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Energy Efficiency in Historic Structures

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ENERGY EFFICIENCY IN HISTORIC STRUCTURES

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ABSTRACT

Preservation and sustainability have long shared fundamental goals. Historic structures are inherently sustainable and will continue to be if their sound construction and superior materials are preserved properly. Despite this fact, historic buildings have gained a stigma for being inefficient and therefore unsustainable in the face of modern, energy efficient structures. Historic structures are and can be energy efficient when retrofitted properly. This study tested and analyzed the efficiency of historic structures in the context of a warm, wet, coastal climate in order to determine how they could be improved without damage to their historic fabric. With this aim, the study performed energy audits on five historic buildings in Charleston, South Carolina to determine their current efficiencies and used energy modeling software to demonstrate the ease with which they could be retrofitted to decrease energy losses. These retrofitting measures were based on guidelines laid out in the Secretary of the Interior's Standards for Rehabilitation and are consistent with good preservation practice.[1] The information revealed through this analysis proves that historic structures can be both sustainable and energy efficient while maintaining their historic integrity.

[1] See Appendix C.

DEDICATION

This thesis is dedicated to my grandmother, Eleanor Flack, whose commitment to my education and unending love and support has allowed me to accomplish this feat.

ACKNOWLEDGEMENTS

I would first like to thank my wonderful family, fiancé and close friends who have given me the love and support necessary to pursue my education to this degree. Your patience and guidance have been especially helpful as I completed this journey. I would also like to give special thanks to Ben Leigh, who taught me everything I needed to know to make this study a success. Thank you for your encouragement, reassurance and advice that were vital to the completion of this project. Finally, I would like to thank my thesis advisor, Jim Ward and my committee members, Dr. Barry Stiefel and Kristopher King, for your insight and constructive comments that brought this work to where it is today.

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INTRODUCTION

Preservation and Sustainability

Historic buildings are inherently sustainable; therefore, it is necessary to both perpetuate their existence and improve upon their construction where appropriate for the use and benefit of future generations. Through an analysis of five historic structures in Charleston, South Carolina, this study provides an understanding of the energy use of these buildings within the context of their warm, coastal climate.[2] Furthermore, the study provides retrofitting options that both improve the overall energy efficiency of the building as well as maintain the durability of historic materials and construction. Through energy audits and careful analysis of the buildings in their context, this study proves that historic structures are capable of higher levels of efficiency than they are currently experiencing, with their historic fabric kept intact and protected. By means of these efforts, this study emphasizes the vital role historic preservation plays within sustainable design both in the lowcountry of South Carolina and around the world.

Historic structures have remained standing for half a century or more because of the quality of their materials and sound construction. The buildings' existence is a testament to their sustainability because they have remained useful spaces without demolition or extensive replacement of their features. Saving materials and the energy required to create a building and its components is a major tenet of sustainable design. Historic structures are also sustainable for the types of architectural elements they

[2] A historic structure is one that was built more than 50 years ago.

employ. Because most of these buildings were built before the advent of air-conditioning, they utilized the earth's natural energies, such as sunlight and wind. In Charleston, these features can range from the siting of the house to catch coastal breezes, large, operable windows with adjacent shutters, long porches, and rainwater collection systems such as cisterns. Several of the houses in this study are Charleston Single Houses, a vernacular design to the city. The Charleston Single House utilizes many features that were created to adapt to the climate. These buildings were two or three stories over an open basement or crawl space, which gave them height to catch the ocean breezes, even if they were not immediately next to the water.[3] The piazzas, or covered porches on one side of the building, were usually located on the south or west walls, which shaded the house from intense sun and brought in the breeze to both levels of the house.[4] Many modern, sustainably focused companies are creating products that achieve the same objective with largely the same technologies, but with a noticeably more cotemporary shell. Modern buildings that use these products are certainly more efficient than some of their contemporaries; however, one must ask: where is the place of these technologies in historic structures? In what situations do we determine that the historic building technology functions just as well, or better, than its modern equivalent and justifiably keep it in place? While assessing the structures in this study, the place of modern technologies had to be carefully considered. The retrofits had to not only be compatible with the building materials so that they would not hinder the appearance of

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[3] Gerald F. Foster. *"American Houses: A Field guide to the Architecture of the Home",* (New York: Houghton Mifflin Harcourt, 2004): *154.*
[4] Ibid.

the building's character-defining features, but also not pose a threat to the integrity of the historic material itself. This consideration is crucial to "greening" a historic building because the original materials have largely performed admirably over decades and even centuries. Removing the historic fabric, or damaging it to the point of necessitating its removal, would thus create a less sustainable structure, even if the replacement was considered more efficient. This study considered removability of the change as well as the risk of creating moisture-related issues when suggesting appropriate changes. Moisture problems were one of the biggest side effects that the 1970s environmental movement had on historic buildings. This issue was due to a combination of factors, which will be discussed later. This study attempts to garner from these previous efforts, the successful technologies that are compatible with historic structures and improve their applications in order to better preserve and protect the historic fabric of these buildings. Through the analysis and suggestions made in this study, these buildings have become part of a greater and growing group of historic structures around the world that are being updated to become greener, more improved versions of themselves.

Figure 1: Porches, operable windows and shutters, and large cornices are all inherent energy saving features of historic structures. *Photos by author.*

Historic preservation groups around the world have begun not only informing others about the role of preservation in sustainability, but also utilizing sustainable practices in their own restoration projects. The U.S National Park Service, which oversees the Secretary of the Interior's Standards, has long advocated for retrofitting historic houses to make them more energy efficient. These standards provide general goals for preservation projects at the national level, as well as guidelines for specific aspects of historic construction. In fact, within the Secretary of the Interior's Standards for Rehabilitation, there are "special requirements for energy efficiency" that fall into their guidelines. These requirements specifically allow for changes like insulating attics and crawlspaces, adding weatherstripping, caulking and storm windows to historic windows, and insulating inside masonry walls when appropriate.[5] Baird Smith wrote Technical Preservation Brief for the National Park Service on "Conserving Energy in

[5] Kay D. Weeks and Anne E. Grimmer, *The Secretary of the Interior's Standards for the treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings.* (Washington D.C: U.S Department of the Interior, 1995): 56-57.

Historic Buildings," which outlines the intrinsic abilities that historic structures have to save energy and recommends preservation-oriented retrofitting measures for improving the performance of these buildings.[6] Even though the brief was written during the first wave of the Environmental Movement of the 1970s, Smith's recommendations are still applicable to rehabilitations performed today. As expected, the brief does contain some outdated technologies, but he clearly states that these are expected to improve over the years and his principles can still be applied to new techniques and products.[7] Now, the National Trust for Historic Preservation and English Heritage are extending the scope of preservation beyond the guidelines of National Park Service and applying them with a perspective on energy efficiency in their own projects.

The National Trust for Historic Preservation is a national, private non-profit organization that seeks to "save historic places and revitalize America's communities."[8] The National Trust has partnered with LEED, or Leadership in Energy and Environmental Design, for several of their preservation projects, showing their dedication to increasing efficiency and sustainability even further in historic structures. LEED is a program run by the national non-profit, U.S Green Building Council (USGBC) that uses a voluntary rating system to acknowledge construction projects that show exceptional use of sustainable development practices.[9] These buildings receive a "qualified", "silver", "gold" or "platinum" rating based on the level of sustainable practice used in the project.

6 Baird M Smith, "Preservation Brief 3: Conserving Energy in Historic Buildings." ((Washington D.C: U.S Department of the Interior, 1978): http://www.nps.gov/history/hps/tps/briefs/brief03.htm.
7 Smith, http://www.nps.gov/history/hps/tps/briefs/brief03.htm.
8 The National Trust for Historic Preservation, "About Us" www.preservationnation.org/about-us
9 Barbara A Campagna, . "How Changes to LEED Will Benefit Existing and Historic Buildings," *Forum News* 15 (2008): 1.

Perhaps the most notable National Trust involvement in the ever-expanding "green movement" was their dedication of their January/February 2008 and March/April 2009 editions of *Preservation Magazine* "Green Issues." These editions feature articles ranging from LEED certified restoration stories to tips on making your house more efficient. In fact, The National Trust has placed quite a heavy emphasis on LEED certifications in many of their other publications as well, including *Forum News* and *Forum Journal*. The Trust utilizes LEED certifications because their standards focus largely on reuse of materials and resources in any construction project, whether it is a new or existing building. This ideal is especially applicable to historic rehabilitations because they aspire to retain as much of the historic fabric as is possible. The National Trust took on even more involvement in this initiative when they partnered with several national groups such as the American Institute of Architects, Association for Preservation Technologies, National Park Service, General Services Administration, and the National Conference of State Historic Preservation Officers to create the Sustainable Preservation Coalition, which made the goal of meeting with the U.S Green Building Council to improve LEED standards.[10] The coalition's goal is to improve certain aspects of the LEED certification system, primarily because the current versions "overlook the impact of projects of cultural value, do not effectively consider the performance…and embodied energy of historic materials and assemblies, and are overly focused on current or future technologies, neglecting the advantages of many traditional building practices."[11] Historic construction is inherently sustainable because it is extremely durable and often

[10] Campagna, 2.
[11] Ibid.

utilizes natural energies and LEED standards should reflect this reality. This study shows that historic fabric, when properly maintained, can be just as sustainable, if not more so, than their modern counterparts and must be treated as such. The USGBC has taken note of the Sustainable Preservation Coalition's suggestions and are implementing features in LEED 2009 that "will directly favor the preservation and continued use of existing buildings."[12] However, even though there are many ways for the LEED certification process to improve, it is still possible for historic buildings to be LEED certified, or even gain higher recognition in silver, gold or platinum LEED ratings. The National Trust has highlighted one project they completed that is expected to receive a LEED silver rating: President Lincoln and Soldiers' Home National Monument in Washington, D.C.[13]

Frank Matero, the director of Architectural Conservation Laboratory at the University of Pennsylvania, summed up the Trust's goals for this project in a single question: "in the transformation of our physical environment, what relationships should exist between change and continuity, between the old and the new?"[14] For the restoration of the Administration Building for the Soldiers' Home in Washington D.C, the Trust focused on utilizing the structure's inherent energy saving aspects that are also character-defining features, such as its south-facing windows and deep overhangs.[15] They also implemented modern technology where appropriate to increase efficiency even further in

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[12] Campana, 2.
[13] Kim A O'Connell. "New Directions for the Old Retreat," *Preservation Magazine,* January/February 2008, http://www.preservationnation.org/magazine/2008/january-february/lincoln-cottage.html.
[14] Sophia Lynn. " I'm Over 100---Can I Still Go Green?"*Forum Journal* 21, no. 3 (2007): 38.
[15] Ibid., 41-43.

order to achieve a LEED rating.[16] By employing this strategy, they were able to retain the important features of the house without risk of damaging them and take advantage of more modern implements at the same time to create a restoration project that serves as a national model for the benefits that combining preservation and sustainability can bring. Beyond even the national audience, preservation groups such as English Heritage, which serves Great Britain, Scotland, Wales, and Northern Ireland, are contributing to worldwide efforts to achieve greater efficiency for historic structures. It is important to understand this movement for increased energy efficiency in historic structures at a global level. Because the U.S has been lacking in a national program for this issue, it therefore has much to learn from efforts made abroad.

English Heritage, officially known as the Historic Buildings and Monuments Commission of England, is similar to the National Trust for Historic Preservation in its purpose to protect historic properties, but is a government-funded entity, like the National Park Service.[17] The group serves as "statutory advisors" to the government on this historic built environment and helps to establish regulations for the treatment of historic structures.[18] Their most recent efforts towards sustainability culminated in a document aptly titled " Building Regulations and Historic Buildings: Balancing the needs for energy conservation with those of building conservation." The guide is meant to be an application of the country's regulation Part L, which deals with energy conservation in

[16] Ibid.
[17] Caroline Davison. "Making Old Buildings Energy Efficient," (Norwich: Norfolk County Council, 2008): 3.
[18] English Heritage's website: "Who We Are": http://www.english-heritage.org.uk/server/show/nav.1665.

new, existing, and historic properties in order to reduce CO_2 emissions.[19] In it, they detail the specifics of how to better insulate and seal the house without creating a moisture-rich environment. While some of their recommendations are, such as avoiding the irreversibility of spray foam insulation, others are more specific to their cooler and wetter climate.[20] Regardless of location or climate, English Heritage has created a useful and well-researched set of guidelines that lead to a successful rehabilitation of the building that protects it from negative impacts related to irreversibility and moisture. U.K county governments are also coordinating with English Heritage to better inform the public about these guidelines and their implementation in residential structures.

The Norfolk County Council in the U.K created a document titled, "Making Old Buildings Energy Efficient" that takes the recommendations from Part L and puts them into an easily understandable, illustrated form. Interestingly, Great Britain is using a very similar system to the Residential Energy Services Network (RESNET) utilized in the U.S, which provides the basis and system for the energy audits used in this study. The government has mandated that within Part L, a Standard Assessment Procedure (SAP) be conducted whenever a building is built, sold or rented. The SAP provides an Energy Performance Certificate (EPC), which includes a rating for both the energy efficiency of the house and its environmental impact as well as recommendations for how to improve its energy consumption.[21] This system requires that the number of air changes per hour

[19] Chris Wood and Tadj Oreszcyn. *Building Regulations and Historic Buildings: Balancing the needs for energy conservation with those of building conservation*, (Swindon: English Heritage, 2002), 3.
[20] Ibid., 12-20.
[21] Davison, 3-4.

(ACH) be measured to determine both the current and predicted air infiltration rate in the building.[22]

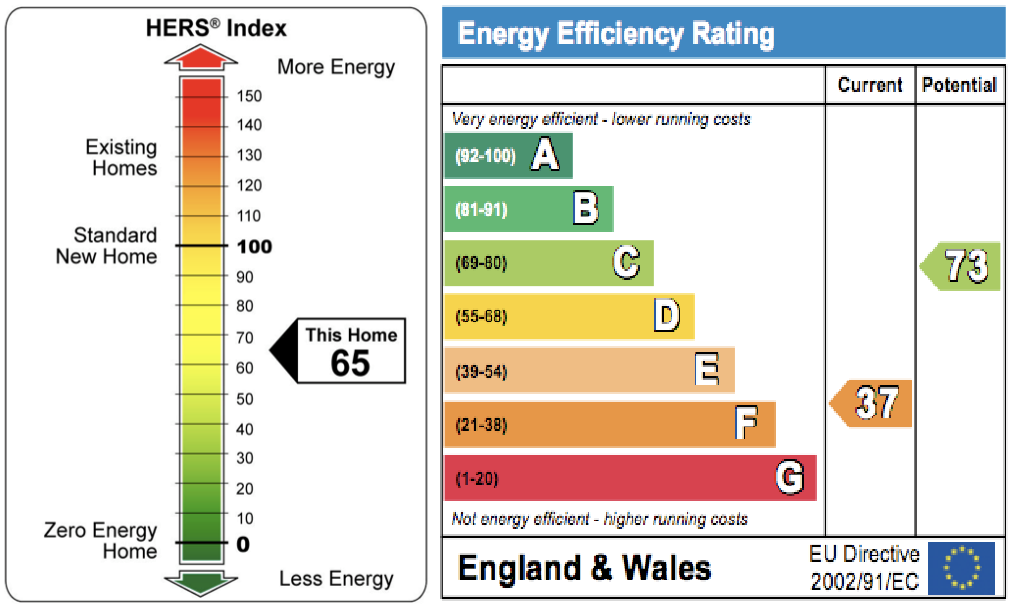

Figure 2: Left: The HERS Index rating chart shows where the tested house falls in comparison to national averages. *Image Courtesy the U.S Department of Energy.* Right: SAP Rating within Energy Performance Certificate (EPC). *Image courtesy the European Union.*

This testing is essentially the same as the blower door test performed in this study, which measures air leakage to the outside of the structure. The results of this testing, along with other tests such as carbon emissions and fuel usage, gives the building its SAP rating, which is comparable to the Home Energy Rating System (HERS) rating given to buildings in the U.S after an energy audit is performed. All of the buildings in this study received a HERS rating, as well as a predicted HERS rating if energy efficiency was

[22] Ibid., 12.

improved with the suggested retrofitting measures. Part L also creates other areas where preservation and sustainability must be combined.

Stipulations in Part L require that anytime a major alteration is performed on an existing building, efficiency improvements are incorporated into the plan as well.[23] These changes do account for historic buildings in a special way, where some requirements can be relaxed, such as replacing single-glazed windows, "if the building is listed, in a conservation area, or can be shown to be of local historic interest."[24] For these buildings, involved parties can shift the focus of the changes towards other means of saving energy, such as insulation, and "can usually be incorporated into the design to compensate for measures which conserve the character or appearance of an old building."[25] English Heritage also has to give consent to apply either interior or exterior insulation for listed buildings and for interior insulation on buildings that are within a conservation area.[26] In addition, consent is also required for the installation of products that use renewable energy, such as solar, wind or geothermal on listed buildings and also on unlisted buildings within a conservation area if the equipment is installed in or on the front of the building.[27] The National Park Service currently has no specific requirements for National Register properties and all restrictions associated with these parties are left to local governments where the property is located. The U.S system for regulating these properties could be greatly improved at the national level, which would provide better

[23] Davison, 5.
[24] Ibid.
[25] Ibid.
[26] Ibid., 8.
[27] Daivson, 17

and more universal treatment of historic properties, as can be seen in English Heritage-controlled properties. With trained professionals overseeing the installation of these retrofits, historic buildings can be better protected during these changes as well as becoming more efficient with less impact on the environment over time. With this understanding of the broader movement for sustainability and preservation internationally, we can begin to focus back on initiatives being performed domestically.

While the National Trust and the National Park Service are providing information about general, sustainable practices in historic structures, physical testing of the efficiency of these structures is just beginning to be popular. Preservationists have long understood the durability of historic construction practices and its merit for its durability and passive heating and cooling measures. However, in order to legitimize historic construction in the context of the modern sustainability movement, it must be quantified through energy audits. These audits, which include blower door and duct blaster testing combined with computer analysis, provide this vital information that will guide any future improvements for energy efficiency, before ever altering the structure. It is important to first discuss the details of the system and equipment used for energy audits in order to understand their place in other studies.

The Residential Energy Services Network (RESNET) is a national non-profit that sets the standards for building efficiency rating systems.[28] These standards are used to

[28] Residential Energy Services Network "Introducing RESNET." 2008. www.resnet.us/about/resnet The Energy Star rating for homes is a title awarded by the EPA and the U.S DOE to homes that are at least 15 percent more efficient than houses built to the 2004 International Residential Code (IRC). This is approximately equivalent to being 20-30 percent more efficient than the average residential house. The

validate energy performance of buildings for the Environmental Protection Agency (EPA) Energy Star qualifications, U.S Department of Energy Building America program and federal tax credit qualifications for energy efficiency.[29] In order to give a quantifiable comparison of ratings, RESNET created the Home Energy Rating System (HERS®) Index that shows where the tested building falls in relation to other existing residential structures, an average house in the U.S., and an Energy Star rated house.[30] The audit computes where the house falls on this index, as well as recommended efficiency improvements using computer software to model the energy usage of the building. There are several software systems that are accepted by RESNET, but this study used REM/Rate™. This software uses data from both plans of the house, as well as data gathered from blower door and duct blaster testing to measure air leakage. From this information, it computes energy loads, determines sizing for necessary mechanical equipment, calculates energy consumption and its cost, and establishes whether the house meets energy conservation code standards. The next chapter discusses the use of this software in better detail.

It is also important to discuss the function of the blower door and duct blaster, as their readings are an important component to the overall energy audit.[31] The blower door is a fairly simple apparatus and provides the most practical way to test air leakage in a house. The "door" essentially consists of an adjustable metal frame with an attached

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Building America program is a partnership of residential building companies and professionals that strive to find economical ways to reduce average energy use in housing from 40 percent to 100 percent.

[29] Ibid.

[30] Ibid.

[31] This study used the Minneapolis Blower Door™ and Duct Blaster® created by the Energy Conservatory to perform the testing in this study.

vinyl cover that fits into a doorframe of the house.[32] At the bottom of the temporary door sits a calibrated fan that as it is turned to higher speed slowly pressurizes the house. A digital manometer attached to the fan determines when the house has reached a pressure of 50 Pascals (pa) and displays the airflow rate of the fan in cubic feet per minute (CFM_{50}).[33] The auditor can then convert these readings to the air change rate when the house pressure is at 50 Pascals (ACH_{50}) and the natural air change rate (ACH_n) can be deduced in turn from that rate.[34] The duct blaster works much the same way as the blower door by using a calibrated fan that is attached to each return vent present in the house, to pressurize the ducts to 25 Pascals and measure the fan flow in CFM_{25}.[35] The duct blaster tests each duct system individually and again simultaneously with the blower door to determine the leakage of each system and the total leakage to the outside.[36] By testing this way, the model can determine the amount of air that is leaking to the inside of the conditioned space, which contributes to the conditioning process and cannot be termed "leakage," and separate it from the amount that is leaking to the outside. Energy

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[32] The doorframe used must be for an exterior door so the machine can compare leakage to the outside. For this study, the primary entrance to each house was used for the blower door setup.

[33] Digital manometers determine the pressure of the house through sensors called pressure transducers, which then compare it to the pressure outside of the house. This assess whether the house has reached a certain pressure level and simultaneously accounts for pressures exerted on the house by outside forces, such as wind. It also measures the airflow of the fan through by sensors that are connected to a thin rubber hose, which is also connected to the fan. When the fan blows, the air inside the tube is pressurized to a certain level, which the manometer converts to a fan flow rate. John Krigger and Chris Dorsi, *Residential Energy* (Helena: Thompson-Shore, 2004), 76.

[34] Ibid., 79. Pascals are a unit of measurement for pressure. Dividing the CFM_{50} by 60 minutes per hour and then dividing by the house volume in cubic feet calculates the ACH_{50}. Numerical factors, such as the average wind speeds, the house's degree of protection from outside forces and the number of stories the house has all factor into determining the ACH_n.

[35] Each return must be tested separately because they correspond to a separate duct system.

[36] For the duct blaster test, all of the supply vents were taped off around the house so that the fan is able to push air in and pressurize the system, with only air leaking out of the ducts themselves and not into the rooms of the house.

auditors around the country commonly use this testing program and it is the same process that was used in a comparative study done by the University of Central Florida (UCF) in 2004.

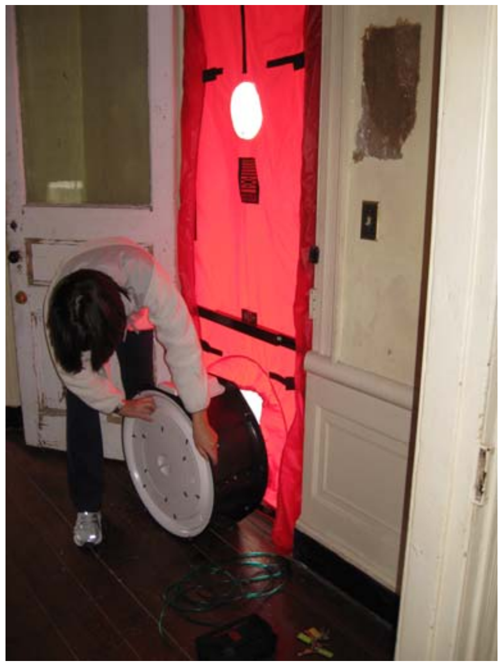

Figure 3: Blower door setup at 63 Smith Street. ***Photo courtesy April Wood.***

The goal of the UCF study was to reduce the cooling loads on the air conditioner of the H.S Wiliiams House, a late nineteenth century museum house near Melbourne, Florida, by determining envelope leakage and retrofitting possibilities and thus, making the building more efficient.[37] Dave Chasar, the author of the study, used blower doors and load calculation software to determine the leakage rates of the Williams house and six other historic houses nearby whose construction dates were within 40 years of the

[37] Chasar, Dave. "Cooling Load Reduction and Air Conditioner Design in a 19th Century Florida House Museum" (Cocoa: The Florida Solar Energy Center at the University of Central Florida: 2004), 1.

Williams museum house and were built with the same method: balloon framing.[38] From this data, Chasar determined how the Williams house compared to the other houses in terms of envelope leakage, which gave him an estimate of the high and low thresholds of infiltration that the museum house could reach.[39] In order to reach a certain level of air leakage control, Chasar assessed six areas of the house for their role in the overall envelope leakage and determined what "load reduction options" were possible according to the *Secretary of the Interior's Standards for Rehabilitation*.[40] By determining a method to decrease leakage at each critical area to an achievable level, the cooling loads were reduced and a significantly smaller air conditioning system could be installed, while still maintaining the integrity of the character-defining features of the house. [41]

Chasar's study sought to improve a single structure and tested only the infiltration rates of the other structures in order to compare them to the Williams house. This report performed an audit similar to the Williams house for all five buildings in the study. From these audits, the study makes recommendations for all of the houses that improve their energy efficiency and are guided by good preservation practice as outlined by the *Secretary of the Interior's Standards for Rehabilitation.*[42] The analysis of these structures with the recommended changes proves that historic structures can achieve higher levels of efficiency, resulting in lower energy costs each year, while retaining and

[38] Ibid., 8.
[39] Chasar., 7-9.
[40] Ibid., 1-7.
[41] Ibid., 10-11. The air conditioner chosen was a standard residential size, which is quite a feat compared to house museums in similar climates, which often employ industrial conditioning and dehumidification systems.
[42] See Appendix C.

preserving the original materials that have endured the lifetime of the building. The data from this study also affirms the need for energy audits of historic structures at a national level, as is seen internationally.

METHODOLOGY

This study performed energy audit analysis on residential houses that were chosen based on historic age, location within the Downtown Historic District of the City of Charleston, or were of historic importance in the greater Charleston area, and represented either masonry or stick frame construction. The study includes: 1 and 84 Tradd Street, 63 Smith Street, and 8 New Street downtown, as well as the museum house at Middleton Plantation located on Highway 61, about twenty miles northwest of downtown Charleston. While the sample set consists of only five houses, it includes structures built of both wood and brick masonry, which provides a sense of comparison for the two main types of historic construction in the area. This distinction provides a means to determine the similarities and differences with respect to the overall energy efficiency of each house and type of construction as well as whether the efficiency of historic structures is similar over different periods and methods of construction.

