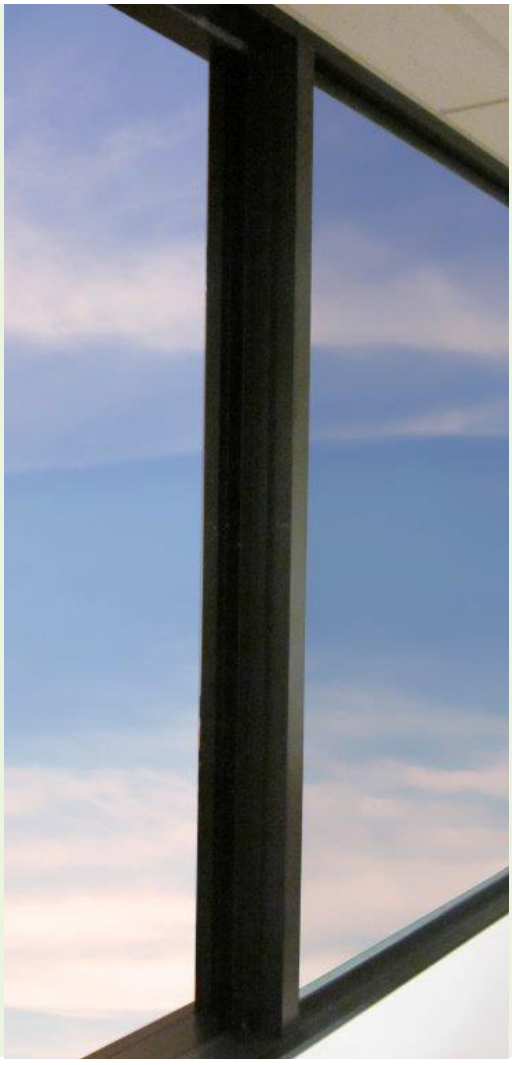
GSA Public Buildings Service

FINDINGS, OCTOBER 2013

HIGHLY INSULATING WINDOW PANELS



Hi-R Panel Retrofits Provide Significant Energy Savings for Low Investment

In a recent assessment, GSA's Green Proving Ground (GPG) program achieved a 41% reduction in winter energy use at a Provo, Utah federal office building by retrofitting 21 single-pane windows with triple-pane highly insulating window panels (Hi-R panels). Hi-R panels are pre-manufactured units designed to improve the insulating power of low-performing windows, without the need for major renovations or costly modifications to existing buildings. Hi-R panels use low emissivity coating and single-, double- and triple-pane configurations to build upon the concept behind residential storm windows, providing greater thermal performance with a long-lasting, simple application. These framed units can easily be installed on the interior side of existing windows, improving their performance at minimal cost with little or no disruption to building occupants. Findings from this study support the consideration of Hi-R panel retrofits as a low-cost option for achieving significant savings in heating and cooling commercial buildings, particularly those located in cold climates. The potential energy savings to be gained from installing high-performance windows in commercial buildings nationwide equals more than 1% of the total U.S. energy consumption—enough to power 5.5 million U.S. households.[1]

GPG Green Proving Ground Program

The Green Proving Ground program leverages GSA's real estate portfolio to evaluate innovative sustainable building technologies. The program aims to drive innovation in environmental performance in federal buildings and help lead market transformation through deployment of new technologies.

INTRODUCTION

"The highly insulating window panel inserts contributed to an over 30% energy reduction in our facility at a very low upfront cost. The installation was non-disruptive to the tenants and immediately created a more comfortable space."

Daniel Wang
Property Manager
Salt Lake City, Utah
GSA

What We Did

COMPARED PERFORMANCE DATA BEFORE AND AFTER RETROFIT

In February 2012, GSA retrofitted 21 single-pane windows with triple-pane Hi-R windows in a 6,400 square foot, single-story office building in Provo, Utah, at a cost of $7,500 for labor and materials, or $32.40 per square foot of glass. Data-logging sensors were deployed to measure window and wall surface temperatures for all four orientations over an eight-month period—three pre-retrofit and five post-retrofit, to discern the heating load reduction resulting from the Hi-R panel installation. Before and after the retrofit, 12 employees who regularly occupy the space participated in a survey that measured their thermal and visual comfort.

What We Measured

HEAT TRANSFER, SOLAR RADIATION, AND VISIBLE LIGHT

The test case measured U-factor, solar heat gain coefficient (SHGC), and visible light transmission (VT) of various wall and window surfaces. The U-factor of glazing is related to the resistance of heat transfer between the interior and exterior of windows; the smaller the U-factor, the better the insulator. The SHGC reports the amount of solar radiation that flows through the window from direct sunlight. VT refers to the amount of light that passes through a window. In conjunction, these three factors determine the balance of heating load reductions, cooling load reductions, and visual comfort generated by specific window types. Local climate, building orientation, internal and external window shading systems, and building type play large roles in the measurement and prioritization of these factors.

