Dynamic Glass Technology Introduction and Application

23 July 2019

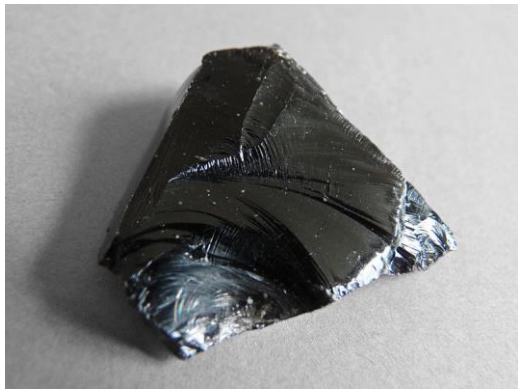
Content

- Development of Architectural Glass
- The dilemma in the built-environment
- Dynamic glass technology
- Continued discussion - What is more we can do for a greener Hong Kong?

- Development of Architectural Glass

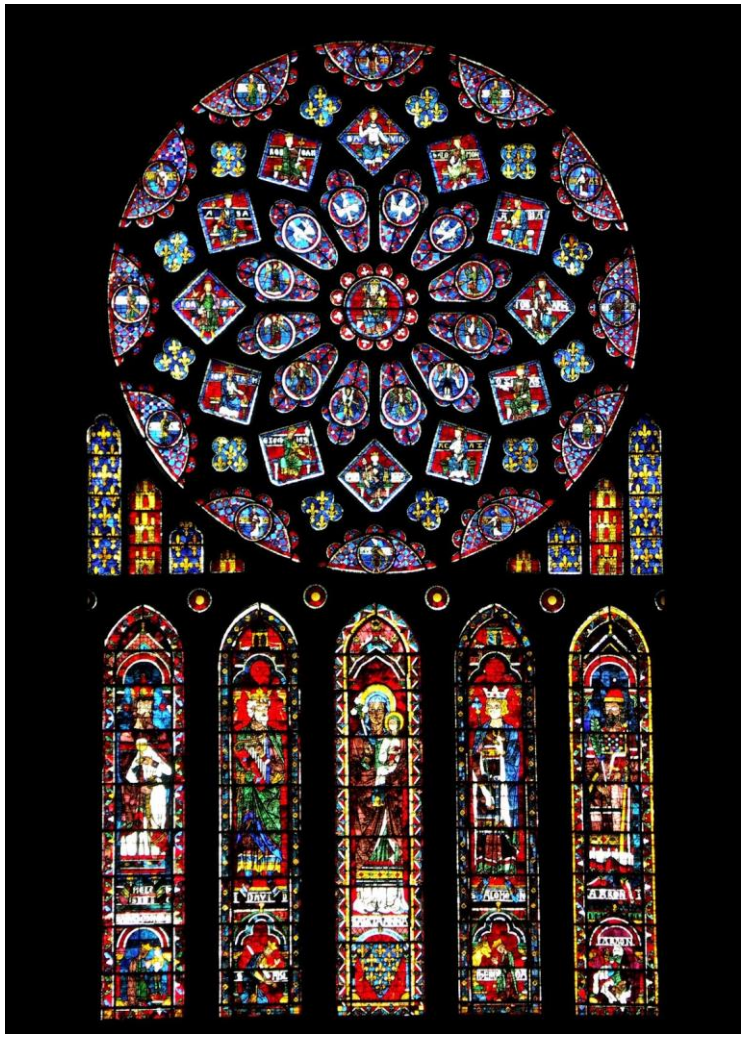
Naturally occurring glass

- Naturally occurring glass, before people can produce glass, was used by Stone Age societies.
- Most commonly it refers to ***Obsidian***, one type of volcanic glass, a rhyolitic glass with high silica (SiO_2) content
- Used as sharp cutting tools / arrow heads
- Extensively traded due to limited source areas

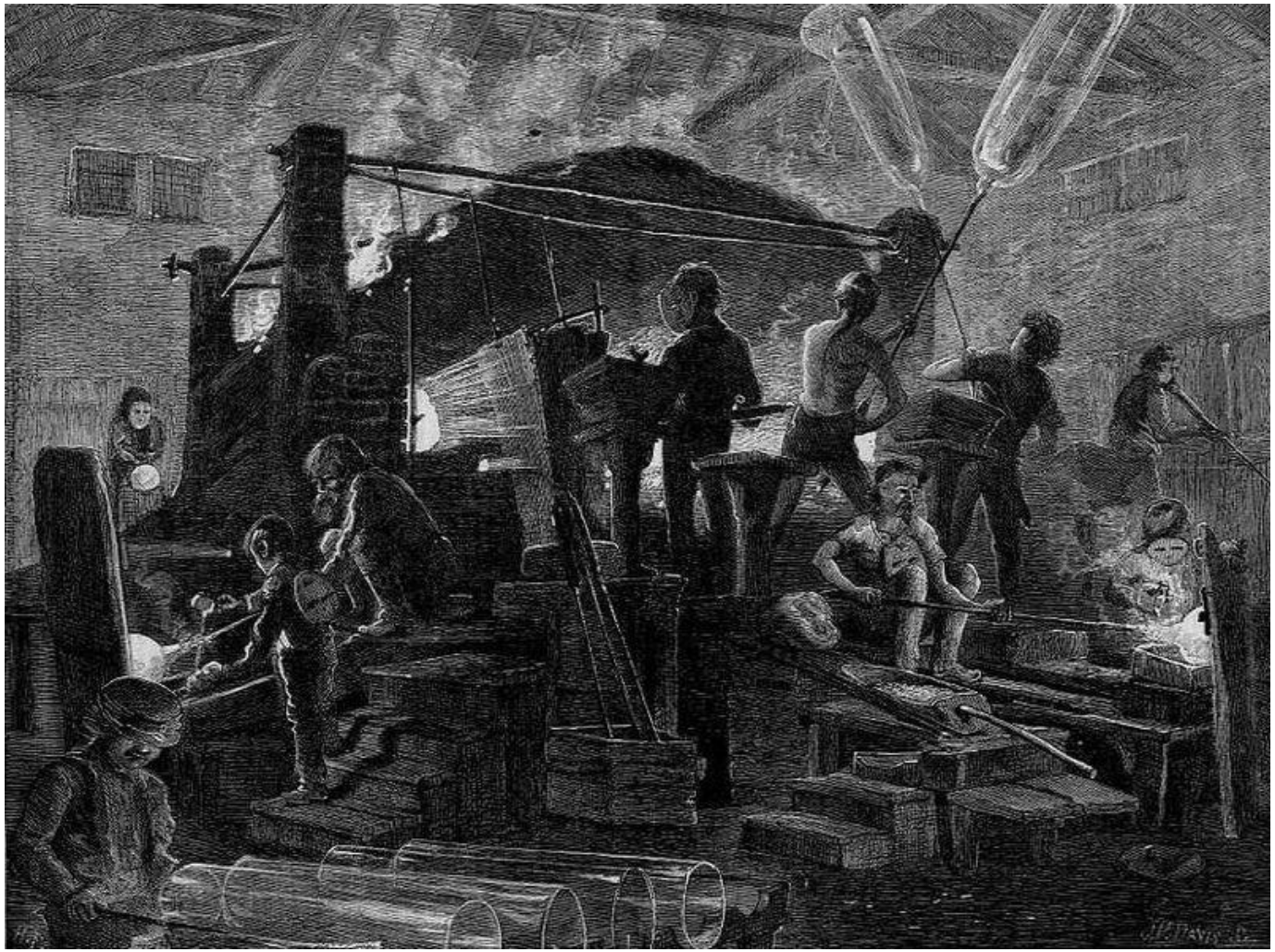


Roman glass (2nd century AD)

In the Renaissance

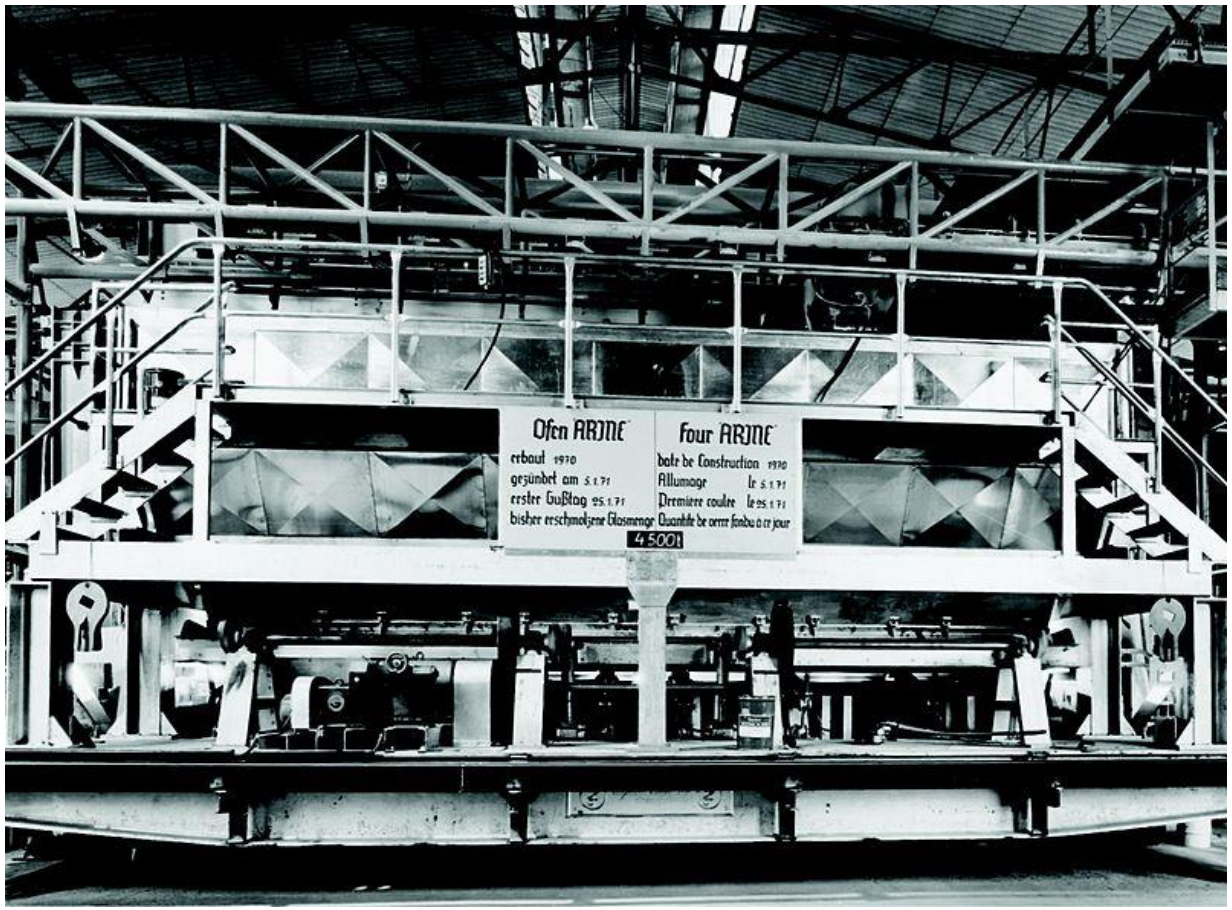


Broad sheet is a type of hand-blown glass



Industrialization

- 1843: An early form of "float glass" invented by Henry Bessemer, pouring glass onto liquid tin. Expensive and not a commercial success.
- 1874: Tempered glass is developed by Francois Barthelemy Alfred Royer de la Bastie (1830–1901) of Paris, France by quenching almost molten glass in a heated bath of oil or grease.
- 1959: Float glass launched in UK. Invented by Sir Alastair Pilkington.[103][104]



