

Smart Solar Glass For

Smart Solar Cities

GUJARAT BOROSIL LTD

FEB 24, 2017

BOROSIL's 302.4 kWp Roof top R & D installation at Bharuch, Gujarat (India)

Smart Cities Mission An urban renewal Program BOROSIL

India imports nearly; 80% of its crude oil consumption, 15% of its coal consumption and 35% of its natural gas consumption and also 75% of Greenhouse gas emissions are produced in Cities & Communities. IT'S A CHALLENGE and Immediate Solution - Dovetail Renewable Energy with Conventional Energy for Smart Cities

The Government of India has a vision of developing 100 SMART CITIES as satellite towns of larger cities by modernizing the existing mid-sized cities.

In 2015, Smart Cities Awas Yojna Mission - A total of ₹980 billion (US\$15 billion) was approved for development of 100 smart cities and rejuvenation of 500 others.

Smart Cities Mission An urban renewal Program

Solar and other forms of renewable energy has been emerged as an essential in changing the face of modern India in the coming years.

The Smart City guidelines insists 10% of the Smart City's energy requirement to come from solar

Hon'ble Prime Minister's vision of making 100 Smart Cities with emphasis on -

- Solar power generation in City & offsite
- Solar Water Heaters for hot water
- Solar PV Rooftop systems for electricity
- Solar street lightings
- Solar pumps for water lifting
- Solar concentrators for steam based cooking
- Solar traffic signals, solar road studs/blinkers



BOROSIL

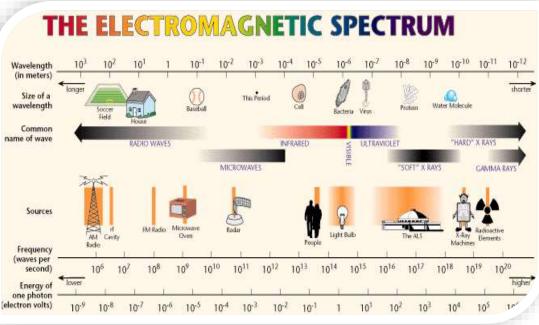
Let's brief on Fundamental of Soda Lime Silica Glass and its significance in Solar Energy Segment

SODA LIME SILICA Glass

- Soda-Lime-Silica glass is the most prevalent glass, used in Civil Construction and glass containers (bottles and jars) for beverages, food, and other commodities.
- □ This is relatively inexpensive, chemically stable, reasonably hard, extremely workable and accounts for more than 90% of manufactured glass.
- □ This is environment friendly as it uses common, easy to extract materials, without generating much waste in the production process. Again the recycling ratios of glass are one of the highest of all materials.
- Typically Soda lime 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 to convert the raw materials into melt at aprx. 1550°C. The melt then converted into sheets of various thickness from 2 to 25 mm by various FORMING Method – Rolled Process, Float, PPG etc.
- The formed sheets are termed as Float Glass, Sheet Glass And Textured Glass based on process and some properties of the product.

What is Solar Radiation?

- Solar radiation is radiant energy emitted by the sun from a nuclear fusion reaction that creates electromagnetic energy.
- The spectrum of solar radiation is close to that of a black body with a temperature of about 5800 K.
- □ The electromagnetic spectrum explains the different types of light waves that are emitted from the sun. About half of the **radiation** is in the visible short-wave part of the electromagnetic spectrum.
- The visible range for Human being start from 380 nanometers Violet Ray and end with 720 nanometers Red Ray. The pneumonic for the visible spectrum is **VIBGYOR** that correspond the all 7 rays within Visible Spectrum.
- Upper and Lower boundary of Visible Spectrum are known as UV (Ultra Violet) and IR(Infra Red).



What is Solar glass?

