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

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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 of this energy retrofit is occupant comfort, as 40% of a buildings' energy use goes toward maintaining this standard. Any effort to make this load more efficient is worth investing in 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 potential 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.

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

Data Collection
For a quantitative understanding of the relationship between heat loss through the window glazing vs. the frames, an IR Camera was used to record color readings of the surface temperatures surrounding the windows.

Window specifications:
Shattuck Hall Orig. (Control)
1/8" single pane glass, wood framed, contiguous mullions.
Shattuck Hall Retrofit Windows (1986)
4/24" double pane, air-filled, 1/2" clear, 1/2" argon filled, 1/2" clear. Frame: double glazed, non-contiguous mullions.
Lincoln Hall Retrofit Windows (2010)
4/24" double pane, air-filled, 1/2" clear with 232 bare making air on the surface, argon, 1/2" clear argon filled, inside pane. Frame: double glazed, non-contiguous mullions.

Figure 1.1 - Shattuck Hall pre-retrofit, glazing is losing heat 4°F over the frame.
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 temperature reaching close to indoor air temperatures, at average temperatures of 66°F and 68°F.
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 7°F and 9°F.

Figure 1.3 - Shattuck Hall pre-retrofit 1986. has a highly efficient envelope, with a surface temperature equal to the ambient outdoor air.
Figure 2.3 - Lincoln Hall post-retrofit 2010. has a highly efficient envelope, with a surface temperature equal to the ambient outdoor air.

Shattuck Hall Orig. (Control)
Shattuck Hall Retrofit (1986)
Lincoln Hall Retrofit (2010)