

Windows and Energy Efficiency for Northeastern Homes

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Nils Petermann
ewc@ase.org

Alliance to Save Energy – Efficient Windows Collaborative
www.ase.org

www.efficientwindows.org / www.commercialwindows.org



ALLIANCE TO
SAVE ENERGY
Creating an Energy-Efficient World

Efficient Windows Collaborative



The Efficient Windows Collaborative (EWC) is a project by the Alliance to Save Energy and the University of Minnesota with funding from the U.S. Department of Energy and contributions from 82 industry and non-profit members.

In partnership with window, door, skylight, and component manufacturers, federal, state and local government agencies, research institutions, and others, the EWC seeks to expand the market for energy efficient window products.

Lead Organizations

- Alliance to Save Energy
- University of Minnesota
- Lawrence Berkeley National Laboratory
- More than 80 active industry and non-profit members

Acknowledgement: This material is based upon work supported by the Department of Energy, Lawrence Berkeley National Laboratory under Award Number DE-AC02-05CH11231.

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What is the Alliance to Save Energy?

The Alliance to Save Energy promotes energy efficiency worldwide to achieve a healthier economy, a cleaner environment and greater energy security.

- Non-profit organization headquartered in U.S.; operations world-wide
- Led by **Senator Jeanne Shaheen (D-NH)** and **Peter Darbee, Chairman of the Board, Retired CEO and President, PG&E Corporation**
- Includes 13 Members of Congress – Bi-Cameral; Bi-Partisan
- Also includes environmental, consumer, and trade association heads, state and local policy makers, corporate executives



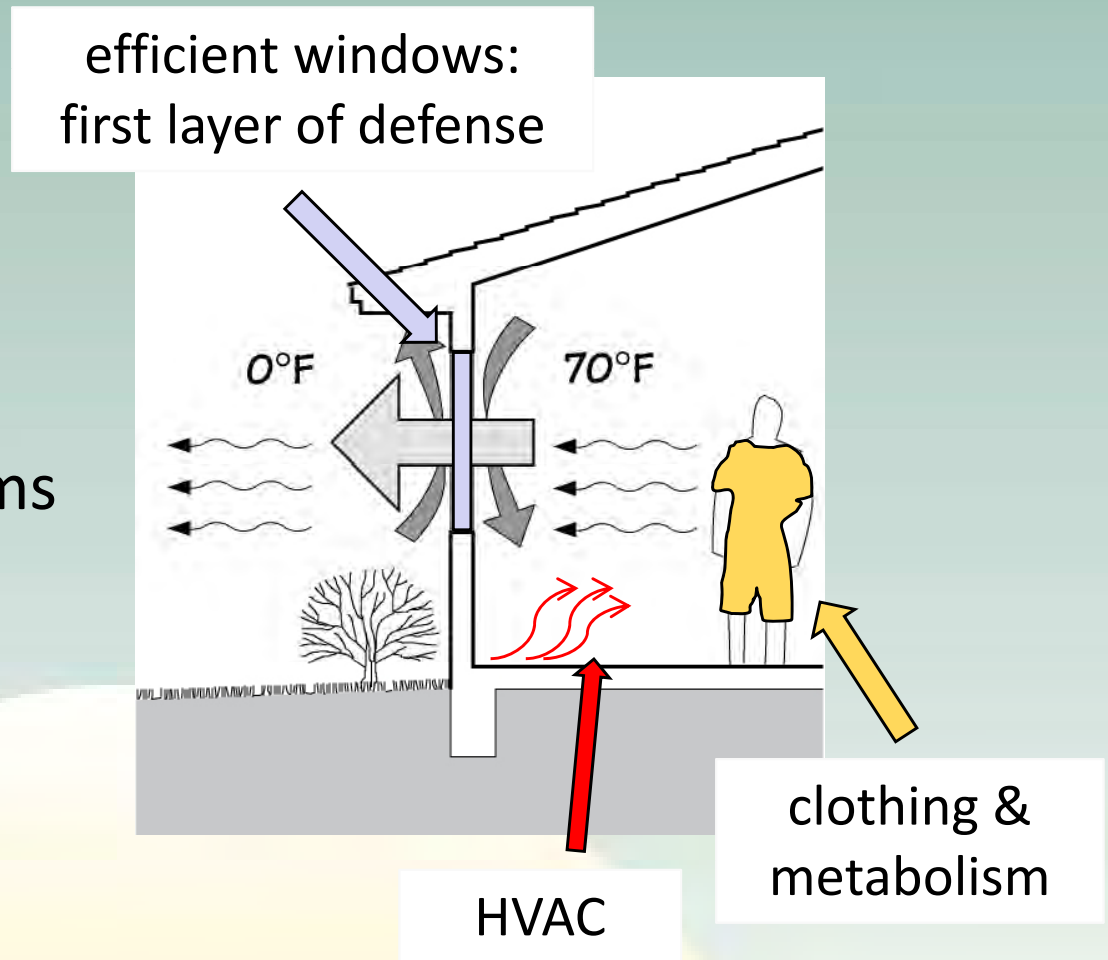
Presentation Topics

- Relevant window energy properties
- Design for cost-effective window energy efficiency
- Affordable high-performance options:
Department of Energy resources



What's the Big Deal About Efficient Windows?

- Windows are often a source of discomfort
- Mechanical heating and cooling = treating the symptoms
- Comfort from efficient windows simply a non-energy benefit?



Window Energy Properties Matter

And we've known it for quite a while



WWII, September 1942:

*“**Blackout insulation:** Fuel oil conservation. (...) Not only are these practical blackout shields, but you'll save one gallon of oil for each square foot of board used.”*

Source: Library of Congress

Relevant Window Energy Properties

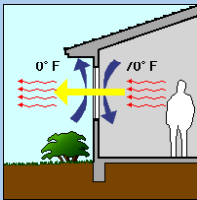
| | | |
|--|--|--|
|  | <p>World's Best Window Co. Millennium 2000⁺ Vinyl-Clad Wood Frame Double Glazing • Argon Fill • Low E Product Type: Vertical Slider</p> | |
| ENERGY PERFORMANCE RATINGS | | |
| U-Factor (U.S./I-P) 0.35 | Solar Heat Gain Coefficient 0.32 | |
| ADDITIONAL PERFORMANCE RATINGS | | |
| Visible Transmittance 0.51 | Air Leakage (U.S./I-P) 0.2 | |
| <p><small>Manufacturer stipulates that these ratings conform to applicable NFRCC procedures for determining whole product performance. NFRCC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRCC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information. www.nfrc.org</small></p> | | |

How do we know how a window performs?



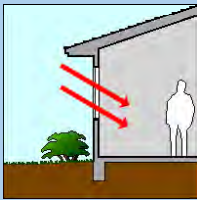
ENERGY STAR

Voluntary program with performance targets appropriate for each climate.



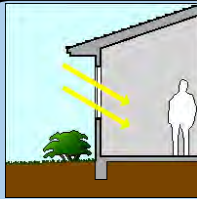
U-factor

Measures of insulating value
Lower = less heat loss



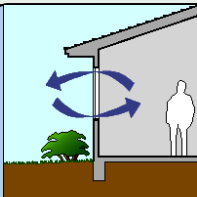
Solar Heat Gain Coefficient (SHGC)

Fraction of solar energy entering the window
Higher = more solar heat gain



Visible Transmittance (VT)

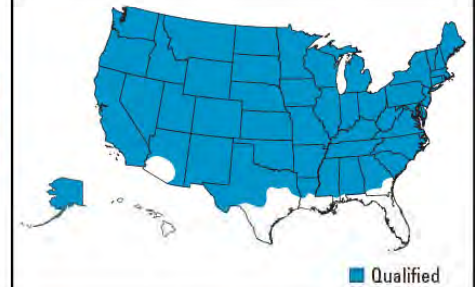
Fraction of visible light entering the window
Higher = more daylight



Air Leakage (AL)

Volume of air infiltration
Lower = less infiltration

ENERGY STAR® Qualified in Highlighted Regions



World's Best Window Co.

