installations.

Applications of Solar glass in Smart and Solar cities – Solar Thermal Hot water and heating systems



Applications of Solar glass in Smart and Solar cities - Floating Solar modules by Kyocera in Japan



- For Cities starved of land space, deploying the solar modules in waterbodies is a new possibility and Japan has pioneered this concept.
- Japan has commissioned around 10 GW of Solar power in 2015.
- Japan has installed floating modules in various ponds, lakes etc as it lacks the landspace.
- For Cities like Mumbai , which lack land space, It could be possible to install the modules in the lakes and ponds to generate Solar power

Applications of Solar glass in Smart and Solar cities – Solar Thermal Hot water and heating systems



Solar Hot Water & Heating Systems

For Residential, Commercial, Military, Government & More



Fort Hood, TX - Solar Hot Water / Heating



- Solar thermal water heating systems with robust copper tubes use Solar glass as cover
- The Solar glass protects the system against weather and at the same time permits the heat from the Solar radiation to go through
- They are economical and at the same time give same mechanical strength and higher transmission
- The System can be also used for room heating systems, HVAC, swimming pool heating etc. The advantage of solar water heating systems is that they are more efficient than electrical systems for heating applications as they donot have to convert radiation into electrical energy and then back to heat thereby saving the efficiency loss associated with such complicated systems.



- BIPV is building integrated Photovoltaics
- Basically in BIPV buildings, conventional materials are replaced by Photovoltaic materials in areas such as roof, skylights and facades. We have already dealt with roof top installations separately
- This low thickness high transmission glass modules will have high efficiency of the modules coupled with low weight which are ideal for roof top installations.
- 2mm fully tempered solar glass finds wide use in BIPV modules
- They are economical and at the same time give same mechanical strength and higher transmission

BIPV can be part of an elegant building at the same time, generating energy which is otherwise a normal glass façade

Window and Façade systems offer many possibilities of combining generation of solar energy and at the same time maintaining the architectural style in a smart way.

Individual crystalline modules can be combined with ventilated/nonventilated facades/windows/ solar shades and canopies

Applications of Solar glass in Smart and Solar cities – BIPV Facade



Applications of Solar glass in Smart and Solar cities – BIPV Facade

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PHOTOVOLTAIC WALL AT SPAIN



- Smart cities adapt themselves to instal sustainable resources without compromising on the elegance and beauty of the city.
- Barcelona has installed a Pergola (framework for creepers or climbing plants) with 240 active solar modules
- They are generating a total of 65 KWp and use it in Municipal gardens around Barcelona.
- They had to use 70 screen printed glasses simulating Pvcell design in shaded areas where PV modules cannot be installed to have the same aesthetics
- This architectural project proves that PV technology can play an important role in the integration of renewable energy in urban spaces

Pergola at Barcelona Municipi park with 240 active modules

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Photovoltaics in Stadium Roof – Taiwan

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The World Games Stadium lies like a reptile in the midst of a subtropical parkland. Japanese star architect Toyo Ito designed this exceptional structure in Kaohsiung, Taiwan.

Image 1 of 8



Photovoltaics in Stadium Roof – Taiwan



Each solar roofing component consists of two glass-glass modules, fitted with six by six polycrystalline cells. Different sizes can be achieved with the aid of an opaque edging strip.



Photovoltaics in Stadium Roof – Taiwan



Framework Struts carry main load and spiral takes temporary Loads from Earthquakes and wind

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The framework struts carry the main load for the undulating roof. The spiral steel tubes take up temporary loads from earthquakes and wind.



- Glass to Glass modules in which the cells are placed at varying distances are widely used. Architects at HHS use this
- One example of this is at the headquarters of inverter manufacturers SMA's headquarters. These double glazed elements with monocrystalline cells in various formats compose the exterior. This gives a glass façade with contrasting squares of light and shadows.
- Another method used by sunrays is to perforate their monocrystalline cells with 64 holes each 5X5 mm square. This permits light come through evenly across the entire surface and gives a transparency of 10%
- Solar cells with round perforations of only 2 mm were used in all façade surfaces of Novartis in Basel. This permits a 10% light to come through, while preventing overheating and at the same time permitting excellent quality light shine in all façade surfaces.
- While transparent modules produce electricity and provide sunlight, they also have an advantage over conventional sun protection – tinted glass as the sunlight filtered through the transparent modules retains its natural colour.