- Solar glass is a type of Construction Material, that designed to block radiant heat transfer, which is basically the amount of heat from the sun that passes through the glass and into whatever space is on the other side.
- 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 energy panels offer alternative solutions to a range of energy requirements, from small scale domestic applications to large scale solar power stations, from cloudy northern rooftops to hot sunny deserts.
- □ Solar glass is an integral and important element of these solar panels.
- Solar glass is used in applications such as Photovoltaic modules, solar thermal water heaters and Green houses.
- The Solar Spectrum used for each of these applications is different.

Application	Solar Spectrum (nm)	Reason
Green houses	300 - 780	Aid in photosynthesis and Better growth of Plant
Photovoltic modules	380 -1100	Photocells respond to solar radiation within this range.
Solar water heaters	up to 2500	Use thermal energy from the sun

BOROSIL

Now, let's see the experience in Solar Initiative Inside and outside our country.

Grid Connected SPV Roof Top System

World Wide Experience



- Germany has highest PV installed capacity of over 38 GW of which 71% is in rooftop segment (as on 31.08.2015).
- Italy has 12.7 GW PV installation with over 60% rooftop systems
- In Europe of total 50.6 GW PV installation, over 50% in in rooftop segment.
- FIT is norm in Europe while net-metering is popular in USA.

Building integrated <1% Social, commercial, Large commercial Private buildings: agricultural buidlings: buildings: 1-10 kWp 10-100 kWp > 100 kWp Rooftop 71% Market share in % of MW installed 28% in 2011

PV Market Segment in Germany

Development of Solar Cities BOROSII



- The solar rooftop is most economical and popular solar energy option. In India market potential for rooftop SPV is 124 GW.
- No additional land Need rooftop of residential, commercial, institutional & industrial buildings.
- □ 10 SQM area is KWp capacity. And Initial Cost would be Rs.75,000 per KWp.
- □ Cost of electricity generation Rs.7.00 per KWh and with 30% subsidy of MNRE is about Rs.5.50 per KWh.
- Low gestation time
- Electricity generated, is opted to be fed into the grid at regulated feed in tariffs or used for self consumption with net-metering. Eventually a Reduction of power bill. with surplus supply of electricity to local EB.
- Initiative will definitely support in Local employment generation.

Applications of Solar glass in Smart Cities - Rooftop BOROSIL® 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 on expansion of its tempering capacity that will enable it to make 2mm fully tempered Solar glass − as a pioneering effort in India as well as very few around the Solar Glass World.
- This low thickness high transmission glass and high efficiency modules coupled with low weight would be ideal for roof top installations.



L&T in Punjab having Largest Roof Top Plant in the World - 7.52MW with more than 30,000 PV panels and Power from the plant being fed to the local grid through a PPA signed with the state distribution company

Rooftop Greenhouse

Gautham Greens, A 20000 sq ft warehouse in New York the first commercial scale greenhouse attached to a supermarket. Equivalent to 6 acre traditional soil farming.

Gautham Greens, Brooklyn, Newyork on rooftop





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- This uses high transmission Solar glass and electronic systems and also outfitted with irrigation system using 20 times less water.
- The Project eliminates long distance travel for food thereby eliminating emissions and at the same time maintaining nutrient quality for customers.

And there are many more such rooftop Green houses built by smart Engineers. 12

Applications of Solar glass in Smart cities – Solar Thermal Hot water and heating systems BOROSIL[®]



Solar thermal water heating systems with robust copper tubes use Solar glass cover.

Glass protects the system against weather and permits the heat from Solar radiation

They are economical, Robust and with higher transmission

The System can be also used for room heating, HVAC, swimming pool heating etc.
 This is more efficient in heating applications as it does not require to convert radiation into electrical energy and then back to thermal energy.

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





For Cities starved of land space, deploying the solar modules in waterbodies is a new possibility and Japan has pioneered this concept.

Japan has installed floating modules in various ponds, lakes etc. as it lacks land space. A 10 GW of Solar power has been commissioned in 2015.

This can be adopted for Cities like Mumbai lacking land space.

Applications of Solar glass in Smart and Solar cities – BIPV Facade World Wide Experience BOROSIL[®]

BIPV - Building Integrated Photovoltaics.

