



Improving Residential Window Performance: There's more that can be done.

Panelists: Katie Cort, Pacific Northwest National Laboratory (PNNL)
Steve Selkowitz, Lawrence Berkeley National Laboratory (LBNL)
Christopher Dymond, Northwest Energy Efficiency Alliance (NEEA)

Pacific Northwest NATIONAL LABORATORY

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neea

Attachments Energy Rating Council AERC

PNNL-SA-141384

Presentation Objectives

- We hope attendees will leave the session with an understanding of:
  - The **energy and non-energy benefits** of low-emissivity (low-e) storm panels and other window attachments
  - How **innovations** in **high-R triple-pane windows** are improving the insulating benefits and bringing down installation and technology costs
  - **Window-related rating, labeling, and certification** programs and how to interpret the new **AERC** Energy Improvement label
  - **Window-related home performance opportunities** with northwest utility and energy-efficiency programs

Agenda

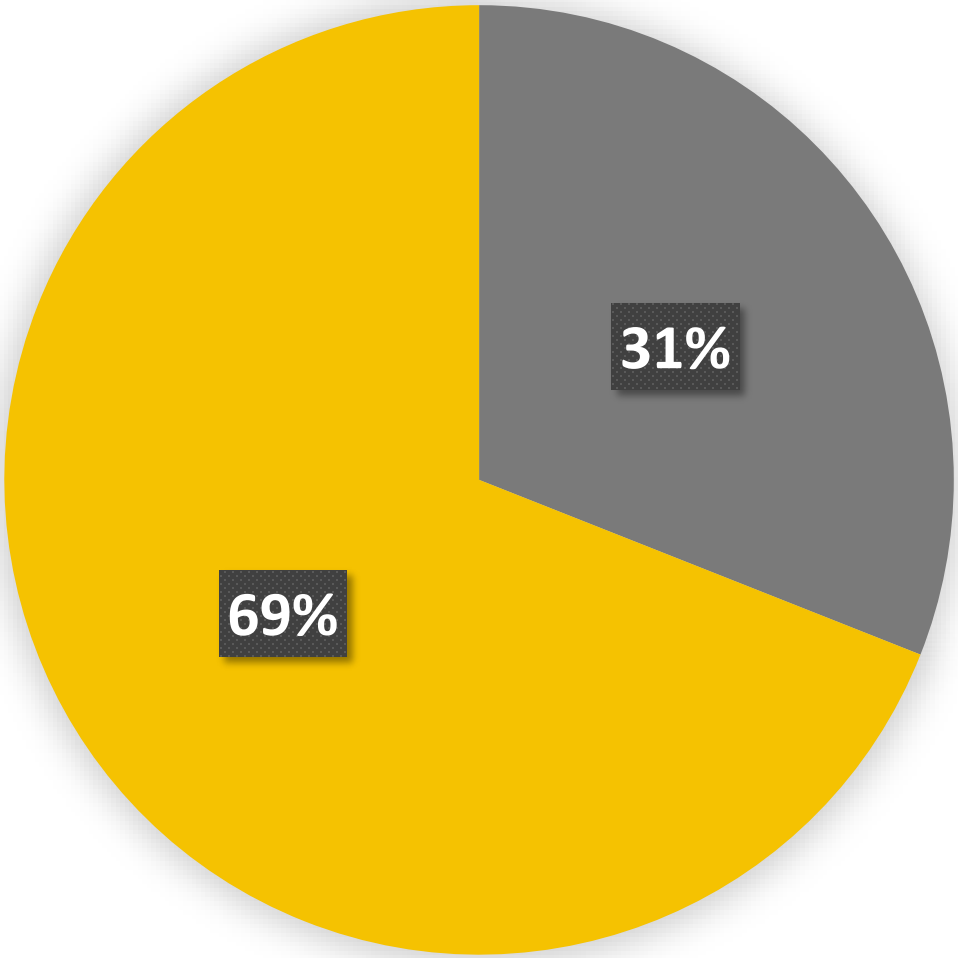
- Part I: Overview of the problem we are trying to solve and potential window retrofit solutions
- Part II: Introduction to window attachments and research results
- Part III: Emerging high-R window technologies (e.g., thin triple-pane windows)
- Part IV: Energy rating, performance labels, and new program opportunities related to windows.

The Problem

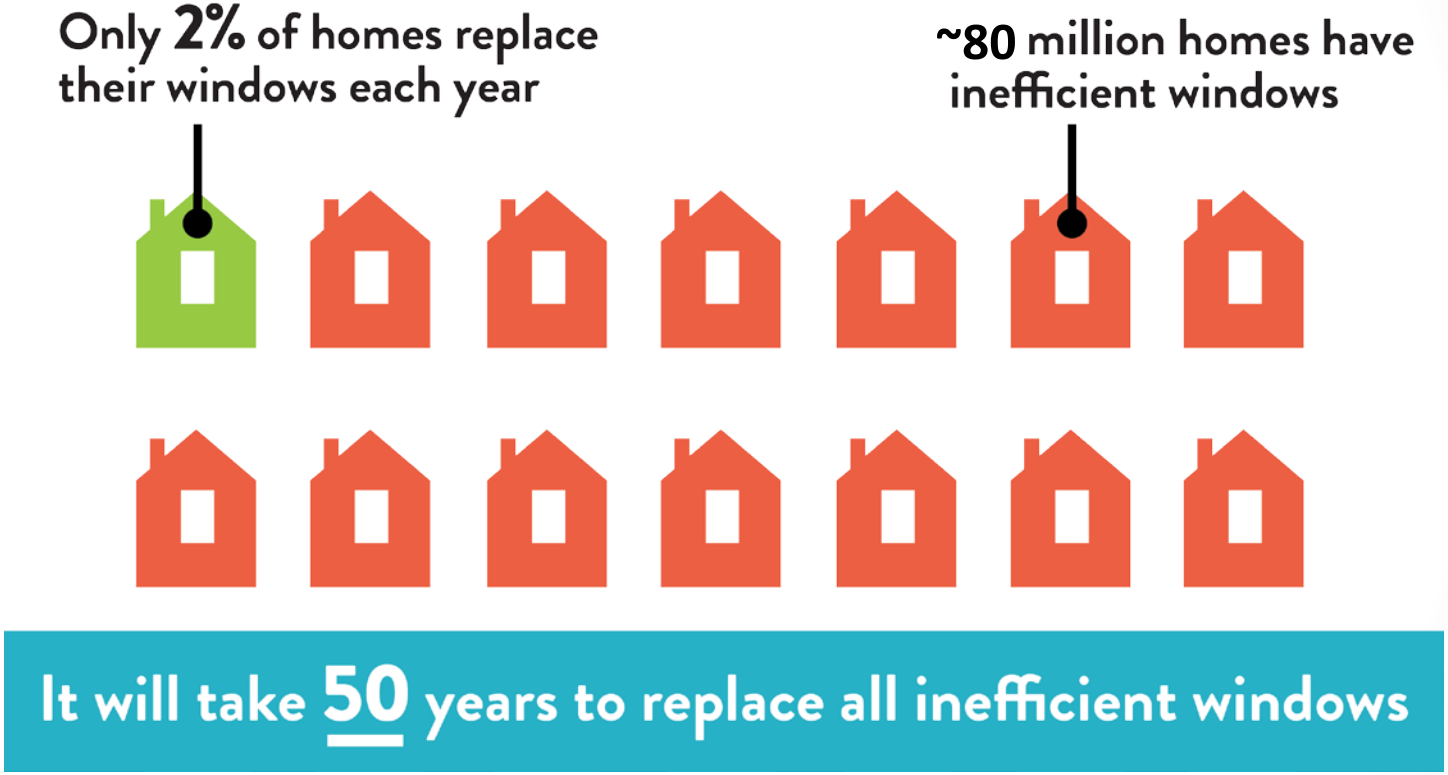
Windows make up
29%
of residential
HVAC consumption

Windows make up
34%
of commercial
HVAC consumption

The Potential



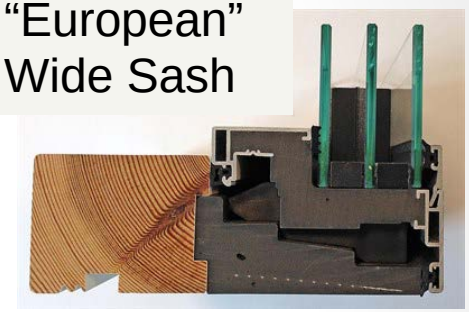
Current Rate and Type of Window Replacements Not Solving the Problem

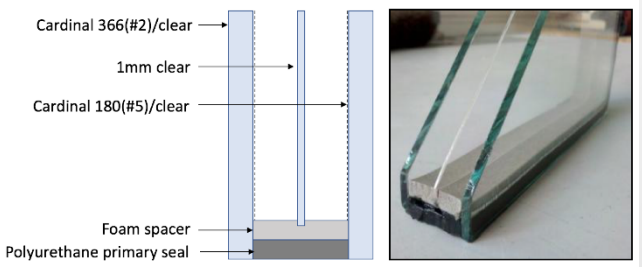


High-R Window Replacements

- **Existing Triple Glazing** (w. gas and low-E)
  - Technology elements available, U ~ 0.1 – 0.2
  - Large existing market share in N. Europe
  - **U.S.: "Too heavy/too wide" -> costly redesign of whole window**
- **"New Technology"**
  - **Modified Triple Glazing- thin glass**
  - **Vacuum glazing** (emerging technology)
  - **Aerogel (** early R&D**)**

"European" Wide Sash





Window Attachments

Storm Windows

Roller Shades

Horizontal Blinds

Cellular Shades

Awnings

Part II: Window Attachments

Katie Cort

Pacific Northwest National Laboratory

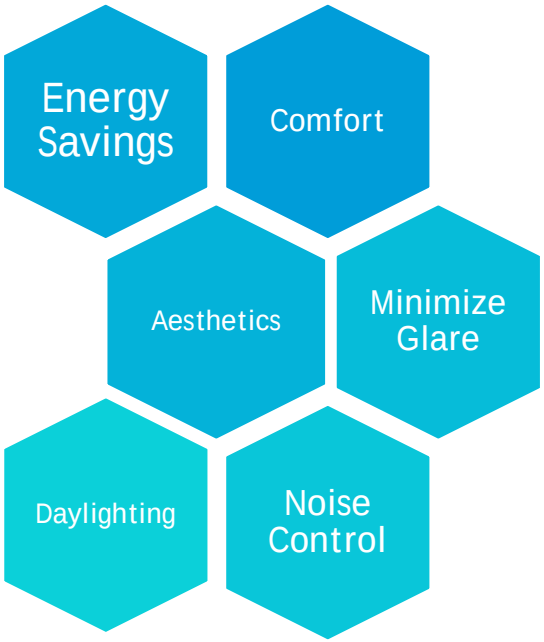
What are Window Attachments?

- "Greatest Benefit"
- "Moderate Benefit"
- "Neutral or Average"
- "Undetermined[1]"
- "Emerging products – Unverified benefits"

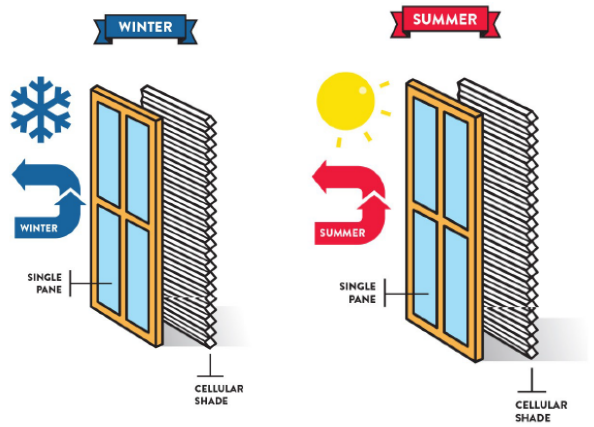
	Insulation	Airtightness	Solar Heat Control	Winter Comfort	Summer Comfort	Condensation Resistance	Ventilation	Low Product Cost	Low Installation Cost	Durability/Service Life
Exterior Attachments										
Storm Windows (including low-e)	●	●	◑	●	◑	◑	●	◑	○	●
Awnings	○	○	●	○	●	○	●	○	▨	◑
Roller Shades	○	○	●	○	●	○	◑	◑	◑	○
Roller Shutters	◑	○	●	○	●	○	○	▨	▨	●
Interior Attachments										
Conventional Roller Shades	○	○	◑	◑	◑	○	○	●	●	○
Conventional Drapes	○	○	◑	◑	◑	○	○	●	●	○
Louvered Blinds	○	○	◑	○	◑	○	◑	●	●	○
Window Panels (including low-e)	●	●	◑	●	◑	◑	▨	◑	●	○
Insulated Cellular Shades	●	◑	◑	●	◑	▨	○	○	◑	◑
Window Quilts	●	◑	◑	●	◑	▨	▨	○	▨	○
Surface-Applied Films	▨	○	◑	▨	◑	○	○	◑	◑	○
Other										
Solar Screens	○	○	●	○	◑	○	◑	◑	●	◑

[1]The benefits of this technology for the given attribute are not generalized and should be examined on a case-by-case basis

Window Attachments Value Proposition



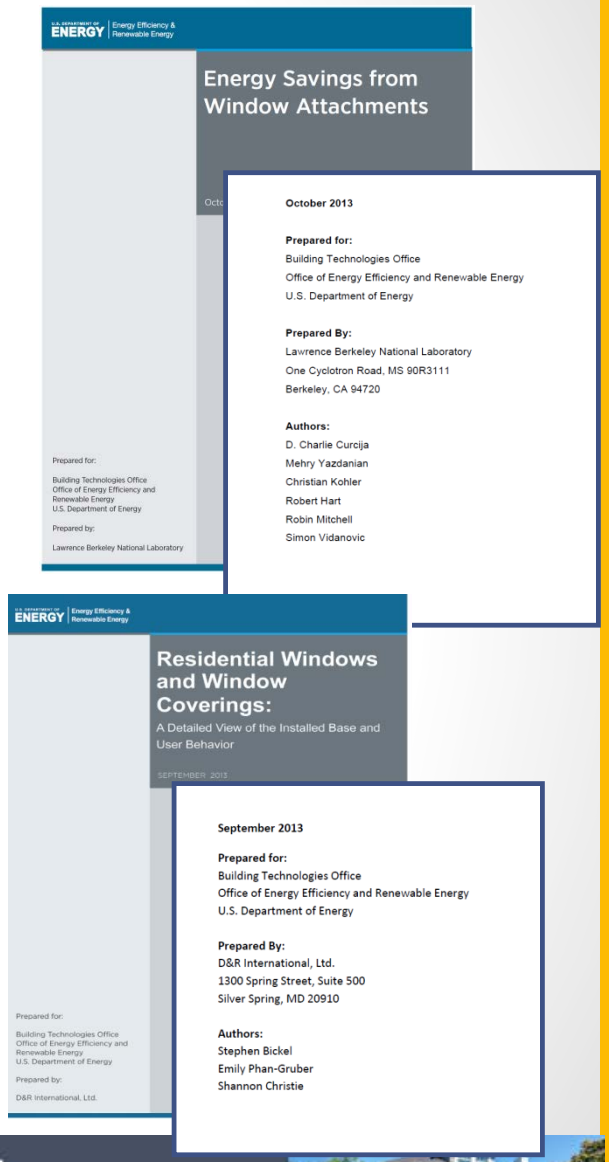
- Energy Savings Potential:
  - Reduces home's HVAC consumption by 3-30%
  - Can also reduce infiltration, glare, and noise



- Large market opportunity:
  - Applicable to new and existing homes
  - Over 80% of homes and small commercial buildings have some form of window attachment
  - Over 80% of window attachments that are in place are relatively low-performing vinyl blinds (horizontal slatted)

Energy Modeling

- Comprehensive energy-modeling study that examined 11 different typical residential window attachments including:
  - shades
  - blinds
  - storm window panels
  - surface-applied films
- Baseline with 4 types of houses, 3 types of windows, in 12 climate zones
- Operation assumptions based on empirical study
- For most attachments examined, energy savings significant, but results depend on type of attachment, season, climate, and operation.
- *In heating-dominated climates in north/central zones,* ***low-e insulating storm panels (both interior and exterior) and insulating cellular shades*** *are the most effective at reducing HVAC .*



The Evolution of Storm Windows

Seasonal Storm Panels

Self-Storing Storm Windows

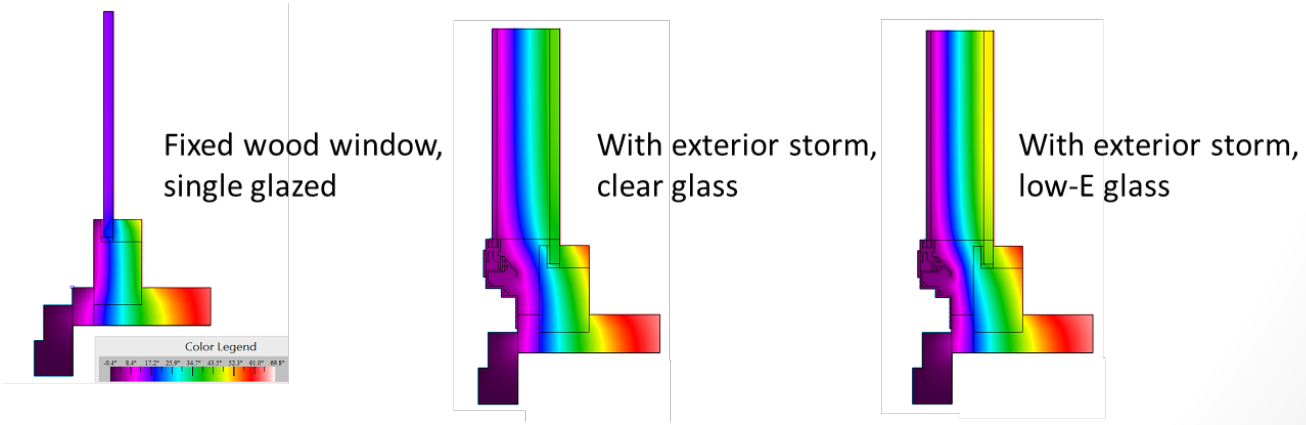
LATEST TECHNOLOGY

High Performance Storm Windows with Low-E glass

Low-E Storm Windows

Low-e storm windows are a cost-effective, **insulating,** and air **sealing** measure for existing windows:

- **Air Sealing** of Prime Window
  - Case studies show 10% reduction in overall home air leakage
- Creation of **"Dead Air Space"**
  - Reduce conduction and convective losses across prime window
- **Reflection of Radiant Heat**
  - 35% increased performance over clear glass



Low-E Storm Windows

Cost

- 1/3 of replacement window
- Payback 4-14 years
- Low installation effort (e.g., 80% DIY installation)

Energy Savings

- 10-33% reduction in HVAC in single-pane or double-pane clear glass window homes
- Reduce air leakage

Characteristics

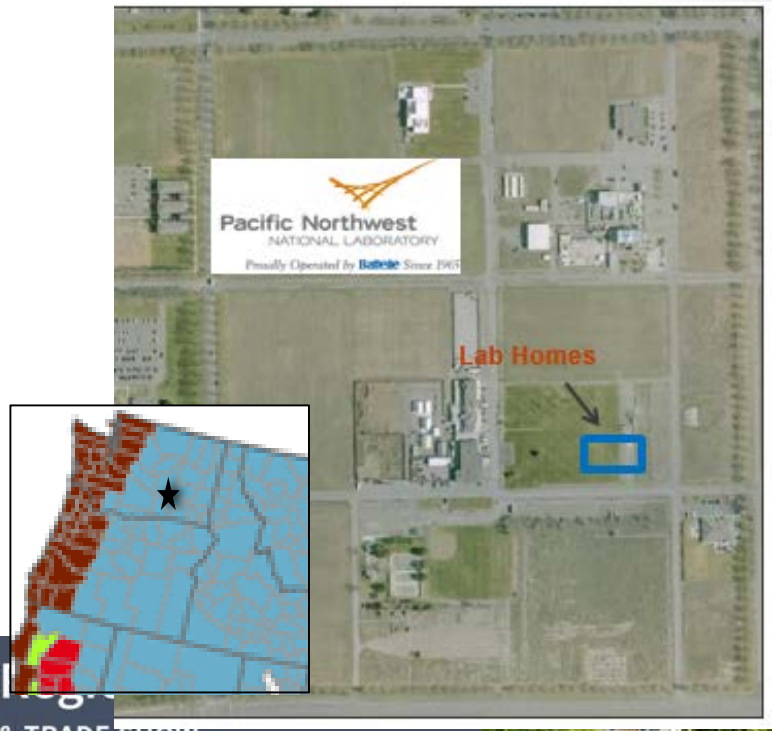
- Operable
- Permanent installation
- Year-round comfort
- Interior or exterior installation
- Aesthetically pleasing

