Green Building

Salient features of a Green Building are:

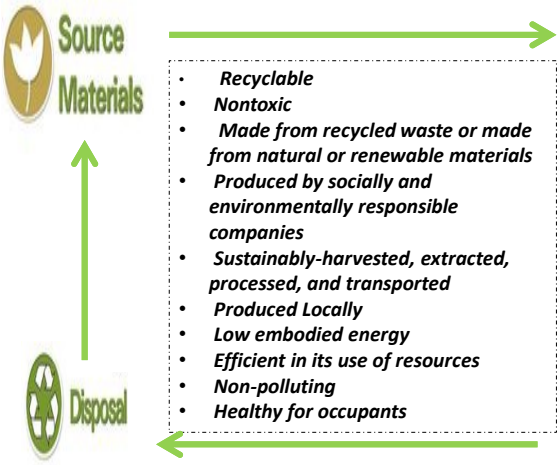
1. Site Planning - Minimal disturbance to the landscape
2. Building envelope design
3. Building system design (eg HVAC)
4. Integration of renewable energy sources to generate energy
5. Efficient use of water, water recycling and waste management
6. Selection of ecologically sustainable materials (with high recycled content, rapidly renewable resources with low emission potential)
7. Use of energy efficient and eco-friendly equipments
8. Indoor environmental quality (maintain indoor thermal & visual comfort and air quality)
9. Effective control and building management systems

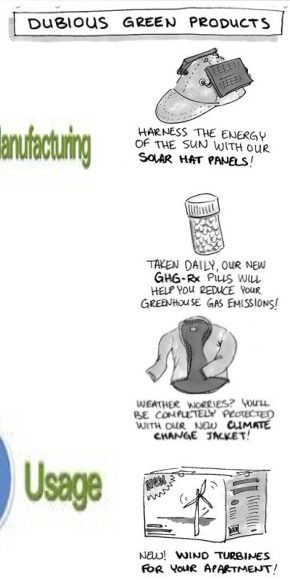
"A green building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building."

The Most Important Element: The Efficient Use of Energy
Buildings can incorporate many green features, but if they do not use energy efficiently, it is difficult to demonstrate that they are truly green.

Green Product

Green product is a term that describes a product that protects the environment and replaces artificial ingredients with natural ones. Green products are less harmful to human health and they conserve energy.





Glass – A quick overview

Glass is an amorphous (non-crystalline) solid material	The word 'Glass' is derived from the Latin term 'Glesum' which means transparent substance	Glass is typically brittle and optically transparent	The commonly used glass types are Flat glass and Container glass

Unmatched aesthetics which allow architects and builders to explore unconventional building shapes.

No deterioration, corrosion, stains or fading throughout its lifespan.

Transparent to visible light.

Zero-degeneration and **easy maintenance** which helps in maintaining a clean environment.

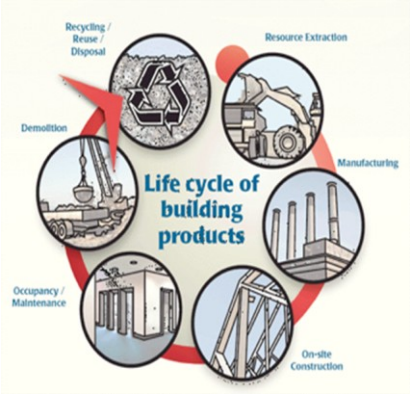
Can be recycled indefinitely as the structure of glass does not deteriorate through the process.

A Sustainable material.

Glass – A Green Building Product

How is Glass Green?

- Recyclable
- Use Renewable resources
- Locally or Regionally produced
- Energy Efficient
- Low Environmental Impact
- Durable
- Minimize Waste
- Positive Social Impact
- Affordable



There is no **Black** and **White** when it comes to **Green**

Glass- Industry Segments

Flat glass is a type of glass, initially produced in plane form, commonly used for windows, glass doors, transparent walls and windshields and of two types:
- Sheet Glass
- Float Glass

Container glass is a type of glass used for the production of glass containers.

