GUARDIAN SUNGUARD®
ADVANCED ARCHITECTURAL GLASS

Glass and High Performance Coatings & Tools

By: Sanjiv Shrivastav

Agenda

- Introduction – Guardian Industries, USA & Gujarat Guardian Limited, India.
- Coating process (Sputtering).
- Performance possibilities with sputter coatings.
- Guardian Tools.

History

1932: Windshield producer in Detroit / MI / USA

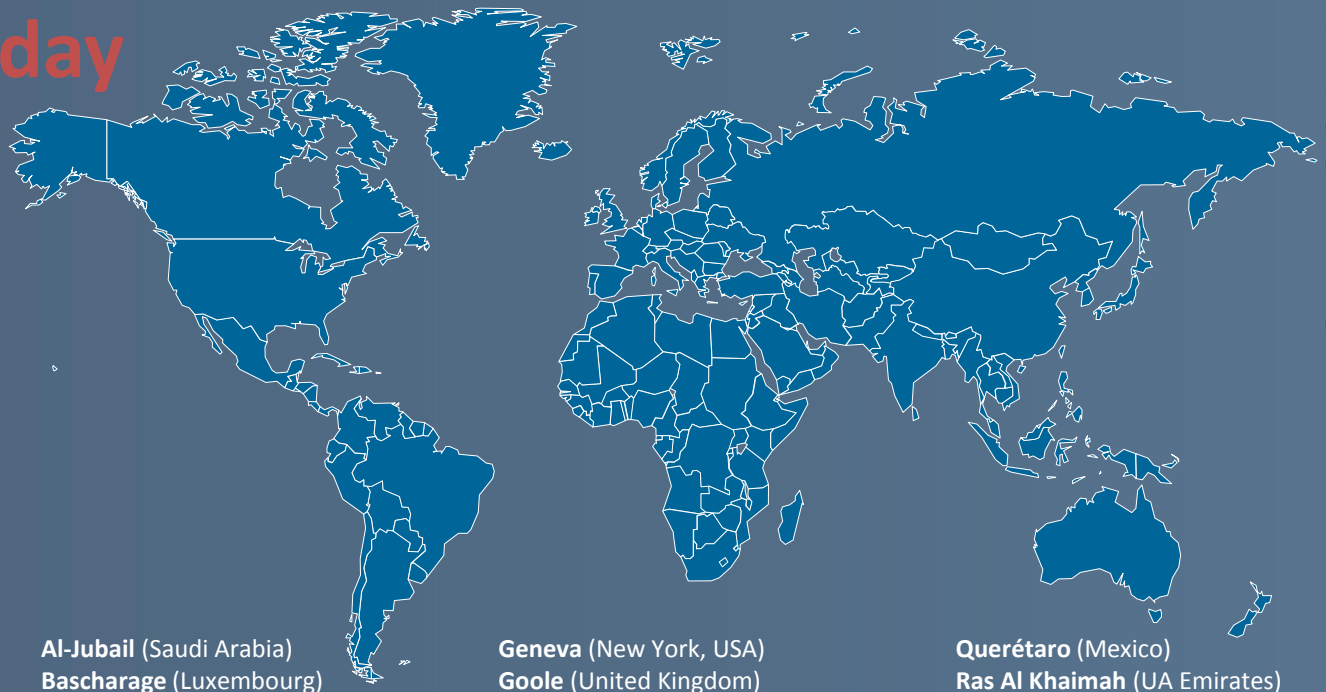
1970: Frist float glass plant in Carleton /MI/USA

1981: First float glass plant in Europe

1991 : Gujarat Guardian Ltd –Gujarat - INDIA

Today: - More than 20,000 employees in 26 countries in 5 continents

Today



20.000 Employees

28 float lines in 18 countries and on 5 continents

17 coating lines – Leader in coated glass products

Al-Jubail (Saudi Arabia)
Bascharage (Luxembourg)
Cairo (Egypt)
Carleton (Michigan, USA)
Corsicana (Texas, USA)
Częstochowa (Poland)
DeWitt (Iowa, USA)
Dudelange (Luxembourg)
Floreffe (Pennsylvania, USA)
Geneva (New York, USA)
Goole (United Kingdom)
Gujarat (India)
Kingsburg (California, USA)
Llodio (Alava, Spain)
Maturin (Venezuela)
Nong Khae (Thailand)
Orosháza (Hungary)
Porto Real (Rio de Janeiro, Brazil)
Querétaro (Mexico)
Ras Al Khaimah (UA Emirates)
Rayong (Thailand)
Ryazan (Russia)
Richburg (South Carolina, USA)
Thalheim (Germany)
T udela (Navarra, Spain)
Tatui (Brazil)
Rostov (Russia)

Guardian Products Across Globe

UltraMirror	- Clear mirrors
HP and SunGuard®	- Solar control
LamiGlass® SC	- Safety & Sound Insulation
SatinDeco	- High quality acid etched
Clarity®	- Anti Reflective Glass
Cristal Guard	- Protection against corrosion of shower enclosures
DiamondGuard	- Scratch resistant glass

Gujarat Guardian Ltd

- *A Joint Venture.*
- *First float glass manufacturer of India.*
- *“Modiguard” synonymous with the highest quality in the glass industry.*

Gujarat Guardian Ltd – Product Mix

- Products — Clear Float, Mirror & Satin Deco
- Maximum Size — 3.66m x 4.5m
- Thickness : — Float – 2mm to 12mm
  Mirror – 2mm to 8mm
- Mirror Coatings : — Clear, Grey & Bronze, Extra Clear
  Low –Iron Substrates
- Coatings — From RAK,Europe & USA

Why do we apply coatings on glass?

