



**NHPC**

2024 | MINNEAPOLIS



 **Xcel Energy**<sup>®</sup>

# ENJOY THE VIEW WITHOUT THE DRAFTS: AIR-SEALING WITH STORM WINDOWS

# PRESENTER(S)



## **Katherine Cort**

Senior Research Economist  
Pacific Northwest National Laboratory (PNNL)



## **Steve Sylvestre**

Initiative Manager, High-Performance Windows  
Center for Energy and Environment



## **Thomas Culp, PhD**

President  
Birch Point Consulting LLC

# LEARNING OBJECTIVES

At the conclusion of this session, participants will:

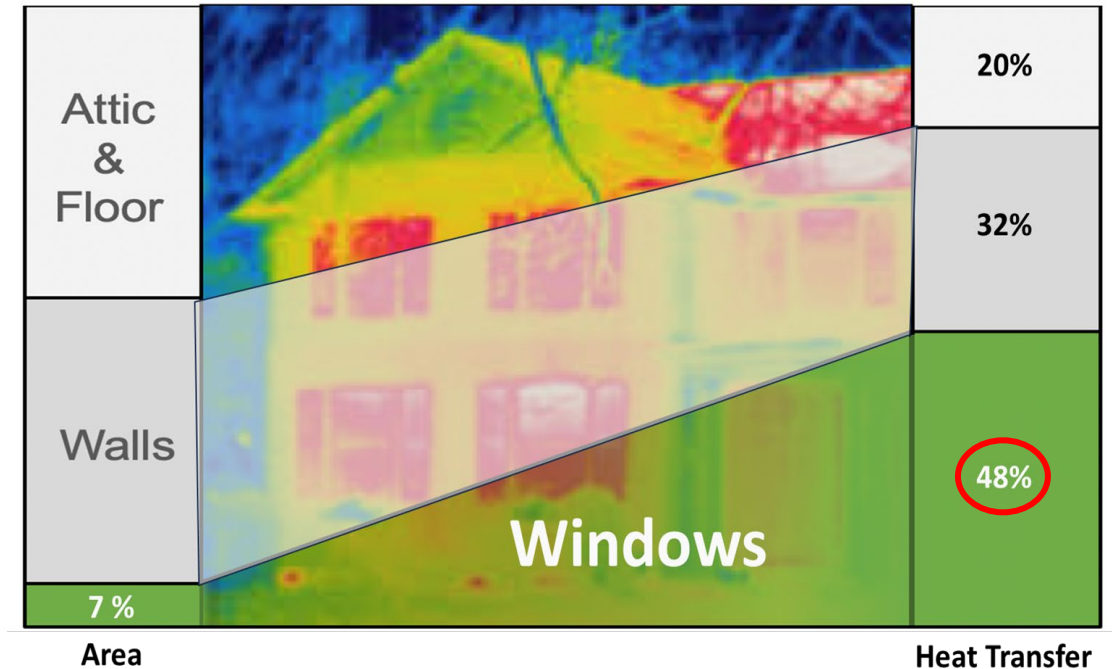
- Discover a non-invasive low-cost easy-to-install retrofit you can upsell to customers or add to your utility line up with federal incentives
- Learn about the benefits of modern storm windows as an effective solution you can offer to cost-conscious customers to improve window performance, reduce comfort complaints, cut energy bills, provide sound mitigation, keep out smoke and pollen, and improve resiliency
- Understand the research, ratings, and resources that can give you the confidence to recommend this cost-effective measure to your customers

**Wouldn't it be great if there were more cost-effective ways to improve the building envelope?**

# WHY WINDOWS?

Windows make up **~7%** of envelope area, but account for nearly **half the thermal transfers** through the envelope.

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



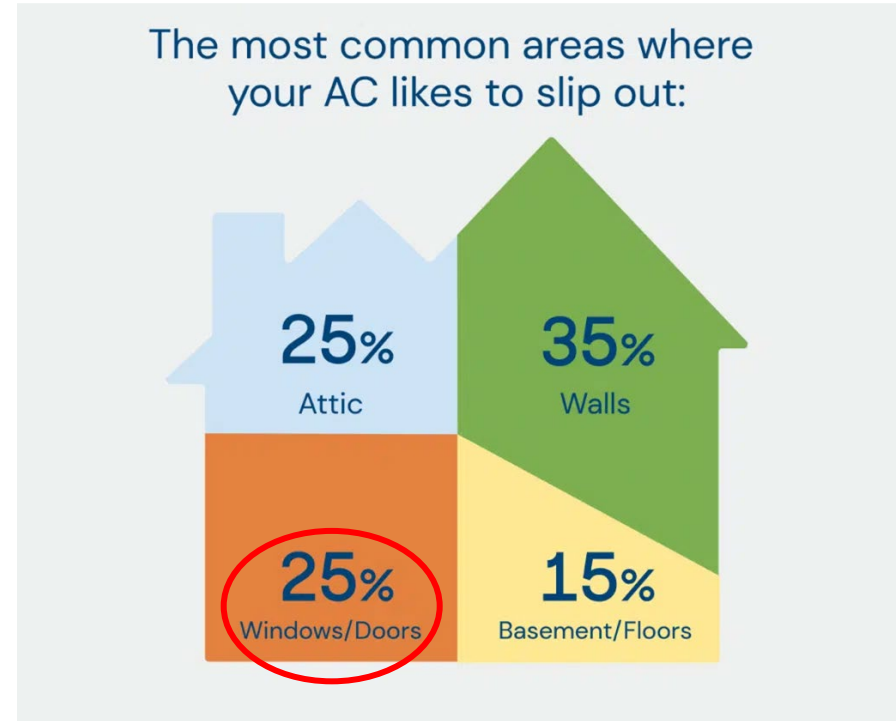
# WHY FOCUS ON AIR SEALING WINDOWS?

Reduces. . .

- Energy Bills
- Draftiness
- Outdoor Noise
- Allergens, dust, smoke

Improves. . .

- Occupant Comfort
- Temperature and Humidity Control
- Indoor Air Quality



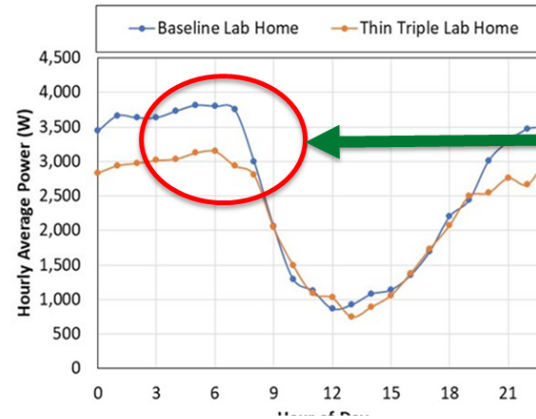
Source: CEMC (cemc.org)



# BETTER WINDOWS ENABLE ELECTRIFICATION EFFORTS

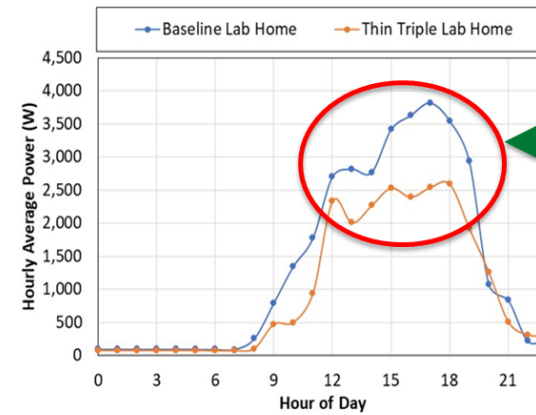
Better window performance and reduced leakage helps achieve. . .

