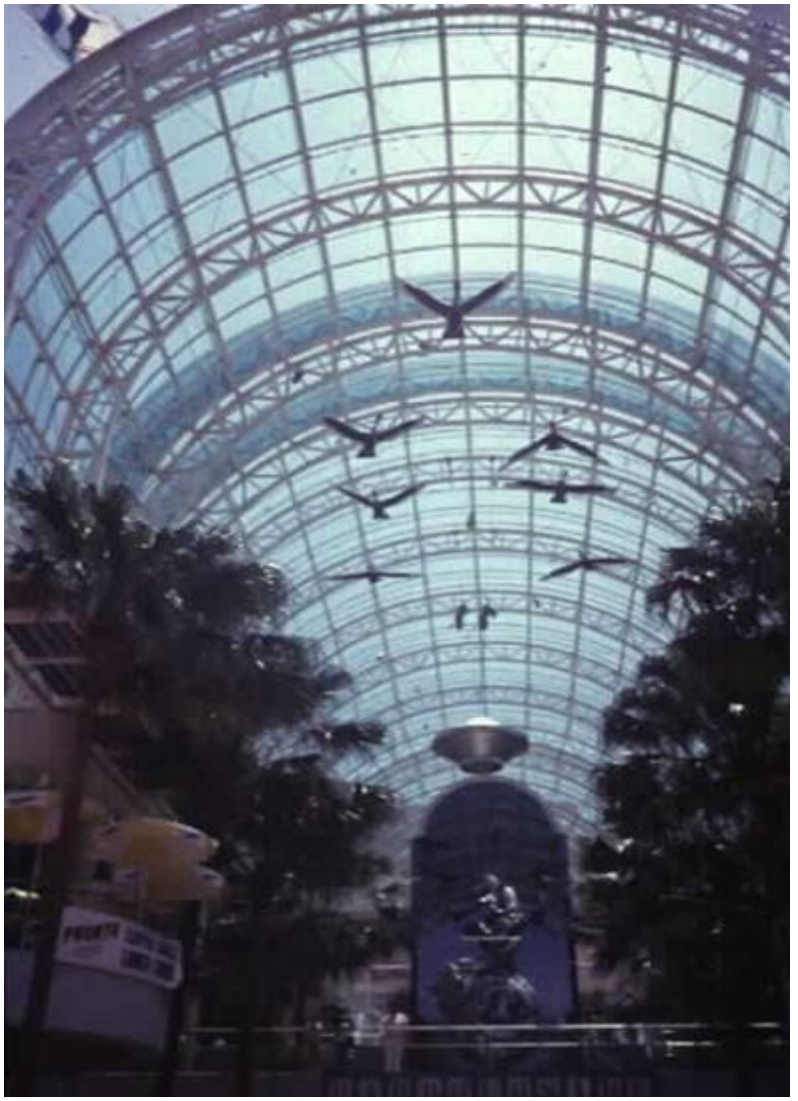
The Distinctive Properties of Glass



Presentation by: Honorary Prof. Mark B. Luther

What is GLASS ?

Glass Properties

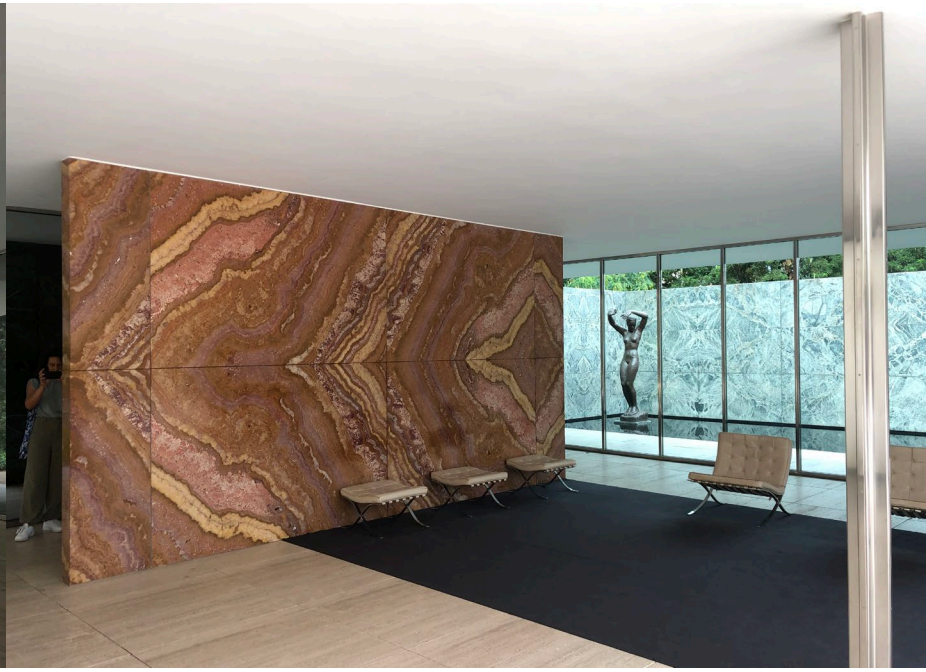
Properties of Glass:

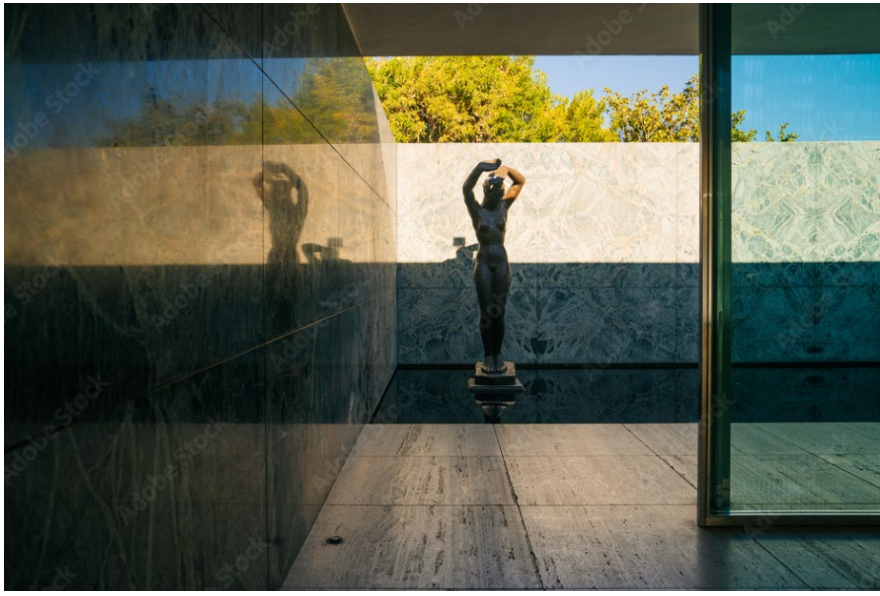
Density (kg/m^3):	2500-2800
Thermal Coefficient of Expansion (ppm/°K):	9
Young's Modulus (Gpa):	72
Heat Capacity (J/kg°K):	0.84
Thermal Conductivity : (W/m°K)	1.05

Properties of Concrete:

Density (kg/m^3):	2240-2400
Thermal Coefficient of Expansion (ppm/°K):	5.5
Young's Modulus (Gpa):	30-50
Heat Capacity (J/kg°K):	0.75
Thermal Conductivity : (W/m°K)	1.0-1.5

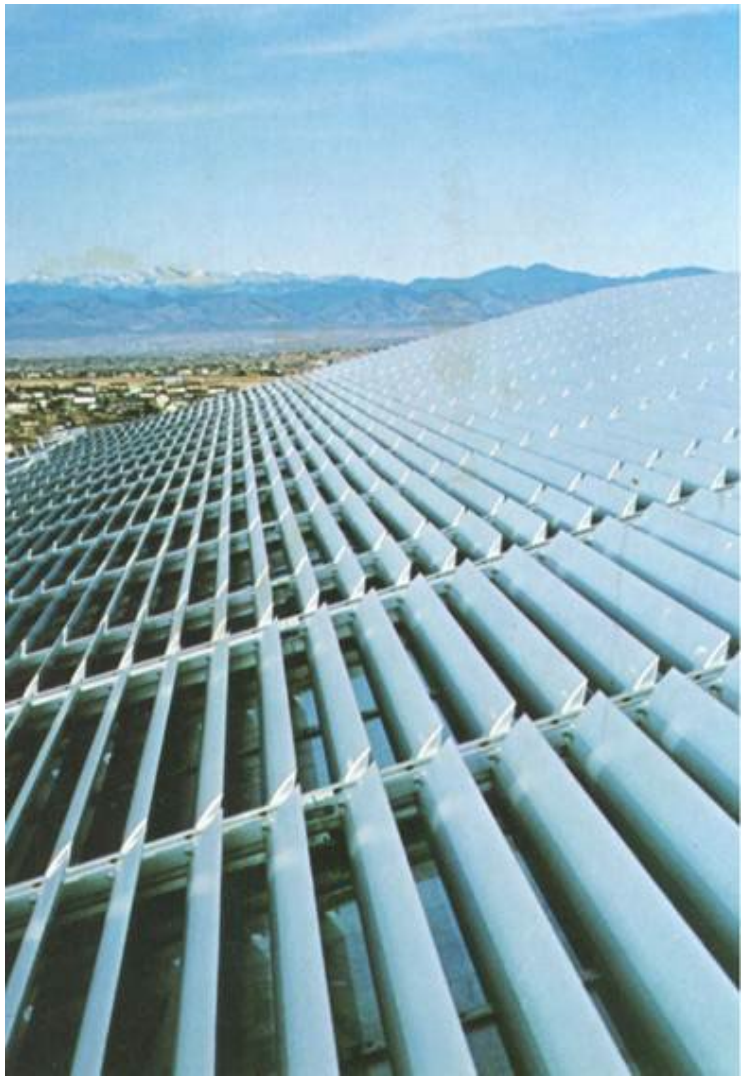
Applications





Applications

Atrium Canopy

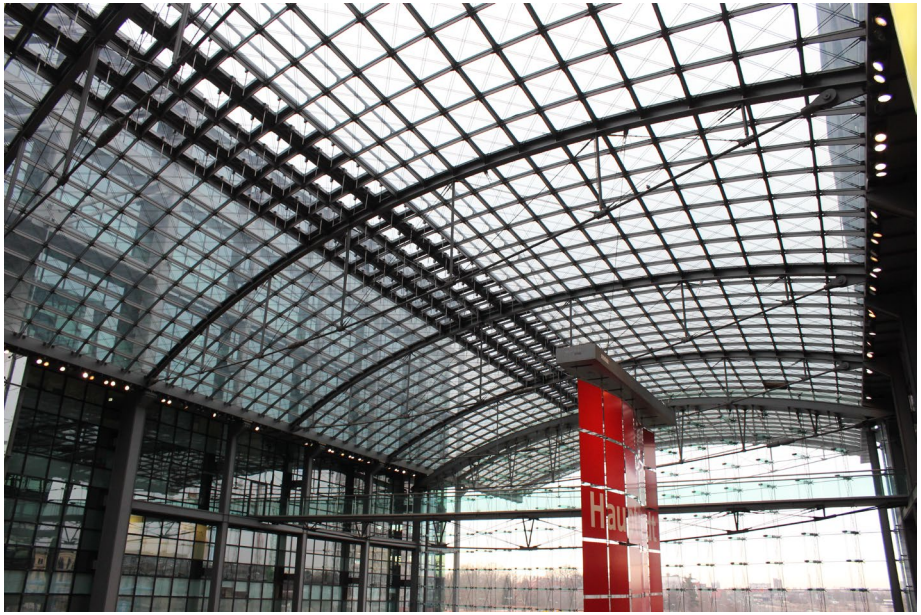


Shaded Glass Roof

Applications

ENVIRONMENTAL
ENERGY SERVICES

Applications



Insulating Glass Units (IGU)

