Understanding Low-E Coatings

Vitro® Architectural Glass

PPG Formerly PPG Glass

CORPORATIVO LEGARIA

ARCHITECT: ZVA ARQUITECTOS

Best Practices

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Learning Objectives

At the conclusion of this presentation, you will understand:

- The solar energy spectrum and common glass performance measures
- The manufacturing processes for pyrolytic and magnetron sputter vacuum deposition (MSVD) low-e coatings
- How passive and solar control low-e coatings differ and impact glass performance measures
- Commercial energy usage and how low-e coatings can improve energy efficiency and earn LEED® credit contributions

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ARCHITECT: EKASH ASSOCIATES

Understanding Low-E Coatings

TOWER AT PNC PLAZA
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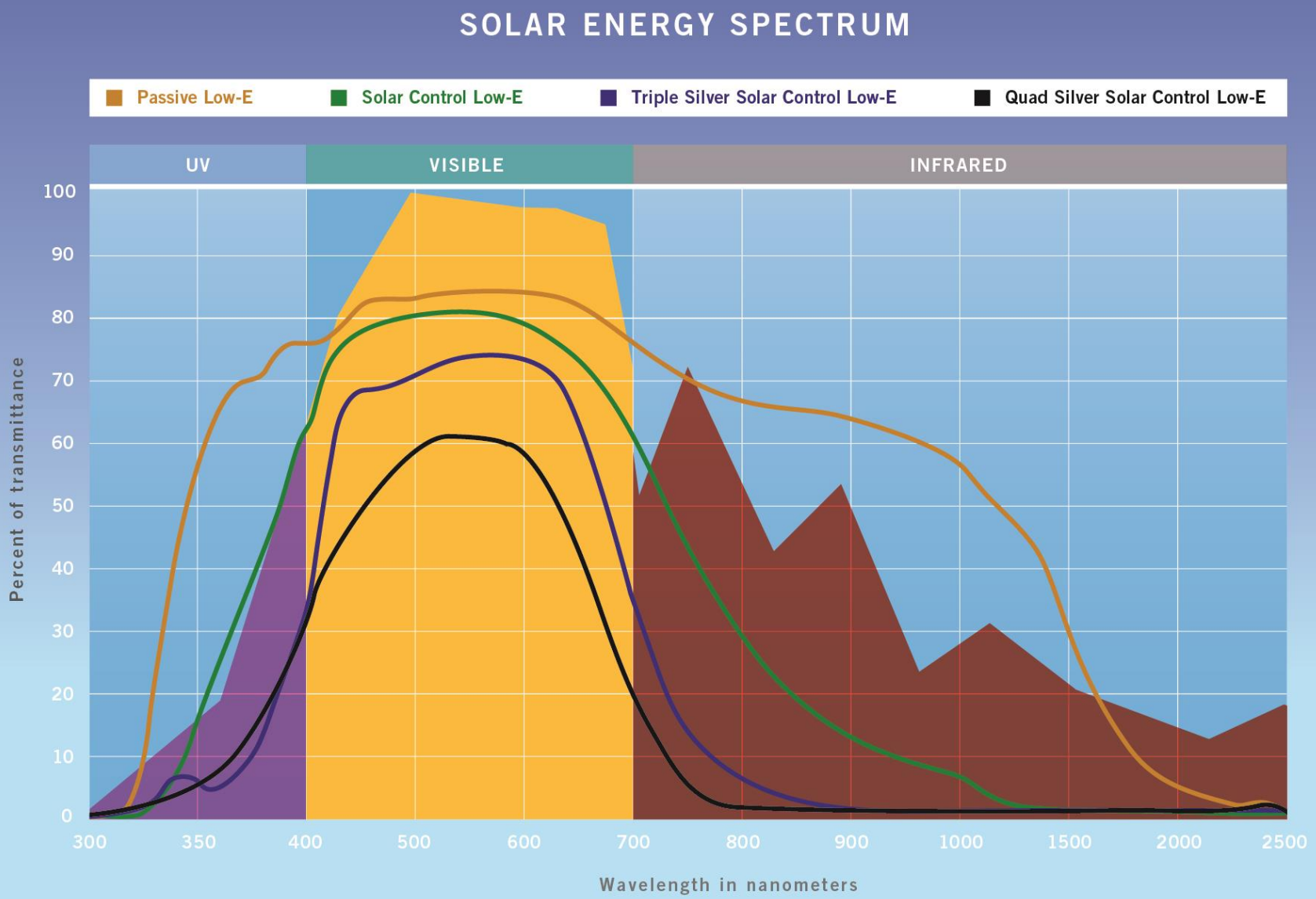
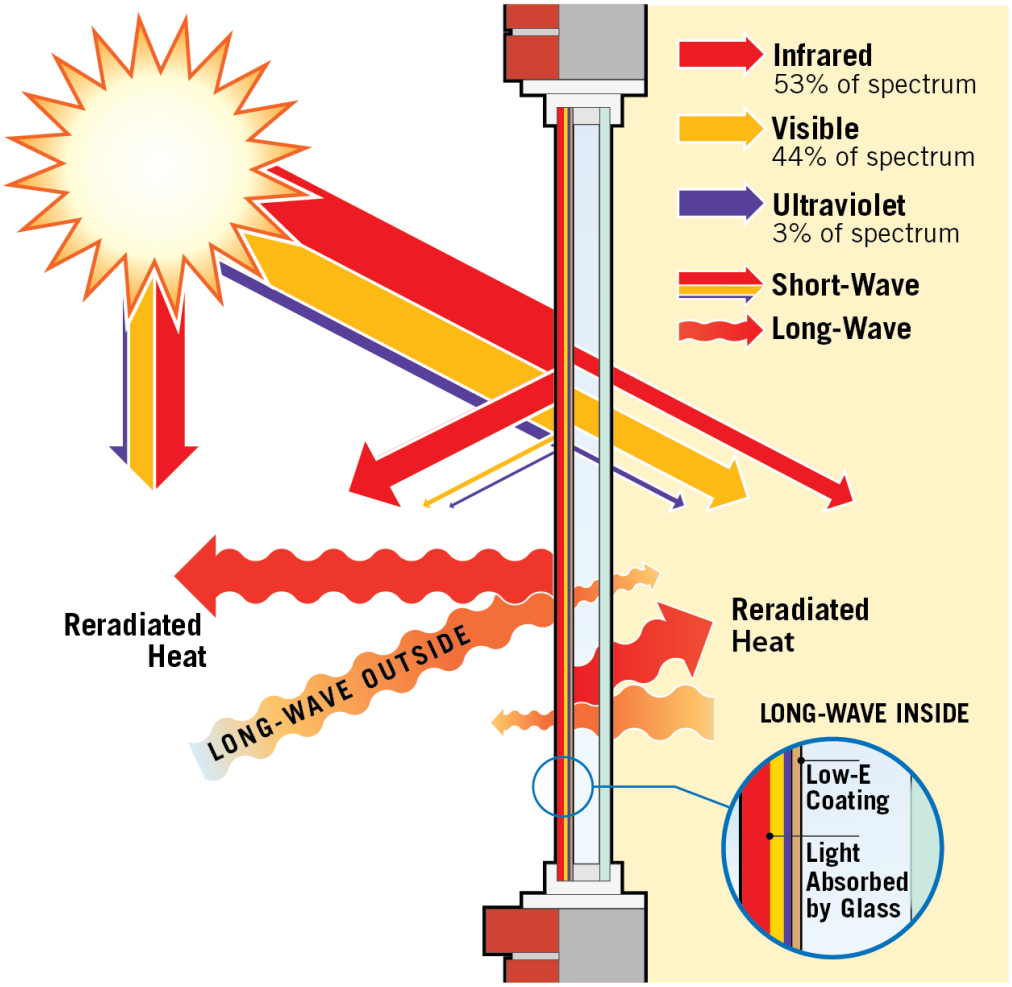
The Solar Energy Spectrum

The Solar Energy Spectrum



Short-Wave and Long-Wave Energy

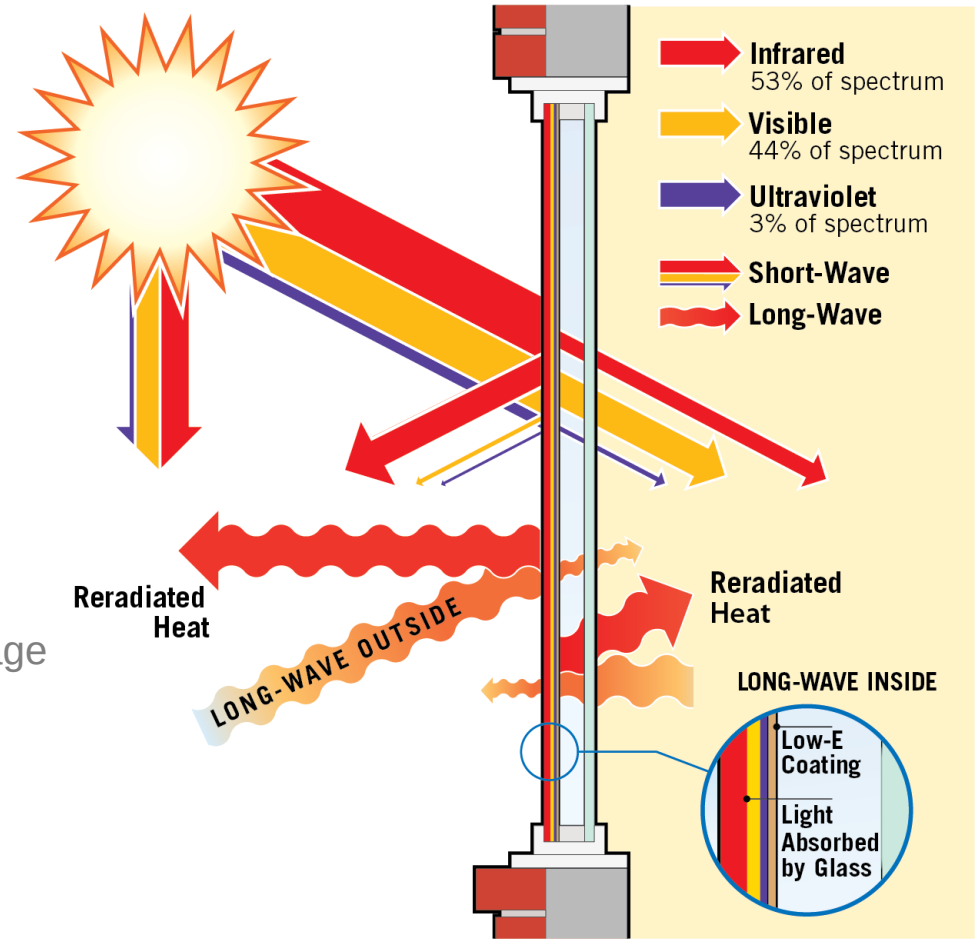


Benefits of Energy-Efficient Glass

- Low infrared heat gain/transfer
- High natural visible light transmittance
- Less artificial lighting
- Reduction of long-wave heat gain/loss
- Increased comfort/productivity

Results

- Overall reduction in energy usage

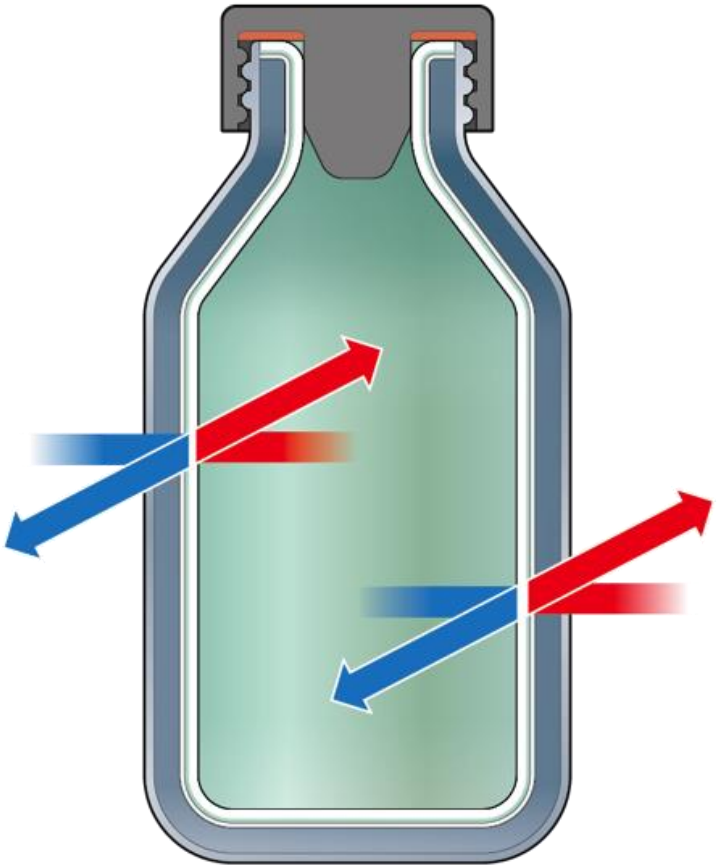


Understanding Emissivity

- The ratio of the thermal energy radiated from a material's surface to the thermal energy radiated from a blackbody (a perfect emitter), at the same temperature and wavelength, under the same conditions.
- Thermal heat that is not radiated away is either absorbed or transmitted through the glass.
- The lower an object’s emissivity, the better it is at reflecting away heat.
- Emissivity works in all seasons and in all climates, always working to slow the transfer of heat. In cold seasons or climates, it reflects heat back into the interior of the building; in warm seasons or climates, it reflects heat back to the outside of the building.
- Reduced emissivity improves a window’s insulating properties. Uncoated clear glass has an emissivity of 0.84 while a solar control low-e glass might have an emissivity as low as 0.02.
- All uncoated glasses have the same emissivity. The addition of a well-engineered low-e coating reduces the emissivity and increases the reflectance of thermal energy. Low-e coatings do not necessarily increase the visible reflectance of the glass and can actually be less visibly reflective than uncoated clear glass.

Thermos® Illustration

- Silver lining reflects the temperature of the drink it contains back in.
- Temperature is maintained because of the constant reflection that occurs.
- Air space provides additional benefits.
- Low-e glass is composed of extremely thin layers of silver.
- The same theory applies.



