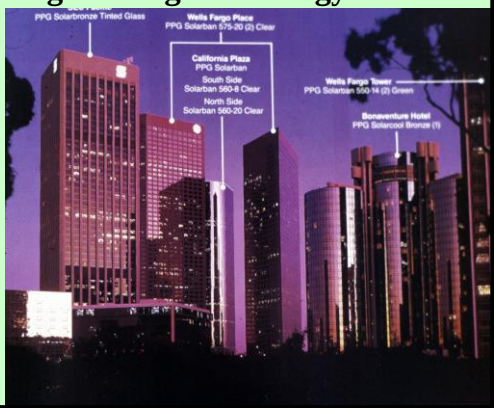
Amazing Glazing Technology



1

Glass has two major flaws:

- In winter it lets the heat out
- In summer it lets the heat in

How can glazing technology cope?

2

Glass must combat intense solar heat gain

So, provide shading devices.

So, could its radiant energy transmission be changed?

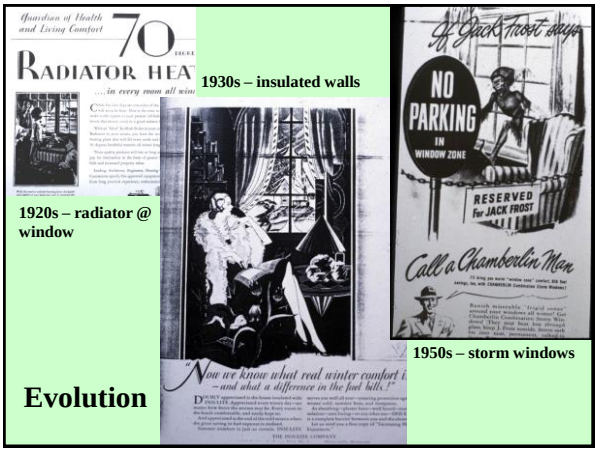
3

…and it must combat rapid heat loss at night in frigid temperatures.

…and provide insulating covers.

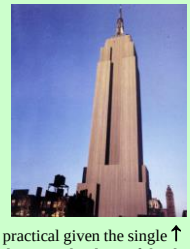
So, could its R-value be better?

4

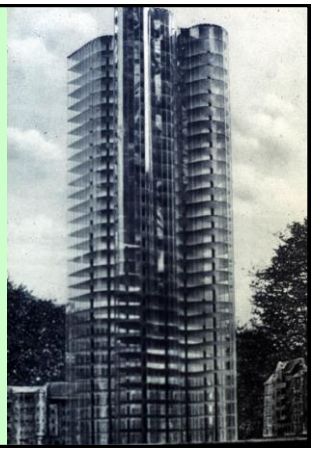


5

In 1921 Ludwig Mies vander Rohe had the impossible dream of a residential all glass high-rise.



More practical given the single ↑ pane glazing technology of the day

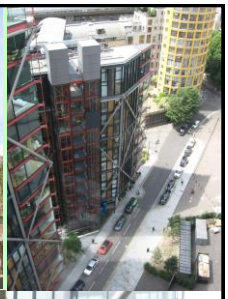


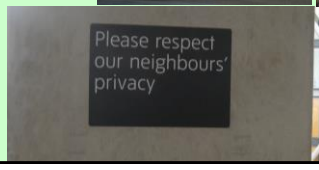
6

Mies' dream come true in London!

Rogers vs. Herzog De Meuron 2017

Across the street neighbors!





7

Since the 1930s technology has been employed to improve glass performance…

1. Thermopane glass
2. Evacuated glass
3. Insulating glass
4. Tinted glass
5. Reflective glass
6. Low emissivity glass
7. Electro-chromatic glass
8. Fritted glass
9. Photovoltaic glass
10. ETFE pillows
11. Biochromatic glass

ETFE Glazing at Canary Wharf Crossrail Station

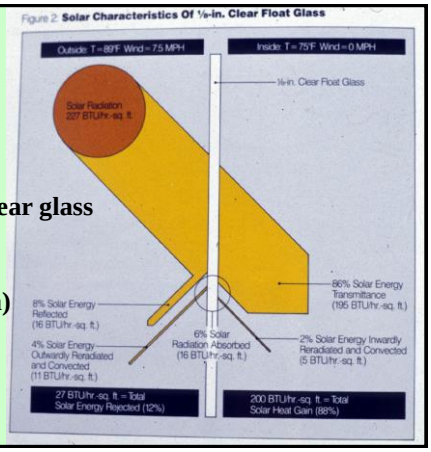
8

Single pane clear glass

Problems

R = 1 (low)

E = .7 (high)