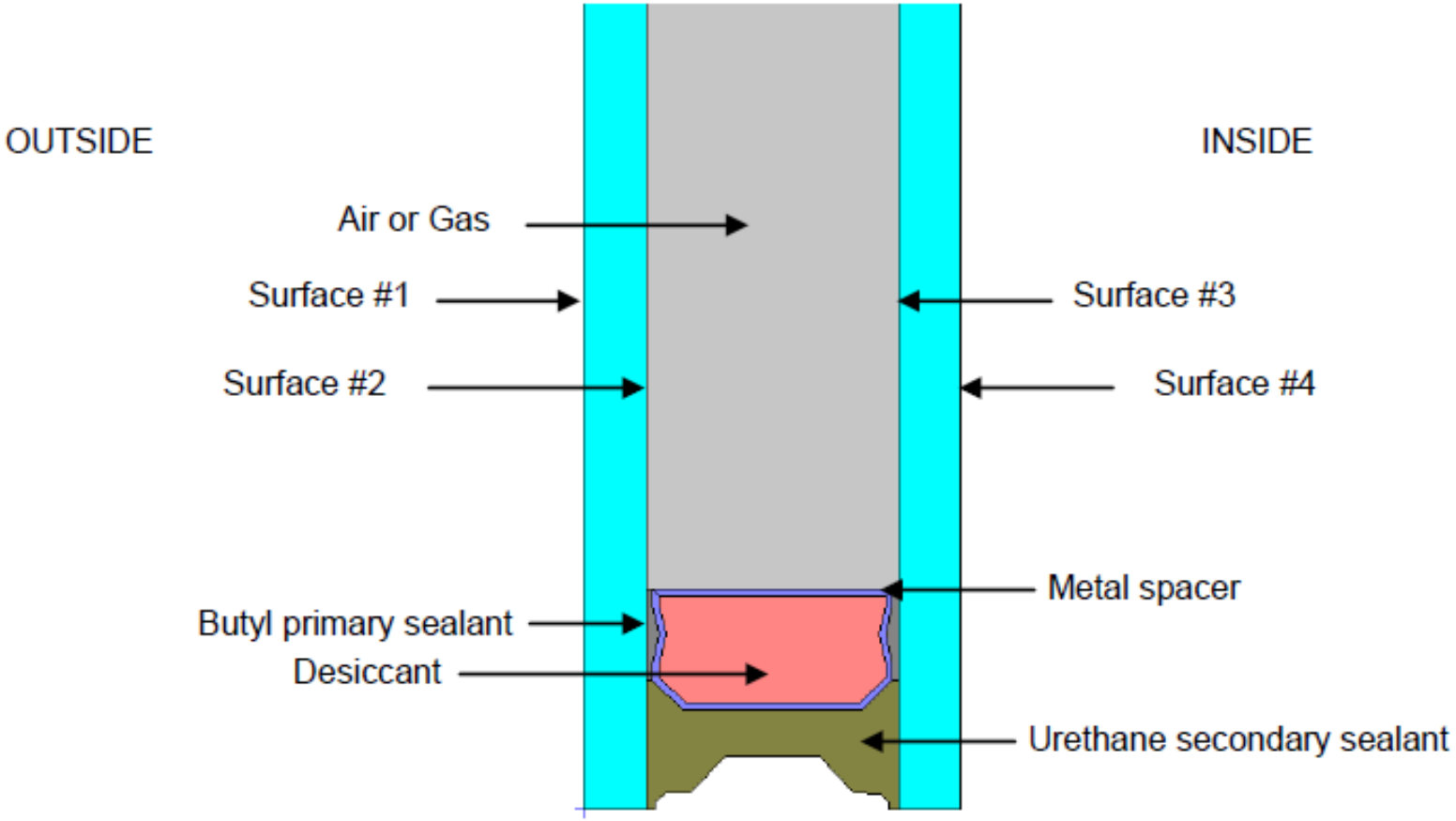


Figure 2-2. Insulating Glass Unit (IGU).

Solar Spectrum, Visible & Longwave Infrared Radiation

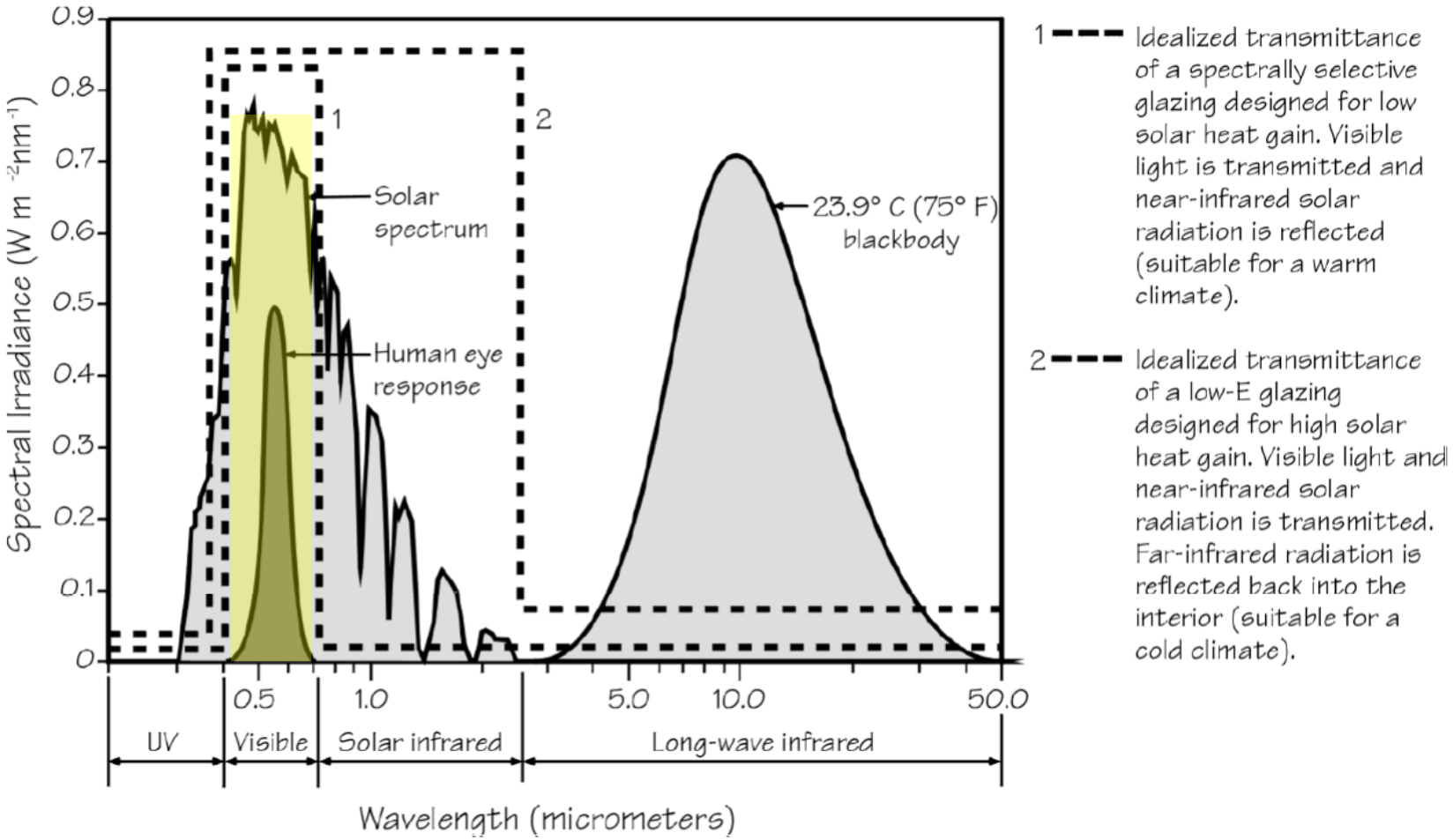
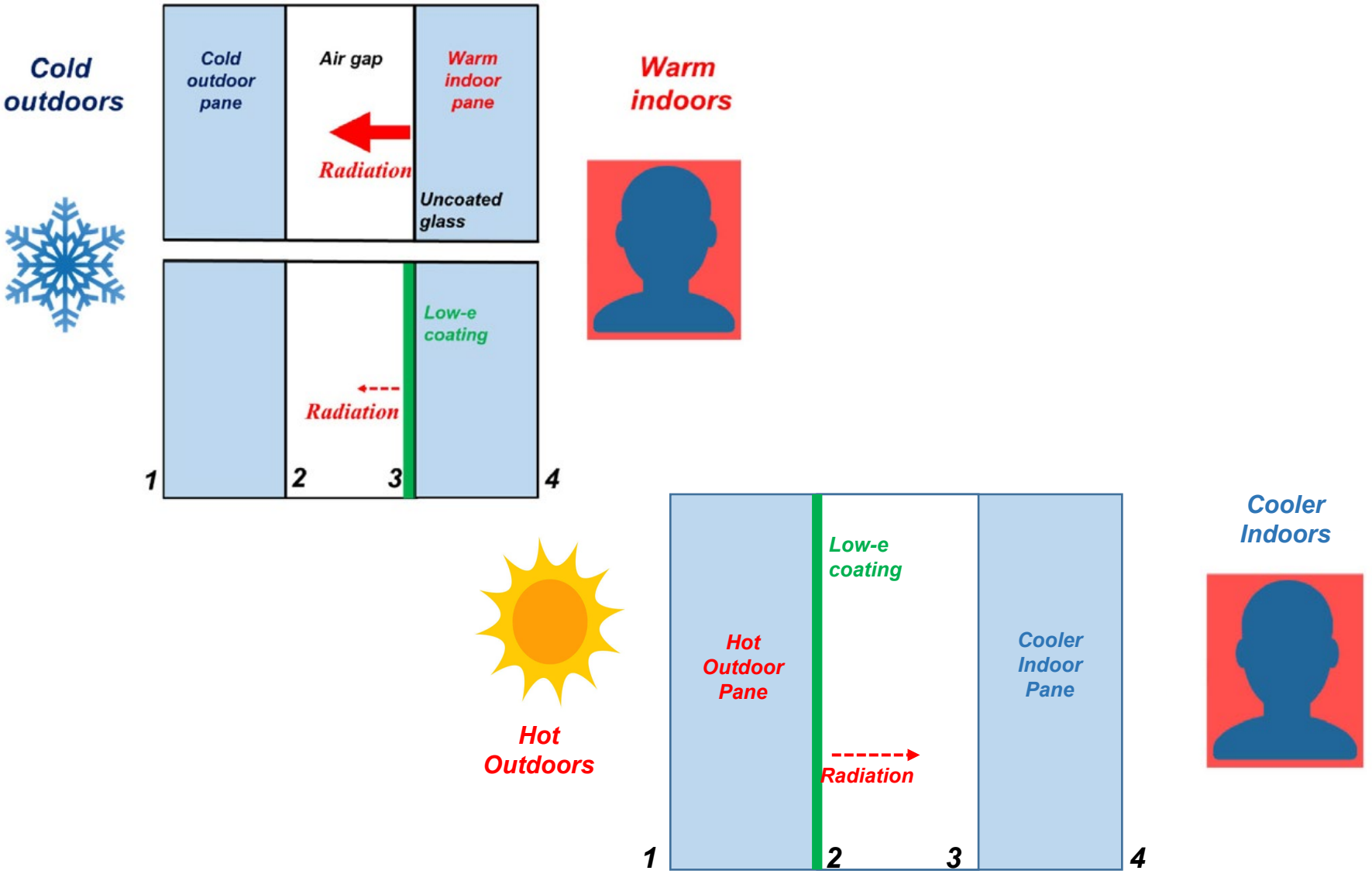
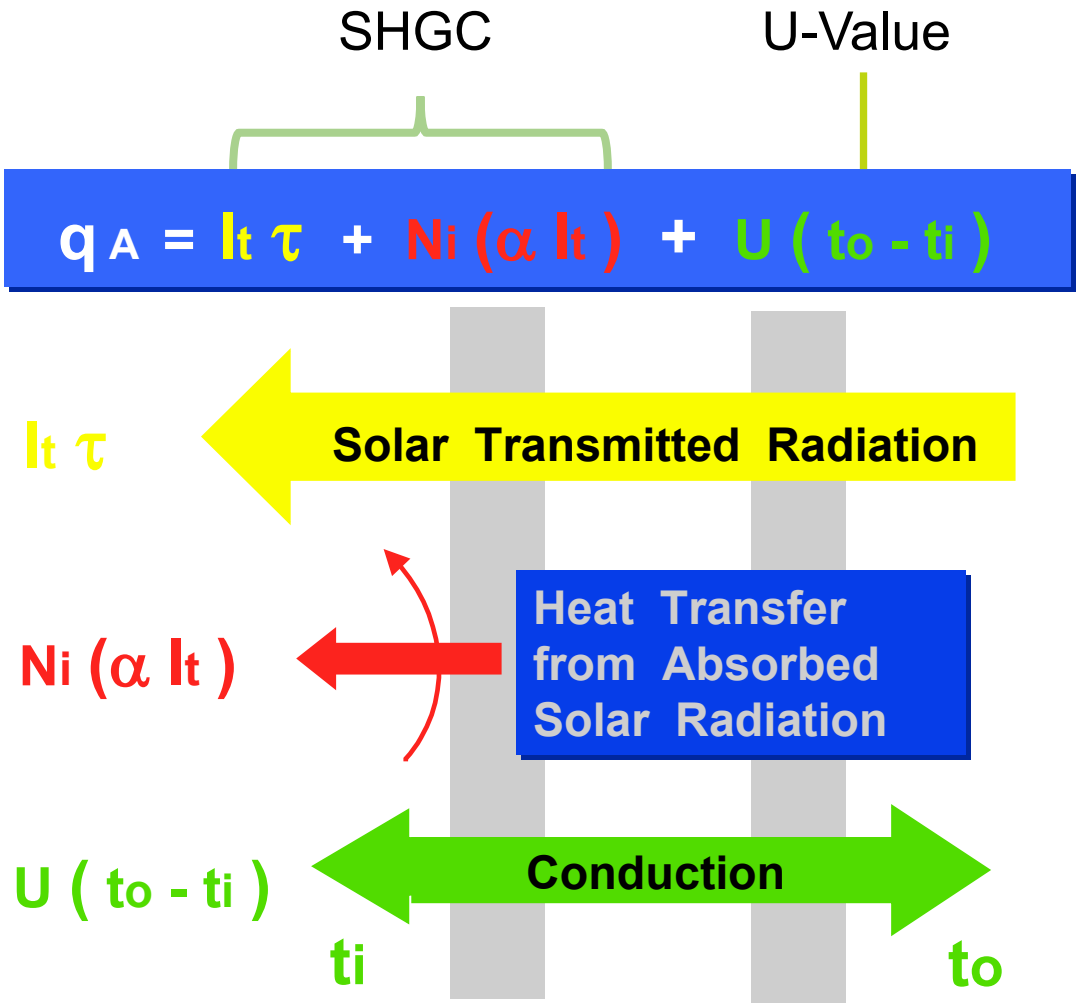


Figure 2-3. Ideal spectral transmittance for glazings in different climates. (Source: "Sensitivity of Fenestration Solar Gain to Source Spectrum and Angle of Incidence." ASHRAE Transactions 10, R. McCluney, June 1996).

