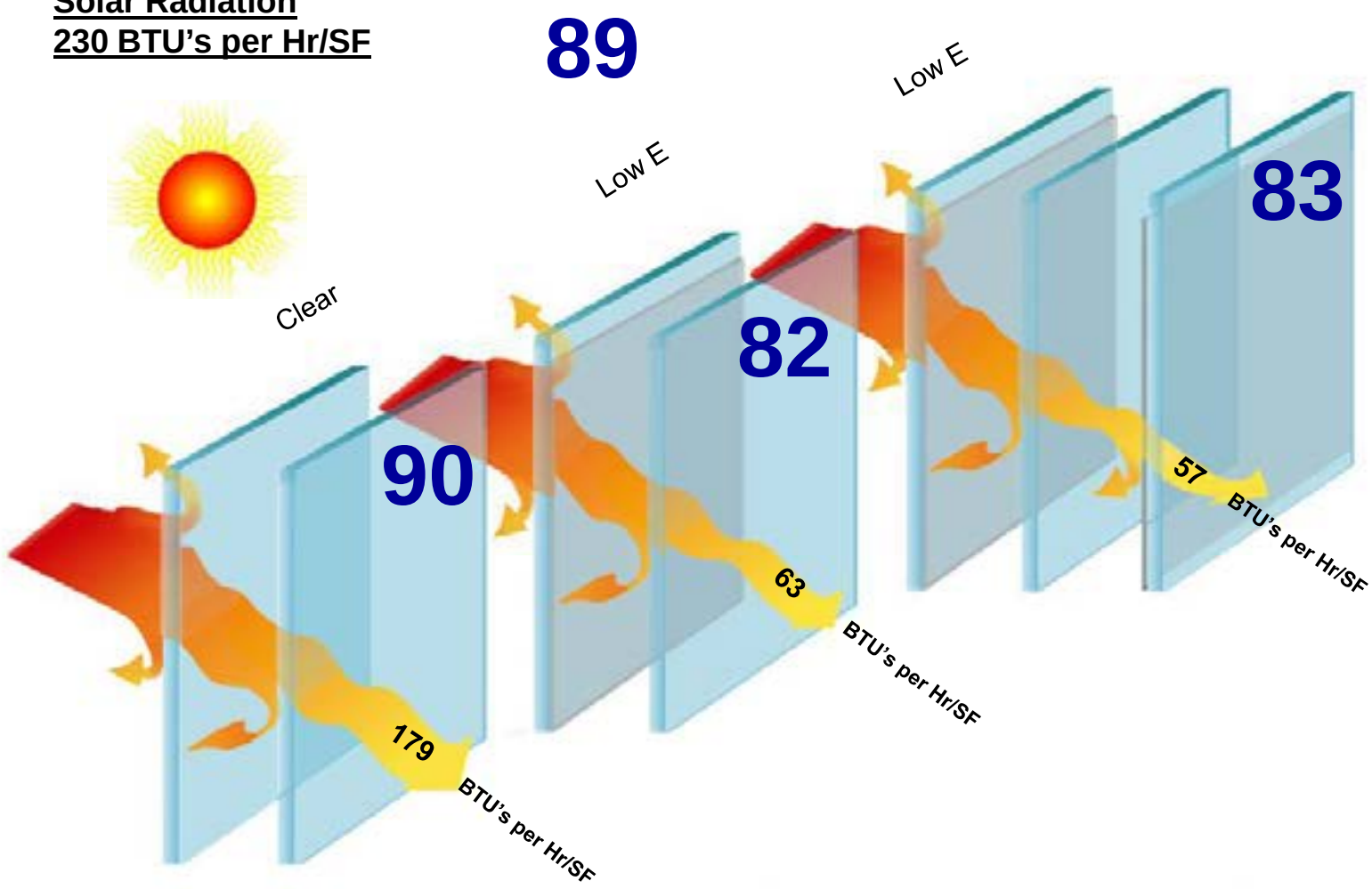


Performance Glazing

Coatings, Layers & Gases

Learning Objectives

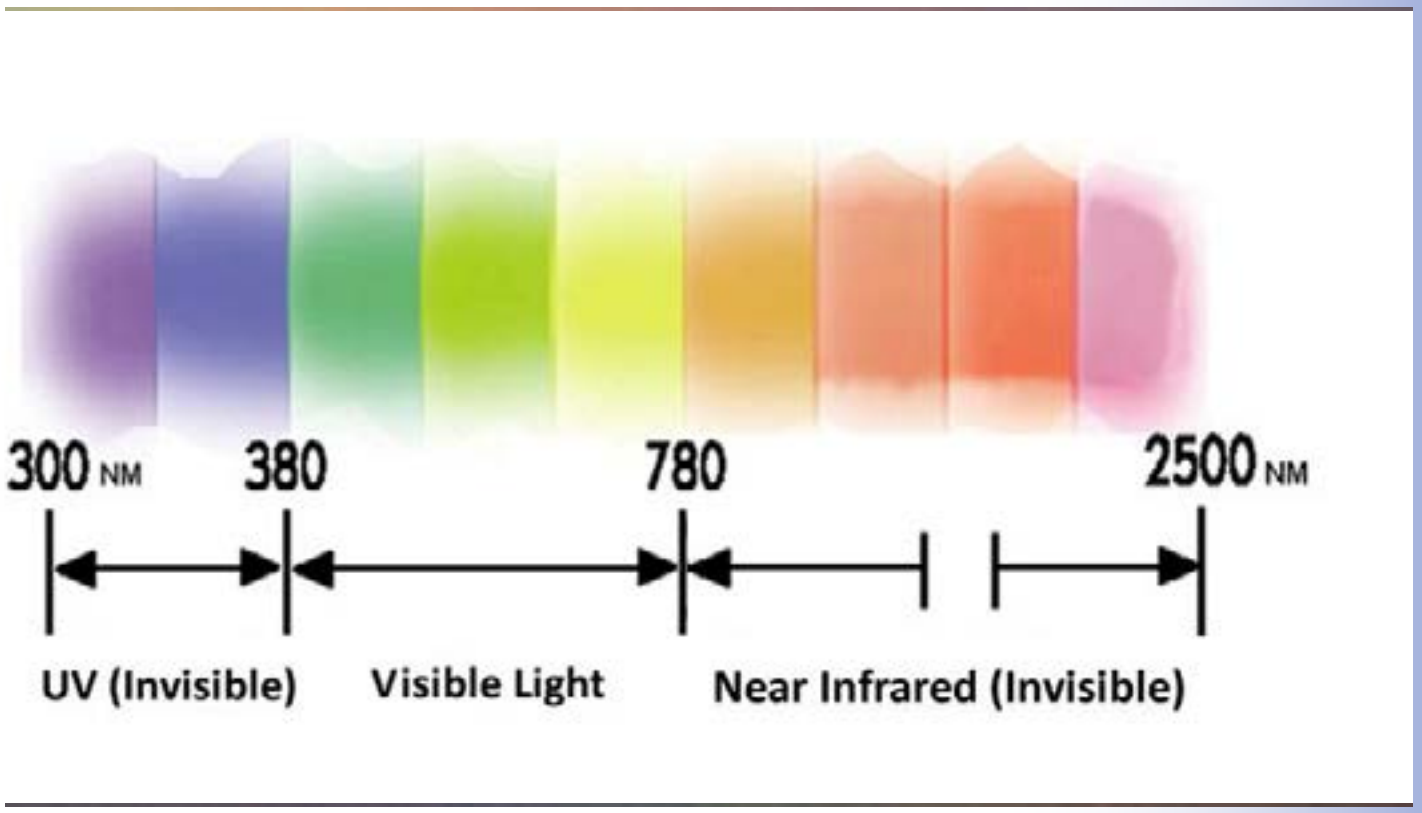
After Viewing This Presentation You Will Understand:

- The NFRC Labeling System
- Light Spectrum
- Coating Performance
- Application Technology
- Engineering
- U-Factor / SHGC / VT / VR
- Building Design Application of Coatings

NFRC Label

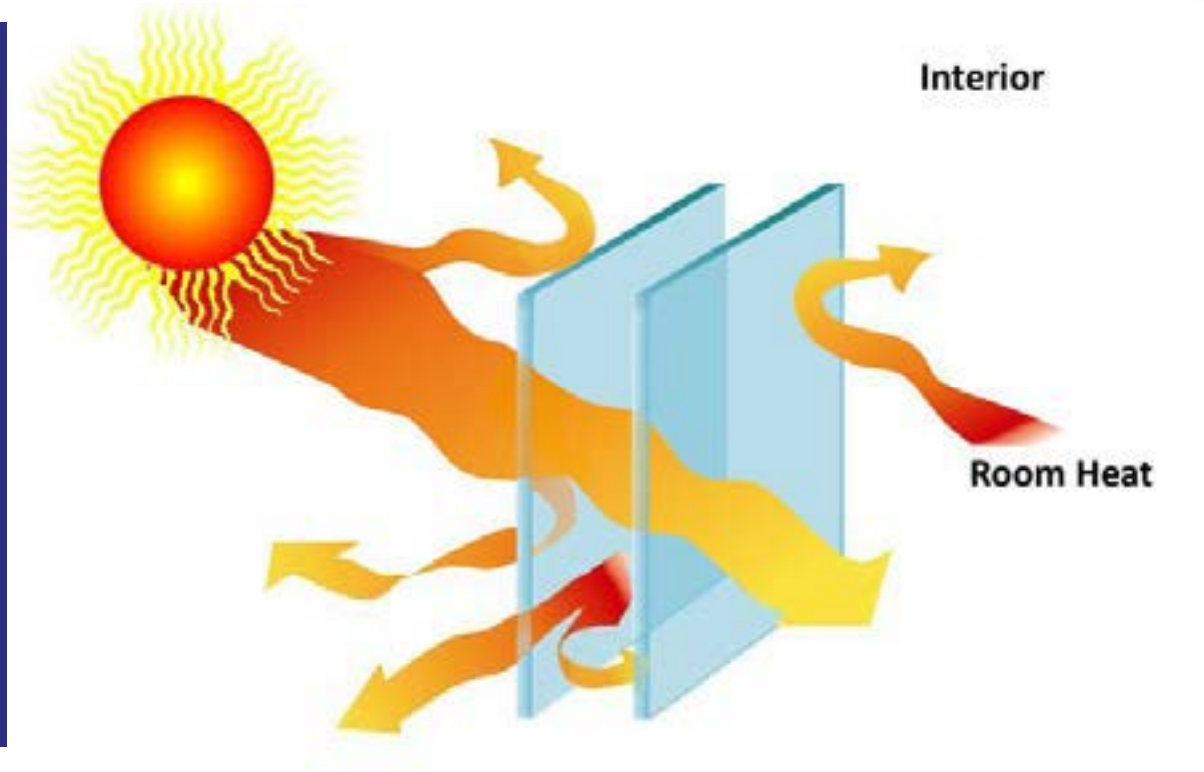
National Fenestration Rating Council

Solar Light Spectrum



Heat Generation	**3%**	**45%**	**52%**

Glazing and the Solar Spectrum

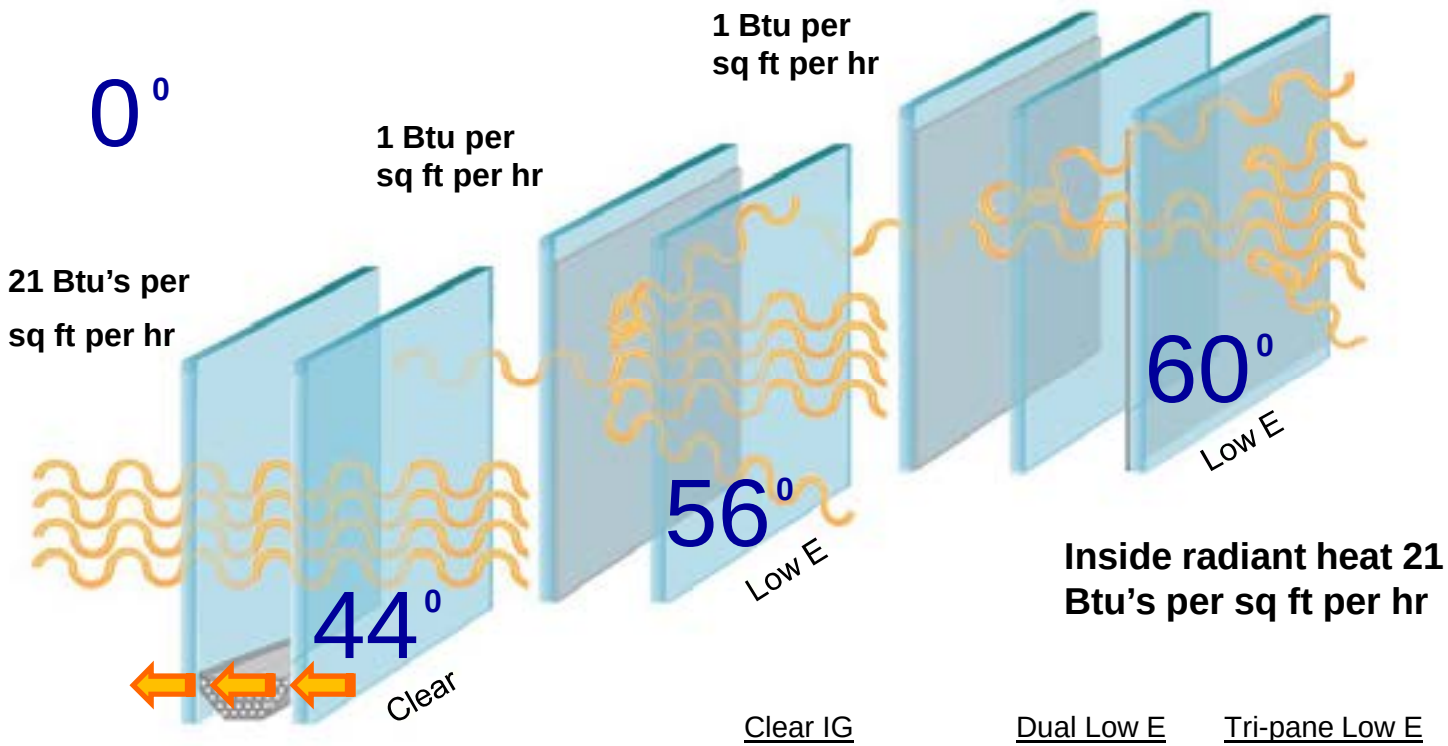


Windows reflect, absorb or transmit visible light, ultraviolet light, and heat.