Change the thermal properties of the glass by

- Reducing the emissivity (thermal heat)
  u-value ⇩ (Low –e glass)
- Increasing the energy reflectance
  solar factor – solar control glass G
  ⇩
- Optimizing the light transmission
  reducing the glare and optimizing the lightning

Is it possible to build a green building without glazing?

- Probably Yes / No .
- Mandatory requirements in terms of day-lighting.
- As per GRIHA 25% living area has to be daylight.
- Along with other performance parameters prescribed under ECBC.

How do we apply coatings on glass?

Chemical Vapor Deposition (CVD)	Physical Vapor Deposition (PVD)
Pyrolytic process	Magnetron Sputtering
• On-Line process	• Off-Line Process

Pyrolytic Process

- Thick layer
- Limited performance
- Low color rendering index
- High internal and external reflection

Guardian Magnetron Sputter Process

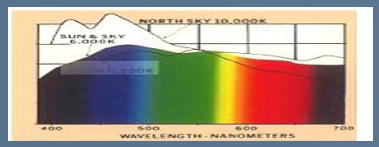
How_Glass_Is_Coated

Coated Glass Process

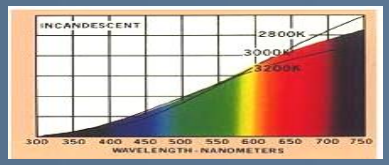
Color Rendering Index (CRI)

- CRI describes how much the window distorts the color appearance compared to a hole in the wall.
- Examples
  - Tungsten bulb & Sunlight/Blue Sky = 100
  - High Quality Fluorescent = 90
  - Green Glass = 80
- Between 80-90 -> Good
- 90-100 -> Very Good
- Museums typically specify 95 or higher.

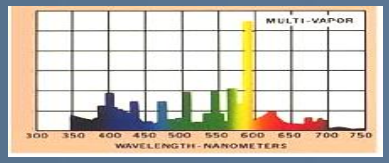
100



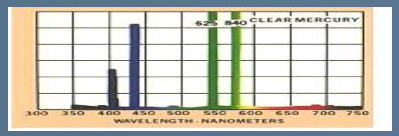
100



32



15



Color Rendering Index

View from inside

Pyrolithyic coatings on body tinded glass

Colored Magnetron Sputtered coatings on clear glass

Color Rendering Index

Example

View through body tinted blue glass

View through Guardian blue reflective glss, coated on clear glass

Post-Temperable Sputter Coatings

Solar Control: Required in Hot Climates
Measured by Solar Factor or G-Value or
Glass Needed: **SunGuard Solar Series**

Thermal Control: Needed whenever temperature difference exists between outdoor & indoor measured by U-Value (W/sqm.K)
Glass Needed: **ClimaGuard Low-E**

or Both: a combination of Solar & Thermal control
Glass Needed: **SunGuard HP or SN or SNX (Single Silver or Double Silver or Triple Silver Coatings)**

Selection of the right glazing

Both Buildings could have the same Solar Factor and U-Value but the Light Transmission

And Outdoor Light Reflections differs

Consequence: Solar Factor and U-Value are not necessarily related to Light Transmission

Selectivity (LSG – Light to Solar Gain Ratio)

One important issue for modern architecture is transparency in order to provide the end user maximum housing comfort.

