
Optimizing Performance
in Commercial Fenestration
AZON

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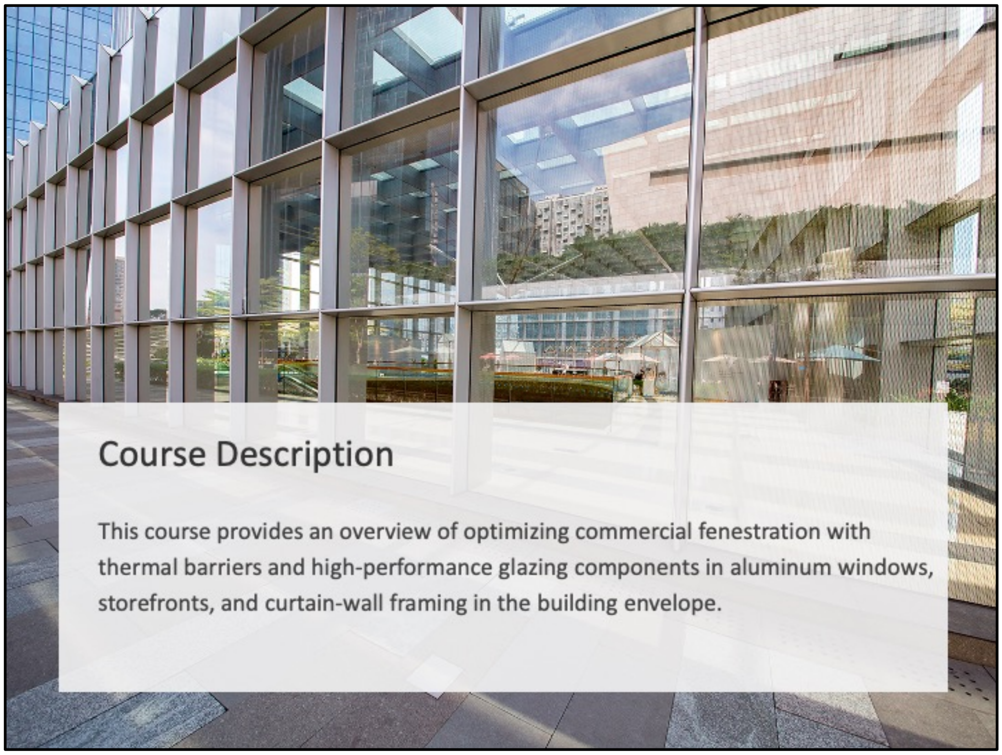

Course Description
This course provides an overview of optimizing commercial fenestration with thermal barriers and high-performance glazing components in aluminum windows, storefronts, and curtain-wall framing in the building envelope.

Learning Objectives

After completing this course, you should be able to:

1. Discuss energy efficiency in commercial buildings and initiatives to reduce energy consumption to save costs while also supporting occupant health.

2. Investigate performance-, health-, and comfort-related topics in aluminum fenestration systems, including material sustainability, thermal and structural performance, noise abatement, and condensation resistance.

3. Evaluate the performance of aluminum window, storefront, and curtain-wall fenestration systems in the building envelope through the application of structural thermal barriers and high-performance glazing.

4. Analyze a range of fenestration product types, measured performance outcomes, energy savings, and LEED and Passive House contribution through observing multiple case studies.

Fenestration Energy Efficiency and Its Terminology

Performance in Fenestration Systems

- Government, nongovernmental organizations (NGOs), policymakers
- Mega-trends: green awareness, sustainability, carbon footprints, zero-net energy (ZNE), Title 24
- EPA, DOE, USGBC, ASHRAE, NFRC, IECC, LCA

Before LEED and other specialty green certification and rating programs, there was no universal method of measuring construction practices and material impacts, so there were no social, environmental, and energy use standards. There was not yet any way to accurately or completely describe community benefits and sustainability impacts using a number.

Governments and nongovernmental organizations throughout the world are looking for more ways to be sustainable, resilient, and promote environmental conservation. Modern buildings are designed to reduce the overall impact of the built environment on human health and the natural environment.

Traditionally constructed buildings account for a large amount of energy consumption through the use of fossil fuels and 24 percent of global carbon dioxide emissions.

Performance in Fenestration Systems

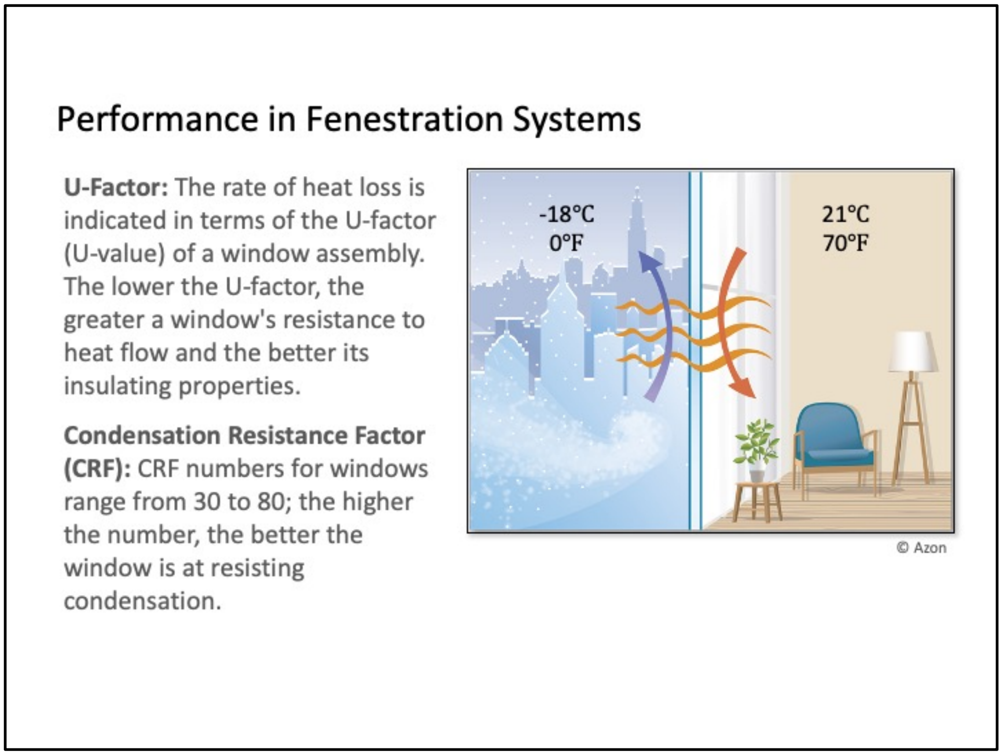
- **Fenestration** (**architecture**) refers to the design, construction, or presence of openings in a building.
- **Fenestration** includes windows, doors, louvres, vents, wall panels, skylights, storefronts, curtain walls, and slope glazed systems.

Photo:
Sangren Hall
Western Michigan University
Kalamazoo, Michigan
LEED BD+C: New Construction v3 – LEED 2009

Sangren Hall is a LEED Gold, 230,000-square-foot facility completed in 2012 that contains the College of Education and Human Development and the Department of Sociology, located in the heart of the Western Michigan University campus.

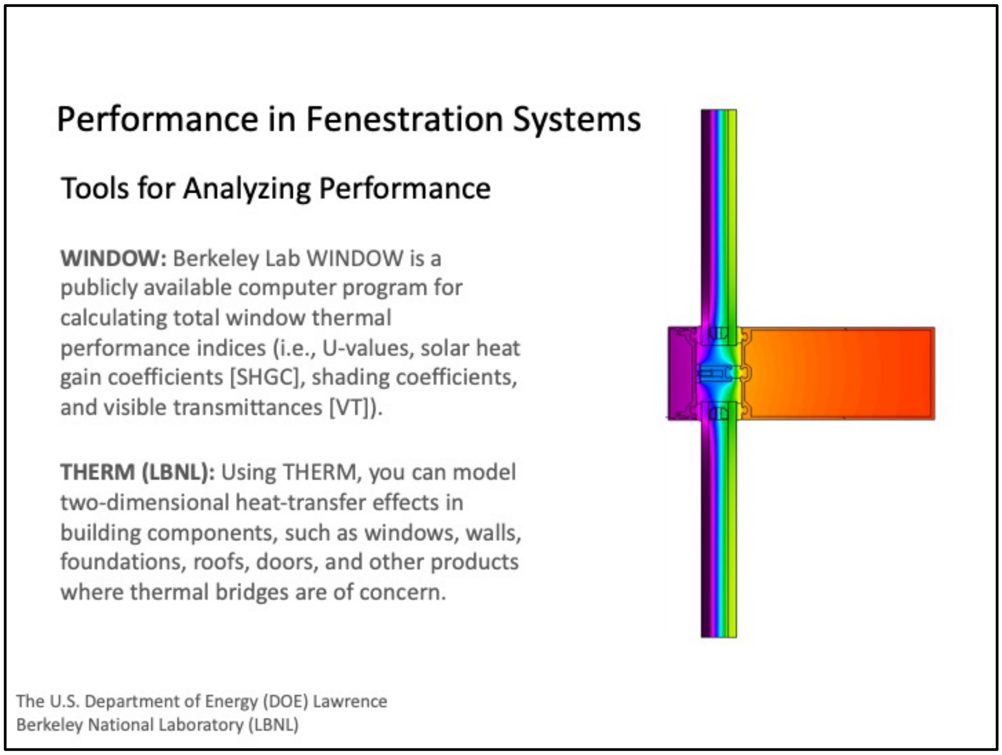
The large windows allow daylight to penetrate into the interior office spaces on every floor of the university building, saving electricity and providing a pleasant atmosphere for occupants.

Daylight must be properly integrated with the electric lighting system for its energy-savings potential to be realized. Sangren Hall employs occupant sensors to detect when a room is not being used, turning off lights or making adjustments to further reduce electricity use. This photo shows the exterior curtain wall that permits daylight to penetrate the space, allowing sufficient natural light to illuminate the interior during the peak hours that the school will be occupied.



U-factor measures the rate of heat transfer and tells you how well the window insulates. U-factor values are measured in Btu/h·ft²·°F. The lower the U-factor, the better the window insulates.

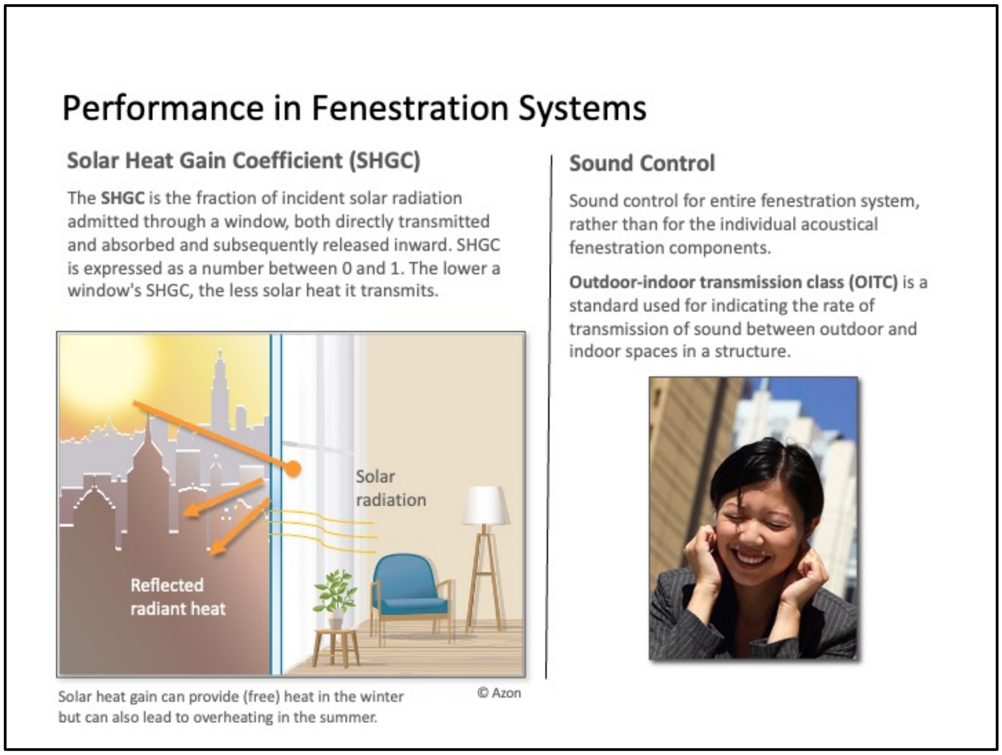
Condensation resistance factor (CRF) measures how well the window resists water buildup. CRF is scored on a scale from 0 to 100. The higher the CRF, the less build up the window allows.



The two most common software tools used to simulate fenestration products in North America are WINDOW and THERM.

WINDOW allows the simulator to create the glazing system(s) that the fenestration product could incorporate. The glazing systems and unique attributes are then imported into THERM, where the framing system is created and the material properties are assigned. Once all of the framing profiles are simulated (jamb, sill, head, meeting rail, etc.), the THERM file is transferred back to WINDOW, where the entire fenestration assembly is modeled and the total performance of the that product is calculated. The results include U-factor, solar heat gain coefficient (SHGC), visible transmittance (VT), and condensation resistance (CR).

Modeling and simulating software allows designers to see how changes in the profile design, thermal barrier material, and glazing options impact the overall performance of the fenestration system.

