Better Buildings®
U.S. DEPARTMENT OF ENERGY

Better Buildings Residential Network
Peer Exchange Call Series

The Latest on Zero Energy Windows, Thin Triples, and Advanced Window Technologies

May 9, 2024

U.S. DEPARTMENT OF ENERGY

Agenda and Ground Rules

- Moderator
  - **Jonathan Cohen,** Better Buildings Residential Network, U.S. DOE Residential Buildings Integration Program (RBI)
- Agenda Review and Ground Rules
- Residential Network Overview and Upcoming Call Schedule
- Opening Poll
- Featured Speakers
  - **Katie Cort,** Pacific Northwest National Laboratory (PNNL)
  - **Ray Garries,** Global Fenestration Advisors
  - **Isaac Smith**, Center for Energy and Environment (CEE)
- Open Discussion
- Closing Poll and Announcements

Ground Rules:

1. **Sales of services and commercial messages are not appropriate** during Peer Exchange Calls.
2. Calls are a safe place for discussion; **please do not attribute information to individuals** on the call.

The views expressed by speakers are their own, and do not reflect those of the Dept. of Energy.

Join the Network

Member Benefits:

- Recognition in media, social media and publications
- Speaking opportunities
- Updates on latest trends
- Voluntary member initiatives
- One-on-One brainstorming conversations

Commitment:

- Members only need to provide *one number*: their organization's number of residential energy upgrades per year, or equivalent.

Upcoming Calls (2nd & 4th Thursdays):

- *5/23: Decarbonizing Low Income Homes – The DOE Affordable Home Energy Shot*
- *6/13: DOE's New National Blueprint for the Buildings Sector – What it Means for the Residential Sector*

Peer Exchange Call summaries are posted on the Better Buildings website a few weeks after the call

Katie Cort

PNNL

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Why Windows Matter

Katie Cort, PNNL

Pacific Northwest
NATIONAL LABORATORY
Proudly Operated by Battelle Since 1965

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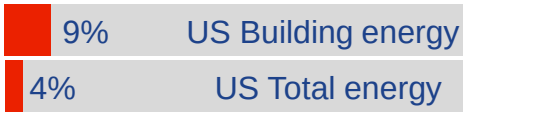
Window's Annual Impact on Energy and Environment

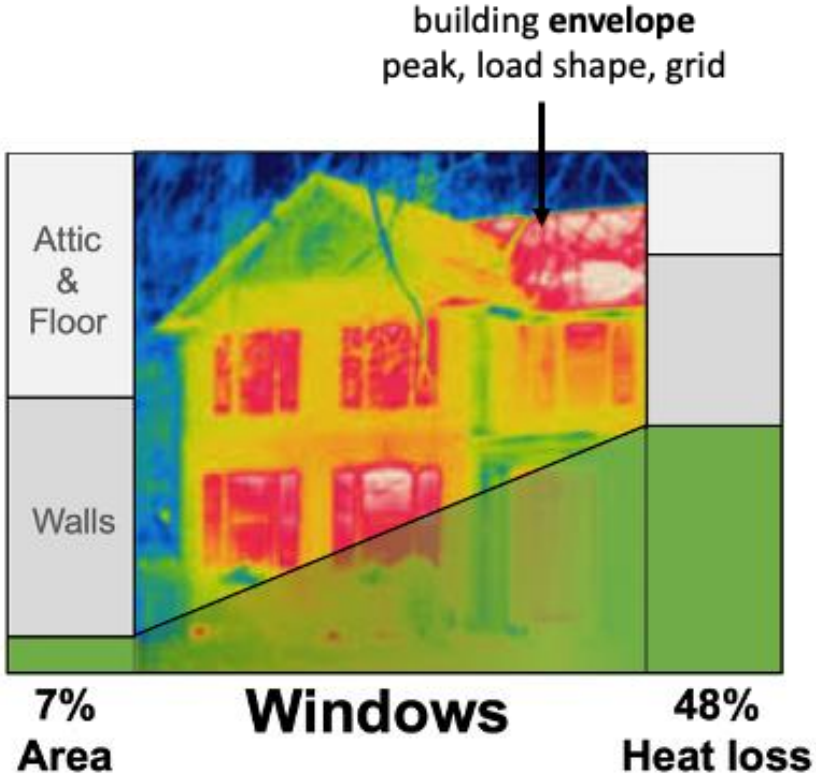
$45 Billion

3.5 Quads

160 Mt CO2



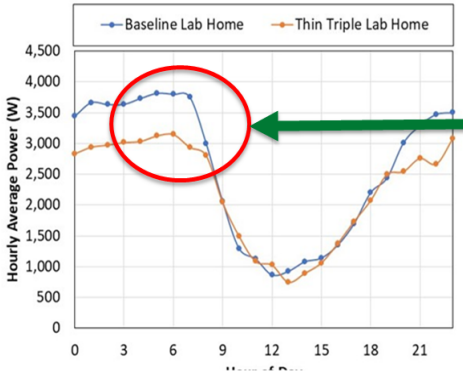
Based on Berkeley Lab Window heat transfer analysis for IECC 2021 prototype building.



Why Advanced Window Solutions are Needed

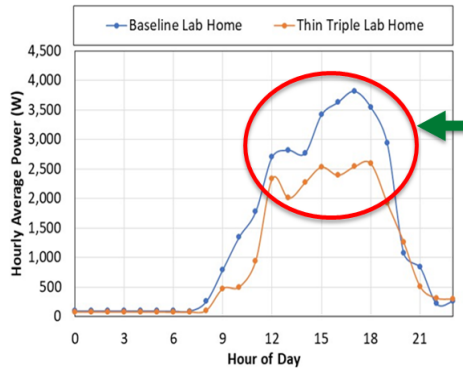
To meet carbon reduction goals, we need to improve window performance for new and existing buildings. Better window performance helps achieve. . .

- Energy Savings/Carbon Reductions
- Peak Load Reductions
- HVAC Electrification
- Energy Equity and Resilience Goals



Winter Avg Peak Electrical Load Reduction: **17%** (650 Watts)

Reduced early morning heating needs (*when heat pumps require auxiliary heat*)



Summer Avg Peak Elect. Load Reduction: **33%** (1200 Watts)

Reduced afternoon and early evening cooling load (*coincident with transmission system peak demand*)

Thin Triples versus Double-Pane Clear: PNNL Lab Home Study (Hunt et al. 2021)

Current Residential Window Performance Standards & Ratings

IECC INTERNATIONAL ENERGY CONSERVATION CODE

Climate Zone	2006		2009		2012		2015		2018		2021	
	U-factor	SHGC	U-factor	SHGC	U-factor	SHGC	U-factor	SHGC	U-factor	SHGC	U-factor	SHGC
1	1.20	0.40	1.20	**0.30**	**NR**	**0.25**	NR	0.25	NR	0.25	NR	0.25
2	0.75	0.40	**0.65**	**0.30**	**0.40**	**0.25**	0.40	0.25	0.40	0.25	0.40	0.25
3	0.65	0.40	**0.50**	**0.30**	**0.35**	**0.25**	0.35	0.25	**0.32**	0.25	**0.30**	0.25
4 except Marine	0.40	NR	**0.35**	NR	**0.32**	**0.40**	0.32	0.40	0.32	0.40	**0.30**	0.40
5 and Marine 4	0.35	NR	0.35	NR	**0.32**	NR	0.32	NR	**0.30**	NR	0.30	0.40
6	0.35	NR	0.35	NR	**0.32**	NR	0.32	NR	**0.30**	NR	0.30	NR
7 & 8	0.35	NR	0.35	NR	**0.32**	NR	0.32	NR	**0.30**	NR	0.30	NR

ENERGY STAR

Climate Zone	V5 - 2009		V6 - 2015		V7- 2023	
	U-factor	SHGC	U-factor	SHGC	U-factor	SHGC
South	≤0.60	≤0.27	**≤0.40**	**≤0.25**	**≤0.32**	**≤0.23**
South-Central	≤0.35	≤0.30	**≤0.30**	**≤0.25**	**≤0.28**	**≤0.23**
North-Central	≤0.32	≤0.40	**≤0.30**	≤0.40	**≤0.24**	≤0.40
North*	≤0.30	NR	**≤0.27**	NR	**≤0.22**	**≥0.17**

*See ENERGY STAR specifications for North trade-offs

ENERGY STAR Most Efficient 2022 www.energystar.gov

U-factor ≤0.20

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Impact of Window Measures on HP Sizing

Retrofit Scenario

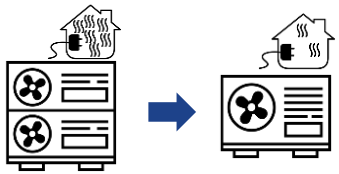
Philadelphia, PA

2,500 ft² single-family detached 2-story

Baseline: Double-clear Wood Frame

Retrofit: ENERGY STAR v7

Cooling-based Sizing



	Baseline	Window Retrofit
HP size	4.6 Ton	2.7 Ton
Backup Heating	13,519 W (70 Amps)	10,275 W (60 Amps)

Annual Energy Savings (kWh): 3,116

Annual Utility Bill Savings ($): 309

Based on Berkeley Lab Decarbonization Modeling and Analysis (2024)

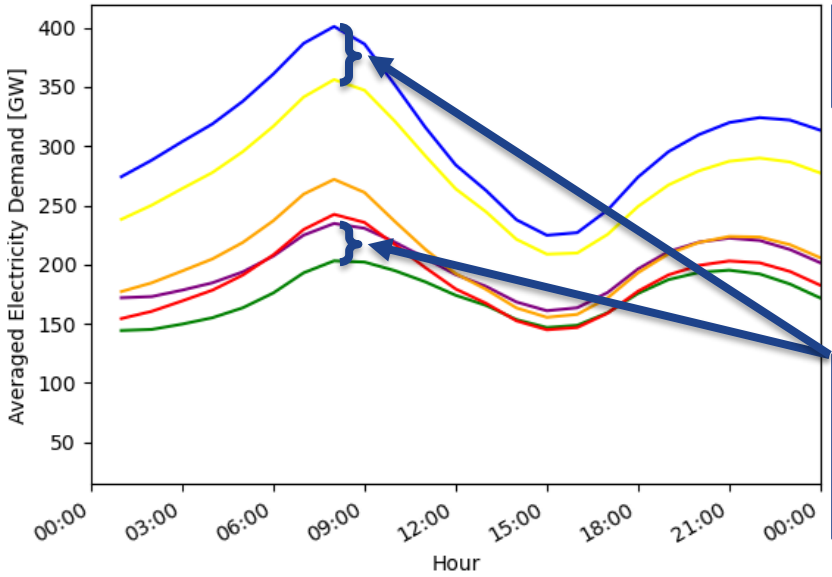
Impact of Window Measures on HP Sizing

Location	Climate Zone	Windows	HP Size	Backup Heating Required (Breaker size)	Annual Energy Savings (kWh)	Annual Utility Bill Savings
Jackson, WY	7	Double clear, wood frame	4.3 ton	13,670 W (70 A)		
		Code minimum	3.7 ton	12,280 W (70 A)	2,590	$282
		ENERGY STAR v7	2.5 ton	9,970 W (50 A)	3,420	$373
		Low-E storm	2.8 ton	9,910 W (50 A)	3,010	$328
Phoenix, AZ	2B	Single clear, aluminum frame	4.7 ton	5,410 W (30 A)		
		Code minimum	3.9 ton	5,040 W (30 A)	1,040	$150
		ENERGY STAR v7	3.2 ton	4,155 W (20 A)	1,620	$233
		Low-E storm	3.3 ton	3,740 W (20 A)	1,190	$171

Based on Berkeley Lab Decarbonization Modeling and Analysis (2024)

Impact of Window Measures on Grid Peak Load

- On the 2018 nationwide peak winter day, triple pane windows reduce consumption by 40-50 GW
- High-R Windows produce greatest savings during peak hours.



