

## ABSTRACT

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HISTORIC WINDOWS AND NEW VIEWS:  
ENERGYPERFORMANCE AND  
ECONOMIC CONCERNS  
AFFECTING THE PRESERVATION OF HISTORIC  
WOOD SASH WINDOWS

Suzanne Elizabeth Stasiulatis, M.H.P, 2008

Directed By:

Dr. Donald Linebaugh, Chair

New approaches regarding the economics and energy performance of replacement windows are affecting the fate of wood sash windows in historic properties. The current vogue for replacement is driven by economics and energy performance. While replacement window manufacturers and dealers often tout their products as inexpensive and more energy efficient, in actuality original or historic windows can perform to the same standards. Cost analysis suggests that replacement options compare to the costs associated with maintenance and repair of original windows.

This project confronts the current issues of economics and energy performance, which are driving decisions to replace instead of preserve historic windows. This study demonstrates that historic windows can be maintained and upgraded to energy performance standards and still be economical. The goal of this project is to provide guidance for homeowners, project leaders, and government agencies, in terms of the decision making process regarding the treatment of historic windows.

HISTORIC WINDOWS AND NEW VIEWS:  
ENERGY PERFORMANCE AND ECONOMIC CONCERNS  
THAT ARE AFFECTING THE PRESERVATION OF HISTORIC WOOD SASH WINDOWS

By

Suzanne Elizabeth Stasiulatis

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Advisory Committee:  
Dr. Donald W. Linebaugh, Chair  
Thomas A. Vitanza, AIA

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## Chapter 1: Introduction

Current economic and energy conservation ideas and marketing programs regarding windows are influencing decisions to replace wood sash windows with new replacement alternatives. Economics and energy performance are two growing concerns that many believe can be solved with modern replacement windows. Yet, historic windows, if maintained and used to their potential, compare favorably to replacements in terms of energy performance and cost.

One organization has recently recognized the effects of these new “solutions.” APVA Preservation Virginia,<sup>1</sup> an organization that promotes the preservation of Virginia’s historic structures, landscapes, collections, communities, and archaeological sites, nominated historic wooden windows to its 11 Most Endangered Sites in Virginia List in 2007.<sup>2</sup> (See Appendix A) Camille Bowman, who nominated historic wooden windows to the list, noted that people are often misinformed regarding the decision to preserve or replace historic windows. Bowman argues that windows are threatened despite their superior materials and construction. Windows, she asserts, are the “eyes” of historic buildings and contribute to the significance of the entire structure. Bowman hoped to push the APVA and other organizations to become more active in informing building owners of the benefits of retaining and restoring windows.<sup>3</sup>

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<sup>1</sup>The mission of the APVA is to ensure protection and vitality of Virginia’s heritage. “APVA Preservation Virginia” (APVA Preservation Virginia, 2008). <http://www.apva.org/> (March 1, 2008).

<sup>2</sup>“APVA Pressroom” (APVA Preservation Virginia, 2 May 2007). [http://www.apva.org/pressroom/press\\_release.php?pr\\_id=46](http://www.apva.org/pressroom/press_release.php?pr_id=46) (March 1, 2008).

<sup>3</sup>“Virginia’s Most Endangered Historic Sites 2007” (APVA Preservation Virginia, 24 May 2007). [http://www.apva.org/pressroom/pdf/endangered\\_sites\\_07.pdf](http://www.apva.org/pressroom/pdf/endangered_sites_07.pdf) (March 1, 2008).

There are many dealers and manufacturers who are capitalizing on the idea that replacement is the best option. In the April 20<sup>th</sup>, 2008, Sunday edition, of the *Washington Post*, there were ten ads and coupons for replacement windows and window products.<sup>4</sup> One dealer advertised that they sold one million windows in 2007.<sup>5</sup> It is estimated that half of the 58,000,000 windows sold every year are replacements. This can be attributed to the fact that vinyl replacement windows must be replaced more often than quality wood windows, old or new. Most vinyl windows being replaced are ten years old; some are only two years old.<sup>6</sup> This replace, replace, replace trend will be ongoing, until new and better technology becomes available. Historic wood windows, with proper maintenance and repair, will not require replacement for decades. Replacing wood windows at this time will add to long-term costs and cyclical replacement.

Warranties are offered for most replacement windows, but they are often inadequate. An Anderson vinyl clad window has a 20 year warranty on glass, but only a 10-year warranty on the non-glass parts.<sup>7</sup> Other vinyl products may offer limited lifetime warranties, but the windows can fail in a number of ways, some not covered by the warranty. Other warranties are only effective for the purchaser and do not extend to new owners if the house is sold. Because warranties are not comprehensive, one can expect the long-term costs of replacing windows every 10 years to be quite costly.

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<sup>4</sup> *Washington Post*, April 20, 2008.

<sup>5</sup> Window World of DC, Inc. "The Big Coupon." *Washington Post*, April 20, 2008.

<sup>6</sup> Daniel S. Morrison, "Get the Right Replacement," *Fine Homebuilding*, October/November 2004, 43.

<sup>7</sup> "Warranties" (Anderson Windows and Doors, 2008).

<http://www.andersenwindows.com/servlet/Satellite/AW/Page/awGeneral-3NoCache/1104867941417> (April 19, 2008).

Many dealers and manufacturers offer promises of cheap and maintenance-free windows. Web resources, articles, and promotional literature echo this idea and advocate the benefits of replacement, but they caught up in the hype of the replacement trend.<sup>8</sup> The truth is that windows, wood, vinyl or otherwise, are not maintenance-free. In actuality, vinyl replacement windows must be cleaned of dirt, grime, and hardware rust to remain serviceable. Power washing may be required to clean vinyl windows. There are many false promises, from maintenance-free to cheap and easy, involved with the replacement window industry, as it is the job of manufacturers and dealers to sell their products. Historic windows are not maintenance-free either, but the superior materials and construction render them the best investment in the long-term.

Window salesmen will also try to convince a buyer that windows are energy efficient.<sup>9</sup> Their arguments include promoting the idea that windows will not allow heat to leave the home. They will try to sell new technologies that are still evolving. New high performance windows, many with costly extra features, will have a better insulating value in some cases. However, historic windows can have comparable energy performance with simple maintenance and repair measures.

There are several good arguments for why we should preserving historic windows. My argument is that historic windows can have good energy performance ratings and be economical. Other arguments range from the abstract to concrete. One broad end of the spectrum includes style and historic character, while the other is the laws and policies that dictate the preservation of historic structures.

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<sup>8</sup> “10 Reasons to Replace Your Windows” (Improvement Web, 18 November 2007). <http://improvementweb.com/10-reasons-to-replace-your-windows/63/> (April 20, 2008).

<sup>9</sup> Allen G. Barclay, Staff, Window Warehouse. Personal Interview. April 30, 2008.

Windows are part of the overall style and character of the exterior and interior of a building. Walter Sedovic and Jill Gotthelf explain that, “Outfitting historic buildings with modern replacement windows can and often does result in a mechanical, contrived, or uniformly sterile appearance. Worse, when historic windows are replaced, authenticity is lost forever.”<sup>10</sup> A window is a central element in design that when removed will impact the architecture as a whole. Within the frame of an entire building, windows are an important feature. For example, when a building is viewed up close, the texture of wood and the visual feel of a building can be distorted with aluminum or vinyl windows. Compromising the elements of a building, tangibly or visually, is a distraction to a buildings uniform style. It creates a dissonance in the architecture. A building is something entirely different from written documents. A building is a record of history that can be appreciated visually by a large number of people. The significance of a whole building is compromised when components are distorted.

On the other end of the spectrum, a good argument focuses on laws that regulate the treatment of historic properties. The National Historic Preservation Act<sup>11</sup> was passed in 1966 in order to protect historic resources and heritage. It established standards and guidelines to control the treatment of historic resources. The Secretary of the Interior’s Standards and Guidelines direct actions concerning a wide range of

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<sup>10</sup> Walter Sedovic and Jill H. Gotthelf, “What Replacement Windows Can’t Replace: The Real Cost of Removing Historic Windows,” *APT Bulletin* 36, no. 4 (2005): 29.

<sup>11</sup> *National Historic Preservation Act of 1966*, Public Law 89-665, 16<sup>th</sup> Cong., 470 et seq.

interventions from Preservation to Rehabilitation to Restoration to Reconstruction.<sup>12</sup>

In the case of windows, the guidelines encourage Preservation focused projects to identify, retain, and preserve windows; protect and maintain windows; or repair windows. Rehabilitation focused projects are encouraged to preserve and repair windows as well. Windows should only be replaced if the level of deterioration is very high. Restoration or Reconstruction is necessary in circumstances of severe deterioration. If windows are missing, designing and installing new windows based on historic records or design is considered appropriate.<sup>13</sup> These guidelines are enforced by National Park Service and State Historic Preservation Office policies, as well as, local level preservation organizations.

This paper will explore two main issues that drive the replacement of historic windows: energy performance and economics. This study argues that historic windows can meet energy performance standards and still be economical, through proper maintenance and/or repair. Chapter 2 examines the techniques and technologies of maintenance, repair, and replacement, providing a basis for understanding how these techniques and technologies relate to energy performance and economics. Chapter 3, Energy Performance, develops the argument that historic windows can perform to the standards of replacement windows. It examines the statistics regarding energy performance in terms of maintenance measures, repair, and replacement options. The chapter aims to underscore that retaining, maintaining, and

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<sup>12</sup> Throughout the paper the terms Preservation, Rehabilitation, Restoration, and Reconstruction are left capitalized when indicating the association of the term to the standards.

“The Secretary of the Interior’s Standards for The Treatment of Historic Properties: With Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings,” (National Park Service, 2001). <http://www.nps.gov/history/hps/tps/standguide/> (March 15, 2008).