*See Culp, et. al, (2015)

PNNL Lab Homes Testing Platform in Richland, Washington

Lab Homes Characteristics

- Specified to represent existing manufactured and stick-built housing
- 3 BR/2BA, ~1500 ft^2
- All-electric with 13 SEER/7.7 HSPF heat pump central HVAC + alternate Cadet fan wall heaters throughout
- R-22 floors, R-11 walls & R-22 ceiling with composition roof
- 195.7 ft^2 (13%) window area with double-pane clear glass aluminum-framed windows

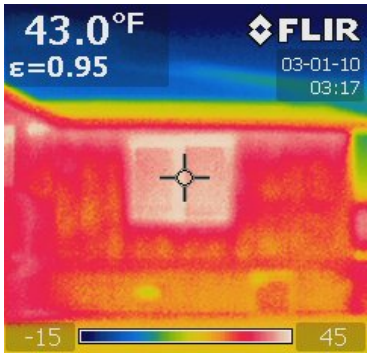


Lab Homes – Low-E Storm Windows Impact on Energy Savings

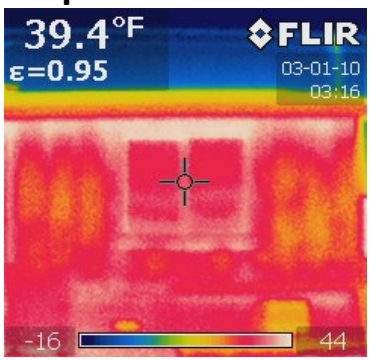
Technology (experiment)	Baseline and Experiment Description	Energy Savings (%)
Exterior low-e storm windows, 2014 (Larson Manufacturing)	Double-pane metal-frame clear glass windows (no window coverings)	Average Annual Savings: **10.1 ±1.4%**
Interior low-e storm windows, 2015 (Quanta Technologies)	Covering 74% of window area over double-pane metal-frame clear glass windows	Average Annual Savings: **7.8 ±1.5%**

Infrared Images – Interior Storm Windows

Baseline Home



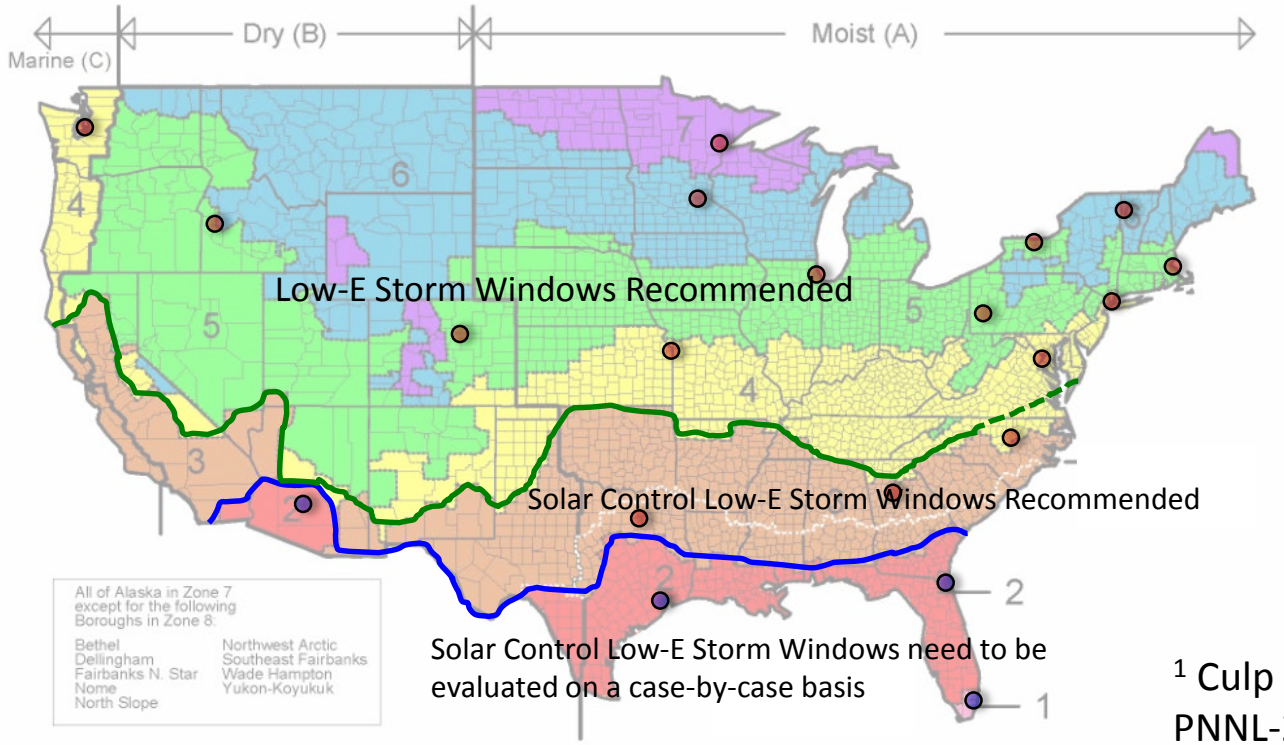
Experimental Home



LES – Climate Zone Modeling

Over all single-pane windows or double-pane metal-framed windows:

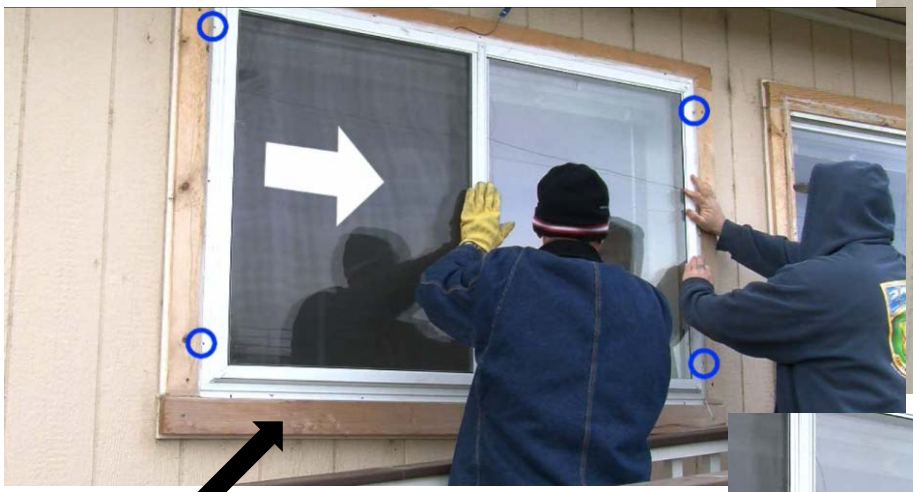
NEAT and RESFEN analysis expanded to 22 cities across all 8 climate zones.[1]



Cost effective in climate zones 3-8 with Savings to Investment Ratio = 1.2 – 3.2

[1] Culp et al. 2014 and 2015. PNNL-22864 rev2 and PNNL-24826

Installation: Exterior Storm Windows

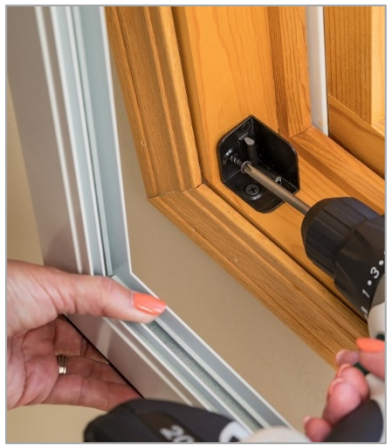


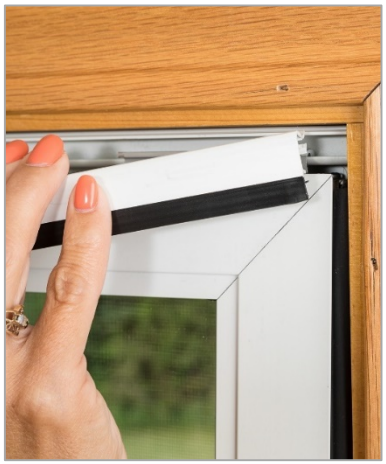
Weep Holes

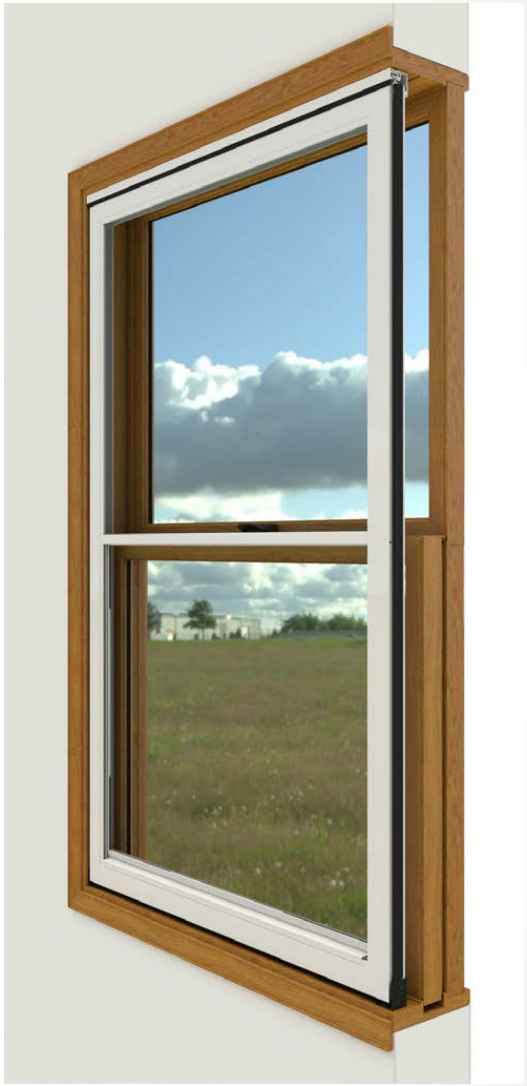
See PNNL youtube video that includes installation instructions: https://www.youtube.com/watch?v=DeU6wn0psrU

Permanent Year-Round Installation

Installation: Interior Storm Windows







Honeycomb or Cellular Shades

Lab Homes – Triple Cell Cellular Shades Impact on Energy Savings (2015-2016 Testing)

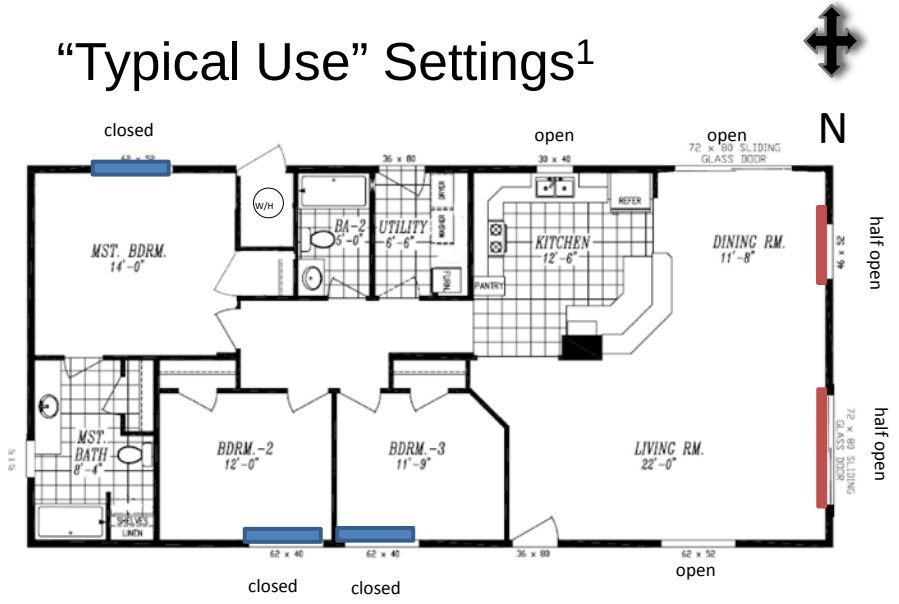
Technology (experiment)	Baseline and Experiment Description	Energy Savings (%)
High Efficiency Cellular Shades: Static Operation – always down	Blinds remain closed for the duration of experiment. Compared to standard vinyl blinds remaining closed for full experiment.	Cooling: **13.3 ±2.8%** Heating: **10.5 ±3.0%**
High Efficiency Cellular Shades: Optimum Operation Comparison	Blinds operated per the Hunter Douglas recommended energy-saving schedule. Compared to standard vinyl blinds operated with same schedule.	Cooling: **10.4 ±6.5%** Heating: **16.6 ±5.3%**
High Efficiency Cellular Shades: Optimum Operation	Blinds operated per the Hunter Douglas recommended energy-saving schedule. Compared to no blinds in baseline home (double-pane clear glass windows)	Cooling: **14.8 ±2.1%** Heating: **14.4 ±2.0%**

Thermal Performance of Double-Cell Cellular Shades compared to the most Common Window Coverings

Experiment	Season	HVAC Savings % (+/- 95% confidence)	Average W-hr/day Savings
All Shades Down: Cellular Shades versus Vinyl Venetian Blinds	Cooling	13.3 (±1.3)	2,650
	Heating	9.3 (±1.9)	7,011
Typical Use: Cellular Shades versus Vinyl Venetian Blinds	Cooling	5.8 (±0.5)	1,487
	Heating	2.0 (±1.3)	1,505

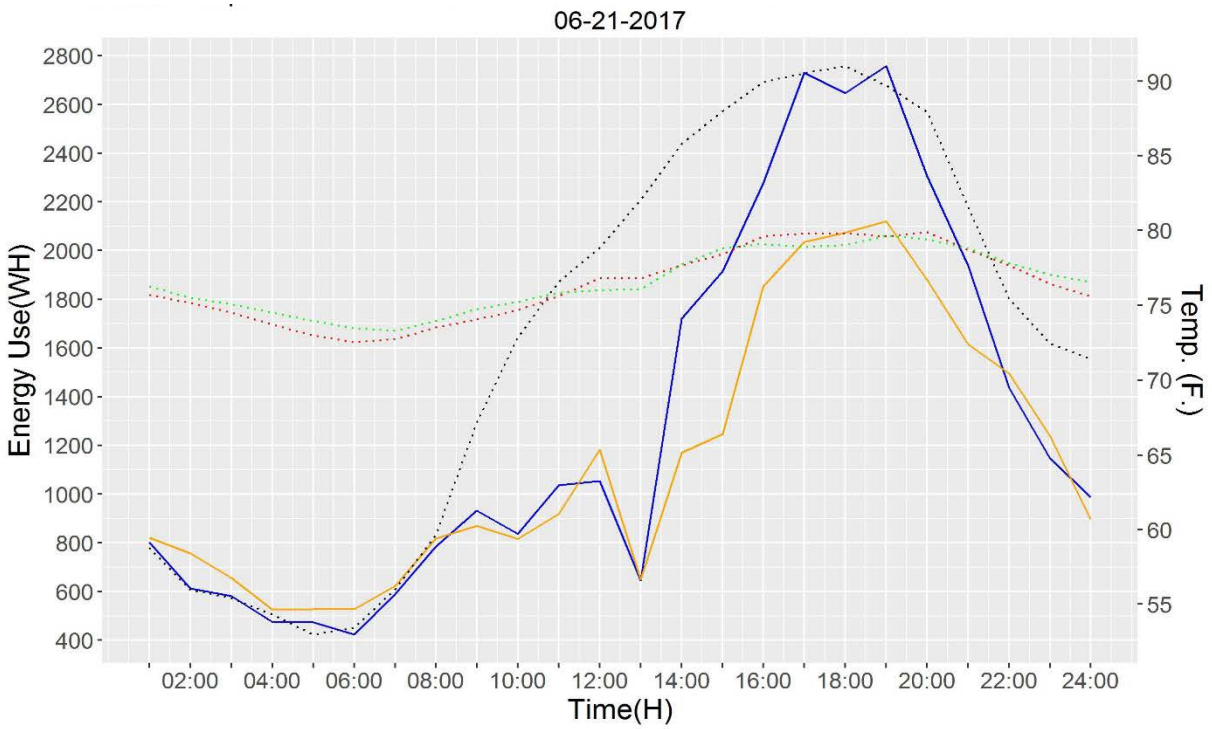
Semi-opaque double-cell shade pulled down (left) allows filtered natural light into north-side bedroom. Close-up view of same shade (right).

"Typical Use" Settings[1]

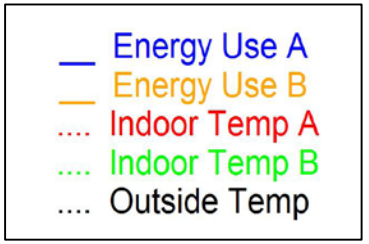


[1]D&R International. 2013. *Residential Windows and Window Coverings: A Detailed View of the Installed Base and User Behavior* http://energy.gov/sites/prod/files/2013/11/f5/residential_windows_coverings.pdf.

Energy Savings Potential of Cellular Shades in the Summer

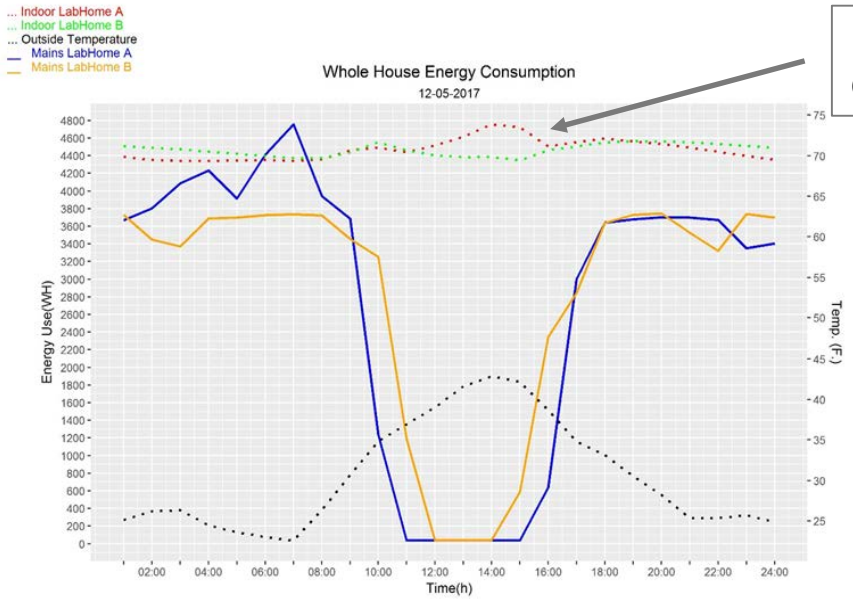


Energy Consumption Comparison between the Lab Homes



Experimental Home	Baseline Home	HVAC Savings % (+/- 95% confidence)	Average W-hr/day Savings
Cellular shades always down	No shades	24.8% (±8.6%)	3,359
Typical Use with Cellular Shades	No shades	4.7% (±1.3%)	1,808

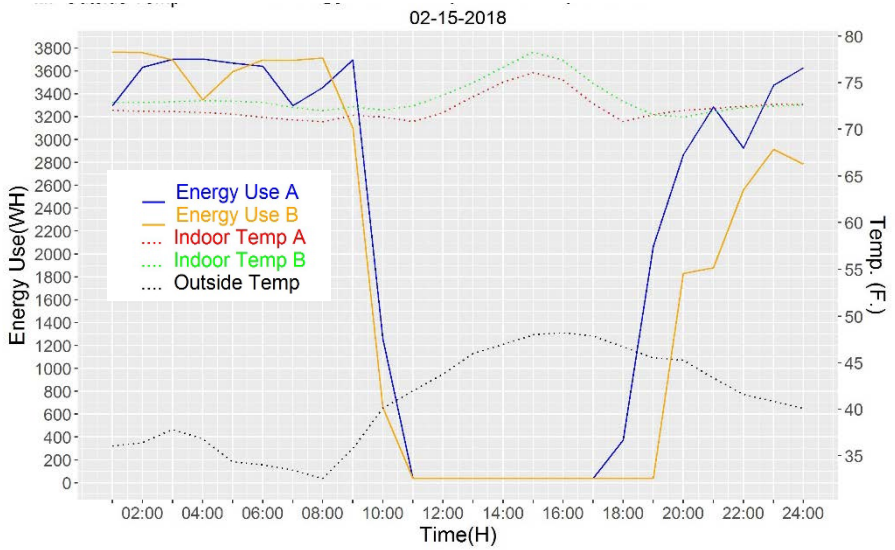
Heating Season: Shades drawn down (always) versus "optimal" operation



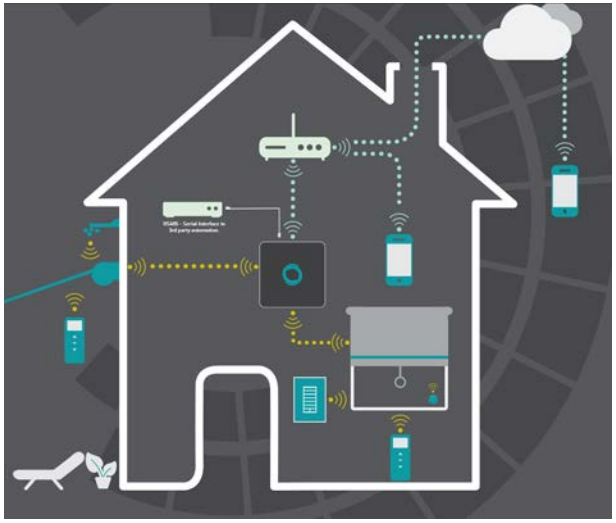
Beneficial heat gains not fully realized when shades are drawn down during the day (Sunny day, avg. temp 31° F)

- **Closed Shades Scenario**: Cellular shades covering all windows in Lab Home B (experimental home) and no shades on Lab Home A (control home) windows
- **Results:** Modest average savings (2%) when shades down all the time. Average of 5% savings recorded on very cloudy days, but negative savings on some sunny days.