Max sized heat pumps show larger savings than ACCA sized

ACCA HP only

ACCA HP + Triple Pane

Max HP only

Baseline

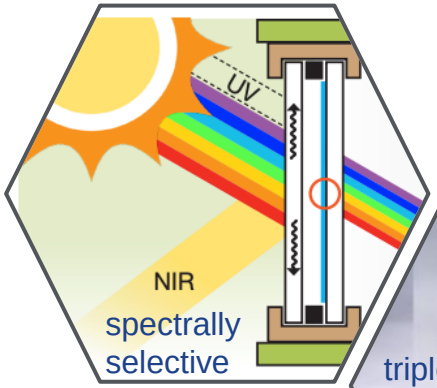
Max HP + Triple Pane

Triple Pane only

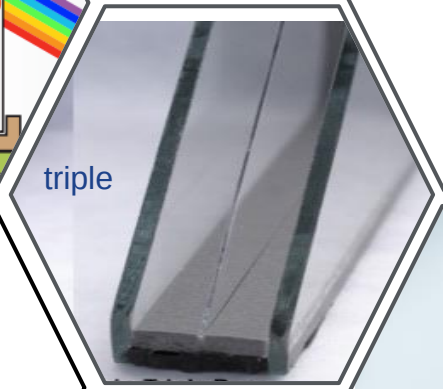
Triple pane windows responsible for 40–50 GW of demand reduction on peak winter day from 7–8 am

Based on Berkeley Lab Decarbonization Modeling and Analysis (2024)

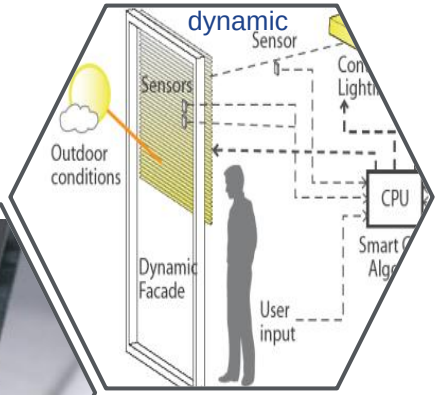
Latest Advancements in Window Technologies



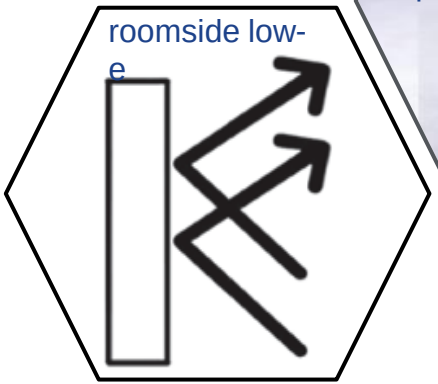
spectrally selective



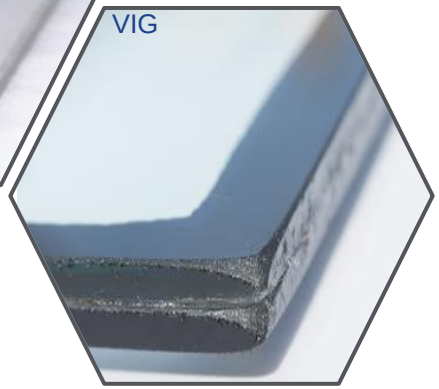
triple



dynamic



roomside low-e



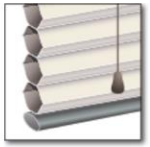
VIG

Aerogels

Window Attachment Options

Interior

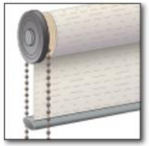

☐ Applied film


☐ Cellular shade


☐ Drape/Curtain


☐ Interior louvered shutter


☐ Interior panel


☐ Interior roller shade


☐ Interior solar screen


☐ Louvered blind


☐ Pleated shade

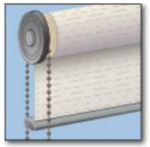

☐ Roman shade


☐ Sheer shade


☐ Window quilt

Exterior


☐ Exterior louvered shutter


☐ Exterior roller shade


☐ Exterior solar screen


☐ Exterior storm


☐ Fixed awning


☐ Retractable awning


☐ Roller shutter

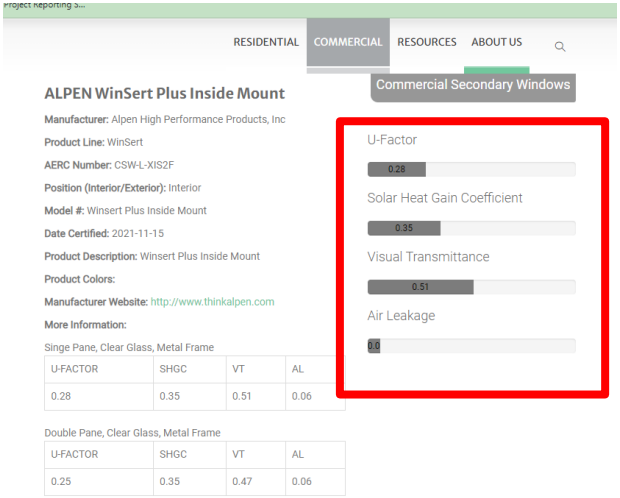
efficientwindowcoverings.org

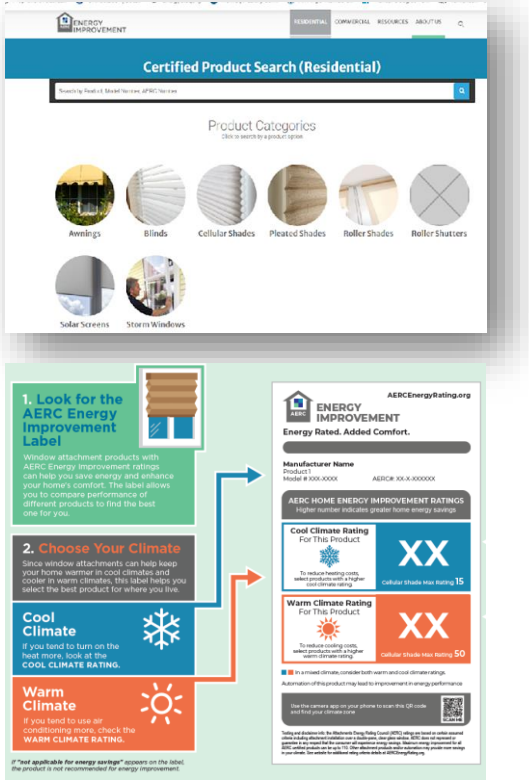
Attachments Energy Rating Council (AERC) Certified Product Database

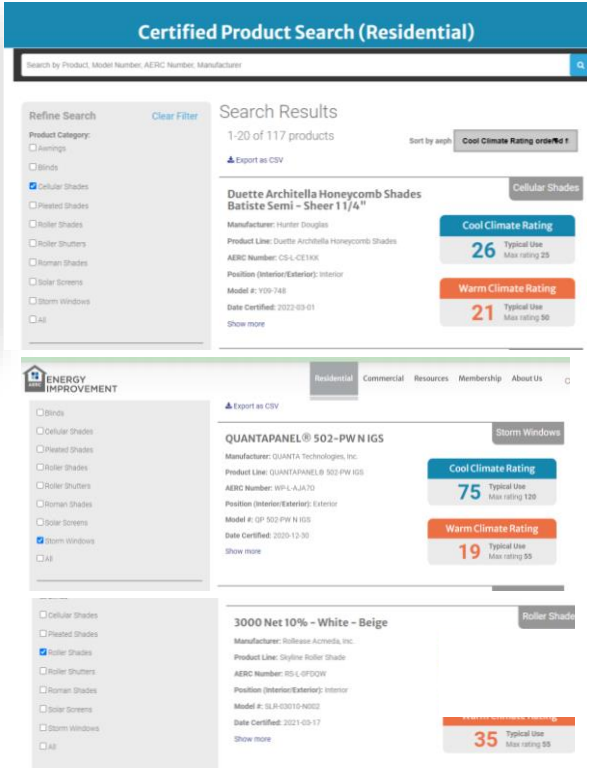
AERC
Attachments Energy Rating Council

AERC ENERGY IMPROVEMENT

https://aercenergyrating.org/







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Windows Field Validation Studies and Analyses

Katie Cort, PNNL

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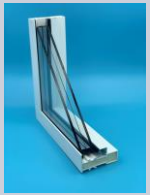
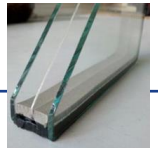
Window and Window Attachments Energy Savings Ranges

Technology	Application	Energy Savings Potential		References
High-R (triple pane) Window Replacements	New and existing homes	7–16% (total energy savings)		• Hart, R et. al. 2019 "Thermal performance and potential annual energy impact of retrofit thin-glass triple-pane glazing in US residential buildings." *building Simulation 12: 79-86* • *Hunt et. al, 2021.* "Evaluation of Thin Triple-Pane Windows in the PNNL Lab Homes. PNNL-31165
Low-e Storm Windows (insulating panels)	Existing homes	10–30% (annual HVAC savings)		• Culp, T. et al. 2015. *Energy Savings of Low-e Storm Windows and Panels across US Climate Zones.* • Knox and Widder. 2014. *Evaluation of Low-e Storm Windows in the PNNL Lab Homes.* PNNL.
Insulating Cellular Shades	New and existing homes	5–25% (heating and cooling HVAC savings)		• Metzger, C et al.. 2017. *Modeling Cellular Shades in Energy Plus.* PNNL. • (Cort, KA et. al) 2018. *Testing the Performance and Dynamic Control of Cellular Shades.* PNNL.
Exterior Shades	South- and west-facing windows	10–20% (cooling HVAC savings)		• Hunt and Cort 2020. *Evaluation of Exterior Shades at PNNL Lab Homes and Occupied Field Sites.* PNNL.

PNNL Led Field Testing of Thin Triples



Existing Manufactured Homes, Pasco, WA: Thin triple IGU-only replacement dropped into existing vinyl frames

Existing SF home, Helena, MT: Thin triple IGU, fiberglass frame

New 2-story home, Minneapolis, MN: Thin triple IGU vinyl frames

New SF home, Kalamazoo, MI: Thin triple IGU, fiberglass frames

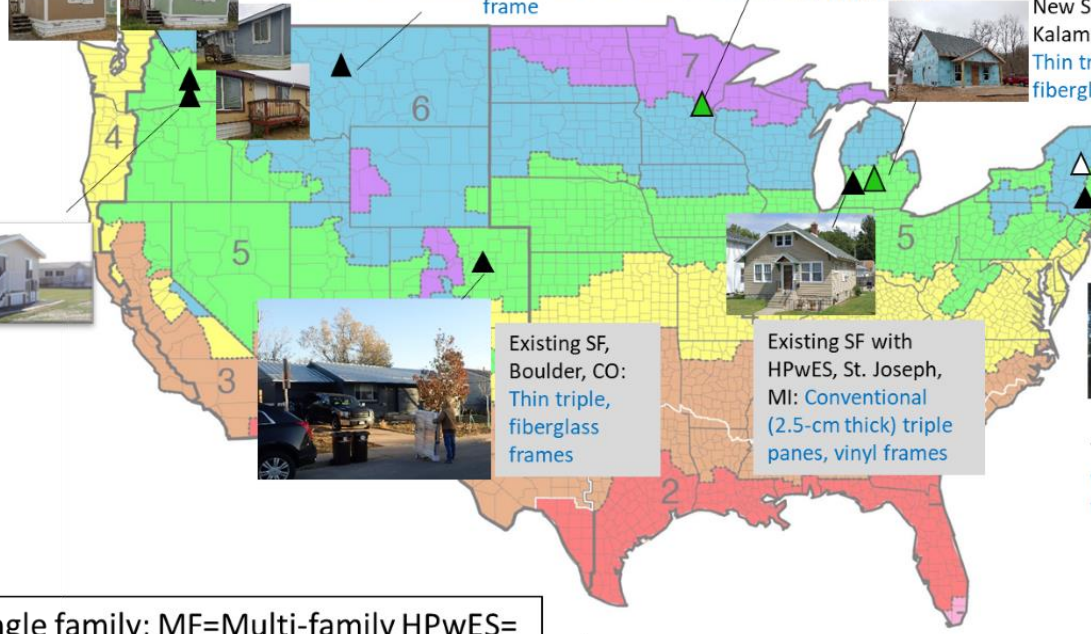
New Multi-family, Rotterdam, NY: Thin triple IGU in 4 units, vinyl frames

PNNL Lab Homes (existing manufactured homes), Richland, WA, Thin triple IGU, fiberglass frame

Existing SF, Boulder, CO: Thin triple, fiberglass frames

Existing SF with HPwES, St. Joseph, MI: Conventional (2.5-cm thick) triple panes, vinyl frames

Existing SF home, Yonkers, NY: Thin triple IGU, vinyl frames

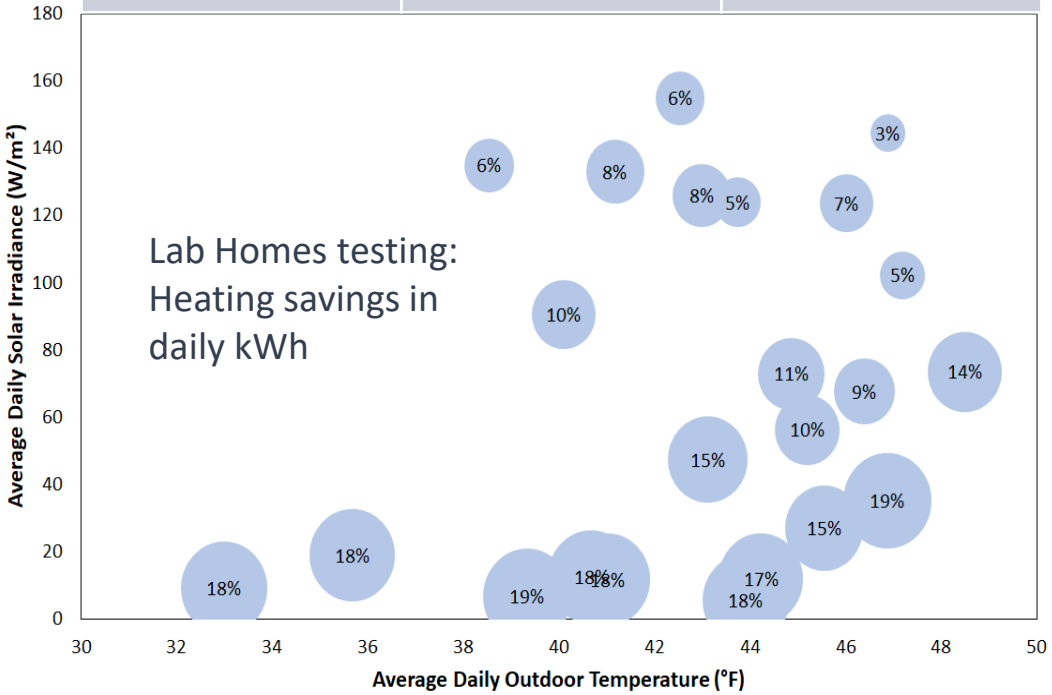


SF=single family; MF=Multi-family HPwES= Home Performance with ENERGY STAR

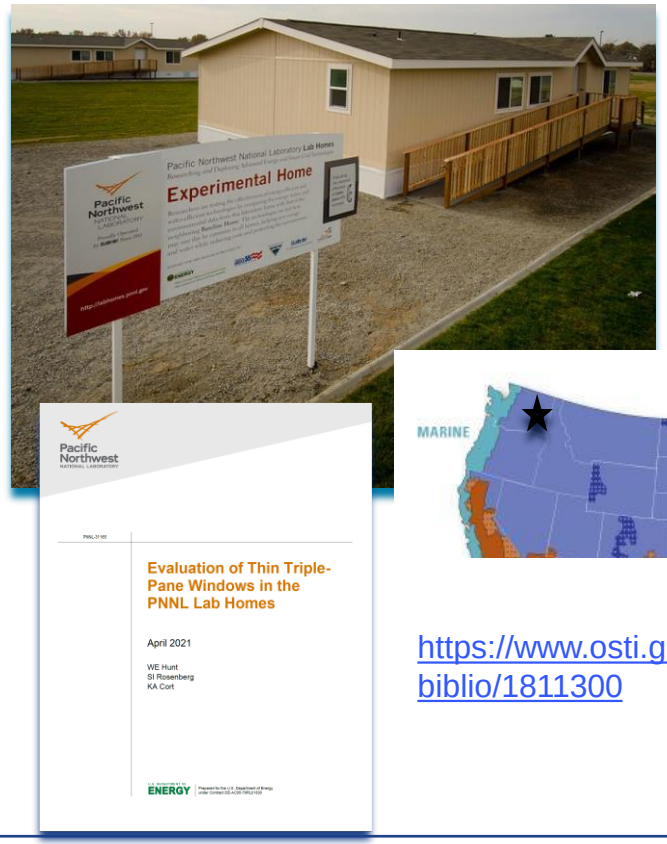
Key: New home △ Existing home ▲ Multi-family (new) △

