

April 25, 2024

# GPG Outbrief 32

## Insulating Panels for Operable Windows

Green Proving Ground | Pacific Northwest National Laboratory



# »» How to Ask Questions

Click the Q&A button to ask questions.

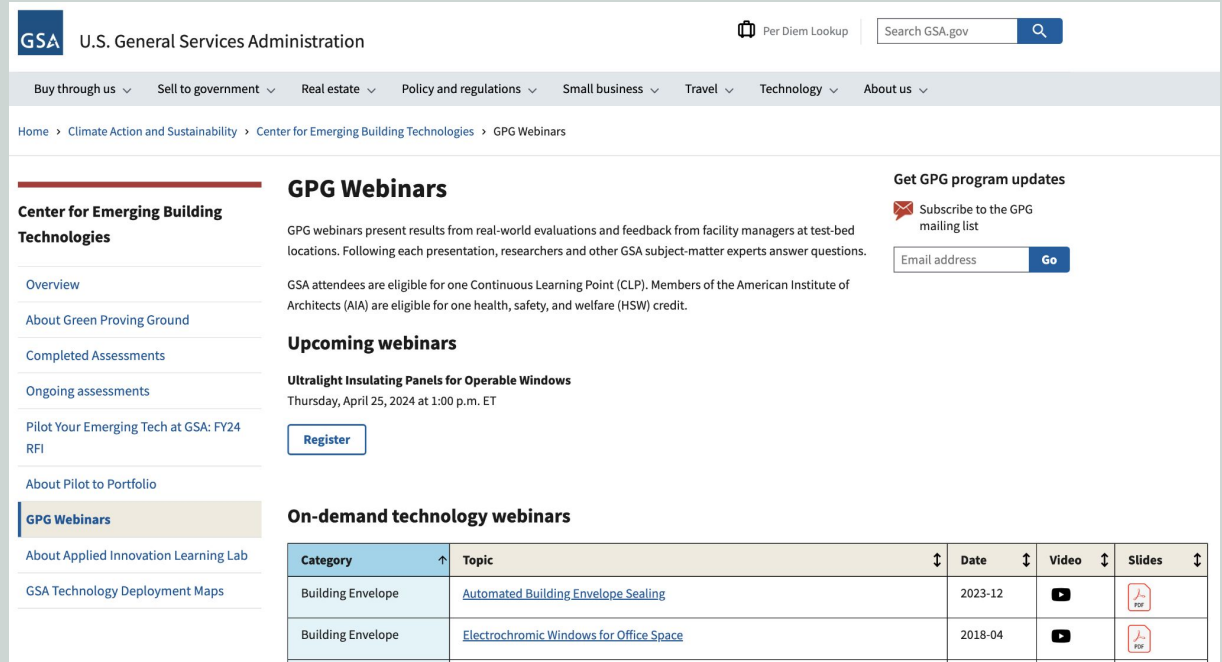


# » Webinar Recording and Slides

@ gsa.gov/gpg

The webinar is being recorded.

The recording and slides will be shared by email and posted to gsa.gov.



The screenshot shows the GSA website's "GPG Webinars" page. The header includes the GSA logo, "U.S. General Services Administration", a "Per Diem Lookup" button, and a search bar. A navigation menu lists various categories like "Buy through us", "Sell to government", etc. The main content area is titled "GPG Webinars" and includes a description of the program, eligibility information, and a "Register" button for an upcoming webinar on "UltraLight Insulating Panels for Operable Windows". A table of "On-demand technology webinars" is also present, listing two past webinars with their dates, video links, and slide links.

**Center for Emerging Building Technologies**

- Overview
- About Green Proving Ground
- Completed Assessments
- Ongoing assessments
- Pilot Your Emerging Tech at GSA: FY24 RFI
- About Pilot to Portfolio
- GPG Webinars**
- About Applied Innovation Learning Lab
- GSA Technology Deployment Maps

### GPG Webinars

GPG webinars present results from real-world evaluations and feedback from facility managers at test-bed locations. Following each presentation, researchers and other GSA subject-matter experts answer questions.

GSA attendees are eligible for one Continuous Learning Point (CLP). Members of the American Institute of Architects (AIA) are eligible for one health, safety, and welfare (HSW) credit.

#### Upcoming webinars

**UltraLight Insulating Panels for Operable Windows**  
Thursday, April 25, 2024 at 1:00 p.m. ET

[Register](#)

#### On-demand technology webinars

Category	Topic	Date	Video	Slides
Building Envelope	<a href="#">Automated Building Envelope Sealing</a>	2023-12		
Building Envelope	<a href="#">Electrochromic Windows for Office Space</a>	2018-04		

# » GPG-054 Ultralight Insulating Panels for Operable Windows

- Infographic
- 4-Page Brief
- Full Report

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Home > Climate Action and Sustainability > Center for Emerging Building Technologies > Completed Assessments > Building Envelope > Insulating Window Panels

## Insulating Window Panels

Windows, especially single-pane windows, are the weakest energy efficiency link in a building envelope. Secondary windows can improve performance without the expense of window replacement.