Millennium 2000+
Vinyl-Clad Wood Frame
Double Glazing • Argon Fill • Low E
Product Type: Vertical Slider

ENERGY PERFORMANCE RATINGS

U-Factor (U.S./I-P)

0.35

Solar Heat Gain Coefficient

0.32

ADDITIONAL PERFORMANCE RATINGS

Visible Transmittance

0.51

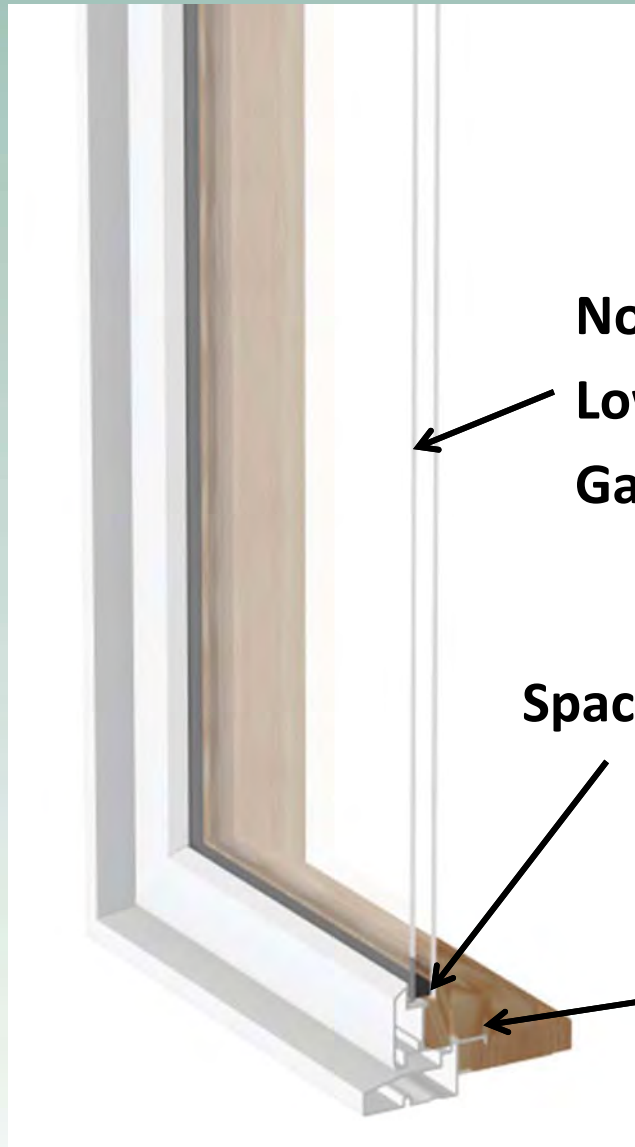
Air Leakage (U.S./I-P)

0.2

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. NFRC does not recommend any product and does not warrant the suitability of any product for any specific use. Consult manufacturer's literature for other product performance information. www.nfrc.org

**National Fenestration
Rating Council (NFRC) label**

What Goes Into a Window's NFRC Ratings?



No. of panes

Low-E coatings

Gas fill

Spacer Type

**Frame type
and design**

NFRC ratings = whole window values

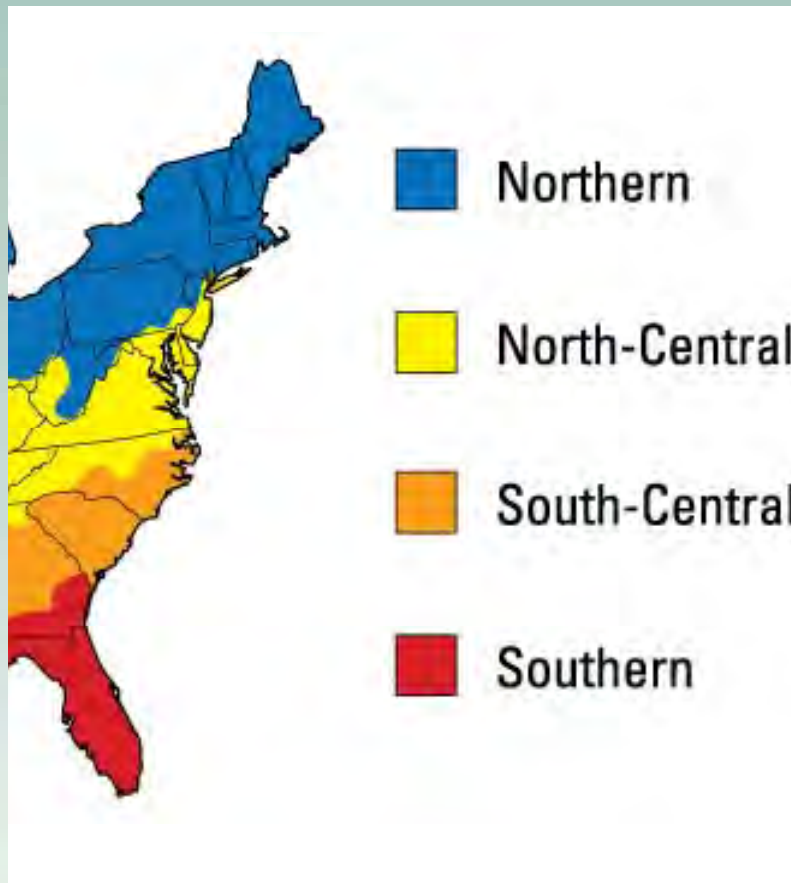
Careful:

Don't confuse NFRC ratings and center-of-glass values.

- Insulating glass generally has a lower U-factor and higher SHGC than whole windows.

NFRC labels always state whole-window ratings.

Window Energy Properties in the Northeast

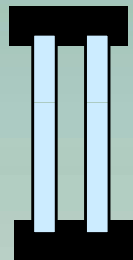


| Climate Zone | U-factor | SHGC |
|--|----------|-------------|
| ENERGY STAR | | |
| Northern Zone | 0.30 | any |
| <i>alternative criteria</i> | 0.31 | ≥ 0.35 |
| | 0.32 | ≥ 0.40 |
| North-Central Zone | 0.32 | 0.40 |
| 2009 IECC (International Energy Conservation Code) | | |
| Zones 4-8 | 0.35 | any |

- Windows with U-factor 0.30 or less encouraged across Northeast
- Optimum SHGC depends

Components of Energy Efficient Windows

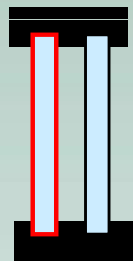
Ball-park impact on window properties



Conventional dual pane

U-factor: 0.45-0.55

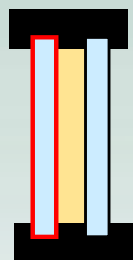
SHGC: 0.50-0.60



Dual pane low-E

U-factor: 0.30-0.40

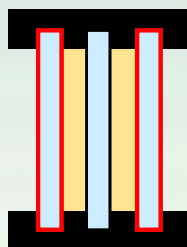
SHGC: low range <0.25
mid-range 0.26-0.40
high range >0.40