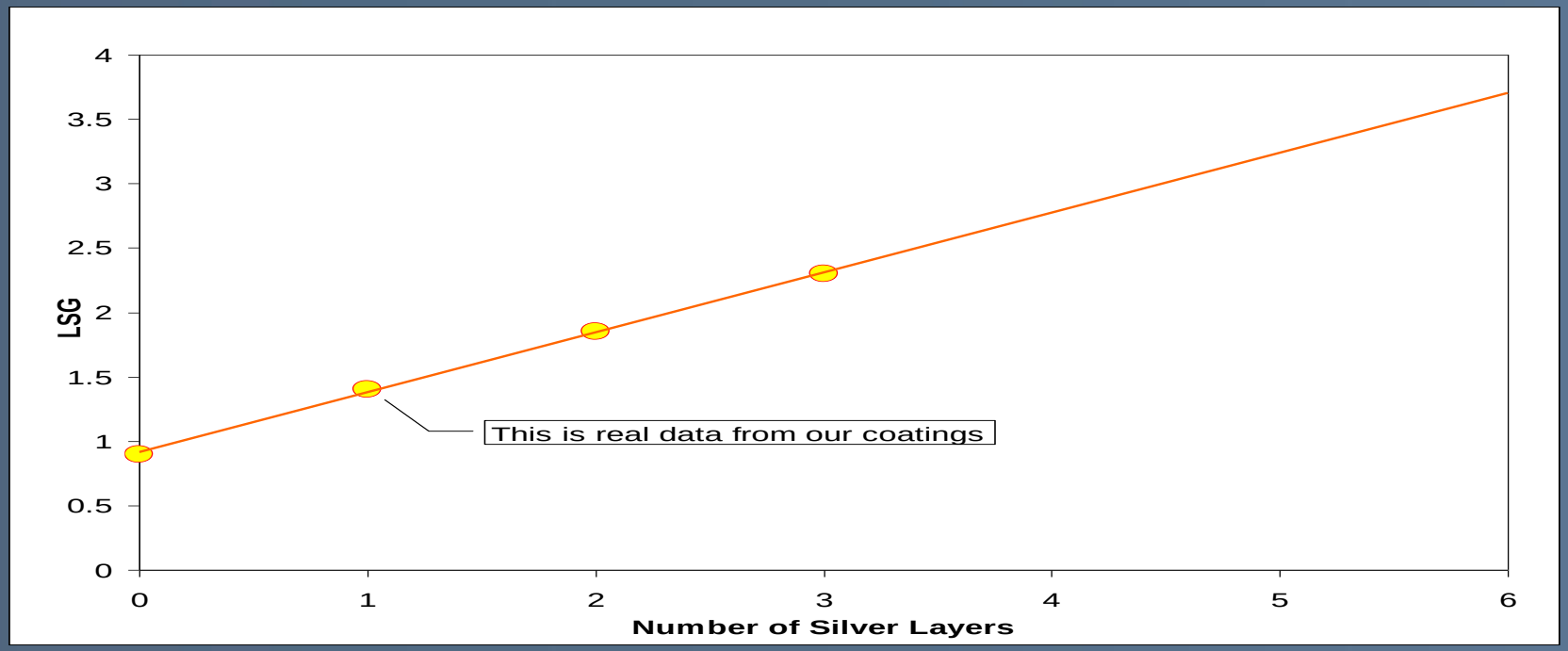
In order to describe a solar contral glass objectively, it‘s always important to consider beside the solar factor (energy transmission) at the same time the day light transmission.

$$S = \frac{\text{Light Transmission}}{\text{Solar Factor}}$$

higher is better

clear float glass: S ~ 1

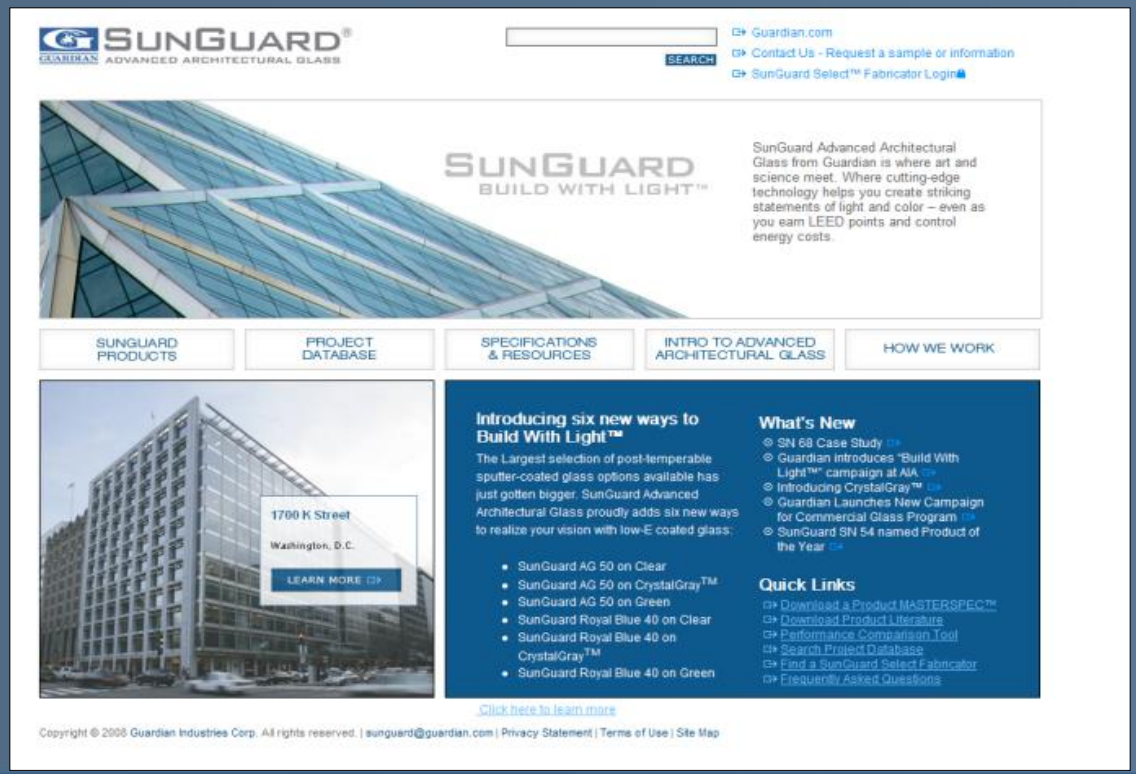
Light to Solar Gain Ratio (LSG) (or Selectivity)



www.sunguardglass.com

Here you'll find …

- Comprehensive information about SunGuard and other products
- Project database
- Brochures and technical datasheets
- Product specification
- Performance comparison
- Guardian Configurator
- Multi lingual



