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Efficacy of Replacement Windows in Building Energy Retrofits: A Post Occupancy Evaluation

Chris Rockhill
Portland State University

Heidi Crespi
Portland State University

Corey T. Griffin
Portland State University, cgriffin@pdx.edu

Boora Architecture

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A Post Occupancy Evaluation

Portland State University

Chris Rockhill, Graduate Student
Heidi Crespi, Graduate Student
Corey Griffin, Professor,
PSU School of Architecture
(in collaboration with)
Mike Manzi, Boora Architecture
(with help from)
Jeff Lauck,
PSU Green Building Research Lab

Abstract

The thermal performance of replacement windows has made considerable progress in a short time frame. Few studies have been carried out with regard to application of new and retrofit windows to pre-retrofit windows. The goal for this energy retrofit is occupant comfort, as 80% of a buildings energy use goes toward maintaining this standard.Any effort to make this load more efficient is worth investing and warrant post occupancy evaluation to make more informed decisions about future investments.

This study gives great insight into the potentials, positives and negatives for utilization and employment of data loggers with thermal couples, infrared thermography, and tools to spot measure temperature. The paper highlighting the potentials of these non-invasive tools attentive to areas of required information the tools cannot produce in order to have comprehensive results. While these programs are not perfect, they offer valuable information with regard to life cycle costing and potential unforeseen problems.

Hand-Held Temperature Gun

The Infrared Thermometer was used to compare the outside temperatures of the glazing and adjacent window frames. Temperatures were taken on the last morning of data collection, before sunrise.

Window specifications:

Shattuck Hall Original Windows(Control)

1/8″ single pane glass, wood-framed, contiguous mullions.

Shattuck Hall Retrofit Windows (1986)

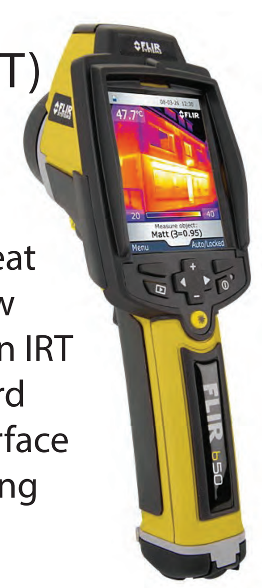
Glazing: 3/4″ overall, 1/8″ glass, 1/2″ air space, 1/8″ glass
Frame: aluminum-clad wood, non-contiguous mullions.

Lincoln Hall Retrofit Windows (2010)

Glazing: 3/4″ overall- Outside Pane: 1/8″, clear with Cardinal 272 low-e coating on #2 surface, Airspace: 1/2 inch, argon filled, Inside Pane: 1/8″ clear.
Frame: aluminum-clad wood, non-contiguous mullions

Infrared Thermography (IRT)

For a qualitative understanding of the relationship between heat loss through the window glazing vs. the frames, an IRT Camera was use to record color readings of the surface temperatures surrounding the windows.



For a qualitative understanding of the relationship between heat loss through the window glazing vs. the frames, an Infrared Thermography (IRT) Camera was use to record color readings of the surface temperatures surrounding the windows. Since Infrared Thermography reads long-wave radiation being emitted from any surface, it is not effective in gauging temperatures directly from glazing, due to their high level of reflectance and light emittance.

This part of the study was purely intended to understand the amount of heat loss through the frames that could be compared with temperatures (from the data collection) showing the glazing heat loss. These photographs were taken before sunrise on the last day of data collection.

Data Collection

For a quantitative understanding of the heat loss through the window glazing, Hobo Data loggers were used to collect surface temperaters on the inside and outside of the glazing on each window. Also, Indoor air temperatures were recorded, simultaneously and correlating outdoor temperatures were collected from the weather station on Shattuck Hall roof.

