

WINDOW REHABILITATION WITH STORMS Compared To REPLACEMENT WINDOWS

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No one disputes that energy conservation is important. However, the replacement of historic, character-defining windows is not usually the best way to improve a building's efficiency. Historic buildings are typically not as inefficient as they've been made out to be.

- Utility costs for historic buildings can be 30% less than for more modern ones.
- Built when heating and cooling were more difficult, many older homes incorporate passive energy-saving features, such as south-facing facades for solar gain, deep eaves for summer shade, and cross-ventilating halls and operable windows.
- Older buildings were built to last, and many historic buildings are energy efficient. The U.S. Energy Information Agency has found that buildings constructed before 1920 are more energy-efficient than those built during the rest of the 20th century.
- The craftsmanship and materials - heavy timbers, granite, handmade bricks, and old-growth wood – used to construct historic homes are unavailable today, or only available at great cost. When lost to the landfill, they are gone forever.
- Research shows that most traditionally designed wood-frame buildings lose more heat through the roof and un-insulated walls than through the windows.
- The Department of Energy finds that only 10 percent of air leakage in homes is attributable to windows. In the average home 14 percent of air escapes through fireplaces and upwards of 30 percent occurs through floors, walls, and ceilings.¹

Studies also illustrate that repairing historic windows and incorporating a storm window is more sustainable, is essentially as effective in reducing energy costs as replacement windows, and costs much less on average.

- Manufacturing, transporting and installing replacement windows consumes large amounts of energy.
- A repaired wood window can easily last more than 100 years. The life of a new window is far shorter. Replacement windows typically fail 10-20 years after installation, and usually after the warranty period has ended.²
- Many historic wood windows can be repaired, especially those dating before 1940. These were constructed with individual parts, each of which can be repaired or replaced. The wood is denser and of a higher quality and is generally more rot and warp resistant.
- Studies demonstrate that properly weatherized windows with storm units can reduce heat loss through windows by 50 percent, resulting in performance and energy savings comparable to or even better than new windows.³
- Embracing replacement windows as a matter of national policy will escalate the environmental impacts of repeatedly manufacturing, replacing, and throwing away windows.⁴

¹ U.S. Department of Energy, Energy Saver Tips for Saving Energy & Money at Home, www.eere.energy.gov/consumer/tips/air_leaks.html.

² Cluver, "Still No Substitute," *Period Homes*, Vol. 7, No. 6 (November 2006), pp. 12-14.

³ Mattison, DePaola, and Arasteh, "What Should I do About My Windows," www.homeenergy.org/hewebsite/19-4.html, July/August 2002; Joseph H. Klems, *Measured winter performance of storm windows* (2002), <http://escholarship.org/uc/item/05p5881m>; Wood, Bordass, and Baker, *Research into the Thermal Performance of Traditional Windows: Timber Sash Windows*, English Heritage, October 2009, www.climatechangeandyourhome.org.uk/live/content_pdfs/579.pdf.

⁴ Sedovic and Gotthelf, "What Replacement Windows Can't Replace: The Real Cost of Removing Historic Windows," *APT Bulletin: Journal of Preservation Technology*, Vol. 36, No. 4 (2005).

EXCERPTS FROM STUDIES COMPARING REPLACEMENT WINDOWS TO SINGLE PANE WINDOWS WITH STORMS

The following tables and charts are taken from various studies to provide the figures associated with the assertion that replacement windows are not necessary to improve energy efficiency; it is typically not a cost effective measure for reducing energy consumption.

MEASURED WINTER PERFORMANCE OF STORM WINDOWS ⁵

Direct comparison measurements were made between various prime/storm window combinations and a well-weatherstripped, single-hung replacement window with a low-E selective glazing. Measurements were made using an accurate outdoor calorimetric facility with the windows facing north. The double-hung prime window was made intentionally leaky. Nevertheless, heat flows due to air infiltration were found to be small, and performance of the prime/storm combinations was approximately what would be expected from calculations that neglect air infiltration. Prime/low-E storm window combinations performed very similarly to the replacement window. Interestingly, solar heat gain was not negligible, even in north-facing orientation.

Table 5. Thermal and Solar Heat Flows During Tests

Test	Prime or Prime/Storm			Replacement Window		
	Thermal Watts	Solar Watts	Solar Fraction	Thermal Watts	Solar Watts	Solar Fraction
Prime Only	-138.6	26.0	19%	-72.0	14.1	20%
Low-e Ext. Storm	-47.5	13.5	28%	-40.4	10.5	26%
Reg. Ext. Storm	-69.3	10.2	15%	-52.1	7.1	14%
Low-e Int. Storm	-61.6	19.6	32%	-56.9	14.3	25%

Conclusions

In tests under actual winter weather conditions of north-facing prime/storm window combinations in comparison with a selective low-E replacement window, we find that