Speciality glass Pressed and blown glass for tableware, cookware, lighting, televisions, liquid crystal displays, laboratory equipment and optical communications

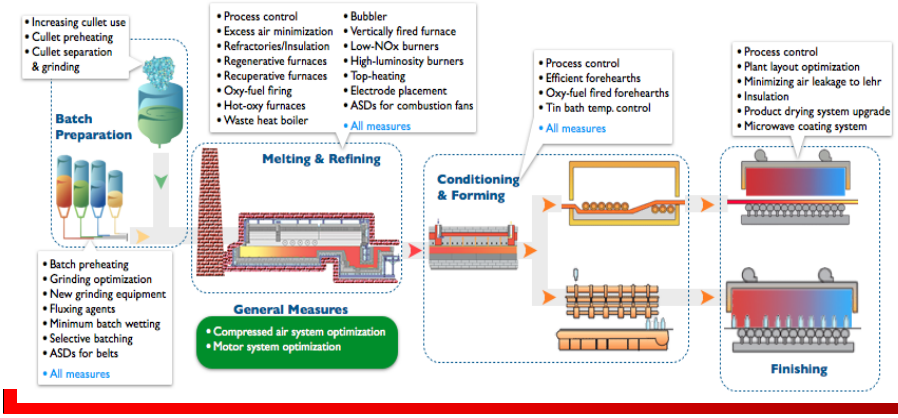
Fibre glass (glass wool) insulation for buildings, roofing and panels. Textile and plastic reinforcement fibers for composites in the construction, transportation and marine industries

(in terms of weight percentage)				
Constituent	Container Glass	Flat Glass	Fiber Glass	Laboratory Ware
SiO_2	73	72	54	80
B_2O_3			10	10
Al_2O_3	1.5	0.3	14	3
CaO	10	9	17.5	1
MgO	0.1	4	4.5	1
Na_2O	14	14		5
K_2O	0.6			

Float or Architectural Glass-Manufacturing

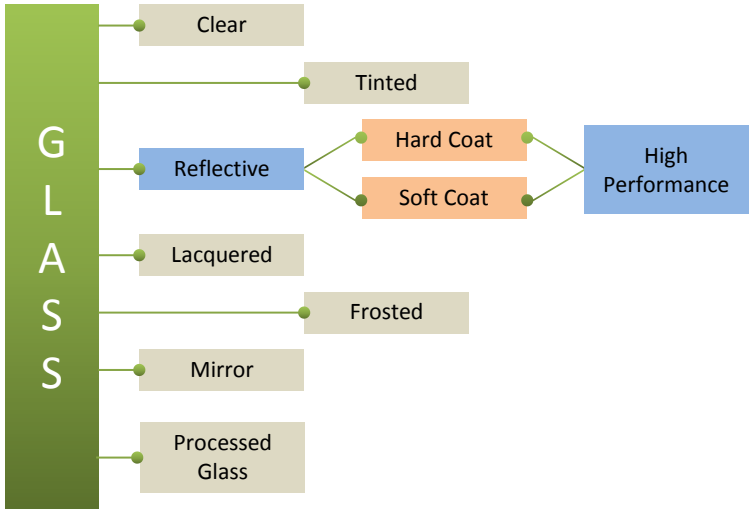
Basic steps:

- raw materials selection.
- batch preparation (i.e. weighing and mixing raw materials).
- melting and refining.
- conditioning.
- forming.
- post-processing (i.e. annealing, tempering, polishing or coating).
- The technologies employed in each step depend on the glass product manufactured.



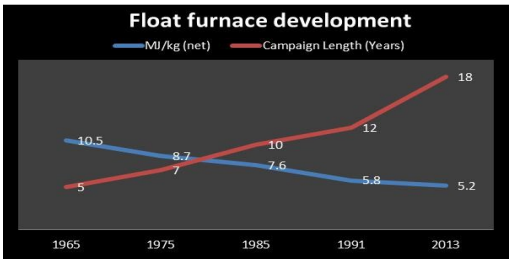
Glass Products

A single element added to glass can significantly change its properties.



Energy consumption in Glass manufacturing

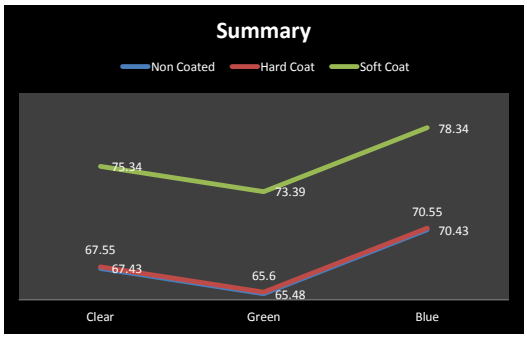
Period	Tonnes Per Day	MJ/kg (net)	Campaign Length (Years)
1965	270-450	10.5	5
1975	320-680	8.7	7
1985	320-820	7.6	10
1991	320-900	5.8	12
2013	upto 1000	5.2	18



