



ENERGY EFFICIENCY
FOR HISTORIC
HOUSES

A PRACTICAL GUIDE FOR
HOMEOWNERS

Making Your Historic House More
Energy Efficient While Maintaining
Its Character

Connecticut Green Bank

DRAFT

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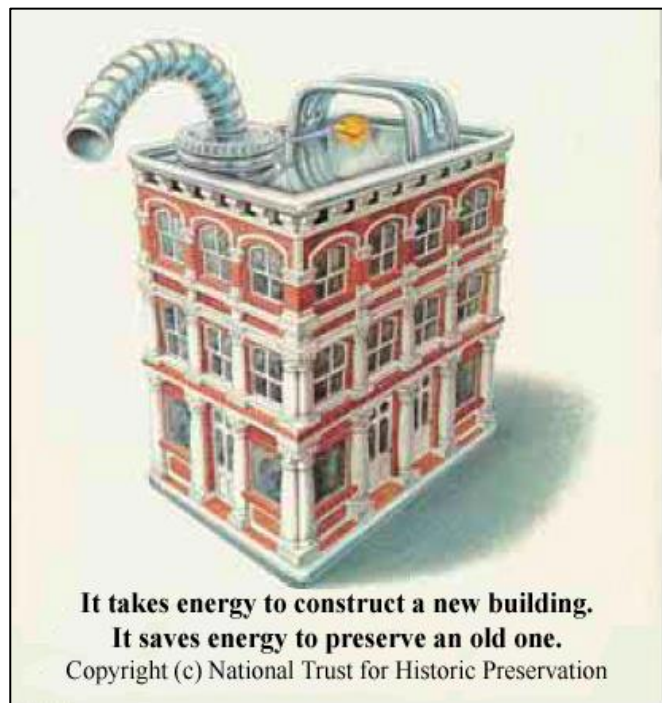
I. Introduction

Interest in environmental sustainability has been on the rise in the last decade, but what does it really mean? For many it means combating global warming or developing renewable energy sources. For others, it means recycling and reducing their travel carbon footprints. It can also mean maintaining and investing in our historic buildings so that they will continue to serve future generations. While the concepts of sustainability and historic preservation may seem at odds, they share many values. Historic preservation is about maintaining and rehabilitating old buildings, sometimes in new and dynamic ways, without compromising their historic character. As the National Trust for Historic Preservation has said for decades, “Reusing buildings is the ultimate form of recycling.” Historic preservation reduces demolition waste and retains the “embodied energy” used to construct the building in the first place, while maintaining a community’s sense of place and history.

Property owners can face real challenges when integrating sustainability measures as they try to maintain their buildings’ historic character. In Connecticut, extreme temperature fluctuations mean that almost half the year is spent producing and retaining heat, while the other half is focused on cooling. This wide range of temperatures (sometimes in the same week!) has a major impact on heating and cooling costs. Like other New England states, Connecticut has some of the highest energy costs in the country. Property owners receive marketing materials and phone calls offering to reduce their heating expenses, but often these are filled with solutions that result in undesirable and irreversible changes to historic buildings. Replacement windows, vinyl siding, spray-foam insulation, and even some renewable energy schemes can have major impacts on a historic house. What may seem like a small change could remove important historic fabric that is irreplaceable. Careful planning can help owners avoid missteps while improving the energy efficiency of their historic properties.

Whether your goal is to lower energy bills, reduce carbon emissions, increase comfort, or conserve natural resources, there are several benefits that result from enhancing your home’s overall energy performance. A well-insulated house with modern, efficient mechanical systems can save money and produce fewer carbon emissions. Similarly, the use of more efficient appliances and equipment will decrease your electricity bills, as will simple measures such as turning off unused lights and programming thermostats. Many of these Do-It-Yourself (DIY) measures can be easily implemented by homeowners and yield immediate and significant results.

A number of programs provide funding or financing for energy efficiency projects, including financial incentives for the rehabilitation of historic properties, all of which are discussed in this



guide. What is important to know up front is that these funding sources include state or federal money. That means that there may be a review process for any properties that are listed or eligible for listing in the National Register of Historic Places. This, too, is explained below. Finding out if your building is listed or eligible for listing in the National Register, or whether it is subject to local ordinances or regulations, is fairly simple, and should be one of the first steps taken before any major projects are planned. An easy rule to remember is that all properties over 50 years of age will receive at least a cursory review if state or federal funds are being used to fund energy-efficiency projects.

