Guidelines for Energy Efficient Windows in New Construction



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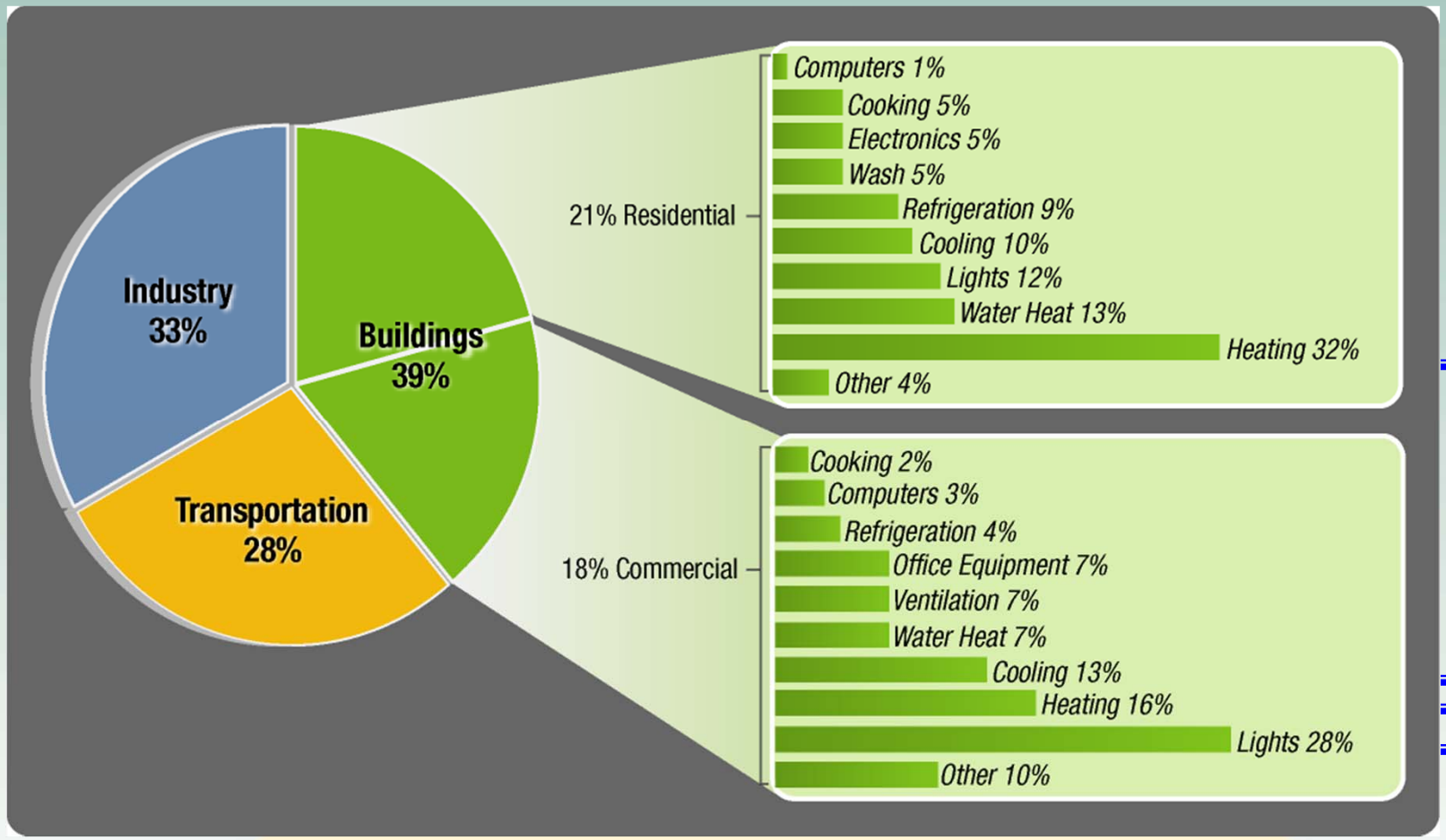
University of Minnesota

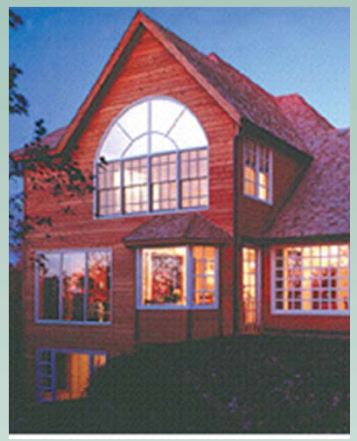
Fenestration Impacts on Building End Use Energy Consumption

Buildings consume 39% of total U.S. energy

- ***71% of electricity and 54% of natural gas***



U. S. Energy Use for Windows



Total U.S. Energy Use = 98.3 Quads

Total Building Energy Use = 38.8 Quads

- Residential buildings = 21.3 Quads
- Commercial buildings = 17.5 Quads

Total Window Energy Use = 4.0 Quads

- Residential heating = 2.0 Quads
- Residential cooling = 0.9 Quads
- Commercial heating = 0.5 Quads
- Commercial cooling = 0.6 Quads

Savings Potential by Daylighting = 1.0 Quad

Economic impact

- Annual energy cost = $40 billion
- Annual window sales = $20 billion

Based on DOE BT 2005 Core Data Book

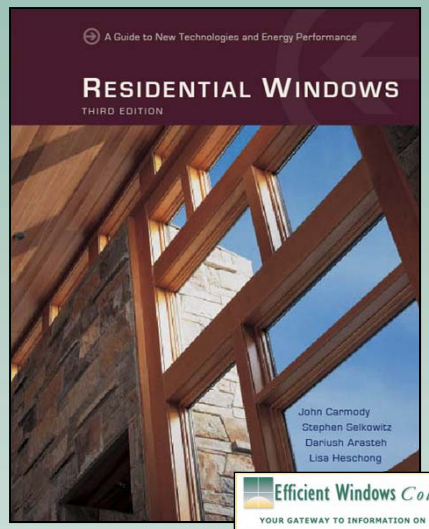
Efficient Windows Collaborative

The Efficient Windows Collaborative (EWC) is a coalition of window, door, skylight, and component manufacturers, federal, state and local government agencies, research institutions, and others who partner to expand the market for energy efficient window products.

Lead Organizations

- Alliance to Save Energy
- Center for Sustainable Building Research, University of Minnesota
- Lawrence Berkeley National Labs
- 159 Active industry members and affiliates

Efficient Windows Collaborative



Residential Tools and Information

- 3rd edition of book: *"Residential Windows: A Guide to New Technology and Energy Performance"*
- EWC Website: *www.efficientwindows.org*
- Fact sheets for 100 cities
- Education and training materials
- Product database for EWC members (NFRC and ENERGY STAR participants)

What Makes an Energy-Efficient Window?

Characteristics of Low-E Coatings

Long-wave radiant heat is reflected, giving an improved U-factor and reduced winter heat loss.

Higher temperatures on the interior glass surface contribute to greater comfort and less condensation in winter.

Visible transmittance is only slightly affected.

With high-solar-gain coatings, solar heat is transmitted.

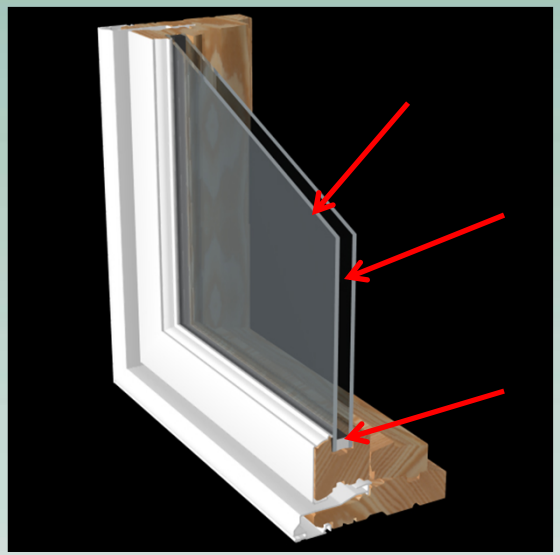
With low-solar-gain coatings, solar radiation is reflected back toward the exterior.

Characteristics of Gas Fills

Thermal resistance is increased with argon and krypton gas fills, reducing winter heat loss and summer heat gain through conduction.

Higher temperatures in winter on the interior glass surface contribute to greater comfort and less condensation.

Visible transmittance is not affected.



- **Low-E coating**
- **Gas fill**
- **Warm-edge spacers**

Characteristics of Thermally Improved Spacers

Overall U-factor is improved because heat loss at the glass edges is reduced.

Higher temperatures on the glass edges produce less condensation.

Glazing Types

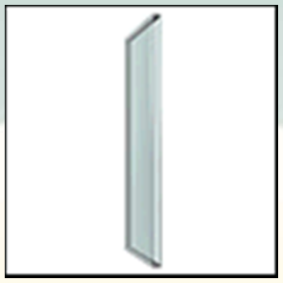
Single Clear

Single with Bronze/Gray Tint

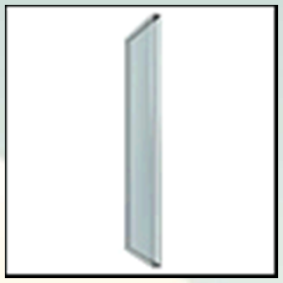
Double Clear

Double with Bronze/Gray Tint

Double with Selective Tint

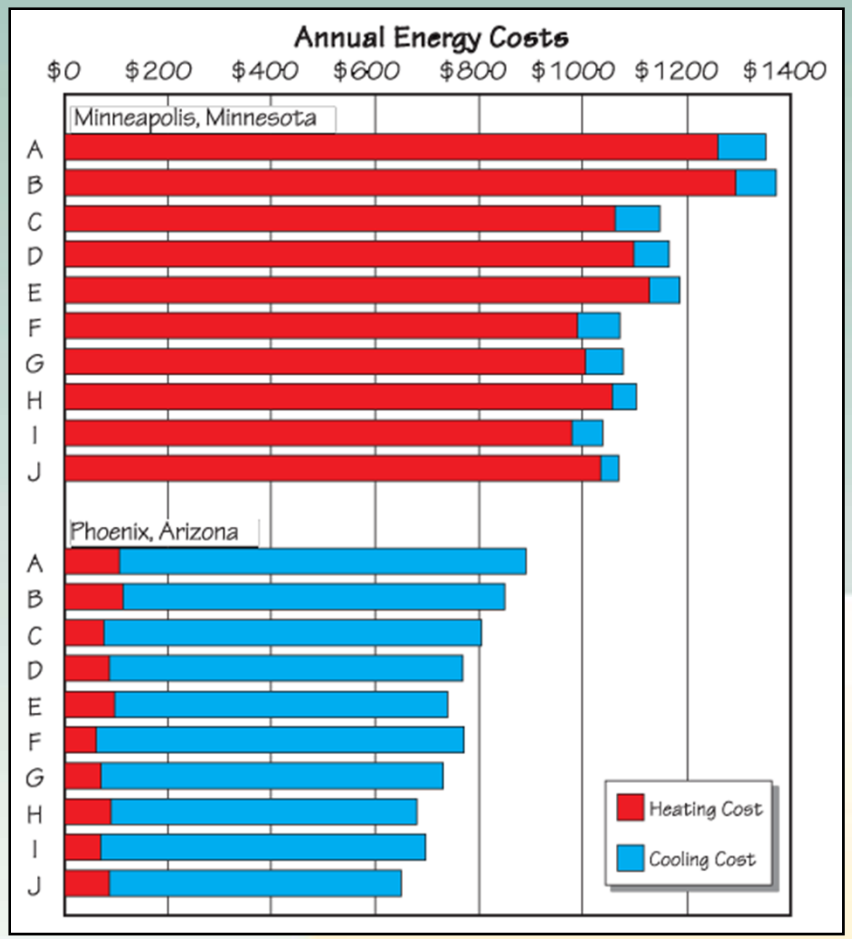


Double With Low-E



Triple With Low-e

Glazing Comparison

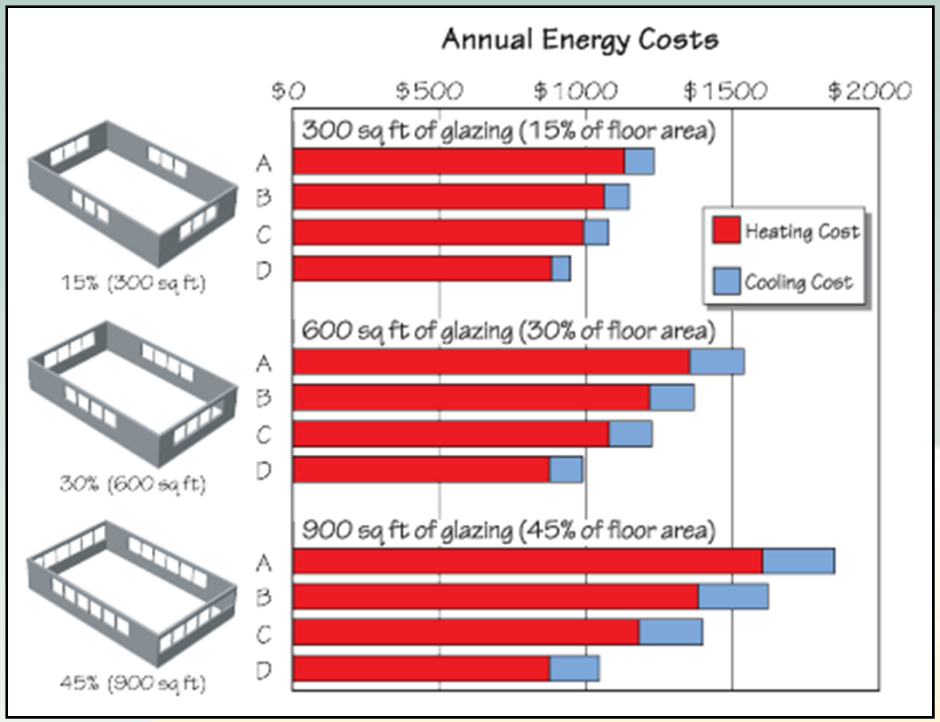


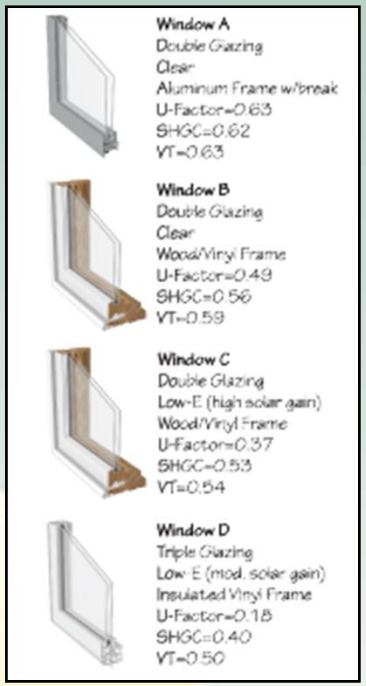
Annual energy performance for a 2000-square-foot house with different glazing types using a wood or vinyl frame in two U.S. climates.

Window	Glazing	U-factor	SHGC	VT
A	single, clear	0.84	0.64	0.65
B	single, tint	0.84	0.54	0.49
C	double, clear	0.49	0.56	0.59
D	double, tint	0.49	0.47	0.44
E	double, high-performance tint	0.49	0.39	0.50
F	double, high-solar-gain low-E	0.37	0.53	0.54
G	double, moderate-solar-gain low-E	0.35	0.44	0.56
H	double, low-solar-gain low-E	0.34	0.30	0.51
I	triple, moderate-solar-gain low-E	0.29	0.38	0.47
J	triple, low-solar-gain low-E	0.28	0.25	0.40

Residential: Selecting the Right Window

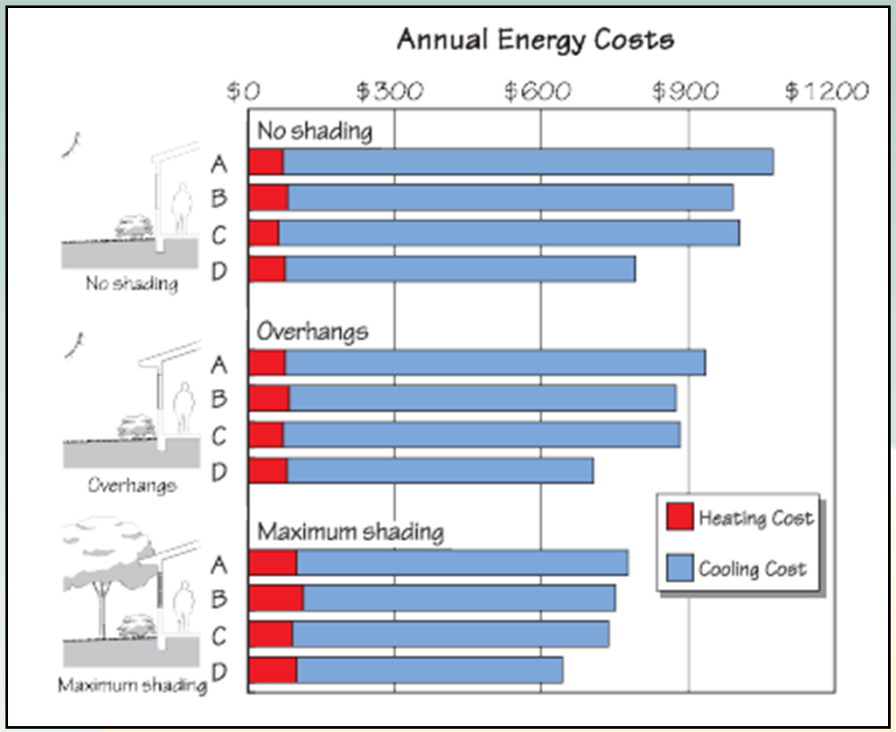
Impact of window glazing area on annual energy use for a typical house in Minneapolis, Minnesota. The better performance of the window — the less of an impact of the glazing area.



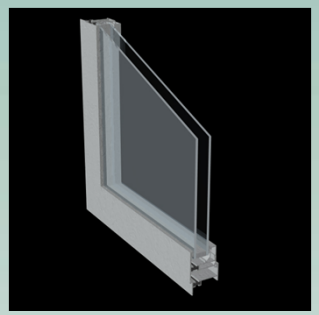


Residential: Selecting the Right Window

Impact of shading on annual energy use for a typical house in Phoenix, Arizona. The better performance of the window — the less of an impact of shading devices.