Transparent Modules and not glass panes in a building designed by architect Frank O. Gehry for Novartis

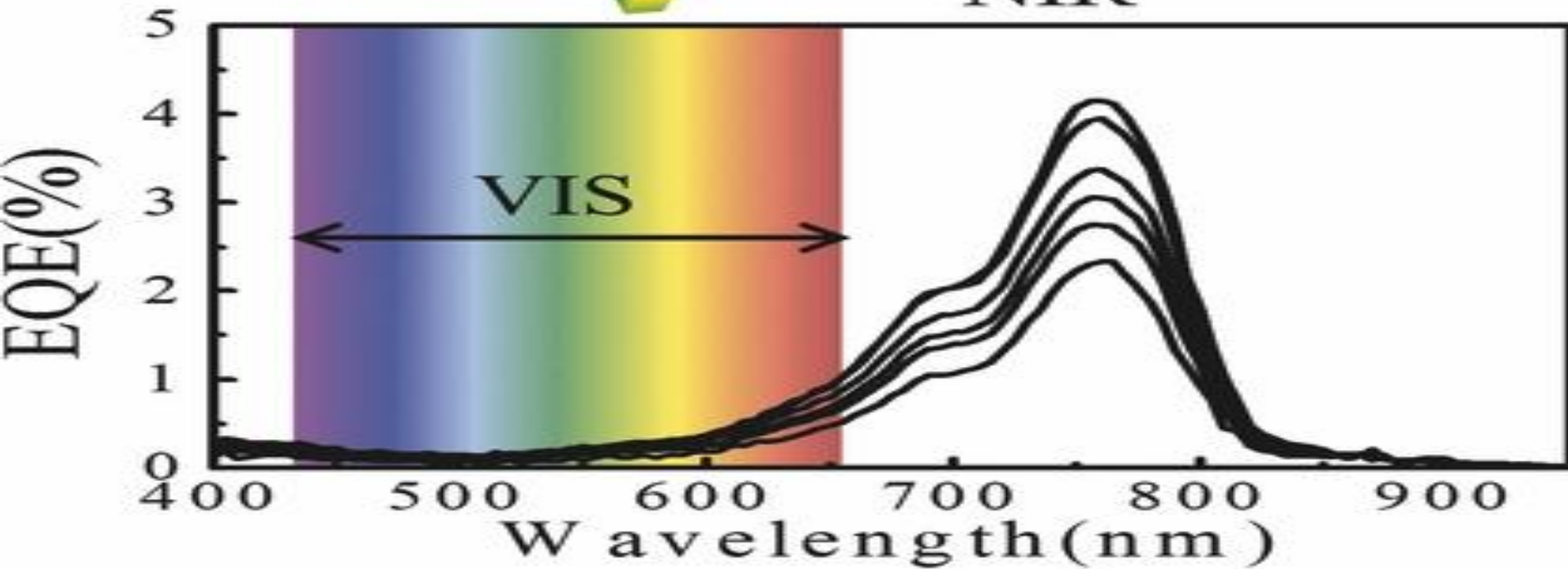
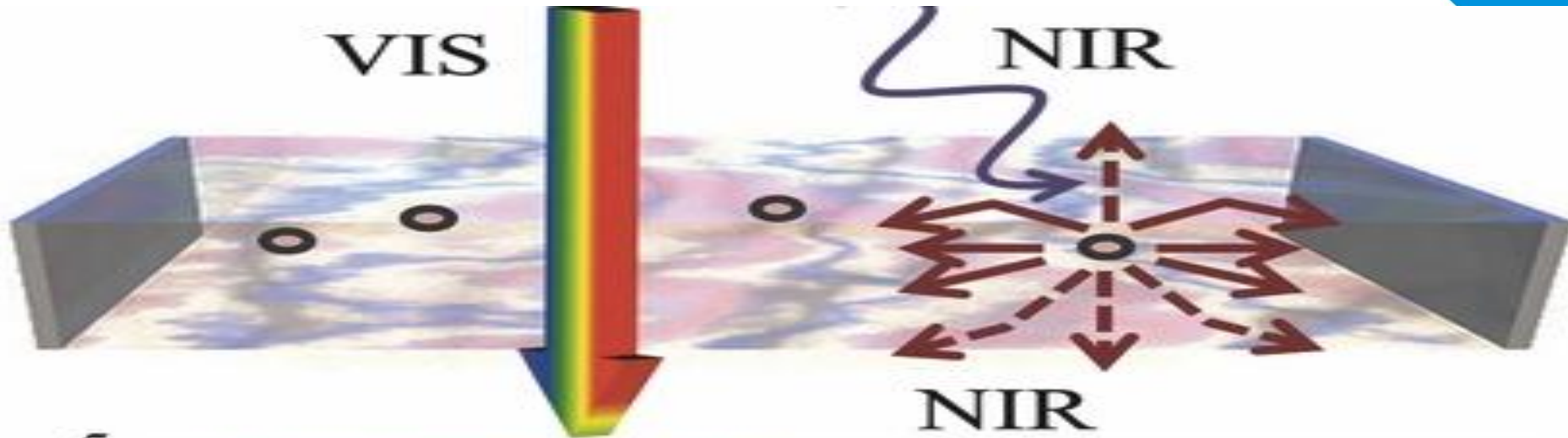
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- Ubiquitous energy from USA, has invented a new technology wherein the Solar glass permits the visible light to go through while absorbing UV and IR and converting them to NIR
- The meaning of Ubiquitous is “present everywhere” or “Omnipresent”. This company talks of tapping energy present everywhere.
- It incorporates a coating on the glass which permits the view and sunlight while remaining invisible
- BIPV are promising to capture solar energy but are not widely adapted as the aesthetics and view from inside the building are severely hampered and this technology overcomes these issues.
- It can also generate power for smart window technology independently