Field Validation: Lab Homes Testing

Heating Savings	Cooling Savings	Annual Savings
12% (7.8 kWh)	28% (5.5 kWh)	19% (7.4kWh)

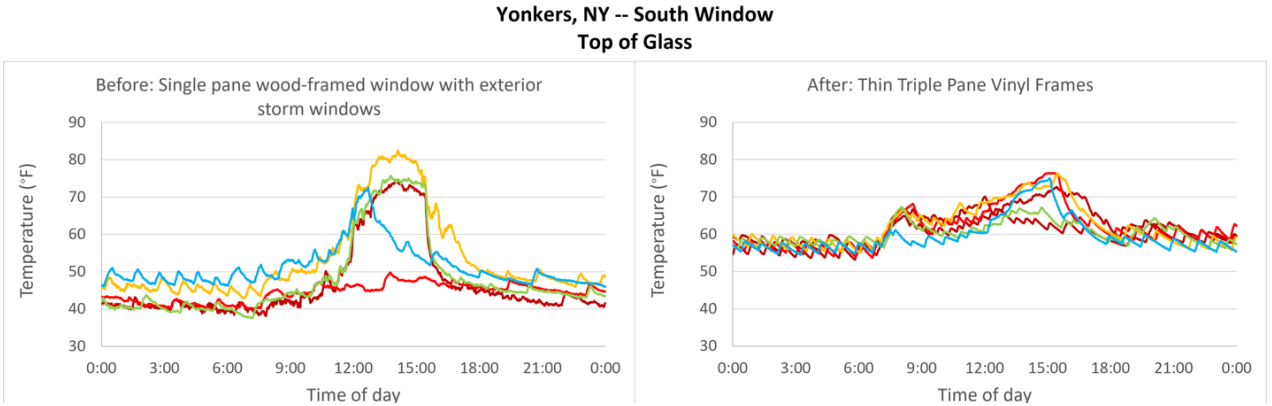


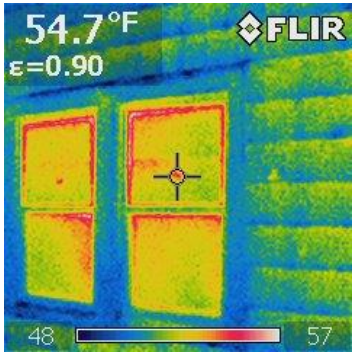
Thin Triples versus Double-Pane Clear



https://www.osti.gov/biblio/1811300

Field Validation: Occupied Field Sites





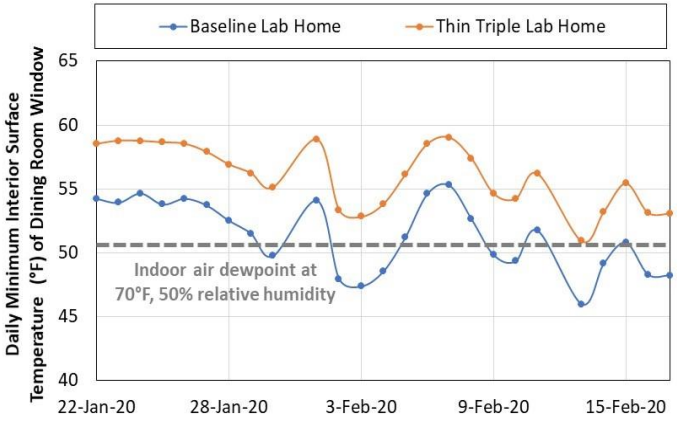
Single-Family Retrofit Home, Yonkers, NY

Site	Utility Energy Savings	HVAC Equip Run-time Savings	Infiltration Improvement, ACH50 Before/After	Infiltration Improvement, ACH50 % Improvement	U-factor^o Ref / Test [Btu/hr/ft^2/°F / (W/m^2/K)]	U-factor^o % Improvement Ref / Test
Yonkers NY	4.9%	20.0%	10.23 / 8.11	20.8%	0.86 (4.9) / 0.2 (1.1)	77%

Thin Triples: Thermal Comfort, Sound, and Condensation Benefits

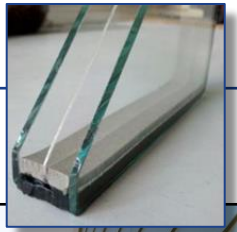
Co-Benefits Validated in the Field:

- **Improved sound insulation**: Thin triple-pane windows reduced sound infiltration by ~10 dB relative to baseline double-pane windows
- **Reduced condensation potential** on interior window surface



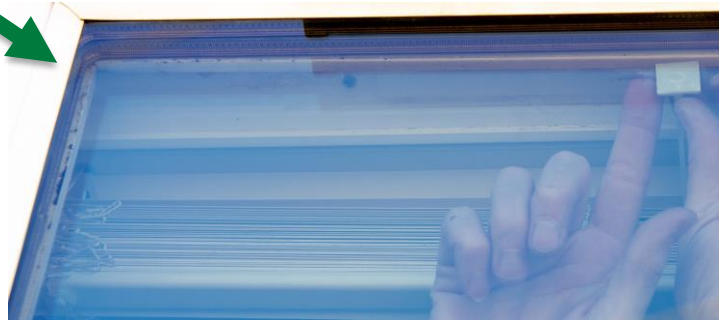
Condensation and ice buildup on interior surface of Helena, MT home field site (double-pane code window).

Cost-Effective Application: Glazing/IGU-only replacement

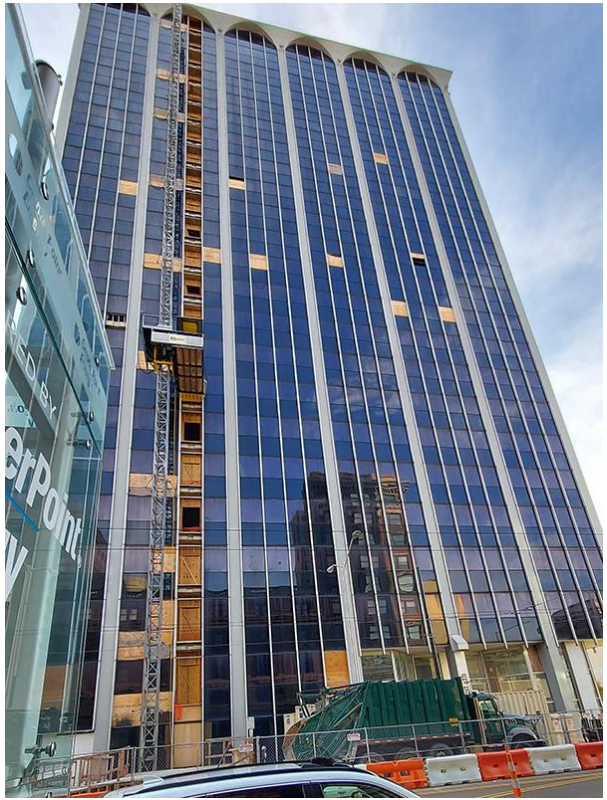


Thin Triple IGU

- 4 manufactured homes retrofit with thin triple-pane IGUs (28 windows) made by regional glass manufacturer
- Thin triple IGUs inserted into double-pane frames (low-income mobile home park in Pasco, WA)
- IGU width ranged from 3/4-inch to ~1-inch
- Made with combination of thin glass (~1.6 mm) and spacers at manufacturing plant
- COG U-factor of 0.12, which results in window U-assembly ~.20



Vacuum Insulated Glass (VIG) – 2024 Office-to-Multifamily/Mixed Use Retrofit



VIG systems made with 2 monolithic lites of flat glass, separated by pillars, and edge sealed with air vacuumed out through a pump-out port.

- 22-story historic office building in Dayton, Ohio, built in 1968 with single-glazing
- Previous owner left building due to high cost of running it
- New owner replacing single monolithic glass windows with VIG systems that maintains the look of the historic annealed monolithic glass
- Converting building to mixed use, including multifamily

https://www.glassmagazine.com/article/next-step-vig-planning-growth

DOE Storm Window (secondary window panel) Field Studies

2012-2013 **Philadelphia Multi-Family** field study (DOE, NAHB, QuantaPanel)

- 2 large 3-story buildings (101 apartments)
- Replaced old clear storm windows over single pane with new low-e storms
- 20% heating and 9% cooling energy use reduction
- Apartment air leakage reduced by 10%

2003-2006 **Chicago** field study (DOE, HUD, LBNL)

- 6 **weatherization homes** with single-pane windows
- Reduced heating load by 21%
- Payback of 4.5 years
- Home air leakage reduced by 6-8% (15 cfm_{50} reduction per window)

2011-2013 **Atlanta** field study (DOE, Larson, QuantaPanel)

- 10 **older single-family homes** with single-pane windows
- ~15% heating savings, 2-30% cooling savings
- Home air leakage reduced by 17% (3.7 cfm_{50})

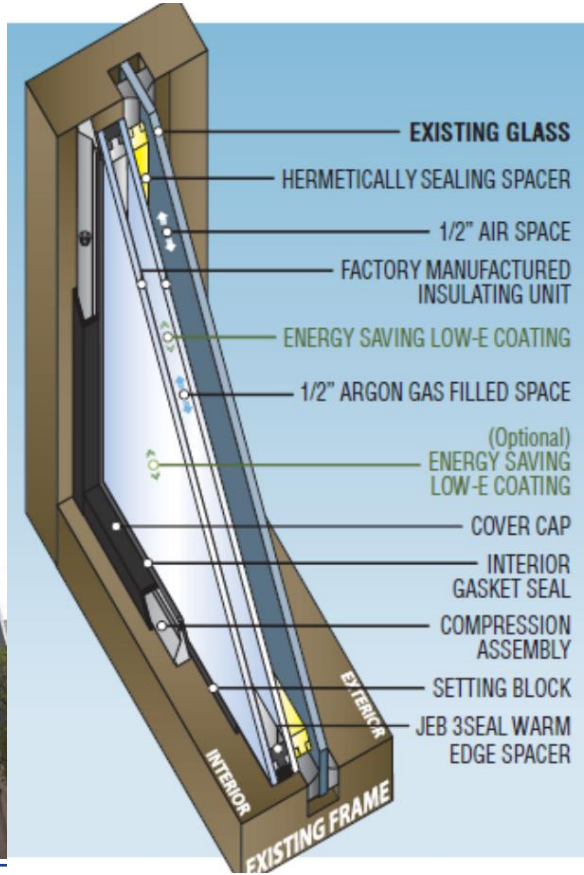
2014-2015 Lab Home field test of interior and exterior panels on PNNL **Richland, WA** campus (DOE, PNNL, NEEA, BPA, Larson, QuantaPanel)

- **Manufactured homes** with metal-framed double-pane clear glass windows
- 11% heating and 8% cooling energy use reduction with application of low-e panels

Low-E Double Pane Interior Secondary Window

A 12-story, 200,000-square-foot office building in Philadelphia, PA built in 1972 with single-pane windows was retrofitted with a double pane secondary window insert that has low-e coatings.

The whole building experienced 25 percent building heating and cooling energy savings, and the perimeter offices of the building saw an even more drastic improvement of 35-60 percent.