Float Glass

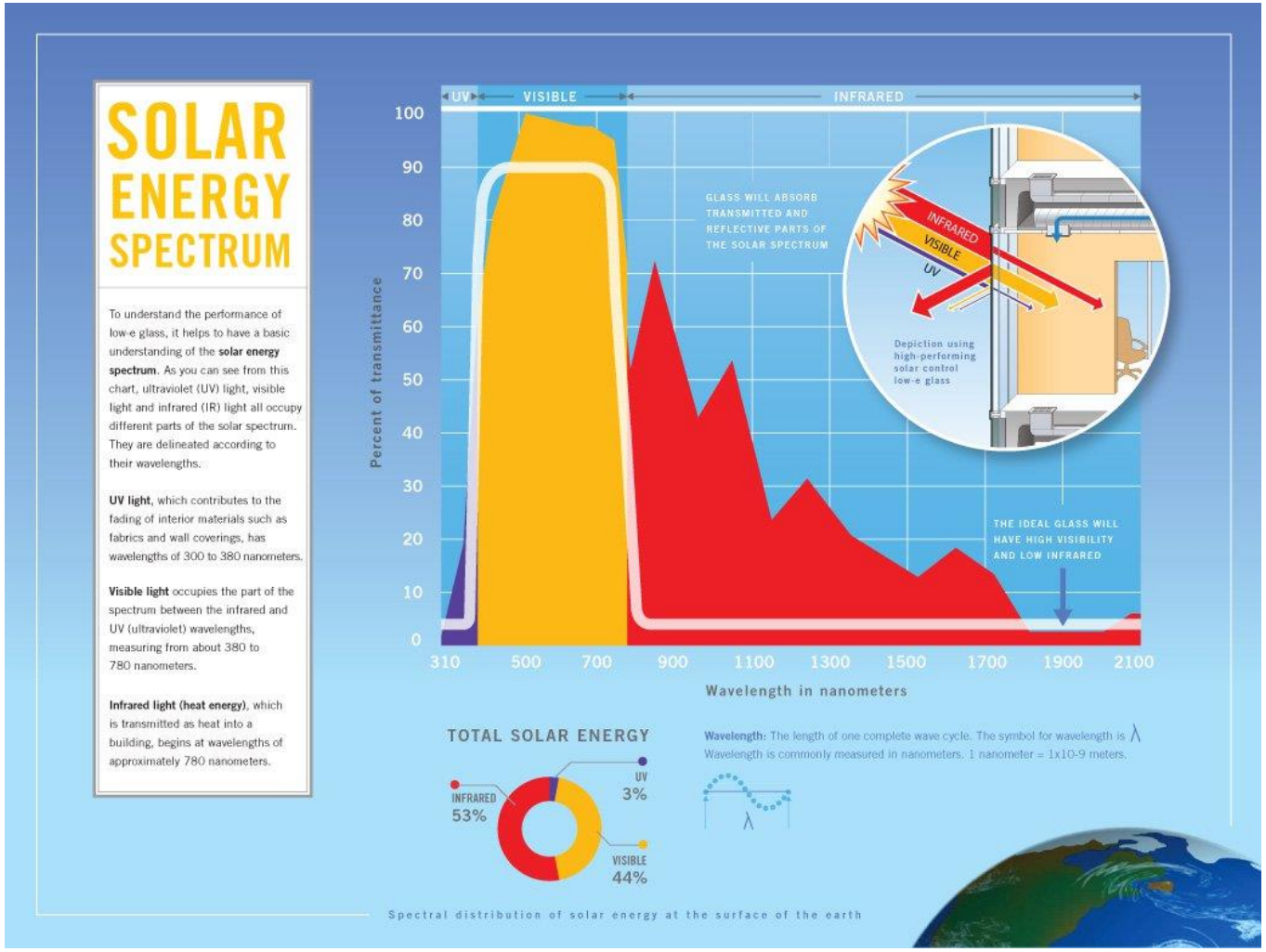
- Key constituent is sand
- Silica (**SiO_2**) matrix

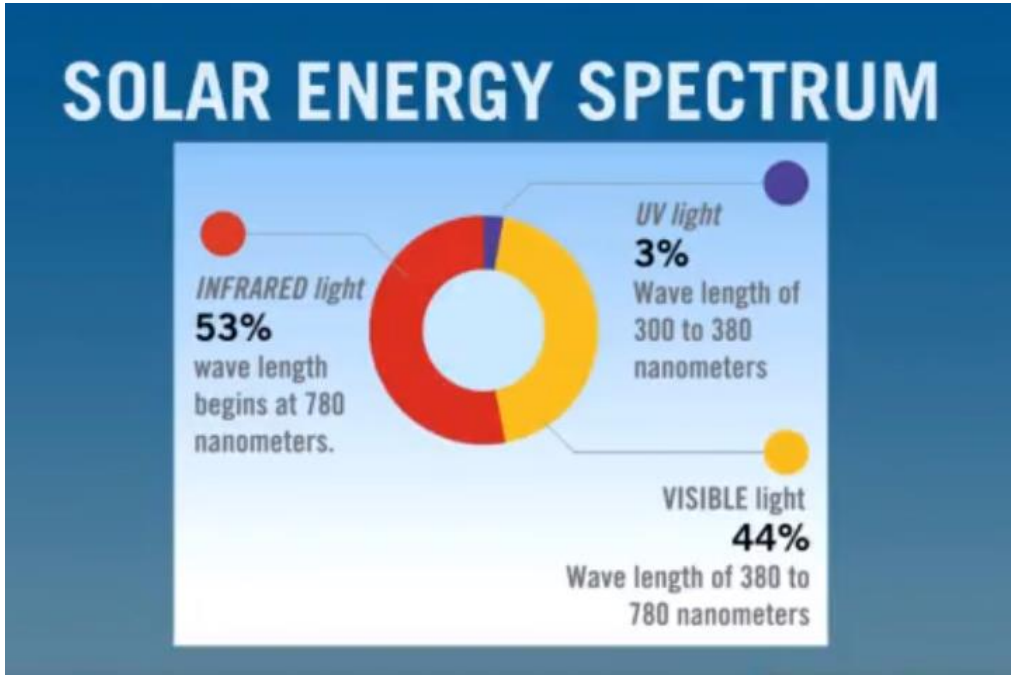
Table 57.1 Range of float glass composition

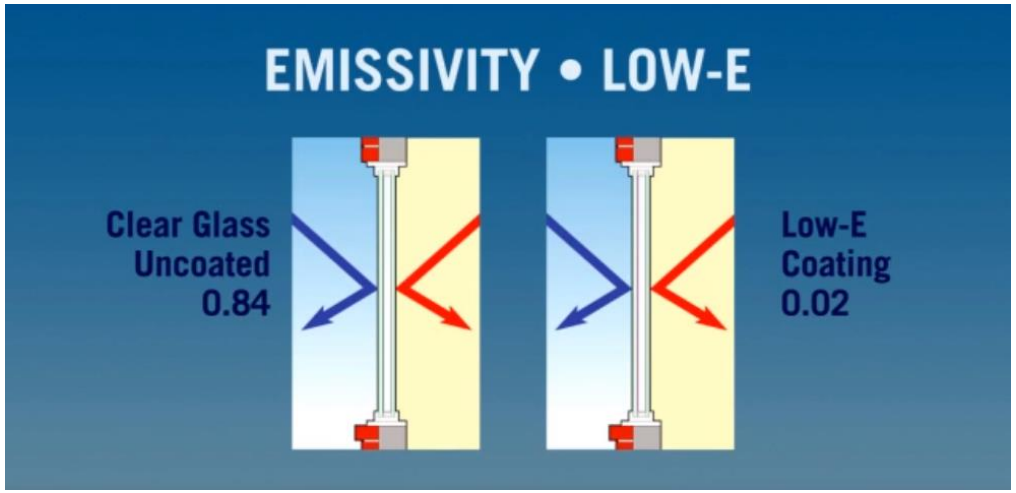
Oxide	*Range (% by wt)*
Silicon dioxide (SiO_2)	69–74
Calcium oxide (CaO)	5–12
Sodium oxide (Na_2O)	12–16
Magnesium oxide (MgO)	0–6
Aluminium oxide (Al_2O_3)	0–3