Fully transparent Power producing Solar glass



Fully transparent Power producing Solar glass



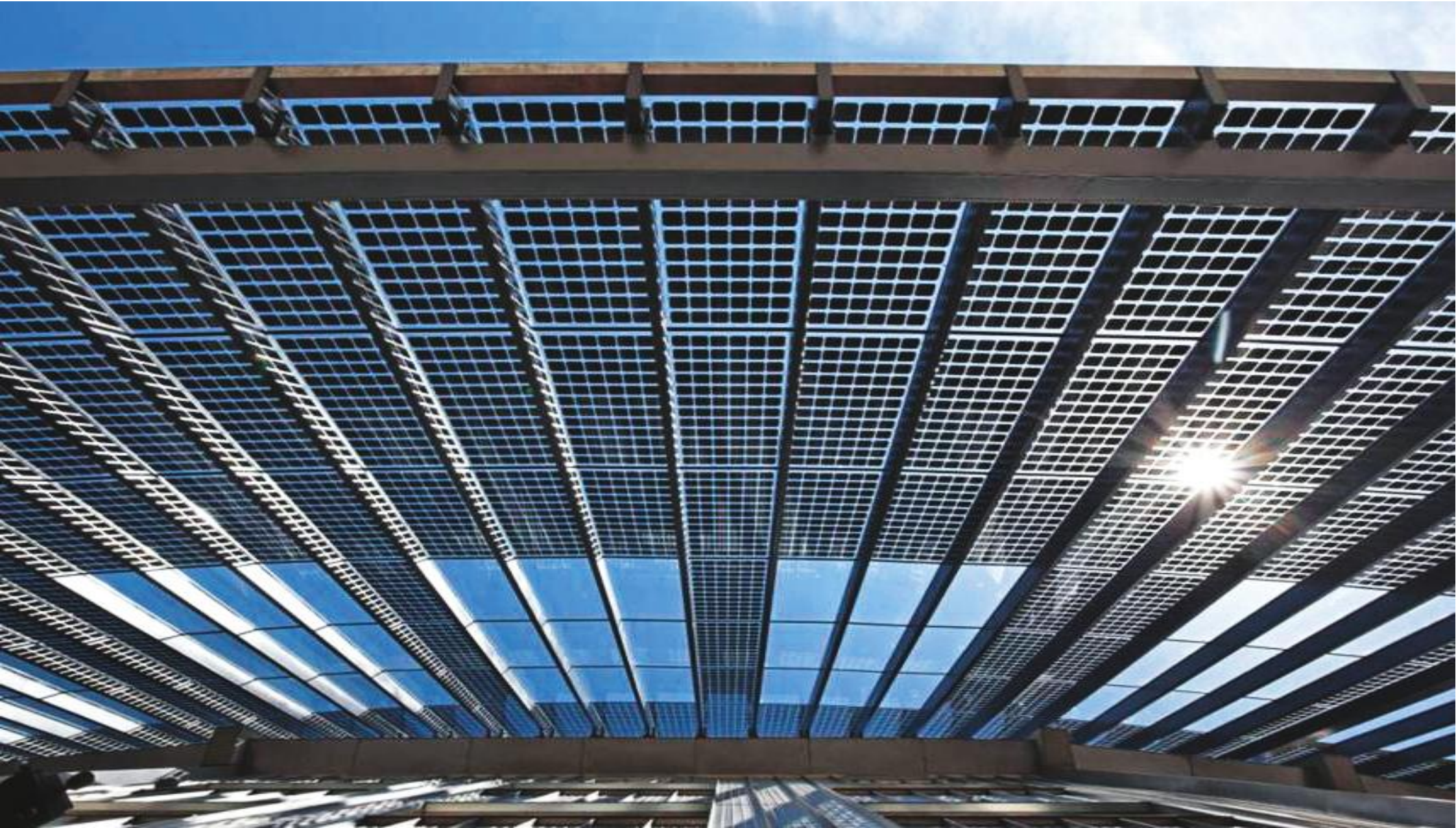
Smart Glass

Clear, Clean Energy



- Glass to Glass BIPV modules have been approved by DIBt Deutsches Institut für Bautechnik for use as Laminated safety glass in buildings.
- This has permitted many architects to use glass to glass modules in their designs as infill units without the need for special additional strengthening of supports
- The mechanical strength of these glass to glass modules are tested to be as good as the laminated safety glass at the same time enabling the users to generate energy.
- As mentioned earlier, the 2 mm fully tempered solar glass from GBL will go a longway in helping the Module manufacturers to produce BIPV glass to glass modules to be used in smart and solar cities

BIPV modules to replace Laminated safety glass



- Bifacial modules are used in space strapped smart cities to make effective use of available space to generate maximum energy .
- They convert the direct, radiant and scattered sunlight to generate energy on both the front and back side of the modules.
- They use IR resistant encapsulate instead of conventional EVA, increasing life expectancy and maximising generation time per day as they use indirect sunlight also.
- Their lamination method with no multilayer backsheet reduces fire hazard and less probability of mechanical damage over lifetime.
- A typical module has about 60 monocrystalline solar cells with 20.5% efficiency on each side to generate more than 350 watt peak
- These replace single axis / multi axis solar tracking system with economical bifacial modules to achieve the same efficiency. While the tracking system costs 1 \$ to get additional 30% energy, the bifacial modules cost only 0.5\$ to get the same additional energy.

- Bifacial modules use 2 mm glass for both sides and thinner glass ensures lesser heat, thermal stability, resistance to impact and elimination of micro fractures.
- They use frameless construction which uses less connections, materials and labour resulting in compact packaging and economical transportation.
- The Glass to Glass bifacial modules have a life expectancy of 50 years as compared to 25 years for conventional modules, without the danger of mechanical damage or temperature /humidity related de-lamination of the backsheet resulting in loss of production or outright damage