Temperatures were averaged every fifteen minutes over the course of one week. Local weather data from a data collector on the roof of Shattuck Hall was also collected for that time period. After data collection, the measurements for each hour were averaged and each hourly measurement was averaged for the course of the week. The results for each window were graphed comparing interior and exterior glazing temperatures as well as interior air temperatures and outdoor air temperatures (via the weather data).

On the Lincoln Hall, post-retrofit graph in (Figure 3.3) in addition to the sixteen-degree separation from interior to exterior surface note the interior glazing temperature reaching close to indoor air temperatures, at average temperatures of 66°F and 68°F.

This indicates improved occupacy comfort (near the windows) and decreased heating load at Lincoln Hall.

Shattuck Hall Orig. (Control)

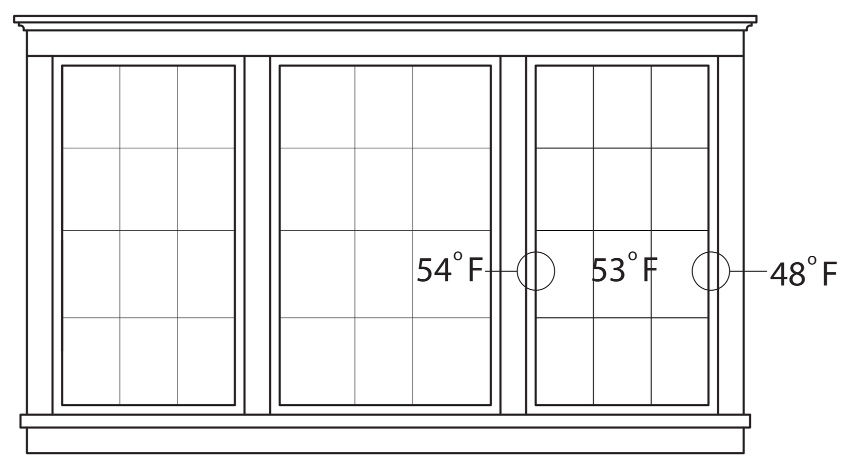


Figure 1.1 - Shattuck Hall pre-retrofit, glazing is losing heat 4°F over the frame.

Figure 2.1 - Shattuck Hall pre-retrofit 1986. has an inefficient envelope, bridging a rate that keeps theexterior facade an average 15.5°F higher than the ambient outdoor air.