Researchers from the Pacific Northwest National Laboratory evaluated ultralight insulating panels that attach to existing windows and maintain window operability. They found that the technology was easy to install and improved the window's insulating performance by 52%. [View full-size infographic \(PDF - 302 KB\)](#).

### REPORT

- [4-Page Brief \(PDF - 489 KB\)](#)
- [Full Report \(PDF - 3 MB\)](#)

### WEBINAR

- [Register for upcoming webinar](#) - April 25, 2024 at 1:00 p.m. ET

### ADDITIONAL RESOURCES

- [Presentation: Enhancing Window Performance with Energy Efficient Attachments \(AERC, 05-2020\) \(PDF\)](#)
- [Presentation: Secondary Windows Products \(NEEA, 2020\) \(PDF\)](#) found on [Lightweight Secondary Windows](#)

### Center for Emerging Building Technologies

Overview

About Green Proving Ground

#### Completed Assessments

- Building Envelope
  - Automated Building Envelope Sealing
  - Chromogenic Windows
  - Dual-Zone Indoor Shades
  - EC Windows for LPOE
  - EC Windows for Office Space
  - Hi-R Window System
  - Insulating Window Panels**
  - Low-E Window Film
  - Quad-Pane Windows
  - Secondary Windows
  - Solar Control Films
  - Vacuum Insulated Panels
- Energy Management
- HVAC
- Lighting

### OPPORTUNITY

How much energy do windows use?

**34%** OF COMMERCIAL ENERGY USE IS ATTRIBUTED TO WINDOWS!

### TECHNOLOGY

How do window insulation panels work?

#### SNAP-ON PANELS

Ultra-light (0.17 lbs/ft<sup>2</sup>) panels mount to the interior glass surface of existing windows.

Two versions: one for shaded facades/cold climates and one with a coating to block solar heat gain for sunny facades/warm climates.

Made with low-embodied carbon materials that can be recycled.

### M&V

Where did Measurement and Verification occur?

**PACIFIC NORTHWEST NATIONAL LABORATORY (PNNL)** assessed the impact of window insulation panels, provided by WexEnergy, at the Eau Claire Federal Building and Courthouse in Eau Claire, Wisconsin.



# »» Webinar Agenda

## Logistics

Andrea Silvestri, GSA Green Proving Ground

## Introduction (5 minutes)

Erin Lannon, Program Manager, Applied Innovation Learning Lab

## Evaluation of Ultralight Insulating Panels for Operable Windows (30 minutes)

Edward Louie, Researcher and Michael Myer, Principal Investigator, Pacific Northwest National Laboratory

## On-the-Ground Feedback (5 minutes)

Daniel Carroll, Eau Claire Property Manager

## Q&A (15 minutes)

# »» Welcome



**Erin Lannon**

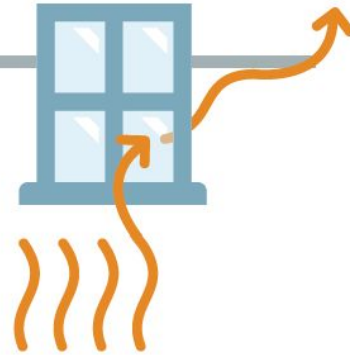
Program Manager, Applied Innovation Learning Lab

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## » Opportunity

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**34%** OF COMMERCIAL ENERGY USE  
IS ATTRIBUTED TO WINDOWS<sup>1</sup>



# » Can Support GSA's Climate Goals

Improving building envelope insulation can be critical for building electrification

## **E.O. 14057: Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability**

**2030** | 100% carbon pollution-free electricity (CFE)  
| 65% reduction of operational GHG (2008 baseline)

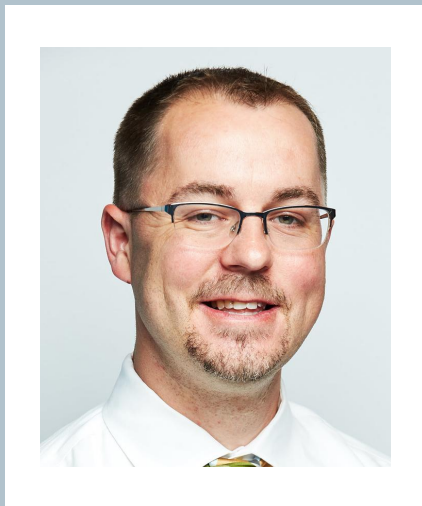
**2045** | Net zero carbon operations across building portfolio

## **Federal Building Performance Standard**

**2030** | 30% of portfolio eliminates scope 1 emissions



# »» Measurement & Verification



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GPG-054

# Ultralight Insulating Panels for Operable Windows

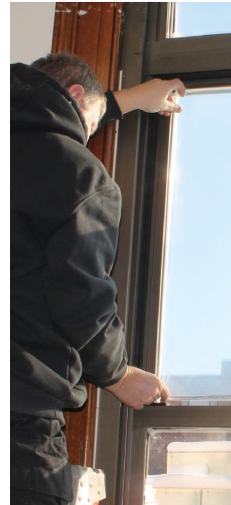
Michael Myer, Edward Louie, Ammar Dehwah  
Pacific Northwest National Laboratory