Bi facial Glass to Glass PV modules use sunlight reflected



from ground



Bi facial Glass to Glass PV modules use sunlight reflected



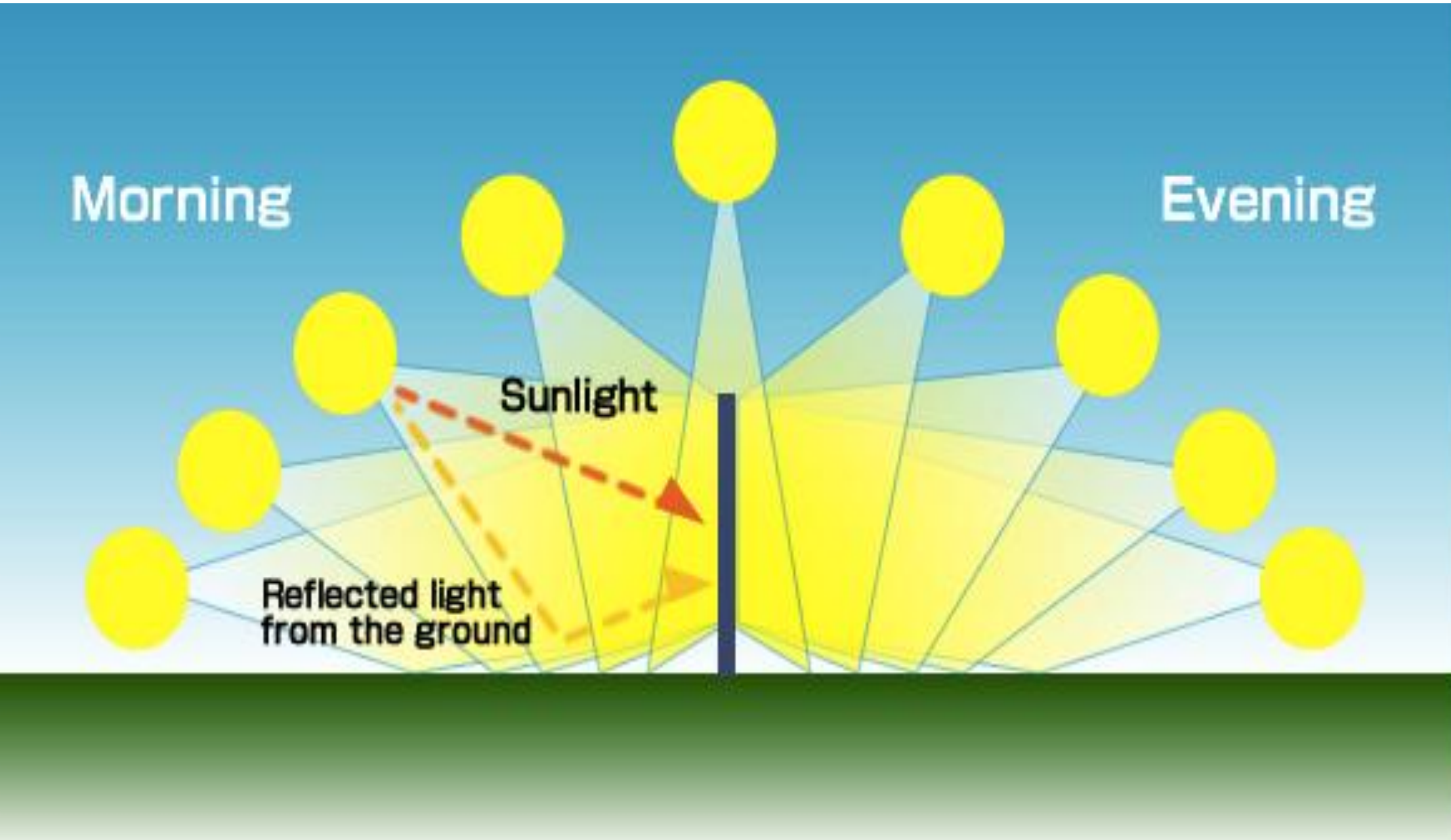
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Bi facial Glass to Glass PV modules use sunlight reflected