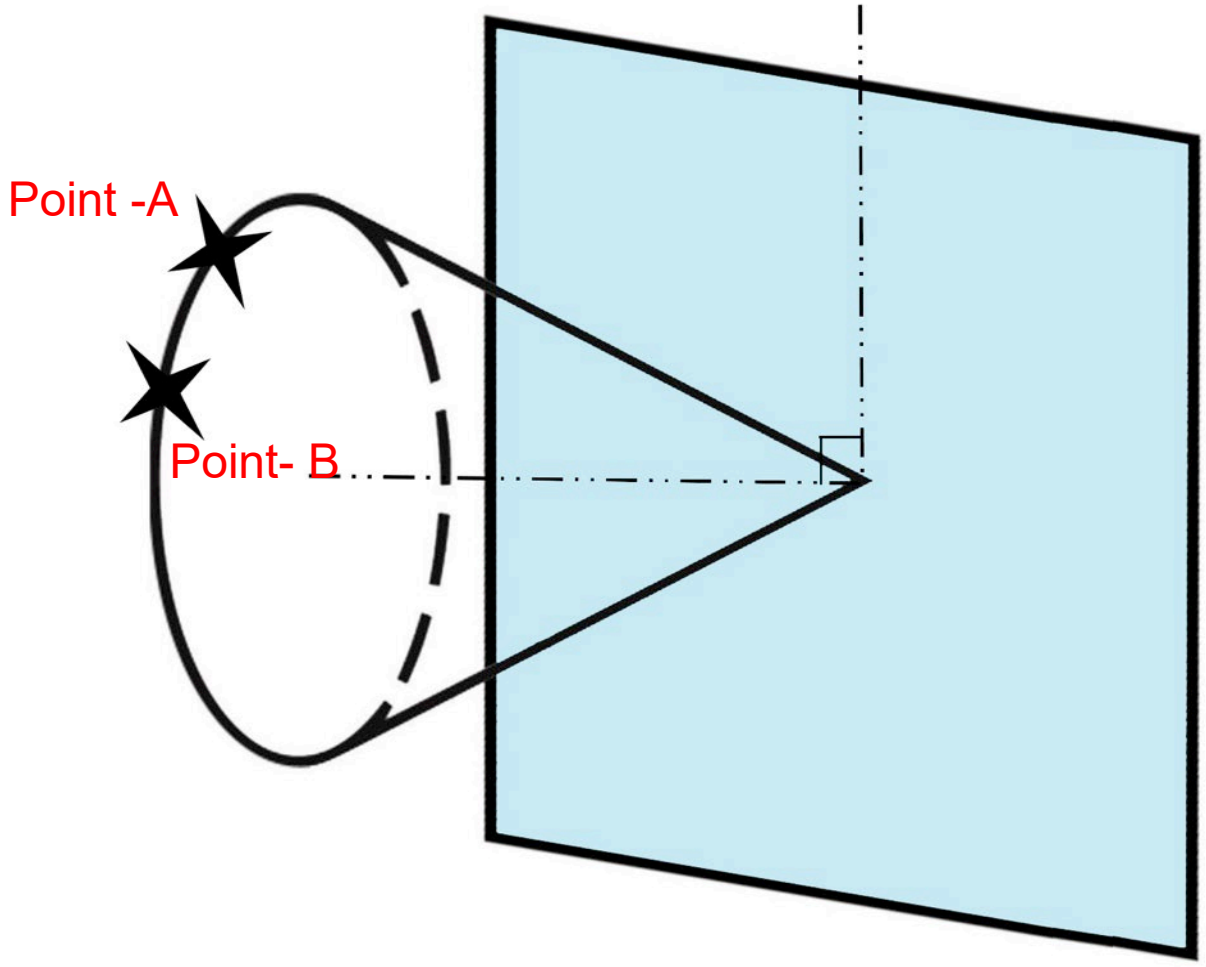
Double Glazing LOW-E Placement



Modes of Heat Transfer through Glass



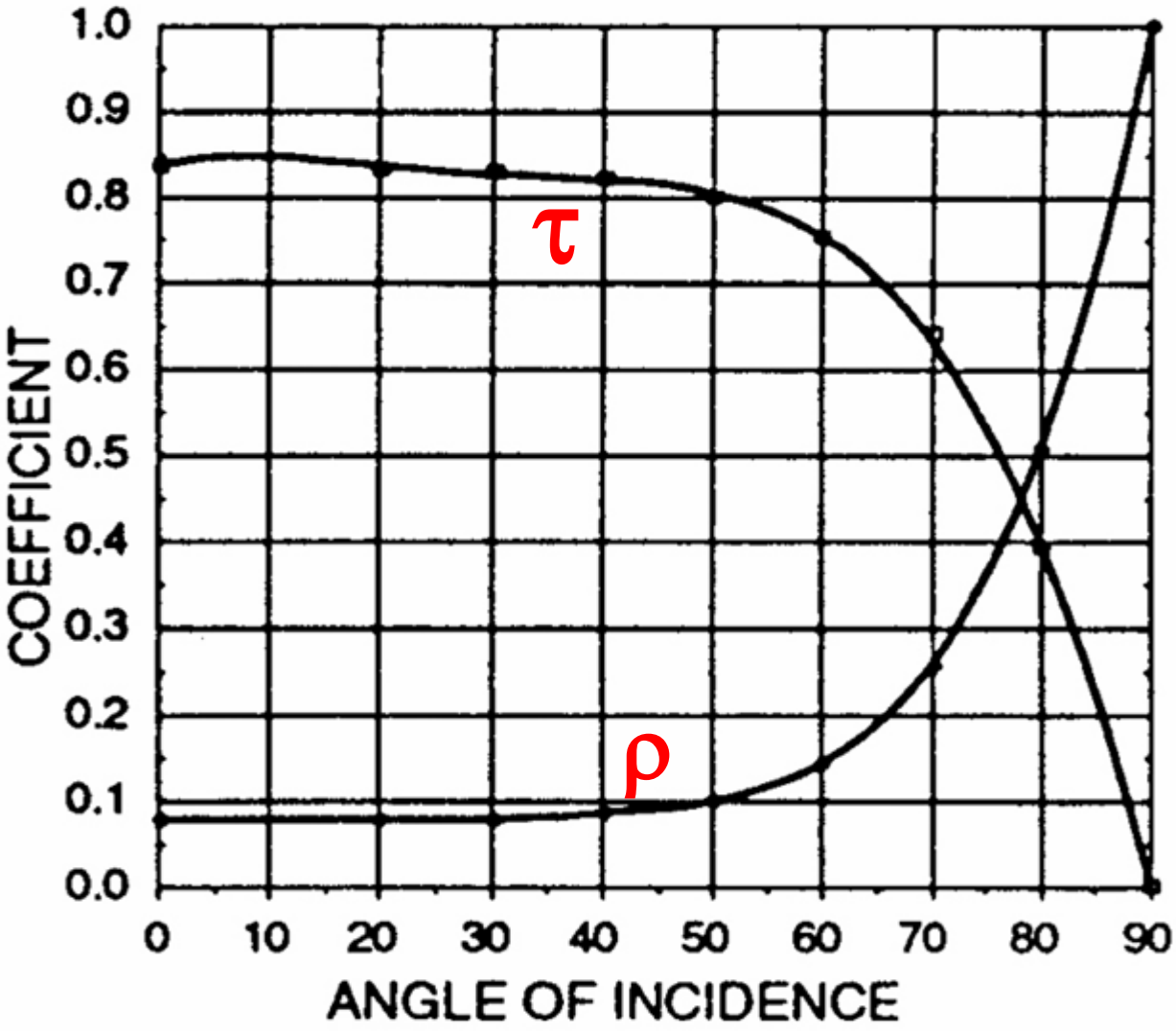
Angle of Incidence



Note: If the surface geometry is complex – the same incident angle may yield different results !