- **Optimal Operation Scenario:** Cellular shades up during some portion of the day and closed at night (3 operating scenarios tested).
- **Results:** Achieved consistent HVAC savings between 5% to 9% compared to the home with blinds operated with typical settings.



Automation and Window Attachments



WORKS WITH amazon alexa

IFTTT

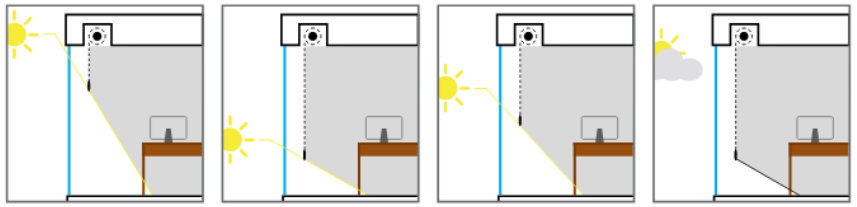
works with the Google Assistant

logitech

Control4

works with nest

Allowable Solar Penetration



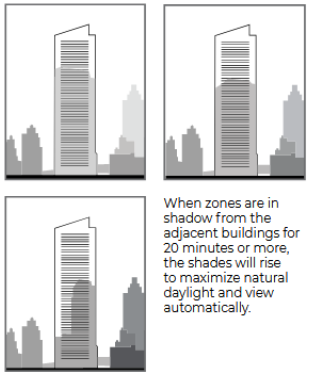
June 21
Shadecloth Position: 1

December 21
Shadecloth Position: 3

March 21 / September 21
Shadecloth Position: 2

Overcast Sky
Shadecloth Position: 3

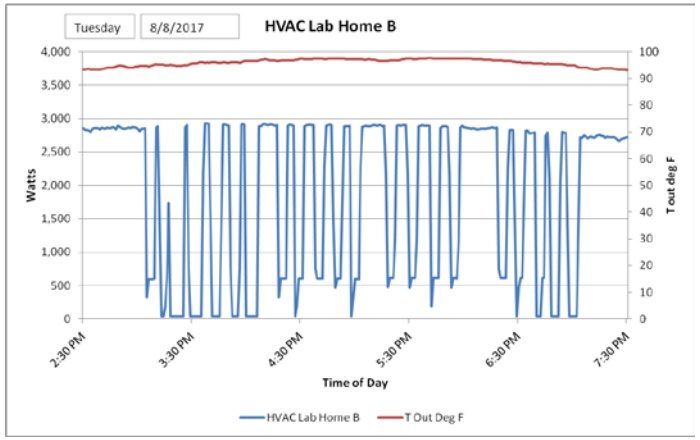
Shadow-Override Module



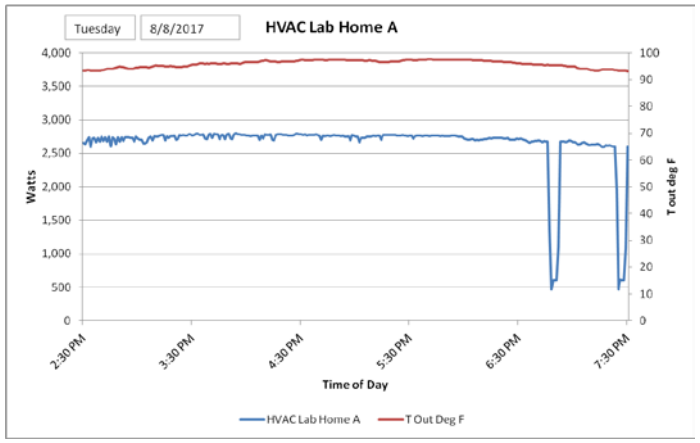
When zones are in shadow from the adjacent buildings for 20 minutes or more, the shades will rise to maximize natural daylight and view automatically.

Demand Response (DR) – Combining Thermostat Adjustments with Shading

HVAC Cycling during Peak Period:
DR Participant vs Non-Participant



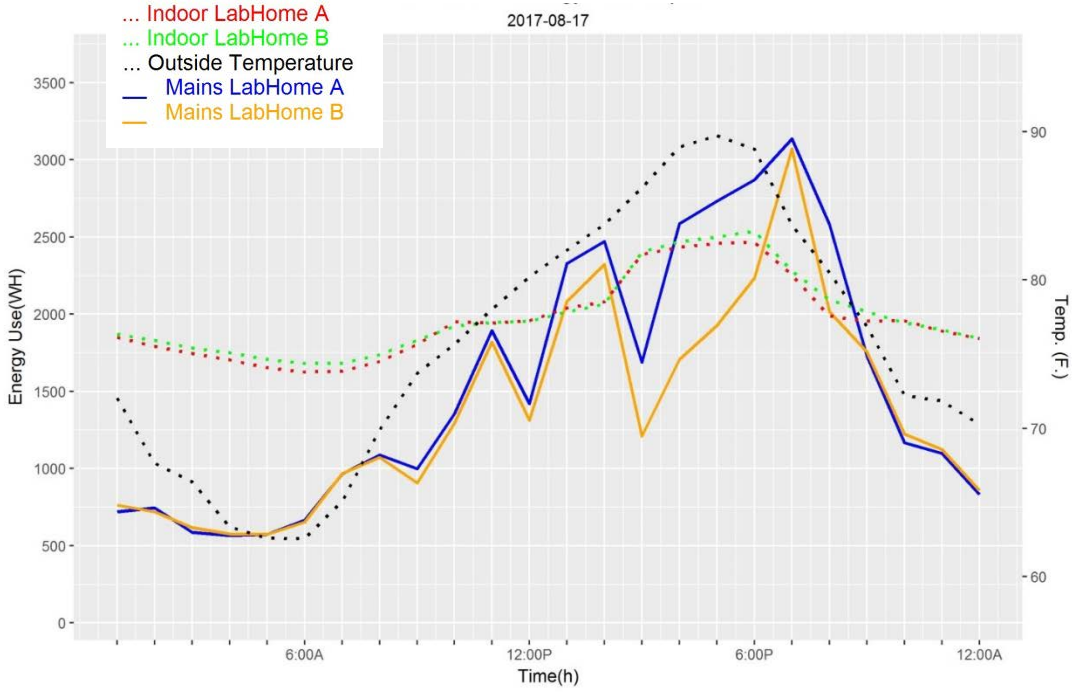
Lab Home B: DR participant (with cellular shades drawn down during peak event)



Lab Home A: Typical blinds, typical use and no participation in DR during peak event

Whole House Energy Use Comparison

Both homes participating in DR (i.e., thermostat setback during peak period), but only Lab Home B pulls down cellular shades in living room during peak event. HVAC savings = 3,936 W-hrs with cellular shades on this day.



Upcoming Experiments. . . Exterior Shades

- Summer season testing
  - Reduces cooling load (and added comfort for those with and without AC)
  - Blocks UV rays before it hits the window
  - Automation available (including solar-powered motors)
  - Non-energy benefits (e.g., privacy, comfort, protection of window, etc.)






Home Performance Retrofit Opportunities

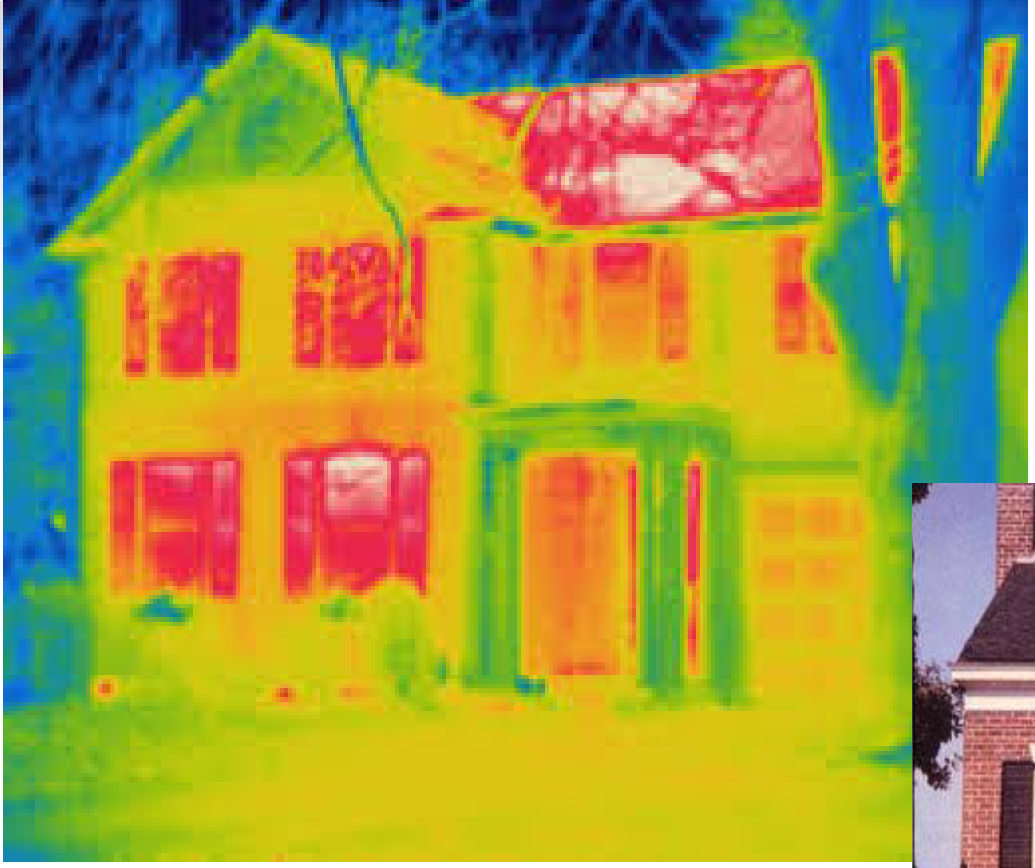
- Utility incentive programs
- Weatherization programs (low-e storms typically meet criteria for Federally subsidized programs)
- Historic homes
- Retirement and assisted living facilities
- Automation and Integrated Control

Retirement Home in Enumclaw, Washington

Part III: Highly Insulating Windows

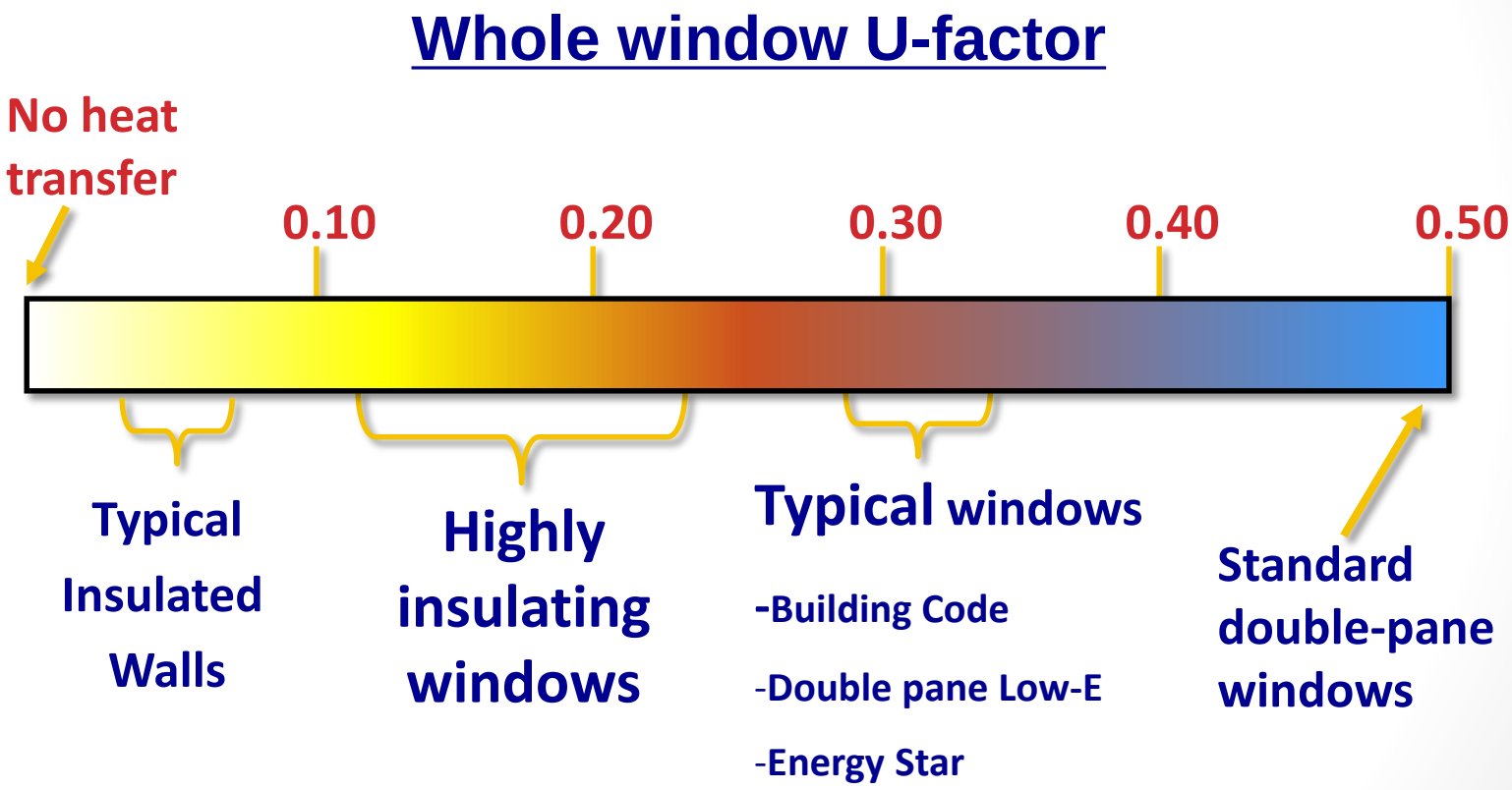
Steve Selkowitz

Lawrence Berkeley National Laboratory



1970: If Windows are thermally poor, then use less of them….

Current State of Windows



Savings from Better Windows

Annual Heating Cost simulated for a heating climate

Single Glazed w/Storm, **$1310**

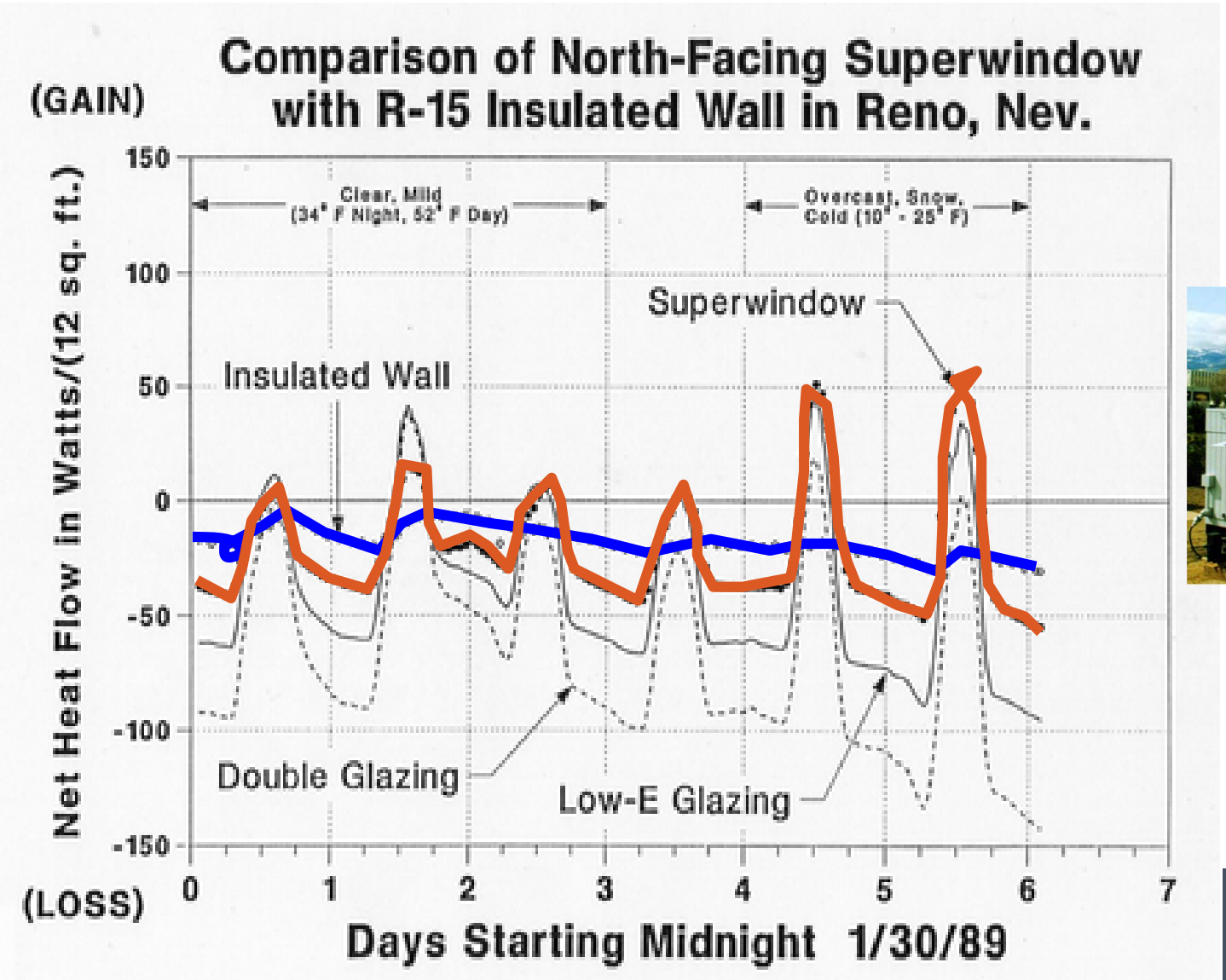
Double Glazed, **$1218**

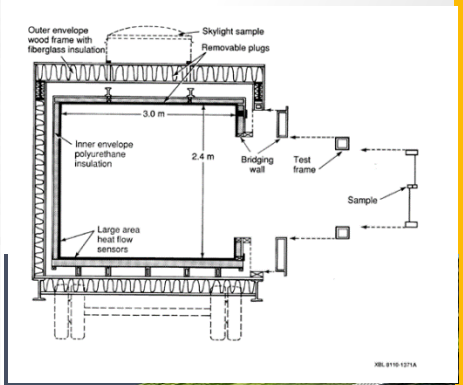
Double w/Low-E, **$1120**

House with no windows, **$1000**

"SuperWindow", **$960**

”North-facing Windows Outperform Insulated Walls during winter heating season” (from 1989!)