FINDINGS

HIGH POTENTIAL SAVINGS BUT INDIVIDUAL SITE EVALUATION NECESSARY Given Provo's relatively extreme climate, the pilot project achieved a significant 41% reduction in winter heating load that may not be typical under other conditions. On average, Hi-R windows are estimated to save 11% of entire building heating and cooling energy demands. Typically, greater savings will be realized in buildings in colder climates that have poor-performing windows. Modeling programs, such as WINDOW and THERM, can reliably evaluate the performance of retrofit panel assemblies, and annual energy computer-simulation tools, like COMFEN, can be used to predict the relative impacts of different glazing choices.

PAYBACK WILL VARY DEPENDING ON BUILDING, CLIMATE, MATERIALS Triple-pane windows were used in Provo, resulting in a simple payback of 9 years. But computer simulation has suggested diminishing returns in energy savings between double- and triple-pane units. Accordingly, the materials cost for Hi-R retrofits can be reduced by purchasing double-pane windows, which will in turn reduce simple payback. In addition, payback is expected to be faster in buildings with a lower wall to window ratio. The Provo test case had a high wall to window ratio 10:1, while a more typical ratio across the GSA portfolio is lower.

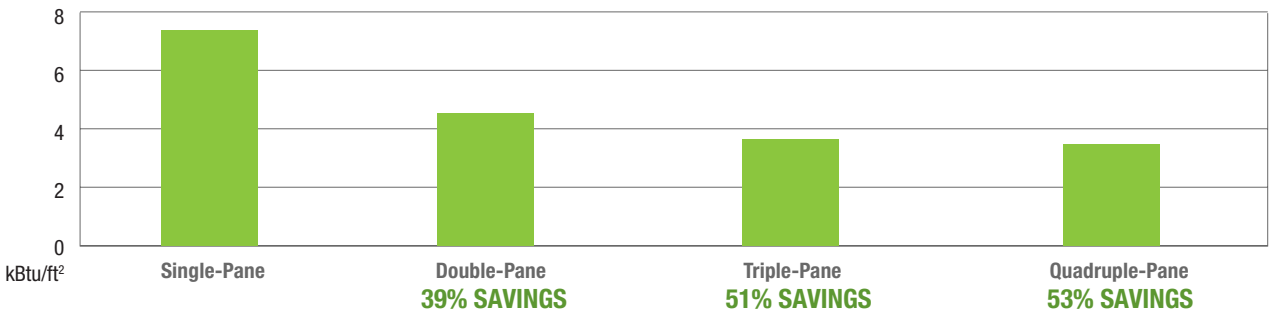
IMPROVED OCCUPANT SATISFACTION In a post-retrofit study, the percentage of occupants who reported being "frequently too cold" dropped from 40% to 0%, and correspondingly, the number of portable electric space heaters dropped by 8%. Similarly, reports of being "occasionally too hot" or "frequently too hot" dropped from 10% to 0% after the retrofit. Reports of glare and visual discomfort from 40% of survey respondents pre-retrofit dropped to 0% after the installation of Hi-R panels.

QUICK INSTALLATION AND LIMITED DISRUPTION TO OCCUPANTS Unlike most modifications to building envelope insulation, pre-manufactured Hi-R panels are installed on top of existing windows and do not require removing or significantly modifying systems already in place. By eliminating the need for demolition or heavy construction, Hi-R panel retrofits can be accomplished at a low cost and with little disruption to building occupants.

RECOMMENDED DEPLOYMENT The Provo case study recommends further deployment of Hi-R window retrofits, particularly in cold climates where single-pane windows perform poorly.

Modelled Heating Energy Savings in Three Retrofit Configurations

COMFEN results compared to base configuration of single pane + bronze film



CONCLUSIONS

These Findings are based on the report, "Highly Insulating Window Panel Attachment Retrofit" which is available from the GPG program website, www.gsa.gov/gpg

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What We Concluded

FAVORABLE FINDINGS FOR LOW INVESTMENT

The Provo test case provided a 34-41% reduction in winter heating load for a project cost of $7,500, resulting in a conservative simple payback estimate of 9 years. Additionally, building occupants reported improved thermal and visual comfort as a result of the retrofit. Significant energy savings, increased occupant satisfaction, and relatively non-intrusive installation methods make Hi-R panels a quick and manageable alternative to the full replacement of low-performance windows.

Lessons Learned

SITE-SPECIFIC EVALUATION NECESSARY FOR OPTIMUM RESULTS

Condensation sensitivity is a potential challenge in Hi-R panels. The dry climate in Provo, Utah and the absence of a building humidification system made this test case a poor gauge of potential weaknesses caused by condensation. Further evaluation should be conducted for site-specific applications.

In general, Hi-R panel retrofits have proven most effective in buildings with low-performing windows in colder climates; however, the impact of windows on energy demand is extremely context-specific. The payback and performance of Hi-R panels are highly dependent on building conditions including climate, existing window types, interior space configuration, and building form. While initial testing generally recommends Hi-R panels as a strong contender for improving thermal performance, site-specific evaluation is essential to gauging the potential success of Hi-R panel retrofits.

Footnotes

[1]Apte, J., Arasteh, D. (2006), Window-Related Energy Consumption in the US Residential and Commercial Building Stock. Berkeley, CA: Lawrence Berkeley National Laboratory report, LBNL-60146 http://gaia.lbl.gov/btech/papers/60146.pdf