- *Natural gas is normally used as the fuel in glass furnaces.*
- *Some furnaces also use electrical boosters, usually based on molybdenum electrodes; since molten glass is an electrical conductor at high temperatures, the boosters, which supply ~ 10 – 30 % of the energy input to the furnace, help melt the glass. The melting of wool-type fiberglass is predominantly done with all electric furnaces.*
- *Glass melting is a large source of NOx emissions which must be reduced, while simultaneously reducing energy costs. Oxy-fuel firing (no N2 as in air-fuel mixtures) reduces the NOx emissions.*

Energy Consumption for different product Types

Coating	Colour	VLT	SF
Non Coated	Clear	79	73
	Green	65	46
	Blue	52	43
Hard Coated	Clear	58	60
	Green	47	37
	Blue	37	35
Soft Coated	Clear	40	30
	Green	35	22
	Blue	30	22



Energy Consumption for Various types of processing:
Tempering – 2.3 KW hr
Lamination – 19.7 KW hr
DGU – 2.5 KW hr

Glazing selection Parameters

Parameters	Importance
Aesthetic	Enhances look of the building
Energy Efficiency	It is a combination of lighting & cooling energy saving
Improved Day-lighting	Reduces artificial lighting requirement by using glazing
Glare Reduction	It can defeat the purpose of using glass
Acoustic	It can reduce sound transmission significantly
Strength	Gives strength that even can be used as flooring

Energy Efficiency

- Use high performance glass
- Use glass in appropriate orientation
- Smartly design building with shades, inclination etc. to reduce direct heat ingress
- Use IGU, if building design requires
- Use rated frames

Climate Response | Orientation & Design | Façade Design | Material used

Design factors impacting Glass Selection

Climate Analysis : -
Climatic condition of the location is important to select type of glazing as different weather impacts differently.

Optimum Orientation of Building: -
Before selecting any glazing material, study of building orientation is must, if rightly oriented, we may get energy efficiency without using high performance glass. (according to Indian context, South West orientation is responsible for maximum heat gain)

Shadow Analysis: -
Shadow of the building as well as surrounding also impacts heat ingress (direct & defused), hence changes the glazing requirement.

Daylight Analysis : -
Study of available lux level, window size and other passive design should be consider before defining the required VLT of a glass.

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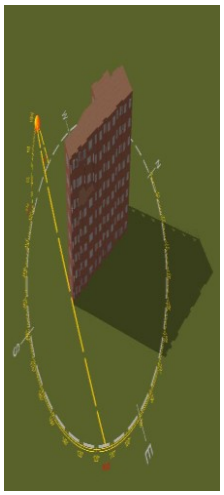
Case Studies-Energy Impact

Hotel in Kolkata

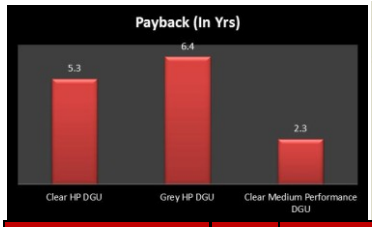
Equalized Glazing area of 1000 sq mtrs

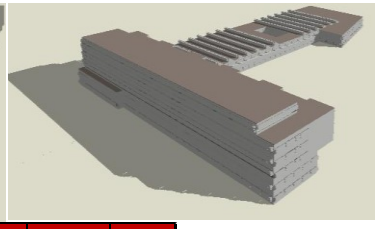
		Energy Consumption in KWHr					
Glass	Cost	Prod & Install	Operation	Total kwhr	Energy Impact	Initial Cost Impact	Payback in yrs
Clear	600000	34770	500160	534930	0		
Green	750000	32820	487650	520470	14460	75060	2.0
Blue	750000	37770	482410	520180	14750	106500	1.4
HPG	1050000	45680	464988	510668	24262	211032	2.1

A star Hotel in Kolkata with the longer sides facing East –West direction and an example of linear relationship where the glass with lower SF was performing the best. However VLT did not have an impact as due to lower depths and direct light incident on the façade even a glass with 17% SF was sufficient for floor space lighting



Case Studies – Learning center in Mumbai





Glass	Cost	Energy Consumption in KWHr			Energy Impact	Initial Cost Impact	Payback in yrs
		Prod & Install	Operation	Total kwhr			
Clear DGU	1600000	67430	538239	605669	0		
Clear HP DGU	2400000	65480	514982	580462	151242	800000	5.3
Grey HP DGU	2400000	70430	489172	559602	125159	800000	6.4
Clear Medium Performance DGU	2000000	78340	451897	530237	176192	400000	2.3