General Services Administration  
Public Buildings Service



GPG-054 | FEBRUARY 2024

## ULTRALIGHT INSULATING PANELS FOR OPERABLE WINDOWS



### Improves Window Performance While Maintaining Operability

Windows are responsible for 34% of all commercial space conditioning energy use, equivalent to roughly 1.5% of the total U.S. energy consumption.<sup>1</sup> Windows typically have a long life (25 to 35 years), but as double- and triple-pane windows age, the seals can start to fail, causing the gas between the glass panes to escape, reducing the thermal insulating properties of the window. Furthermore, because window replacement is costly, particularly in older buildings where lead paint and asbestos must be remediated, windows often remain in place for more than 50 years. Ultralight window insulation panels snap on the interior glass surface, simplifying retrofit installation. The panels create an air gap between the glass and plastic panel to minimize conductive and convective heat loss, and the windows remain operable, which can be important for climate control, compliance with local building codes, and egress. GSA collaborated with the Pacific Northwest National Laboratory (PNNL) to evaluate the performance of window insulation panels at a federal building and courthouse in Eau Claire, Wisconsin. Researchers found that the technology improved the window's insulating performance by 52%. The window insulation panels also increased the interior winter surface temperature by 7°F on average. Modeled whole building savings ranged between 2% and 7% for cold climates and 4% and 7% for warm climates. At current GSA utility rates (\$0.13/kWh for electricity and \$9.10/MMBtu for gas), warm climates had the best return on investment.

The GPG program enables GSA to make sound investment decisions in next-generation building technologies based on their real-world performance.

# » Improving Performance Without Replacement

- Windows typically have a long life—25 to 35 years.
- As double- and triple-pane windows age, the seals can start to fail, causing the gas between the glass panes to escape and reducing the thermal insulating properties of the window.
- Window replacement is costly, particularly in older buildings where lead paint and asbestos must be remediated, so windows often remain in place for more than 50 years.

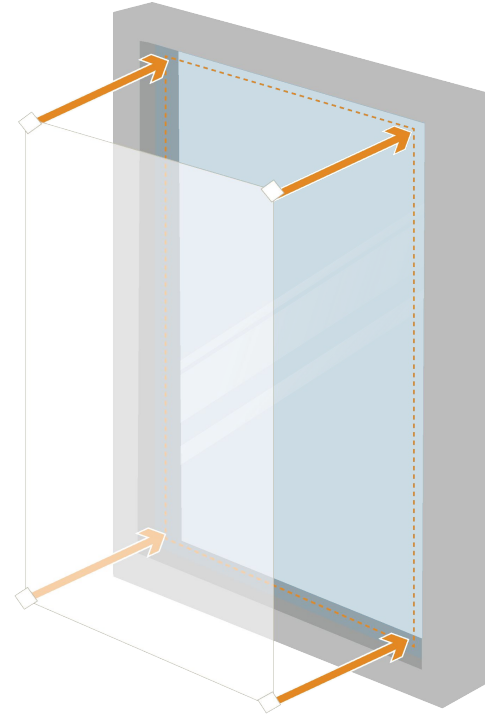


Condensation is between the panes of glass of the original window, indicating that the seal has failed.

# » How Do Insulating Panels for Operable Windows Work?

Transparent snap-on panels mount onto existing windows

- Panels mount to the interior glass surface of existing windows via small translucent snap-together connectors.
- Clear silicone sealant is applied to each corner to further secure the fasteners.
- Existing window remains operable, which can be important for climate control and egress.



# » Insulating Panels for Operable Windows from WexEnergy

## Panel features

- Made from thin (20 mil), ultra lightweight (0.17 lbs/ft<sup>2</sup>), copolyester plastic
- Two versions
  - One for shaded facades/cold climates
  - One with a coating to block solar heat gain for sunny facades/warm climates
- Panels are recyclable, made of plastic and low-carbon materials, and 100% made in America



## » Two profiles

Maintaining a window's operability may require the low-profile version

- The default high-profile design (0.6") creates a 0.5" gap of air space between the panel and the window, which maximizes the insulating value.
- The low-profile design (0.33") is 2–3% less insulating.



Corners of insulation panels have attachment devices.



Panel has metal edges and is a fraction of an inch in width.