<sup>13</sup> “Standards for Rehabilitation and Guidelines for Rehabilitating Historic Buildings (Windows)” (Washington, DC: National Park Service, 1991).

applying selected special treatments can ensure energy performance that compares to new replacement windows. The section develops the argument that windows are functional and should be used. Other treatments and measures can improve energy performance to a greater degree. Environmentalists and what they promote are examined in the context of the preservation of windows. Chapter 4 examines the proposition that the preservation of windows is economical. Durability and life-cycle costs, energy consumption, and the costs of maintenance, repair, and replacement in the short and long-term are presented. This chapter develops the costs associated with maintenance, repair, and replacement measures. It also discusses financial incentives that help keep the preservation of windows economical in the short-term. The conclusion chapter offers other reasons to retain historic windows, existing policies for the treatment of windows, and steps to be taken to promote and advocate the retention of historic windows.

Windows are an important feature of the overall exterior envelope of a historic building, and they are also one of the most endangered. Misunderstood economic and energy performance statistics are affecting decisions about whether to replace or preserve historic windows. The issues and problems related to historic window preservation require careful study to provide sound advice and guidance to those making decisions.

## Chapter 2: Techniques and Technologies: Maintenance, Repair, and Replacement

In this chapter, I will explore the techniques and technologies associated with historic window maintenance, repair, and replacement. Maintenance is important to the overall preservation of windows. This treatment is advised over any other option. Effective maintenance requires planning for the future. In order to critically evaluate the choice of retaining or replacing windows, one must understand the issues and methods involved in maintenance and repair, and the issues and technologies related to replacement windows. With this knowledge, there can be a true comparison of the energy performance and costs involved in the treatment of historic windows, including maintenance, repair, and replacement.

Preplanning includes identifying and determining the treatments for the windows in a project. The *Preservation Brief* series is published by the National Park Service and adheres to the vision of Secretary of the Interior's Standards, which advocates preserving and repairing features over replacing them. The briefs are guiding documents for the treatment of historic windows. *Preservation Brief 9: "The Repair of Historic Wooden Windows,"* establishes stabilization classes for repair and treatment. Repair Class I is Routine Maintenance. The *Preservation Brief* argues that it is most cost effective to maintain windows over time. Routine maintenance can create a window that is new in appearance. Stabilization is the second repair class. If a window has deterioration and vulnerable areas, such as wood decay, it will require repair. A third repair class includes splicing and parts replacement. The brief recommends replacing deteriorated parts with matching pieces or splicing wood into an existing sash. This type of repair work, which can be avoided through routine

maintenance, may require a restoration contractor who specializes in windows.<sup>14</sup>

These repair classes categorize the level of the problem with the window and the treatment required to return the window to its original appearance.

It is important to prioritize the plan for window maintenance and repair. Each window should be put into one of the three stabilization classes, determined by the condition and deterioration. The window should be documented to identify feature details, and deterioration should be identified, in order to correct the problem. With these factors, a plan should be set to correct problems causing deterioration and address the windows in the poorest condition first.

Routine maintenance provides the opportunity to diagnose and correct problems early. Simple maintenance can reduce future problems. With proper maintenance, there should be no need for replacement with new windows. Maintenance may include: paint removal and repainting, weatherstripping, removal and repair of the sash, and frame repairs.<sup>15</sup> For example, removing and reinserting historic glass may improve thermal performance. Other methods, such as repriming a window, have been proven to increase their durability and life-cycle. These maintenance measures can improve the integrity and visual character of a window, while also reducing long-term costs and increasing energy performance.

Identifying the problem is the first step in assessing the maintenance needs for wooden windows. Problems may include water infiltration, air infiltration, and poor operation. There are relatively simple solutions to economically preserve the

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<sup>14</sup> John H. Myers, "The Repair of Historic Wooden Windows," *Preservation Briefs* 9 (1991): 1-7.

<sup>15</sup> *Ibid.*

character and energy performance of windows, such as using storm windows, weatherstripping, and caulking.

Moisture is by far the biggest contributor to deterioration, causing wood windows to rot. Deterioration can occur from rainwater driving against exterior surfaces, penetrating into loose joints, or standing on sloped surfaces. Condensation can also form on interior surfaces, and cause damage to paint and wood. Water saturation in wood may allow microscopic fungi growth; this most often occurs in a window that has not been regularly painted. End cuts, across grain, typically draw moisture into the wood. Moisture can transfer into the sash's lower rail and the lower section of the frame, often identified by paint failure. Paint failure can be identified on a scale ranging from chalking and powdering to crazing to alligating to wrinkling and blistering. Moisture may enter into rough parts or pits in the wood, causing regular problems.

Air infiltration is another problem commonly associated with windows. Windows often admit air through spaces at junctures of the window system, including the window frame and the wall, the sash and the frame or other sash members, the glass panel and the sash, and at sash weight pockets. Also, air infiltration can occur due to warped wood or because of building movement and settlement. Water saturation of the wood will lower the resistance to heat loss, because moisture is a good conductor.

Window operation is also important, because windows were designed to be functional. A working double-hung sash should open completely. The sash must fit snugly, but not too tight, not only to work, but also to insure energy performance. Excessive paint buildup can contribute to poor working condition. Weatherseals or

caulking that are deformed or improperly applied may also prohibit proper operation. Racking or deflection in the frame is a less common but serious problem. If such a problem occurs, a new window will not solve the problem indefinitely. Weatherstripping or rebuilding portions of the sash is an option if the sash has weathered.<sup>16</sup>

There are other considerations when deciding the extent of the problem with windows, including the presence of lead paint, the condition of the glazing, and window hardware. Lead abatement is a serious problem that affects health issues and must be corrected by a trained restoration contractor. Window hardware has historic character and should be cleaned and lubricated.

Several maintenance measures and minimally invasive upgrades, including weatherstripping, exterior storm windows, and interior storm windows, are recommended to correct the problems of moisture deterioration, air infiltration, and window operation.

Weatherstripping is a relatively simple and effective solution to correct both water and air infiltration. Weatherstripping is a long strip of metal or foam that is applied to the V-channel between the sash stiles and the jamb. Other areas of the window can be weatherstripped as well. Historically, felt weatherstripping was used to decrease drafts. However, felt weatherstripping may not last as long as other methods currently available. Current options include: spring and metal strips, plastic strips, plastic foam strips, rolled vinyl with rubber gaskets, film-clad foam, and pile weatherstripping. Caulking can eliminate drafts that affect energy performance as

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<sup>16</sup> New York Landmarks Conservancy, *Repairing Old and Historic Windows: A Manual for Architects and Homeowners* (New York: John Wiley and Sons, 1992), 64-78.

well. There are various types of caulking including: oil-based caulks, butyl rubber caulks, polysulfide caulks, silicone caulks, and polyurethane caulks. Glazing compounds ensure a seal at the joint of the panes and the glass. Oil-based putty is typical for a wood sash. Regular painting is also a maintenance measure. Proper paint removal and application is necessary for effective operation of the sash and also visual appearance.

The use of storm windows is highly recommended by the National Park Service and many preservationists.<sup>17</sup> Storm windows act as a second barrier against weathering. They are an effective solution to prevent water deterioration, weathering, and air infiltration, especially in very cold environments. Storm windows, usually exterior storms, are sometimes a component of the original building and are especially significant in that regard. One main problem with storm windows is condensation. The conflict of hot air and the cool surface of the window can allow condensation to form between the storm and window, causing deterioration. Exterior storms are especially effective when used to decrease wear and weathering to wooden windows. Another, perhaps preferable, option is the use of interior storms, and the option is clear, if energy performance is the goal.

Interior storms, instead of replacement exterior storms, are an answer to many visual and energy performance problems. Buildings where the exterior can be viewed up close, in urban areas especially, benefit from interior storms. One negative aspect is that moisture and condensation can infiltrate the windows and deterioration can occur on the interior of the wood sash. Magnetic seal storms are an interior storm option, which has been tested with more successful results than storms than storms

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<sup>17</sup> John Sandor, National Park Service. Personal Communication. March 3, 2008.

screwed into the wall.<sup>18</sup> One downside is that magnetic seals may be easily jarred loose. Velcro or screw interior storms are other options that provide more secure attachment. Interior storms can reduce the air infiltration through the sash and the rough opening, making them a better barrier than exterior storms.

If there are more than minor problems with a window, a second option is repair. Preservationists hold that windows should be preserved and repaired before replacing a building with new fabric.

The Secretary of the Interior's Standards for Historic Properties address Preservation, Rehabilitation, and proper, prudent Restoration and Reconstruction. The Standards generally support retention and repair over replacement wherever possible. The standards were created to advise owners, developers, and Federal managers about the treatment of historic properties. Ten Rehabilitation standards must be met for all projects wishing to be certified as a historic building. One Rehabilitation standard deals directly with historic features:

Standard 6: Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities, and, where possible, materials.

Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.<sup>19</sup>

Rehabilitation projects, where there is considerable damage, may require treatments such as sill repair, weather check filling, deep decay treatment, sill

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<sup>18</sup> Charles F. Fisher, "Windows No. 9 Interior Storm Windows: Magnetic Seal," *Preservation Tech Notes* (September 1984): 1-6.

<sup>19</sup> "The Secretary of the Interior's Standards for The Treatment of Historic Properties: With Guidelines for Preserving, Rehabilitating, Restoring, and Reconstructing Historic Buildings" (National Park Service, 2001). <http://www.nps.gov/history/hps/tps/standguide/> (March 15, 2008).

replacement, sash and joint repairs, joint stabilization. Many of these procedures can be done by an individual for small projects or on a larger scale by a restoration contractor.<sup>20</sup> There are only a few window restoration contractors in each state, but their expertise is valued and for larger projects. They can ensure the windows are as effective as they can be, through and professional restoration and proper reinstallation.

Glazing covers more than half of the window, making it a significant part of historic windows. Yet, new technologies are emerging regarding glass. Restoration contractors can replace historic window glass with character glass, which has the same texture and feel as historic glass. If available, glass can be salvaged from other historic windows in a building. Modern glass is usually replaced with modern glass unless a full Restoration project is undertaken.