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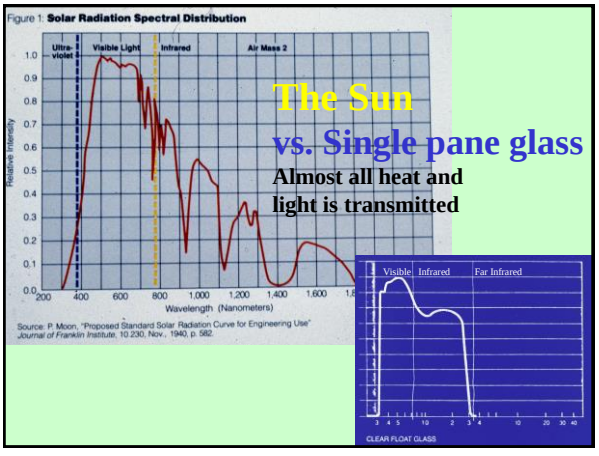
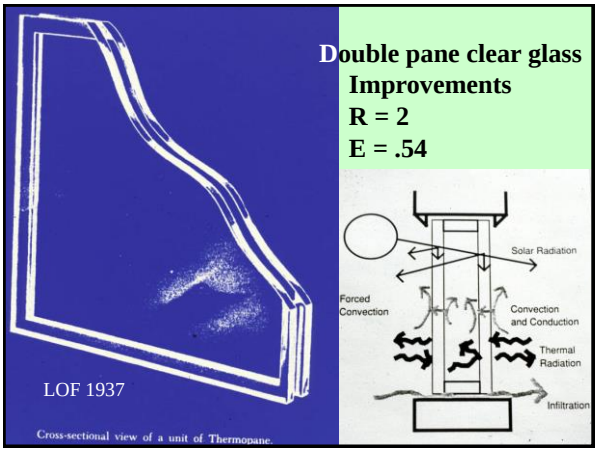
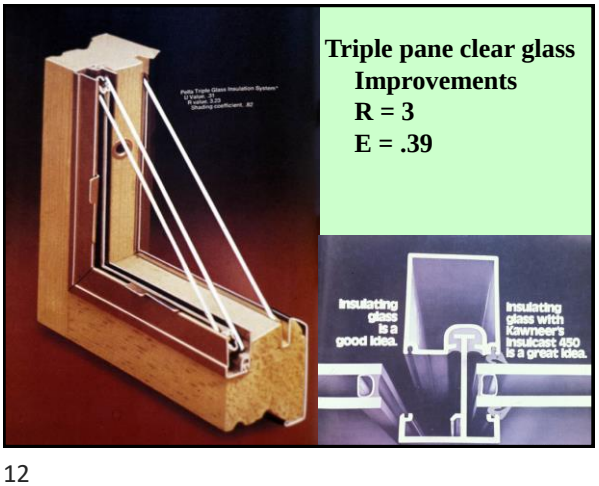


Figure 1: Solar Radiation Spectral Distribution
Ultra-violet
Visible Light
Infrared
Air Mass 2
Relative Intensity
Wavelength (Nanometers)
Source: P. Moon, "Proposed Standard Solar Radiation Curve for Engineering Use" Journal of Franklin Institute, 10.230, Nov., 1940, p. 582.
The Sun
vs. Single pane glass
Almost all heat and light is transmitted
Visible
Infrared
Far Infrared
CLEAR FLOAT GLASS

10


Double pane clear glass
Improvements
R = 2
E = .54
LOF 1937
Cross-sectional view of a unit of Thermopane.
Solar Radiation
Forced Convection
Convection and Conduction
Thermal Radiation
Infiltration

11


Triple pane clear glass
Improvements
R = 3
E = .39
Insulating glass is a good idea.
Insulating glass with Kawneer's Insulcast 450 is a great idea.

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Thermo-Set
versatile outside glazing system
from
ted States Aluminum Corporation
Radius Framing
from
United States Aluminum Corpora
What's the difference?

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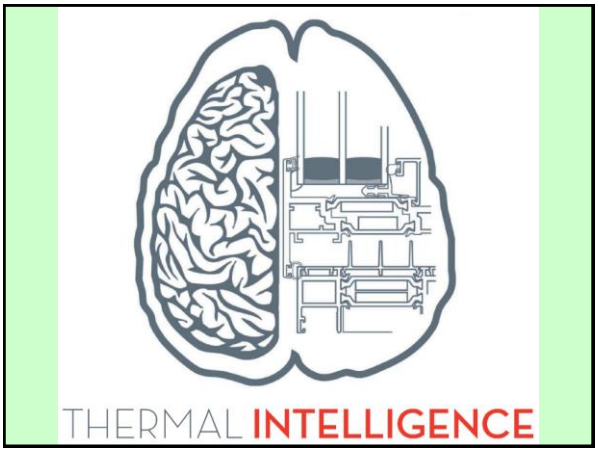
THERMAL INTELLIGENCE

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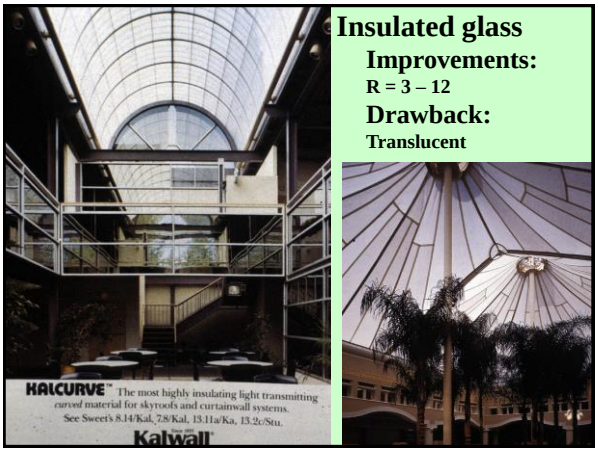
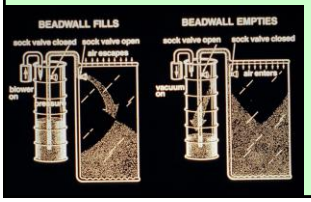

Insulated glass
Improvements:
R = 3 – 12
Drawback:
Translucent
KALCURVE™ The most highly insulating light transmitting curved material for skyroofs and curtainwall systems.
See Sweet's 8.14/Kal, 7.8/Kal, 13.11a/Ka, 13.2c/Stu.
Kalwall

15

Beadwall 1970s Only translucent when filled



Glass-X 2015 (nano-tech)

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1980s research

Silica Aerogel – the Right Stuff for Active/Passive Glazing

John Hartmann, Michael Rubin, and Dariush Arasteh
Applied Science Division, Lawrence Berkeley Laboratory, University of California, Berkeley, California

Sandwiched between two panes of glass, silica aerogel can greatly reduce heat transfer without significantly curbing solar transmission. Decreasing the pressure within the aerogel window can further reduce such a window's overall U value.