Excellence of Glass Structure

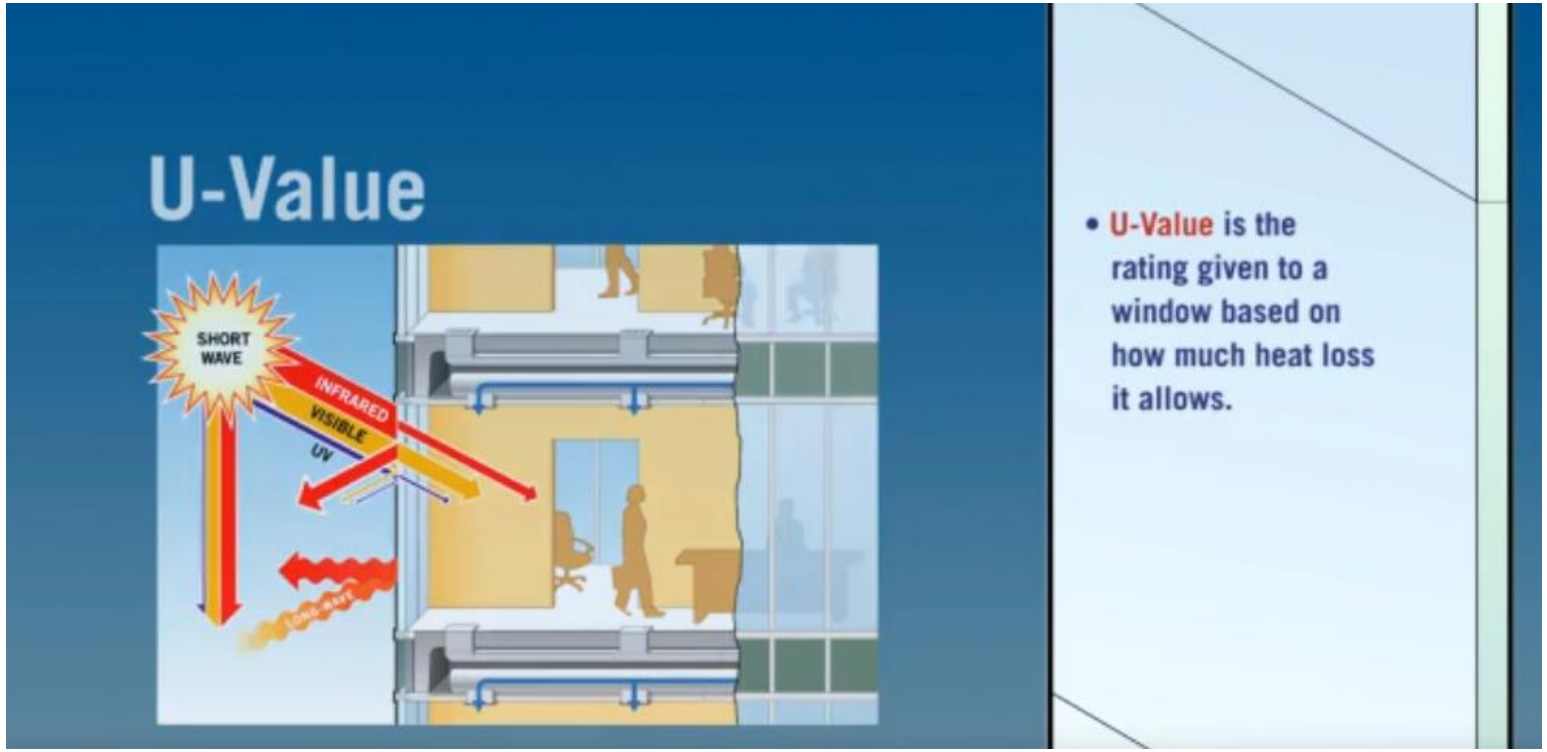
Solar Energy Spectrum



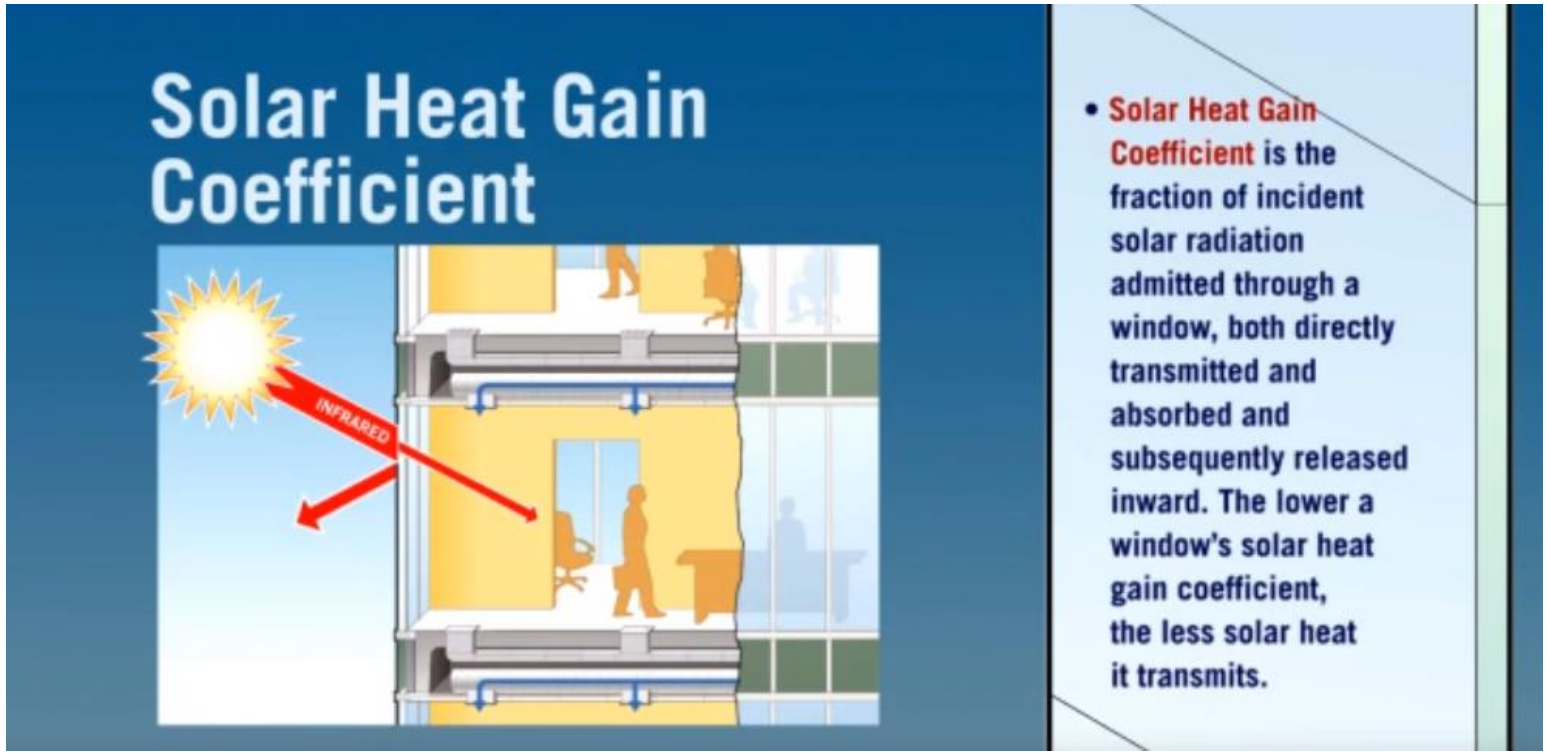




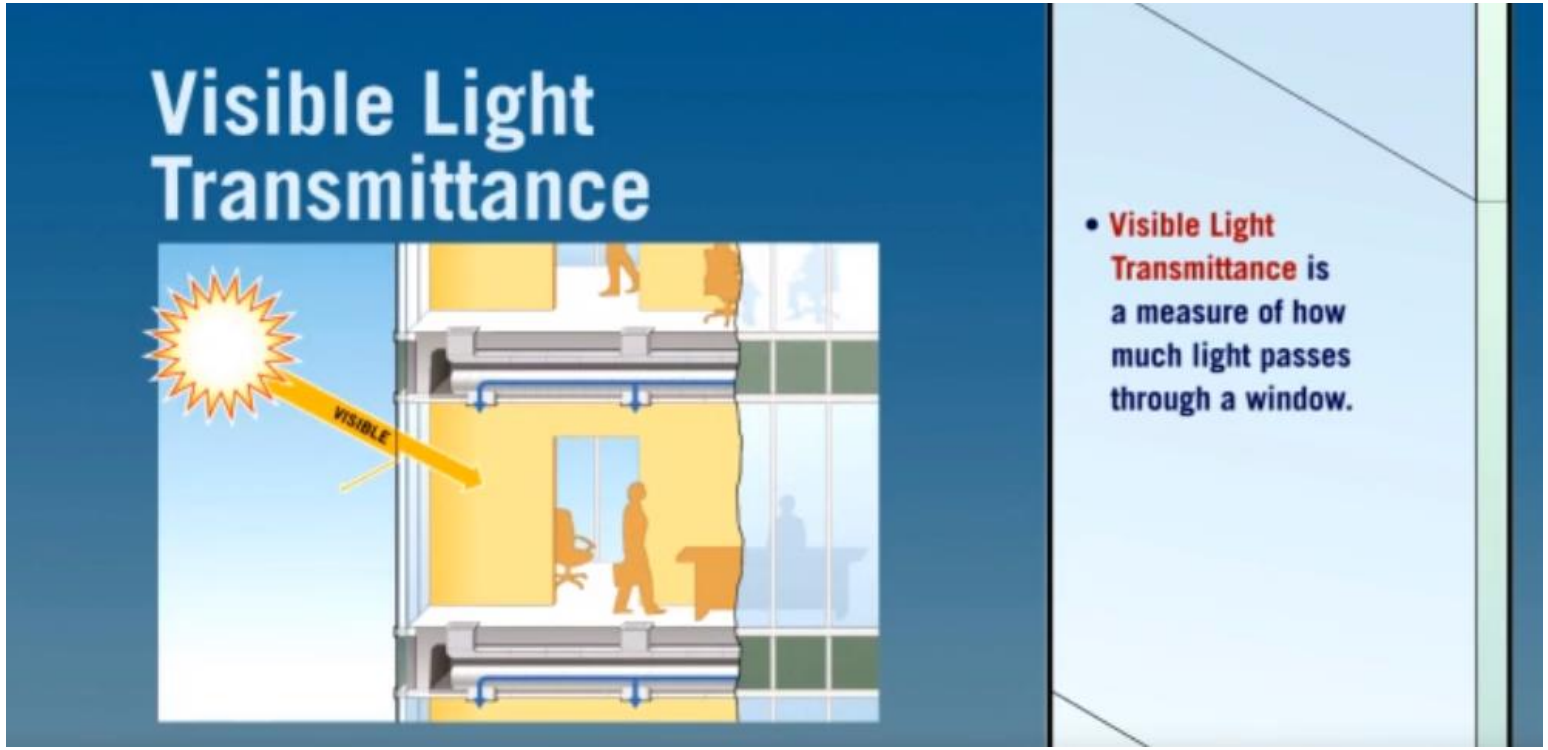
Key Indicators



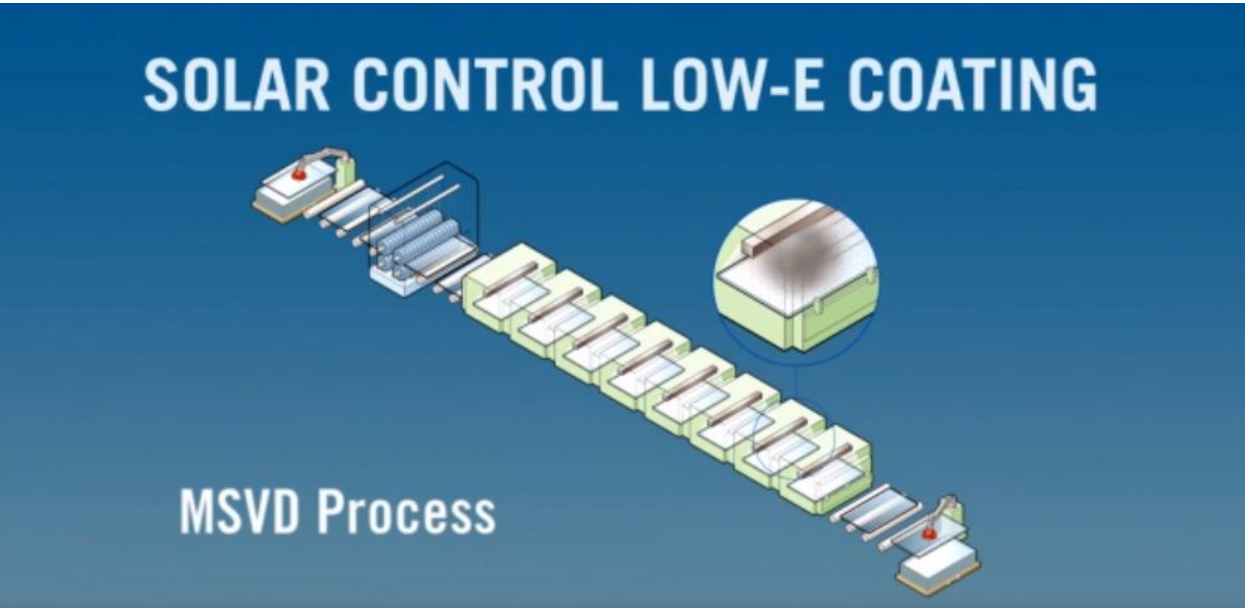
Key Indicators

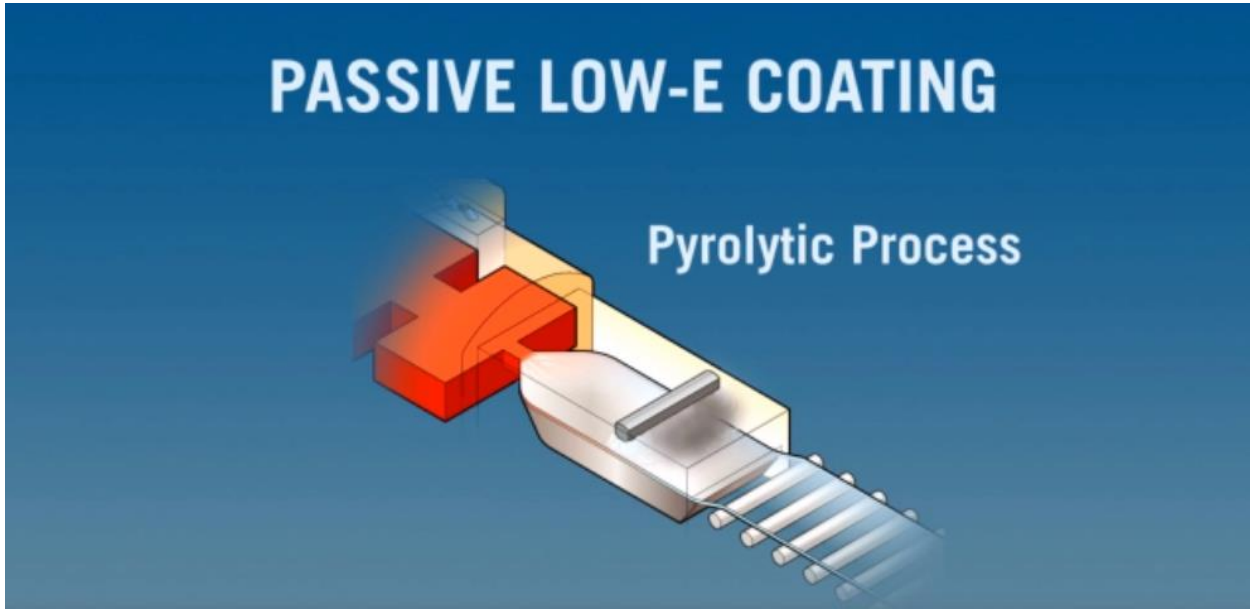


Key Indicators

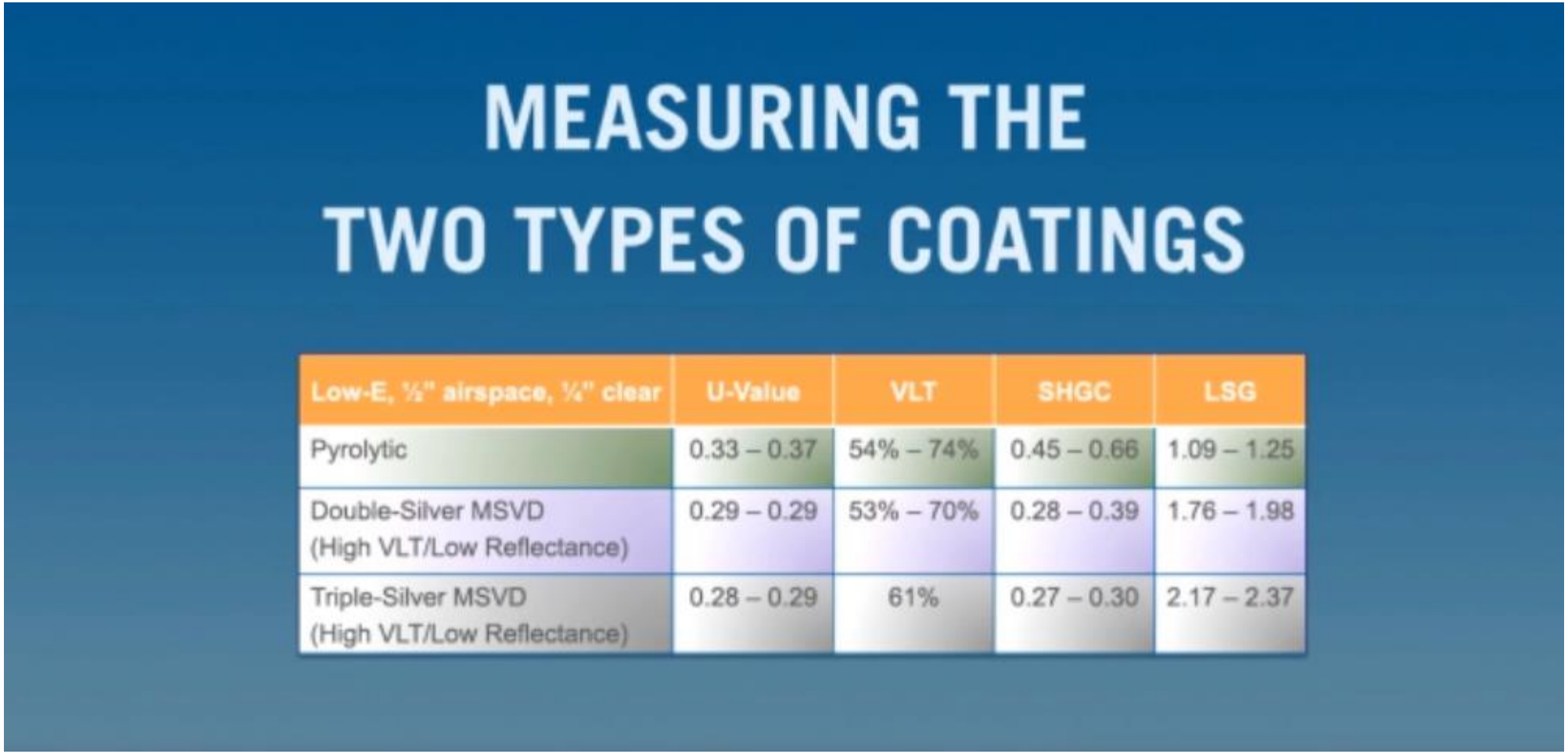


Low-e coating application



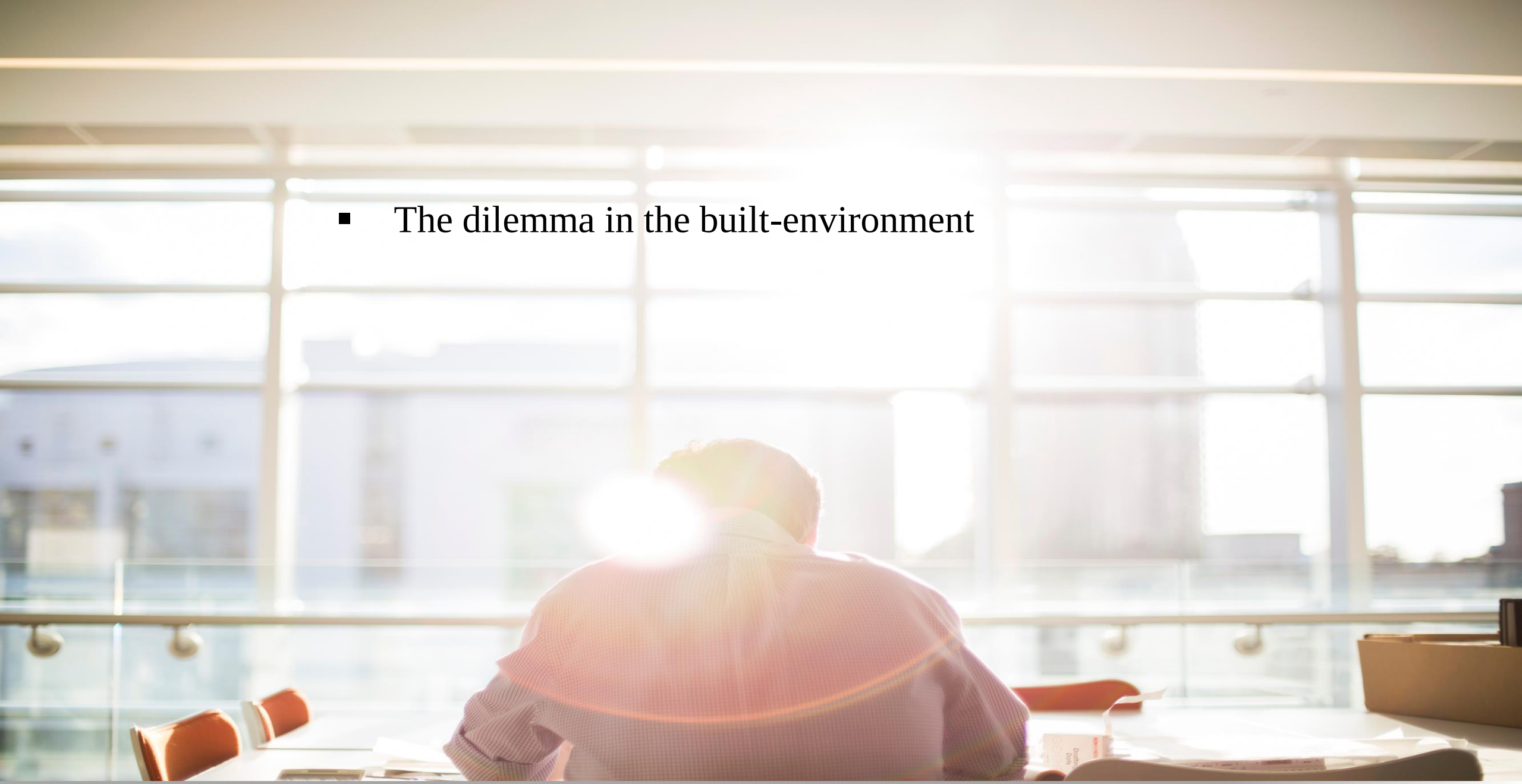


Low-e coating application

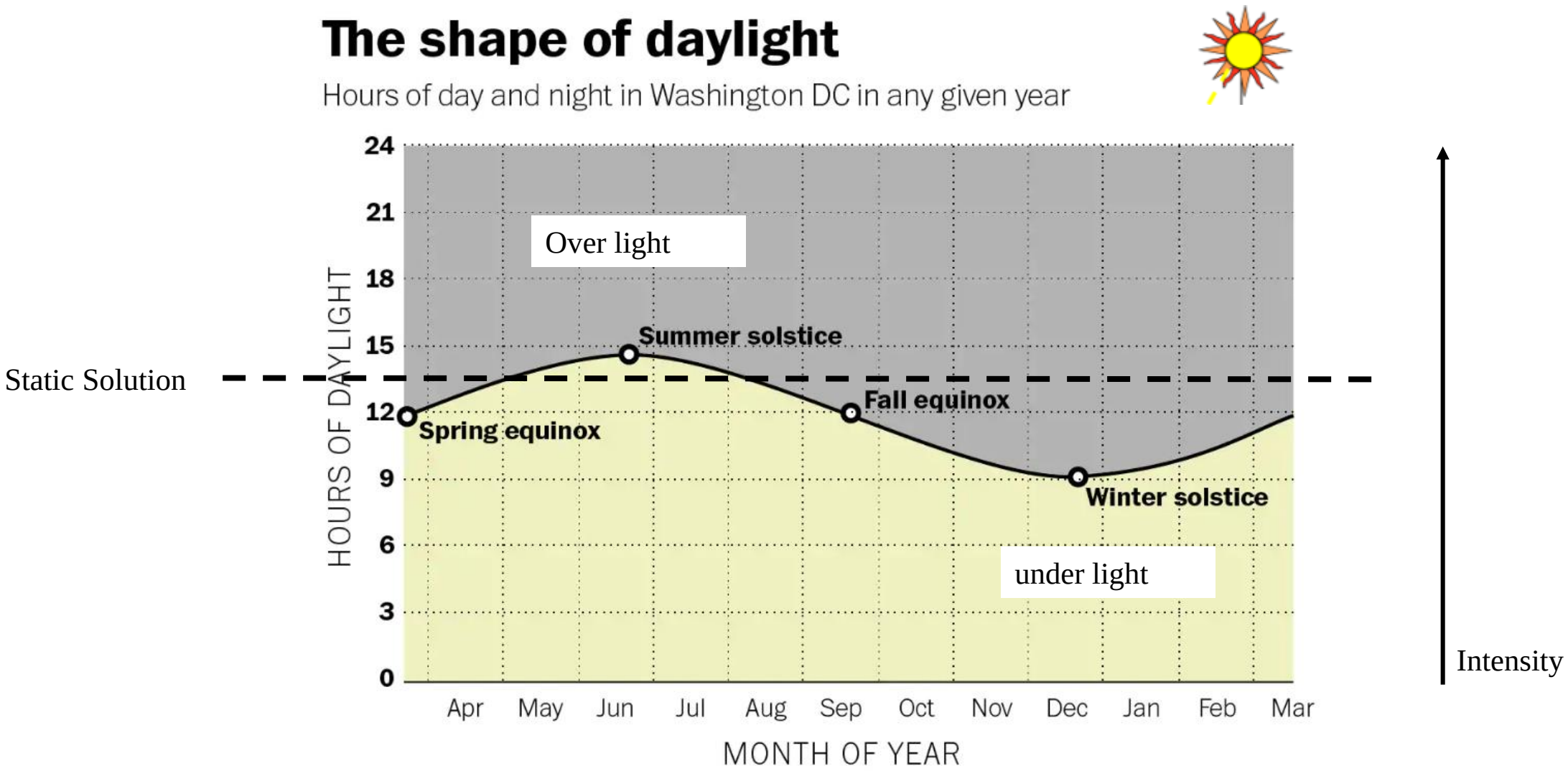


Low-E, ½" airspace, ¼" clear	U-Value	VLT	SHGC	LSG