- Energy Savings/Carbon Reduction
- Peak Load Reductions
- Improved Comfort
- 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)

# HOW STORM WINDOWS CAN BE A SOLUTION

- **Air Seals** Primary Window
- Creates “Dead Air Space” to improve thermal insulating performance
- Low-e Glass can Reflect Radiant Heat
- Solar Control Coatings can Reduce Solar Heat Gain

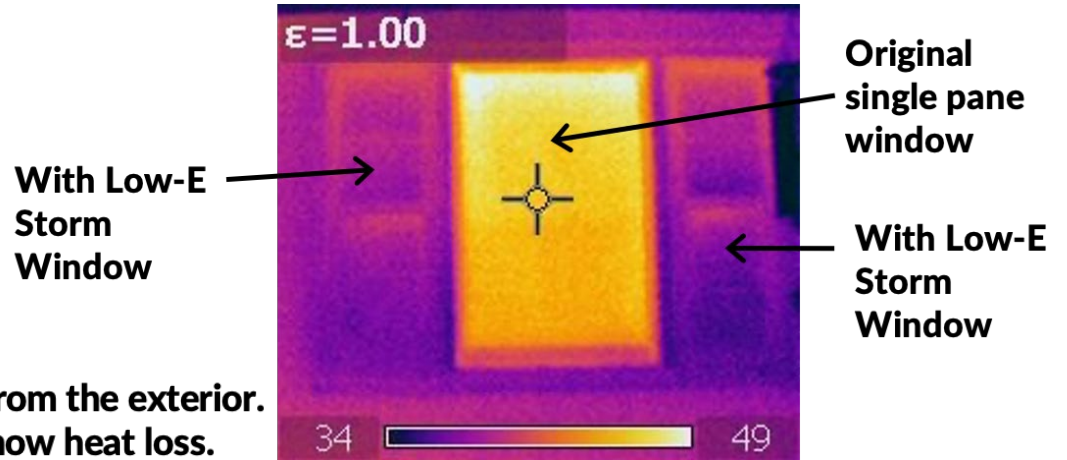
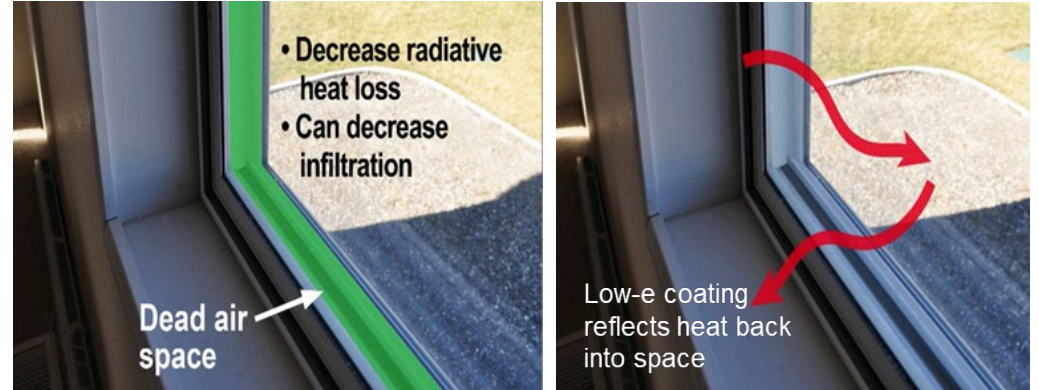


Image taken from the exterior.  
Light colors show heat loss.



# MODERN STORM WINDOWS

Your grandmother's traditional seasonal storm window



Aluminum-framed self-storing storm window and screen



High-performance operable low-e exterior storm window



Operable low-e interior storm window



Modern Low-E coatings

Added comfort

Operable and fixed models

Year-round energy savings

Reduce home air leakage

Reduce outdoor noise

Aesthetically pleasing



# THE MODERN STORM WINDOW SOLUTION



- Aesthetically pleasing
- Operable or fixed
- Interior or Exterior
- Improved comfort and acoustics
- Permanent year-round installation

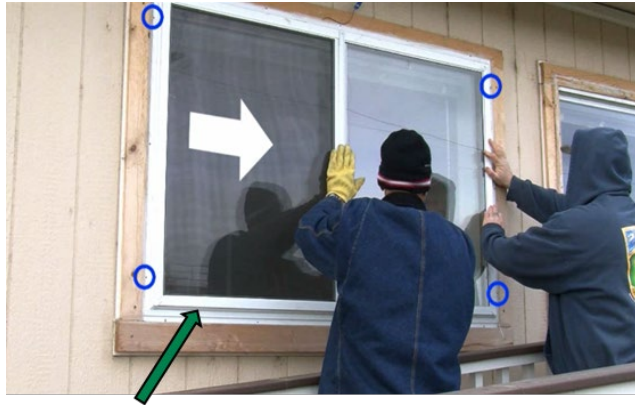
- Cost ~1/3 of the cost of full window replacement
- **Insulation and air sealing measure**
- Similar energy savings to full window replacement
- Options with low-e glass, films, and acrylic panels



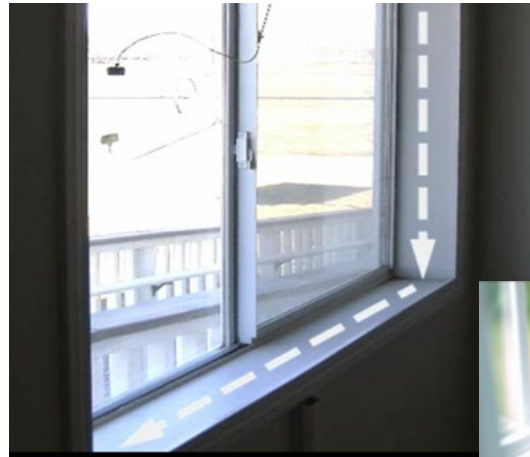
Images courtesy of Indow, Alpen, Quantapanel, and Larson.

# SIMPLE INSTALLATION

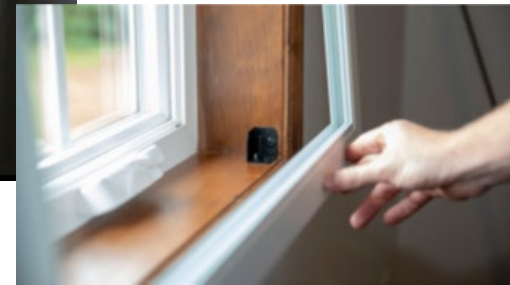
Straightforward, minimally invasive installation requires only a measuring tape, caulk, and screwdriver



Weep holes on exterior panels allow any water or condensation buildup to drain



Interior panels are measured to fit into window opening, mounted up to a blind stop





# DOE STORM WINDOW 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<sub>50</sub> 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<sub>50</sub>)



## 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

# MISSION: LEAVE NO POOR-PERFORMING WINDOW BEHIND



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.





