How Windows Are Designed, Tested, and Rated for Comfort and Energy Efficiency

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Course Description

- Buildings consume 40 percent of all the energy used nationwide.
- Achieving optimal energy efficiency in buildings can drastically reduce overall energy consumption.
- Windows can play a key role in achieving improved performance.

Learning Objectives

After completing this course, you should be able to:

- Describe how window performance improves the building's comfort and energy efficiency.
- Explain how the National Fenestration Rating Council (NFRC) tests and rates windows.
- Discuss how the American Architectural Manufacturing Association (AAMA) tests and rates windows.
- Identify high-performance window technologies that increase energy efficiency and sustainability.
- Assess what criteria must be met for windows to contribute to various standards, codes, and voluntary practices for performance and energy efficiency.

Learning Objective 1

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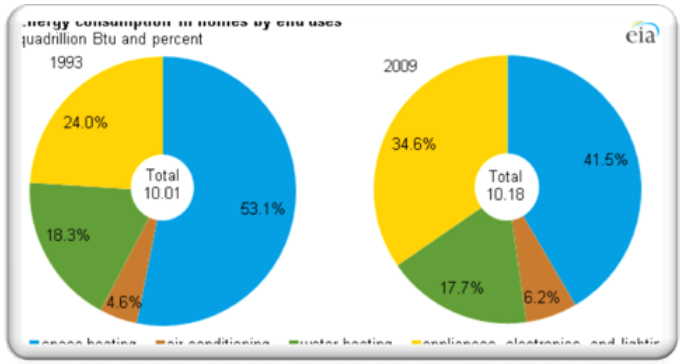


Role of Windows in Building Performance

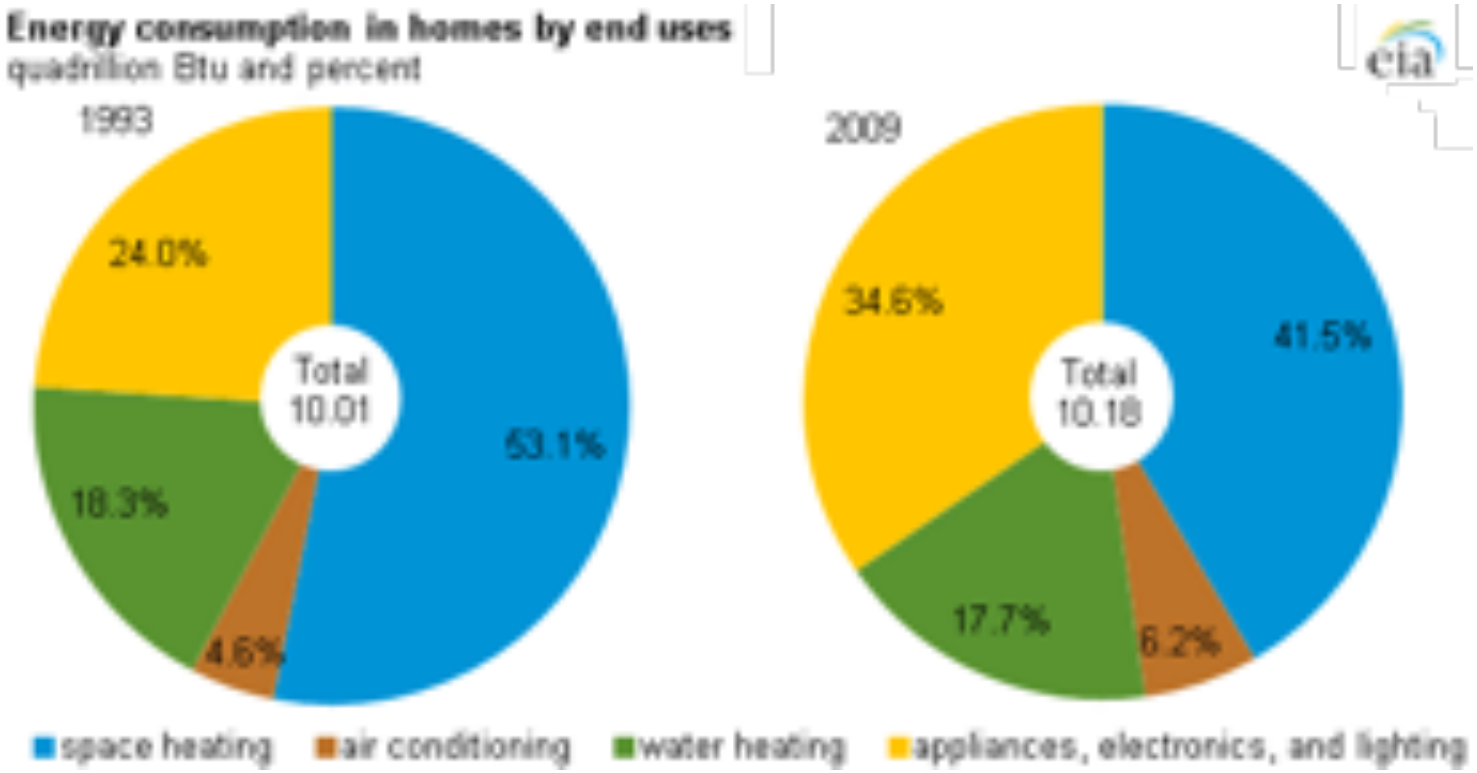
- Buildings consume 40 percent of all energy used nationwide.
- Windows play a key role in achieving energy efficiency.