U.S. Department of Energy, Performance Comparison of a Low-e Retrofit Window in a Philadelphia Office Building, 2013. http://www.rbbwindow.com/wpcontent/uploads/DOE_Performance_Comparison_400_Market_St_10_23_2013-Final.pdf

Energy Savings Potential – Cellular Shades

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

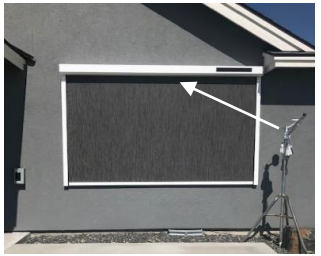
Thermal Performance of Cellular Shades: compared to the most common window coverings (horizontal slatted blinds)

Lab Homes 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
HD Green Schedule: Cellular Shades versus Vinyl Venetian Blinds	Cooling	10.4 (±6.5)	NA
	Heating	16.6 (±5.3)	NA

Field Testing Exterior Shades

10-20% cooling savings when applied to south and west-facing windows (compared with home with interior blinds [10%] and no shades [20%] on same windows)

View through window when fully deployed



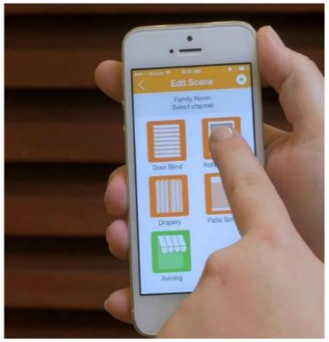
Solar-powered motorization

Glare with shade up

Light with Shade down

Powered with exterior outlet installed near window

Boost Energy Savings with Automation



High Efficiency Shades

+

Automation

→

Improve energy savings

(14% heating; 15% cooling)

Smart Home Energy Management Systems

ENERGY STAR

Automation Rating

AERC

Thanks!

katherine.cort@pnnl.gov

Proudly Operated by **Battelle** *Since 1965*

U.S. DEPARTMENT OF ENERGY

Ray Garries

Global Fenestration Advisors

INNOVATIONS IN WINDOW PERFORMANCE

THE LATEST WINDOW AND DOOR TECHNOLOGY

FOR BETTER BUILDINGS

AGENDA

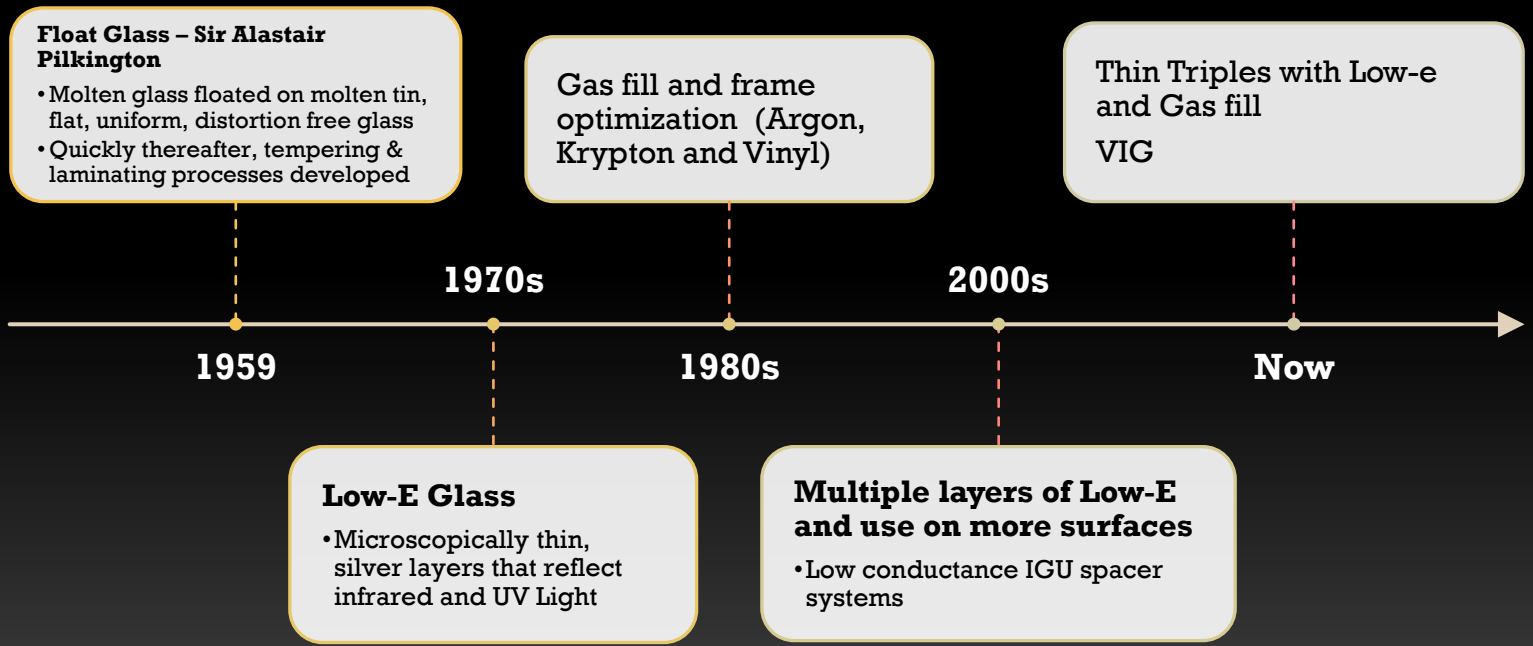
- Fenestration is the right place to start retrofit programs
- Glass Technology Overview
- Thin Triples – Overview/History
- Thin Triples Featuring Corning ATG
- Thermal Values/Benefits
- Thin Laminates Featuring Corning ATG

WHY START WITH HIGH PERFORMANCE FENESTRATION IN RETROFIT?

- **According to the U.S. Department of Energy, approximately 25%–30% of a home's heating and cooling energy is lost through its windows. This significant energy loss occurs due to heat transfer between the interior and exterior of the house.**

Glass Technology

GLASS TECHNOLOGY



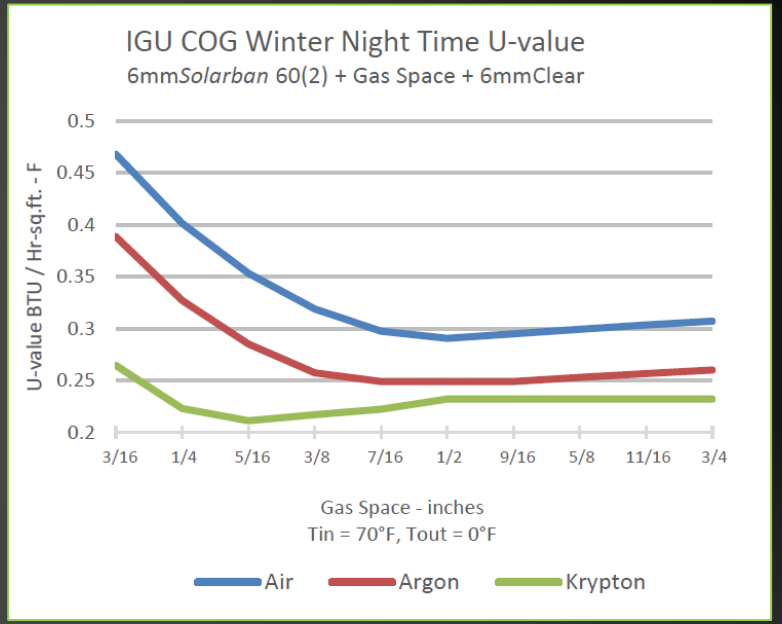
SEE THE DIFFERENCE

TRADITIONAL GLASS

TRI-ULTRA IGU

TRI-ULTRA IGU SIMULATED CENTER OF GLASS (COG) ENERGY PERFORMANCE VALUES

Overall IGU Thickness	Outboard Lites	Gaps	Inner Lite	U-Factor (COG)	SHGC (COG)	VT (COG)
3/4"	1/8" SB60 - Surface 2 & 5	1/4" Argon	0.5mm ATG	0.20	0.35	0.60
	1/8" SB70 - Surface 2 & 5	1/4" Argon	0.5mm ATG	0.19	0.23	0.45
7/8"	1/8" SB60 - Surface 2 & 5	5/16" Argon	0.5mm ATG	0.17	0.35	0.60
	1/8" SB70 - Surface 2 & 5	5/16" Argon	0.5mm ATG	0.16	0.23	0.45
1"	1/8" SB60 - Surface 2 & 5	3/8" Argon	0.5mm ATG	0.15	0.35	0.60
	1/8" SB70 - Surface 2 & 5	3/8" Argon	0.5mm ATG	0.14	0.23	0.45



Thin Glass Technical Update - LBNL

February 1, 2024

Stephen Selkowitz
Retired/Affiliate
Building Technology & Urban Systems Division
Lawrence Berkeley National Laboratory

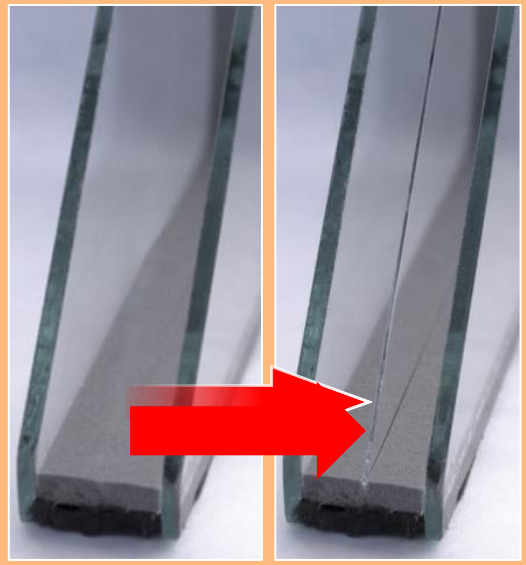
EMERGING OPPORTUNITY: THIN TRIPLES

Drop-in replacement

low entry **cost**

double COG performance

minimal weight



CONVENTIONAL TRIPLE

DOUBLE-PANE

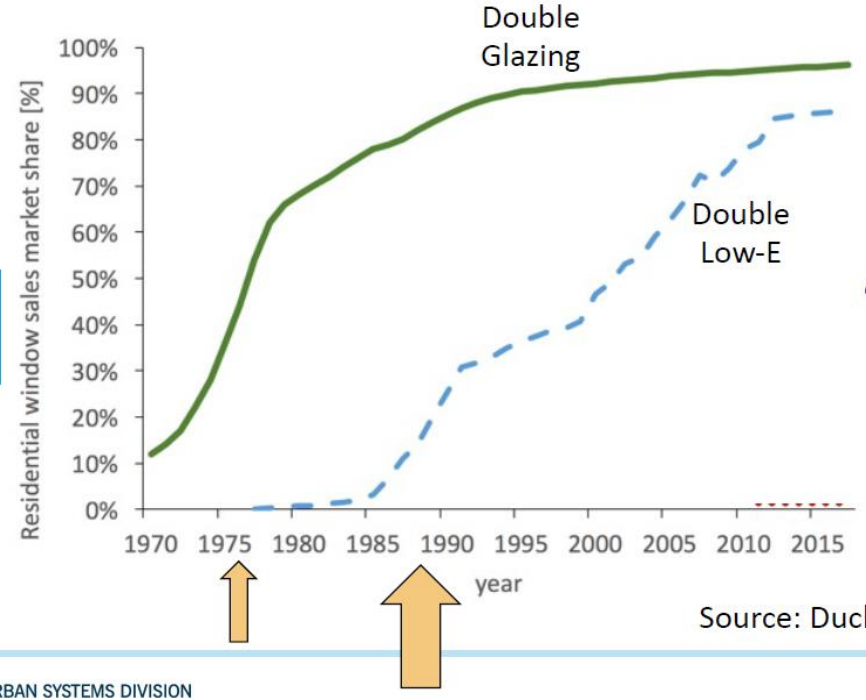
THIN-TRIPLE

INDUSTRY LOOKING FOR…

- **Drop-in Replacement to Double Glazed Unit**
  - Home Builders – do not want to change standard trade practice (4" wall systems)
  - Manufacturers- do not want to redesign, re-tool, re-certify existing designs
  - Architects - do not want to limit sizes, operator types, or frame materials

Transforming the Window Glazing Market

Market Share:



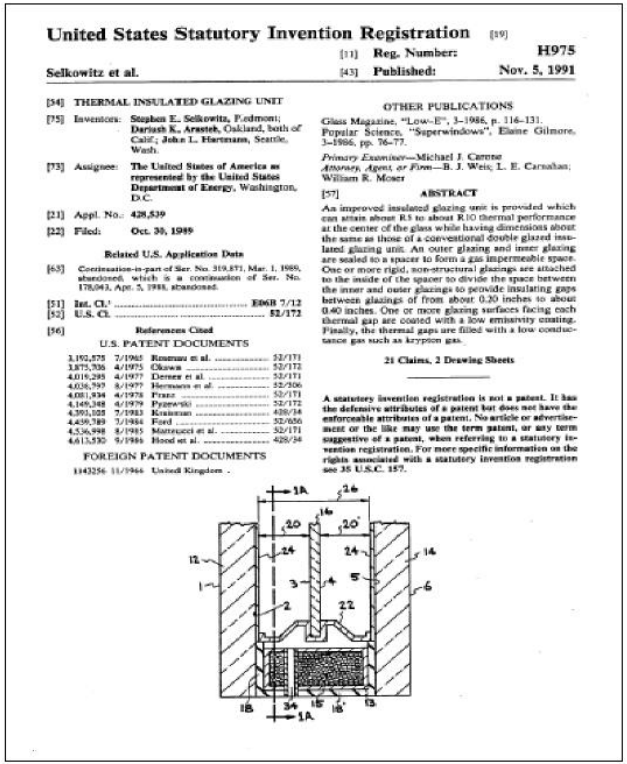
Source: Ducker

Low-E IGU was a "drop-in replacement" for Clear Double; What's Next??

"Superwindow"

Thin Triple Concept: 1989

Proposed as the "next easy step" beyond double/low-E, with conventional U.S. thin window frames…



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, Redmond; 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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Glass Magazine, "Low-E", 3-1986, p. 116-131.

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 R3 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

Breaking the Log Jam: 2017

"Moore's Law for Windows": 2016

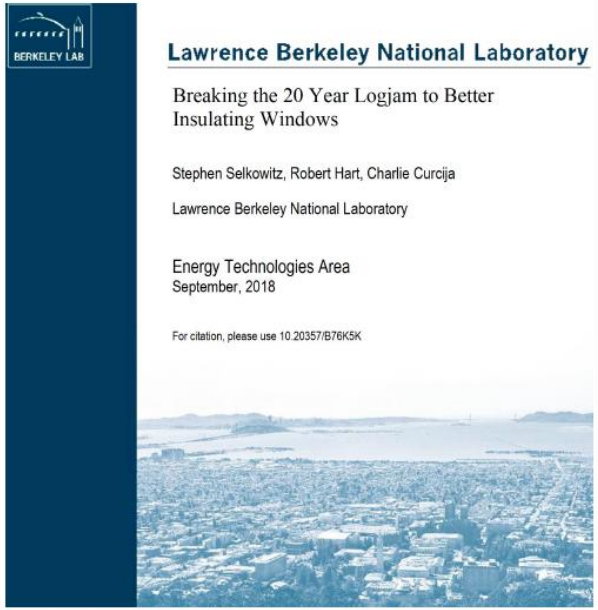
- We only need to double IGU R twice to get to Zero Net Energy window: R2 → R4 → R8
- **(Note: R8 IGU → R5 or R6 Window)**
- (Superwindow from 1990s….)