- Photovoltaic materials replace Conventional Glass Façade in areas like Skylights and facades.
- This enhance elegance of a building at the same time being used as energy resource.
- 2 mm fully tempered solar glass can be the ideal solution for BIPV modules. They are economical in form of higher transmission, Cost and less construction load.

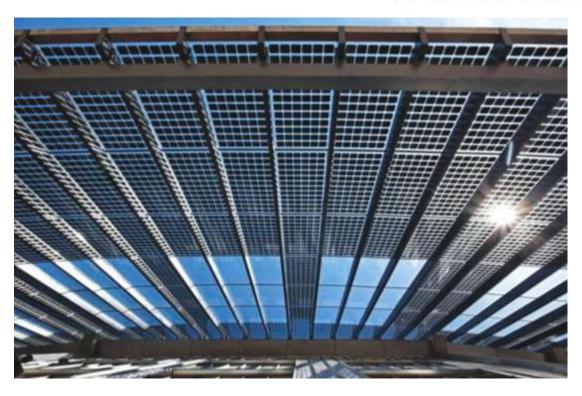


Window and Façade systems offer many possibilities of combining generation of solar energy and at the same time maintaining the architectural style in a smart way. Individual crystalline modules can be combined with ventilated/non-ventilated facades/windows/ solar shades and canopies

BIPV modules to replace Laminated safety glass World Wide Experience BOROSIL[®]

Glass to Glass BIPV modules have been approved by DIBt Deutsches Institut fur Bautechnik for use as Laminated safety glass in buildings.

Many architects start using glass to glass as infill units without the need for special additional strengthening of supports.



The mechanical strength of glass to glass modules are tested and this found to be as good as the laminated safety glass and Solar Energy Generation is in addition to.

The 2 mm fully tempered solar glass can find an ideal economy for smart solar cities

Bi facial Glass to Glass PV modules use sunlight reflected from ground

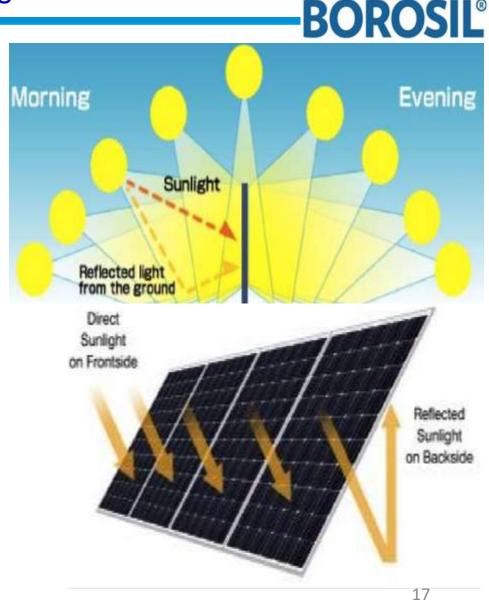
Bifacial modules is another solution where space is constraint.

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.

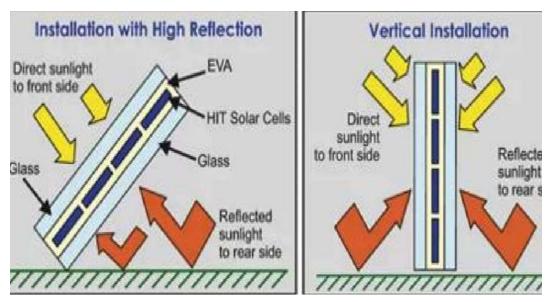
This increase life and enable in maximizing generation time per day by using indirect sunlight also.

The lamination method with no multilayer back sheet reduces fire hazard and risk of mechanical damage over lifetime.



Bifacial modules

World Wide Experience



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 / multi axis solar tracking system with economical bifacial modules to achieve the same efficiency. While the tracking system costs 1 \$ as against bifacial modules cost only 0.5\$ to get additional 30% energy.
- Bifacial modules have a life span of 50 years as compared to 25 years for conventional modules.
- 2 mm glass for both sides will be ideal for best economy.