Heat Sources

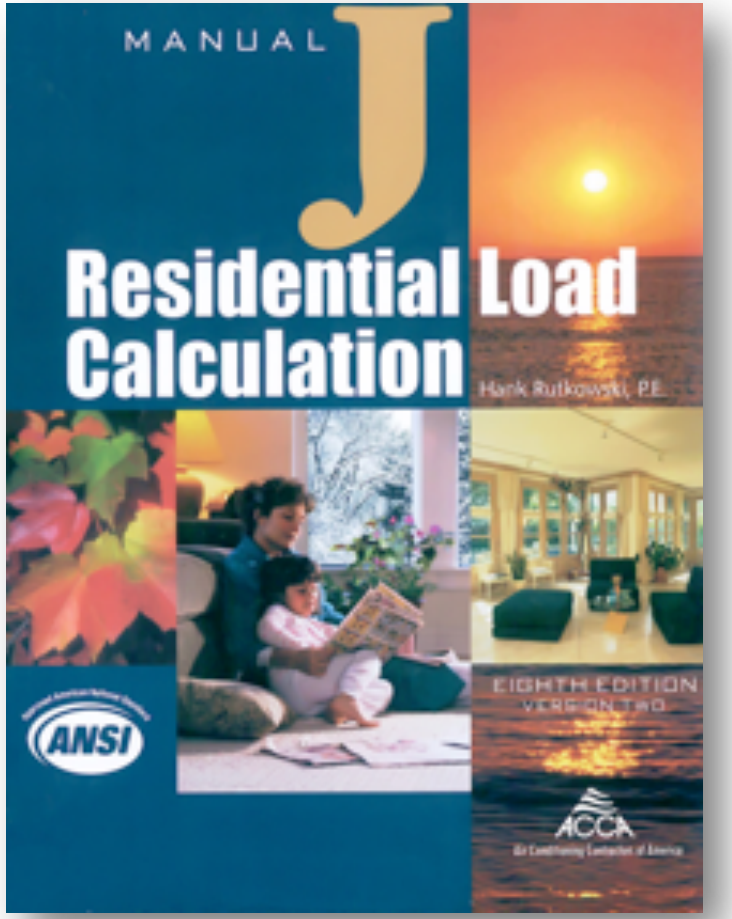
- Infiltration
- Natural ventilation
- Mechanical ventilation
- Air exchange rate

Daylighting for Comfort and Energy Savings

Primary Sources of Energy Consumption



Whole House and Manual J Calculations



- Developed by the Air Conditioning Contractors of America (ACCA)

Manual J and Window Orientation

Manual J Calculations and Windows

Learning Objective 2

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National Fenestration Rating Council (NFRC)

- A non-profit, public/private organization created by the window, door, and skylight industry
- All major standards and programs for window energy efficiency base their criteria on NFRC ratings
- Certification and labeling program for products

NFRC

National Fenestration Rating Council®

NFRC

NFRC Mission Statement

NFRC develops and administers energy-related rating and certification programs that serve the public by providing fair, accurate, and credible information on fenestration performance.

NFRC Vision

NFRC is the leader in energy performance information, education, and certified ratings for fenestration products.

NFRC Label

- Certifies that a window has been tested by an independent third party
- Helps determine whether performance values on label meet building energy codes
- ENERGY STAR compliant residential windows must be NFRC certified

NFRC Label

Examples

NFRC Label


Understanding the NFRC Label
NFRC
National Fenestration Rating Council®
U-factor measures the heat from INSIDE a room that can escape. The lower the number the lower the potential for wasted heating expenses.
Visible Transmittance measures how much natural light can come into a room -- a HIGH number means more natural light.
Solar Heat Gain Coefficient measures the amount of OUTDOOR heat that can enter a room. The lower the number, the lower the potential for wasted cooling expenses.
Air Leakage measures how much air will enter a room through the product. The lower the number, the lower the potential for draft through the product.
This image mirrors the four sections of the certified NFRC Label, providing the consumer with visual illustrations of what the label ratings mean. More in-depth information on the NFRC Label and purchasing the best possible windows, visit
www.WindowRatings.org
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Solar Heat Gain Coefficient (SHGC)

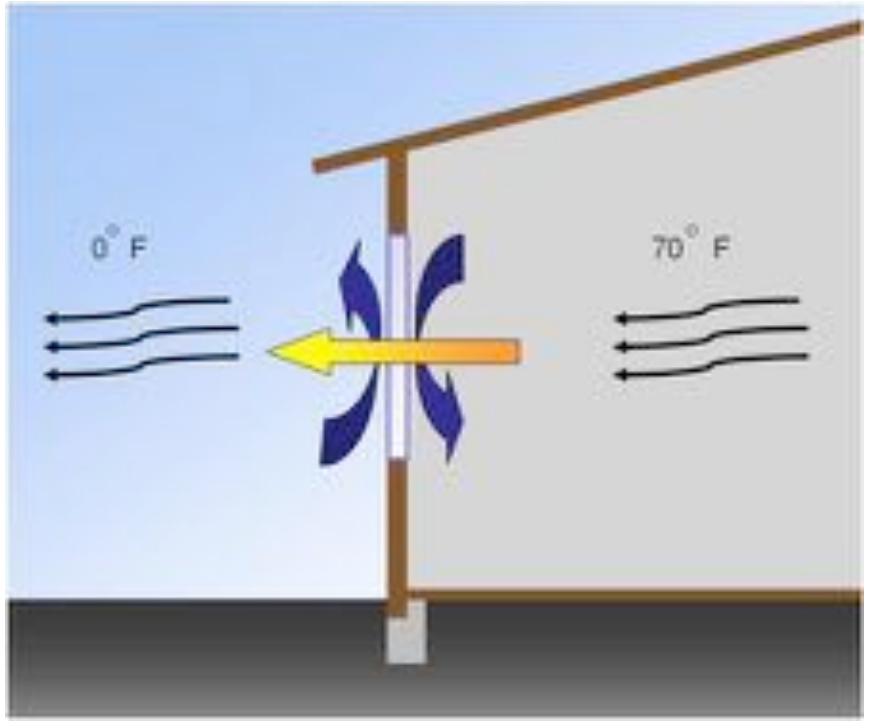
- SHGC measures how well window blocks heat from the sun.
- It is expressed as a number between 0 and 1 (i.e., 0.22)
- The lower the SHGC, the less solar heat is transmitted into the building.
- SHGC can be improved by using an energy-efficient glass, such as Low E2 or Low E3 glass.