# MINNEAPOLIS STORM WINDOW PILOT



# MINNEAPOLIS CASE STUDY

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



# BLOWER DOOR TESTING

- Measure of a home's leakiness
- Membrane with blower in front doorway
- Air blown out to a static pressure of 50 Pascals
- airflow logged in cubic feet per minute (**CFM50**)



# STORM WINDOW RETROFIT OPTIONS

## Exterior Storm Windows



Operable or fixed exterior storm window (low-e or clear glass)

## Interior Secondary Window Panels



Operable low-e interior panel



Interior acrylic panel with compression weatherstripping (fixed, but removable)



# SINGLE-FAMILY INTERIOR STORM INSERT (Acrylic)

Home Characteristics:

- Home Size: 3800 sq. ft.
- Single-Family
- Glazed Area: 341 sq. ft.
- Window Count: 25



# SINGLE-FAMILY INTERIOR STORM INSERT (ACRYLIC)

Air Leakage Improvement:

- Whole-building CFM50: **18.6%**
- Per window: 38 CFM50
- Per glazed sq. ft.: **2.8 CFM50**



# SINGLE-FAMILY EXTERIOR STORM WINDOW

Home Characteristics:

- Home Size: 3200 sq. ft.
- Single-Family
- Glazed Area: 268 sq. ft.
- Window Count: 31





# SINGLE-FAMILY EXTERIOR STORM WINDOW

Air Leakage Improvement:

- Whole-building CFM50: **9.8%**
- Per window: 11 CFM50
- Per glazed sq. ft.: **1.2 CFM50**



# MULTI-FAMILY #1 EXTERIOR STORM WINDOW (LOW-E)

Home Characteristics:

- Home Size: 4300 sq. ft.
- Units: 4-plex
- Glazed Area: 602 sq. ft.
- Window Count: 55



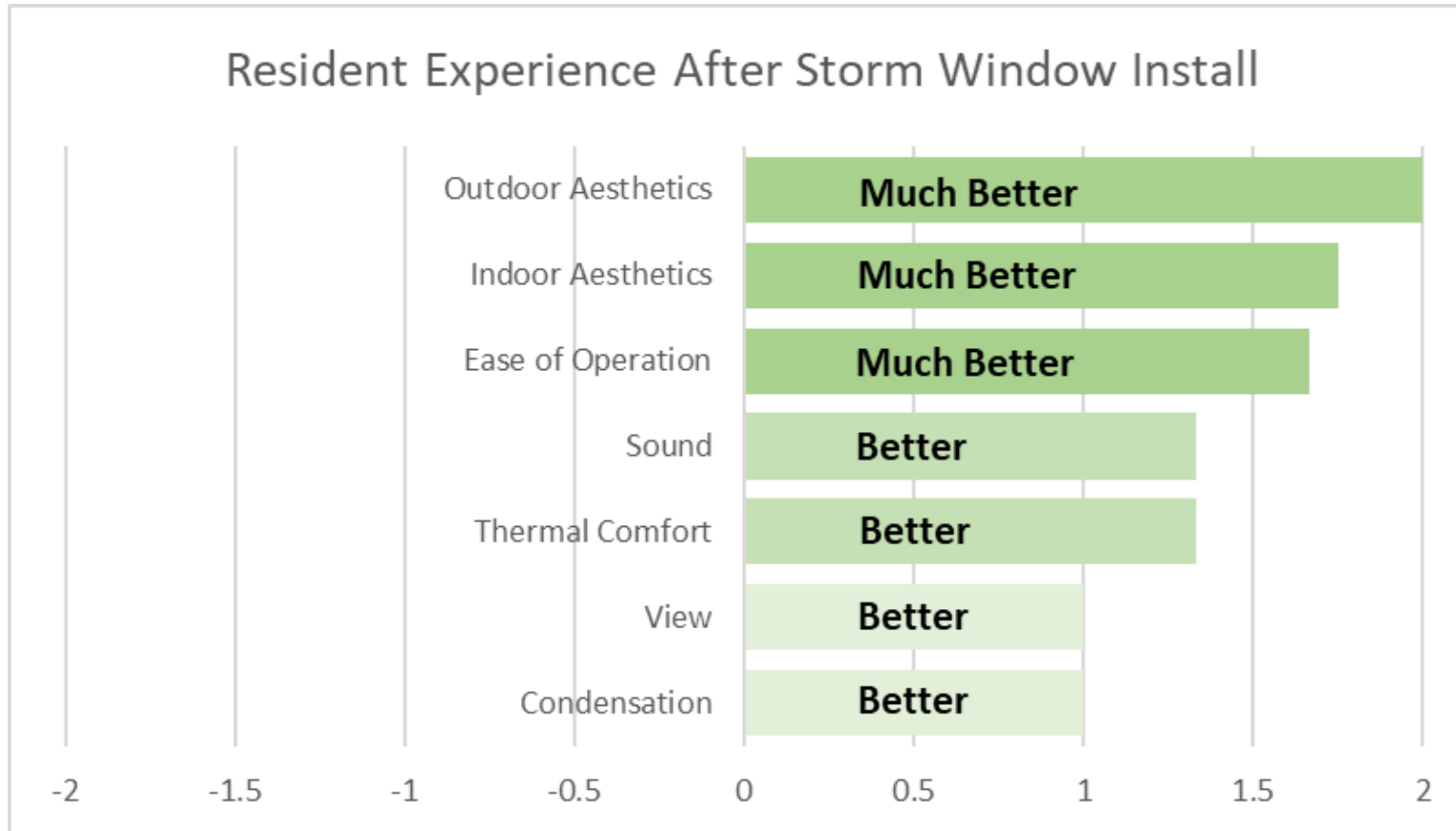
# MULTI-FAMILY #1 EXTERIOR STORM WINDOW (LOW-E)

Air Leakage Improvement:

- Whole-building CFM50: **18.9%**
- Per window: 27 CFM50
- Per glazed sq. ft.: **2.5 CFM50**



# TENANT FEEDBACK





# MULTI-FAMILY #2 EXTERIOR STORM WINDOW (LOW-E)

Home Characteristics:

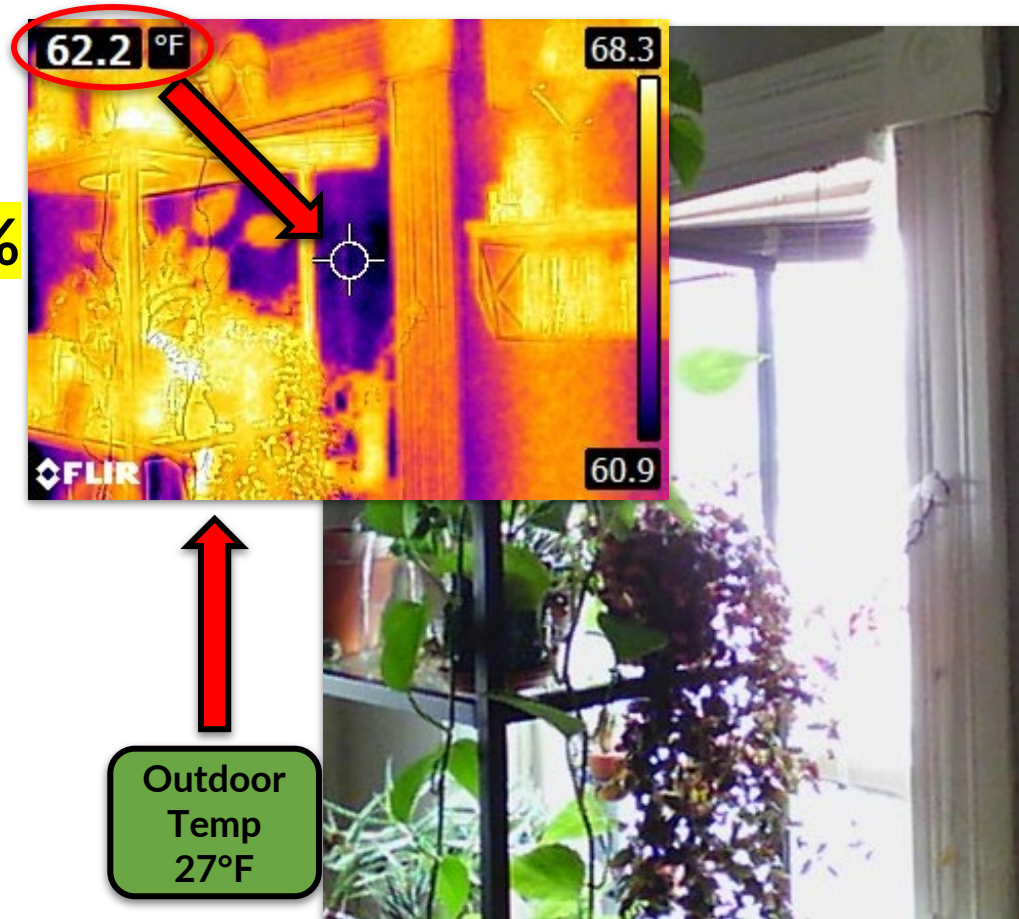
- Home Size: 1900 sq. ft.
- Units: Duplex
- Glazed Area: 259 sq. ft.
- Window Count: 29