Why Low E Coatings?

- Code Compliance
- Energy Savings
- Improved Comfort
- Reduced Fading
- Less Condensation
- Increased Light & View

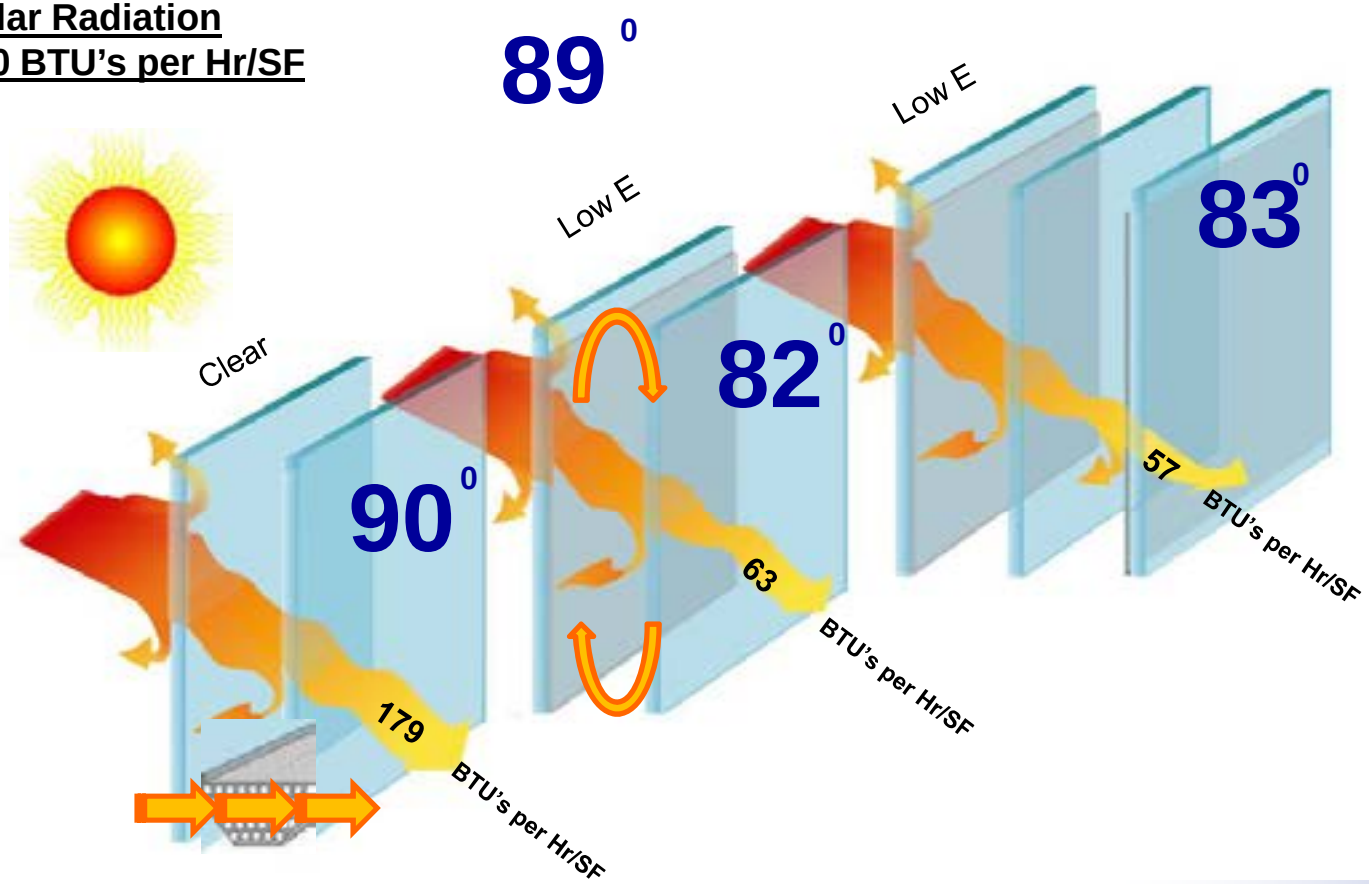
Low E Effect On Winter Nights



	Clear IG	Dual Low E	Tri-pane Low E
Btu's of interior radiant heat exiting the home:	21 Btu's	1 Btu	1 Btu
Conduction heat exiting through materials:	13 Btu's	16 Btu's	10 Btu's
Inside glass temp at 0 degrees F outside :	44 deg	56 deg	60 degrees
Total Btu's exiting through the glazing	**34 Btu's**	**17 Btu's**	**11 Btu's**