Solar Heat Gain Coefficient (SHGC)

- Balancing SHGC depends on climate, orientation, and shading conditions.
- Northern climate such as Seattle may require a higher SHGC, such as 0.40.
- Southern climates such as Palm Springs may require a lower SHGC, such as 0.25.

U-Factor

- U-factor is the rate of heat loss in a window assembly.
- Typical ratings fall between 0.20 and 1.20:
  - ENERGY STAR South = 0.35
  - ENERGY STAR North = 0.30
- The lower the U-factor, the greater a window's resistance to heat flow.
- U-factor is usually expressed in Btu/h ft^2 F.



U-Factor

Improve U-factor by using:

- Energy-efficient glass
- High-performance spacers
- Argon gas
- Dual- and triple-pane glass
- Various frame options

Visible Transmittance (VT)

- VT measures the amount of visible light that passes through the glazing material of a window, door, or skylight.

- Products with a higher VT transmit more visible light.

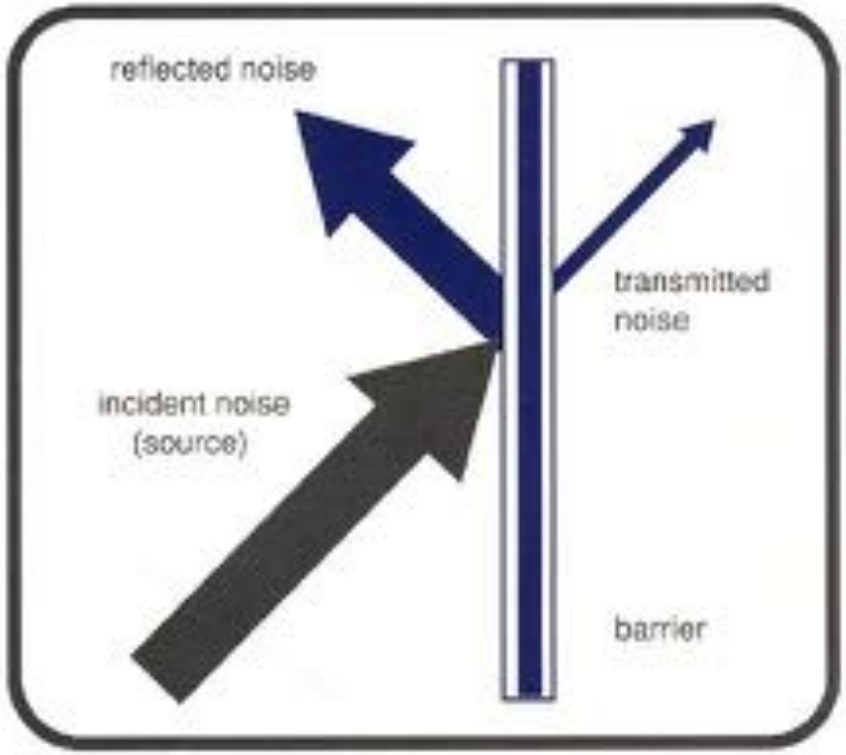
Visible Transmittance (VT)

- Visible light transmittance (VLT) measures center of glass only and is expressed as a number between 0 and 1.
- The numbers in the chart represent the center of the glass; the frame and grids will reduce transmittance.

Product	Visible Light Transmittance %
Double pane, clear	0.82
LoE^2-270	0.70
LoE^3-366	0.66

Sound Transmission Class (STC)

- Sound transmission is sound traveling through air and transmitting through a material, assembly, or partition to become noise.
- STC is single-number rating of a material's or assembly's ability to resist airborne sound transfer at frequencies of 125–4,000 Hertz.
- Typical dual-glaze windows have a standard STC rating between 29 and 35.



Sound Transmission Class (STC)

- STC can be improved in dual-glaze windows by varying thicknesses of glass.
- Sound-control windows can be used to produce an STC of 41–48 with dual-glazed primary panel and a secondary single-glazed panel.
- To minimize costs, specify sound-control windows only for the side of a building where sound issues are most prevalent.

Air Leakage (AL)

- AL is a measure of the rate of air leakage around a window, door, or skylight in presence of a specific pressure difference.
- It is expressed in units of cubic feet per minute per square foot of frame area (cfm/sq ft).
- The lower a window's air-leakage rating, the more airtight it is.

Condensation

- Interior condensation on window and door surfaces is caused by high humidity and low air exchange inside the home.

- To reduce interior condensation:
  - Reduce moisture sources.
  - Increase ventilation.

Condensation Resistance (CR)

- CR measures how well a window resists the formation of condensation on the inside surface
- It is expressed as a number between 1 and 100.
- Frame materials and spacers can effect condensation rating.

Learning Objective 3

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American Architectural Manufacturers Association

American Architectural Manufacturer's Association (AAMA)

The AAMA's North American Fenestration Standard (NAFS) defines basic performance requirements for a wide variety of styles and materials, including:

- Double-hung
- Casement
- Horizontal sliding
- Aluminum
- Vinyl (PVC)
- Fiberglass
- Wood

American Architectural Manufacturers Association

AAMA/WDMA/CSA 101/I.S.2/A440:
North American Fenestration Standard (NAFS)

Performance Grade

- The product type defines the operating style of the window.
- The Performance Class of window defines for which type of project a window is best suited.