Some of the houses currently have air conditioning or heating systems (HVAC), while others do not. This does not affect the degree of efficiency for the building's materials or construction. While the implicit understanding of this study does address HVAC systems in historic houses, the central purpose is to define the current energy use of these historic structures in a quantifiable way and to make recommendations for preservation-oriented, sustainable retrofitting to achieve better energy efficiency. The energy audits conducted on the five historic structures combine information gathered from historic preservation resources, the load calculations determined by the

REM/Rate™ software system, and the infiltration results of the blower door and duct blaster tests to yield an energy profile of historic timber-framed and masonry houses in the context of a warm, coastal climate.

Creating a complete energy audit of these structures began with measured drawings of the building. In the cases of 1 Tradd Street, 84 Tradd Street, and Middleton Place, the owners provided drawings that area architects had drawn for various purposes. For 63 Smith and 8 New Street, this study used simplified field drawings to convey the necessary information for the audit.[43] From these measurements, the total square footage, volume, and glazing area of the houses were determined.[44] The frequency of glass openings and their degree of shading throughout the day impacts the energy efficiency of the house as a result of passive heating or cooling. For this reason, site visits also included important notation of adjacent shutters, trees and even nearby buildings to determine the natural air changes per hour in the analysis of the testing data.

The site visits to each house also included blower door testing and if the house was conditioned, a duct blaster test as well. Other notes taken while on site visits include the method of construction, the conditions and types of attic and crawl spaces and the specific sizes and types of mechanical systems currently in place. REM/Rate™ requires this data to create an accurate representation of the house's energy use. Because this

[43] These drawings differ greatly from documentation drawings because they focus largely on surface area of the walls and fenestration as well as the volume of the building. The relative locations of windows and doors to overhangs were also an important measurement noted on the drawings.
[44] The glazing area is the amount of glass, whether in windows or doors, that is present on the exterior walls of the building.

software system is instrumental to the data analysis, this study will explain the specific information required and its importance to the accuracy of this report.

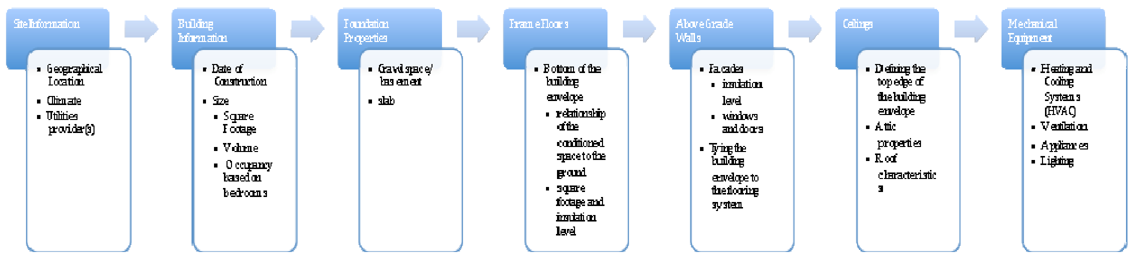

Figure 4: REM/Rate Process of Energy Modeling

The most basic, but vital information required concerns the site of the building. When the user enters the city and state where the building is located, the system can accurately depict the climate zone, while the building's local utility providers and their rates for electricity, gas, propane, oil, and other fuel sources helps to calculate the yearly cost of the structure's energy use. This information came from historical data of utility bills provided by the owners of the building. This allows the software to combine the modeled energy usage expressed in BTUs, or British thermal units, with its monetary equivalent.[45] By providing a dollar amount connected to the energy usage of the building, the owner can determine whether a specific component of retrofitting the house for increased energy efficiency will be cost effective.

[45] Krigger and Dorsi, 28. Just as gas usage is measured in therms and electricity is expressed in kilowatts per hour, British thermal units (BTUs) quantify heat (read: energy) flow.

Next, the square footage and volume of the building calculated from the site visit enter the system under general building information. The system also requires the year that the house was built, along with its type (i.e. single family detached, apartment, mobile home, etc.), and the number of floors above grade.[46] Next, the number of bedrooms allows the system to approximate the number of occupants who use the house on a daily basis and thus model for energy consumption in areas like lighting and heat gains from bodies occupying the space.[47]. The foundation is also important to the system's understanding of the building envelope and it allows for an open crawl space, conditioned crawl space, conditioned or unconditioned basement, slab, or even more than one type. If the house contains an enclosed crawl space, then the auditor can specify if it is vented or unvented. This feature makes a considerable difference in the building's performance because affects the temperature of the space. If the crawl space is vented, it allows conditioned and unconditioned air to flow in an out; however, if the area is closed, it holds in conditioned air and secludes outside air. These specifications are important because they give information about the thermal boundary of the building, which determines how easily air can move out of the house from below the bottom floor.

[46] The term "above grade" refers to anything portion of the building that exists above ground level.
[47] REM/Rate™ models based on an average per person consumption inside a house. This average may be slightly higher or lower than the actual use for a specific residence; however, it is meant to provide a generally accepted representation of energy use caused by human involvement in the building.

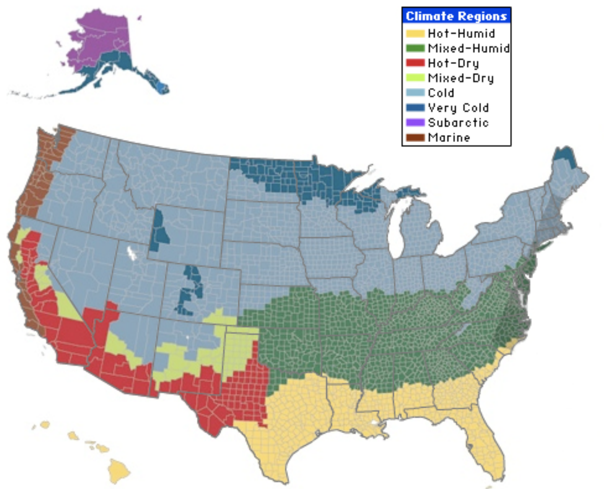

Figure 5: The U.S Department of Energy defines climate zones, which REM/Rate uses to model the temperature, humidity and wind variances the house experiences. ***Image courtesy The U.S Department of Energy.***

After identifying the foundation type, REM/Rate™ requires more information about the materials that compose the foundation. Here, the user can enter as many types of foundation walls that exist in the structure. Multiple entries may be required if, for example, a house has an addition attached with a different foundation type. The construction material and level of insulation are determined for each foundation wall present. If insulation exists, the amount, location and thickness are taken into account. By entering these specifics, the software determines the R-value of the foundation and any insulation, which will show how air flows thorough or around the foundation walls.[48] The foundation information cannot be confused with the slab, as it is a separate entry in

[48] R-values are a measurement of a building material's thermal resistance. The rating ranges from 1-60, with R-1 providing the least insulation value and R-60 with the most thermal resistance. Unlike sunscreen, if materials are stacked on top of one another, their R-values can be added together to create a greater thermal resistance than if they stood alone. Krigger and Dorsi, 67.

REM/Rate™. This is especially important for this study because many Charleston houses are built on open or enclosed crawl spaces and do not have a poured concrete slab. If a slab does exist, as it did for 84 Tradd, the user enters the square footage, perimeter, and the area and perimeter above, below or on grade. The combined information concerning the slab and foundation determines how the house interacts with the ground and models for the paths the air in the house may take as a result of this connection.

When the software asks for information about the "frame floors," it can be somewhat misleading. For the purposed of an energy audit, the term "frame floor" only refers to floors that exist over unconditioned spaces, not all of the framed floors in the building.[49] This distinction is necessary for the software to model how conditioned air from the interior of the house will flow out to unconditioned spaces. If the space underneath the bottom floor is conditioned (i.e. a sealed and conditioned crawl or conditioned basement), any leakage will serve to further condition the area and cannot be deemed "leakage" because it is not lost to the outside. For the appropriate floors, an entry was made for each, which included the area in square feet, its level of insulation and what type of space from which it was separated (i.e. garage, unconditioned basement or crawl space). The frame floor is not the only space between floors in the house where leakage occurs, however.

In a modern building, the rim and band joists are the supportive beams that connect the floor system cavities at each level of the house. This construction method is

[49] For all of the houses contained in this study, "frame floor" described the first floor only, but if any homes had had a conditioned basement or a simple concrete slab, there would be no frame floor entries.

less common in historic structures and for this reason, the “rim/band joist” as defined for the purposes of this study, is the vertical area of the envelope wall space that meets the perimeter of the flooring system cavity.[50] Even though this characteristic makes the rim/band joists part of the above grade walls portion of the building envelope, they have to be defined separately because the space are often insulated differently than other parts of the envelope such as walls, floors and ceilings.

The above grade walls, another component of the building envelope, have to be defined as well. Because these walls are part of the building envelope, their entries only include those that separate the interior from the exterior of the house.[51] These walls are generally grouped into whole facades of the house, as long as they have the same orientation and are constructed the same way. Their area, construction, and exterior color are all entered to give the system a complete understanding of their ability to keep air in or out and protect against thermal transmission. The exterior color is important for its ability because of its ability to absorb or reflect sunlight during different seasons. Once the user defines the exterior walls, they can then assign fenestration to its respective façade.

Proper entry of windows and doors is essential to the accuracy of an energy audit. REM/Rate™ defines windows according to four criteria: their construction, orientation,

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[50] If the attic is an unconditioned space, its floors are considered a “ceiling” for its role as part of the building envelope. If the attic is finished and functions as a conditioned space, it would be included within these properties.
[51] The walls that separate only interior rooms from one another are not considered here for the same reason that the frame floor properties did not include the floor properties separating conditioned spaces. The audit’s goal is to determine how energy is being lost and thus is only concerned with areas that provide potential for leakage outside the building.

and proximity to an overhang or adjacent shading, which were all recorded at the time of the site visit. The construction type is a combination of the window's material (wood, metal or vinyl) as well as if the panes are single, double, or triple paned, or filled with argon gas, a feature reserved for the most efficient of modern windows. The orientation of the window and its proximity to shading is important because it determines the amount of passive heating and cooling the house receives. Three types distinguish the shading of the glazing area: interior shading, exterior shading, and overhangs.[52] The system allows for interior and exterior shading to be entered separately for the summer and winter seasons according to use. The user also defines the type of doors present according to their material and thickness, as well as if it is solid or paneled.   All of these characteristics combine to determine its R-value.   Finally, the auditor inputs the total area of each type of fenestration and assigns them to their corresponding "above grade wall".

The ceiling properties are the final part of the building envelope entered into the model. As stated before, the frame floor properties describe only the barrier between conditioned and unconditioned/semi-conditioned spaces; ceilings follow the same rule. The attic is perhaps the most common unconditioned space found in existing buildings, whether they are of modern or historic construction.[53] Like the "above grade walls," the

[52] Types of interior shading include blinds and curtains. Exterior shading can be in the form of trees, shutters, or nearby buildings. Overhangs are often roof ledges and protruding cornices, especially for historic structures.

[53] For half of the structures in this study, the ceiling specified was the top floor ceiling that bordered the attic space. For 84 Tradd and 63 Smith, the "attic" was finished, livable space with unconditioned attic space separated by knee walls. For these instances, ceilings were defined where the conditioned attic

audit requires information about the level of insulation, area, and its exterior color and whether or not a radiant barrier exists.[54] These specifics allow the program to understand just how much temperature variance is possible between the attic and conditioned space, which affects the load requirements for the house's heating and cooling systems.[55] To determine whether the load requirement of the house and the mechanical equipment are a balanced match, the type of equipment currently used is specified.

Once the rater defines the building envelope in REM/Rate™, they enter information gathered from the site visit about the building's mechanical equipment. This includes any air conditioning, heating, water heating, and ventilation and dehumidifying systems. For each piece of equipment, the software requires the type, size and load capacity in addition to its location in a conditioned or unconditioned portion the house. This information demonstrates the capacity of the system to serve a certain purpose and area of the house and whether its location in a conditioned or unconditioned area is contributing to conditioned air leakage to the outside. The owners provide average thermostat temperatures for both heating and cooling, as well as if the thermostat is programmable, to better reflect typical energy use that is specific to that house. The computer combines this data with the climate zone information entered earlier to create an accurate model of energy use for the building.

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ceiling was in contact with the roof and where the ceiling of the floor below connected to the knee wall attic area.

[54] A radiant barrier is a foil lined paper that is installed by stapling it, shiny side up, to the bottom of rafters or roof sheathing to "reflect heat radiation and impede heat flow" from the sun onto the roof materials. Krigger and Dorsi, 204.

[55] When a great temperature difference exists between a conditioned and unconditioned space, the HVAC system has to work harder to compensate for the radically hotter or colder air that infiltrates from that space into the livable areas of the house.

Where HVAC systems exist, duct systems are typically nearby. The auditor next defines the duct systems that correspond to each of the heating and cooling equipment in the house. The study estimated the percentage of their supply and return areas that are in conditioned and unconditioned spaces according to what was observed in the site visit. The location of these ducts is important because any leakage of conditioned air in the duct systems will filter into its surrounding area. If the ducts are in a conditioned space, this leakage is irrelevant to the overall leakage figure because it contributes to the conditioning of the habitable space. The supply and return areas also inform the software about how much of the house each HVAC unit is serving. This information, combined with the leakage in the rest of the house, determines the load requirements for the heating and cooling systems. The type of water heater and its efficiency level is also entered to determine its energy use. The mechanical equipment for the HVAC and water heating is crucial to the understanding energy use and leakage in the structure, but other electrified equipment are present can be accounted for as well to give an even more detailed analysis of each individual building.

Data for lighting and appliances such as refrigerators, dishwashers and ceiling fans provides a level of detail that gives a unique profile of the occupants of the building and their energy consumption patterns.[56] Furthermore, the user is able to specify the type of fuel that these appliances use, which is reflected in the energy cost through the utility information provided at the beginning of the audit. The lighting details can be specified

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[56] This information can be found either on the appliances themselves, through a simple lookup on the product's website or through the Energy Star database at http://www.energystar.gov/index.cfm?fuseaction=find_a_product.

depending on the needs of the audit, but is not required for the purpose of this study. It can be included as specifically as desired, including the number and type of light bulbs present in the house. Skylights are also taken into account for their day lighting abilities, thus reducing the usage of the electrified lights in the house. Their location and size show how much of the house is lit from these features. After this information is put in, all of the details of the house itself and its mechanical equipment are complete. The final step is to put in the infiltration measurements taken from the blower door and duct blaster testing.

As discussed earlier, this study used the Minneapolis Blower Door and Duct Blaster equipment from the Energy Conservatory to conduct the testing in this study. The fan brought the house to a pressure of 50 Pascals, where the fan flow rate was recorded in cubic feet per minute, or CFM_{50}. Once the house reached this point, the duct system was ready to be tested. The fan flow readings from both the blower door and duct blaster provide a leakage measurement for the entire house and its HVAC components. Once converted to air changes per hour, the infiltration rates provide the last piece of information required for the software to model the building’s energy use.

REM/Rate™ then calculates the HERS rating score for the structure. With this baseline energy model in place, the study then created improvement analyses that determined the energy and cost savings of various retrofitting measures. By altering many different aspects of the building within the building file, the study could model anything from changing insulation levels to replacing windows without ever changing a single item in the structure itself. Once the study had determined which changes were the “best case scenario” for energy savings, it then modified these choices to include only those that follow the *Secretary of Interior’s Standards for Rehabilitation* to create a “most likely scenario” of energy retrofitting for each historic structure. A new file was then saved to reflect the building in its hypothetical changed state. Using a reporting system within REM/Rate™, the study compared the energy consumption and air leakage of the current (baseline) energy model to the proposed changed version of the building. These reports allow the owners of these buildings to understand how different changes within their house will affect their energy usage over the course of a year, while still maintaining the historic integrity of their house.

Finally, the study used REM/Rate™ reports to summarize the information provided about the structures, in order to compare them to each other, as well as the Florida houses included in Chasar’s study. This material determined trends and patterns of energy usage of these historic structures with respect to their building type, climate, and other historic buildings in their region. These facts were key to understanding the implications of this study and will be discussed in the following chapters.

INFLUENCES ON ENERGY USES

Understanding the Building Envelope: Air Leakage and Heat Transmission

Perhaps the most important concept to understand before anything else in residential energy use is the building envelope. The envelope consists of the sides of the house that have contact with the outside, including the foundation and bottom floor, exterior walls and the roof. The building uses its envelope to keep conditioned air inside its walls and the outside air from penetrating indoors. This characteristic is commonly referred to as a thermal boundary, which for more modern houses involves the presence of insulation and an air barrier.[57] Air barriers resist air leakage and should not be confused with vapor barriers, which keep moisture from entering the wall cavities of the house.[58] A historic house in a hot, humid climate can have an air barrier, but not a vapor barrier, which will allow moisture to enter and exit the walls as is typical for the structure, while reducing air infiltration. The building's efficiency is determined by how well the envelope performs this duty. Of course, there are always points in a building envelope where air will leak out and heat will be transmitted; this action can comprise anywhere from five to forty percent of conditioning costs in a residential structure.[59] Heat flows through the building envelope through two means: transmission and air leakage, each determined directly by thermal resistance and surface area.[60] Because these issues can be such a large influence on energy use in a house, the causes and effects as well as possibilities for slowing the process are vital to this study.

[57] Krigger and Dorsi, 50.
[58] Ibid.,251.
[59] Ibid., 73.
[60] Ibid., 56.

Air leakage exists in two forms, infiltration, which involves outside air entering the building, and exfiltration, which occurs when conditioned air leaks outdoors. Both types cause the air conditioning systems in the house to work harder, regardless of season. However, some air leakage is not only acceptable, but also necessary for houses to have for ventilation to reduce moisture, air pollutants and odors from building up inside.[61] Houses are often ventilated by natural air entering the house, which factors in when determining the degree to which air sealing is necessary or desired.[62] Natural ventilation can be defined as the uncontrolled movement of air into and out of the house through small cracks and vents.[63] This is especially true for historic houses that were built long before air conditioning systems were being used because they allowed air to enter and exit in certain situations to heat and cool the house more effectively. When dealing with ventilation and air leakage in historic structures, the question becomes: how much air sealing is necessary and how can it be achieved without damage to the historic fabric of the house?

When considering the appropriate or optimal amount of ventilation to allow in a house, the safety of the building's component materials as well as the health of the inhabitants must be considered. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) requires a minimum of .35 air changes per hour (ACH) to occur naturally, or air changes lower than .35 have mechanical fresh air

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[61] Office of Building Technologies Program, "Spot Ventilation," *Technology Fact Sheets* (Atlanta: U.S Department of Energy, 2002): 1.
[62] Krigger and Dorsi, 73.
[63] U.S Department of Energy, " Spot Ventilation", 1.

ventilation.[64] Mechanical ventilation requires the use of fans and duct systems to remove stale indoor air and replace it with outdoor air. Whole house ventilation systems control the amount of leakage much more precisely than natural ventilation would and can be used in the form of exhaust-only, supply-only, or balanced systems.[65] As evidenced in their names, exhaust only systems expel stale air out and rely on leakage to infiltrate fresh air, while supply-only brings in the fresh air and allows leakage points throughout the house to let stale air out.[66] These systems are much more comprehensive than spot ventilation, such as bathroom and kitchen exhaust fans, and depending on the existing ductwork present in the house, may not be appropriate for a historic structure. Adding ductwork to a historic building can be an invasive and tricky maneuver that often leaves the integrity of the historic interior compromised. This study will later address ductwork installations and the options available to historic buildings. The main point to understand with ventilation and infiltration is the building needs to have fresh air circulated through it and cannot be air-sealed completely. However, some control to air leakage is necessary and desirable to create energy efficiency.

To control air leakage, whether it is infiltration or exfiltration, one must first define the points of entry or exit and how great their surface areas are because the greater the area of the entry point, the more air that can leak in or out of the structure. Some points are obvious, including corners, around openings such as windows and doors, and even entries for mechanical equipment like dryers and dishwashers, but others are less so.

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[64] Air changes per hour (ACH) represent that number of times in an hour that the air in the house is being replaced with fresh, outside air.
[65] U.S Department of Energy, " Spot Ventilation", 1.
[66] Ibid.

Any place where more protrusions or indentations occur, more seams are created and thus more possibility for air leakage. Examples include dormers and porches, which are both extremely common in the lowcountry of South Carolina. As stated earlier, porches and other overhangs provide important shading for the house, however where they connect to the house, seams are created, which increase areas for air leakage. These seams must be properly sealed to reduce infiltration. Overall, the major points of infiltration occur around chimneys and pipes, crawl spaces and basements, porches, roof overhangs, protruding or indented windows and doorways, wall cavities without insulation, suspended ceilings, attic and roof cavities, plumbing and wiring entries, building cavities used as ducts and interconnecting spaces between floor, wall and ceiling cavities.[67] While all of these issues are counter productive to controlling air leakage, the last two items are perhaps the most concerning, and common, of all.

Interconnecting spaces between floor, wall and ceiling cavities is an inherent air leakage problem depending on the type of construction used for the house. Balloon-frame construction, used on many historic, wood-frame houses, is especially prone to leakage because it is built with the corner posts and studs extending in a continuous assembly from the ground floor sill to the roof plate, thus the wall cavities are open from the crawl space to the attic.[68] Because this continuous open cavity exists, unconditioned or semi-conditioned air can flow unobstructed through the walls and leak into the interior

[67] Krigger and Dorsi, 53.
[68] Curl, James Stevens, *The Oxford Dictionary of Architecture and Landscape Architecture.* (Oxford: Oxford University Press, 2006): 59.

of the house at every seam, crack, or opening.[69] Masonry structures are considerably more resistant to infiltration, especially when insulated or simply built with substantial thickness in the exterior walls, as many historic structures are. Masonry materials such as brick and stone have somewhat low R-values, but when placed in mass or with insulating materials, they can provide an effective air barrier to reduce heat transmission through the walls.[70] Heat transmission is the second of the two means of heat flow through a building envelope and should not be confused with air leakage.

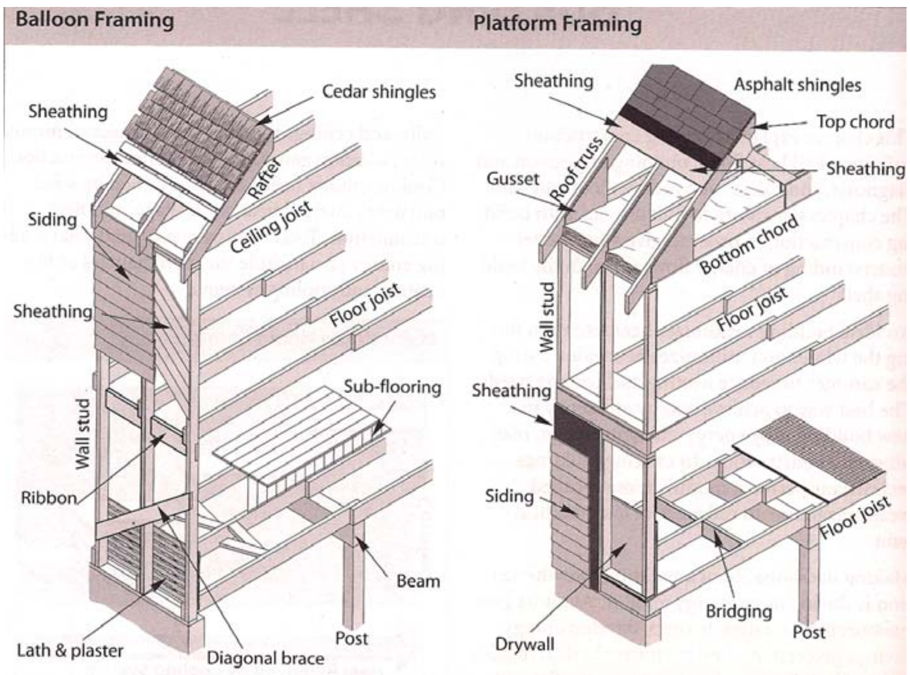

Figure 6: Balloon framing creates a continuous space from the ground floor sill to the roofline that allows air infiltration to circulate through the building envelope. ***Image taken from Residential Energy by John Krigger and Chris Dorsi, 50.***

[69] Krigger and Dorsi, 51.
[70] Ibid., 52.

Air leakage is simply the flow of air, not necessarily heat, into and out of a building. Heat transmission is dependent on insulation levels and their ability to resist conduction, convection and radiation.[71] Insulation achieves this task by pushing heat through its fibers and small air pockets, which causes it to transmit heat much slower than it would in an uninsulated space where convection and radiation rapidly occur.[72] Insulation needs to be placed in direct contact with an air barrier in order to make an effective thermal boundary on the building envelope. This combination is necessary because infiltrating air will move through the building cavities, increasing transmission of heat through convection, pushing it from the surface of the insulation through to the inside of the house.[73] In this way, the air barrier and insulation, in whatever form they may exist, come together to stop heat transmission and air leakage by giving the building an effective envelope to produce greater efficiency overall.

Components contributing to Air Leakage and Heat Transmission

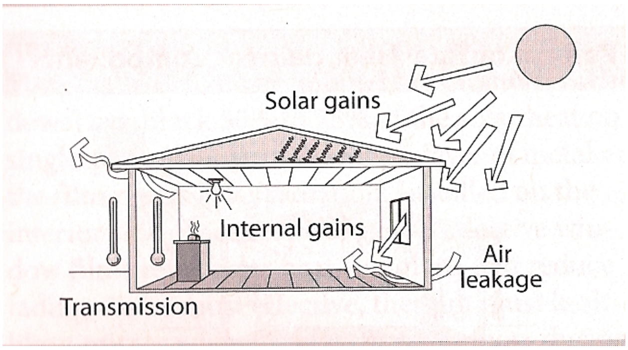

Figure 7: Heat gains and air infiltration are the largest influences on energy use in any building. ***Image taken from Residential Energy by John Krigger and Chris Dorsi, 199.***

[71] Krigger and Dorsi, 57.
[72] Ibid.
[73] Ibid.,75.