# MULTI-FAMILY #2 EXTERIOR STORM WINDOW (LOW-E)

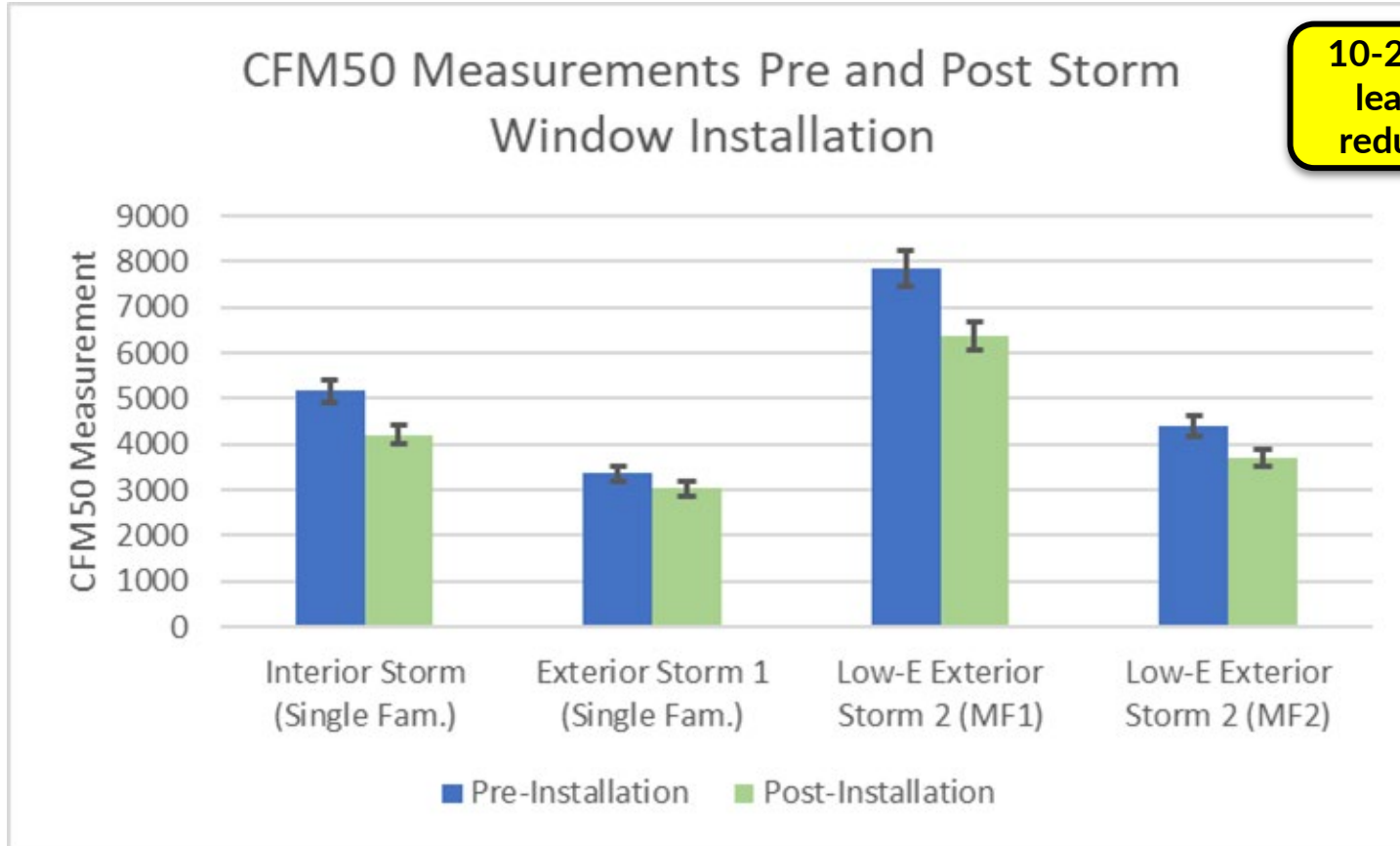
Air Leakage Improvement:

- Whole-building CFM50: **16.2%**
- Per window: 25 CFM50
- Per glazed sq. ft.: **2.8 CFM50**