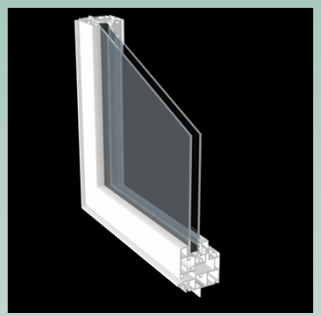


Frame Types



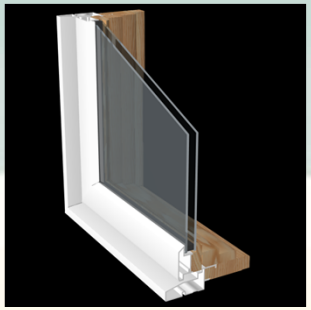
Aluminum

Wood

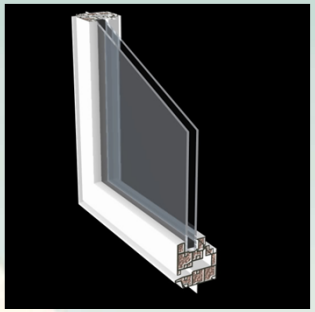


Vinyl

Clad

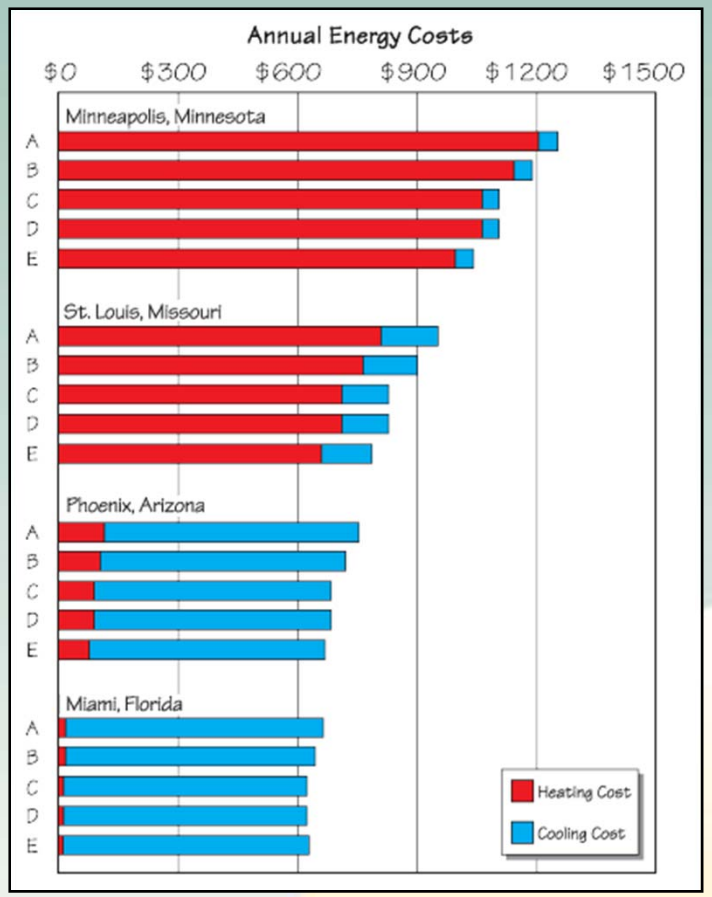


Hybrid/Composite



Fiberglass

Frame Types



Annual energy performance for a 2000-square-foot house with different frame types using identical low-E glass in four U.S. climates

Window	Glazing	Frame	U-factor	SHGC	VT
A	double, low-solar-gain low-E	aluminum	0.59	0.37	0.59
B	double, low-solar-gain low-E	aluminum w/break	0.47	0.33	0.55
C	double, low-solar-gain low-E	wood/wood clad	0.34	0.30	0.51
D	double, low-solar-gain low-E	vinyl	0.34	0.30	0.51
E	double, low-solar-gain low-E	insulated fiberglass	0.26	0.31	0.55

Selecting the Right Window

1. Look for the ENERGY STAR

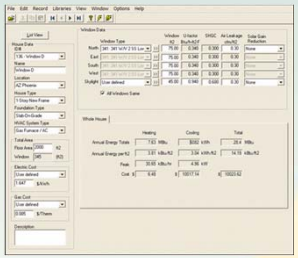
   Look for a product that qualifies for the Energy Star in your area.

2. Look for Energy Efficient Window Properties on the NFRC Label

   The key window properties are U-factor, Solar Heat Gain Coefficient (SHGC), and Visible Transmittance (VT). The NFRC label provides the only reliable way to determine the window properties and to compare products.

3. Compare Annual Energy Costs for a Typical House

   The annual energy use from computer simulations for a typical 2000-square-foot house in your region can be compared for different window options.



4. Estimate and Compare Annual Energy Costs for Your House

   Using a computer program such as RESFEN to compare window options is the only method of obtaining reasonable estimates of the heating and cooling costs for your climate, house design, and utility rates.

The NFRC Label

NFRC has established a voluntary national energy performance rating and labeling system for fenestration products.

The NFRC label rates:

• U-factor, or how well a window keeps heat inside a building.

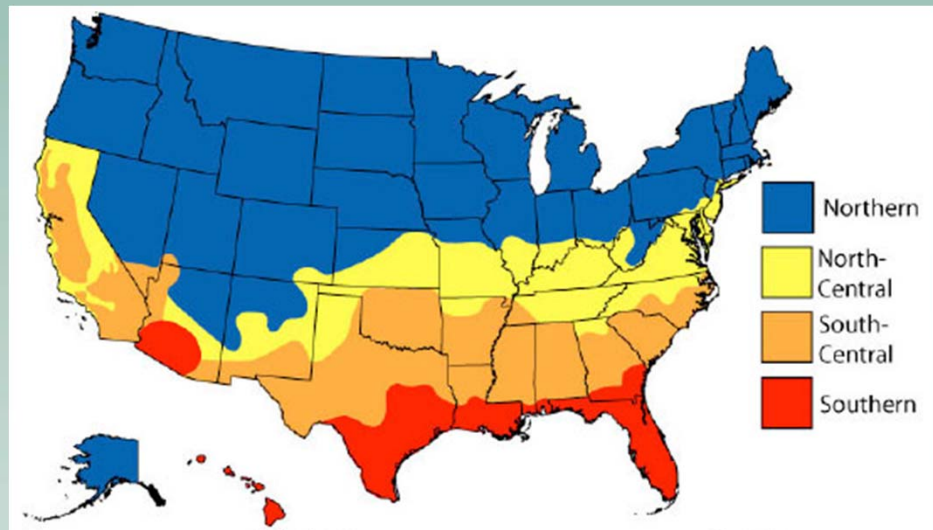
• Solar heat gain, or a window's ability to block warming caused by sunlight.

• Visible light transmittance, or how much light gets through a product.

• Air leakage, heat loss and gain occur by infiltration through cracks in the window assembly.

• Condensation resistance, the ability of a product to resist the formation of condensation on the interior surface of that product.

Look for the ENERGY STAR® Label



Windows

Climate Zone	U-Factor[1]	SHGC[2]	
Northern	! 0.30	Any	Prescriptive
	=0.31	' 0.35	Equivalent Energy Performance
	=0.32	' 0.40	
North-Central	! 0.32	! 0.40	
South-Central	! 0.35	! 0.30	
Southern	! 0.60	! 0.27	

[1] Btu/h.ft².°F

[2] Fraction of incident solar radiation

Doors

Glazing Level	U-Factor[1]	SHGC[2]
Opaque	! 0.21	No Rating
! ½-Lite	! 0.27	! 0.30
> ½-Lite	! 0.32	! 0.30

Skylights

Climate Zone	U-Factor[1]	SHGC[2]
Northern	! 0.55	Any
North-Central	! 0.55	! 0.40
South-Central	! 0.57	! 0.30
Southern	! 0.70	! 0.30

RESFEN

for Calculating the Heating and Cooling Energy Use of Windows in Residential Buildings

RESFEN can be used to run performance comparisons of different window and skylight options and to calculate annual energy use, peak heating and cooling loads, and costs.

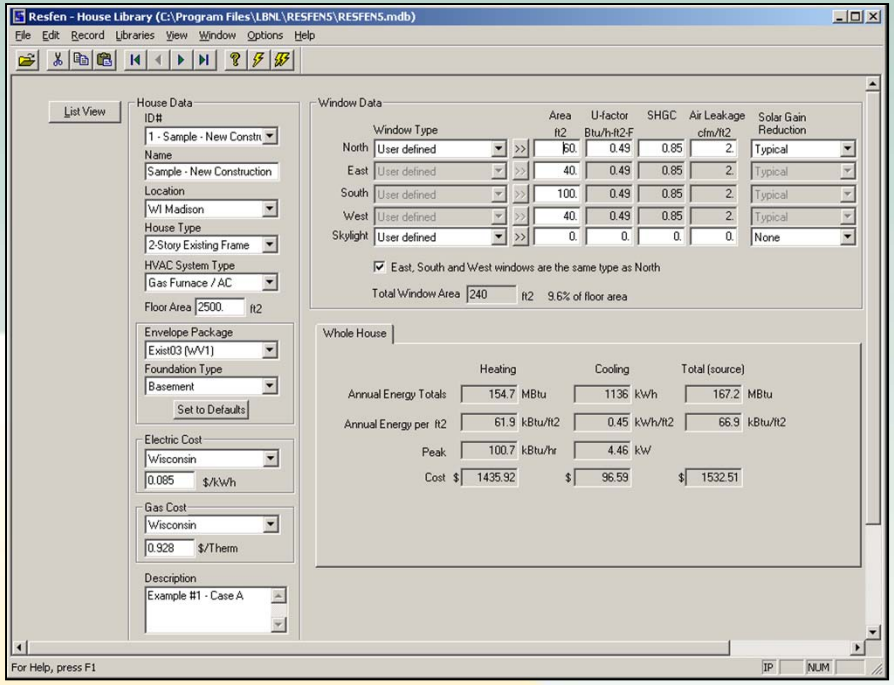
Calculates the heating and cooling energy use of a building:

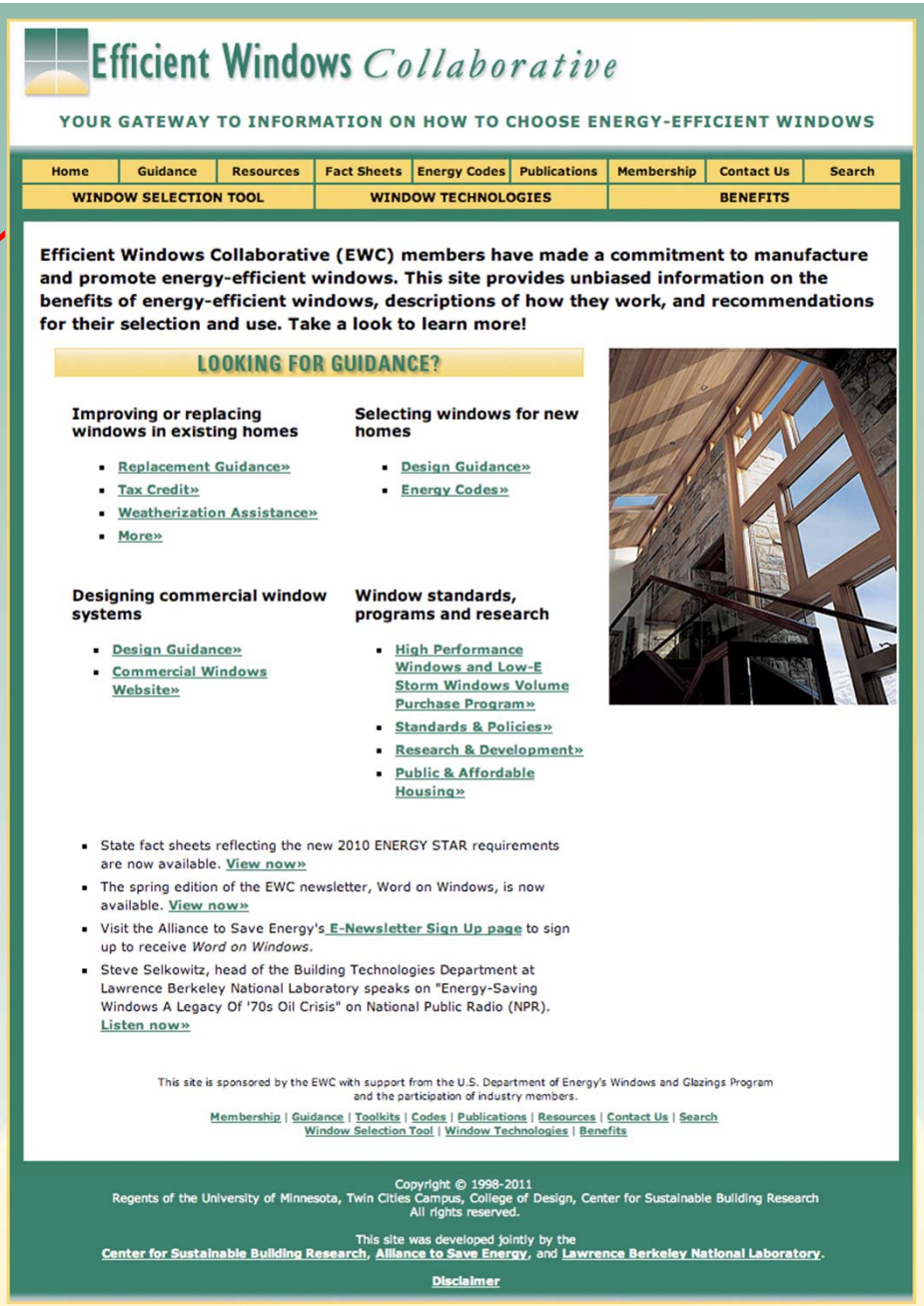
- –for a specific house
- –in a specific location
- –with specific window products