What Makes the Solar glass Smart BOROSIL®

The Solar Glass is smart when it performs better in desired solar application than normal Solar Glass e.g. cheap import from China, Malaysia and Taiwan. Solar Glass is the prime aid in New and Renewable energy resources with green environment.

- Soda Lime Silica Glass is an universally accepted ecofriendly product, but it threatens the environment while enriched with toxic elements like Antimony.
 USEPA defined the safe limit of Antimony in edible water is 6 parts per billion.
- Developing ANTIMONY FREE SOLAR GLASS was one of its main goals as Solar energy is touted to be a green energy but the public in general are not aware of the dangers of millions of tones of Antimony laced glass that will be dumped in their landfills in twenty years. In past Mumbai High court, banned use of PET bottles in medicines as those contain antimony.
- The 2mm fully tempered solar glass will enable the module manufacturers to cater new generation of PV modules for use in Smart cities.

- The basic function of solar glass is to maximize transmission of solar energy and secure the solar cell and entire grid that produces and channelizes electricity.
- Iron in glass absorbs solar energy passing through the glass and reduces the solar radiation for solar cells to produce power. Mostly the Ferrous state of iron in glass absorbs a little energy in 600 to 900 nm range that is response region of normal solar cells. Despite best efforts, some residual iron will be always remain in raw materials.
- Addition of Antimony makes an oxidizing batch, and that ensure iron in Ferric state that absorbs solar energy in the range 380 to 435 nm which is lower than the threshold limit of response of normal solar cells. Thus it does not affect output of Solar module.
- Hence Module manufacturers prefer glass with antimony.

The problem posed by solar glass containing Antimony is a threat -Antimony is a toxic substance.

Antimony	ls	the	ca	use	of	several	diseases:
Induces	re	solra	tor		ble	ms	

Interferes with gastro-intestinal functions Causes skin problems Inhibits healthy reproduction Carcinogenic Breaks down chromosomes in human leukocytes

Causes DNA damage

Antimony in glass is leachable by water. Rain water collected from Solar modules were found to contain Antimony.

The usual method of disposal of solar panels is to crush and use as land fill. Eventually such land fill, inundated by rain will contaminate ground, corn field and our drinking water with severe toxicity several thousand times more than 6 ppb the prescribed limit of EPA in USA for drinking water.

0.6 Mil-Tons of solar panels will be disposed off till 2034 in Germany For Example, alone & the figure rises to 0.6 Mil Germany's Annual Disposal: Tons per year since 2035.

In addition Japan, China and India have announced extensive solar programs. India announced its 100 GW of solar power program by 2022. This will need 0.6 Mil-Tons of panels!

Test can be carried out as prescribed by **GBL**

A sample was crushed to a powder of 300

- 500 microns and was put inside a container with 50 times its volume of distilled water. This container was raised to a temperature of 121°C and kept in an autoclave at 1 bar for just 2 hours. This water was tested and was found with 4.5 PPM Antimony which is 750 times higher than prescribed limit of EPA in **USA for drinking water.**

BOROSIL

Vear	Tons of Modules
2029	40.200
2030	57.060
2031	50.580
2032	76.260
2033	117.000
2034	266.760
2035	419.280
2036	449.100
2037	456.240
2038	198.300

As one can infer from the table, with the current rate of 3000 MW each year in Germany, 180,000 tons of PV modules will contribut to be added annually.

The proposal to ban of Antimony trioxide through amendment 87 was adapted by the committee of European Parliament set up to work on revision of the EU directive 2002/95/EC on the Restriction of the use of certain Hazardous Substances in electrical and electronic equipment (RoHS recast) on 2.6.2010

At that time, dispensation was granted to optical glass and solar glass because the industry represented then that it wasn't possible to make these products without Antimony

Since then, the world's top glass companies have been hard at work, trying to develop glass without Antimony.