Residential Windows: 2.3 Q Annual Energy (Heating: 1.30 Q Cooling: .94 Q)

Window Type	Energy Savings over Current Stock (quads)		
	Heating	Cooling	Total
Sales (Business as usual)	0.49	0.37	0.86
Energy Star (Low-e)	0.69	0.43	1.12
Dynamic Low-e	0.74	0.75	1.49
Triple Pane Low-e	1.20	0.44	1.64
Mixed Triple, Dynamic	1.22	0.55	1.77
High-R Superwindow	1.41	0.44	1.85
High-R Dynamic	1.50	0.75	2.25

Heat Transfer Crash Course

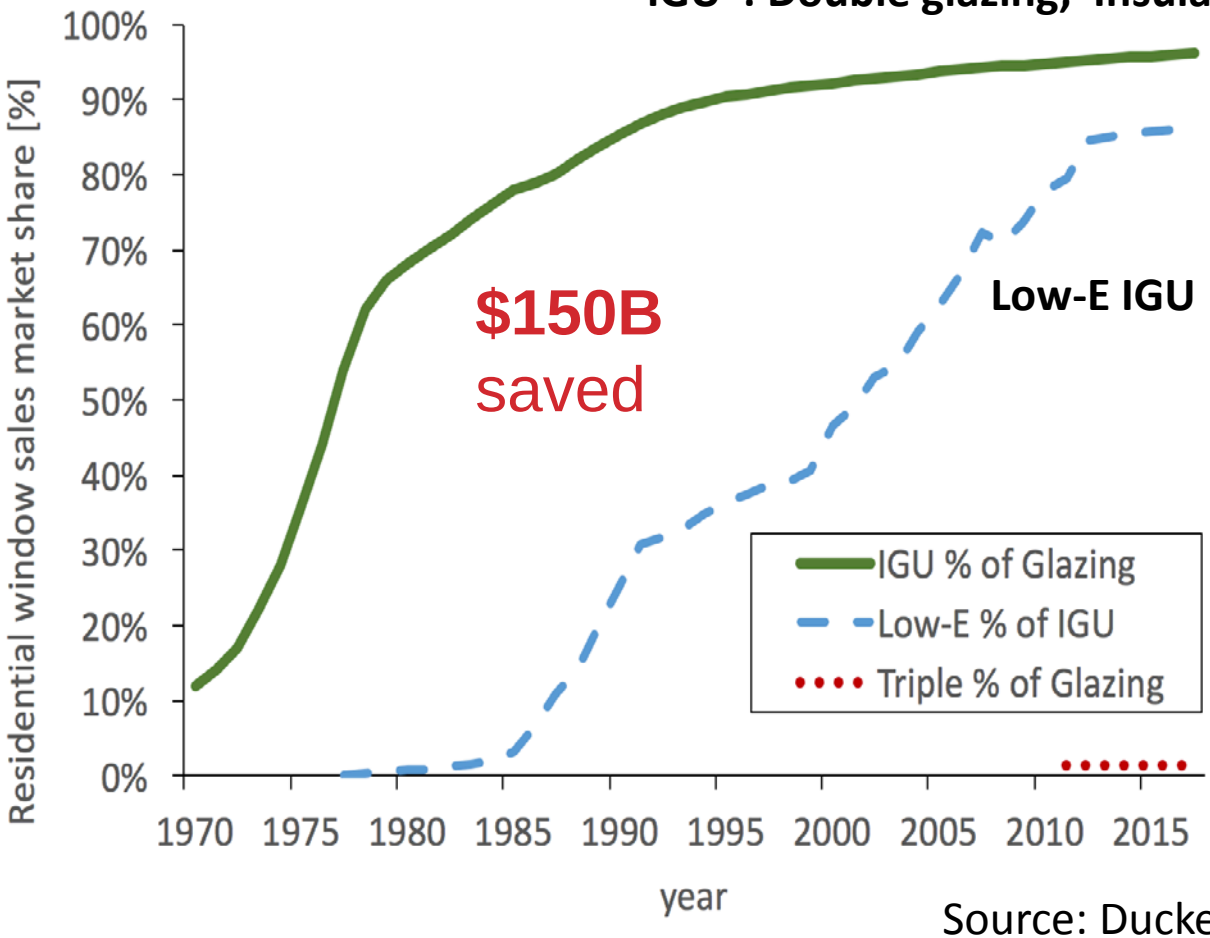
- **U factor**: overall heat transfer rate, Btu/ft^2-hr-F
  - U ranges: ~1 (single) → .1 (high R window, Superwindow)
- **R: Resistance** = 1/U R1 → R10

- **Glazing** properties
  insulating glass unit = "IGU"
- **Whole window** properties

- SHGC, Tv, Air leakage... Properties of glass, window
- Annual Energy Impact... Location, orientation, HVAC...

U.S. Residential Glazing Market Share

"IGU": Double glazing, Insulating Glass Unit



Source: Ducker Associates

Low-E Coatings as Oil Wells
(36 M Barrels of Oil)

Conservation Research Note

from the Center for Building Science / Lawrence Berkeley Laboratory

May 1988

New Energy Supply Technology for the 21st Century

High Tech Window Coatings "Supply" Energy Services

Buildings account for over one third of all U.S. energy consumption. Energy policy has emphasized the development of new secure energy supply options such as off-shore oil. But advanced building technology that effectively reduces the need for current consumption can also be viewed as a supply option.

Consider the following two choices for "supplying" $1 billion of energy services:

Low-E Window Technology

Heat loss from windows is responsible for about 4% of total U.S. energy consumption, or the equivalent of 1.4 million barrels of oil per day. Transparent low emissivity (low-E) coatings provide one third reductions in window heat loss.

This industrial low-E coater (See ***Recipe 1***) can coat over 20 million square feet of glass for windows each year. Savings accumulate rapidly since each window continues to save energy over its entire lifetime, at least 20 years.

Offshore Oil Wells

Oil under the continental shelf is a secure, but environmentally fragile, costly and depletable supply option. (See ***Recipe 2***).

Recipe #1

Low-E Window Technology

Step 1: Invest $8 million in a low-E coating system.
Step 2: Coat 20 million square feet of windows per year for the 10 year nominal life of the coating system.
Step 3: Accumulate energy savings over the 20 year life of the window.

Step 4: RESULT: Savings of 36 million barrels of oil equivalent!

Figure 1

Glass coaters such as this high-rate sputtering system can coat large sheets of glass with sophisticated multilayer coatings for control of heat and light in buildings.
Photo courtesy of Airco Solar Products, Concord, CA.

Recipe #2

Offshore Oil Wells

Step 1: Invest $300 million in a 10 well offshore oil platform, producing 10,000 barrels per day.
Step 2: Pump oil for the 10 year nominal life of the oil field (don't spill a drop).

Step 3: RESULT: Supply of 36 million barrels of oil!

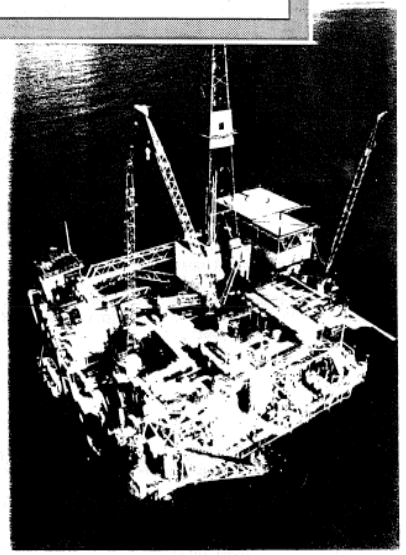


Figure 2

An oil company's 10,000 barrel/day, 700 foot-high, $ 300-million platform off the Santa Barbara, California coast.

Window Energy Snapshot: Progress…

- **Good news**:
  - With DOE R&D support, industry transformed markets from single -> double -> double, low-E, argon
  - 90%+ sales of all window are low-E

- **Bad news: little tech innovation since 1990**
  - Biggest Energy Opportunity- highly insulating glazing for heating dominated climates (~ 1- 2 Q at stake)
  - Market "Saturated" at double, low E: >90% Market Share
  - Triple glazing: only 1.7% market share, **no recent change**
  - **Need: "Better" triples or new technology options**

Why Not Make Better Windows Now… ??

- **Window Manufacturers "could" redesign product lines to offer triple glazing**
  - No easy path to high performance window today
  - Costly – to manufacturers to retool; → costly to end-users
  - "No Demand" now; uncertain demand at higher price point
- **Europe – Northern countries "mandate" triple glazing**;
  - Base window accommodates triple IGU
  - Offered by all suppliers
  - Supported by codes, higher energy prices
  - So no fundamental "technical" obstacle to adoption

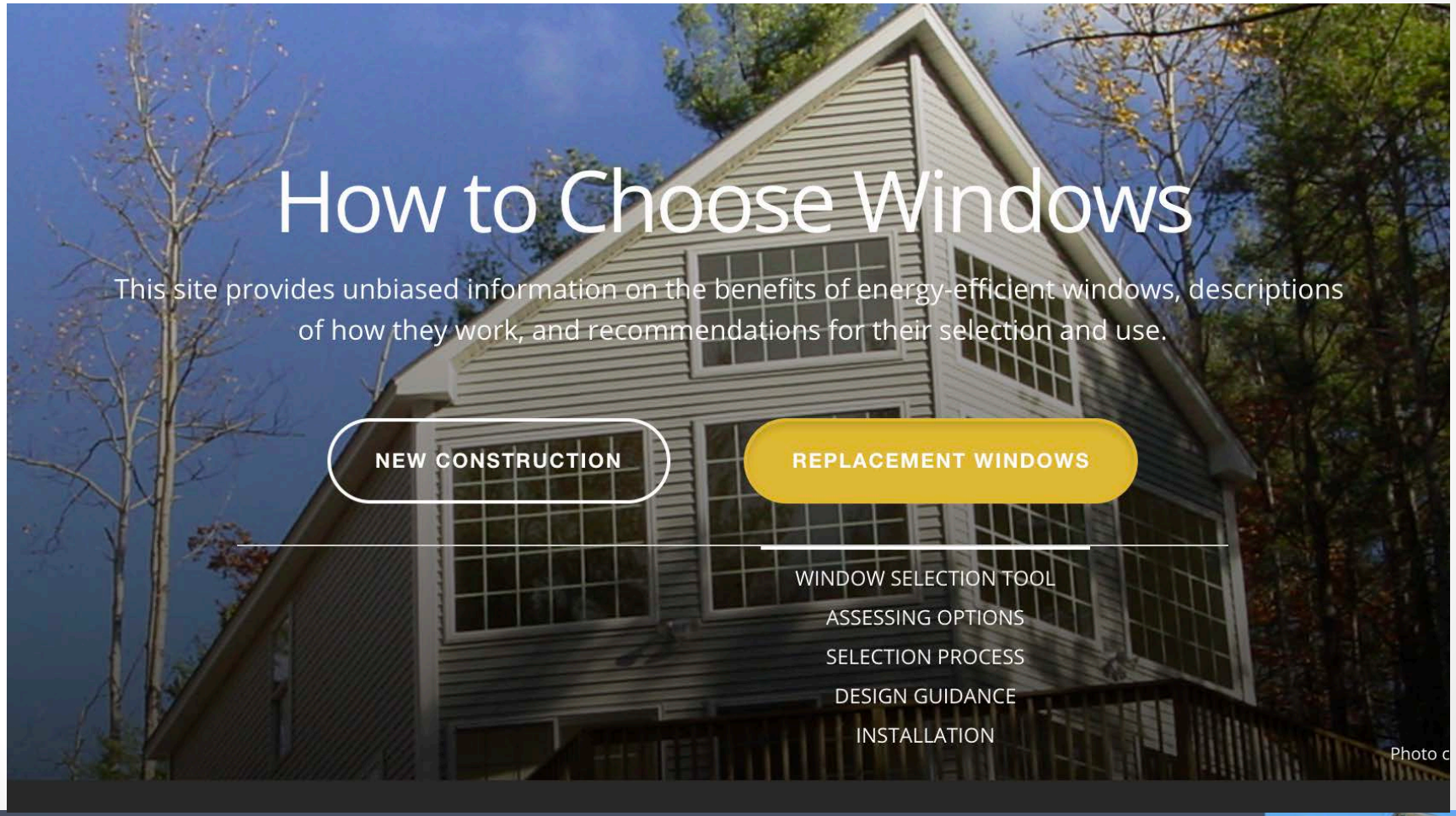
Success of Low-E, Double Glazed IGU: U: 0.5 -> 0.3

- **3 stage "adoption" process to increase market share**
  1. Introduction -> ~20% market share: **Innovation push**
  2. 20% -> 60% **NFRC Ratings**, **Voluntary market pull (ES)**
  3. 60% -> 95%: **Codes and Standards**

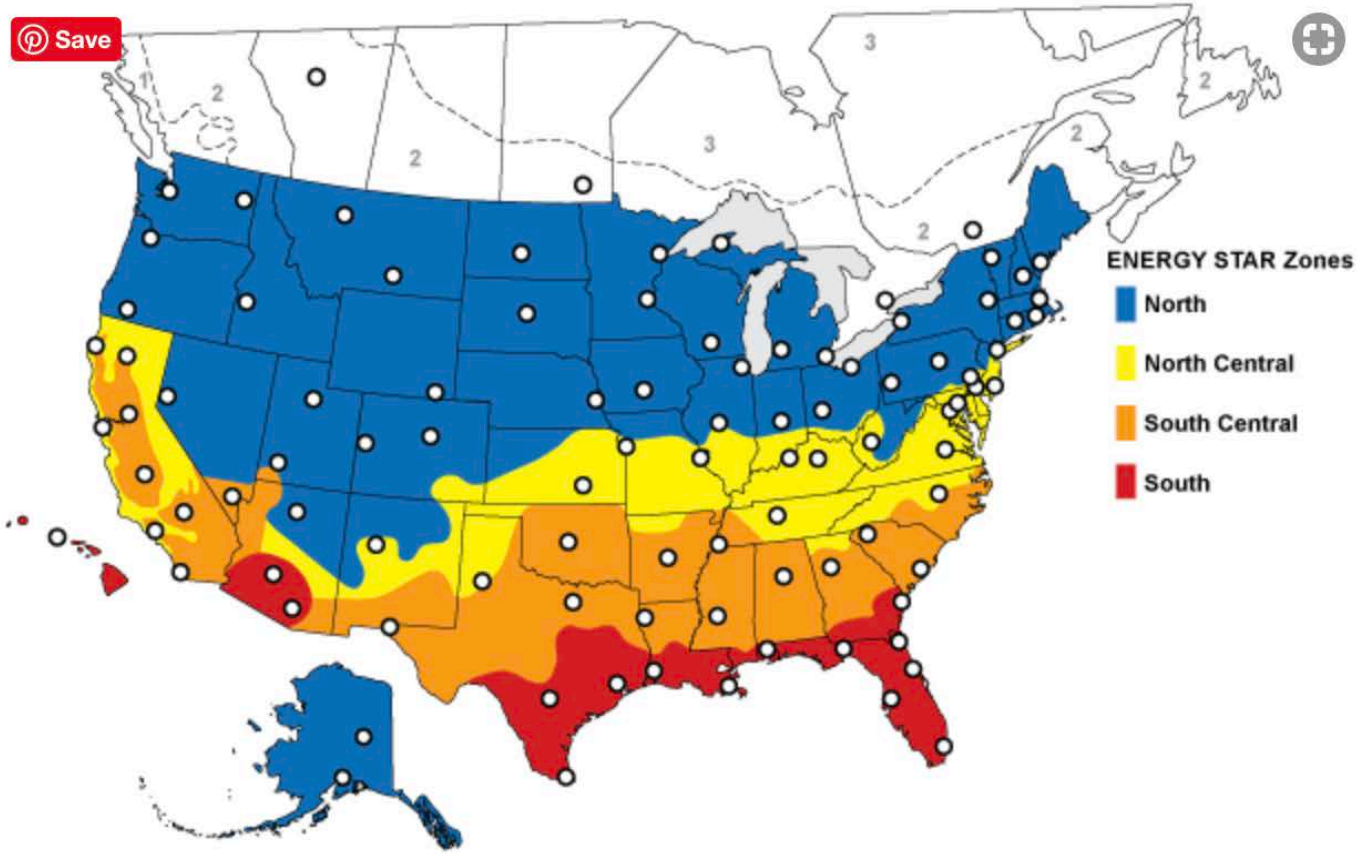
- **"Criteria" for rapid adoption:**
  - Window manufacturers must accept cost and risk
    - New Investment, Disruption to manufacturing process?
    - See a Competitive Market opportunity – or threat
  - Glass package is affordable, durable, …
  - Market Acceptance and Demand:
    - Work with Early adopters, Niche Markets, Incentives,...

National Fenestration Rating Council - NFRC

Choosing Better Windows
Efficient Window Collaborative
www.efficientwindows.org



OR PORTLAND | SELECT HOUSE TYPE: | SELECT WINDOW TYPE: | NEXT



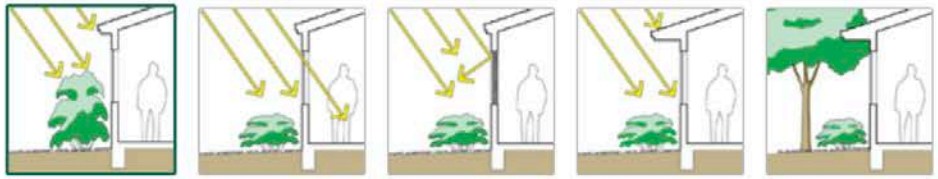
SELECT ORIENTATION:

Equal | North | East | South | West

SELECT WINDOW AREA:

Small (10%) | Moderate (15%) | Large (20%)

SELECT SHADING TYPE:



Typical | None | Interior | Overhangs | Maximum

PREVIOUS NEXT

Location: Portland, Oregon
House Type: 1 Story
Window Type: Windows

ENERGY STAR Zones | IECC Zones

Energy Costs
Natural Gas: $1.133/therm
Electricity: $0.108/kWh

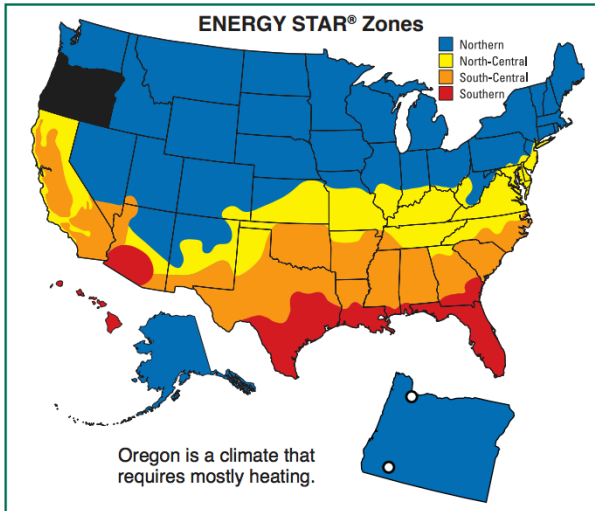
Additional Tools & Information:

- Oregon Fact Sheet
- State Code Information
- Selection Guidance Fact Sheet

Efficient Windows™ Collaborative

Selecting Energy Efficient New Windows in Oregon

www.efficientwindows.org January 2016



U-factor	SHGC	Air Leakage
Windows: U ≤ 0.27 Windows: U = 0.28 Windows: U = 0.29 Windows: U = 0.30 Skylights: U ≤ 0.50	Windows: Any Windows: SHGC ≥ 0.32 Windows: SHGC ≥ 0.37 Windows: SHGC ≥ 0.42 Skylights: Any	Windows: AL ≤ 0.30 Skylights: AL ≤ 0.30

For superior energy performance, select windows with a U-factor of 0.25 or less. If air conditioning is not a concern, look for a higher Solar Heat Gain Coefficient (SHGC) of 0.35–0.60 so winter solar heat can help offset the heating energy need. If cooling is a significant concern and no shading is available, select windows with a SHGC less than 0.32.

U-factor	SHGC	Air Leakage
Windows: U ≤ 0.30 Skylights: U ≤ 0.53	Windows: SHGC ≤ 0.40 Skylights: SHGC ≤ 0.35	Windows: AL ≤ 0.30 Skylights: AL ≤ 0.30

The larger your heating bill, the more important a low U-factor becomes. For superior energy performance, select windows with a U-factor of 0.25 or less. A low SHGC value reduces summer cooling demand, but also

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

Windows must comply with your local energy code. Windows that are ENERGY STAR certified often meet or exceed energy code requirements. To verify if specific window energy properties comply with the local code requirements, look for the NFRC label.

2. Look for Efficient Properties on the NFRC Label

The National Fenestration Rating Council (NFRC) label is needed for verification of energy code compliance. The NFRC label displays whole-window energy properties and appears on all fenestration products which are part of the ENERGY STAR program (www.nfrc.org).

3. Compare Annual Energy Costs for a Typical House

Use computer simulations for a typical house to compare the annual energy performance of different window types. A comparison of the performance of a set of windows for this climate begins on Page 3 or use the Window Selection Tool on the EWC web site or the Window Selection Tool Mobile App (www.efficientwindows.org).