Dual pane low-E w/ argon

U-factor: 0.25-0.35

SHGC: same as w/o argon



Triple pane low-E w/ argon or krypton

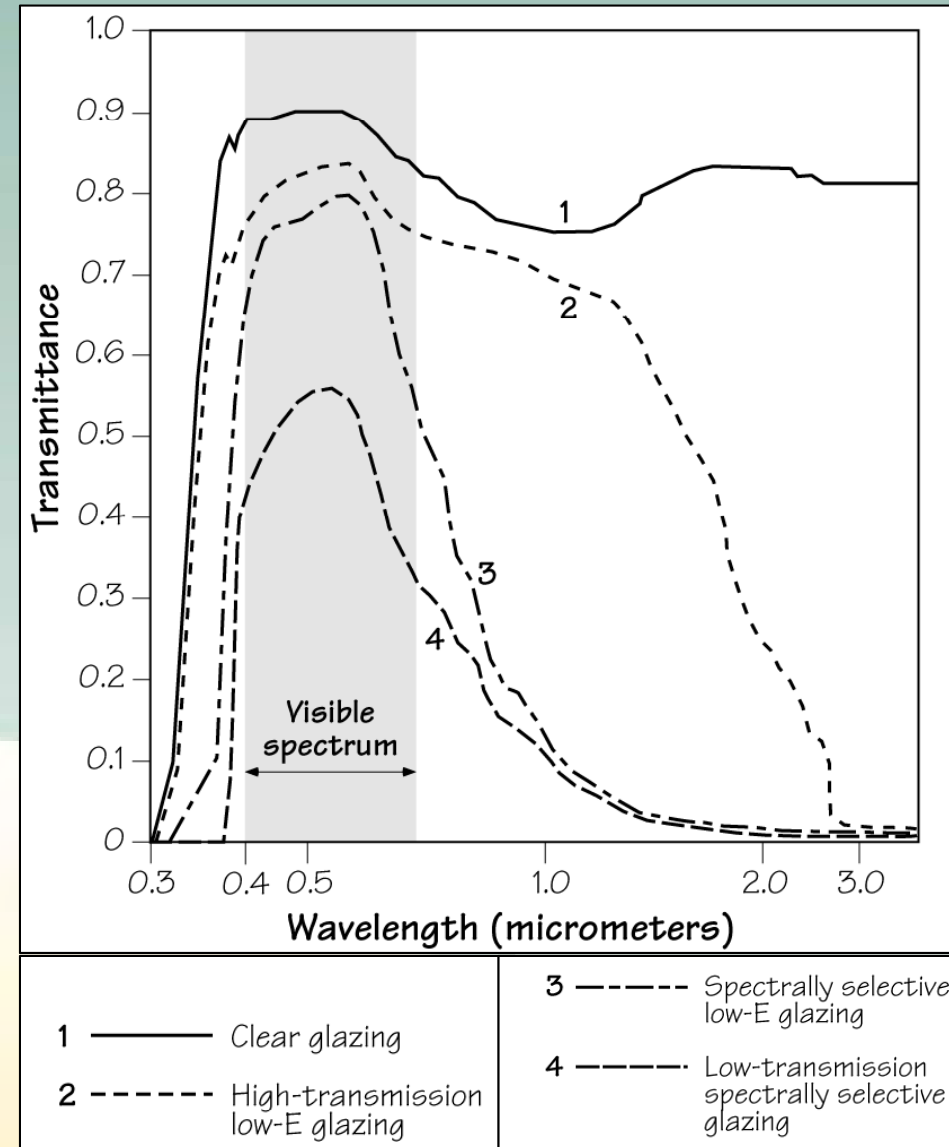
U-factor: <0.25

SHGC: high range >0.25
low range <0.25

Effect of Low-E Coatings

Low-E affects U-factor and SHGC

- Insulates
- Different coating types available for different SHGC
- Blocks ultraviolet light
- Looks similar to clear glass



How to Assess the Performance of Existing Windows?

- Where available, NFRC and ENERGY STAR labels are best performance indicators
- Without labels, some things can be checked:
 - Is there a energy code certificate on the electrical panel?
 - Is any other documentation available (e.g. invoices)?
 - Can you tell if there is a low-E coating (lighter trick, low-E detector)?
- Default window U-factor (absent other info):

| | Frame type | Single pane | Double pane |
|----------|------------------------|-------------|-------------|
| U-factor | Metal frame | 1.20 | 0.80 |
| | Nonmetal or metal clad | 0.95 | 0.55 |

Source: 2009 International Energy Conservation Code

Air Leakage

- Energy code limits air leakage to 0.3 cfm/ft²
 - Air leakage not typically included among NFRC ratings
 - Air/water/structural test standards (AAMA/WDMA/CSA 101/I.S.2/A4440) allow maximum air leakage of 0.3 cfm/ft²
- Air leakage changes over time
 - weatherstripping wears out
 - frame and sashes expand and contract with temperature and humidity changes
- Projecting windows (e.g. casements) usually shut tighter than sliding windows (e.g. double hung)
- Installation quality plays big role

Design for Cost-Effective Window Energy Efficiency



Basic Cost Considerations in Energy Efficient Window Design

Attention to solar heat gain

Low cost/
No cost



Orientation

Low-E choice based on SHGC

Can be
costly



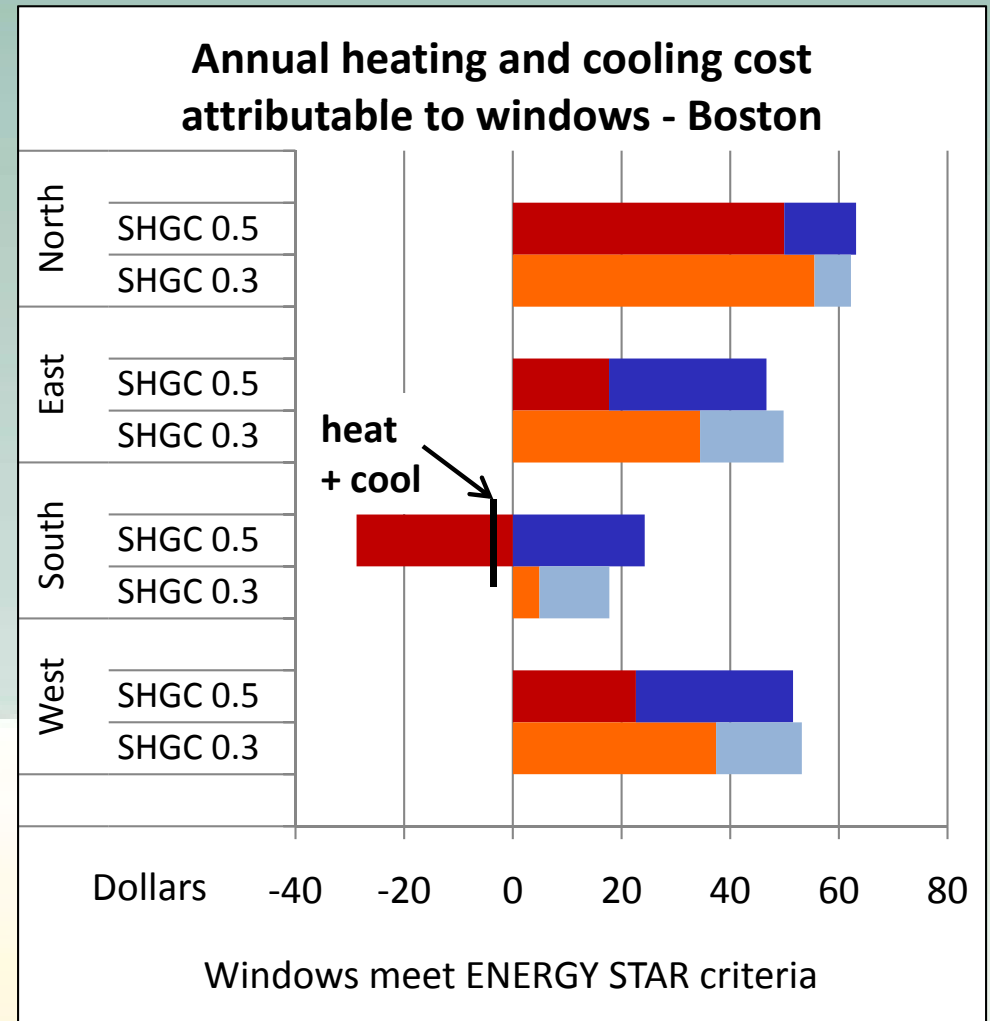
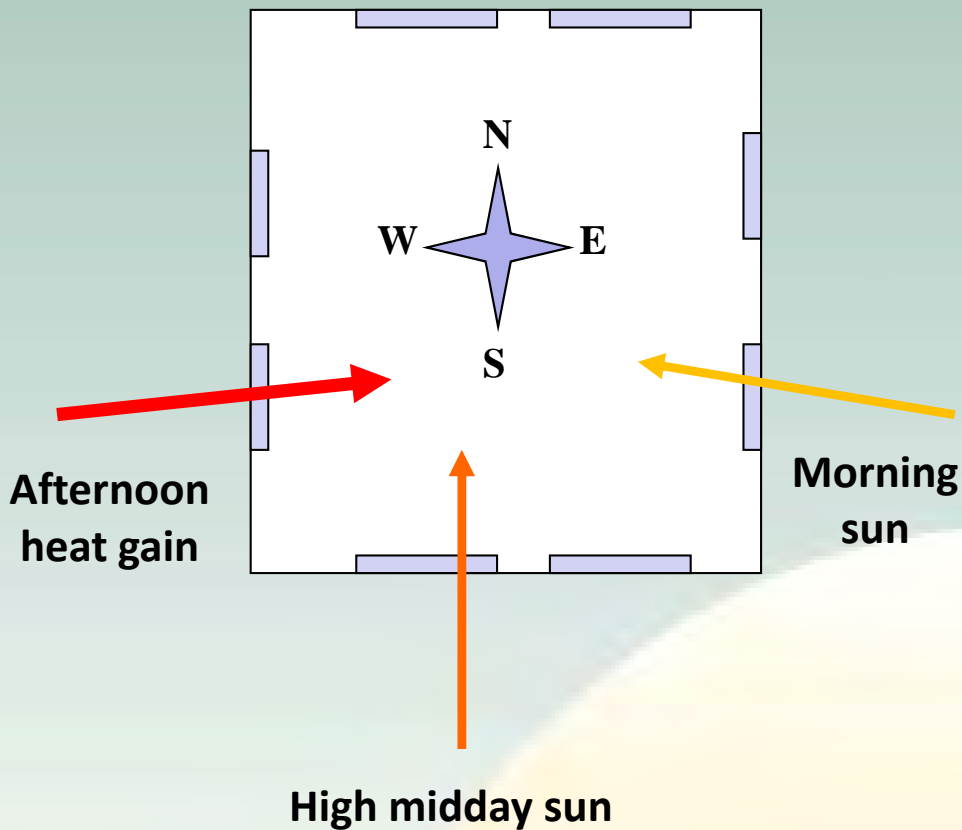
Minimize heat loss