ORTHOPEDIC CENTER AT LANCASTER GENERAL HOSPITAL
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Passive and Solar Control Low-E Coatings

Types of Coated Glass

- **Low-E Glass**
  - **Solar Control Low-E**: Blocks solar radiation to reduce cooling costs. Higher-performing glasses are applied or produced by a magnetron sputtered vacuum deposition (or MSVD) soft coat process.
  - **Passive Low-E**: Transmits solar radiation for passive heating applications. Reduces heating costs. Applied on products by a pyrolytic or MSVD soft coat process.
- **Non-Low-E Glass**
  - Tinted Glass
  - Reflective Glass
  - Anti-Reflective Glass
  - Shower Glass

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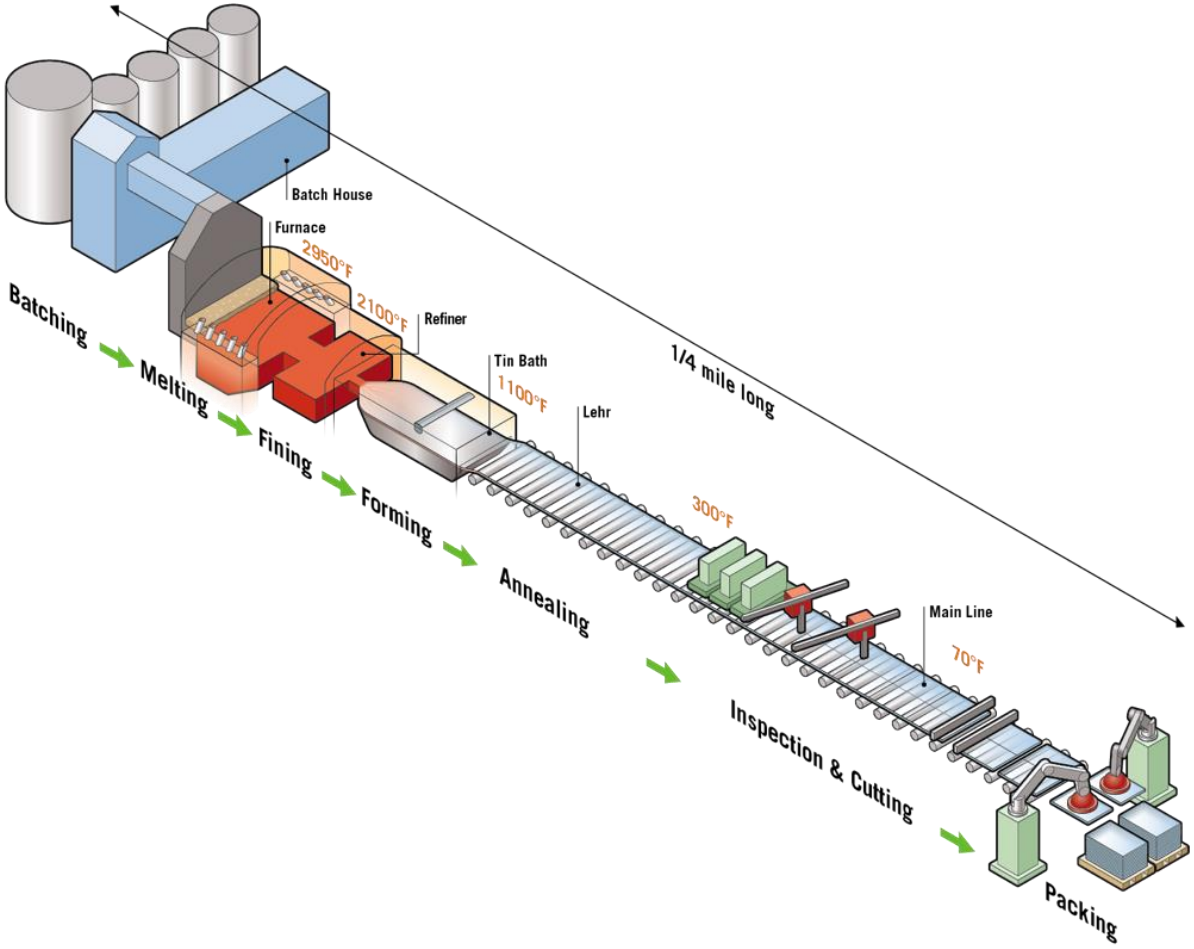
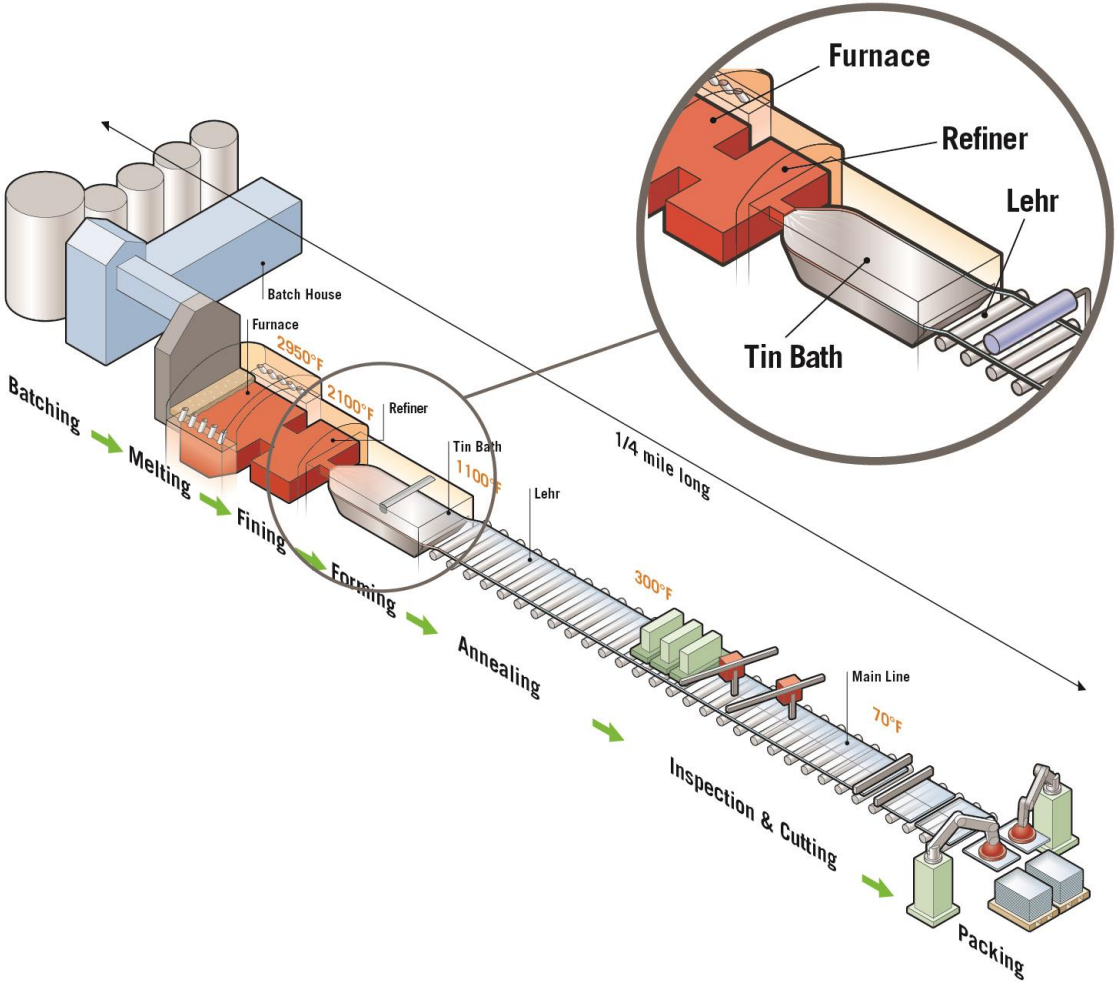
The Float Glass Process

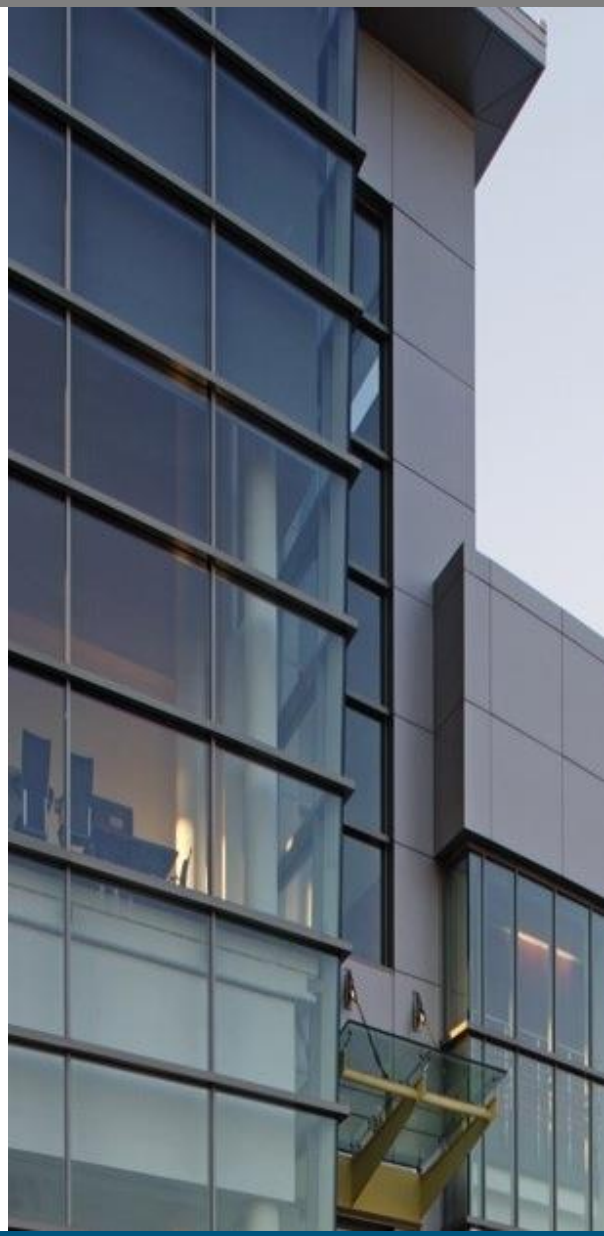


CVD Coating (or “Hard Coat”) Process



CVD Coating (or “Hard Coat”) Process

- On-line process where the coating is applied in the bath
- Stands up very well to further processing and fabrication
- Has an unlimited shelf life
- Limited ability to achieve high-performance solar control levels



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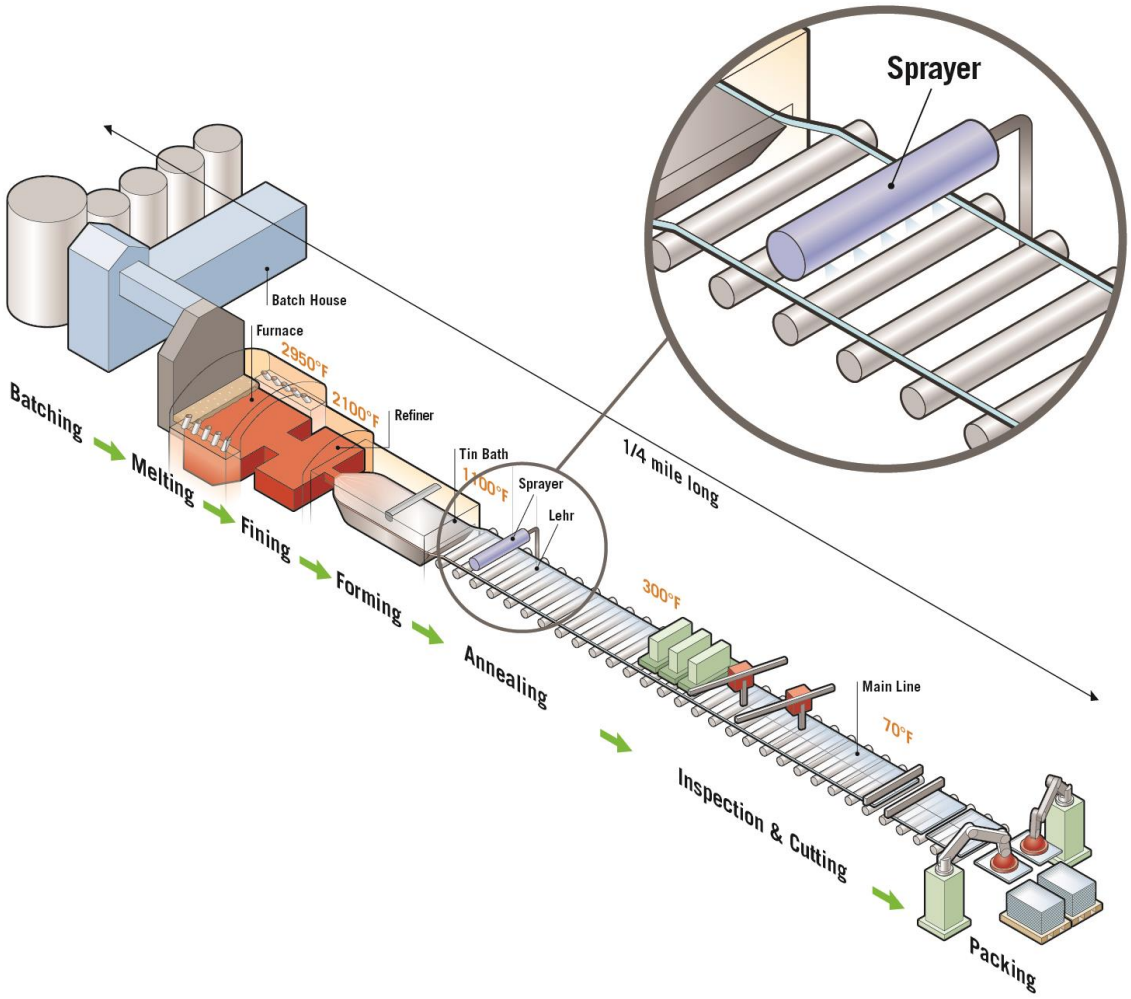
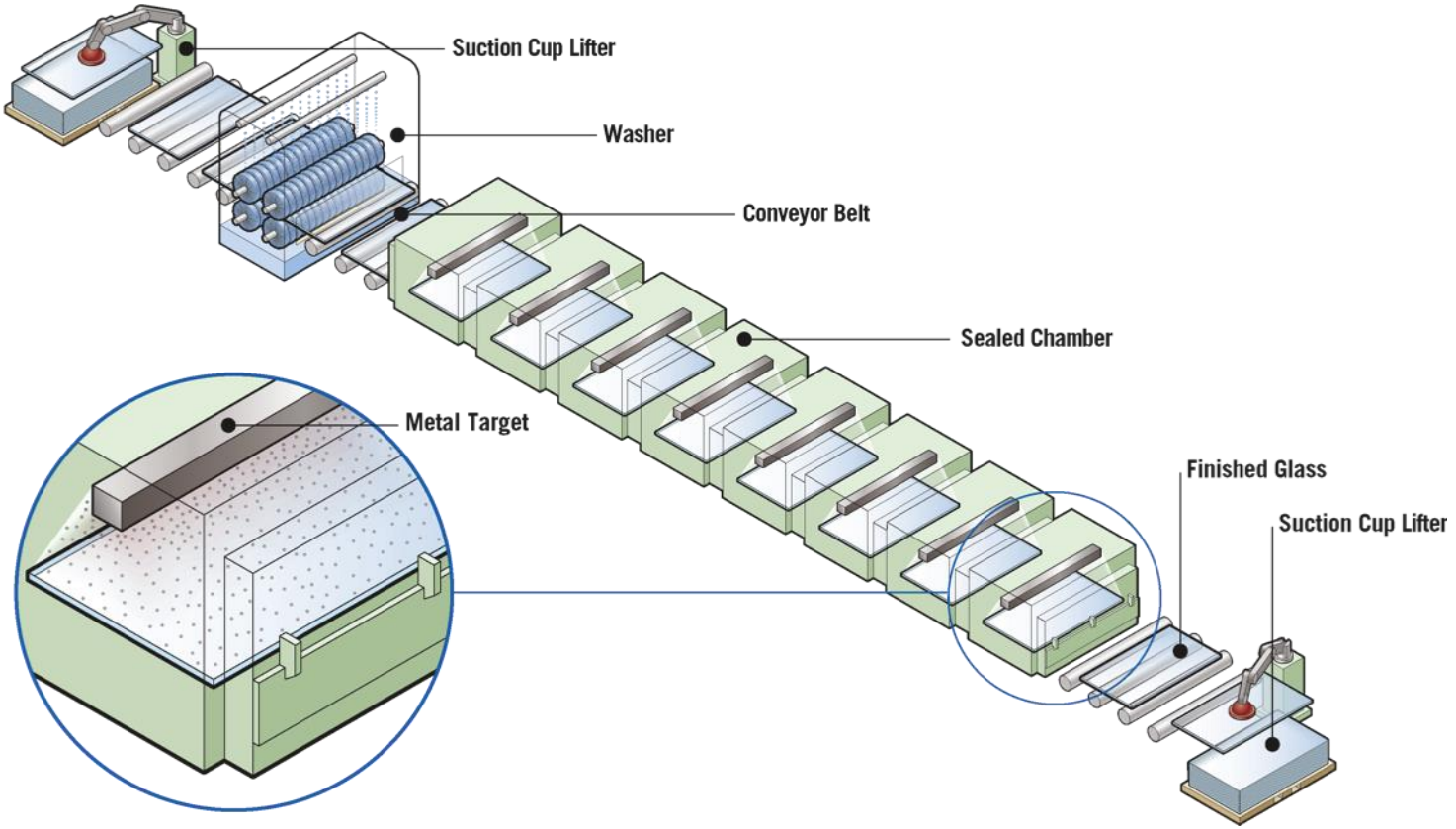
Sprayed-On Coatings (Spray Pyrolysis)