Thin Glass Evolves:

→ Cell phones, Laptops, Flat Screen TV !!!

- Multiple sources for glass
- Large sizes
- Lower cost

Today: As much thin glass goes into U.S. homes each year as goes into residential windows…



RECENT STAKEHOLDER ATTENTION ON THIN TRIPLES

GSA

U.S. DEPARTMENT OF ENERGY

NGA
NATIONAL GLASS ASSOCIATION with GANA

BERKELEY LAB

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

NFRC
National Fenestration Rating Council®

FGIA
Fenestration & Glazing Industry Alliance

Vitro
Architectural Glass

CORNING

DWM
DOOR AND WINDOW MARKET

NEW ARCHITECTURAL THIN GLASS OPTIONS VIA FUSION PROCESS: CORNING

Proprietary **FUSION** process makes glass that is

WHAT SETS CORNING's GLASS APART FROM TRADITIONAL FLOAT GLASS

3x

- **LOWER CTE[4]** *(coefficient of thermal expansion)*
- **MORE SCRATCH RESISTANT**
- **LOWER THICKNESS VARIATION**

6x

- **THINNER**
- **LIGHTER WEIGHT**
- **LOWER CARBON FOOTPRINT**

https://youtu.be/OTEIDfnO8M4?si=xaYFRRcEz_u0HogB

FUSION GLASS PROCESS VIDEO

BENEFITS OF CORNING ATG WITHIN GLASS STACK

Available Products (Shown at IBS 2023)

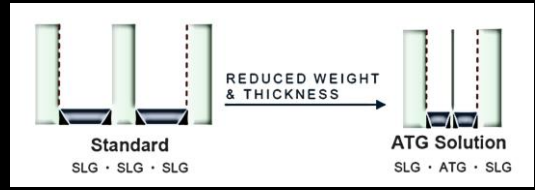
- U-Lite – Drop-in Thin Triples
- Diamond Glass – Drop-in Thin Laminates

Future Products (Shown at IBS 2024)

- Ultra Thin Laminates – Interior Building Retrofits
- Multi-Layer Laminates – Ballistic/Security
- Smart Panel – Dynamic Tinting

International Builders Show 2023 (PGT/Corning)

MARKET DRIVERS FOR THIN TRIPLE IGUs



- EnergyStar Version 7
- Colorado Energy Regulations
- California title 24
- Inflation Reduction Act (Most Efficient)

Significant Stringency in Energy Codes inevitable

"U.S. homes and commercial buildings consume a staggering 40% of the country's total energy." Department of Energy

- Glass doesn't fit in current designs
- Hardware won't support the weight
- Thin float glass fragile & small sizes
- 2x4 Construction Challenges

Float manufacturers unable to provide a solution to industry

Glass suppliers asking window manufacturers to redesign systems, manufacturers asking glass suppliers to provide a drop in solution

- Allows use of current frames
- Allows use of current hardware
- Thin Strong glass at large sizes (5x10)
- Drop in Solution, 2x4 Construction

Corning's Thin/Strong Glass Provides the solution to industry

Drop in Solution to enable Existing ¾" and 7/8" IGU Windows and Doors to meet EnergyStar V7 and Most Efficient

THIN TRIPLE PANE INSULATED GLASS (IG) VALUE PROPOSITION

33% less soda lime glass sourcing required (because the center pane is ATG)
Corning's proprietary fusion process produces glass on dedicated assets different than those used to produce traditional float glass, alleviating current capacity constraints with Soda Lime Glass.

Up to 30% weight reduction (vs. SLG thin triple solutions)
Resulting in $2-3/ft^2 cost reduction for shipping, handling and installation.

80x better field reliability (vs. annealed SLG thin triple solutions)
Due to ATG's low CTE, it is more resistant to thermal stress that glass may undergo in applications where thermal gradients are experienced. Per ASTM E2431, ATG shows 0.04% field thermal breakage rate compared to annealed SLG at 3.2% (1.6mm).

5-8% improvement of thermal performance compared to alternate solutions
ATG Thin Triple meets Uw of 0.23 whereas as 2mm SLG shows Uw of 0.25 and 1.6mm shows Uw of 0.23, per industry software (WINDOW7.7).

6-7x less field condensation risk (vs. DGU with room side coating)
Corning thermal modeling shows more than 130 days/year of condensation in Minneapolis with DGU with room facing coating as opposed to 20 days for Thin Triple.

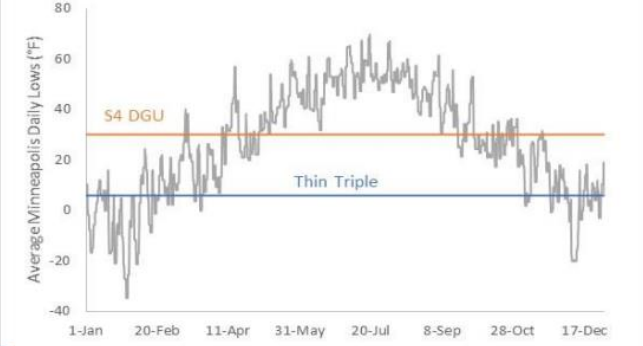
ROOM SIDE COATING (S4) DGU CONDENSATION CHALLENGES

Note:
*Krypton most efficient design ATG Thin Triple = **1 day** of condensation only in Minneapolis*

Room Side coating condensation risk modeling in different US cities[1]

City	IECC Zone	ENERGY STAR Zone	Days per year	
			DGU w/S4 coating	ATG Thin triple
Minneapolis	6	Northern	130	23
Chicago	5	Northern	105	15
NYC	4	N central	48	2
Washington DC	4	N central	72	0
San Francisco	3	S central	0	0
Miami	1	Southern	0	0

Minneapolis daily lowest temperatures



(1) Assumptions:
- Modeling performed on COMFEN software, Energyplus.net weather data and 45% in-room humidity
- See "The effect of #4 surface Low-E coatings on fenestration condensation resistance" Tracy G. Rogers

Moisture and damage to a wood window sash and frame

Condensation damage to wall surround (Building Envelope Forum) – S O'Brien

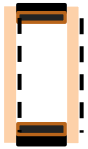
ALUMINUM REINFORCED VINYL DOUBLE HUNG PATHS TO ENERGYSTAR V7

Current Glass

3/4" IG with Low-E

Makeup	UF	SHGC	COG UF	COG SHGC	ES v6.0	ES v7.0
180 - ARG - Clear	0.30	0.50	0.26	0.67	None	None
272 - ARG - Clear	0.29	0.31	0.25	0.41	NC	None
366 - ARG - Clear	0.28	0.20	0.24	0.27	NC, SC, S	SC, S

AND-N-66-00722-00001
AND-N-66-00723-00001
AND-N-66-00725-00001

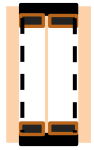


Future RoomSide Low-E Options

3/4" IG with Roomside Low-E

Makeup	UF	SHGC	COG UF	COG SHGC	ES v6.0	ES v7.0
180 - ARG - i89	0.26	0.45	0.21	0.62	N	N
272 - ARG - i89	0.25	0.30	0.20	0.41	N, NC	NC
366 - ARG - i89	0.25	0.20	0.19	0.27	All	NC, SC, S

AND-N-66-00726-00001
AND-N-66-00727-00001
AND-N-66-00729-00001



PGTI Thin Triple

3/4" IG (Argon - Whole Product Values Estimated)

Makeup	UF	SHGC	COG UF	COG SHGC	ES v6.0	ES v7.0
180 - ARG - 180	0.26	0.43	0.21	0.61	N	N
SB70 - ARG - SB70	0.25	0.17	0.19	0.23	All	NC, SC, S

7/8" IG (Argon - Whole Product Values Estimated)

Makeup	UF	SHGC	COG UF	COG SHGC	ES v6.0	ES v7.0
180 - ARG - 180	0.23	0.43	0.18	0.61	N	N
SB70 - ARG - SB70	0.22	0.17	0.16	0.23	All	All

7/8" IG (Krypton – Whole Product Values Estimated)

Makeup	UF	SHGC	COG UF	COG SHGC	ES v6.0	ES v7.0
180 - KRY - 180	0.18	0.42	0.13	0.60	N	N
SB70 - KRY - SB70	0.17	0.17	0.11	0.23	All	All

NC – North-Central S – Southern

MARKET DRIVERS FOR THIN LAMINATES

- Trend toward larger glass
- Growth in Laminated Insulated Glass
- Growing FL Impact Resistant Market
- Growing Coastal OOS market
- Installation Labor Shortage

Customer Quotes in Blind Installation Test

"They look identical, the difference is baffling, how they're able to get that much weight off the window"

"Cosmetically looks the same, the difference is that window "b" is a hell of a lot lighter, that equates to paying less to install"

- Extreme glass and product weight
- Lami IG does not fit into Non-Impact frames
- Wear and tear on labor/install crew
- Increased distortion on large Lami IG

Products regularly weigh in excess of 300#

- Reduces weight by up to 45%
- Improved clarity/less distortion
- Allows Non Impact products to meet light duty impact (Drop-In solution)
- Improves Sound/Security

Product (Individual Panel)	Standard Glass	Diamond Glass	Percent Decrease
SGD – Lami – Aluminum	149 lbs	82 lbs	45%
SGD – Lami IG - Vinyl	233 lbs	153 lbs	34%

TRIPLE DIAMOND GLASS™

Triple Diamond Glass™ offers innovative solutions to window and door manufacturers in the areas of energy efficiency, security, and sound abatement glass type applications.


Cuttingg thin glass
Vacuun insated glass
Triple gliazing
Triple glaing glasss
Vacum insuted glass
Triple glazing
Low-E coatings
Questions?

Isaac Smith

Center for Energy and Environment

THE LATEST ON ZERO ENERGY WINDOWS, THIN TRIPLES, AND ADVANCED WINDOW TECHNOLOGIES

May 9, 2024

PAWS
PARTNERSHIP FOR ADVANCED WINDOW SOLUTIONS

Center for Energy and Environment

We discover and deploy the most effective energy solutions that strengthen the economy and improve the environment

Our research drives every move we make.

We use a "lab-to-field" research approach that allows us to design innovative programs.

We design and deliver equitable programs.

Guided by our mission and tailored to meet clients' goals, we undertake research, create programs, and advance public policies to ensure the clean energy transition works for everyone.

We test small before we go big.

Thanks to our comprehensive market thinking, our pilot programs focus on everything from testing new technologies to enhancing program outreach and engagement.

We achieve successful program delivery across the country.

Tailoring programs to achieve success is what we do.

Efficient Technology Accelerator (ETA)

Minnesota Efficient Technology Accelerator (ETA)

A statewide market transformation program to accelerate the adoption of efficient technologies.
A partnership of:

- Investor-owned utilities (funders)
- Minnesota Department of Commerce, Division of Energy Resources (administrator)
- Center for Energy and Environment (implementer)

ETA Program Goals

- Accelerate market deployment of key technologies.
- Reduce cost of emerging and innovative efficient technologies.
- Become a hub for collaboration among stakeholders.
- Bring lower energy bills and environmental benefits to Minnesotans.

ETA Market Transformation Initiatives

- **High - Performance Windows (HPWs)**
- Residential Air Source Heat Pumps (ASHPs)
- High Performance RTUs
- Luminaire-Level Lighting Controls (LLLCs)

etamn.org

ETA™

PARTNERSHIP FOR ADVANCED WINDOW SOLUTIONS

PURPOSE

- PAWS promotes cost-effective, high performance window solutions for the nation's new and existing building stock. The Collaborative includes government agencies and research organizations, regional energy-efficiency groups, utilities, builders and window-solutions manufacturers.

MISSION

- Through collaborative research and programs, PAWS will aggregate market demand, reduce product cost, quantify benefits, and accelerate the adoption of high-performance windows and window attachments.

PAWS
PARTNERSHIP FOR ADVANCED WINDOW SOLUTIONS

WHO IS PAWS?