Compares different window options

Helps select energy-efficient windows

windows.lbl.gov/software/resfen/resfen.html

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Efficient Windows Collaborative (EWC) members have made a commitment to manufacture and promote energy-efficient windows. This site provides unbiased information on the benefits of energy-efficient windows, descriptions of how they work, and recommendations for their selection and use. Take a look to learn more!
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Selecting windows for new homes
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Designing commercial window systems
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Commercial Windows Website»
Window standards, programs and research
High Performance Windows and Low-E Storm Windows Volume Purchase Program»
Standards & Policies»
Research & Development»
Public & Affordable Housing»
State fact sheets reflecting the new 2010 ENERGY STAR requirements are now available. View now»
The spring edition of the EWC newsletter, Word on Windows, is now available. View now»
Visit the Alliance to Save Energy's E-Newsletter Sign Up page to sign up to receive Word on Windows.
Steve Selkowitz, head of the Building Technologies Department at Lawrence Berkeley National Laboratory speaks on "Energy-Saving Windows A Legacy Of '70s Oil Crisis" on National Public Radio (NPR). Listen now»
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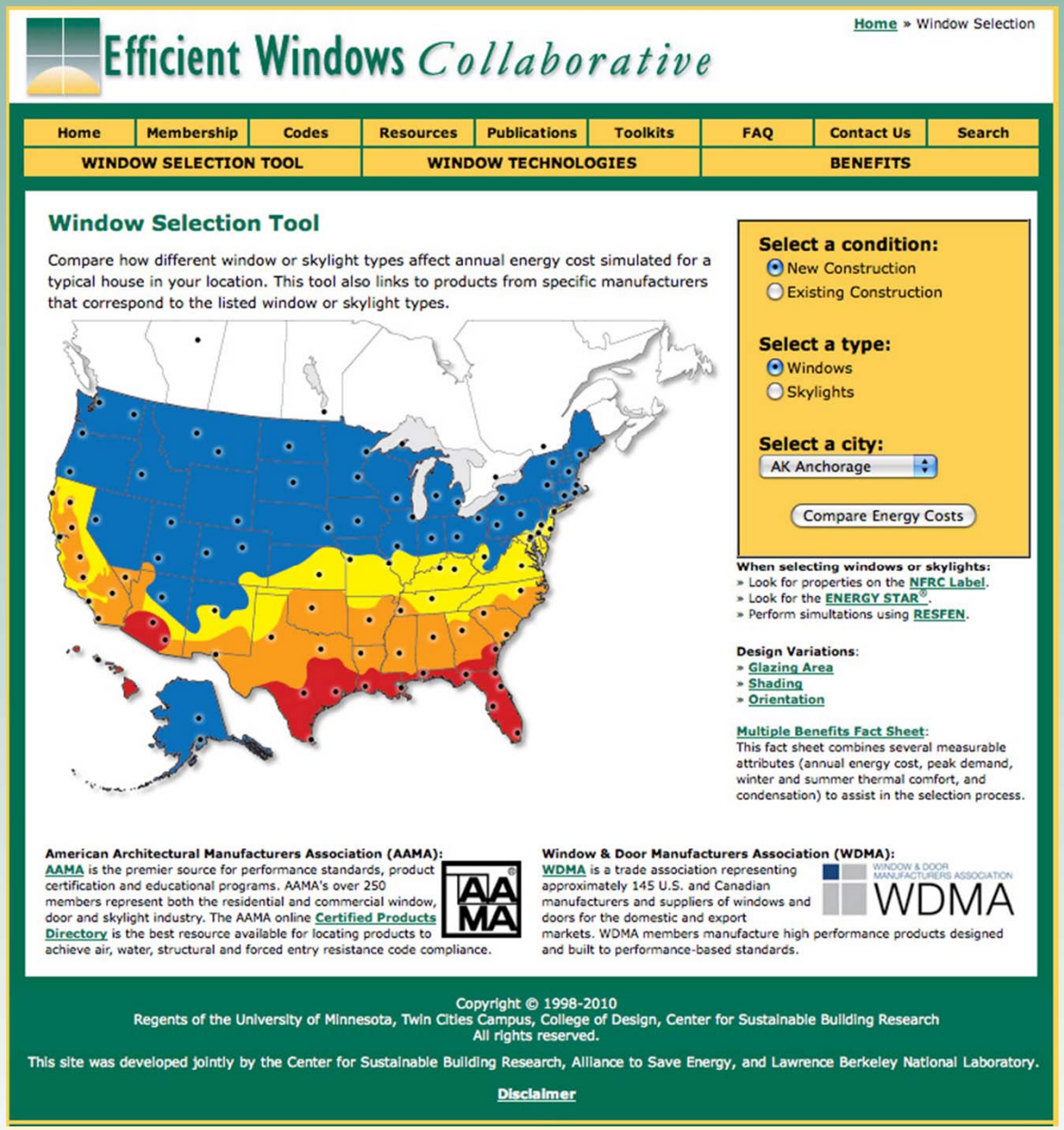
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Window Selection Tool
Compare how different window or skylight types affect annual energy cost simulated for a typical house in your location. This tool also links to products from specific manufacturers that correspond to the listed window or skylight types.
Select a condition:
New Construction
Existing Construction
Select a type:
Windows
Skylights
Select a city:
AK Anchorage
Compare Energy Costs
When selecting windows or skylights:
» Look for properties on the NFRC Label.
» Look for the ENERGY STAR®.
» Perform simulations using RESFEN.
Design Variations:
» Glazing Area
» Shading
» Orientation
Multiple Benefits Fact Sheet:
This fact sheet combines several measurable attributes (annual energy cost, peak demand, winter and summer thermal comfort, and condensation) to assist in the selection process.
American Architectural Manufacturers Association (AAMA):
AAMA is the premier source for performance standards, product certification and educational programs. AAMA's over 250 members represent both the residential and commercial window, door and skylight industry. The AAMA online Certified Products Directory is the best resource available for locating products to achieve air, water, structural and forced entry resistance code compliance.
AAMA
Window & Door Manufacturers Association (WDMA):
WDMA is a trade association representing approximately 145 U.S. and Canadian manufacturers and suppliers of windows and doors for the domestic and export markets. WDMA members manufacture high performance products designed and built to performance-based standards.
WINDOW & DOOR MANUFACTURERS ASSOCIATION
WDMA
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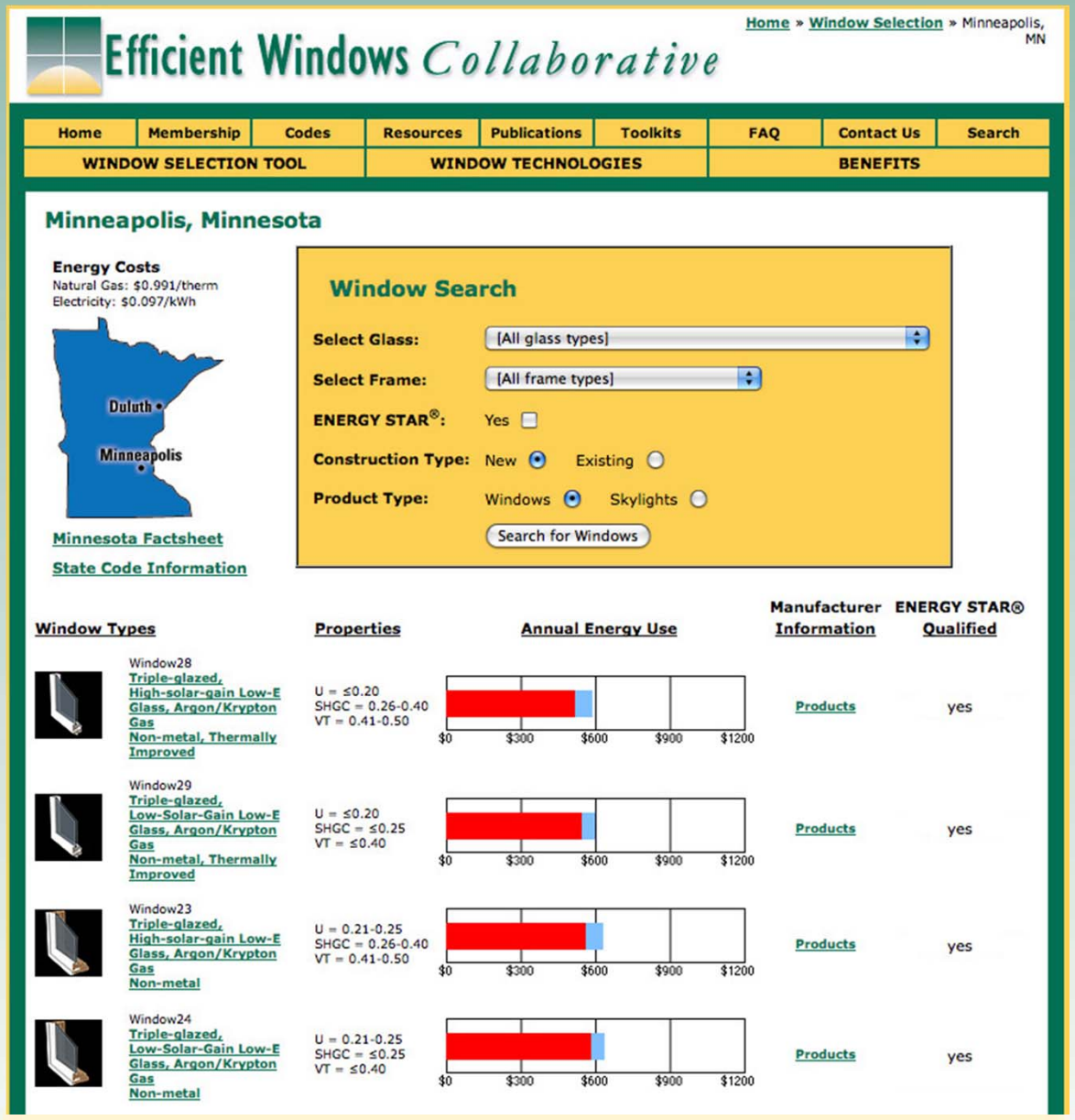
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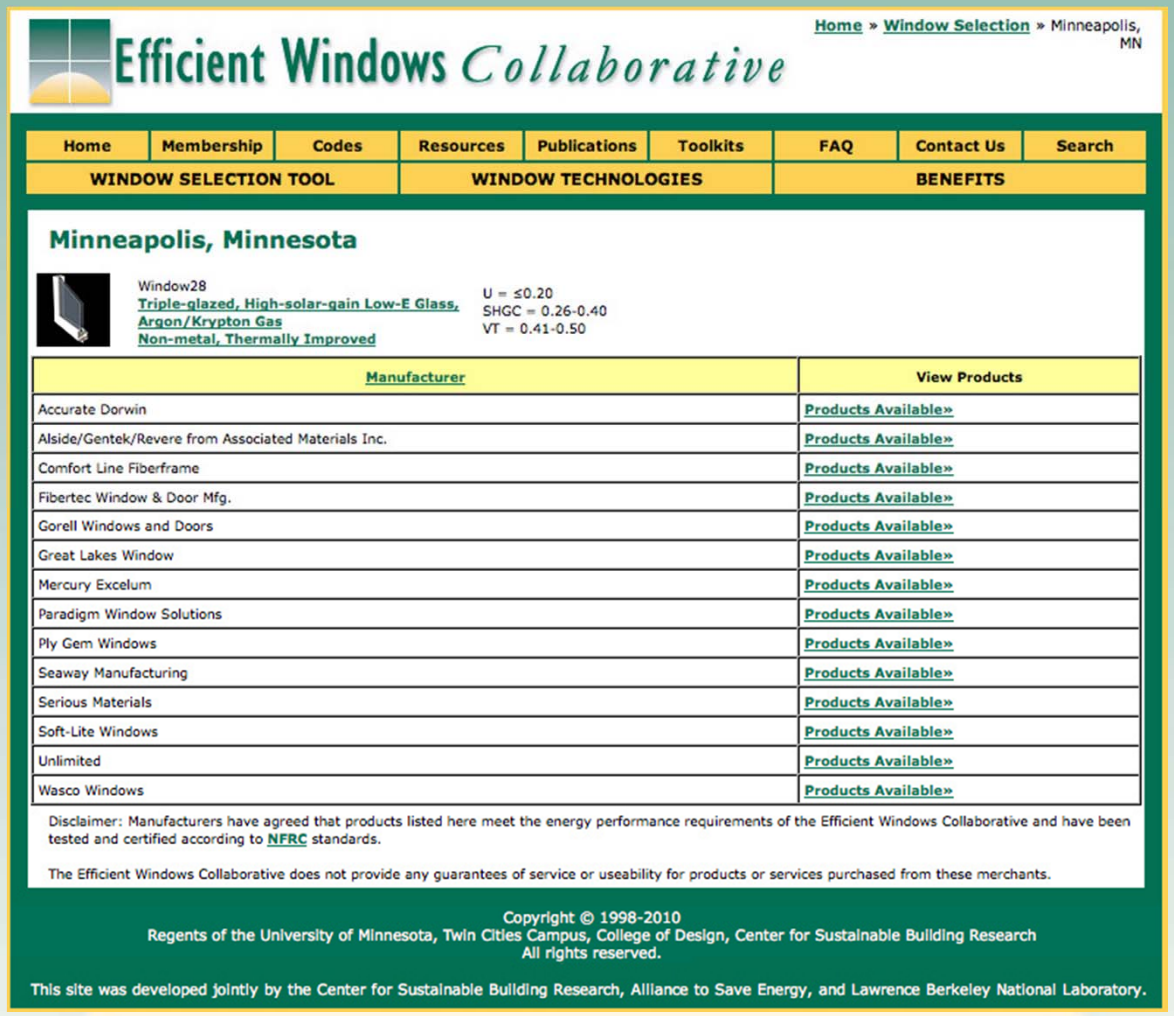
Energy Costs
Natural Gas: $0.991/therm
Electricity: $0.097/kWh
Duluth
Minneapolis
Minnesota Factsheet
State Code Information
Window Search
Select Glass: [All glass types]
Select Frame: [All frame types]
ENERGY STAR®: Yes
Construction Type: New Existing
Product Type: Windows Skylights
Search for Windows
Window Types
Properties
Annual Energy Use
Manufacturer Information
ENERGY STAR® Qualified
Window28
Triple-glazed, High-solar-gain Low-E Glass, Argon/Krypton Gas
Non-metal, Thermally Improved
U = ≤0.20
SHGC = 0.26-0.40
VT = 0.41-0.50
$0 $300 $600 $900 $1200
Products
yes
Window29
Triple-glazed, Low-Solar-Gain Low-E Glass, Argon/Krypton Gas
Non-metal, Thermally Improved
U = ≤0.20
SHGC = ≤0.25
VT = ≤0.40
$0 $300 $600 $900 $1200
Products
yes
Window23
Triple-glazed, High-solar-gain Low-E Glass, Argon/Krypton Gas
Non-metal
U = 0.21-0.25
SHGC = 0.26-0.40
VT = 0.41-0.50
$0 $300 $600 $900 $1200
Products
yes
Window24
Triple-glazed, Low-Solar-Gain Low-E Glass, Argon/Krypton Gas
Non-metal
U = 0.21-0.25
SHGC = ≤0.25
VT = ≤0.40
$0 $300 $600 $900 $1200
Products
yes



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Minneapolis, Minnesota

Window28
Triple-glazed, High-solar-gain Low-E Glass, Argon/Krypton Gas
Non-metal, Thermally Improved

U = ≤0.20
SHGC = 0.26-0.40
VT = 0.41-0.50

Manufacturer	View Products
Accurate Dorwin	Products Available»
Alside/Gentek/Revere from Associated Materials Inc.	Products Available»
Comfort Line Fiberframe	Products Available»
Fibertec Window & Door Mfg.	Products Available»
Gorell Windows and Doors	Products Available»
Great Lakes Window	Products Available»
Mercury Excelum	Products Available»
Paradigm Window Solutions	Products Available»
Ply Gem Windows	Products Available»
Seaway Manufacturing	Products Available»
Serious Materials	Products Available»
Soft-Lite Windows	Products Available»
Unlimited	Products Available»
Wasco Windows	Products Available»

Disclaimer: Manufacturers have agreed that products listed here meet the energy performance requirements of the Efficient Windows Collaborative and have been tested and certified according to NFRC standards.

The Efficient Windows Collaborative does not provide any guarantees of service or useability for products or services purchased from these merchants.

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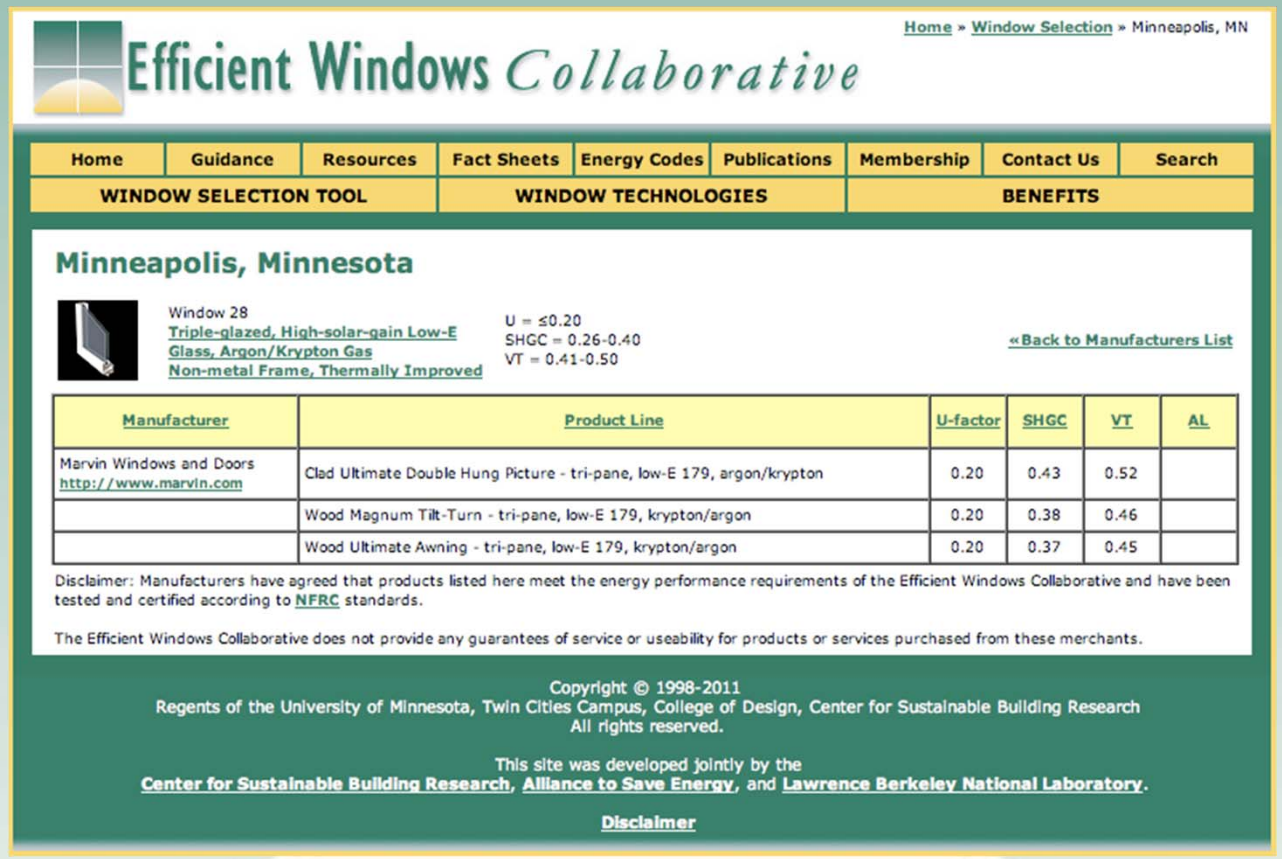

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WINDOW SELECTION TOOL | WINDOW TECHNOLOGIES | BENEFITS

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Window 28
Triple-glazed, High-solar-gain Low-E Glass, Argon/Krypton Gas
Non-metal Frame, Thermally Improved

U = ≤0.20
SHGC = 0.26-0.40
VT = 0.41-0.50

«Back to Manufacturers List

Manufacturer	Product Line	U-factor	SHGC	VT	AL
Marvin Windows and Doors http://www.marvin.com	Clad Ultimate Double Hung Picture - tri-pane, low-E 179, argon/krypton	0.20	0.43	0.52	
	Wood Magnum Tilt-Turn - tri-pane, low-E 179, krypton/argon	0.20	0.38	0.46	
	Wood Ultimate Awning - tri-pane, low-E 179, krypton/argon	0.20	0.37	0.45	

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Disclaimer

State Fact Sheets

Efficient Windows Collaborative

New Homes: Selecting Energy Efficient Windows in Minnesota

www.efficientwindows.org January 2011

Minnesota is mainly a heating dominated climate.

ENERGY STAR® Zones
- Northern Climate Zone (mostly heating)
- North/Central Climate Zone (heating & cooling)
- South/Central Climate Zone (heating & cooling)
- Southern Climate Zone (mostly cooling)

Benefits of High Performance Windows

Heating and Cooling Season Savings
Low-E coatings, gas-fills, and insulating spacers and frames result in a lower U-factor, meaning less winter heat loss. Many low-E coatings also reduce solar heat gain.

Improved Daylight and View
Many low-E coatings can reduce solar heat gain significantly with a minimal loss of visible light (compared to older tints and films).

Improved Comfort
With a low U-factor, window temperatures are more moderate and there are fewer cold drafts. With a lower solar heat gain coefficient (SHGC), there is less discomfort from the summer sun.

Less Condensation
Frame, spacer and glazing materials that resist heat conduction do not become as cold and this results in less condensation.

Reduced Fading
Coatings on glass or plastic films within the window assembly can significantly reduce the ultraviolet (UV) and other solar radiation which causes fading of fabrics and furnishings.

Lower Mechanical Equipment Costs
Using windows that reduce solar heat gain (low SHGC) may allow for smaller, less expensive cooling equipment. Windows with a very low U-factor may ensure winter comfort even without the need for heat registers near the windows.

Visit www.efficientwindows.org for more information on the benefits of efficient windows, how windows work, how to select an efficient window, and what manufacturers provide efficient windows.

1. Meet the Energy Code and Look for the ENERGY STAR®

Windows must meet the locally applicable energy code requirements. Windows that are ENERGY STAR qualified typically meet or exceed energy code requirements. To verify if specific window energy properties comply with the local code requirements, go to Step 2.

2. Look for Efficient Properties on the NFRC Label

The National Fenestration Rating Council (NFRC) label is needed for verification of energy code compliance (www.nfrc.org). The NFRC label displays whole-window energy properties and appears on all fenestration products which are part of the ENERGY STAR program. For typical cost savings from efficient windows in a specific location, go to Step 3.

3. Compare Annual Energy Costs for a Typical House

Use computer simulations for a typical 2250 square-foot house to compare the annual energy performance of different window types. A comparison of the energy performance of a set of windows for this climate begins on Page 3.

4. Customize Energy Use for a Specific House

A computer simulation program, such as RESFEN (windows.lbl.gov/software), lets you compare window performance options by calculating performance based on utility rates for your climate, house design options, and window design options.

5. Ensure Proper Installation

Proper installation is necessary for optimal window performance, to ensure an airtight fit and avoid water leakage. Always follow manufacturers installation guidelines and use trained professionals for window installation.

Efficient Windows Collaborative

Existing Homes: Selecting Energy Efficient Windows in Minnesota

www.efficientwindows.org January 2011

Minnesota is mainly a heating dominated climate.

ENERGY STAR® Zones
- Northern Climate Zone (mostly heating)
- North/Central Climate Zone (heating & cooling)
- South/Central Climate Zone (heating & cooling)
- Southern Climate Zone (mostly cooling)

Benefits of High Performance Windows

Heating and Cooling Season Savings
Low-E coatings, gas-fills, and insulating spacers and frames result in a lower U-factor, meaning less winter heat loss. Many low-E coatings also reduce solar heat gain.

Improved Daylight and View
Many low-E coatings can reduce solar heat gain significantly with a minimal loss of visible light (compared to older tints and films).

Improved Comfort
With a low U-factor, window temperatures are more moderate and there are fewer cold drafts. With a lower solar heat gain coefficient (SHGC), there is less discomfort from the summer sun.

Less Condensation
Frame, spacer and glazing materials that resist heat conduction do not become as cold and this results in less condensation.

Reduced Fading
Coatings on glass or plastic films within the window assembly can significantly reduce the ultraviolet (UV) and other solar radiation which causes fading of fabrics and furnishings.