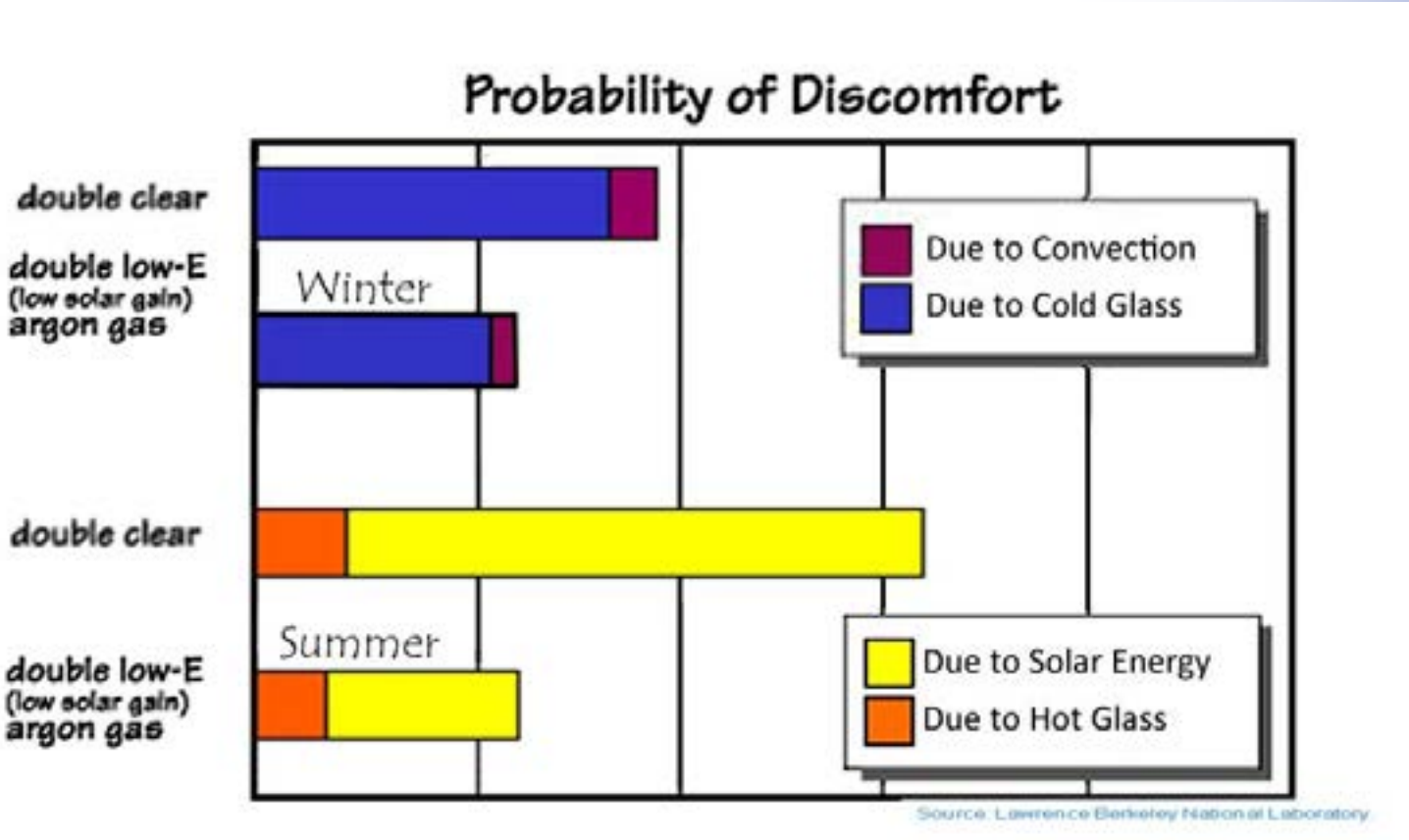
n Low E Effect On Summertime Sun

Solar Radiation
230 BTU's per Hr/SF

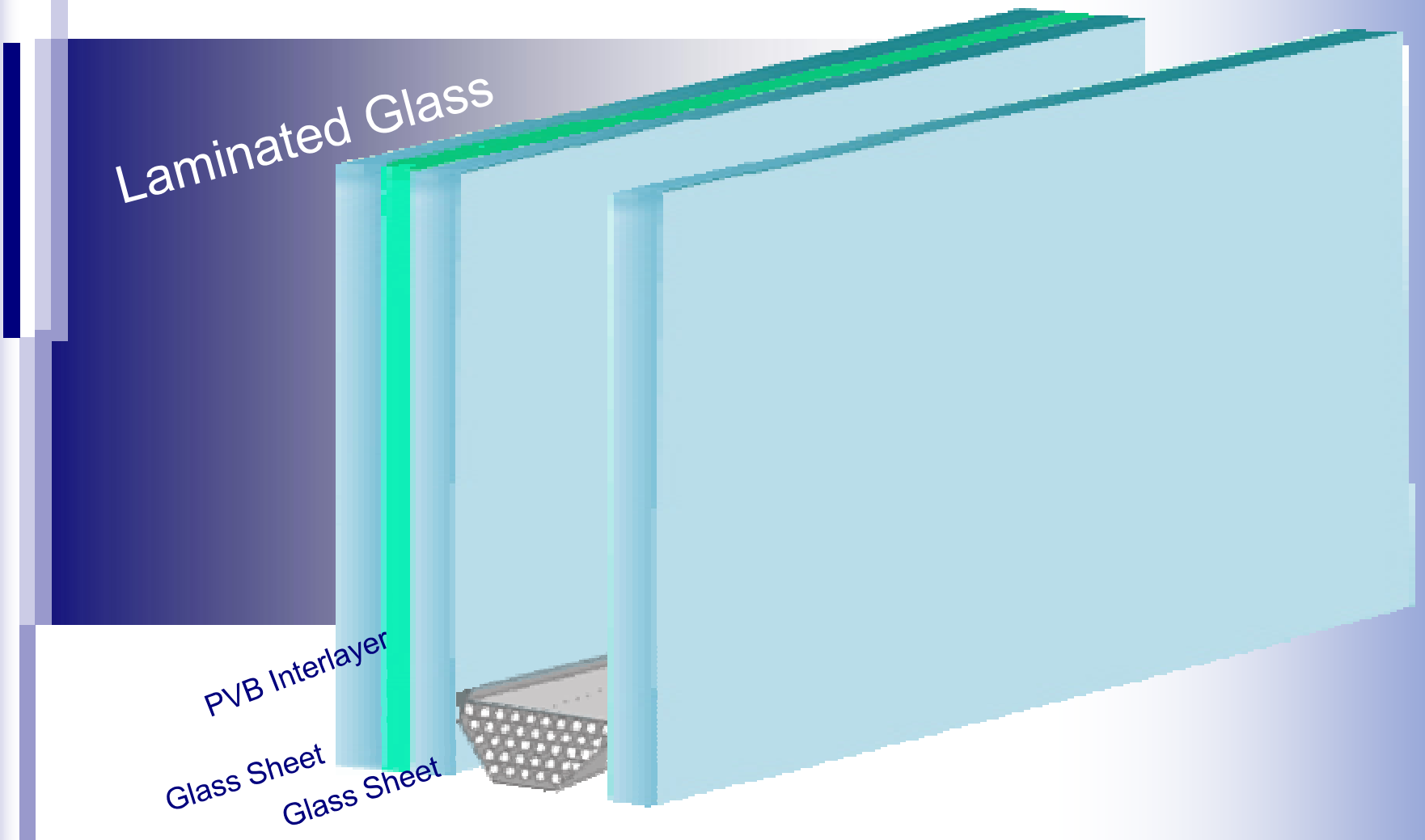


Btu's from solar radiation is reduced:	22%	73%	75%
Conduction heat entering materials:	7 Btu's	3 Btu's	2 Btu's
Convection heat transferred:	12 Btu's	6 Btu's	8 Btu's
Inside glass temperature:	90 degrees	82 degrees	83 degrees

Improved Comfort



Greater Protection from UV



Greater Protection from Fading

Less Condensation

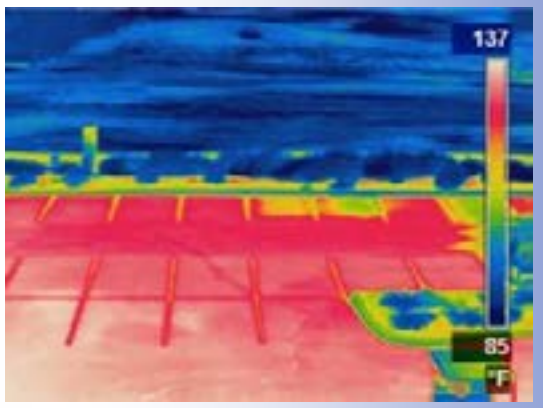
Increased Light and View

Energy-efficient glazing systems

- Defining Emissivity (E)
- Types of Low E
- Where Low E is Applied
- How it's Applied
- Engineering for Performance

n Emissivity (E)