## » Simplified Installation

- Involves few tools and no skilled labor
- Panels at Eau Claire were installed by GSA staff and took ~10 minutes/panel
- Installation was easier than other retrofits because the panels are ultralight and can be easily moved around furniture
- Existing film on windows needed to be removed to adhere the corner attachments
- Multiple panels (typically 10) are shipped in a box that can be moved by one or two people



# » Insulation Panel Properties

## PERFORMANCE SPECIFICATIONS

Ultralight Window Insulation Panel

### HIGH-PERFORMANCE PANEL: COLD CLIMATES

U-Factor (rated)	<b>0.8</b>
U-Factor (measured)	<b>0.6</b>
R-Value (rated)	<b>1.2</b>
R-Value (measured)	<b>1.7</b>
% Solar Heat Gain Reduction	<b>10%</b>
VT	<b>0.9</b>

### HIGH-PERFORMANCE PANEL: WARM CLIMATES

U-Factor (rated)	<b>0.7</b>
R-Value (rated)	<b>1.4</b>
% Solar Heat Gain Reduction	<b>35-50%*</b>
VT	<b>0.4</b>

U-factor values based on product attached to either a single-pane window or an older double-pane window that performs like a single-pane window

\*35% solar heat gain reduction on clear double-pane window and 50% reduction on clear single-pane.

U-Factor/R-Value = capacity to insulate

VT = visible light transmission



# » Insulating Panels for Operable Windows Testbed



## Federal Building and U.S. Courthouse Eau Claire, WI

- Built in 1909
- 37,000 ft<sup>2</sup>
- Listed in National Register of Historic Places
- Windows replaced in the 1980s with double-pane windows, many of seals had failed
- Cold and humid climate – Zone 6A

# » Evaluation Framework and Schedule

- October 2022: Retrofitted 75 windows, 287 individual lites, with 57 different sized insulation panels
- Building energy data 2021–2023
- M&V period: Nov. 1, 2022–Mar. 31, 2023
- Measured U-Factor, interior glass surface temperature, room temperature variation and energy use from the building heating system
- Assessed occupant comfort, ease of installation, and cost-effectiveness

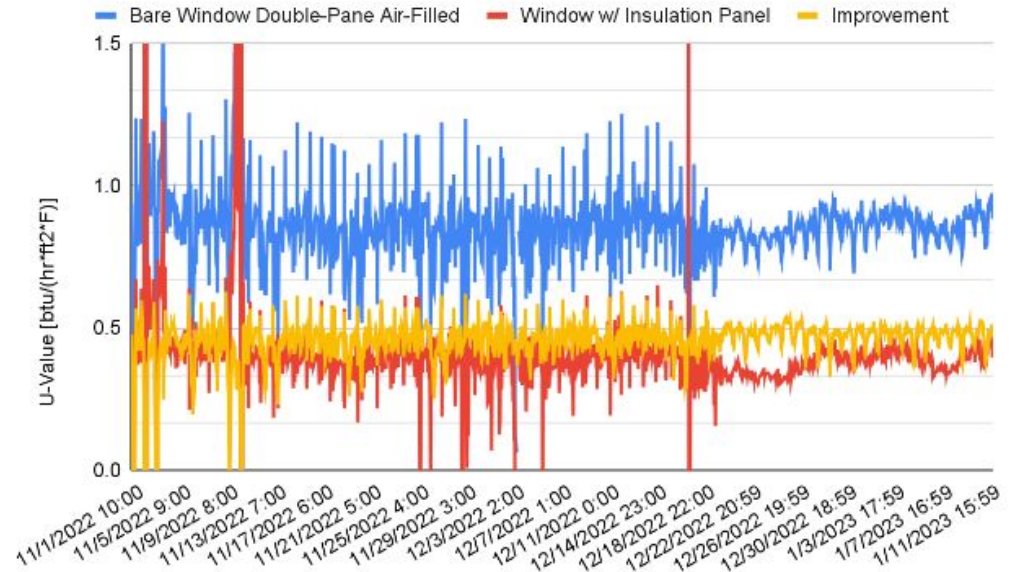


Window with heat flux sensors installed.

# » Improved Center of Glass U-Factor

Original window is double pane, but a U-Factor near 1.0 is the expected performance of a single-pane window demonstrating after 40 years, the window performance had degraded

Improved the insulation by 52%, from a center-of-glass U-Factor of 1.15 to 0.55.



# » Decreased Heat Loss in Perimeter Windows

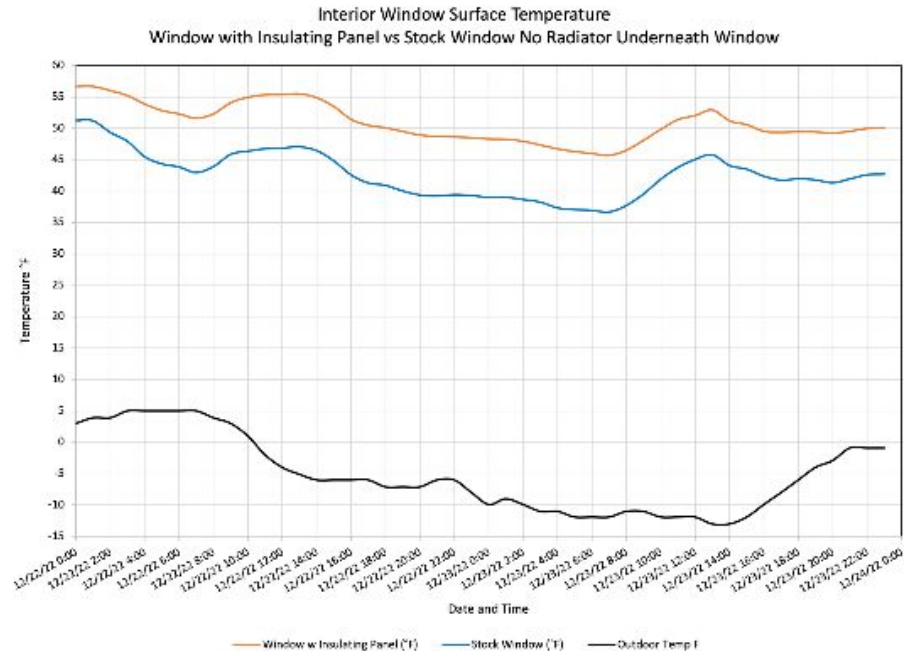
Slowed the room's natural cooldown due to heat loss by 31% during cold winter months