Preservation includes maintaining and repairing a feature to its original appearance, in order to present tangible history to the public. However, new ideas are emerging that challenge traditional repair techniques in favor of technological advances that can increase energy performance.

Several retrofitting glazing options are currently available. Yet, these retrofit techniques are not recommended. They will irreversibly alter the integrity of a window.

Low-emissivity (low-e) glass is a technology that blocks radiant heat and can reduce the heat flow through the glass. Low-e glass contains a layer of metal oxide. It is transparent to short-wave solar energy and opaque to long-wave infrared energy,

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<sup>20</sup> John C. Leeke, ed., *Windows on Preservation* (Windsor, Vermont: American Precision Museum, 2005).

thus it reflects heat energy back into the room. This technology is used most often in colder climates. Stick-on low-e films are one solution, but they have a mirrored appearance that can affect character. Another concern is that the coating, in some cases, has proven to be susceptible to wear, scratching, and smudges, affecting the visual quality.

Insulated glass units (IG units), or double glazing, is a technology that incorporates two panes of glass for additional protection from heat loss. Often, the space between the glass is filled with Krypton or Argon gas. IG units require routing out the stiles, rails, and muntins, in order to accommodate a greater thickness. This may compromise structural integrity, particularly because the weight of the sash increases. Counterbalances and hardware must be adjusted. Some modification methods include replacing the counterweight system with a spring balance. This method can affect operation, durability, and causes irreversible damage. Not all sashes can accommodate IG units. Slimmer IG units, which are required in retrofits, have considerably less thermal benefits. Additionally, if the sash has slight warping, the IG unit may not be able to be installed. Glass character is lost, not only because IG unit glass is not historic, but also because with two panes of glass a window appears entirely out of character.<sup>21</sup>

Low-e glazing and IG units are technologies that have impacts on the integrity of the sash. There are many considerations to take into account before using these solutions. IG units are difficult and costly to repair. Low-e glazing is subject to scratching and atmospheric deterioration. The warranty for these products is usually

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<sup>21</sup> Natalie Bull, "Old Dogs, New Tricks: Assessing the Worth of Retrofit Techniques," in *Window Rehabilitation Guide for Historic Buildings*, eds. Charles E. Fisher, Deborah Slaton, and Rebecca A. Shiffer (Washington, DC: Historic Preservation Education Foundation, 1997), IV37 – IV43.

10 years. Although this alternative is preferable to replacement, the costs outweigh the benefits.

Another alternative option is replacement. Replacement, as I will discuss below, is unwarranted in most cases. The exception is a window that is entirely missing or drastically deteriorated beyond repair. If replacement is the only option, the window should be replaced to mimic size, configuration, and detail. There are contractors and firms who replace windows to exact specifications. There are many new materials and technologies that are emerging, which makes it hard to decide what is appropriate and beneficial over other options. However, many new technologies are not time tested and are still being evaluated. Current window replacement products are made from wood, vinyl, and aluminum or a combination of these materials.

There are two wood replacement window options available. Hardwoods, which most historic windows are made of, should be the first choice for historic wood window replacements. Oak, maple, and walnut are the most durable choice and the benefits both from a preservation and energy performance standpoint are positive. However, hardwoods are regulated and can be quite expensive. On the other hand, softwoods are less expensive and can be procured more easily. Softwoods will not last the 100 years the original windows lasted. They will weather more easily, even though they are visually more similar to historic windows than aluminum or vinyl replacements.

Vinyl, polyvinyl chloride, windows have been used since the 1980s. More and more homeowners are deciding to use this option based on manufacturer's promises that they are maintenance-free and easy to install. Also, it is becoming common for

historic project leaders to ask State Historic Preservation Offices and local Historic Preservation Review Boards if they can use vinyl windows on upper levels of buildings or on secondary facades. There are some benefits to vinyl windows. The moisture resistance rating is good. There is no finish that can be damaged or deteriorated, and they do not require painting. There are even companies who now offer surface treatments including wood veneer, paintable/stainable, and laminates and coatings. Testing has also shown that vinyl frames are comparable to hardwoods regarding thermal performance.<sup>22</sup> However, texture and visual appearance is not comparable to wood.

Vinyl windows commonly fail at the seal, desiccants, coating systems, and vinyl, shortening their life-span dramatically.<sup>23</sup> Other maintenance problems may surface in a ten year life-span. Specialized reproduction of historic details is necessary to approximate the original in a replacement window. This requires a monetary investment that could be better spent on maintenance or repair measures. Most importantly, the windows are not appropriate on primary facades, because of the strong impact on the character of the most visible portion of the building. The National Park Service, State Historic Preservation Offices, and many local Historic Preservation Review Boards echo this idea.

Aluminum frames are light and strong. They are also considered low maintenance. However, there are disadvantages to aluminum; it is a high thermal conductor, and easily allows in heat, giving it a high U-value. The U-value is an

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<sup>22</sup> “Vinyl” (Efficient Window Collaborative, 2008).  
[http://www.efficientwindows.org/frames\\_.cfm?id=1](http://www.efficientwindows.org/frames_.cfm?id=1) (March 6, 2008).

<sup>23</sup> Patrice Frey, “Making the Case: Historic Preservation and Sustainable Development,” (Paper presented at the Sustainable Preservation Research Retreat, October 2007), 14.

industry rating that translates the windows resistance to heat flow and insulating value. If a window has a high U-value, the insulating value is low. In colder climates, aluminum windows can let frost and moisture inside the window frames, because it adopts the exterior temperature. Aluminum frames with thermal breaks have been developed to improve insulating value.<sup>24</sup> Aluminum replacements are not currently in vogue given the enthusiasm surfacing about vinyl windows.

There are many options for the maintenance, repair, and replacement of historic windows. Maintenance and repair are recommended over window replacement. This chapter was meant to provide an understanding of techniques and technology associated with both the retention and repair of windows and replacement. In the next two chapters, I will discuss the effectiveness of these techniques and technologies in the context of energy performance and economics.

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<sup>24</sup> “Aluminum” (Efficient Window Collaborative, 2008).  
[http://www.efficientwindows.org/frames\\_.cfm?id=1](http://www.efficientwindows.org/frames_.cfm?id=1) (March 6, 2008).

## Chapter 3: Energy Performance

Historic wood windows can be energy efficient with proper maintenance, yet they are regularly being replaced with new windows that may perform only slightly better. Many federally endorsed fenestration rating systems evaluate new products, but do not consider historic windows or the various options for minimally invasive treatments, such as weatherstripping. Energy efficiency is at the forefront of current practice, and this is driving the replacement cycle. However, few voices are advocating the renewal of the resources that already exist, for example historic windows. There are also other options to increase energy performance, while still allowing for the preservation of windows.

TABLE 1:  
NATIONAL FENESTRATION RATING COUNCIL RATINGS

The National Fenestration Rating Council (NFRC) considers various criteria for windows from most manufacturers. The U-value, or U-factor, is the measure of how well a window can prevent heat from escaping the interior. The U-value can be .20 or 1.20. However, the lower the U-value, the better the window resists heat flow and the better its insulating value. The R-value is the inverse of the U-value. The Solar Heat Gain Coefficient (SHGC) is the rating given to the ability of a window to block heat caused by sunlight. It is the value of the solar radiation allowed through a window, both transmitted and absorbed. SHGC is valued between 0 and 1, with a lower value indicating less solar heat transmittance into the structure. Visible transmittance (VT) measures the amount of light allowed through a window. It is an optical property. A value between 0 and 1 is assigned to a window. A higher VT indicates more light is transmitted. Condensation resistance (CR) is the ability of a product to resist condensation formation on the interior of a window. A higher CR, rated between 0 and 100, means the product can resist condensation formation better.<sup>25</sup>

Careful attention to maintenance and repair measures can make a historic window more effective, and even comparable to new windows. Studies have show

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<sup>25</sup> “The NFRC Label” (National Fenestration Rating Council, 2005). <http://www.nfrc.org/label.aspx> (March 6, 2008).

that properly maintained historic windows can meet efficiency standards.<sup>26</sup> Storm windows are a simple option for improving energy performance. Intense repair strategies for deteriorated or loose windows can drastically improve energy performance. Glazing options are available, as a last resort, if historic windows fall short of standards. Replacement should be given a close look and actual energy savings should be calculated. Energy performance ratings should be a factor if replacement is necessary.

In a report for the Vermont Division of Historic Preservation, “Testing the Energy Performance of Wood Windows in Cold Climates,” the study team’s data supports the idea that regular maintenance increases the thermal performance of historic wood windows. This study is conclusive evidence that maintenance can affect and improve the performance of windows to the standard of replacement windows. Windows were tested first in original condition with loose glass, missing putty, and little paint and then retested after maintenance. Maintenance, in this study, included painting, applying new putty, and caulking. After routine maintenance, the overall air leakage reduction of the study windows was 65% at the sash, and leakage at the trim/wall junction was reduced 90%. Six of seven areas that were treated to reduce air infiltration were certifiable after treatment at or above industry standards. The team concluded that significant air leakage is reduced by maintenance in loose windows, but there is still leakage. Already tight windows may not receive substantial leakage reduction.<sup>27</sup> The report illustrates a practical test of historic windows and their

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<sup>26</sup> Brad James, Andrew Shapiro, Steve Flanders, and David Hemenway, “Testing the Energy Performance of Wood Windows in Cold Climates,” A Report to the State of Vermont Division of Historic Preservation Agency of Commerce and Community Development. August 30, 1996.

<sup>27</sup> Ibid.

performance with proper maintenance. The study concludes that not only do simple maintenance techniques increase performance, they result in substantial increases in performance.