While Glass leaders Schott and Corning have developed Antimony Free glass for applications such as Cooktop Glass, OLED packaging, Solar glass and BOROSIL took the cudgels to develop the same in Solar Glass and succeeded in their efforts and at the same time meeting SPF's stringent testing to obtain P1 grade for Solar glass. It has also obtained TuV certification for Antimony Free Glass.

Common methodology of selecting Solar Glass in India by Flash Tester.

- Conventional Solar glass with Antimony retains a slight edge over solar glass without or low Antimony.
- A non conventional Solar Glass with low or 0 antimony would show CTM loss in flash tester of about 2 watt in a 250 W module a, which is less than 1%. The tendency amongst the module manufacturer is not to accept a single watt of output loss even compromising by endangering the mankind with usage of toxic glass.

Although Developing ANTIMONY FREE SOLAR GLASS should be one of prime moto of Solar energy, touted to be a green energy. But lacking awareness in general create dangers - millions of tones of Antimony laced glass that will be dumped in their landfills in twenty years. From Green aspect of Smart Cities initiative, the regulatory bodies need to decide banning Antimony for solar glass.

- The PV Solar business and regulatory bodies must turn its attention to disposal of these solar panels when they become defunct.
 - **How will these be disposed?**
 - □ What will be the method and cost of disposal?
 - Who will bear the cost of disposal? The users? If so, should they be warned that disposal of panels having glass with Antimony could become exorbitant?
 - □ Can the 1% higher output justify any additional disposal cost?

e.g. Lead used to be added to petrol for better performance. A temporary dip in performance with unleaded petrol was soon overcome with better engine design. New engines significantly outperform the old engines which used petrol with lead.

GBL Antimony Free Glass

Test certificates from SPF, Rapperswil Switzerland prove antimony-free solar glass to be the highest performer in the world today.

P1 Class Certificate from SPF (Prismatic/Matt) Antimony Free Solar Glass

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Austral für Solerisettell (197, Michaelusk Reported) 1007, Childab Reported) were spillet The process of making antimony-free glass led to the complete re-engineering of the glass composition.

In addition to making the glass toxin free, Borosil SolarBurst glass has many additional attributes that lead to better performance-

High resistance to PID

A high degree of resistance to Potential Induced Degradation (PID) is built into the glass. Tests conducted by the Photovoltaic Institute in Berlin have demonstrated that glass from Borosil is the most resistant to PID as compared to the product from other leading manufacturers.

High Chemical Durability

Chemical durability of our antimonyfree glass is 6.7 ml vs. an average of 8.6ml for other solar glasses, as measured in tests laid down by USP.

BOROSIL

Lowest Iron Content

With an iron content of less than 80 ppm, antimony-free glass is the lowest iron content solar glass in the world.

Solar Burst smart Glass that holds Sunlight

Borosil SolarBurst glass is already the world's best. Every single day is a journey to make it even better. Each milestone has proven to be a leap for the solar industry.

Anti-reflective coating

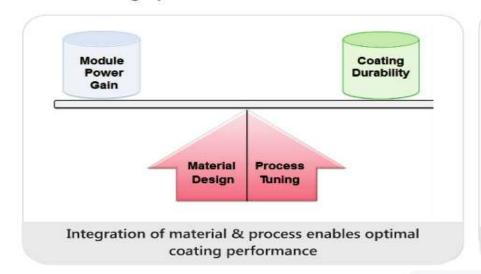
AR Coating Optimization

- Light transmission and performance durability certified by TUV Rheinland, Netherlands
- Light transmission > 93.5 ~ 94% for single side AR coated glass
- Cost effective model that achieves a balance between optimal light transmission gain and coating durability
- Smooth and uniform surface morphology ensures a seamless contact surface and hydrophobic characteristics

Anti Reflective Coating in a clean room

BOROSIL





ARC Structural Design

<u>Borosil</u>	Compa	any.A	Company B
1000	e notes a secondaria de la companya		
	Borosil	Company A	Company B
Morphology	Consistently small voids High strength Hydrolytic stability	Very big random voids Low strength React w/moisture	Big particles and big void Low strength Allow moisture to penetrate
Surface	Smooth & uniform Difficult for dust to collect	Non-uniform surface Very bad scratch resistance	Rough surface Easy for dust to collect Bad scratch resistance
	· Good scratch resistance		

Tighter porosity control = higher transmittance & durability

Solar Burst smart Glass that holds Sunlight BOROSIL®

Glass efficiency

Paths Phickoge SP/F Posting

improve Add. Adv.