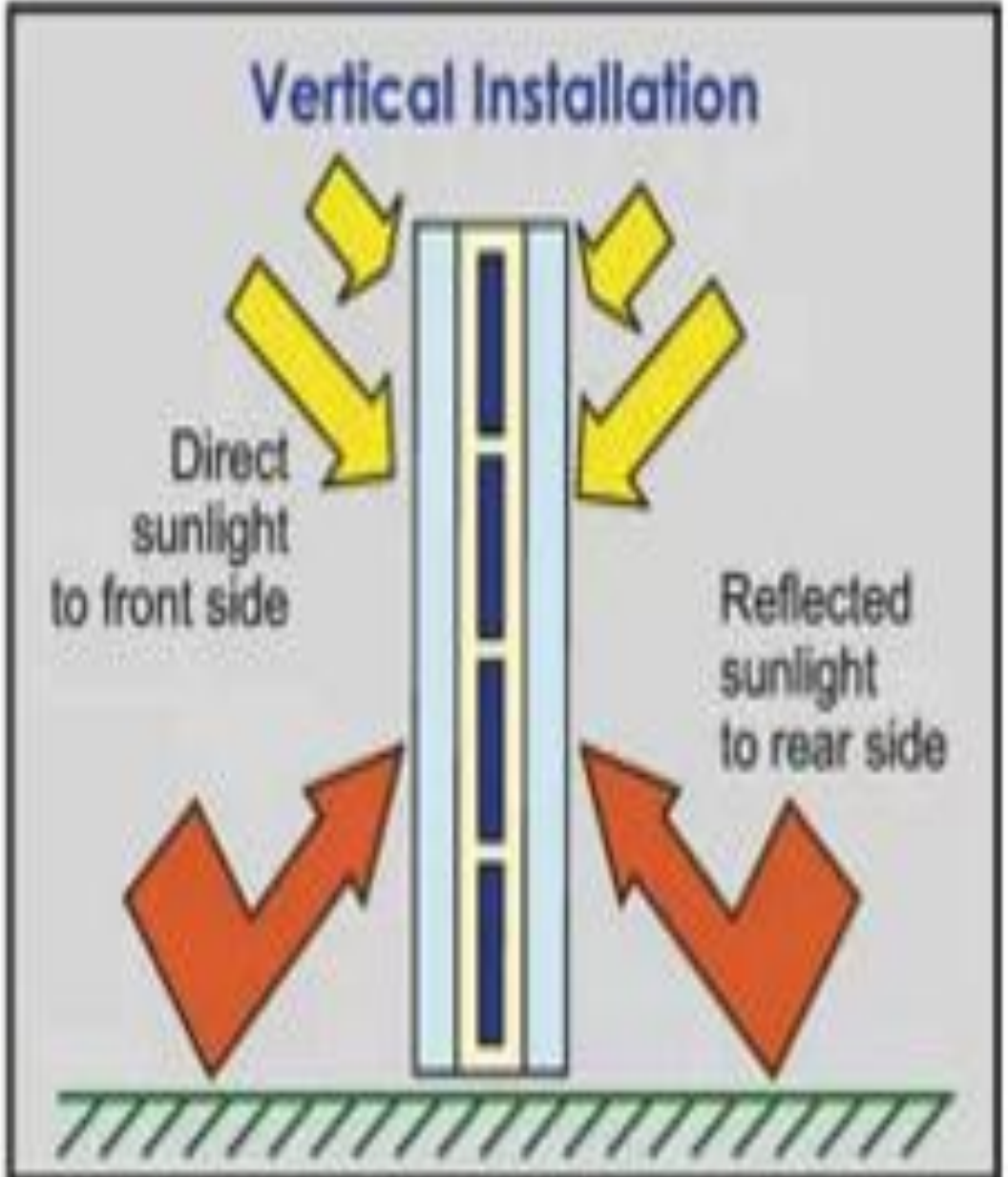