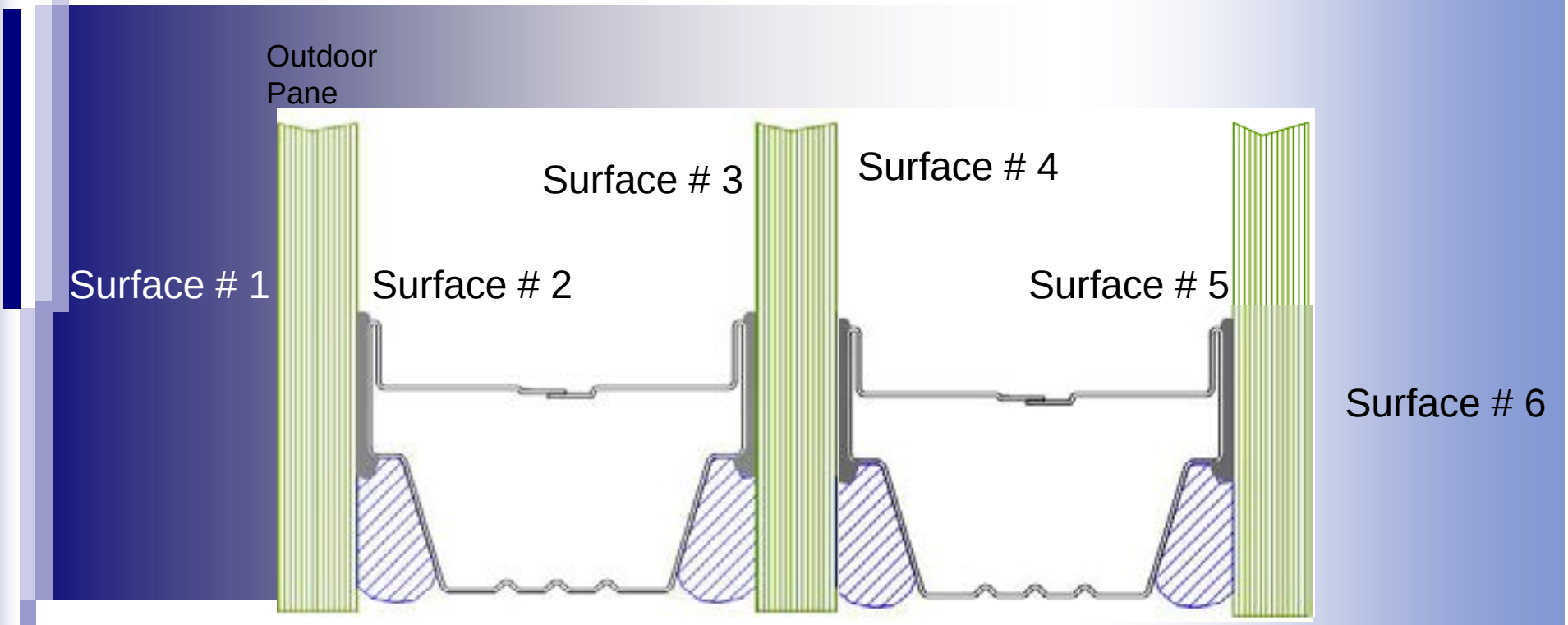
Measure of a material's ability to emit long wave radiation (heat).



Types of Coatings

Sputtered	vs.	Pyrolytic
Low emissivity		Medium emissivity
Low-Med-High SHG		High SHG
Silver based		Metal oxides
Vacuum deposition		Spray process
Uniform		Can be non-uniform
Neutral color		Can have color
Low Haze		Can have haze
Must be insulated		Single Glaze

Surface Designation



Low E Coating Locations

Surface #2 (Dual Pane)

- Better overall performance
- Reduces Solar Heat Gain
- Reduces Summer Inside Glass Temperature
- Reduces Winter Thermal Breakage Potential