Borosil SolarBurst Glass has been measured by SPF Switzerland to have a glass efficiency value of 0.952 which is the highest amongst photovoltaic glasses tested by them.



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Solar Burst smart Glass that holds Sunlight BOROSII

Lowest Iron Content

With an iron content of less than 80 ppm, Borosil SolarBurst Glass is the lowest iron content glass in the world.

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What Makes the Solar glass Smart

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.



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Light transmission and IAM of Tempered Glass WUR Test Report



Report optical lab Wageningen UR Greenhouse Horticulture

General

Client	Borasil	
Date	28 February 2014	
Researcher	Vida Mohammadkhani	

Results

Mean Values

Measurement (appendix)	T normal	T hemispherical
Method (appendix)	WUR-TNO	WUR-TND
Mean (appendix)	NEN 2675	NEN 2675
Tempered glass	92.2 ± 0.5 %	77.1 ± 0.5 %

	Angle of incidence								
Sample	10	20	- 30	40	50	60	70	80	
Tempered glass	92.4	91.4	90,0	84.2	77.8	69.2	58.2	40.8	

Light transmission and IAM of ARC Glass

WUR Test Report



General

Client	Borosil	
Date	28 February 2014	
Researcher	Vida Mohammadkhani	

Results

Mean Values

Measurement (appendix)	T normal	T hemispherical
Method (appendix)	WUR-TNO	WUR-TNO
Mean (appendix)	NEN 2675	NEN 2675
Tempered ARC glass; ARC liquid Honeywell	94.7 ± 0.5 %	79.2 ± 0.5 %

	Angle of incidence						10	
Sample	10	20	30	40	50	60	70	80
Tempered ARC glass; ARC liquid Honeywell	94.9	93.8	91.7	85.9	79.5	71.0	60.5	45.7

What Makes the Solar glass Smart

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 1000 V and above, causing damage of the modules or reduction in power output.

Resistance to Potential Induced Degradation

In tests conducted by Photovoltaik Institut AG, Berlin, solar glass from Borosil has proved to be the most highly resistant to PID, as compared to the product from several other manufacturers.

- 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.

Glass from the leading Chinese glass maker

Test	Report				PI
3.1 Overview of	Test Results				
Serial number	Status	P (W)	Power de Initial [%]	Prevents (1963)	PID quality criteria (as defined in test stand description.)
	initial	16.24			-
	after PID 6h	16.14	-0.65	-0.65	Α.
2015090007	after PID 19h	13.68	-15.78	-15.77	B
	after PID 25h	12.10	-25.50	-11.54	в
	after PID 48h	9.46	-41.78	-21.85	- C

Glass from the leading European glass maker

3.1 Overview of	Test Results				
Serial number	Status	P _{uee} [W]	Power de	Previouse [76]	PID quality criters (as defined in tex stand description
	initial	16.07		-	1
	after PID Gh	16.06	-0.08	-0.08	A
2015090009	after PID 19h	15.41	-4.12	4.04	A
	after PID 25h	15.13	-5.90	-1.85	В
	after PID 48h	12.90	-19.74	-14.72	В

Test	Report				PI
3.1 Overview of	Test Results				1.00
Serial number	Status	P _{ure} [W]	Power de Initial [%]	viation to Previous [%]	PID quality criteria (as defined in test stand description)
	initial	15.96		-	
	after PID 6h	15.94	016	016	A
2015090004	after PID 19h	15.31	4.31	-3.96	A
	after PID 25h	15.03	-5.87	-1.83	В
	after PID 48h	12.94	-18.97	-13.91	в