In the Vermont study, storm windows attached to historic windows were also tested for their energy performance when closed and open. On average, the energy saving was about 50%. The most effective method, reducing air leakage by 91%, was accomplished with a closed spring-loaded frame interior storm or a closed plexi with magnetic strip interior storm. Exterior storms did reduce air infiltration, but in some cases, to a lesser degree.<sup>28</sup> Thus, as far as energy performance, interior replacement storms are preferable over exterior replacement storms, because of the reduction in air leakage.

Weatherstripping cuts down on draft and reduces air infiltration that affects the energy performance of a window. The Vermont study reported that infiltrative losses were reduced from 37% to 17% of total house thermal losses. The reduction of energy costs was approximately 24%. The study used metal rib-type weatherstripping.<sup>29</sup> Other estimates gauge weatherstripping as accounting for up to 50% of a window's energy performance.<sup>30</sup> Weatherstripping is an easily applied energy saving technique that can minimally affect the historic fabric. Thus, historic windows can be made to

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<sup>28</sup> Andrew M. Shapiro and Brad James, "Retain or Retire? A Field Study of the Energy Impacts of Window Rehab Choices," in *Window Rehabilitation Guide for Historic Buildings* eds. Charles E. Fisher, Deborah Slaton, and Rebecca Shiffer (Washington, DC: Historic Preservation Education Foundation, 1997), IV15 –IV27.

<sup>29</sup> Brad James, Andrew Shapiro, Steve Flanders, and David Hemenway, "Testing the Energy Performance of Wood Windows in Cold Climates," A Report to the State of Vermont Division of Historic Preservation Agency of Commerce and Community Development. August 30, 1996: 5.

<sup>30</sup> New York Landmarks Conservancy, *Repairing Old and Historic Windows: A Manual for Architects and Homeowners* (New York: John Wiley and Sons, 1992), 113.

be as energy efficient as replacement windows using techniques that affect integrity to a minor degree.

Removing excess paint and then repainting windows can improve the fit of a sash in a frame. This type of routine maintenance can increase the longevity of a window, and create a tighter seal, which will add to the overall energy performance of a window. Routine maintenance is important to enhance the visual historic character and the energy performance of a building. Maintenance also preserves the integrity of the window and the building. Many replacement windows do not have to be painted, but if they are not installed correctly they can fit poorly in the existing frame. If the entire frame is replaced to accommodate a new sash, the integrity of the wall may be compromised.

Repair can create a window that performs as good as or better than when it was new. If a sash has deep decay, loose joints, loose glass, or bowed meeting rail, it seriously affects the energy performance of a window. It can be daunting if there are major repairs that have to be done, but in actuality the repairs can often be done by a homeowner or a restoration contractor and can drastically increase the life-cycle compared to replacement windows.

Other measures are available to boost performance. Increasing a window's energy performance with glass technologies is a way to retain the wood sash, without relying on replacement, but it is an irreversible process. The technique also may increase condensation. Stick-on Low-emissivity (low-e) glass can reduce emissivity from .84 to .35. It can reduce U-value from 1.06 to .75. For non-commercial projects, the energy saved in heat retention may counteract the reductions in solar gains. Low-e

and the effects of light transmittance can be counteracted by interior lighting and the energy savings are compromised. Because the low-e glass reflects light and heat, occupants in a building will have to use more artificial light more frequently, raising electric bills. In another respect, lack of natural light caused by low-e glass may affect health and productivity of building occupants. Daylight is important to the atmosphere of a building, which makes the choice to use this method debatable. Energy performance is increased with low-e glazing, but it is not preferred in all situations, both as far as energy performance and the impact on integrity.

Another option is insulated glass units (IG units). IG units are optimal at a space about 12mm to 25mm apart. Heat loss increases as the gap increases. The center of the glass reduces conduction. However, the aluminum edge spacer within the unit conducts heat and reduces thermal performance. Multi-light sash windows translate into a more detrimental effect on the U-value. Improvements to counteract this effect are being developed. On average, the U-value of an IG unit with 6mm air space is .67. With a 12mm air space the U-value is .49. With additional low-e glazing, the U-value is .28. However, low-e glazing is not preferable if solar heat gain is desirable.<sup>31</sup> The technology of low-e glass and IG units is warranted in certain locations and circumstances. They are not necessarily appropriate in historic projects unless the conditions of the project demand it. These retrofit techniques can increase performance, but they are irreversible.

Maintenance and repair can improve energy performance to the level of a new window. Minimally invasive treatments may also increase performance in special

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<sup>31</sup> Natalie Bull, "Old Dogs, New Tricks: Assessing the Worth of Retrofit Techniques," in *Window Rehabilitation Guide for Historic Buildings*, eds. Charles E. Fisher, Deborah Slaton, and Rebecca A. Shiffer (Washington, DC: Historic Preservation Education Foundation, 1997), IV37 – IV43.

situations. If a window is missing or severely deteriorated, replacement may be necessary. A discretionary eye should be used when choosing a replacement, because not all replacements meet Energy Star<sup>32</sup> ratings or are appropriate for all areas.

The National Fenestration Rating Council (NFRC) has a website that publishes ratings for windows including: U-value, solar heat gain coefficient, visible transmittance, and condensation resistance. Replacement windows may or may not be greater than the performance of the historic windows in situ.

As a general rule, in the north central areas of the US, U-values should equal .40 or lower to qualify for the Energy Star program. The SHGC should equal .55 or lower. In Northern areas of the country a U-value should be .35 or lower, and the SHGC can be any rating.<sup>33</sup> The energy performance results of vinyl and aluminum windows may vary depending on manufacturer, type of window, and special treatments. (See Appendix B) As we have seen, historic windows can be maintained, used in combination with storm windows, or repaired to meet many of these standards. It should be noted that if replacement is required, a window's performance may not equal the ratings projection, due to the quality of the installation.

One must also consider the quality of installation. If a window is not properly installed, water may leak and affect the sash and the frame, reducing the life-cycle of the window and its frame. Also, air infiltration may lower the rating originally given to the window.

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<sup>32</sup> Energy Star is a program of the US Environmental Protection Agency and the US Department of Energy tasked with protecting the environment through promotion of energy efficient products and practices. "About Energy Star" (Energy Star, 2008).

[http://www.energystar.gov/index.cfm?c=about.ab\\_index](http://www.energystar.gov/index.cfm?c=about.ab_index) (April 15, 2008).

<sup>33</sup> "Residential Windows, Doors, Skylights Key Product Criteria" (Energy Star, 2008).

[http://www.energystar.gov/index.cfm?c=windows\\_doors.pr\\_crit\\_windows](http://www.energystar.gov/index.cfm?c=windows_doors.pr_crit_windows) (February 28, 2008).

Replacement manufacturers may say that their windows are durable. However, one of the problems with replacements is the life of the window is only relative to the life of the glazing and seals. Window seals may fail and allow water vapor, reducing energy performance.<sup>34</sup> Replacement windows are maintenance-free, as described by the manufacturer, but this is only because they can't be repaired. As problems develop, they may appear effective, but in actuality they are failing.

If a historic window is missing, then replacement is necessary. As Rehabilitation tax credit policy indicates, if a window requires replacement it should be a replica of the historic window matching in design, proportion, configuration of panes, muntin shape, frame, and color.

There are many ancillary arguments, secondary to my primary goal, which support the idea that windows do not need to be replaced for better energy performance. These measures and treatments can enhance the overall energy performance of a building. Historic buildings were designed with features to make them efficient, and using these features increases energy performance. Windows were meant to be used and are a functional part of a building. Energy performance will increase, if they are used correctly. Environmentalists often advocate complimentary methods to increase energy performance in historic buildings. These ideas and methods should be considered in concert with maintenance and repair.

Historic homes and buildings were constructed with characteristics that helped to make them comfortable in times before efficient heating and air-conditioning. The entire building was often constructed to adapt to the region. In the south, exterior

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<sup>34</sup> John M. Corbett, "A Last Look at Historic Wooden Windows." *Traditional Building*, November/December 2001.

balconies, porches, roof overhangs, awnings, and shade from trees were used to cool a building. Interior layouts reflected the need for heat or breezes through windows and doors. Walls were painted to reflect sun in the south and with dark colors to absorb heat in the north. Large masonry walls contributed to a good thermal envelope.<sup>35</sup> Many older historic buildings in the north face south, so that the maximum amount of sun and heat will fall upon the house, particularly in the winter months.

Historic buildings were also made comfortable using fully functional windows. Windows were made to be operable and take advantage of natural ventilation and light. Double-hung windows could be raised or lowered to make use of air currents during different weather conditions. Storm windows, shutters, or blinds enhanced the window's performance and were used when they were necessary. The number of windows in a building was determined by the amount of light and ventilation needed. Often, the percentage of windows to wall space was 20% or less, contributing to better energy conservation.<sup>36</sup> Many historic buildings are already poised to be comfortable and efficient according to the climatic zone they are located in.

Environmentalists are concerned with increasing energy performance to lower the impact on the environment. Preserving historic windows is responsible to the environment in other ways. Retaining historic windows is environmentally sound, because of both energy performance and concerns about embodied energy.

Environmentalists are promoting energy performance. Maintaining historic windows actually represents an environmentally responsible measure. Embodied

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<sup>35</sup> Baird M. Smith, "Conserving Energy in Historic Buildings," *Preservation Briefs* 3 (1978): 1-8.

<sup>36</sup> *Ibid.*

energy is the energy invested in manufacture, transportation, and disposal of a feature, window, or a building over its entire life-cycle. It is important to consider this invested energy when an advocate touts claims of environmental soundness. A building, historic or otherwise, has invested energy, which renders it more environmentally sound to preserve and reuse it than to undertake new construction and replace it. The manufacture of components, the transportation of those components, and the construction labor invested into a building are all energy costs that must be considered. The costs of new construction consist of 25% of the operational energy requirement of a building over the life of the building.<sup>37</sup> Windows, although on a smaller scale, represent embodied energy. The maintenance and repair of windows promotes the use of local labor and the local economy, negates high costs for construction and labor, and sensibly recycles materials instead of manufacturing new windows and disposing of old windows. From the beginning, environmentalists have said, “Renew, Reuse, Recycle,” not “Replace, Replace, Replace.”