4. Customize Energy Use for a Specific House

ORIENTATION

- (•) Equal
- ( ) North
- ( ) East
- ( ) South
- ( ) West

WINDOW AREA

- ( ) Small
- ( ) Moderate
- (•) Large

SHADING TYPE

- ( ) Typical
- (•) None
- ( ) Interior
- ( ) Overhangs
- ( ) Maximum

LOCATION: Portland, Oregon
HOUSE TYPE: 1 Story
WINDOW TYPE: Windows

NEW SEARCH

MODIFY SEARCH

SUMMARY | Energy | Comfort | Condensation

Window System							Standards		Performance						Info
ID	Panes	Glass	Frame	U-factor	SHGC	VT	ENERGY STAR	2012 IECC	Heating	Energy Cooling	Total	Comfort Winter	Summer	Cond.	Manufacturers
18	3	HSG Low-E	Non-metal, Improved	≤0.22	0.41-0.60	0.41-0.50	Yes	Yes							products
21	2	HSG Low-E	Non-metal, Improved	0.23-0.30	0.41-0.60	0.51-0.60	Yes	Yes							products
15	2	HSG Low-E	Non-metal, Improved	0.23-0.30	0.41-0.60	0.51-0.60	Yes	Yes							products
19	3	MSG Low-E	Non-metal, Improved	≤0.22	0.26-0.40	0.41-0.50	Yes	Yes							products
22	2	MSG Low-E	Non-metal, Improved	0.23-0.30	0.26-0.40	0.51-0.60	Yes	Yes							products
16	2	MSG Low-E	Non-metal, Improved	0.23-0.30	0.26-0.40	0.51-0.60	Yes	Yes							products
20	3	LSG Low-E	Non-metal, Improved	≤0.22	≤0.25	≤0.40	Yes	Yes							products
23	2	LSG Low-E	Non-metal, Improved	0.23-0.30	≤0.25	0.41-0.50	Yes	Yes							products
9	2	HSG Low-E	Metal, Improved	0.41-0.55	0.41-0.60	0.51-0.60	No	No							products
17	2	LSG Low-E	Non-metal, Improved	0.23-0.30	≤0.25	0.41-0.50	Yes	Yes							products
10	2	MSG Low-E	Metal, Improved	0.41-0.55	0.26-0.40	0.51-0.60	No	No							products
4	2	HSG Low-E	Metal	0.56-0.70	>0.60	>0.60	No	No							products
11	2	LSG Low-E	Metal, Improved	0.41-0.55	≤0.25	0.51-0.60	No	No							products
5	2	MSG Low-E	Metal	0.56-0.70	0.26-0.40	0.51-0.60	No	No							products

ORIENTATION

- (•) Equal
- ( ) North
- ( ) East
- ( ) South
- ( ) West

WINDOW AREA

- ( ) Small
- ( ) Moderate
- (•) Large

SHADING TYPE

- ( ) Typical
- (•) None
- ( ) Interior
- ( ) Overhangs
- ( ) Maximum

LOCATION: Portland, Oregon
HOUSE TYPE: 1 Story
WINDOW TYPE: Windows

NEW SEARCH

MODIFY SEARCH

Summary | **ENERGY** | Comfort | Condensation

Window System							Annual Energy						Peak		Info
ID	Panes	Glass	Frame	U-factor	SHGC	VT	Annual Energy Cost	Total Cost	Heat Cost	Cool Cost	Heat (Mbtu)	Cool (kWh)	Heat (kBtu/hr)	Cool (kW)	Manufacturers
18	3	HSG Low-E	Non-metal, Improved	≤0.22	0.41-0.60	0.41-0.50		$999	$888	$111	78.4	1025	71.43	3.596	products
21	2	HSG Low-E	Non-metal, Improved	0.23-0.30	0.41-0.60	0.51-0.60		$1002	$879	$122	77.62	1133	71.83	3.781	products
15	2	HSG Low-E	Non-metal, Improved	0.23-0.30	0.41-0.60	0.51-0.60		$1018	$882	$136	77.85	1255	72.43	3.997	products
19	3	MSG Low-E	Non-metal, Improved	≤0.22	0.26-0.40	0.41-0.50		$1030	$956	$74	84.36	683	71.35	3	products
22	2	MSG Low-E	Non-metal, Improved	0.23-0.30	0.26-0.40	0.51-0.60		$1030	$952	$79	84	729	71.67	3.093	products
16	2	MSG Low-E	Non-metal, Improved	0.23-0.30	0.26-0.40	0.51-0.60		$1048	$967	$81	85.37	747	72.21	3.138	products
20	3	LSG Low-E	Non-metal, Improved	≤0.22	≤0.25	≤0.40		$1054	$998	$56	88.05	518	71.21	2.65	products
23	2	LSG Low-E	Non-metal, Improved	0.23-0.30	≤0.25	0.41-0.50		$1055	$996	$59	87.93	548	71.54	2.717	products
9	2	HSG Low-E	Metal, Improved	0.41-	0.41-	0.51-		$1063	$919	$144	81.08	1334	74.42	4.179	products

Generic Window

Window 18

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

U = ≤0.22
SHGC = 0.41-0.60
VT = 0.41-0.50

LOCATION: Portland, Oregon
HOUSE TYPE: 1 Story
WINDOW TYPE: Windows

Manufacturer	View Products
Accurate Dorwin	Products Available»
Fibertec Window & Door Mfg.	Products Available»
Great Lakes Window	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.

Specific Manufacturer Product Lines

Window 18

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

U = ≤0.22
SHGC = 0.41-0.60
VT = 0.41-0.50

LOCATION: Portland, Oregon
HOUSE TYPE: 1 Story
WINDOW TYPE: Windows

Manufacturer	Product Line	Options	U-factor	SHGC	VT	AL
Fibertec Window & Door Mfg. http://www.fibertec.com	Series 600 Next Generation Fixed Window - Heat Mirror TC88		0.21	0.43	0.55	
	Series 300 Fixed Window - triple pane Energy Advantage		0.22	0.51	0.59	
	Series 300 Fixed Window - Heat Mirror TC88, krypton		0.16	0.44	0.56	
	300 Series Casement Window	Triple Glaze, 2 LoE LOF, Argon Gas	0.21	0.43	0.46	
	300 Series Awning Window	Triple Glaze, 2 LoE LOF, Argon Gas	0.21	0.43	0.46	
	300 Series Fixed Window	Triple Glaze, 2 LoE LOF, Argon Gas	0.18	0.51	0.55	
	400 Series Side Slider Window	Triple Glaze, 1 LoE LOF, Krypton Gas	0.27	0.47	0.52	

ORIENTATION

- (•) Equal
- ( ) North
- ( ) East
- ( ) South
- ( ) West

WINDOW AREA

- ( ) Small
- ( ) Moderate
- (•) Large

SHADING TYPE

- ( ) Typical
- (•) None
- ( ) Interior
- ( ) Overhangs
- ( ) Maximum

LOCATION: Portland, Oregon
HOUSE TYPE: 1 Story
WINDOW TYPE: Windows

NEW SEARCH

MODIFY SEARCH

Summary | Energy | **COMFORT** | Condensation

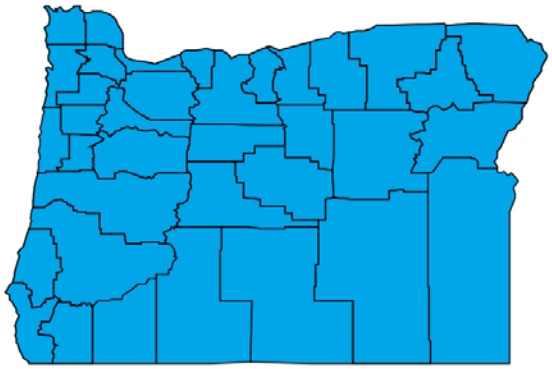
Window System							Comfort			Info
ID	Panes	Glass	Frame	U-factor	SHGC	VT	Summer and Winter Comfort	Summer	Winter	Manufacturers
18	3	HSG Low-E	Non-metal, Improved	≤0.22	0.41-0.60	0.41-0.50	Cold Neutral Hot	Warm	Neutral	products
21	2	HSG Low-E	Non-metal, Improved	0.23-0.30	0.41-0.60	0.51-0.60	Cold Neutral Hot	Warm	Neutral	products
15	2	HSG Low-E	Non-metal, Improved	0.23-0.30	0.41-0.60	0.51-0.60	Cold Neutral Hot	Warm	Neutral	products
19	3	MSG Low-E	Non-metal, Improved	≤0.22	0.26-0.40	0.41-0.50	Cold Neutral Hot	Slightly Warm	Neutral	products
22	2	MSG Low-E	Non-metal, Improved	0.23-0.30	0.26-0.40	0.51-0.60	Cold Neutral Hot	Neutral	Neutral	products
16	2	MSG Low-E	Non-metal, Improved	0.23-0.30	0.26-0.40	0.51-0.60	Cold Neutral Hot	Slightly Warm	Neutral	products
20	3	LSG Low-E	Non-metal, Improved	≤0.22	≤0.25	≤0.40	Cold Neutral Hot	Neutral	Neutral	products
23	2	LSG Low-E	Non-metal, Improved	0.23-0.30	≤0.25	0.41-0.50	Cold Neutral Hot	Neutral	Neutral	products

IECC Compliance Guide for Homes in Oregon

Code: 2018 International Energy Conservation Code

Step-by-Step Instructions

1. Using the climate zone map to the right, match the jurisdiction to the appropriate IECC climate zone. Use the simplified table of IECC building envelope requirements (below) to determine the basic prescriptive requirements for the thermal envelope associated with the jurisdiction.
2. Use the "Outline of 2018 IECC Requirements" printed on the back of this sheet as a reference or a categorized index to the IECC requirements. Construct the building according to the requirements of the IECC and other applicable code requirements.



The 2018 International Energy Conservation Code

The 2018 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. 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. To obtain a copy of the 2018 IECC, contact the ICC or visit www.iccsafe.org. IECC compliance training is also available from many sources.

Limitations

This guide is an energy code compliance aid for Oregon based upon the simple prescriptive option of the 2018 IECC. It does not provide a guarantee for meeting the IECC. This guide is not designed to reflect the actual energy code, with amendments, if any, adopted in Oregon and does not, therefore, provide a guarantee for meeting the state energy code. For details on the energy code adopted by Oregon, including how it may differ from the IECC, please contact your local building code official. Additional copies of this guide are available on www.reca-codes.com.

CLIMATE ZONE 5	
Baker	Lake
Benton	Lane
Clackamas	Lincoln
Clatsop	Linn
Columbia	Malheur
Coos	Marion
Crook	Morrow
Curry	Multnomah
Deschutes	Polk
Douglas	Sherman
Gilliam	Tillamook
Grant	Umatilla
Harney	Union
Hood River	Wallowa
Jackson	Wasco
Jefferson	Washington
Josephine	Wheeler
Klamath	Yamhill

Efficient Window Collaborative

www.efficientwindows.org

Window Replacement Options

- Full frame replacement (new window)
- Pocket solution
- Sash replacement
- In place retrofit

How Do You Fit a 5” Wide Triple Glazed Window into a 2 x 4 Framed Wall?

Sash/Frame and IGU Dimensions

Highly Insulating, Low Heat Loss Glazing

Today: U-value ~ .3 BTU-sf-h/F

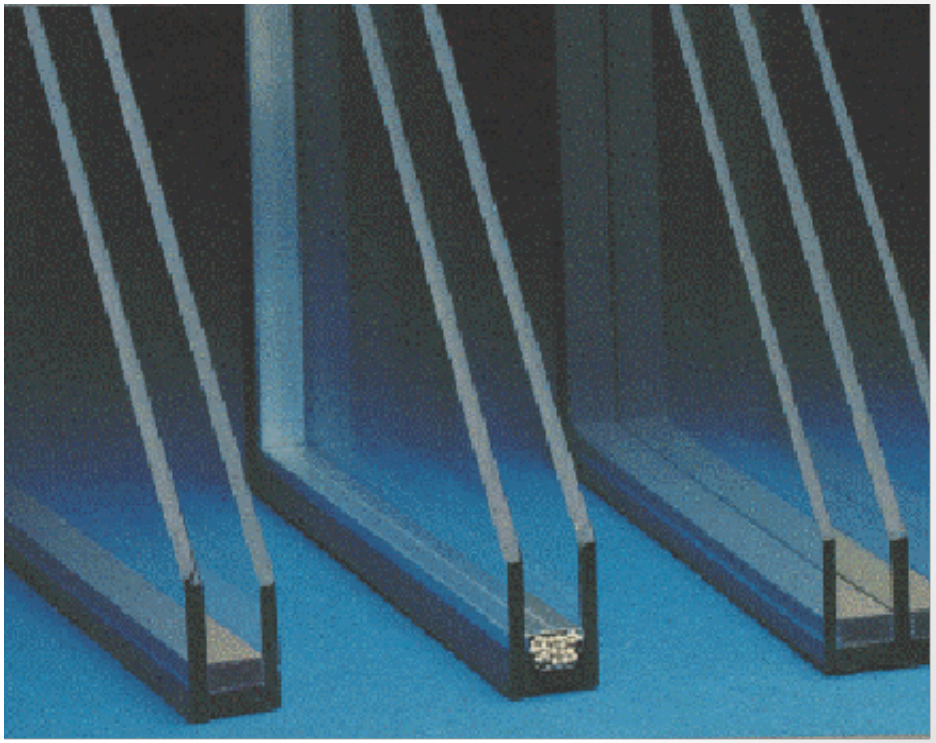
Nearer Term Objective: U-value < 0.2 BTU-sf-h/F

Longer Term Target: U-value < 0.1 BTU-sf-h/F

Current Approaches: 30 years

- Low-Emissivity Coatings
- Low Conductance Gas Fills
- "Warm edge" low conductance spacers
- Insulated Frame Systems

New Approaches??



Glazing Changes to Lower Heat Loss

	$U_{glazing}$ (Btu/sf-hr-F) Typical values
• Single ⇨ double	1 ⇨ .5
• Double ⇨ Triple	.5 ⇨ .35
• Double ⇨ Low-E	.5 ⇨ .35
• Double ⇨ Argon-filled	.5 ⇨ .44
• Double ⇨ Low-E, argon	.5 ⇨ .25
• Double ⇨ Low-E, argon, #4 low-E	.5 ⇨ .22

Triple with Low-E, gas fill	⇨ ~.1 -- .15
Triple with suspended low-E plastic film	⇨ ~.1 -- .15
Vacuum glazing with low-E	⇨ ~.1 -- .15

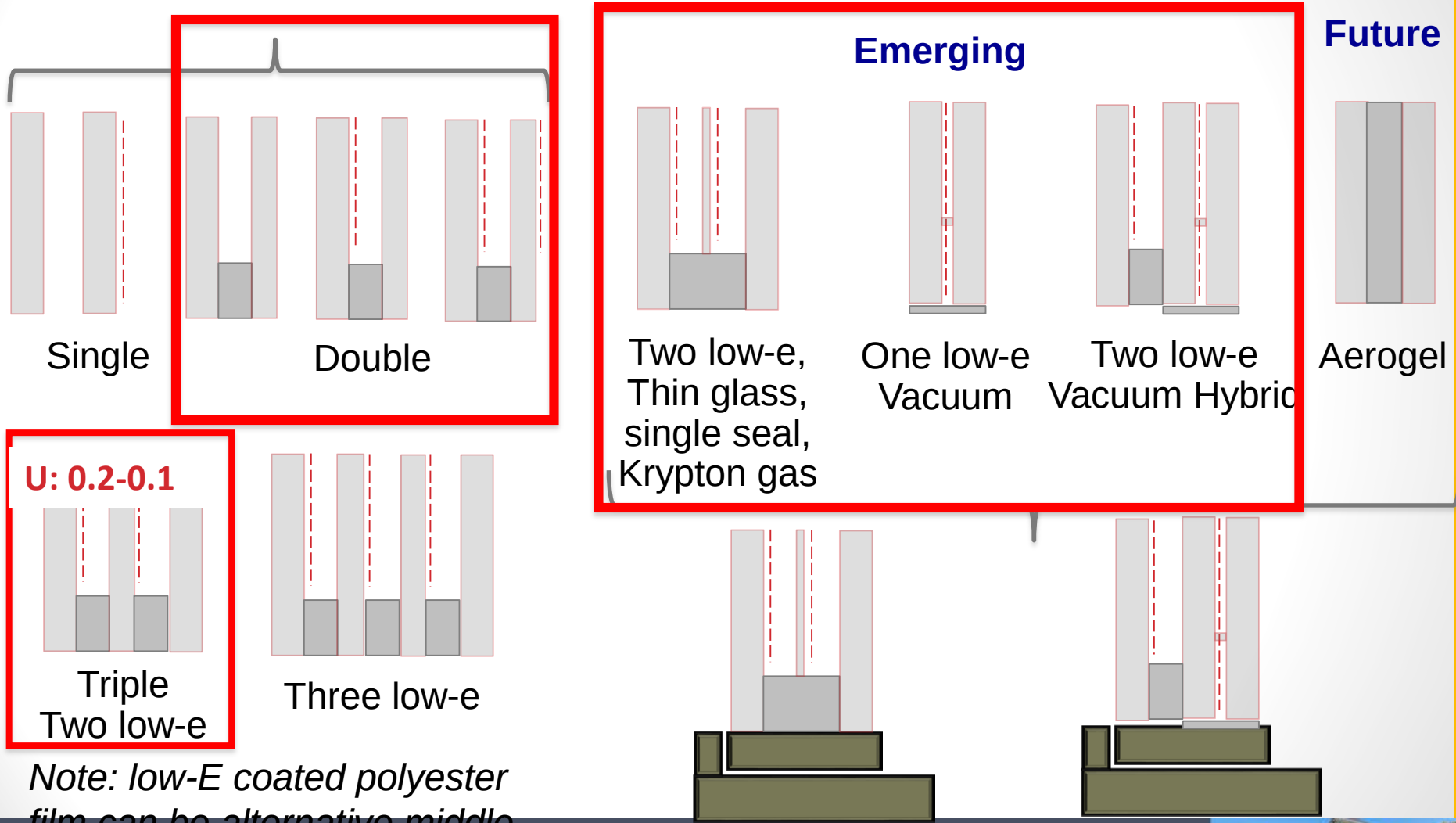
U.S. Insulating Glazing Landscape Today:

Market Today **U: 0.5-> 0.3**

U: 0.2-> 0.06

Emerging

Future

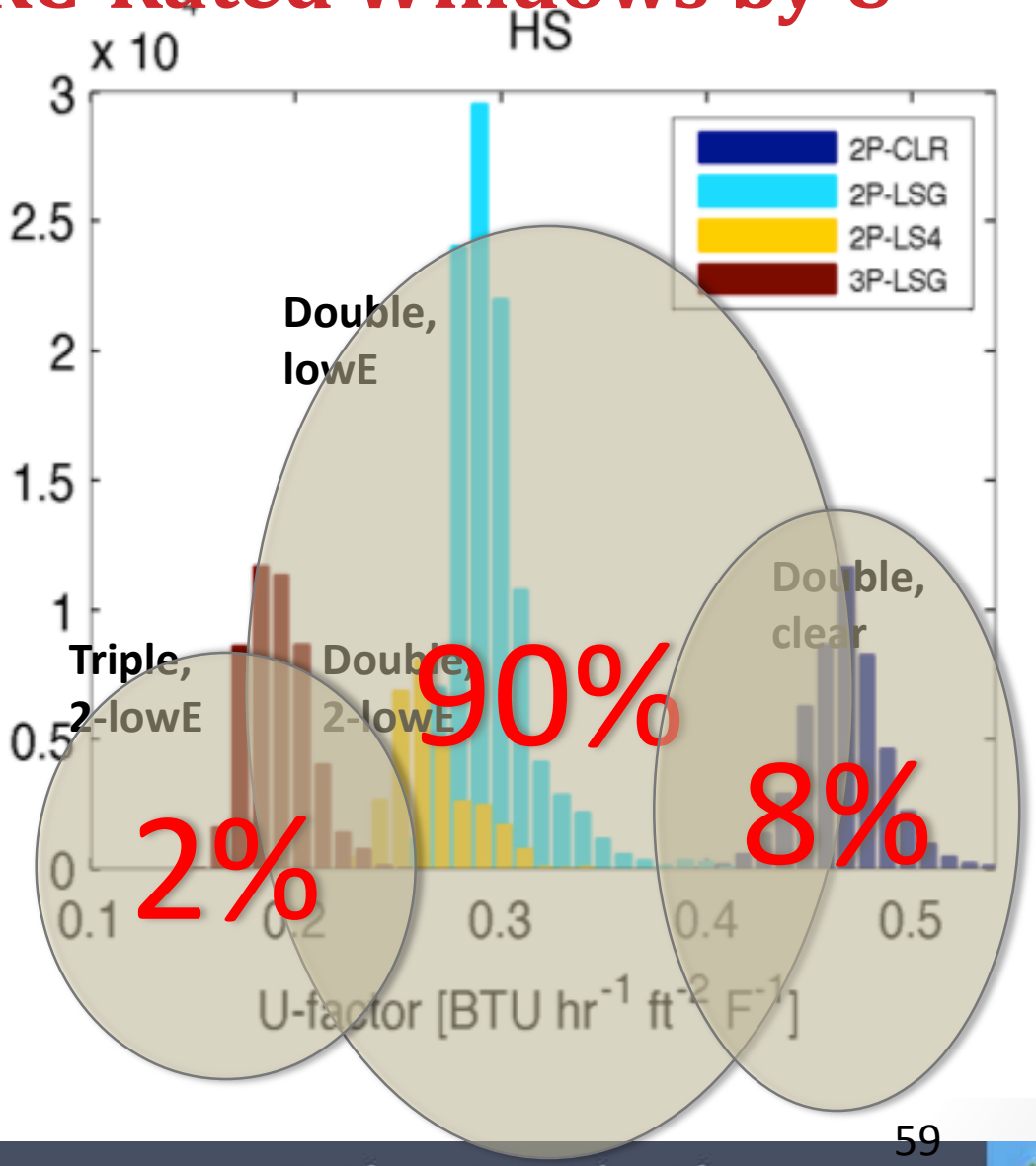


Note: low-E coated polyester film can be alternative middle glazing.