Surface #3 (Dual Pane) Passive Solar

- Increased Solar Heat Gain
- Increased Inside Glass Temperature

Note: Winter Nighttime U-Value is the same for both surface #2 or surface #3

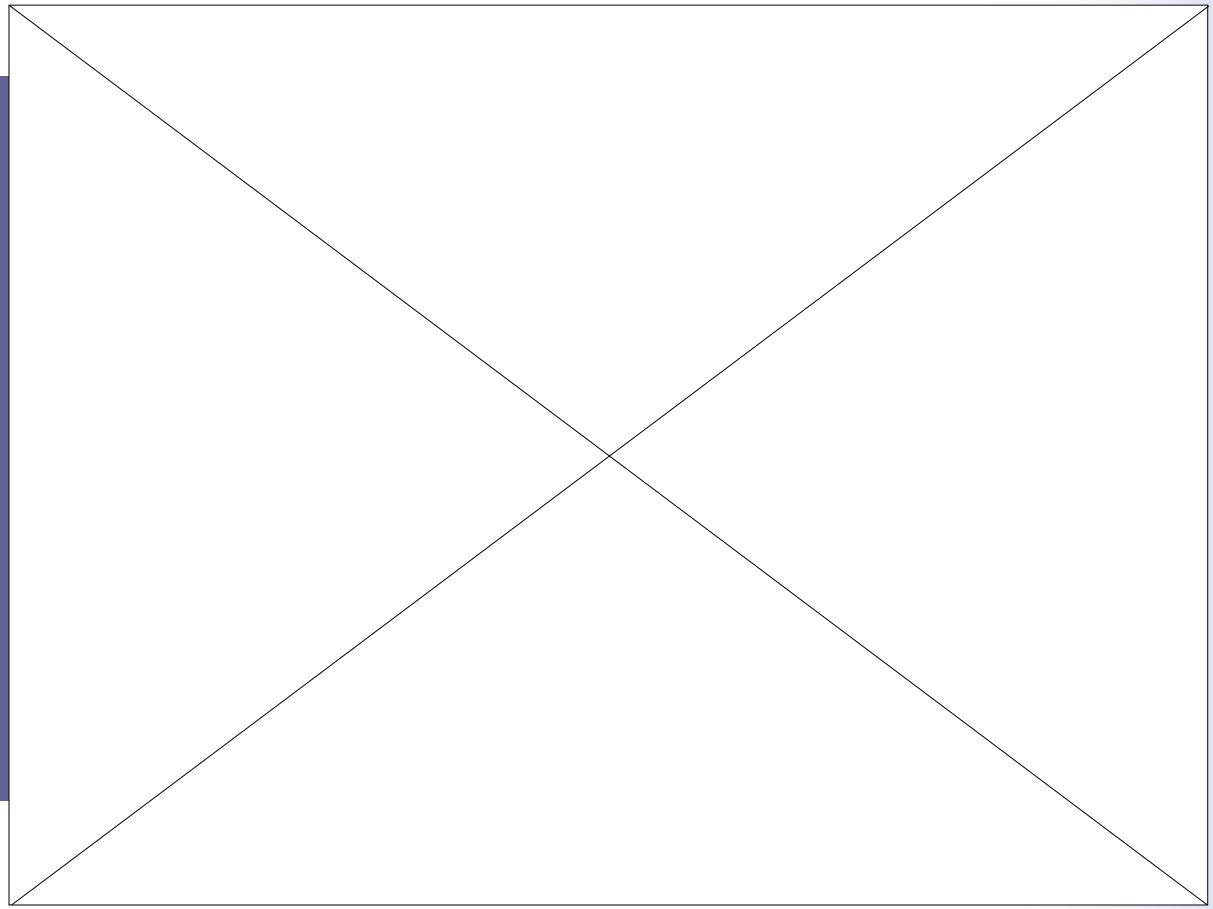
Low E Coating Locations

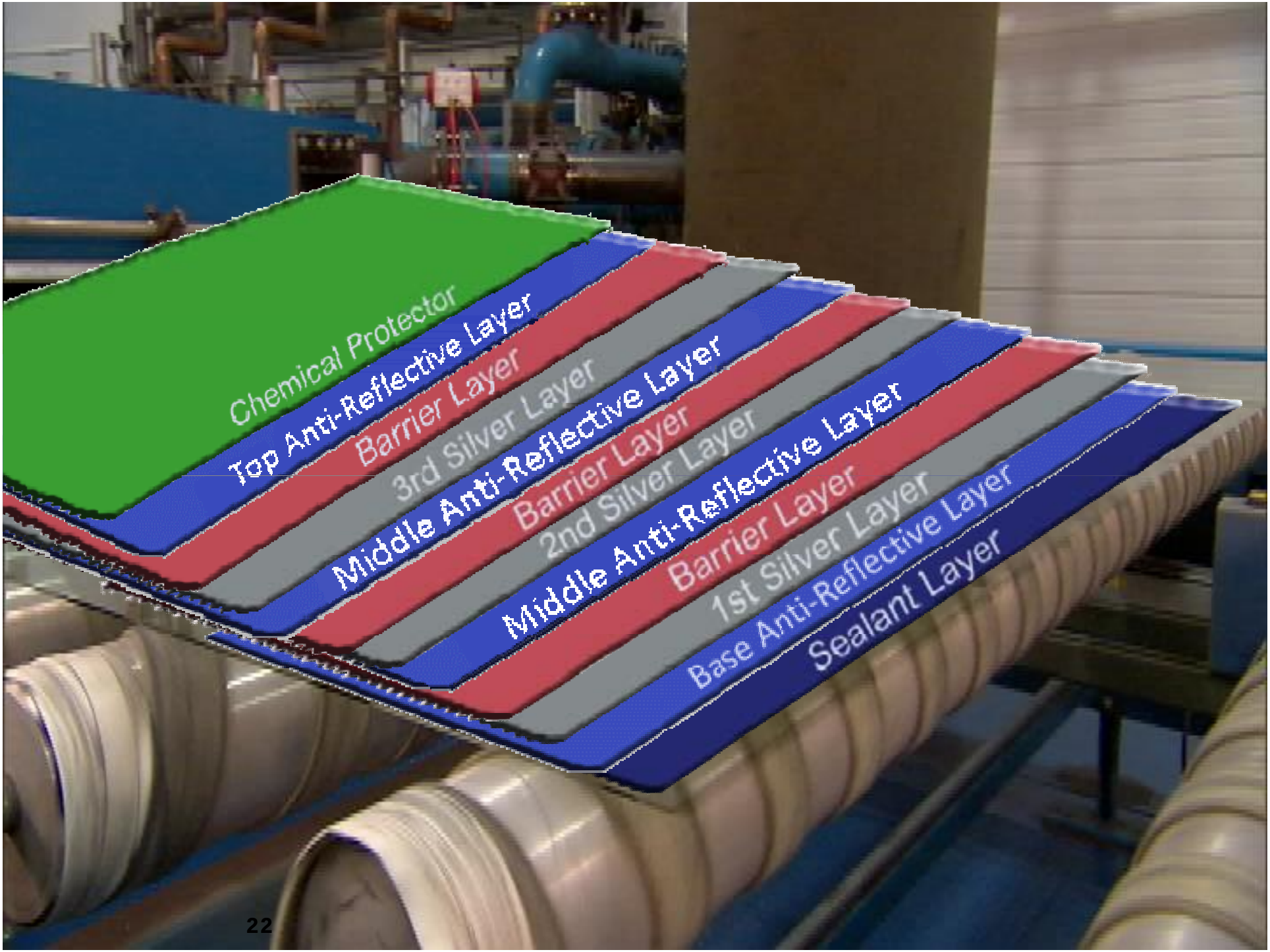
- Surface #4 (Dual Pane)
  - Reflects Heat
  - Lowers U Factor
  - Reduces Solar Heat Gain
  - Decreases Inside Glass Temperature
    (*Increasing the Risk of Condensation*)
  - Rivals Tri-Pane Performance

Tri-pane is typically assembled with the coatings on surfaces 2 and 5.

How Coatings are Applied

How Coatings are Applied




Chemical Protector
Top Anti-Reflective Layer
Barrier Layer
3rd Silver Layer
Middle Anti-Reflective Layer
Barrier Layer
2nd Silver Layer
Middle Anti-Reflective Layer
Barrier Layer
1st Silver Layer
Base Anti-Reflective Layer
Sealant Layer

§Typical Available Low E Coatings

LoĒ Products	Silver Layers	Visible Light Transmission
LoĒ-180	1	80
LoĒ²-272	2	72
LoĒ²-240	2	40
LoĒ³-366	3	66

- Spectrally Selective Coatings

  Adjusting the various coatings will cause variations in the

  - U-Value
  - Solar Heat Gain (SHGC)
  - Visible Light Transmittance (VLT)
  - Visible Light Reflectance

U-factor / R-value

U-factor: The measurement of heat loss or gain through a material or assembly.

R-value: The resistance a material has to heat flow.