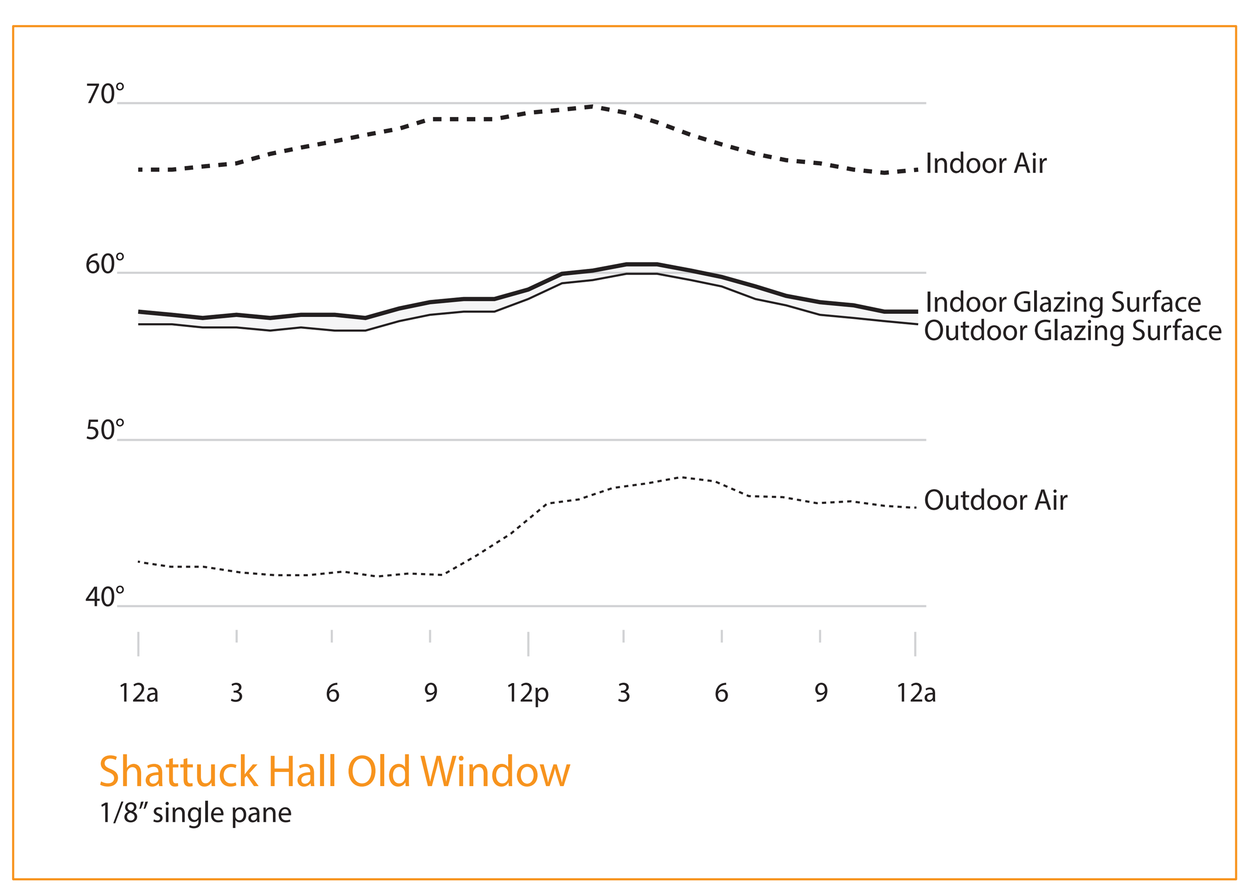


Figure 3.1 - Interior glazing surface is a mere one-degree higher than the exterior at an average of 59°F. It can be inferred that heat is escaping this glazing at a significant rate. This places considerable load on the mechanical heating and air conditioning and impacts occupant comfort near the window.

Shattuck Hall Retrofit (1986)

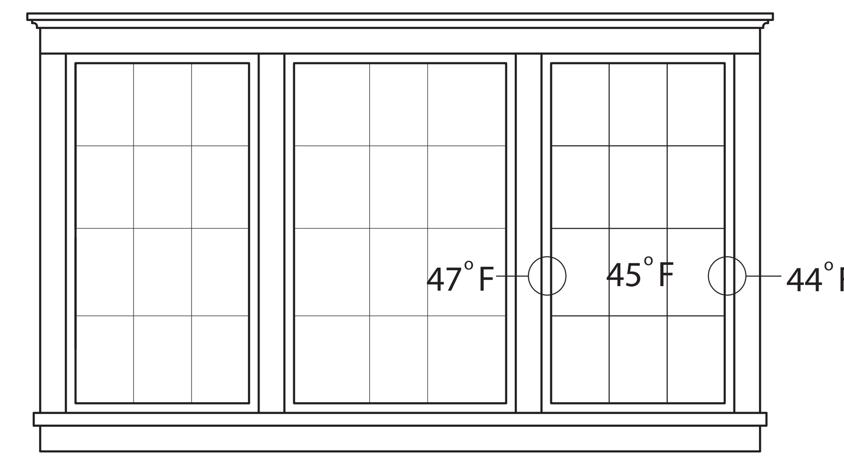


Figure 1.2 - Glazing shows an increased efficiency in heat retention of +8°F. The frame shows an increased efficiency in heat retention of +7-10°F. The glazing is retaining heat equal to the frame.