Pyrolytic	0.33 – 0.37	54% – 74%	0.45 – 0.66	1.09 – 1.25
Double-Silver MSVD (High VLT/Low Reflectance)	0.29 – 0.29	53% – 70%	0.28 – 0.39	1.76 – 1.98
Triple-Silver MSVD (High VLT/Low Reflectance)	0.28 – 0.29	61%	0.27 – 0.30	2.17 – 2.37

- The dilemma in the built-environment



- The dilemma in the built-environment


The shape of daylight
Hours of day and night in Washington DC in any given year
24
21
18
15
12
9
6
3
0
HOURS OF DAYLIGHT
Over light
Summer solstice
Fall equinox
Spring equinox
Winter solstice
under light
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
MONTH OF YEAR
Static Solution
Intensity

Any solution?

- Dynamic glass technology

Dynamic Glass Technology

Now the dynamic glass is one of the new solution being able to correspond to a range of scenarios, enhancing the conform of occupants and improving the performance of the building.

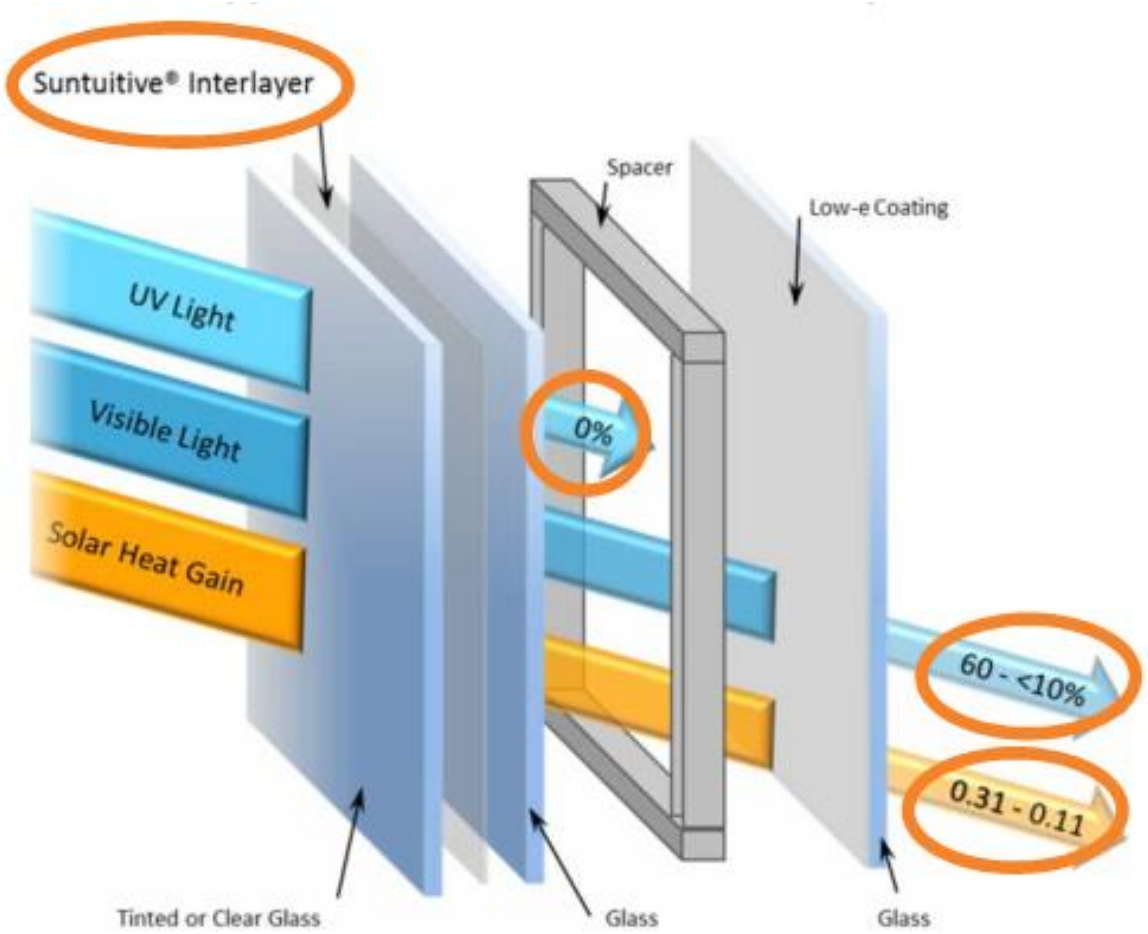
There are two types if dynamic glass generally available in the market:

- Passive: thermochromic (TC) glass
- Active: electrochromic (EC) glass

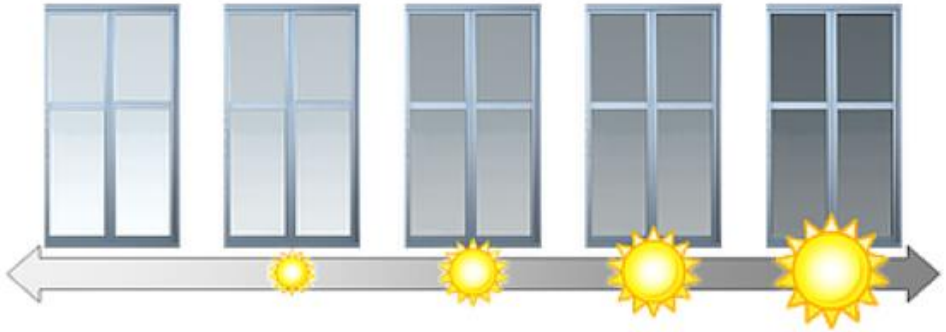
(Source: eeNEWS, https://www.eenewsanalog.com/news/dynamic-glass-maker-raises-1-billion)