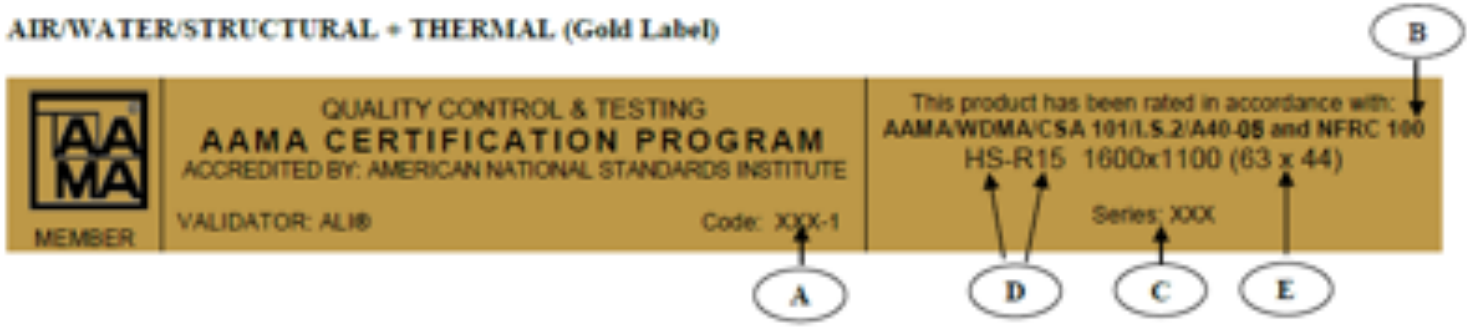
Performance Class	
R	Residential
LC	Light Commercial
CW	Commercial
AW	Architectural

Performance Grade

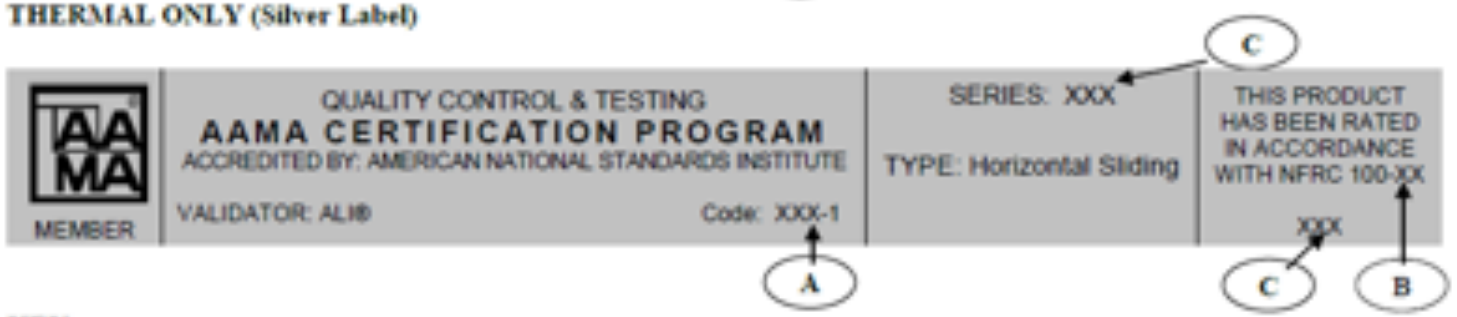
- Design pressure
- Product type
- Performance class
- Water and air infiltration

Performance Grade

AIR/WATER/STRUCTURAL + THERMAL (Gold Label)



THERMAL ONLY (Silver Label)



KEY:

A = Manufacturer's Code Number. As an option, manufacturer may show company name in addition to the required Manufacturer's Code Number.
B = Specification Identification (AAMA/WMDA/CSA 101/I.S.2/A440-05) (NFRC 100-01)
C = Manufacturer's Series Number
D = Product, Class, Grade
E = Maximum Size Tested

Performance Grade

AIR/WATER/STRUCTURAL + THERMAL (Gold Label)

THERMAL ONLY (Silver Label)

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Performance Grade

- Performance Grade has replaced Structural Rating.
- PG tests air infiltration, water infiltration, and structural load.
- NAFS-11 refers to a product's overall rating as a Performance Grade.

Design Pressure (DP)

- Design pressure (DP) is the amount of wind pressure a window can withstand.
- Project DP ratings are determined by structural engineers.

Performance Grade

A product achieves a Performance Grade rating only upon successful completion of all applicable tests, primarily those for:

- Structural performance under wind loading
- Resistance to water penetration
- Resistance to air leakage

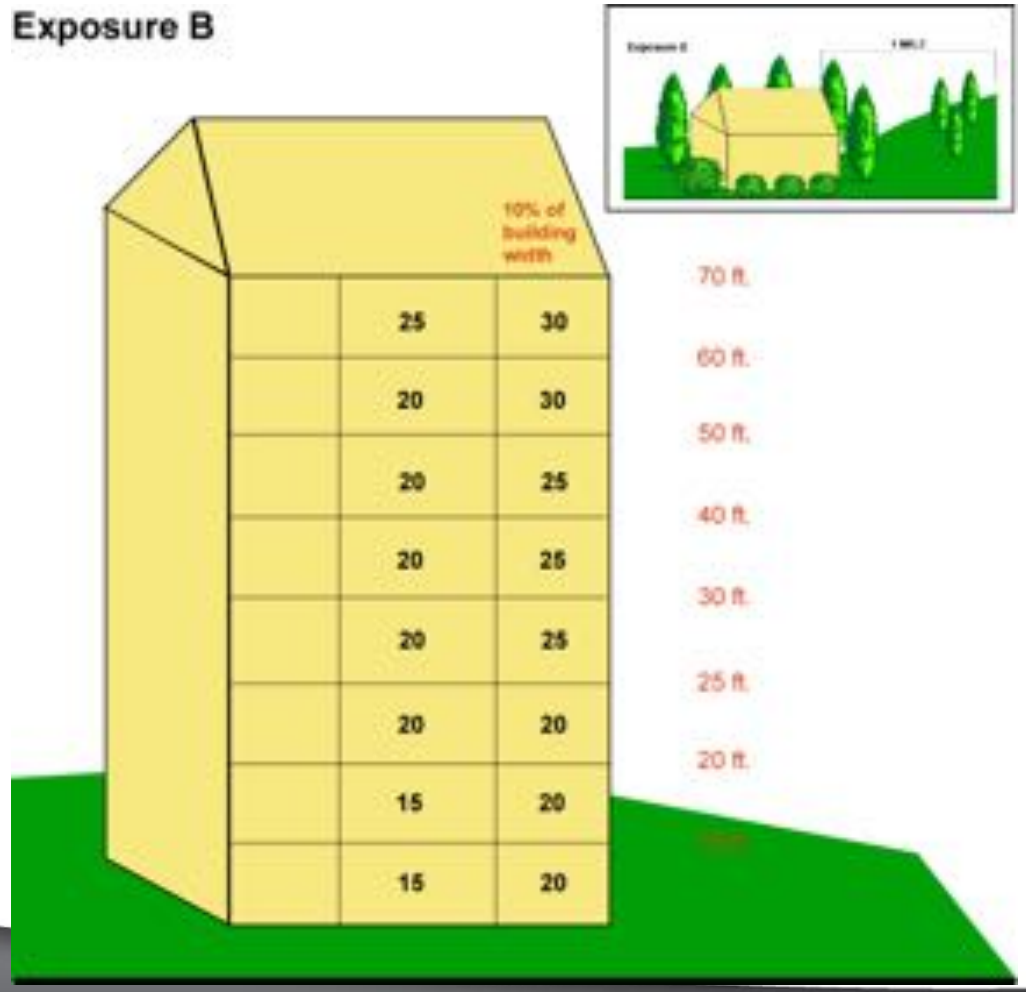
	PG Rating	Wind Speed
R	15 PSF (720 Pa)	78 mph
LC	25 PSF (1200 Pa)	100 mph
CW	30 PSF (1440 Pa)	110 mph
AW	40 PSF (1920Pa)	127 mph