Guardian Glass Analytics

A comprehensive suite of engineering and analytical tools for glass applications

- Performance Calculator: Thermal-Optical simulations
  - Comprehensive Center-of-Glass Performance Data for virtually any Architectural Glass make-up.
- BIM File Generator: Custom Building Information Modeling (BIM) files
  - Generate Revit 2013 BIM content for virtually any glazing composition
- Building Energy Calculator: Building energy cost, consumption and payback analysis
  - Comparative building energy analyses associated with virtually any glazing construction
- Glass Visualizer: Glass visualizations
  - Dynamic depiction of glass appearance based on context, perspective, and indoor / outdoor lighting and sky conditions

Guardian Total Performance Calculator

My Settings | Order a Sample | SunGuard Website

GUARDIAN SUNGUARD | TOTAL PERFORMANCE CALCULATOR

Performance Calculator | My Project Center | Analyze | Energy Calculator

Performance Calculator

SunGuard's Performance Calculator simplifies the calculation of glass make-ups through a simple point-and-click, Web-based interface. In addition, you can use the calculator to archive project data and generate client-ready reports. It is, quite simply, the most useful yet easy-to-use glass performance calculator in the business.

1. Start from Scratch or Load an Existing Glass Type | Help?

Create a new Make-up

Product Region: North America

Monolithic | Double | Triple | Single Laminate | IG with laminated outboard | IG with laminated inboard

Load an existing glass type from the project center

Performance Calculator Make-Up Generation

2. Define and Analyze | Help?

Project Name: February Overview (edit)

Glass Type: GL-1 (edit)

Copy This Make-up | Import Make-ups

Make-up Name: Clear + Clear (edit) | Help?

Region:North America

outdoor side

			Help?
LITE	Clear 1/4" = 6mm	1 - 2 -	+ x
GAP	100% Air, 1/2" = 12mm		
LITE	Clear 1/4" = 6mm	3 - 4 -	+ x

indoor side

OUTSIDE INSIDE 1 2 3 4

TOTAL THICKNESS: 0.942 in / 23.927 mm

GLAZING SLOPE: 90°

...ct Database

Thermal Stress Guidelines			
Status	Meaning	Temperature Range	
		Celsius	Fahrenheit
Stop	Heat strengthening is advised.	x > 73.9	x > 165
Caution	Borderline situation.	65.6 <= x <= 73.9	150 <= x <= 165
Go	Go for annealed SunGuard Products	x < 65.6	x < 150

As the Performance Calculator does not account for the sizes of the units, heat strengthening is also advised for all lites outboard for the first Low-E coating when the area of the unit is 3.25 square meters (35 square feet) or greater, regardless of the output Thermal Stress Guidline.

Performance Calculator Summary Data

Summary Data | Layer Data | Visual Appearance | Graphs

Help?

Customize Summary Data

			Transmission		Reflectance	U-Value					
Make-up Name	Outboard Substrate & Coating	Inboard Substrate & Coating	Visible Light %	Solar Energy %	Visible Out %	Winter Night (Btu/hr-ft²-F)	Summer Day (Btu/hr-ft²-F)	SHGC	LSG	CRI	
Clear + Clear	Clear	Clear	**80**	66	16	0.47	0.50	**0.73**	1.09	97	

CALCULATION STANDARD: NFRC 2004

Create Labels | Generate Report

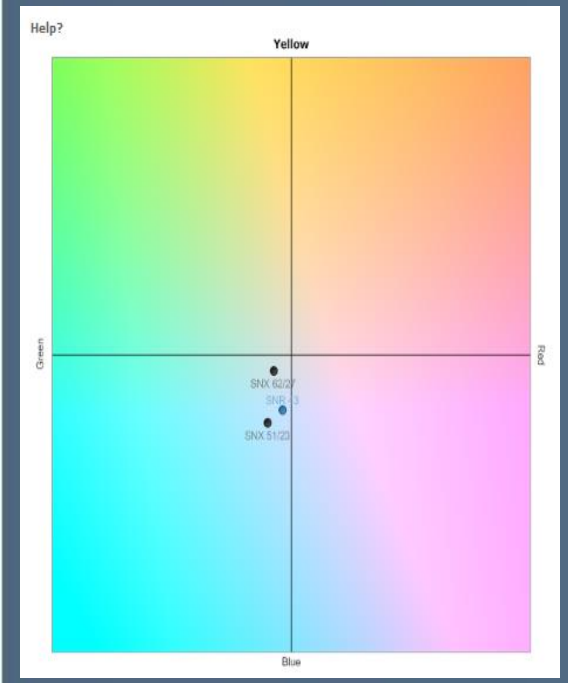
Performance Calculator Report Example

Make-up Name	Make-up	Outboard Substrate & Coating	Transmission			Reflectance			U-Value		RHG (Btu/h r-ft²)	SC	SHGC	LSG
			Visible Light %	UV %	Solar Energy %	Visible Out %	Visible In %	Solar Energy Out %	Winter Night (Btu/hr-ft²-F)	Summer Day (Btu/hr-ft²-F)				
RAK BRONZE N-50		SunGuard® AG 50 on Bronze	25	8	15	11	18	17	0.30	0.28	55	0.25	0.22	1.12
RAK BRONZE N-60		SunGuard® Neutral 61 on Bronze	30	8	19	9	14	15	0.30	0.29	63	0.30	0.26	1.17
RAK BRONZE N-40		SunGuard® Neutral 40 on Bronze	20	8	13	9	11	12	0.33	0.33	55	0.25	0.22	0.89
RAK BRONZE N-70		Guardian Neutral 70 on Bronze	34	13	26	7	11	10	0.33	0.33	83	0.39	0.34	0.99