With simple maintenance measures, the energy performance of a historic building can be efficient without replacement windows. Weatherstripping, painting, and storm windows are effective in improving the efficiency of historic buildings. There are also other ways to improve energy performance to increase the performance of a building even further. Simple measures can contribute to a whole building that environmentalists approve of, and render replacement unnecessary.

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<sup>37</sup> Coldham and Hartman Architects, “(Embodied) Energy in Residential Building Construction” (Coldham and Hartman Architects). <http://www.coldhamandhartman.com/whitepaper.php?id=31> (February 28, 2008).

## Chapter 4: Economics

Historic windows have value, although they are not often dealt with as precious features. Windows are often replaced because of current ideas about energy performance savings, the promise of inexpensive replacement, and the desire for maintenance-free living. In fact, wood windows can have over a century long life-span, making them the long-term choice. Compared to overall life-cycle costs, the data supports the retention and repair of historic windows. Side by side comparisons of the costs associated with repair and replacement actually favor repair. The energy performance of a historic window may be slightly below that of a replacement window, but the energy savings are negligible in dollars. Tax credits are available that encourage the preservation of historic windows. It is important to note that simple, regular maintenance will prevent drastic repairs or replacement.

In the long-term, an analysis of life-cycle costs favors preservation. In this instance, the life-cycle is the entire viable use from a window, including its initial cost, all costs incurred during use, and the cost of its disposal. Initial costs for a replacement window can be up to \$450 for a quality vinyl window, and a wood window may cost \$1,500. Another approach is to simply repair a window with spot repairs. Spot repairs cost \$50 to \$400 per unit, depending on the extent of damage.<sup>38</sup> There are other life-cycle issues as well. The life-cycle of a historic wood window is over 100 years. Historic wood windows are typically composed of durable, straight grain wood of high quality. This may include oak, maple, walnut, or other hardwoods that cannot be found in today's market. Salvage woods can be bought for repair of a

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<sup>38</sup> John C. Leeke, ed., *Windows on Preservation* (Windsor, Vermont: American Precision Museum, 2005), 23.

sash. Repairs using old growth hardwoods can help insure the durability of a window. Unfortunately, replacing a wood sash with a new wood sash can create problems. Commercial firms may not use salvage lumber and new softwoods are inferior to the original materials. The second growth lumber currently being used by commercial firms can rot after 10 years.<sup>39</sup> A vinyl replacement window could last 15 years and may have a warranty for even fewer years. Choosing a replacement window may be ten times more expensive than repair, because of the number of times the window must be replaced. The long-term cost effective choice, that may have an upfront cost, is repair. This is in the best long-term interest of the building, for future homeowners, future generations, and history. Even in the short-term, rehabilitating windows may increase property value.<sup>40</sup>

In the table below, an economical replacement window is estimated to be \$450. The life span of this window is 15 years. After one-hundred years, the cost of replacing the window will be at least \$3,000. By comparison, replica wood windows and repair options have about 100 year life-spans. The option of repair is not only the most economical in the long-term; it ensures the enduring integrity of a structure.

Table 2:  
BASIC WINDOW LIFE-CYCLE COSTS<sup>41</sup>

	Initial Costs	Life Span	100 Year Cost
Window Replacement	\$450	15 years	\$ 3,000+
Replica wood windows	\$1,500	100 years	\$ 1,500
Repair	\$800	80 years	\$ 1,000

<sup>39</sup> John M. Corbett, "A Last Look at Historic Wooden Windows." *Traditional Building*, November/December 2001.

<sup>40</sup> J. Randall Cotton. "What's Restoration Worth?" *Old House Journal*, April 2003.

<sup>41</sup> John C. Leeke, ed., *Windows on Preservation* (Windsor, Vermont: American Precision Museum, 2005), 23.

Replacement window energy performance can reduce energy costs, but the amount is incremental and depends on type and amount of the replacements and if it is installed correctly. Other methods can be used to increase energy performance on a whole building scale.<sup>42</sup> Energy savings for a window with simple upgrades can average \$10 - \$20 per window/per year in a house. Some energy studies have found that replacement windows energy costs are very similar to renovating an old sash.<sup>43</sup>

Maintenance should be promoted as the most cost efficient, preservation friendly option. The maintenance and repair for a residential window project can be from \$75 - \$150 per window.<sup>44</sup> In actuality, if a homeowner is willing to maintain and restore windows on their own, it can be quite economical compared to a \$450 vinyl window that could require replacement after just 10 years.

Below is a cost estimate for an easy maintenance project an individual homeowner can complete on his or her own. The tools and materials needed are for a joint stabilization project, which may cost \$3 per joint. Joint stabilization is the processes of attaching a corner iron to the junction of the stile and rail on a sash. This is necessary if the sash is deteriorated or loose at the junction. The process is relatively simple and can be economical.

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<sup>42</sup> English Heritage. "Framing Opinions: A National Campaign to Protect Our Legacy of Traditional Windows and Doors." in *Window Rehabilitation Guide for Historic Buildings*, eds. Charles E. Fisher, Deborah Slaton, and Rebecca A. Shiffer. (Washington, DC: Historic Preservation Education Foundation, 1997).

<sup>43</sup> Andrew M. Shapiro and Brad James, "Creating Windows of Energy-Saving Opportunity." *Home Energy Magazine Online*. September October 1997.  
<http://www.homeenergy.org/archive/hem.dis.anl.gov/eehem/97/970908.html> (April 3, 2008).

<sup>44</sup> John C. Leeke, ed., *Windows on Preservation* (Windsor, Vermont: American Precision Museum, 2005), 23.

TABLE 3:  
 FAILING JOINT STABILIZATION – SUPPLIES AND COSTS - 20 windows

Supplies	Cost
Wooden Stick and Shingle	\$1
Nitrile Rubber Gloves	\$5
Borate Wood Preservative (14oz)	\$35
Flat Corner Irons (\$0.35/each)	\$14
Removable Sealant (10.1 oz)	\$6
TOTAL	\$56 (About \$3 per joint)

Please note: Other tools may be necessary, including tape, rags, leather gloves, goggles, putty knife, brush, screwdriver, electric drill, caulking gun, and pliers.

LABOR TIME: 15 minutes for two joints at one window – 5 hours for 20 windows

It is important to estimate the time commitment. Smaller projects such as joint stabilization may only take about 15 minutes. Removing sashes may take 35 minutes. There are many types of small projects that can be done individually or with a small team. If one is unwilling to do the tasks individually, a restoration contractor may be hired. New window installation may seem like a cheap, quick and easy answer, but additional installation charges may apply. There are also worries that the replacement may not be installed correctly.

Weatherstripping can be a cost effective method to increase energy performance. Historically, felt was used for weatherstripping. However, it is not an effective technique today, because it deteriorates quickly and needs to be replaced regularly. Weatherstripping can give typical first year savings between \$.20 and \$15 per window.<sup>45</sup> With an initial cost of \$75 for an entire residential structure, this is the most cost effective investment. It is especially effective if air infiltration around the

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<sup>45</sup> Andrew M. Shapiro and Brad James, “Retain or Retire? A Field Study of the Energy Impacts of Window Rehab Choices,” in *Window Rehabilitation Guide for Historic Buildings* eds. Charles E. Fisher, Deborah Slaton, and Rebecca Shiffer (Washington, DC: Historic Preservation Education Foundation, 1997), IV25.

sash is a problem. Weatherstripping is one of the least expensive methods that can contribute to energy performance without resorting to destructive retrofit measures.

Storm windows can help cut down on building energy costs and lower maintenance costs due to weathering. Especially during cold, damaging winters, storm windows can make a difference. Interior low-e storms have an upfront cost of about \$155. However, the first year savings can be from \$4.70 to \$19 per window.<sup>46</sup> As discussed earlier in this report, interior storms are preferable if the building does not currently have historic storms. Interior low-e storms are the most effective option over new exterior storms. Exterior storms can cost as little as \$39-\$51 at Home Depot for a Do-It-Yourself Kit.<sup>47</sup> Harvey offers a higher end storm window that may increase energy performance even further.<sup>48</sup> Several companies sell interior and exterior storms for larger historic preservation projects. If a building has exterior storms still intact and in good condition, it is advisable to use them. Importantly, energy savings will increase as a result of storm use. The table below outlines the costs and savings for using weatherstripping or interior storms in a building.

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<sup>46</sup> Ibid.

<sup>47</sup> “Home Depot” (Home Depot, 2008). <http://www.homedepot.com> (April 19, 2008).

<sup>48</sup> “Tru-Channel Storm Windows” (Harvey Industries, Inc., 2008). [http://www.harveyind.com/product\\_info/storm\\_windows/tru\\_channel.asp](http://www.harveyind.com/product_info/storm_windows/tru_channel.asp) (April 12, 2008).

TABLE 4:  
UPFRONT COSTS AND PAYBACK PERIODS FOR WEATHERSTRIPPING,  
INTERIOR STORMS, AND REPLACEMENT

	Upfront Cost	Number of Units	Total Upfront Cost	Energy Savings (per window/ per year)	Payback Period
Weatherstripping	\$75 entire building	20 windows	\$75	Up to \$15	3 months
Interior Storms	\$150/ per storm	20 storms	\$3,000	Up to \$19	8 years
Replacement	\$600 per window	20 windows	\$12,000	Up to \$20	None

If maintenance is not possible, the next most cost efficient option is repair. The American Precision Museum reports a cost for complete refurbishing of double-hung wood windows as ranging from \$400 to \$1,000 per window.<sup>49</sup> Marlow, a window restoration firm, estimates that a complete restoration project can cost an average of \$1,500 per window. This includes durable epoxy repairs, borate wood preservation, installation, weatherseals, glazing resetting, painting, and storm installation.<sup>50</sup>

If glass or other components, such as hardware, are restored, there are additional costs that are not considered in most studies. The Historic Preservation Training Center<sup>51</sup> buys lite restoration glass, a character glass that mimics historic glass, from Bendheim Glass<sup>52</sup> in Germany. The cost is \$14/sq foot.<sup>53</sup> Replacement glass can cost between \$3/sq foot to \$4/sq foot average for regular glass for aluminum and wood

<sup>49</sup> John C. Leeke, ed., *Windows on Preservation* (Windsor, Vermont: American Precision Museum, 2005), 23.