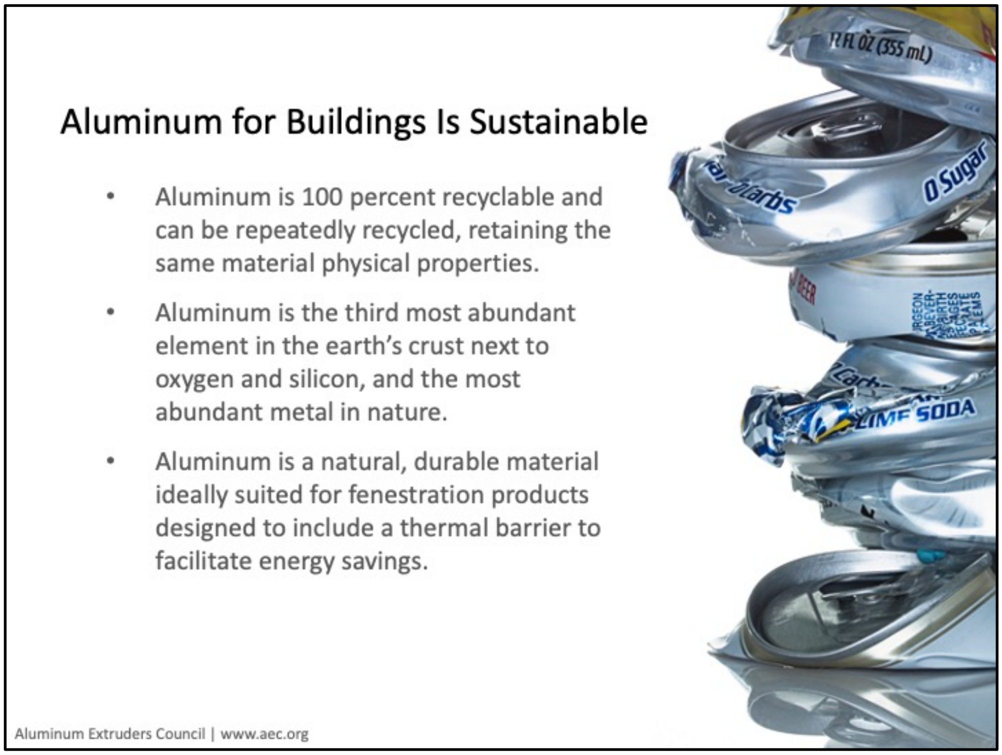


Solar heat gain coefficient (SHGC) measures how well an opening blocks heat from sunlight. The SHGC is the fraction of the heat from the sun that enters through a window expressed as a number between 0 and 1. The lower the SHGC number, the less solar heat is transmitted.

Building codes, along with building owners and architects, are now specifying sound control for the entire fenestration system, rather than for the individual acoustical fenestration components.

Outdoor–indoor transmission class (OITC) is a standard used for indicating the rate of transmission of sound between outdoor and indoor spaces in a structure. Based on the ASTM E-1332: Standard Classification for the Determination of Outdoor-Indoor Transmission Class, OITC utilizes a source noise spectrum that considers frequencies down to 80 Hz (aircraft/rail/truck traffic) and is weighted more to lower frequencies.

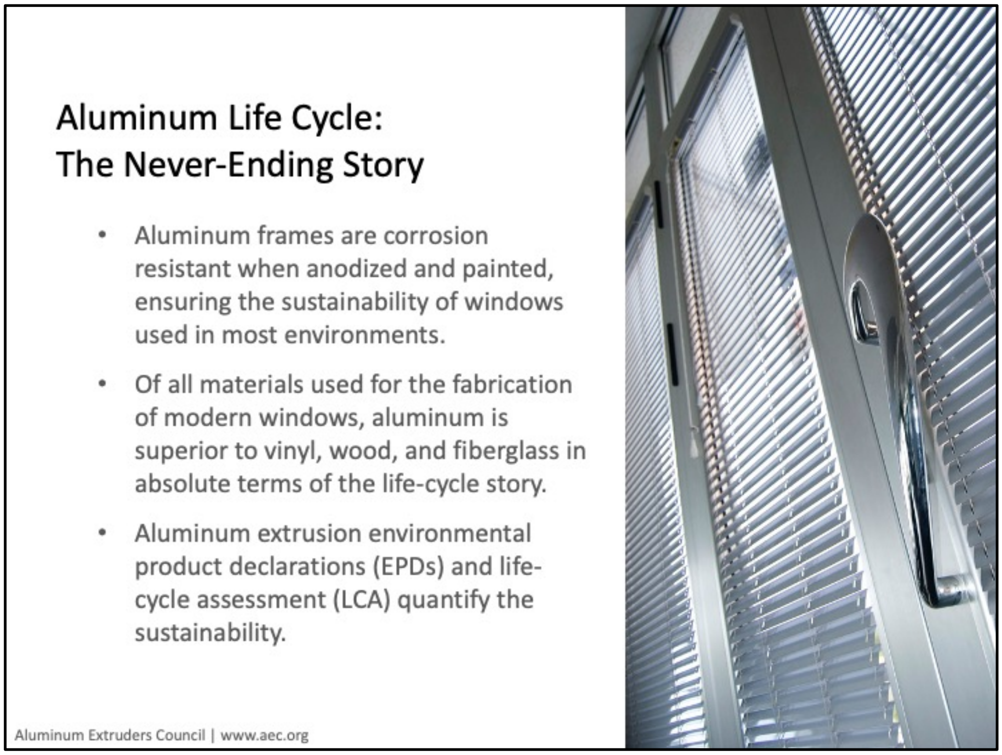
Commercial Fenestration and Its Efficiency and Sustainability Possibilities



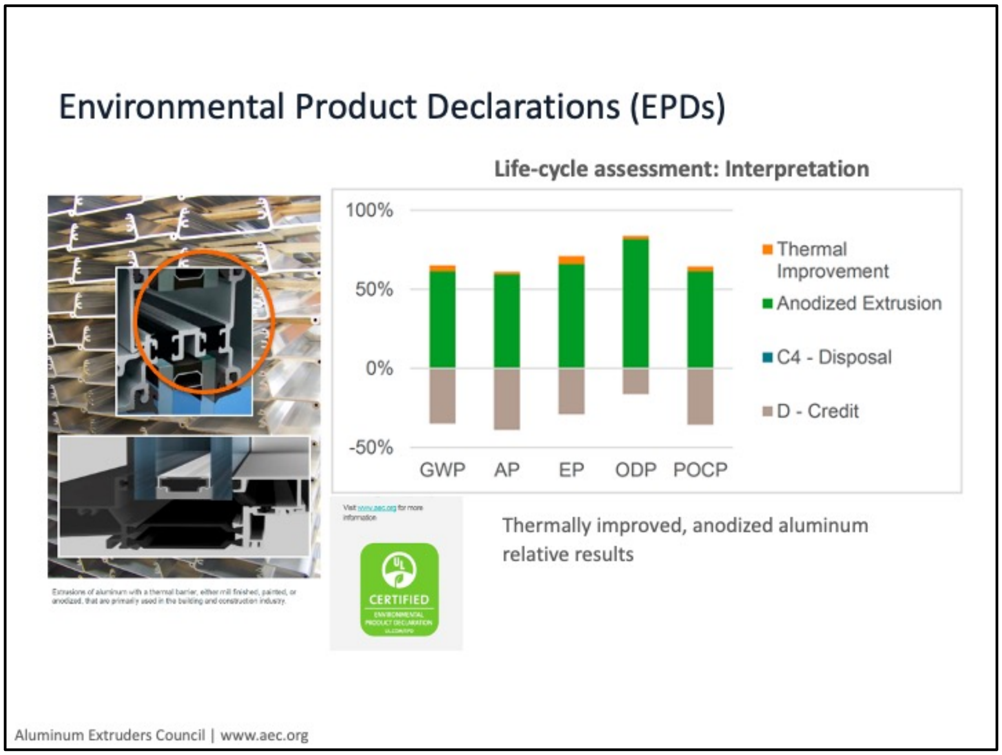
Everything manufactured comes from something that was mined from the earth or grown from its soil. As long as industry demands energy, chemicals, and metals, environmental factors are in question.

Why is aluminum for buildings sustainable?

- Aluminum is a noncombustible and natural material.
- It is the third most abundant element in the earth's crust next to oxygen and silicon, and the most abundant metal in nature.
- Aluminum is environmentally friendly and nontoxic, including at high temperatures.



- Of all the aluminum ever produced, 73 percent is still in use today.
- Annual benefits of aluminum recycling:
  - Approximately 7.5 million tons of solid waste is avoided.
  - About 27 million tons of CO2 equivalent of greenhouse gas emissions is avoided—equivalent to eliminating five large (1,000 MW) coal-fired power plants.



UL Environment was the program operator and verifier of the EPD for thermally improved aluminum extrusion products on behalf of the Aluminum Extruders Council. The results represent the cradle-to-gate and end-of-life environmental performance of thermally improved aluminum extrusions with the three finishing options: mill finished, painted, and anodized, as shown in the EPD.

GWP: Global warming potential

ODP: Ozone-depletion potential; depletion potential of the stratospheric ozone layer

AP: Acidification potential of land and water

EP: Eutrophication potential; form the Greek word “well-nourished,” excessive richness of nutrients in a lake or other body of water, frequently due to runoff from the land, which causes a dense growth of plant life and death of animal life from lack of oxygen

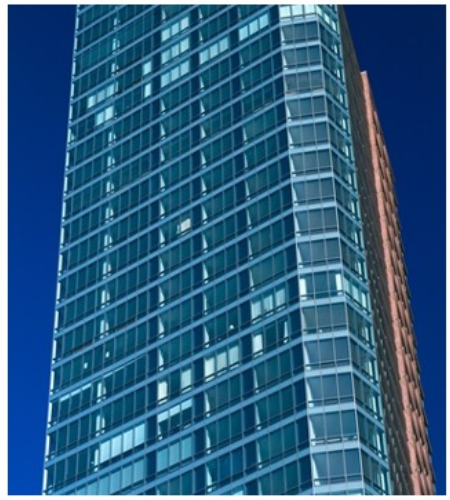
POCP: Photochemical ozone creation potential; examples: aromatic and olefinic hydrocarbons showed the highest POCP values, with halocarbons the lowest

Aluminum Framing in Commercial Fenestration

- Building designers look for a variety of attributes in a commercial fenestration system: structural performance, finish and color options, design capability, strength, and the ability to withstand climatic stress.

Aluminum windows are able to provide all of these benefits:

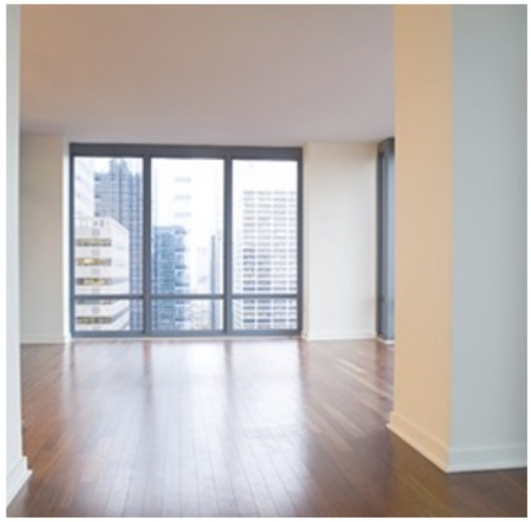
- Excellent structural performance
- Narrow sightlines
- Recycled content
- 100 percent reusability
- Unlimited color finish options
- Contributions to green building program credits
- Catastrophic event protection: hurricane, blast, tornado, intrusion



Aluminum frames also provide increased design flexibility over other framing materials. The thinner frames possible with aluminum make for narrow sightlines, enabling large expanses of glass to be supported with minimal aluminum material.

While maximizing daylighting provides both energy savings and health benefits, the same aluminum that makes large glazed areas possible is also a highly conductive material. The solution to aluminum's conductive properties is to be found with the use of thermal barriers. They eliminate the metal-to-metal bridge that acts as a conductor of hot or cold temperatures through the aluminum frame, replacing it with a very low conductive material so that high thermal performance with expansive glazing is maintained.

Commercial Fenestration and Its Contribution to Occupant Health



Sound Transmission and Health

- Fenestration system components affect outdoor-indoor sound transmission in the exterior wall.
- The Park Central Hotel New York is located in a busy traffic area near Central Park. Glazing includes a warm-edge spacer and polymer thermal barrier in the framing. The combined system is proven to contribute to overall sound-transmission improvements.

One characteristic of optimal window performance is minimized sound transmission. Building codes, owners, and architects are now requiring sound control for the entire fenestration system, rather than for the individual acoustical fenestration components.

Outdoor-indoor transmission class (OITC) is a standard used for indicating the rate of transmission of sound between outdoor and indoor spaces in a structure. Based on the ASTM E1332: Standard Classification for the Determination of Outdoor-Indoor Transmission Class, OITC utilizes a noise spectrum that considers frequencies down to 80 Hz and includes the lower frequencies produced by aircraft as well as rail and truck traffic.

Building Strength and Health

Maximizing window strength is another important consideration. Devoting sufficient attention to the building envelope design and material selection becomes especially important in regions prone to hurricanes, earthquakes, and other catastrophic occurrences. The high shear strength and load resistance of aluminum frames add safety elements to a structure.

Blast Protection

- Improvements to the historical 1960s John F. Kennedy Federal Building in Boston added high security, comfort, energy efficiency, and long-term durability.
- Nearly 5000 original windows—including bent corner units—were replaced with high-performance, energy-efficient, blast-resistant windows.