Super-insulating frame with highly insulated glazing

Market Snapshot
NFRC-Rated Windows by U

Number of Product Lines

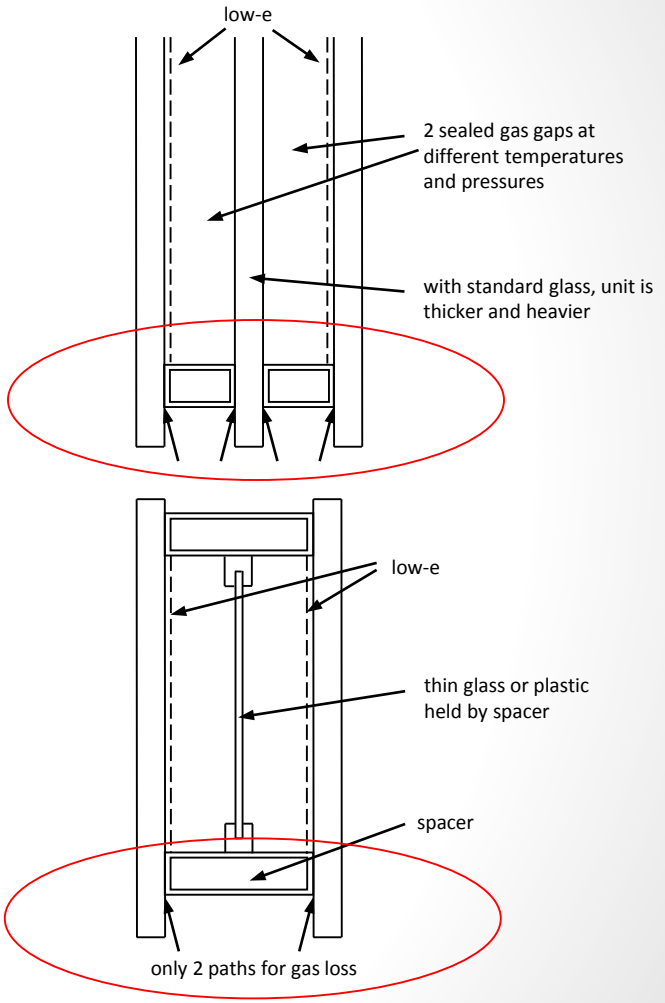


Source:
EPA ENERGYSTAR analysis,
Horiz. sliding windows

Non-Structural Center-Layers

- **Current technologies for highly insulating products use multiple layers of low-e and gas fill**
  - All glass is heavy
  - Thin film products expensive
  - Multiple spacers can lead to gas leakage

- **LBNL research aims to develop lower-cost, non-structural center layers**
  - Utilize available low-e and gas-fill technologies
  - Research novel center layer designs and materials

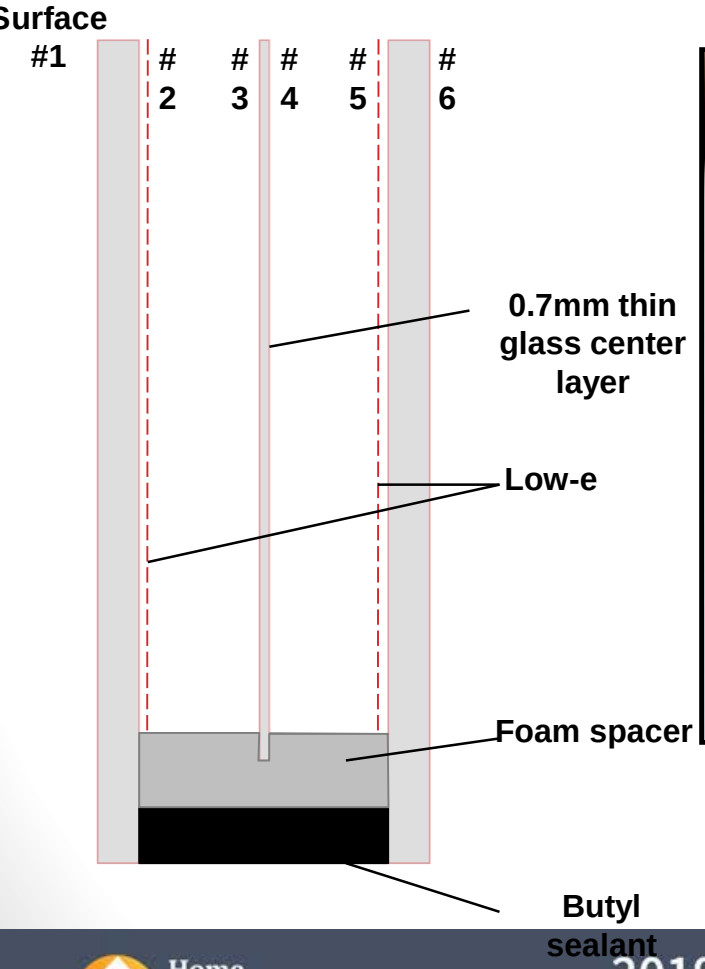


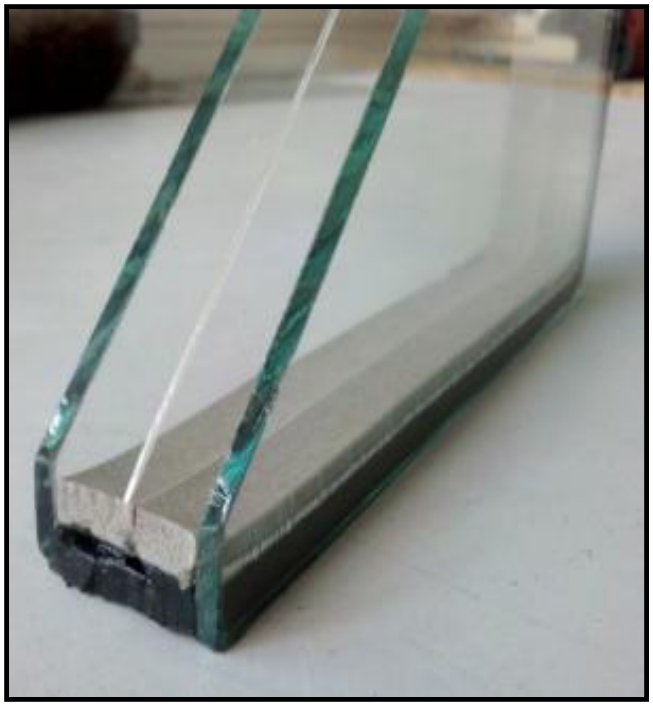
Criteria for Success

- Significant Improvement in Thermal Properties: >R5
- Drop-In Replacement for IGU: No Window Redesign
- Affordable Cost: < $5/sf retail
- Scalable Rapidly
- Low Manufacturer Risk
- Acceptable Aesthetics
- Value Proposition to Builder, Homeowner

Drop-In "Thin Lightweight Triple"

Upgrade" all R3 double glazed windows to R4-7 without redesign using new IGU with same width, weight



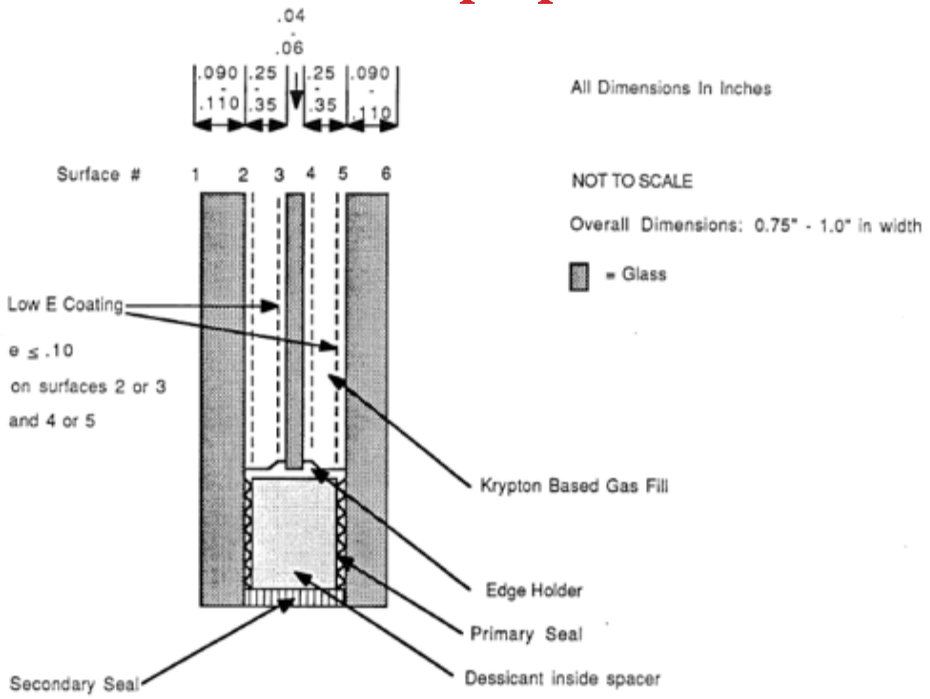


- **Platform: U: ~.10-.15**
- **Thin float glass**
  - .3, .5, .7, 1.1 mm
- Multiple suppliers
- **2 Low-E coatings**
- **Krypton gas fill**
- Non-structural center
  - 2 seals, not 4
- Infrastructure exists
- "Affordable"

Not a New Concept; Thin Glass, Thin Triple Concept Developed "Before its Time"

1991 Design Patent >

1989 ASME paper



United States Statutory Invention Registration [19]

Selkowitz et al.

[11] Reg. Number: H975

[43] Published: Nov. 5, 1991

[54] THERMAL INSULATED GLAZING UNIT

[75] Inventors: **Stephen E. Selkowitz**, Piedmont; **Dariush K. Arasteh**, Oakland, both of Calif.; **John L. Hartmann**, Seattle, Wash.

[73] Assignee: **The United States of America as represented by the United States Department of Energy**, Washington, D.C.

[21] Appl. No.: **428,539**

[22] Filed: **Oct. 30, 1989**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 319,871, Mar. 1, 1989, abandoned, which is a continuation of Ser. No. 178,043, Apr. 5, 1988, abandoned.

[51] Int. Cl.[5] E06B 7/12

[52] U.S. Cl. 52/172

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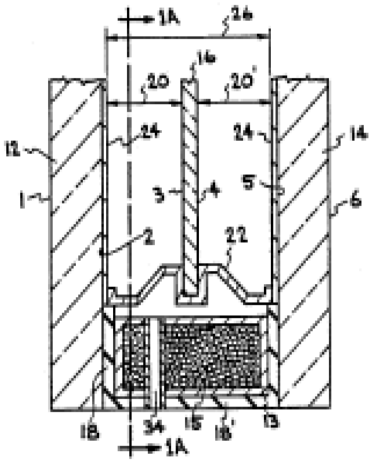
Popular Science, "Superwindows", Elaine Gilmore, 3-1986, pp. 76-77.

Primary Examiner—Michael J. Carone
Attorney, Agent, or Firm—B. J. Weis; L. E. Carnahan; William R. Moser

[57] **ABSTRACT**

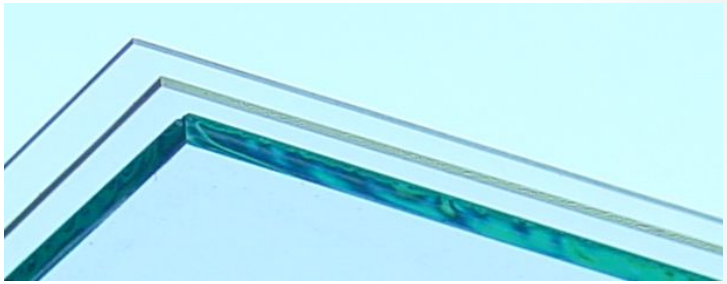
An improved insulated glazing unit is provided which can attain about R5 to about R10 thermal performance at the center of the glass while having dimensions about the same as those of a conventional double glazed insulated glazing unit. An outer glazing and inner glazing are sealed to a spacer to form a gas impermeable space. One or more rigid, non-structural glazings are attached to the inside of the spacer to divide the space between the inner and outer glazings to provide insulating gaps between glazings of from about 0.20 inches to about 0.40 inches. One or more glazing surfaces facing each thermal gap are coated with a low emissivity coating. Finally, the thermal gaps are filled with a low conductance gas such as krypton gas.

21 Claims, 2 Drawing Sheets



Why Will It Work Now?

- **Thin Glass**:
  - **4 years ago**: Corning offered glass at **~ $5.00/sf**
  - **Today**: Major float glass suppliers **~ $0.60/sf** due to huge demand for large flat screen TVs



- **Krypton Gas**
  - **4 years ago:** variable demand from other sources kept prices high and volatile; Gas fill wasted 50% -> Net cost **> $2.00/sf**
  - **Today**: Xenon requirements make Kr available; traditional Kr use has reduced; suppliers now sign long term contracts at **~$0.50/sf**
  - New high rate gas fill with only 10% loss

Where Can We Find "Thin" Glass Today? 2017 – Total Glass Area Sold/Year??

Flat Screen TVs

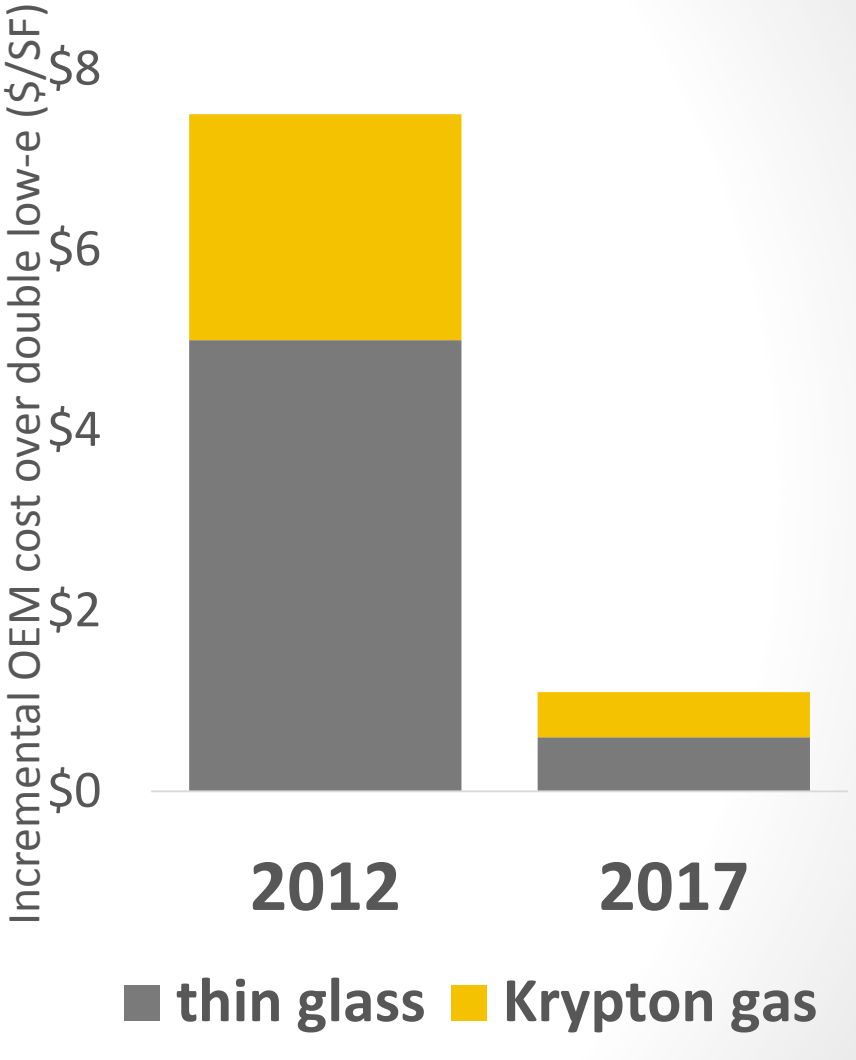
350M sf

Residential Windows

600M sf

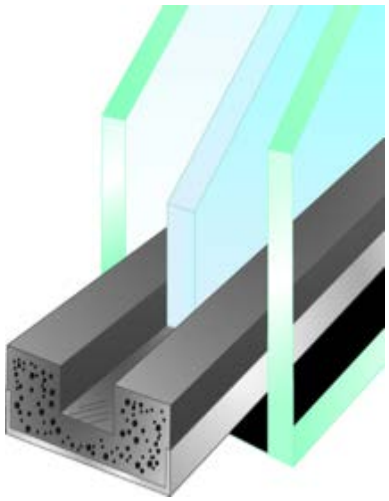
Message: Build on the extensive display industry capability in flat glass

Flat Screen TV, Satellites, LEDs → 80+% reductions in cost



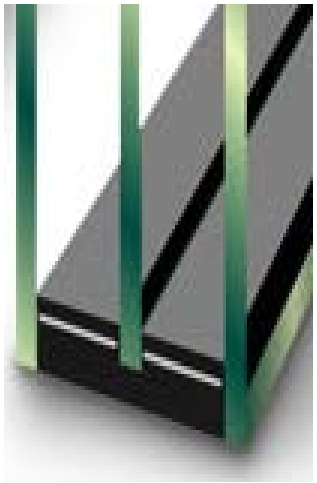
“Thin-triple” spacer: Single spacer dual seal systems

Products are already entering the market



Edgetech

Swisspacer



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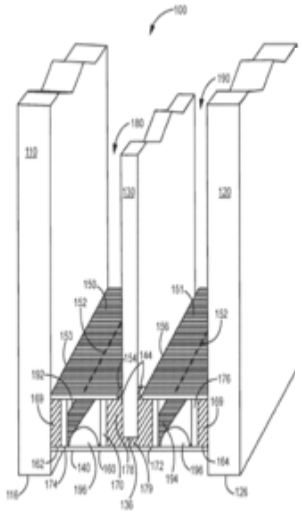
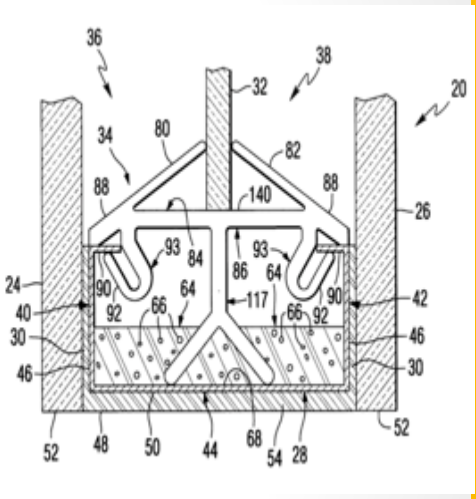