<sup>50</sup> John M. Corbett, "A Last Look at Historic Wooden Windows." *Traditional Building*, November/December 2001.

<sup>51</sup> The Historic Preservation Training Center is an organization of the National Park Service that encourages the preservation of historic structures. "Historic Preservation Training Center." Brochure. National Park Service.

<sup>52</sup> "Bendheim" (Bendheim Corporation, 2007). <http://www.bendheim.com/> (March 15, 2008).

<sup>53</sup> Dean Wigfield, Historic Preservation Training Center. Personal Communication. March 5, 2008.

windows. Restoration glass is more expensive, but if Preserving or Restoring the historic character of the glass is the goal, it is an option.

A typical restoration project cost estimate is outlined below with typical work plans, which vary from window to window. The total cost of any one project may differ, because windows are typically in various states of disrepair. Each window in the project below may require one or several treatments outlined below.

TABLE 5:  
HISTORIC WINDOW REPAIR PROJECT COST  
HISTORIC RESTORATION SPECIALISTS  
DOUBLE-HUNG SASH REPAIR – 22 windows  
WORK

- Stripping on shutters, minor repairs, priming, and two coats of new paint
- Complete paint removal of exterior window unit (sash, frame, sill, and jamb), sanding and preparation of surfaces and application of wood preservative coating
- Stripping of paint from one or two parts of exterior side of one window unit (sash, frame, jamb, or sill)
- Minor repairs to sash, frames, jambs, and sills
- Total replacement of window sill with Black Walnut
- Exterior repainting with one coat of latex acrylic paint
- Replacing modern glass with historical cylinder glass (upper and lower sash)
- Construction of new upper and lower sash with Northeaster White Pine
- Installation of new sash into existing frame
- Fabrication and installation of third floor window

TOTAL PROJECT COST for 22 Window Units, Shutters, Installation of Three New Window Units, and Management: \$45,000 to \$55,000<sup>54</sup>

**\$2,045 PER WINDOW to \$2,500 PER WINDOW**

In some cases, when windows are missing or severely deteriorated, they must be replaced. There are options to replace windows with historically accurate details, size, and configuration. The National Park Service approves of Marvin Windows and Doors for their exceptional work history, and other regional firms are approved by State Historic Preservation Offices.

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<sup>54</sup> Denise Troxell, Historic Restoration Consultants, Email Communication, April 22, 2008.

An inexpensive modern residential window replacement, including the sash only, can cost under \$300. Replacing only the sash can be less expensive, but there are problems associated with this method. This window option can only be used if the frame or sill is in good condition. The problems associated with this type of window include the fact that it may not fit correctly into the window opening, causing water damage and other problems. A second option is replacing the frame and sash. This is the easiest replacement method. The national average list price for the common option of replacing the frame and sash is \$560 without installation. Replacing both the frame and sash ensures better energy ratings. This type of window's glass area will be smaller, because a larger frame is required. A third residential option is to replace the entire window. This is necessary when the entire opening has water damage or deterioration. This window replacement option can cost \$450 without labor costs. This is the most difficult and invasive method for any house, but can be the most energy efficient model.<sup>55</sup>

The American Precision Museum reports similar costs for replacement windows. They list economical, residential vinyl replacement windows as costing between \$200 and \$450. A replacement for a deteriorated wood sill and frame may cost an additional \$100 to \$200. It is better to repair a sill in-situ, because it is much less expensive. They indicate that one could expect to pay \$500 - \$1,500 for a wood replacement window. The treatment for this cost range includes removing the existing wood frame and replacing it with a vinyl covered wood frame and sash.<sup>56</sup>

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<sup>55</sup> Daniel S. Morrison, "Get the Right Replacement." *Fine Homebuilding*, October/November 2004.

<sup>56</sup> John C. Leeke, ed., *Windows on Preservation* (Windsor, Vermont: American Precision Museum, 2005).

A larger, commercial project may use any number of large replacement window manufacturers who do historic replicas. Maintenance and repair are the recommended actions. However, some projects resort to large Rehabilitation replacement options. Warranties are an important factor in modern window replacement. If windows are not properly installed, they may need to be replaced within ten years due to damage to the window and may not optimally increase energy performance. Below is a summary of a typical historic window commercial project, including the work procedures involved in the cost estimate. TRACO is a window and door manufacturer that makes replica historic windows for residential and commercial projects.<sup>57</sup>

TABLE 6:  
WINDOW REPLACEMENT PROJECT COST  
TRACO

TRACO TR 9900 – 50 windows 60”w x 96”h

SPECIFICATIONS

- Finish AAMA 2605 – Color: Standard
- Class 5 Balances – Automatic Head and Sill Locks
- Muntin: Interior and Exterior Applied Muntins – 6 lite over 6 lite
- Historical Pre-Set Panning and Historical Trim and Clip

WORK

- Removing existing sash.
- Preparing existing frame to install installation accessories and windows
- Installing new accessories and windows
- Finishing exterior and interior materials.

TOTAL PROJECT COST: \$132,800<sup>58</sup>

**\$2,656 PER WINDOW**

The cost estimate of \$2,656 per window from TRACO compares to the restoration cost estimate from Historic Restoration Specialists, which projects a \$2,045 to \$2,500 cost per window. The difference is incremental. The replacement of windows should not be justified with claims that replacements are drastically lower.

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<sup>57</sup> “TRACO” (TRACO, 2007). <http://www.traco.com/index.htm> (March 30, 2008).

<sup>58</sup> Matt Matlak, Regional Sales Manager, TRACO, Email Communication, March 12, 2008.

A historic replica is warranted in cases of missing windows. However, historic fabric should be retained if the costs are relatively equal. A project applying for Rehabilitation tax credits cannot justifiably claim that repair is less expensive.

Various types of glazing can be used with replacement windows, and are generally added costs on replacement window projects. Low-emmissivity (low-e) films cost about \$3.75 per foot. Coated glazing is two to three times more expensive than uncoated glass. Life expectancy of the coated glazing is 15-20 years. No standards or tests have been conducted for long-term durability. Insulated glass units (IG units) are three times more expensive than single thickness glass. With low-e coatings, they are 35% more expensive than without low-e. The joint between IG unit and sash has vulnerability and may require maintenance or a shortened service life. Standard five year warranties are usually offered on IG units. A gas-filled, low-e coated IG unit costs considerably more. Long-term evaluation is not currently reported, but it may not continue to perform as well as it does when installed. It is subject to damage and failure, because of the weight of the unit and the durability of the edge seal.<sup>59</sup>

There are savings in annual energy costs associated with new windows. However, this does not counteract initial cost. *Consumer Reports* recognizes that windows may cost \$7,000 to \$20,000 for an average house. They report that one will not receive benefits for at least 20 years, even if you are saving 10% or more on

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<sup>59</sup> Natalie Bull, "Old Dogs, New Tricks: Assessing the Worth of Retrofit Techniques," in *Window Rehabilitation Guide for Historic Buildings*, eds. Charles E. Fisher, Deborah Slaton, and Rebecca A. Shiffer (Washington, DC: Historic Preservation Education Foundation, 1997), IV37 – IV43.

energy benefits per year.<sup>60</sup> Because windows may not last over 15 years, the investment is unwarranted. *Consumer Reports* acknowledges that replacement may be necessary for visual and comfort reasons. Historic preservationists argue that replacement ruins visual qualities of a historic building. Annual energy savings are negligible and the reasons for replacing a window are not substantial.

Energy Star projects that energy savings for replacing a single paned window with Energy Star windows could save an owner \$126-\$465 a year.<sup>61</sup> High performance Energy Star windows can cost \$600 per window. An average house could have 20 windows. This would make the upfront cost \$12,000. After 15 years, the typical life of a window, the average energy savings would be \$4,440. In this typical scenario the owner’s total loss is \$7,560. Compared to the 3 month payback period for weatherstripping, illustrated in an earlier table, replacement does not yield the desired results.

TABLE 7:  
UPFRONT COSTS AND ENERGY SAVINGS FOR REPLACEMENT WINDOWS

WINDOW COSTS	20 windows	\$600 per window	\$12,000 up front cost
ENERGY SAVINGS	15 years	\$296 savings per year	\$4,440 savings
LOSS			<b>\$7,560 loss</b>

Economics is an important consideration to a property owner. Each situation is different, so a part of the planning stage should include life-cycle cost analysis and factor non-monetary benefits into the equation, for both repair and replacement

<sup>60</sup> “Windows: Clear Choices” (Consumer Reports, October 2007).  
<http://www.consumerreports.org/cro/home-garden/home-improvement/hardware-building-supplies/windows/windows-10-07/overview/wind-ov.htm> (April 19, 2008).

<sup>61</sup> “Save Money and Energy – Choose ENERGY STAR Qualified Windows, Doors, and Skylights” (Energy Star, 2008). [http://www.energystar.gov/index.cfm?c=windows\\_doors.pr\\_savemoney](http://www.energystar.gov/index.cfm?c=windows_doors.pr_savemoney) (May 1, 2008).

options. A budget should be prepared, but should consider the long-term effects of the intervention. Above all, the project should factor the value of historic preservation into the equation.

Windows are a distinct feature of historic buildings and are treated as such in policies related to Rehabilitation tax credits. The guiding principles are designed to provide for a consistent review of windows. The project is evaluated to assure compliance and provides an opportunity for Rehabilitation projects to request replacement in special circumstances.