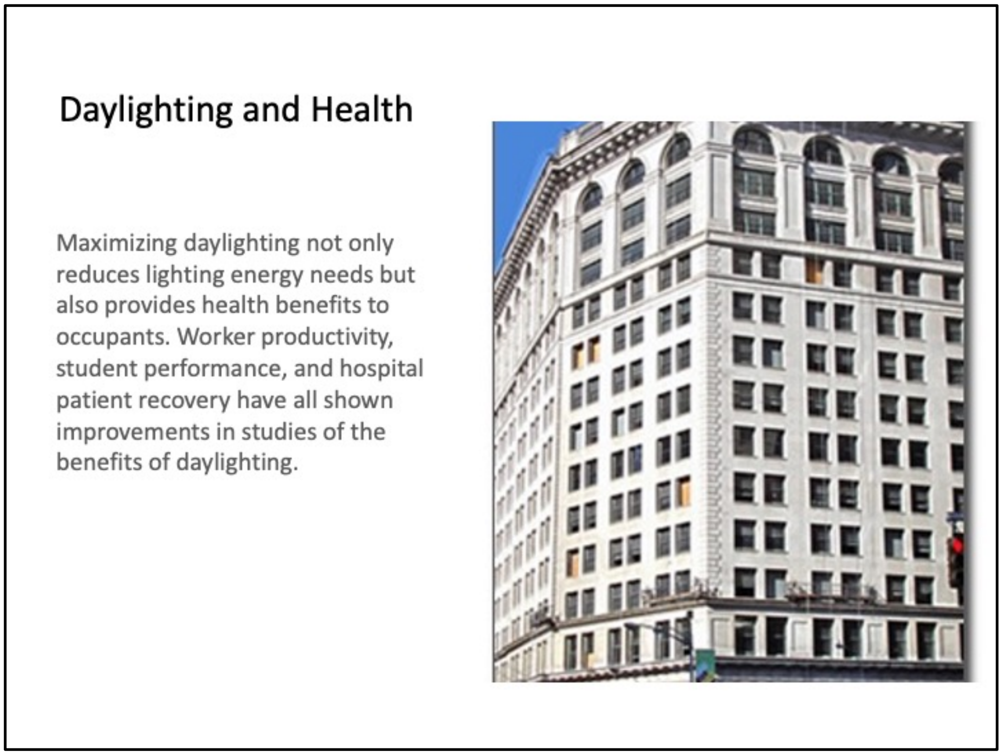
Photo: © George Doyle, Thinkstock

Maximizing window strength is another important consideration. Devoting sufficient attention to the building envelope design and material selection becomes especially important in regions prone to hurricanes, earthquakes, and other catastrophic occurrences. The high shear strength and load resistance of aluminum frames add safety elements to a structure.

In the fabrication of the frame, the thermal barrier must be able to adhere strongly to the finished substrate. When polyurethane is placed into an aluminum profile that has already been painted or anodized, additional measures must be taken to ensure the frame’s strength is maintained. A process that abrades the cavity surface to create hooks holds the thermal barrier securely, mechanically locked in place, and is designed to provide years of reliable performance. The resulting aluminum polymer composite offers undiminished structural integrity over a long service life, even under extreme conditions and temperature changes.

Example: Improvements to the historical 1960s John F. Kennedy Federal Building in Boston added high security, comfort, energy efficiency, and long-term durability.

Nearly 5000 original windows—including bent corner units—were replaced with high-performance, energy-efficient, blast-resistant windows. The JFK Building windows are intended to survive catastrophic events and protect occupants, and they exceed the industry standards for high shear and tensile strength. The material properties of the aluminum thermal barrier framing with a mechanical lock are ideal for use in government and public buildings where impact or blast hazard is at a high risk.

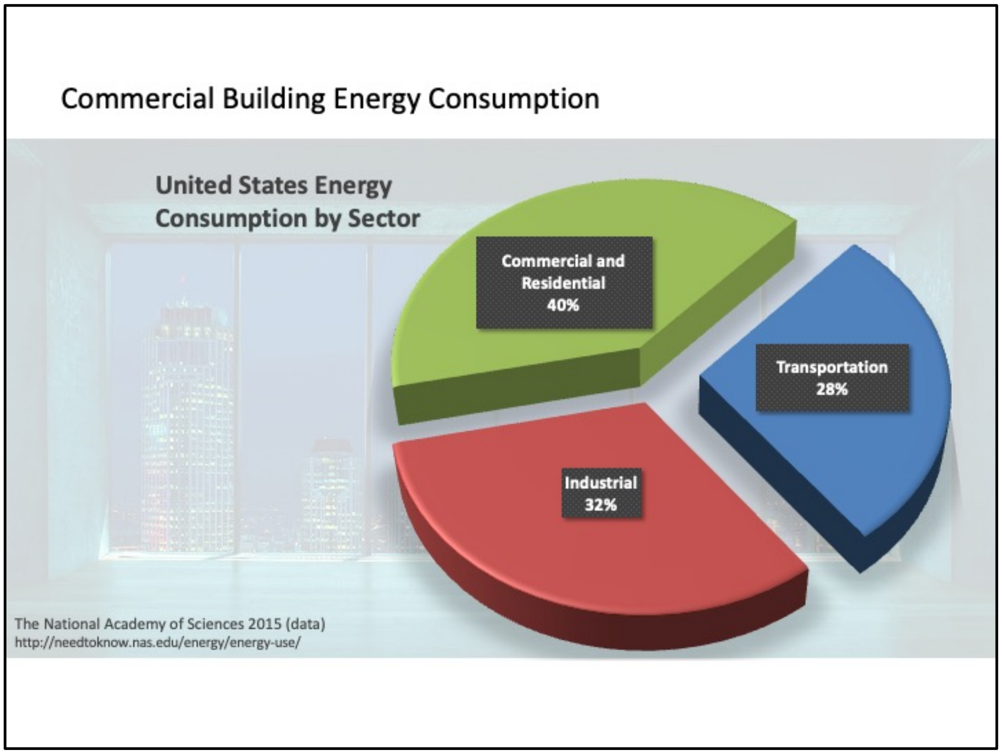


Maximizing daylighting not only reduces lighting energy needs but also provides health benefits to occupants. Worker productivity, student performance, and hospital patient recovery have all shown improvements in studies of the benefits of daylighting.

The strength of aluminum allows slim frame profiles to support a higher percentage of glass for improved daylighting and views.

To achieve the best possible daylight transmittance with the least amount of heat gain or loss, window performance is dependent on both the glazing and frame efficiency.

Commercial Fenestration for Energy and Cost savings



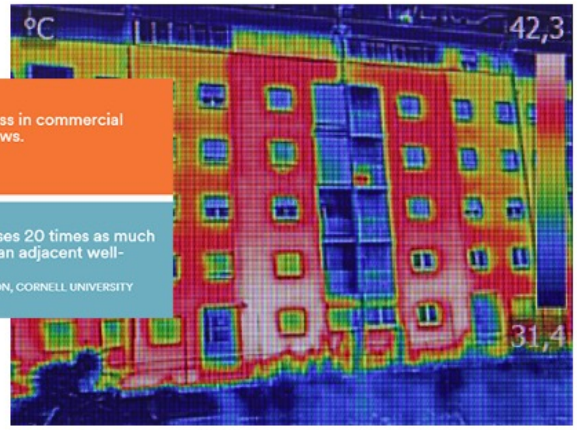
We use energy in homes and commercial buildings in similar ways.

We keep rooms at a comfortable temperature, illuminate our spaces, heat water for bathing and laundry, and depend on computers, copiers, appliances, and other technologies. So perhaps it is not surprising that in 2015, 40 percent of all the energy consumed in the United States went to powering homes and commercial buildings.

Energy Loss in Commercial Buildings

40% Nearly 40% of heating loss in commercial buildings is due to windows.
U.S. DEPARTMENT OF ENERGY

20x A single pane window loses 20 times as much heat as the same area in an adjacent well-insulated wall.
CORNELL COOPERATIVE EXTENSION, CORNELL UNIVERSITY



Infrared thermal image showing poor thermal insulation on multistory building

CALIFORNIA
ENERGY COMMISSION

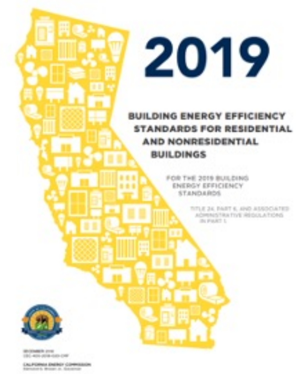
Title 24:
Building Energy Efficiency Program

Current nonresidential criteria:

	Max U-factor	Max SHGC	Min VT
Curtain wall / Storefront	0.41	0.26	0.46
Fixed	0.36	0.25	0.42
Operable	0.46	0.22	0.32

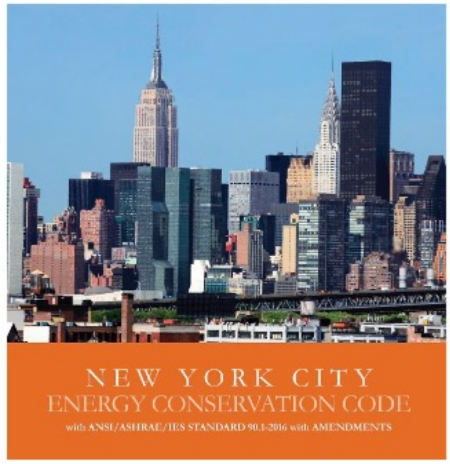
Whole product numbers, not just center-of-glass

California: Single-family homes:
updated to U-0.30, SHGC-0.23 in 2019



The 2020 NYC Energy Conservation Code

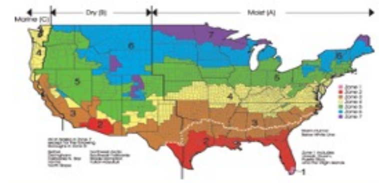
A local law to bring the New York City Energy Conservation Code up to date with the 2020 Energy Conservation Code of New York State, which is based on the 2018 edition of the International Energy Conservation Code and ASHRAE Standard 90.1-2016.



NEW FENESTRATION REQUIREMENTS

- Non-metal framing (all)
  - **U-0.28 (all heights)** *previously U-0.38 fixed, U-0.45 operable*
- Metal framing, fixed
  - **U-0.30 (below 95')** *previously U-0.38*
  - **U-0.36 (95' and above)** *previously U-0.38*
- Metal framing, operable
  - **U-0.40 (below 95')** *previously U-0.45*
  - **U-0.42 (95' and above)** *previously U-0.45*
- Curtain wall fixed
  - **U-0.36 (all heights)** *previously U-0.38*

IECC 2018: Commercial Windows



2018 IECC Prescriptive Fenestration Requirements						
Climate Zone	1	2	3	4 & 5	6	7 & 8
Vertical Fenestration U-factor Requirements						
Fixed fenestration	0.50	0.50	0.46	0.38	0.36	0.29
Operable fenestration	0.65	0.65	0.60	0.45	0.43	0.37
Entrance doors	1.10	0.83	0.77	0.77	0.77	0.77
Skylight U-factor Requirements						
Maximum U-factor	0.75	0.65	0.55	0.50	0.50	0.50
Maximum SHGC	0.35	0.35	0.35	0.40	0.40	Any

Vertical Fenestration & Skylight SHGC Requirements										
Climate Zone	1-3		4		5		6		7 & 8	
Orientation	S, E, W	N	S, E, W	N	S, E, W	N	S, E, W	N	S, E, W	N
PF<0.2	0.25	0.33	0.36	0.48	0.38	0.51	0.40	0.53	0.45	NR
0.2≤PF<0.5	0.30	0.37	0.46	0.53	0.46	0.56	0.48	0.58	NR	NR
PF≥0.5	0.40	0.47	0.58	0.58	0.61	0.61	0.64	0.64	NR	NR

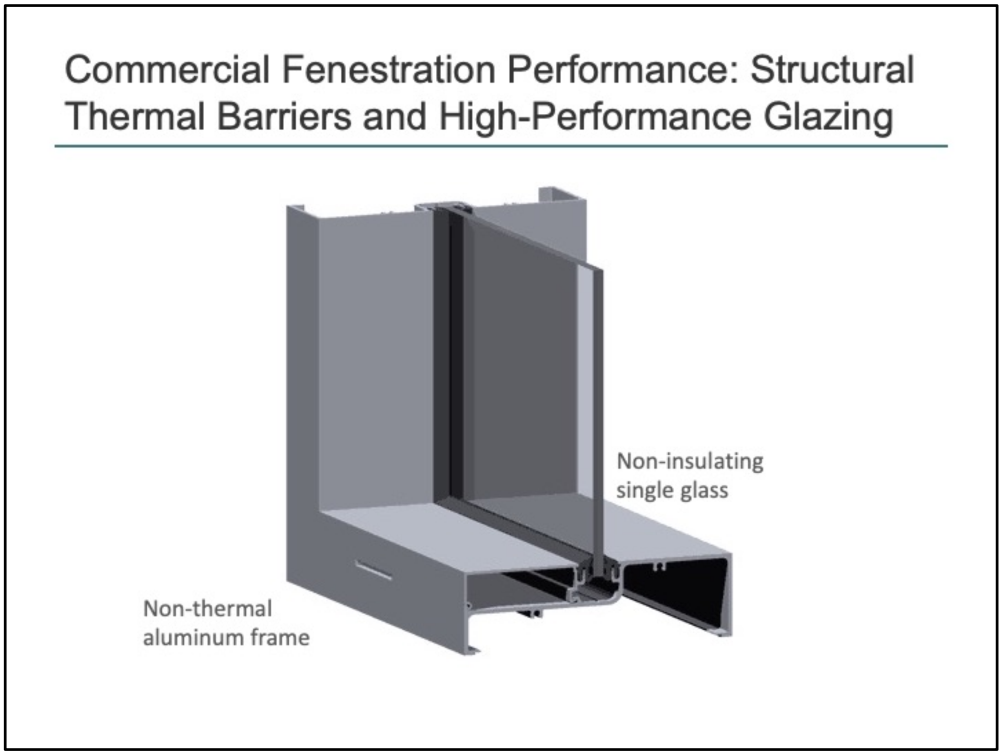
ENERGY STAR 2020: Residential

WINDOWS			
CLIMATE ZONE	U-FACTOR[1]	SHGC[2]	
Northern	≤0.27	Any	Prescriptive
	=0.28	≥0.32	Equivalent Energy Performance
	=0.29	≥0.37	
	=0.30	≥0.42	
North Central	≤ 0.30	≤ 0.40	
South Central	≤ 0.30	≤ 0.25	
Southern	≤ 0.40	≤ 0.25	

SKYLIGHTS		
CLIMATE ZONE	U-FACTOR[1]	SHGC[2]
Northern	≤ 0.50	Any
North Central	≤ 0.53	≤ 0.35
South Central	≤ 0.53	≤ 0.28
Southern	≤ 0.60	≤ 0.28