Lower Mechanical Equipment Costs
Using windows that reduce solar heat gain (low SHGC) may allow for smaller, less expensive cooling equipment. Windows with a very low U-factor may ensure winter comfort even without the need for heat registers near the windows.

Visit www.efficientwindows.org for more information on the benefits of efficient windows, how windows work, how to select an efficient window, and what manufacturers provide efficient products.

1. Meet the Energy Code and Look for the ENERGY STAR®

Windows must meet the locally applicable energy code requirements. Windows that are ENERGY STAR qualified typically meet or exceed energy code requirements. To verify if specific window energy properties comply with the local code requirements, go to Step 2.

2. Look for Efficient Properties on the NFRC Label

The National Fenestration Rating Council (NFRC) label is needed for verification of energy code compliance (www.nfrc.org). The NFRC label displays whole-window energy properties and appears on all fenestration products which are part of the ENERGY STAR program. For typical cost savings from efficient windows in a specific location, go to Step 3.

3. Compare Annual Energy Costs for a Typical House

Use computer simulations for a typical 2150 square-foot house to compare the annual energy performance of different window types. A comparison of the energy performance of a set of windows for this climate begins on Page 3.

4. Customize Energy Use for a Specific House

A computer simulation program, such as RESFEN (windows.lbl.gov/software), lets you compare window performance options by calculating performance based on utility rates for your climate, house design options, and window design options.

5. Ensure Proper Installation

Proper installation is necessary for optimal window performance, to ensure an airtight fit and avoid water leakage. Always follow manufacturers installation guidelines and use trained professionals for window installation.

Look for the ENERGY STAR

Recommendations in the Northern Zone (mostly heating)

U-factor	SHGC
Windows: U≤0.30 **Skylights: U≤0.55** If windows provide good access to winter solar heat gain (SHGC 0.40 or higher and southern orientation), a U-factor of 0.32 is also acceptable. For superior insulation, windows with a U-factor of 0.22 or less are available.	**No requirement.** If air conditioning is not a concern, look for a high SHGC (0.30-0.60) so that winter solar heat gains can offset a portion of the heating energy need. If cooling is a significant concern and no shading is available, select windows with a SHGC less than 0.40. Select skylights with a SHGC of 0.40 or less.

Recommendations in the North/Central Zone (heating & cooling)

U-factor	SHGC
Windows: U≤0.32 **Skylights: U≤0.55** The larger your heating bill, the more important a low U-factor becomes. For superior insulation, windows with a U-factor of 0.22 or less are available.	**Windows: SHGC≤0.40** **Skylights: SHGC≤0.40** If you have significant air conditioning costs or summer overheating problems, look for SHGC values of 0.30 or less. While windows with lower SHGC values reduce summer cooling demand, they also reduce free winter solar heat gain.

Recommendations in the South/Central Zone (heating & cooling)

U-factor	SHGC
Windows: U≤0.35 **Skylights: U≤0.57** The larger your heating bill, the more important a low U-factor becomes.	**Windows: SHGC≤0.30** **Skylights: SHGC≤0.30** Windows with low SHGC values reduce summer cooling and overheating. However, they also reduce winter solar heat gain.

Recommendations in the Southern Zone (mostly cooling)

U-factor	SHGC
Windows: U≤0.60 **Skylights: U≤0.70** A low U-factor is useful during cold days when heating is needed. A low U-factor is also helpful during hot days when it is important to keep the heat out, but it is less important than SHGC in warm climates.	**Windows: SHGC≤0.27** **Skylights: SHGC≤0.30** A low SHGC is the most important window property in warm climates.

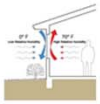
Look for Efficient Window Properties on the NFRC Label

U-Factor
The rate of heat loss is indicated in terms of the U-factor (U-value). This rate of non-solar heat loss or gain through a whole window assembly is measured in Btu/hr-sf-°F. The lower the U-factor, the greater a window's resistance to heat flow and the better its insulating value.

Solar Heat Gain Coefficient (SHC
The SHGC is the fraction of incide solar radiation admitted through a window. SHGC is expressed as a number between 0 and 1. The lowe window's solar heat gain coefficier the less solar heat it transmits. Whether a higher or lower SHGC is desirable depends on the climate orientation, shading conditions, an other factors.

Visible Transmittance (VT)
The VT is an optical property that indicates the amount of visible ligh transmitted. VT is a whole window rating and includes the impact of th frame which does not transmit any visible light. While VT theoreticall varies between 0 and 1, most value are between 0.3 and 0.7. The highe the VT, the more light is transmitte

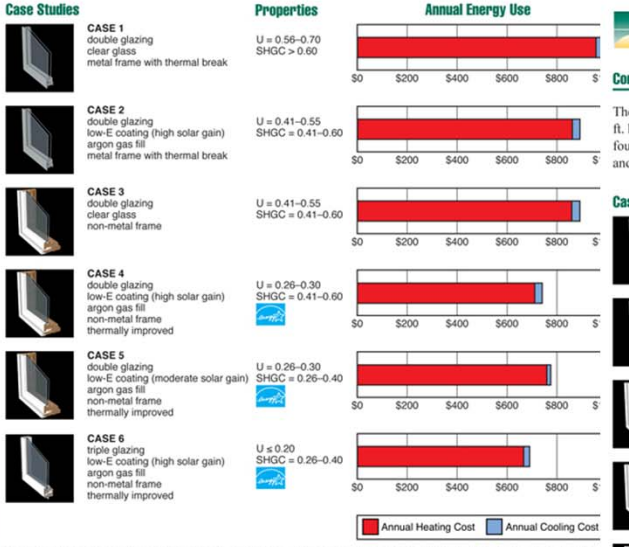
Air Leakage (AL)
AL is expressed in cubic feet of air passing through a square foot of window area (cfm/sf). The lower th AL, the less air will pass through cracks in the assembly. AL is very important, but not as important as U-factor and SHGC. AL is an optic rating on the NFRC label.



Condensation Resistance (CR)
CR measures how well a window resists the formation of condensatic on the inside surface. CR is expres as a number between 1 and 100. Th higher the number, the better a pro is able to resist condensation. CR i meant to compare products and the potential for condensation formatic CR is an optional rating on the NFI label.

Comparing Window Performance in Duluth, Minnesota

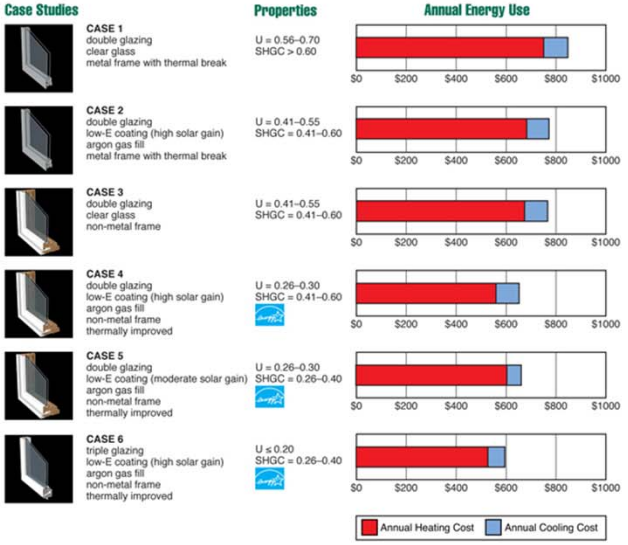
The annual energy performance figures shown here assume a typical new 2250 sq. ft. house with 15% window-to-floor area. The windows are equally distributed on all four sides of the house and include typical shading (interior shades, overhangs, trees and neighboring buildings).



Note: The annual energy performance figures shown here were generated with regression expressions provided by Lawrence Berkeley National Laboratory (windows.lbl.gov/EStar2008). Results assume a typical new 2250 sq ft house with 15% window-to-floor area. The windows are equally distributed on all four sides and include typical shading (interior shades, overhangs, trees, and neighboring buildings). U-factor and SHGC are for the total window including frame. The costs shown here are annual costs for space heating and space cooling only and thus will be less than total utility bills. Costs for lights, appliances, hot water, cooking, and other uses are not included in these figures. The mechanical system uses a gas furnace for heating and air conditioning for cooling. Natural gas prices used are projections of the average natural gas price for the heating seasons of 2010-2020 in real 2009 dollars. Projections are based on state-specific natural gas retail price data by the Energy Information Administration (EIA) for the heating seasons of 2006-08 and are adjusted based on EIA projections of national natural gas price trends for 2010-2020. Electricity prices used are projections of the average electricity price for the cooling seasons of 2010-2020 in real 2009 dollars. Projections are based on state-specific electricity retail price data by the Energy Information Administration (EIA) for the cooling seasons of 2006-08 and are adjusted based on EIA projections of national electricity price trends for 2010-2020 (www.eia.doe.gov).

Comparing Window Performance in Minneapolis, Minnesota

The annual energy performance figures shown here assume a typical new 2250 sq. ft. house with 15% window-to-floor area. The windows are equally distributed on all four sides of the house and include typical shading (interior shades, overhangs, trees and neighboring buildings).



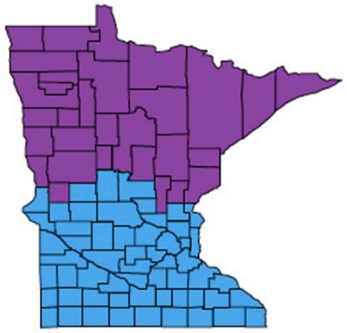
Note: The annual energy performance figures shown here were generated with regression expressions provided by Lawrence Berkeley National Laboratory (windows.lbl.gov/EStar2008). Results assume a typical new 2250 sq ft house with 15% window-to-floor area. The windows are equally distributed on all four sides and include typical shading (interior shades, overhangs, trees, and neighboring buildings). U-factor and SHGC are for the total window including frame. The costs shown here are annual costs for space heating and space cooling only and thus will be less than total utility bills. Costs for lights, appliances, hot water, cooking, and other uses are not included in these figures. The mechanical system uses a gas furnace for heating and air conditioning for cooling. Natural gas prices used are projections of the average natural gas price for the heating seasons of 2010-2020 in real 2009 dollars. Projections are based on state-specific natural gas retail price data by the Energy Information Administration (EIA) for the heating seasons of 2006-08 and are adjusted based on EIA projections of national natural gas price trends for 2010-2020. Electricity prices used are projections of the average electricity price for the cooling seasons of 2010-2020 in real 2009 dollars. Projections are based on state-specific electricity retail price data by the Energy Information Administration (EIA) for the cooling seasons of 2006-08 and are adjusted based on EIA projections of national electricity price trends for 2010-2020 (www.eia.doe.gov).

Code Fact Sheets†

Energy Code Compliance Guide to Window Selection in Minnesota

Code: 2009 International Energy Conservation Code

This guide is designed to help select windows, doors and skylights that will meet the requirements of the 2009 IECC for residential buildings as it relates to Minnesota. The requirements in the 2009 IECC are the same for windows used in new buildings, remodeling & additions to existing buildings, and as replacements of existing windows.



IECC CLIMATE ZONE 7

Aitkin	Grant	Mahnomen	Roseau
Becker	Hubbard	Marshall	St. Louis
Beltrami	Itasca	Mille Lacs	Wadena
Carlton	Kanabec	Norman	Wilkin
Cass	Kittson	Otter Tail	
Clay	Koochiching	Pennington	
Clearwater	Lake	Pine	
Cook	Lake of the Woods	Polk	
Crow Wing		Red Lake	

IECC CLIMATE ZONE 6

Anoka	Goodhue	Mower	Stearns
Benton	Hennepin	Murray	Steele
Big Stone	Houston	Nicollet	Stevens
Blue Earth	Isanti	Nobles	Swift
Brown	Jackson	Olmsted	Todd
Carver	Kandiyohi	Pipestone	Traverse
Chippewa	Lac Qui Parle	Pope	Wabasha
Chisago	Lake	Ramsey	Waseca
Cottonwood	Le Sueur	Redwood	Washington
Dakota	Lincoln	Renville	Watonwan
Dodge	Lyon	Rice	Winona
Douglas	Martin	Rock	Wright
Faribault	McLeod	Scott	Yellow Medicine
Fillmore	Meeker	Sherburne	
Freeborn	Morrison	Sibley	

Step-by-Step Instructions

1. Using the climate zone map or table, match the jurisdiction to the appropriate IECC climate zone. Use the "IECC Prescriptive Window Energy Efficiency Requirements" (on the back of this sheet) to determine the window performance requirements associated with the climate zone.
2. Construct the home with windows that have area weighted average U-factor and SHGC values less than or equal to the values for the climate zone and meet the code maximum air leakage requirements.

The 2009 International Energy Conservation Code

The 2009 IECC was developed by the International Code Council (ICC) and is currently available to states for adoption. The IECC is the national model standard for energy-efficient residential construction recognized by federal law. The American Recovery and Reinvestment Act of 2009 makes funds available to jurisdictions that have committed to adopt and implement the 2009 IECC. Users of this guide are strongly recommended to obtain a copy of the IECC and refer to it for any questions and further details on compliance. IECC compliance training is also available from many sources. To obtain a copy of the 2009 IECC, contact the ICC or visit www.iccsafe.org.

IECC Prescriptive Window Energy Efficiency Requirements

Code: 2009 International Energy Conservation Code

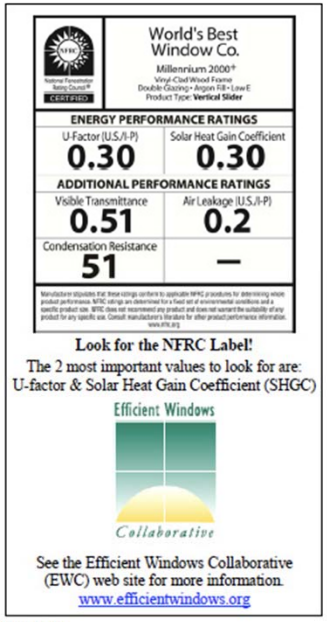
This table of window, door and skylight requirements is from the 2009 IECC and does not necessarily reflect the version of the IECC that may have been adopted by the state or any state-specific amendments. These requirements apply to all fenestration products in residential buildings, including those used in new residences, in additions and to replace existing windows. For a definition of "fenestration" see Note 2 below. The IECC specifies additional requirements for other parts of the building envelope not listed here, such as insulation for walls and ceilings.

Package	Fenestration U-factor	Skylight U-Factor	Glazed Fenestration SHGC
Climate Zone 7	0.35	0.60	NR
Climate Zone 6	0.35	0.60	NR

"NR" means no requirement is specified in this package.

NOTES:

1. This table applies to residential buildings as defined in the IECC for compliance under the prescriptive compliance option. The 2009 IECC permits unlimited window area, so long as the prescriptive requirements are satisfied.
2. "Fenestration" refers to glazed window and door products in exterior walls of buildings, including glass doors and glass block, along with the accompanying sashes, frames, etc. and opaque doors. "Skylight" refers to glazed products installed at a slope of 15 degrees or more from vertical. "Glazed Fenestration" includes all glazed fenestration and all skylights.
3. U-factor is a number, generally between 0.2 and 1.20, that indicates the rate of heat loss (or gain) through a window. A lower U-factor demonstrates a greater resistance to heat loss and gain, i.e., better insulating value of the window. As a result, a lower number produces greater winter comfort.
4. SHGC, or Solar Heat Gain Coefficient, is a number between 0 and 1 that indicates the fraction of radiation (heat) from the sun that is transmitted through the window; the lower the SHGC, the less the amount of solar radiation that is allowed to pass through the window and become unwanted additional heat in the summer. As a result, a lower number produces greater summer comfort.
5. Window and skylight U-factor and SHGC values are maximum acceptable levels. An area-weighted average of fenestration products shall be permitted to satisfy the U-factor and SHGC requirements.
6. Up to 15 square feet of glazed fenestration is permitted to be exempt from the U-factor and SHGC requirements. One side-hinged opaque door assembly up to 24 square feet is exempted from the Fenestration U-factor requirement. These exceptions apply in the prescriptive path only. Certain impact rated fenestration may be permitted to have a higher U-factor in climate zones 2 and 3. Special exceptions may apply for fenestration U-factor requirements in thermally isolated sunrooms.
7. Window, door and skylight U-factors and SHGCs must be determined from a National Fenestration Rating Council (NFRC) rating that is independently certified and set forth on a label on the product or from a limited table of product default values in the IECC. See www.nfrc.org for more details on the NFRC rating system.
8. Windows, doors and skylights must be labeled in a manner to determine that they meet the IECC's air infiltration requirements.
9. The labeled product U-factor and SHGC should also be used in calculation procedures to properly size the home's HVAC equipment. The IECC requires the use of an appropriate computational procedure to size equipment.



Look for the NFRC Label!

The 2 most important values to look for are: U-factor & Solar Heat Gain Coefficient (SHGC)

Efficient Windows Collaborative

See the Efficient Windows Collaborative (EWC) web site for more information.
www.efficientwindows.org

Limitations

This guide is an energy code compliance aid for window selection in Minnesota based upon the simple prescriptive option of the 2009 IECC and reflects the prescriptive values from Table 402.1.1 of that code. This guide only addresses window requirements and not the requirements applicable to the rest of the home. It does not provide a guarantee that a home meets the IECC. This guide is not designed to reflect the actual energy code, with amendments, if any, adopted in Minnesota and does not, therefore, provide a guarantee for meeting the state energy code. For additional details on Minnesota's energy code, including how it may differ from the IECC, please contact your local building guide official.

Other Fact Sheets†

Efficient Windows Collaborative

Energy Efficient Windows for Mid- & High-rise Residential Buildings

www.efficientwindows.org January 2011

Energy-efficient windows save heating and cooling energy and improve occupant comfort while allowing for downsized HVAC equipment. Residential-type ENERGY STAR windows are a good choice for saving energy in single family and many multifamily buildings. However, structural, safety and façade design considerations in mid- and high-rise buildings often call for commercial-type windows which are not part of the ENERGY STAR program. Whichever the case, the simple guidelines presented here can help you specify energy efficient options from among the different types of windows used in mid- and high-rise residential applications.

This fact sheet was produced with funding from the Building Technologies Program at the U.S. Department of Energy in support of the EWC. For more information, contact:

EWC / Alliance to Save Energy
1850 M Street NW, Suite 600
Washington, DC 20036
Phone: 202-530-2254
Email: ewc@ase.org

Visit www.efficientwindows.org for more information on the benefits of efficient windows, how windows work, how to select an efficient window, and what manufacturers provide efficient products.