Low U-factor windows

When considering costs and benefits, account for:

- comfort
- opportunities to downsize and simplify HVAC

Effect of Orientation & SHGC on Annual Energy



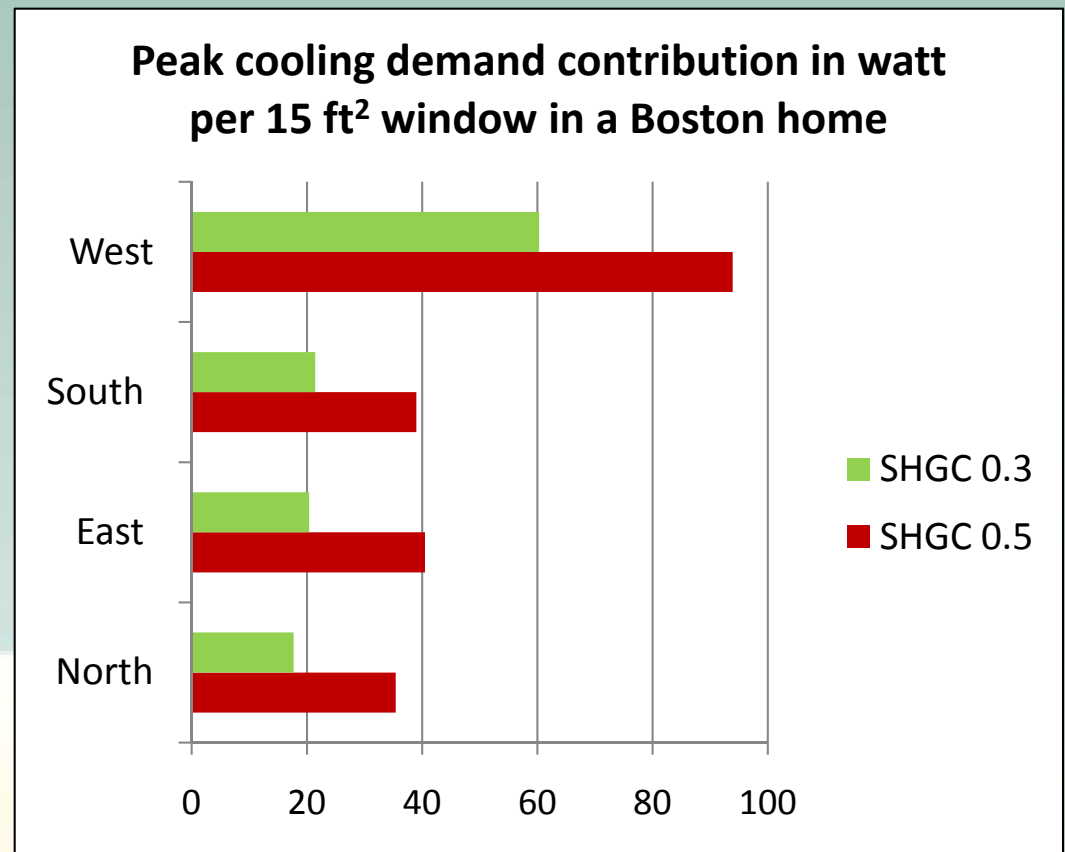
Simulated with RESFEN by **Lawrence Berkeley National Laboratory**. Costs are for 75 sq ft of windows on each side. \$1.51/therm of natural gas for heating, \$0.17/kWh for cooling.

Effect of Orientation & SHGC on Peak Cooling Demand

Window selection, orientation, and shading impact summer comfort and what size AC equipment (if any) is required.

Oversizing of HVAC systems should be avoided:

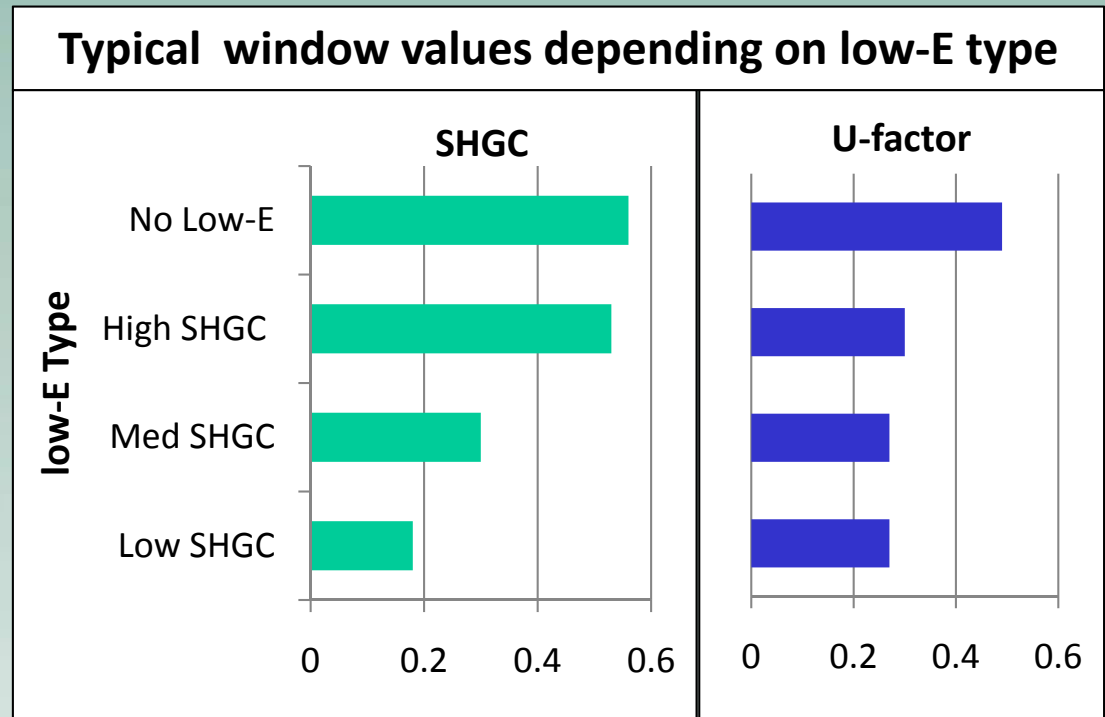
- Saves equipment cost
- Right-sized equipment runs more smoothly
 - Better against humidity
 - Better comfort



Simulated with RESFEN by **Lawrence Berkeley National Laboratory**. Windows meet ENERGY STAR criteria.