Nanawall (clear)

Profilit (semi-)

Kalwall (translucent)

Silica Aerogel
Transparent insulation
R = 5-20, E = .75

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Metea Valley High School, in Aurora, Illinois, Kalwall w/Aerogel

Aerogel
R = 20

Performance Data: 2.75" (70mm) Panel

FRP Face Sheet Combinations		Visible Light Transmission (VLT) %					
Exterior FRP	Interior FRP	0.53 U	0.29 | 0.23* U	0.22 | 0.14* U	0.18 | 0.10* U	0.05* U	SHGC
Greenish Blue	White	25%	14%	5%	3%	14%	.19
Aqua	White	29%	17%	6%	4%	15%	.21
Rose	White	30%	18%	6%	4%	16%	.21
Ice Blue	White	35%	20%	8%	6%	21%	.26
White	White	20%	15%	8%	5%	14%	.18
Crystal	White	35%	20%	12%	8%	20%	.25
Crystal	Crystal	50%	30%	15%	10%	NA	N/A

= Air Gap Only = Fiberglass TI = Cabot's Lumira™ Aerogel

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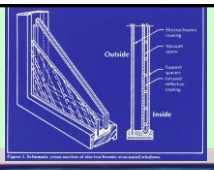
Evacuated Glass

R = 12

1980s research

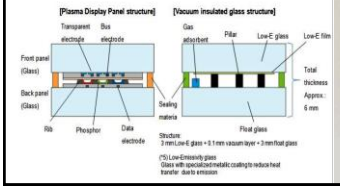


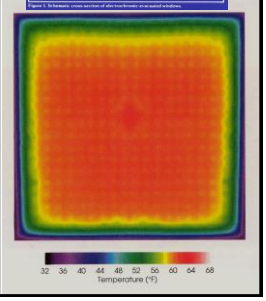
2019 using cell phone glazing technology

Features in Detail

1. Industry's top-class(*1) insulation performance for anneal glass with a total thickness of approximately 6 mm (heat transfer coefficient U value = 0.7 (W/m²•K))(*2) = 0.123 BTUH/SQFT(R = 8.13)

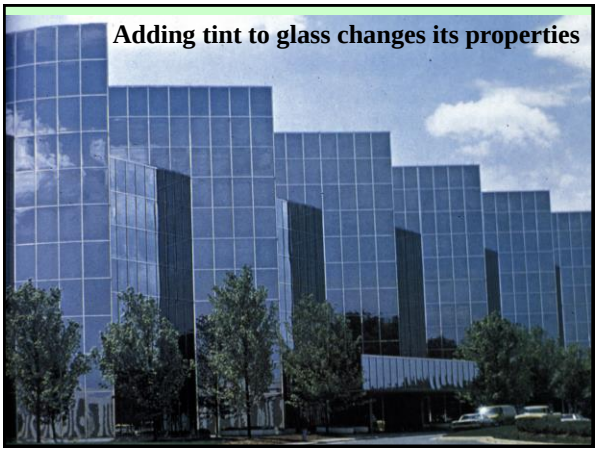
A PDP displays an image by causing phosphors to emit light within an extremely thin vacuum layer between two sheets of glass that are vacuum-sealed. Panasonic utilized its accumulated PDP development and manufacturing technology to develop a unique slim-model vacuum insulated glass with a total thickness of approximately 6 mm, featuring insulation performance equivalent to triple argon-containing glass (total thickness approximately 3 cm).





19

Adding tint to glass changes its properties



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How do you choose?

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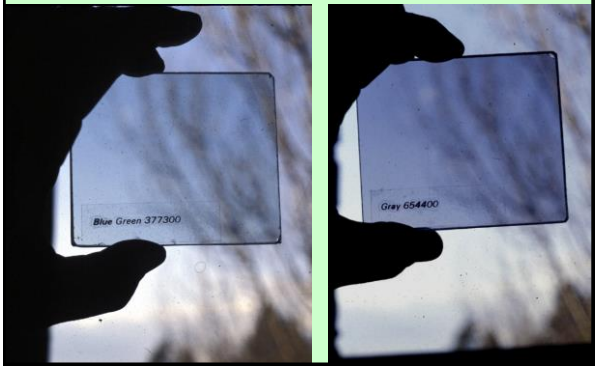
COLOR	AESTHETIC EFFECT	GLASS
CLEAR	Transparent	Clear
	Transparent	Sungate 100 (2) or (3) Clear
CHROME	Silver Bronze	Solarcool (1) Bronze
	Silver Gray	Solarcool (1) Gray
	Silver Black	Solarcool (1) Black
SILVER	Silver (Ice Crystal)	Solarban 560-8, 14, 20 (2) Clear
PEWTER	Soft Pewter (Polished Pewter)	Solarban 550-13, 18, 22 (3) Clear
	Bright Pewter (Antique Silver)	Solarban 550-13, 18, 22 (2) Clear
BLACK	Black	Solarcool (2) Black
	Black	Graylite Tinted
GRAY	Light Gray (Black Pearl)	Solarban 560-8, 14, 20 (2) Gray
	Medium Gray	Solargray Tinted
	Medium Gray	Sungate 100 (2) or (3) Gray
	Medium Gray (Sunstone)	Solarban 565-20 (2) Gray
	Soft Gray (Cameo Onyx)	Solarban 550-13, 18, 22 (3) Gray
	Blue Gray (Jet Crystal)	Solarban 570-20 (2) Gray
	Blue Gray (Jet Crystal)	Solarban 570-30 (2) Gray
	Blue Gray (Crystal Cobalt)	Solarban 470-20 (2) Gray
	Dark Gray (Smokey Quartz)	Solarban 550-13, 18, 22 (2) Gray
	Dark Gray	Solarcool (2) Gray
	Red Gray (Fire Opal)	Solarban 575-20 (2) Gray
	Red Gray (Copper Gray)	Solarban 575-30 (3) Gray
BLUE	Light Blue (Blue Quartz)	Solarban 570-20 (2) Clear
	Medium Blue (Blue Sapphire)	Solarban 570-30 (2) Clear
	Dark Blue (Tanzanite)	Solarban 470-20 (2) Clear
BLUE-GREEN	Deep Blue-Green (Crystal Turquoise)	Solarban 470-20 (2) Green
	Blue-Green (Blue Jade)	Solarban 570-30 (2) Green
	Blue-Green (Blue Jade)	Solarban 570-20 (2) Green