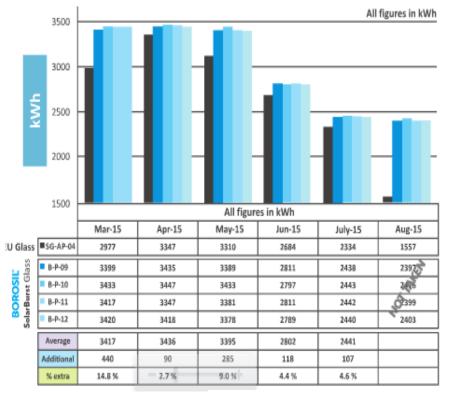
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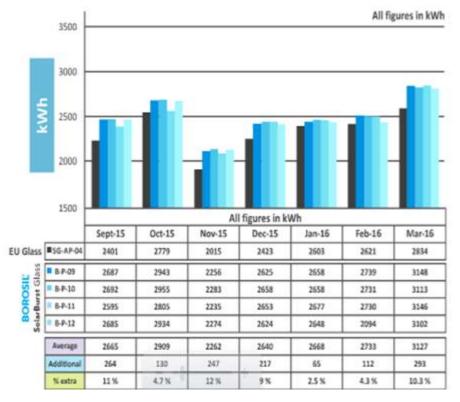
BOROSIL

Field Tests

The phenomenal leaps Borosil took in the research labs needed to be proven on the field, so field tests were conducted on modules made from Borosil SolarBurst Glass against modules made with glass from a leading European producer. The results speak for themselves. Over a period of 12 months, clusters of 96 modules placed side by side in our rooftop R&D installation, have yielded the results shown below. All modules were made by EMMVEE Photovoltaic Power Pvt. Ltd. at the same time, using identical components, except for the glass.

The results are automatically posted continuously online and are in the public domain.





The tests re-affirmed the fact that BOROSIL SolarBurst Glass has superior performance even in field conditions.

Conformity of EN 12150-1 (4mm) Fragmentation and Mechanical Strength

		200 - POP &	Right		
				Certif	ficate
		Test report			
	EN12180-1, improved	a glass product according to European st ation and mechanical strength, concern	ing the	Standard	ISO 9001:2008
	manufacturer: Gujara	ark: Tempered Prismatic Solar Glass, type t Borosil Limited	c.emn,	Certificale Registr. No	01 100 106716
					T.IV Ithemand Cart GmbH confiles:
	Report a inter Dato	1994 12 12 19 19 19 19 19 19 19 19 19 19 19 19 19		Certificato Holden	GUJARAT BOROSIL LIMITED
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	Clart	Oujent Scruel Limited Village Rocks Tempt Lice and Chilles Element 196339 Sinis Sujace India			Village: Goveli, Ta.: Jhagadia, Dist. Bharuch – 393 001, Gujarat, India.
	Prigor: Canther	410.8.025		Scope:	Manufacturing and supply of sheet glass
	Project in anne	EM12165 4 x 4 glass		3.4	Including annealed, tempered and AR coates
	Nandor Of Ages				solar glass, figured/patterned glass.
					An such easy performed Report No. 109718, Proof has been Limished that the regularization according to ISO 9001-2000 are fulfiled
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BOROSIL[®]

ISO 9001:2008

from TUV Rheinland

	of Performance ARC Glass ormance Durability	Conformity of Performance EN 12600 (3.2mm) Drop Pendulum test
TÜV Rheinland Nederlar	nd B.V. A TÜVRheinland" Practasiy Riger.	TÜV Rheinland Nederland B.V. A TÜVRheinland [®]
slandard ASTM	Test report ting to a glass product according to – amongst others - D3363, and DMI 50021, concerning the product market place with AR coaling PV modules, manufactured by: Ltd.	Test report Test report relating to a glass product according to European standard EM 12600, Pendulum test for flat glass, concerning the product marked as: Bornell 3.2 mm class patterned, manufactured by: Gujarat Dercell Limited
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Certificate of constancy of performance (CE Mark)