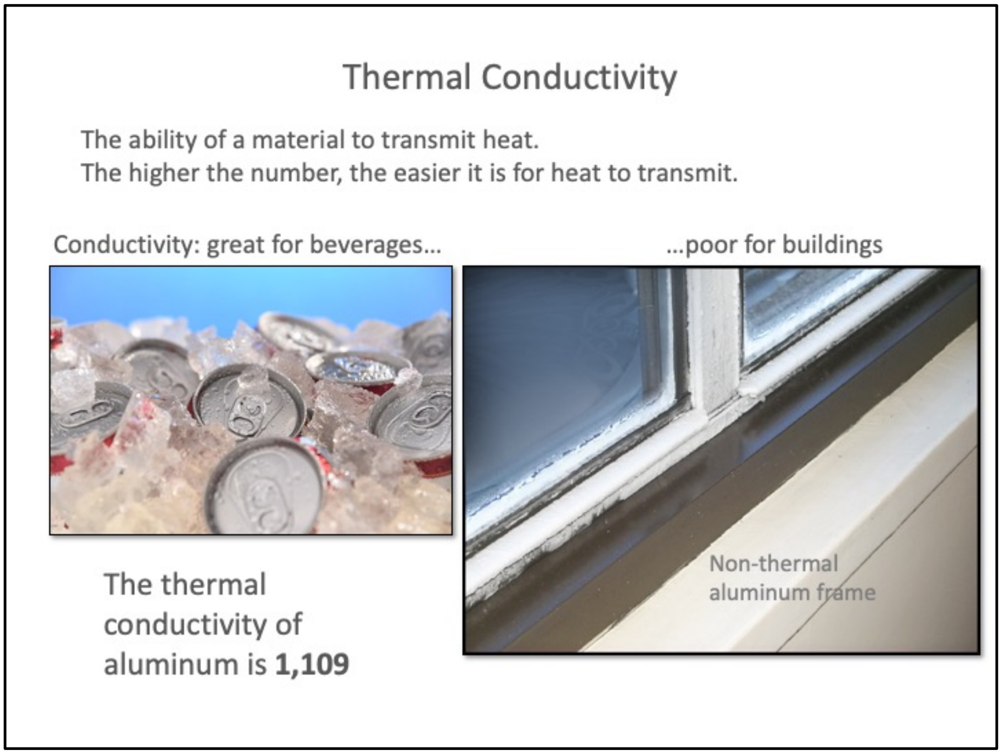
Air Leakage ≤ 0.3 cfm/ft2

[1] Btu/h ft2 °F
[2] Solar Heat Gain Coefficient



Beginning in the 1950s, single-pane products advanced into insulating glass, slowly replacing the once-popular storm panel applied to a single-glazed window. In these units, the cavity between the two glass panes acts as an insulator, preventing exterior climate conditions (whether hot or cold) from transferring in.

By the 1970s, the use of insulating glass in residential and commercial applications grew in popularity, making significant strides in energy conservation for windows. By replacing aluminum spacers with warm-edge spacers, and filling with inert gases such as argon or krypton, insulating glass units can reduce convection by as much as 10 percent compared to normal air.

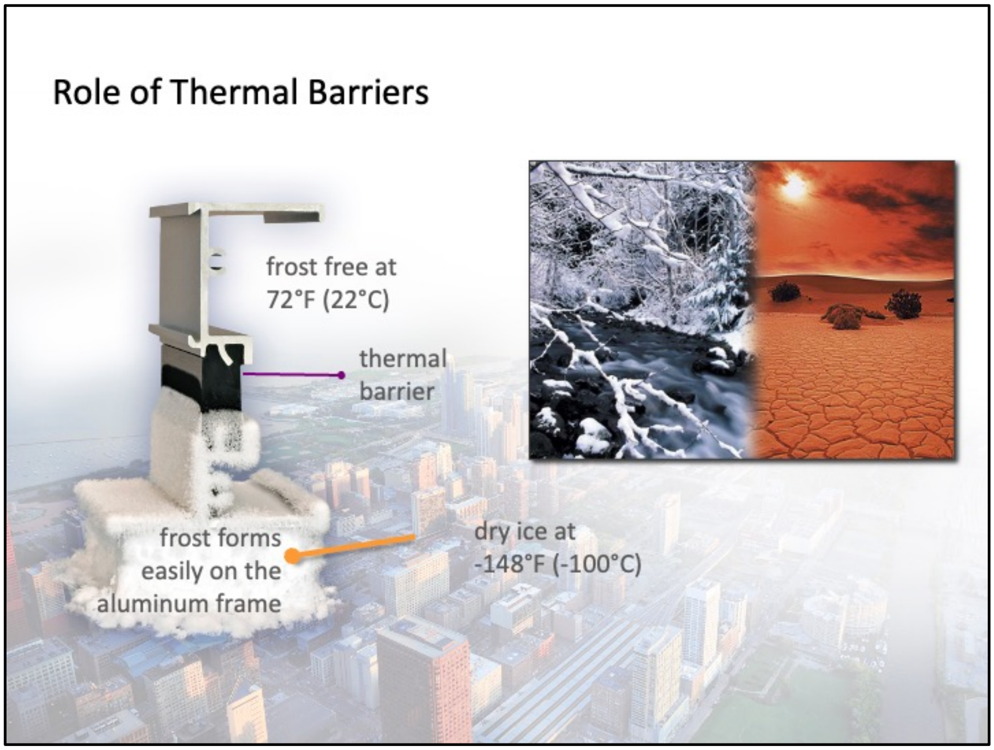


Aluminum is an outstanding material for soda cans; however, it is highly conductive.

Single-pane windows, together with metal-framing materials, offered little or no energy savings, as they were both thermally inefficient and offered paths for climatic conditions to pass, including condensation and frost.

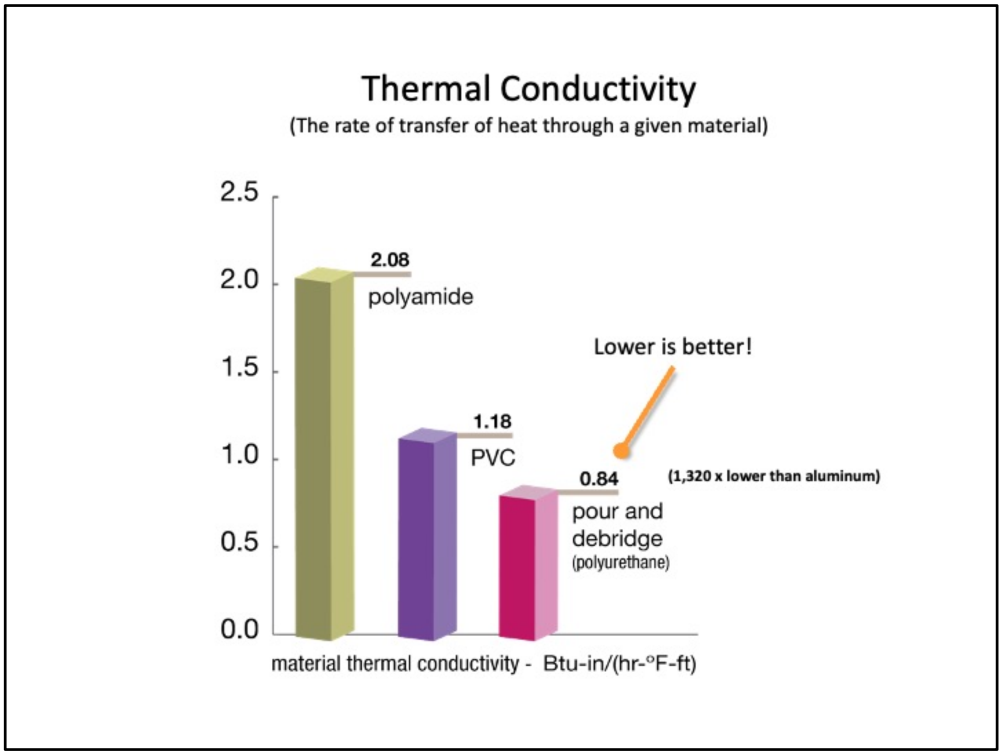
Optimizing window performance must include minimizing heat transfer and condensation while maximizing energy savings.

The potential health effects of excessive water vapor with non-thermal windows must also be considered.



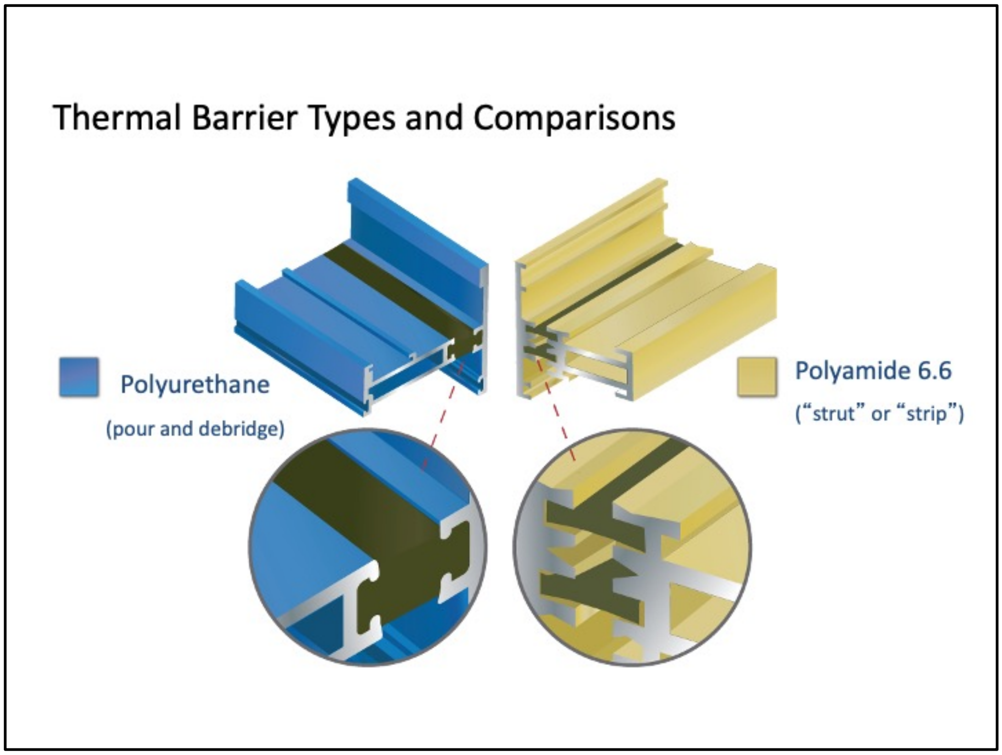
When used in a frame, an element of low-conductance material known as a thermal barrier provides aluminum significant thermal performance characteristic.

No metal-to-metal contact means the high conductivity of aluminum is no longer an issue. Heat now must pass through the very low conductive polyurethane polymer material, resulting in improved thermal performance of the unit.



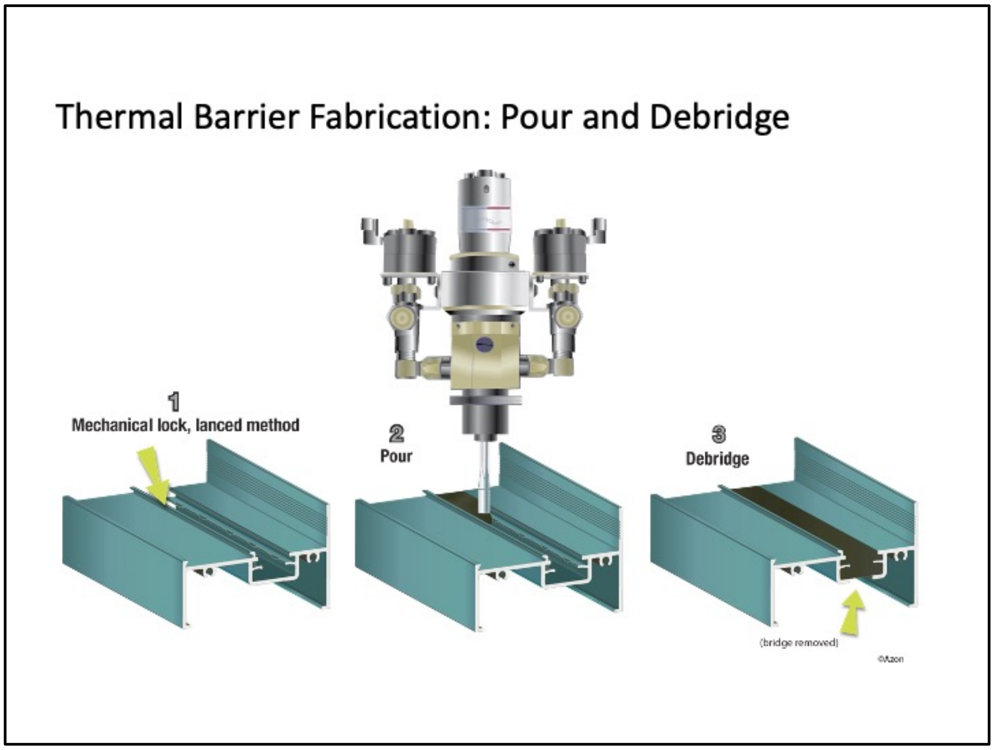
Among the attributes demanded by building designers, improving building thermal efficiency for long-term energy conservation typically tops the list. The use of a thermal barrier material within the frame allows aluminum fenestration to provide better thermal performance by lowering the thermal conductive.

Not all insulant material used for the purpose of interrupting heat flow in aluminum perform the same.