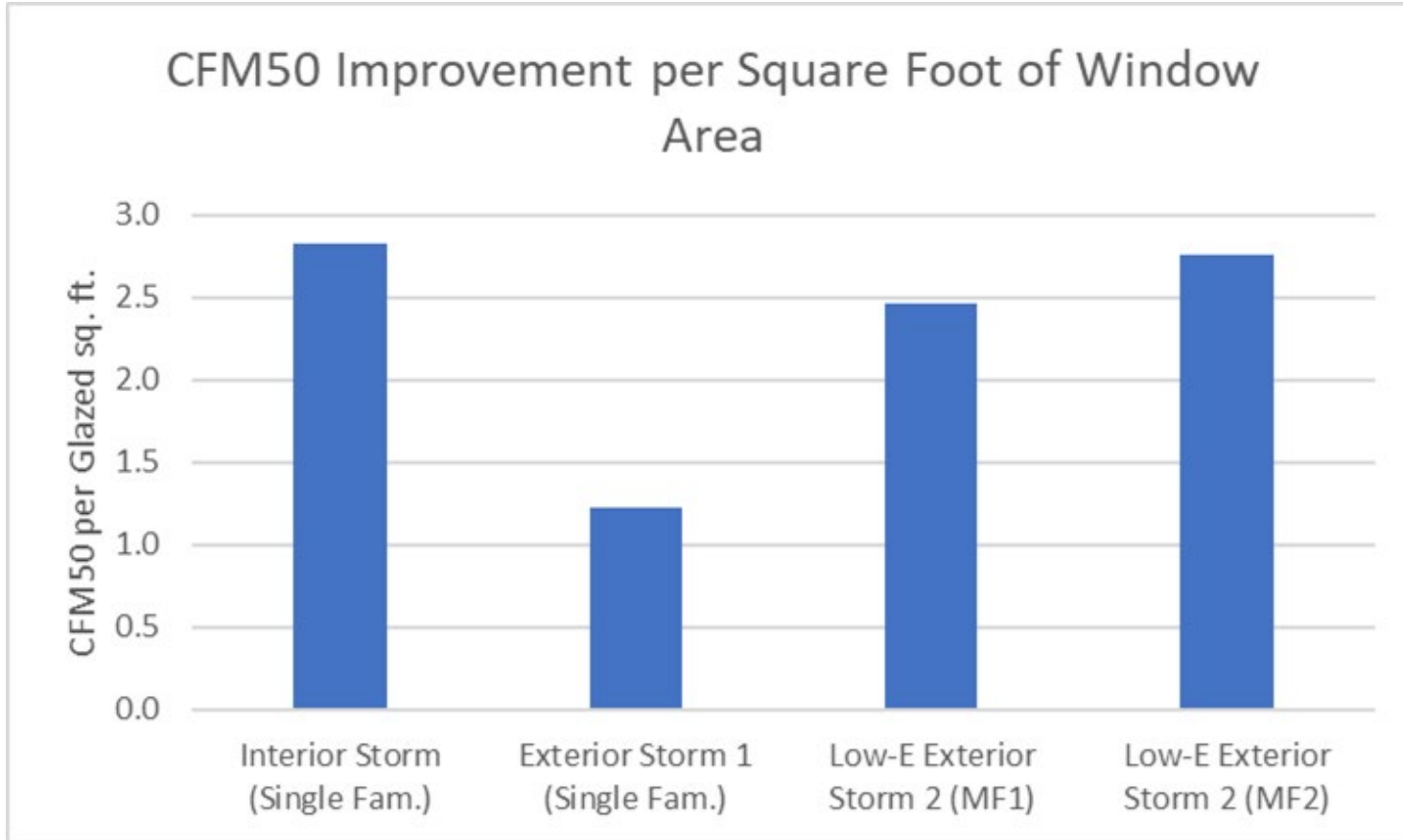




# MINNEAPOLIS STORM WINDOW PILOT RESULTS



# MINNEAPOLIS STORM WINDOW PILOT RESULTS



# Programs, Initiatives, Ratings, and Incentives

# APPLICATION - WEATHERIZATION

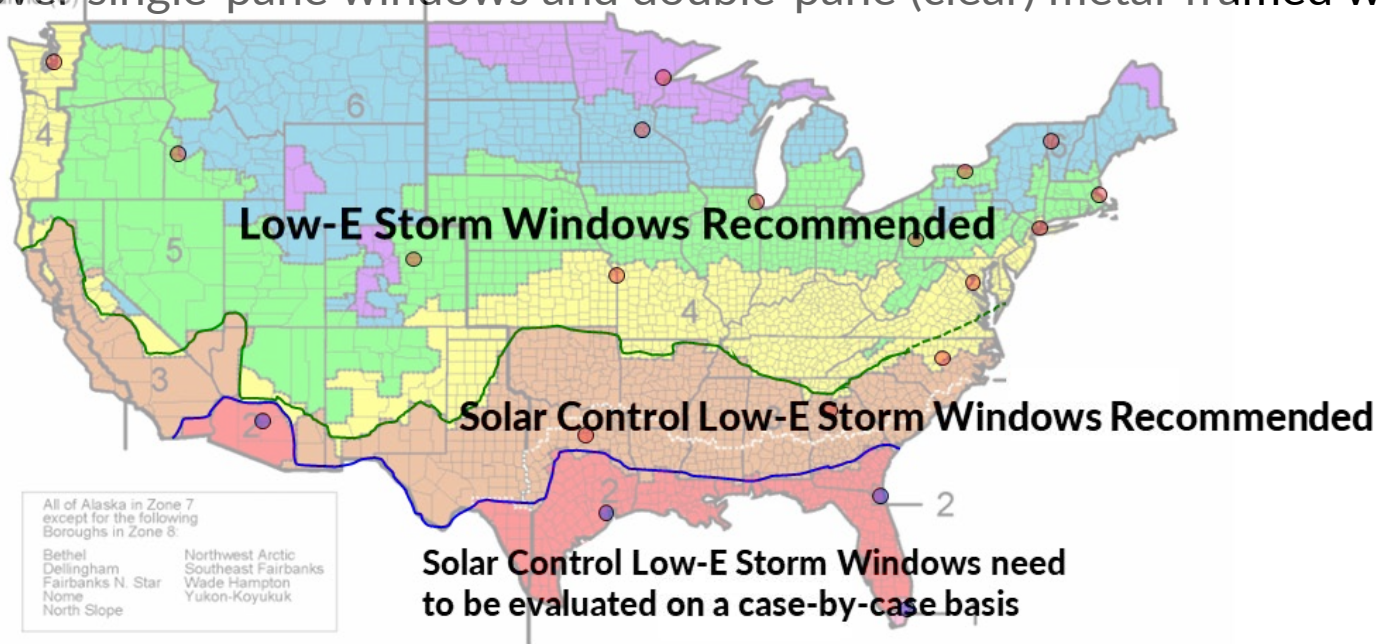
- 2009: Ability to include low-E storm windows added to NEAT/Weatherization Assistant software
- 2010: With DOE support, low-E storm windows added to Pennsylvania's Weatherization Measure Priority List for single-family homes
  - NEAT analysis for 37 home types in 4 cities
  - SIR 1.4-2.2 over single pane windows
  - SIR 1.3-2.1 over metal-framed dual pane windows
  - SIR much higher when using propane fuel



# COST-EFFECTIVENESS - WEATHERIZATION

NEAT / Weatherization Assistant analysis in 22 cities across all 8 climate zones.

Low-E storm windows are cost-effective in zones 3-8 with SIR 1.2-3.2 when installed over single-pane windows and double-pane (clear) metal-framed windows.



Over 30% of windows are single-pane in climate zones 3 through 8! <sup>2</sup>

<sup>1</sup>Culp et. al, 2014  
<sup>2</sup>DOE-EIA 2009

# SAMPLE NEAT RESULTS

## Pittsburg PA

- Wood frame house with vented crawl space
- R11 floor, R11 wall, R19 attic
- Single-pane wood windows

SIR changes based on climate and local fuel prices, but order is roughly the same for this particular model house.

## Annual Energy and Cost Savings

| Index | Recommended Measure  | Components      | Heating |      | Cooling |      | BaseLoad |      | Total   |
|-------|----------------------|-----------------|---------|------|---------|------|----------|------|---------|
|       |                      |                 | (MMBtu) | (\$) | (kWh)   | (\$) | (kWh)    | (\$) | (MMBtu) |
| 1     | Infiltration Redctn  |                 | 11.2    | 134  | -20     | -3   | 0        | 0    | 11.1    |
| 2     | Low Flow Showerheads |                 | 0.0     | 0    | 0       | 0    | 836      | 34   | 2.9     |
| 3     | DWH Pipe Insulation  |                 | 0.0     | 0    | 0       | 0    | 246      | 10   | 0.8     |
| 4     | Lighting Retrofits   | LT1,LT2,LT3,LT4 | 0.0     | 0    | 0       | 0    | 2169     | 278  | 7.4     |
| 5     | Smart Thermostat     |                 | 2.6     | 32   | 0       | 0    | 0        | 0    | 2.6     |
| 6     | DWH Tank Insulation  |                 | 0.0     | 0    | 0       | 0    | 260      | 11   | 0.9     |
| 7     | Storm Windows        | WD9,WD3,WD5,WD1 | 13.5    | 162  | 38      | 5    | 0        | 0    | 13.6    |
| 8     | Attic Ins. R-11      | A1              | 3.0     | 36   | 16      | 2    | 0        | 0    | 3.1     |
| 9     | A/C Tuneup           | AC1             | 0.0     | 0    | 578     | 74   | 0        | 0    | 2.0     |
| 10    | IID                  | HS1             | 2.8     | 33   | 0       | 0    | 0        | 0    | 2.8     |

## Energy Saving Measure Economics

| Index | Recommended Measure  | Components      | Measure Savings (\$/yr) | Measure Cost (\$) | Measure SIR | Cumulative Cost (\$) | Cumulative SIR |
|-------|----------------------|-----------------|-------------------------|-------------------|-------------|----------------------|----------------|
| 1     | Infiltration Redctn  |                 | 131                     | 150               | 7.4         | 150                  | 7.4            |
| 2     | Low Flow Showerheads |                 | 34                      | 40                | 10.4        | 190                  | 8.0            |
| 3     | DWH Pipe Insulation  |                 | 10                      | 15                | 7.2         | 205                  | 7.9            |
| 4     | Lighting Retrofits   | LT1,LT2,LT3,LT4 | 278                     | 194               | 7.1         | 399                  | 7.5            |
| 5     | Smart Thermostat     |                 | 32                      | 75                | 5.1         | 474                  | 7.1            |
| 6     | DWH Tank Insulation  |                 | 11                      | 40                | 2.8         | 514                  | 6.8            |
| 7     | Storm Windows        | WD9,WD3,WD5,WD1 | 167                     | 1386              | 1.9         | 1899                 | 3.2            |
| 8     | Attic Ins. R-11      | A1              | 38                      | 330               | 1.8         | 2229                 | 3.0            |
| 9     | A/C Tuneup           | AC1             | 74                      | 125               | 1.7         | 2354                 | 2.9            |
| 10    | IID                  | HS1             | 33                      | 225               | 1.2         | 2579                 | 2.8            |