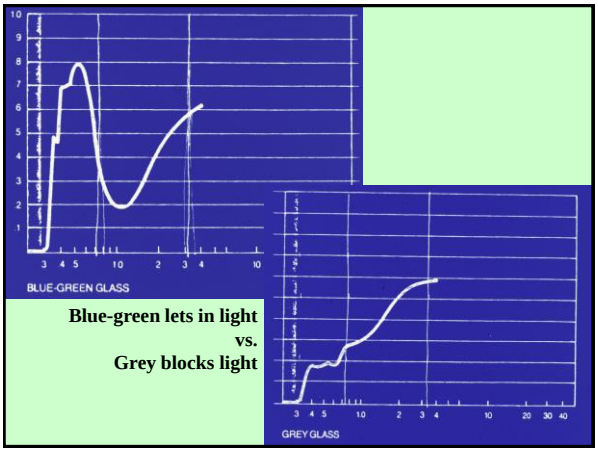
COLOR	AESTHETIC EFFECT	GLASS
GREEN	Light Green (Aquamarine)	Solarban 560-8, 14, 20 (2) Green
	Medium Green	Solex Tinted
	Medium Green	Sungate 100 (2) or (3)Green
	Olive (Verdelite)	Solarban 565-20 (2) Green
	Dark Green (Emerald)	Solarban 550-13, 18, 22 (2) Green
	Soft Green (Green Sapphire)	Solarban 550-13, 18, 22 (3) Green
	Green-Brown (Rock Crystal)	Solarban 575-20 (2) Green
	Green-Brown (Copper Jade)	Solarban 575-30 (3) Green
BRONZE	Light Bronze (Tourmaline)	Solarban 560-8, 14, 20 (2) Bronze
	Light Bronze	Solarbronze Tinted
	Light Bronze	Sungate 100 (2) or (3)Bronze
	Light Bronze	Solarcool (2) Bronze
	Medium Bronze (Citrine Quartz)	Solarban 565-20 (2) Clear
	Medium Bronze (Honey Opal)	Solarban 565-20 (2) Bronze
	Dark Bronze (Jasper Quartz)	Solarban 550-13, 18, 22 (2) Bronze
	Soft Bronze (Crystal Topaz)	Solarban 550-13, 18, 22 (3) Bronze
	Bronze Blue (Moonstone)	Solarban 570-20 (2) Bronze
	Bronze Blue (Moonstone)	Solarban 570-30 (2) Bronze
	Blue Bronze (Scenic Agate)	Solarban 470-20 (2) Bronze
	Red Bronze (Rose Cinnabar)	Solarban 575-20 (2) Bronze
	Red Bronze (Copper Brown)	Solarban 575-30 (3) Bronze
COPPER	Bright Pink (Topaz)	Solarban 575-20 (2) Clear
	Silver Pink (Copper Topaz)	Solarban 575-30 (3) Clear

22

Blue-Green vs. Gray



23



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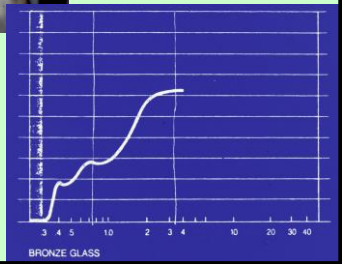
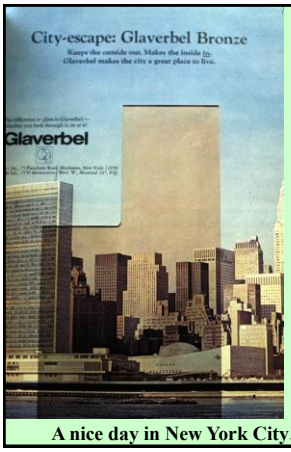
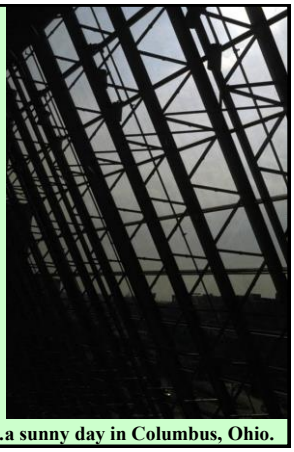
Reflective Glass

Bronze



25

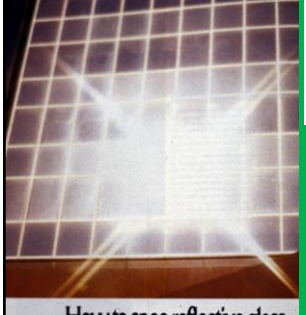




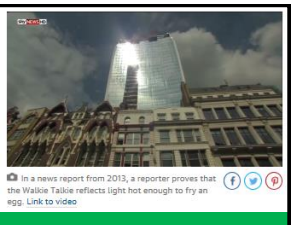
A nice day in New York City…a sunny day in Columbus, Ohio.