Perimeter Room	Baseline (2022)	With Insulation Panels (2023)	Change
<b>Room #20 2nd Court Room</b>	0.27	0.21	22%
<b>Room #21B Judge's Chambers</b>	0.49	0.36	27%
<b>Room #27 Jury Room</b>	1.7	0.90	47%
<b>Room #32 Trac Office</b>	0.9	0.60	33%
<b>Room #33 Amanda's Office</b>	0.72	0.55	24%
<b>Average</b>	0.82	0.52	31%

Rates of Cooling for the Perimeter Rooms (Decrease in Degrees Fahrenheit per Hour)

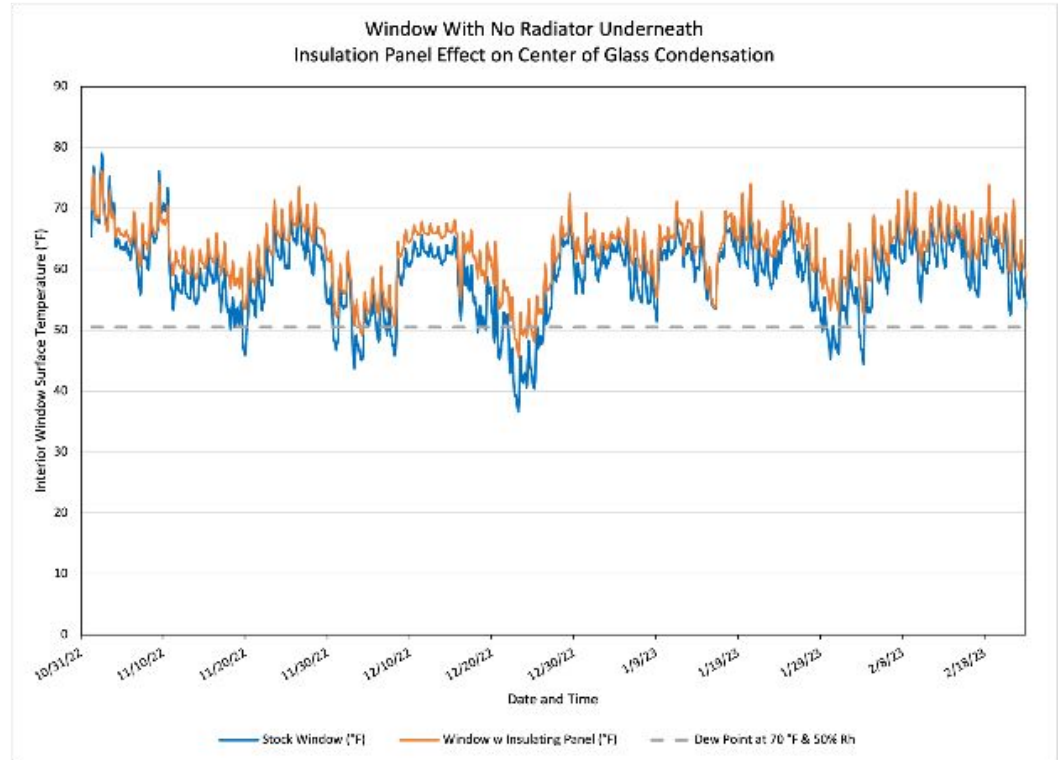
# » Improved Interior Glazing Surface Temperature

- When the outdoor air temperature was  $0^{\circ}\text{F}$ , the average interior glazing surface temperature improved by  $7^{\circ}\text{F}$ .
- During a particularly cold period in Eau Claire, Wisconsin, when the outdoor air temperature averaged  $-5.2^{\circ}\text{F}$ , the interior glazing surface temperature improved by  $8.25^{\circ}\text{F}$ .



# »» Reduced Condensation Risk

- Measurements indicated that the insulation panels reduced condensation on the interior glazing surface, but remains an area that needs further empirical research.



# » Mixed Occupant Feedback

## Pre-production version tested

- Feedback from 15 occupant surveys was mixed, but there were many factors that may have impacted these results.
- The tested panels included pre-production milky white spacers for panes greater than 3 feet and white 3D-printed cutouts around window locks.
- The vendor now offers versions with clear spacers and cut-outs.