# Modeling storm windows in NEAT

We can provide more details separately, but some hints:

- Don't confuse low-e storm windows with the "Low-E windows" or "Window replacement" measures, which have very different cost and SIR.
- Use "storm windows" measure, but for low-e storm windows, modify it under the Setup Library to have emittance = 0.16.
- Under Library Measures, make storm windows active, and enter the lifetime as 20 years.
- Air leakage reductions described earlier are not explicitly assigned to storm windows, but will hopefully be updated in future versions.
- For other software programs, preferably use ratings from the Attachments Energy Rating Council (AERC)  
<https://aercenergyrating.org/product-search>, or alternatively use representative "typical" values in PNNL report #24444

# MANUFACTURED HOMES

- Modeled Low-E Storm Windows in Manufactured Home Energy Audit (MHEA) to analyze:
  - Cost-effectiveness by savings-to-investment ratio (SIR)
  - Site energy savings
  - Utility bill savings
- Gain a better understanding of MHEA
  - Are default storm window parameters reflective of modern technology?
  - How difficult is it to model low-e storm windows?
  - How is window infiltration or air leakage reduction modeled?

\* Publication Pending

# MANUFACTURED HOMES

## Low-E Storm Windows: Savings-to-Investment Ratio (SIR)

| HVAC  | Climate Zone | City, State    | Primary Window                     |                                    |                          |
|---|--------------|----------------|------------------------------------|------------------------------------|--------------------------|
|   |              |                | Single-Pane, Wood- or Vinyl- Frame | Double-Pane, Wood- or Vinyl- Frame | Double-Pane, Metal-Frame |
| <b>Heat Pump</b><br>14 SEER<br>8.2 HSPF                       | 7            | Duluth, MN     | 3.2                                | 1.3                                | 1.6                      |
|   | 6A           | Burlington, VT | 3.5                                | 1.5                                | 1.8                      |
|   | 5A           | Boston, MA     | 2.2                                | 1                                  | 1.1                      |
|   | 4C           | Seattle, WA    | 0.7                                | 0.3                                | 0.4                      |
|   | 3A           | Atlanta, GA    | 0.6                                | 0.2                                | 0.3                      |
| <b>Central AC/<br/>Propane Furnace</b><br>13 SEER<br>80% AFUE | 7            | Duluth, MN     | 5.6                                | 2.4                                | 2.7                      |
|   | 6A           | Burlington, VT | 6.4                                | 2.8                                | 3.2                      |
|   | 5A           | Boston, MA     | 4.7                                | 2                                  | 2.4                      |
|   | 4C           | Seattle, WA    | 3.1                                | 1.2                                | 1.4                      |
|   | 3A           | Atlanta, GA    | 2.0                                | 0.8                                | 1.0                      |

\* Includes heating and cooling energy savings

# MANUFACTURED HOMES

## Low-E Storm Windows: Heating Utility Bill Savings

| HVAC  | Climate Zone | City, State    | Primary Window                     |                                    |                           |
|---|--------------|----------------|------------------------------------|------------------------------------|---------------------------|
|   |              |                | Single-Pane, Wood- or Vinyl- Frame | Double-Pane, Wood- or Vinyl- Frame | Double-Pane, Metal- Frame |
| <b>Heat Pump</b><br>14 SEER<br>8.2 HSPF                       | 7            | Duluth, MN     | \$288                              | \$128                              | \$146                     |
|   | 6A           | Burlington, VT | \$364                              | \$157                              | \$180                     |
|   | 5A           | Boston, MA     | \$246                              | \$108                              | \$124                     |
|   | 4C           | Seattle, WA    | \$77                               | \$30                               | \$35                      |
|   | 3A           | Atlanta, GA    | \$54                               | \$22                               | \$26                      |
| <b>Central AC/<br/>Propane Furnace</b><br>13 SEER<br>80% AFUE | 7            | Duluth, MN     | \$417                              | \$185                              | \$211                     |
|   | 6A           | Burlington, VT | \$467                              | \$202                              | \$232                     |
|   | 5A           | Boston, MA     | \$354                              | \$159                              | \$181                     |
|   | 4C           | Seattle, WA    | \$227                              | \$92                               | \$106                     |
|   | 3A           | Atlanta, GA    | \$143                              | \$61                               | \$70                      |

\* Includes heating utility bill savings only



# AUDIT TOOL OBSERVATIONS

| Name                                     | Value | Units         |
|--|-------|---------------|
| Window U-value - 1-glazing, Winter       | 0.93  | Btu/F-sqft-hr |
| Window U-value - 1-glazing, Summer       | 0.93  | Btu/F-sqft-hr |
| Window U-value - 1/plastic storm, Winter | 0.53  | Btu/F-sqft-hr |
| Window U-value - 1/plastic storm, Summer | 0.53  | Btu/F-sqft-hr |
| Window U-value - 1/glass storm, Winter   | 0.48  | Btu/F-sqft-hr |
| Window U-value - 1/glass storm, Summer   | 0.48  | Btu/F-sqft-hr |
| Window U-value - 2-glazing, Winter       | 0.57  | Btu/F-sqft-hr |
| Window U-value - 2-glazing, Summer       | 0.57  | Btu/F-sqft-hr |
| Window U-value - 2/plastic storm, Winter | 0.43  | Btu/F-sqft-hr |
| Window U-value - 2/plastic storm, Summer | 0.43  | Btu/F-sqft-hr |
| Window U-value - 2/glass storm, Winter   | 0.38  | Btu/F-sqft-hr |
| Window U-value - 2/glass storm, Summer   | 0.38  | Btu/F-sqft-hr |
| Skylight U-value - 1-glazing, Winter     | 1.15  | Btu/F-sqft-hr |
| Skylight U-value - 1-glazing, Summer     | 0.8   | Btu/F-sqft-hr |
| Skylight U-value - 1/plstc storm, Winter | 0.5   | Btu/F-sqft-hr |
| Skylight U-value - 1/plstc storm, Summer | 0.36  | Btu/F-sqft-hr |
| Skylight U-value - 1/glass storm, Winter | 0.52  | Btu/F-sqft-hr |
| Skylight U-value - 1/glass storm, Summer | 0.38  | Btu/F-sqft-hr |
| Skylight U-value - 2-glazing, Winter     | 0.7   | Btu/F-sqft-hr |

Screenshot from Weatherization Assistant 8.9.0.5

## No Low-E Storm Window Measure

- Plastic and clear glass storm windows only
- Needs updated performance, cost, and lifetime values

## Modifications to MHEA setup library necessary

- U-Values (Btu/°F-sqft-hr)
  - Single pane w/glass storm 0.48 to 0.36
  - Double pane w/glass storm 0.38 to 0.29-0.33\*
- No input for Solar Heat Gain Coefficient

\* Depending on frame material (metal or wood/vinyl)

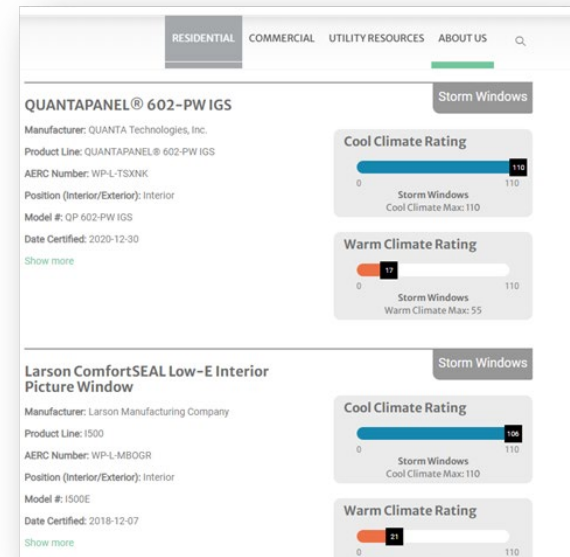
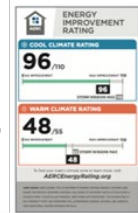
# Where get Product Info?