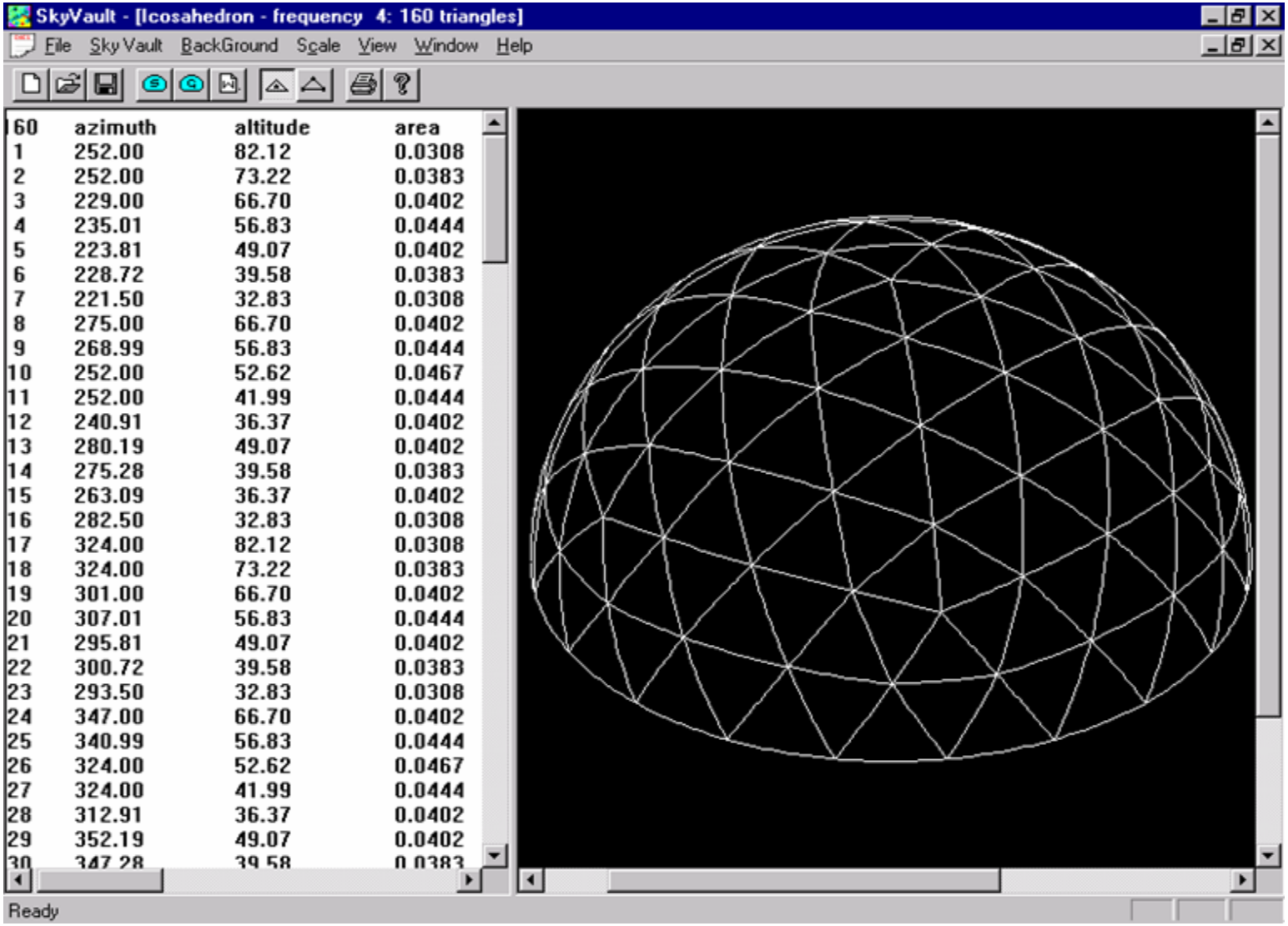
The Law of Reciprocity

$\tau + \alpha + \rho = 1.0$

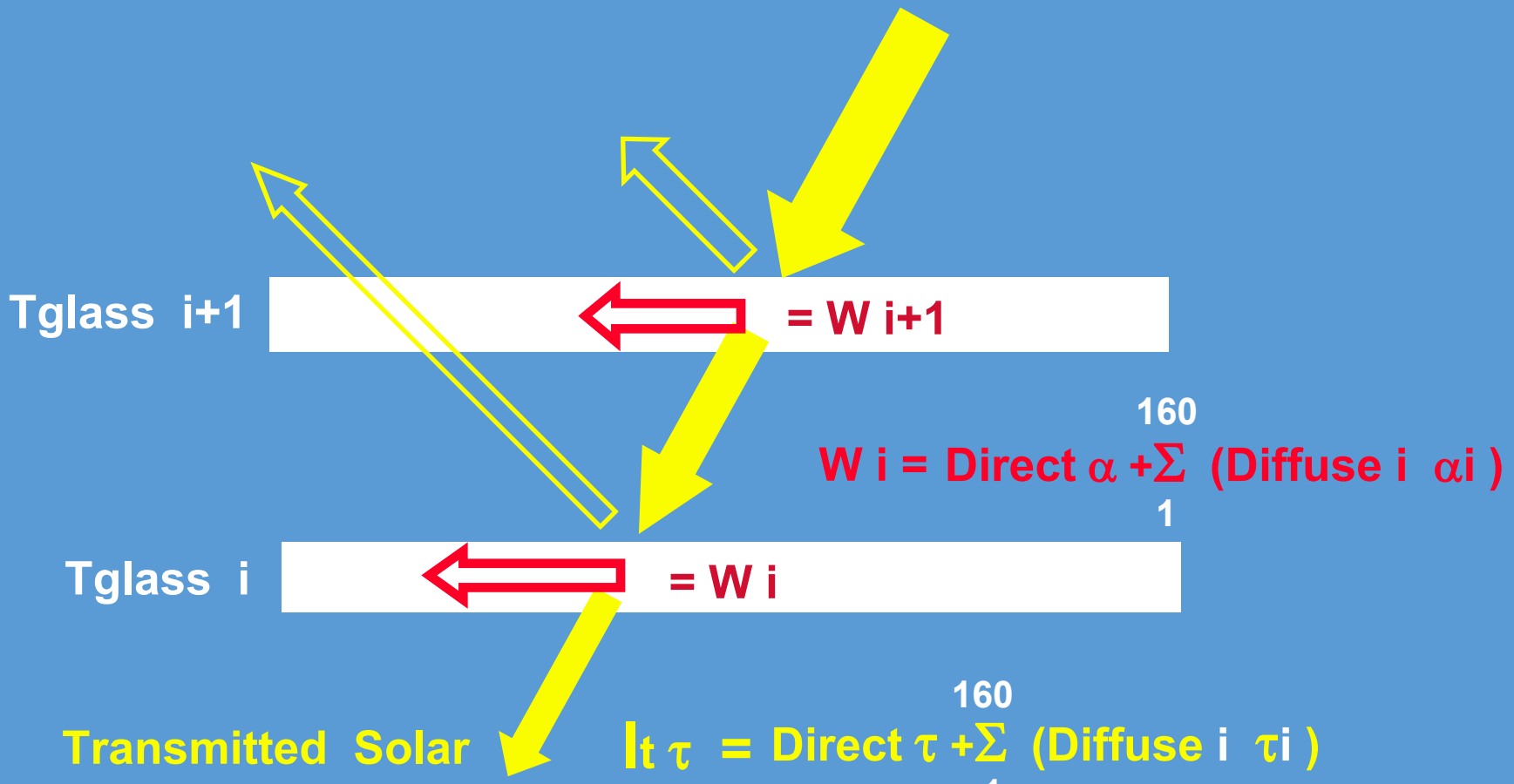


Diffuse Solar – Sky vault Representation

Skyvault Representation for Diffuse Solar Distribution



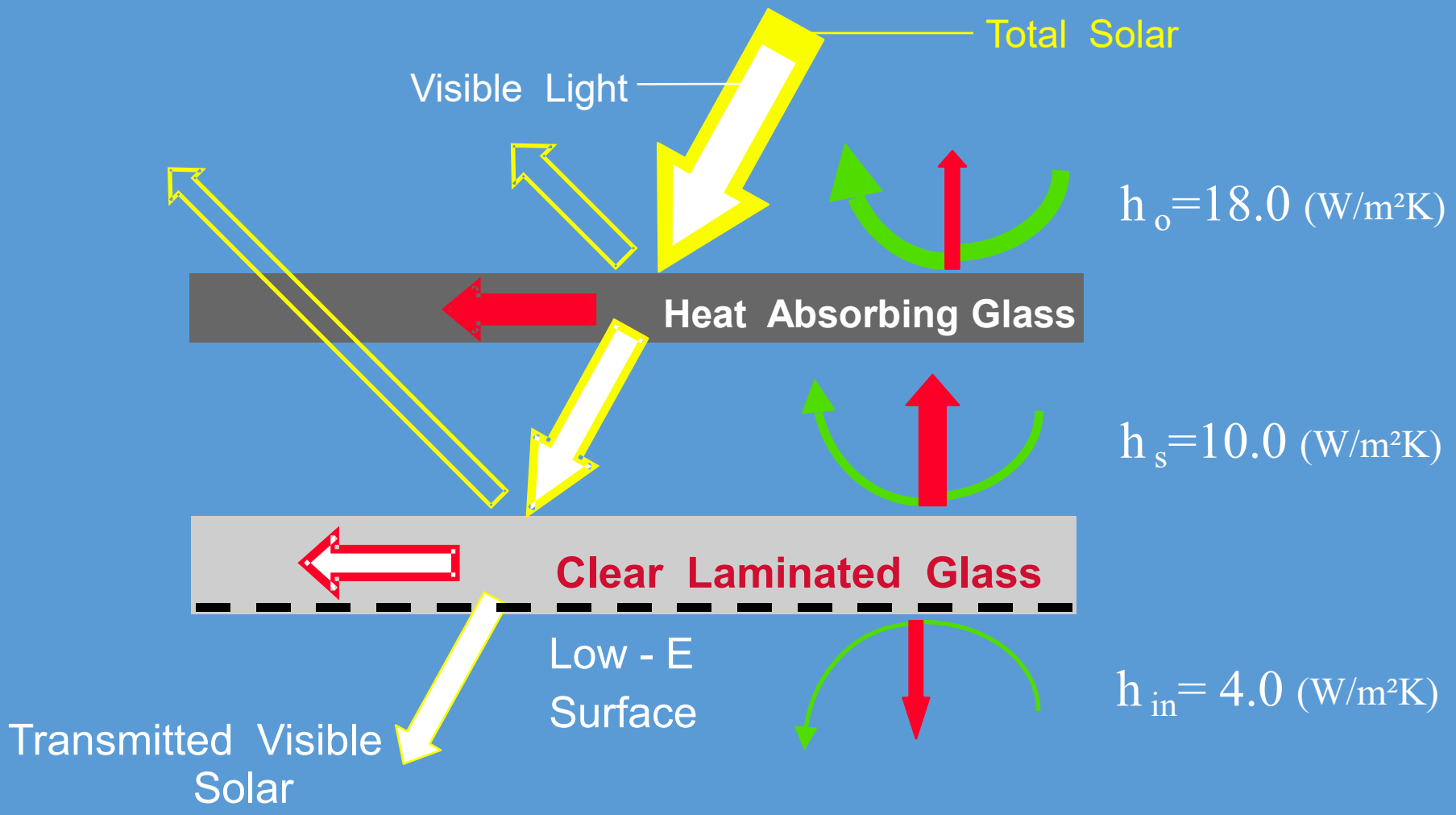
Double Glazing Design Considerations



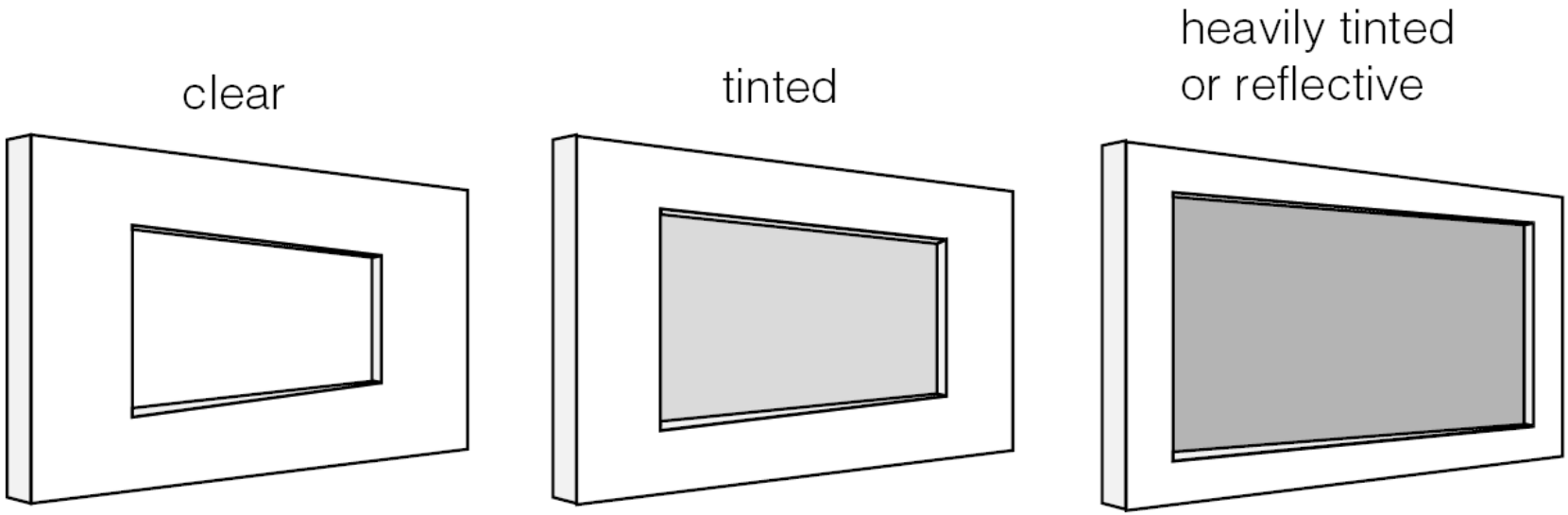
$$W_i = \text{Direct}\,\alpha + \sum_{1}^{160} (\text{Diffuse}\ i\ \alpha i)$$

$$I_t\,\tau = \text{Direct}\,\tau + \sum_{1}^{160} (\text{Diffuse}\ i\ \tau i)$$

A Skylight Glazing System - Design



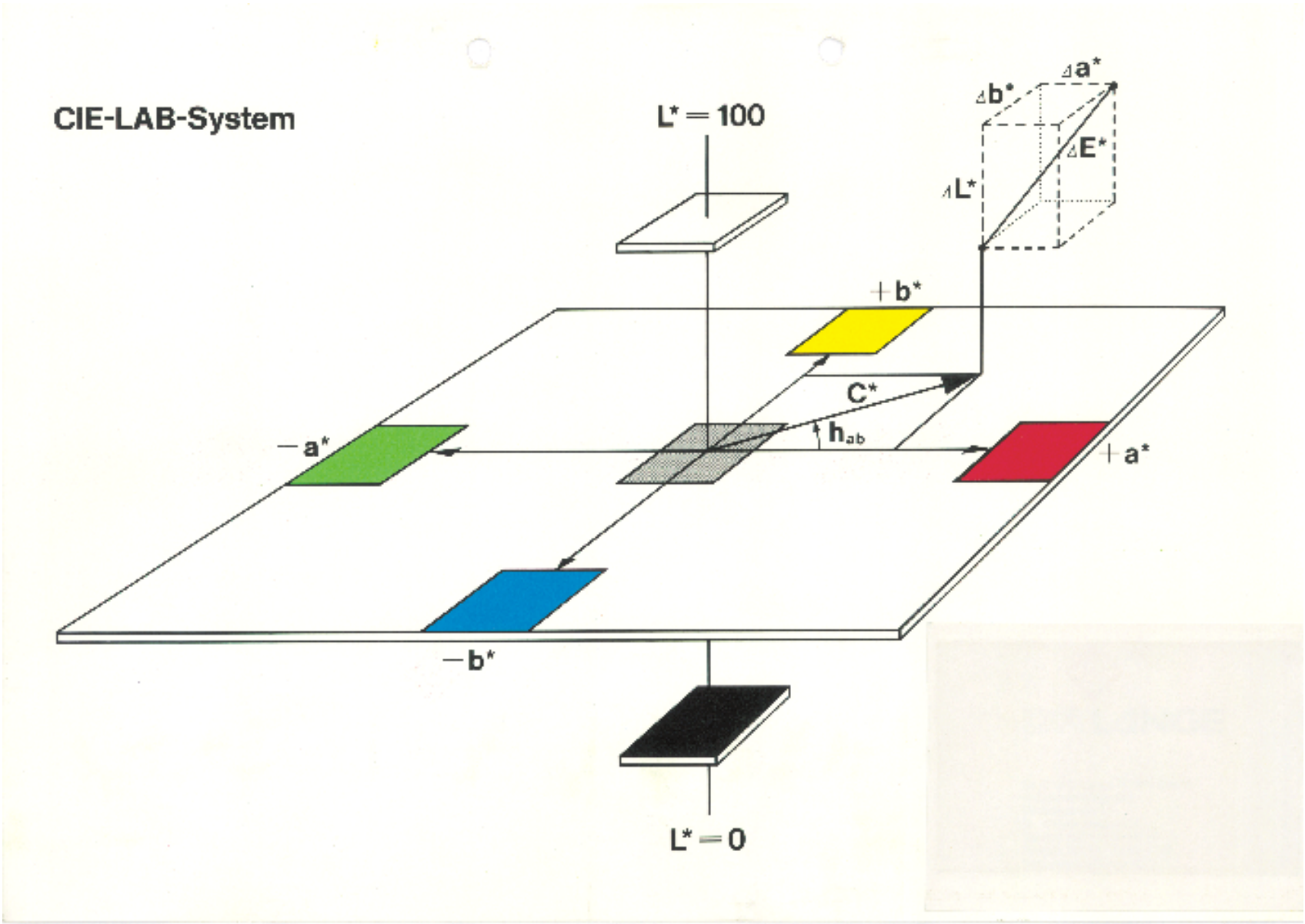
WWR vs. Visible Transmittance



Effective Aperture (EA) is visible transmittance (VT) x window-to-wall ratio (WWR). These three windows all have the same EA.

ref: Lawrence Berkeley National Laboratory, USA

Visible Transparency & Light Colour



Luminous Efficacy: Ke

A very useful index of the daylighting potential of a glazing is the *luminous efficacy* (Ke),

Ke = Tv / SHGC

Tv = visible transmittance
SHGC = solar heat gain coefficient

NOTE: The greater this ratio the better; higher values indicate the glazing is better at transmitting light than heat.