26

Another problem



How to spec reflective glass without making your neighbors h



In a news report from 2013, a reporter proves that the Walkie Talkie reflects light hot enough to fry an egg. Link to video

Carbunkle Award-Winning 20 Fenchurch bldg

http://www.theguardian.com/uk-news/video/2013/sep/03/london-walkie-talkie-skyscraper-video

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Low-E Glass

Reflects heat w/o
Reflecting light

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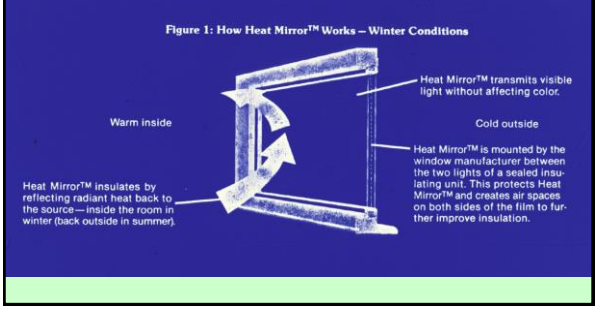
Residential Low-E

Design Goal—keep heat in.

E = .25

R = 3.3



30

Commercial Low-E

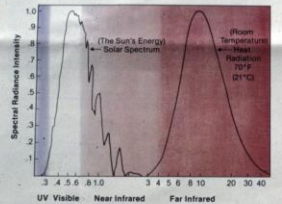
Design Goal—keep solar heat out.

E = .10

R = 7.14

Exactly what is transmitted or reflected falls into two major categories: solar radiation, and far infrared, or heat. Solar radiation, in turn, is divided into ultraviolet, visible light, and invisible near infrared, or solar heat. Figure 2 shows these wavelengths.

Figure 2: Important Wavelengths in Energy Efficient Window Design



Ultraviolet fades furniture, drapes, and carpets, and should not be transmitted by efficient windows. Transmission of visible light, the

Figure 3: Transmission Characteristics of Heat Mirror™ Insulations

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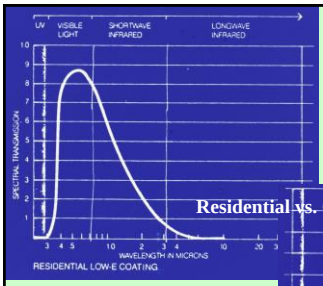
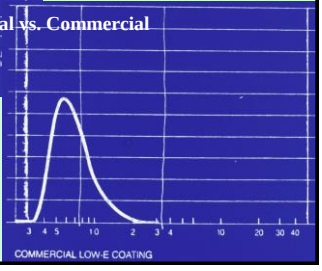


Residential vs. Commercial

Trade-off: less daylight With lower emissivity (commercial low-e)



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Superwindow

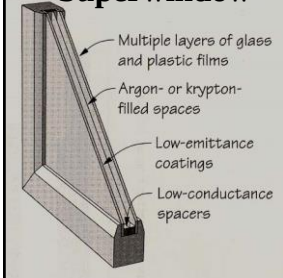
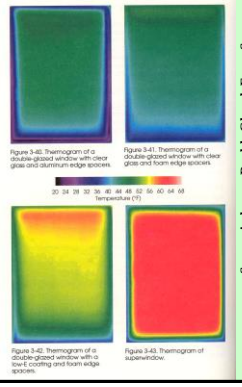


Figure 3-38. Superwindows improve thermal resistance with multiple layers of glass and suspended plastic films, argon and krypton gas fills, low-emittance coatings, and low-conductance spacers.

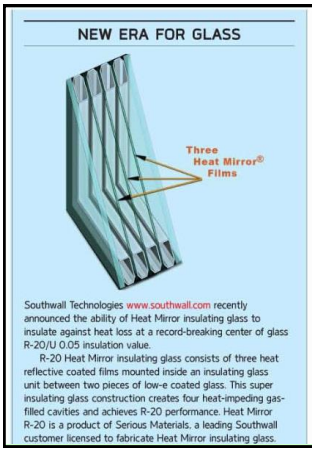
Indoor surface temperature winter day

Double Glazed Low-E vs. Double Glazed, Metal Spacers



Superwindow vs. Double Glazed, Foam Spacers

33



Double pane low-e, triple heat mirror, 2010
Improvement
R = 20
Low-E

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Electro-chromatic Glazing

Selective transmission

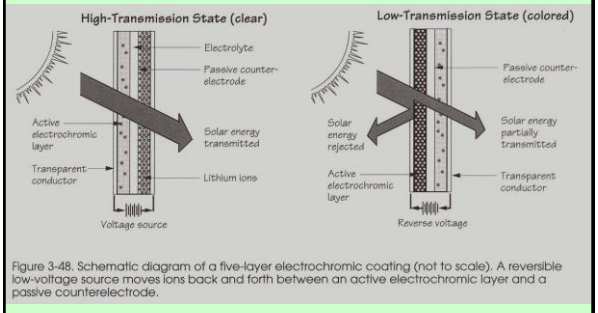

Figure 3-48. Schematic diagram of a five-layer electrochromic coating (not to scale). A reversible low-voltage source moves ions back and forth between an active electrochromic layer and a passive counterelectrode.