Exposure Ratings

- Exposure ratings are taken from American Society of Civil Engineers (ASCE) 7–10. They are the minimum design loads for buildings and other structures.

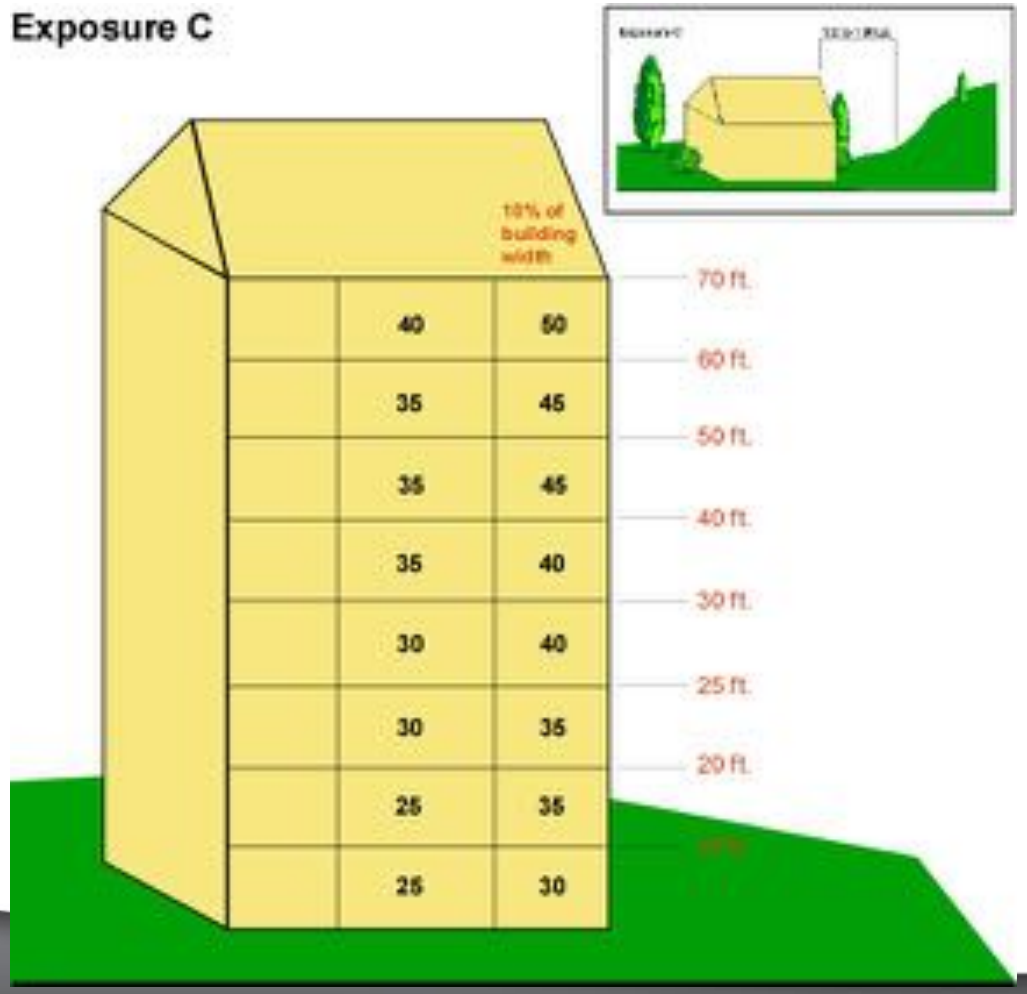
- It is up to the structural engineer to determine what the design pressure rating is for exposure ratings.