Calculation Standard: NFRC 2010

RAK BRONZE N-70

Performance Calculator Visual Appearance Tools are Options



RGB Color Information: Outdoor Reflected Color

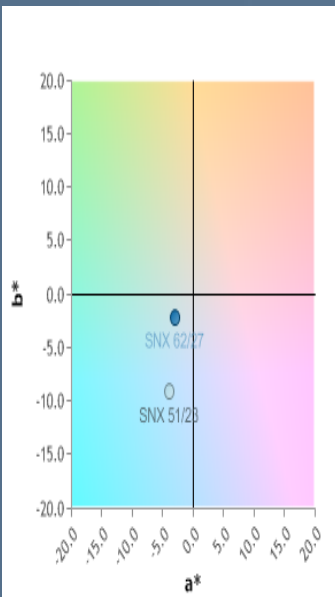
SNR 43	SNX 51/23	SNX 62/27
R = 133 G = 144 B = 156	R = 86 G = 105 B = 117	R = 86 G = 95 B = 97

RGB Color Information: Transmitted Color

SNR 43	SNX 51/23	SNX 62/27
R = 164 G = 178 B = 176	R = 178 G = 193 B = 182	R = 198 G = 209 B = 195

RGB Color Information: Indoor Reflected Color

SNR 43	SNX 51/23	SNX 62/27
R = 91 G = 106 B = 118	R = 100 G = 101 B = 115	R = 92 G = 97 B = 100



	SNX 62/27	SNX 51/23	Delta
ROut:			
L*	39.6	43.2	-3.59
a*	-2.91	-3.84	0.928
b*	-2.16	-9.15	6.99
DE*			7.91
Trans:			
L*	82.7	76.6	6.09
a*	-6.62	-7.02	0.399
b*	5.80	3.51	2.29
DE*			6.52
RIn:			
L*	40.9	43.0	-2.09
a*	-1.42	2.90	-4.32
b*	-2.43	-8.36	5.94
DE*			7.63

Guardian Building Energy Calculator

Building Energy Calculator Project Settings

My Settings | Order a Sample | SunGuard Website

GUARDIAN SUNGUARD® | PERFORMANCE & BUILDING ENERGY CALCULATORS

Performance Calculator | **My Project Center** | **Analyze** | **Energy Calculator**

Energy Calculator

{x} Collapse First-time user? Download our guide. Assumptions and Terminology

The Guardian Building Energy Calculator helps you compare annual energy costs for a variety of glazing types in locations throughout North America and Latin America. Set up your project; choose a building type, and add some building details. Compare energy cost and consumption information for as many glass make-ups as you'd like. Results are summarized in data tables, illustrated graphically, and available for customized report generation when you're done.

Guardian developed the Building Energy Calculator for use by its sales and technical staffs to perform general comparative energy analyses of various combinations of glazing products. The Energy Calculator is intended for general comparative purposes only. Please consult a qualified professional for project-specific energy analysis.

Project Settings

{x} Collapse

Select Project:	WWR Analysis	Fuel Type:	Electric + Gas Heat
Region:	North America	Average Gas Cost:	0.954 USD/Therm
Location:	USA, AZ, Phoenix	Average Electricity Cost:	0.073 USD/kWh
Currency:	United States Dollar	Electric Demand Charge:	8.25 USD/kW

Building Energy Calculator Project Building Settings

Building Settings [-] Collapse

Building Type:	Office	Number of Stories:	12
Floor Length (long axis) (ft):	200	Floor Width (ft):	100
Floor-to-ceiling Height (ft):	9	Perimeter Zone Depth (ft):	15

Analyze the Impact of Automated Daylighting Controls: ☐

	Elevation 1	Elevation 2	Elevation 3	Elevation 4
Window Area (ft²):	6000	Same As Elevation 1	Same As Elevation 1	Same As Elevation 1
Overhang (ft):	0	Same As Elevation 1	Same As Elevation 1	Same As Elevation 1
Window Type:	Curtain Wall	Same As Elevation 1	Same As Elevation 1	Same As Elevation 1
Window Height (ft):	8	Same As Elevation 1	Same As Elevation 1	Same As Elevation 1
Window Width (ft):	4	Same As Elevation 1	Same As Elevation 1	Same As Elevation 1
Frame Type:	T/B Aluminum			
Spacer Type:	T/B Aluminum			

Site Orientation {+} Expand

Glazing Scenarios

Project Building Settings

Elevation View

Elevation View

Elevation View

Retail

Window Area (area²)
Window to Wall Area (1-100%)

(ft):	0.2	Same As Elevation 1	Same As Elevation 1	Same As Elevation 1
ype:	Curtain Wall	Ribbon	Punched	Same As Elevation 1
(ft):			6	Same As Elevation 1
Window Width (ft):			4	Same As Elevation 1
Frame Type:	T/B Aluminum			
Spacer Type:	T/B Aluminum			