Ke values exceeding 1.2 are possible and recommended.

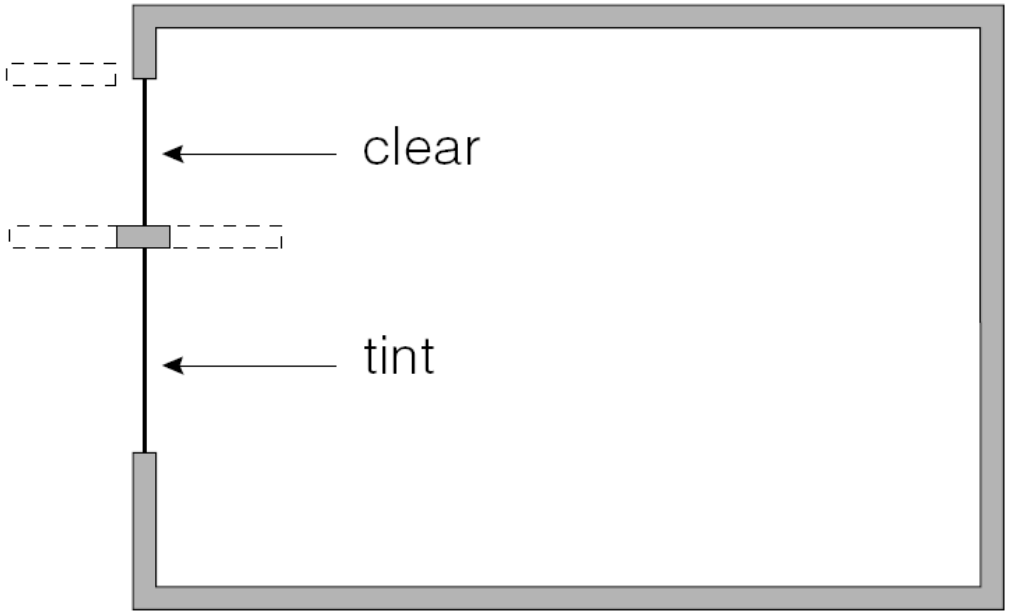
Ref.: Dr. Peter Lyons, PROPERTIES AND RATING SYSTEMS FOR GLAZINGS, WINDOWS AND SKYLIGHTS (INCLUDING ATRIA), RAIA – Environmental Design Guides, PRO 32, 2004

A Sunroom Skylight Retrofit

Visible Light: 81% U-value: 1.4 SHGC: 0.61 Visible Light: 64% U-value: 1.3 SHGC: 0.27

A Sunroom Skylight Retrofit

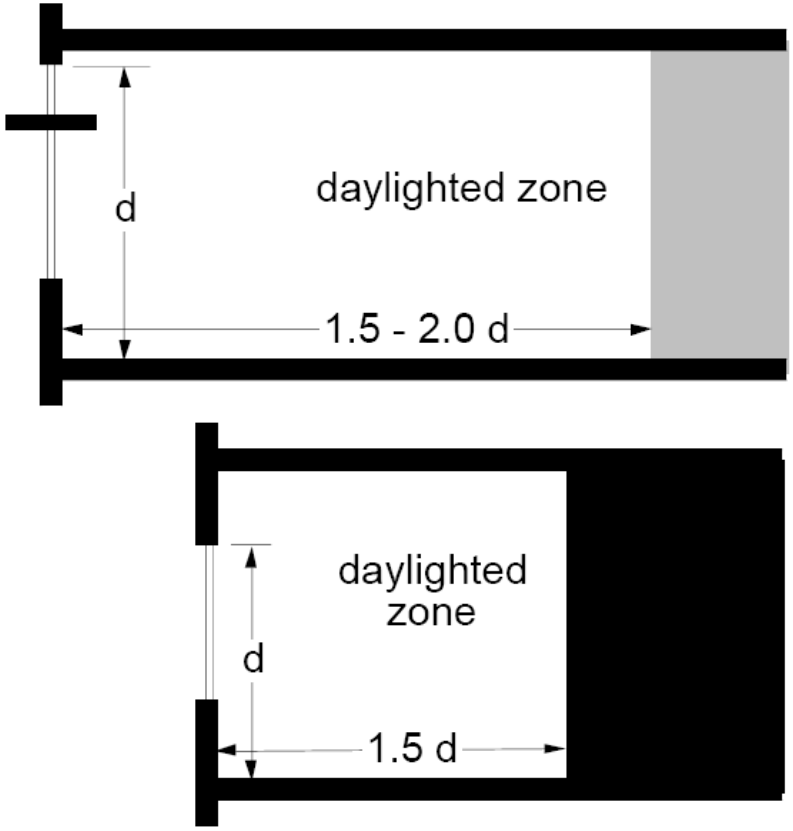
Designing for Light



Different apertures for daylight and view: clear glazing above for maximum daylight, tinted glazing below for glare control. The structure between the two provides a visual break and an opportunity to attach a light shelf or shading device.

ref: Lawrence Berkeley National Laboratory, USA

Designing for Light

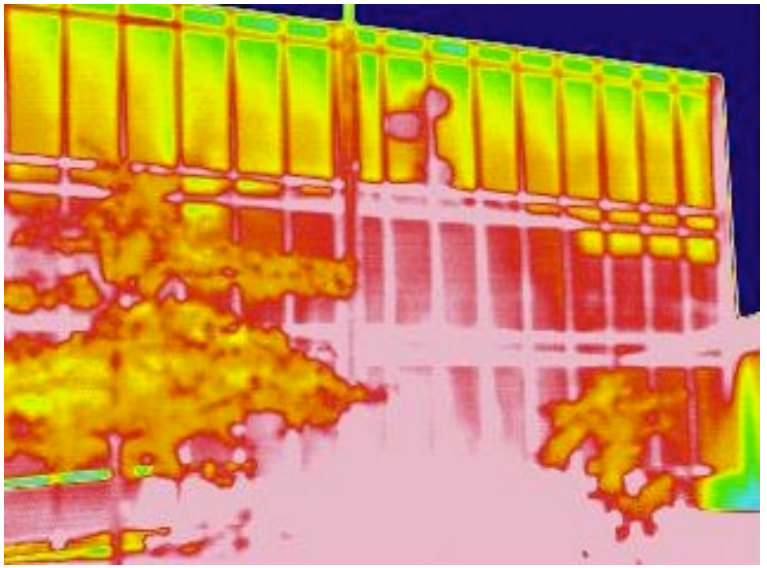


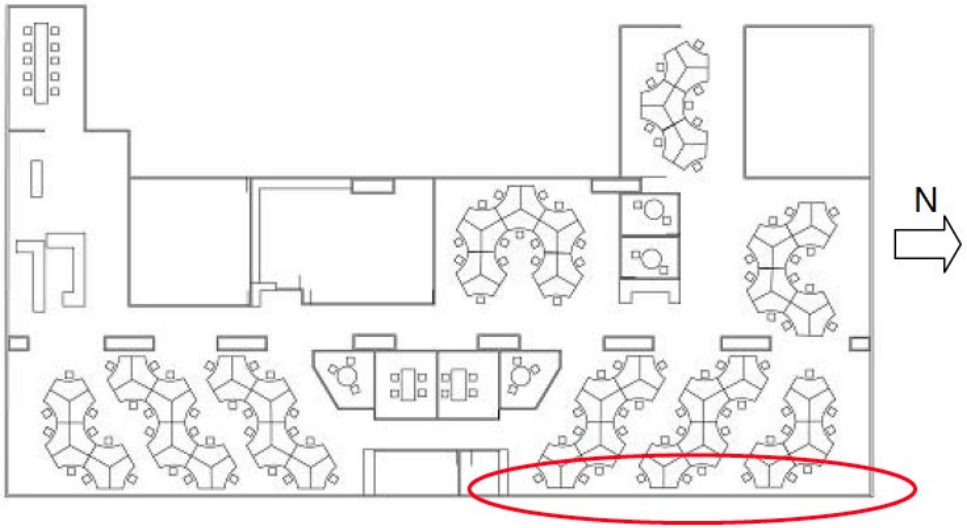
A rule of thumb for daylight penetration with typical depth and ceiling height is 1.5 times head height for standard windows, 1.5 to 2.0 times head height with light shelf, for south-facing windows under direct sunlight.