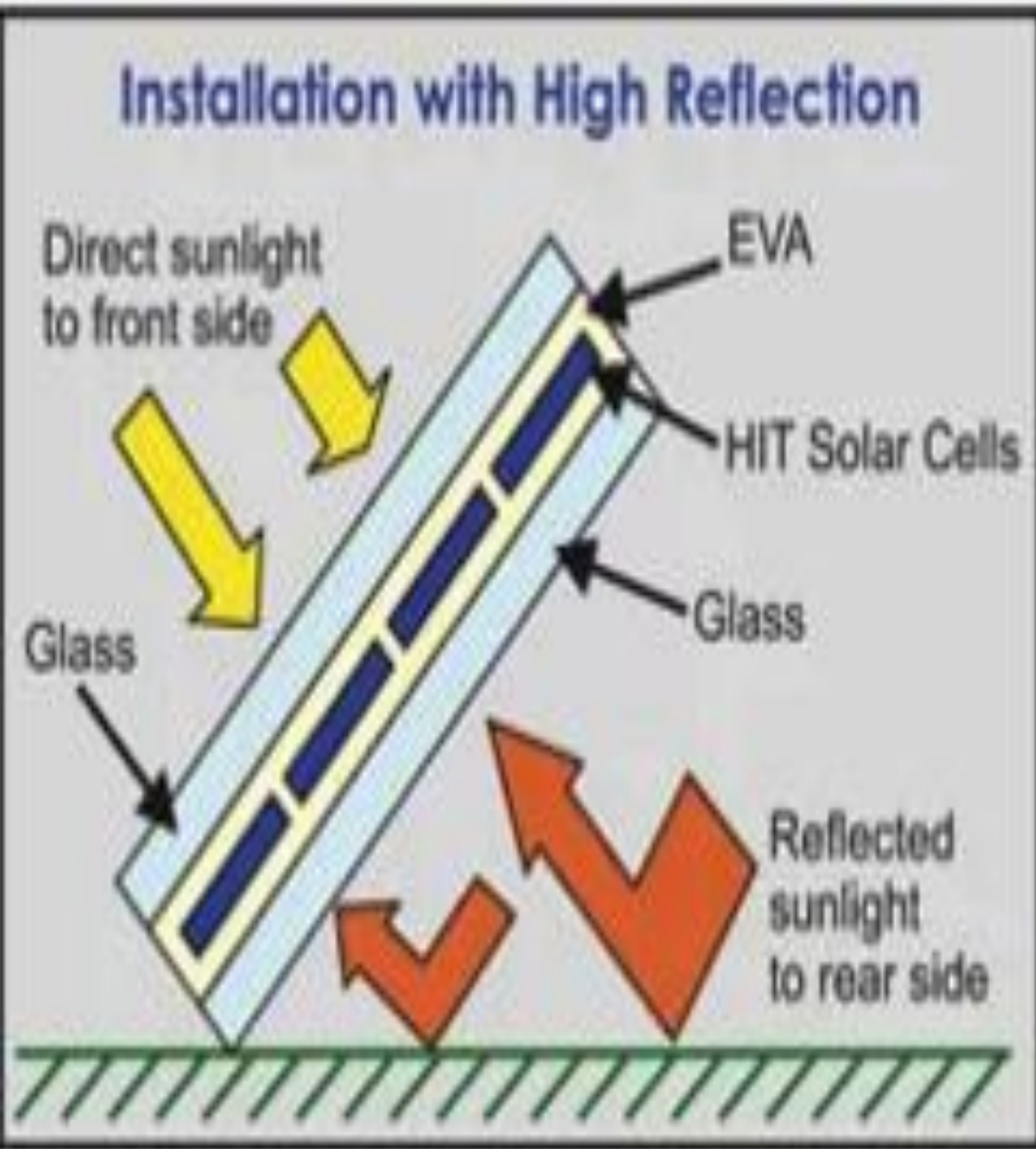