- Thermochromic (TC) glass

Thermochromic glass – One Example



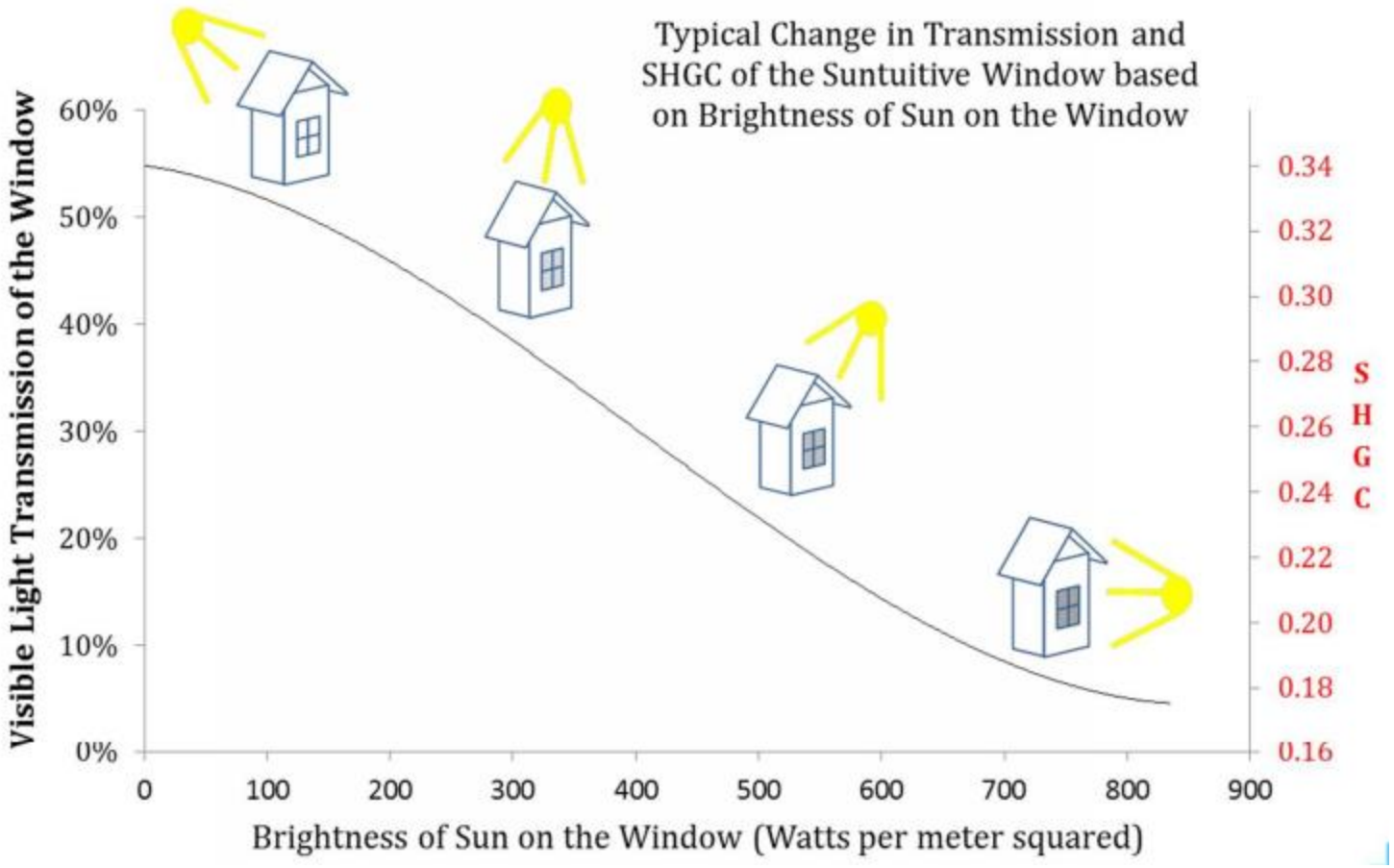
Tint stage: gradually change



The warmer the glass, the darker the tint.
The cooler the glass, the clearer the view.

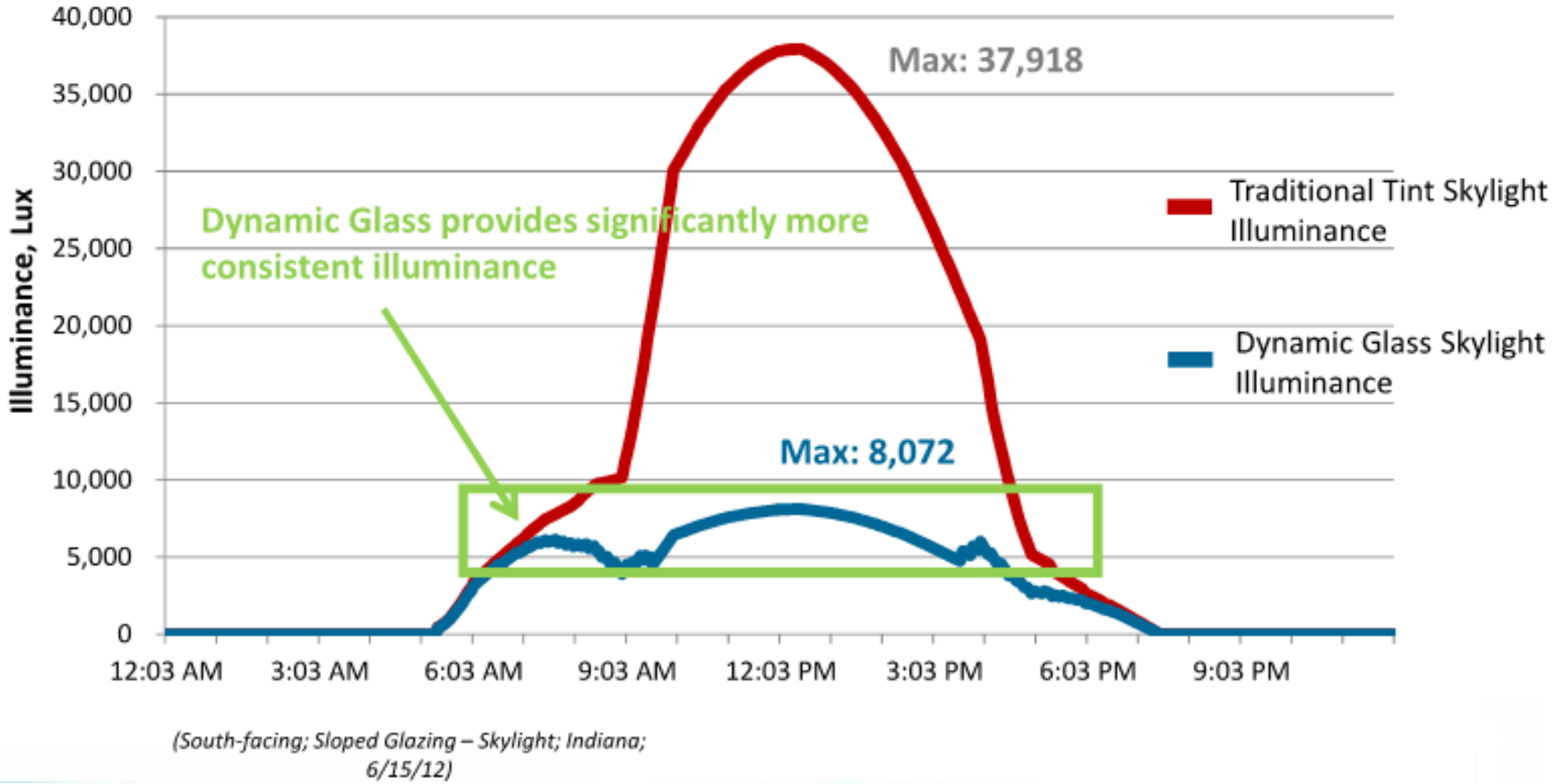
Ref: Suntuitive®

Thermochromic glass



Ref: Suntuitive®

Thermochromic glass



(South-facing; Sloped Glazing – Skylight; Indiana; 6/15/12)

Thermochromic glass

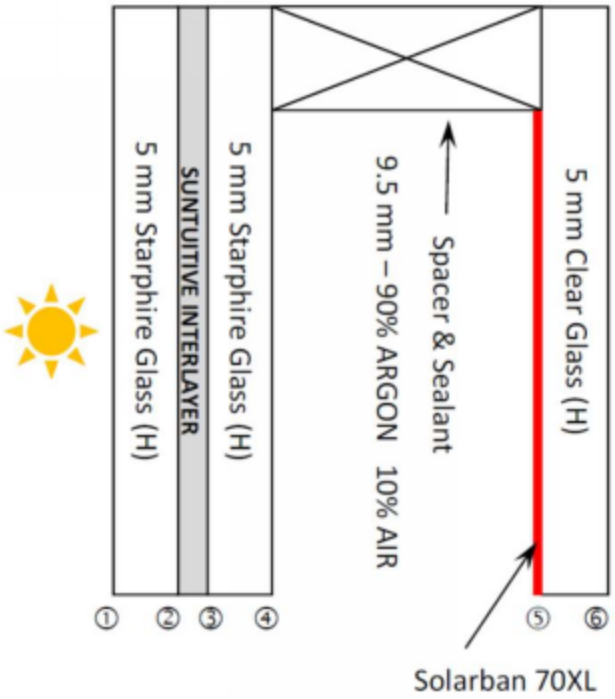
MORNING

AFTERNOON

EVENING

Thermochromic glass

Performance Data			
Center of Glass values calculated with LBNL Optics 6.0 and Window 7.5.15.0 software. Environmental conditions were NFRC 100-200 with tilt of 90˚			
	Winter (glass temp 5˚C)		Summer (glass temp 55˚C)*
Visible Light Transmittance	51%	← progressive →	16%
Shade Coefficient	0.36	← progressive →	0.19
Relative Heat Gain (W/m^2)	239	← progressive →	132
Indoor Reflectance	0.11	← progressive →	0.10
Outdoor Reflectance	0.10	← progressive →	0.05
Solar Transmission	19%	← progressive →	7%
U-value ($W/(m^2 \cdot K)$)	1.41	← progressive →	1.41



Thermochromic glass - Advantages

- Off the grid, no electrical parts or wire, no safety concern
- No training, maintenance, or recalibration
- Echo the environment
- Relatively economic solution
- Saving in life-cycle cost

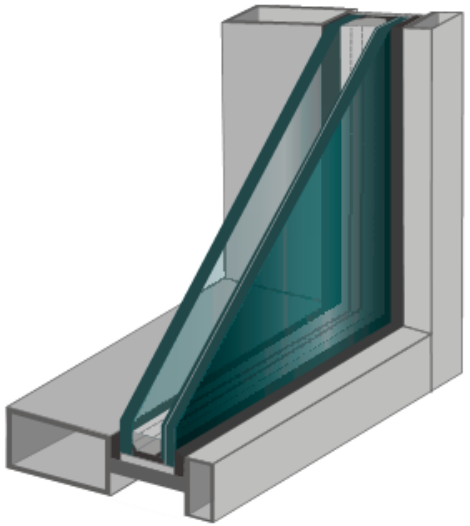
	Standard	Dynamic Glass	Differe
Total Energy	$709,000	$672,000	($37,000
HVAC	$50,000	$40,000	($10,000
Shading	$66,000	$0	($66,00
	$825,000	$712,000	($113,000) 14% Savings

Self-tinting Dynamic Glass provides an 14% savings in cash flow for the life of the building.