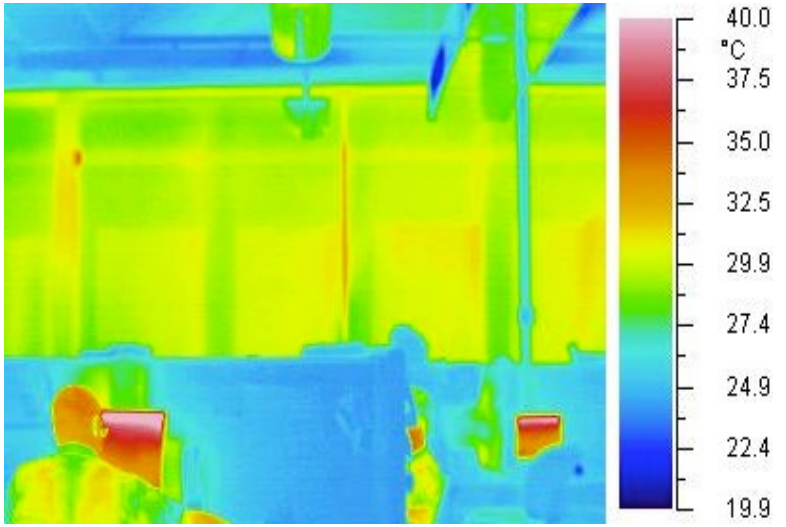
Walter Gropius – Arbeitsamt

Reducing Glazing System Heat Gain for a Large Open Office Space

The Research Problem

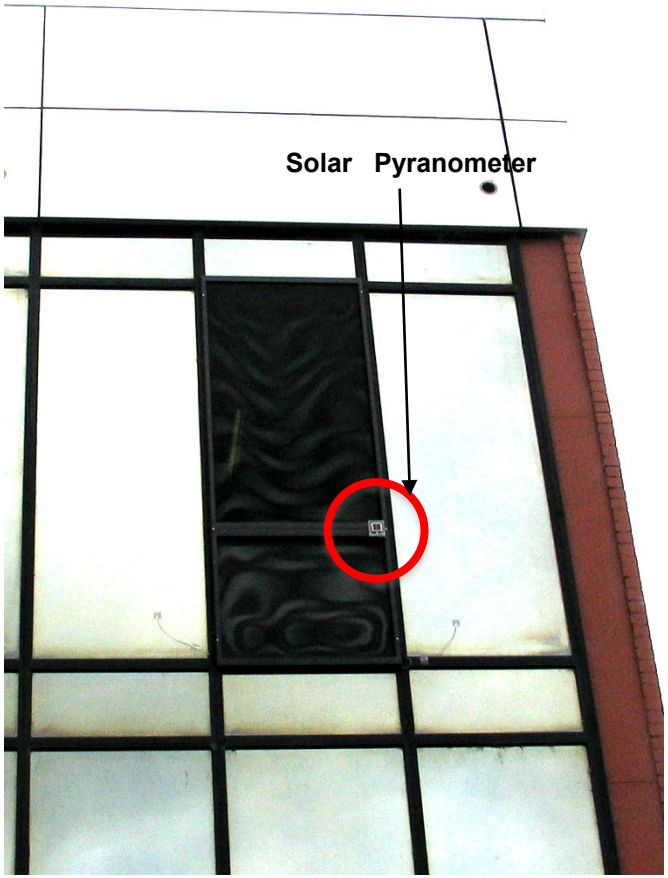




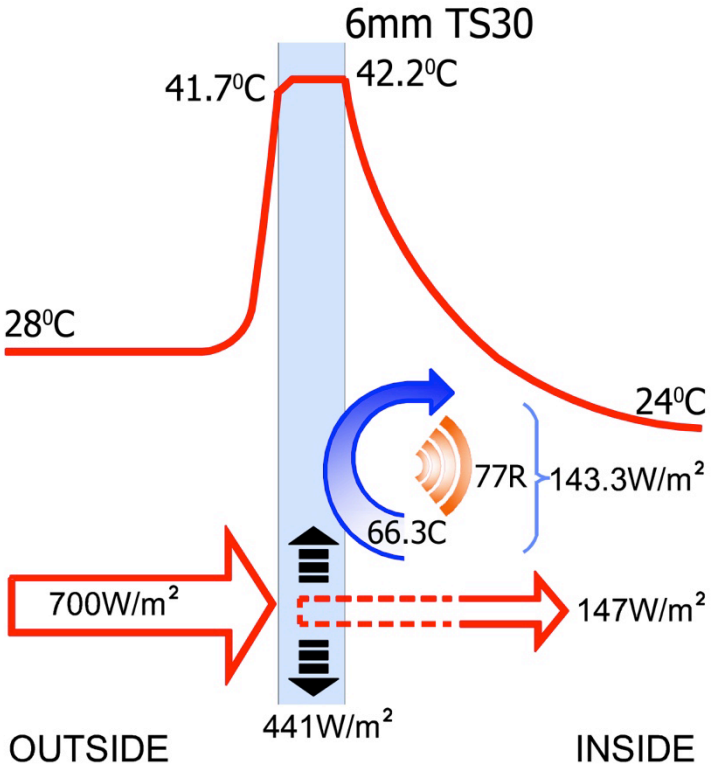


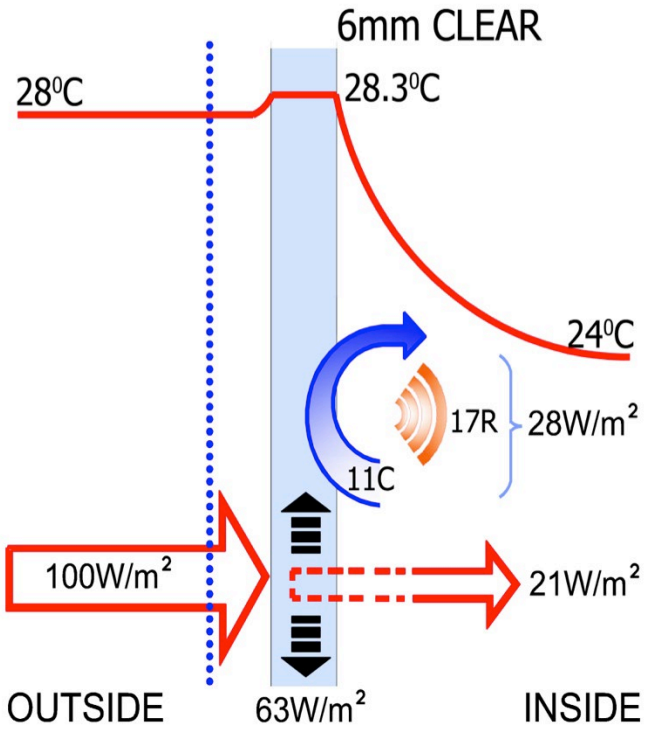
Option: External Shaded Glazing

Mounted test case sample on East facing Facade

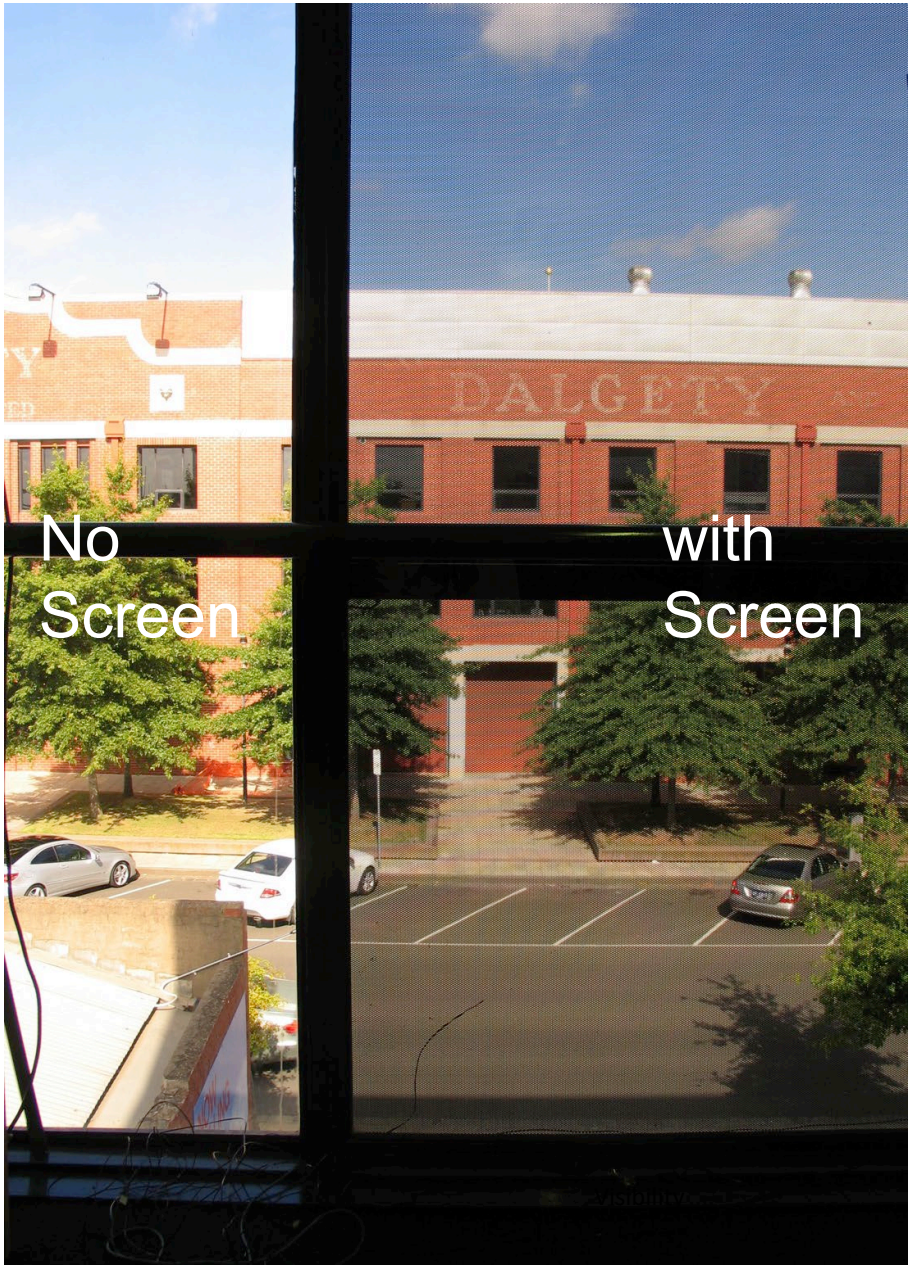


Heat Transfer through Glazing Systems

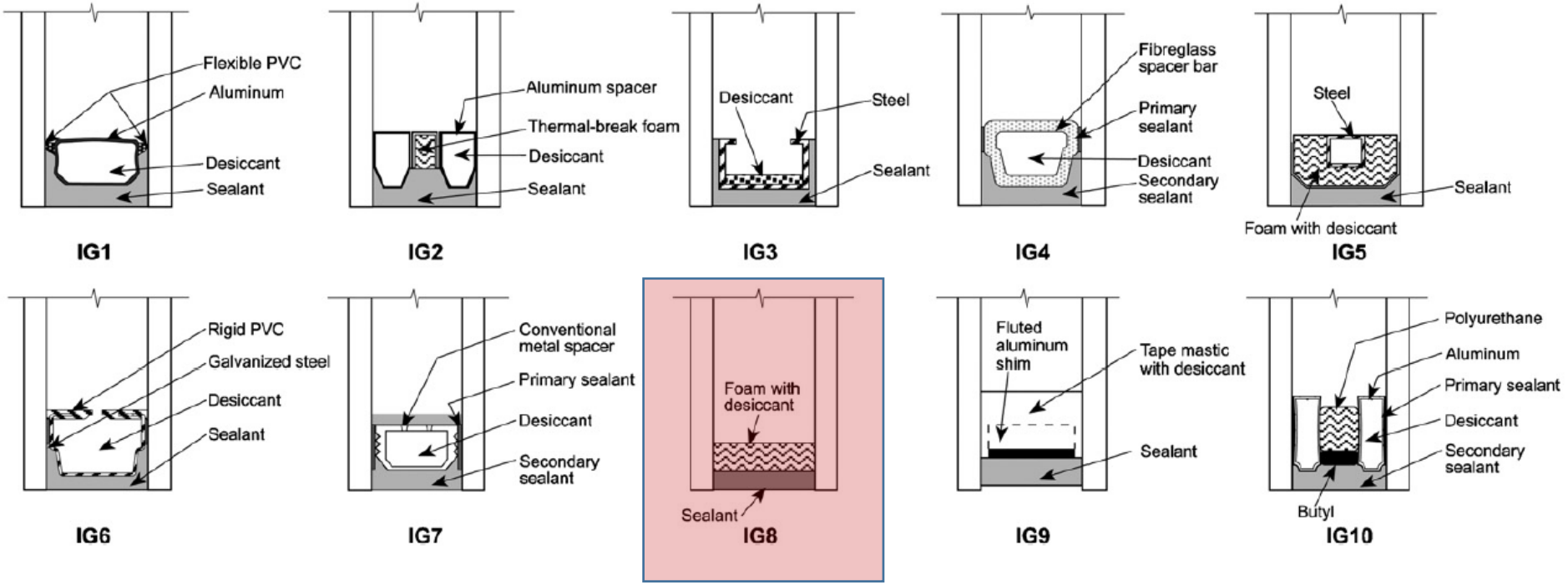




Visibility through the Glazing System

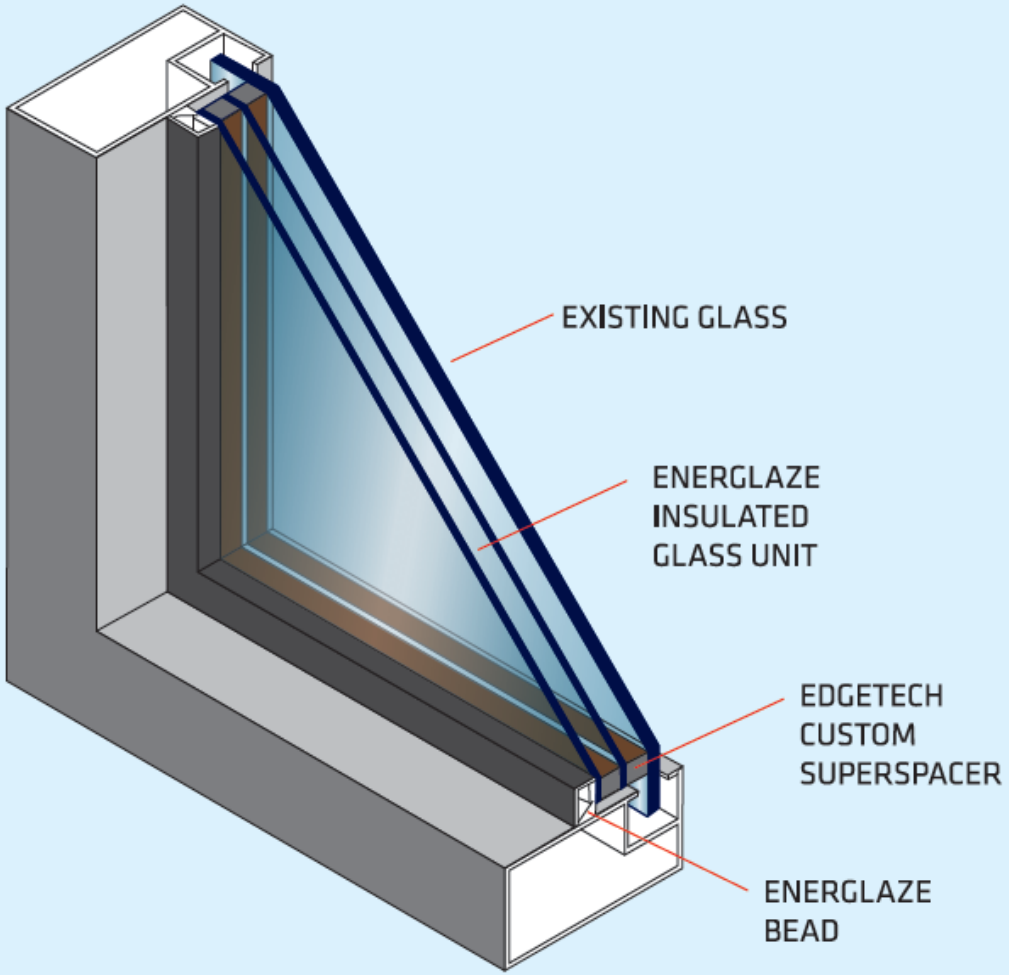


Edge Seal Technology