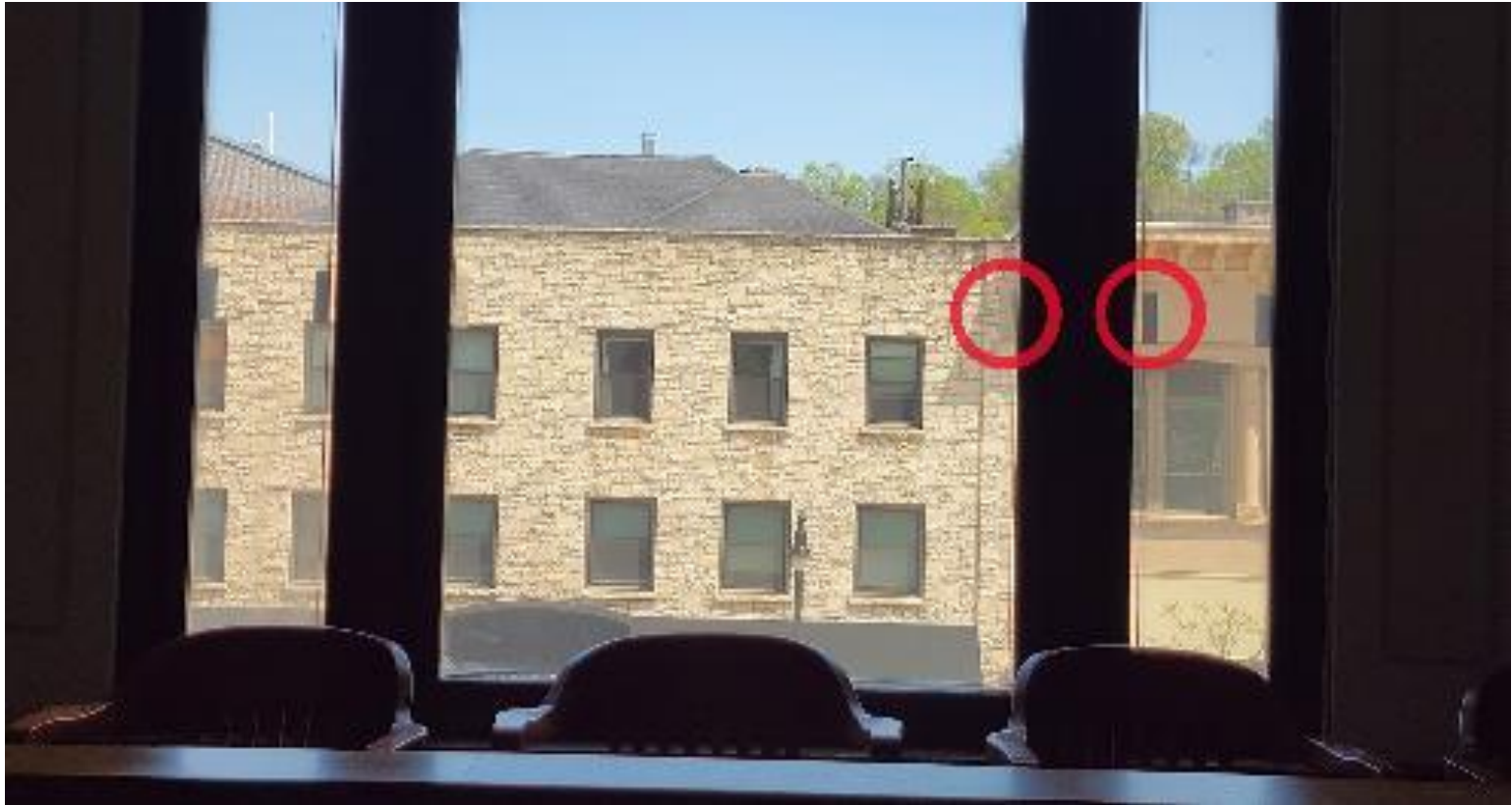


Pre-production model used milky-white spacers.



White border was a 3D-printed portion of a panel that surrounds the window lock (May 1, 2023).

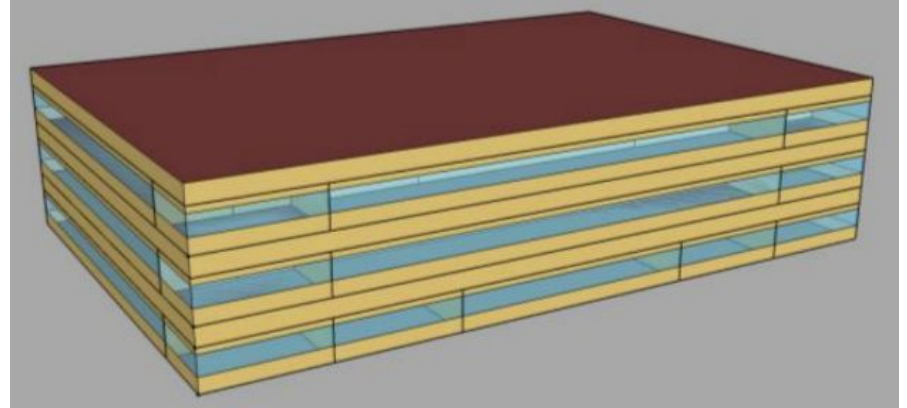
# » Production (left circle) vs. Pre-Production (right circle)