Leadership Team

WHY WINDOWS MATTER

- We can't have better buildings without better windows!
- Currently the weakest link of building envelope
- Better windows enable better electrification
- Need to be incorporated into efficiency and electrification programs

House A: Common Modern Envelope Design

Windows: R-3

Wall Insulation: R-20

Whole Wall Average: R-10.8

House B: Upgraded Envelope Design

Windows: R-5

Wall Insulation: R-38

Whole Wall Average: R-19

House C: Upgraded Insulation Design

Windows: R-3

Wall Insulation: R-330

Whole Wall Average: R-19

ENERGY STAR 7.0 UPDATE

FINAL VERSION 7 WINDOW SPECIFICATION

- Energy Star Windows deliver more energy savings
- Creates opportunity for more utility programs and incentives

Went into effect 10/23/23

Version 6

Climate Zone	U-Factor	SHGC	
Northern*	≤ 0.27	Any	Prescriptive
	= 0.28	≥ 0.32	Equivalent Energy Performance
	= 0.29	≥ 0.37	
	= 0.30	≥ 0.42	
North-Central	≤ 0.30	≤ 0.40	
South-Central	≤ 0.30	≤ 0.25	
Southern	≤ 0.40	≤ 0.25	

Final Version 7

Climate Zone	U-Factor	SHGC	
Northern*	≤ 0.22	≥ 0.17	Prescriptive
	= 0.23	≥ 0.35	Equivalent Energy Performance
	= 0.24		
	= 0.25	≥ 0.40	
	= 0.26		
North-Central	≤ 0.25	≤ 0.40	
South-Central	≤ 0.28	≤ 0.23	
Southern	≤ 0.32	≤ 0.23	

= Change

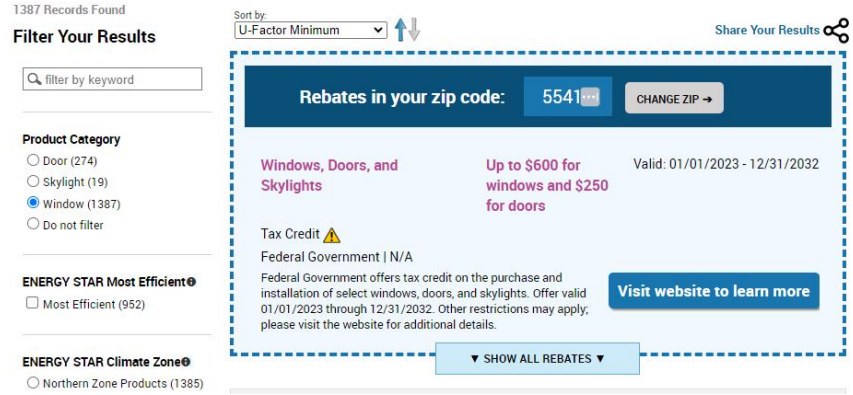
Average Annual Household Savings for Version 7 Windows

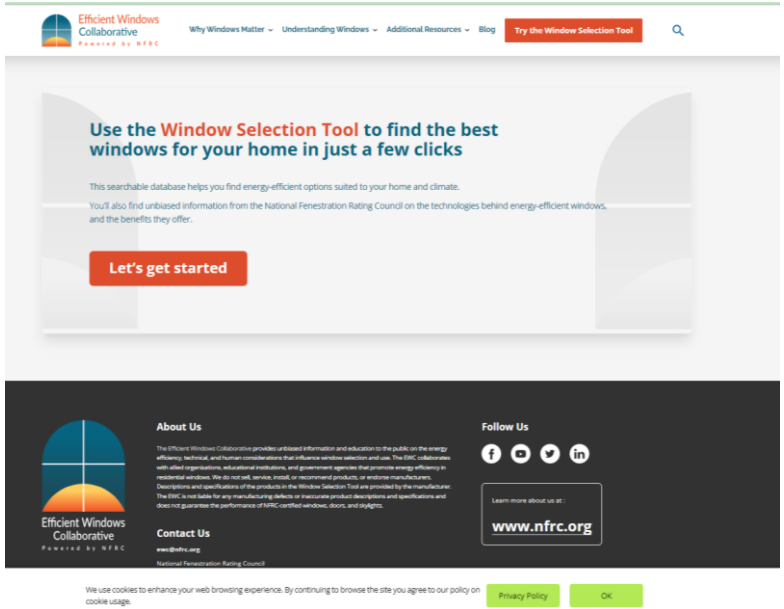
Average Version 7 Windows Savings over Single and Double Pane Clear Windows by Zone		
Zone	Average Savings Single Pane Clear	Average Savings Double Pane Clear
Northern	$503.61	$252.41
North-Central	$442.91	$224.61
South-Central	$493.79	$307.41
Southern	$433.14	$275.76

FINDING AND SELECTING WINDOWS

Efficient Windows Collaborative
Powered by NFRC

Find your ENERGY STAR Climate Zone Here.



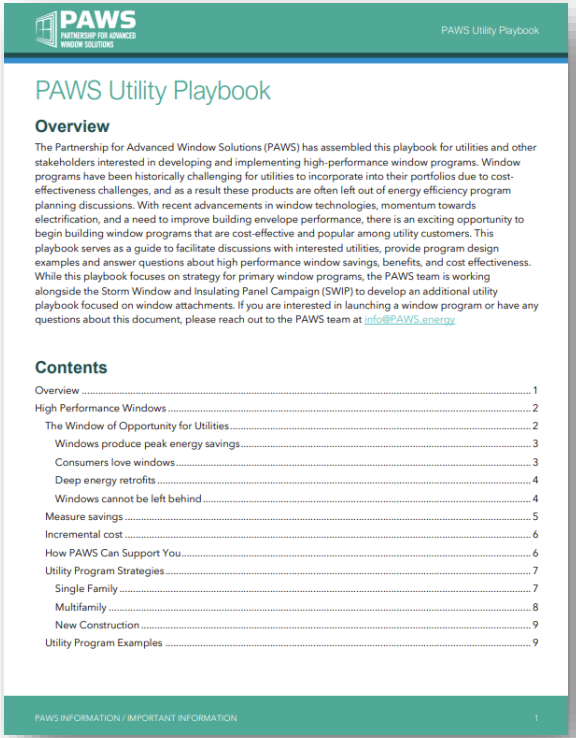


PAWS TOOLS

For Utility Programs

BUILT TOOLS

Utility Playbook



PAWS PARTNERSHIP FOR ADVANCED WINDOW SOLUTIONS

PAWS Utility Playbook

PAWS Utility Playbook

Overview

The Partnership for Advanced Window Solutions (PAWS) has assembled this playbook for utilities and other stakeholders interested in developing and implementing high-performance window programs. Window programs have been historically challenging for utilities to incorporate into their portfolios due to cost-effectiveness challenges, and as a result these products are often left out of energy efficiency program planning discussions. With recent advancements in window technologies, momentum towards electrification, and a need to improve building envelope performance, there is an exciting opportunity to begin building window programs that are cost-effective and popular among utility customers. This playbook serves as a guide to facilitate discussions with interested utilities, provide program design examples and answer questions about high performance window savings, benefits, and cost effectiveness. While this playbook focuses on strategy for primary window programs, the PAWS team is working alongside the Storm Window and Insulating Panel Campaign (SWIP) to develop an additional utility playbook focused on window attachments. If you are interested in launching a window program or have any questions about this document, please reach out to the PAWS team at info@PAWS.energy

Contents

Energy Savings Calculator

HIGH PERFORMANCE WINDOW INCENTIVE CALCULATOR

INPUTS - *Select location, baseline and performnce window specs, and incentive levels for your region.*

Location		Baseline Window		Performance Window		Incentive Rebate Level	
State	City	U-Factor	SHGC	U-Factor	SHGC	Gas ($/therm)	Electric ($/kWh)
MN	Minneapolis-St.Paul.Intl.AP.726580	0.32	0.3	0.22	0.3	$4.00	$0.20

OUTPUTS

Gas Savings (therms)			Proposed Incentive (per window)
percent	per window	per home	
4%	2.98	71	$11.91

Electric Savings (kWh)			Proposed Incentive (per window)
percent	per window	per home	
1%	2.60	62	$0.52

Key Assumptions*:

Assumes 23.8 3'x5' windows per home
Analysis assumes common existing building characteristics for building envelope and air infultration
Energy savings are normalized over common heating and cooling types for each region

*see input data summary tab for a detailed explanation of assumptions

To inquire about additional data calculations specific to your region, or provide feedback for this calculator, email gdiller@mncee.org

ENERGY SAVINGS – COMPARED TO CODE BASELINE

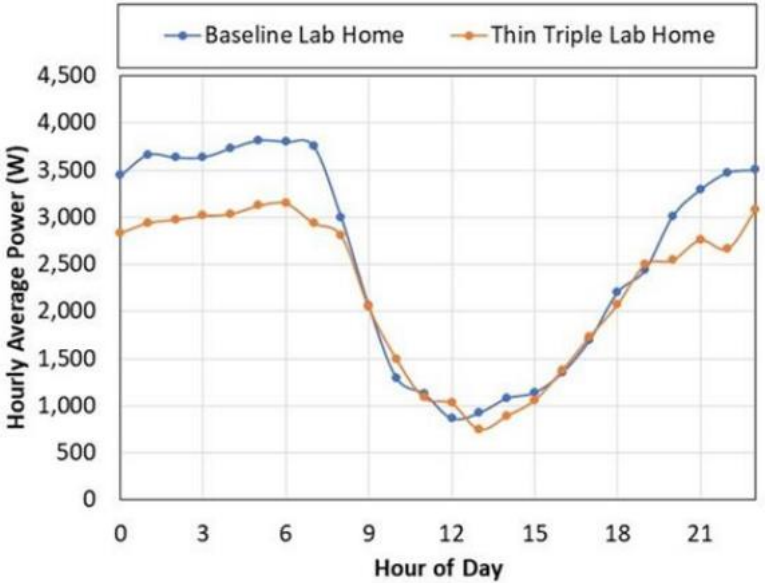
Climate Zone (model city)	Window Assumptions				Electric Savings	Gas Savings
	Baseline		Performance			
	U-value	SHGC	U-value	SHGC	kWh/window	therms/window
1 (Miami, FL)	0.35*	0.25	0.32	0.23	6.25	0.03
2 (Phoenix, AZ)	0.35*	0.25	0.32	0.23	7.96	0.09
3 (Charleston, SC)	0.35*	0.30	0.28	0.23	17.07	0.21
4 (Philadelphia, PA)	0.32	0.40	0.24	0.40	8.94	1.26
5 (Salt Lake City, UT)	0.32	0.30	0.22	0.30	1.45	2.3
6 (Minneapolis, MN)	0.32	0.30	0.22	0.30	2.60	2.98
7 (Anchorage, AK)	0.30	0.30	0.22	0.30	2.09	3.36

*Cities with code minimum U-values for windows above 0.35 were modeled using a default U-value of 0.35 for the baseline.

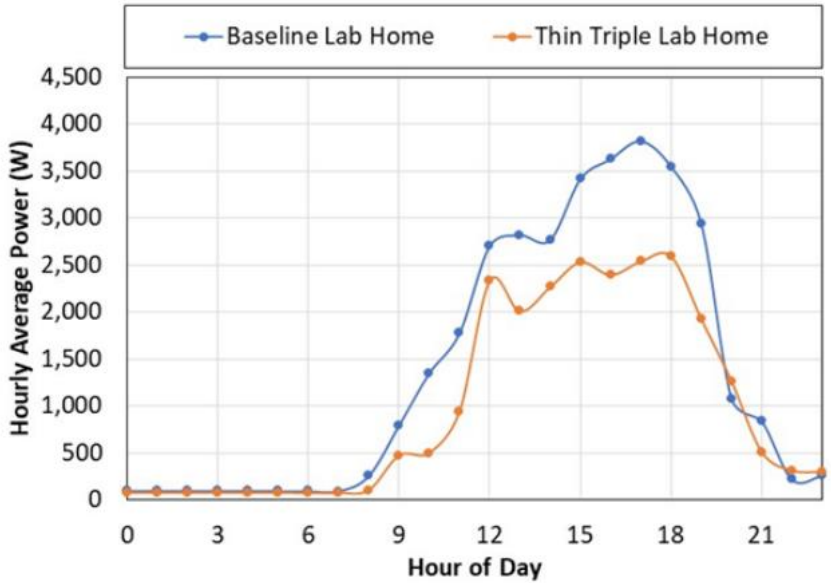
Note: Savings were calculated for 132 cities across 8 climate zones utilizing modeling data compiled for the ENERGY STAR Version 7 Specification for Windows and Skylights. The baseline for each city was determined based on the current adopted energy code, or a default baseline of U-0.35 and 0.30 SHGC. These savings values are for a 3'x5' window.