Sun-Tempered or Passive Solar Design

- Preference for **south-facing windows** and **summer shading** can be effective strategies for any house.
- True passive solar design (maximum solar heat gain through large southern glass areas with high SHGC) requires careful shading and thermal mass.
- Since first passive solar design strategies were developed, technologies and products have changed (better insulating windows and walls).
- Low-E windows for high solar heat gain and low U-factor are available.
 - but SHGC is rarely as high as 0.60



Useful DOE guide: <http://www.nrel.gov/docs/fy01osti/27954.pdf>

Insulate! What's a Good Window U-factor?

ENERGY STAR (Northern Zone): U-factor ≤ 0.30

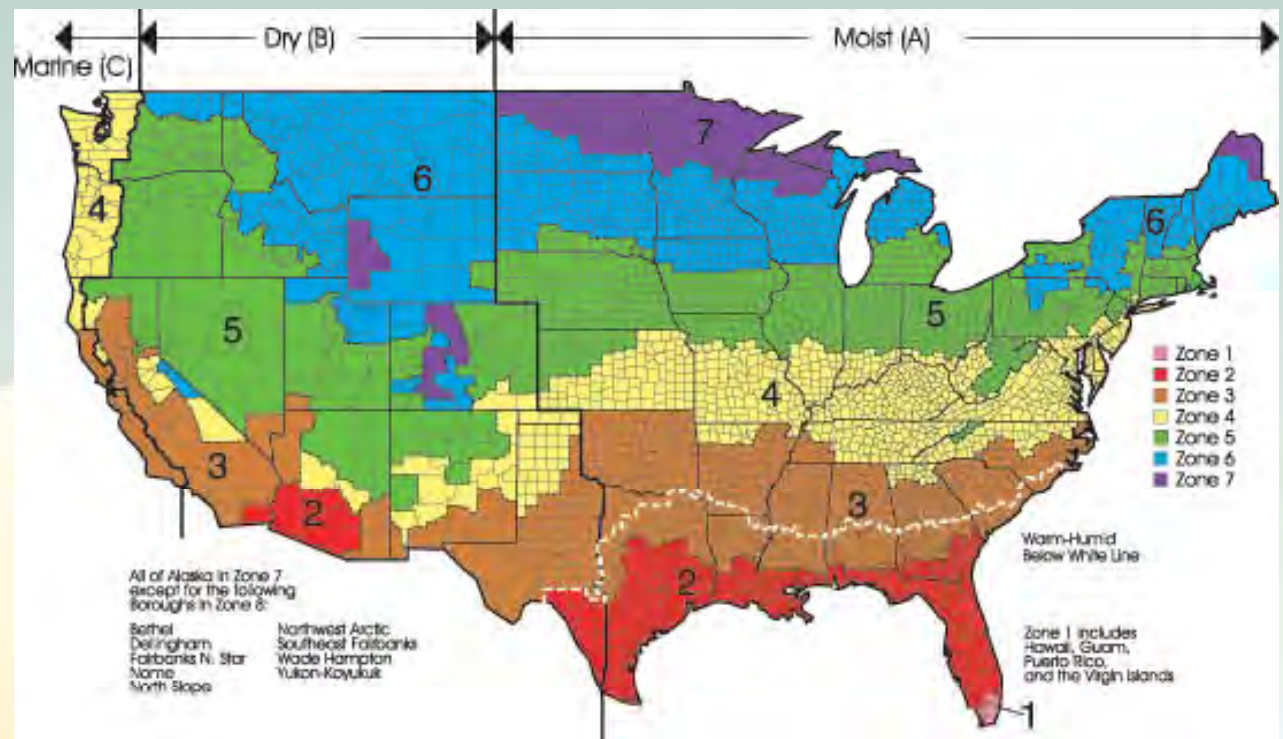
DOE High Performance Window Specifications: U-factor ≤ 0.22

Passivhaus Institut recommendation: U-factor ≤ 0.8 (NFRC 0.14-0.16)

**Building America
Special Research Project
recommendations:**

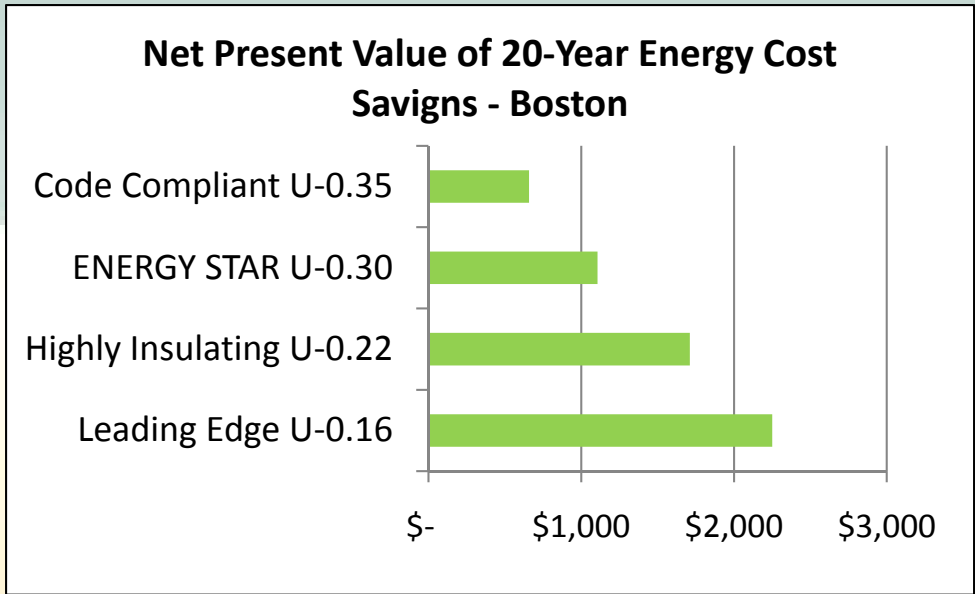
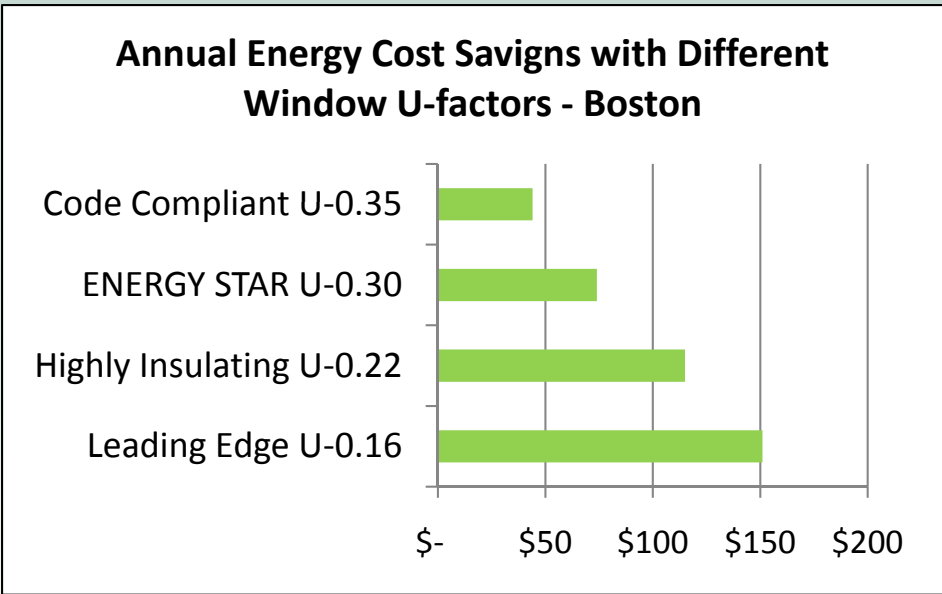
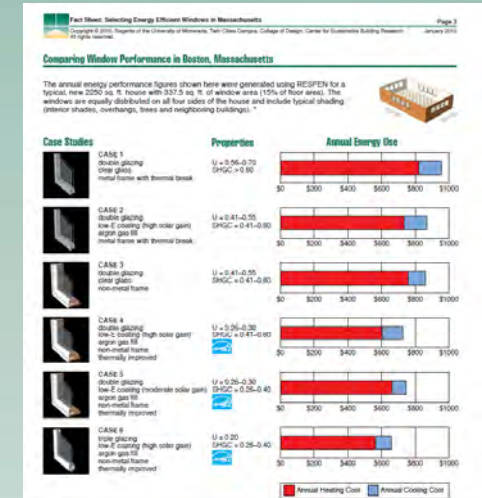
| Climate | U-factor |
|---------|----------|
| 7-8 | 0.15 |
| 6 | 0.18 |
| 5 | 0.24 |
| 4 | 0.30 |
| 3 | 0.30 |
| 2 | 0.35 |
| 1 | any |