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Precisely Right

Conformity of ITT Report (3.2mm and 5mm)



Conformity of TUV **Conformity of Performace** Hail Stone Imapct Resistance (3.2mm) IEC 61215 Zero Antimony WESTPAK, INC. TUVRheinland* GARDY BRANKED No that is not the Precisely Right. GUJARAT BOROSIL LIMITED HAL TESTING of the Glass Shouts LETTER OF COMPLIANCE Report No. 112-15-1335A, Rev. 2 Proposal No. 3887G, Rev. B. Ref 1803029250 Customer Information Report No. IND/ELR/CH/2014/00919. **Gularet Boroall Limited** 44 Khonne Construct House Holder : **Gujarat Borosil Limited** ROThedeni Ming Munstei, India 400018 Village Govali Tehsil Jhagadia District Sharuch- 392001, State Gujarat, India. Laboratory Information Janaka Solvi, Tyler Garlinik, and Potor Novak. Weagaak** Product Glass Tast segments July 16. 2015 Test ctate: Wastpak** ishoratory San Jose, California WEETPAK, Inc. is accredited to 19D 17025 General Competence for Testing and Calibration Laboratories. WESTPAR, Inc. a also registered to 190 8001 Quality This letter of compliance is based on the testing of samples of Management and IBO 14001 Environmental Management Systems (#10001175 and the above mentioned product and to certify that the sample #10004200). For accredited test methodologies, please visit www.wsstpak.com for the ficope of Accreditation of Westpair, Inc. tested according to the SEM - EDS Analysis of glass and fulfils the requirements of Zero Antimony content. Purpose of Testing The purpose of leading was to verify that the giass sheets were capable of withstanding the impact of hallstones. Three glass sheets were subjected to the following last input. Mate The report order this investigation will not imply the PDV Humand Linux. For flock in Recognition the product ner dass bisekterte de ses gittebeg et treftsatet ideats in seter Bebrane is TOT Bearland an er in teresetter whith the product Tast trgat Randarti Bafalacani EC ES215, Editors 2.8, Cause 10, 17 DURG THE Hall Test Acceptation otheris are specified by Clause 10.17 of IEC 61215, Editor: 2.0. Bargaien 18.00.2014 trial Plant Street, But Main Stand Results and Observations faiction/Bala (184 Phase 1 CONTRACTOR OF TAXABLE PARTY. Twailing at Observator. Appendix which the party is not 101 10 1010-1010 No reagon visual defects, an apportfect by Clauses 10.17 of RC 01215. while and sends where the Hair Treat Editors 2.0, were atomised on the gass shoets on a read of the test -10.4 Sincial Contract 1000 Pandinas ture: WESTPAK, INC **Bandust** Peige 17025 100 9001 3808 highly in the **ISCI HOOL2894** KORDERTS & KORDERAL CONTRACT & ANOMACINE bage (testification 10 Great Data Bialevart - Sen Jose - CA - 95119 - Phone: 408.224.1303 - Fac: 406.224.8113 Statement and statements 10100 Rosale Street , Sule 181 , San Diego , CA., 92121 , Proce 858,623,8130 , Fax 658,623,8131 new weeksek cont

GBL'S Solar Burst Smart Glass

- Lowest Iron (<100 ppm) Textured Glass
 - Prismatic Matt & Matt Texture
 - □ Anti-Reflective coated textured solar glass
 - Lowest even 0 Antimony among all textured solar glass.
- ❑ Light Transmission in visible range : ≥91.5% in Uncoated and ≥ 93.5% in AR Coated Glass
- □ 7.5% more power output.
 - □ Major Area of Application
 - Photovoltaic modules
 - □ Flat thermal collectors
 - Greenhouse applications



- Our Smart Vision -Working Towards Preserving The Earth Every Way We Can. Thank You