Rehabilitation tax credits are available at the federal level and in some states. A 20% Federal Rehabilitation Tax Credit may be awarded for certified heritage structures, those that are eligible or listed on the National Register and are occupied by income-producing businesses. A 10% federal credit may be awarded for non-historic structures built before 1936, as long as it is rehabilitated for a non-residential use.<sup>62</sup> A number of states offer a state tax credit. The State of Maryland offers a 20% Heritage Preservation Tax Credit for non-income producing or income producing properties that are certified heritage structures.<sup>63</sup> Tax credits can substantially balance a project budget. With this in mind, tax credits should be awarded to projects with a vested interest in preserving historic structures, including attention to windows.

The National Park Service (NPS) has published three documents specifically related to window treatment and replacement, guidelines that must be followed to

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<sup>62</sup> "Historic Preservation Tax Incentives" (National Park Service, December 2007). <http://www.nps.gov/history/hps/tps/tax/index.htm> (April 15, 2008).

<sup>63</sup> "Maryland Rehabilitation Tax Credits" (Maryland Historical Trust, 17 April 2008). <http://www.marylandhistoricaltrust.net/taxcr.html> (April 17, 2008).

obtain Federal Rehabilitation Tax Credits.<sup>64</sup> (See Appendix C) These documents provide general standards and guidelines for the treatment of historic windows based on the Secretary of the Interior's Standards for Rehabilitation.

Tax credit projects are reviewed individually and a number of factors come into play when evaluating whether windows should be preserved, rehabilitated, or replaced. A reviewer for the National Park Service considers if windows are an integral part of the building's historic fabric and the significance of the windows. Windows that are not 50 years, possess low integrity, or are on secondary facades may be granted approval for replacement. If the window is highly visible from the exterior, on any façade of the main building, on a principal façade of an attached building, or on the lower floors of a high rise it renders the window significant. Another significance factor is if the windows contribute to the interior design scheme or are located in a significant interior space. One last factor is if the details of the windows represent the design and technology of the era of the building.

Some treatments to historic windows are allowed more frequently on larger commercial projects. This includes low-e glazing, which accomplishes energy goals and has low impact on historic integrity. Exterior storms are often suggested by the National Park Service, in order to counteract weathering on windows.

In order to receive Historic Preservation Tax Credits, a property must pass a review process. The tax credit award is contingent on compliance. A high standard

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<sup>64</sup> "Evaluating Historic Windows for Repair or Replacement," (Washington, DC: National Park Service: December, 2007). "Documentation Requirement for Proposed Window Replacement," (Washington, DC: National Park Service: December, 2007). "Replacement Windows that Meet the Standards," (Washington, DC: National Park Service: December, 2007).

should be set in order to encourage the maintenance and repair of windows and all valuable preservation activities.

Another financial incentive for windows is the Energy Credit. The Energy Credit, a tax incentive provided by the Internal Revenue Service, was available for energy efficient purchases in 2007. Homeowners buying qualified energy efficient windows and storm windows qualify for a tax credit. The credit can be applied to 10% of the cost of all windows, up to \$200. The State of Maryland only awards an 8% green building credit for construction related projects.<sup>65</sup>

The Energy Credit may influence the decision to replace windows instead of retain and repair windows. However, there are many reasons why preserving windows can be more economical using the Rehabilitation Tax Credit or state tax credits. The IRS Energy Credit is, in fact, less than that given by the Maryland Heritage Tax Credit Program administered by the Maryland Historical Trust, which provides income tax credits of 20% for capital costs for an eligible building. This includes National Register properties or those eligible for the National Register, located in a local or National Register Historic District, or located in a certified heritage area certified as contributing to significance. If the homeowner or commercial property owner is eligible for historic preservation tax credits, it should be a deciding factor in the decision to repair the windows.

A property can earn historic preservation tax credits for windows, but can also earn energy credits for storm windows. A homeowner can earn up to 10% of the cost, up to \$200, for all storm windows. A manufacturer's certification statement is

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<sup>65</sup> "Green Building Tax Credit" (Maryland Energy Administration, 2007).  
<http://www.energy.state.md.us/programs/commercial/greenbuilding/> (February 12, 2008).

necessary.<sup>66</sup> Installing exterior storm windows do change the appearance of the exterior of the building or building, but it does, in effect, preserve the windows from deterioration and weathering. In a seasonal climate, storm windows are only necessary for the colder months of the year.

Historic preservation tax credits are an incentive to make maintaining or repairing windows economical. In fact, the benefits are better than those that the IRS offers in the Energy Tax Credit or state energy credits. Attention is given to windows in tax credit projects and participation in maintaining and rehabilitating windows requires encouragement. Policy should make clear which actions are enforced and which may be compromised.

Overall, it can be cost-effective to maintain and repair historic windows. There are other resources, tax incentives and grants, which one must consider to offset the costs even further. Do-It-Yourself projects can make window preservation economical for homeowners. For larger projects, there should be consideration of short-term and long-term savings, as well as, the value to the structure. Proper maintenance and repair techniques can ensure low costs over the lifetime of the window. Over a 100 year period, maintenance and repair measures are, in fact, lower than replacement costs. Replacement windows can be a costly venture. The loss is not only in dollars, but also in the irreparable damage to the historic building and loss of integrity. Non-monetary benefits are a factor that must be incorporated into a cost analysis.

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<sup>66</sup> “Treasury and IRS Provide Guidance for Energy Credits for Homeowners” (IRS, 21 February, 2006). <http://www.irs.gov/newsroom/article/0,,id=154657,00.html> (February 12, 2008).

## Chapter 5: Conclusions

New technologies and ideas are emerging about windows. While these technologies might be appropriate in new construction, they compromise the integrity of historic buildings and the benefits do not outweigh the costs. As Camille Bowman has noted, more attention is needed from state and local agencies to increase awareness about the loss of historic windows and to establish programs to promote their retention.<sup>67</sup> Due to current issues of economics and energy performance, many homeowners and project leaders are making decisions to replace windows. These decisions are compromising the integrity of historic buildings. More emphasis must be placed on the importance of the maintenance and repair of historic windows, in order to guide all historic projects and promote preservation.

TABLE 8:  
PHILOSOPHICAL MATRIX –  
VALUE OF IMPACT ON TREATMENTS TO HISTORIC WOOD WINDOWS

	Integrity		Economics		Energy Performance	
	Short-term	Long-term	Short-term	Long-term	Short-term	Long-term
Maintenance	High	High	High	Moderate	High	Moderate
Repair	High	High	Low	High	High	Moderate
Replication	Moderate	Moderate	Low	High	Moderate	High
Replacement	Low	Low	High	Low	High	Low

The above table places a value on the treatments of maintenance, repair, replication, and replacement in regard to short-term and long-term issues of integrity, economics, and energy performance. The value, low, moderate, or high, signifies the importance of the treatment in respect to the issues. For example, maintenance has a high impact on the short-term integrity of a building.

<sup>67</sup> “Virginia’s Most Endangered Historic Sites 2007” (APVA Preservation Virginia, 24 May, 2007). [http://www.apva.org/pressroom/pdf/endangered\\_sites\\_07.pdf](http://www.apva.org/pressroom/pdf/endangered_sites_07.pdf) (March 1, 2008).

There are many reasons, which cannot be quantified, to preserve historic windows. The character of the whole building, including windows, is a consideration. The effect of multiple types of windows on multiple facades can affect the way a building is presented overall. Historic value is the most important value. Historic buildings are valued by the public and should be preserved for their importance as a record of history. Replacing windows erases history for future generations. Windows should be analyzed and valued with non-quantifiable benefits to accurately relay the impact of replacing those windows. Non-quantifiable benefits should be described fully for each alternative scenario and rated according to the degree of benefit. The Analytical Hierarchy Process (AHP) is one way to critically analyze the impact of alternatives.<sup>68</sup>

There are more reasons to preserve windows beyond energy performance and economics. A business occupying a historic building should consider the positive impacts of preservation. The public is concerned about historic preservation. The message a building projects to the public should be considered. A business in a historic building doesn't have to be a tourist attraction, but it is occupying a historic building and should carry stewardship for the building. A historic structure should also be a sense of pride for the owner and the workers in a building. The internal quality of light should be considered. The quality of light associated with low-e glazing, IG units, or storm windows can affect worker productivity. A method that has not been used in respect to energy performance is Life-cycle Cost Analysis

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<sup>68</sup> *Standard Practice for Applying Analytical Hierarchy Process (AHP) to Multiattribute Decision Analysis of Investments Related to Buildings and Building Systems*. (West Conshohocken, PA: ASTM International, 2007).

(LCCA).<sup>69</sup> In application, this method could measure all costs of a building or feature from its purchase to use to disposal. A building owner should consider all the impacts and benefits associated with preserving windows and the overall character of a building.

At the NPS and SHPO levels, Rehabilitation projects are reviewed for the feasibility and need for retention of historic windows. The NPS and SHPOs are tasked with rewarding projects for their adherence to the standards of historic preservation. Currently, many projects are being accepted, despite proposals of the removal of windows on secondary facades and similar issues. Agencies should consider sliding scale tax credits. Rewards may be given on an incremental basis for projects that include maintenance and repair. The tax credits could even be extended to cover future maintenance costs. Developing degrees of rewards would encourage a greater degree and standard of preservation. It is advisable that agencies look closely at options, develop a maintenance schedule and life-cycle cost analysis, and think about the value of preservation. Since these factors are not required, it is suggested that they become components of a tax act review. There is no one correct answer for any project, but preservationists can require a closer look at the costs and benefits of maintenance and repair.

The General Services Administration (GSA) is one agency that sets a high standard for the treatment of windows. The GSA owns and operates over 400 historic buildings. The GSA develops analysis of alternative upgrade approaches, including

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<sup>69</sup> “Life-cycle Cost Analysis.” (Whole Building Design Guide, 2008).  
<http://www.wbdg.org/resources/lcca.php> (April 30, 2008).

cost, life-cycle, energy efficiency, functionality, and preservation. The agency shows a high standard for the preservation and retention of buildings and all their features.