Sprayed-On Coatings (Spray Pyrolysis)

- Application is considered an on-line process.
- Pyrolitic coatings are sprayed onto hot glass just after it exits the tin bath.
- Liquid suspension of various metal oxides reacts with surface, forming bonded and durable coating.
- May impart color to the substrate glass.
- Increases reflectivity while reducing light transmission through glass.

MSVD Coating Process



MSVD Coating Process

- Considered an off-line coating process.
- Total thickness of low-e coating is 150 nanometers.
- Applied to pre-cut glass in vacuum chamber at room temperature.
- Most solar control low-e glasses are MSVD.
- Depending on materials used, most should be sealed in an IGU or laminated.
- Enables lower emissivity and superior solar control performance.

BANK OF AMERICA
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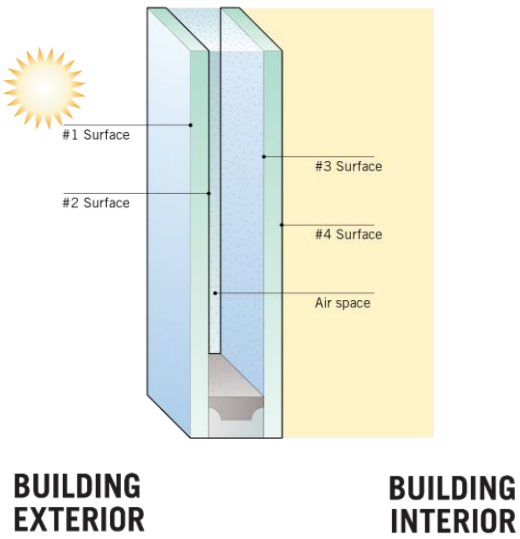
Insulating Glass Units (IGUs)

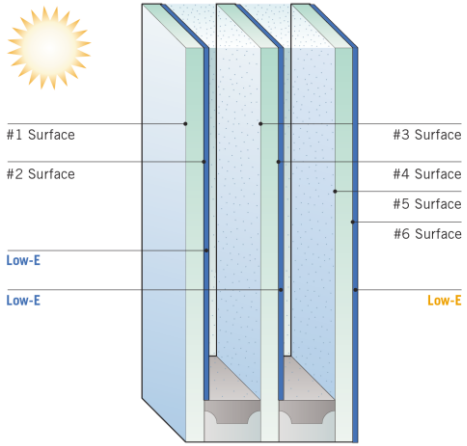
Four potential coating surfaces:

- Each glass surface in the IGU is numbered sequentially from the building exterior to the building interior.
  - The first (#1) surface faces outdoors.
  - The second (#2) and third (#3) surfaces face each other inside the IGU and are separated by an air space.
  - In a dual-pane IGU, the fourth (#4) surface faces directly indoors; in a triple-glazed IGU the sixth (#6) surface faces directly indoors.
  - The #5 surface in a triple-glazed IGU is the outermost surface of the room-side lite.

Double-Pane IGU



Triple-Pane IGU



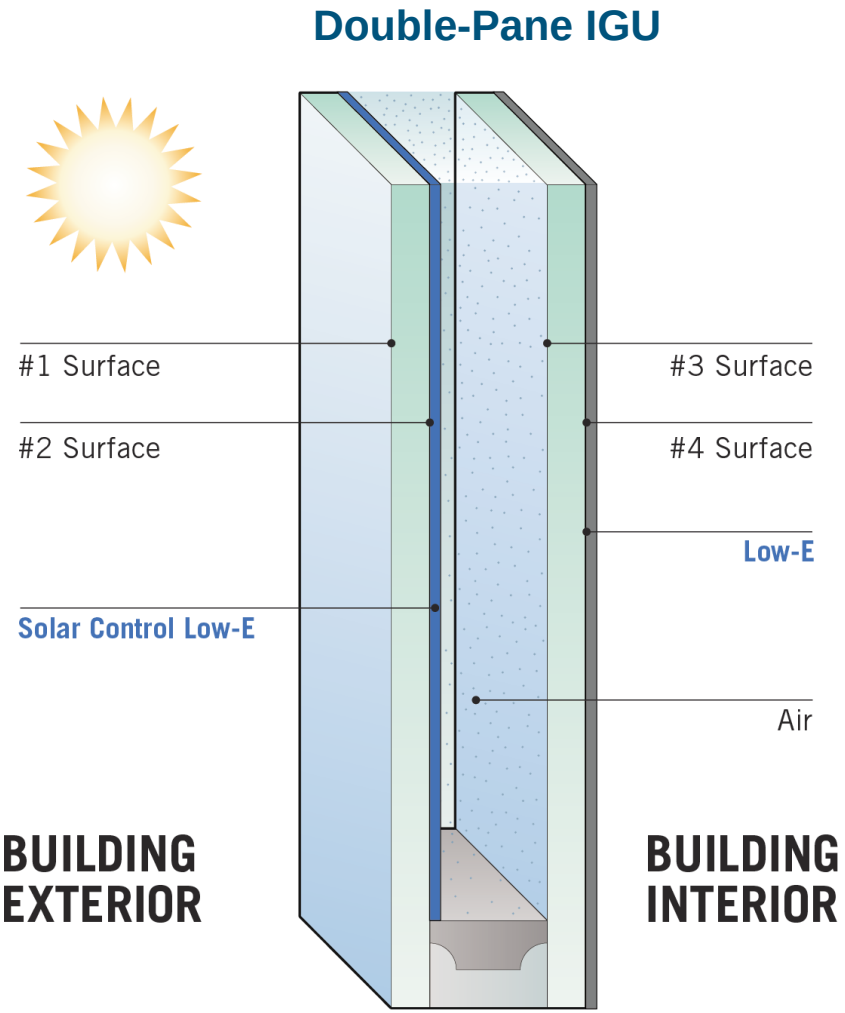
Defining Your Low-E Coating Strategy

Factors that may influence your low-e coating selection and placement strategy include:

- Heating or Cooling dominated climate
- Energy performance
  - Building codes
  - Project HVAC requirements
- Aesthetic objectives
- Site characteristics
- Additional design factors

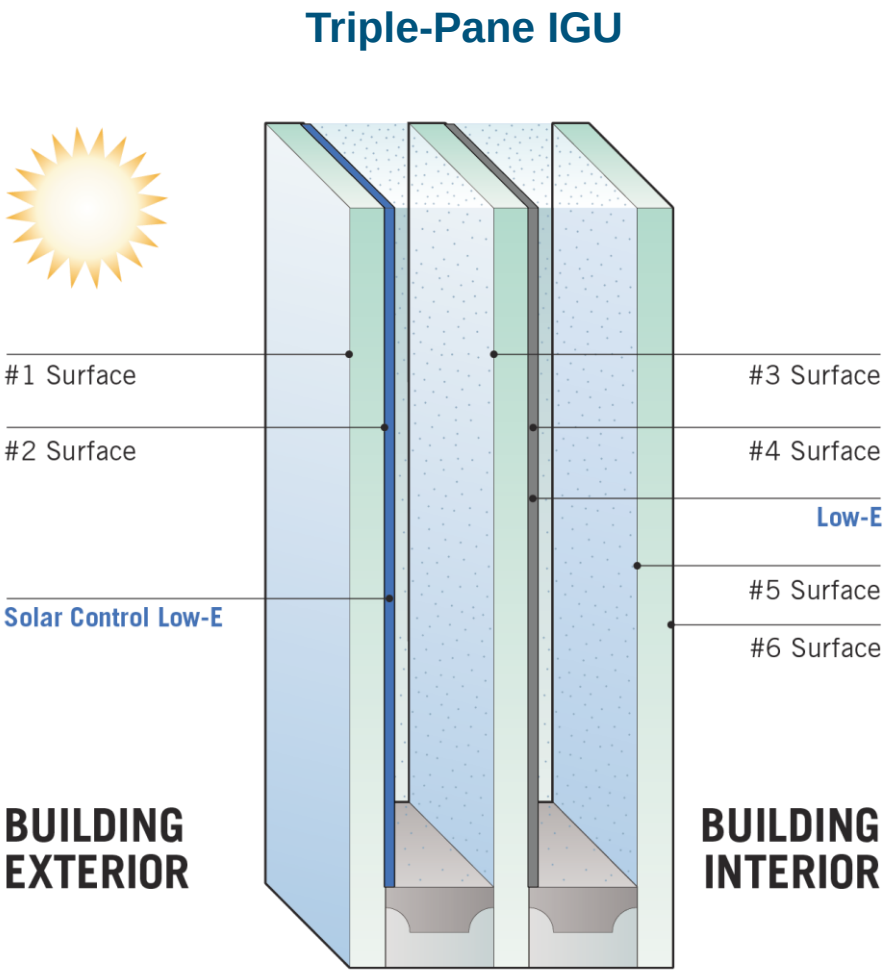
Double-Pane Solar Control Low-E Coating Placement Strategy

- Apply solar control low-e coating to #2 surface of the IGU to maximize solar control performance.
- A second low-e coating (engineered for “interior surface”) can be placed on surface #4 to optimize insulating performance.
- Only one low-e coating should be in an airspace for best performance.



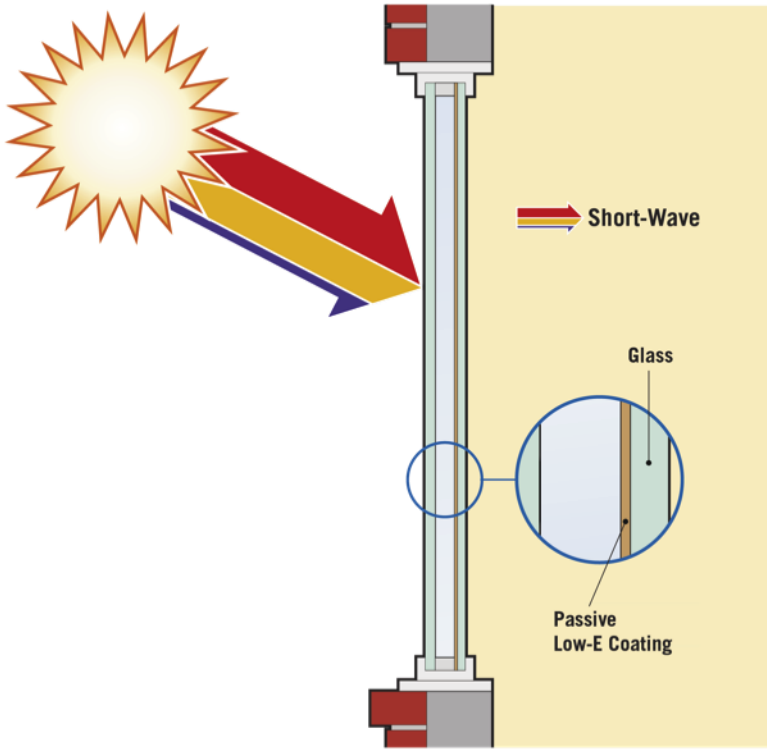
Triple-Pane Solar Control Low-E Coating Placement Strategy

- Apply a solar control low-e coating to the #2 surface and a second low-e coating to the #4 surface of the IGU to optimize solar control performance.
- Placing a third low-e coating engineered for “interior surface” (surface #6) of a triple-pane IGU will further enhance insulating performance.



Passive Low-E Coatings Placement Strategy

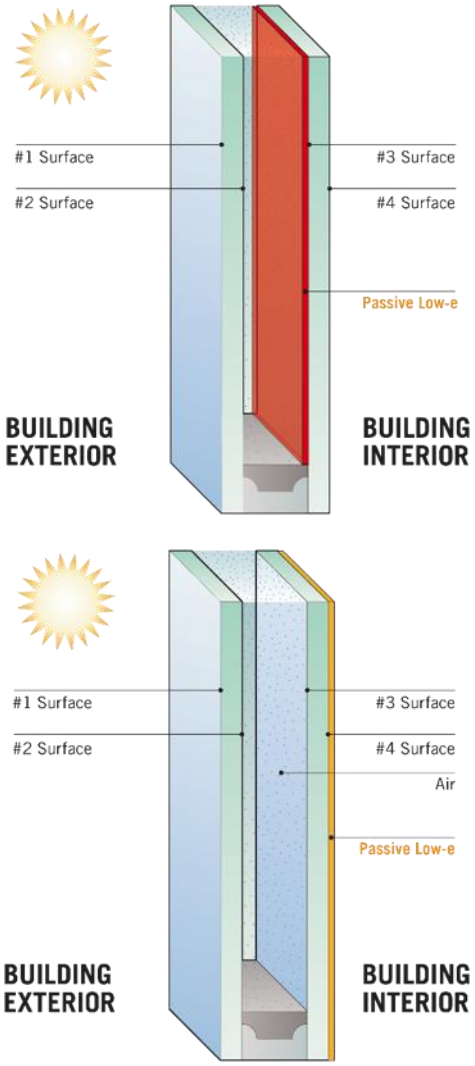
Unlike solar control low-e coatings, passive low-e coatings allow some of the sun's short-wave infrared energy to pass through and help heat building interiors.