Curtain Wall
Ribbon
Punched Oper

Aluminum
Aluminum
T/B Aluminum
Silicone Foam
Stainless Steel

Adding Glazing Scenarios

Glazing Scenarios

Name: Green + Clear (edit)

Override Building Settings: None

	Elevation 1	Elevation 2	Elevation 3	Elevation 4
	GL-1: Green + Clear	Same As Elevation 1	Same As Elevation 1	Same As Elevation 1
Glass Make-up Cost ($/ft²):	9.50	Same As Elevation 1	Same As Elevation 1	Same As Elevation 1

Override Building Settings

Only include the information that is different from the baseline scenario. The noted values will override the baseline values, but keep the rest of the values the same.

	Elevation 1	Elevation 2	Elevation 3	Elevation 4
Window to Wall Area (0-100%):				
Overhang (ft):				
Window Type:				
Window Height (ft):				
Window Width (ft):				
Frame Type:				
Spacer Type:			Clear All	
Orient Elevation 1 to Face:				

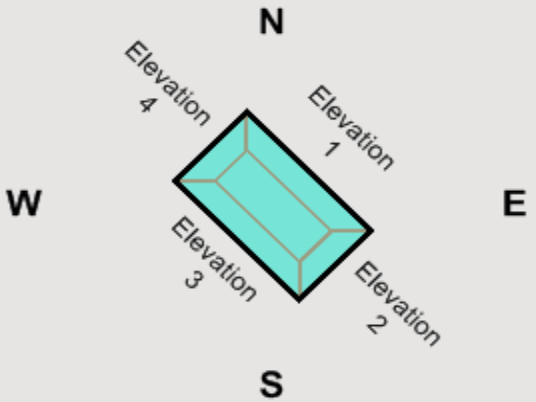
Save Cancel

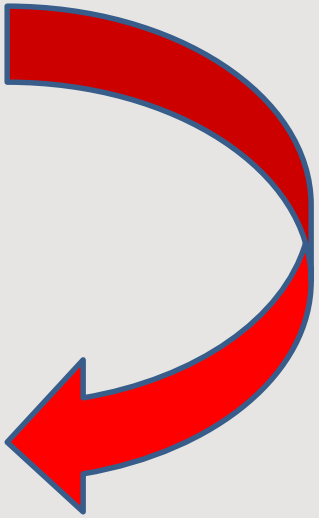
Building Energy Calculator Project Site Orientation

Site Orientation {x} Collapse

Elevation View

Plan View





Elevation 1
Elevation 2
Elevation 3
Elevation 4

Orient Elevation 1 to

North
Northeast
East
Southeast
South
Southwest
West
Northwest

Building Energy Calculator: Glazing Scenario Results

Glazing Scenarios

Name: **Uncoated Clear** (edit)

	Elevation 1	Elevation 2	Elevation 3	Elevation 4
	GL 1: Uncoated Clear	Same As Elevation 1	Same As Elevation 1	Same As Elevation 1
Glass Make-up Cost ($/ft²):	4.00	Same As Elevation 1	Same As Elevation 1	Same As Elevation 1

Calculate | Add New Glazing Scenario

Results | Comparison | Payback | Graphs | Report

Glazing Scenario	Total Annual Energy Cost ($/ft²)	Annual Electricity Cost ($/ft²)	Annual Gas Cost ($/ft²)	Annual Electricity Consumption (kWh/ft²)	Annual Gas Consumption (Therm/ft²)	Peak Electricity Demand (W/ft²)	CO_2 Emissions (kg/ft²)	
Uncoated Clear	$8.31	$8.16	$0.14	79.55	0.14	27	54	
SN 68 UltraWhite [air]Clr	$7.70	$7.56	$0.15	72.94	0.14	27.5	49.6	
Royal Blue 40 [air]Clr	$7.54	$7.39	$0.15	71.17	0.15	27	48.5	
SN 54[air]Clr	$7.50	$7.35	$0.15	70.84	0.15	26.9	48.2	
SNR 43[air]Clr	$7.42	$7.27	$0.15	69.74	0.15	26.5	47.5	
SNX 62/27 Gray[air]Clr	$7.31	$7.17	$0.14	68.45	0.14	26.2	46.6	

Display values as: Per window area (Per window area / Total building)

Building Properties:

Building Area (ft²): 381,150

	Elevation 1	Elevation 2	Elevation 3	Elevation 4	TOTAL
Window Area (ft²):	15,750	9,075	15,750	9,075	49,650

- Glazing Scenarios are Defined.
  - Each Glazing Scenario Requires Assignment of Compositions to Elevations, and Input of Glazing Costs Per Area.
- One Glazing Scenario is Selected as the Comparative Baseline.
- An Output Format of Total Metrics, or Metrics per Area, is Selected.
- An Analysis is Run, Evaluating Hourly Conditions Across a Calendar Year.