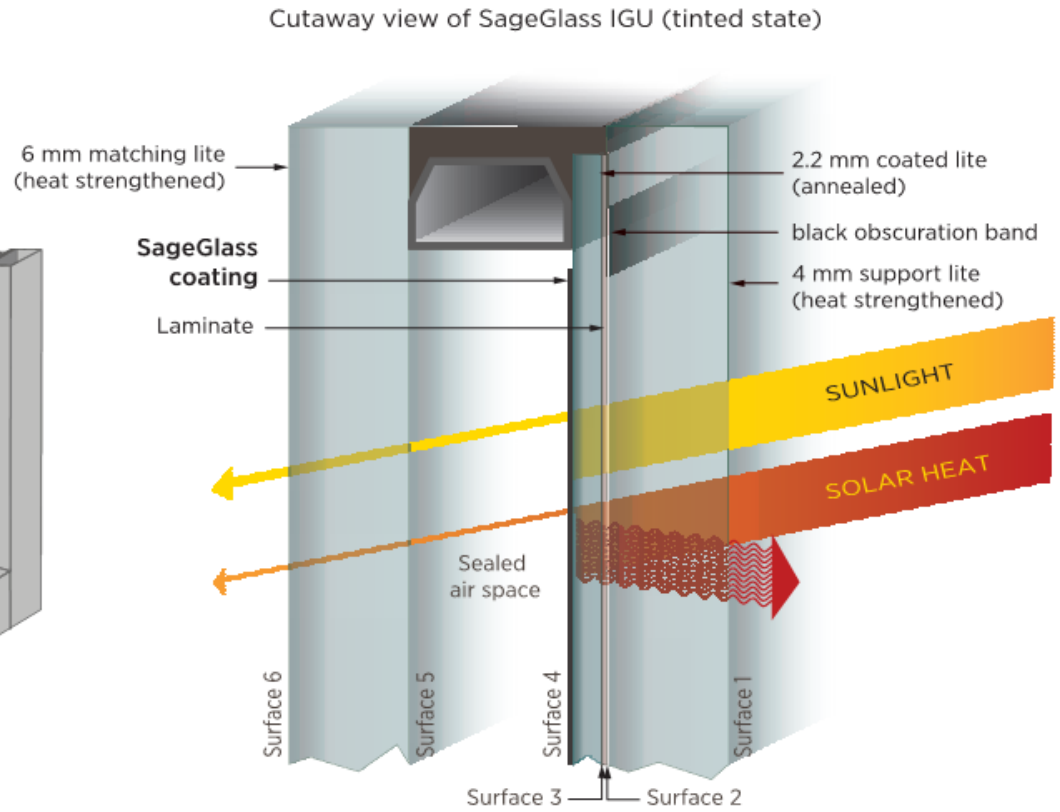
- Electrochromic (EC) glass

Electrochromic glass – Product 1

Metal oxide sputtered coating



SageGlass IGU shown in a frame

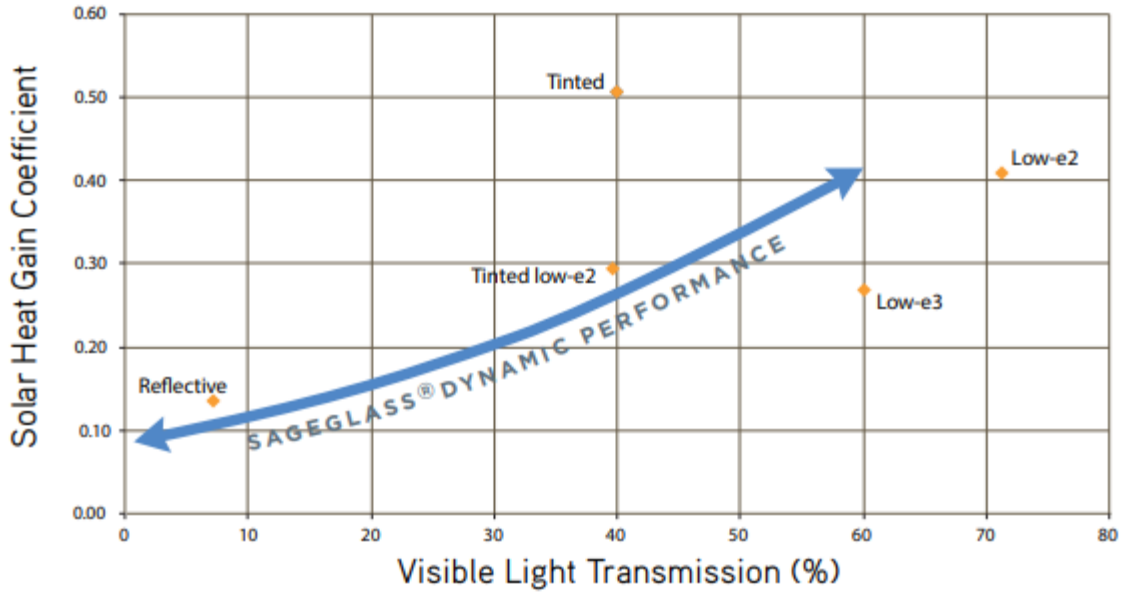


Tint stage:

Visible light transmission from top: 60%, 18%, 6%, 1%

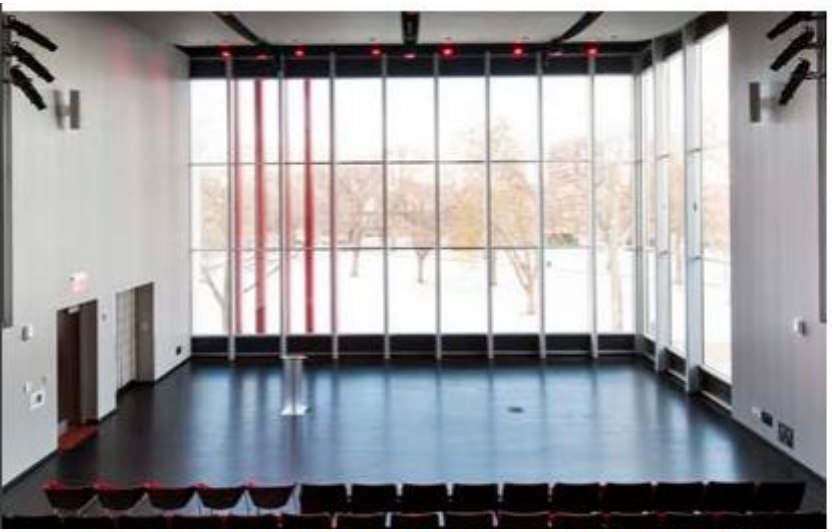
Electrochromic glass – Product 1

Performance



SageGlass® Clear w/SR2.0	%Tvis	%Rf Ext.	%Rb Int.	%Tsol	SHGC	U-factor	%Tuv	Tdw-K
Clear State	60	16	14	33	0.41	0.28	0	15
Intermediate State 1	18	10	9	7	0.15	0.28	0	5
Intermediate State 2	6	10	9	2	0.10	0.28	0	2
Fully Tinted	1	11	9	0.4	0.09	0.28	0	0.6

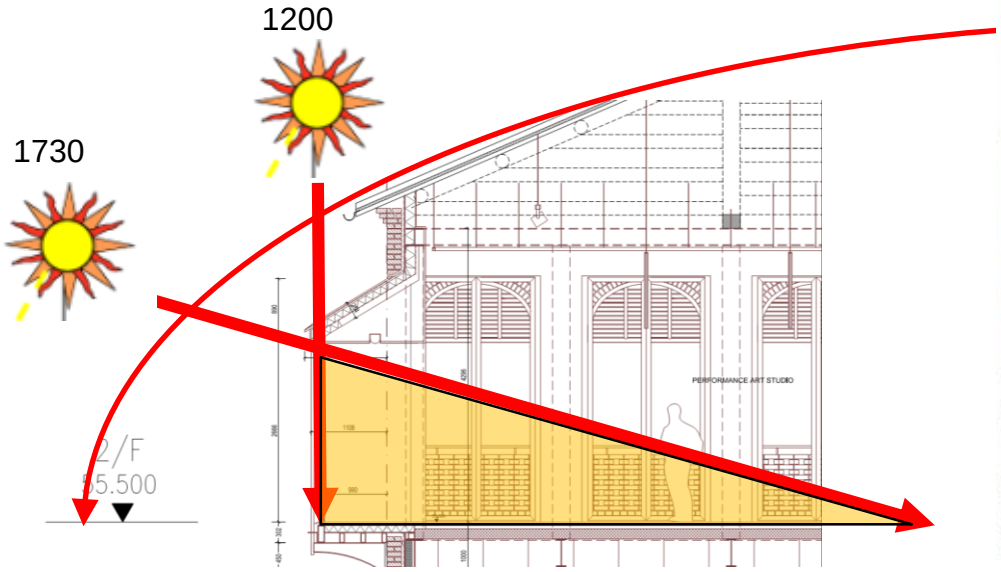
Electrochromic glass – Product 1






Electrochromic glass – Product 1

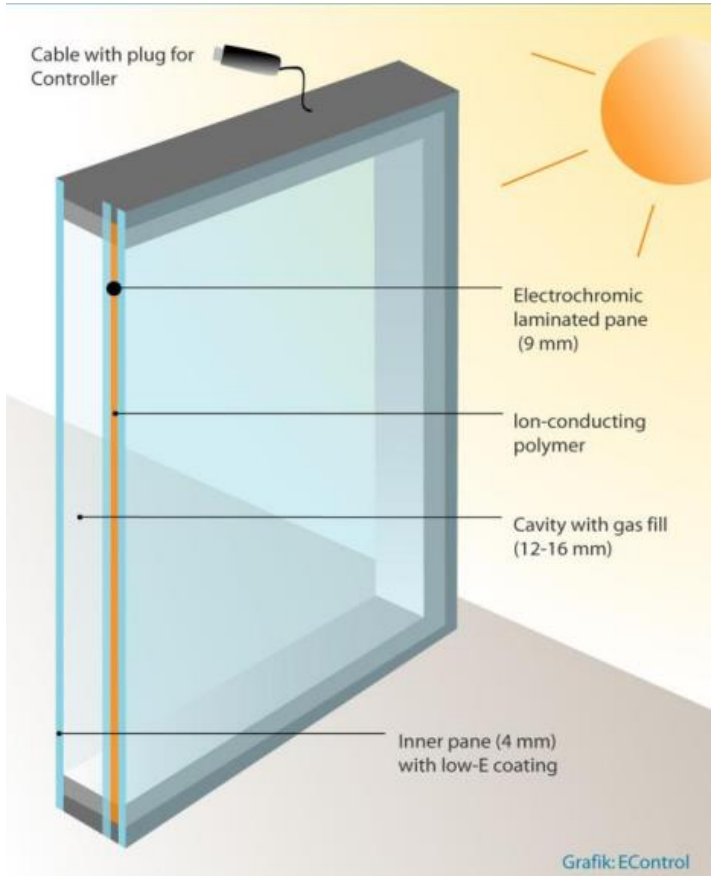
More than one tint zones with single unit