Double-Pane Passive Low-E Coatings

- Apply passive low-e coatings to the surface of the innermost lite of glass, which are the #3 or #4 surfaces.
- The further away from the sun a passive low-e coating is placed, the more solar heat will be transmitted into the building.

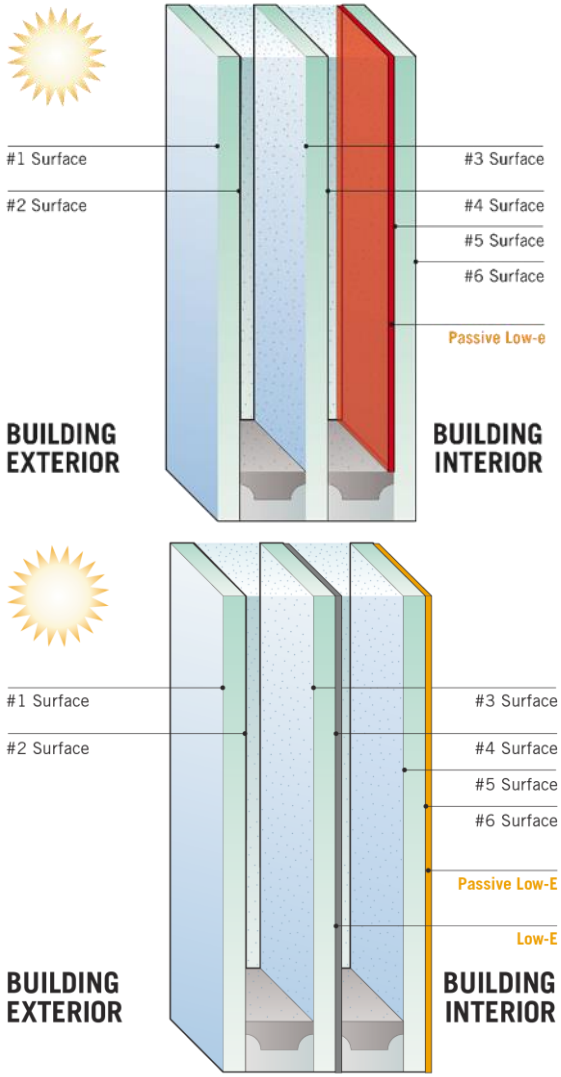
Double-Pane IGU



Triple-Pane Passive Low-E Coatings

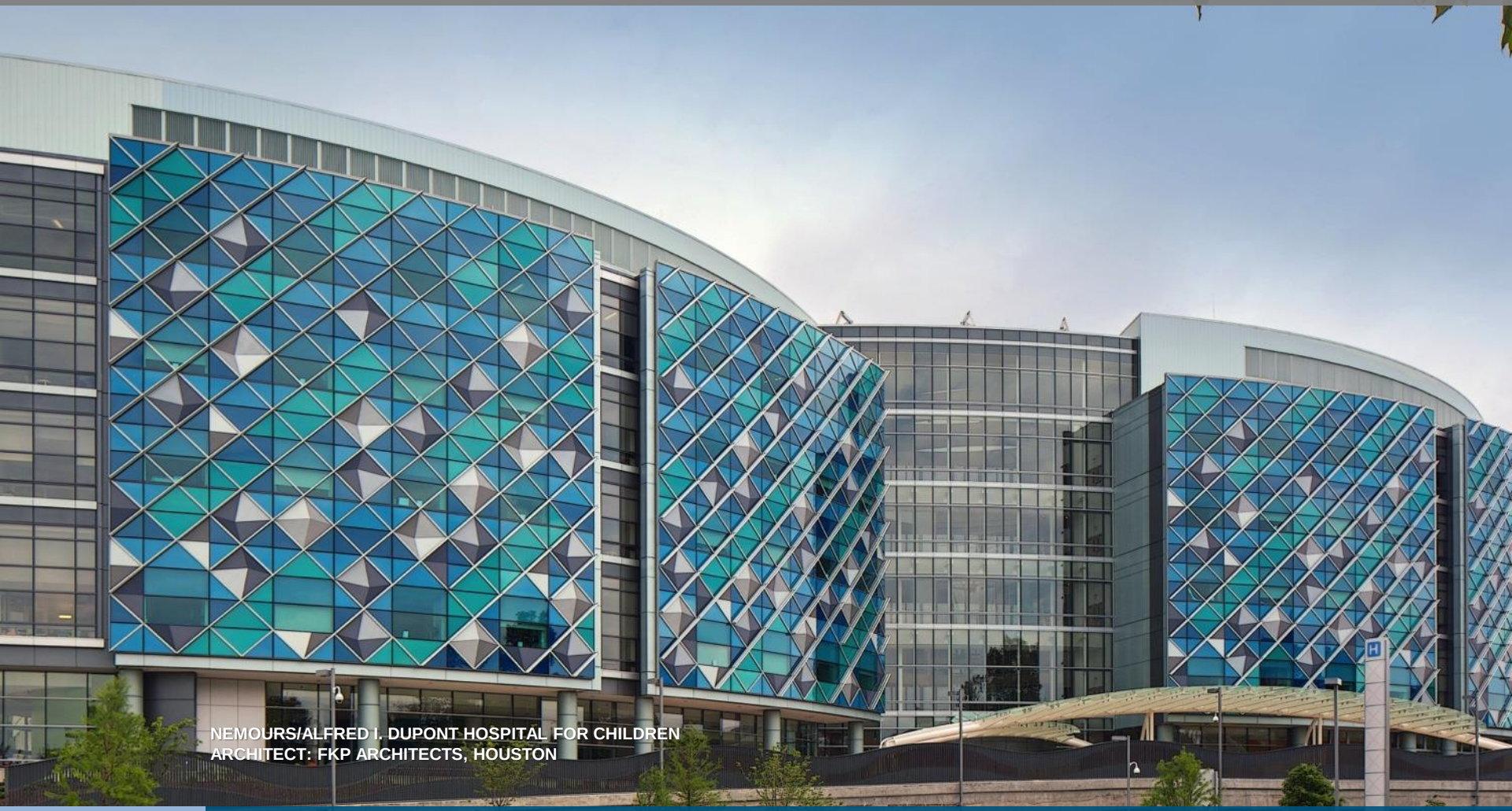
- For optimal performance, place the low-e coating on surface #5.
  - For additional insulating performance, the low-e coating can be moved to surface #4 and a second low-e coating engineered for “interior surface” can be added to surface #6.
- Marginally improve insulating performance by adding a second passive low-e coating to surface #3.

Triple-Pane IGU



Jumbo Glass

- Specify even larger expanses of low-e glass
- Most common sizes:
  - 130" x 204"
  - 130" x 236"
- Available on various substrates and at different thicknesses
- Considerations before specifying
  - Impact on fabrication-installation chain
  - Increased glass thickness to meet wind load requirements
  - Specialized processing equipment, such as tempering ovens, and special handling equipment to account for added weight and size
  - Not all fabricators have these capabilities



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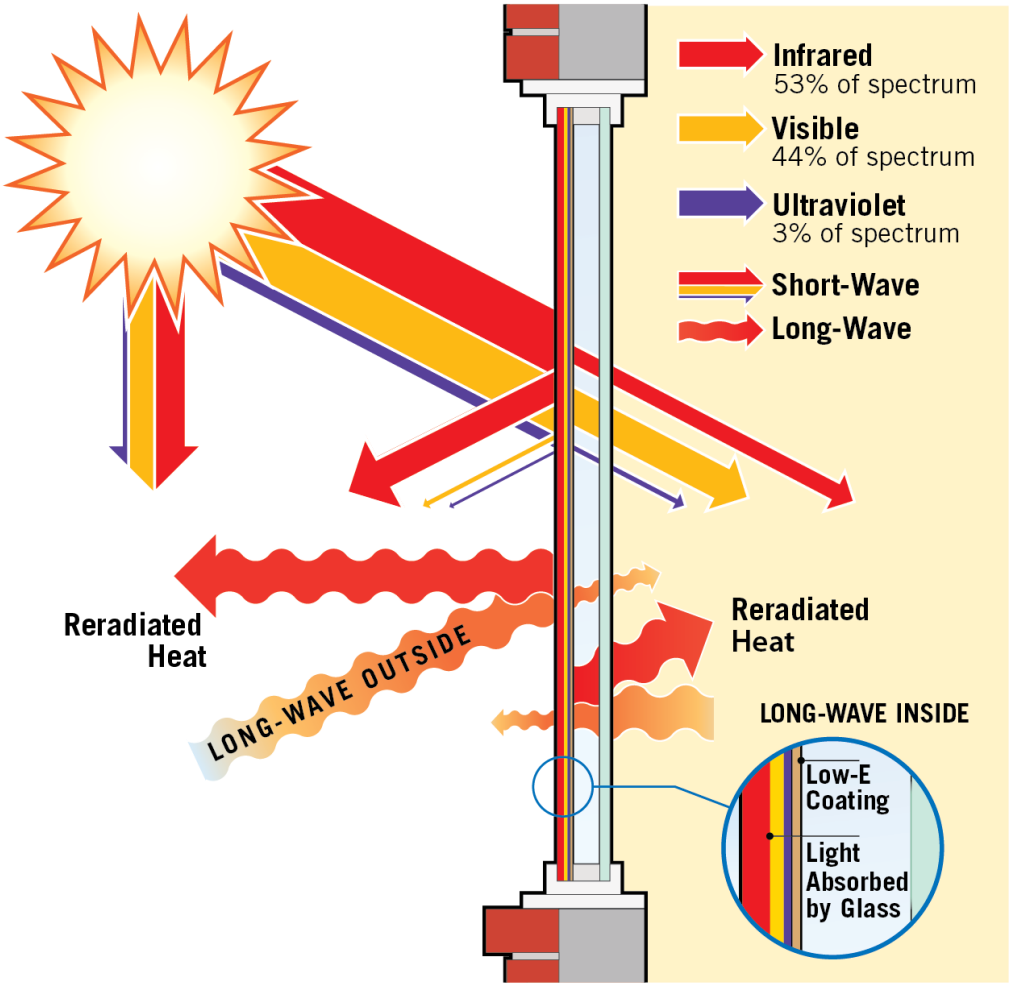
Definitions & Comparisons of Glass Performance Measures

Short-Wave and Long-Wave Energy



Important Measurements

There are four important measurements of glass performance. They are:

- Visible light transmittance (VLT)
- Solar heat gain coefficient (SHGC)
- Winter nighttime u-value
- Light to solar gain (LSG)

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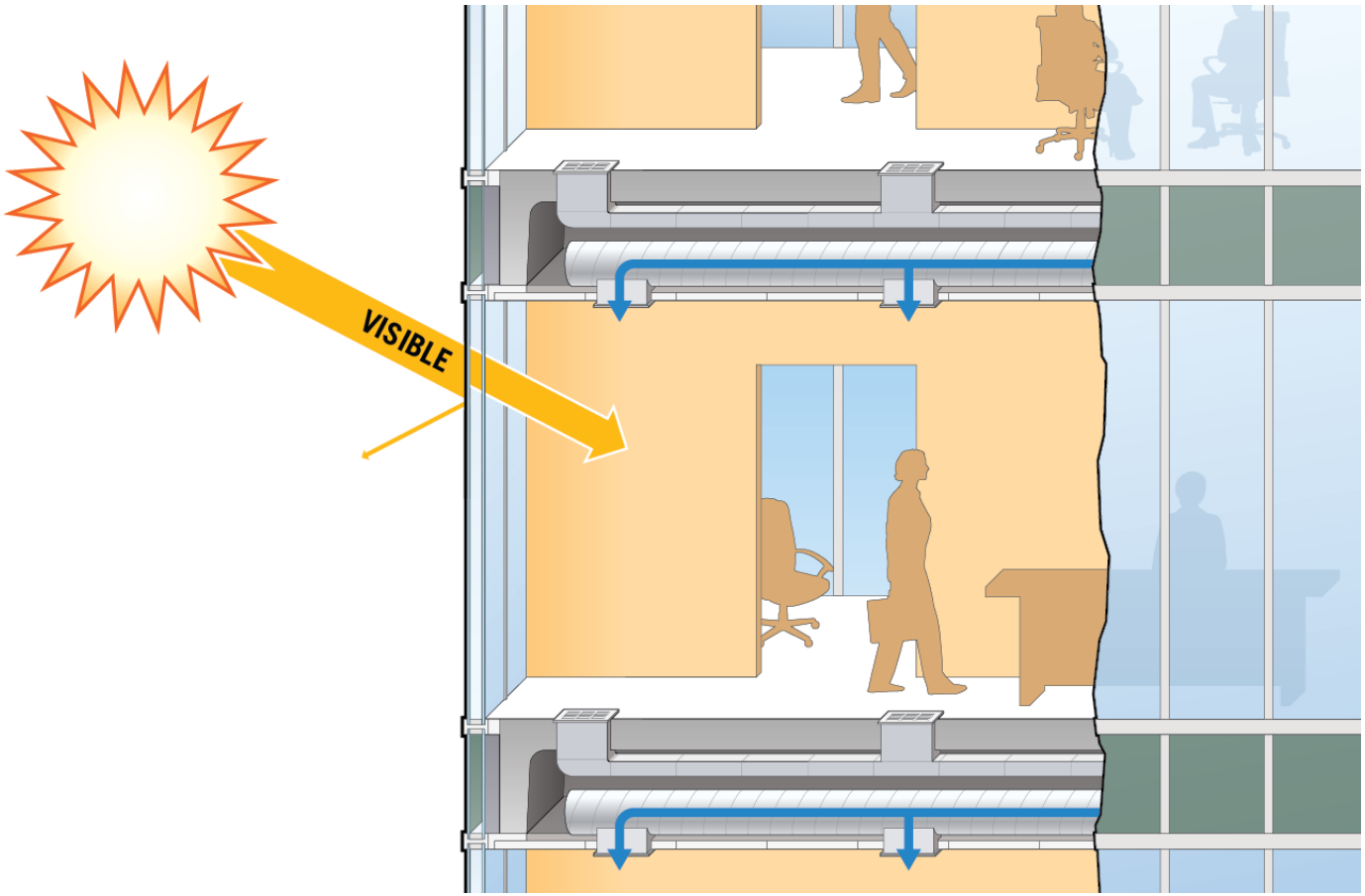
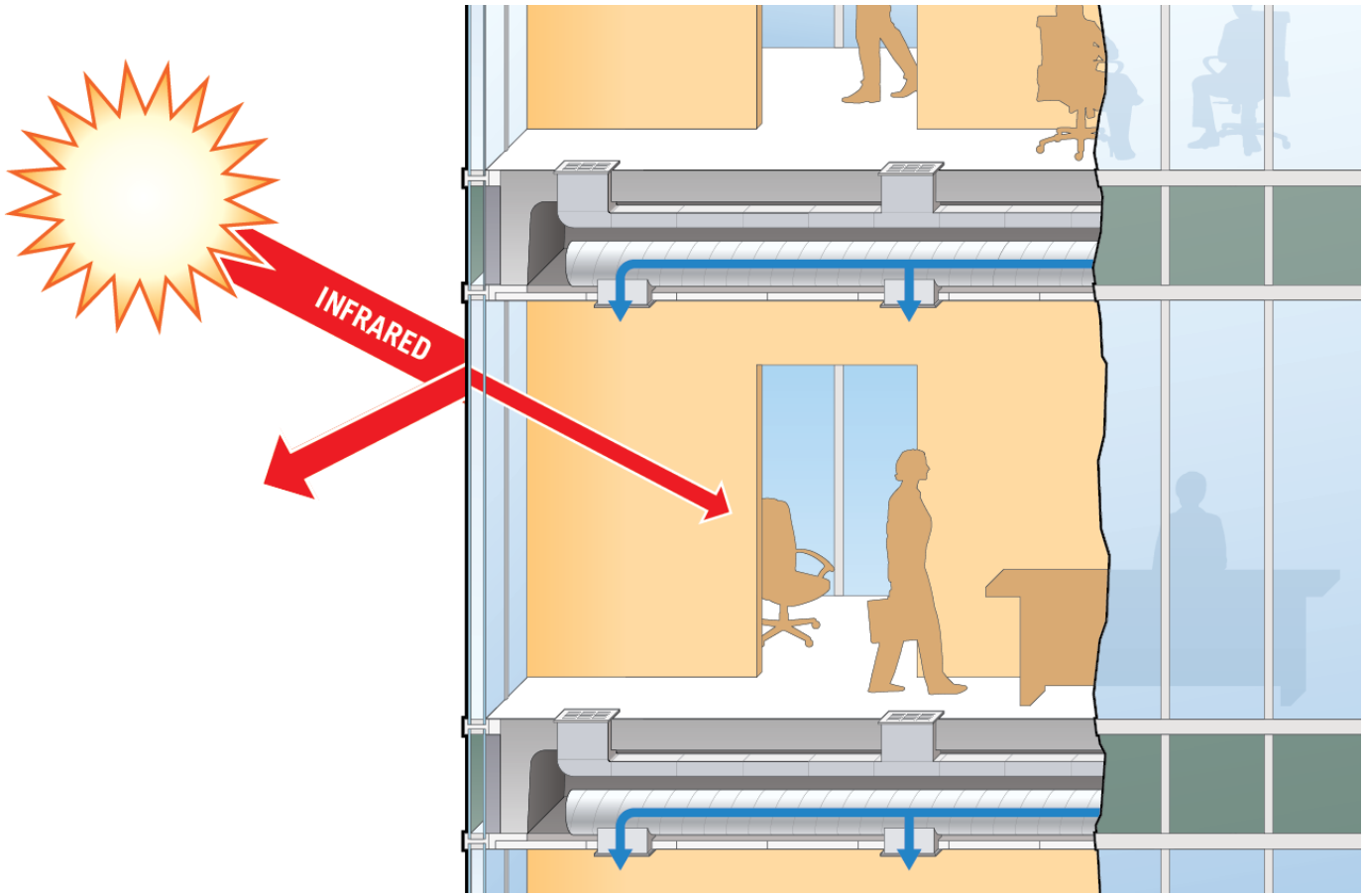
Coated Glass Terms