Source: Building Science Corporation



Energy Cost Savings Estimates

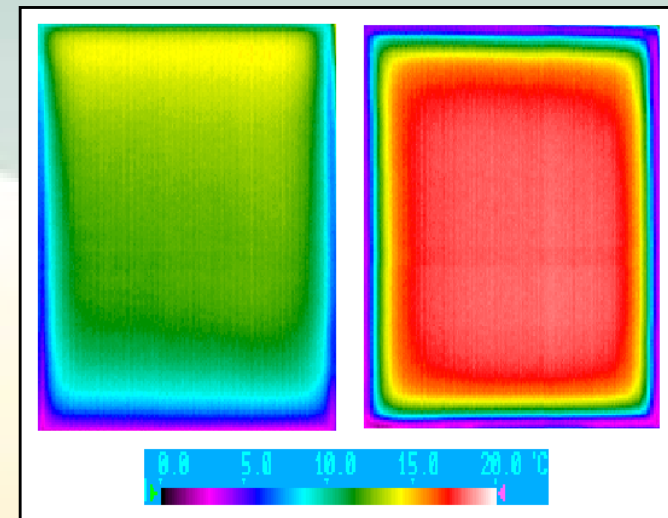
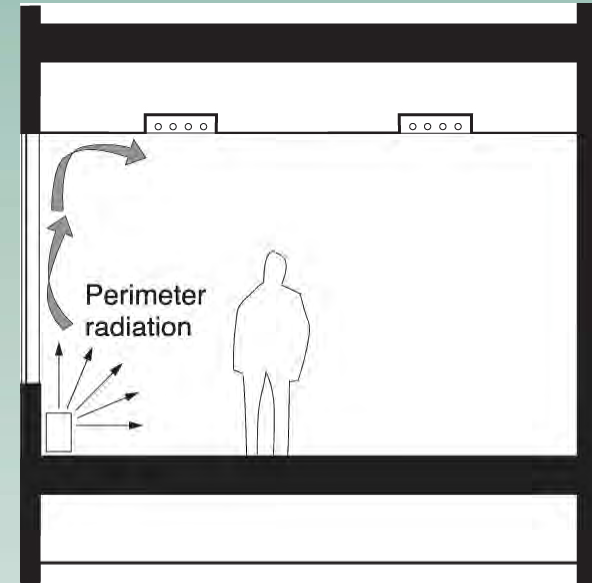
- Fact sheets and Window Selection Tool with pre-run simulations assuming typical houses: www.efficientwindows.org
- RESFEN by Lawrence Berkeley National Laboratory – free window energy simulation tool: www.efficientwindows.org/resfen.cfm



Savings estimates based on regression expressions provided by Lawrence Berkeley National Laboratory. Assuming a house with 340 ft² window area and \$1.51/therm of natural gas for heating, \$0.17/kWh for cooling. NPV estimated using 3% discount rate on top of inflation.

Comfort Benefits of Well-Insulating Windows

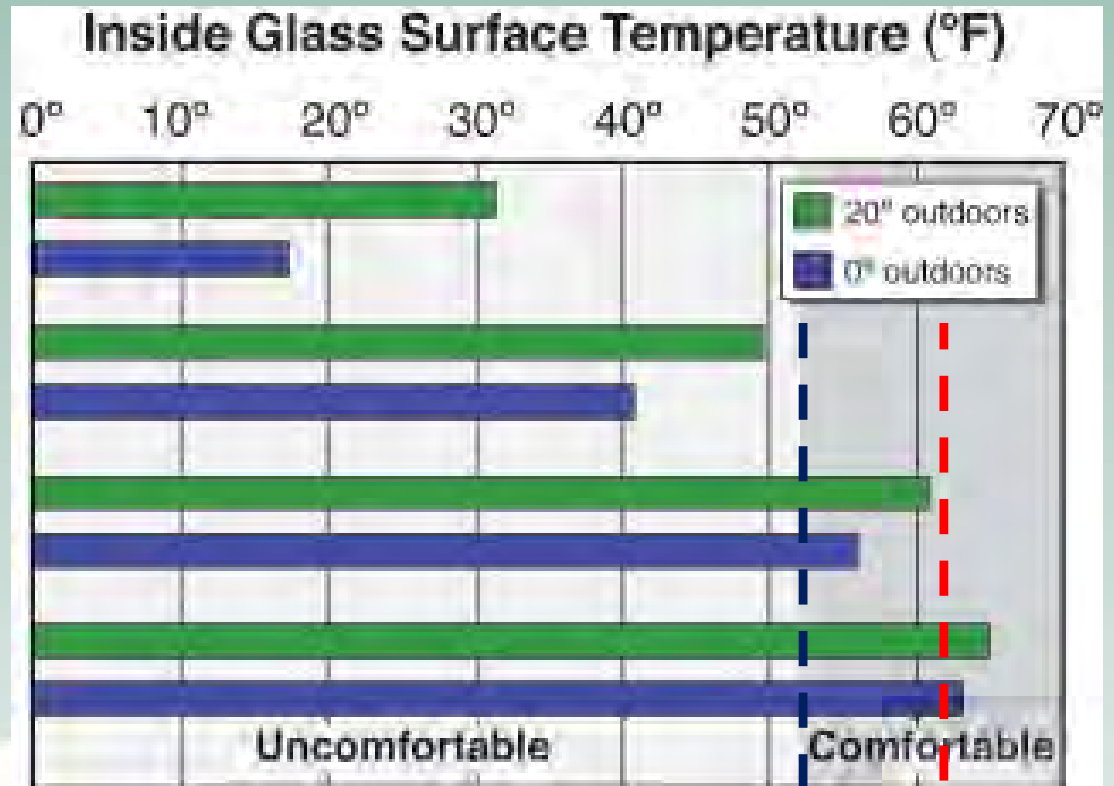
- Areas near windows are often places of great temperature variation and discomfort
- Conventional practice to avoid discomfort: perimeter heating near windows
- Perimeter heat may not be necessary with highly insulating windows



Thermograms comparing a conventional dual-pane with a highly insulating window

U-factor and Winter Comfort

Graphic source: Lawrence Berkeley National Laboratory (modified)



Single pane (U ~0.85)

Dual pane (U ~0.50)

Dual pane low-E, gas fill (U ~0.35)

Triple pane low-E, gas fill (U ~0.20)

Passivhaus Institut estimates based on ISO 7730:
 If window surface temperature is no more than 7-9°F below average room temperature, heating registers near windows are not needed.

comfortable
with heat
near windows

comfortable
without heat
near windows

Affordable High-Performance Options: Department of Energy Resources



DOE's High Performance Windows Volume Purchase Program

Market transformation program

- Goal: increase the availability of affordable, high performance windows and storm windows for mixed and cold climates