Attics and Crawl Spaces

Attic and crawl spaces are typically unconditioned spaces in residential structures and therefore, can have a significant impact on the ability to heat and cool the building efficiently. In an area like Charleston, attic temperatures can reach upwards of 140 degrees in the summer, while crawl spaces can be significantly cooler than the outside temperature. For this reason, it can be difficult to determine whether or not to insulate or seal and condition these spaces. Historic buildings, unlike many of their modern counterparts, do not typically have attic ventilation systems or insulation in the attic, unless it has been retrofitted into the space. This issue is paramount to the energy use of the building because even for newer houses, 40 percent of air infiltration occurs through the ceiling of the building envelope, making it the largest contributor to infiltration in the house.[74] This condition combined with the uninsulated state of the attic floors in this study, allows for the extremely hot (or cold) air in the attic to have an easy path straight into the conditioned space in the house. Insulating the attic space, both on its floor and on the underside of the roof sheathing, is an easy and affordable way to reduce infiltration and thus energy cost in any building. The method of insulating this space is extremely important and must be tailored to the historic assembly of the attic. By insulating specifically for a historic attic, the system can better control moisture and keep it from being trapped against the historic fabric. This study addresses these assemblies in the following chapter.

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[74] G.K and D.P Yuill, "A Field Study of Whole House Air Infiltration in Residences" (paper presented at the Excellence in Building Conference for the Energy Efficient Building Association, Denver, Colorado, October 7, 1997).

A radiant barrier, as described earlier, can be added to the underside of the roof sheathing, separate from an insulation scheme, to reduce heat gains from the roof's exterior. The attic can also be air sealed and then become a conditioned part of the house, making the influence of hot air on the rooms below much less dramatic. This system must be treated more delicately in a historic structure and is not appropriate in all instances. Sealing an attic can cause moisture damage if the system is improperly designed for a historic building in a hot, humid climate. However, if it is appropriate, a sealed and conditioned attic can provide great improvements in overall efficiency. Heating and cooling systems are often located in the attic of residential housing. If the attic becomes a conditioned space, air leakage from any duct systems located there will also become a positive, instead of a negative impact on the heating and cooling of the house. Because attics have the largest impact on the house's ability to heat and cool and requires a small amount of skill to insulate, it should be addressed first when choosing which improvements should be made to the house.

Crawl spaces are also a major source of infiltration, with over 35 percent of the total leakage occurring through the bottom floor of the house.[75] These spaces can be insulated and air sealed much the same way as attics; however, for a warm, coastal area like Charleston, the choices are more mixed. The air in a crawl space or basement is often more temperate, even in the summer, than the exposed outside air. For this reason, the bottom floor is often left uninsulated because the infiltration often contributes to cooling the space above it. The houses used in this study were often in a very low lying

[75] G.K Yuill and D.P Yuill, "A Field Study of Whole House Infiltration in Residences"

area that is prone to flooding even during high tide. In areas similar to Charleston, owners must consider the risks and consequences associated with air sealing and insulating a moisture-rich area. Insulation choices for attics and crawls are, therefore, dependent on varying conditions from place to place and should be tailored to the needs of the house.

Walls

Treating infiltration in walls is a much more difficult and expensive task to accomplish. For any existing building, historic or otherwise, adding insulation to the wall cavities is a highly intensive and destructive process because the existing wall treatments have to be removed. For modern buildings, spray foam insulation is applied through a significantly smaller hole than batt insulation would require.[76] Applying insulation in wall cavities, especially in historic structures, can often cause moisture to build up inside if not done correctly. If the walls of the building are intact, insulating them is simply more trouble than the at-most 14 percent decrease in infiltration. In addition, historic wall construction can provide an effective thermal and air barrier. Masonry materials generally have low thermal quality; however, when combined in mass as is seen in historic masonry construction, it will decrease heat transmission considerably.[77] In addition, plaster and lath assemblies on the interior of historic houses provide an effective air barrier that is comparable to modern drywall. Because these historic assemblies

[76] Sprayed insulations typically use a polyurethane or polystyrene foam to fill the wall cavity. This type of insulation provides more complete insulation and air sealing with less error on the part of the installer. Batt insulation, such as fiberglass or mineral wool, comes in a soft, but solid form that is laid in sections and can be cut to fit different areas.
[77] Krigger and Dorsi, 52.

already provide valuable contributions to efficiency and removing them to install more insulation is so difficult to achieve, this study does not suggest insulating wall cavities for historic structures.

Windows and Doors

Historic windows are often the first feature to be replaced in historic structures because they are the easiest to remove when energy costs become excessive. Countless window manufacturers and installers claim, with some credit, that installing new windows will improve a building's efficiency. They are correct in this claim, however the cost effectiveness of the change, as well its detrimental effect on this historic appearance of the building, does not justify the savings on the utility bill. Windows only account for 10 percent of air infiltration in the typical residential structure, which makes them by far the smallest contributor to the building's inefficiencies.[78] For historic buildings in particular, keeping the house's original windows, which can be just as efficient when properly restored and weatherized as a modern window, is a step that both follows good preservation practice and is logical. Proper maintenance, weatherization and storm windows can be applied to the original windows to create an assembly that is competitive with even the most modern, efficient window, as can be seen in the analyses of the buildings in this study. The historic window construction is also far more durable than modern replacements, which can have a lifespan of less than 30 years. The amount of skill, time and money required to remove, purchase new replacements and reinstall all of the windows in a house is far greater than 10 percent decrease in infiltration. Keeping

[78] G.K Yuill and D.P Yuill, "A Field Study of Whole House Infiltration in Residences"

the historic windows in a historic house allows the building to function efficiently and maintains the historic integrity and durability of the historic assembly.

Heating, Ventilation, and Cooling Equipment (HVAC) and Duct Systems

While the heating and cooling systems in a house do not directly influence air leakage or heat transmission, their surrounding spaces may. If these systems are located in an unconditioned and uninsulated space, the conditioned air that they leak will be lost to the outside of the building envelope. Property owners should consider two vital steps for improving their house's HVAC system: correct sizing of this equipment and properly insulating and sealing the connecting ductwork. Even if they decide not to make any other alterations to the house, these two steps will make a significant difference in the house's efficiency. Conversely, if they make changes to improve the building envelope, they *must* size their HVAC system to reflect the new conditions of the building. In the 1970s efforts towards sustainability, property owners often did not follow through with this critical action. Many of the techniques and building technologies offered in this study were researched and created over 35 years ago, such as insulating attics and walls, radiant barriers, air sealing and even blower door testing, but because HVAC systems were not altered in conjunction with these changes, countless houses faced moisture related issues as a result. This occurred because the building became better insulated and protected from infiltration, but the HVAC system kept providing the same amount of conditioning. Because the house was tighter, the air conditioning was greater than required by the house, creating condensation on the inside of the building envelope. This moisture collected on the historic materials of the house, causing them to rot and decay. These issues were unseen by the owners because insulation and vapor barriers hid the problems behind them. The changes suggested in this study take these previous issues into consideration and create breathable, visible options for insulation and controlling condensation surfaces. After these changes have been made, the HVAC system must then account for the reduced load requirements. By modeling for energy use and testing for infiltration within the energy audit, it accounts for the house's HVAC load capacity requirements both before and after the proposed retrofitting measures. This process allows the owners to incorporate this essential phase in the plan to increase efficiency in the building. Energy auditing proves the necessity of this change and provides the sizing necessary to make an informed decision.

Air leakage and heat transmission are the largest influences on a building's efficiency. While they can seem insurmountable, a wide range of options is available for improving the building envelope of a historic structure. These changes can provide improved efficiency as well as continued protection of the historic construction and materials. The analyses of the five Charleston houses in this study show the potential for considerable energy savings through simple, but effective, retrofitting measures. The results of the energy modeling and infiltration testing provide a convincing argument for the potential of a preservation-friendly, "green" treatment of these structures.

BUILDING ANALYSES

The following are the results of the REM/Rate analysis and air leakage testing for the five structures in this study.[79] Below the study will explain the current conditions at each site, accompanied by my recommended energy improvement scheme for each building.[80] These improvements have then been combined into a single, hypothetical version of the structure in REM/Rate with the preservation-minded recommendations included. The energy savings from each recommended change have been expressed in monetary form for easier understanding. The cost of each of these retrofits will vary between cities, as will the energy savings as it is based on the local utility rates. However, the monetary expression of energy savings has been included to indicate where the greatest possibilities for energy improvements lie. By determining where the highest gains can be achieved, the retrofitting will be focused on the areas with the greatest potential for improvement. The results are as follows.

63 Smith Street

This house is a three-story Charleston single house built in 1824 by Charles Magwood.[81] It is situated on a rare double lot at 63 Smith Street downtown. The foundation and first floor are brick masonry with the other three floors being of wood frame construction. This house is unique to the sample set because it is currently vacant and is currently waiting to be renovated. It has not yet had heating and cooling systems

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[79] See Appendix A for the building file for each house entered into REM/Rate.
[80] See Appendix B for individual analysis for each retrofitting option.
[81] Poston, Jonathan. *The Buildings of Charleston*. (Columbia: University of South Carolina Press, 1997), 565.

installed, other than window units on the ground floor, making it a unique candidate for this process.

Year Built	Number of Stories	Square Footage	Glazing Area	Building Material
1824	3	5517	788	Masonry and Frame

Figure 8: Building Information for 63 Smith Street.

Figure 9: East and South Facades of 63 Smith Street. ***Photo by Author.***

Envelope Leakage

Testing envelope leakage at 63 Smith was much more difficult than expected. The blower door could not reach a standardized testing pressure and therefore, its exact envelope leakage could not be determined. This problem was caused by several factors. The house has been vacant for many years, other than a caretaker living on the ground floor. Because the upper three floors have been unoccupied, the doors and windows do not close properly. In addition, the current owners have altered the staircase to reflect its original configuration, leaving the wall cavities exposed. These two factors create an extremely leaky environment for which the blower door fan cannot compensate. The study assumed 65 percent leakage for this house, which is close to the national average for existing residential structures. This house is clearly more leaky than this figure, however, if it were currently occupied, its leakage would be much more comparable to this figure.

Possibilities for Improvement

Envelope leakage is perhaps the simplest issue to correct, while still providing a significant impact on energy efficiency. The most obvious ways to reduce leakage in this house is to repair the windows and doors to ensure that they close properly. Closing any gaping holes and cracks are the first priority for reducing infiltration. Weather stripping and caulking around the windows and doors, including access doors to attics and crawlspaces can all improve leakage.   These changes are simple and can be completed with little skill required by the average person. This also makes the changes much less expensive and therefore easily achievable. Leakage in this house could reasonably be reduced to 40 percent leakage if the proper care is taken to weatherize the openings in the building envelope. If this level were achieved, it would result in $155 savings each year.

Floor & Crawl Space

As stated earlier, this house was built with brick masonry crawl space and ground floor walls. The crawlspace is very shallow and enclosed, but vented underneath the ground floor. These conditions provide a well-protected space that is often more temperate than the exposed outside temperature.

Possibilities for Improvement

Because the ground floor and crawl are of masonry construction and the crawlspace is so protected, both should remain uninsulated. The shallow area in the crawlspace makes insulating underneath the floor extremely difficult, if not impossible. The other option for insulating the floor is removing the flooring materials and insulating underneath. This study does not recommend this action because it compromises the original wood flooring. The enclosed, vented masonry crawlspace allows for a well-shielded area that keeps the air at a more compatible temperature with the conditioned space above. Insulating it, even at an R-30 level, affords less than $100 reduction in energy costs. For this reason, my recommendation is to leave the “frame floor” uninsulated.

Walls

The interior walls of the house are all plaster on lathe construction and are original to the building. Other than the central staircase, the walls of this building remain intact. The condition of the plaster and the cavity behind it is unknown, but if possible, this feature should be retained.

Possibilities for Improvement

A model including R-13 batt insulation in the framed wall area of the house was created and resulted in a yearly savings of $442. While this savings is significant, it does not counter balance the cultural loss associated with removing the original interior finishes. This type of insulation also has the ability to hold moisture and dries slowly, creating the possibility of moisture and deterioration within the wall cavity.[82] Therefore, insulating the walls is not recommended.

Windows

This house contains a great number of windows, many of which are nearly floor-to ceiling in height. On the south façade of the building, these windows open up in a French-door fashion creating a doorway out onto the piazza.[83] These windows are original to the building and are certainly a character-defining feature of this historic house. Most of the windows elsewhere on the house are two-over-two construction and are also original to the house.

Possibilities for Improvement

The original wood, single-paned windows are in moderately good condition and with some repair, could be functional as well as more efficient. The study modeled for several window alterations, with the most improved efficiency being double paned, low-energy,

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[82] Joseph Lstiburek, *Builder's Guide to Hot, Humid Climates* (Westford: Building Science Press, 2005),158.
[83] Piazzas are covered porches common to houses in Charleston and typically extend the length of the house.

argon gas-filled, vinyl replacements. Replacing all of the house's windows with this type results in $347 in energy savings each year. This savings is one of the larger differences modeled overall for the house. However, when the model included a double-paned wood window change throughout the house, it created a $234 savings per year. If a compatible, wood-framed storm window were added to the windows, this would create the same R-value as a double paned wood window. The Preservation Brief on energy conservation states that adding a storm window to a historic window can even outperform a modern double paned replacement.[84] The *Secretary of the Interior's Standards for Rehabilitation* recommends this option for improved window efficiency and it is only about $100 less in savings per year than with the modern replacements. Fully restoring a wood window in Charleston costs around $800 to $900 per window, which involved removing the sash, repairing it, and replacing it back in the house.[85] If the window has severe rot and needs elements or wholesale replacement of materials, the cost can be considerably more.[86] It is important to consult with a local restoration contractor before determining whether restoring all of the historic windows is necessary or cost effective.[87] Because the windows are so important to the character of the house and their efficiency can be greatly improved through restoration, this study recommends that the windows be kept as they are, with the possibility of adding wood-framed storm windows if desired.

Roof and Attic Space

[84] Smith, http://www.nps.gov/history/hps/tps/briefs/brief03.htm
[85] Palmetto Craftsmen. *Telephone Interview*. 14 April, 2009.
[86] Ibid.
[87] A text such as the RSMeans Cost Data guides can also be helpful in determining the cost of these changes. One has been written specifically on the restoration of historic strcutres.

The roof is currently standing-seam metal, painted a bright red color. The gabled roof is visible from the street, which makes it important to the historic appearance of the house. The attic is mostly a finished space with two habitable rooms each with a small knee-wall area of unfinished attic accessible through small hatch doors.

Possibilities for Improvement

Many property owners have the misunderstanding that changing to roof color will help heat and cool the house, which is rarely the case.[88] Changing the roof color from a medium shade, which it currently has, to a light color only provides $12 difference in energy per year, hardly justifying the efforts required to do so. Roof work can be very dangerous, especially on a steep slant like this house has, and requires a licensed professional. This type of work is much more difficult and cannot be completed by the average resident. Meanwhile, there are other options for increasing the efficiency of the roof assembly. A radiant barrier, as described earlier, is a reflective lining that can be stapled to the underside of the roof deck or onto the rafters. In this house, it would amount to $135 in savings each year, dwarfing the improvements on the roof's exterior. This option is unobtrusive, removable and does not change the character-defining features of the house. It is also not a vapor barrier when properly vented during installation.[89]

The unfinished attic space could also be insulated and conditioned, reducing any heat gains to the space and making duct leakage in this space a non-contributing factor to

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[88] Lstiburek,158.
[89] Lstiburek,158.

envelope leakage. The *Secretary of the Interior's* Standards state that insulating the attic is one of the best measures that can be taken to improve the efficiency of a historic structure.[90] Baird Smith emphasizes this in his *Preservation Brief*, stating that insulation in the attic "should be one of the highest priorities in preservation retrofitting."[91] Not only does this action reduce heat gains dramatically, but it is also fairly simple to achieve.

This study suggests insulating the space with at an R-30 level and conditioning it, which alone will reduce energy costs by almost $500 per year. This can be done using R-30 unfaced batt insulation, which will not stop vapor diffusion, on the underside of the roof deck and inside the attic in between rafters.[92] The interior of attics in historic structures should not have vapor barriers installed because they have "unvented roof assemblies" and "these assemblies are expected to be able to 'dry' towards the interior."[93] This action should be combined with the application of R-5 rigid insulation underneath the metal roofing on the exterior. This would lift the metal roofing a few inches, but would not be apparent to from the street view. This system is effective because it controls the area where condensation occurs by mitigating the temperature range that the inside of the roof deck experiences, which does not require vapor barriers to function properly.[94] This configuration would keep air from flowing in and out of the space and would not include a vapor barrier, which would still allow vapor to enter and exit the cavity.

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[90] Weeks and Grimmer, 56-57.
[91] Smith, http://www.nps.gov/history/hps/tps/briefs/brief03.htm
[92] Lstiburek, 169. Batt insulation is termed "unfaced" when it does not have a vapor retarding material already attached.
[93] Ibid., 162.
[94] Lstiburek, 156, 158.

A sealed and conditioned attic can also be achieved by using spray-foam insulation, which seals and insulates in a single step. Both techniques require the skill of a contractor, however the first is more viable for historic structures because spray foams are permanent and are strong moisture barriers. If a leak occurs, the first option allows the property owner to find the affected area and correct it, while the spray foam is extremely difficult to remove. Overall, a sealed and conditioned attic will give high returns in energy efficiency, but should only be considered if roof work has already been planned. As stated earlier, to seal and condition an attic properly in a historic structure the roofing material will need to be taken off in order to install the rigid insulation underneath. This type of retrofitting is best done when the roof is being replaced, or other major work is being done to the roof materials.

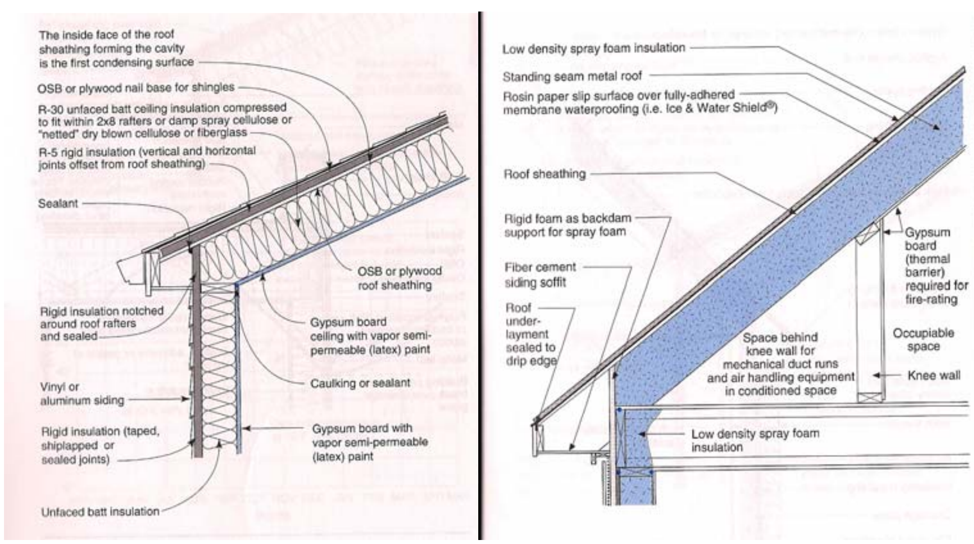

Figure 10: Left: Insulation and sealing an attic space in a preservation sensitive manner. Right: Spray foam insulation, which is not recommended for historic structures. ***Images taken from Hot Humid Climates, by Joseph Lstriburek, 167,169.***

Ducts

The duct systems followed the same protocol as the HVAC systems. They were estimated based on the suggested HVAC systems. Like the envelope leakage, the model estimated their leakage as ten percent, typical of an average existing structure in the U.S.[95]

Possibilities for Improvement

Duct leakage can be improved with little to no impact on the historic integrity of the building or its materials.[96] Duct mastic is the best sealing method for reducing duct leakage.[97] It should be painted on over a reinforcing fiber tape at joints to provide a comprehensive seal on the duct system. With this treatment, it is very likely that the ducts can reach a 4 percent leakage level.[98] This improvement would yield $138 in savings and can be completed easily by the property owner or an air conditioning professional.

HVAC and Water Heating

63 Smith Street currently has no heating or cooling systems, other than window units for the ground floor tenant. The study entered hypothetical mechanical systems in REM/Rate because they are required for the complete audit. The systems' sizes were estimated based on the area of the house for the baseline reading. While this choice was completely conjectural, it is not an unlikely change for the house because when it is

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[95] According to other building audits reviews at the Sustainability Institute files.
[96] Smith, http://www.nps.gov/history/hps/tps/briefs/brief03.htm
[97] Duct mastic is a latex sealant in liquid form than creates a durable seal on a joint. It is the best material to use for this purpose because it is "more durable, more dirt-tolerant, and tougher than duct tapes" and can provide "some of the largest and most predictable air leakage reductions." Krigger and Dorsi, 98.
[98] 1 Tradd Street had 2percent duct leakage, which exceeds this estimate.

purchased and renovated, HVAC systems will likely be added. This estimation simply provided a stepping-stone on which the system could base any increases in system efficiency.

Possibilities for Improvement

This house's site provides a great deal of possibilities for efficient heating and cooling systems. Perhaps the most efficient system possible is to use a geothermal heat pump.[99] This system requires drilling several wells in the ground, which is possible for this building due to its double lot site. This type of system would improve the estimate 14 SEER rated system and provide $260 in savings each year.[100] This is a much more complicated endeavor than more conventional systems and may not be desired by the average property owner. If a 17 SEER upgrade were used, it would result in $154 less in costs per year. Both of these are viable options and would improve efficiency in the structure.

Solar water heating is also recommended for this structure because it has a flat roof on its rear hyphen addition, making it hidden from view. A solar water heater is $323 cheaper to use than a .68 rated electric water heater, which is common for residential structures. A tankless water heating system is more common and would require less skill to install, but would yield nearly half of the savings as a solar system,

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[99] Geothermal heat pumps use the ambient ground temperature, deep below the surface to provide conditioned air. This system utilizes the mild temperature underground, which requires less energy to alter to a comfortable temperature inside the building.

[100] The Seasonal Energy Efficiency Ratio (SEER) is a rating measurement of the efficiency of air conditioning systems "based on how many BTU's of heat per hour the unit can remove from the air for each watt of power it draws. " Krigger and Dorsi, 210.

with $158 saved annually. The solar water heater is the most efficient and earth-friendly system to use for this house based on its roofline.

Overall Increases in Energy Efficiency

Combining all of the recommended changes into the house, the study created an audit of the improved building. If the property owner chose to complete all of these changes, the structure's historic materials would be protected and the energy efficiency would be improved by a cost savings of nearly $1600 per year with the geothermal heating and cooling system in place or $1300 with the use of the 17 SEER conventional heating and cooling system. These changes resulted in a six-ton reduction in HVAC load requirements for the 17 SEER system. For the geothermal system, the building passes Energy Star rating requirements.   All of these changes could be achieved without damage to the historic structure and with relatively little skill on the part of the property owner, or with the help of a local, licensed professional.

1 Tradd Street

This brick masonry and stucco house, located at the corner of Tradd and East Bay Streets downtown, is the most efficient house in the study. It is a three-story structure built circa 1800 and has been renovated several times, the first time occurring in 1927.[101] There are several factors that likely contribute to its efficiency and will be discussed below.

[101] Poston, 137.

Year Built	Number of Stories	Square Footage	Glazing Area	Building Material
1800	3	3686	701	Masonry and Stucco

Figure 11: Building Information for 1 Tradd Street.

Envelope Leakage

The current envelope leakage in this building is very low by any existing structure standards. Testing showed the house has .42 $ACH_{n,}$ or 42 percent air leakage to the outside. This is by far the lowest leakage of the audits in the study, but a building in Chasar's study had .25 $ACH_{n,}$ which is significantly lower than this house.[102] Because this building has such low envelope leakage, it is not necessary to tighten the building envelope much further. ASHRAE standards require mechanical fresh air ventilation if the house has less than .3 ACH_n. For this reason, this study only recommends achieving .35 ACH_n or greater so the property owners do not have to install more ventilation mechanisms. This can be achieved through the same techniques as stated earlier, such as caulking and weather stripping around major openings like windows, doors, and attic hatches. The energy savings is quite small since it is such a small change and only amounts to around $10 per year, so the owners may want to focus on other changes that may be more beneficial.

[102] Chasar, 8. The house in Chasar's study had been extensively altered with much of the interior wall materials removed and the original windows replaced. While the first floor of 1 Tradd was converted to a small apartment, features like the windows and other historic materials have been preserved.

Floor & Crawl Space

This building is extremely close to the Ashley River and therefore its crawlspace is prone to receive moisture, especially during harsh weather conditions. While the *Secretary of the Interior's Standards* suggests insulating the floor where it is open to the crawlspace, the environment in Charleston must be accounted for in this decision.[103] Insulation, if exposed to water, will absorb it readily and be slow to dry, holding moisture next to the building materials. Insulating the frame floor and crawl space to an R-30 level also only provides $61 in yearly energy savings. The frame floor and crawl space should remain uninsulated because of the risks associated with insulating a space so close to a large body of water and the relatively small resulting energy savings.

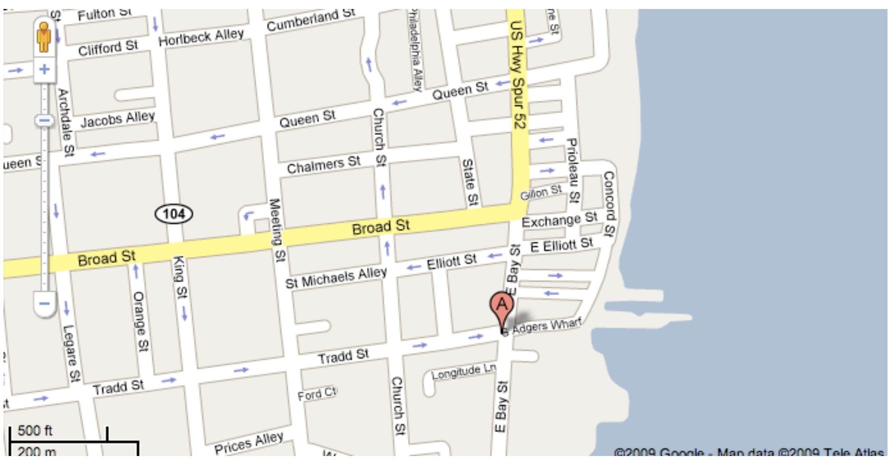

Figure 12: 1 Tradd Street can nearly be considered waterfront property. Its location makes insulating its crawl space an unsafe option for the health of the structure. *Image courtesy Google Maps.*

[103] Weeks and Grimmer, 56-57.