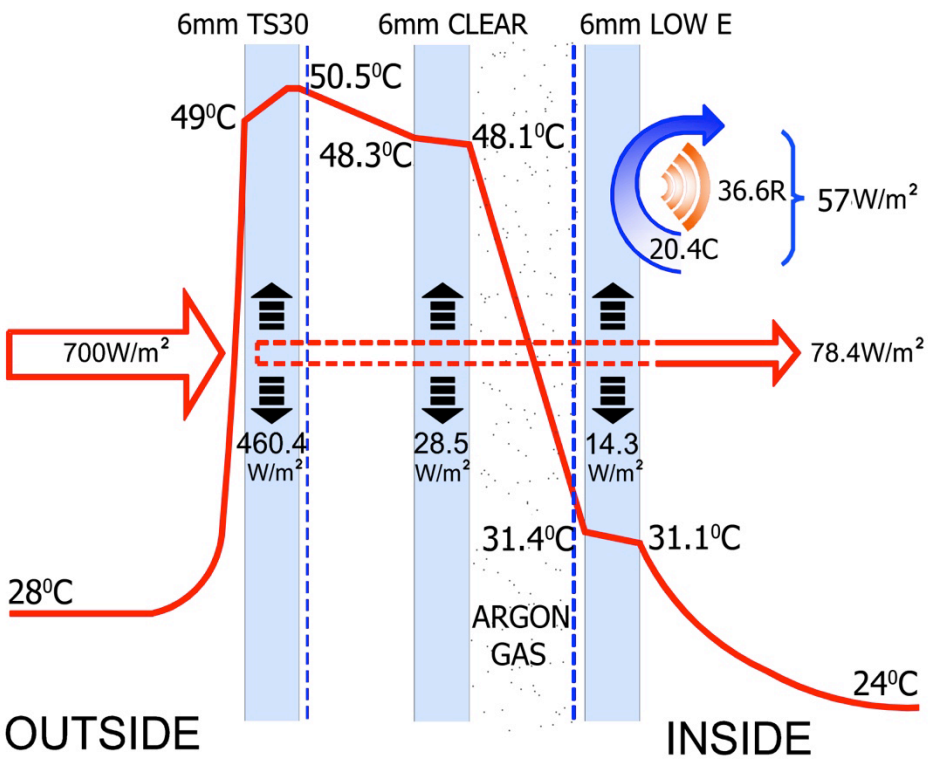


Van Den Bergh, S., Hart, R., Jelle, B.P. and Gustavsen, A., 2013. Window spacers and edge seals in insulating glass units: A state-of-the-art review and future perspectives. *Energy and Buildings*, *58*, pp.263-280.

Edge Seal Technology & In-situ Retrofitting

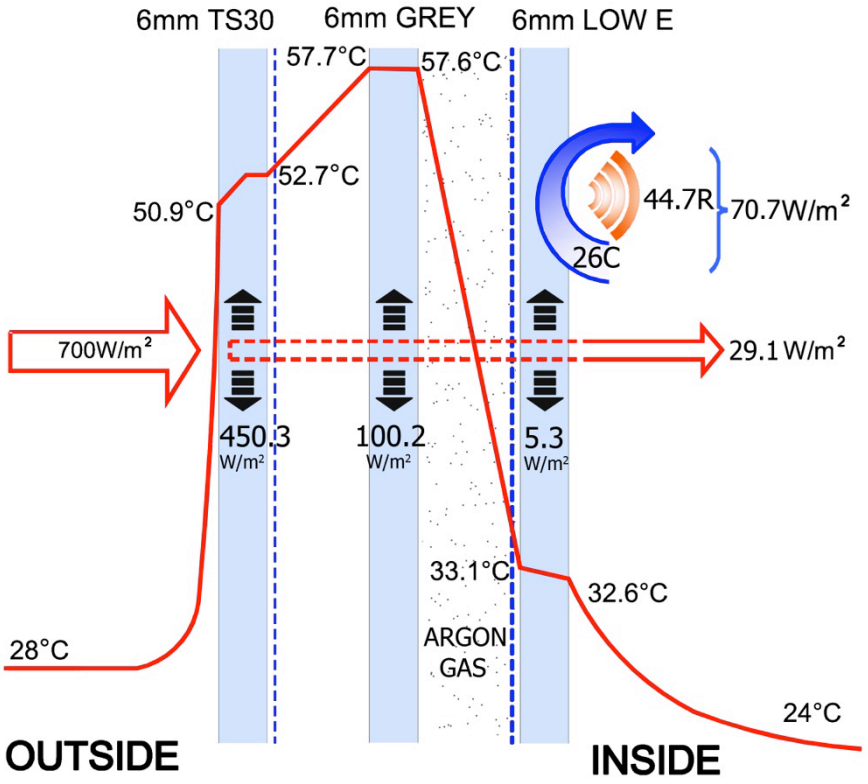


Triple Glazing Options



Clear Glass w/ Low-E

U-value: 1.36
SHGC: 0.19

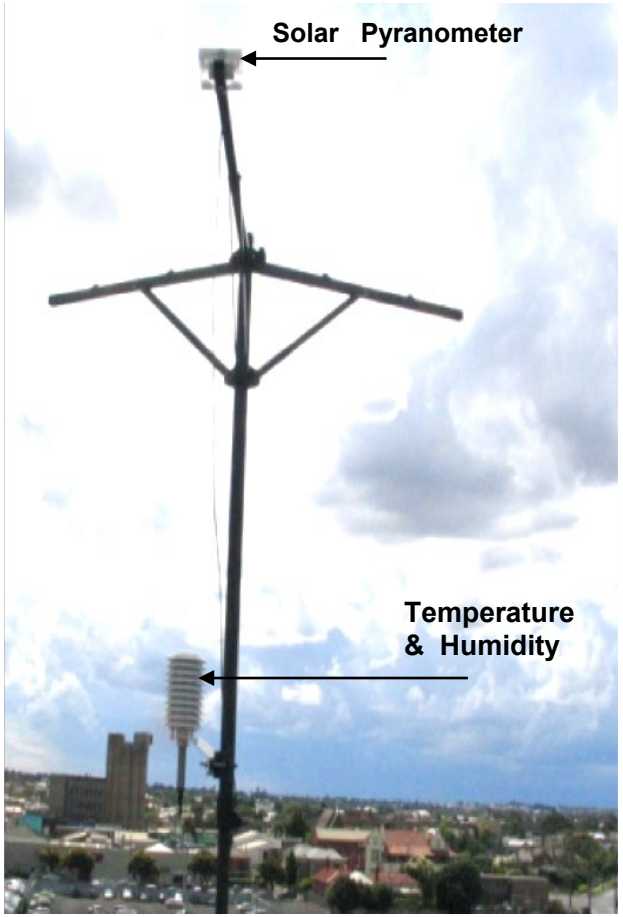


Grey Glass w/ Low-E

U-value: 1.41
SHGC: 0.14

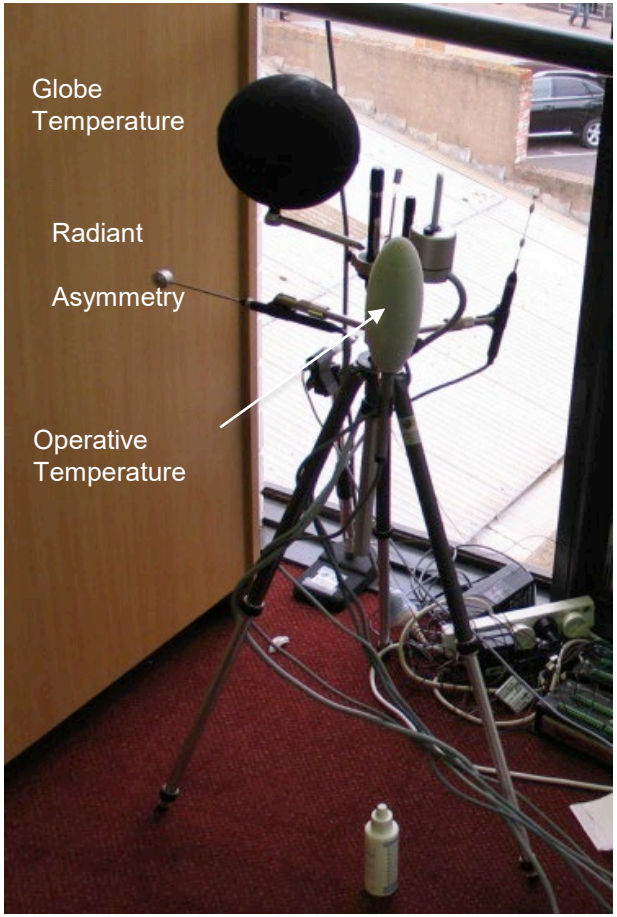
Installation of the new IG Unit – Triple Glazing