- **U-Value:** A measure of the insulating characteristics of the glass or how much heat loss it allows. U-values generally range from 0.2 (very little heat loss) to 1.2 (high heat loss).
- **Visible Light Transmittance (VLT):** A measure of how much light passes through a window. VLTs range from 0 (no light) to 1 (all light).
- **Solar Heat Gain Coefficient (SHGC):** Measures how well a window blocks the heat from sunlight. SHGC is the fraction of solar radiation transmitted through a window or skylight, as well as the amount that is absorbed by the glass and reradiated to the interior. SHGC is expressed as a decimal between 0 and 1. The lower a window's SHGC, the less solar heat it transmits and the greater its shading ability.
- **Light to Solar Gain (LSG):** Measures the ratio of visible light to solar heat gain (LSG = VLT ÷ SHGC).

Visible Light Transmittance (VLT)

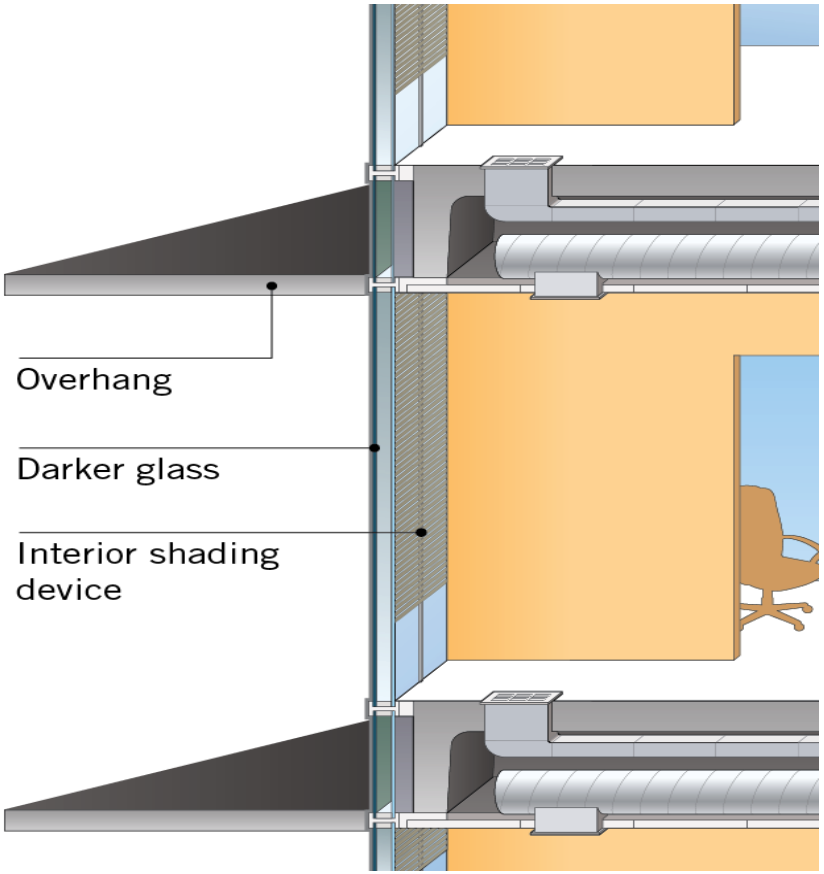


Solar Heat Gain Coefficient (SHGC)

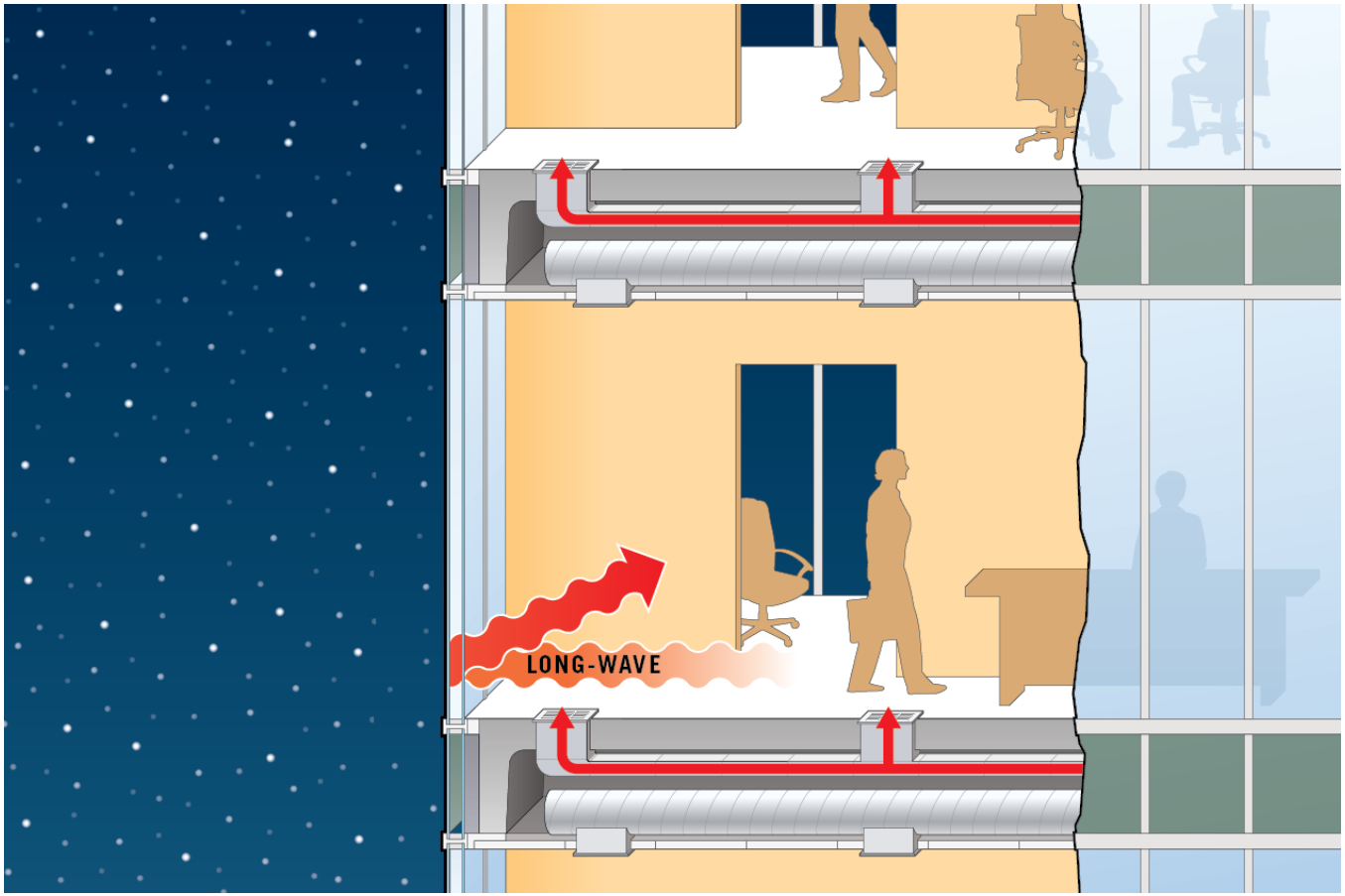


Additional Ways to Reduce Heat Gain

- Darker glass/multiple glass types
- Overhangs
- Interior shading devices
- Switchable technologies
- Ceramic frit
- White laminate



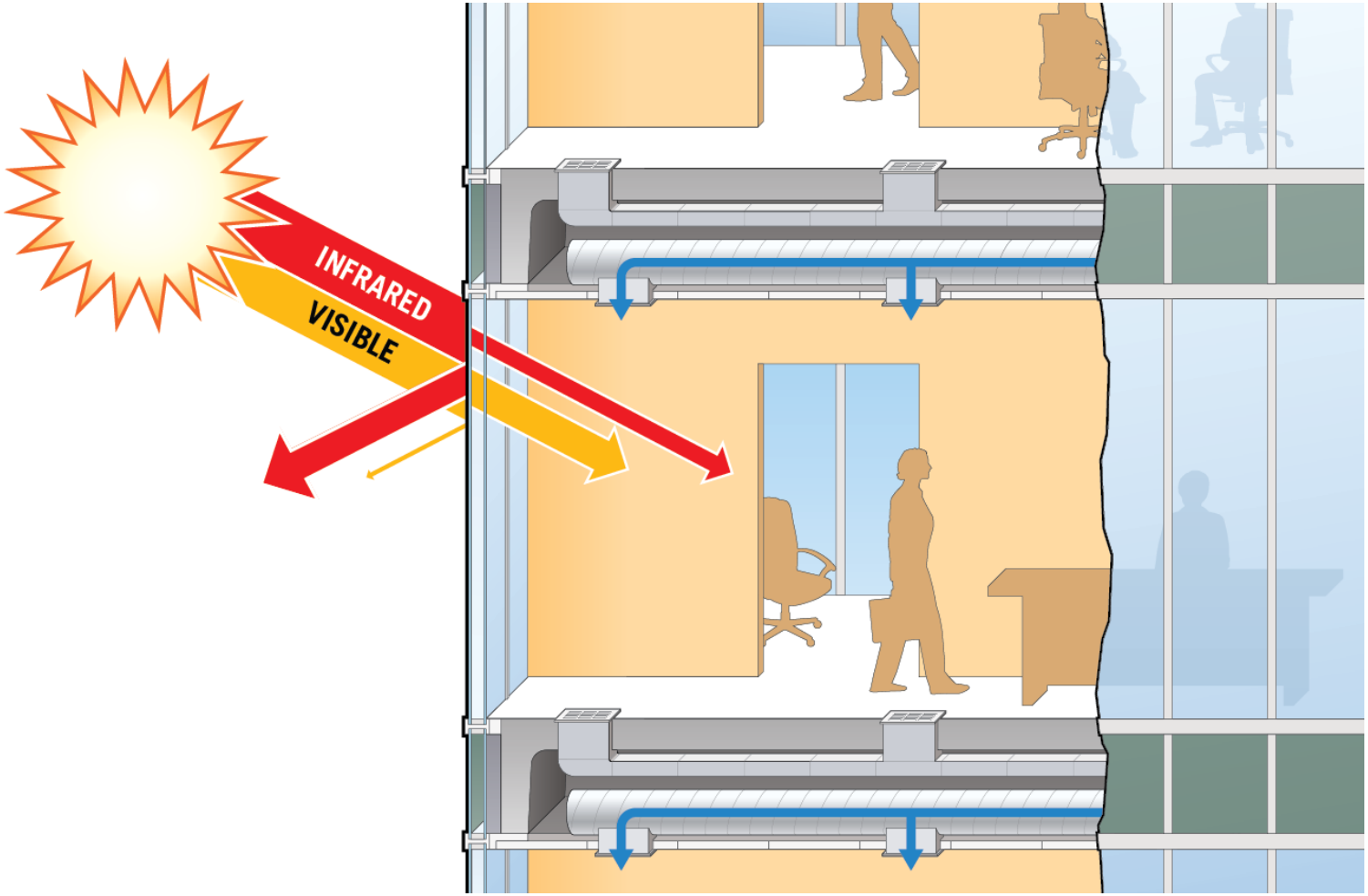
Winter Nighttime U-Value



Ways to Reduce U-Values & Improve Insulating Performance

- Utilize low-e coatings
- Use double-or triple-glazing
- Optimize gas cavity
- Use a noble gas (Argon or Krypton) fill
- Specify warm-edge spacers
- Apply low-e coatings within air cavity and to interior surfaces