Walls

Insulating the walls at 1 Tradd Street is not recommended because it creates too much disturbance in the house by requiring the removal of the interior finishes. The owners occupy this house most of the year and are therefore unlikely to undergo such extensive changes. Masonry walls also provide a great deal of protection against air infiltration. The masonry exterior of this house likely contributes to its overall low leakage, but not enough houses were studied to conclusively state such a claim. In addition, insulating masonry walls is often much more difficult to achieve than insulating a frame structure.[104] Like 63 Smith Street, this study recommends keeping the walls uninsulated.

Windows

All of the windows on this house were recently restored and are all in working condition. The owners installed single-pane wooden storm windows on all of the windows except for those on the front façade, which faces East Bay Street. These storm windows provide an extra layer of glazing, without the need to replace the originals. The restoration of the original windows, in conjunction with the installation of storm windows, has seemingly had a significant impact on the low air leakage coming from the house. This building is an example of how proper maintenance can both reduce leakage and keep the original materials in good condition. This study does not recommend any

[104] Schwartz, James. "Going Green at Home" *Preservation Magazine*, March/April 2009, http://www.preservationnation.org/magazine/2009/march-april/architect-goes-green-at-home.html.

changes to the windows other than some caulking around the casings in an overall weatherization plan.

Figure 13: East Façade of 1 Tradd Street: note the operable shutters and storm windows. ***Photo by author*.**

Roof & Attic

1 Tradd's roofline is not visible from the street, but has a dark, metal, hipped roof. While the roof is not a character-defining feature of the house because it is unseen from the street, changing the roof color is not recommended because even in a light shade, only provides only $6 in annual energy savings. Insulating the attic space, as advocated by the *Secretary of Interior's Standards,* is a much better investment.

The owners at 1 Tradd complained of a warmer space on the second floor, which in the southeastern U.S is typically due to hot air infiltrating in the attic and down through the ceiling of the space below. The attic should use R-30 insulation to alleviate this discomfort and reduce the load on the HVAC system to cool this space. Like 63 Smith Street, this is most easily accomplished using unfaced batt insulation, which does not create a vapor barrier in the attic. This level of insulation reduces energy cost in this structure almost $200 per year. R-38 insulation is achievable for this space, but only provides $5 more per year in savings, not worthy of the additional efforts required to bring the attic to this higher insulation level.

In addition to insulating the space, the historic construction of this attic makes the installation of a radiant barrier quite simple and effective. Because historic attics do not have intersecting trusses like more modern construction, a radiant barrier is easily attached to the underside of the beams supporting the roof deck. A property owner with an average skill level can complete this installation, making it an ideal option.   The construction of the roof also allows for the barrier to be open at both the top and the bottom of the beams, allowing the materials to breathe, as is desirable for historic properties. This condition does not hinder the effectiveness of the barrier because it stops radiant heat, not conduction or convection, which require a continuous covering of the whole space with no breaks or openings.

Ducts

The duct systems at 1 Tradd Street are also a major reason why leakage to the outside of this house is so low. The duct leakage to the outside was extremely low for both HVAC systems in the house. The ducts systems on the first floor and the upper two floors had 1.22 percent and 2.16 percent leakage to the outside respectively. These are both extremely tight and are a representation of the goal installers should have for leakage control. This low level of leakage was the result of two conditions: the location in conditioned space and excellent installation of the ductwork.

The system that serves the first floor apartment has 100 percent of its supply located in the unconditioned crawl space, with 25 percent of the return ducts in the conditioned space. The extremely low leakage to the outside is quite unusual for a system located entirely in an unconditioned area. The third floor's duct system is also located in an unconditioned space: the attic.   Because the installer knew these were unconditioned areas, these ducts have been very well sealed and insulated.   The installer used duct mastic extensively, which was discussed earlier as the best way to seal ductwork and prevent leakage.

The second floor's duct system is located almost entirely in the conditioned area of the building, making it much less prone to leakage to the outside. For this reason, these ducts were not insulated as meticulously as the other systems were. The overall leakage of this space was greater than the systems elsewhere, but because they were placed within the conditioned space, their leakage contributes to the conditioning of the air indoors instead of the ambient air outside. There are many options for installing ductwork inside the conditioned space. This house installed them as a continuation of the rim/band joist area. This study does not advocate for any specific technique because these conditions vary from house to house; however, as much of the duct system as is possible should be placed in the conditioned area of the building. The low levels of leakage to the outside through these duct systems provide proof that this technique is successful and that levels this low *are* possible for historic structures.

HVAC and Water Heating

The mechanical cooling equipment in this house consists of two 10 SEER units, one 2.5 ton serving the first floor and one 5 ton serving the top two floors. These systems are combined with two 80 AFUE gas furnaces, sized respectively with the cooling systems.[105] These efficiency ratings are relatively low and provide room for considerable upgrades.

Possibilities for Improvement

If at the next system replacement, 14 SEER and 92 AFUE rated equipment were installed, it would result in an annual savings of $425. If 17 SEER and 94 AFUE systems were used, a $556 reduction in energy costs per year could be expected. The owners' means would determine which system they chose. However, 17 SEER and 94 AFUE systems should be used because the skill required to install either of these is the same and the savings would clearly be greater with higher efficiency system.

Even though this building has a hipped roof, its close proximity to other structures makes its roofline impossible to see from the street. For this reason, a solar water heating system is best for this house. This system reduces the annual energy costs for this house

[105] AFUE, or Annual Fuel Utilization Efficiency, provides an efficiency rating for equipment like furnaces and boilers. Krigger and Dorsi, 251.

by $400. Tankless water heating, the next most efficient option, only save the owners $30 per year. Both require installation by a professional and the great disparity in savings between these two options makes the solar system much more practical.

Overall Increases in Energy Efficiency

With all the recommended changes considered, the owners could save over $1300 per year in energy costs while still adhering the *Secretary of the Interior's Standards*. If the house were updated to this level of efficiency, it would qualify as an Energy Star rated house.

Middleton Place Plantation House Museum

The Museum House at Middleton Place Plantation is an exposed brick masonry structure, built in 1755 as the gentleman's quarters to the main house.[106]   Williams Middleton returned after the Civil War and restored the building in 1870 to become the family's primary residence.[107] The house became a museum in 1975, however for the purposes of this study, the model will treat the structure as if it is currently used as a residence, as it originally was intended.

Year Built	Number of Stories	Square Footage	Glazing Area	Building Material
1755	2	5059	1017	Masonry

Figure 14: Building Information for Middleton Place Plantation

[106] Middleton Foundation " House History," http://middletonplace.org
[107] Ibid.

Figure 15: The Middleton Place Plantation House Museum. ***Image Courtesy the Middleton Place Foundation.***

Envelope Leakage

Because the structure is currently used as a museum, testing its air infiltration was not possible. This circumstance was due to the high volume of visitors the house receives, making it difficult to close for testing. In addition, the house holds important artwork and antiques, whose environment has been carefully maintained for quite some time. In order to perform this test, the climate control systems must be turned off, which was not an option in this circumstance. Like 63 Smith, the study used an infiltration estimate of .65 ACH_n using national averages for existing structures in order to compensate for the absence of this testing in the modeling protocol.

Possibilities for Improvement

Like any other structure, a museum house can benefit from weatherization. The National Park Service, in their Preservation Brief on energy conservation, advocates for caulking and weatherstripping along with regular maintenance for windows, doors and other building seams and openings.[108] These actions ensure the proper working condition of these elements, making infiltration less likely. This study recommends a comprehensive weatherization of the structure, with care taken to keep such changes minimally invasive to the appearance of the historic features. If this is done properly, it should be relatively easy to achieve an infiltration rate of .4 ACH_n, which reduces energy cost by nearly $250 per year for this building.

Floor & Crawl Space

The museum house at Middleton Place has a small crawl space, which should not be insulated. While the house is situated at a high elevation, it is in extremely close proximity to the river and is at risk for moisture underneath the house. Like the other houses in the study, insulating the crawl space here is simply too risky given the surrounding environment.

Figure 16: The house museum, located in the upper left corner, is located extremely close to tidal river waters. ***Photo courtesy The Middleton Place Foundation*.**

[108] Smith, http://www.nps.gov/history/hps/tps/briefs/brief03.htm

Walls

The interior walls at Middleton Place have been carefully restored to their original plaster appearance. The exterior masonry walls provide a great defense against infiltration, making their insulation largely unnecessary. Furthermore, insulating masonry walls can be quite difficult to achieve without damage to the materials or disruption of interior surface finishes. This study does not recommend insulating the walls for this structure.

Windows

All of the windows at Middleton Place have been restored and are in good working condition. There are few French-door style windows, making this structure a good candidate for storm windows. The National Park Service advocates for the use of storm windows as an efficient, preservation-minded alternative to historic window replacement.[109] For this building, storm windows would save $320 per year in energy costs.

Roof and Attic Space

This house features a historic, dark slate roof in a unique intersecting cross pattern. Because the construction of the roof and attic is somewhat unusual, it makes sealing and conditioning the attic rather difficult. The attic should be insulated to a level of R-38 and a radiant barrier applied to combat heat gains into the attic and transfer of

[109] Smith, http://www.nps.gov/history/hps/tps/briefs/brief03.htm

that heat to the space below. This would also provide a less extreme environment for the ducts and HVAC systems that are currently located in the attic. The concurrent savings would amount to $470 per year for this building, making it a priority for energy retrofitting. Adding a radiant barrier to the underside of the roof deck would provide $160 in additional energy savings each year. The study highly recommends this combination for its ease of installation and the size of the subsequent savings.

Ducts

Ductwork can be insulated and sealed to reduce air leakage while protecting the historic space around them. In this house, almost all of the ductwork in the house is located in uninsulated spaces, making it extremely important to reduce leakage for this structure. This study recommends reducing duct leakage to 4 percent, which provides a $340 reduction in energy cost from the estimated 20 percent leakage currently.[110] Like attic insulation, this is an area where major efficiency increases are achievable, requiring little skill to accomplish and nearly no potential for damage to the structure.

HVAC and Water Heating

The mechanical equipment at Middleton Place has nearly reached its life expectancy and will need replacing in the near future. The current systems are outdated and thus provide ample opportunity for energy savings with little effort. A simple upgrade to a 17 SEER system amounts to nearly $940 in savings alone for this structure. Because the house is located on a former plantation and near the riverbed, it has ample

[110] This figure is average for existing structures. This study determined that this figure was likely for this system based on the level of air sealing and insulation currently present on the ducts.

space and ideal conditions to install a geothermal heat pump system. This choice would reduce energy costs by nearly $1500 per year, making it an important option to consider. While the 17 SEER upgrade is most likely to be used in this circumstance, the geothermal system should be considered as well for its overwhelming positive attributes.

Overall Increases in Energy Efficiency

The study modeled for all of the above changes with both 17 SEER and geothermal systems in the preservation-sensitive energy model of this building. The 17 SEER model provides a total annual energy savings of $2315, while the geothermal system would yield almost $2500 in savings each year. These savings provide an overwhelmingly positive impact on the environment as well as the owners' pocketbook, while still following preservation practice as laid out by the National Park Service.

84 Tradd Street

This structure can be categorized as a typical two-story Charleston single house, built in 1918. However, what appears to be an enclosed front portion of the piazzas is actually a vernacular, Victorian-era spin on the classic single house design.[111] One feature that is not original to the house is a 1970s addition in the rear. This addition was built in a much different style from the rest of the building with its walls are almost entirely composed of windows. These features have a sizeable impact on the efficiency of the building, as is described below.

[111] Poston, 281.

Year Built	Number of Stories	Square Footage	Glazing Area	Building Material
1918	2	3357	1256	Frame

Figure 17: Building Information for 84 Tradd Street.

Figure 18: 84 Tradd Street has an enclosed crawl space, which is vented away from the street. ***Photo by author.***

Envelope Leakage

Air leakage was quite high for this structure. At 1.38 ACH_n, it falls in the upper end of the structures tested.[112] The large amount of air leaking in and out of this structure greatly affects its efficiency and must be addressed. This high infiltration rate allows for a great deal of improvement to be made. The frame construction combined with a large glazing area and piazzas on both floors of the main house create an abundance of opportunities for leakage. These can be reduced significantly through a simple weatherization scheme, which can be accomplished with little skill required. Caulking

[112] 63 Smith Street was clearly more leaky, but a testing pressure could not be reached and therefore cannot specifically be compared.

around window casings and door frames and weather stripping doors and access hatches can greatly improve the air leakage, while still maintaining the health and appearance of historic materials in a structure like this. If proper care was taken to ensure that these openings are better sealed, energy cost could be reduced $330 per year, even at a .4 ACH_n level, providing more than enough natural ventilation than the ASHRAE requirements.

Floor & Crawl Space

This building has a considerable crawl space of about 4' under the house. It is enclosed and vented, but the vents are several feet above the ground level. The house is near the Ashley River, but is not as prone to flooding as much as other areas on the Charleston peninsula. The elevated vents and height of the bottom floor above the ground makes this house a good candidate for insulation.

Possibilities for Improvement

It is possible to insulate the building envelope underneath the bottom floor of the house, without damage to its original flooring. Because the crawl space is so easily accessible, it can be insulated fairly easily, however the savings from this alone are not astonishing. My analysis showed a $65 decrease in energy consumption per year if the bottom floor was insulated to R-30. This is still significant given the ease of installing insulation in this area of the house. The property owner would have to decide if they felt past flooding in the area, if any, permitted such a change.

Walls

The walls of this house have original plasterwork and have been recently been painted. As indicated with other houses in this study, insulating wall cavities is extremely disruptive to the house and should really only be undertaken when a house must be reduced to its studs in conditions that demand such a dramatic change. If the frame walls were insulated to an R-19 level, it would amount to saving approximately $350 each year. This is a considerable savings, but the difficulty and loss of historic material must be weighed as well. Reducing infiltration, perhaps the simplest means of increasing efficiency in the house accounts for $330 per year in energy savings. The time and expertise alone required to remove all of the walls, install insulation, replace the wall coverings, and reapply finishes is no comparison to weatherization. For this reason, this study does not recommend insulating the wall cavities at 84 Tradd, despite their influence on the efficiency of the house.

Windows

The windows at 84 Tradd, collectively including those on the addition and the early twentieth century building, play a more significant role in this structure than the others in the study. The original wood, single-pane windows on the main house are numerous, but in no way comparable to those found on the addition. The 1970s addition has floor to ceiling, curtain-walls of windows on both floors that wrap continuously around the envelope. The space in between floors and at the ceiling is the only solid wall space on its exterior walls. These windows are double paned, metal-framed windows, some which have been replaced in-kind several times due to failure. These conditions pose special circumstances that while they are unique to this study, are not uncommon in preservation elsewhere in the United States.

The windows themselves are not necessarily the biggest issue, but their frequency and placement within the design of the structure causes the biggest impact. The 1970s addition has not yet reached a “historic” age of fifty years or older, but falls into a broadening category of recent architectural history, whose fate has been debated more often in recent years. Until this addition’s importance has been determined in the greater context, mediatory measures should be taken to increase the efficiency of the structure without removing these windows, which could become historic in the near future. For both window types, storm windows with similar construction and materials should be used. These will provide an extra layer of defense for the building against infiltration, while still adhering to the guidelines set forth by the National Park Service and the *Secretary of the Interior’s Standards for Rehabilitation*. Adding storm windows would provide over $400 in annual energy savings without removing the windows, historic or otherwise, or changing them from their original appearance or configuration. To combat radiant heat, as is a significant problem with the windows on the addition, more shade trees should be planted, which is an extremely sustainable practice.[113] The overhangs of the piazzas shade most of the windows on the main house, making them less of a contributor to radiant heat gains in the southern climate.

[113] Interior shading is also an important technique for combating radiant heat gains, however the owners of 84 Tradd have already installed blinds and curtains.

Roof and Attic Space

Much of the attic has been finished and conditioned, adding to the livable area of the house. This does not leave as many options for improvement in this area of the house, as has been available for other structures in this study. The application of a radiant barrier and insulation in the unconditioned knee wall areas in the attic together provide significant savings, nearly $150 per year, with little effort required. As described in detail earlier, the property owner can complete installation of batt insulation and a radiant barrier in attic space with relative ease. These changes provide a greater efficiency at the roof area, decreasing load requirements for HVAC systems and thus, even more energy savings.

Ducts

The duct leakage at 84 Tradd tested with 17 percent of their conditioned area leaking to the outside of the building. This is about average for existing houses, regardless of whether they are historic or not. As in the other houses in this study, improving this factor can increase the house's efficiency without compromising its historic integrity. This study suggests a comprehensive regime of sealing the joints with duct mastic and insulating around them. Using ductless HVAC systems is also a way to decrease leakage, as is discussed below.

HVAC and Water Heating

The load requirements on this structure are extremely high because of infiltration and the large glazing area present. With the other reductions in leakage and heat gains, the load requirements will decrease, demanding a sizing change in order to ensure the safety of the building against moisture damage. The HVAC systems in this building are nearing the age of replacement, making it an opportune time to complete these energy retrofits followed by a more efficient system installation.

Possibilities for Improvement

There are two main options for HVAC improvements in this house: adding more ductless systems or an upgrade to higher efficiency, ducted system. The addition to the house already features ductless mini-splits, which heat and cool the area without intrusion from duct systems and are relatively unobtrusive due to their small size. These systems can be used elsewhere in the house if the owner chooses, making the improvements to the duct systems unnecessary. However, these systems are already in place and are in relatively good working order and would not need very extensive improvements. The second option follows the same path as the efficiency increases in the other structures studies. Like 63 Smith, a geothermal system may be possible on the site because it has a decent backyard area where wells could be installed. A geothermal system would certainly be the “best case scenario” and would save almost $850 a year in energy costs if it were deemed achievable for this site by an accredited professional. Efficiency upgrades to a similar system with either a 14 or 17 SEER rating would create a much smaller, but still significant savings of about $250 per year for either system. This change would be much simpler, but the more difficult option would provide over $600 per year more in energy savings. Both of these options have their positive and negative attributes and the choice would greatly depend on the attitudes of the property owners.

Solar water heating could easily be installed on the flat roof of the addition, without risking any obstruction of the historic view of the house. This change would provide over $280 in savings each year. A tankless system is also practical, but yields significantly less savings, at $82 per year.

Overall Increases Energy Efficiency

Using all of my recommended energy retrofits in one building file, the study created a preservation-friendly energy model for the house. When the all of the suggested retrofits were modeled with the 14 SEER upgrade, it returned an overall annual energy savings of almost $1,200 and reduced the heating and cooling load by four tons. The model with geothermal provided $1,640 in savings per year, with 1 ton less in HVAC loads requirements. The geothermal model would also bring the house up to meet Energy Star efficiency requirements, without straying from proper preservation practice.

8 New Street

The frame structure at 8 New Street was built in 1870 and marks a significant departure from the traditional Charleston single house construction. It features two porches, but they are located on the first and second floors of the front of the house, instead of the side as is typically seen in single house construction. It also features several cantilevered windows, which make it unique to this study. The house is currently being renovated, putting it in an excellent position to take advantage of proper air sealing and HVAC system sizing in a historic structure. This condition has made the house difficult to test as well.

Year Built	Number of Stories	Square Footage	Glazing Area	Building Material
1870	2	3706	1069	Frame

Figure 19: Building Information for 8 New Street.

Envelope Leakage

Because this structure has been under renovation, its envelope leakage could not be accurately determined. Like 63 Smith, the blower door was not able to reach a testing pressure, but this was largely due to exposed wall cavities in certain areas and other conditions inherent to rehabilitation projects.

Floor & Crawl Space

Like the other houses in the study, 8 New is located in close proximity to water and flooding must be considered for this change. Like 84 Tradd, 8 New has a significantly large crawl space, making ample room to insulate under the floor system. This study recommends keeping the space uninsulated due to the risk of flooding and the insulation holding moisture against the floor system. However, the owners can determine what is best for this house based on the history of flooding in the crawl space.

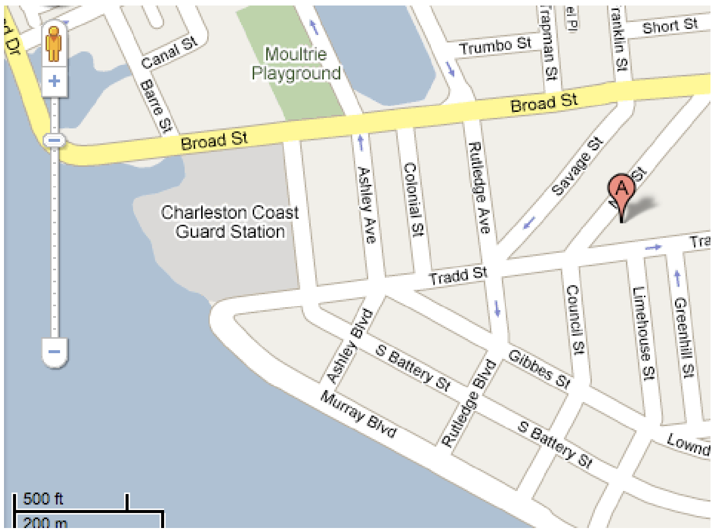

Figure 20: The house at 8 New Street is located extremely close to the Ashley River, making a sealed and conditioned crawl space unlikely. *Image courtesy Google Maps.*

Walls

Several areas in the house feature original plaster walls, while some walls have been replaced with drywall traditional for more modern construction. The current owners want to keep as much of the historic plaster walls as are possible, but existing moisture problems behind some of the walls require its removal. Before these areas are treated and replaced with new plaster, they intend to insulate the wall cavity. In this instance, this study recommends this action because the finishes must be removed anyway and it provides some vital insulation possibilities in a frame structure, which is especially prone to leakage. However, the model cannot determine the energy savings for such a change until the owners determine the amount of insulation to install.

Windows

Nearly all of the windows in this building are original and are single pane, wood construction, but two are double pane, vinyl replacements. Storm windows are certainly an option for this house, as has been for the other houses in this study; however, like 63 Smith, this house has several floor to ceiling windows that function more like doors, opening out onto the front porches. These make storm windows difficult to use in their original fashion; instead, this study recommends using compatible wood-framed storm windows on the other facades of the house where this application is more practical. This change provides $344 in annual energy savings for the house.

Figure 21: The French-door style windows combined with the shade of its porches once provided much-needed ventilation in its hot climate. *Photo by author.*

Roof and Attic Space

This study recommends using a radiant barrier and insulating the attic space to a level of R-30, which combined reduces energy cost by $400 per year. Because this house has a hipped roof construction, sealing and conditioning it can be much more difficult. Because this study does not recommend spray foam insulation, which provides the best air sealing with less skill required, even a professional installer would be likely to leave places uncovered. Improper air sealing and insulation in an attic greatly reduces its effectiveness and can open the space up to moisture problems.

Ducts

The duct systems are being replaced as part of the house's renovations. The duct systems could not be tested; however, the owners should require the contractor to guarantee at a 4 percent leakage rate for the new system. This level was included in the "likely" and "best" case modeling for this structure.

HVAC and Water Heating

Along with the ductwork, the owners were also replacing the heating and cooling systems in the house. The existing system included two 12 SEER air conditioners and an 80 AFUE gas furnace. These should be replaced using 17 SEER and 94 AFUE equipment, both are modern higher-efficiency versions of the same systems. This upgrade would save the owners nearly $700 annually in energy costs. Geothermal is not an option for this structure because the lot is too small for the wells.

The water heating system could also be upgraded, as it currently uses two pieces of equipment with 43 and 50-gallon capacities respectively. These two systems are fairly efficient with 91 and 94 percent efficiency ratings for each. When the owners do decide to replace these systems, they should install a tankless system, which would reduce energy cost at the house about $40 per year. This figure is not very large because the efficiency of the current systems is fairly high. The roofline at 8 New does not allow for a conspicuous addition of solar water heating, therefore this study does not recommend it for this historic structure.

Overall Increases Energy Efficiency

The combined effect of all of the recommended changes resulted in nearly $1300 in savings each year. These include all of the insulation and weatherization, as well as upgrading the mechanical equipment to a 17 SEER air conditioner, 94 AFUE furnaces, and tankless water heating.

The analyses of all of the houses in this study show the significant impact preservation-friendly retrofitting can have on annual energy costs. This study's recommendations are tailored to a hot, humid climate and specifically to the unique conditions at each structure. However, these structures have shown to be capable of higher levels of efficiency, comparable to national averages for existing buildings. Because these structures have the ability to reach these levels without damaging their original, historic fabric, other buildings around the nation and the world can achieve this feat as well.

Conclusions

Historic structures have always been sustainable; however, this has not always been the way they have been viewed. In order to change perceptions about the inefficiency of historic buildings, they should be tested using energy audits. This study performed audits on five historic structures in Charleston, South Carolina in order to determine how historic structures perform in comparison to other existing structures and to understand how they could improve their efficiencies without damaging their historic fabric. The results of these audits showed that historic structures are easily capable of reaching efficiencies on par or greater than the average existing building in the U.S.

All of the buildings studied showed the possibility for significant energy savings each year without jeopardizing the historic materials or assemblies in the house. All of the recommendations made in the study followed the principles set forth by the *Secretary of the Interior's Standards for Rehabilitation* and could be completed with fairly little disruption to the site. When all of these recommendations were combined, the savings was well over $1000 per year for each house in the study. In fact, the annual energy savings from employing preservation-friendly retrofitting ranged from $1300 to $2200 for the buildings studied. Two structures qualified for an Energy Star rating with only the use of preservation- based recommendations on the house. These changes involved anything from basic batt insulation to upgrading the efficiency of the heating and cooling equipment when necessary. Although the recommendations were slightly different for each house based on their unique conditions, none required the removal of historic fabric.

Furthermore, great care was taken to understand retrofitting assemblies that did not pose a threat for moisture or other damage to these materials. This primary consideration formed the basis for the building analyses in the study.