Exposure Rating B



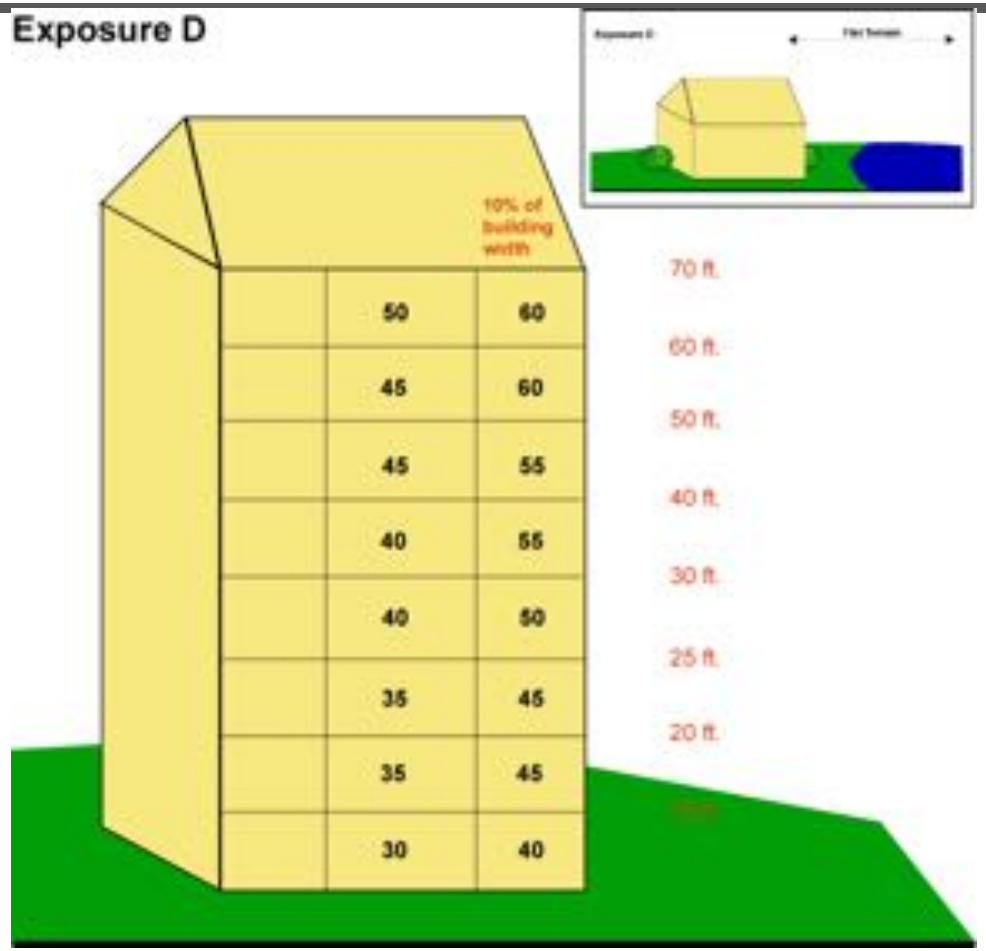
Exposure Rating B has terrain with buildings, forest, or surface irregularities covering at least 20 percent of the ground-level area and extending 1 mile or more from the site.

Exposure Rating C



Exposure Rating C has terrain that is flat and generally open, extending ½ mile or more from the site in any direction.

Exposure Rating D



- Exposure Rating D has wind zones of 80 mph or greater and terrain that is flat and unobstructed, facing a large body of water over 1 mile in width relative to any direction from the building.
- Exposure D extends inland from the shoreline ¼ mile.

Learning Objective 4

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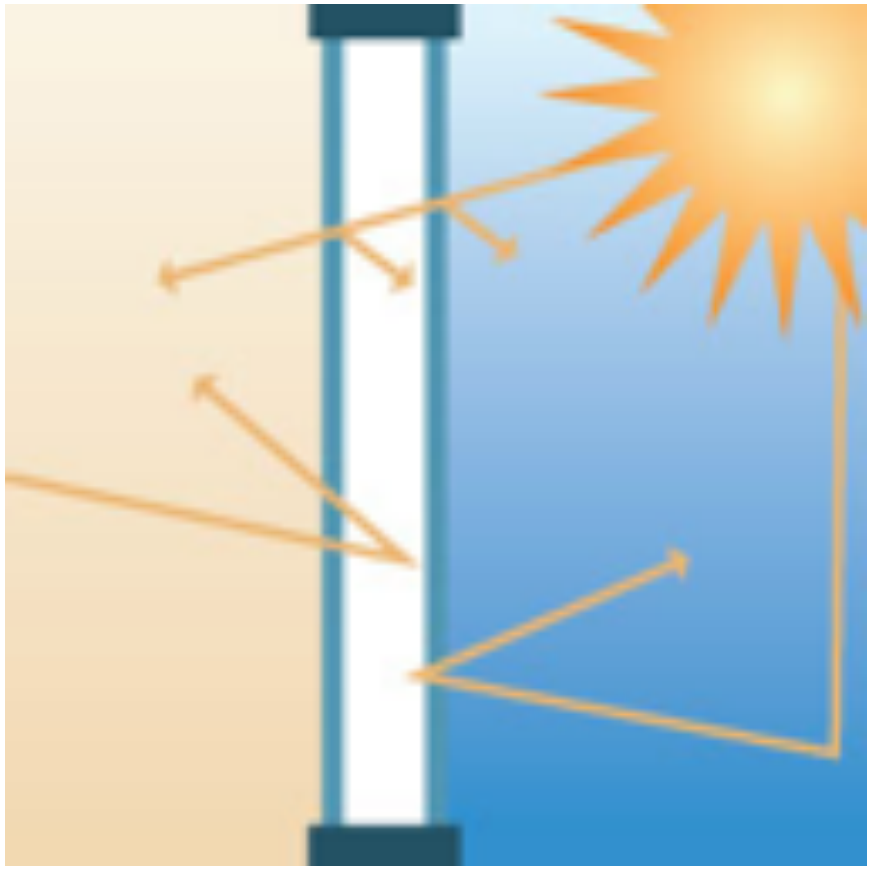
Improving Energy Performance

There are two approaches to improving energy performance:

- Apply coating to glazing material.
- Assemble layers of glazing and control properties of spaces between layers.

Low-E Coatings

- Allows maximum visible light while preventing heat from direct sunlight
- Prevents heat from entering during the summer
- Keeps heat in the building during the winter



Low-E Coatings

Glass Unit Spacers

- Layers of glazing are held apart by window spacers.
- Window spacers provide energy and sound insulation.
- Aluminum spacers conduct heat and can cause condensation.

Glass Unit Spacers

Innovative new spacers:

- Constructed of less-conductive material, such as stainless steel and foam
- Shape of spacer can reduce condensation and reduce heat loss

Argon Gas

- Thermal performance is improved by reducing the conductance of air space between layers of insulating glazing units (IGUs).
- In the past, the space was filled with air or flushed with dry nitrogen prior to sealing.
- Heat rose to the top, and cold pooled at the bottom.