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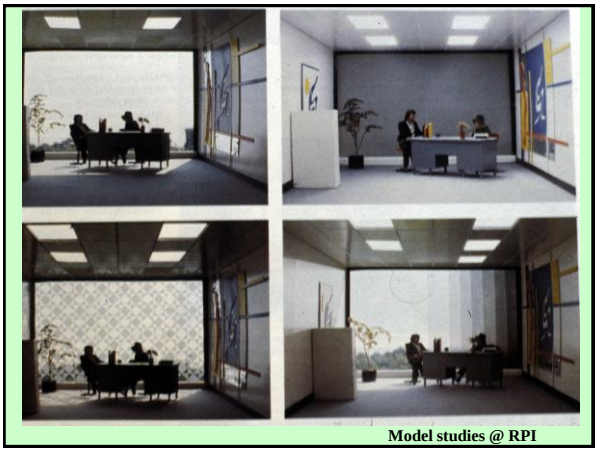

Model studies @ RPI

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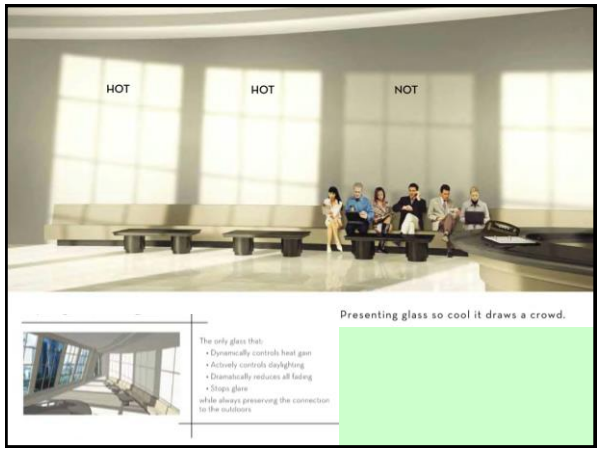

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SHGC = .09 VT = 1% SHGC = .41 VT = 60%

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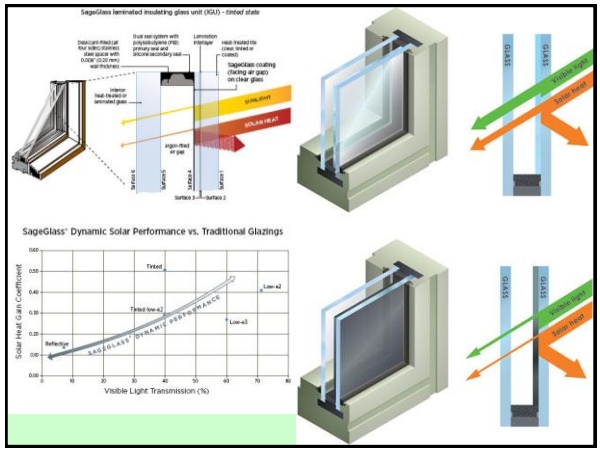
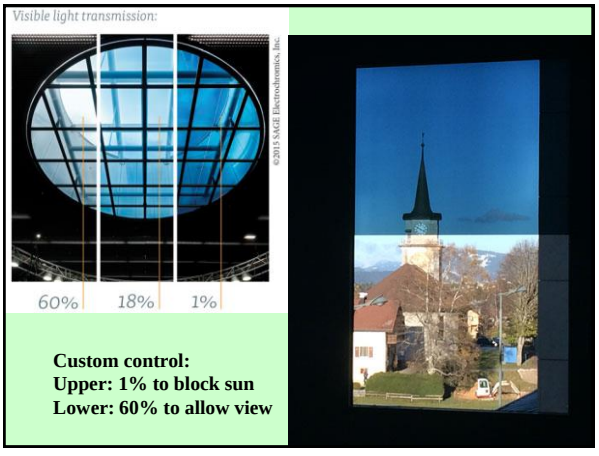


39


Visible light transmission:
60%
18%
1%
©2015 SAGE Electrochromics, Inc.
Custom control:
Upper: 1% to block sun
Lower: 60% to allow view

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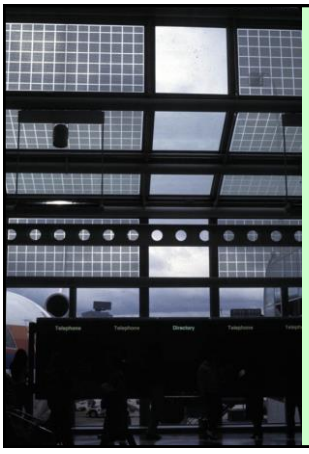
View Dynamic Glass-also electrochromatic
Transitions automatically
View Dynamic Glass seamlessly transitions through 4 variable tint states to provide continuous unobstructed views without heat or glare. It can automatically adapt to changing external conditions or be controlled by a user to meet specific preferences.
TINT STATE 1
70°F
TVIS 58
SHGC 0.41
U-VALUE 0.29
TINT STATE 2
58°F
TVIS 40
SHGC 0.28
U-VALUE 0.29
TINT STATE 3
74°F
TVIS 6
SHGC 0.11
U-VALUE 0.29
TINT STATE 4
78°F
TVIS 1
SHGC 0.09
U-VALUE 0.29

41


Sunset on British Air
(Electrochromaticly)