Guardian: US 9,677,321 B2



PPG: US6289641B1

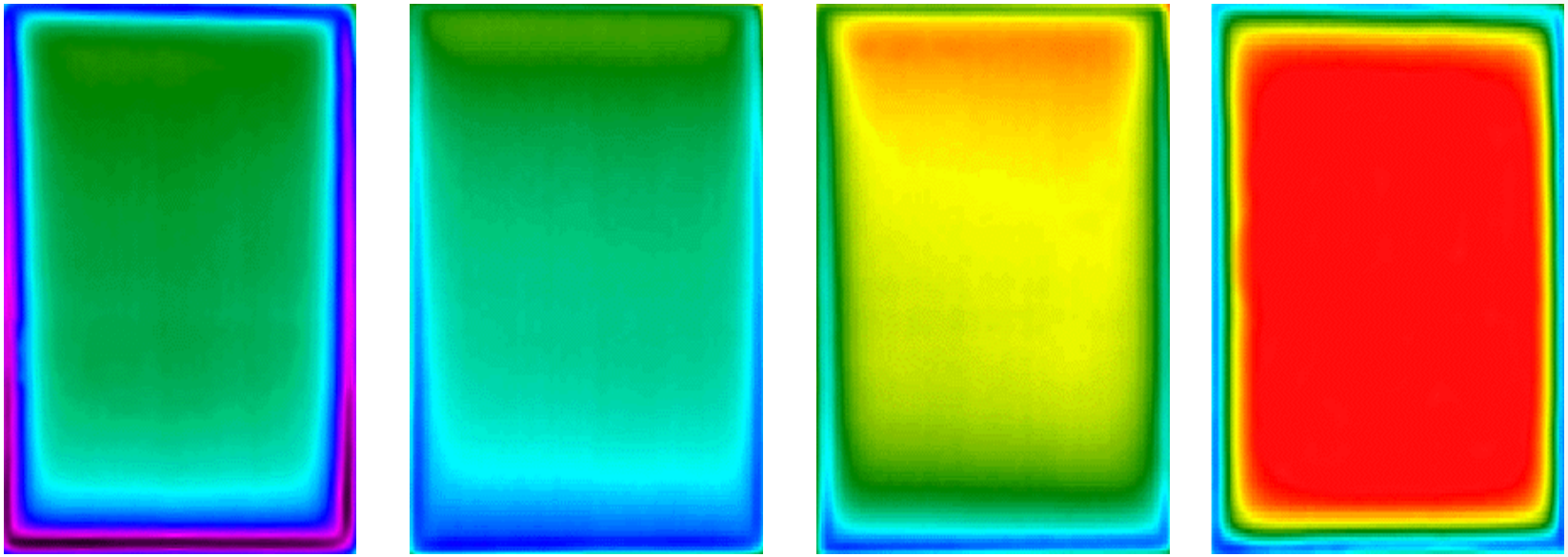
Technologies to Reduce Heat Loss
Glass, Glass Edge

Dual, Clear, Alum. spacer

Dual, Clear, Foam spacer

Dual, Low-e, Foam spacer

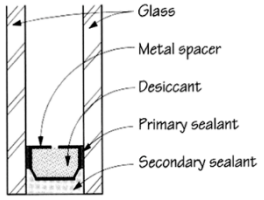
Superwindow, 4-lites, low-e, Kr



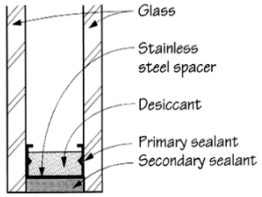
-6.0˚ C *20˚ C*

Images from LBNL Infrared Thermography Lab

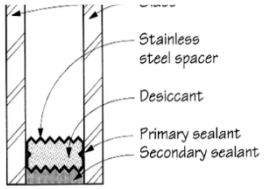
“Warm Edge” IGUs



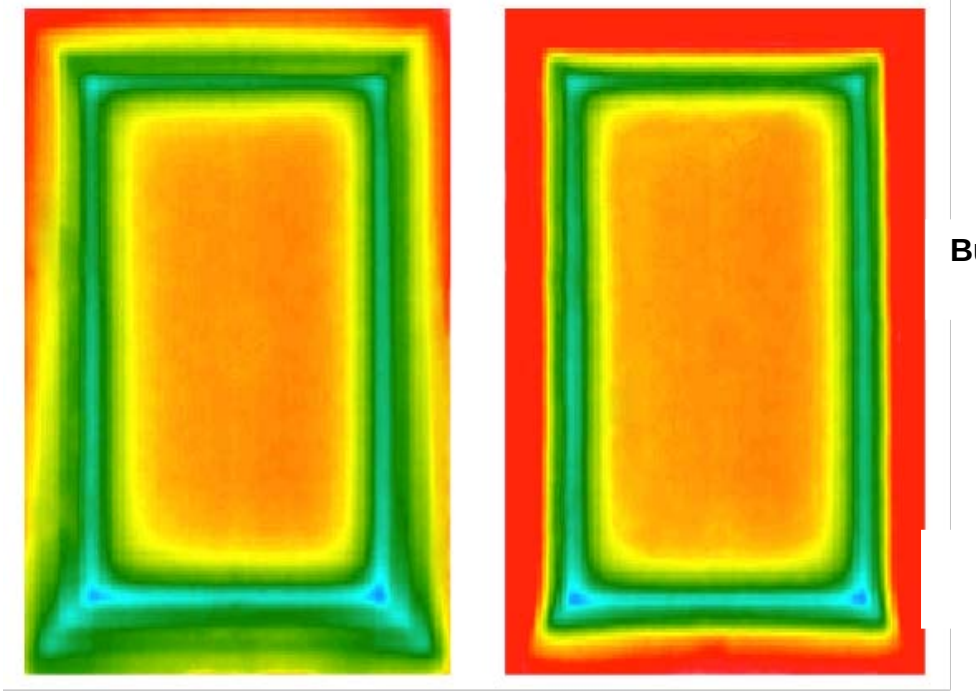
Double-Seal Metal Spacer



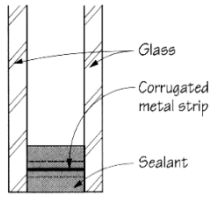
Stainless Steel Spacer



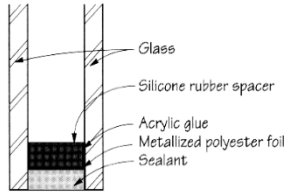
Stainless Steel Spacer



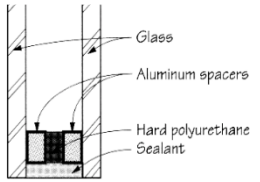
Reduce heat loss and condensation at perimeter of window with warm edge technology



Butyl Tape Spacer with Metal

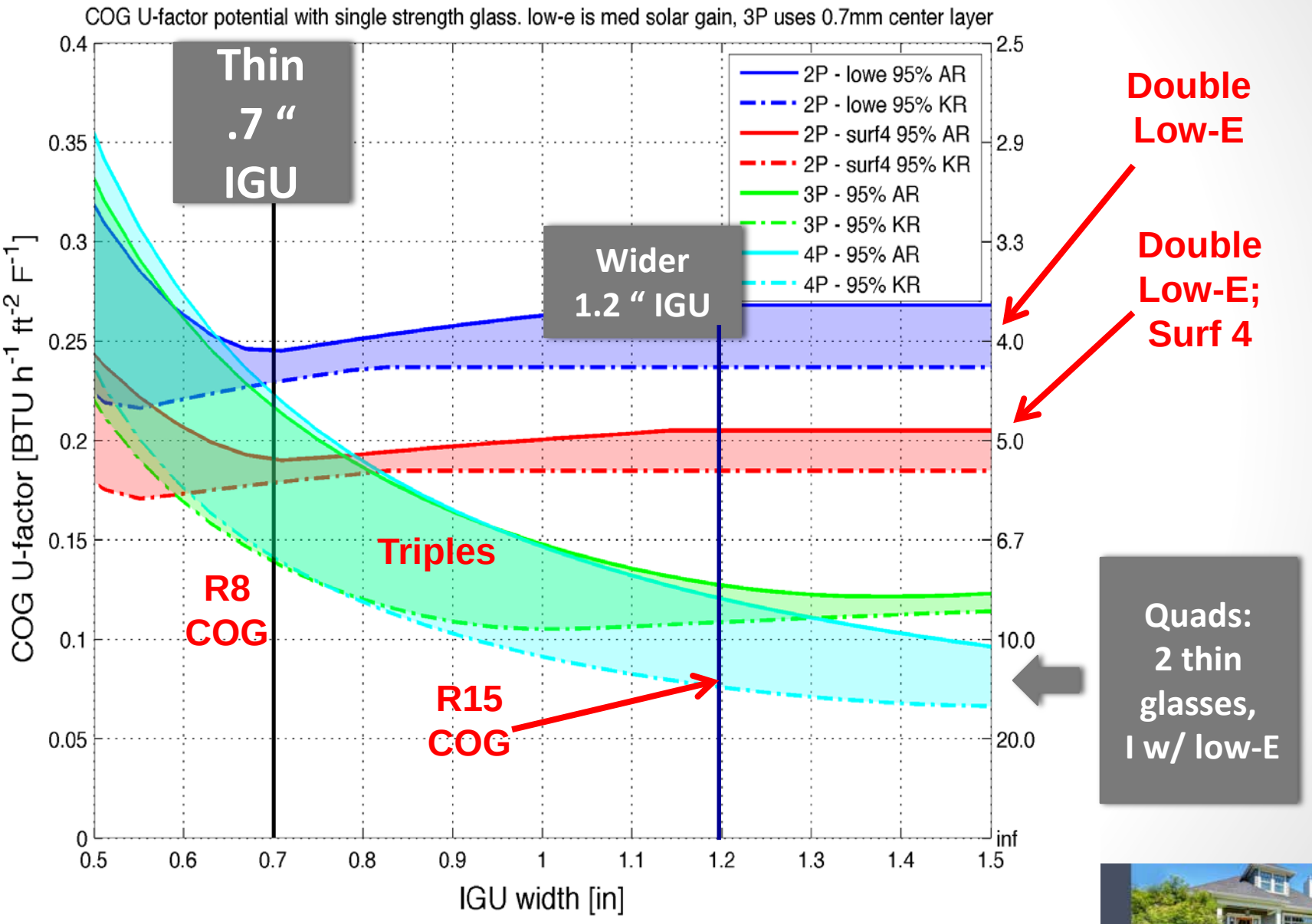


Silicon Foam Spacer



Aluminum Spacer with Thermal Break

Thin Lightweight Triple → Thin Quad



Alpen HPP

Triple and Quad Windows Corner Samples

In Fiberglass Frames

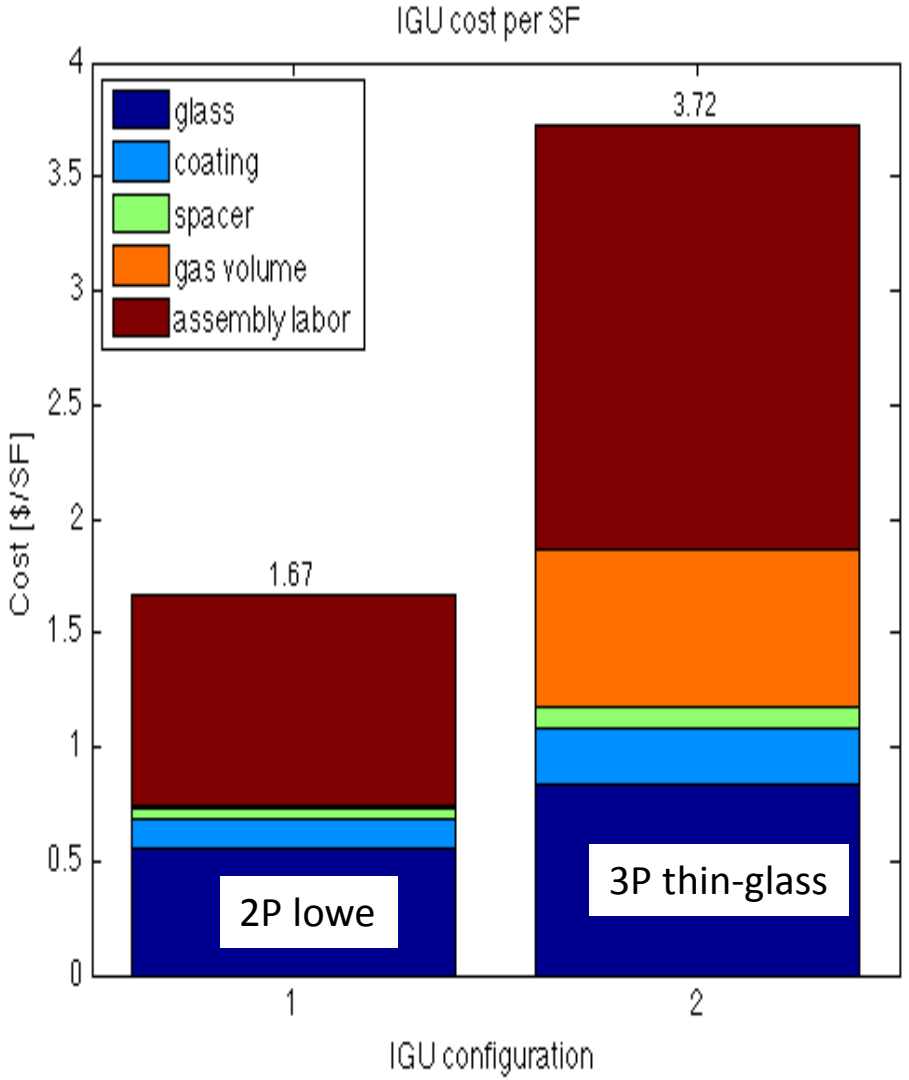
IGU Fabrication: Cost Estimates

Incremental Cost to IGU Fabricator

Short term:
Delta: + ~ $3/SF

Long term:
Delta: + ~ $2/SF

+ Supply Chain Markups



Market Drivers: Who Wants This? Needs This?

- **Builders/Building Owners**
  - Energy/$$ Savings
  - Thermal comfort
  - Larger window area
  - Early Adopters
    - Passive House buyers
    - Zero Net Energy Home buyers

- **Architects/Engineers**
  - Builders- first cost dominated-
    - Emerging early adopters
  - Comfort/Daylight
  - "Justifying" larger window area
  - HVAC system
    - first cost savings- reduced size
    - Duct system reductions, distributed/zonal HVAC

Potential Performance Metrics (+ Energy)

Comfort

- Mean radiant temperature
- Operative temperature
- Uncomfortable hours
- Winter comfort temperature
- Summer comfort temperature
- Draft
- Sound transmission

Health

- Condensation resistance - Interior
- Condensation resistance - Exterior
- UV transmittance
- Sound transmission

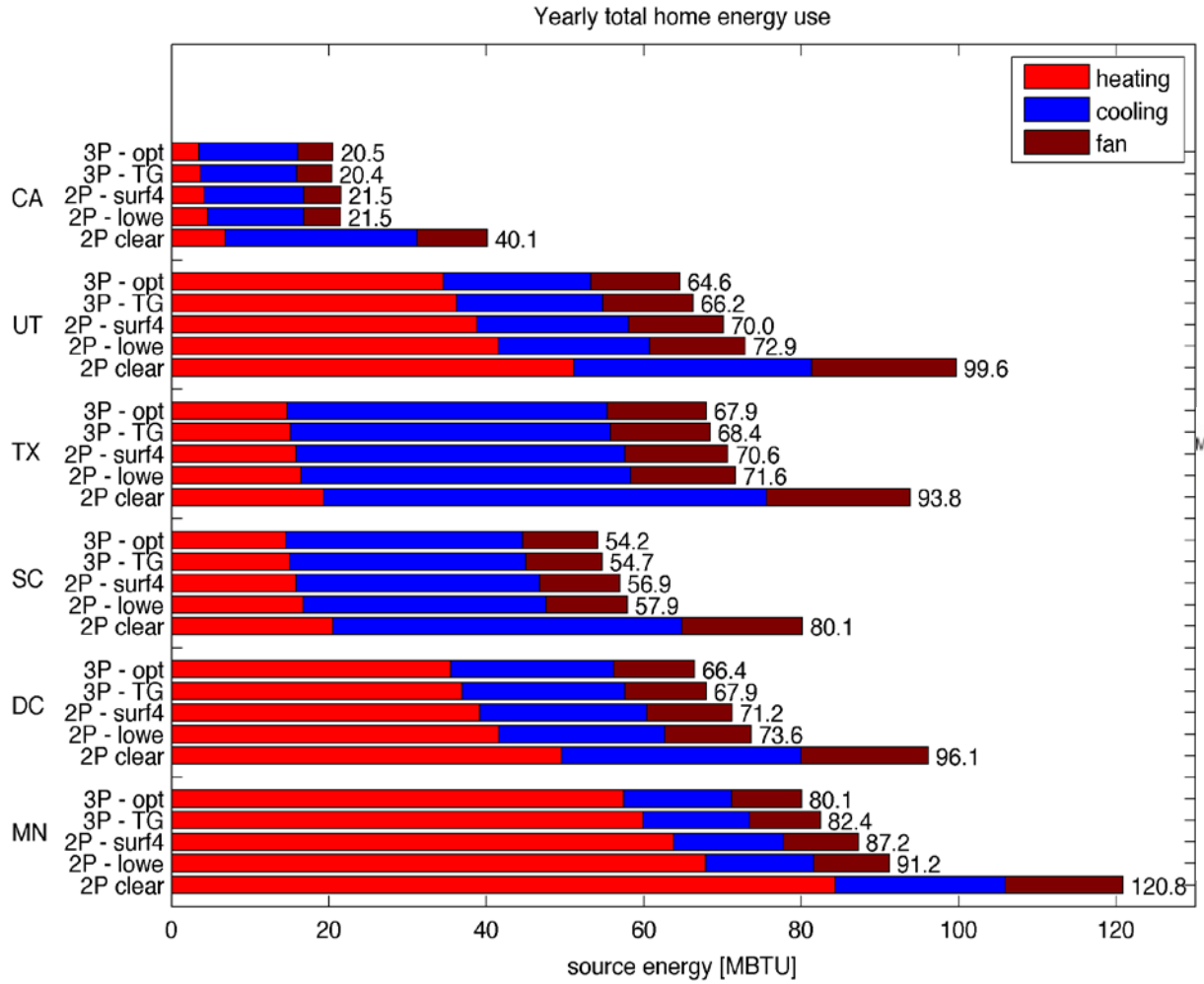
Building resiliency

- Demand response
- Life safety (maintain temperature during power/gas outage)
- Mechanical equipment sizing
- Eliminate perimeter heating/cooling

Annual Energy Cost/Savings (6 U.S. Cities)

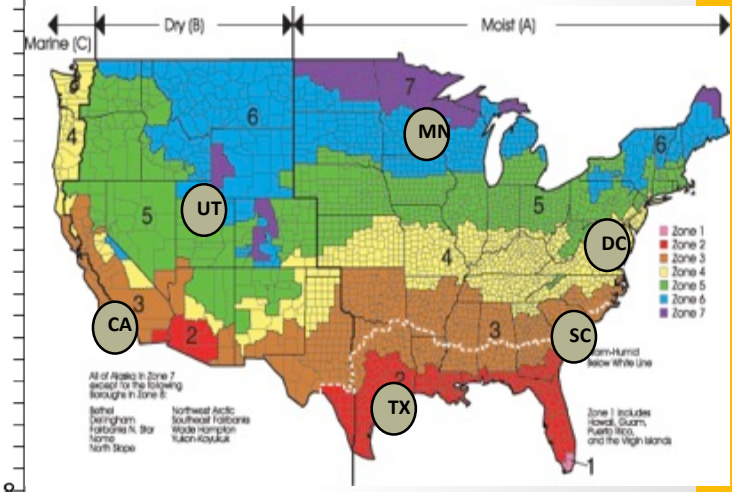
5 Alternative Window Designs

End use multipliers: Elec=3.167,Gas=1.084



Payback?

Different U.S. Climate Zones



"Early Adopters"

Passive House/Buildings

- Need "highly insulating" windows
- Two Competing Certification Groups, PHI, PHIUS
- Many builders import windows from Europe
- **Activity Level ??**

Zero Net Energy Homes/buildings

- Role of High Performance Windows
- Systems impacts on HVAC Design, sizing
- **Activity Level =?**

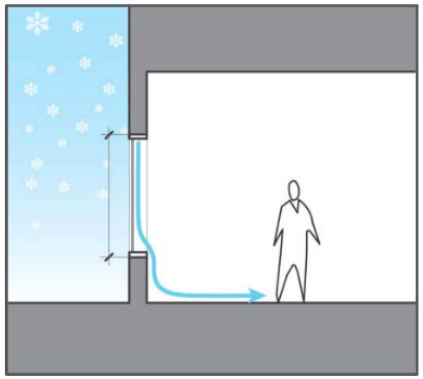
LEED/ Living Building Challenge

- Need for High Performance Windows?