Argon Gas

Argon gas is:

- Less conductive and more viscous than air
- Minimizes convection currents and transfer of heat
- Inexpensive
- Non-toxic
- Non-reactive
- Clear
- Odorless

Frame Type

- Aluminum
- Thermally broken aluminum
- Vinyl
- Fiberglass
- Wood
  - Aluminum clad
  - Vinyl clad
  - Fiberglass clad

Frame Type

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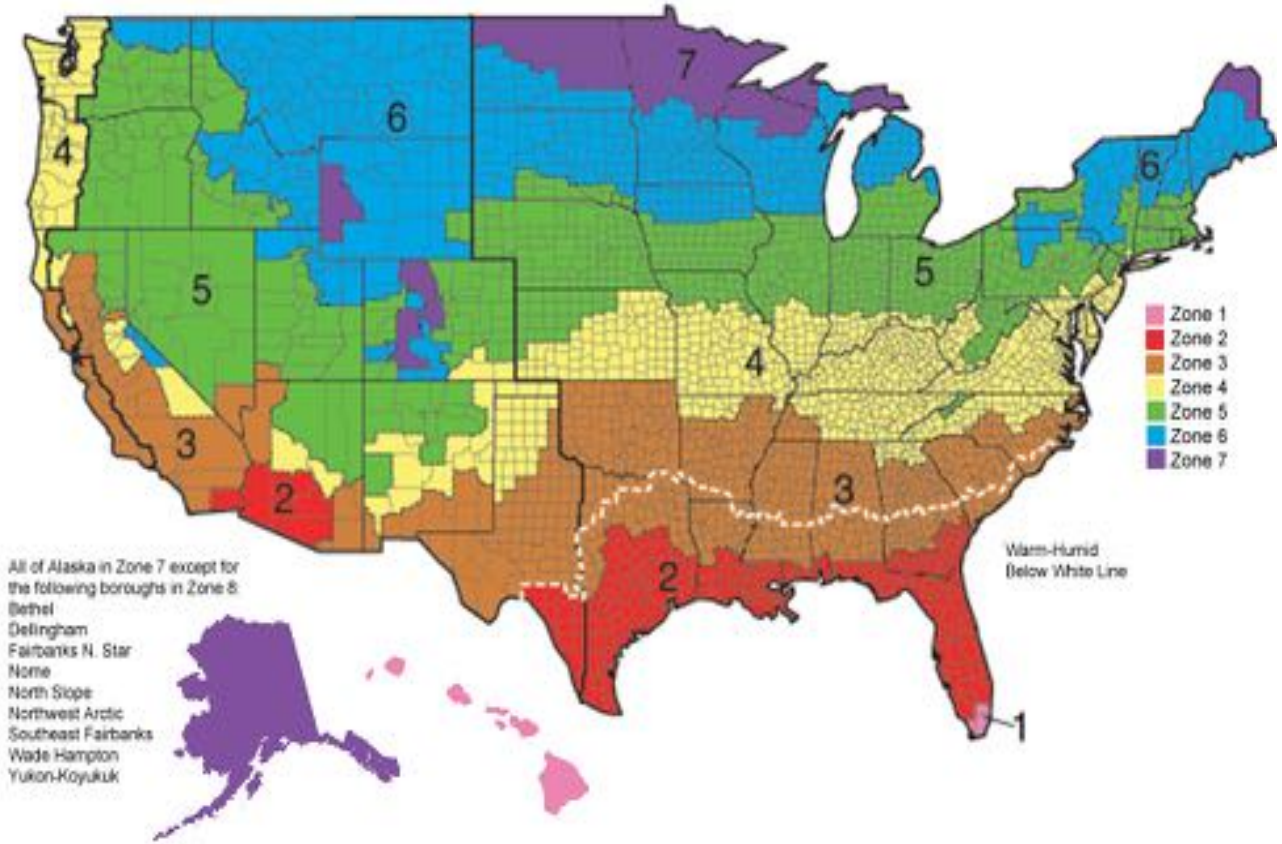
International Code Council (ICC)

- The International Code Council (ICC) is the most widely used set of model codes.
- The 2015 edition of the code (IECC 2015) has begun to gain traction, and several states have full or limited adoption.
- The ICC website (www.iccsafe.org) offers updated information on which edition of its codes is in effect in each state and various cities and counties around the country.

ICC INTERNATIONAL CODE COUNCIL®

People Helping People Build a Safer World™

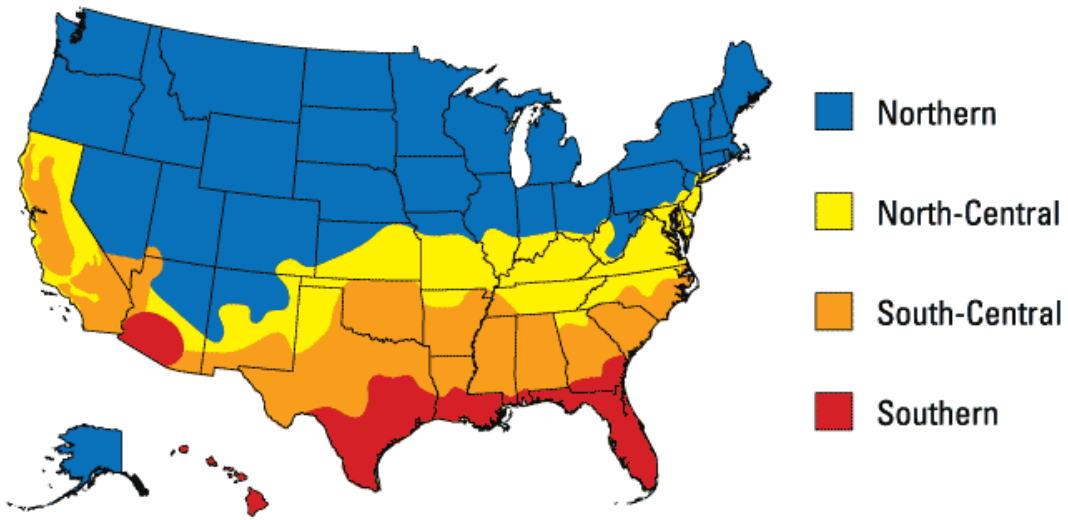
IECC 2015



Climate Zone	U-Factor	SHGC
1	NR	0.75
2	0.40	0.65
3	0.35	0.55
4 except marine	0.35	0.55
5 and marine 4	0.32	0.55
6	0.32	0.55
7 and 8	0.32	0.55