1. Comply with Energy Code Requirements

Most jurisdictions base their building energy code on the International Energy Conservation Code (IECC). Reside… buildings higher than three stories are covered by the IE… commercial chapter, which references ASHRAE Stan… 90.1 as a compliance alternative. Both the IECC and Stan… 90.1 require that window energy ratings are determin… accordance with NFRC standards. *See "Window E… Ratings" on the next page.*

2. Look for Well-insulating Windows

In tall buildings, structural and safety considerations are… addressed with metal framing or metal reinforcement. … this may impact insulating properties, energy codes us… allow some flexibility for window U-factors for reside… buildings higher than three stories. Nonetheless, adva… window designs can limit the conductivity of metal fr… or boost the strength of non-metal frames—allowing… specification of windows with beyond-average insul… properties while meeting structural and safety requirem… *See next page for U-factor specification recommenda… and for an overview of structural performance classes*

3. Pay Particular Attention to Solar Heat Gain

Solar heat gain is a particular concern for mid- and high… buildings where shading is difficult to provide and … units may have their windows only in a single, unfavo… orientation. Building energy codes limit window solar… gain coefficients (SHGC) in warmer climates. But … in colder climates, you may want to consider low-S… windows to prevent overheating, particularly with west-f… windows or large glass areas. Control of window solar… gain can substantially reduce the required cooling equip… size. *See next page for SHGC specification recommenda…*

4. Limit Air Leakage and Ensure Proper Installation

Air leakage is a particular concern for higher buildings w… windows are exposed to greater wind loads. Controllin… leakage requires not only that windows are tested to co… with the energy code's air leakage limit, but also that … are properly installed. Window installation is critical f… airtight fit, to avoid thermal bridging, and to prevent … penetration around the window. Field testing in accord… with ASTM E783 can evaluate both the window asse… and installation details for air leakage. Water penetratio… be evaluated in accordance with ASTM E 1105.

Efficient Windows Collaborative

Window Energy Efficiency Solutions for Public and Affordable Housing

www.efficientwindows.org January 2011

Energy-efficient windows lower energy bills, improve occupant comfort, and reduce condensation. Although initial cost is often a barrier in low-income housing, window energy efficiency measures may qualify for financing and incentive programs and may allow for smaller, less expensive HVAC equipment due to lower heating and cooling loads. Also note that in buildings with lead paint hazard, window replacement can be the single most effective way to eliminate lead dust. Where windows are in good condition and without lead paint, storm windows and shading devices are also feasible energy efficiency options.

This info sheet presents window energy efficiency considerations for both new and existing public and affordable housing.

This fact sheet was produced with funding from the Building Technologies Program at the U.S. Department of Energy in support of the EWC. For more information, contact:

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Visit www.efficientwindows.org for more information on the benefits of efficient windows, how windows work, how to select an efficient window, and what manufacturers provide efficient products.

Specify for maximum energy savings

Windows must meet local energy code requiremen… even higher energy performance, consider ENERGY … windows, which are recommended for low-rise dwellin… are often suitable for mid-rise dwellings as well.

For window and storm window options with su… performance in cold climates, check out the U.S. Depa… of Energy's highly insulating windows purchasing pr… (see next page).

Seize Opportunities to Reduce Cost

Government or utility incentives and financing n… available for energy efficiency in low-income housing. … www.dsireusa.org for up-to-date information on in… programs.

New construction often offers low- and no-cost opport… for window energy efficiency. For instance, buildin… be orientated and shaded to invite the low winter sun… minimizing solar heat gain in the summer. Where … window performance reduces heating and cooling … HVAC equipment downsizing helps reduce initial co…

Alternatives to window replacement, such as storm wi… and shading, can boost energy efficiency at a lower … cost. With all window retrofit options, lifetime energy s… and durability should be considered in addition to fir…

Ensure Proper Implementation for Full Benefits

For optimal window performance, proper installa… necessary to ensure an airtight fit and avoid water le… Always follow manufacturers' installation guidelin… use trained professionals for window installation. Th… prominent standard for window installation is ASTM St… E 2112.

In older homes with lead paint, windows are often the … source of lead hazard. For window replacement to … effective remedy and for worker protection, ensu… contractors are lead-safe certified and perform their w… accordance with the EPA Renovation, Repair and Paintin…

Efficient Windows Collaborative

The Efficient Windows Collaborative Multiple Benefits Fact Sheet

www.efficientwindows.org September 2008

Selecting a window or skylight involves many considerations such as appearance, energy performance, human factor issues, technical performance, and cost. This fact sheet combines several measurable attributes (annual energy cost, peak demand, winter and summer thermal comfort, and condensation) to assist in the selection process.

Making purchasing decisions based on one attribute, such as energy performance, may not always lead to a completely balanced outcome. For example, two windows that are similar in their effect on annual energy use may be very different in their condensation resistance or in the comfort they provide at extreme temperatures.

To assist in decision-making, tables showing multiple attributes of windows, representing each of the four ENERGY STAR climate zones, are shown on the following pages. The representative cities are Minneapolis, Minnesota (northern), Washington, DC (north/central), Phoenix, Arizona (south/central), and Miami, Florida (southern). On each table, a rating of below average, average, and above average is given for the five attributes:

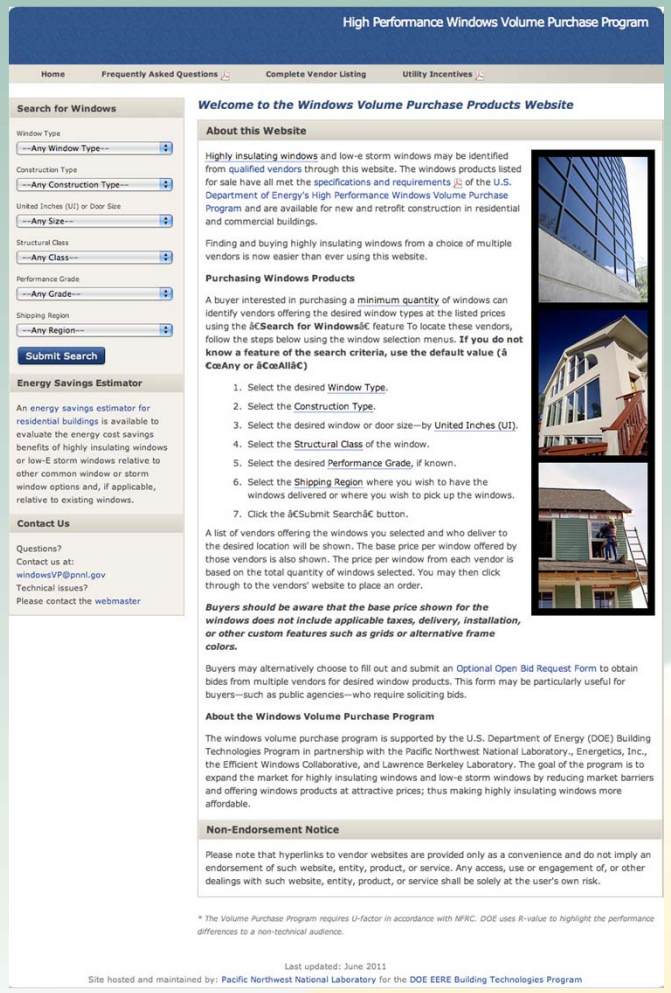
Multiple Benefits Fact Sheet Contents

annual energy cost, electricity peak, winter comfort, summer comfort, and condensation resistance. There are 34 generic window types—various glazing types combined with four frame types—shown for each climate. It is important to note that not all of the attributes have the same priority and this varies by region. For example, winter comfort and condensation are less important in a southern climate zone.

Annual energy costs and peak demand are simulated using the computer program, RESFEN. The range of results for a given city are divided into three groups designated as below average, average and above average. Similarly, results of the Winter and Summer Thermal Comfort Index developed at the University of California, Berkeley, and the National Fenestration Rating Council's (NFRC) condensation rating (CR) are divided into three groups as well.

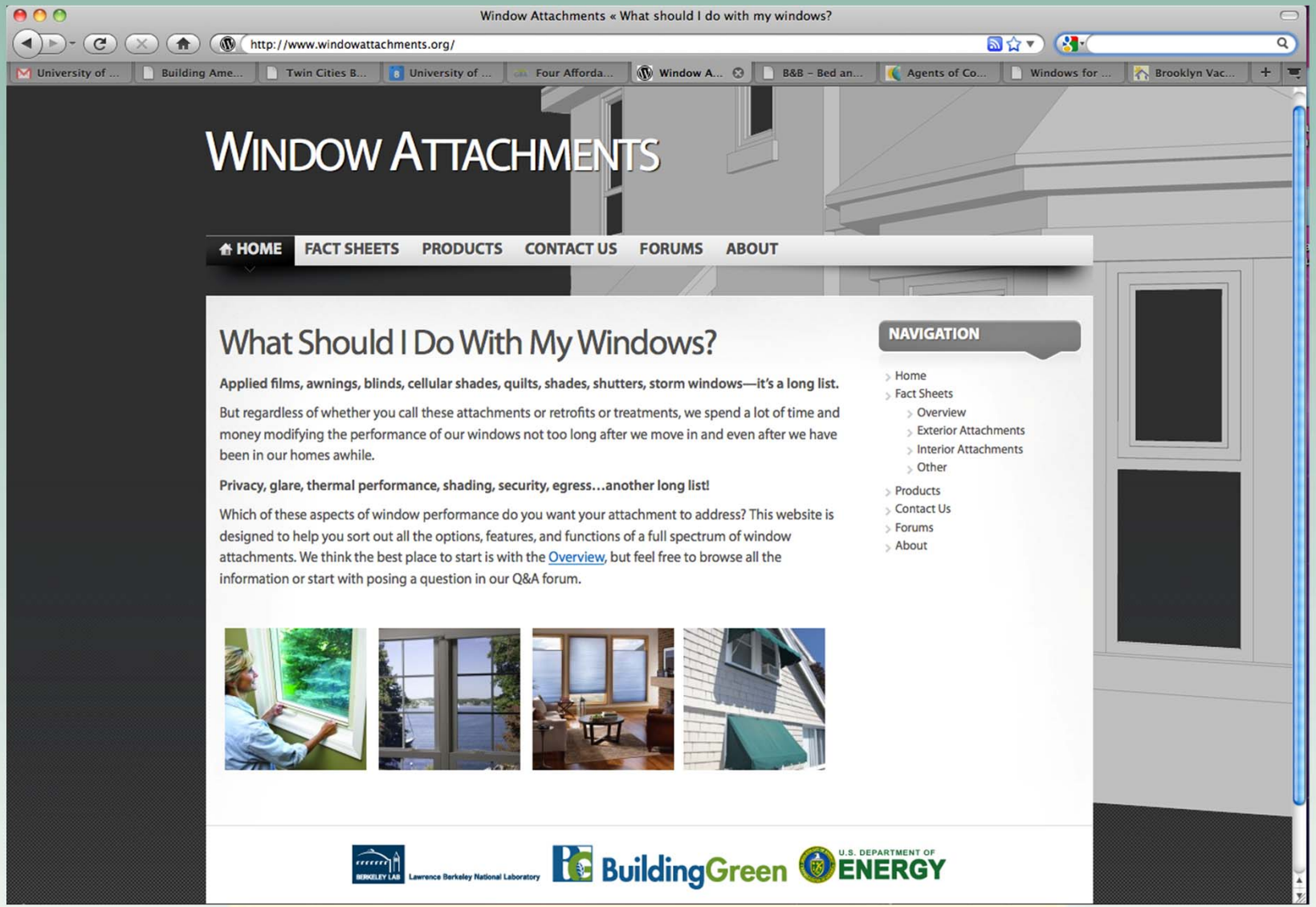
Visit www.efficientwindows.org for more information on the benefits of efficient windows, how windows work, how to select an efficient window, and what manufacturers provide efficient windows.

High-performance Windows and Low-E Storm Windows Volume Purchase Program



For those interested in maximizing heating energy savings through window energy efficiency, the U.S. Department of Energy (DOE) started the *Highly Insulating (R-5) Windows and Low-E Storm Windows Volume Purchase Program* in 2010. This program connects potential buyers with vendors of highly insulating windows and low-E storm windows by allowing buyers to check out available product options and price ranges at www.windowsvolumepurchase.org.

While DOE does not offer any incentives for purchases through this program, the web platform encourages competitive pricing among the participating vendors, and the program's qualification criteria ensure that the listed windows and storm windows offer superior insulating performance.


Window Attachments « What should I do with my windows?
http://www.windowattachments.org/
WINDOW ATTACHMENTS
HOME
FACT SHEETS
PRODUCTS
CONTACT US
FORUMS
ABOUT
What Should I Do With My Windows?
Applied films, awnings, blinds, cellular shades, quilts, shades, shutters, storm windows—it's a long list.
But regardless of whether you call these attachments or retrofits or treatments, we spend a lot of time and money modifying the performance of our windows not too long after we move in and even after we have been in our homes awhile.
Privacy, glare, thermal performance, shading, security, egress…another long list!
Which of these aspects of window performance do you want your attachment to address? This website is designed to help you sort out all the options, features, and functions of a full spectrum of window attachments. We think the best place to start is with the Overview, but feel free to browse all the information or start with posing a question in our Q&A forum.
NAVIGATION
Home
Fact Sheets
Overview
Exterior Attachments
Interior Attachments
Other
Products
Contact Us
Forums
About
Lawrence Berkeley National Laboratory
BuildingGreen
U.S. DEPARTMENT OF ENERGY

Zero Energy Windows: Technologies of the Future

Highly insulating windows
- Aerogel
- Vacuum
- Multi-layer gas-filled low-E

Dynamic Glazings
- Glazing with intrinsic optical control
- Add-on shading systems

Integrated facades
- Daylight redirection
- Automatically dimming lights
- Multi-layer gas-filled low-E

Highly Insulating Windows

Three panes of glass or suspended film between two panes of glass

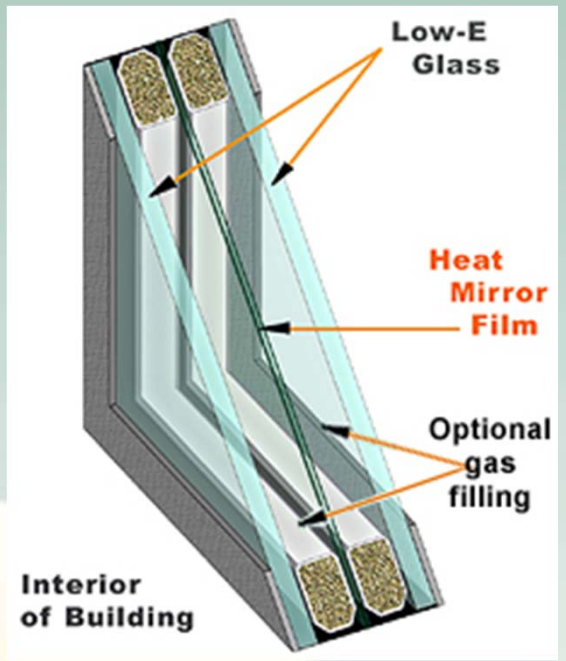


Image source: Southwall Technologies

Low-conductance Frame Heat Transfer

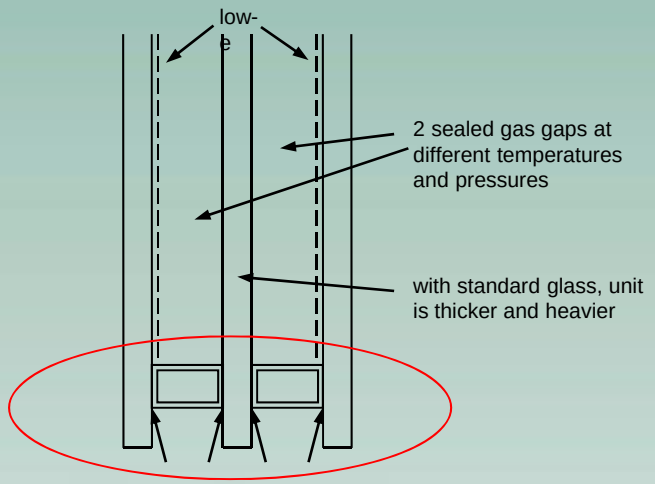
- Frame often 25% of area and thus a critical element of a high R window
- Little US experience with high R frames; European products of interest
- Ongoing research:
  - Identifying frame features (thermal breaks, cavity sizes, cavity emissivities) which are most significant in reducing heat transfer
  - Upgrading test and computational procedures for low-conductance products

Report at: http://windows.lbl.gov/adv_Sys/NTNU-LBNL-EuropeanFramesReport.pdf

Non-structural Center Layer

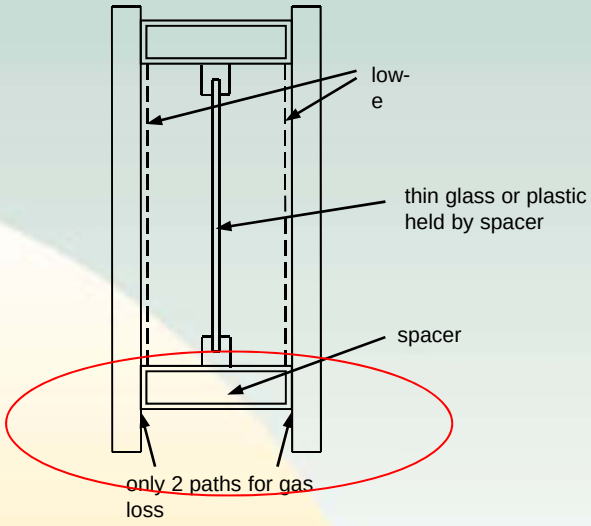
Current technology

- Glass is heavy
- Thin film products expensive
- Multiple spacers lead to gas leakage



Non-structural center layer

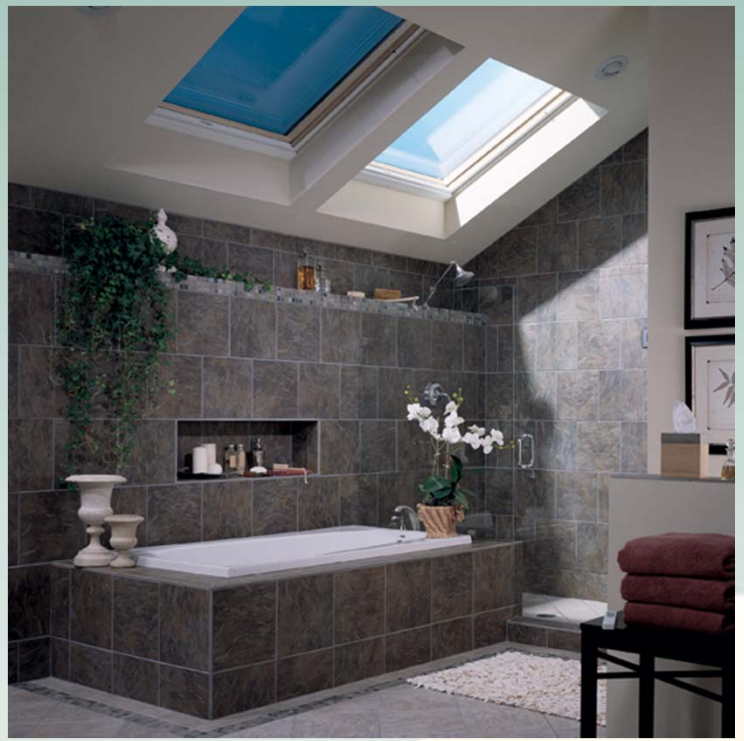
- IR thermography shows equal performance with non-structural “loose” layers
- Research on novel center layer designs and materials (rigid plastics and thin glass) in progress