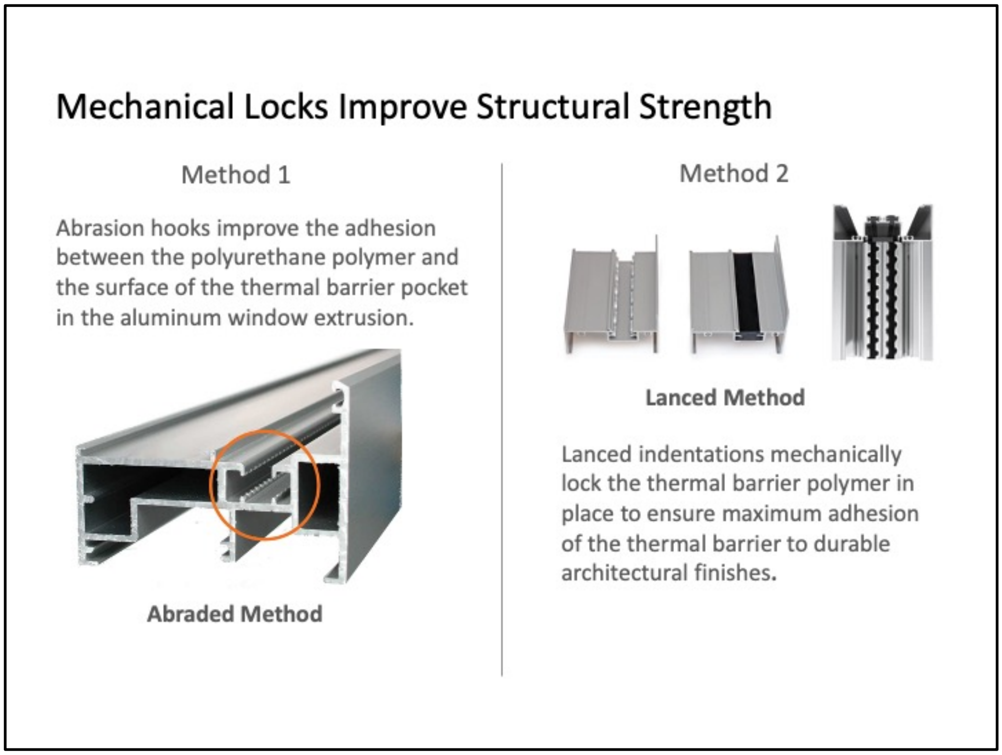


The two most common types of thermal barrier for aluminum fenestration products are shown at right. The blue images show a pour and debridge system that uses a polyurethane polymer material.

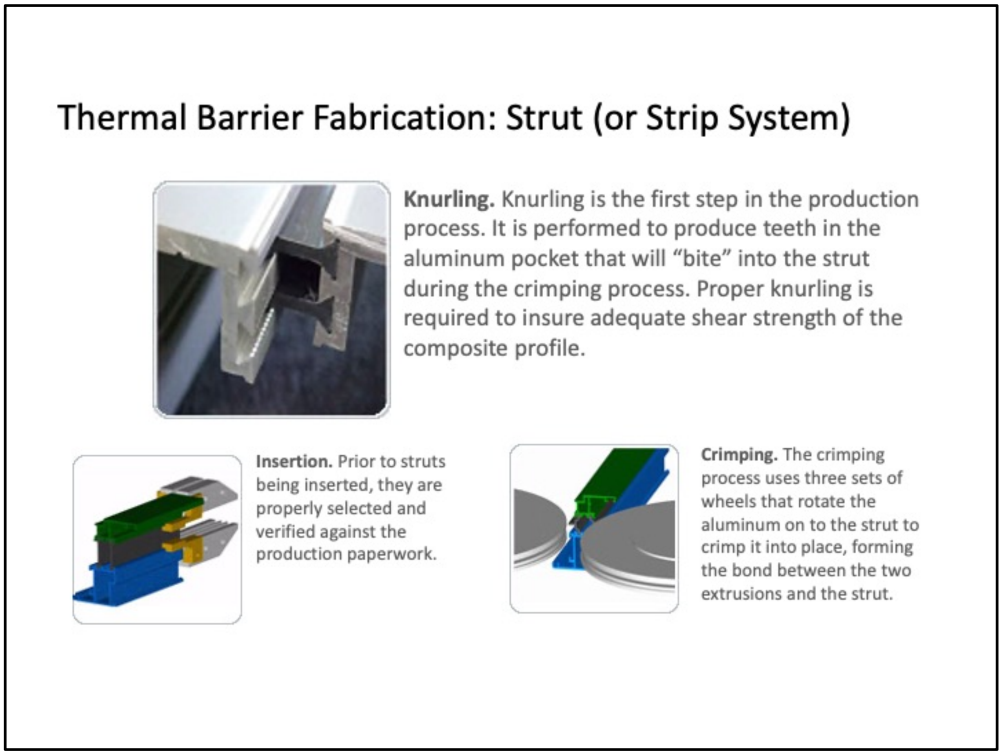
The yellow images show a strip system, also called a strut system. This type of system incorporates a polyamide material.



The pour and debridge system starts with a single aluminum profile. After the profile is finished a mechanical lock is prepared within the fill cavity of the aluminum profile. Next, the cavity is filled with a liquid polyurethane polymer. The polymer then solidifies within the aluminum cavity. Lastly, the bottom part of the aluminum cavity is removed and forms a non-continuous aluminum profile that requires the heat transfer to pass through a very low conductive material, thus improving the thermal performance of the unit.



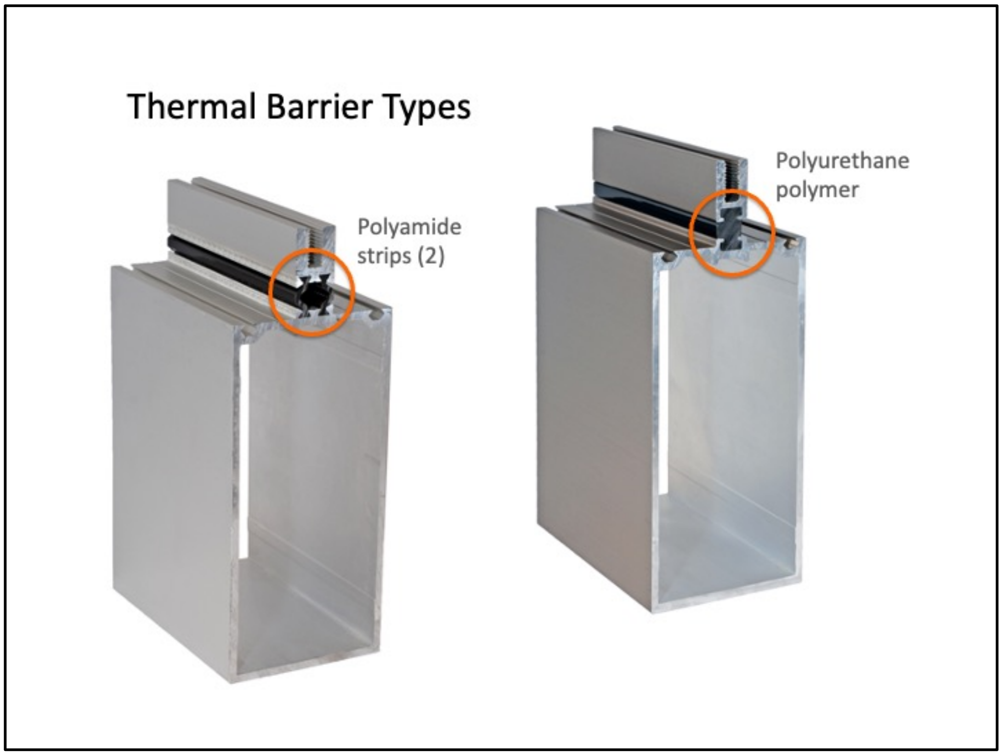
The structure must remain strong, thus mechanically locking and embedding the polymer to the aluminum results in high shear strength.



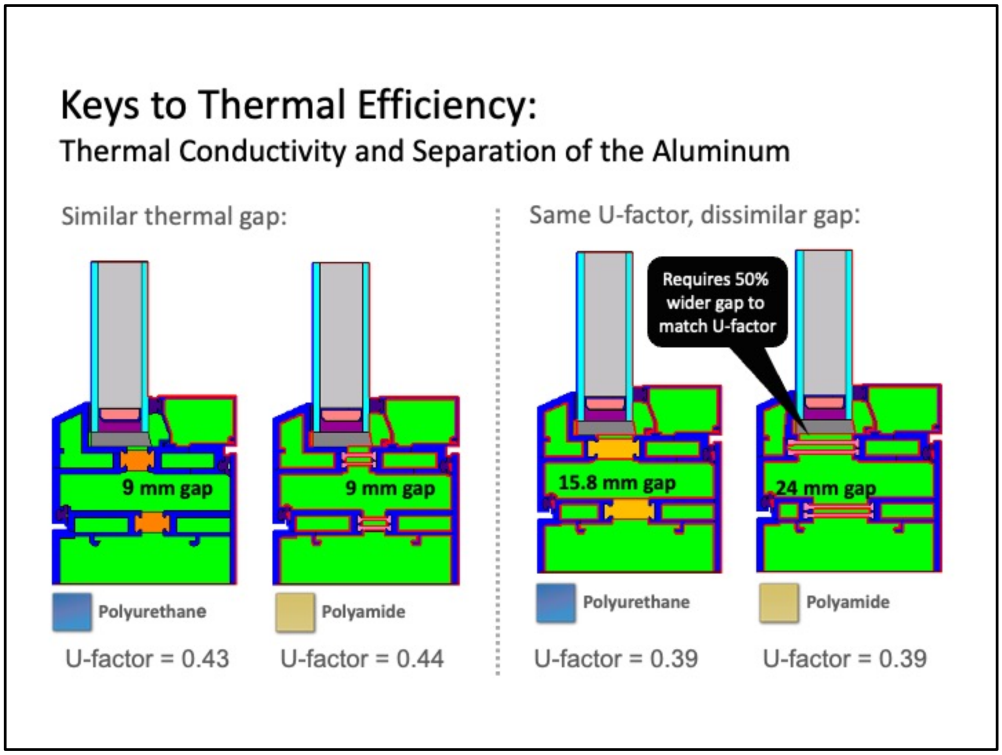
The polyamide strip system is composed of two separate aluminum profiles that are connected by the thermal barrier material.

The interior and exterior of the profiles are finished and then run through a knurling machine that puts ridges on the thermal barrier cavity of the aluminum profile.

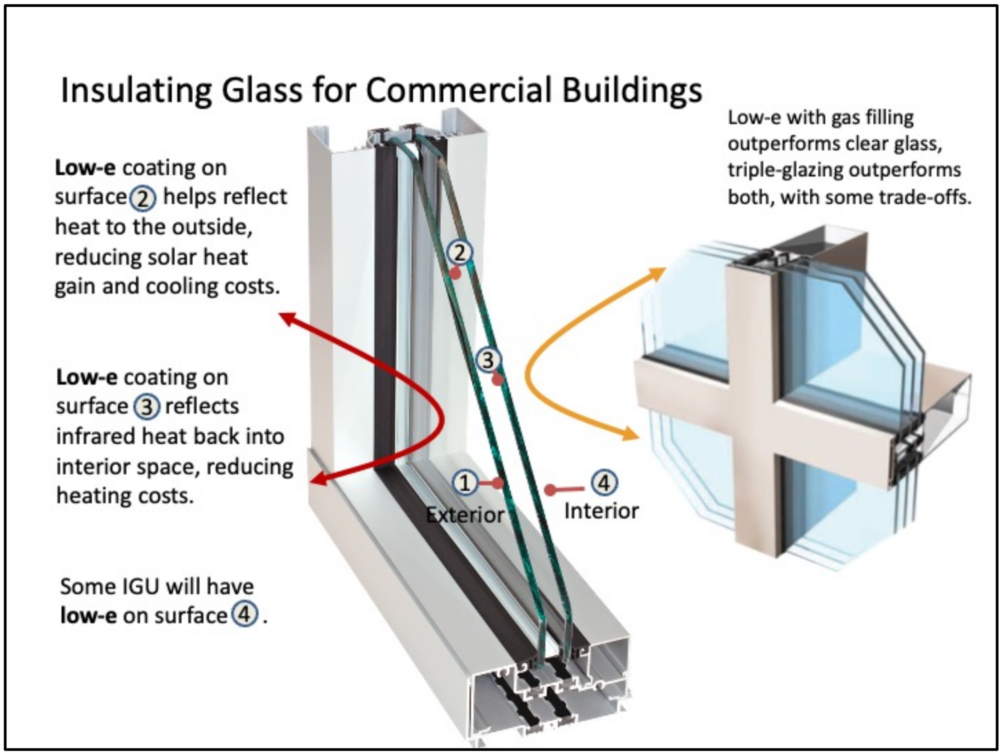
The polyamide comes to the manufacturer in strips, and these strips are threaded into the cavities of the aluminum profiles.



The majority of thermally broken aluminum fenestration extrusions used in commercial buildings contain either polyurethane or polyamide thermal barrier systems because they meet or exceed the thermal and structural specifications of most projects.



Along with thermal conductivity, the thermal performance can be improved by the "gap" of the thermal barrier or the distance that the heat must flow through the low conductive material. Here you can see how the material with the lower thermal conductivity has superior performance when the gap is the same (9 millimeters) and how the lower conductive material will have the same performance with a smaller gap.