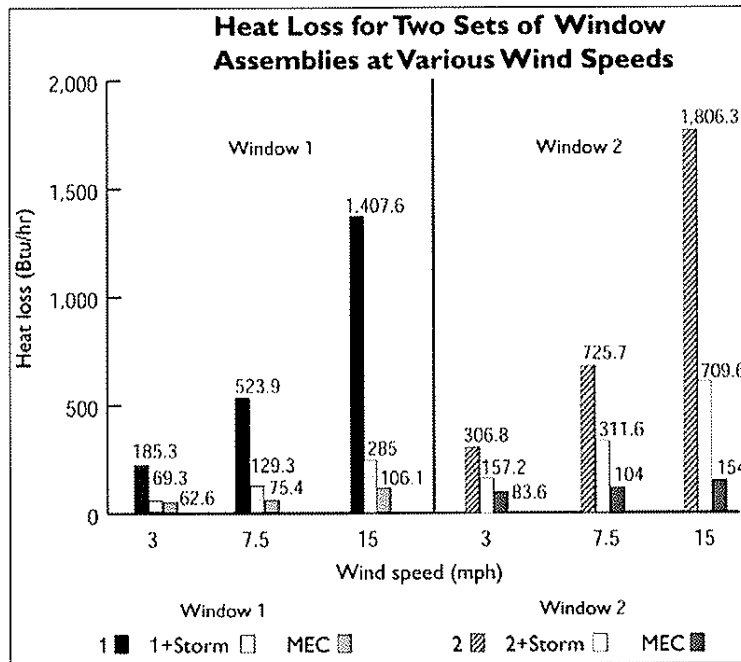
- Infiltration does not significantly degrade the expected performance. This was true even though the prime window was intentionally made moderately leaky, and (in one case) no special effort was made to seal the (interior) storm window. It would certainly be true if the interior member of the prime/storm combination were properly weatherstripped.
- The general performance pattern followed that expected from calculations made neglecting infiltration, although direct quantitative comparisons between the measurements and calculations have not yet been completed (due to the difficulty of determining exterior convective conditions).
- The addition of low-E storm windows to the prime window provided performance very similar to that of the replacement window, and expected differences in performance were only detectable through a sensitive fitting procedure (essentially, a long-term averaging).
- Solar heat gain was not negligible, even though only diffuse solar energy was incident on the windows.

⁵ Klems, J.H., MEASURED WINTER PERFORMANCE OF STORM WINDOWS, Windows and Daylighting Group, Building Technologies Department, Lawrence Berkeley National Laboratory, Berkeley, California 94720-8134; <http://www.parks.ca.gov/pages/1054/files/berkeley%20storm%20window%20research.pdf>

STORM WINDOWS SAVE ENERGY:⁶

A team of researchers at Oak Ridge National Laboratory fitted two single-glazed, double-hung sash windows with storm windows, but the assemblies in a simulated weather changer, and measured air pressure and temperatures on both sides of each assembly for a period of 30 days. Both of the windows were single-glazed and 40-50 years old. Window #1 was a single, double-hung unit with three lights at the top half and one in the bottom. Window Two was a dual, double hung unit with eight lights in each sash.

As shown in the figure below, energy flow was substantially reduced in both windows after the storm windows were installed. The difference is in the air infiltration in Window #2 where the mulling joint occurred. The study shows that heat loss decreased significantly as a result of storm window installation.



⁶ Turrell, Colleen. "Storm Windows Save Energy", *Home Energy Magazine Online*, July/August 2000. <http://homeenergy.org/archive/hem.dis.anl.gov/eehem/00/000711.html>

FIELD EVALUATION OF LOW-E STORM WINDOWS⁷

A field evaluation comparing the performance of low emittance (low-e) storm windows with both standard clear storm windows and no storm windows was performed in a cold climate. Six homes with single-pane windows were monitored over the period of one heating season. The homes were monitored with no storm windows and with new storm windows. The storm windows installed on four of the six homes included a hard coat, pyrolytic, low-e coating while the storm windows for the other two homes had traditional clear glass. Overall heating load reduction due to the storm windows was 13% with the clear glass and 21% with the low-e windows. Simple paybacks for the addition of the storm windows were 10 years for the clear glass and 4.5 years for the low-e storm windows.