Preservation Note 6 highlights the General Services Administration's policy for installing storms in historic buildings. The GSA is the steward for a large amount of historic governmental buildings. They mandate that only interior storms should be used. The storm windows should align with window stiles, rails, mullions, and muntins. New divisions should not be introduced into a window's muntin pattern. Storm windows should be selected with frames and muntins the same size or less wide than the current sash frames and muntins. The storms should match the sash color, according to historic color. The storm painting should coincide with the cyclical painting of the windows. Velcro is the mandated method for affixing storm windows.<sup>70</sup> This policy regarding storm windows is specific and detailed. Most projects do not follow the rigid rules of a government agency. Government buildings are a special case. Often, they are in urban areas and windows become a close-up character defining element. This internal GSA policy takes into consideration the problem of thermal efficiency and creates a governmental policy to address the problem.

The policies of government agencies, state agencies, and local preservation organizations clearly impact the treatment of windows. The significance of windows, the non-monetary benefits of retention, energy performance, and economic data should be presented at all levels, so that the importance and necessity of the retention of historic windows can be evaluated.

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<sup>70</sup> "Preservation Note 6: Interior Storm Windows," (Washington, DC: General Services Administration, August 1991).

This paper considers wood sash windows. However, it can extend to other types of windows. Each type of window has special considerations, but the guidance in this document provides a basis for further inquiry. Casement, Palladian, stained glass, and other windows with intricate detail can be unique and therefore seen as very important to preserve. Wood sash windows should not be considered insignificant in this light. Rather, setting the bar for what we preserve and acknowledging the importance of the overall integrity of a building should be a primary concern.

The focus of this paper has been to demonstrate that it is not difficult to maintain and repair historic wood sash windows, it is financially feasible, and energy performance can be achieved comparable to new high performance windows. There are other issues concerning the preservation of historic wood sash windows. (See Appendix D) However, energy performance and economics are not justifiable arguments for replacing historic windows. Maintenance is integral to the presentation, retention, and performance of historic windows. Maintenance requires forethought and planning, and is critical for the long-term survival of historic elements. Energy performance is an issue that is currently affecting the treatment of windows. With proper maintenance and minimal upgrades, historic windows can be as energy efficient as replacements. Further, energy performance can improve, with minimally invasive techniques. Economically, preserving a historic window rather than replacing it can be cost effective. Maintenance and repair measures can be less expensive than entire replacement, considering some might fail within 15 years. Simple upgrades, such as weatherstripping and storms windows, can cut energy costs

dramatically. With new issues emerging, careful examination of the facts is warranted before deciding to make damaging, irreversible changes to a building.

The next step is to promote preservation as sustainable and economically viable. Architects with sustainable focuses and preservationists are starting to come together. They should be tasked with making sure the data reaches the general public and project leaders. Government officials, outside the preservation world, should be informed of the findings of this study, in order to guide future regulation that may conflict with preservation regulation. Within the historic preservation field, independent projects should be reviewed with a careful eye, paying attention to life-cycle cost analysis and performance data. State Historic Preservation Offices should evaluate resources, give direction, and review project proposals with a discretionary eye. Local historic preservation organizations should be tasked with the promotion of the values and benefits of the retention of historic windows. Starting workshops and programs is one step to inform the public and homeowners about the techniques of repair. In these programs, the cost effective reasons for preserving windows and their energy performance capabilities should be highlighted. Showing how to make historic windows energy efficient is important in light of energy efficient replacement marketing. With all the new issues surrounding historic windows, analysis of the benefits of retention should be brought to the public, in order to inform decisions about the best routes for undertakings.

## Appendices

APPENDIX A:  
APVA Nomination: Historic Wooden Windows<sup>71</sup>

APPENDIX B:  
National Park Service – Federal Historic Preservation Tax Incentives Guidelines for  
Windows<sup>72</sup>

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<sup>71</sup> “Virginia’s Most Endangered Historic Sites 2007” (APVA Preservation Virginia, 24 May 2007). [http://www.apva.org/pressroom/pdf/endangered\\_sites\\_07.pdf](http://www.apva.org/pressroom/pdf/endangered_sites_07.pdf) (March 1, 2008).

<sup>72</sup> “Evaluating Historic Windows for Repair or Replacement,” (Washington, DC: National Park Service: December, 2007). “Documentation Requirement for Proposed Window Replacement,” (Washington, DC: National Park Service: December, 2007). “Replacement Windows that Meet the Standards,” (Washington, DC: National Park Service: December, 2007).

APPENDIX C:  
National Fenestration Ratings Council Ratings for Select Types of Double Hung Sash  
Windows<sup>73</sup>

PERFORMANCE	U-Value	SHGC	Visible transmittance	Condensation Resistance
Vinyl single-glazed clear typical	.84	.64	.65	
Aluminum single-glazed clear typical	1.16	.76	.75	
Marvin AAHC Historical DHS	.82	.59	.61	12
Graham Aluminum DHS Series 2500/2526	.55	.30	.50	32
TRACO Vinyl TR4200 DHS clr/air/clr TRA-A-5-00035	.47	.58	.61	41
American Craftsman Series 8500 –Vinyl w/ low-e	.35	.31		45
Anderson 400 Series Woodwright (Terratone and maple) w/ low-e	.34	.29	.48	

<sup>73</sup> “National Fenestration Rating Council” (National Fenestration Rating Council, 2005). <http://www.nfrc.org/> (March 6, 2008).; “Window Technologies” (Efficient Window Collaborative, 2008). <http://www.efficientwindows.org/ftypes.cfm> (March 6, 2008).

## APPENDIX D: Other Issues Affecting Windows

There are other issues affecting the treatment of windows. The issues of security, sound transmission, and sensitive interiors are relatively new, due to the changing currents of our country. It is important to weigh the costs and benefits of retaining or replacing historic windows in any situation. Developing a codified policy is impossible for all situations. The only option is the careful review of project circumstances.

It is important to note there are regulations about the safety of buildings and the need for security windows. Since the events of September 11, 2001, there has been an effort to increase the security of many government buildings. Most of these buildings are historic. In many cases, the adverse effects of changing historic components are mitigated through consultation and agreements. In 2004, the National Historic Preservation Act was updated with 36CFR Part 800, which encourages agencies, in coordination with The Advisory Council on Historic Preservation, SHPOs/THPOs, and affected Indian and Native Hawaiian organizations, to develop procedures for disaster or emergency situations declared by the President, tribal government, or the Governor of a State. These procedures should be set up through programmatic agreements before or after a national disaster.<sup>74</sup> The regulations of the Department of Defense, who owns and controls many historic buildings, acknowledge compliance with the National Historic Preservation Act and the Archaeological Resources Protection Act, but state that those laws do not negate the

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<sup>74</sup> *National Historic Preservation Act*, 36 CFR Part 800 Protection of Historic Properties. Revised August 5, 2004.

DoD policy.<sup>75</sup> The General Service Administration owns and controls an even larger number of historic buildings. It has regulations that acknowledge safety measures, but they codify that replacement windows should match in exact original frame and muntin profile.<sup>76</sup>

There are techniques and technologies that minimally impact historic buildings. Blast resistant storms or screens are reversible measures. In other instances, reassigning work areas and fire exits away from historic windows may be appropriate. Relying on security cameras, alarms, and surveillance is appropriate in some situations.<sup>77</sup> Other measures may include, designing reversible perimeter barriers and using perimeter barriers with sensitivity to the main façade may be necessary and also more effective in preserving historic character of the actual building.<sup>78</sup> Antishatter films, laminated glass, cable bars, polymer replacement glass, and geotextiles are all options for increasing security through historic windows. Windows can be a structurally weak portion of the building. Even if glass is reinforced, frames of windows can still be susceptible to blasts. Security is a sensitive issue. Preservationists should begin to evaluate primary values and the regulations of different disciplines. Compromise is necessary in certain situations, but in others it is unwarranted.

The problem of sound transmission is also a consideration in many Rehabilitation projects. Historic buildings along highways that are under consideration for

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<sup>75</sup> “DoD Minimum Antiterrorism Standards for Buildings.” UFC 4-010-01. (Washington, D.C.: Department of Defense, 2007).

<sup>76</sup> “Facilities Standards for Public Building Service, P100 Chapter 8” (General Services Administration, March 2005). <http://www.wbdg.org/ccb/GSAMAN/p100.pdf> (March 1, 2008).

<sup>77</sup> Sharon C. Park and Claire Scholfield Mastroberardino, “Guidance for Security Enhancements to Historic Buildings,” *APT Bulletin* 35, no. 1 (2004): 2-12.

<sup>78</sup> Caroline Alderson, Paul Westlake, and Bayard Whitmore, “Perimeter Security Retrofitting for Historic Buildings,” *APT Bulletin* 35, no. 1 (2004): 37-47.

Rehabilitation are targets for “new and improved” sound resistant windows. This is especially true for urban projects. There are no standing laws for controlling sound transmission, yet projects are occasionally allowed with approval from the State Historic Preservation Offices and the National Park Service. Measures include replacement with acoustic units and using jamb extensions. While comfort is a main concern in many living and working situations, careful consideration must be given before a window is irreparably altered.

When considering historic interiors, one factor is the effect of light on wall paper, paint, or furnishings. Certain UV coatings are available to counteract this problem. Interiors of historic buildings are important, especially if they are significant features within them. However, up close, finishes on glass are important, just as paint or wall paper finishes are. At all costs, interiors should be protected from natural light through non-invasive measures. Shades, blinds, and curtains are solutions. Storm windows may be appropriate for winter months. Also, movable objects may be relocated to minimize effects.

There are many new issues and views arising that affect the treatment of windows. There are alternatives for entirely replacing windows. The careful consideration and evaluation of these alternatives is required to make the best choice for the resources.

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