Center of Glass U-factor (Btu/hr/ft^2/^{0}F)

Clear / Clear	0.47
Clear / LoE-180 tm	0.28
LoE -272 tm / Clear	0.25
LoE -366 tm / Clear	0.24
LoE -240 tm / Clear	0.26
Triple-Pane LoE-180 tm / Clear / LoE-180 tm	0.17
Triple-Pane LoE -366 tm / Clear / LoE -180 tm	0.13

Solar Heat Gain Coefficient (SHGC)

Number between 0 and 1

The lower the SHGC the less solar heat is transmitted and the greater its shading ability

n Solar Heat Gain Coefficient (SHGC)

	SHGC	Indoor Glass Temp ^{0} F
Double-Pane Clear	0.78	90
Double-Pane LoE-180 tm	0.70	86
Double-Pane LoE-180 tm Gray Tint	0.37	93
Double-Pane LoE-240 tm	0.25	86
Double-Pane LoE -272 tm	0.41	84
Double-Pane LoE -366 tm	0.27	82
Triple-Pane LoE-180 tm	0.57	95
Triple-Pane LoE -366 tm	0.24	92

Krypton Gas Typically Decreases SHGC by -0.02

Visible Light Transmittance (VT)

An optical property that indicates the amount of visible light transmitted.

Number between 0 and 1

Visible Light Transmittance (VT)

Clear / Clear	0.82
Clear / LoE-180 tm	0.80
LoE-180 tm Gray Tint	0.53
LoE -272 tm / Clear	0.72
LoE -366 tm / Clear	0.66
LoE -240 tm / Clear	0.40
Triple-Pane LoE-180 tm / Clear / LoE-180 tm	0.69
Triple-Pane LoE -366 tm / Clear / LoE -180 tm	0.51

n Visible Light Reflectance (VR)

Outdoor Visible Light Reflectance

In the visible light spectrum, the percentage of light that is reflected from the glass surfaces relative to the C.I.E. Standard Observer.

C.I.E. Standard Observer:
Since Humans perceive color and appearance in different ways , subjectively, The C.I.E. Standard Observer attempts to standardize the human observer as a numerical representation of what the average person sees.

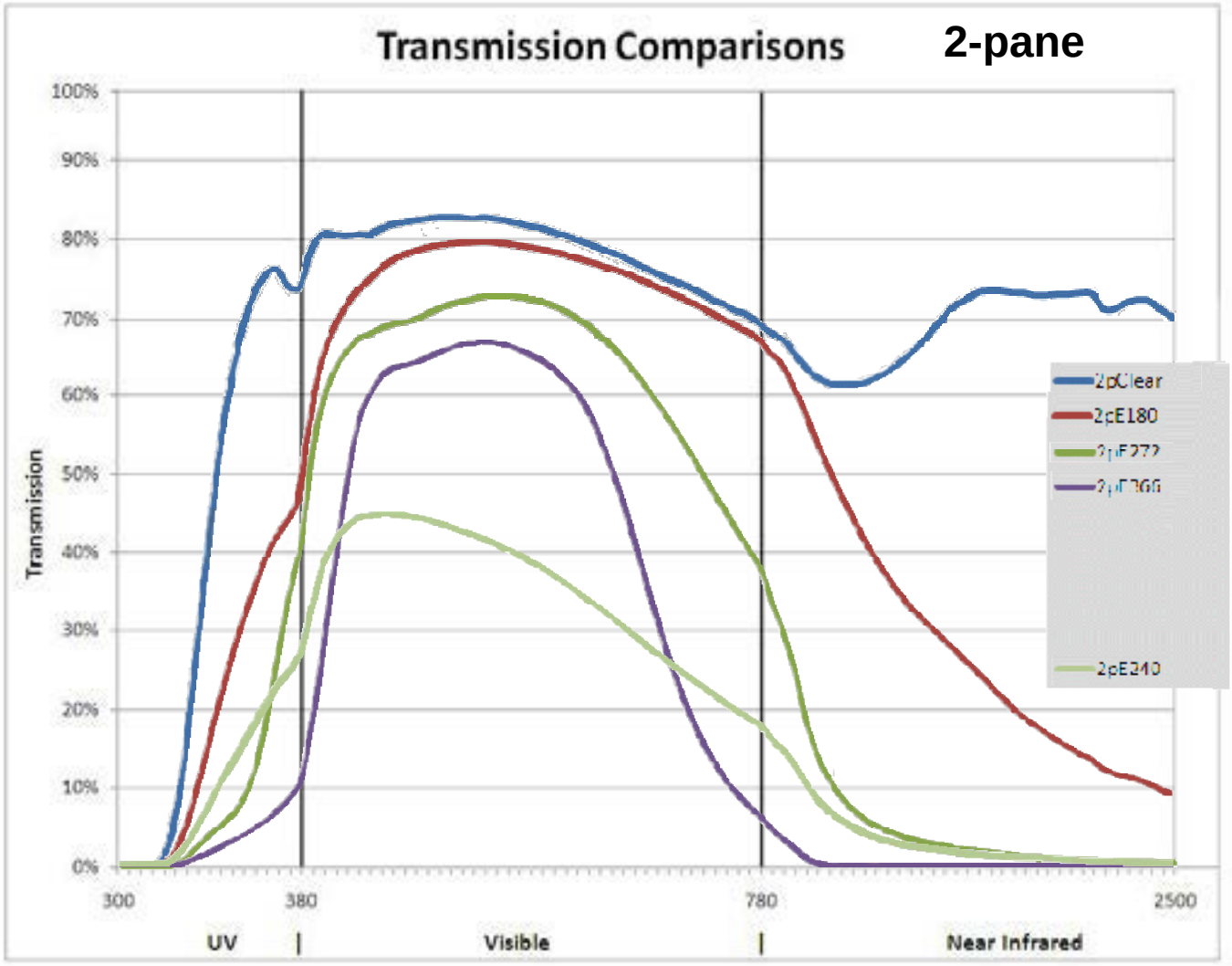
Indoor Visible Light Reflectance

The percentage of visible light that is reflected
from the glass surfaces to the inside of the building.