42



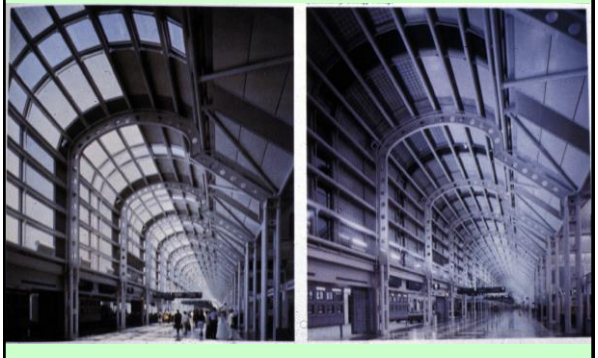
Fritted Glass

Built-in shading device

United O'Hare Terminal, Chicago
Helmut Jahn

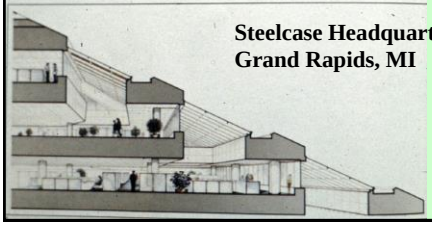
43

Day vs. Night

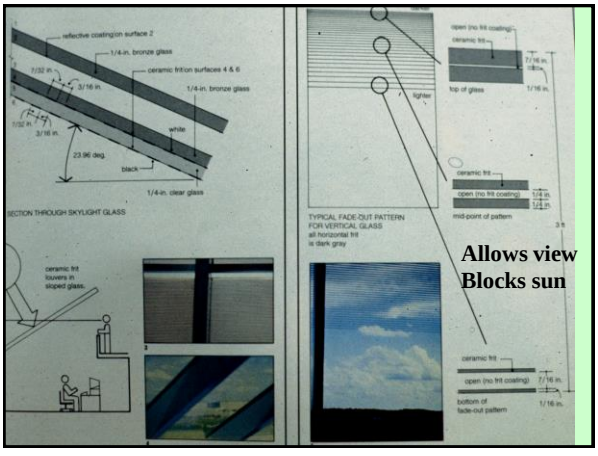


44

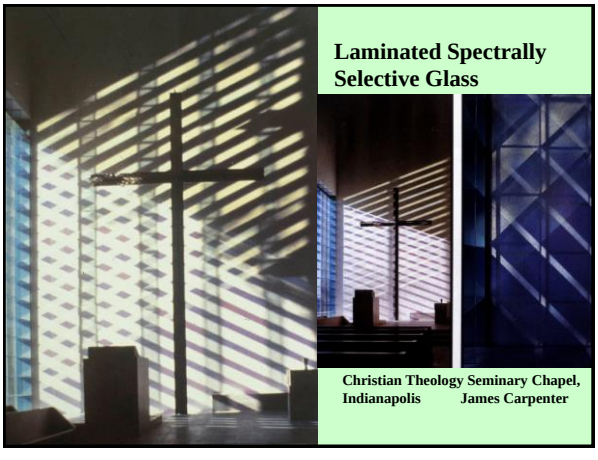
Steelcase Headquarters, Grand Rapids, MI



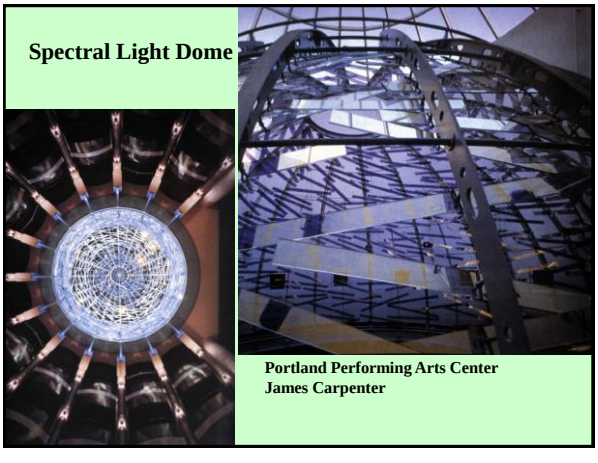
45


reflective coating on surface 2
1/4-in. bronze glass
ceramic frit on surfaces 4 & 6
1/4-in. bronze glass
white
black
23.96 deg.
1/4-in. clear glass
SECTION THROUGH SKYLIGHT GLASS
TYPICAL FADE-OUT PATTERN FOR VERTICAL GLASS
ceramic frit louvers in sloped glass
Allows view
Blocks sun

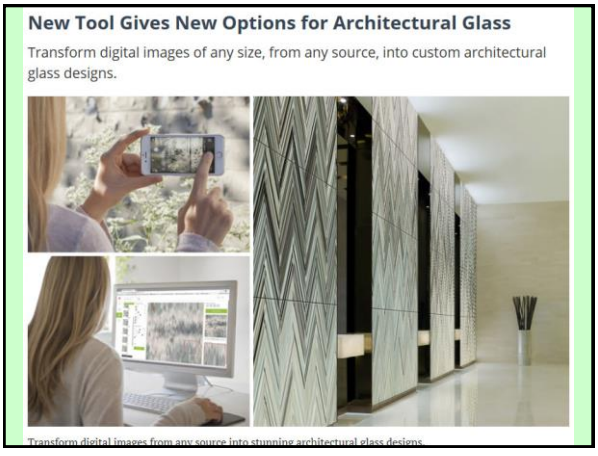
46


Laminated Spectrally Selective Glass
Christian Theology Seminary Chapel, Indianapolis
James Carpenter

47


Spectral Light Dome
Portland Performing Arts Center
James Carpenter

48


New Tool Gives New Options for Architectural Glass
Transform digital images of any size, from any source, into custom architectural glass designs.
Transform digital images from any source into stunning architectural glass designs.

49

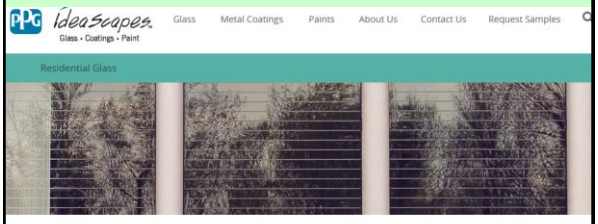

Photovoltaic Glazing
Shades
Produces electricity

50


Bi-metal self-shading glazing
The bi-metal changes shape to shade when heated by the sun

51

Glass is hazardous for birds!