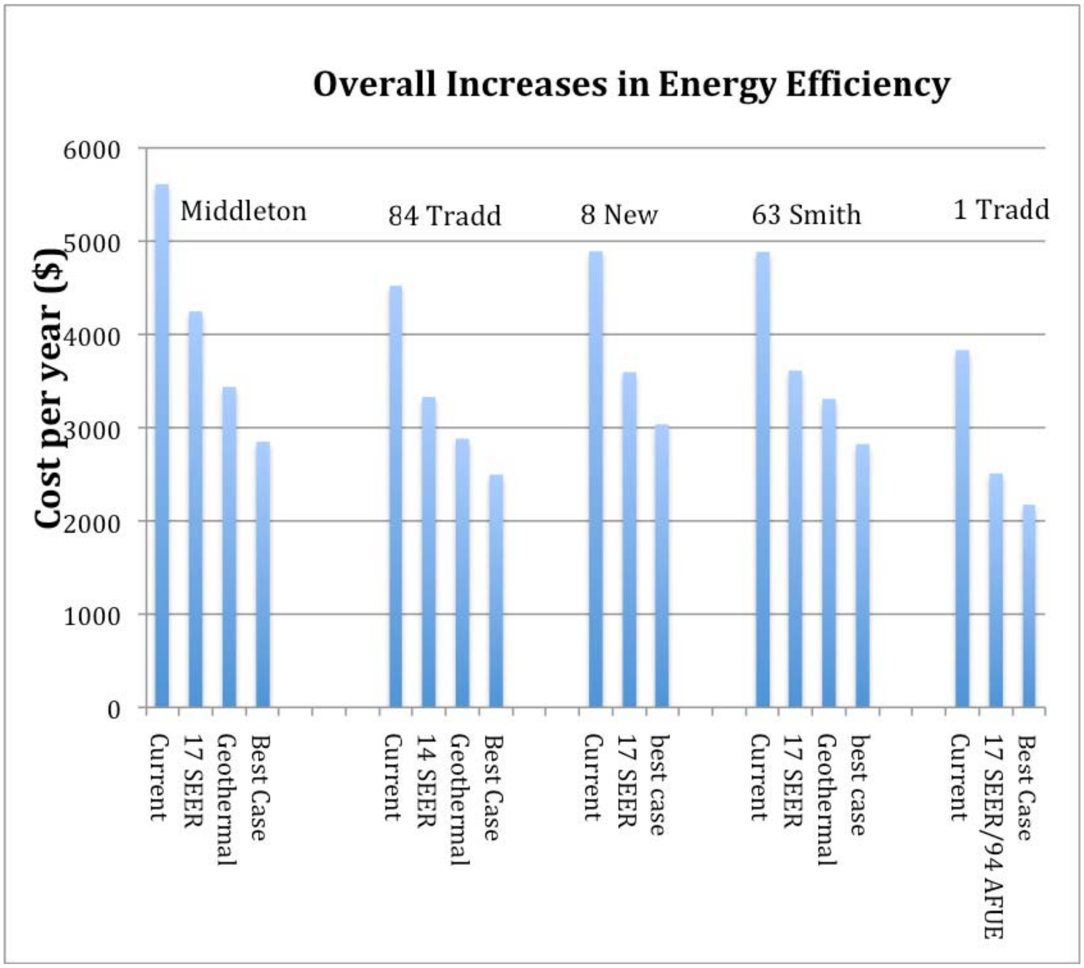

Figure 22: Energy costs for all of the houses in the study. "Best Case" refers to the changes that reduce costs the most, regardless of preservation. Those labeled for their mechanical systems reflect preservation-friendly practice.

The materials and assemblies in historic structures are inherently sustainable because they have stayed durable over decades and even centuries. The cost of materials and energy used to create, transport and install them into the structure, also known as embodied energy, has withstood a much longer lifetime than my modern materials can ever aspire to do. For this reason, these materials should have the utmost respect in any rehabilitation project, especially one that seeks to be sustainable. By combining the retrofits suggested in this study with the already sustainable aspects of historic construction, these buildings can be brought to the forefront of the modern sustainability movement.

This study has shown how simple it can be to create a historic building that both maintains its integrity and improves upon its sustainable architecture. Energy auditing of historic structures should be more widespread in the United States in order to increase the positive effects of this system. English Heritage has established a well-researched and thorough system for testing existing structures and implementing retrofitting measures. This system has created an environment where historic structures are not only being protected, but improved upon to meet modern requirements for efficiency. If this type of system is carried out successfully, preservation is able to gain momentum and hold an even stronger place in the built environment. Historic structures will not only be better preserved by educating and mandating good preservation practice nationwide, but will also be more desirable to the public for use and reuse if their efficiencies are competitive with other existing structures.

Testing historic structures for energy efficiency is an important tool for employing good preservation practice. Through this study, historic structures have been shown to be sustainable, both for their existing materials and assemblies, as well as for the ease with which they can be updated for increased efficiency. Historic structures can and have achieved levels of efficiency comparable to modern existing structures. Preservation and sustainability can be synonymous if only their stories are told.

Areas for Further Research

There are certainly areas where the ideas presented in this thesis can be further researched. Cost analysis is a major component to energy retrofitting that is vital to decision-making for a property owner. This area varies over time and place and should take into account current inflation, travel costs, and environmental impact; it should also be tailored to fit the geographical area under study. Another study could be done on the best types of materials to use when retrofitting, such as insulation, storm windows, and caulking whose material characteristics are most compatible with historic materials. Questions were also raised in this thesis pertaining to the influence of energy auditing on a national scale as seen in the U.K. A study could be done on the current level of energy auditing in the U.S and determine the effects of expanding this activity on the national level. The U.K also provides grants to help pay for auditing and retrofitting; this area could be explored in the context of the United States. Finally, a follow-up study would be extremely beneficial to the findings of this thesis by employing the retrofitting recommendations offered here and testing the house again to determine actual versus projected energy improvements.

APPENDIX A

Baseline Building Files

63 SMITH STREET

BUILDING FILE REPORT

File Name: 63 Smith Baseline.blg — Date: March 10, 2009

Property/Builder:		**Rating**	
Building Name:	Baseline	Org. Name:	The Sustainability Institute
Owner's Name:	Historic Charleston Foundation	Address:	E. Montague Ave
Property Address:	63 Smith Street	City, St, Zip:	North Charleston, SC
City, St, Zip:	Charleston, SC 29403	Phone No:	
Phone No:		Website:	sustainabilityinstitutesc.org
		Rater's Name:	Benjamin Leigh
Builder's Name:		Rater's No.:	
Phone No:		Rater's Email:	ben@sustainabilityinstitutesc.
Email Address:			
Model:		Rating Date:	
Development:		Rating Type:	
		Reason:	
		Rating No.:	

General Building Information	
Area of Cond. Space(sq ft):	5517
Volume of Cond. Space:	49021
Year Built:	1824
Housing Type:	Single-family detached
Level Type(Apartments Only):	None
Floors on or Above-Grade:	3+
Number of Bedrooms:	7
Foundation Type:	Enclosed crawl space
Enclosed Crawl Space Type:	Vented

Foundation Wall Info:	1		
Name	Foundation		
Library Type	Uninsulated		
Length(ft)	194.0		
Total Height(ft)	2.0		
Depth Below Grade(ft)	1.0		
Height Above Grade(ft)	1.0		
Location	Enclsd crwl->amb/grnd		
Uo Value	0.503		

Foundation Wall: Uninsulated

Type:	Solid concrete or stone
Thickness(in):	8.0
Studs:	None
Interior Insulation:	
Continuous R-Value:	0.0
Frame Cavity R-Value:	0.0
Cavity Insulation Grade:	3.0
Ins top:	0.0 ft from top of wall
Ins Bottom:	0.0 ft from bottom of wall
Exterior Insulation:	
R-Value:	0.0
Ins top:	0.0 ft from top of wall
Ins bottom:	0.0 ft below grade
Note:	

Frame Floor Info:	1
Name	First Floor
Library Type	Uninsulated
Area (sq ft)	1347
Location	Btwn cond & enclsd crwl
Uo Value	0.257

Frame Floor: Uninsulated

Information From Quick Fill Screen:

Continous Insulation R-Value	0.0
Cavity Insulation R-Value	0.0
Cavity Insulation Thickness (in.)	0.0
Cavity Insulation Grade	3.0
Joist Size (w x h, in)	1.5 x 9.5
Joist Spacing (in oc)	16.0
Framing Factor - (default)	0.1300
Floor Covering	CARPET

Note:

Layers	Paths		
	Cavity	Framing	Grade
Inside Air Film	0.920	0.920	0.920
Floor covering	1.230	1.230	1.230
Subfloor	0.820	0.820	0.820
Cavity ins	0.000	0.000	0.000
Continuous ins	0.000	0.000	0.000
Framing	0.000	0.000	0.000
	0.000	0.000	0.000
Outside Air Film	0.920	0.920	0.920
Total R-Value	3.890	3.890	3.890
U-Value	0.257	0.257	0.257
Relative Area	0.820	0.130	0.050
UA	0.211	0.033	0.013

Total Component UA: 0.257

Total Component Area: 1.0

Component Uo: 0.257

Rim and Band Joist:	1	2	3
Name	1st Floor Band	2nd Floor	Attic
Area(sq ft)	194.0	194.0	44.0
Continuous Ins	0.0	0.0	0.0
Framed Cavity Ins	0.0	0.0	0.0
Cavity Ins Thk(in)	0.0	0.0	0.0
Joist Spacing	16.0	16.0	16.0
Location	Enclsd crwl -> ambient	Cond -> ambient	Cond -> ambient
Uo Value	0.267	0.267	0.267

Above-Grade Wall:	1	2	3
Name	Front 1st floor	Front upper	Left 1st floor
Library Type	Double Brick	Uninsulated Stud	Double Brick
Gross Area(sq ft)	242.00	473.00	801.00
Exterior Color	Medium	Light	Medium
Location	Cond -> ambient	Cond -> ambient	Cond -> ambient
Uo Value	0.201	0.267	0.201

Above-Grade Wall:	4	5	6
Name	Left upper	Right 1st floor	Right upper
Library Type	Uninsulated Stud	Double Brick	Uninsulated Stud
Gross Area(sq ft)	1638.70	895.20	1603.80
Exterior Color	Light	Medium	Light
Location	Cond -> ambient	Cond -> ambient	Cond -> ambient
Uo Value	0.267	0.201	0.267

Above-Grade Wall:	7	8	9
Name	Back 1st floor	Back upper	Knee Walls
Library Type	Double Brick	Uninsulated Stud	Uninsulated Stud
Gross Area(sq ft)	154.00	605.00	308.00
Exterior Color	Medium	Light	Dark
Location	Cond -> ambient	Cond -> ambient	Cond -> attic
Uo Value	0.201	0.267	0.267

Above-Grade Wall: Double Brick

Information From Quick Fill Screen:

Double Brick

Continuous Insulation (R-Value)	0.0
Frame Cavity Insulation (R-Value)	0.0
Frame Cavity Insulation Thickness (in)	0.0
Frame Cavity Insulation Grade	3
Stud Size (w x d, in)	1.5 x 3.5
Stud Spacing (in o.c.)	16.0
Framing Factor - (default)	0.2300
Gypsum Thickness (in)	0.5

Note:

Layers	Paths Cavity
Inside Air Film	0.680
Gyp board	0.450
Continuous ins	0.000
Brick	1.350
Air Gap	0.970
Brick	1.350
	0.000
Outside Air Film	0.170
Total R-Value	4.970
U-Value	0.201
Relative Area	0.950
UA	0.191

Total Component UA: 0.191

Total Component Area: 0.9

Component Uo: 0.201

Above-Grade Wall: Uninsulated Stud

Information From Quick Fill Screen:

Standard Wood Frame

Continuous Insulation (R-Value)	0.0
Frame Cavity Insulation (R-Value)	0.0
Frame Cavity Insulation Thickness (in)	0.0
Frame Cavity Insulation Grade	3
Stud Size (w x d, in)	1.5 x 3.5
Stud Spacing (in o.c.)	16.0
Framing Factor - (default)	0.2300
Gypsum Thickness (in)	0.5

Note: No insulation between studs

Layers	Paths		
	Cavity	Framing	Grade
Inside Air Film	0.680	0.680	0.680
Gyp board	0.450	0.450	0.450
Air Gap/Frm	1.030	4.375	1.030
Cavity ins/Frm	0.000	0.000	1.030
Continuous ins	0.000	0.000	0.000
Ext Finish	0.940	0.940	0.940
	0.000	0.000	0.000
Outside Air Film	0.170	0.170	0.170
Total R-Value	3.270	6.615	4.300
U-Value	0.306	0.151	0.233
Relative Area	0.720	0.230	0.050
UA	0.220	0.035	0.012

Total Component UA: 0.267

Total Component Area: 1.0

Component Uo: 0.267

Window Information:	1	2	3
Name	Front 2-3 floors	Front 4th floor	Front 1st floor
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	57.50	11.25	30.00
Orientation	South	South	South
Overhang Depth	0.0	2.0	0.0
Overhang To Top	0.0	0.0	0.0
Overhang To Bottom	0.0	4.5	0.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 2	AGWall 2	AGWall 1

Window Information:	4	5	6
Name	Left 1st Floor	Left 2-3 floors	Left 4th floor
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	95.00	222.00	35.70
Orientation	West	West	West
Overhang Depth	9.5	9.5	0.0
Overhang To Top	3.0	3.0	0.0
Overhang To Bottom	7.0	9.0	0.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 3	AGWall 4	AGWall 4

Window Information:	7	8	9
Name	Back 1st Floor	Back 2-3 floors	Right 1st floor
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	17.50	43.50	88.50
Orientation	North	North	East
Overhang Depth	9.5	9.5	0.0
Overhang To Top	3.0	3.0	0.0
Overhang To Bottom	10.0	10.0	0.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 7	AGWall 7	AGWall 5

Window Information:	10		
Name	Right 2-3 floors		
Library Type	Single - Wood		
U-Value	0.900		
SHGC	0.650		
Area(sq ft)	187.50		
Orientation	East		
Overhang Depth	0.0		
Overhang To Top	0.0		
Overhang To Bottom	0.0		
Interior Winter Shading	0.85		
Interior Summer Shading	0.70		
Adjacent Winter Shading	None		
Adjacent Summer Shading	None		
Wall Assignment	AGWall 6		

Window: Single - Wood

U-Value:	0.900
Solar Heat Gain Coefficient:	0.650
Note:	

Door Information:	1	2	3
Name	Right 1st floor	Back 1st floor	Back 2nd floor
Opaque Area(sq ft)	20.0	37.7	6.0
Library Type	1-3/4 Wd solid core	1-3/4 Wd solid core	1-3/4 Wd solid core
Wall Assignment	AGWall 5	AGWall 7	AGWall 8
Uo Value	0.329	0.329	0.329

Door Information:	4	5	6
Name	Left 1st floor	Left 2-3 floors	Knee Wall Doors
Opaque Area(sq ft)	36.0	105.0	70.0
Library Type	1-3/4 Wd solid core	1-3/4 Wd solid core	Plywood
Wall Assignment	AGWall 3	AGWall 4	AGWall 9
Uo Value	0.329	0.329	0.697

Door: 1-3/4 Wd solid core	
R-Value of Opaque Area:	2.1
Storm Door:	No
Note:	

Door: Plywood	
R-Value of Opaque Area:	0.5
Storm Door:	No
Note:	This is typical of a knee wall access door.

Roof Information:	1	2	
Name	Attic	Addition	
Library Type	Uninsulated Vaulted	Uninsulated Ceiling	
Gross Area(sq ft)	816.00	350.00	
Color	Medium	Medium	
Radiant Barrier	No	No	
Type(Attic)	Vaulted	Attic	
Uo Value	0.391	0.599	

Ceiling: Uninsulated Vaulted

Information From Quick Fill Screen:

Continous Insulation (R-Value)	0.0
Cavity Insulation (R-Value)	0.0
Cavity Insulation Thickness (in)	0.0
Cavity Insulation Grade	3.0
Gypsum Thickness (in)	0.500
Bottom Chord/Rafter Size(w x h, in)	1.5 x 3.5
Bottom Chord/Rafter Spacing (in o.c.)	24.0
Framing Factor - (default)	0.1100
Ceiling Type	Vaulted

Note: No insulation in the attic

Layers	Paths		
	Framing	Cavity	Grade
Inside Air Film	0.610	0.610	0.610
Gyp board	0.450	0.450	0.450
Cavity Ins/Frm	0.000	0.000	0.000
Continuous ins	0.000	0.000	0.000
Plywood	0.930	0.930	0.930
Shingles	0.400	0.400	0.400
	0.000	0.000	0.000
Outside Air Film	0.170	0.170	0.170
Total R-Value	2.560	2.560	2.560
U-Value	0.391	0.391	0.391
Relative Area	0.110	0.840	0.050
UA	0.043	0.328	0.020

Total Component UA: 0.391

Total Component Area: 1.0

Component Uo: 0.391

Ceiling: Uninsulated Ceiling

Information From Quick Fill Screen:

Continous Insulation (R-Value)	0.0
Cavity Insulation (R-Value)	0.0
Cavity Insulation Thickness (in)	0.0
Cavity Insulation Grade	3.0
Gypsum Thickness (in)	0.500
Bottom Chord/Rafter Size(w x h, in)	1.5 x 3.5
Bottom Chord/Rafter Spacing (in o.c.)	24.0
Framing Factor - (default)	0.1100
Ceiling Type	Attic

Note: No insulation in the attic

Layers	Paths		
	Framing	Cavity	Grade
Inside Air Film	0.610	0.610	0.610
Gyp board	0.450	0.450	0.450
Cavity Ins/Frm	0.000	0.000	0.000
Continuous ins	0.000	0.000	0.000
	0.000	0.000	0.000
	0.000	0.000	0.000
	0.000	0.000	0.000
Outside Air Film	0.610	0.610	0.610
Total R-Value	1.670	1.670	1.670
U-Value	0.599	0.599	0.599
Relative Area	0.110	0.840	0.050
UA	0.066	0.503	0.030

Total Component UA: 0.599

Total Component Area: 1.0

Component Uo: 0.599

Mechanical Equipment: General

Number of Mechanical Systems:	6
Heating SetPoint(F):	68.00
Heating Setback Thermostat:	Present
Cooling SetPoint(F):	78.00
Cooling Setup Thermostat:	Present

ASHP: 60k 14seer 8.5hspf

Fuel Type:	Electric
Heating Seasonal Efficiency:	8.50 HSPF
Compressor Heating Output Capacity (kBtuh):	60.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	60.0
Cooling Seasonal Efficiency:	14.00 SEER
Desuperheater:	No
Note:	
Location:	Conditioned area
Performance Adjustment:	100
% Heating Load Served:	25
% Cooling Load Served:	25
Number Of Units:	1

ASHP: 60k 14seer 8.5hspf

Fuel Type:	Electric
Heating Seasonal Efficiency:	8.50 HSPF
Compressor Heating Output Capacity (kBtuh):	60.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	60.0
Cooling Seasonal Efficiency:	14.00 SEER
Desuperheater:	No
Note:	
Location:	Conditioned area
Performance Adjustment:	100
% Heating Load Served:	25
% Cooling Load Served:	25
Number Of Units:	1

ASHP: 60k 14seer 8.5hspf

Fuel Type:	Electric
Heating Seasonal Efficiency:	8.50 HSPF
Compressor Heating Output Capacity (kBtuh):	60.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	60.0
Cooling Seasonal Efficiency:	14.00 SEER
Desuperheater:	No
Note:	
Location:	Attic
Performance Adjustment:	100
% Heating Load Served:	25
% Cooling Load Served:	25
Number Of Units:	1

ASHP: 60k 14seer 8.5hspf

Fuel Type:	Electric
Heating Seasonal Efficiency:	8.50 HSPF
Compressor Heating Output Capacity (kBtuh):	60.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	60.0
Cooling Seasonal Efficiency:	14.00 SEER
Desuperheater:	No
Note:	
Location:	Attic
Performance Adjustment:	100
% Heating Load Served:	25
% Cooling Load Served:	25
Number Of Units:	1

Water Heating Equipment: 50 gal. 0.54EF Gas	
Water Heater Type:	Conventional
Fuel Type:	Natural gas
Energy Factor:	0.54
Recovery Efficiency:	0.76
Water Tank Size (gallons):	50
Extra Tank Insulation (R-Value):	0.0
Note:	
Location:	Conditioned area
Percent Load Served:	50
Performance Adjustment:	100
Number Of Units:	1

Water Heating Equipment: 50 gal. 0.54EF Gas	
Water Heater Type:	Conventional
Fuel Type:	Natural gas
Energy Factor:	0.54
Recovery Efficiency:	0.76
Water Tank Size (gallons):	50
Extra Tank Insulation (R-Value):	0.0
Note:	
Location:	Conditioned area
Percent Load Served:	50
Performance Adjustment:	100
Number Of Units:	1

Duct System Information:	
Name	1st floor
Heating System	60k 14seer 8.5hspf
Cooling System	60k 14seer 8.5hspf
Supply Area(sq ft)	304.7
Return Area(sq ft)	56.4
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	269.70 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	
Type	Supply	Return	
Percent Area	100.0	100.0	
R-Value	0.0	0.0	
Location	Conditioned space	Conditioned space	

Duct System Information:	
Name	2nd floor
Heating System	60k 14seer 8.5hspf
Cooling System	60k 14seer 8.5hspf
Supply Area(sq ft)	304.7
Return Area(sq ft)	56.4
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	347.80 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	
Type	Supply	Return	
Percent Area	100.0	100.0	
R-Value	0.0	0.0	
Location	Conditioned space	Conditioned space	

Duct System Information:	
Name	3rd Floor
Heating System	60k 14seer 8.5hspf
Cooling System	60k 14seer 8.5hspf
Supply Area(sq ft)	304.7
Return Area(sq ft)	56.4
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	347.80 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	
Type	Supply	Return	
Percent Area	100.0	100.0	
R-Value	0.0	0.0	
Location	Attic, exposed	Attic, exposed	

Duct System Information:

Name	4th Floor
Heating System	60k 14seer 8.5hspf
Cooling System	60k 14seer 8.5hspf
Supply Area(sq ft)	203.1
Return Area(sq ft)	37.6
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	138.20 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	
Type	Supply	Return	
Percent Area	100.0	100.0	
R-Value	0.0	0.0	
Location	Attic, exposed	Attic, exposed	

Infiltration and Mechanical Ventilation

Whole House Infiltration

Measurement Type:	Blower door test
Heating Season Infiltration Value:	0.65 Natural ACH
Cooling Season Infiltration Value:	0.65 Natural ACH

Mechanical Ventilation for IAQ

Type:	None
Rate(cfm):	0
Sensible Recovery Efficiency(%):	0.00
Total Recovery Efficiency(%):	0.00
Hours per Day:	24.00
Fan Power (watts):	0.00

Ventilation Strategy for Cooling

Cooling Season Ventilation:	Natural Ventilation

Lights and Appliances

Simplified Audit	
Oven/Range Fuel Type:	Natural gas
Clothes Dryer Fuel Type:	Natural gas
Percent Fluorescent - Pin-Based:	10.00
Percent Fluorescent - CFL:	0.00
Refrigerator KWh:	775

Lights and Appliances

Dishwasher EF:	0.46
Ceiling Fan CFM / Watt:	0.00

Notes

assumed enclosed vented crawl

assumed conditioned

1 TRADD STREET

BUILDING FILE REPORT

File Name: 1 Tradd St. baseline.blg

Date: March 10, 2009

Property/Builder:		Rating	
Building Name:	Baseline	Org. Name:	The Sustainability Institute
Owner's Name:	Harriet Williams	Address:	E. Montague Ave
Property Address:	1 Tradd Street	City, St, Zip:	North Charleston, SC
City, St, Zip:	Charleston, SC 29403	Phone No:	
Phone No:		Website:	sustainabilityinstitutesc.org
		Rater's Name:	Benjamin Leigh
Builder's Name:		Rater's No.:	
Phone No:		Rater's Email:	ben@sustainabilityinstitutesc.
Email Address:			
Model:		Rating Date:	2.10.09
Development:		Rating Type:	
		Reason:	
		Rating No.:	

General Building Information	
Area of Cond. Space(sq ft):	3686
Volume of Cond. Space:	32693
Year Built:	1800
Housing Type:	Single-family detached
Level Type(Apartments Only):	None
Floors on or Above-Grade:	3+
Number of Bedrooms:	5
Foundation Type:	Unconditioned basement
Enclosed Crawl Space Type:	N/A

Foundation Wall Info:	1		
Name	Bsement		
Library Type	Uninsulated		
Length(ft)	160.0		
Total Height(ft)	5.0		
Depth Below Grade(ft)	4.0		
Height Above Grade(ft)	1.0		
Location	Uncond bsmt->amb/grnd		
Uo Value	0.294		

Foundation Wall: Uninsulated

Type:	Solid concrete or stone
Thickness(in):	8.0
Studs:	None
Interior Insulation:	
Continuous R-Value:	0.0
Frame Cavity R-Value:	0.0
Cavity Insulation Grade:	3.0
Ins top:	0.0 ft from top of wall
Ins Bottom:	0.0 ft from bottom of wall
Exterior Insulation:	
R-Value:	0.0
Ins top:	0.0 ft from top of wall
Ins bottom:	0.0 ft below grade
Note:	

Frame Floor Info:	1
Name	Crawl
Library Type	Uninsulated
Area (sq ft)	1176
Location	Btwn cond & enclsd crwl
Uo Value	0.257

Frame Floor: Uninsulated

Information From Quick Fill Screen:

Continous Insulation R-Value	0.0
Cavity Insulation R-Value	0.0
Cavity Insulation Thickness (in.)	0.0
Cavity Insulation Grade	3.0
Joist Size (w x h, in)	1.5 x 9.5
Joist Spacing (in oc)	16.0
Framing Factor - (default)	0.1300
Floor Covering	CARPET

Note:

Layers	Paths		
	Cavity	Framing	Grade
Inside Air Film	0.920	0.920	0.920
Floor covering	1.230	1.230	1.230
Subfloor	0.820	0.820	0.820
Cavity ins	0.000	0.000	0.000
Continuous ins	0.000	0.000	0.000
Framing	0.000	0.000	0.000
	0.000	0.000	0.000
Outside Air Film	0.920	0.920	0.920
Total R-Value	3.890	3.890	3.890
U-Value	0.257	0.257	0.257
Relative Area	0.820	0.130	0.050
UA	0.211	0.033	0.013

Total Component UA: 0.257

Total Component Area: 1.0

Component Uo: 0.257

Rim and Band Joist:	1	2	3
Name	1st Floor	2nd Floor	Crawl
Area(sq ft)	160.0	160.0	160.0
Continuous Ins	0.0	0.0	0.0
Framed Cavity Ins	0.0	0.0	0.0
Cavity Ins Thk(in)	0.0	0.0	0.0
Joist Spacing	16.0	16.0	16.0
Location	Cond -> ambient	Cond -> ambient	Cond -> ambient
Uo Value	0.267	0.267	0.267