PEAK SAVINGS

- **17%** peak heating savings and **33%** peak cooling savings

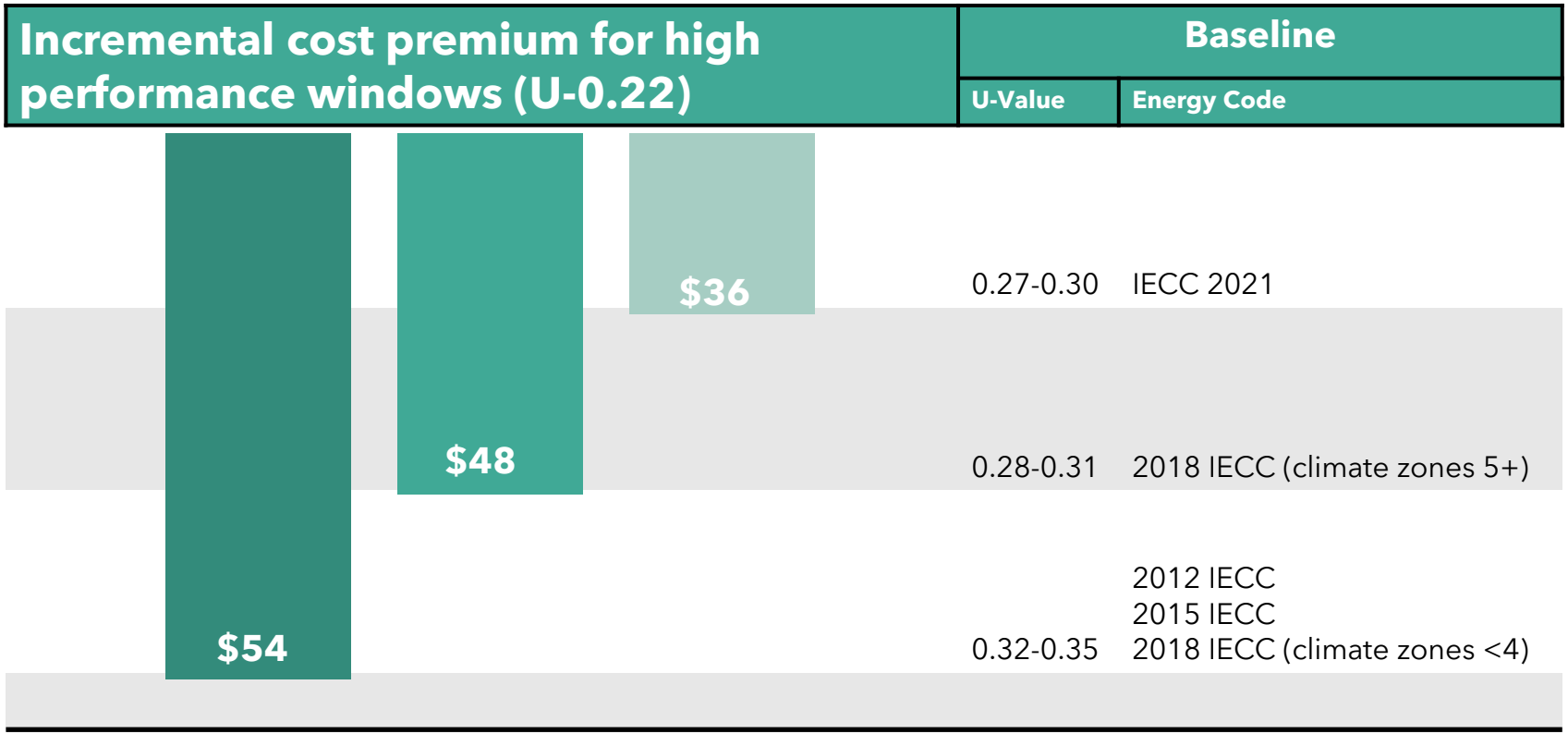


HVAC Load Heating Season



HVAC Load Cooling Season

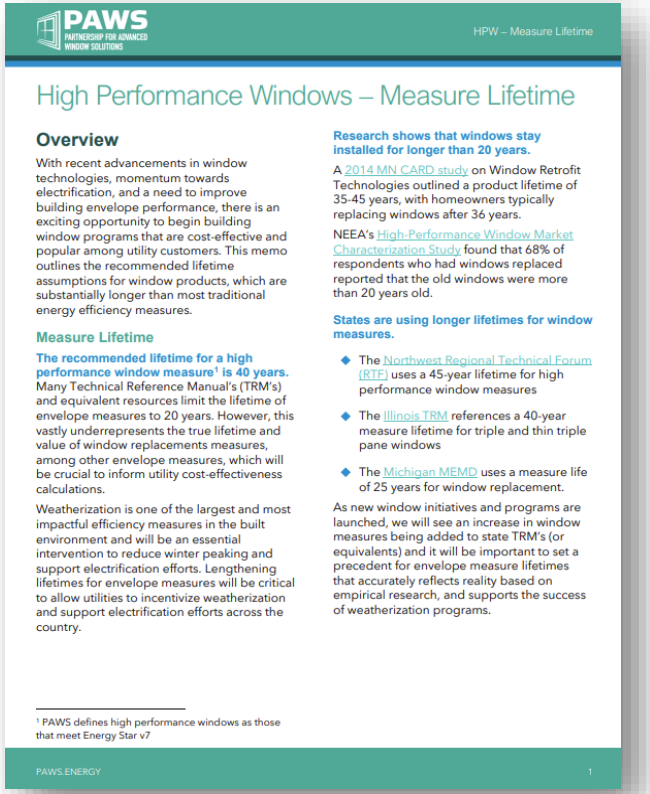
INCREMENTAL COST



MEASURE LIFETIME

- Windows have a 35-45 year lifetime
- Northwest Regional Technical Forum (RTF) uses a 45 year lifetime
- IL TRM uses a 40 year lifetime

Measure Lifetime Memo



PAWS
PARTNERSHIP FOR ADVANCED WINDOW SOLUTIONS

HPW – Measure Lifetime

High Performance Windows – Measure Lifetime

Overview

With recent advancements in window technologies, momentum towards electrification, and a need to improve building envelope performance, there is an exciting opportunity to begin building window programs that are cost-effective and popular among utility customers. This memo outlines the recommended lifetime assumptions for window products, which are substantially longer than most traditional energy efficiency measures.

Measure Lifetime

The recommended lifetime for a high performance window measure[1] is 40 years. Many Technical Reference Manual's (TRM's) and equivalent resources limit the lifetime of envelope measures to 20 years. However, this vastly underrepresents the true lifetime and value of window replacements measures, among other envelope measures, which will be crucial to inform utility cost-effectiveness calculations.

Weatherization is one of the largest and most impactful efficiency measures in the built environment and will be an essential intervention to reduce winter peaking and support electrification efforts. Lengthening lifetimes for envelope measures will be critical to allow utilities to incentivize weatherization and support electrification efforts across the country.

Research shows that windows stay installed for longer than 20 years.

A 2014 MN CARD study on Window Retrofit Technologies outlined a product lifetime of 35-45 years, with homeowners typically replacing windows after 36 years.

NEEA's High-Performance Window Market Characterization Study found that 68% of respondents who had windows replaced reported that the old windows were more than 20 years old.

States are using longer lifetimes for window measures.

- The Northwest Regional Technical Forum (RTF) uses a 45-year lifetime for high performance window measures
- The Illinois TRM references a 40-year measure lifetime for triple and thin triple pane windows
- The Michigan MEMD uses a measure life of 25 years for window replacement.

As new window initiatives and programs are launched, we will see an increase in window measures being added to state TRM's (or equivalents) and it will be important to set a precedent for envelope measure lifetimes that accurately reflects reality based on empirical research, and supports the success of weatherization programs.

[1] PAWS defines high performance windows as those that meet Energy Star v7

PAWS.ENERGY 1

RESOURCES – PAWS.ENERGY – UTILITY WORKING GROUP

Utility Playbook

PAWS Utility Playbook

Overview

The Partnership for Advanced Window Solutions (PAWS) has assembled this playbook for utilities and other stakeholders interested in developing and implementing high-performance window programs. Window programs have been historically challenging for utilities to incorporate into their portfolios due to cost-effectiveness challenges, and as a result these products are often left out of energy efficiency program planning discussions. With recent advancements in window technologies, momentum towards electrification, and a need to improve building envelope performance, there is an exciting opportunity to begin building window programs that are cost-effective and popular among utility customers. This playbook serves as a guide to facilitate discussions with interested utilities, provide program design examples and answer questions about high performance window savings, benefits, and cost effectiveness. While this playbook focuses on strategy for primary window programs, the PAWS team is working alongside the Storm Window and Insulating Panel Campaign (SWIP) to develop an additional utility playbook focused on window attachments. If you are interested in launching a window program or have any questions about this document, please reach out to the PAWS team at info@PAWS.energy

Contents

Incremental Cost Memo

High Performance Window – Incremental Cost

Overview

With recent advancements in window technologies, momentum towards electrification, and a need to improve building envelope performance, there is an exciting opportunity to begin building window programs that are cost-effective and popular among utility customers. This memo outlines the incremental cost of high-performance Window Products

During the process of developing the new ENERGY STAR specification for windows, doors and skylights the cost of window products was evaluated. Based on this analysis it was determined that the incremental cost between a 0.32 U-Value Window (IECC 2015 code baseline) and a High-Performance Window meeting ENERGY STAR Version 7 criteria is $54[1]. As the baseline energy code becomes more stringent, the incremental cost decreases. These details are outlined in the figure below -

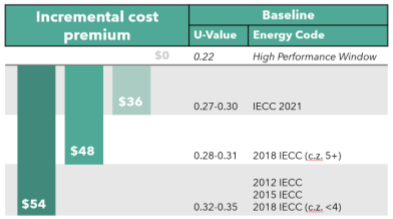


Figure 1 Incremental cost premium for a 3'x5' high-performance window over various code baselines

[1] Incremental cost was evaluated during the specification revision process for ENERGY STAR Version 7. Anonymized cost data was collected and summarized per window in a presentation to stakeholders (see slide 20).

Measure Lifetime Memo

High Performance Windows – Measure Lifetime

Overview

With recent advancements in window technologies, momentum towards electrification, and a need to improve building envelope performance, there is an exciting opportunity to begin building window programs that are cost-effective and popular among utility customers. This memo outlines the recommended lifetime assumptions for window products, which are substantially longer than most traditional energy efficiency measures.

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UTILITY PROGRAMS

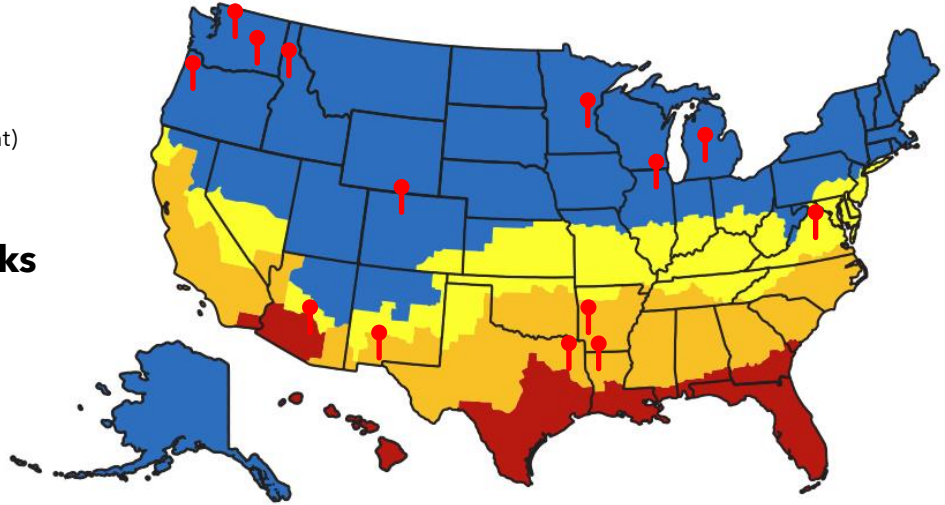
Avista (WA)
Retrofit
$225 (contractor install)

Avista (ID)
Retrofit
$225 (contractor install)

Consumers Energy
Retrofit
$15

Columbia Gas (VA)
Retrofit
$1/sqft

Cascade Natural Gas
Retrofit
$9/sqft (single pane replacement)



Efficiency Works
Retrofit
$3.75/sqft

SWEPCO (AR)
Retrofit
$30

SWEPCO (LA)
Retrofit
$2.50/sqft

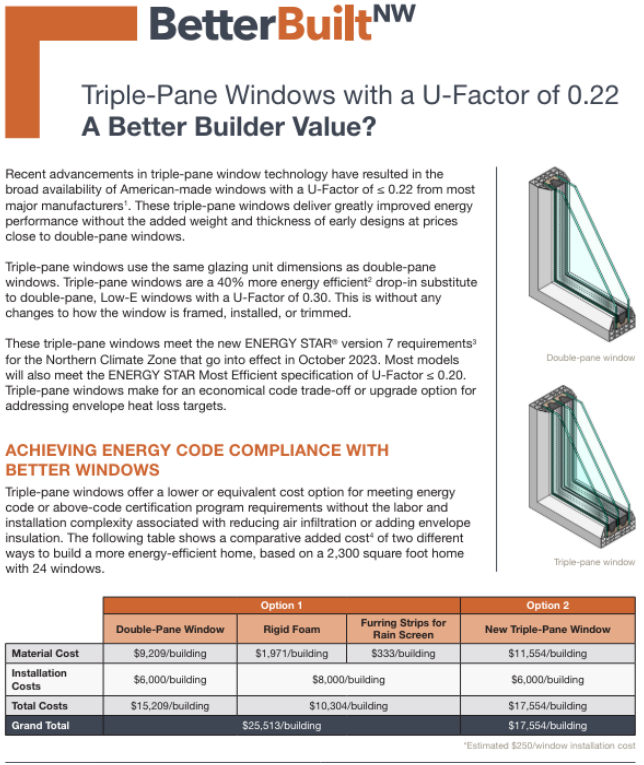
Southwest Gas (AZ)
Retrofit
$1/sqft

El Paso Electric (NM)
Type
$1.50-$3/sqft

SWEPCO (TX)
Retrofit
$2.50/sqft

MARKET TRANSFORMATION PROGRAMS

- **IL Programs – Nicor and Ameren**
  - Launching builder pilots in IL
- **NEEA MT program**
  - Conducted builder pilots in 2023
    - Production builder pilot (link)
    - Habitat for humanity
- **MN MT Program**
  - Launching builder pilots in 2024
  - WAP pilot with state of MN – 89 homes



BetterBuiltNW

Triple-Pane Windows with a U-Factor of 0.22
A Better Builder Value?

Recent advancements in triple-pane window technology have resulted in the broad availability of American-made windows with a U-Factor of ≤ 0.22 from most major manufacturers[1]. These triple-pane windows deliver greatly improved energy performance without the added weight and thickness of early designs at prices close to double-pane windows.

Triple-pane windows use the same glazing unit dimensions as double-pane windows. Triple-pane windows are a 40% more energy efficient[2] drop-in substitute to double-pane, Low-E windows with a U-Factor of 0.30. This is without any changes to how the window is framed, installed, or trimmed.

These triple-pane windows meet the new ENERGY STAR® version 7 requirements[3] for the Northern Climate Zone that go into effect in October 2023. Most models will also meet the ENERGY STAR Most Efficient specification of U-Factor ≤ 0.20. Triple-pane windows make for an economical code trade-off or upgrade option for addressing envelope heat loss targets.

Double-pane window

Triple-pane window

ACHIEVING ENERGY CODE COMPLIANCE WITH BETTER WINDOWS

Triple-pane windows offer a lower or equivalent cost option for meeting energy code or above-code certification program requirements without the labor and installation complexity associated with reducing air infiltration or adding envelope insulation. The following table shows a comparative added cost[4] of two different ways to build a more energy-efficient home, based on a 2,300 square foot home with 24 windows.