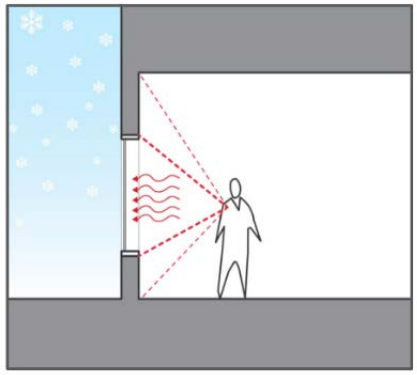
Building the Case for High R Windows

- **Energy (current supply -> decarbonize**
- Load shape, demand
- Occupant comfort ----------→
- HVAC System peak sizing
- HVAC System type, distribution

- **Codes**
- **Utility Incentives and Rebates**
- **Energy Star**



Draft Discomfort
(Ankle Discomfort)



Radiant Discomfort
(Full-body Discomfort)

Thermal Comfort Considerations

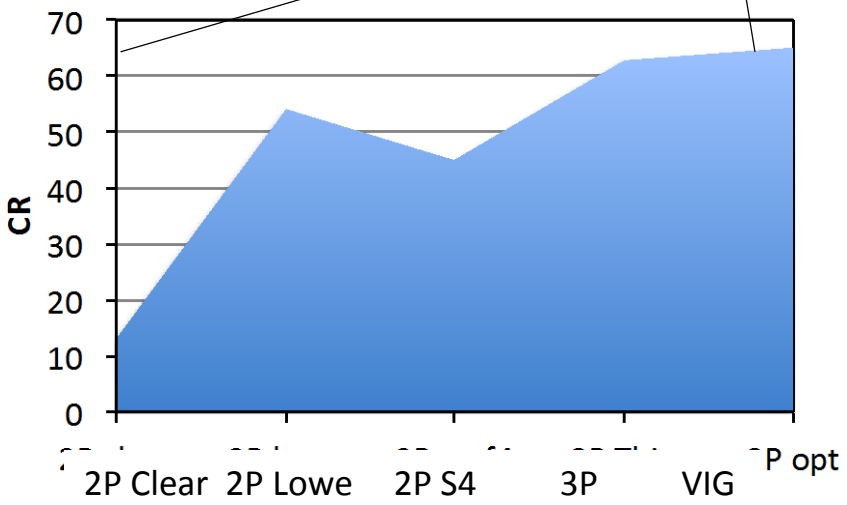
- Condensation Resistance
- Winter Outdoor Comfort Temperature

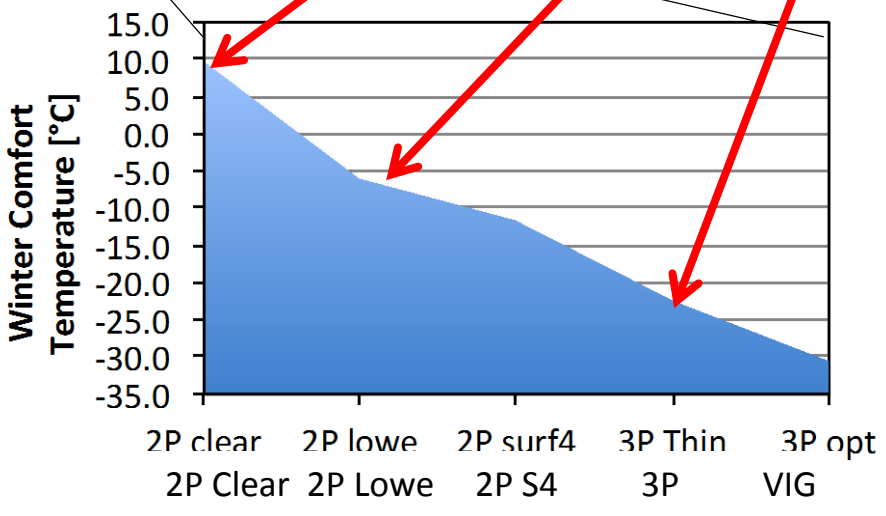
	Glazing Type	Condensation Resistance [CR]	Winter Comfort Temperature [°C]	Acoustic	Security
1	2P clear	13	9.7		
2	2P lowe	54	-6.1		3 panes
3	2P surf4	45	-11.8	?	>
4	3P Thin Glass	63	-22.6		2 Panes
5	3P opt	65	-30.6		

Double 50 F

Double Low-E: 21F

Triple - 11F





Window Industry Partners

- **Alpen HPP**
  - Small, “Boutique” manufacturer, 30+ years, High Performance Markets
  - History: R10 windows with fiberglass frame and heat mirror film
  - Active engagement w/ senior management
  - Currently supplying prototypes for pilot projects
  - Aggressively pursuing thin triple window product designs
    - Double spacer design
    - Fabricating larger size IGUs

- **Andersen Corporation**
  - “Largest” U.S. manufacturer; National markets, 100+ years
  - History: Early adopter of low-E, Energy Star leader
  - Active engagement with R&D/Retrofit window team
  - Fabricating windows for initial LBNL testing
  - Scaling/Manufacturing issues being explored

Industry Attention

DWM 11/2018

Building Green 2/4/2019

BuildingGreen

PRODUCT REVIEW

Thin Glass to Change High-Performance Window Market

Alpen is rolling out triple-pane products that are thinner and lighter—and will eventually be cheaper.

by Peter Yost

February 4, 2019

The good news about window performance is that the market has been transformed by the building industry moving to dual-pane, low-e, argon-filled glazing with performance around R-4, according to Lawrence Berkeley National Laboratory (LBNL). See Figure 1 in the slideshow.

The bad news is that since around 1990, the performance of the vast majority of our windows has not really changed much. See Figure 2 for a current breakdown of the market based on performance of windows rated by the National Fenestration Rating Council (NFRC).

Yes, we now have triple-pane glazing in the R-6 and beyond range, but these windows are quite heavy, expensive, and not really embraced by the U.S. market.

Enter thin glass triple glazing (TGT) technology. In Figure 3, you can see the key ways TGT is a breakthrough:

1. The "thin"—1 mm—glass is inserted in the middle of a standard dual-pane insulated glazing unit.
2. Krypton gas replaces argon in the now half-as-wide spacing of the three glass panes.

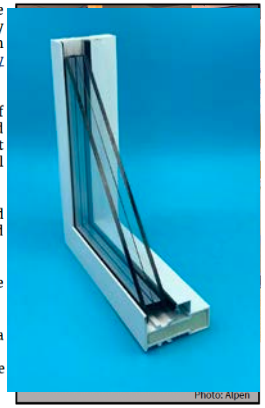


Photo: Alpen

Energy & Environmental News

NET-ZERO

Glass From Flat-Panel TVs Makes Zero-Energy Homes More Feasible

Taken from flat-panel televisions, thinner glass makes triple-pane IG more economically feasible, researchers say.

Even with the latest windows producing U-factor ratings of as low as 0.11 (roughly equivalent to R-9), windows have quite a way to go before they catch up to solid walls in insulating performance. Meanwhile, a price check on the best windows shows that current costs are prohibitive enough to deter the average homeowner. But a recent report by Rocky Mountain Institute (RMI), an independent, nonprofit organization, suggests that glass borrowed from the flat-panel televisions market is about to upend the costs for triple-pane glass, making it feasible for everyday windows while also making net-zero homes more attainable. The idea corroborates with info gained by Door and Window Market (DWM) magazine from researchers at Lawrence Berkley National Laboratories (LBNL).

RMI's report, "The Economics of Zero-Energy Homes: Single Family Insights," by Iacob Corvidae, Michael Gartman and Alisa Petersen, suggests that, these days, builders can utilize upgrades to building envelopes for residential homes in order achieve net-zero energy performance, to the tune of a 6-8 percent increase in costs—a far cry from the nearly 20 to 30 percent increases previously cited by some experts.

"It's now clear that zero-energy-ready homes make sense economically today, even as they provide multiple benefits over standard construction," says Corvidae, RMI's principal and coauthor of the report. And for this reason, he suggests that zero-energy homes may become the norm sooner than later. "Building anything else today runs a risk of creating homes that will be seen as out of date in only five years," Corvidae suggests.

In addition to more efficient HVAC, lighting and insulation, RMI's prescription for cost-feasible, net-zero performance includes the use of triple-pane windows, which researchers say they've found to be more economically feasible these days, thanks to what they say is an approximately 80-percent price drop in some of the glass that's used to produce such products. Those decreases, they say, stem from a crossover from the glass used in flat-panel televisions to the inner-lite of triple-pane windows, dropping their price to as little as $360. According to DWM's research, that number is on par with the cost of even a middle-of-the-road, double-pane window from just two years ago, when it cost around $236 to upgrade to R-9 performance (the best available at the time). That's also a number that may decrease going forward, according to researchers at LBNL (*see article with full details on page 20*), who say they're closing in on a more than 20-year project, aimed at developing super-efficient, cost-effective, triple-pane windows.

"Twenty years ago we couldn't find any companies that could make thin glass sheets in volume," says LBNL researcher Charlie Curcija. "Now the flat screen TV industry has pushed the glass industry to create precisely the glass we need for windows, and at a price the window market can afford."

CMS Proves 100 Percent Landfill Free Attainable

CMS Window Systems recently set a high mark for door and window manufacturers, by reaching its goal for becoming 100 percent "landfill free"—eliminating any and all waste previously sent to landfills. Officials for the U.K.-based manufacturer say they reached that goal by using a special waste system that separates leftover doors and windows (removed and broken down) into seven different waste streams, including: plastic, mixed metals, timber and glass. Materials are then sent away for reprocessing.

"Hitting our zero landfill target is a tremendous achievement which reflects the focus and effort of everyone in the CMS team to re-use and recycle," says David Ritchie, the company's CEO.

"It's a vitally important milestone in being one of the most sustainable fenestration partners in the U.K. market and is coupled with our strategy to minimize resource use by designing out waste at project inception. Waste is also minimized during manufacture and installation and our range of windows and doors are designed to help our end-customers cut their own energy consumption."

Collaboration Around Aggressive Market Acceleration Programs

- Window Manufacturers – Training, Promotion
- Education and Training – Architects, Engineers
- Voluntary Programs – ENERGY STAR
- Builders, Renovators, Developers
- **Utility Rebates and Incentives**
  - **Midstream, Upstream?**
- **Pilot Programs, Field Demonstration, Test Houses**
- **Codes and Standards**

Energy Trust of Oregon – Window Rebates

Windows

$1.75–$4.00/sq. ft. cash incentive

Windows play a large part in regulating energy use and costs. ENERGY STAR® c windows reduce condensation, decrease drafts and air leaks, and can increase y curb appeal. Installing new, tight-fitting windows also helps seal your home agai intrusion or escape.

Steps | Details | Resources

Equipment	Incentive	Requirements
Windows	$1.75 per square foot	U-Value 0.28-0.30
Windows	$4.00 per square foot	U-Value 0.27 or less

Table 1: Percent of Sales by Efficiency Tier

U-Value Tier	Relative Market Share
> 0.35	2.78%
.33 to .35	26.25%
.31 to .32	15.05%
.29 to .30	45.87%
.26 to .28	7.91%
.25 or lower	2.15%
Total	**100.00%**

California T24 Code, 2019 U: .32 -> .30 High Efficiency Window Tradeoffs

Measure	EDR Contribution	43.5	18.9
HPA	4.2		
HPW	1.7	3000 sf Deficit If Measure Removed	
QII	2.0		
QII+Entire HPA&HPW	7.9		
4-Orientation Impact	2.5		
Windows - 2019 Over 2016	0.6		
HP Windows-0.23U&0.20 SHGC 0.23	1.6	300 sf Compliance Credit If Measure Installed	
HP Windows-0.21U&0.21 SHGC 0.21	1.8		
HP Windows-0.20U&SHGC	2.2		
R38 Below Deck Insulation	0.9		
94 Furnace	1.2		
13 EER	0.8		
0.94 Water Heater	0.7		
94 Furnace+13EER+0.94 WH	2.7		
Battery Storage Credit	3.2		

EDRs: Energy Design Ratings

Example: Delete "High Performance Walls";
-1.7 EDR

Add "High Efficiency Windows"
+1.8, +2.2 EDR

Canadian Window Code Changes are Coming…

Fenestration Canada Annual General Meeting, June 2017

Aspirational goals for residential windows

- By 2020, residential windows for sale in Canada meet an average U-factor of 1.6 (ER 25) **U= .28**
- By 2025, **U= .21**
  - All residential windows for sale in Canada meet a U-factor of 1.2 (ER 34)
  - Residential windows with a U-factor of 0.8 can be manufactured and installed cost effectively.
- By 2030, all residential windows for sale in Canada meet a U-factor of 0.8 (~ ER 40) **U= .14**

Our Role – Next Steps

- **Window Industry**
  - Work with manufacturers to refine technology
  - Introduce cost effective options to market
- **Supply Chain**
  - Automated assembly -> lower cost
- **Objective Estimates of Savings, Paybacks**
  - + Comfort, HVAC sizing, etc
- **Pilots, Field tests to Validate Performance**
  - California
  - Oregon/Washington
  - National
- **Promote Rebates, Incentives**
- **Enhanced Codes/Standard**

Your Role – Next Steps

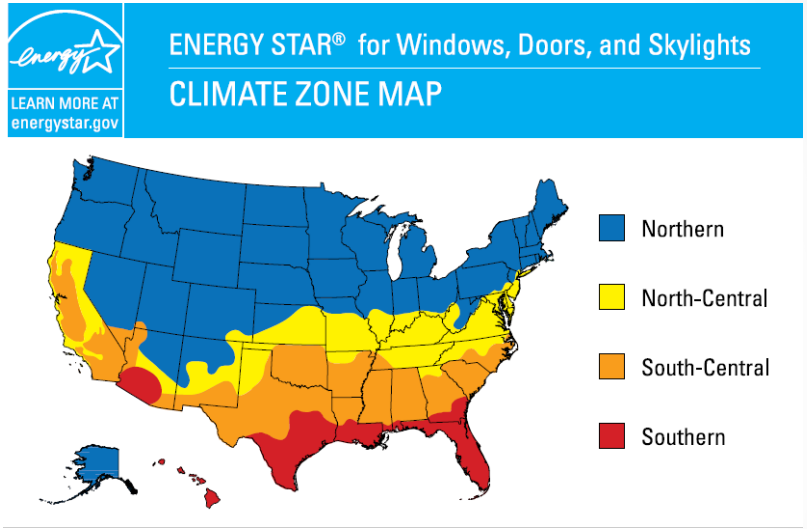
- **Window Industry messaging:**
  - Signal to manufacturers that you want more high performance options
- **Sell clients** on the full range of performance advantages of better windows
- **Engage with Pilots, Field tests** to Validate Performance
  - Check with NEEA, ETO, BPA, etc
- **Take Advantage of Rebates, Incentives**

- **Provide Feedback to Us**
- **Collaborate in our Projects**

Part IV: Window-Related Energy Ratings and Efficiency Program Opportunities

Christopher Dymond, NEEA

Window Ratings and Labels (NFRC, Energy Star)



ENERGY STAR Most Efficient 2019
www.energystar.gov

- Energy Star's "Most Efficient" label includes triple-panes in northern climate zones
- Limited market uptake of "Most Efficient" label

NW Window Replacement Utility Incentives

BPA Utility:

- **Residential** replacing aluminum or single pane windows with 0.22 U-factor or better
  - Incentives depend on depend on HVAC system.
- **Residential (low-income qualifying)** - replace single pane or double pane metal frame as part of Weatherization Specification
  - Incentives tbd

Energy Trust of Oregon

- $1.75/s.f. (U-Factor .28-.30)
- $4.00/s.f. (U-factor .27 or less)
- Low-Market Uptake

Attachment Energy Rating Council (AERC)

The window Attachment Energy Rating Council (AERC) is an independent, **public interest** organization whose mission is to provide consumers with **credible, relevant, and comparable** information about **window attachments** and their **performance.**

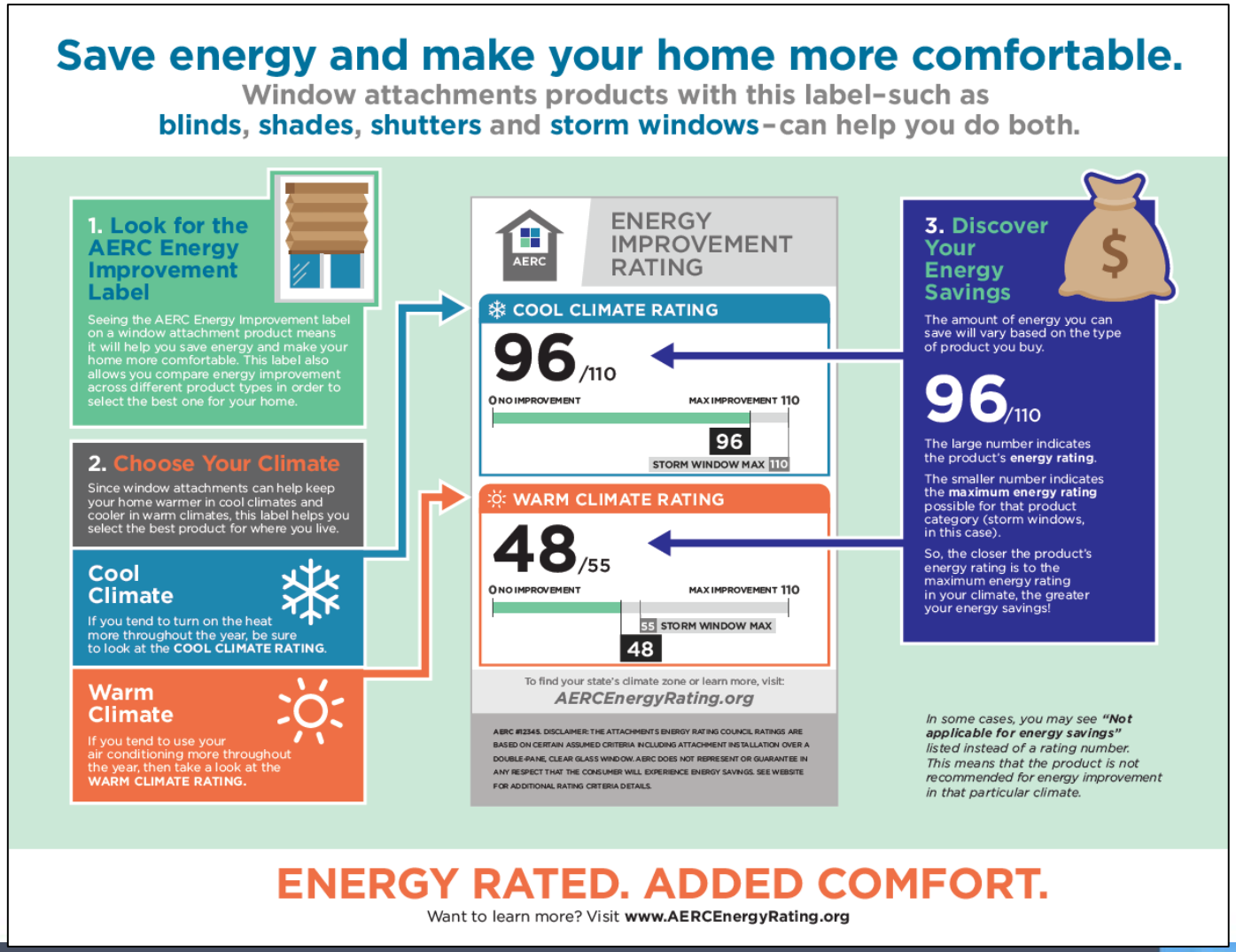
- AERC members include
  - Public Interest Groups
  - National Labs
  - Commercial Labs
  - Product Manufacturers
  - Component Manufacturers
  - Utilities

Why is AERC Necessary?

- Window attachments can **save energy**
  - However, many consumers are unaware of their energy-saving capability
- Consumers have no way to **compare the energy performance** of attachments
- Energy Efficiency program managers also benefit from ratings and energy performance information

The AERC rating allows consumers to make more informed decisions.

AERC Energy Improvement Rating



Low-E Storm Windows now Energy Star Certified

ENERGY STAR

AERC Rating

Status of Low-e Storm (LES) Window Program in the Northwest

- RTF Approved Measure
- Utilities with Low-e Storm Programs – Requiring Qualified Home Performance Contractors
  - Chelan PUD – little uptake
  - Snohomish PUD – little uptake
  - Cowlitz PUD - pilot in 2017-2018, no home performance contractors interest
- Expressed Interest
  - City of Richland, Franklin PUD, Benton PUD, and Idaho Power. Clark County

Retail Pilot Programs – Good Response

Pilot (year)	Overall storm window sales increase	Low-E sales increase	Low-E market share
Efficiency Vermont	37%	337%	2014 – 22% 2015 – 70%
focus on energy Partnering with Wisconsin utilities	9.6%	125%	2016 – 30% 2017 – 62%

Thank you!

Any Questions?

Extra Slides

Installation Methods: Exterior Storm Windows