from ground



Bi facial Glass to Glass PV modules use sunlight reflected

from ground





- Gautham Greens is constructing a 20000 sq ft warehouse in Brooklyn, Newyork which is the first commercial scale greenhouse attached to a supermarket.
- Organic food will be grown in the greenhouse and sold in its stores year round
- The rooftop farm is outfitted with irrigation system which uses 20 times less water. It uses high transmission Solar glass and electronic systems to reduce energy consumption
- The Project eliminates long distance travel for the food thereby eliminating emissions and at the same time maintaining freshness,quality and nutrition for thousands of its customers
- They grow 7 to 8 times more food and their rooftop farm is equal to 6 acre traditional soil farming.
- They grow, cut and deliver products in the same day which is an amazing ability given their consistent quality
- They were able to supply vegetables right after hurrrycane “Sandy”
- There are many more such rooftop Green houses built by smart Engineers

Rooftop Greenhouse running on Solar energy?



Gautham Greens, Brooklyn, Newyork on rooftop



Rooftop Greenhouse running on Solar energy?

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Gautham Greens, Brooklyn, Newyork on rooftop



Florida state university, King Life Science Building

Roof Top Greenhouses



Nexus has been building rooftop greenhouses for decades. They allow people to use wasted roof space, especially if their footprint doesn't allow them room to use a greenhouse on the ground. The designs are custom fit to the buildings that they are built on and require expert engineering knowledge.

- There are innumerable innovative ways of using smart solar glass in smart and solar cities
- Non toxic Solar glass such as Antimony Free Solar glass of GBL which is also PID free and having high efficiency helps in manufacturing high efficiency Solar PV modules for use in Smart cities
- The 2mm fully tempered solar glass is enabling the module manufacturers to manufacture a new generation of PV modules for use in Solar cities
- There are other applications such as Green houses in rooftop which make the cities produce their own food using their rooftops

Thank You