Measurement



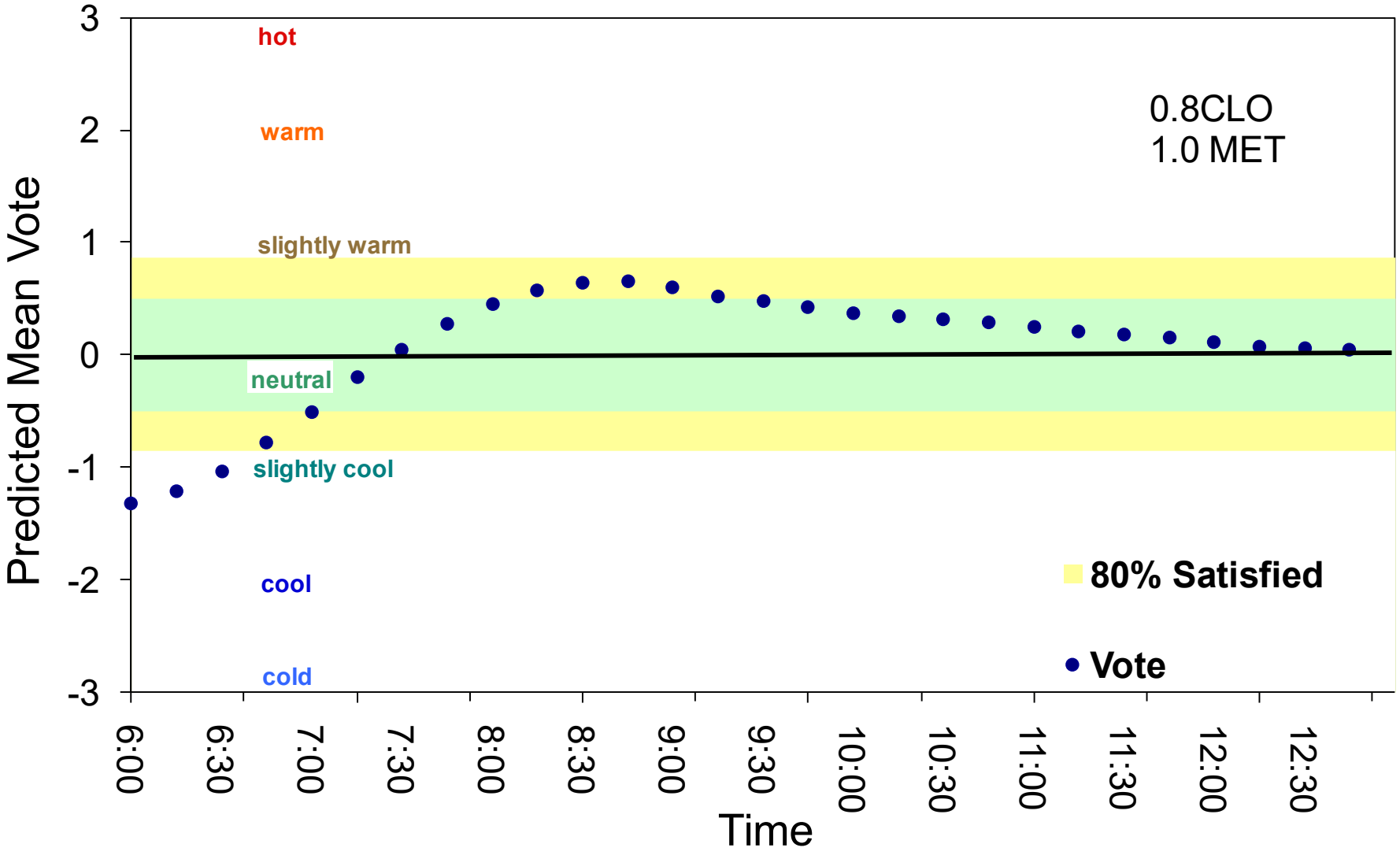
Weather & Solar
Instrumentation

Instrumentation:
Radiant Asymmetry

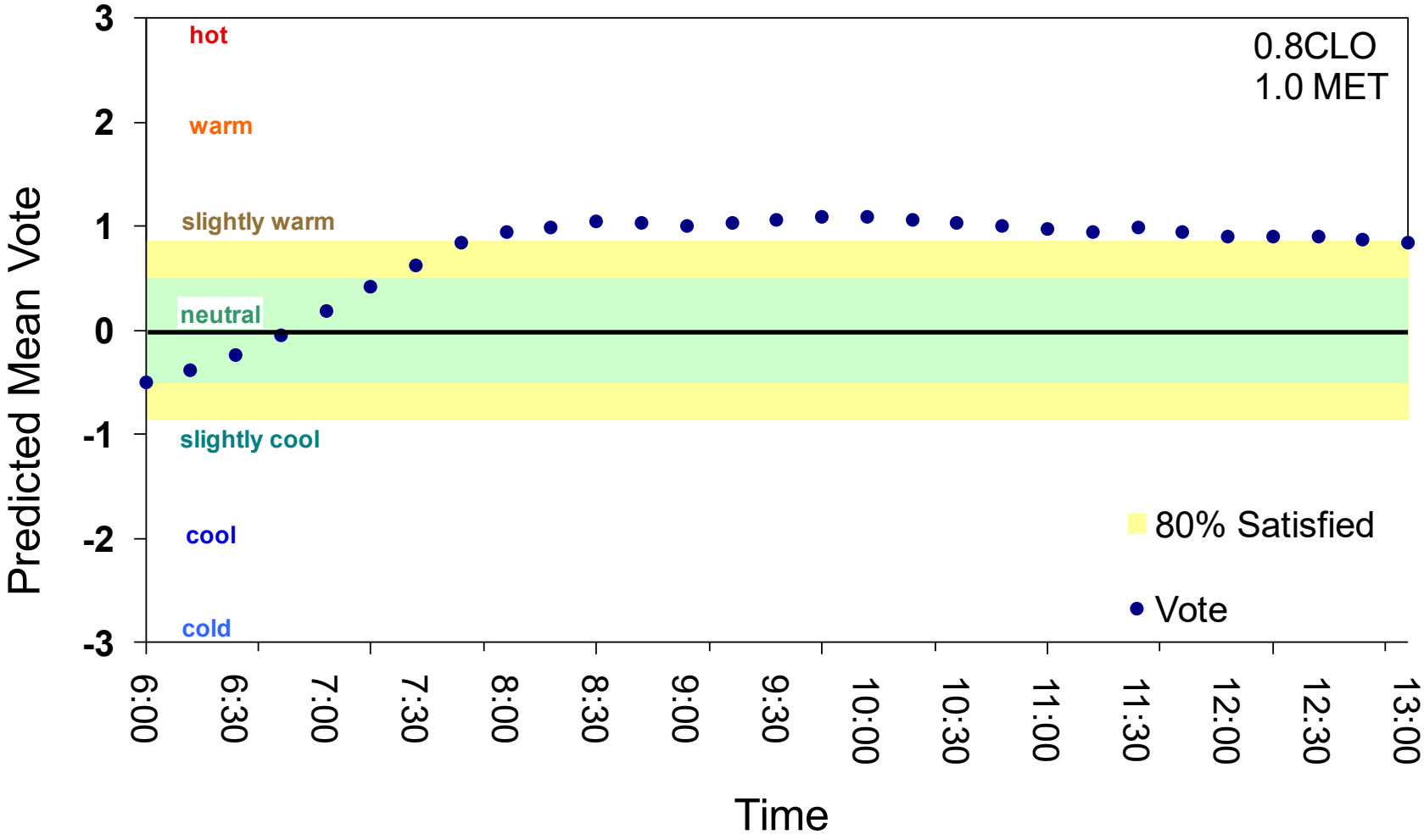


Instrumentation:
Façade Comfort Meter

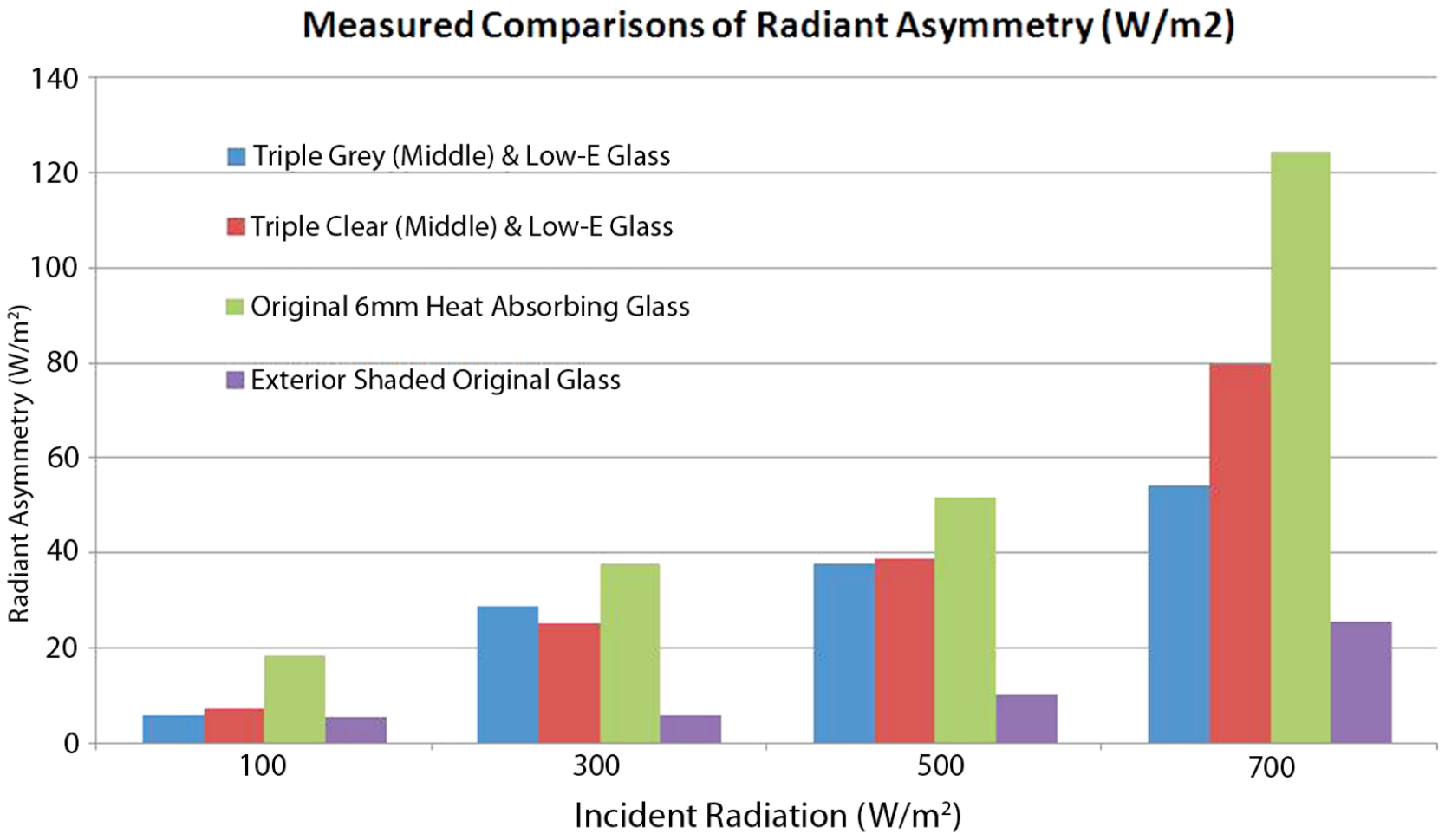
Thermal Comfort of the Shaded Glass



Thermal Comfort of Triple Grey & Low-E



Measured Interior Radiant Asymmetry



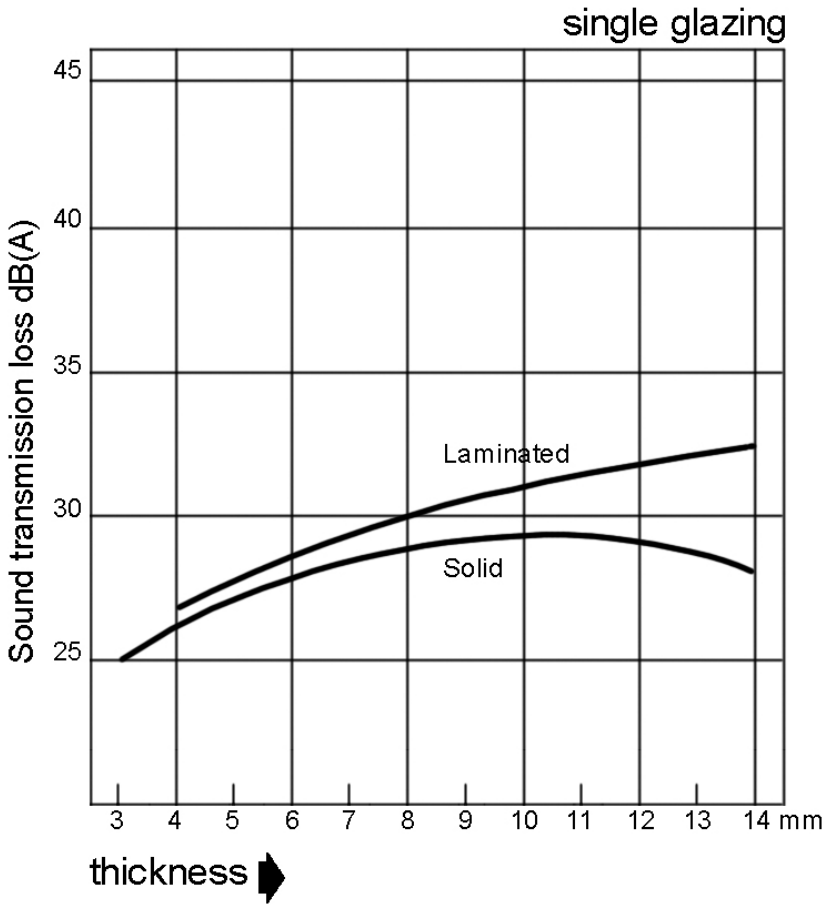
ENVIRONMENTAL
ENERGY SERVICES

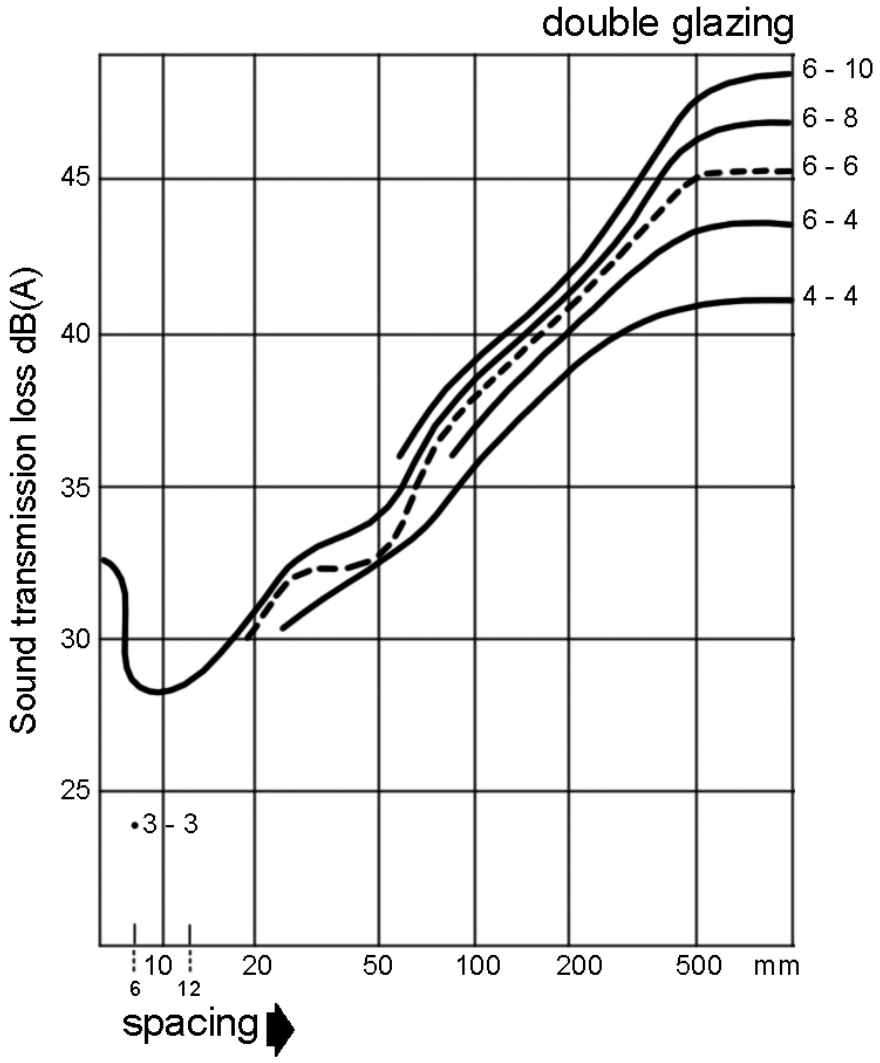
RESULTS:

The existing single glazed heat absorbing glass façade system, under a measured peak load hour, transmits and releases **45 kW** into the office.

The proposed addition of the external screen to this façade reduces this peak load to **7 kW**. As a result, a tremendous reduction in mechanical equipment use, energy savings and increased occupant comfort can all be achieved, within a low cost (2-3 year payback) solution.

Acoustic Transmission Loss of Glazing Systems





ENVIRONMENTAL
ENERGY SERVICES