# »» Energy Savings Simulation Design

- Field measurements for energy savings were not possible because of multiple factors, including that the building was under construction during the evaluation period, and variable occupancy during the baseline and evaluation periods.
- A DOE medium-sized office was used to simulate whole-building energy savings.
- Existing building model—uses data from buildings constructed pre-1980



Department of Energy medium-sized office prototype

# » Whole-Building Energy Savings Between 2% and 7%

Savings are an average of 12 configurations:

- 2 panes (single, double),
- 2 frame materials (metal, non-metal), and
- 3 frame areas (10%, 20%, 30%) per climate/location

Highest savings for single-pane windows with non-metal or thermally broken aluminum frames

Location		Window Insulation Type	Savings			
Climate Zone	City		Heating kBtu/(ft <sup>2</sup> -year)	Cooling kBtu/(ft <sup>2</sup> -year)	Fan kBtu/(ft <sup>2</sup> -year)	Total
1A	Miami, FL	Warm-climate	0.04	0.11	0.13	5%
2A	Houston, TX	Warm-climate	(0.04)	0.12	0.13	5%
2B	Phoenix, AZ	Warm-climate	(0.04)	0.13	0.13	6%
3A	Atlanta, GA	Warm-climate	(0.03)	0.14	0.12	5%
3B	Las Vegas, NV	Warm-climate	(0.08)	0.13	0.14	5%
Average		Warm-climate	(0.03)	0.12	0.13	5%
3C	San Francisco, CA	Moderate-climate	0.14	0.06	0.06	2%
4A	Baltimore, MD	Moderate-climate	0.10	0.05	0.06	3%
Average		Moderate-Climate	0.12	0.05	0.06	2%
5A	Chicago, IL	Cold-climate	0.10	0.06	0.07	4%
5B	Boulder, CO	Cold-climate	0.11	0.06	0.06	3%
6A	Minneapolis, MN	Cold-climate	0.09	0.06	0.07	4%
Average		Cold-climate	0.10	0.06	0.07	4%

# » Warm Climates Most Cost-Effective

Location			Savings from Single-Pane Window with Non-Metal Frame					
Climate/Panel	Zone	City	Electricity Savings kW/ft <sup>2</sup> /yr	Gas Savings kbtu/ft <sup>2</sup> /yr	Annual Savings \$/ft <sup>2</sup> /yr	Whole-Building Savings %	Payback* yrs	SIR positive ROI if >1
Warm SHGC Coating	1A	Miami, FL	1.3	0.0	\$0.17	6%	14	1.1
	2A	Houston, TX	1.2	0.1	\$0.16	6%	15	1.0
	2B	Phoenix, AZ	1.7	0.1	\$0.23	7%	10	1.5
	3A	Atlanta, GA	1.2	0.3	\$0.15	6%	15	1.0
	3B	Las Vegas, NV	1.4	0.1	\$0.19	7%	13	1.2
	<b>WARM CLIMATE AVG.</b>			<b>1.4</b>	<b>0.1</b>	<b>\$0.18</b>	<b>6%</b>	<b>13</b>
Moderate SHGC Coating	3C	San Francisco, CA	0.2	0.3	\$0.03	2%	78	0.2
	4A	Baltimore, MD	0.5	1.6	\$0.08	4%	38	0.5
	<b>MODERATE CLIMATE AVG.</b>			<b>0.3</b>	<b>0.9</b>	<b>\$0.05</b>	<b>3%</b>	<b>58</b>
Cold No Coating	5A	Chicago, IL	0.5	2.9	\$0.09	6%	21	1.0
	5B	Boulder, CO	0.5	1.8	\$0.08	5%	22	0.9
	6A	Minneapolis, MN	0.5	4.0	\$0.10	7%	20	1.1
	<b>COLD CLIMATE AVG.</b>			<b>0.5</b>	<b>2.9</b>	<b>\$0.09</b>	<b>6%</b>	<b>21</b>

\* Assuming a 54K ft2 building with < 10 uniquely-sized fixed ribbon windows; average GSA utility rates of \$0.13/kWh for electricity and \$9.10/MMBtu for gas; installation cost of \$1.6/ft2; and material cost of \$16/ft2 for the panel with SHGC coating in zones 1A-4A and \$9/ft2 for the panel without coating in zones 5A-6A.

# Positive ROI Possible at Scale

At average GSA fuel rates of \$0.13/kWh and \$9.1 / MMBtu, max panel costs range between \$3.18 to \$21.53 to be cost-effective.

At panel costs of \$8/ft<sup>2</sup> for cold climates and \$17/ft<sup>2</sup> for warm climates, fuel costs range across climate zones to be cost-effective.