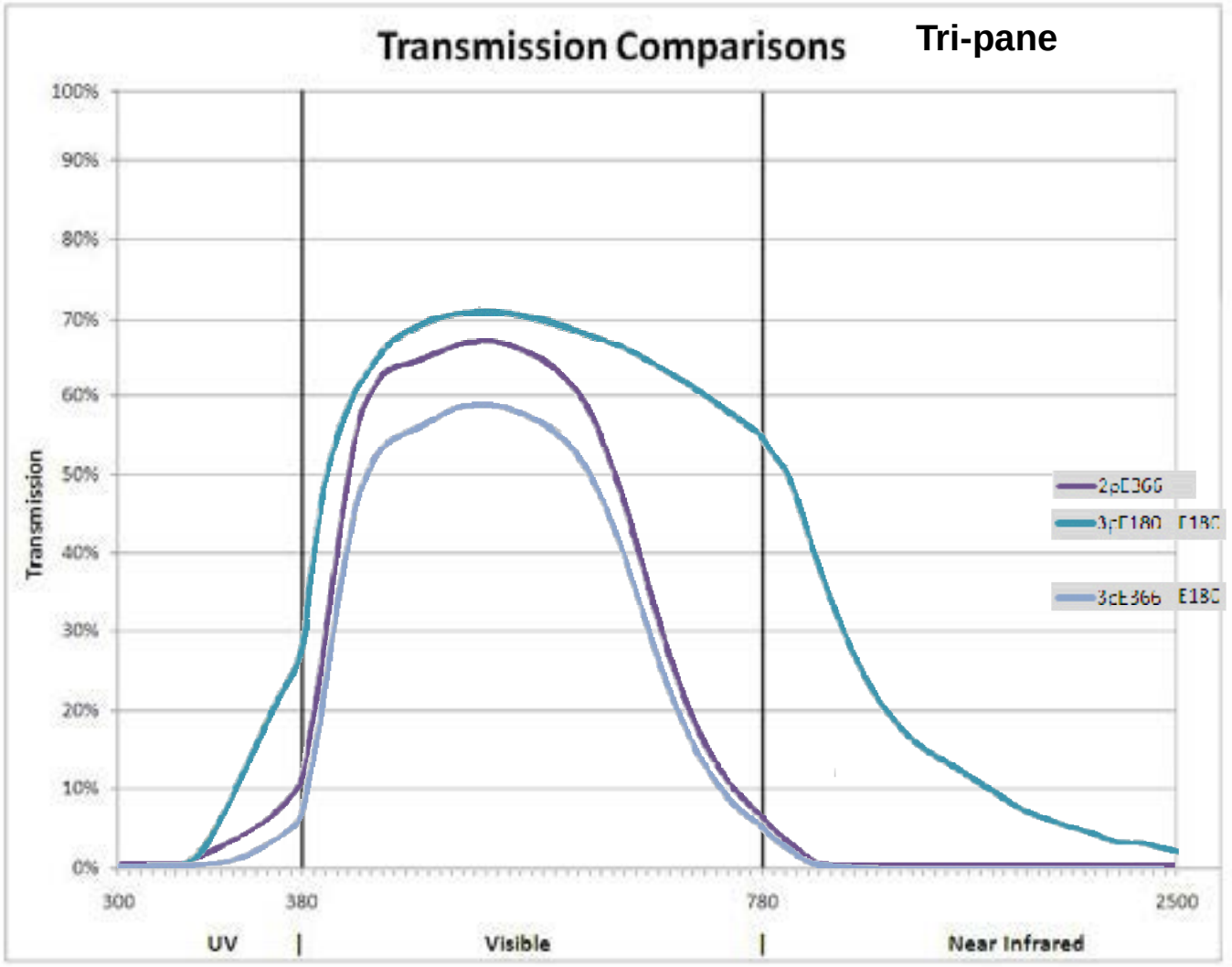
n Visible Light Reflectance (V)

	% OUT	% IN	
Clear / Clear	15%	15%	
Clear / LoE-180 tm	14%	14%	
LoE-180 tm Gray Tint	9%	13%	(Surface #3)
LoE -272 tm / Clear	11%	12%	
LoE -366 tm / Clear	11%	12%	
LoE -240 tm / Clear	14%	10%	
Triple-Pane LoE-180 tm / Clear / LoE-180 tm	19%	19%	
Triple-Pane LoE -366 tm / Clear / LoE -180 tm	14%	17%	

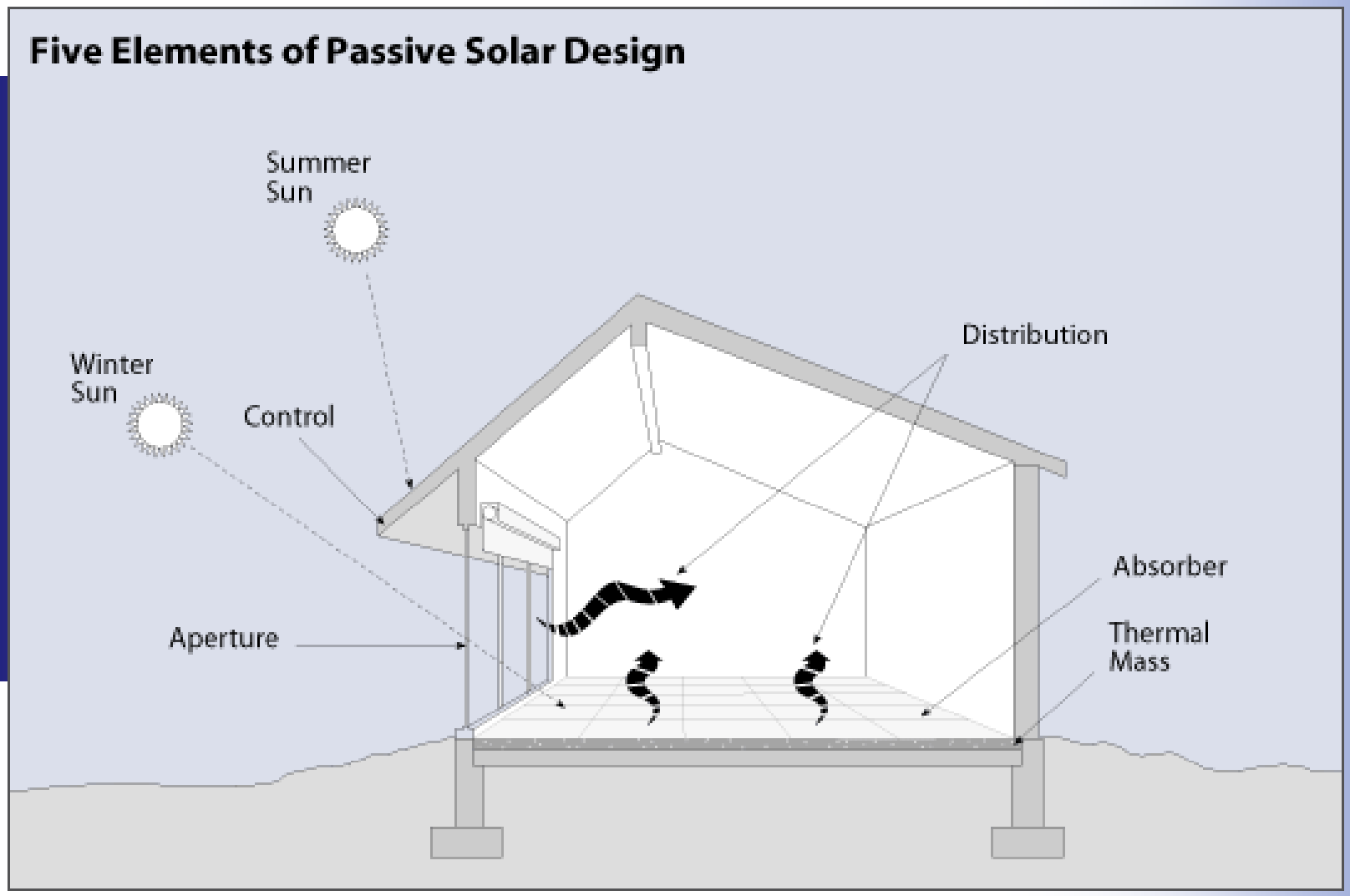
Solar Spectrum



Solar Spectrum



n Spectrally Selective Coatings



Resources

Cardinal Glass

http://www.cardinalcorp.com

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- Questions?

Thank you