Light to Solar Gain (LSG)



Benefits of Double- and Triple-Glazing

Double-glazing

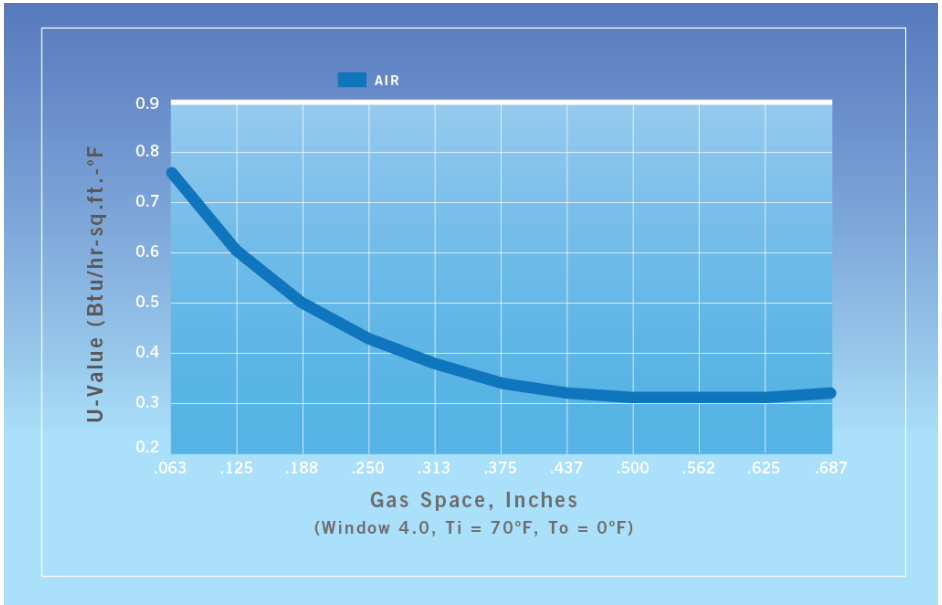
- Energy efficient
- Thermal insulation benefit

Triple-glazing

- More surfaces available for additional low-e coatings
- More energy efficient
- Thermal insulation benefit
- Acoustic performance

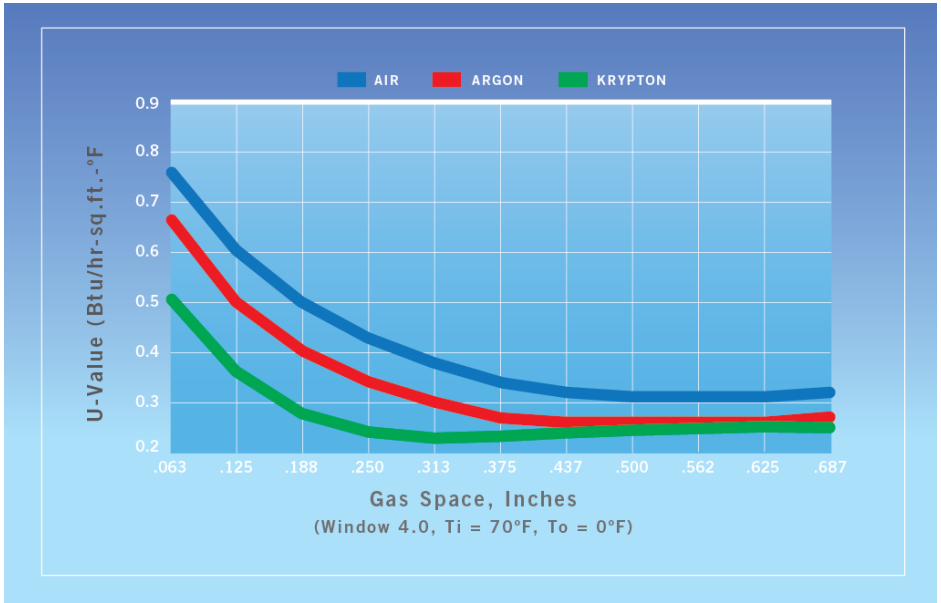
Optimizing Glass Cavity

- Insulating glass units, or IGUs, are designed to keep buildings warmer in the winter and cooler in the summer.
- ½" is the optimal cavity size for air-filled units.



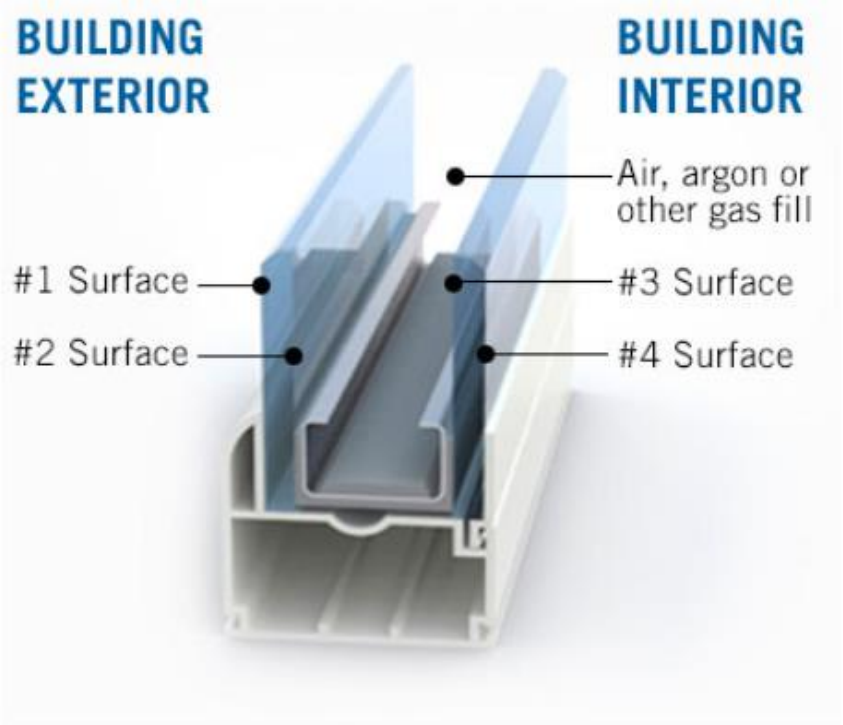
Using a Noble Gas (Argon or Krypton)

- Performance can be improved by filling the space between the two lites with a noble gas, such as argon or krypton.
- 90% argon gas-fill insulating value can be improved by up to 16%.
- Krypton can improve the insulating value in a low-e IGU by up to 27%.



Specifying Warm-Edge Spacers

- Create an effective thermal barrier at the edge of the IGU to help reduce heat loss.
- Can strengthen the glazing system better retain insulating gases.

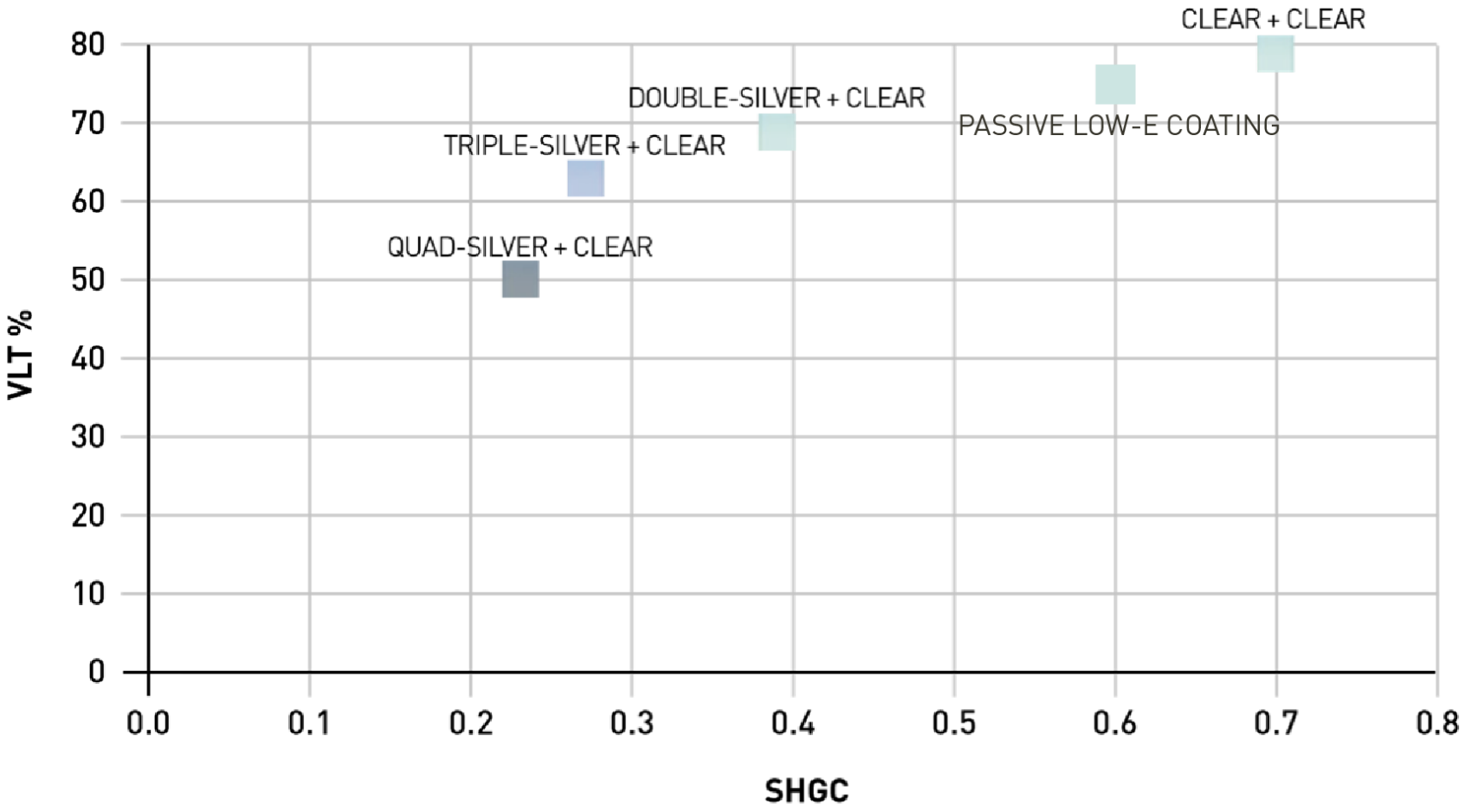


Key Glass Performance Measures (in 1-inch IGU + Clear Glass)

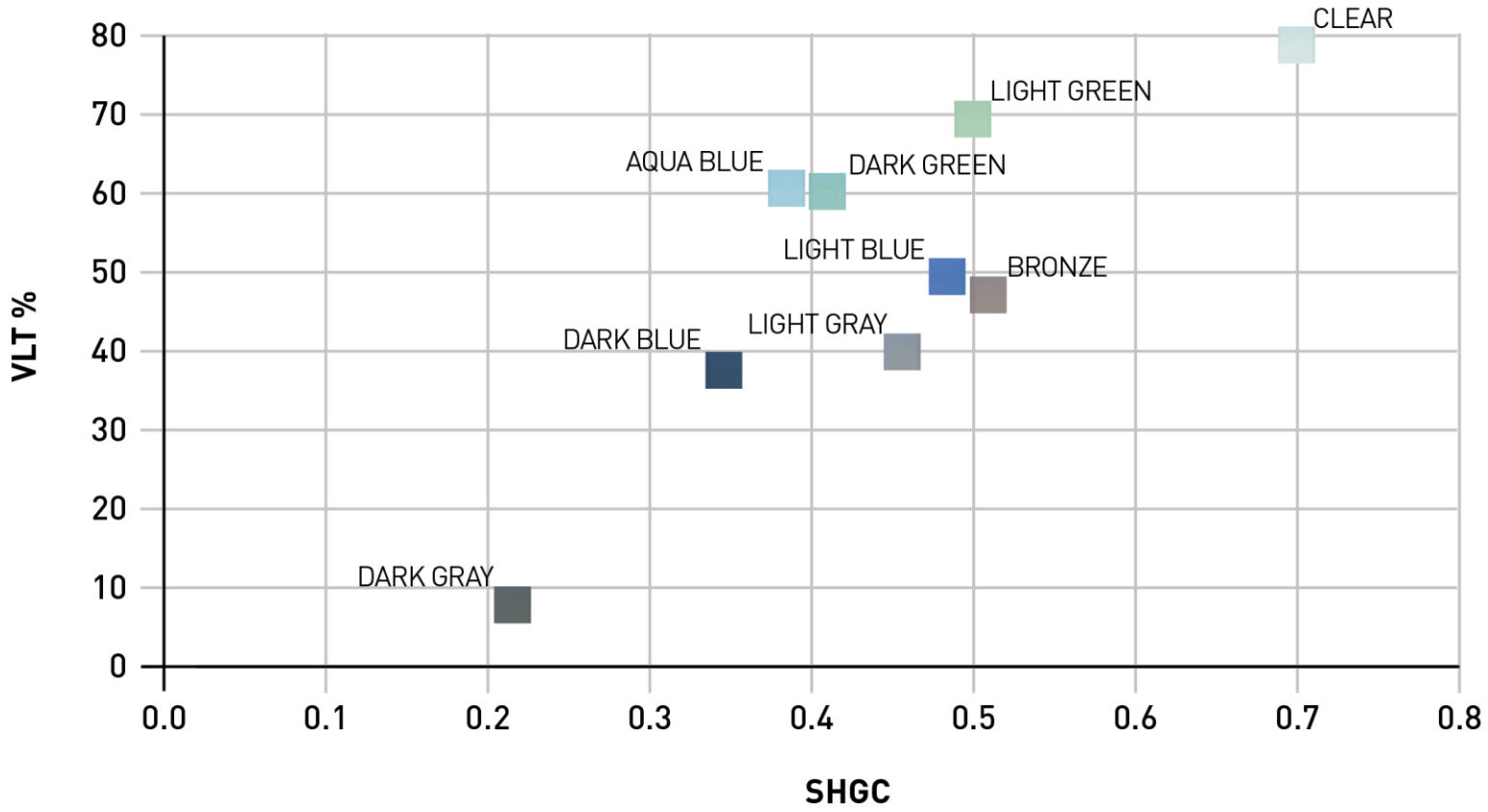
Low-e, ½" airspace, ¼" clear	U-Value	VLT	SHGC
Clear (Uncoated)	0.47	79%	0.70
Passive Low-E	0.32	76%	0.60
Double-Silver Solar Control Low-E (High VLT/Low Reflectance)	0.29	70%	0.39
Triple-Silver Solar Control Low-E (High VLT/Low Reflectance)	0.28	64%	0.27
Quad-Silver Solar Control Low-E (High VLT/Low Reflectance)	0.29	51%	0.23