Advanced criteria

- Windows with U-factor 0.22 or lower
- Storm windows with low-E glass

Website lists products from about 30 manufacturers

- Helps buyers find products
- Price comparisons facilitated since May 2011

www.windowsvolumepurchase.org

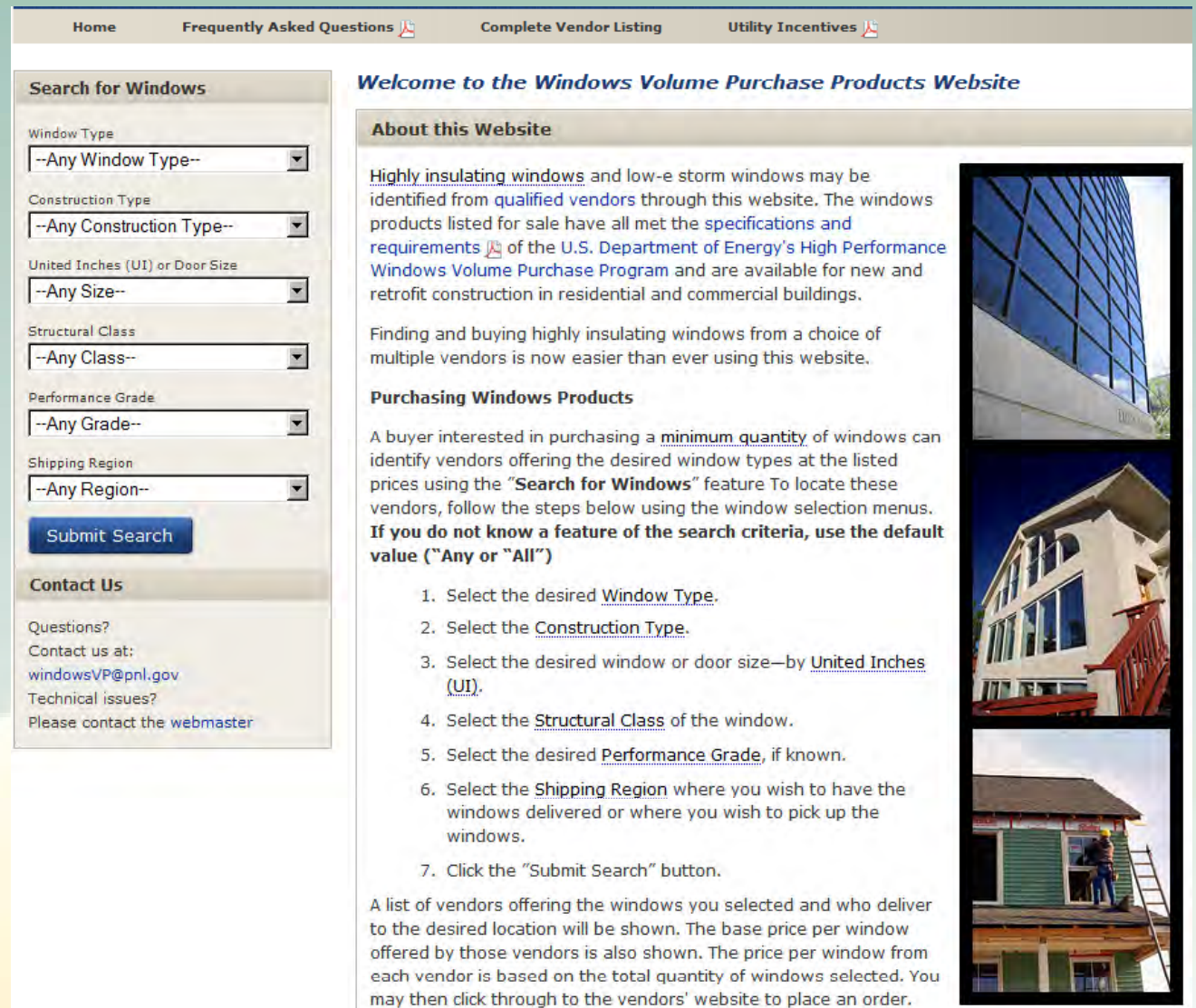


www.windowsvolumepurchase.org

Database allows for filtering by:

- Window type and size
- Structural performance class and grade
- Shipping Region

Discrete manufacturers' prices shown for each product



The screenshot shows the website's navigation bar with links for Home, Frequently Asked Questions, Complete Vendor Listing, and Utility Incentives. The main content area is titled "Welcome to the Windows Volume Purchase Products Website" and includes an "About this Website" section, a "Purchasing Windows Products" section with a 7-step guide, and a "Contact Us" section. On the right side, there are three images: a modern glass skyscraper, a multi-story house with a red balcony, and a construction site with a worker on a ladder.

Home Frequently Asked Questions Complete Vendor Listing Utility Incentives

Search for Windows

Window Type:

Construction Type:

United Inches (UI) or Door Size:

Structural Class:

Performance Grade:

Shipping Region:

Contact Us

Questions?
Contact us at:
windowsVP@pnl.gov
Technical issues?
Please contact the [webmaster](#)

Welcome to the Windows Volume Purchase Products Website

About this Website

Highly insulating windows and low-e storm windows may be identified from [qualified vendors](#) through this website. The windows products listed for sale have all met the [specifications and requirements](#) of the U.S. Department of Energy's High Performance Windows Volume Purchase Program and are available for new and retrofit construction in residential and commercial buildings.

Finding and buying highly insulating windows from a choice of multiple vendors is now easier than ever using this website.

Purchasing Windows Products

A buyer interested in purchasing a [minimum quantity](#) of windows can identify vendors offering the desired window types at the listed prices using the "Search for Windows" feature. To locate these vendors, follow the steps below using the window selection menus. **If you do not know a feature of the search criteria, use the default value ("Any" or "All")**

1. Select the desired [Window Type](#).
2. Select the [Construction Type](#).
3. Select the desired window or door size—by [United Inches \(UI\)](#).
4. Select the [Structural Class](#) of the window.
5. Select the desired [Performance Grade](#), if known.
6. Select the [Shipping Region](#) where you wish to have the windows delivered or where you wish to pick up the windows.
7. Click the "Submit Search" button.

A list of vendors offering the windows you selected and who deliver to the desired location will be shown. The base price per window offered by those vendors is also shown. The price per window from each vendor is based on the total quantity of windows selected. You may then click through to the vendors' website to place an order.

DOE High Performance Window Specifications

- U-factor:
 - 0.20-0.22 (R and LC class)
 - 0.24-0.27 (CW class)
 - 0.27-0.32 (AW class)
- Air leakage: ≤ 0.30 cfm/ft²
- Condensation Resistance: ≥ 50
- Certifications: NFRC/NAFS
- Warranty (yr): 20 glass/10 non-glass
- Minimum order: 20