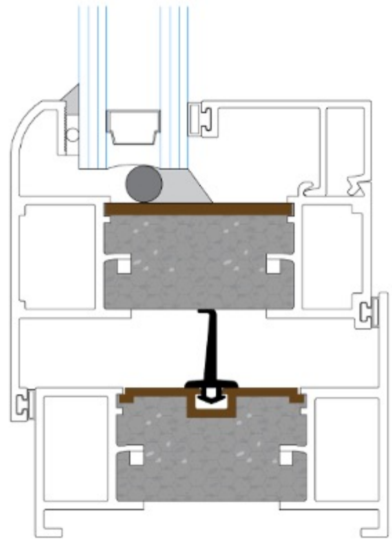


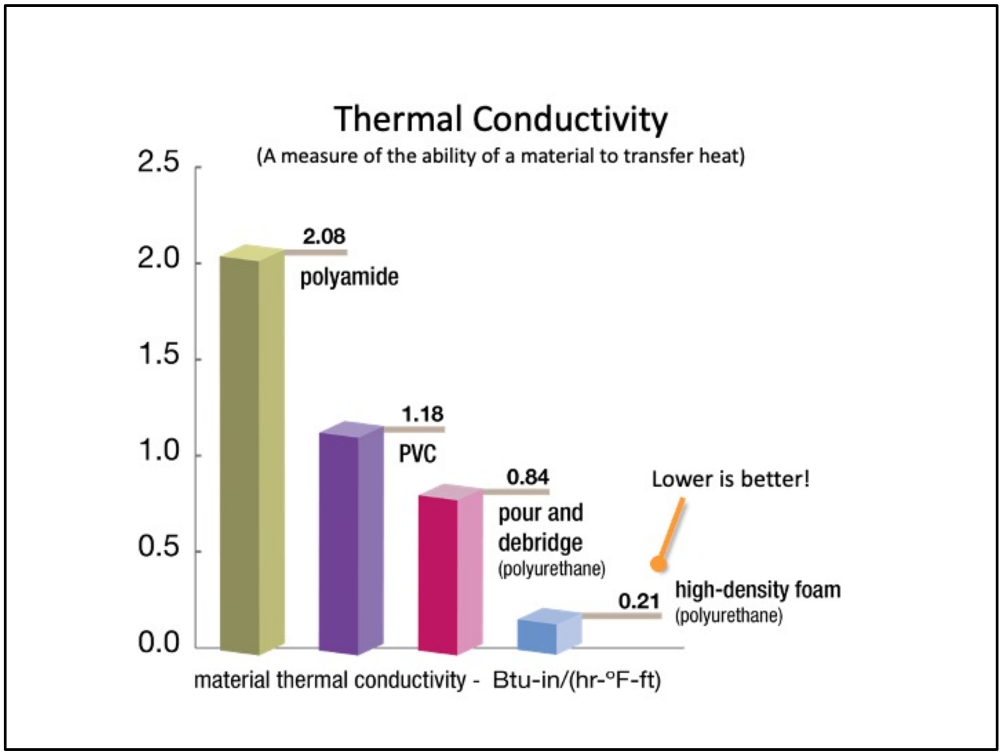
Low-e coatings, warm-edge spacers, and other high-performance glazing materials help offset some of the difference in U-factor and condensation resistance while keeping the SHGC and visible light transmittance high in the insulating glass units.

High-Density Polyurethane Foam

Significant Performance Improvement

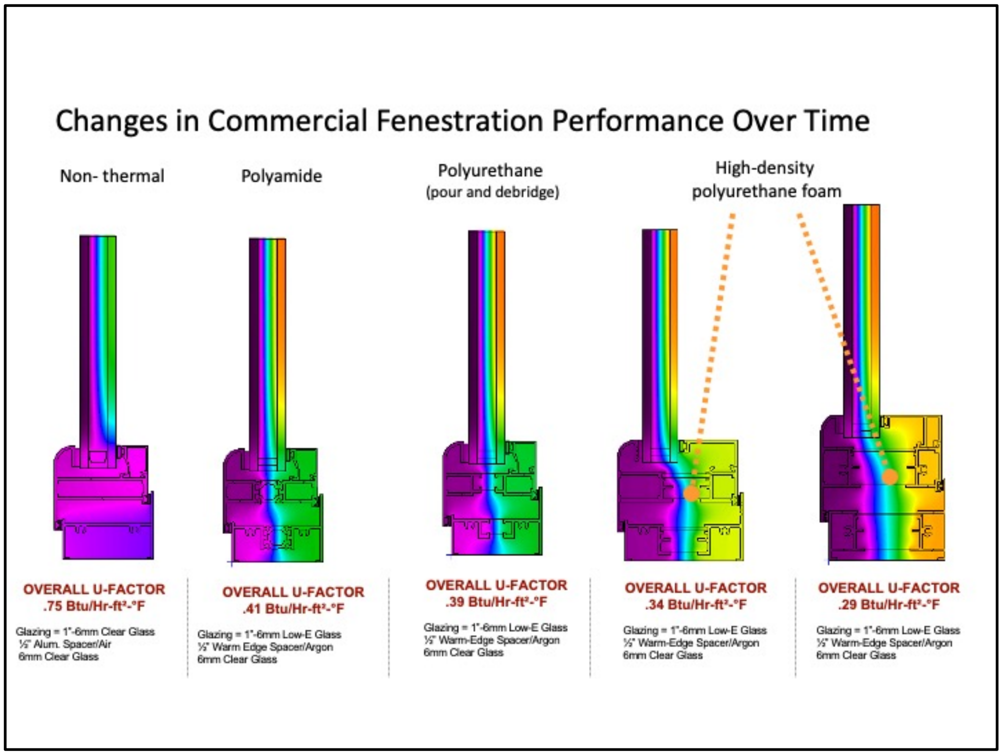
- High-density polyurethane foam core for commercial windows and doors
- Major breakthrough in thermal performance for aluminum fenestration products
- Thermal barrier system with the lowest conductivity
- Meeting stringent global energy standards including ENERGY STAR, PassiveHouse, and International Energy Conservation Code (IECC)





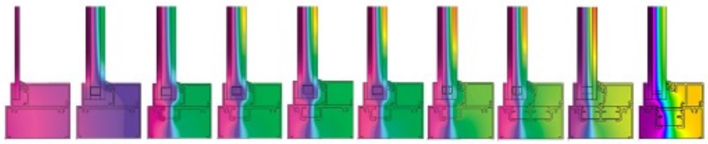
As mentioned earlier, the use of a thermal barrier material within the frame allows aluminum fenestration to provide better thermal performance by lowering thermal conductivity.

To further interrupt heat flow in aluminum is the introduction of high-density polyurethane foam, the thermal barrier material with the lowest conductivity.



Operable commercial windows thermal performance has increased greatly in the past 10 years, and with new thermal barrier foam technology, the performance is taking another step forward with U-factors below 0.30.

Advances in thermal barriers, glass configuration, and spacers have led to substantial improvement in fenestration performance over time.



	1950	1960	1970	1980	1990	2000	2005	2010	2015	2020
U-factor	1.00	0.66	0.50	0.44	0.41	0.39	0.37	0.32	0.29	0.25
Condensation Resistance*	16	28	52	54	55	56	61	65	64	74
U-cog (Btu/h ft²F)	1.03	0.49	0.49	0.36	0.29	0.24	0.24	0.24	0.20	0.20

Image courtesy of ©Azon

Source: Azon

Beginning in the 1950s, single-pane products advanced into Insulating glass, slowly replacing the once-popular storm panel applied to a single-glazed window. By the 1970s, the use of insulating glass in residential and commercial applications grew in popularity, making significant strides in energy conservation for windows. In these units, the cavity between the two glass panes acts as an insulator, preventing exterior climate conditions (whether hot or cold) from transferring in. By adding warm-edge spacers, inert gases, such as argon or krypton, an insulating glass unit can reduce convection by as much as 10 percent compared to normal air. The air-space improvement will account for a reduction of 0.02–0.03 units in total U-factor.

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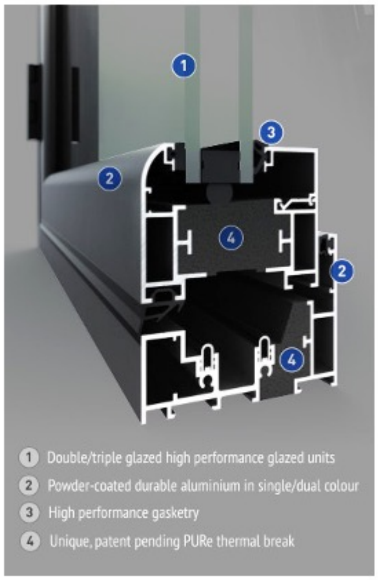
New Standard in Sustainability

Creative and Innovative Product



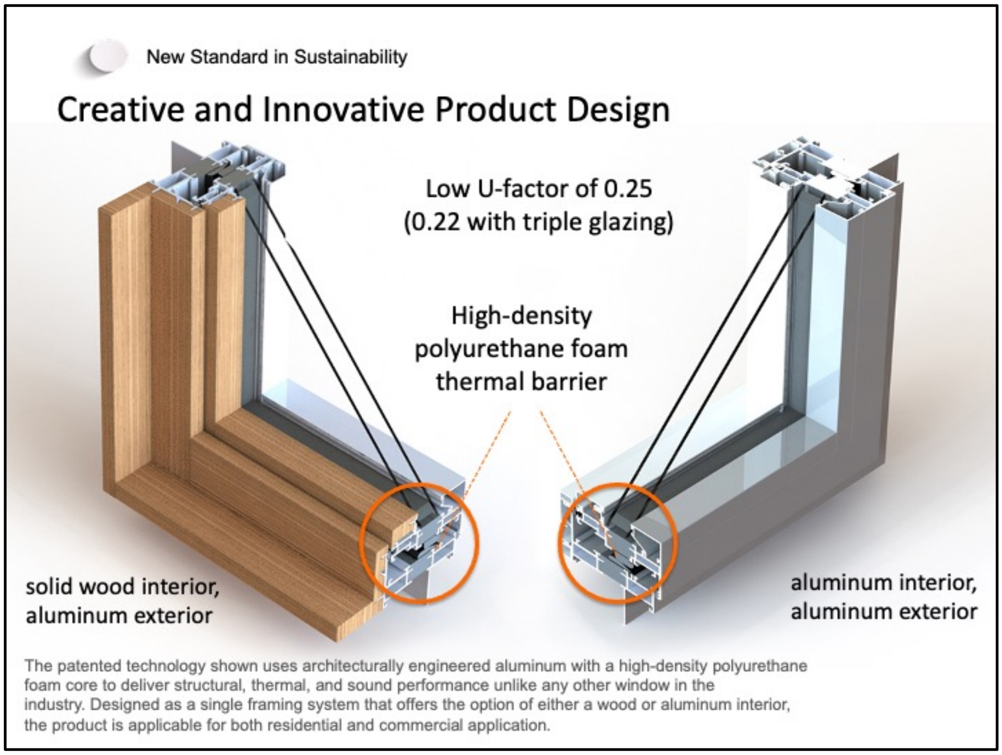
High-Density Polyurethane Foam

- After two years of intense research, the largest privately owned provider of fenestration solutions in the United Kingdom develops a high-density polyurethane foam thermal barrier to cope with extreme weather conditions.

- Simple, cost effective, and lowest U-factor
- 100 percent recyclable and has been designed to meet the Passivhaus (Europe) standard.
- Green Guide rating of A for use in commercial projects and a life expectancy in excess of 40 years
- Able to receive double or triple glazing for maximum thermal and acoustic performance

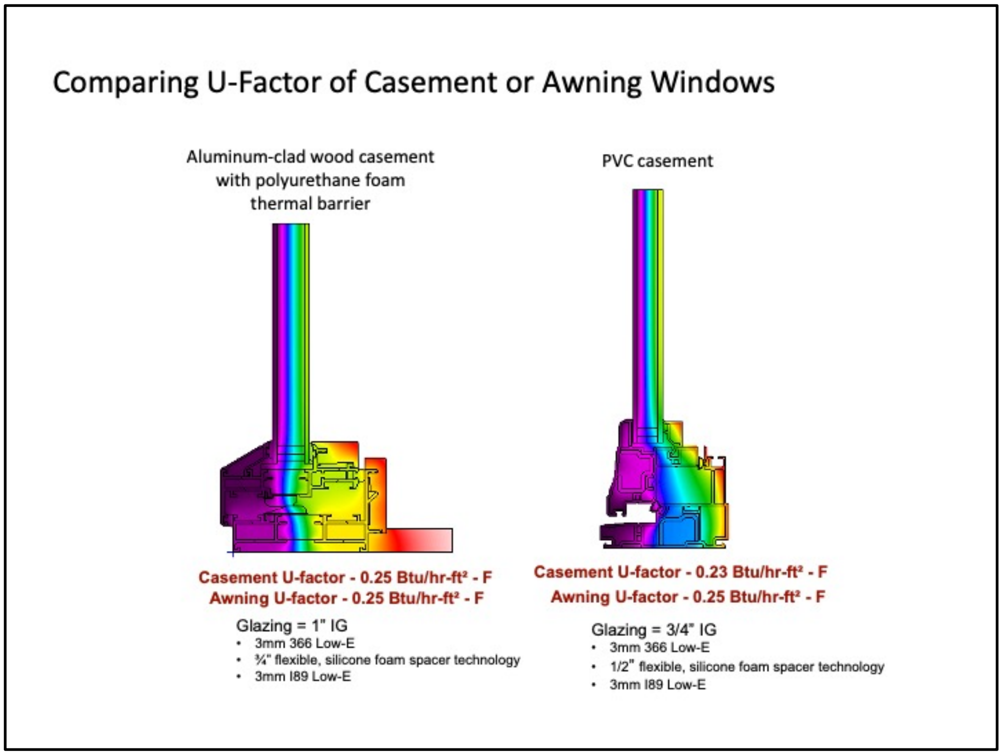
The next step in thermal barrier technology for commercial windows and doors is a high-density foam.

This commercial aluminum window when triple glazed is the first to meet the Passivhaus requirements in the UK (must be 0.80 ((0.14)) or lower).



Manufactured in the United States*, the patent-pending series of windows offers both a wood or aluminum interior with a high-density polyurethane foam core.

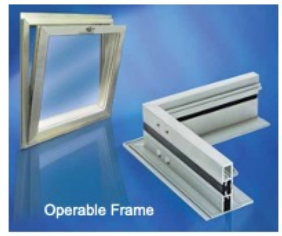
*An American company founded in 1949

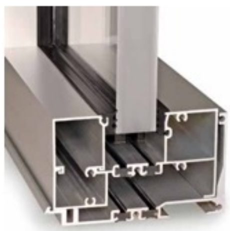


The commercial aluminum window on the left can compete thermally with the residential PVC window on the right.