**Specific manufacturers' values may vary slightly*

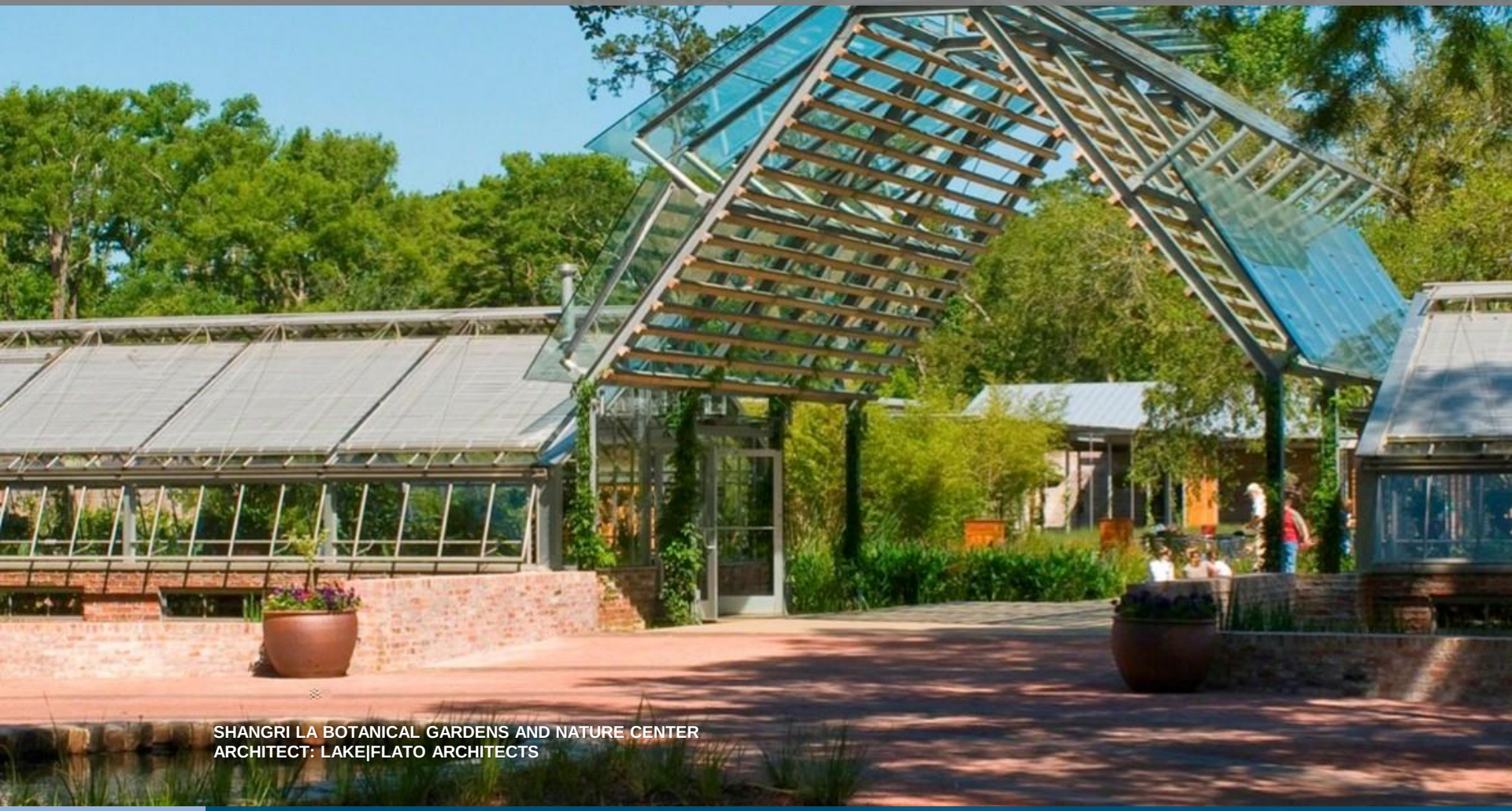
Tradeoffs Between VLT and SHGC for Coated Glass



Tradeoffs Between VLT and SHGC for Tinted Glass



Data based on a 1-inch IGU of tinted glass + clear.



SHANGRI LA BOTANICAL GARDENS AND NATURE CENTER
ARCHITECT: LAKE|FLATO ARCHITECTS

How Low-E Coatings Improve Energy Efficiency

Energy and Environmental Performance for Glazing

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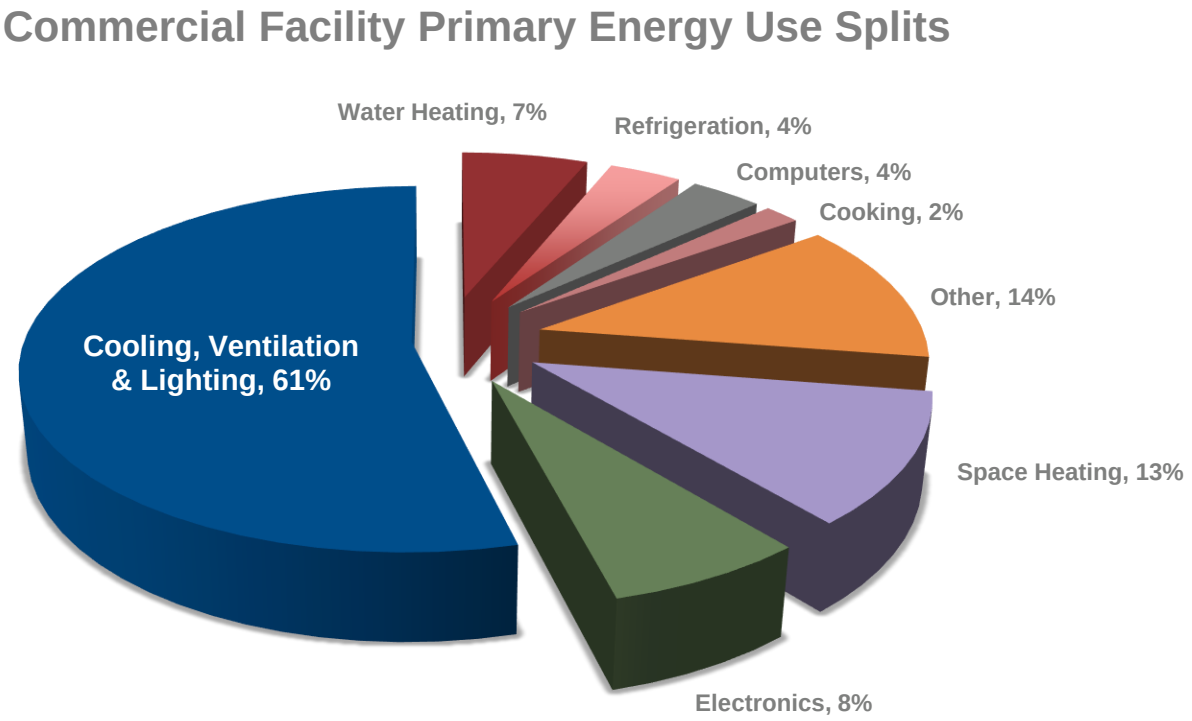
**Specific manufacturers' values may vary slightly*

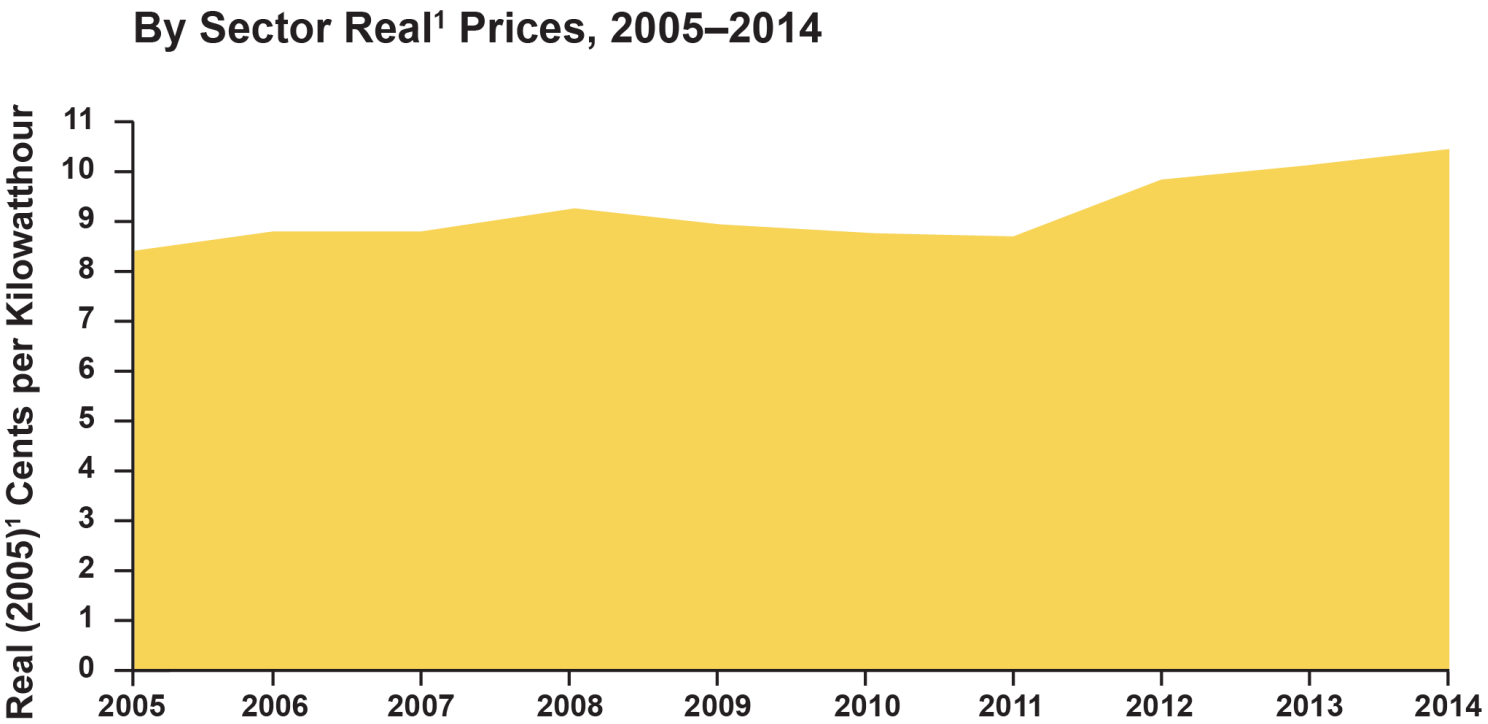
HVAC, Ventilation and Artificial Lighting

- **61%** of a building's energy use
- **Higher-performing** low-e glasses quickly recoup upfront investment



U.S. DOE, Office of Energy Efficiency and Renewable Energy (2012) 2011 Buildings Energy Data Book.

Commercial Electricity Prices



http://www.eia.gov/electricity/annual/html/epa_02_04.html

Source: U.S. Energy Information Administration,
Annual Energy Review 2015

Potential Impact of Energy-Efficient Glazing

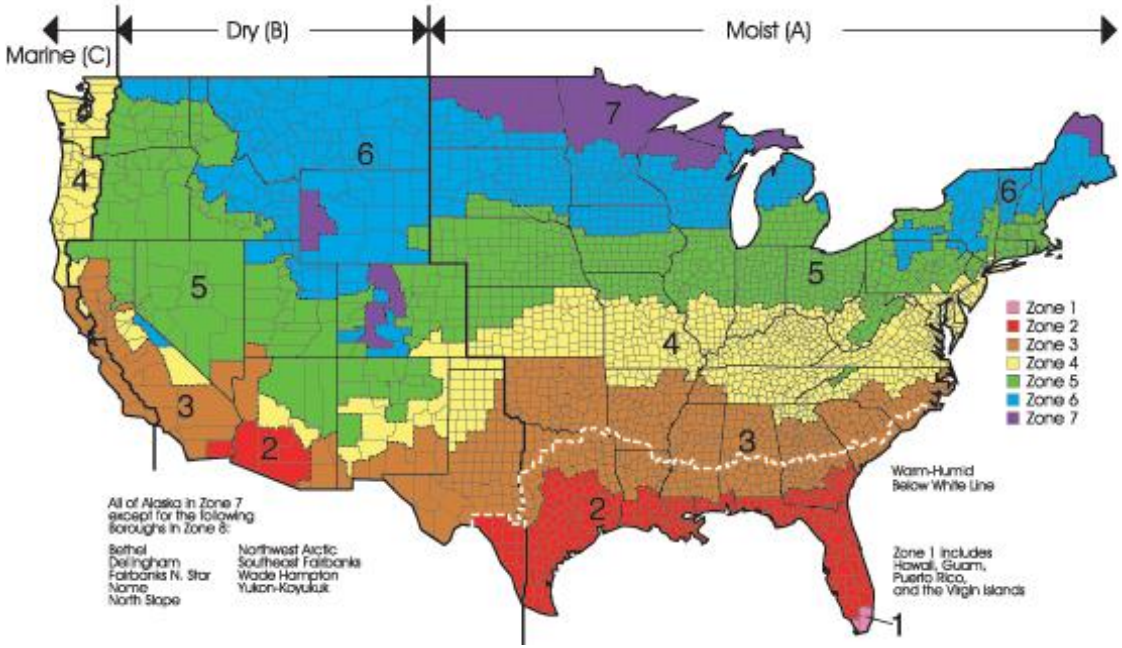
- Most buildings in the country are not clad with the most efficient glass available.
- Commercial buildings consumed 19% of all energy in the U.S. in 2012.[1]
- There are approximately 5.6 million commercial buildings comprising 87 billion square feet of built environment in the U.S.[2]
- By 2035 that figure is expected to climb to 103 billion square feet.[3]
- If this new development incorporates the most efficient glass technology available, significant upfront and long-term savings will result.

[1] U.S. DOE, Energy Information Administration (EIA) (2012) Annual Energy Review 2015. [2] EIA (2016) 2012 Commercial Buildings Energy Consumption Survey. [3] EIA (2012) Annual Energy Outlook 2012.

