Forum Focus
Putting the *Saving Windows, Saving Money* Report to Work
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Putting the *Saving Windows, Saving Money* Report to Work

The Preservation Green Lab’s recently released report, *Saving Windows, Saving Money: Evaluating the Energy Performance of Window Replacement and Retrofit*, helps owners of historic homes make informed decisions about the pros and cons of retrofitting or replacing older windows in order to achieve energy savings. Researchers set out to determine the potential energy savings related to common practices for upgrading older, single-pane residential windows. Variables such as climate, regional energy costs, heating system efficiency, and window system performance were evaluated to understand which options provide the greatest energy savings for homeowners.

This comprehensive and ground breaking report includes

- key findings
- study objectives and approach
- recommendations and conclusion

**THE GENESIS OF THIS REPORT**

Over the past decade, homeowners have increasingly sought ways to increase the energy efficiency of their homes. Many people start with their windows, assuming that replacing older, leaky windows with new ones is the best way to save money and make their home more energy efficient. This assumption is only reinforced by companies that sell replacement windows and by the availability of utility incentives for installing new, high performance windows. So it is not surprising when preservation commissions and local preservation organizations speak up in favor of retaining older windows they are often met with skepticism.

This 59-page report, *Saving Windows, Saving Money: Evaluating the Energy Performance of Window Retrofit and Replacement*, helps homeowners and preservationists choose the best options for improving the energy performance of older homes. The report, which was released in October 2012, examines window replacement and retrofit objectively, evaluating the energy-saving potential of each approach in various climate regions.

The study is a follow-up to a report published by the National Trust’s
Preservation Green Lab in February 2012 titled *The Greenest Building: Quantifying the Environmental Value of Building Reuse*, which evaluated environmental impacts calculated over the entire life of different types of buildings and found that reusing existing buildings and retrofitting them for greater energy efficiency offers immediate reductions in CO2 emissions and other environmental impacts. For a summary of this report, read the *Forum Focus “Putting the Green Building Report to Work for Historic Preservation”* published May 2012.

*Saving Windows, Saving Money* goes further, delving into the thorniest issue for preservationists—windows.

The study was carried out by the National Trust’s Green Lab along with the Cascadia Green Building Council, an education, research, and advocacy organization in the Pacific Northwest, and Ecotope, a company that specializes in energy and resource conservation in the built environment. It was funded by the National Center for Preservation Technology and Training, a unit of the National Park Service.

**GETTING THE WORDS RIGHT**

**Heating-dominated climate**—reference to cold climates. This study tested window performance in two heating-dominated cities—Boston and Chicago.

**Cooling-dominated climate**—reference to warm climates. This study tested window performance in two cooling-dominated cities—Atlanta and Phoenix.

**Air leakage rate**—the movement of air through unintentional cracks between window components within the window frame itself or between the window assembly and the building structure.

**Solar heat gain coefficient**—the fraction of incident solar radiation admitted through a window, both directly transmitted and absorbed and subsequently released inward. SHGC is expressed as a number between 0 and 1. The lower a window’s solar heat gain coefficient, the less solar heat it transmits. Solar heat gain can provide free heat during cold weather, but can also lead to overheating during the warmer months. ([www.efficientwindows.org/shgc.cfm](http://www.efficientwindows.org/shgc.cfm))

**U-factor**—measurement of the rate of heat loss of a window assembly. The lower the U-factor, the greater a window’s resistance to heat flow and the better its insulating properties. ([www.efficientwindows.org/ufactor.cfm](http://www.efficientwindows.org/ufactor.cfm))

**Simple Energy and Enthalpy Model (SEEM)**—a program designed to model residential building energy use, which conducts concurrent hourly simulations of heat transfer, moisture (humidity), and infiltration.
UNDERSTANDING THE METHODOLOGY AND RESEARCH

*Saving Windows, Saving Money* used computer simulation to model energy use in a typical, prototype home both before and after window improvements. Researchers analyzed the energy and cost savings for several commercially available window improvement options ranging from simple, low-cost applications to more expensive treatments. These included the following options:

- weather stripping existing windows
- adding interior window panels
- adding exterior storm windows
- adding insulating cellular shades
- applying interior-applied surface film
- adding new, high performance replacement windows

Since differing weather conditions across the country affect the energy performance of the window improvement options, researchers evaluated the prototype home’s performance in the following five U.S. cities:

- Boston (cold)
- Atlanta (hot/humid)
- Chicago (extreme hot/cold)
- Phoenix (hot/arid)
- Portland (temperate)

THE PROTOTYPE HOUSE

The research team used an actual, rather than a theoretical house, for the study, which allowed them to simulate an existing house with a variety of window interventions. The team chose a two-story, Queen Anne style home in Portland, Ore., with wood, double-hung windows, as the prototype home. The home “traveled” to four other cities to determine how variations in climate and energy costs affect potential window choices.
ENERGY SAVINGS

To measure energy savings, energy simulations for the prototype house and each window upgrade measure were carried out using the SEEM (Simple Energy and Enthalpy Model) program. Designed specifically to model residential building energy use, this program conducts concurrent hourly simulations of heat transfer, moisture (humidity), and infiltration. (http://rtf.nwcouncil.org/measures/support/SEEM/)

COST SAVINGS

Not only did researchers measure the performance of the various window options, they also measured and compared the cost effectiveness of the various measures. Volunteer industry experts for each installation practice looked at the cost of labor, materials, and contractor mark-up. Results were also adjusted to reflect the differences between construction costs in each city. Using this information together with the simulated energy savings, the research team calculated the average return on investment (ROI) for each option. ROI was defined as the annual energy cost savings divided by the initial installation cost.