	Option 1			Option 2
	Double-Pane Window	Rigid Foam	Furring Strips for Rain Screen	New Triple-Pane Window
Material Cost	$9,209/building	$1,971/building	$333/building	$11,554/building
Installation Costs	$6,000/building	$8,000/building		$6,000/building
Total Costs	$15,209/building	$10,304/building		$17,554/building
Grand Total	$25,513/building			$17,554/building

[4]Estimated $250/window installation cost

NEW INCENTIVES IN 2024

Utility	State	Rebate Requirement	Home Type	Rebate Amount	Rebate Recipient
Center Point Energy	MN	ENERGY STAR v7 (Windows & Storm Windows)	Existing Homes	$15	Contractor
Minnesota Power	MN	ENERGY STAR v7	Existing Homes	$15	Homeowner
Otter Tail	MN	ENERGY STAR v7	Existing Homes	$25	Homeowner
Minnesota Energy Resources	MN	ENERGY STAR v7	New & Existing Homes	$50 ($75*)	Homeowner
Nicor Gas	IL	ENERGY STAR v7	New Homes	$15 ($60+**)	Builder
Ameren Illinois**	IL	ENERGY STAR v7	New Homes	$60+**	Builder

** Low Income ** Pilot*

HOW PAWS CAN SUPPORT YOU

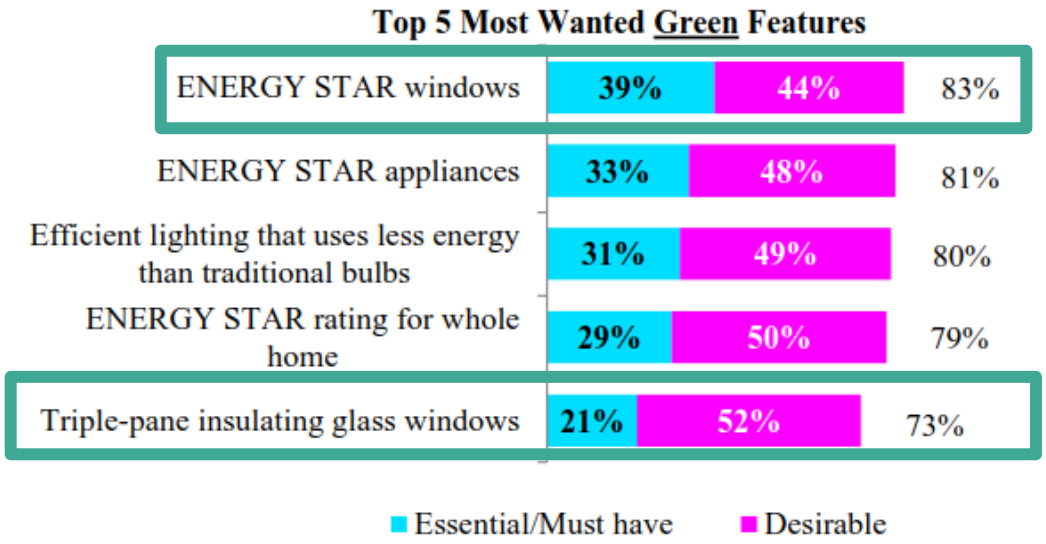
PAWS can offer 1:1 support for interested utilities

- **TRM Analysis Support**
- Region Specific Savings Analysis
- **Program & Pilot Design, Support**
- Manufacturer Engagement
- Resources (Memos, 1-Pagers, etc.)
- What else?

REMINDER - PEOPLE LOVE WINDOWS

- Window programs can drive participation to utility programs
- Consumers Energy pairs window rebates with insulation

NAHB Survey



STORM WINDOWS

SWIP CAMPAIGN: LEAVE NO POOR-PERFORMING WINDOW BEHIND

SWIP

Affordable Window Retrofit Campaign

https://www.energy.gov/

A collaborative initiative to accelerate the adoption of modern, high-efficiency window attachments, delivering affordable energy savings and comfort to home occupants.

Partners: Pacific Northwest National Laboratory; U.S. Department of Energy; Weatherization Assistance Program; ENERGY STAR; AERC; Efficiency Vermont; neea; nep Northeast Energy Efficiency Partnerships; cee Center for Energy and Environment

Better Buildings U.S. Department of Energy

MINNEAPOLIS CASE STUDY

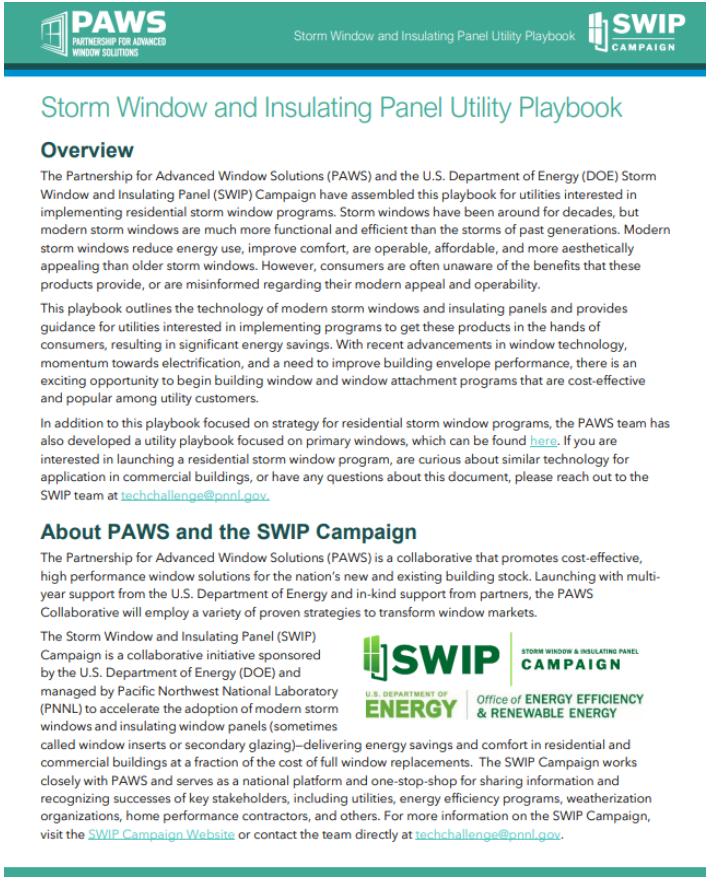
Internal and external storm windows were assessed at several sites, showing notable air leakage improvements (**10-20%**)

MF – 4-PLEX

- **19%** whole-building CFM50 reduction
- (25 CFM50 reduction per window)
- **$200**/window

STORM WINDOW UTILITY PLAYBOOK

- SWIP Utility Program Playbook
- Mpls Storm Window Case Study
  - Additional case studies coming



PAWS PARTNERSHIP FOR ADVANCED WINDOW SOLUTIONS

Storm Window and Insulating Panel Utility Playbook

SWIP CAMPAIGN

Storm Window and Insulating Panel Utility Playbook

Overview

The Partnership for Advanced Window Solutions (PAWS) and the U.S. Department of Energy (DOE) Storm Window and Insulating Panel (SWIP) Campaign have assembled this playbook for utilities interested in implementing residential storm window programs. Storm windows have been around for decades, but modern storm windows are much more functional and efficient than the storms of past generations. Modern storm windows reduce energy use, improve comfort, are operable, affordable, and more aesthetically appealing than older storm windows. However, consumers are often unaware of the benefits that these products provide, or are misinformed regarding their modern appeal and operability.

This playbook outlines the technology of modern storm windows and insulating panels and provides guidance for utilities interested in implementing programs to get these products in the hands of consumers, resulting in significant energy savings. With recent advancements in window technology, momentum towards electrification, and a need to improve building envelope performance, there is an exciting opportunity to begin building window and window attachment programs that are cost-effective and popular among utility customers.

In addition to this playbook focused on strategy for residential storm window programs, the PAWS team has also developed a utility playbook focused on primary windows, which can be found here. If you are interested in launching a residential storm window program, are curious about similar technology for application in commercial buildings, or have any questions about this document, please reach out to the SWIP team at techchallenge@pnnl.gov.

About PAWS and the SWIP Campaign

The Partnership for Advanced Window Solutions (PAWS) is a collaborative that promotes cost-effective, high performance window solutions for the nation's new and existing building stock. Launching with multi-year support from the U.S. Department of Energy and in-kind support from partners, the PAWS Collaborative will employ a variety of proven strategies to transform window markets.

The Storm Window and Insulating Panel (SWIP) Campaign is a collaborative initiative sponsored by the U.S. Department of Energy (DOE) and managed by Pacific Northwest National Laboratory (PNNL) to accelerate the adoption of modern storm windows and insulating window panels (sometimes called window inserts or secondary glazing)–delivering energy savings and comfort in residential and commercial buildings at a fraction of the cost of full window replacements. The SWIP Campaign works closely with PAWS and serves as a national platform and one-stop-shop for sharing information and recognizing successes of key stakeholders, including utilities, energy efficiency programs, weatherization organizations, home performance contractors, and others. For more information on the SWIP Campaign, visit the SWIP Campaign Website or contact the team directly at techchallenge@pnnl.gov.

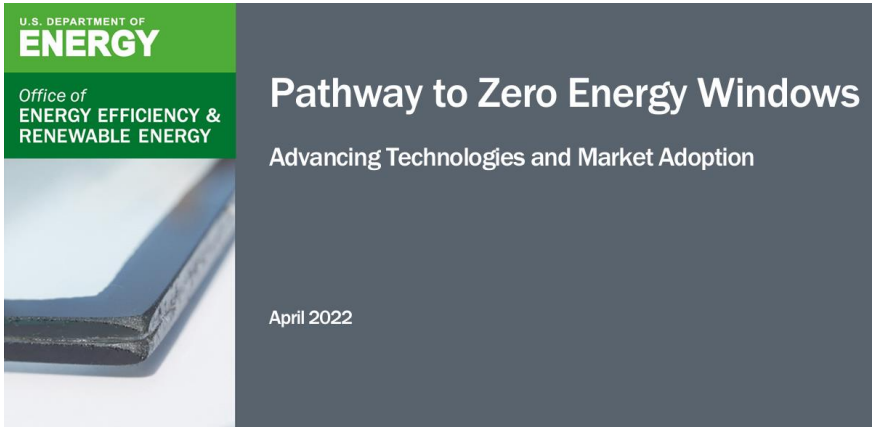
SWIP STORM WINDOW & INSULATING PANEL CAMPAIGN

U.S. DEPARTMENT OF ENERGY | Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

THANK YOU!

Pathway to Zero Energy Windows: Advancing Technologies and Market Adoption

In this report the Building Technologies Office (BTO) outlines multiple avenues for technology development, deployment, and adoption to increase the impact that high-performance windows can have on decarbonizing buildings.



AFFORDABLE HOME ENERGY SHOT™ VIRTUAL SUMMIT

June 5

10:30 a.m. to 4:30 p.m. ET

- ✓ Equity-driven solutions
- ✓ Stakeholder perspectives
- ✓ Cost reduction strategies
- ✓ Technology R&D needs

bit.ly/AHES-summit

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Affordable Home Energy™

Smart Tools for Efficient HVAC Performance (STEP) Campaign

Pacific Northwest NATIONAL LABORATORY

STEP CAMPAIGN

Scan this QR code to visit our website

Contact: christian.valoria@pnnl.gov

The STEP Campaign aims to increase adoption of smart diagnostic tools to streamline HVAC system performance testing and troubleshooting, reducing energy-wasting faults and improving occupant comfort.

To join the STEP Campaign, visit: bit.ly/3DFmEaE

HVAC Contractors and Technicians

- Reduce callbacks, improve consistency and quality, streamline processes
- Find out where to get training on smart diagnostic tools
- Be recognized for successful adoption of smart diagnostic tools!

Utilities and Program Implementers

- Streamline quality installation and quality maintenance programs
- Improve engagement with your contractors
- Be recognized for programs that utilize smart diagnostic tools!

HVAC Training Organizations

- Offer qualified training on System Performance with smart diagnostic tools
- Promote your training events
- Be recognized for providing training!

Weatherization Organizations

- Ensure your ASHP/CAC installations are operating at optimized efficiency
- Develop pilot with PNNL team
- Be recognized!

ORGANIZING PARTNERS

ACCA · BUILDING PERFORMANCE ASSOCIATION · CEE Working Together, Advancing Efficiency · HVAC Excellence · NATE · neea · U.S. DEPARTMENT OF ENERGY

Explore the Residential Program Guide

Resources to help improve your program and reach energy efficiency targets:

- Handbooks - explain *why* and *how* to implement specific stages of a program.
- Quick Answers - provide answers and resources for common questions.
- Proven Practices posts - include lessons learned, examples, and helpful tips from successful programs.
- Technology Solutions NEW! - present resources on advanced technologies, **HVAC** & **Heat Pump Water Heaters**, including installation guidance, marketing strategies, & potential savings.
- Health + Home Performance Infographic – spark homeowner conversations.

https://rpsc.energy.gov

Health + Home Performance Infographic

DOE's Health + Home Performance Infographic reveals the link between efficiency and health – something everyone cares about. Efficiency programs and contractors can use the question-and-answer format to discover a homeowner's needs.

The infographic is ideal for the "kitchen table" conversations where people decide what to do – and who they want to do it. It also has links for homeowners to find a qualified contractor if they do not already have one.

Download this infographic from DOE's Better Buildings Residential Network.

Looking for photos to help tell your energy efficiency story? Visit our image libraries: https://www.energy.gov/eere/better-buildings-residential-network/articles/image-libraries

Thank You!

Follow us to plug into the latest Better Buildings news and updates!

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[Office of Energy Efficiency and Renewable Energy Facebook]

Please send any follow-up questions or future call topic ideas to:
bbresidentialnetwork@ee.doe.gov