ENERGY STAR

ENERGY STAR v6.0 – Fully effective January 1, 2016



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	

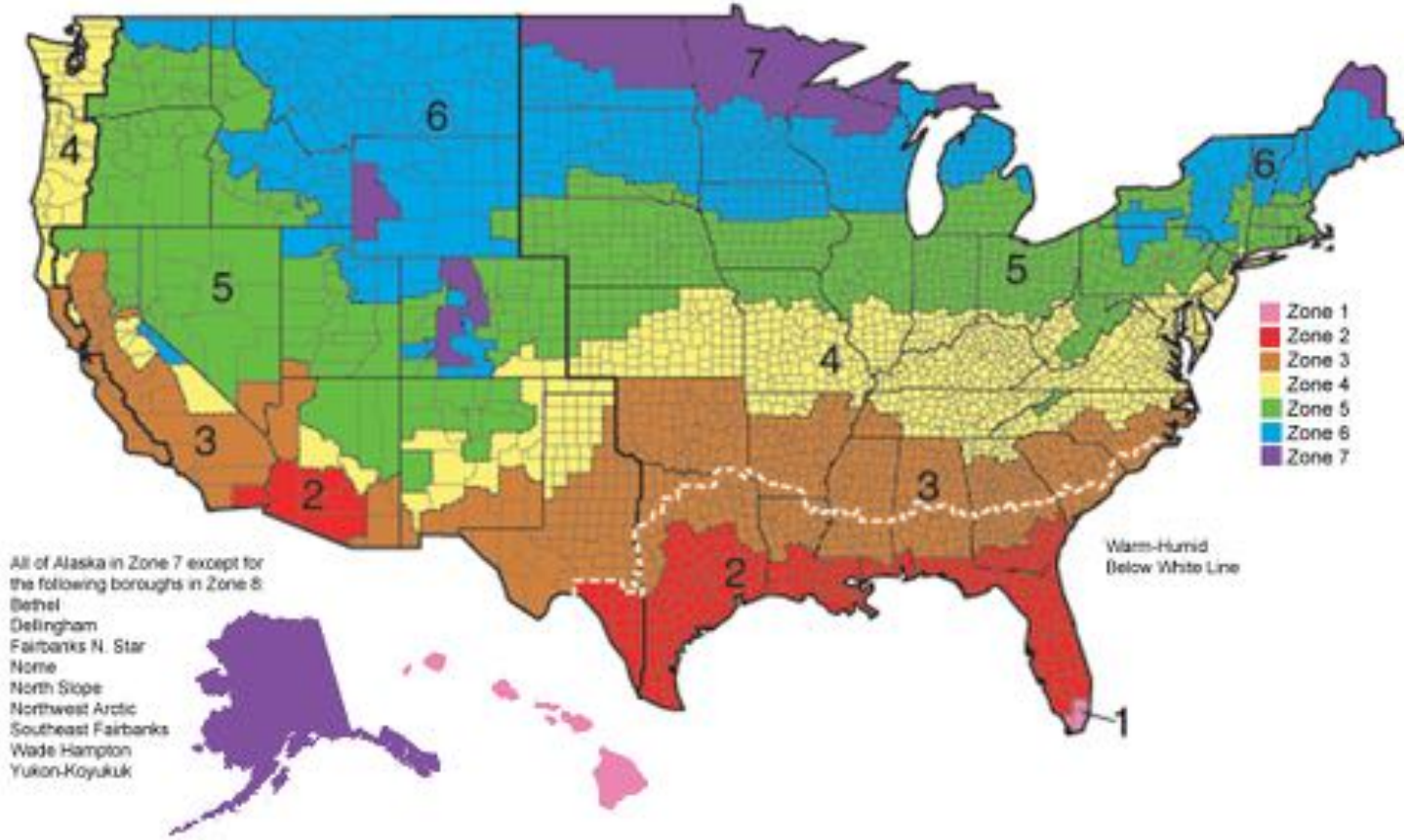
LEED

- Administered by the U.S. Green Building Council
- Voluntary rating system encouraging sustainable green building and development practices
- Windows play important role in obtaining green building certification:
  - Optimize energy performance
  - Increase ventilation
  - Use of low-emitting materials
  - Use of recycled content

LEED BD+C: Homes, Version 4

- There are three possible points in the Windows Credit category.
- The intent is to maximize the energy performance of windows.
- The requirements are to design and install windows, skylights, and glass doors whose ratings from the National Fenestration Rating Council exceed the requirements in the ENERGY STAR for Homes, Version 3, Prescriptive Pathway.

Window-to-Floor-Area and LEED Window Credit



Net-Zero Building

- A building that produces as much energy as it consumes in a year
- Reduced carbon emissions and dependence on fossil fuels
- Often off-grid
- Energy harvested on-site from renewable energy sources

- High efficiency windows can contribute:
  - Daylighting
  - Stable internal temperatures
  - Natural ventilation

Conclusion

- Achieving optimal energy efficiency in buildings can drastically reduce overall energy consumption.
- Windows can play a key role in achieving improved building performance.
- Window energy and performance ratings help educate architects, contractors, and other specifiers.
- Building energy codes, standards, and voluntary practices exist to provide a target for achieving recognized and acceptable levels of energy efficiency.

Thank You

Thank you for your interest in this course.

Please contact Milgard Windows & Doors directly with questions:

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