Above-Grade Wall:	1	2	3
Name	Front	Right	Left
Library Type	Double Brick****	Double Brick****	Double Brick****
Gross Area(sq ft)	623.50	1769.00	1769.00
Exterior Color	Light	Light	Light
Location	Cond -> ambient	Cond -> ambient	Cond -> ambient
Uo Value	0.201	0.201	0.201

Above-Grade Wall:	4		
Name	Back		
Library Type	Double Brick****		
Gross Area(sq ft)	623.50		
Exterior Color	Light		
Location	Cond -> ambient		
Uo Value	0.201		

Above-Grade Wall: Double Brick**

Information From Quick Fill Screen:

Double Brick

Continuous Insulation (R-Value)	0.0
Frame Cavity Insulation (R-Value)	0.0
Frame Cavity Insulation Thickness (in)	0.0
Frame Cavity Insulation Grade	3
Stud Size (w x d, in)	1.5 x 3.5
Stud Spacing (in o.c.)	16.0
Framing Factor - (default)	0.2300
Gypsum Thickness (in)	0.5

Note:

Layers	Paths
	Cavity
Inside Air Film	0.680
Gyp board	0.450
Continuous ins	0.000
Brick	1.350
Air Gap	0.970
Brick	1.350
	0.000
Outside Air Film	0.170
Total R-Value	4.970
U-Value	0.201
Relative Area	0.950
UA	0.191

Total Component UA: 0.191

Total Component Area: 0.9

Component Uo: 0.201

Window Information:	1	2	3
Name	Front 1st Floor	Front 2nd Floor	Front 3rdFloor
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	54.00	54.00	36.00
Orientation	East	East	East
Overhang Depth	4.0	0.0	1.0
Overhang To Top	1.0	0.0	1.0
Overhang To Bottom	7.0	0.0	5.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 1	AGWall 1	AGWall 1

Window Information:	4	5	6
Name	Right 1 & 2 Floors	Right 3rd Floor	Left 1 & 2 Floors
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	227.00	84.00	126.00
Orientation	North	North	South
Overhang Depth	0.0	1.0	0.0
Overhang To Top	0.0	1.0	0.0
Overhang To Bottom	0.0	5.0	0.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 2	AGWall 2	AGWall 3

Window Information:	7	8	9
Name	Left 3rd Floor	Back 1& 2 Floors	Back 3rd floor
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	60.00	36.00	24.00
Orientation	South	West	West
Overhang Depth	1.0	0.0	1.0
Overhang To Top	1.0	0.0	1.0
Overhang To Bottom	5.0	0.0	5.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 3	AGWall 4	AGWall 4

Window: Single - Wood	
U-Value:	0.900
Solar Heat Gain Coefficient:	0.650
Note:	

Door Information:	1	2	
Name	Right Doors	Back Door	
Opaque Area(sq ft)	45.0	21.5	
Library Type	1-3/8 Wd panel	1-3/8 Wd panel	
Wall Assignment	AGWall 2	AGWall 4	
Uo Value	0.545	0.545	

Door: 1-3/8 Wd panel	
R-Value of Opaque Area:	0.9
Storm Door:	No
Note:	

Roof Information:	1		
Name	3rd Floor		
Library Type	Uninsulated Ceiling****		
Gross Area(sq ft)	1229.00		
Color	Dark		
Radiant Barrier	No		
Type(Attic)	Attic		
Uo Value	0.599		

Ceiling: Uninsulated Ceiling****

Information From Quick Fill Screen:

Continous Insulation (R-Value)	0.0
Cavity Insulation (R-Value)	0.0
Cavity Insulation Thickness (in)	0.0
Cavity Insulation Grade	3.0
Gypsum Thickness (in)	0.500
Bottom Chord/Rafter Size(w x h, in)	1.5 x 3.5
Bottom Chord/Rafter Spacing (in o.c.)	24.0
Framing Factor - (default)	0.1100
Ceiling Type	Attic

Note: No insulation in the attic

Layers	Paths		
	Framing	Cavity	Grade
Inside Air Film	0.610	0.610	0.610
Gyp board	0.450	0.450	0.450
Cavity Ins/Frm	0.000	0.000	0.000
Continuous ins	0.000	0.000	0.000
	0.000	0.000	0.000
	0.000	0.000	0.000
	0.000	0.000	0.000
Outside Air Film	0.610	0.610	0.610
Total R-Value	1.670	1.670	1.670
U-Value	0.599	0.599	0.599
Relative Area	0.110	0.840	0.050
UA	0.066	0.503	0.030

Total Component UA: 0.599

Total Component Area: 1.0

Component Uo: 0.599

Mechanical Equipment: General

Number of Mechanical Systems:	5
Heating SetPoint(F):	68.00
Heating Setback Thermostat:	Present
Cooling SetPoint(F):	78.00
Cooling Setup Thermostat:	Present

Cooling Equipment: 10SEER A/C 2.5 ton

System Type:	Air conditioner
Fuel Type:	Electric
Rated Output Capacity (kBtuh):	30.0
Seasonal Equipment Efficiency:	10.0 SEER
Sensible Heat Fraction (SHF):	0.70
Note:	
Location:	Uncond bsmnt/enclosed crawl
Performance Adjustment:	100
Percent Load Served:	33
Number Of Units:	1

Heat: 80AFUE Gas Furn 32k

SystemType:	Fuel-fired air distribution
Fuel Type:	Natural gas
Rated Output Capacity (kBtuh):	32.0
Seasonal Equipment Efficiency:	80.0 AFUE
Auxiliary Electric:	447 Eae
Note:	
Location:	Conditioned area
Performance Adjustment:	100
Percent Load Served:	33
Number Of Units:	1

Heat: 80AFUE Gas Furn 64k

SystemType:	Fuel-fired air distribution
Fuel Type:	Natural gas
Rated Output Capacity (kBtuh):	64.0
Seasonal Equipment Efficiency:	80.0 AFUE
Auxiliary Electric:	776 Eae
Note:	
Location:	Attic
Performance Adjustment:	100
Percent Load Served:	67
Number Of Units:	1

Cooling Equipment: 10SEER A/C 5 ton	
System Type:	Air conditioner
Fuel Type:	Electric
Rated Output Capacity (kBtuh):	60.0
Seasonal Equipment Efficiency:	10.0 SEER
Sensible Heat Fraction (SHF):	0.70
Note:	
Location:	Attic
Performance Adjustment:	100
Percent Load Served:	67
Number Of Units:	1

Water Heating Equipment: 40 gal. 0.93F Elec***	
Water Heater Type:	Conventional
Fuel Type:	Electric
Energy Factor:	0.93
Recovery Efficiency:	0.98
Water Tank Size (gallons):	40
Extra Tank Insulation (R-Value):	0.0
Note:	
Location:	Conditioned area
Percent Load Served:	100
Performance Adjustment:	100
Number Of Units:	1

Duct System Information:	
Name	1st Fl apartment
Heating System	80AFUE Gas Furn 32k
Cooling System	10SEER A/C 2.5 ton
Supply Area(sq ft)	248.8
Return Area(sq ft)	46.1
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	15.00 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	4
Type	Supply	Return	Return
Percent Area	100.0	95.0	5.0
R-Value	6.0	6.0	0.0
Location	Unconditioned basement	Unconditioned basement	Conditioned space

Duct System Information:

Name	Upper Floors
Heating System	80AFUE Gas Furn 64k
Cooling System	10SEER A/C 5 ton
Supply Area(sq ft)	497.6
Return Area(sq ft)	92.2
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	53.00 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	3
Type	Supply	Return	Supply
Percent Area	50.0	75.0	50.0
R-Value	6.0	6.0	0.0
Location	Attic, exposed	Attic, exposed	Conditioned space

Duct Information:	4		
Type	Return		
Percent Area	25.0		
R-Value	0.0		
Location	Conditioned space		

Infiltration and Mechanical Ventilation

Whole House Infiltration

Measurement Type:	Blower door test
Heating Season Infiltration Value:	3282 CFM @ 50 Pascals
Cooling Season Infiltration Value:	3282 CFM @ 50 Pascals

Mechanical Ventilation for IAQ

Type:	Exhaust Only
Rate(cfm):	328
Sensible Recovery Efficiency(%):	0.00
Total Recovery Efficiency(%):	0.00
Hours per Day:	24.00
Fan Power (watts):	24.90

Ventilation Strategy for Cooling

Cooling Season Ventilation:	Natural Ventilation

Lights and Appliances

Simplified Audit	
Oven/Range Fuel Type:	Natural gas
Clothes Dryer Fuel Type:	Natural gas
Percent Fluorescent - Pin-Based:	10.00
Percent Fluorescent - CFL:	0.00
Refrigerator KWh:	775
Dishwasher EF:	0.46
Ceiling Fan CFM / Watt:	0.00

Notes

History:
Thomas Barksdale House
Constructed circa 1800, restored 1927

This simple single house built of brick and covered with stucco represents the typical dual residential and commercial occupation of this area post-Revolutionary Charleston. The building was restored in 1927 with the addition of an old balcony to its second-floor front facade. Reflecting the reclamation of this street at the beginning of Charleston's preservation fervor, the structure was restored by Mrs. T.W Punnett, a cousin of President Franklin D. Roosevelt. --The Buildings of Charleston by Jonathan Poston

MIDDLETON PLACE PLANTATION

BUILDING FILE REPORT

File Name: Middleton Baseline.blg | Date: March 10, 2009

DRAFT

Property/Builder:		Rating	
Building Name:	Baseline	Org. Name:	The Sustainability Institute
Owner's Name:	Middleton Foundation	Address:	
Property Address:	4300 Ashley River Road	City, St, Zip:	,
City, St, Zip:	Charleston, SC 29414	Phone No:	(843) 452-7610
Phone No:	(843) 556-6020	Website:	
		Rater's Name:	Benjamin Leigh
Builder's Name:	Henry Middleton	Rater's No.:	0052
Phone No:		Rater's Email:	
Email Address:			
Model:		Rating Date:	7/14/08
Development:		Rating Type:	Site Visit
		Reason:	Home Improvement
		Rating No.:	A1252

General Building Information	
Area of Cond. Space(sq ft):	5059
Volume of Cond. Space:	55878
Year Built:	2008
Housing Type:	Single-family detached
Level Type(Apartments Only):	None
Floors on or Above-Grade:	2
Number of Bedrooms:	4
Foundation Type:	Enclosed crawl space
Enclosed Crawl Space Type:	Vented

Foundation Wall Info:	1	2	3
Name	North	South	East
Library Type	Dbl brick unins**	Dbl brick unins**	Dbl brick unins**
Length(ft)	50.0	49.0	94.0
Total Height(ft)	1.5	1.5	1.5
Depth Below Grade(ft)	0.5	0.5	0.5
Height Above Grade(ft)	1.0	1.0	1.0
Location	Enclsd crwl->amb/grnd	Enclsd crwl->amb/grnd	Enclsd crwl->amb/grnd
Uo Value	0.262	0.262	0.262

Foundation Wall Info:	4		
Name	West		
Library Type	Dbl brick unins**		
Length(ft)	94.0		
Total Height(ft)	1.5		
Depth Below Grade(ft)	0.5		
Height Above Grade(ft)	1.0		
Location	Enclsd crwl->amb/grnd		
Uo Value	0.262		

Foundation Wall: Dbl brick unins**

Type:	Double Brick
Thickness(in):	10.0
Studs:	None
Interior Insulation:	
Continuous R-Value:	0.0
Frame Cavity R-Value:	0.0
Cavity Insulation Grade:	3.0
Ins top:	0.0 ft from top of wall
Ins Bottom:	0.0 ft from bottom of wall
Exterior Insulation:	
R-Value:	0.0
Ins top:	0.0 ft from top of wall
Ins bottom:	0.0 ft below grade
Note:	

Frame Floor Info:	1		
Name	Main		
Library Type	Uninsulated		
Area (sq ft)	2763		
Location	Btwn cond & enclsd crwl		
Uo Value	0.257		

Frame Floor: Uninsulated

Information From Quick Fill Screen:

Continous Insulation R-Value	0.0
Cavity Insulation R-Value	0.0
Cavity Insulation Thickness (in.)	0.0
Cavity Insulation Grade	3.0
Joist Size (w x h, in)	1.5 x 9.5
Joist Spacing (in oc)	16.0
Framing Factor - (default)	0.1300
Floor Covering	CARPET

Note:

Layers	Paths		
	Cavity	Framing	Grade
Inside Air Film	0.920	0.920	0.920
Floor covering	1.230	1.230	1.230
Subfloor	0.820	0.820	0.820
Cavity ins	0.000	0.000	0.000
Continuous ins	0.000	0.000	0.000
Framing	0.000	0.000	0.000
	0.000	0.000	0.000
Outside Air Film	0.920	0.920	0.920
Total R-Value	3.890	3.890	3.890
U-Value	0.257	0.257	0.257
Relative Area	0.820	0.130	0.050
UA	0.211	0.033	0.013

Total Component UA: 0.257

Total Component Area: 1.0

Component Uo: 0.257

Rim and Band Joist:	1	2	
Name	Sunroom Band	Main Band	
Area(sq ft)	39.0	220.0	
Continuous Ins	0.0	0.0	
Framed Cavity Ins	0.0	0.0	
Cavity Ins Thk(in)	0.0	0.0	
Joist Spacing	16.0	16.0	
Location	Cond -> another cond unit	Cond -> ambient	
Uo Value	0.267	0.267	

Above-Grade Wall:	1	2	3
Name	Rear Main (E)	Front Main (w)	left Main (N)
Library Type	UninsulatedDbl Brick*	UninsulatedDbl Brick*	UninsulatedDbl Brick*
Gross Area(sq ft)	888.50	1331.00	825.00
Exterior Color	Medium	Medium	Medium
Location	Cond -> ambient	Cond -> ambient	Cond -> ambient
Uo Value	0.201	0.201	0.201

Above-Grade Wall:	4	5	6
Name	Right Main (S)	Sunporch	Addition
Library Type	UninsulatedDbl Brick*	Uninsultd Brk Veneer*	Uninsultd Brk Veneer*
Gross Area(sq ft)	374.00	724.50	1859.00
Exterior Color	Medium	Medium	Medium
Location	Cond -> ambient	Cond -> ambient	Cond -> ambient
Uo Value	0.201	0.192	0.192

Above-Grade Wall: UninsulatedDbl Brick*

Information From Quick Fill Screen:

Double Brick

Continuous Insulation (R-Value)	0.0
Frame Cavity Insulation (R-Value)	0.0
Frame Cavity Insulation Thickness (in)	0.0
Frame Cavity Insulation Grade	3
Stud Size (w x d, in)	0.0 x 0.0
Stud Spacing (in o.c.)	16.0
Framing Factor - (default)	0.1363
Gypsum Thickness (in)	0.5

Note:

Layers	Paths Cavity
Inside Air Film	0.680
Gyp board	0.450
Continuous ins	0.000
Brick	1.350
Air Gap	0.970
Brick	1.350
	0.000
Outside Air Film	0.170
Total R-Value	4.970
U-Value	0.201
Relative Area	0.950
UA	0.191

Total Component UA: 0.191

Total Component Area: 0.9

Component Uo: 0.201

Above-Grade Wall: Uninsultd Brk Veneer*

Quick Fill not used.

Note: Uninsulated Brick Veneer, including air gap (1.00) and brick (.44) R Values.

Layers	Paths		
	Cavity	Framing	Grade
Inside Air Film	0.680	0.680	0.680
Drywall	0.450	0.450	0.450
Framing	1.030	4.375	1.030
Cavity ins/Frm	0.000	0.000	1.030
Continuous ins	0.000	0.000	0.000
Ext Sheathing	0.940	0.940	0.940
Air Gap & Brick	1.440	1.440	0.000
Outside Air Film	0.170	0.170	0.170
Total R-Value	4.710	8.055	4.300
U-Value	0.212	0.124	0.233
Relative Area	0.770	0.230	0.000
UA	0.163	0.029	0.000

Total Component UA: 0.192

Total Component Area: 1.0

Component Uo: 0.192

Window Information:	1	2	3
Name	Left Main 1&2 (NO)	Sunroom Left (NO)	Right Main 1(1ft)
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	52.50	48.75	35.00
Orientation	North	North	South
Overhang Depth	0.0	0.0	1.0
Overhang To Top	0.0	0.0	1.5
Overhang To Bottom	0.0	0.0	6.5
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 3	AGWall 5	AGWall 4

Window Information:	4	5	6
Name	Addition Right (NO)	Sunroom Right (NO)	Front Main 2nd(1ft)
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	52.50	48.80	70.00
Orientation	South	South	West
Overhang Depth	0.0	0.0	1.0
Overhang To Top	0.0	0.0	1.5
Overhang To Bottom	0.0	0.0	6.5
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 6	AGWall 6	AGWall 2

Window Information:	7	8	9
Name	(F)Main hall & 1st	Addit 2nd (1ft)	Addit (1st) (NO)
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	169.80	70.00	70.00
Orientation	West	West	West
Overhang Depth	0.0	1.0	0.0
Overhang To Top	0.0	1.0	0.0
Overhang To Bottom	0.0	6.5	0.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 2	AGWall 6	AGWall 6

Window Information:	10	11	12
Name	Rear main 2nd (1ft)	Rear main	Add Rear 2nd (1ft)
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	122.50	35.00	70.00
Orientation	East	East	East
Overhang Depth	1.0	0.0	1.0
Overhang To Top	1.0	0.0	1.0
Overhang To Bottom	6.5	0.0	6.5
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 1	AGWall 1	AGWall 6

Window Information:	13	14	
Name	Add Rear 1st	Sunroom Rear (NO)	
Library Type	Single - Wood	Single - Wood	
U-Value	0.900	0.900	
SHGC	0.650	0.650	
Area(sq ft)	52.50	120.00	
Orientation	East	East	
Overhang Depth	1.0	0.0	
Overhang To Top	1.0	0.0	
Overhang To Bottom	6.5	0.0	
Interior Winter Shading	0.85	0.85	
Interior Summer Shading	0.70	0.70	
Adjacent Winter Shading	None	None	
Adjacent Summer Shading	None	None	
Wall Assignment	AGWall 6	AGWall 5	

Window: Single - Wood

U-Value:	0.900
Solar Heat Gain Coefficient:	0.650
Note:	

Door Information:	1	2	3
Name	Front	Rear Sunroom	South Door
Opaque Area(sq ft)	32.0	48.0	29.0
Library Type	2-1/4 Wd solid core	2-1/4 Wd solid core	2-1/4 Wd solid core
Wall Assignment	AGWall 2	AGWall 5	AGWall 6
Uo Value	0.268	0.268	0.268

Door Information:	4		
Name	North Door		
Opaque Area(sq ft)	32.0		
Library Type	2-1/4 Wd solid core		
Wall Assignment	AGWall 3		
Uo Value	0.268		

Door: 2-1/4 Wd solid core	
R-Value of Opaque Area:	2.8
Storm Door:	No
Note:	

Roof Information:	1		
Name	2nd Floor		
Library Type	R-12 Blown, Attic*		
Gross Area(sq ft)	2295.25		
Color	Dark		
Radiant Barrier	No		
Type(Attic)	Attic		
Uo Value	0.110		

Ceiling: R-12 Blown, Attic*

Information From Quick Fill Screen:

Continous Insulation (R-Value)	0.0
Cavity Insulation (R-Value)	12.0
Cavity Insulation Thickness (in)	3.5
Cavity Insulation Grade	3.0
Gypsum Thickness (in)	0.500
Bottom Chord/Rafter Size(w x h, in)	1.5 x 3.5
Bottom Chord/Rafter Spacing (in o.c.)	24.0
Framing Factor - (default)	0.1100
Ceiling Type	Attic

Note:

Layers	Paths		
	Framing	Cavity	Grade
Inside Air Film	0.610	0.610	0.610
Gyp board	0.450	0.450	0.450
Cavity Ins/Frm	4.375	12.000	0.000
Continuous ins	0.000	0.000	0.000
	0.000	0.000	0.000
	0.000	0.000	0.000
	0.000	0.000	0.000
Outside Air Film	0.610	0.610	0.610
Total R-Value	6.045	13.670	1.670
U-Value	0.165	0.073	0.599
Relative Area	0.110	0.840	0.050
UA	0.018	0.061	0.030

Total Component UA: 0.110

Total Component Area: 1.0

Component Uo: 0.110

Mechanical Equipment: General

Number of Mechanical Systems:	5
Heating SetPoint(F):	68.00
Heating Setback Thermostat:	Not Present
Cooling SetPoint(F):	78.00
Cooling Setup Thermostat:	Not Present

ASHP: 36k 10seer 6.8hspf

Fuel Type:	Electric
Heating Seasonal Efficiency:	6.80 HSPF
Compressor Heating Output Capacity (kBtuh):	36.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	36.0
Cooling Seasonal Efficiency:	10.00 SEER
Desuperheater:	No
Note:	
Location:	Ambient
Performance Adjustment:	100
% Heating Load Served:	25
% Cooling Load Served:	25
Number Of Units:	1

Water Heating Equipment: 50 gal. 0.62EF Gas

Water Heater Type:	Conventional
Fuel Type:	Natural gas
Energy Factor:	0.62
Recovery Efficiency:	0.80
Water Tank Size (gallons):	50
Extra Tank Insulation (R-Value):	0.0
Note:	
Location:	Conditioned area
Percent Load Served:	100
Performance Adjustment:	100
Number Of Units:	1

ASHP: 48k 10seer 6.8hspf

Fuel Type:	Electric
Heating Seasonal Efficiency:	6.80 HSPF
Compressor Heating Output Capacity (kBtuh):	48.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	48.0
Cooling Seasonal Efficiency:	10.00 SEER
Desuperheater:	No
Note:	
Location:	Attic
Performance Adjustment:	100
% Heating Load Served:	33
% Cooling Load Served:	33
Number Of Units:	1

ASHP: 36k 10seer 6.8hspf

Fuel Type:	Electric
Heating Seasonal Efficiency:	6.80 HSPF
Compressor Heating Output Capacity (kBtuh):	36.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	36.0
Cooling Seasonal Efficiency:	10.00 SEER
Desuperheater:	No
Note:	
Location:	Attic
Performance Adjustment:	100
% Heating Load Served:	25
% Cooling Load Served:	25
Number Of Units:	1

ASHP: 24k 10seer 6.8hspf

Fuel Type:	Electric
Heating Seasonal Efficiency:	6.80 HSPF
Compressor Heating Output Capacity (kBtuh):	24.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	24.0
Cooling Seasonal Efficiency:	10.00 SEER
Desuperheater:	No
Note:	
Location:	Ambient
Performance Adjustment:	100
% Heating Load Served:	17
% Cooling Load Served:	17
Number Of Units:	1

Duct System Information:

Name	2nd Floor
Heating System	48k 10seer 6.8hspf
Cooling System	48k 10seer 6.8hspf
Supply Area(sq ft)	341.5
Return Area(sq ft)	63.2
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	327.85 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	4
Type	Supply	Return	Return
Percent Area	100.0	90.0	10.0
R-Value	6.0	6.0	0.0
Location	Attic, exposed	Attic, exposed	Conditioned space

Duct System Information:

Name	1st floor
Heating System	36k 10seer 6.8hspf
Cooling System	36k 10seer 6.8hspf
Supply Area(sq ft)	256.1
Return Area(sq ft)	47.4
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	327.85 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	4
Type	Supply	Return	Return
Percent Area	100.0	90.0	10.0
R-Value	6.0	6.0	0.0
Location	Enclosed crawl space	Enclosed crawl space	Conditioned space

Duct System Information:

Name	Sunroom
Heating System	24k 10seer 6.8hspf
Cooling System	24k 10seer 6.8hspf
Supply Area(sq ft)	170.7
Return Area(sq ft)	31.6
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	93.60 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	4
Type	Supply	Return	Return
Percent Area	100.0	90.0	10.0
R-Value	0.0	0.0	0.0
Location	Conditioned space	Conditioned space	Exterior wall

Duct System Information:

Name	Addition
Heating System	36k 10seer 6.8hspf
Cooling System	36k 10seer 6.8hspf
Supply Area(sq ft)	256.1
Return Area(sq ft)	47.4
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	262.40 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	4
Type	Supply	Return	Return
Percent Area	100.0	90.0	10.0
R-Value	0.0	0.0	0.0
Location	Attic, exposed	Attic, exposed	Conditioned space

Infiltration and Mechanical Ventilation

Whole House Infiltration

Measurement Type:	Blower door test
Heating Season Infiltration Value:	0.65 Natural ACH
Cooling Season Infiltration Value:	0.65 Natural ACH

Mechanical Ventilation for IAQ

Type:	None
Rate(cfm):	0
Sensible Recovery Efficiency(%):	0.00
Total Recovery Efficiency(%):	0.00
Hours per Day:	24.00
Fan Power (watts):	0.00

Ventilation Strategy for Cooling

Cooling Season Ventilation:	Natural Ventilation

Lights and Appliances

Simplified Audit

Oven/Range Fuel Type:	Electric
Clothes Dryer Fuel Type:	Electric
Percent Fluorescent - Pin-Based:	10.00
Percent Fluorescent - CFL:	0.00
Refrigerator KWh:	775

Lights and Appliances

Dishwasher EF:	0.46
Ceiling Fan CFM / Watt:	0.00

Notes

www.middletonplace.org
The House Museum, built by Henry Middleton in 1755 as a gentlemen's guest quarters, is the only surviving portion of the three-building residential complex that once stood overlooking the Ashley River. The House contains one of the finest collections of family-owned artifacts. Expect to see Middleton family furniture, paintings, books and documents dating from the 1740s through the 1880s. Guided tours of the house introduce visitors to the men, women and children who made Middleton Place their home for over two centuries.

I was unable to perform blower door and Duct Blasting at this time. It is thought that the testing procedure will rase humiditity levels in the building enough to damage the historic collection. We have scheduled the performance testing of the building for a time period when the outside humidity levels will pose less of a danger to the collection.

House divided into three sections based on construction techniques. The main house (1) was constructed of double brick construction as was common practice at the period. The addition (2) and the Sunporch (3) were added around 1920 and are brick veneer construction as was the practice for the period.

The main band between the 1st & Second Floors intersects the single story sunporch and is therefor adiabatic.

THe HVAC systems and ductwork zoning could not be determined. I have divided the systems based on the likely zone based on ease of install and likely square footage served.
System 1 (36k) Likely serves the 1st main floor 1639 sqft
System 3 (48k) likely serves the 2nd main floor 1639 sqft.
System 4 (36k) Likely serves the 1st & 2nd floor addition 1312 sqft
System 5 (24k) DEFINATELY serves the sun porch (468) (packaged unit). These ducts are primarily within the conditioned space of the sunporch. 10% of the ducts are on the exterior of the building. As there is no library location for Exterior ductwork, I made the location Exterior wall.