Figure 2.2 - Shattuck Hall post-retrofit 1986. has a leaky frame thermally bridging a rate that keeps the exterior facade an average 7.4°F higher than the ambient outdoor air.

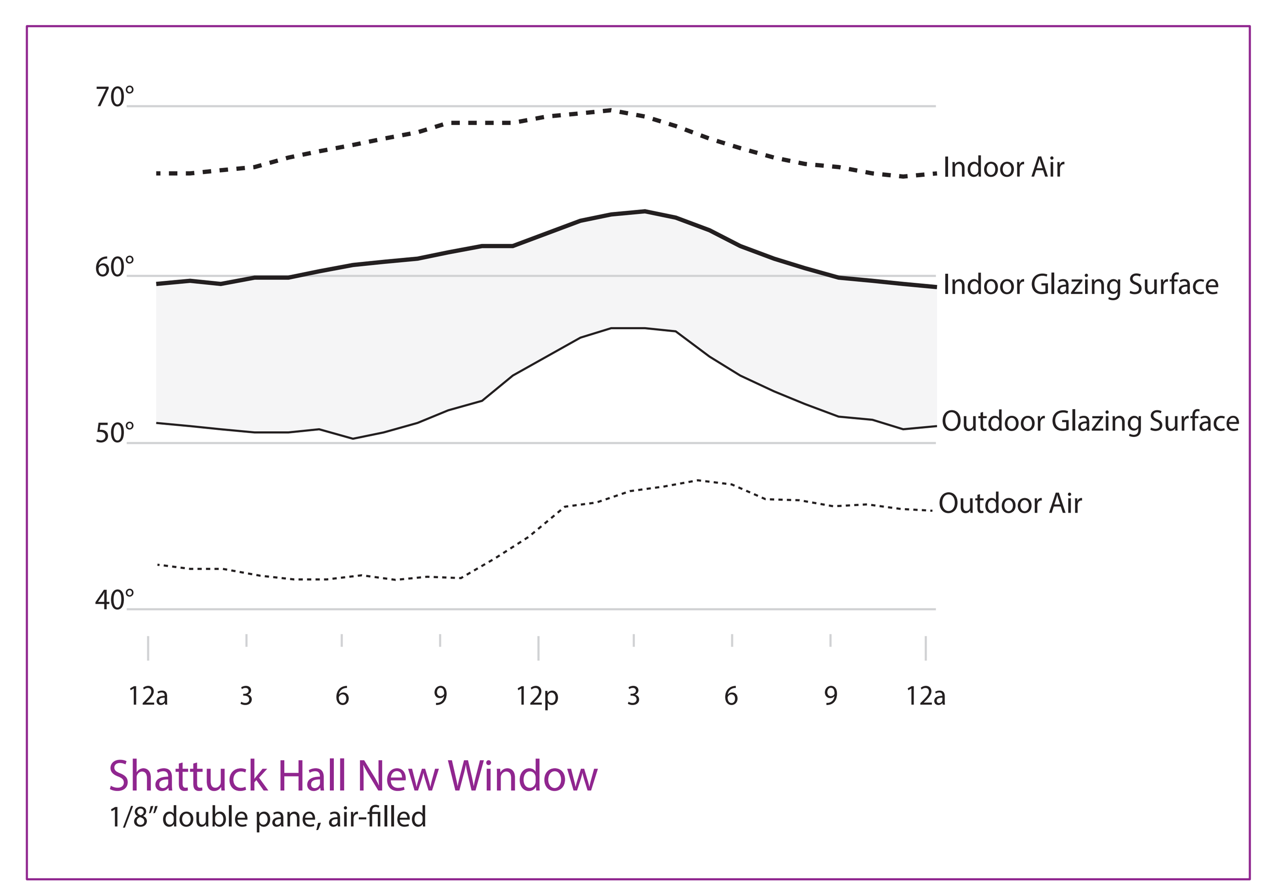


Figure 3.2 - Note an average of nine-degree difference between the interior, at average of 63°F and the exterior at an average of 54°F.