Storefront, Window, and Curtain-Wall Systems

- High-performance thermal barrier windows, storefront, and curtain-wall systems are available in dual- or single-cavity designs.





Storefront, dual cavity

Storefront, single cavity

Curtain wall, dual cavity

Curtain wall, single cavity

Real-Time Application: Commercial Fenestration Outcomes in the Field

CASE STUDY

Window Project: Empire State Building

- Opened in 1931
- Worlds tallest building at the time
- Steel-framed windows with single-pane glass
- 1994 renovation
  - 5,460 new windows
  - Polyurethane thermal barrier
  - Insulating glass
  - Project cost: $5.5 million
  - Annual energy savings: $948,000
  - Payback period: six years

ENERGY USER NEWS

NEWS FOR BUILDING MANAGERS & ENGINEERS VOL. 19 NO. 11 • NOVEMBER 1994 • $7.00

Windows Save Empire State Bldg. $948K

By JENNIFER A. GORDON

NEW YORK—A 5,460-window retrofit that was completed in June at the Empire State Building here is expected to cut the facility's annual energy costs by at least $948,000.

The project is the first of three phases during which all the building's windows will be replaced, according to Charles Guigno, director of operations for the Empire State Building and vice-president of property management firm Helmsley-Spear Inc. The entire $5.5 million project cost was paid from the capital budget and received no utility rebates, he noted.

The new windows are expected to cut the 102-floor, 2.25 million-square-foot office building's annual electricity costs by at least $848,000, Guigno told EUN, adding that electricity consumption is expected to drop by 6,974,311 kilowatt hours a year. In addition, the window replacement is expected to cut costs for steam purchased from local utility Consolidated Edison by about $100,000 a year, he continued. Yearly steam savings are expected to total 10,764,000 pounds.

The savings estimates represent a 16 percent reduction in energy consumption and costs, Guigno observed. However, he claimed the projections are conservative and savings could actually approach 25 percent. Based on the most conservative estimate, payback would be achieved in about six years.

Phase 1 of the retrofit involved installing 5,460 TR-9000 heavy commercial double-hung windows by Traco, Pittsburgh, Pa. The 60-by-85-inch aluminum-frame windows utilize one-inch-thick insulated tempered safety glass, according to Dell Granlund, Traco's special projects manager. The TR-9000 has an R-value of 1.6, while the building's original single-pane windows had an R-value of 1.4. The new windows can also be tilted in to allow them to be washed from inside the building, Granlund noted.

continued on page 6

In the first portion of a three-phase retrofit, owners of New York's Empire State Building replaced over 5,000 windows with energy-efficient models that are expected to provide steam and electricity cost savings amounting to almost $1 million a year.

Retrofits Cut Elec. Use by 32MMKwh/Yr.

By MIKE RANDAZZO

FORT POLK, La.—Thanks to a shared savings deal, Fort Polk Army Base here expects to

NEW CONSTRUCTION PROFILE: SCHOOLS

District to Use New Bldgs. as Future Models

By RUSSELL L. NELSON

SPOKANE—Three new energy-efficient elementary school buildings completed here in February will be used as templates for future facilities built by Spokane School District 81.

Hamblen, Logan, and Stevens Elementary Schools

PSI Opens Wheeling Tariff to 25 Users

PLAINFIELD, Ind.—PSI Energy here has told 25 large customers they qualify for a transmission tariff that lets them buy power from other suppliers. Rider 19 was created in connection with a contract signed with Newcor Steel in 1990 a spokeswoman said.

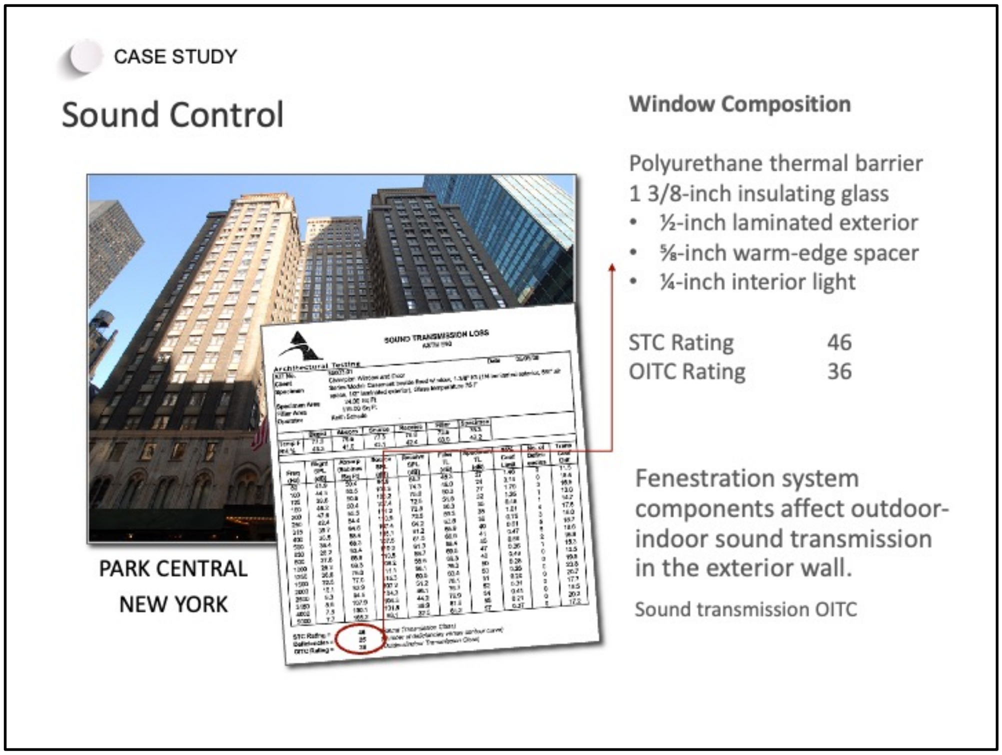
Each Rider 19 contract must be negotiated individually. It is open to users with at least five megawatts (Mw) of nonfirm load at one location. PSI can wheel a total of up to 300 Mw at Rider 19 rates. Minimum contract term is 10 years, with five years' termination notice.

"This would have been a greater act of courage for a more expensive utility," she admitted; PSI has an industrial rate around three cents a kwh. "We're doing this because our largest customers told us they want choice. The utilities who will succeed in a more competitive world will be the ones who are good at serving customers. We have to learn to operate more like a business and Rider 19 will allow us to gain valuable experience in dealing with the day-to-day realities of competition. We think end

The Empire State Building is one of the most recognizable buildings in the world, and a perfect example of the energy savings that can be realized when energy-efficient thermally improved windows are installed.

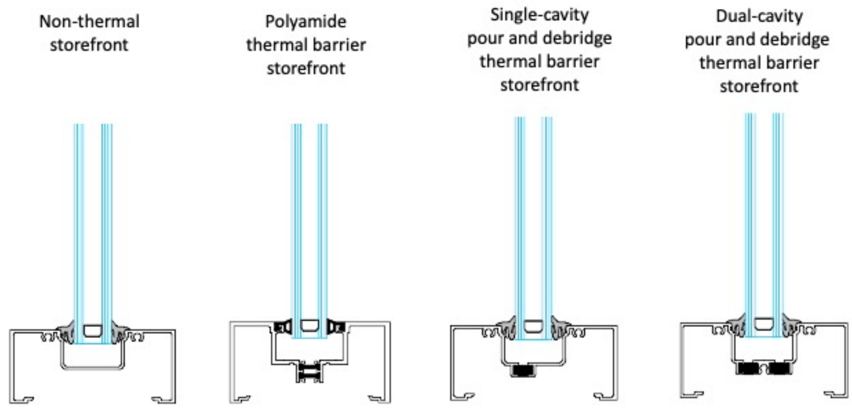
When the Empire State Building was completed in 1931, it contained steel-framed windows with single-pane glass and offered poor thermal efficiency.

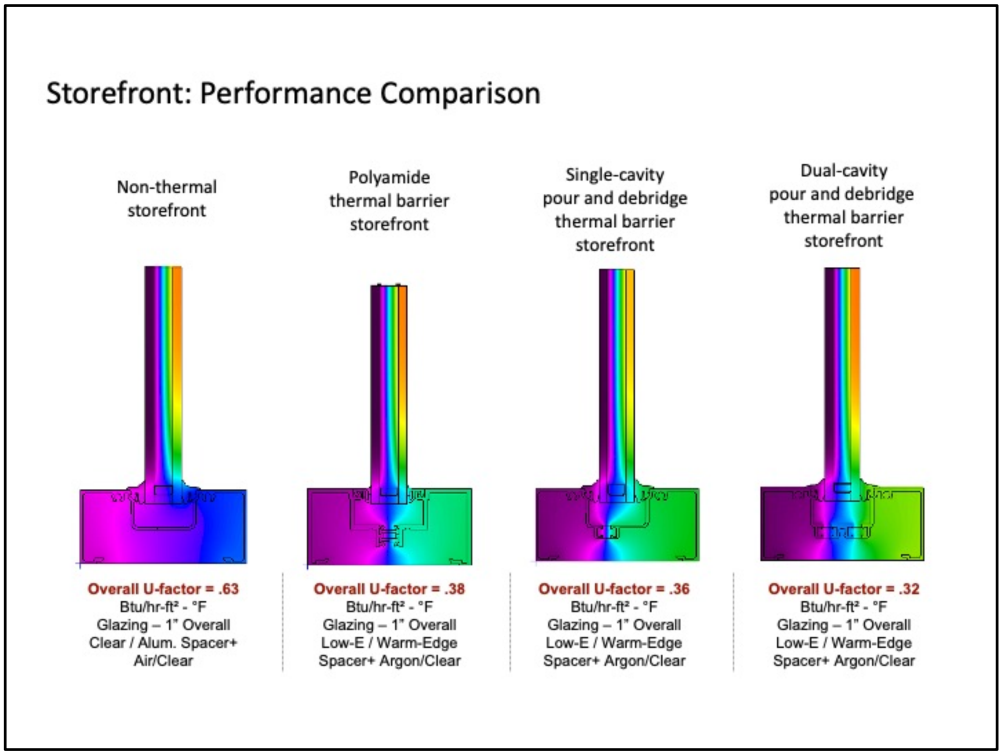
In 1994, the renovation of the building was completed with the installation of 5,460 thermal barrier aluminum windows containing insulating glass. These energy-efficient windows are expected to save the Empire State Building $948,000 in heating and cooling costs annually, representing a 16–25 percent reduction in energy consumption and costs.



Glazing system components in the Park Central New York (located in a busy traffic area near Central Park) include a warm-edge spacer and polymer thermal barrier in the framing. The combined system is proven to contribute to overall sound-transmission improvements (based on sound transmission OITC).

Storefront: Framing Types





A dual-glazed storefront's performance can vary greatly depending on the thermal requirements as shown here. The key with storefront is to keep the width at the traditional 4½ inches and the sightlines as small as possible.

CASE STUDY

Safety and impact strength against hurricane-force winds and flying debris

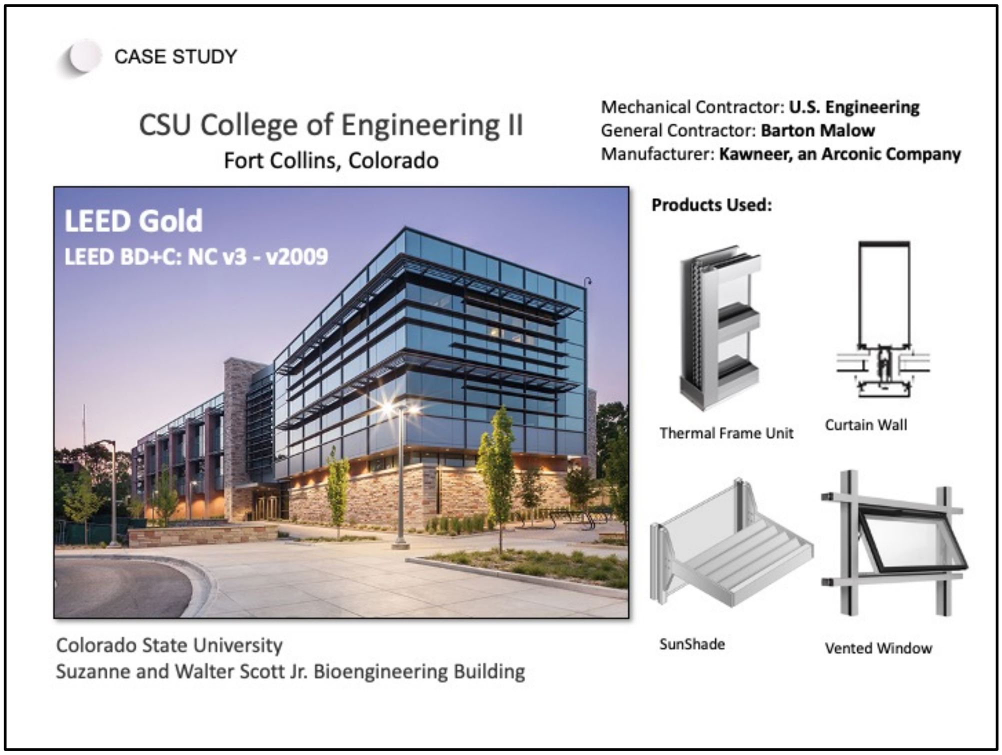
Impact-Resistant Thermal Barrier Window Wall

Architect: **Morris Adjmi**
G.C : **Woodward Design + Build**
Glazing Contractor: **Zinsel Glass**
Manufacturer: **YKK AP America Inc.**

Price-point between storefront and curtain wall

- Completely factory glazed and assembled, or inside glazing at jobsite
- Hurricane and blast mitigating
- Window wall for midrise

An energy-efficient, 6-inch-wide offset storefront used in an application that would typically be curtain wall. It is hurricane and impact resistant while complying with ASHRAE 90.1 versions of the energy code thru 2013 using 1-inch low-e IGUs.