Building Energy Calculator: Scenario Comparison and Payback Analysis

Results | **Comparison** | Payback | Graphs | Report

Baseline Glazing Scenario: Uncoated Clear

Comparison Glazing Scenario: Embedded SN 68 CrystalGray

	Total Annual Energy Cost ($)	Annual Electricity Cost ($)	Annual Gas Cost ($)	Annual Electricity Consumption (kWh)	Annual Gas Consumption (Therm)	Peak Electricity Demand (W)	CO_2 Emissions (kg)
Uncoated Clear	$412,808	$406,005	$6,803	3,944,912	6,710	1,344,200	2,678,694
Embedded SN 68 CrystalGray	$374,331	$365,073	$9,257	3,514,083	9,130	1,331,200	2,402,879
SAVINGS	$38,477	$40,931	($2,453	430,829	-2,420	13,000	275,814

Display values as: Total building

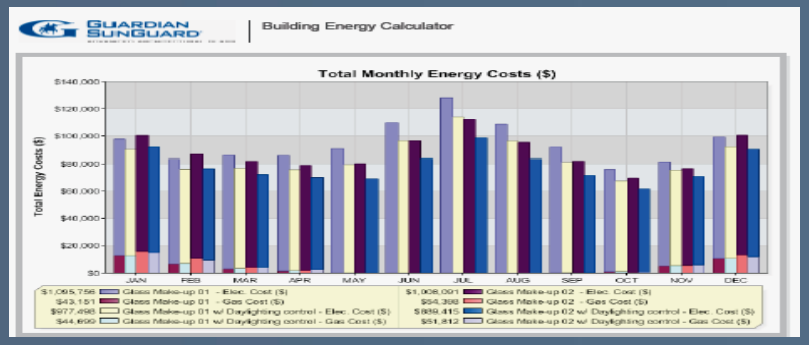
Per window area

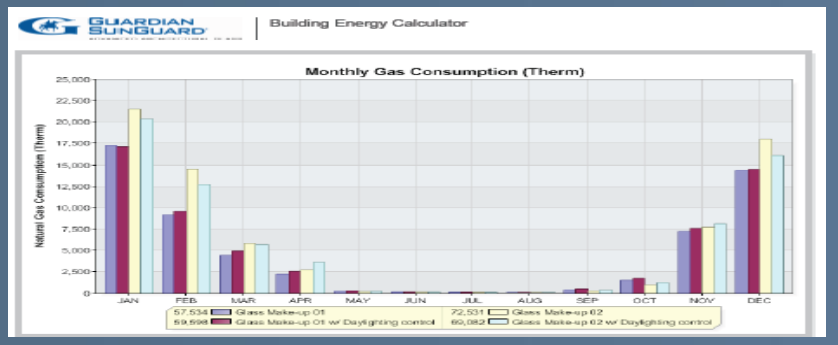
Total building

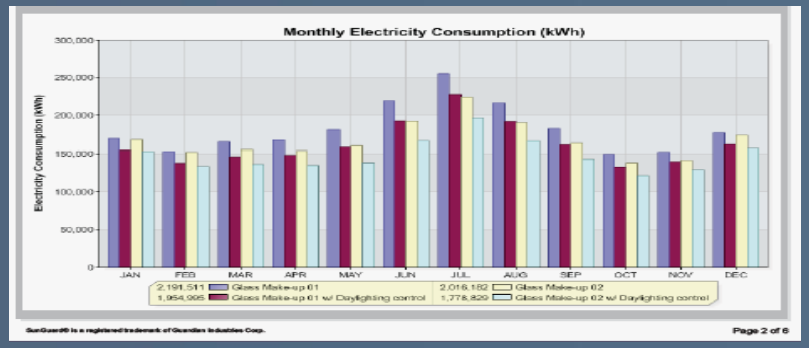
Results | Comparison | **Payback** | Graphs | Report

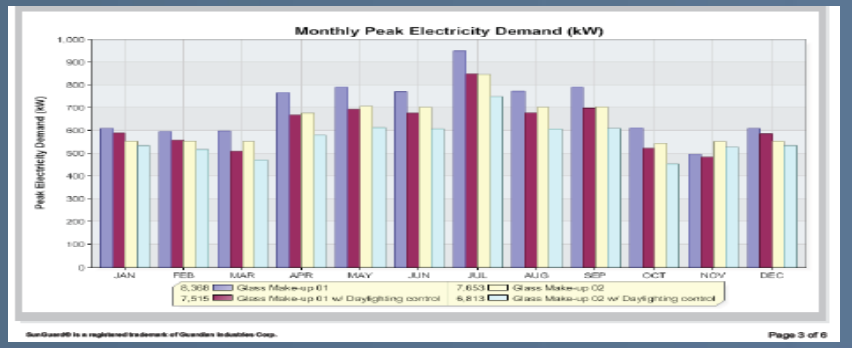
Glazing Scenario	Glass Make-up Cost (per ft²)	Building Glass Cost	Annual Building Energy Cost (Glass)	Initial HVAC Cost Compared To Baseline	Payback Period	First Year Savings (HVAC and Energy Costs)	Ten-Year Savings (HVAC and Energy Costs)
Uncoated Clear	$0.00	$0	$412,809				
Light Blue 63	+$6.50	+$322,725	-$20,982	-$201,139	5.8 years	-$100,604	+$88,231
Embedded SN 68 CrystalGray	+$11.00	+$546,150	-$38,478	-$412,081	3.5 years	-$95,591	+$250,707
SN 68 CrystalGray	+$7.50	+$372,375	-$38,749	-$399,694	Immediate	+$66,068	+$414,812
Embedded SN 68 CrystalGray + Clr	+$15.00	+$744,750	-$43,426	-$455,218	6.7 years	-$246,107	+$144,724
SNX 62/27 CrystalGray	+$8.00	+$397,200	-$45,498	-$473,198	Immediate	+$121,497	+$530,980