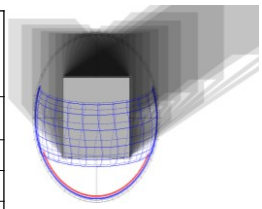
Buffer on the E-W façade. Classrooms in N-S orientation, although critical, but using louvers to reduce heat gain, the best performing glass was a normal SC contrary to expectations

Case Studies – Commercial Building in Chennai

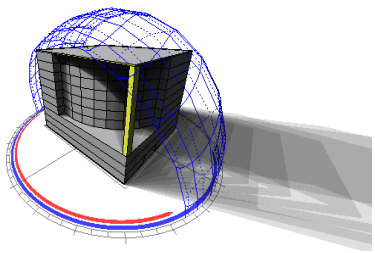
Commercial building in Chennai

Equalized Glazing area of 1000 sq mtrs

Glass	Cost	Energy Consumption in KWHr			Energy Impact	Initial Cost Impact	Payback in yrs
		Prod & Install	Operation	Total kwhr			
Clear DGU	1600000	67430	403849	471279	0		
Green DGU	1750000	65480	336573	402053	69226	415357	2.2
Blue DGU	1750000	70430	348794	419224	52055	312331	2.9
HPG DGU	2500000	78340	198029	276369	194910	1169459	4.6



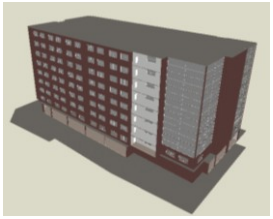
A 5 storey office building in Chennai which was oriented properly E-W showed expected results in terms of improving performance as the SF decreased. However as the VLT increased beyond 30% there was risk of glare along the periphery. Even the higher embedded energy whilst during production was offset by better operational savings

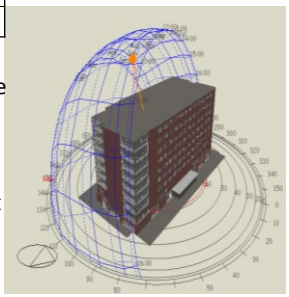


Case Study – Residential Building in Bangalore

Residential building in Bangalore

Equalized Glazing area of 1000 sq mtrs							
		Energy Consumption in KWHr					
Glass	Cost	Prod & Install	Operation	Total kwhr	Energy Impact	Initial Cost Impact	Payback in yrs
Clear	600000	34770	609685	644455	0		
Green	750000	32820	625431	658251	-13796	-94474	negative
Blue	750000	37770	637520	675290	-30835	-167008	negative
HPG	1050000	45680	604845	650525	-6070	29043	15.5





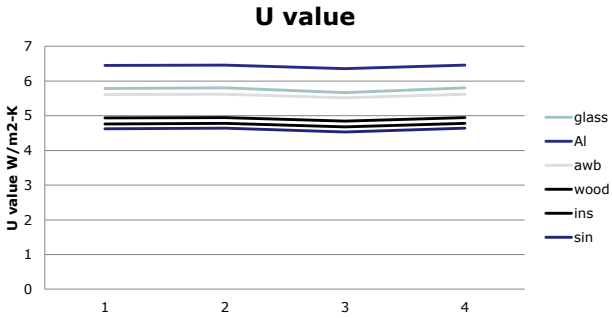
A favorite example of mine where the so-called high performance glasses were found to be wanting. The orientation was spot-on And the activity zones intelligently designed so as to reduce the HVAC loads. The moderate weather conditions in Bangalore only Proved to be a blessing where the Clear Glass itself was sufficient In terms of meeting the functional requirements

Do's in Indian context

- Add overhead shading
- Add internal shading
- Have more windows on North and South facades
- Use glazing with Optimum VLT ; low SHGC and U value
- Use dark tinted glass at visible height and clear at higher levels
- Use EA between 0.2 to 0.3
- Add light shelves to interiors
- Use high windows (ventilators in naturally ventilated buildings)

Don’t in Indian context

- Do not use glass with very low U value and moderate SHGC.
- Do not assume dark tinted glass brings solar control
- Do not use un-insulated frames
- Do not use Tempered glass as safety glass
- Do not use IGU as sound insulation glass



Learning

- Remember that same fenestration product behaves differently w.r.t. the specific design.
- It should not be assumed that products with Low U-value and SHGC are best and universal solution.
- Direct radiation falling on the windows should be minimized.
- For shaded windows, products with lower U values perform better.
- For un-shaded windows receiving high amount of sola radiation, products with low SHGC would perform better.
- Hence glazing should be selected after thoroughl considering the design.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