Lincoln Hall Retrofit (2010)

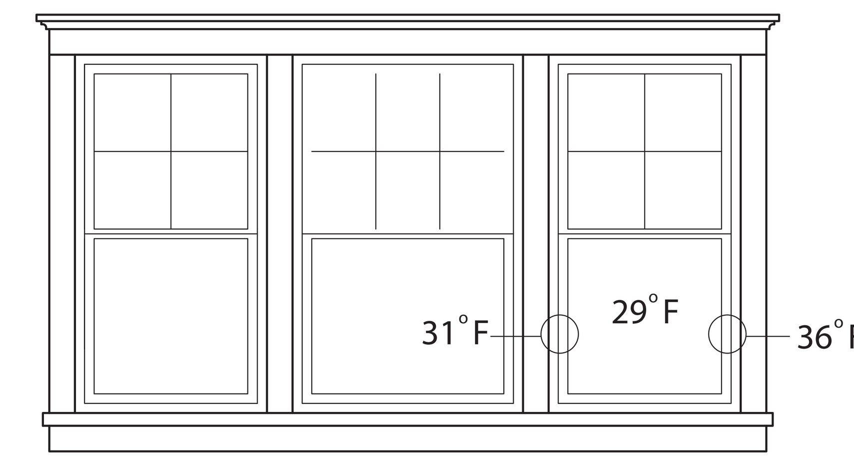


Figure 1.3 - Shattuck Hall pre-retrofit, Glazing shows an increased efficiency in heat retention of +7°F. The Frame shows an increased efficiency in heat retention of +13-18°F. The glazing is retaining heat 2-5°F over the frame.

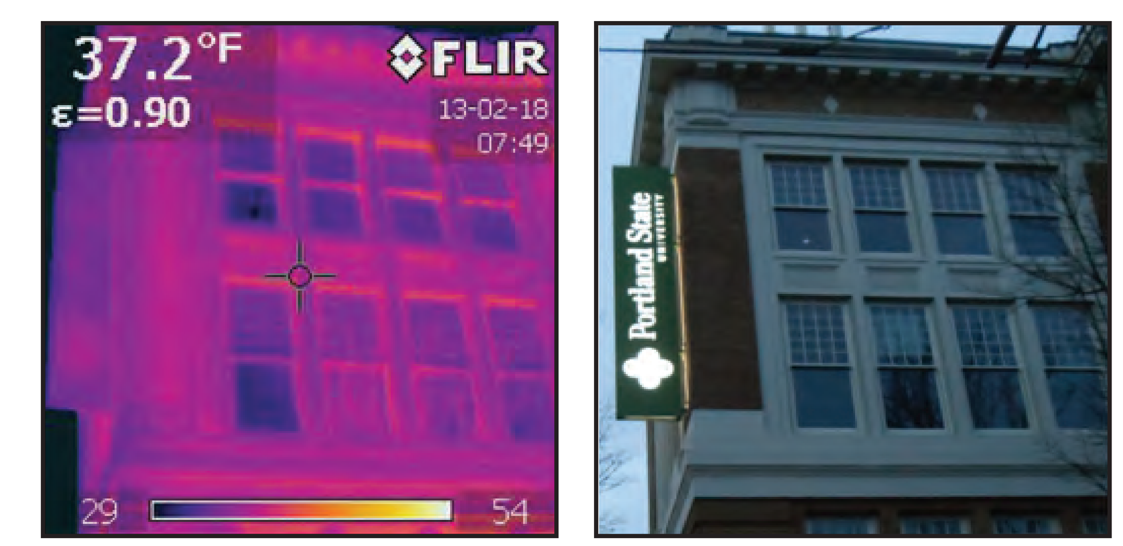


Figure 2.3 - Lincoln Hall post-retrofit 2010. has a highly efficient envelope, with a surface temperature equal to the ambient outdoor air.