MCGILL UNIVERSITY, SCHULICH SCHOOL OF MUSIC
ARCHITECT: MENKÈS SHOONER DAGENAIS LETOURNEUX; SAUCIER + PERROTTE ARCHITECTES

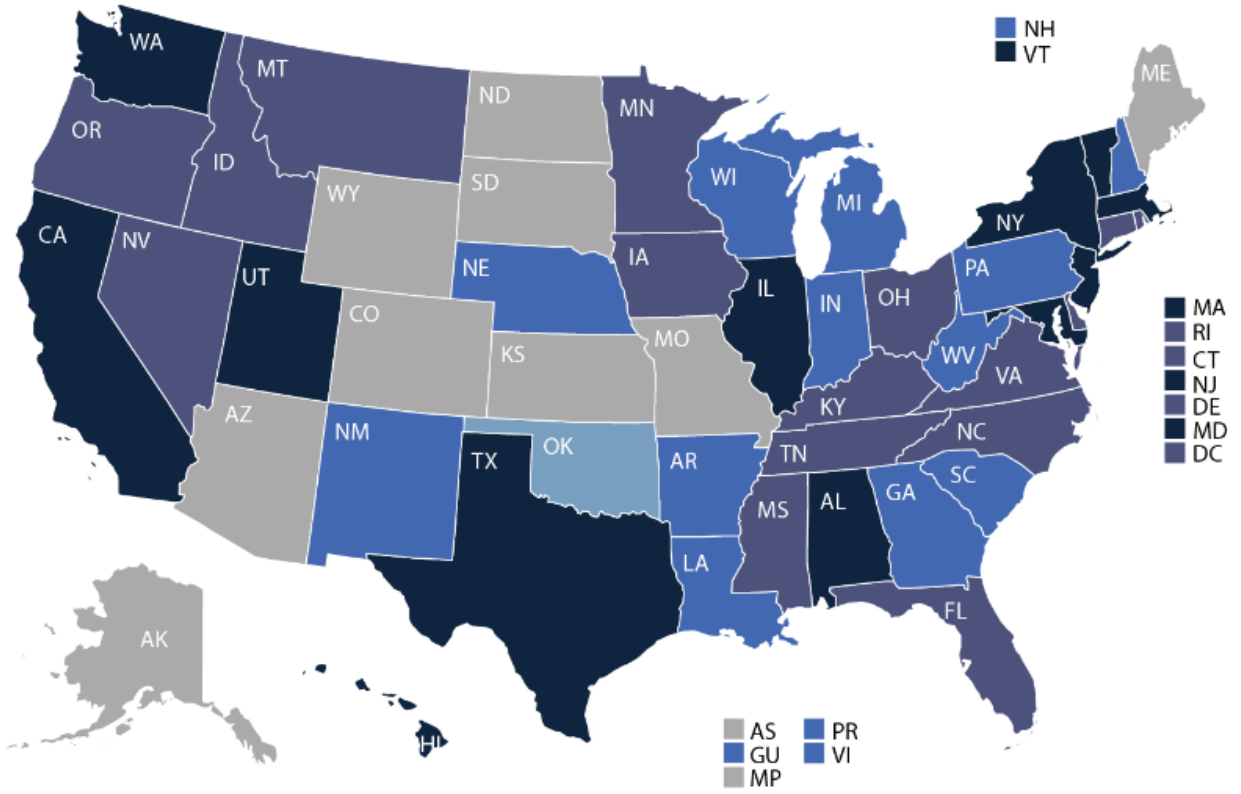
IECC®: Mapping Performance Needs

- IECC® prescribes energy performance requirements.
- Eight U.S. regions with patterns of annual heating/cooling demands.
- Glass and window products can be specified based upon their “fit” for the region in which they will be installed.

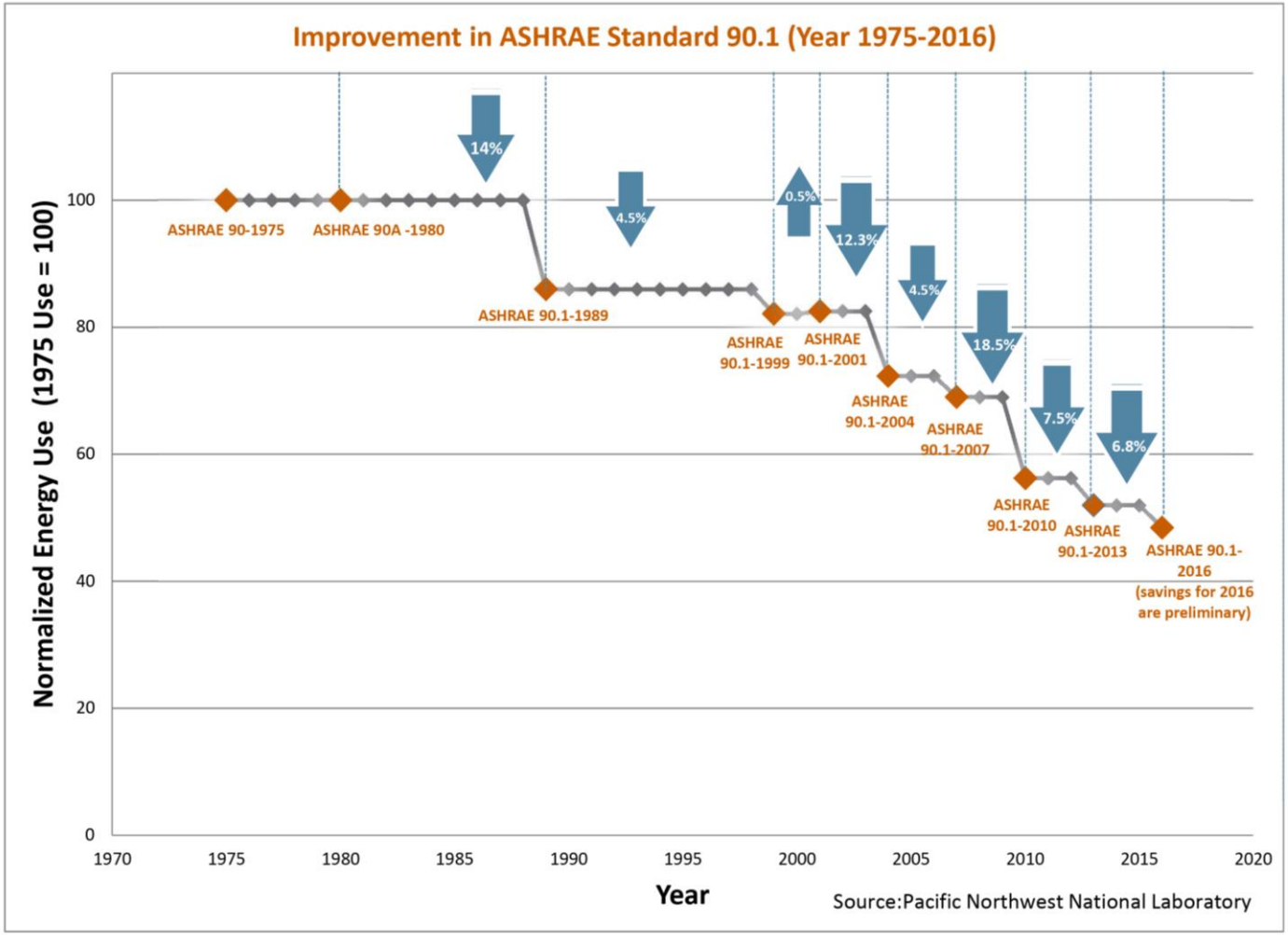


Commercial Energy Code Status

As of November 2017



Increasing Stringency – ASHRAE 90.1



Increased Stringency for Windows

U-factor has seen steady decrease. Example in zone 5 (Chicago):

- For ASHRAE 90.1, 7%-9% reduction from 2010 to 2013 and then another 8%-10% reduction from 2013 to 2016.
- IECC made the jump all at once – 16%-18% reduction from 2009 to 2012, then stayed same for 2015.

SHGC has been more stable. From 2007-2016:

- 0.25 in south, higher in central and northern zones (0.36 to 0.45).
- Credit given for exterior shading from overhangs, sun shades.
- 90.1 includes additional requirements encouraging proper building orientation, and lower SHGC or shading on west and east.

IMPORTANT: Code requirements are for the whole assembly including both the framing and glazing, not just center-of-glass only. Must be based upon NFRC technical procedures, but does not have to be full NFRC certification, except in certain locations, such as California and Seattle.

Energy and Environmental Performance

- The U.S. Green Building Council
  - Promote energy efficiency and sustainable design
  - LEED® (Leadership in Energy and Environmental Design) program
  - LEED ® credits influenced by glass selection:
    - Energy and Atmosphere (Energy Savings) – 18 points available
- Cradle to Cradle Certification, MBDC
- Environmental Product Declarations (EPD)

LEED ® Overview

- Established by the USGBC in 1998
- Premier benchmark for sustainable design
- New construction after Nov. 1, 2016 requires LEED ® v4
  - Older projects may be “grandfathered” to previous versions
- Must collect at least 40 points for minimum level of LEED®

Certified	Silver	Gold	Platinum
			
40-49 points	50-59 points	60-79 points	80+ points

LEED® Credit Categories Where Glass Can Contribute

- Points can be earned across numerous credit categories:
  - Integrative Process – 1 point
  - Sustainable Sites – 2 points
  - Material & Resources – 2 points
    - Building Product Disclosure & Optimization – 1 point
  - Indoor Environmental Quality – 1 point
  - Innovation – 6 points
  - **Energy & Atmosphere – 18 points available**

Energy & Atmosphere (EA)

Credit: Optimize Energy Performance

- 18 points available
- **Intent:** To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic impacts associated with excessive energy use.
- **Applicable Requirements:**
  - *Whole Building Energy Simulation* (Option 1) – 18 points available
  - *Prescriptive compliance: ASHRAE Advanced Energy Design Guide* (Option 2) – 1 point available

BUILDING: BAKERY SQUARE
ARCHITECT: ASTORINO

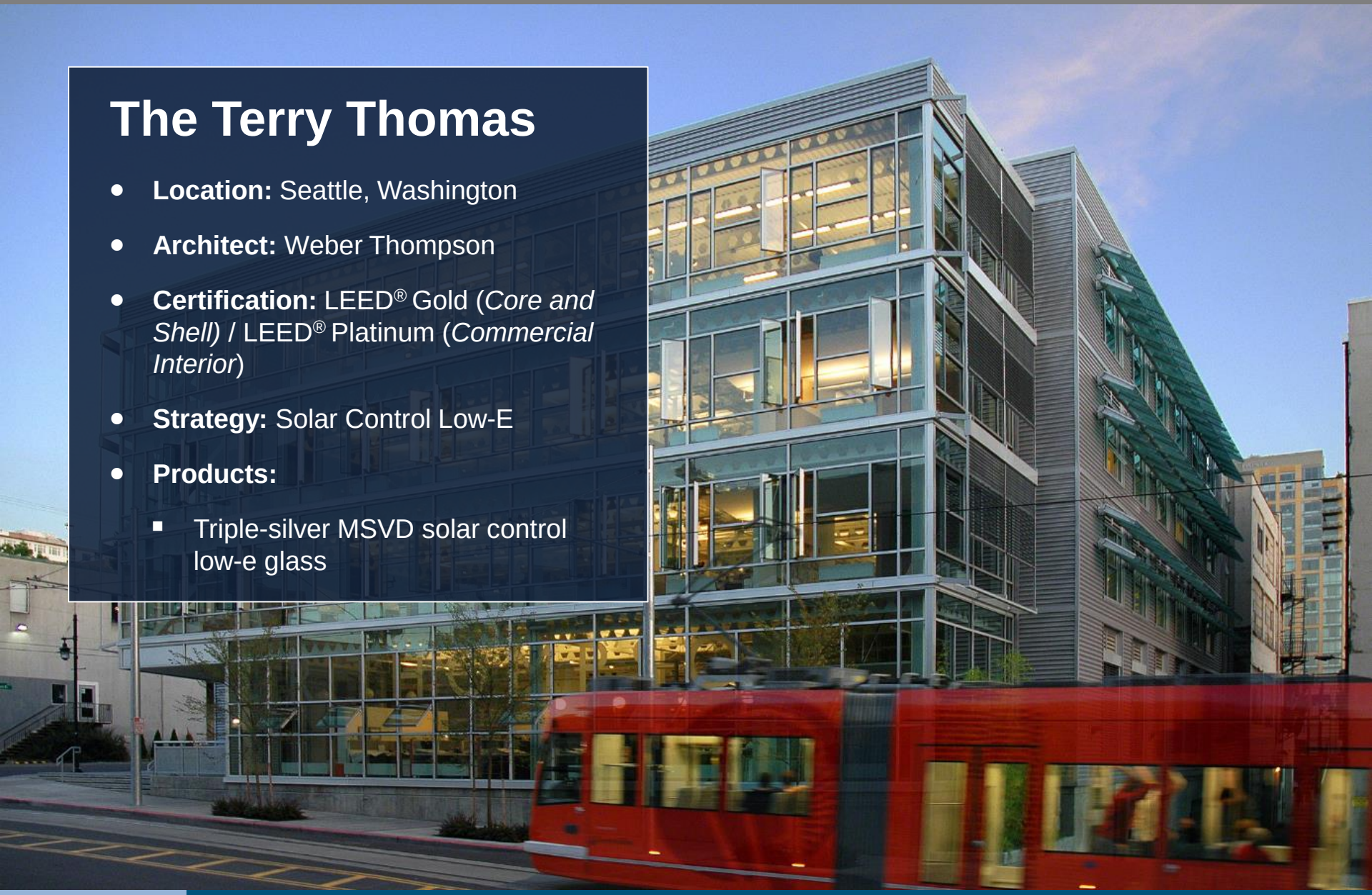
Low-E Glass Case Studies

Nemours/duPont Hospital for Children

- **Location:** Wilmington, Delaware
- **Architect:** FKP Architects
- **Certification:** LEED® Silver
- **Strategy:** Solar Control Low-E
- **Products:**
  - Double-silver MSVD solar control low-e glass with aqua-blue tint
  - Triple-silver MSVD solar control low-e glass

The Tower at PNC Plaza

- **Location:** Pittsburgh, Pennsylvania
- **Architect:** Gensler
- **Certification:** LEED® Platinum
- **Strategy:** Double-wall design with passive low-e glass
- **Products:**
  - MSVD passive low-e on low-iron glass



The Terry Thomas

- **Location:** Seattle, Washington
- **Architect:** Weber Thompson
- **Certification:** LEED® Gold (*Core and Shell)* / LEED® Platinum (*Commercial Interior*)
- **Strategy:** Solar Control Low-E
- **Products:**
  - Triple-silver MSVD solar control low-e glass

This concludes the continuing education portion of the course.

Here is a quick review of the learning objectives we discussed today:

- The solar energy spectrum and common glass performance measures
- The manufacturing processes for pyrolytic and magnetron sputter vacuum deposition (MSVD) low-e coatings
- How passive and solar control low-e coatings differ and impact glass performance measures
- Commercial energy usage and how low-e coatings can improve energy efficiency and achieve LEED® credits

Thank You

For more information visit **vitroglazings.com**
or call **1.855.887.6457** (1.855.VTRO.GLS)

Vitro Architectural Glass
Formerly PPG Glass

Vitro Architectural Glass is an industry leader in manufacturing architectural glass and was the first to introduce triple-silver MSVD solar-control Low-E glass.
For more information on the study and its results you can contact Vitro by visiting vitroglazings.com, or by calling 1-855-VTRO-GLS (887-6457).