A CLOSER LOOK AT ONE OPTION: INSULATING CELLULAR SHADE

The installation of insulated cellular shades to the inside of window openings to improve thermal performance best illustrates one of the high performing options evaluated during the study. And it turned out this relatively inexpensive option reaps huge rewards in terms of energy savings.

Research team members found that cellular shades improve thermal performance, minimize drafts, and provide daylight control and privacy. In addition, they can be combined with air sealing and repair of existing window and with exterior storm windows and offer minimal interference with existing window operability and egress.

In terms of drawbacks, researchers noted that cellular shades require proper deployment daily; views and daylight are reduced when in use; and there is no energy benefit when shades are raised for light and views.

Cellular shades also offered by far the highest average return on investment, from 4.8 to 7.8 percent, in heating-dominated climates. Researchers found that this low-cost measure offers fairly significant energy performance returns, making this approach the clear winner in terms of return on investment.
UNDERSTANDING THE RESULTS

The results of the study show that window retrofit and replacement options have the potential to significantly improve the energy efficiency of homes with existing single-pane windows. How much improvement depends on a number of variables including climate, energy costs, and the type of retrofit chosen. In some cases, combining retrofit options, such as the addition of storm windows combined with cellular shades, proved to be almost as efficient, and considerably less expensive, than high performance replacement windows.

Let’s look at eight key findings:

1. **Retrofit measures can achieve performance results comparable to new replacement windows.** There are readily available retrofit measures that can achieve energy savings within the range of savings expected from new, high performance replacement windows. This challenges the common assumption that replacement windows alone provide the greatest benefit to homeowners.
2. The range of energy performance for retrofit options varies significantly.
The study showed that the range of energy savings for a set of upgrade measures applied to existing windows results in as little as 1 percent energy savings and as much as 30 percent energy savings. The highest performing measures included exterior storm windows, interior window panels, a combination of insulating shades plus exterior storm windows, and high performance replacement windows.

3. Improving window airtightness alone is not enough.
The simulation analysis showed that weather stripping offered the least amount of energy savings—only 1 to 3 percent for all cities studied.

4. Energy costs and carbon savings vary by city and climate. The cost of electricity and gas varies considerably from city to city. This affected the energy cost and carbon savings of each window option because higher or lower energy costs have a multiplier effect on the energy savings. So even though energy savings in Chicago are a little higher than in Boston, the higher gas prices in Boston as compared to Chicago create greater costs savings for each test condition.

5. Climate is an important factor in determining the appropriate application of interior surface film. Houses in cold climates benefit from direct solar exposure during the cooler months. However, houses in Phoenix, for example, benefit from the addition of interior surface films, in order to cut down on solar exposure during the long cooling season.

6. Almost every retrofit option offers a better return on investment than replacement windows. Before undertaking any kind of retrofit, homeowners should consider the cost of the initial investment. New, high performance windows are costly, averaging approximately $30,000 for materials, installation, and general construction commonly required for an existing home. In cold climates, other retrofit measures, except for professionally installed weather stripping and heat-reducing surface films, offer a higher average return on investment than new replacement windows. In hot climates, retrofit measures offer a better average return on investment than new windows, except for professionally installed weather stripping.

7. The impact of window improvements is diminished if the heating system has already been upgraded. As the total energy needed for heating is reduced, the potential savings from the windows is also reduced proportionately. This also holds true for upgraded cooling systems.
8. **The best returns on investment are generated for do-it-yourself measures such as simple weather stripping and interior surface film.** Even though the weather stripping option has the lowest energy cost savings and a low average return on investment compared to other options, these savings can be captured through homeowner installation, producing higher returns than any of the other window options studied.

**RECOMMENDATIONS**

The report also offers useful guidance for homeowners and industry professionals choosing among window retrofit or other replacement options:

1. **Don't start with windows:** Tackle other energy-efficiency measures first. Homeowners should consider other upgrades first, such as installing high-efficiency lighting and motion detectors, hiring a professional to analyze air leakage and perform whole-house air sealing, improving insulation especially in attics, and upgrading appliances, water heaters, and HVAC systems with high-efficiency equipment.

2. **Choose window retrofits over replacements.** Window retrofits can achieve comparable energy savings at a much lower cost. Furthermore, the reuse of existing windows avoids the environmental effects associated with the manufacture of new windows. The reuse of the existing windows also means less discarded building material ends up in landfills.

3. **Take climate into consideration.** The best retrofit option for Phoenix may not be right for Chicago. Consider the temperature and sun exposure of the house when choosing the right options for improving window performance.

4. **Take matters into your own hands.** Perform high-return, do-it-yourself installations first, where possible.