Location		Window Insulation Type	Savings			Max. Panel Cost	Fuel Costs	
Climate Zone	City		Electric Savings (kWh)	Gas Savings (MMBtu)	Total Savings*		Electricity (\$/kWh)	Gas (\$/MMBtu)
1A	Miami, FL	Warm-climate	61,560	0.01	5%	\$17.09	\$0.13	\$12.35
2A	Houston, TX	Warm-climate	54,551	(1.49)	5%	\$15.10	\$0.15	\$13.94
2B	Phoenix, AZ	Warm-climate	77,618	(0.44)	6%	\$21.53	\$0.11	\$9.80
3A	Atlanta, GA	Warm-climate	54,322	(2.80)	5%	\$15.02	\$0.15	\$14.00
3B	Las Vegas, NV	Warm-climate	63,799	(4.38)	5%	\$17.62	\$0.13	\$11.92
	Average	Warm-climate	62,370	(1.82)	5%	\$17.27	\$0.13	\$9.41
3C	San Francisco, CA	Moderate-climate	10,873	6.53	1%	\$3.18	\$0.76	\$69.95
4A	Baltimore, MD	Moderate-climate	19,958	41.53	3%	\$6.60	\$0.41	\$38.11
	Average	Moderate-climate	15,416	24.03	2%	\$4.75	\$0.59	\$40.97
5A	Chicago, IL	Cold-climate	21,144	75.67	4%	\$7.34	\$0.23	\$21.66
5B	Boulder, CO	Cold-climate	20,252	45.54	3%	\$6.51	\$0.24	\$22.61
6A	Minneapolis, MN	Cold-climate	21,456	105.82	4%	\$8.01	\$0.23	\$21.34
	Average	Cold-climate	20,951	75.68	4%	\$7.28	\$0.24	\$16.58

Note: Range of savings represents the minimum and maximum savings from all 12 configurations evaluated.

# »» Lessons Learned



- Improving building envelopes in moderate climates can be difficult to achieve cost-effectively.
- Aftermarket film applied to the glass may make it more difficult to apply the fasteners.
- Maintaining a window's operability may require using the low-profile version of this technology, which has a 2–3% reduction in insulating value relative to the high-profile version of this technology.

# » Best Practices



- Site-specific evaluation is essential to gauge the potential success of secondary window retrofits.
- Have the vendor take field measurements of the windows to ensure the panel sizing is correct.
- Clean interior glass panes before installation and factor this into installation costs and processes.
- If air infiltration or noise are issues with the existing windows, consider alternative retrofit technologies that are mounted in a frame.
- If operability isn't important, GPG has evaluated fixed frame secondary windows that have higher performance.

# »» Deployment Recommendation

Consider for historic buildings and to maintain window operability

- Appropriate for historic buildings because they do not impact the façade's appearance.
- Best suited for single-pane or older double-pane operable windows with non-metal or thermally broken aluminum frames without condensation issues.
- Consider for large windows that are comprised of smaller glass panes.
- Maximum window pane size: 4 ft x 6 ft,  
Minimum size is 1 ft x 1.5 ft



# » GSA Feedback

## **Daniel Carroll**

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## **Scott Jacobs**

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## » Installation Feedback

- Having the field measurements of the windows taken by the vendor was important, if the window measurements were off, GSA might have a financial liability regarding the reordering of the window insulation panels.
- Cleaning the windows before installation was imperative, and this should be factored into the process.



Corner mounts are placed in the corner of each window lite.



Window lites were pre-measured, and panels were fabricated to size.

# » Operability Feedback

- Did not change views
- You can see the white piece on every window from the outside so clear would be better.
- Did not see any condensation between the window insulation panels and the glass panes of the windows.
- Appeared to be fewer space heaters in the building after the window insulation panels were installed.



## » Operability Feedback

- Having to remove the top window panel to open the lower window is a hindrance.
- With minimal savings reduction, we would have preferred the low-profile insert on the top window.



## » Maintains Window Operability

- People want to be able to open windows. Even if they don't do it very often, they like having the option.





Q&A




# » Survey and Continuing Education Credit

GPG webinars offer 1 Continuing Education Learning Unit through the American Institute of Architects. GSA attendees are eligible for 1 Continuous Learning Point (CLP).

## To receive credit:

Complete the post-webinar email survey. If you don't receive the survey, contact [donna.creason@gsa.gov](mailto:donna.creason@gsa.gov)

### GPG Webinar 32: Ultralight Insulating Panels for Operable Windows

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\* Indicates required question

Email \*

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Check here to request a certificate for 1 GSA Continuous Learning Point (CLP).

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Members of the American Institute of Architects are eligible for 1 health, safety and wellness credit. If requesting AIA credit, enter your AIA number below.

Your answer

First and Last Name \*

Your answer

The information presented in the webinar was helpful. \*

1 2 3 4 5

Strongly disagree 🙄      😊 Strongly agree

Thank you!



For more information: [gsa.gov/GPG](https://gsa.gov/GPG)

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Erin Lannon, GSA Program Manager, AILL, [erin.lannon@gsa.gov](mailto:erin.lannon@gsa.gov)

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