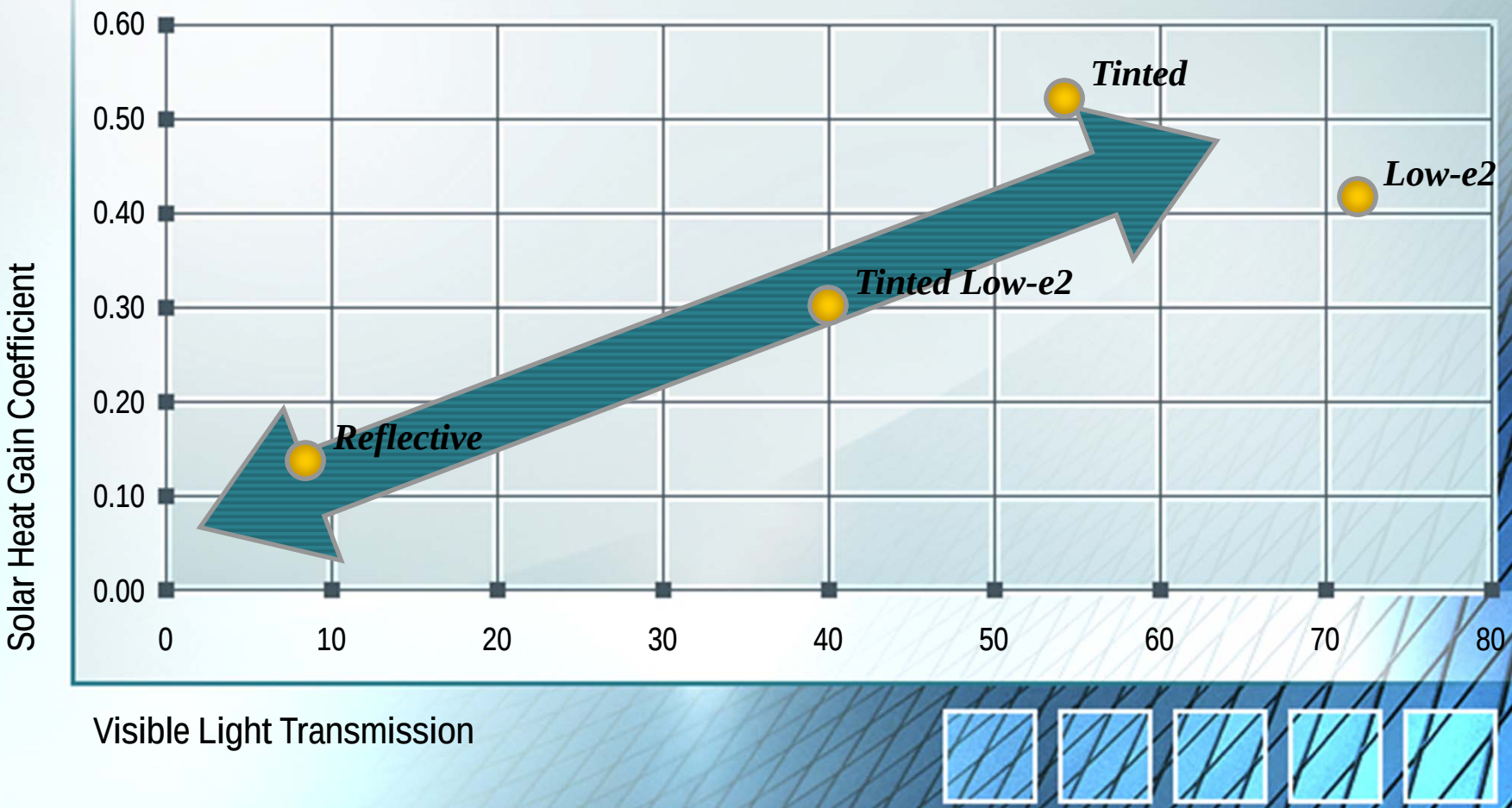
Emerging Technologies
Electrochromics

Clear state **Dark state**

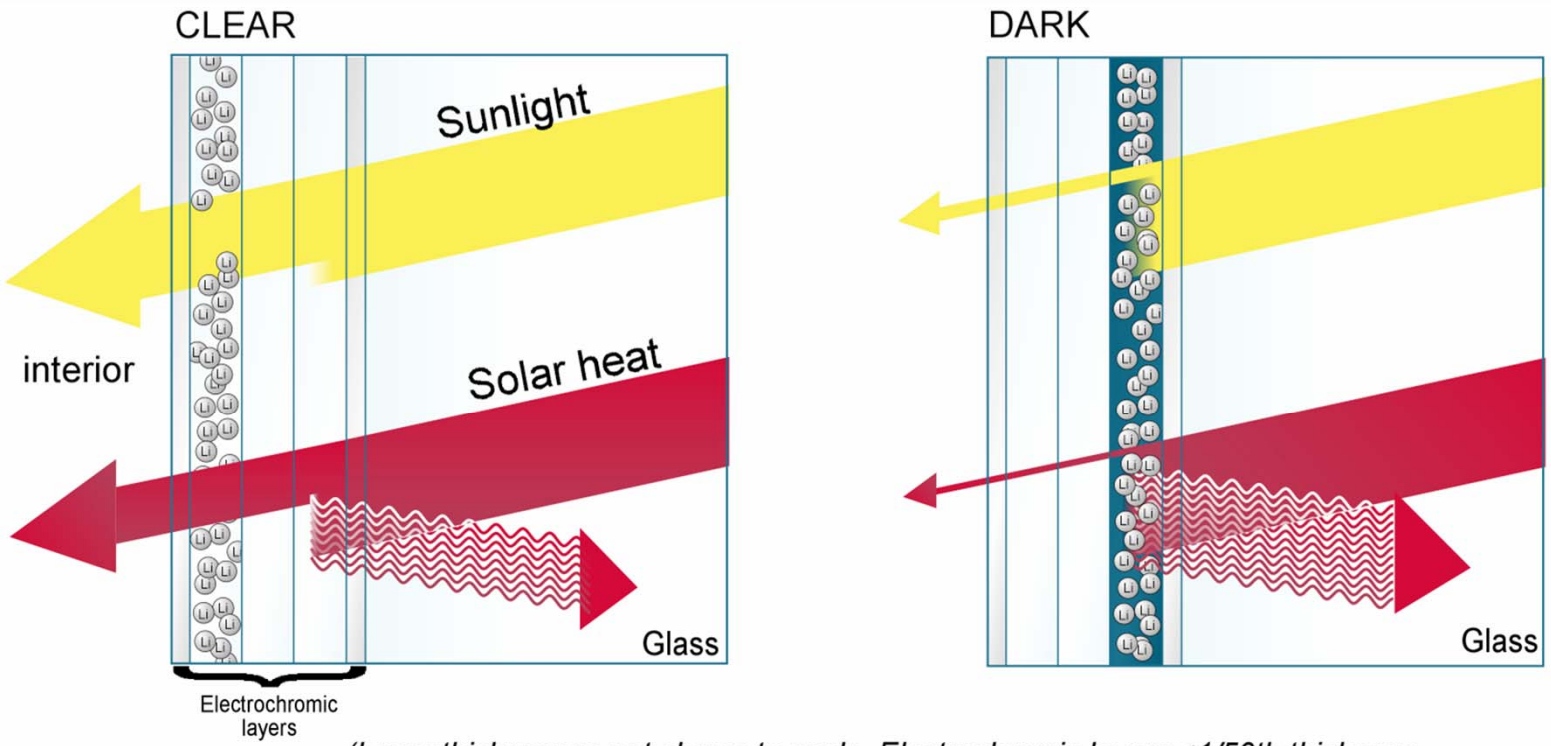
Emerging Technologies
Electrochromics



Performance Comparison



Electrochromic Technology



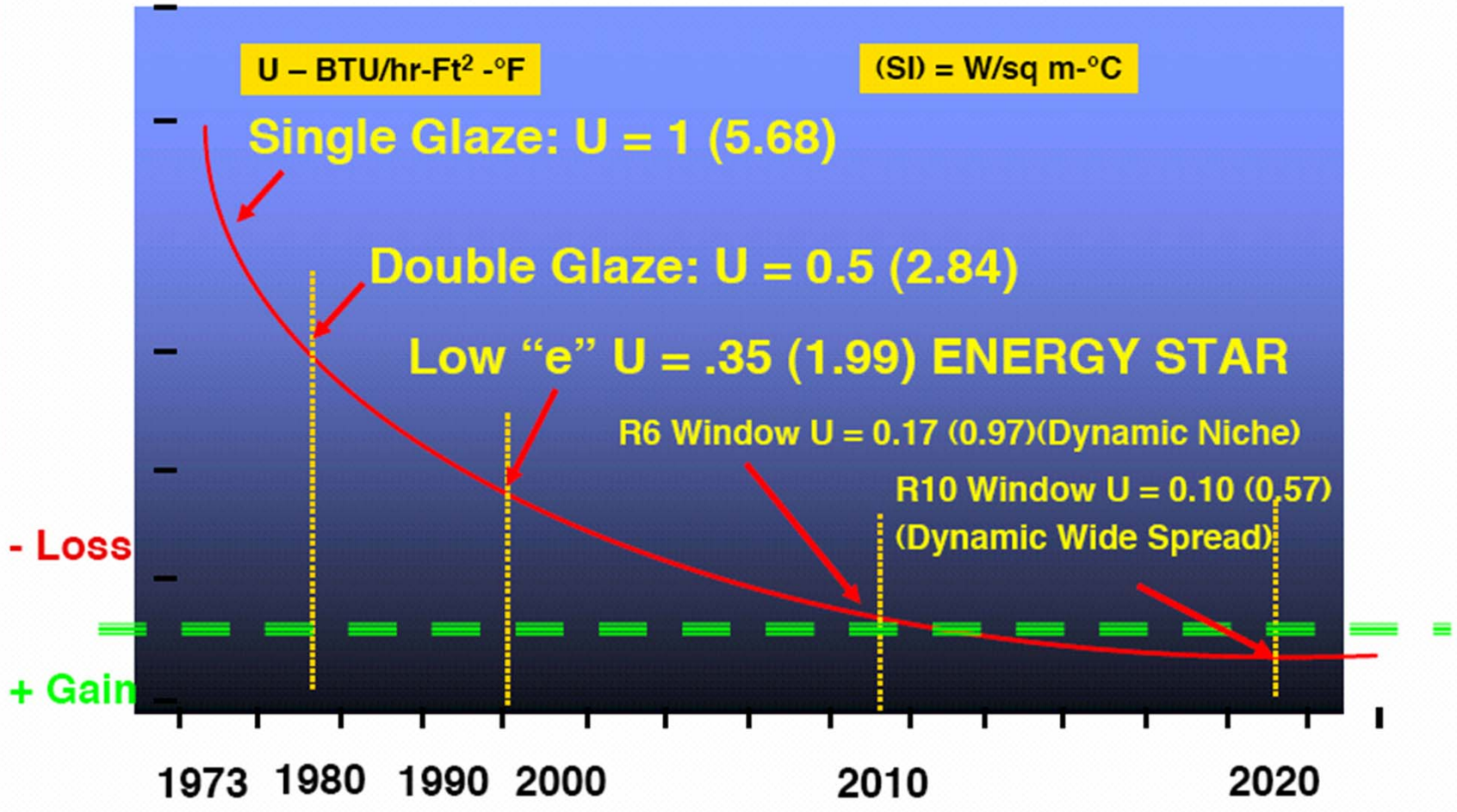
(Layer thicknesses not shown to scale. Electrochromic layers <1/50th thickness of a human hair. Powered by low voltage DC.)

Advanced Window Technology Prototype

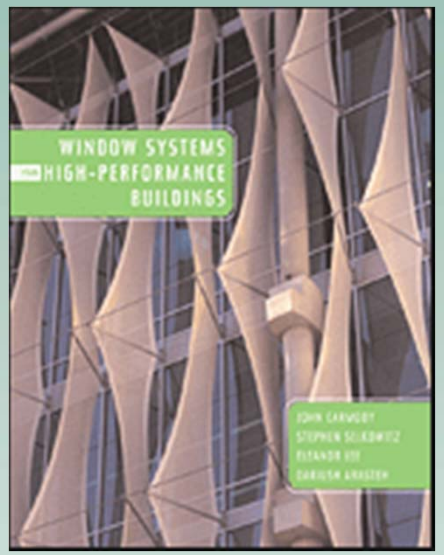
Prototype – Concept Window
(Highly Insulating and Dynamic
R 5.6, SHGC 0.04 – 0.34)
Low cost unsealed center lite

- LBNL is developing fundamental new window technologies in the laboratory with private industry
- The next generation window is both highly insulating and dynamic
- R-10 windows may be possible in the future with vacuum glazings

Next Generation Windows Can Become Energy Producers (US Mixed and Northern Climates)



Efficient Windows Collaborative

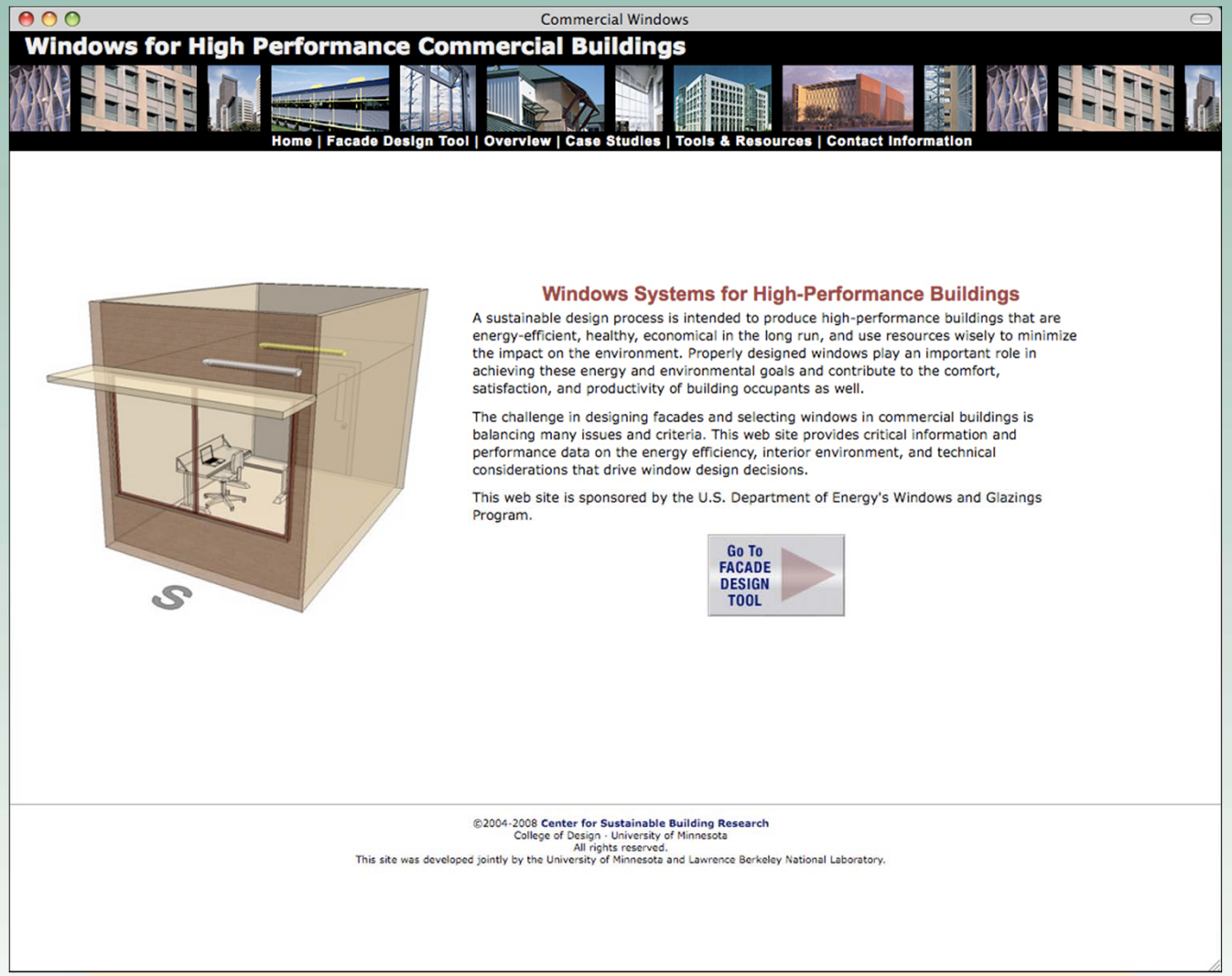


Commercial Tools and Information

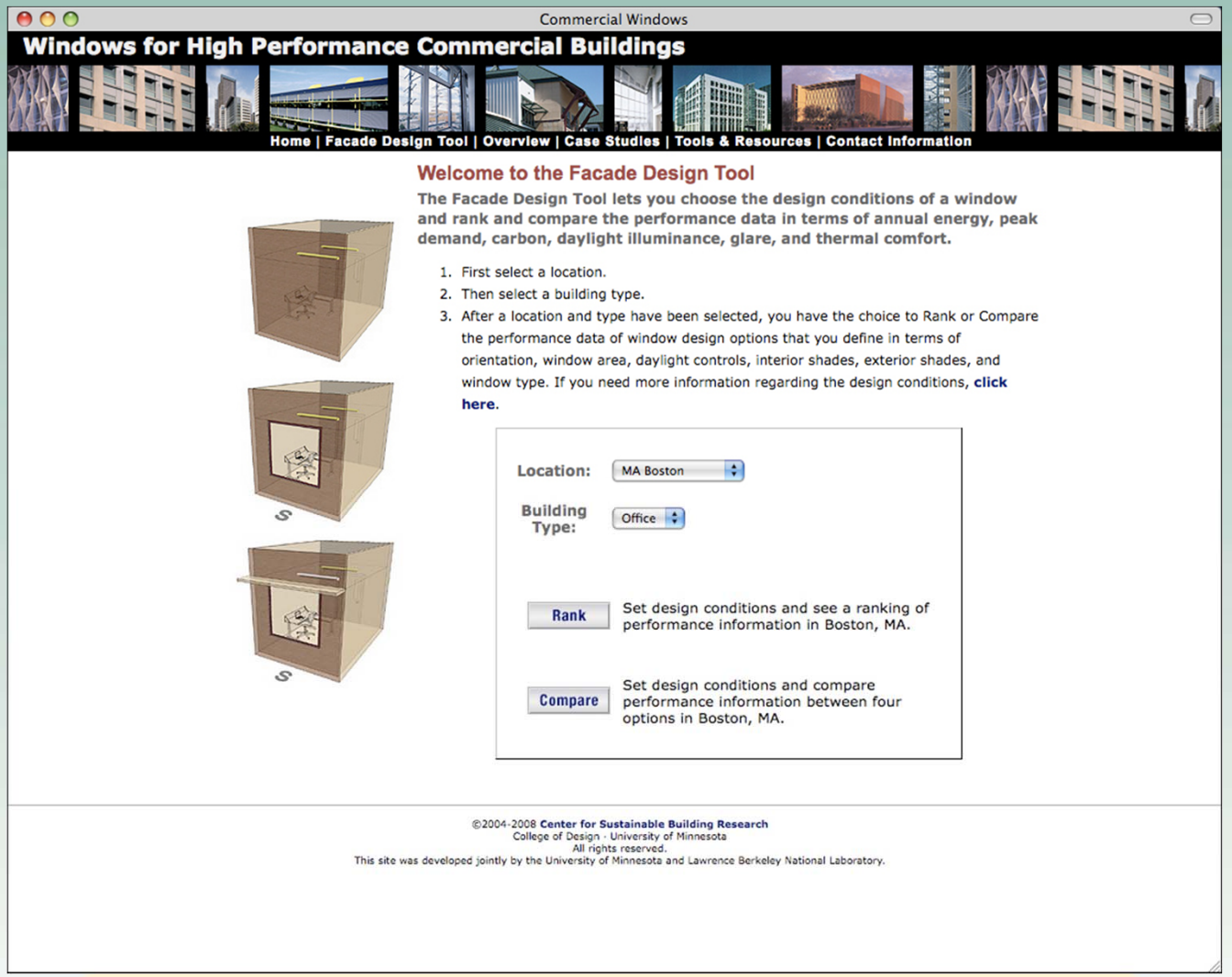
- Book: *"Window Systems for High Performance Buildings"*
- Web site