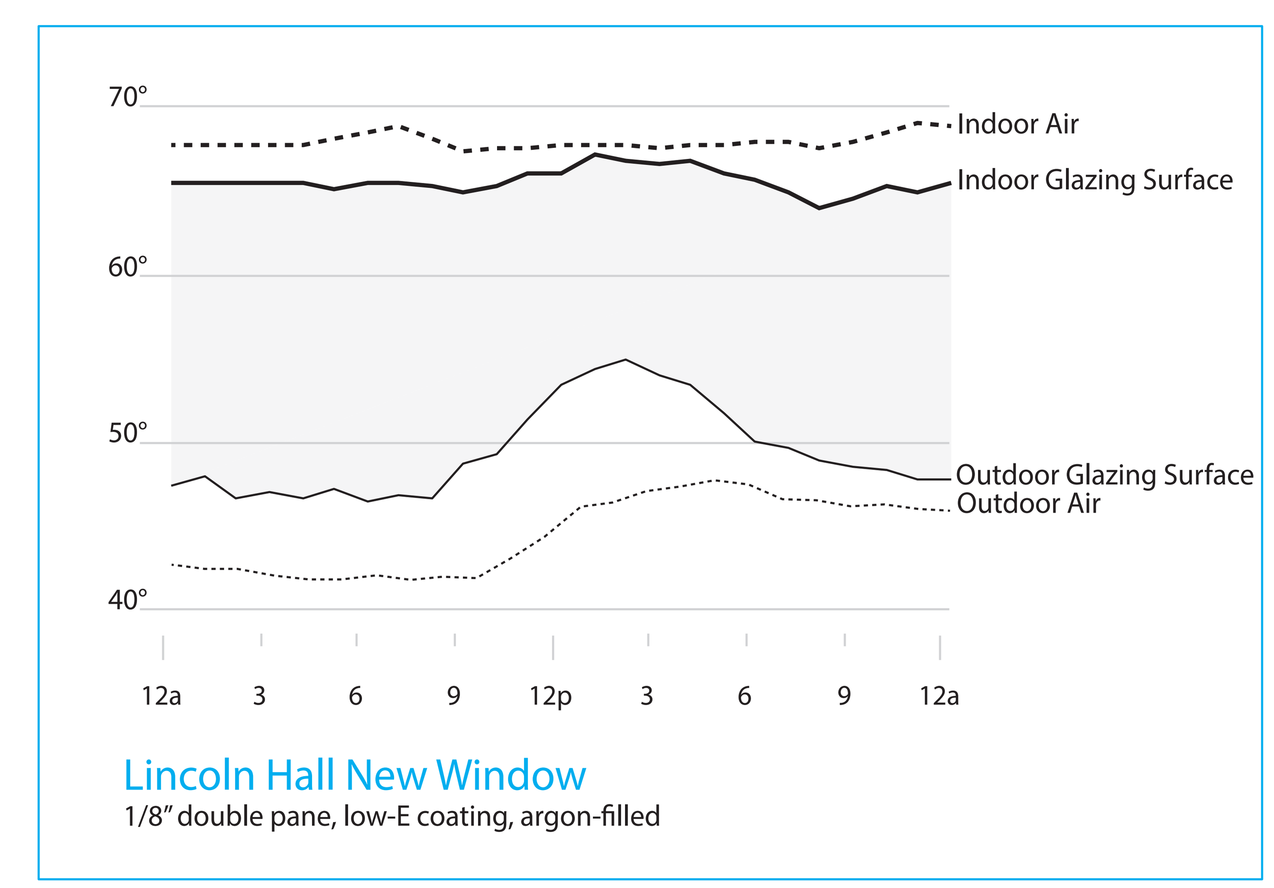


Figure 3.3 - In addition to the sixteen-degree separation from interior to exterior surface note the interior glazing temperature reaching close to indoor air temperatures, at average temperatures of 66°F and 68°F.