**EPA ENERGY STAR®** program for exterior and interior storm windows

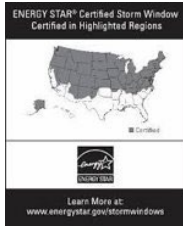
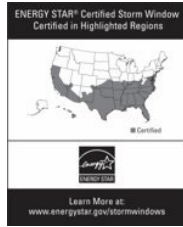
<https://www.energystar.gov/productfinder/product/certified-storm-windows/>

**Attachments Energy Rating Council (AERC)** certification program for storm windows and commercial secondary windows.

<https://aercenergyrating.org/product-search/>



# Energy-Rated Products



20 Records Found

Filter Your Results

filter by keyword

ENERGY STAR Partner®

- Chosen Wood Window Maintenance, Inc (1)
- QUANTA Technologies, Inc. (19)

Brand Name®

- Chosen (1)
- QUANTAPANEL (19)

Product Type®

- Exterior Storm Window (10)
- Interior Storm Window (10)

ENERGY STAR Storm Window Zone®

- Northern (17)
- Southern (3)

Operator type®

- Fixed/Stationary/Picture (6)
- Horizontal Slider (2)
- Vertical Slider/Single-Double Hung (12)

Sort by: Emissivity

Share Your Results

No repeats for Storm Windows found in ( 99338 ) - click here to search other areas >>

**QUANTA Technologies, Inc. : QUANTAPANEL - 506-SL Architectural Low-e Storm Window N**  Compare

Product Type: Exterior Storm Window ENERGY STAR Storm Window Zone: Northern

Operator type: Vertical Slider/Single-Double Hung

Emissivity: 0.16 Solar Transmittance: 0.74

[CLICK FOR PRODUCT DETAILS](#)

**QUANTA Technologies, Inc. : QUANTAPANEL - 605-DH Architectural Low-e Storm Window**  Compare

Product Type: Interior Storm Window ENERGY STAR Storm Window Zone: Northern

Operator type: Vertical Slider/Single-Double Hung

Emissivity: 0.16 Solar Transmittance: 0.74

[CLICK FOR PRODUCT DETAILS](#)

**QUANTA Technologies, Inc. : QUANTAPANEL - 502-PW Architectural Low-e Storm Window N**  Compare

Product Type: Exterior Storm Window ENERGY STAR Storm Window Zone: Northern

Operator type: Fixed/Stationary/Picture

Emissivity: 0.16 Solar Transmittance: 0.74

[CLICK FOR PRODUCT DETAILS](#)

ENERGY IMPROVEMENT

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Refine Search Clear Filter

Product Category:

- Awnings
- Blinds
- Cellular Shades
- Heated Shades
- Roller Shades
- Roller Shutters
- Roman Shades
- Solar Screens
- Storm Windows
- All

Position

- Exterior
- Interior

Energy Performance

Cool Climate Rating

Warm Climate Rating

U Factor

Search Results

1-20 of 38 products

Sort by A to Z

Expert as CSV

**1/4" Low-e SLIP** Storm Windows

Manufacturer: Chosen Wood Window Maintenance, Inc

Product Line: Slim Line Insulating Panel (SLIP)

AERC Number: WP-L-05YY0

Position (Interior/Exterior): Exterior

Model #: 4

Date Certified: 2022-04-07

Show more

Cool Climate Rating: Storm Windows Cool Climate Max: 110

Warm Climate Rating: Storm Windows Warm Climate Max: 53

**1/4" SLIP** Storm Windows

Manufacturer: Chosen Wood Window Maintenance, Inc

Product Line: Slim Line Insulating Panel (SLIP)

AERC Number: WP-L-UGFPY

Position (Interior/Exterior): Exterior

Model #: 3

Date Certified: 2022-04-07

Show more

Cool Climate Rating: Storm Windows Cool Climate Max: 110

Warm Climate Rating: Storm Windows Warm Climate Max: 53

# EXISTING BUILDINGS - BUILDING PERFORMANCE STANDARDS

**New local action to address climate change by addressing existing buildings.**

- Energy Disclosure Laws
- Building Performance Standards - limits on existing building energy use or emissions

**Building Performance Standards have been enacted in:**

- New York City (carbon limits starting 2024)
- St. Louis (energy use limits starting 2025)
- Boston (carbon limits starting 2025)
- Washington State (energy use limits starting 2026)
- District of Columbia (energy use limits starting 2026)
- Colorado (limits still in development, targeting 2025)

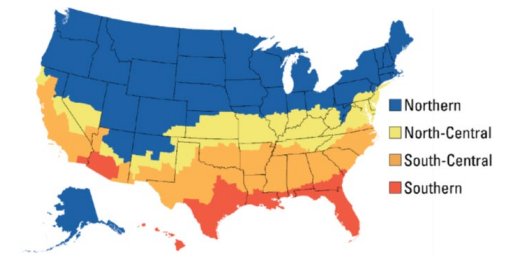
Fines start 2025-2026 ... but building owners have already started planning

**Large incentive to upgrade existing buildings, including envelope & windows!**





# ENERGY STAR Windows (V7)



## Version 6

| Climate Zone  | U-Factor    | SHGC        |                               |
|---------------|-------------|-------------|-------------------------------|
| Northern      | $\leq 0.27$ | Any         | Prescriptive                  |
|               | $= 0.28$    | $\geq 0.32$ | Equivalent Energy Performance |
|               | $= 0.29$    | $\geq 0.37$ |                               |
|               | $= 0.30$    | $\geq 0.42$ |                               |
|               |             |             |                               |
| North-Central | $\leq 0.30$ | $\leq 0.40$ |                               |
| South-Central | $\leq 0.30$ | $\leq 0.25$ |                               |
| Southern      | $\leq 0.40$ | $\leq 0.25$ |                               |



## Version 7

Effective **October 20, 2023!**

| Climate Zone  | U-Factor <sup>1</sup> | SHGC <sup>2</sup> |                               |
|---------------|-----------------------|-------------------|-------------------------------|
| Northern      | $\leq 0.22$           | $\geq 0.17$       | Prescriptive                  |
|               | $= 0.23$              | $\geq 0.35$       | Equivalent Energy Performance |
|               | $= 0.24$              |                   |                               |
|               | $= 0.25$              | $\geq 0.40$       |                               |
|               | $= 0.26$              |                   |                               |
| North-Central | $\leq 0.25$           | $\leq 0.40$       |                               |
| South-Central | $\leq 0.28$           | $\leq 0.23$       |                               |
| Southern      | $\leq 0.32$           | $\leq 0.23$       |                               |

Air Leakage for windows  $\leq 0.3$  cfm/ft<sup>2</sup>

<sup>1</sup> Btu/h ft<sup>2</sup>·°F

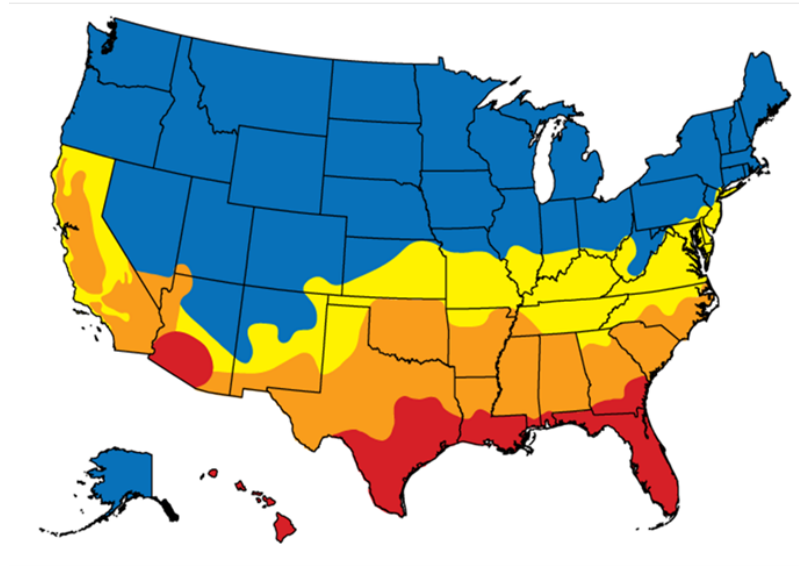
<sup>2</sup> Solar Heat Gain Coefficient