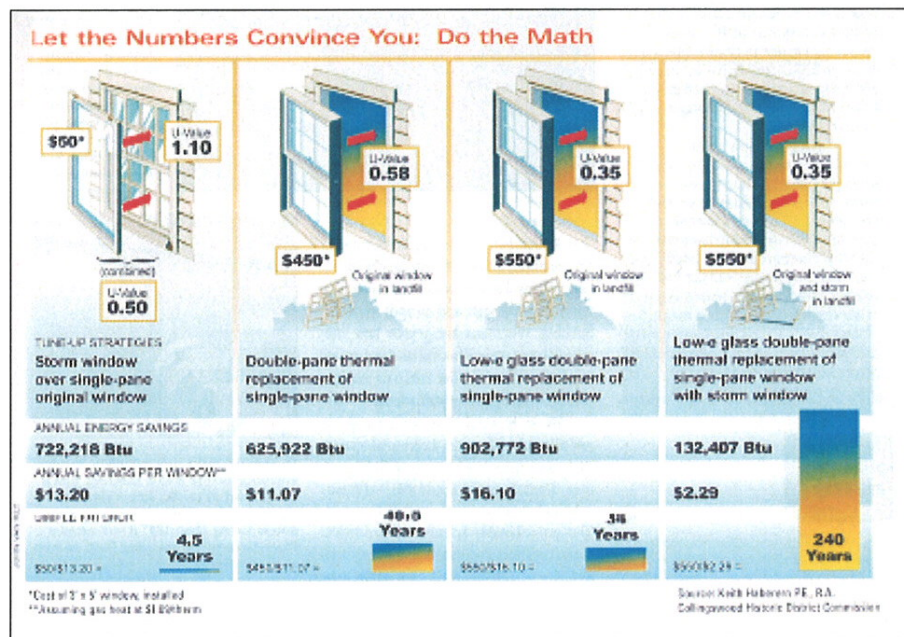
Table 4. Storm Window Energy Savings

	Percent Energy Savings	Reduced Therm Usage	Annual Savings (at \$1.39/Therm)	Glass Area, ft ² (m ²)	Therms Saved per ft ² (m ²)
House 1 [*] – low-e	27%	432	\$600	132 (12.3)	3.27 (35.2)
House 2 – low-e	19%	353	\$490	72 (6.7)	4.90 (52.7)
House 3 – Clear	8%	80	\$111	107 (9.9)	0.75 (8.1)
House 4 – Clear	18%	228	\$317	62 (5.8)	3.68 (39.6)
House 5 – low-e	23%	245	\$341	58 (5.5)	4.23 (45.5)
House 6 [*] – low-e	19%	105	\$145	65 (6.0)	1.61 (17.3)

* Homes 1 and 6 did not have very high daily temperatures to generate correlation coefficients requiring them to be removed from the final energy data analysis.

EMBRACING ENERGY EFFICIENCY:⁸

The following table is included in an article written for Old House Journal. The concept of energy payback or how long it takes to pay off your home improvement and get a return on the investment is clarified in this table comparing the cost of different window improvements.



⁷ Drumheller, S. Craig, et al, *Field Evaluation of Low-E Storm Windows*, ASHRAE 2007 – http://www.ornl.gov/sci/buildings/2010/Session%20PDFs/22_New.pdf

⁸ Lord, Noelle. *Old House Journal*, September/October 2007; www.oldhousejournal.com

References:

Field Evaluation of Low-E Storm Windows, a study done on Chicago bungalows in 2005.

http://www.ornl.gov/sci/buildings/2010/Session%20PDFs/22_New.pdf

Energy Update Newsletter with a review of the study:

http://www.focusonenergy.com/files/Document_Management_System/Extranet/energydesignupdatefeb08_newsletter.pdf

Window Condensation in Historic Buildings..., National Research Council Canada.

<http://www.nrc-cnrc.gc.ca/eng/ibp/irc/ctus/ctus-n5.html>

Improving the Thermal Performance of Traditional Windows, for English Heritage by Dr Paul Baker, Glasgow Caledonian University, October 2009,

http://www.climatechangeandyourhome.org.uk/live/content_pdfs/579.pdf

Improving the Thermal Performance of Traditional Windows, from Scotland:

<http://www.historic-scotland.gov.uk/thermal-windows.pdf>

English Heritage Proves Saving Windows Better than Replacing: summary with good quotes, all the window repair methods, scientific methods and data complete, very easy to understand.

http://www.climatechangeandyourhome.org.uk/live/research_generic.aspx

A windows tip sheet from the National Trust for Historic Preservation.

<http://www.ohp.parks.ca.gov/pages/1054/files/july2008windowstipsheet.pdf>

"Measured Winter Performance of Storm Windows"

<http://www.ohp.parks.ca.gov/pages/1054/files/berkeley%20storm%20window%20research.pdf>

"Building Regulations and Historic Buildings: balancing the needs for energy conservation with those of building conservation"

http://www.ohp.parks.ca.gov/pages/1054/files/english%20heritage%20interim_guidance.pdf

"Repair or Replace Windows in Historic Buildings: Arriving at a Sustainable Solution"

<http://www.ohp.parks.ca.gov/pages/1054/files/heritage%20canada.pdf>

"Life Cycle Of Window Materials - A Comparative Assessment"

<http://www.ohp.parks.ca.gov/pages/1054/files/uk%20window%20frame%20lca.pdf>

"Domestic Retrofitting Strategies in the UK: Effectiveness vs. Affordability"

<http://www.ohp.parks.ca.gov/pages/1054/files/domestic%20retrofit%20uk.pdf>

"What Replacement Windows Can't Replace: The Real Cost of Replacing Historic Windows"

http://www.ohp.parks.ca.gov/pages/1054/files/replacement_windows%20sedovic%20gotthelf.pdf

"Testing the energy performance of wood windows in Cold Climates"

<http://www.ohp.parks.ca.gov/pages/1054/files/testing%20windows%20in%20cold%20climates.pdf>

"Lincoln Hall Windows Research Report: A Case Study of Options for Treatment for Windows at Lincoln Hall, University Of Illinois, Urbana Champaign"

<http://www.ohp.parks.ca.gov/pages/1054/files/illinois%20lincoln%20hall%20study.pdf>