  www.commercialwindows.org
- Education and training materials
- COMFEN

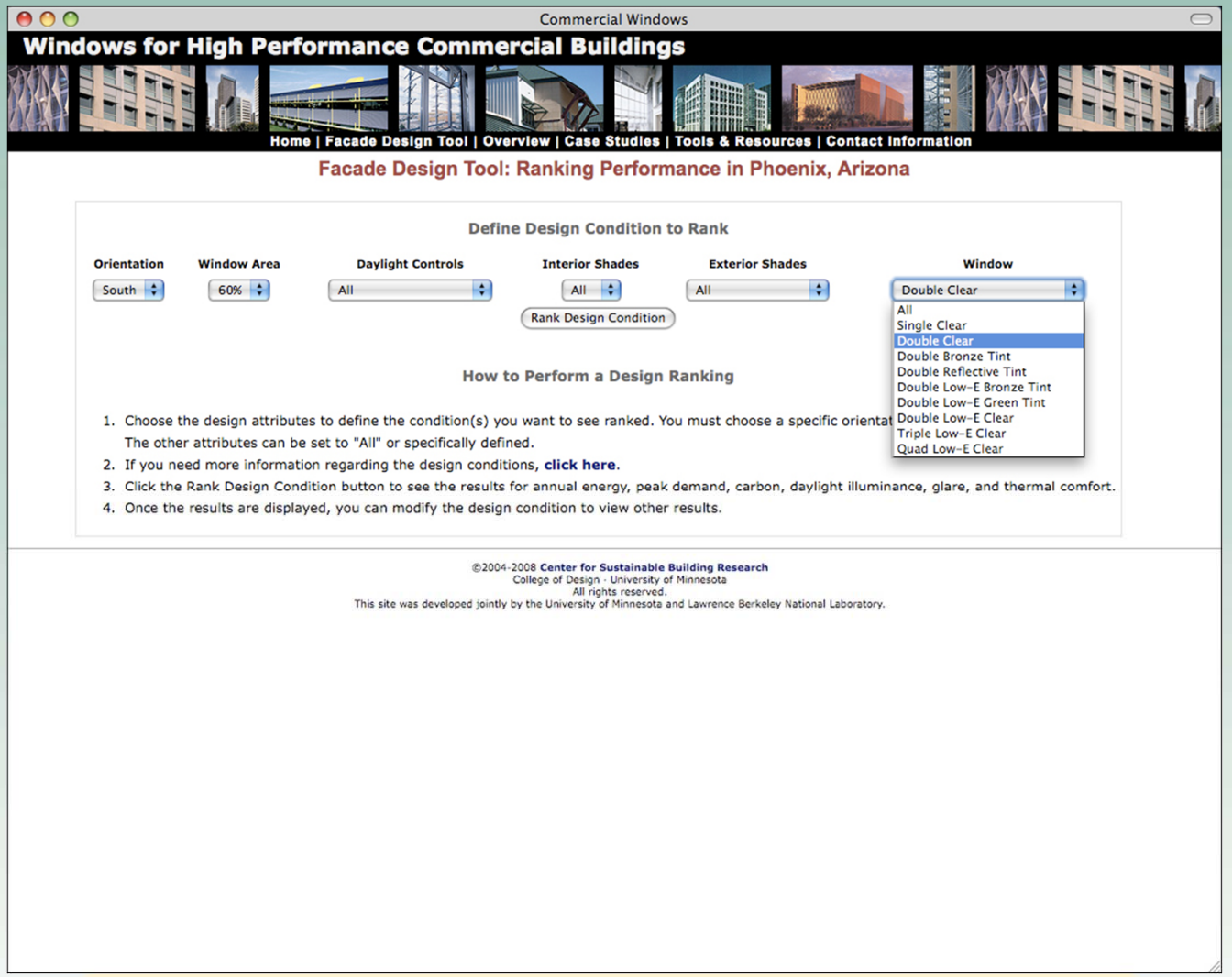
www.commercialwindows.org



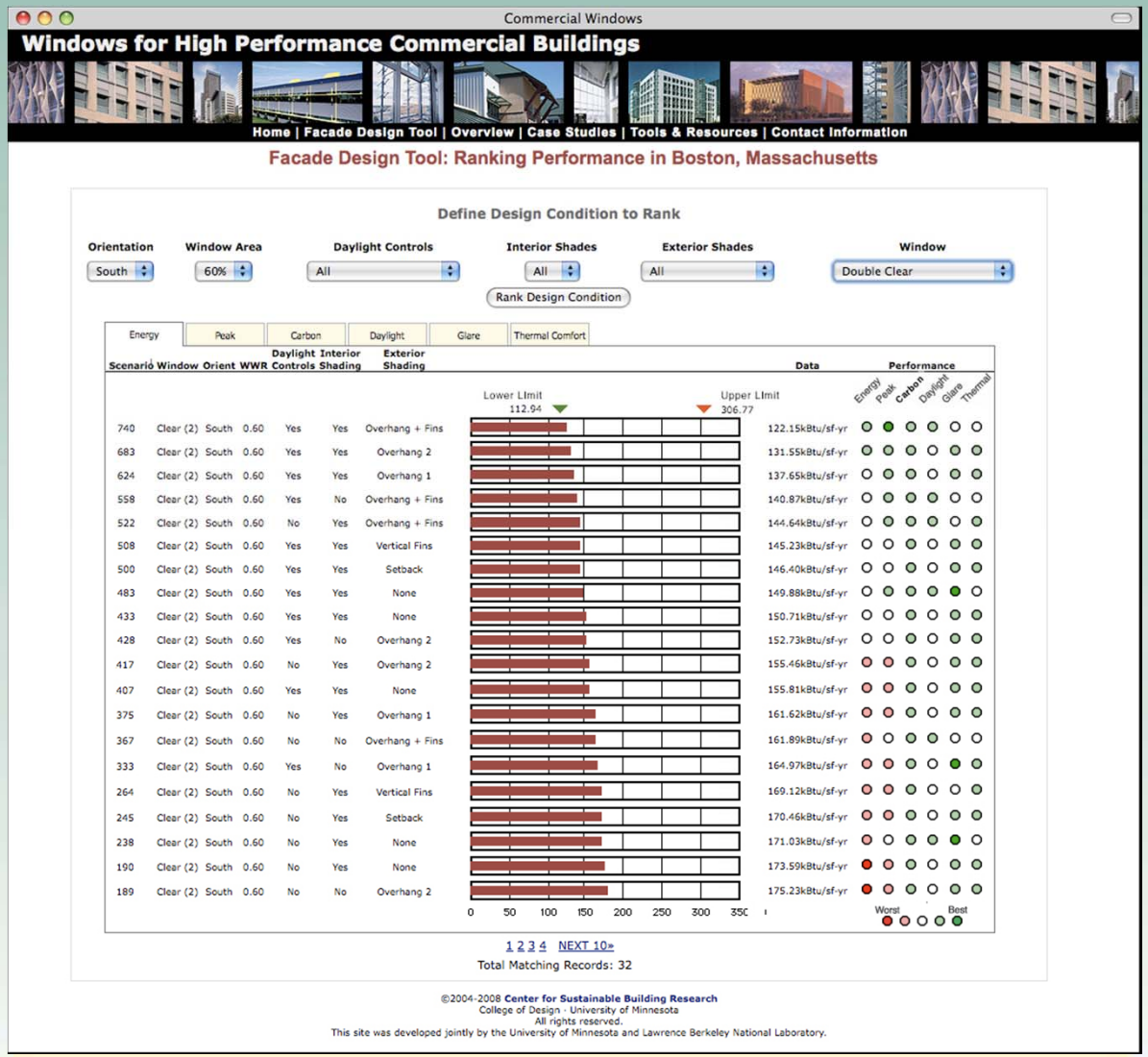
Façade Design Tool



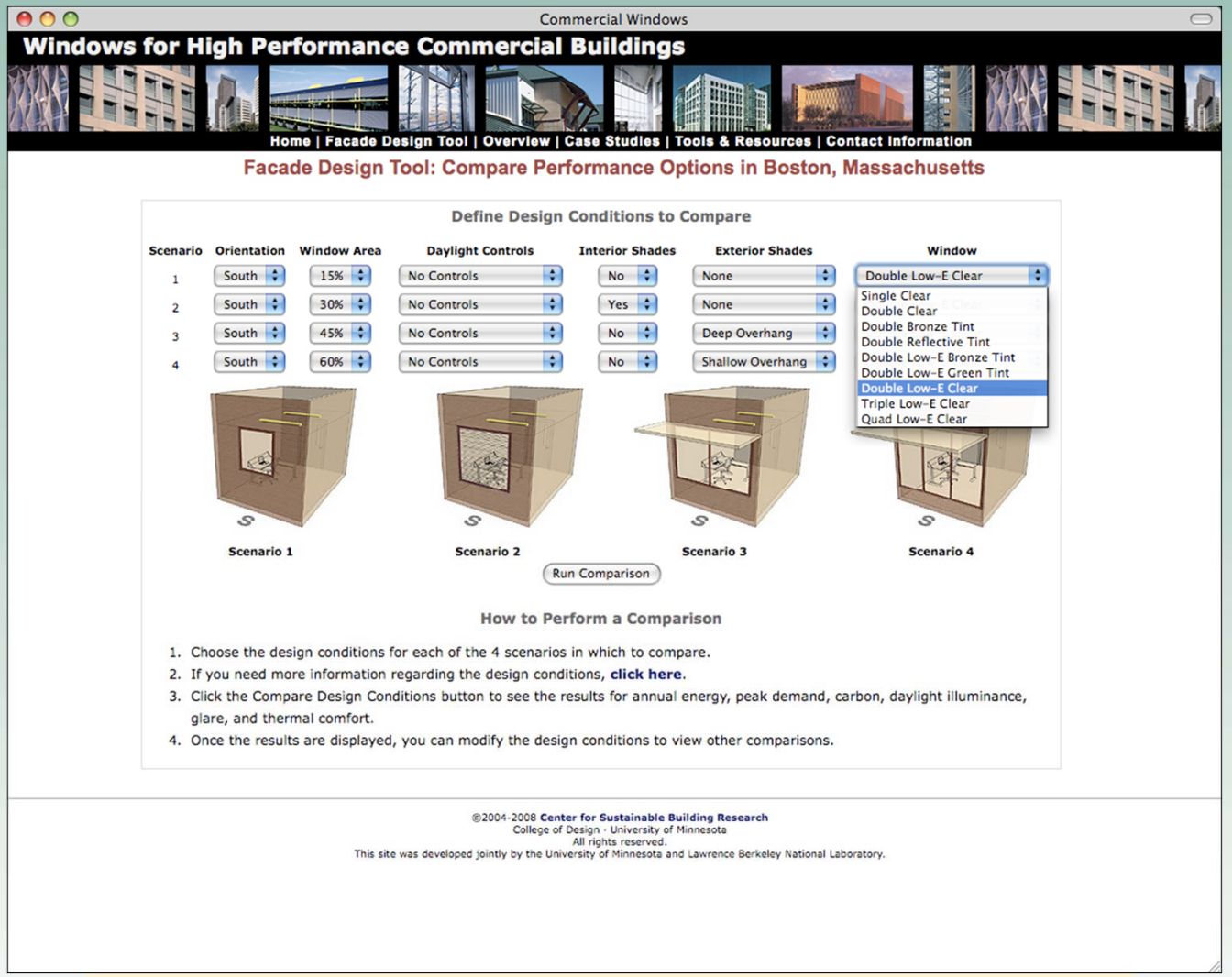
Façade Design Tool



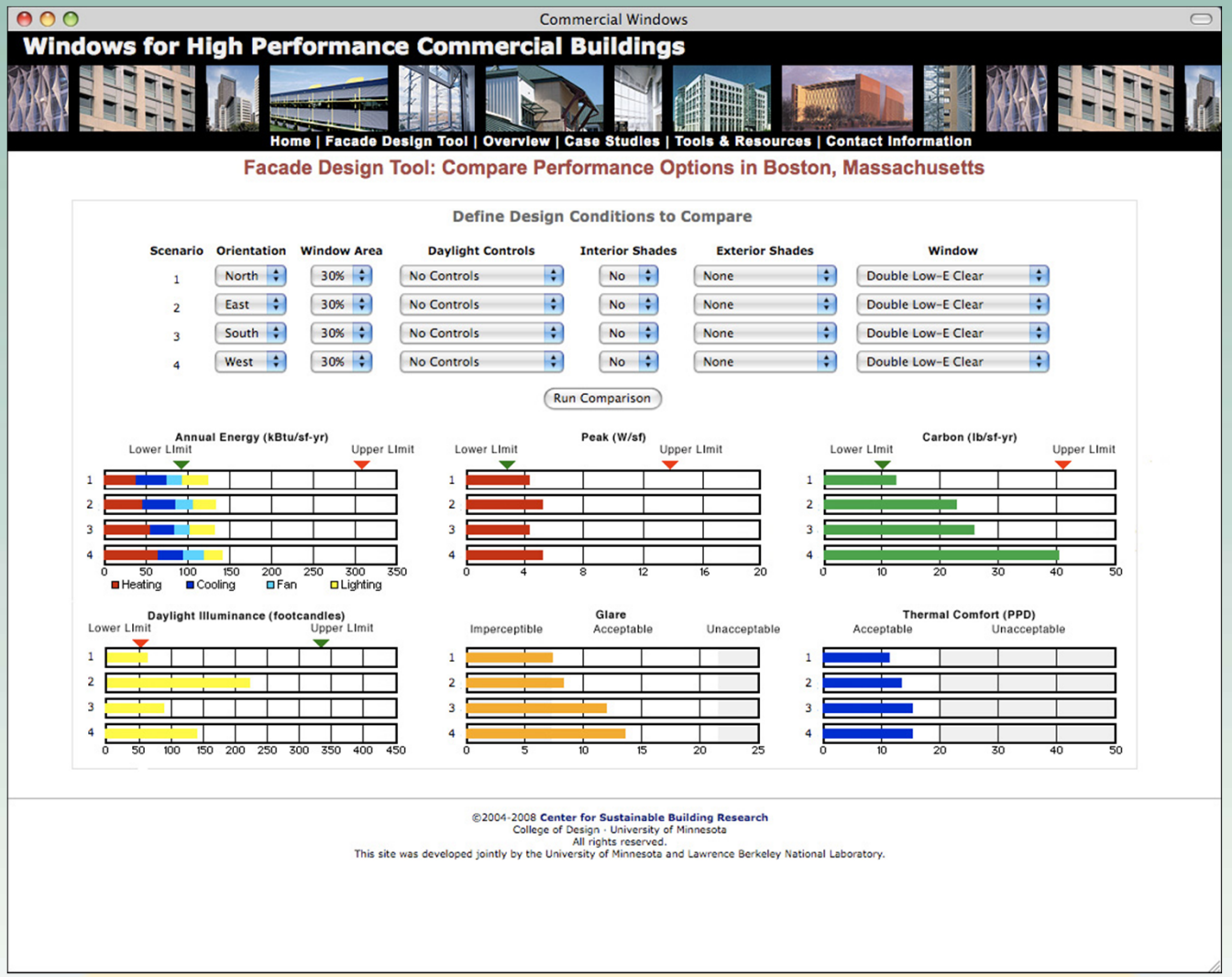
Façade Design Tool



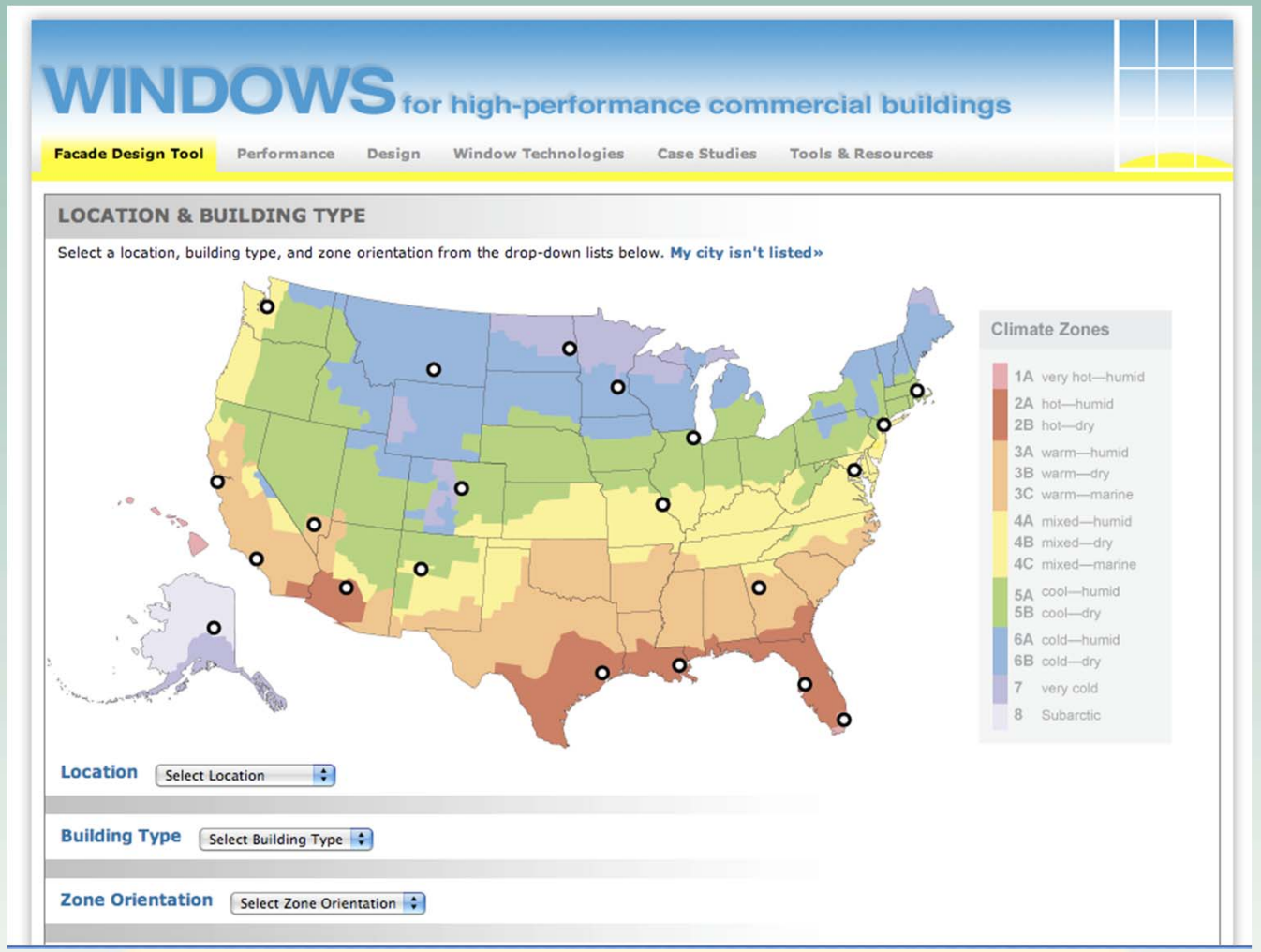
Façade Design Tool



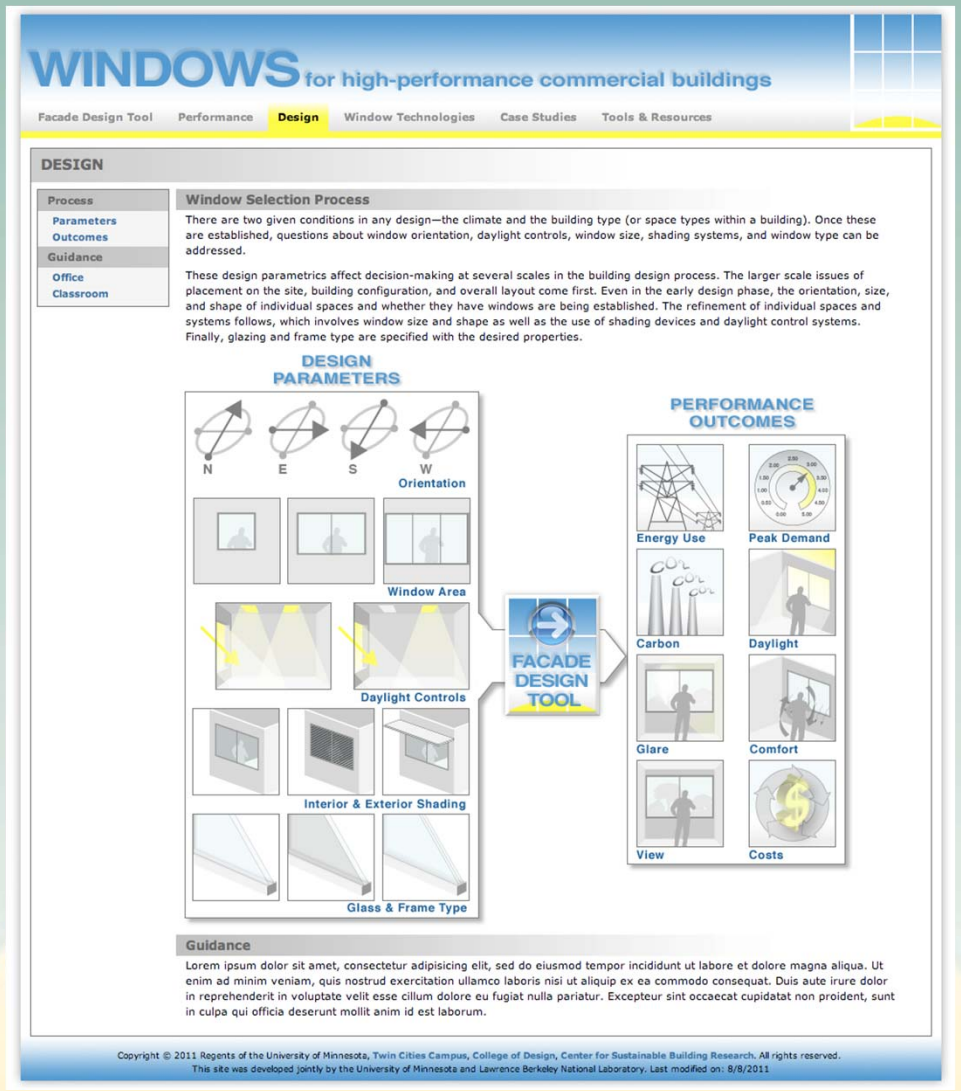
Façade Design Tool



Redesign Coming Soon

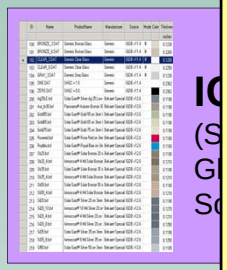


Redesign Coming Soon



Tools to Determine Window Performance

Developed by: Lawrence Berkeley National Lab



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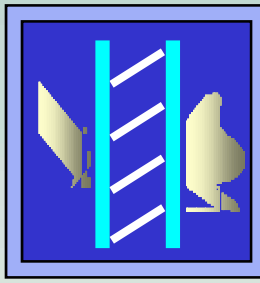

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Optics
Analyze glazing optical properties

IGDB (International Glazing Database)
Database of glazing materials

CGDB (Complex Glazing Database)
Database of complex glazing materials

THERM
Analyze two-dimensional heat transfer through building products

WINDOW
Analyze window thermal and optical performance

RESFEN
Calculate the heating and cooling energy use of windows in residential buildings

COMFEN
Calculate the heating and cooling energy use of windows in commercial buildings, as well as evaluating daylighting and thermal comfort

THERM
(Window Frame)

Design / Simulation To
DOE-2, EnergyPlu