# ENERGY STAR Climate Zone Map

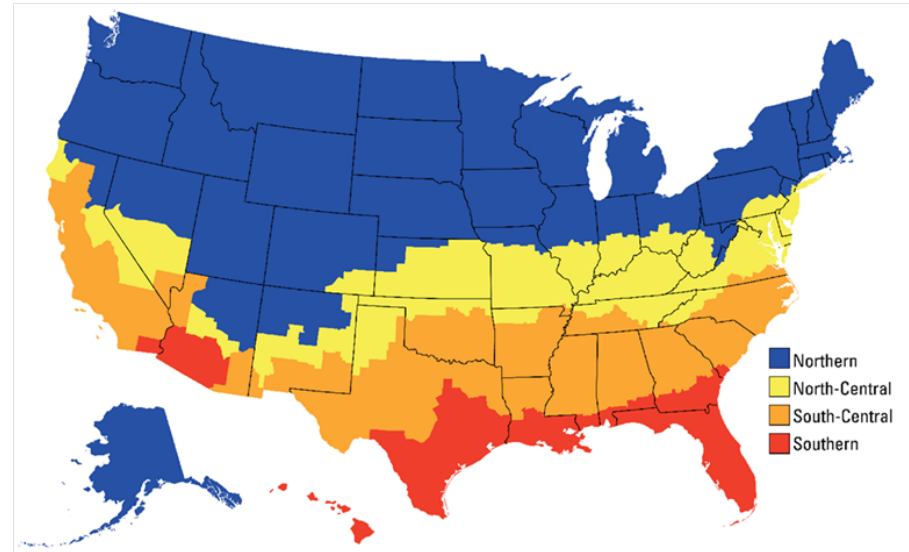
## Final Version 7 Climate Zone Map

**Note:** EPA has developed a web-based tool to identify your climate zone

Version 6 Climate



New - Version 7 Climate Zones



Zone changes based on IECC 2021  
- with adjusted zone islands

7

# MINNESOTA-SPECIFIC UTILITY WINDOW REBATES

New MN rebates in 2024!

| Utility                    | Rebate Requirements                                | Application                     | Rebate Amount  | Type              |
|----------------------------|--|---------------------------------|----------------|-------------------|
| CenterPoint Energy         | ENERGY STAR v.7 windows, ENERGY STAR storm windows | Retrofit/Existing Homes         | \$15           | Contractor Rebate |
| Minnesota Power            | ENERGY STAR v.7 windows                            | Retrofit/Existing Homes         | \$15           | Homeowner Rebate  |
| Otter Tail                 | ENERGY STAR v.7 windows                            | Retrofit/Existing Homes         | \$25           | Homeowner Rebate  |
| Minnesota Energy Resources | ENERGY STAR v.7 windows                            | New Homes and Retrofit/Existing | \$50 / \$75 LI | Homeowner Rebate  |

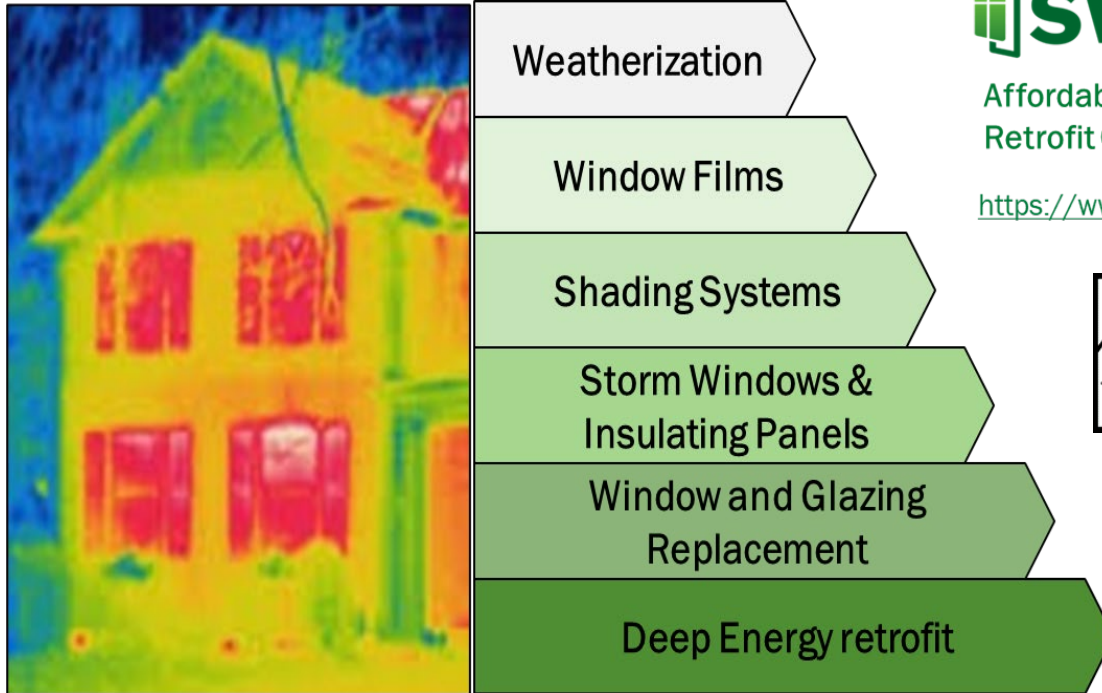
ENERGY STAR Homes v3.2: **\$2,500** tax credit

ZERH: **\$5,000** tax credit (SB2030 requires ZERH for buildings <20,000 sqft)

ENERGY STAR Most Efficient: **\$600** tax credit / year, up to 30% of cost



# Affordable Window Retrofit Options and Initiatives



**SWIP**  
Affordable Window  
Retrofit Campaign

<https://www.energy.gov/>

**PAWS**  
PARTNERSHIP FOR ADVANCED  
WINDOW SOLUTIONS

<https://paws.energy/>





**QUESTIONS?**

# | THANK YOU

## CONNECT WITH ME:

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# APPENDIX: MINNEAPOLIS STORM WINDOW PILOT TABULATED RESULTS

|                               | Interior Storm<br>(Single-Family Site 1) | Exterior Storm mfg 1<br>(Single-Family Site 2) | Exterior Storm mfg 2<br>(Multi-Family Site 1) | Exterior Storm mfg 2<br>(Multi-Family Site 2) |
|-------------------------------|--|--|---|---|
| Home Sq. Ft.                  | 3792                                     | 3238   | 4290  | 1877  |
| Window Count                  | 25                                       | 31   | 55  | 29  |
| Glazed sq. ft.                | 341                                      | 268  | 602   | 259   |
| Pre CFM50                     | 5162                                     | 3356   | 7857  | 4405  |
| Post CFM50                    | 4200                                     | 3026   | 6373  | 3692  |
| Difference                    | 962                                      | 330  | 1484  | 713   |
| Percentage Reduction          | 18.6%                                    | 9.8%   | 18.9%   | 16.2%   |
| cfm50 per Window              | 38                                       | 11   | 27  | 25  |
| cfm50 per sq. ft. glazed area | 2.8                                      | 1.2  | 2.5   | 2.8   |