84 TRADD STREET

BUILDING FILE REPORT

File Name: 84 Tradd Baseline.blg — Date: March 10, 2009

DRAFT

Property/Builder:		**Rating**	
Building Name:	Baseline	Org. Name:	Sustainability Institute
Owner's Name:	Hurd Residence	Address:	1441 E. Montague Ave
Property Address:	84 Tradd St	City, St, Zip:	North Charleston Sc, SC 29405
City, St, Zip:	Charleston, SC 29403	Phone No:	843 529 3421
Phone No:		Website:	sustainabilityinstitutesc.org
		Rater's Name:	Benjamin Leigh
Builder's Name:		Rater's No.:	0052
Phone No:		Rater's Email:	ben@sustainabilityinstitutesc.
Email Address:			
Model:		Rating Date:	10/07/08
Development:		Rating Type:	Site Visit
		Reason:	Home Improvement
		Rating No.:	

General Building Information	
Area of Cond. Space(sq ft):	3357
Volume of Cond. Space:	31022
Year Built:	1918
Housing Type:	Single-family detached
Level Type(Apartments Only):	None
Floors on or Above-Grade:	3+
Number of Bedrooms:	5
Foundation Type:	More than one type
Enclosed Crawl Space Type:	Vented

Foundation Wall Info:	1	2	
Name	Main Foundation Wal	Addition Foundation	
Library Type	Uninsulated*********	Uninsulated*********	
Length(ft)	148.0	16.5	
Total Height(ft)	3.5	3.5	
Depth Below Grade(ft)	0.0	0.0	
Height Above Grade(ft)	3.5	3.5	
Location	Enclsd crwl->amb/grnd	Cond->enclsd crwl/grnd	
Uo Value	0.625	0.625	

Foundation Wall: Uninsulated*********	
Type:	Solid concrete or stone
Thickness(in):	8.0
Studs:	None
Interior Insulation:	
Continuous R-Value:	0.0
Frame Cavity R-Value:	0.0
Cavity Insulation Grade:	3.0
Ins top:	0.0 ft from top of wall
Ins Bottom:	0.0 ft from bottom of wall
Exterior Insulation:	
R-Value:	0.0
Ins top:	0.0 ft from top of wall
Ins bottom:	0.0 ft below grade
Note:	

Slab Floor Info:	1		
Name	Family Room Slab		
Library Type	Uninsulated		
Area(sq ft)	363		
Depth Below Grade(ft)	0.0		
Full Perimeter(ft)	77		
Exposed Perimeter(ft)	77		
On-Grade Perimeter(ft)	77		

Slab Floor: Uninsulated	
Slab Covering	Carpet
Perimeter Insulation (R-Value):	0.0
Perimeter Insulation Depth (ft):	0.0
Under-Slab Insulation (R-Value):	0.0
Under-Slab Insulation Width (ft):	0.0
Slab Insulation Grade:	1
Radiant Slab:	No
Note:	

Frame Floor Info:	1		
Name	First Floor		
Library Type	Uninsulated		
Area (sq ft)	1047		
Location	Btwn cond & enclsd crwl		
Uo Value	0.257		

Frame Floor: Uninsulated

Information From Quick Fill Screen:

Continous Insulation R-Value	0.0
Cavity Insulation R-Value	0.0
Cavity Insulation Thickness (in.)	0.0
Cavity Insulation Grade	3.0
Joist Size (w x h, in)	1.5 x 9.5
Joist Spacing (in oc)	16.0
Framing Factor - (default)	0.1300
Floor Covering	CARPET

Note:

Layers	Paths		
	Cavity	Framing	Grade
Inside Air Film	0.920	0.920	0.920
Floor covering	1.230	1.230	1.230
Subfloor	0.820	0.820	0.820
Cavity ins	0.000	0.000	0.000
Continuous ins	0.000	0.000	0.000
Framing	0.000	0.000	0.000
	0.000	0.000	0.000
Outside Air Film	0.920	0.920	0.920
Total R-Value	3.890	3.890	3.890
U-Value	0.257	0.257	0.257
Relative Area	0.820	0.130	0.050
UA	0.211	0.033	0.013

Total Component UA: 0.257

Total Component Area: 1.0

Component Uo: 0.257

Rim and Band Joist:	1	2	3
Name	1/2 Band Joist	Crawl Band Joist	2/3 Band Joist
Area(sq ft)	224.3	224.3	37.5
Continuous Ins	0.0	0.0	0.0
Framed Cavity Ins	0.0	0.0	0.0
Cavity Ins Thk(in)	0.0	0.0	0.0
Joist Spacing	16.0	16.0	16.0
Location	Cond -> ambient	Enclsd crwl -> ambient	Cond -> ambient
Uo Value	0.267	0.267	0.267

Above-Grade Wall:	1	2	3
Name	Main	Hyphen	Addition
Library Type	Uninsulated Stud*******	Uninsultd Brk Veneer*******	Uninsultd Brk Veneer*******
Gross Area(sq ft)	2664.00	414.00	903.00
Exterior Color	Light	Light	Light
Location	Cond -> ambient	Cond -> ambient	Cond -> ambient
Uo Value	0.267	0.192	0.192

Above-Grade Wall:	4	5	
Name	3rd floor walls	knee walls	
Library Type	Uninsulated Stud*******	R-130*******	
Gross Area(sq ft)	127.00	379.00	
Exterior Color	Light	Light	
Location	Cond -> ambient	Cond -> attic	
Uo Value	0.267	0.097	

Above-Grade Wall: Uninsulated Stud*****

Information From Quick Fill Screen:

Standard Wood Frame

Continuous Insulation (R-Value)	0.0
Frame Cavity Insulation (R-Value)	0.0
Frame Cavity Insulation Thickness (in)	0.0
Frame Cavity Insulation Grade	3
Stud Size (w x d, in)	1.5 x 3.5
Stud Spacing (in o.c.)	16.0
Framing Factor - (default)	0.2300
Gypsum Thickness (in)	0.5

Note: No insulation between studs

Layers	Paths		
	Cavity	Framing	Grade
Inside Air Film	0.680	0.680	0.680
Gyp board	0.450	0.450	0.450
Air Gap/Frm	1.030	4.375	1.030
Cavity ins/Frm	0.000	0.000	1.030
Continuous ins	0.000	0.000	0.000
Ext Finish	0.940	0.940	0.940
	0.000	0.000	0.000
Outside Air Film	0.170	0.170	0.170
Total R-Value	3.270	6.615	4.300
U-Value	0.306	0.151	0.233
Relative Area	0.720	0.230	0.050
UA	0.220	0.035	0.012

Total Component UA: 0.267

Total Component Area: 1.0

Component Uo: 0.267

Above-Grade Wall: Uninsultd Brk Veneer*****

Quick Fill not used.

Note: Uninsulated Brick Veneer, including air gap (1.00) and brick (.44) R Values.

Layers	Paths Cavity	Framing	Grade
Inside Air Film	0.680	0.680	0.680
Drywall	0.450	0.450	0.450
Framing	1.030	4.375	1.030
Cavity ins/Frm	0.000	0.000	1.030
Continuous ins	0.000	0.000	0.000
Ext Sheathing	0.940	0.940	0.940
Air Gap & Brick	1.440	1.440	0.000
Outside Air Film	0.170	0.170	0.170
Total R-Value	4.710	8.055	4.300
U-Value	0.212	0.124	0.233
Relative Area	0.770	0.230	0.000
UA	0.163	0.029	0.000

Total Component UA: 0.192

Total Component Area: 1.0

Component Uo: 0.192

Above-Grade Wall: R-130*****

Information From Quick Fill Screen:

Standard Wood Frame

Continuous Insulation (R-Value)	0.0
Frame Cavity Insulation (R-Value)	13.0
Frame Cavity Insulation Thickness (in)	3.5
Frame Cavity Insulation Grade	3
Stud Size (w x d, in)	1.5 x 3.5
Stud Spacing (in o.c.)	16.0
Framing Factor - (default)	0.2300
Gypsum Thickness (in)	0.5

Note:

Layers	Paths		
	Cavity	Framing	Grade
Inside Air Film	0.680	0.680	0.680
Gyp board	0.450	0.450	0.450
Air Gap/Frm	0.000	0.000	0.000
Cavity ins/Frm	13.000	4.375	1.030
Continuous ins	0.000	0.000	0.000
Ext Finish	0.940	0.940	0.940
	0.000	0.000	0.000
Outside Air Film	0.170	0.170	0.170
Total R-Value	15.240	6.615	3.270
U-Value	0.066	0.151	0.306
Relative Area	0.720	0.230	0.050
UA	0.047	0.035	0.015

Total Component UA: 0.097

Total Component Area: 1.0

Component Uo: 0.097

Window Information:	1	2	3
Name	dormer windows	front attic window	front
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	30.00	12.00	108.00
Orientation	West	South	South
Overhang Depth	0.0	1.5	0.0
Overhang To Top	0.0	2.0	0.0
Overhang To Bottom	0.0	6.0	0.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 1	AGWall 1	AGWall 1

Window Information:	4	5	6
Name	left under porch	left 2nd floor	left 2nd small
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	202.00	18.00	13.50
Orientation	West	West	West
Overhang Depth	7.5	1.5	1.5
Overhang To Top	0.0	0.0	0.0
Overhang To Bottom	6.0	6.0	4.5
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 1	AGWall 1	AGWall 1

Window Information:	7	8	9
Name	left 1st floor	right overhang	right
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	36.00	18.00	90.00
Orientation	West	East	East
Overhang Depth	0.0	1.5	0.0
Overhang To Top	0.0	2.5	0.0
Overhang To Bottom	0.0	8.5	0.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 1	AGWall 1	AGWall 1

Window Information:	10	11	12
Name	right stair overhan	left add-1st floor	right add-1st floor
Library Type	Single - Wood	Double - Metal	Double - Metal
U-Value	0.900	0.870	0.870
SHGC	0.650	0.730	0.730
Area(sq ft)	18.00	126.50	126.50
Orientation	East	West	East
Overhang Depth	1.5	0.0	0.0
Overhang To Top	5.3	0.0	0.0
Overhang To Bottom	11.3	0.0	0.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.66	0.66
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 1	AGWall 3	AGWall 3

Window Information:	13	14	15
Name	left add-2nd floor	right add-2nd floor	back add-2nd floor
Library Type	Double - Metal	Double - Metal	Double - Metal
U-Value	0.870	0.870	0.870
SHGC	0.730	0.730	0.730
Area(sq ft)	82.50	82.50	120.00
Orientation	West	East	North
Overhang Depth	1.0	1.0	1.0
Overhang To Top	2.0	2.0	2.0
Overhang To Bottom	9.5	9.5	9.5
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.66	0.66	0.66
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 3	AGWall 3	AGWall 3

Window Information:	16		
Name	back add 1st floor		
Library Type	Double - Metal		
U-Value	0.870		
SHGC	0.730		
Area(sq ft)	172.50		
Orientation	North		
Overhang Depth	0.0		
Overhang To Top	0.0		
Overhang To Bottom	0.0		
Interior Winter Shading	0.85		
Interior Summer Shading	0.66		
Adjacent Winter Shading	None		
Adjacent Summer Shading	None		
Wall Assignment	AGWall 3		

Window: Single - Wood

U-Value:	0.900
Solar Heat Gain Coefficient:	0.650
Note:	

Window: Double - Metal

U-Value:	0.870
Solar Heat Gain Coefficient:	0.730
Note:	

Door Information:	1		
Name	left doors		
Opaque Area(sq ft)	45.0		
Library Type	1-3/4 Wd panel		
Wall Assignment	AGWall 1		
Uo Value	0.447		

Door: 1-3/4 Wd panel

R-Value of Opaque Area:	1.3
Storm Door:	No
Note:	

Roof Information:	1	2	3
Name	Attic vaulted	Attic dormers	2nd Floor Flat
Library Type	R-13 Batt, Valuted********	Uninsulated Ceiling5********	Uninsulated Ceiling5********
Gross Area(sq ft)	920.00	36.00	663.00
Color	Dark	Dark	Dark
Radiant Barrier	No	No	No
Type(Attic)	Vaulted	Attic	Attic
Uo Value	0.085	0.599	0.599

Ceiling: R-13 Batt, Valuted*******

Information From Quick Fill Screen:

Continous Insulation (R-Value)	0.0
Cavity Insulation (R-Value)	13.0
Cavity Insulation Thickness (in)	5.5
Cavity Insulation Grade	3.0
Gypsum Thickness (in)	0.500
Bottom Chord/Rafter Size(w x h, in)	1.5 x 5.5
Bottom Chord/Rafter Spacing (in o.c.)	24.0
Framing Factor - (default)	0.1100
Ceiling Type	Vaulted

Note:

Layers	Paths		
	Framing	Cavity	Grade
Inside Air Film	0.610	0.610	0.610
Gyp board	0.450	0.450	0.450
Cavity Ins/Frm	6.875	13.000	0.000
Continuous ins	0.000	0.000	0.000
Plywood	0.930	0.930	0.930
Shingles	0.400	0.400	0.400
	0.000	0.000	0.000
Outside Air Film	0.170	0.170	0.170
Total R-Value	9.435	15.560	2.560
U-Value	0.106	0.064	0.391
Relative Area	0.110	0.840	0.050
UA	0.012	0.054	0.020

Total Component UA: 0.085

Total Component Area: 1.0

Component Uo: 0.085

Ceiling: Uninsulated Ceiling5********

Information From Mobile Home Quick Fill Screen:

Unrestricted Depth (in)	0.0
Unrestricted R-Value (R-Value)	0.0
Ceiling Width (ft)	0.0
Ceiling Rise (ft)	0.0
Truss Height (in)	0.0
Ceiling Width (ft)	0.0
Gypsum Thickness (in)	0.500
Chord Size(w x h, in)	1.5 x 3.5
Chord Spacing (in o.c.)	24.0
Framing Factor - (default)	0.1100
Insulation Type	Blown

Note: No insulation in the attic

Layers	Paths		
	Framing	Cavity	Grade
Inside Air Film	0.610	0.610	0.610
Gyp board	0.450	0.450	0.450
Cavity Ins/Frm	0.000	0.000	0.000
Continuous ins	0.000	0.000	0.000
	0.000	0.000	0.000
	0.000	0.000	0.000
	0.000	0.000	0.000
Outside Air Film	0.610	0.610	0.610
Total R-Value	1.670	1.670	1.670
U-Value	0.599	0.599	0.599
Relative Area	0.110	0.840	0.050
UA	0.066	0.503	0.030

Total Component UA: 0.599

Total Component Area: 1.0

Component Uo: 0.599

Mechanical Equipment: General	
Number of Mechanical Systems:	5
Heating SetPoint(F):	68.00
Heating Setback Thermostat:	Not Present
Cooling SetPoint(F):	78.00
Cooling Setup Thermostat:	Not Present

ASHP: 48k 13seer 7.5hspf*********	
Fuel Type:	Electric
Heating Seasonal Efficiency:	7.50 HSPF
Compressor Heating Output Capacity (kBtuh):	48.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	48.0
Cooling Seasonal Efficiency:	13.00 SEER
Desuperheater:	No
Note:	
Location:	Ambient
Performance Adjustment:	100
% Heating Load Served:	37
% Cooling Load Served:	37
Number Of Units:	1

Water Heating Equipment: 50 gal. 0.54EF Gas	
Water Heater Type:	Conventional
Fuel Type:	Natural gas
Energy Factor:	0.54
Recovery Efficiency:	0.76
Water Tank Size (gallons):	50
Extra Tank Insulation (R-Value):	0.0
Note:	
Location:	Conditioned area
Percent Load Served:	100
Performance Adjustment:	100
Number Of Units:	1

ASHP: 48k 13seer 7.5hspf0*********

Fuel Type:	Electric
Heating Seasonal Efficiency:	7.50 HSPF
Compressor Heating Output Capacity (kBtuh):	48.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	48.0
Cooling Seasonal Efficiency:	13.00 SEER
Desuperheater:	No
Note:	
Location:	Ambient
Performance Adjustment:	100
% Heating Load Served:	37
% Cooling Load Served:	37
Number Of Units:	1

ASHP: 9000btu Mini Split********

Fuel Type:	Electric
Heating Seasonal Efficiency:	8.20 HSPF
Compressor Heating Output Capacity (kBtuh):	10.8
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	9.4
Cooling Seasonal Efficiency:	17.00 SEER
Desuperheater:	No
Note:	9,000Btu Ductless minisplit Unit
Location:	Conditioned area
Performance Adjustment:	100
% Heating Load Served:	8
% Cooling Load Served:	7
Number Of Units:	1

ASHP: 24k 12seer 7.5hspf

Fuel Type:	Electric
Heating Seasonal Efficiency:	7.50 HSPF
Compressor Heating Output Capacity (kBtuh):	24.0
Electric Resistance Backup Capacity (kW):	0
Cooling Output Capacity (kBtuh):	24.0
Cooling Seasonal Efficiency:	12.00 SEER
Desuperheater:	No
Note:	
Location:	Uncond bsmnt/enclosed crawl
Performance Adjustment:	100
% Heating Load Served:	18
% Cooling Load Served:	19
Number Of Units:	1

Duct System Information:

Name	Addition
Heating System	48k 13seer 7.5hspf0********
Cooling System	48k 13seer 7.5hspf0********
Supply Area(sq ft)	252.2
Return Area(sq ft)	46.7
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	176.50 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	
Type	Supply	Return	
Percent Area	100.0	100.0	
R-Value	0.0	0.0	
Location	Conditioned space	Conditioned space	

Duct System Information:	
Name	2/3 Floors
Heating System	48k 13seer 7.5hspf*********
Cooling System	48k 13seer 7.5hspf*********
Supply Area(sq ft)	252.2
Return Area(sq ft)	46.7
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	198.00 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	3	4
Type	Supply	Supply	Return
Percent Area	25.0	75.0	100.0
R-Value	0.0	0.0	0.0
Location	Conditioned space	Attic, exposed	Attic, exposed

Duct System Information:	
Name	1st Floor
Heating System	24k 12seer 7.5hspf
Cooling System	24k 12seer 7.5hspf
Supply Area(sq ft)	126.1
Return Area(sq ft)	23.3
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	182.00 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	4
Type	Supply	Return	Return
Percent Area	100.0	90.0	10.0
R-Value	6.0	6.0	0.0
Location	Enclosed crawl space	Enclosed crawl space	Conditioned space

Infiltration and Mechanical Ventilation

Whole House Infiltration

Measurement Type:	Blower door test
Heating Season Infiltration Value:	10786 CFM @ 50 Pascals
Cooling Season Infiltration Value:	10786 CFM @ 50 Pascals

Mechanical Ventilation for IAQ

Type:	None
Rate(cfm):	0
Sensible Recovery Efficiency(%):	0.00
Total Recovery Efficiency(%):	0.00
Hours per Day:	24.00
Fan Power (watts):	0.00

Ventilation Strategy for Cooling

Cooling Season Ventilation:	Natural Ventilation

Lights and Appliances

Simplified Audit

Oven/Range Fuel Type:	Electric
Clothes Dryer Fuel Type:	Electric
Percent Fluorescent - Pin-Based:	10.00
Percent Fluorescent - CFL:	0.00
Refrigerator KWh:	775
Dishwasher EF:	0.46
Ceiling Fan CFM / Watt:	0.00

Notes

BELIII 11-7
Removed Duct System for mini-split
Mechanical systems 1 & 3 are packaged units on the roof. They are identical.
Changed 1st floor duct system location to enclosed crawl space
Addition is on a slab on grade. The main foundation walls are 3.5 feet high. The Addition foundation wall describes the wall that separates the conditioned space of the addition from the enclosed crawl space.

GWP 11-06-08
Rating Check

Do not need to enter duct system for mini-split.
Is addition foundation location correct
Should have crawl band joist
Is Mechanical system #1 amd#3 outside? Are they identical
Check duct location for 1st floor duct system...is there an open crawl space?

House is a historic 3 story Charleston single. THe house was built around 1910. House has finished attic space on one half of the buildign and flat roof over one of many additions, Slab construction under addition and framed floor over exiusting house,

(Above grade wall summary)
attic: 107 (perimeter) by 4 (knee wall)

Ceiling Properties:
R-13 in attic based on the age of the addition (added 1970's)

Mechanical Equiptment:
Carrier Units
http://www.commercial.carrier.com/commercial/hvac/product_description/0,,CLI1_DIV41_LNK8172_ETI4926_PRD1138,00.html
48XP PerformanceTM 13

Duct System Properties
The "Set Default Areas" assigns supply & return area for a ductless mini-split. I could reduce these areas to zero to reflect the lack of ducts. However I have set duct leakage to zero to compensate. if return and supply areas need to be removed please advise.

8 NEW STREET

BUILDING FILE REPORT

File Name: 8 New Baseline.blg | Date: March 10, 2009

Property/Builder:		Rating	
Building Name:	Base line	Org. Name:	Sustainability Institute
Owner's Name:	James Bakker	Address:	1441 E. Montague Street
Property Address:	8 New Street	City, St, Zip:	North Charleston, SC 29405
City, St, Zip:	Charleston, SC 29401	Phone No:	843-529-3421
Phone No:	843-813-5557	Website:	SustainabilityInstituteSC.org
		Rater's Name:	Ben Leigh
Builder's Name:	James Meadors	Rater's No.:	0052
Phone No:	843-723-8585	Rater's Email:	Ben@SustainabilityInstituteSC.
Email Address:			
Model:		Rating Date:	09/16/2008
Development:		Rating Type:	Site Visit
		Reason:	Informational
		Rating No.:	A1254

General Building Information	
Area of Cond. Space(sq ft):	3706
Volume of Cond. Space:	17632
Year Built:	1900
Housing Type:	Single-family detached
Level Type(Apartments Only):	None
Floors on or Above-Grade:	2
Number of Bedrooms:	3
Foundation Type:	Enclosed crawl space
Enclosed Crawl Space Type:	Vented

Foundation Wall Info:	1		
Name	Crawl Space		
Library Type	Uninsulated		
Length(ft)	204.0		
Total Height(ft)	5.0		
Depth Below Grade(ft)	1.0		
Height Above Grade(ft)	4.0		
Location	Enclsd crwl->amb/grnd		
Uo Value	0.577		

Foundation Wall: Uninsulated

Type:	Solid concrete or stone
Thickness(in):	8.0
Studs:	None
Interior Insulation:	
Continuous R-Value:	0.0
Frame Cavity R-Value:	0.0
Cavity Insulation Grade:	3.0
Ins top:	0.0 ft from top of wall
Ins Bottom:	0.0 ft from bottom of wall
Exterior Insulation:	
R-Value:	0.0
Ins top:	0.0 ft from top of wall
Ins bottom:	0.0 ft below grade
Note:	

Frame Floor Info:	1	2	3
Name	1st floor	2nd Floor bk right	2nd Floor bk closet
Library Type	Uninsulated	Uninsulated	Uninsulated
Area (sq ft)	1810	18	24
Location	Btwn cond & enclsd crwl	Btwn cond & ambient	Btwn cond & garage
Uo Value	0.257	0.257	0.257

Frame Floor Info:	4		
Name	2nd Fl Bay Window		
Library Type	Uninsulated		
Area (sq ft)	22		
Location	Btwn cond & ambient		
Uo Value	0.257		

Frame Floor: Uninsulated

Information From Quick Fill Screen:

Continous Insulation R-Value	0.0
Cavity Insulation R-Value	0.0
Cavity Insulation Thickness (in.)	0.0
Cavity Insulation Grade	3.0
Joist Size (w x h, in)	1.5 x 9.5
Joist Spacing (in oc)	16.0
Framing Factor - (default)	0.1300
Floor Covering	CARPET

Note:

Layers	Paths		
	Cavity	Framing	Grade
Inside Air Film	0.920	0.920	0.920
Floor covering	1.230	1.230	1.230
Subfloor	0.820	0.820	0.820
Cavity ins	0.000	0.000	0.000
Continuous ins	0.000	0.000	0.000
Framing	0.000	0.000	0.000
	0.000	0.000	0.000
Outside Air Film	0.920	0.920	0.920
Total R-Value	3.890	3.890	3.890
U-Value	0.257	0.257	0.257
Relative Area	0.820	0.130	0.050
UA	0.211	0.033	0.013

Total Component UA: 0.257

Total Component Area: 1.0

Component Uo: 0.257

Rim and Band Joist:	1	2	
Name	1st band	1st/Crawl Band	
Area(sq ft)	206.0	206.0	
Continuous Ins	0.0	0.0	
Framed Cavity Ins	0.0	0.0	
Cavity Ins Thk(in)	0.0	0.0	
Joist Spacing	16.0	16.0	
Location	Cond -> ambient	Enclsd crwl -> ambient	
Uo Value	0.267	0.267	

Above-Grade Wall:	1	2	
Name	Wall	Back Closet Wall	
Library Type	Uninsulated Stud	Uninsulated Stud	
Gross Area(sq ft)	4479.50	41.00	
Exterior Color	Dark	Dark	
Location	Cond -> ambient	Cond -> garage	
Uo Value	0.267	0.267	

Above-Grade Wall: Uninsulated Stud

Information From Quick Fill Screen:

Standard Wood Frame

Continuous Insulation (R-Value)	0.0
Frame Cavity Insulation (R-Value)	0.0
Frame Cavity Insulation Thickness (in)	0.0
Frame Cavity Insulation Grade	3
Stud Size (w x d, in)	1.5 x 3.5
Stud Spacing (in o.c.)	16.0
Framing Factor - (default)	0.2300
Gypsum Thickness (in)	0.5

Note: No insulation between studs

Layers	Paths		
	Cavity	Framing	Grade
Inside Air Film	0.680	0.680	0.680
Gyp board	0.450	0.450	0.450
Air Gap/Frm	1.030	4.375	1.030
Cavity ins/Frm	0.000	0.000	1.030
Continuous ins	0.000	0.000	0.000
Ext Finish	0.940	0.940	0.940
	0.000	0.000	0.000
Outside Air Film	0.170	0.170	0.170
Total R-Value	3.270	6.615	4.300
U-Value	0.306	0.151	0.233
Relative Area	0.720	0.230	0.050
UA	0.220	0.035	0.012