Radiance

RESFEN
(Whole Building Residential)

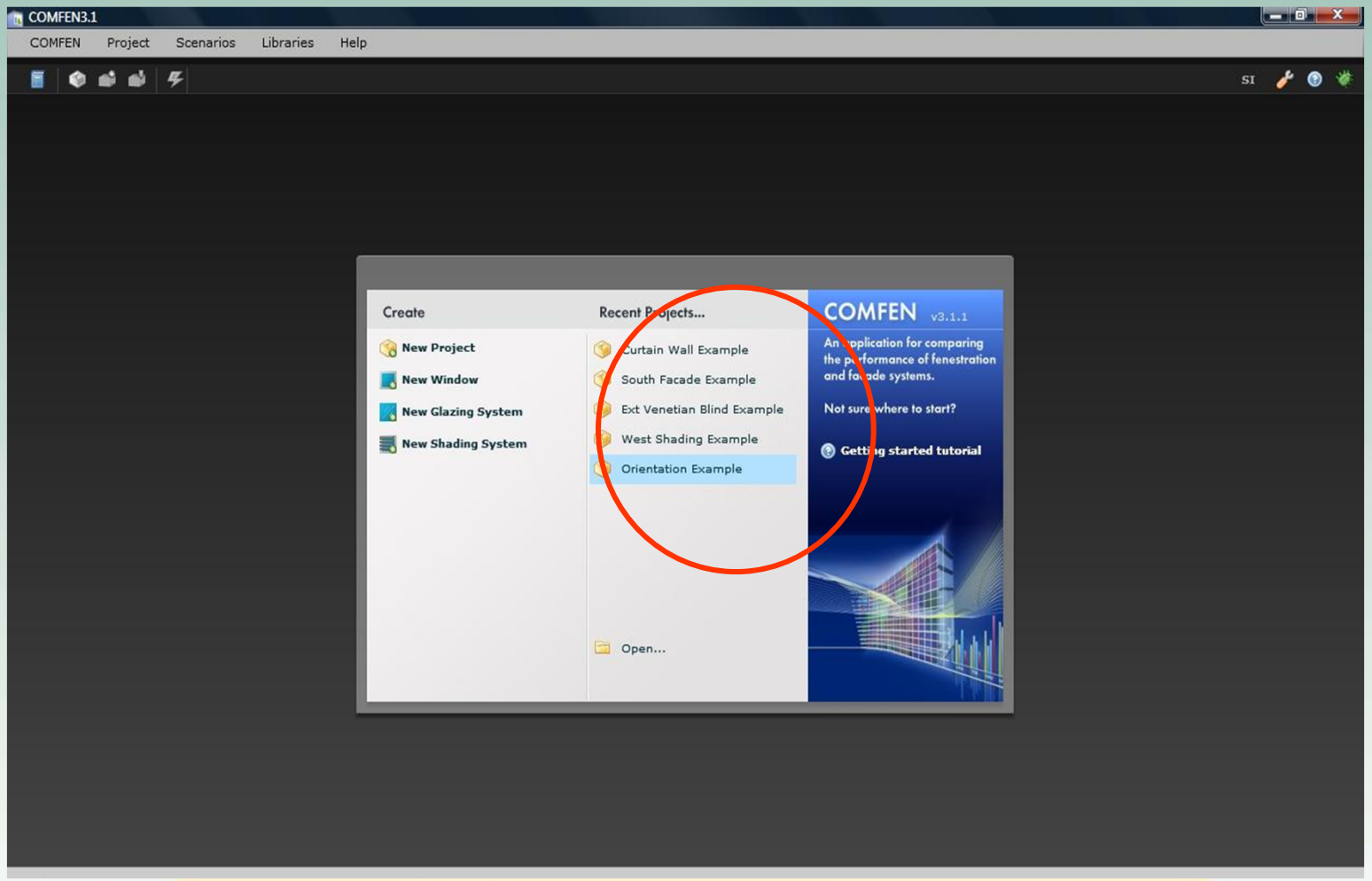
COMFEN:
Commercial Fenestration/Façade Design Tool

Windows & Daylighting Group
Building Technologies Department
Ernest Orlando Lawrence Berkeley National Laboratory

Download from
http://windows.lbl.gov/software

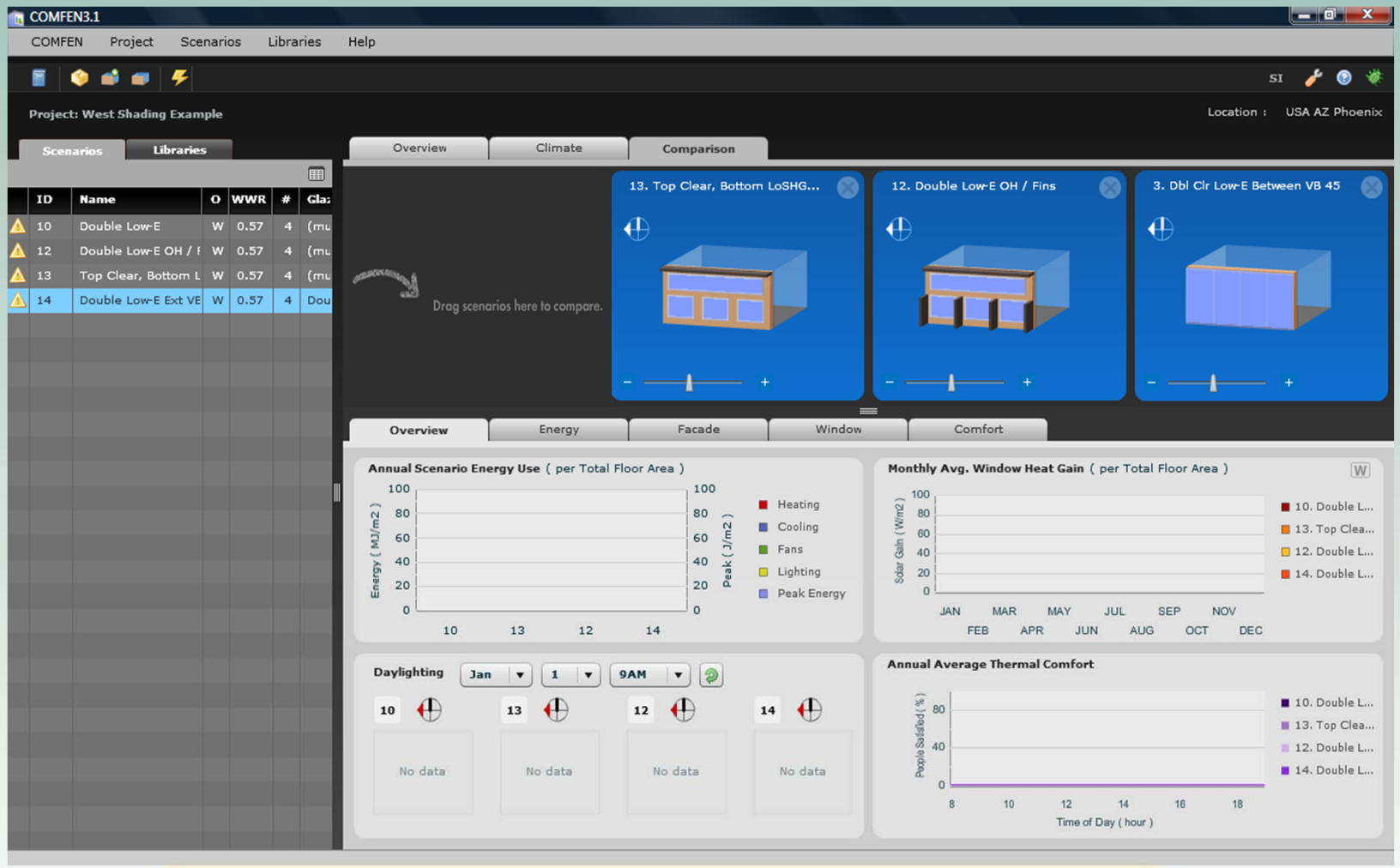
COMFEN 3 – Getting Started

- Can start with predefined perimeters/facades

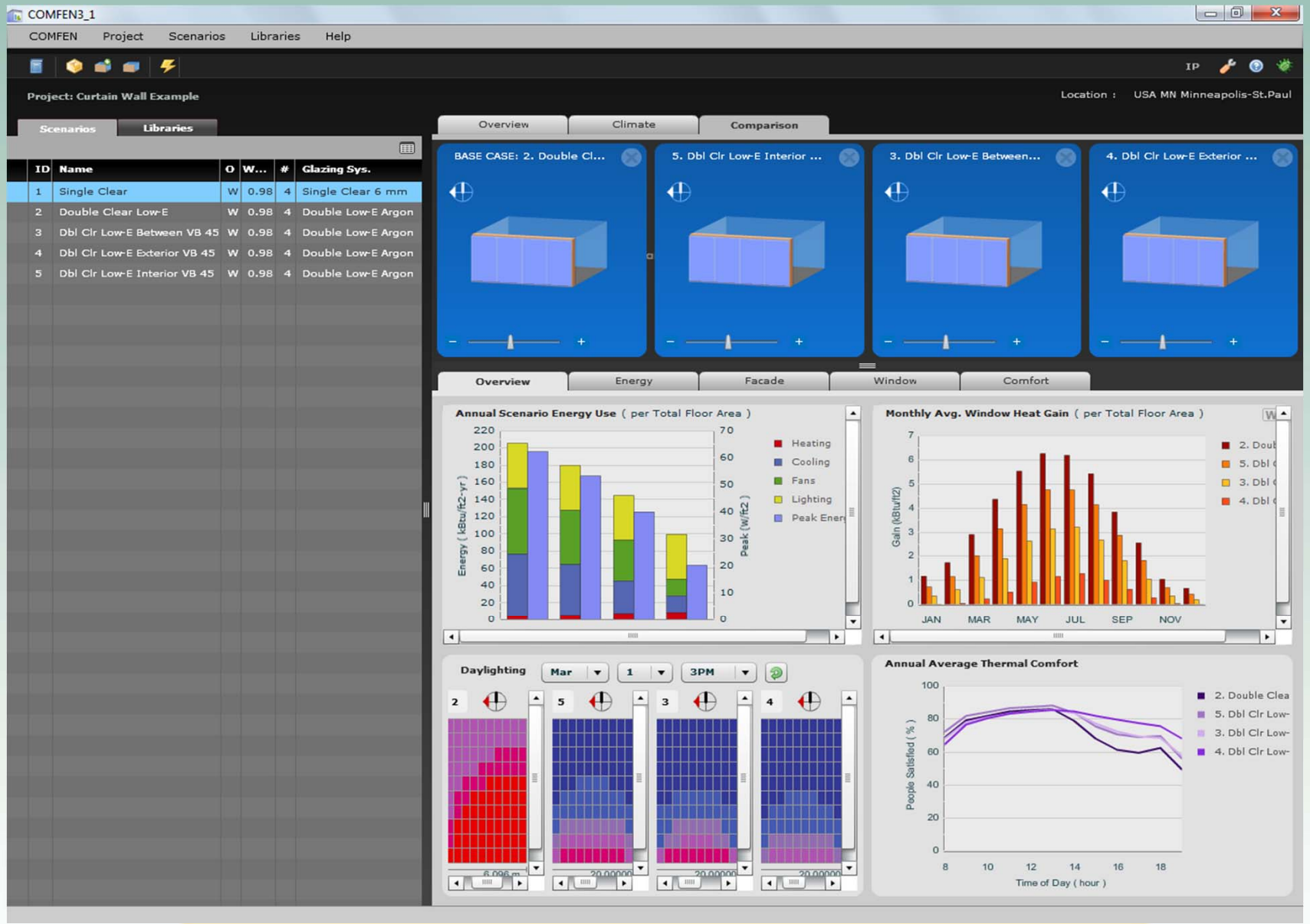


COMFEN 3 – Getting Started

- Can start by ‘drag + drop’ predefined perimeters/facades



COMFEN 3 – Scenario Comparison Summary



Sources and Links

Alliance to Save Energy
www.ase.org

Building Codes Assistance Project
www.bcap-energy.org

Center for the Built Environment
www.cbe.berkeley.edu

Center for Sustainable Building Research
www.csbr.umn.edu

Efficient Windows Collaborative (EWC)
www.efficientwindows.org

Energy Star
www.energystar.gov

National Fenestration Rating Council (NFRC)
www.nfrc.org

RESFEN
windows.lbl.gov/software/resfen/resfen.html

Responsible Energy Codes Alliance (RECA)
www.reca-codes.org

US Department of Energy
Energy Efficiency and Renewable Energy
www.eere.energy.gov

Window Installation
Water Management Guide by Joseph W. Lstiburek
www.eeba.org

Windows and Daylighting
Lawrence Berkeley National Laboratory
windows.lbl.gov

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