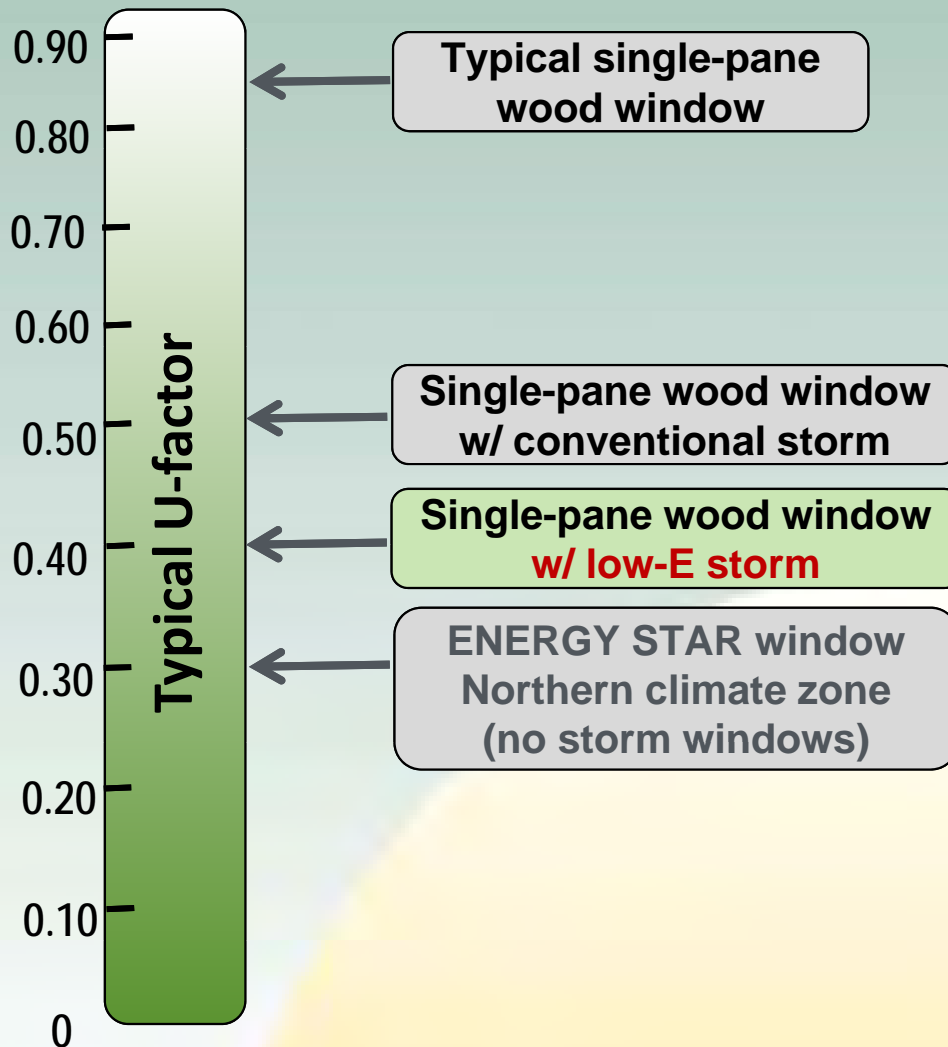
DOE Low-E Storm Window Specifications

- Emissivity: <0.22
- Structural test: ANSI/AAMA 1002.10-93 or ASTM E1886-05
- Performance Grade: ≥ 15
- Registry: IGDB (LBNL database)
- Certification required
- Warranty (yr): 10 glass/non-glass
- Minimum order: 20



Low-E Storm Windows

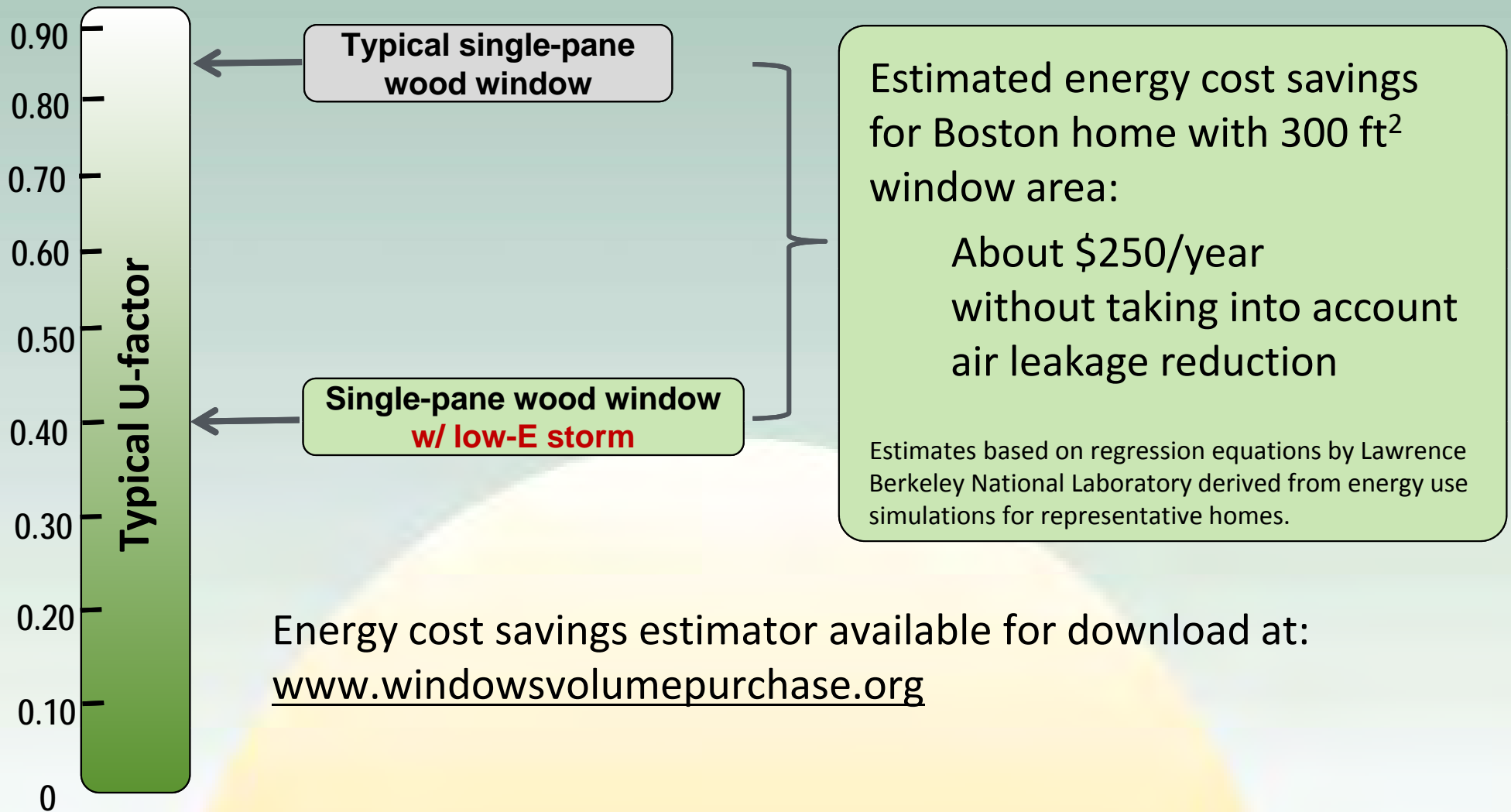
A low-E storm window is similar to a typical storm, but with the addition of durable low-E coating



- Use of low-E glass in storm windows is not yet very widespread – but cost effective
- Installation costs are identical to standard storm windows

Low-E Storm Windows

A low-E storm window is similar to a typical storm, but with the addition of durable low-E coating



More Info about Window Retrofits and Treatments

www.windowattachments.org

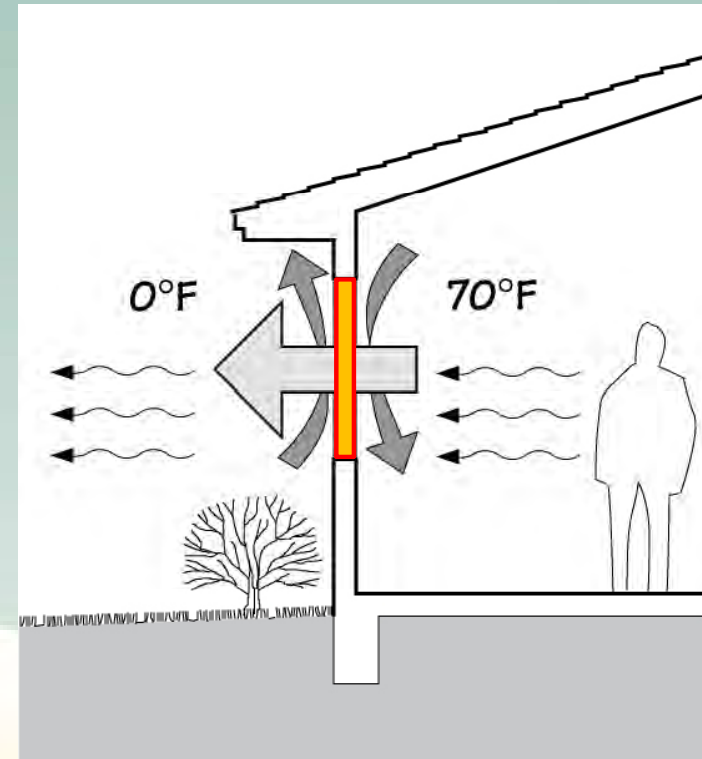
Information by BuildingGreen with support from DOE, Lawrence Berkeley National Lab and EWC:

- Low-E storm windows
- Window films
- Roller shades and shutters
- Insulating shades/blinds
- Awnings



The Big Deal About Efficient Windows

- High-performance windows and window treatments can ensure comfort regardless of heating system design
- Comfort is an energy benefit
- Monetary benefits include energy cost savings and opportunities for lower-cost HVAC choices



Thank You for Your Time

Efficient Windows Collaborative Contacts:

Questions?

www.efficientwindows.org

Nils Petermann

Alliance to Save Energy

(202) 530-2254

NPetermann@ase.org

Neal Humphrey

Alliance to Save Energy

(202) 448-8760

NHumphrey@ase.org