Total Component UA: 0.267

Total Component Area: 1.0

Component Uo: 0.267

Window Information:	1	2	3
Name	Front Door Window	Front Door Glass	4 - French Dr Glass
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	44.00	13.50	106.67
Orientation	Southeast	Southeast	Southeast
Overhang Depth	8.0	8.0	8.0
Overhang To Top	0.5	4.3	1.0
Overhang To Bottom	2.0	8.5	10.0
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	Complete	None	None
Adjacent Summer Shading	Complete	None	None
Wall Assignment	AGWall 1	AGWall 1	AGWall 1

Window Information:	4	5	6
Name	Bay Window	Bay Window	Window
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	36.00	18.00	355.50
Orientation	East	East	Northeast
Overhang Depth	2.0	0.0	0.0
Overhang To Top	4.3	4.3	4.3
Overhang To Bottom	9.3	9.3	9.3
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	Some	None	None
Adjacent Summer Shading	Some	None	None
Wall Assignment	AGWall 1	AGWall 1	AGWall 1

Window Information:	7	8	9
Name	Window	Window	Window
Library Type	Double - Vinyl	Double - Vinyl	Single - Wood
U-Value	0.460	0.460	0.900
SHGC	0.570	0.570	0.650
Area(sq ft)	117.00	41.30	27.00
Orientation	Northeast	Northeast	Northeast
Overhang Depth	0.0	0.0	0.0
Overhang To Top	4.3	4.3	4.3
Overhang To Bottom	9.3	8.5	8.5
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	None	None	None
Adjacent Summer Shading	None	None	None
Wall Assignment	AGWall 1	AGWall 1	AGWall 1

Window Information:	10	11	12
Name	Window	Window	Window
Library Type	Single - Wood	Single - Wood	Single - Wood
U-Value	0.900	0.900	0.900
SHGC	0.650	0.650	0.650
Area(sq ft)	15.00	195.00	87.00
Orientation	North	Northwest	Southwest
Overhang Depth	2.0	0.0	0.0
Overhang To Top	2.0	4.3	4.3
Overhang To Bottom	4.0	9.3	9.3
Interior Winter Shading	0.85	0.85	0.85
Interior Summer Shading	0.70	0.70	0.70
Adjacent Winter Shading	Most	None	None
Adjacent Summer Shading	Most	None	None
Wall Assignment	AGWall 1	AGWall 1	AGWall 1

Window Information:	13		
Name	Rear Door Glass		
Library Type	Single - Wood		
U-Value	0.900		
SHGC	0.650		
Area(sq ft)	13.50		
Orientation	Northeast		
Overhang Depth	2.0		
Overhang To Top	4.3		
Overhang To Bottom	8.8		
Interior Winter Shading	0.85		
Interior Summer Shading	0.70		
Adjacent Winter Shading	None		
Adjacent Summer Shading	None		
Wall Assignment	AGWall 1		

Window: Single - Wood	
U-Value:	0.900
Solar Heat Gain Coefficient:	0.650
Note:	

Window: Double - Vinyl	
U-Value:	0.460
Solar Heat Gain Coefficient:	0.570
Note:	

Door Information:	1	2	3
Name	Front Door	Front French Door	Rear Door
Opaque Area(sq ft)	13.5	52.2	6.8
Library Type	1-3/4 Wd solid core****	1-3/4 Wd solid core****	1-3/4 Wd solid core****
Wall Assignment	AGWall 1	AGWall 1	AGWall 1
Uo Value	0.329	0.329	0.329

Door: 1-3/4 Wd solid core****	
R-Value of Opaque Area:	2.1
Storm Door:	No
Note:	2/3 rds glass french doors

Roof Information:	1		
Name	2nd Floor Ceiling		
Library Type	Uninsulated Ceiling*********		
Gross Area(sq ft)	1896.00		
Color	Dark		
Radiant Barrier	No		
Type(Attic)	Attic		
Uo Value	0.599		

Ceiling: Uninsulated Ceiling*******

Information From Mobile Home Quick Fill Screen:

Unrestricted Depth (in)	0.0
Unrestricted R-Value (R-Value)	0.0
Ceiling Width (ft)	0.0
Ceiling Rise (ft)	0.0
Truss Height (in)	0.0
Ceiling Width (ft)	0.0
Gypsum Thickness (in)	0.500
Chord Size(w x h, in)	1.5 x 3.5
Chord Spacing (in o.c.)	24.0
Framing Factor - (default)	0.1100
Insulation Type	Blown

Note: No insulation in the attic

Layers	Paths Framing	Cavity	Grade
Inside Air Film	0.610	0.610	0.610
Gyp board	0.450	0.450	0.450
Cavity Ins/Frm	0.000	0.000	0.000
Continuous ins	0.000	0.000	0.000
	0.000	0.000	0.000
	0.000	0.000	0.000
	0.000	0.000	0.000
Outside Air Film	0.610	0.610	0.610
Total R-Value	1.670	1.670	1.670
U-Value	0.599	0.599	0.599
Relative Area	0.110	0.840	0.050
UA	0.066	0.503	0.030

Total Component UA: 0.599

Total Component Area: 1.0

Component Uo: 0.599

Mechanical Equipment: General

Number of Mechanical Systems:	6
Heating SetPoint(F):	68.00
Heating Setback Thermostat:	Not Present
Cooling SetPoint(F):	78.00
Cooling Setup Thermostat:	Not Present

Water Heating Equipment: 50 gal. 0.94EF Elec

Water Heater Type:	Conventional
Fuel Type:	Electric
Energy Factor:	0.94
Recovery Efficiency:	0.98
Water Tank Size (gallons):	50
Extra Tank Insulation (R-Value):	0.0
Note:	
Location:	Conditioned area
Percent Load Served:	38
Performance Adjustment:	100
Number Of Units:	1

Water Heating Equipment: 43 gal. 0.913F Elec**

Water Heater Type:	Conventional
Fuel Type:	Electric
Energy Factor:	0.93
Recovery Efficiency:	0.98
Water Tank Size (gallons):	40
Extra Tank Insulation (R-Value):	0.0
Note:	Rheem Model 81v30d d 240v
Location:	Conditioned area
Percent Load Served:	31
Performance Adjustment:	100
Number Of Units:	1

Water Heating Equipment: Demand-Elec*******

Water Heater Type:	Instant water heater
Fuel Type:	Electric
Energy Factor:	1.00
Recovery Efficiency:	0.00
Water Tank Size (gallons):	0
Extra Tank Insulation (R-Value):	0.0
Note:	
Location:	Conditioned area
Percent Load Served:	31
Performance Adjustment:	100
Number Of Units:	1

Cooling Equipment: 11.4 SEER A/C 3 ton**

System Type:	Air conditioner
Fuel Type:	Electric
Rated Output Capacity (kBtuh):	36.0
Seasonal Equipment Efficiency:	11.4 SEER
Sensible Heat Fraction (SHF):	0.70
Note:	
Location:	Ambient
Performance Adjustment:	100
Percent Load Served:	46
Number Of Units:	1

Cooling Equipment: 12SEER A/C 3.5 ton*******

System Type:	Air conditioner
Fuel Type:	Electric
Rated Output Capacity (kBtuh):	42.0
Seasonal Equipment Efficiency:	12.0 SEER
Sensible Heat Fraction (SHF):	0.70
Note:	
Location:	Conditioned area
Performance Adjustment:	100
Percent Load Served:	54
Number Of Units:	1

Heat: 80AFUE Gas Furn 32k

SystemType:	Fuel-fired air distribution
Fuel Type:	Natural gas
Rated Output Capacity (kBtuh):	32.0
Seasonal Equipment Efficiency:	80.0 AFUE
Auxiliary Electric:	447 Eae
Note:	
Location:	Conditioned area
Performance Adjustment:	100
Percent Load Served:	100
Number Of Units:	1

Duct System Information:

Name	crawl space or ceil
Heating System	80AFUE Gas Furn 32k
Cooling System	11.4 SEER A/C 3 ton**
Supply Area(sq ft)	346.4
Return Area(sq ft)	320.7
# of Registers	7
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	366.80 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	
Type	Supply	Return	
Percent Area	100.0	100.0	
R-Value	0.0	0.0	
Location	Enclosed crawl space	Enclosed crawl space	

Duct System Information:

Name	Attic
Heating System	80AFUE Gas Furn 32k
Cooling System	12SEER A/C 3.5 ton*********
Supply Area(sq ft)	404.1
Return Area(sq ft)	74.8
# of Registers	1
Duct Leakage	
Qualitative Assessment - Not Applicable	
Total Duct Leakage:	375.20 CFM @ 25 Pascals
Supply Duct Leakage - Not Applicable	
Return Duct Leakage - Not Applicable	

Duct Information:	1	2	
Type	Supply	Return	
Percent Area	100.0	100.0	
R-Value	0.0	0.0	
Location	Attic, exposed	Attic, exposed	

Infiltration and Mechanical Ventilation

Whole House Infiltration

Measurement Type:	Blower door test
Heating Season Infiltration Value:	0.65 Natural ACH
Cooling Season Infiltration Value:	0.65 Natural ACH

Mechanical Ventilation for IAQ

Type:	None
Rate(cfm):	0
Sensible Recovery Efficiency(%):	0.00
Total Recovery Efficiency(%):	0.00
Hours per Day:	24.00
Fan Power (watts):	0.00

Ventilation Strategy for Cooling

Cooling Season Ventilation:	Natural Ventilation

Lights and Appliances

Simplified Audit

Oven/Range Fuel Type:	Electric
Clothes Dryer Fuel Type:	Electric
Percent Fluorescent - Pin-Based:	10.00
Percent Fluorescent - CFL:	0.00
Refrigerator KWh:	775
Dishwasher EF:	0.46
Ceiling Fan CFM / Watt:	0.00

Notes

This is an Historic home that is in the process of being renovated. The selection of heating, air conditioning equipment, and hot water heating is still in question. There is still some question to improvements in ductwork, insulating walls that have had inside plaster removed due to mold growth, lighting, & some interior improvements.

Duct System Properties
This building file has no duct systems attached to heating & cooling equipment.

APPENDIX B

Improvement Analyses Data

63 Smith Street

Envelope Leakage		HERS	Energy	Cost
	0.65	137	186.8	4885
	0.5	134	183.5	4790
	0.4	132	181.3	4730
	0.25	***131***	***178.1***	***4639***

Duct Leakage		HERS	Energy	Cost
		137	186.8	4885
	0.06	133	182.8	4767
	0.05	133	182.5	4758
	0.04	***132***	***182.1***	***4748***

Attic	HERS	Energy	Cost
Uninsulated	137	186.8	4885
R-30	129	179	4656
R-38	129	179	4657
Sealed & Conditioned w/R-30	***120***	***170.6***	***4410***

Crawl	HERS	Energy	Cost
Uninsulated	**137**	**186.8**	**4885**
R-19	135	184	4808
R-30	*135*	*183.7*	*4798*

Windows	HERS	Energy	Cost
Single Wood	**137**	**186.8**	**4885**
Double Wood	130	178.6	4651
Triple Wood	127	176.4	4587
Double Vinyl	129	177.9	4633
Dbl/LoE/Arg-Vinyl	*125*	*174.8*	*4538*

HVAC	HERS	Energy	Cost
Current (14 SEER)	137	186.8	4885
17 SEER	**131**	**181.9**	**4731**
Geothermal	***125***	***178.9***	***4625***

Water Heater	HERS	Energy	Cost
Current	137	186.8	4885
Thermal Blanket	136	182.7	4832
.68 Gas Water Heater	134	178.8	4783
Tankless	132	174.5	4727
Solar	***130***	***162.2***	***4562***

Roofing	HERS	Energy	Cost
Current (medium)	137	186.8	4885
Light	137	186.5	4873
Radiant barrier (w/medium)	***132***	***182.4***	***4750***

Final Improvement Analysis	HERS	Energy	Cost	% Change
Current	137	186.8	4885	n/a
Likely case (with 17 SEER 6 tons less)	**98**	**129.7**	**3612**	**27%**
Likely case (with geothermal)	**84**	**115.7**	**3309**	**32%**
Best case	*73*	*104.7*	*2825*	*41%*

1 Tradd Street

Envelope Leakage	HERS	Energy	Cost
0.42	140	201.9	3831
0.35	***139***	***203.6***	***3823***
0.25	138	202.7	3812

Duct System	HERS	Energy	Cost
1.22 and 2.16 % leakage is sufficiently low.			

Attic	HERS	Energy	Cost
Uninsulated	140	201.9	3831
R-30	**131**	**188.9**	**3633**
R-38	*130*	*188.5*	*3628*

Crawl	HERS	Energy	Cost
Uninsulated	**140**	**201.9**	**3831**
R-19	137	199.2	3777
R-30	*137*	*198.5*	*3770*

<u>Windows</u>	HERS	Energy	Cost
Single Wood	140	201.9	3831
Double Wood	**129**	**183.8**	**3581**
Double Vinyl	128	182.3	3561
Dbl/LoE/Arg-Vinyl	*122*	*176.8*	*3450*

<u>HVAC</u>	HERS	Energy	Cost
Current (10 SEER/80AFUE)	140	201.9	3831
14 SEER/92 AFUE	116	180	3406
17 SEER/94 AFUE	108	174.6	3275
Geothermal	101	100.7	2945

<u>Water Heater</u>	HERS	Energy	Cost
Current (.93 Electric)	140	201.9	3831
Thermal Blanket	139	203.8	3819
Tankless	138	203.2	3801
Solar	***131***	***190.5***	***3430***

<u>Roofing</u>	HERS	Energy	Cost
Current (dark)	140	201.9	3831
Medium	139	203.0	3828
Light	139	204	3825
Radiant barrier (w/dark)	***133***	***198***	***3719***

Final Improvement Analysis	HERS	Energy	Cost	% Change
Current	140	201.9	3831	n/a
Likely Case	**85**	**130.8**	**2509**	**35%**
Best Case	*70*	*100.2*	*2173*	*43%*

Middleton Place Plantation Museum House

Envelope Leakage		HERS	Energy	Cost
	0.65	180	194.1	5612
	0.5	170	184.8	5344
	0.4	***171***	***185.4***	***5365***

Duct Leakage		HERS	Energy	Cost
	0.2	180	194.1	5612
	0.06	171	186.1	5378
	0.05	170	185.5	5360
	0.04	***168***	***184.3***	***5323***

Attic	HERS	Energy	Cost
Current (R-12)	180	194.1	5612
R-30	158	179.7	5179
R-38	***158***	***178.4***	***5143***

Crawl	HERS	Energy	Cost
Uninsulated	**180**	**194.1**	**5612**
R-19	177	190.4	5509
R-30	*176*	*189.9*	*5494*

<u>Windows</u>	HERS	Energy	Cost
Single Wood	**180**	**194.1**	**5612**
Double Wood	168	182.9	5292
Double Vinyl	162	177.7	5141
Dbl/LoE/Arg-Vinyl	*153*	*170.8*	*4934*

<u>HVAC</u>	HERS	Energy	Cost
Current	180	194.1	5612
14 SEER	148	168.4	4848
17 SEER	**139**	**162.9**	**4673**
Geothermal	***118***	***143.7***	***4117***

<u>Water Heater</u>	HERS	Energy	Cost
Current 50 gal .62 gas	180	194.1	5612
Thermal Blanket	180	192.8	5595
.68 Gas Water Heater	179	192.6	5593
Tankless	**177**	**190.3**	**5563**
Solar	*175*	*176.5*	*5276*

<u>Roofing</u>	HERS	Energy	Cost
Current (dark)	180	194.1	5612
Medium	180	194.1	5608
Light	179	193.9	5601
Radiant barrier (w/dark)	***173***	***188.8***	***5449***

Final Improvement Analysis	HERS	Energy	Cost	% Change
Current	180	194.1	5612	n/a
Likely 17 SEER	**122**	**146.2**	**4247**	**25%**
Likely Geothermal	**89**	**118.7**	**3437**	**39%**
Best Case	*71*	*91.3*	*2850*	*49%*

84 Tradd Street

Envelope Leakage	HERS	Energy	Cost
1.38	191	160.2	4522
1	190	158.9	4487
0.65	181	152.7	4311
0.5	178	150.1	4237
0.4	***176***	***148.6***	***4193***

Duct System	HERS	Energy	Cost
0.17	191	160.2	4522
0.06	186	156.7	4416
0.05	185	156.3	4406
0.04	***184***	***155.9***	***4395***

Attic	HERS	Energy	Cost
Uninsulated	191	160.2	4522
R-30	189	158.9	4484
R-38	***188***	***158.3***	***4467***

<u>Crawl</u>	HERS	Energy	Cost
Uninsulated	**191**	**160.2**	**4522**
R-19	189	158.1	4463
R-30	*188*	*157.9*	*4457*
Sealed & Conditioned	185	155.1	4373

<u>Windows</u>	HERS	Energy	Cost
Single Wood/ dbl metal	191	160.2	4522
Double Wood/ Triple Metal	144	215.9	4113
Double Vinyl	143	214.5	3994
Dbl/LoE/Arg-Vinyl	137	209.1	3884

<u>HVAC</u>	HERS	Energy	Cost
Current (13, 12 SEER)	191	160.2	4522
14 SEER	**178**	**151.7**	**4273**
17 SEER	176	152.6	4282
Geothermal	*146*	*131.7*	*3681*

<u>Water Heater</u>	HERS	Energy	Cost
Current	191	160.2	4522
Thermal Blanket	190	158.2	4495
.68 Gas Water Heater	187	156.3	4471
Tankless	**185**	**153.8**	**4439**
Solar	*181*	*138.8*	*4240*

Roofing	HERS	Energy	Cost
Current (Dark)	191	160.2	4522
Medium	191	160.2	4520
Light	190	160.1	4515
Radiant barrier (dark)	***186***	***157.3***	***4430***

Final Improvement Analysis	HERS	Energy	Cost	%Change
Current	191	160.2	4522	n/a
17 SEER	**129**	**115.3**	**3328**	**27%**
Geothermal	**104**	**100.3**	**2882**	**37%**
Best Case	*90*	*78.8*	*2497*	*45%*

8 New Street

Envelope Leakage		HERS	Energy	Cost
	0.65	186	266	4892
	0.5	183	261.8	4838
	0.4	***182***	***259***	***4801***

Duct System		HERS	Energy	Cost
	0.06	188	268.6	4936
	0.05	187	267.9	4923
	0.04	***187***	***267.1***	***4911***

Attic	HERS	Energy	Cost
Uninsulated	186	266	4892
R-30	***176***	***250***	***4681***
R-38	176	249.6	4675

Crawl	HERS	Energy	Cost
Uninsulated	**186**	**266**	**4892**
R-19	182	254.7	4783
R-30	*181*	*253.5*	*4772*

Windows	HERS	Energy	Cost
Single Wood/ Double Vinyl	186	266	4892
Double Wood/Double Vinyl	**171**	**236.9**	**4548**
Dbl/LoE/Arg-Vinyl & Double Wood	*170*	*235.3*	*4520*

HVAC	HERS	Energy	Cost
Current 12 SEER/80AFUE	186	266	4892
14 SEER/ 92 AFUE	161	236.2	4424
17 SEER/94 AFUE	***148***	***227.3***	***4211***
Geothermal	Not possible		

Water Heater	HERS	Energy	Cost
Current 43 gal .91 & 50 gal .94	186	266	4892
Tankless	**186**	**264.9**	**4858**
Solar	*180*	*255.4*	*4580*

Roofing	HERS	Energy	Cost
Current (Dark)	186	266	4892
Medium	185	267.9	4891
Light	184	269.8	4890
Radiant barrier (w/dark)	***175***	***258.9***	***4704***

Final Improvement Analysis	HERS	Energy	Cost	% Change
Current	186	266	4892	n/a
Likely case (with 17 SEER)	**123**	**179.8**	**3595**	**27%**
Best case	*106*	*147.8*	*3036*	*38%*

APPENDIX C

Secretary of the Interior's Standards for Historic Preservation

Excerpted from *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating, Restoring and Reconstructing Historic Buildings* by Kay D. Weeks and Anne E. Grimmer

The Secretary of the Interior's Standards for Rehabilitation

1. A property will be used as it was historically or be given a new use that requires minimal change to its distinctive materials, features, spaces, and spatial relationships.

2. The historic character of a property will be retained and preserved. The removal of distinctive materials or alteration of features, spaces, and spatial relationships that characterize a property will be avoided.

3. Each property will be recognized as a physical record of its time, place, and use. Changes that create a false sense of historical development, such as adding conjectural features or elements from other historic properties, will not be undertaken.

4. Changes to a property that have acquired historic significance in their own right will be retained and preserved.

5. Distinctive materials, features, finishes, and construction techniques or examples of craftsmanship that characterize a property will be preserved.

6. Deteriorated historic features will be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature will match the old in design, color, texture, and, where possible, materials. Replacement of missing features will be substantiated by documentary and physical evidence.

7. Chemical or physical treatments, if appropriate, will be undertaken using the gentlest means possible. Treatments that cause damage to historic materials will not be used.

8. Archeological resources will be protected and preserved in place. If such resources must be disturbed, mitigation measures will be undertaken.

9. New additions, exterior alterations, or related new construction will not destroy historic materials, features, and spatial relationships that characterize the property. The new work shall be differentiated from the old and will be compatible with the historic materials, features, size, scale and proportion, and massing to protect the integrity of the property and its environment.

10. New additions and adjacent or related new construction will be undertaken in a such a manner that, if removed in the future, the essential form and integrity of the historic property and its environment would be unimpaired.

Bibliography

Campagna, Barbara A. "How Changes to LEED Will Benefit Existing and Historic Buildings," *Forum News* XV, no. 2 (2008): 1-2.

Chasar, Dave. *Cooling Load Reduction and Air Conditioner Design in a 19th Century Florida House Museum* Cocoa: The Florida Solar Energy Center at the University of Central Florida: 2004.

Curl, James Stevens, *The Oxford Dictionary of Architecture and Landscape Architecture.* Oxford: Oxford University Press, 2006.

Curtis, Wayne. "A Cautionary Tale," *Preservation Magazine,* January/February 2008 http://www.nationaltrust.org/magazine/current/feature1.htm

Davison, Caroline. "Making Old Buildings Energy Efficient," Norwich: Norfolk County Council, 2008.

Dobson, Andrew, ed. *The Green Reader: Essays Toward a Sustainable Society*. New York: Mercury House, 1991.

Elephante, Carl. "The Greenest Building Is…One that is Already Built" *Forum Journal 21 (*2007): 14-17.

Farneth, Stephen. "Sustaining the Past," *GreenSource Magazine*, October 2007.

Gallagher Adams, Elaine and Jean Caroon, " Green Historic Buildings: Old and New Learn from Each Other" Paper presentated at the AIA Convenetion, San Antonio, Texas, May 3, 2007.

Geva, Anat. "Energy Simulation of Historic Buildings: St. Louis Catholic Church, Castroville, Texas," *APT Bulletin,* 29 (1998): 36-41.

Hadley, James. "The Home of the Future?" *Architecture Boston* 10 (2006): 44-48.

Karlovits, Bob. "Keeping it green," *Pittsburgh Tribune-Review,* October 28, 2006, Local section.

Krigger, John and Chris Dorsi. *Residential Energy: Cost Savings and Comfort for Existing Buildings.* Helena: Saturn Resource Management, 2004.

Leadership in Energy and Environmental Design, "LEED for Existing Buildings Rating System" U.S Green Building Council, https://www.usgbc.org/ShowFile.aspx?DocumentID=799.

Lstiburek, Joseph. *Builder's Guide to Hot, Humid Climates.* Westford: Building Science Press, 2005.

Lynn, Sophia. " I'm Over 100---Can I Still Go Green?" *Forum Journal* 21 (2007): 36-44.

National Park Service. Code of Federal Regulations. *The Secretary of Interior's Standards for Rehabilitiation*, Part 67, Title 36, 1995.

O'Connell, Kim A. "Finding Common Ground," *Traditional Building Magazine*, June 2007, http://www.ipedinc.net/isroot/ipedinc/referencematerials/Article_Finding_Common_Ground_by_Kim_OConnell_Traditional_Building_June_2007.pdf.

O'Connell, Kim A. "New Directions for the Old Retreat," *Preservation Magazine*, January/February 2008, http://www.preservationnation.org/magazine/2008/january-february/lincoln-cottage.html.

Office of Building Technologies Program. "Spot Ventilation" *Technology Fact Sheets.* Atlanta: U.S Department of Energy, 2002.

Petersen, Stephen R. Retrofitting *Existing Housing for Energy Conservation: An Economic Analysis*, Washington, D.C.: U.S. Government Printing Office, 1974.

Poston, Jonathan. *The Buildings of Charleston*. Columbia: University of South Carolina Press, 1997.

Residential Energy Services Network. "Introducing RESNET." 2008. www.resnet.us/about/resnet.htm

Roberts, Tristan. "Historic Preservation and Green Building: A Lasting Relationship," *Environmental Building News,* January 2007. http://www.ncshpo.org/PDFs/2007AM/LEED/HPandGreenBuildingArticle.pdf

Smith, Baird M, "Preservation Brief 3: Conserving Energy in Historic Buildings." Washington D.C: U.S Department of the Interior, 1978. http://www.nps.gov/history/hps/tps/briefs/brief03.htm.

U.S Department of Energy, " Trends in LEED and where do historic buildings fit in?" http://www1.eere.energy.gov/femp/pdfs/ee_historicbldgs_leed.pdf.

Van Horn, Catherine. "Downtown landmark building retains history but loses high energy bills," Oregon Office of Energy, http://www.oregon.gov/ENERGY/LOANS/docs/PublicServ.pdf

Weeks, Jennifer. "From Mold to Gold" *Preservation Magazine,* January/February 2008, http://www.nationaltrust.org/magazine/current/reporter_story.htm

Weeks, Kay D. and Anne E. Grimmer, *The Secretary of the Interior's Standards for the Treatment of Historic Properties with Guidelines for Preserving, Rehabilitating,* *Restoring and Reconstructing Historic Buildings.* Washington D.C: U.S Department of the Interior, 1995, 56-57.

Wood, Chris and Tadj Oreszcyn. *Building Regulations and Historic Buildings: Balancing the needs for energy conservation with those of building conservation*. Swindon: English Heritage, 2002.

Yuill, G.K and D.P Yuill, "A Field Study of Whole House Infiltration in Residences" Paper presented at the Excellence in Building Conference for the Energy Efficient Building Association, Denver, Colorado, October 7, 1997.