In Colorado, state-funded higher-education buildings are required to be designed and built to LEED Gold standard. The new Bioengineering Building qualified for LEED Gold certification.

A highly efficient curtain-wall system, integrated fenestration, and high-performance glazing systems, along with interior and exterior sunshades on the building's south facade, allow for ample daylighting, and all labs and offices have light sensors to decrease electrical usage.

The building's efficient envelope, position on site, and naturally ventilated three-story atrium takes advantage of the Colorado air as it flows west to east.

Located in the heart of downtown Minneapolis, the renovated 90-year-old Baker Center showcases a prominent new building entry featuring thermal barrier curtain-wall and storefront systems.

The project consists of four buildings combined over the years into one. With different construction techniques for each, and no existing drawings from the original architects or the many earlier remodeling contractors, drawings and revisions were nonstop throughout the renovation.

CASE STUDY

Crosstown Concourse

Memphis, Tennessee

Once abandoned, this 90-year-old Sears-Roebuck Catalog Distribution Center was converted to more than 1.3 million square feet of mixed-use living and working space.

Largest Historic Adaptive Reuse Project in the World

Contractor: **Grinder, Taber & Grinder**
Glazing: **Pitman Glass Company**
Architect: **Looney Ricks Kiss**
Manufacturer: **Quaker Window**
Product category: **Historic window**

Products Used:

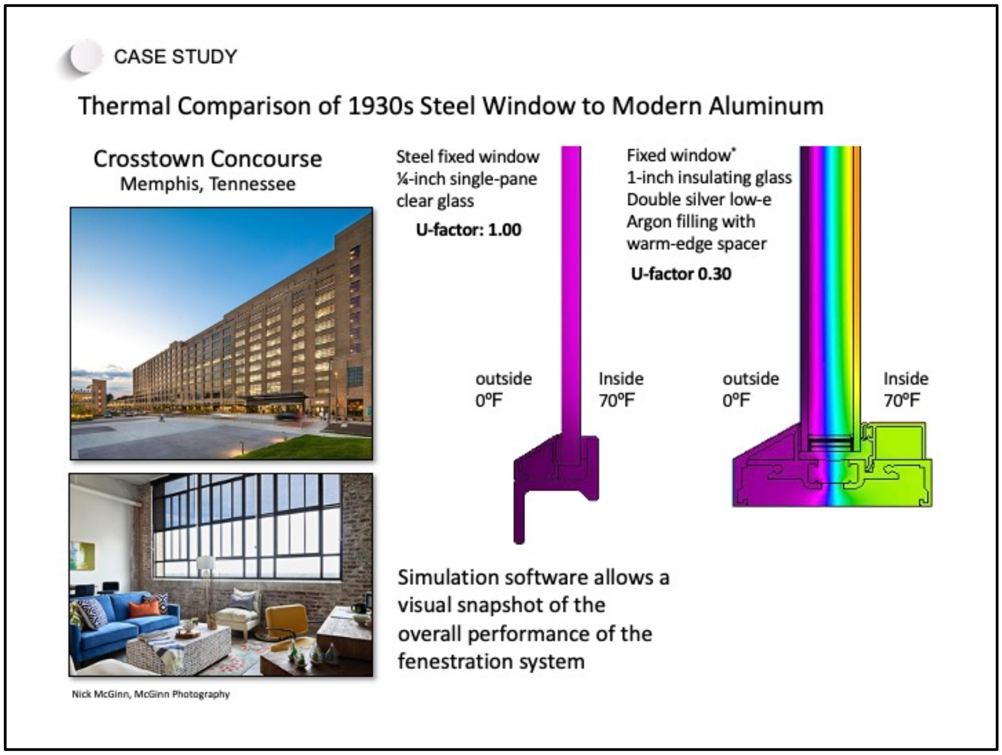
- Window Glazing is 1-inch insulated high performance with argon gas
- Mechanical lock, ½-inch-wide pour and debridge thermal break main frame and vent rail extrusions

https://crosstownconcourse.com/about/

*Data reporting by Arc dashboard

The Crosstown Concourse project achieved LEED Platinum in 2017.

Daylighting strategies and the recycling more than 65 million pounds of material, which was 94 percent of all waste produced during the construction demolition process, attributed to the Platinum certification.

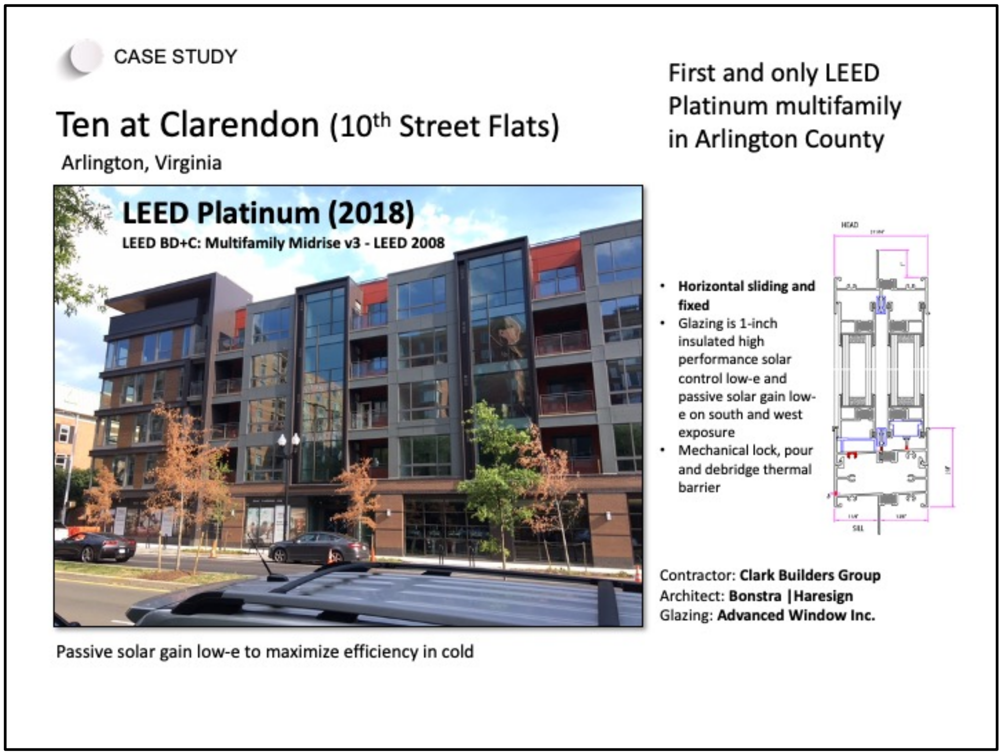


Modeling and thermal simulation software allows designers to see how changes in the profile design, thermal barrier material, and glazing options impact the overall performance of the fenestration system. The pour and debridge technology allows manufacturers to reach thermal-efficiencies levels never thought attainable in historic aluminum windows.

The first convention center in Tennessee to be certified LEED Silver for Existing Buildings from the USGBC and Green Certified through the TN Green Hospitality Certification program.

The Convention Center also includes a solar array.

- Knoxville Convention Center annually recycles approximately 16 tons of food and materials
- Largest city-owned solar voltaic system
- Energy retrofits provide the center with $165,000 in cost savings each year



Arlington County's Green Building Density Bonus Program incentive scheme was established in 1999 and has been consistently updated in step with the ever-evolving standards of LEED.

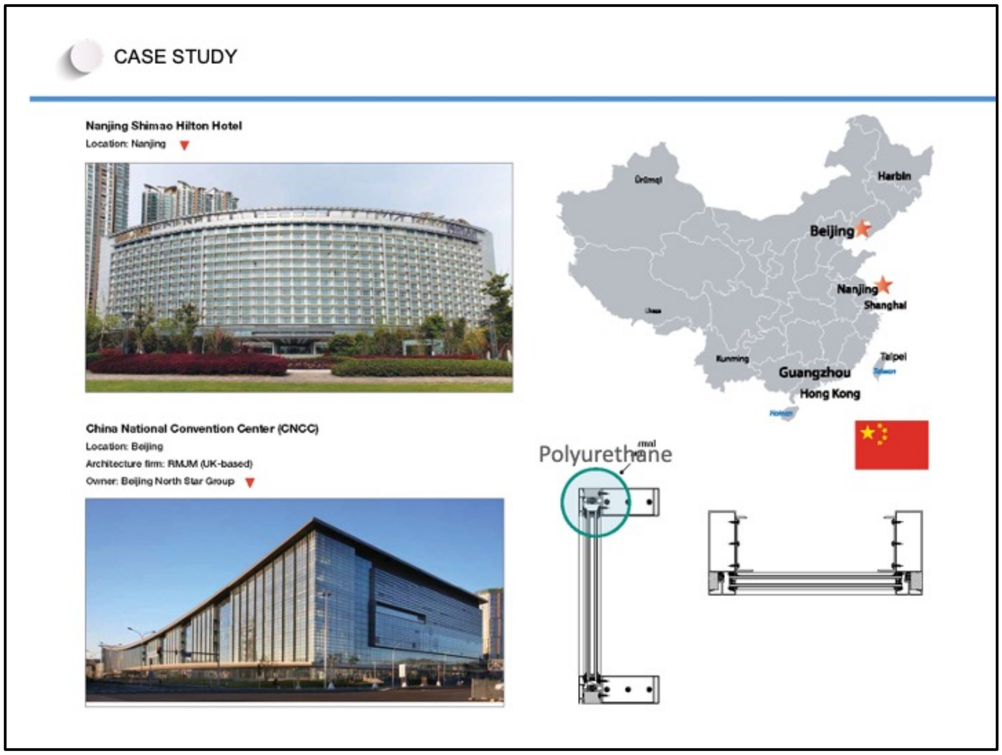
2019 Best in Green Awards (BIG) Winner
Type: Multifamily Market Rate
Project: Ten at Clarendon

For more information, please visit the official site of National Association of Home Builders

In 2016, Arlington County was named the nation's First Platinum-level county under the U.S. Green Building Council's newly created LEED for Communities program.

Note: The project location is less than 4 miles from the USGBC headquarters in Washington, D.C.

In this project located in Vancouver, the windows are actually different heights, changing in size from floor to floor to maximize natural daylight while reducing heat gain. The lowest office level gets the most shading from other buildings so has the biggest windows. The middle floor has a slightly lower floor-to-ceiling height. The windows on the top floor are the smallest and shaded by panels on the cornice, which wraps around the top of the building.



The 2008 Olympic venues in Beijing set sustainable standards for Beijing 2022.

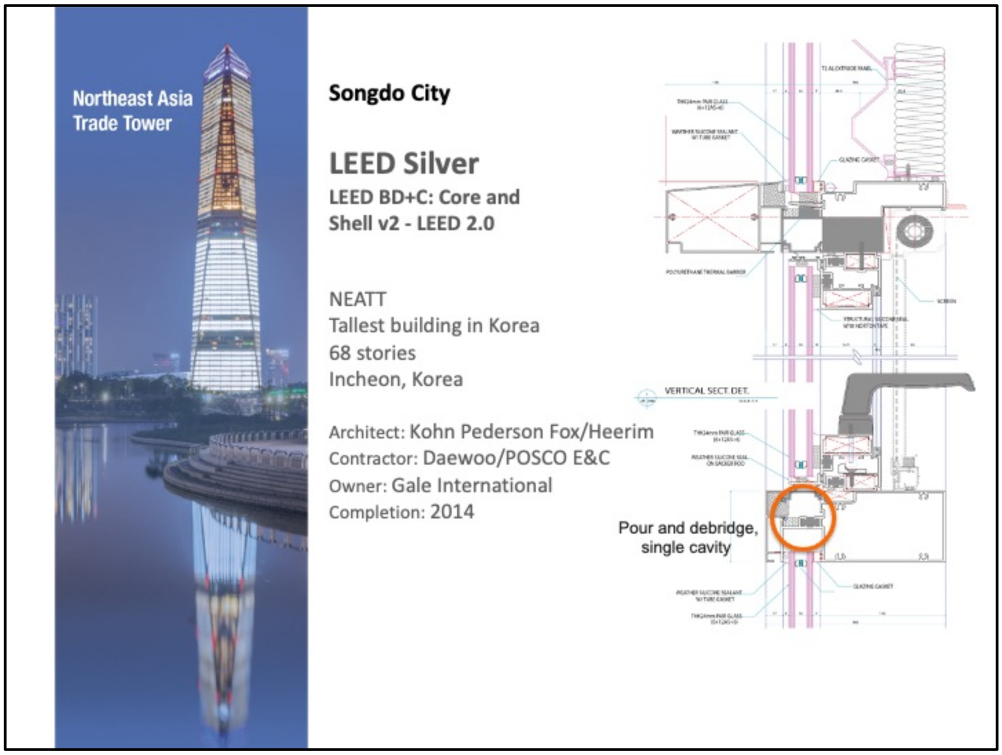
The largest conference venue in China, the China National Convention Center is still in use as an international convention and exhibition center.

The building is very well insulated with thermal barrier aluminum framing and energy-recovery systems to further boost efficiency. Natural light and ventilation are also used to advantage.

China Hits Milestone with More Than 1,000 LEED-Certified Projects

The L & H project implements numerous green and sustainable products and methods, including high-performance building envelope materials. The dual-cavity, double pour system utilizes a mechanical lock to provide the highest structural shear value in any curtain wall assembly—an ideal fenestration product for use in the monumental Korean master plan project exceeding the Passive House standards planned for Korea in 2016.

Architectural firm: DRDS - Seoul, in collaboration with Mooyoung and Tomoon Architects



In this LEED Silver project in Songdo City, the most modern advanced framing and glazing system components where developed for the Northeast Asia Trade Tower to help the building reduce energy loss and costs. Most of the other projects in the massive complex feature similar fenestration designs.

This concludes The American Institute of Architects Continuing Education Program.

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