Energy Calculator Monthly & Annual Results









Building Energy Calculator Report Example

Results

Glazing Scenario	Total Annual Energy Cost (INR)	Annual Electricity Cost (INR)	Annual Gas Cost (INR)	Annual Electricity Consumption (kWh)	Annual Gas Consumption (MJ)	Peak Electricity Demand (W)	CO2 Emissions (kg)
1. SGU Clear	37,743,480	37,743,480	0	5,118,454	0	1,559,600	N/A
2. Clear DGU	35,882,236	35,882,236	0	4,866,048	0	1,495,600	N/A
3. DGU with Neutral 34	31,968,856	31,968,856	0	4,335,348	0	1,390,000	N/A

Payback

Glazing Scenario	Glass Make-up Cost (per m²)	Building Glass Cost	Annual Building Energy Cost (Glass)	Initial HVAC Cost Compared To Baseline	Payback Period	First Year Savings (HVAC and Energy Costs)	Ten-Year Savings (HVAC and Energy Costs)
1. SGU Clear	700.00	4,283,662	37,743,480				
2. Clear DGU	+1,400.00	+8,567,330	-1,861,242	-118,271	4.5 years	-6,587,817	+10,163,359
3. DGU with Neutral 34	+1,900.00	+11,627,089	-5,774,624	-304,156	2.0 years	-5,548,310	+46,423,304

Glass Visualizer

- This new tool leverages the glass modeling power of Guardian's Performance Calculator, giving the user the ability to immediately visualize photo-realistic images of glass make-up generated by the Performance Calculator.
- The Glass Visualizer provides a simple interface that guides the user through a series of selections in order to view their glass make-ups under varying lighting conditions.
- The Glass Visualizer dynamically generates visualizations based on glass make-up spectral data (DNA) exported from the Performance Calculator.
- Glass Spectral data combined with standard indoor lighting conditions outdoor sky conditions to generate photo-realistic images that depicting reflected
- transmitted glass appearance.

Guardian Glass Visualizer

Building Corner View With Clear Sky and Full Sun

SNR 43 on UltraWhite

Silver 20 on Green

Building Corner View With Cloudy Sky

SNR 43 on UltraWhite

Silver 20 on Green

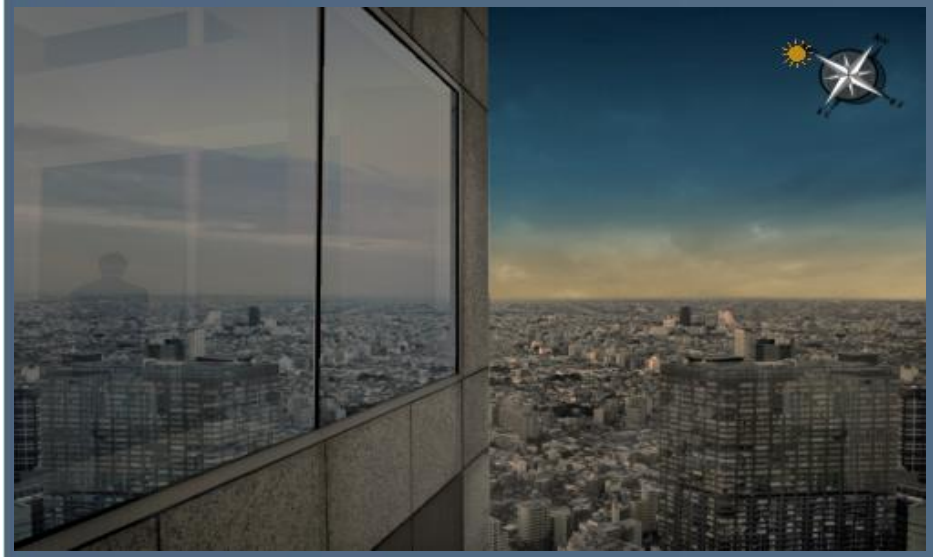
Building Corner View Clear Day at Sunrise

SNR 43 on UltraWhite

Silver 20 on Green

Building Corner View Cloudy Day at Sunset

SNR 43 on UltraWhite



Silver 20 on Green

Building Corner View Clear Night Sky

SNR 43 on UltraWhite

Silver 20 on Green

Building Inside View With Clear Sky Full Sun

SNR 43 on UltraWhite

Silver 20 on Green

Building Inside View Cloudy Day

SNR 43 on UltraWhite

Silver 20 on Green

Building Inside View Clear Day at Sunrise

SNR 43 on UltraWhite

Silver 20 on Green

Building Inside View Cloudy Day at Sunset

SNR 43 on UltraWhite

Silver 20 on Green

Building Inside View With Clear Night Sky

SNR 43 on UltraWhite

Silver 20 on Green

www.sunguardglass.com

Thank You