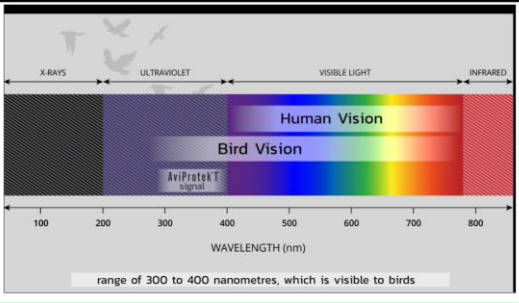


New Bird-Friendly AviProtek Glass Features Solarban Solar Control Low-E Glass

Each year, more than 600 million birds die from collisions with glass in the United States.

52

Walker Avi-Protect-T

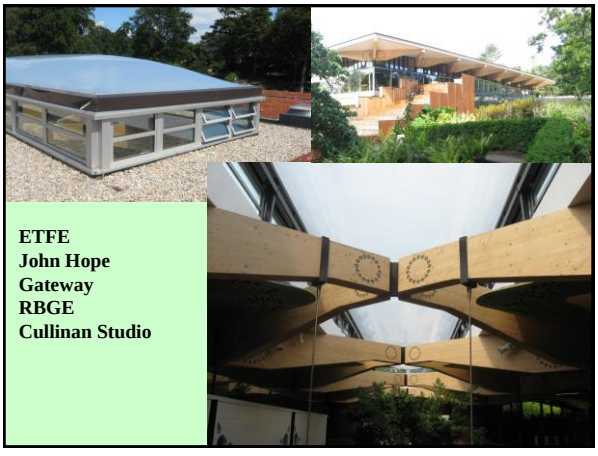


Glazing can contain images visible to birds, but not to humans!

53

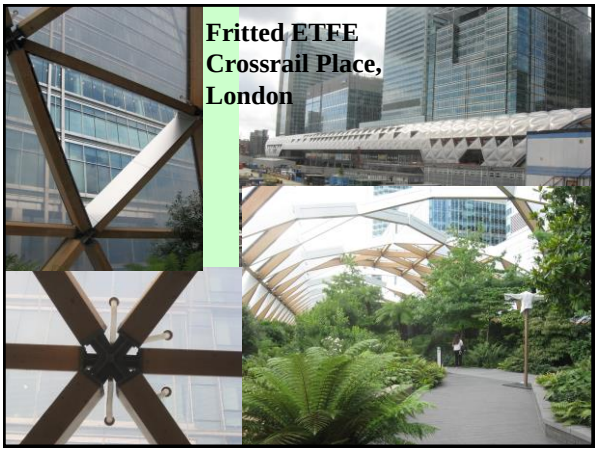
Ethylene/Tetrafluoroethylene Copolymer (ETFE)
Flexible glazing, better insulator than triple glazing, light weight.

54



ETFE
John Hope Gateway
RBGE
Cullinan Studio

55



Fritted ETFE
Crossrail Place, London

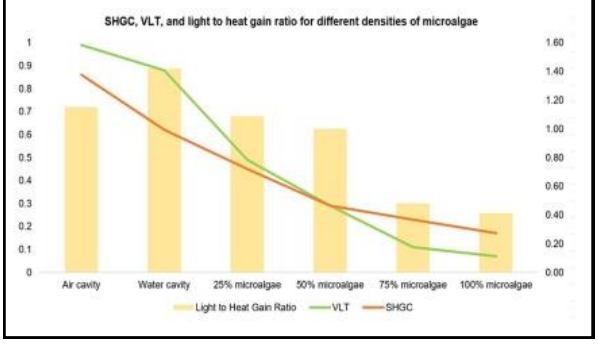
56

Biochromatic Glazing

Transmits light, reduces heat gain, and grows algae!

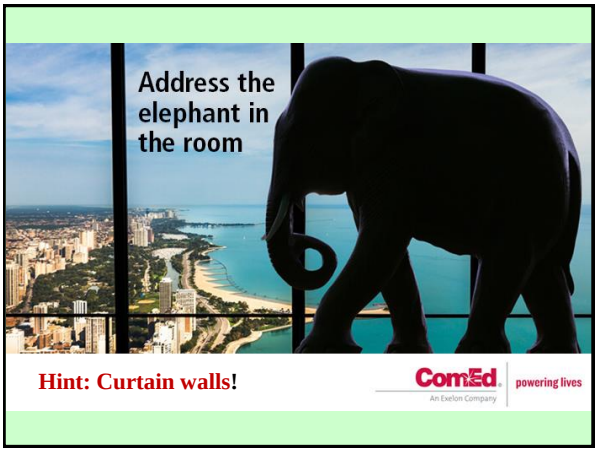
57

Density of the microalgae determines VT and SHGC

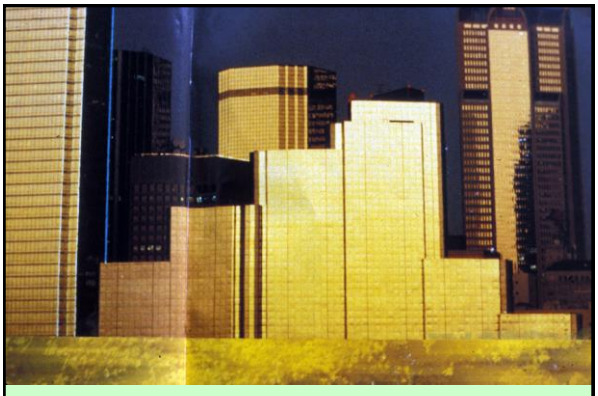


58

59



60



The sun sets in Dallas…Oh no!!!

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