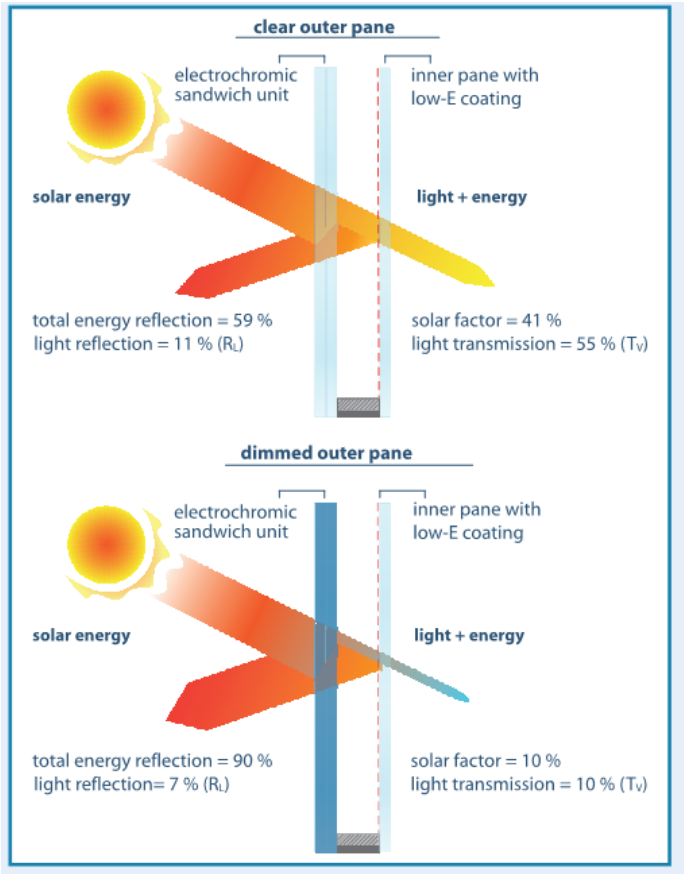


Electrochromic glass – Product 1

More than one ti

Electrochromic glass – Product 2

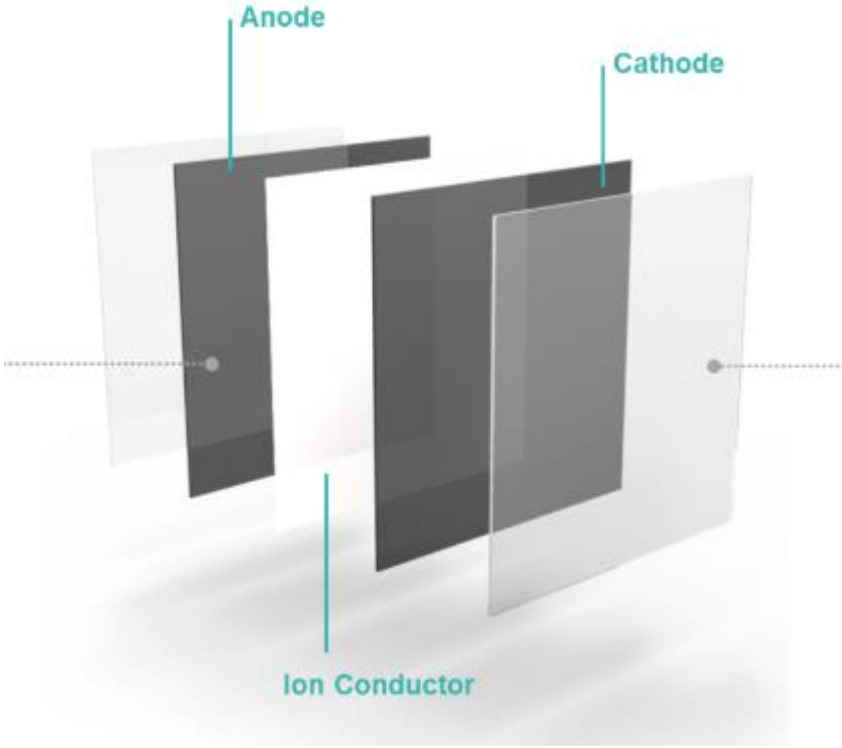


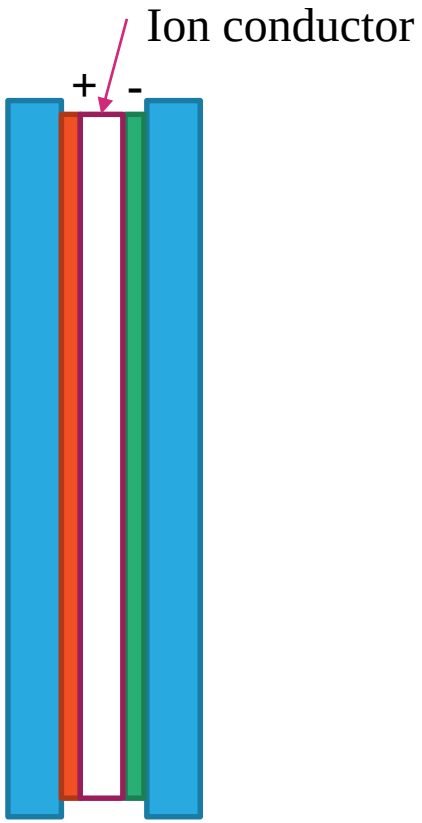


Tint stage:

Electrochromic glass – Product 2

MAIN PROPERTIES	Halio	Halio Black
Maximum Light Transmission - Tv (EN 410)	66%	53%
Minimum Light Transmission - Tv (EN 410)	3%	0.1%
Maximum Solar factor – g (EN 410)	46%	35%
Minimum Solar factor - g (EN 410)	5%	4%





(Ion-conductive polymer laminated inside)

Electrochromic glass – Product 2

PROPERTIES	Halio	Halio Black
Maximum Light Transmission - Tv (EN 410)	66%	53%
Minimum Light Transmission - Tv (EN 410)	3%	0.1%

FROM CLEAR TO DARK...

UNDER 3 MINUTES

Natural clear state allows over 66% light transmission

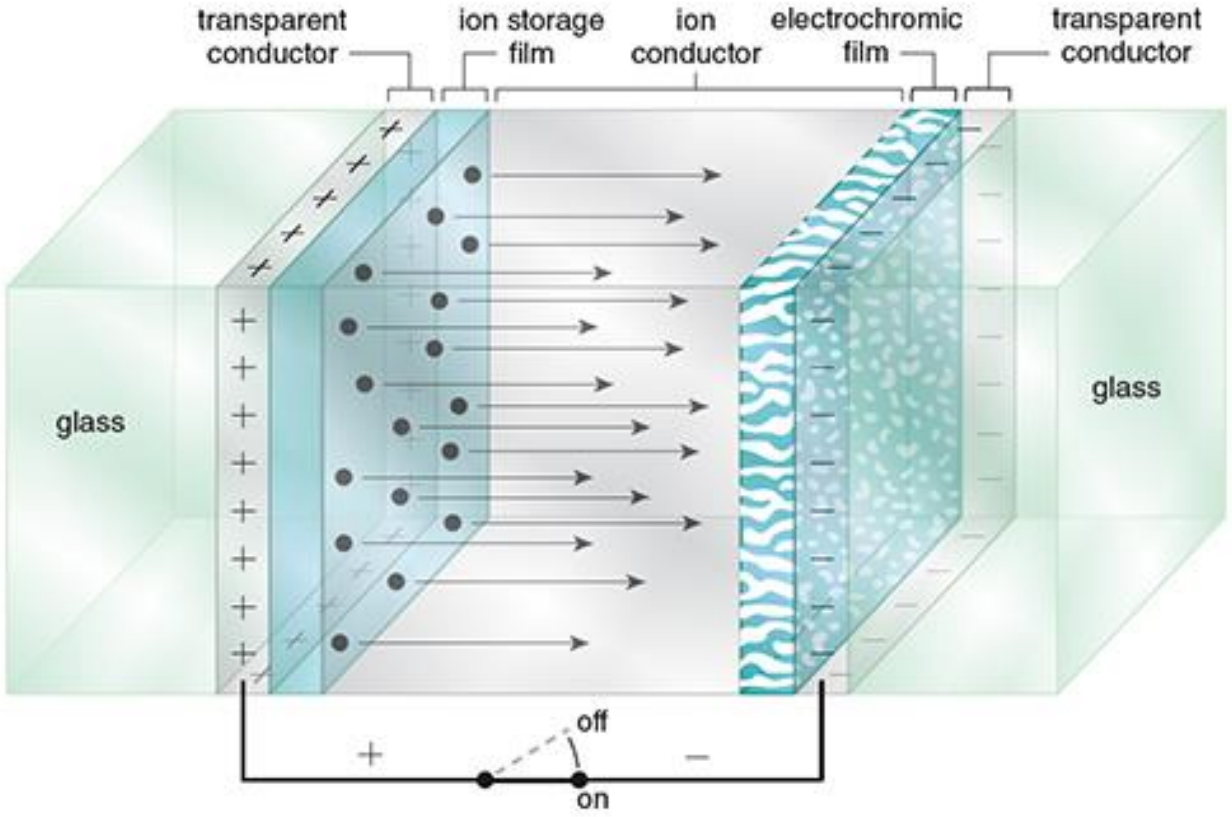
Uniform switching makes intermediate tints useable

Dark neutral grey state provides **energy efficiency and privacy**, by blocking up to 99.9%* of transmitted light

Halio Black

(Ion-conductive polymer laminated inside)

Electrochromic material



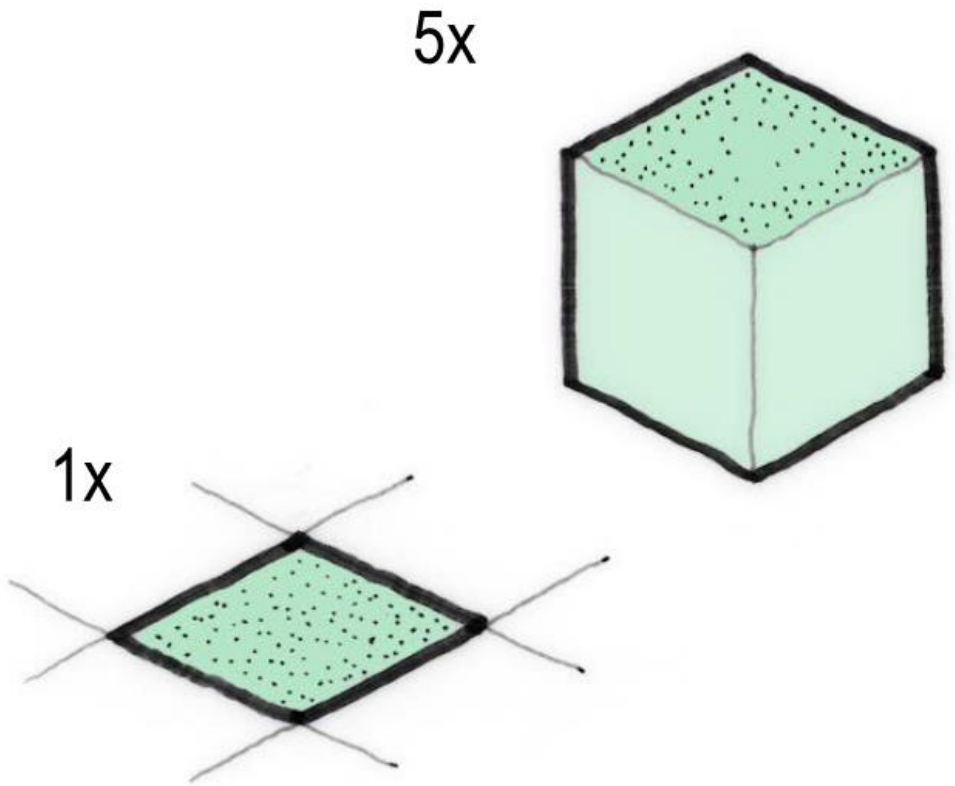
Prussian Blue

Prussian blue was first created in the early 1700s. As the earliest modern synthetic pigment, it has an extensive history of use in the formulation of paints, lacquers, printing inks, typewriter ribbons and carbon paper. It has the molecular formula $C_{18}Fe_7N_{18}$ and it forms crystals with a cubic lattice structure. Its synthesis is based on the *hexacyanoferrate* anion, which, like metal coordination complexes, has a central iron atom surrounded by six ligands of carbon triple-bonded to nitrogen.

(Ion-conductive polymer laminated inside)

Continued discussion

- What is more we can do for a greener Hong Kong?


5x
1x

- As an engineer, we must aim to make good use of resource for the built environment.
- A building actually multiplies the interface between human and natural environment. Those interfaces mean exposure and flow of energy.
- Dynamic glass is a new solution on top of current prevailing technology, that helps us to adapt to the changing environment.