This guide was funded by the Connecticut Green Bank in coordination with the Connecticut State Historic Preservation Office (SHPO) to help owners of historic buildings. The focus is on historic houses, but some information may be helpful to owners of historic commercial properties. The first goal is to help you understand that integrating historic preservation and energy efficiency *can* be successful. The second is to help you figure out if your house is considered “historic,” what that means, and what the review process is for state- or federally-funded energy-efficiency upgrades. The final goal is to help you navigate the vast amount of information available on energy improvements so you can make the best possible decisions for your property. With projects ranging from weather stripping and window repair to installing renewable energy sources like solar panels and geothermal heat pumps, many historic buildings can become more energy efficient and remain vital contributors to their communities for many years to come.

Embodied energy (also called embedded energy) is the amount of energy required to extract, process, deliver, and install the materials to construct a building. Using a wood stud wall as an example, embodied energy takes into account the amount of energy used from when the tree is cut down to the point when the studs are nailed into place. This includes transporting logs, sawing timbers, kiln drying, cutting or planning to size, and transporting the finished lumber. Historic buildings have been around for a significant amount of time—enough time for their embodied energy to have “done its time.” By keeping and updating historic buildings, we conserve the materials and work energy already invested rather than spending a great deal more energy on demolition and reconstruction.

The U. S. Green Building Council reports that in 2004, almost 40 percent of carbon dioxide emissions in the United States are a result of construction, operation, and demolition of buildings.¹ Although embodied energy is difficult to quantify, it is generally accepted that it takes 20 to 30 years for most buildings to compensate for the initial energy output of their construction. The takeaway message is that the “greenest,” or most energy-efficient building, is the one that is already standing.

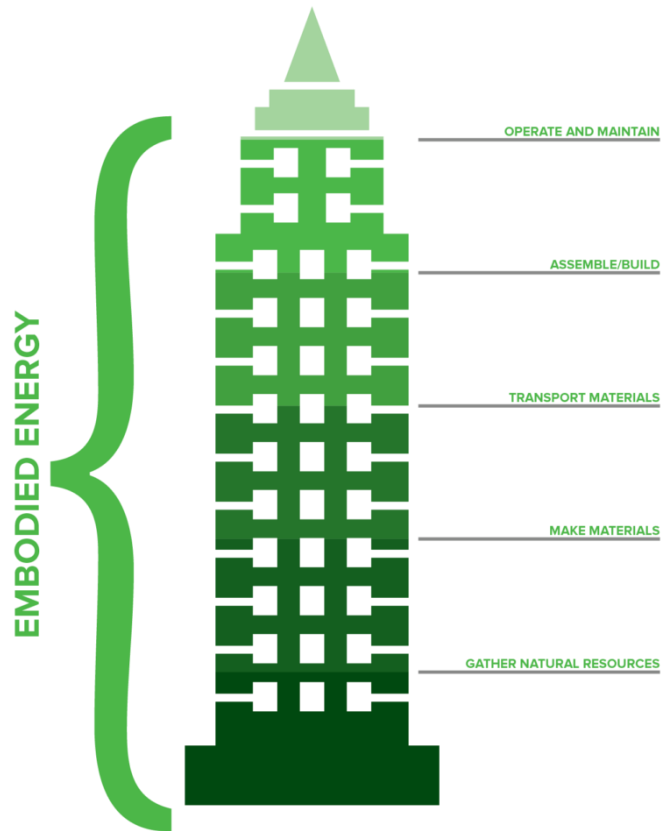


Image courtesy of U.S. Green Buildings Council

Getting Started

Regardless of your proposed project—HVAC system upgrades, window improvements, insulation, or the addition of solar photovoltaic panels—it is important to learn as much as possible about your building and to ask several basic questions before moving forward:

- What are my energy improvement goals?
- Is my building historic?
- If it is historic, how do I integrate these goals?
- What are the building’s inherent energy efficiencies and deficits?
- What features are crucial to maintain the historic character?

¹ <http://www.eesi.org/files/climate.pdf>

This guide will help you to answer these and many other questions, getting you started in gathering the information you need to plan your project.

Setting Energy Efficiency Goals

To begin, it is important to establish a set of goals for your energy improvement project. The U.S. Energy Information Administration published data in 2005 showing that residential buildings constructed prior to 1950 are approximately 30 percent to 40 percent less energy-efficient than buildings constructed after 2000. A reasonable goal is a 30 percent to 40 percent increase in energy efficiency for these buildings. While it's possible to achieve a more ambitious energy goal, it is typically more difficult for the average homeowner and would involve more invasive renovations that damage or destroy historic building components. An example of such a project can be found at the [Mallet House Deep Energy Retrofit](#)² in Freeport, Maine, projected to reduce energy costs by 69 percent.

Getting to Know Your Building

Many buildings erected before modern heating and cooling are naturally energy efficient. Thick walls, central chimneys, and placement of the building in relation to the sun's path are all examples of building practices that warmed or cooled early houses. In the nineteenth and twentieth centuries, porches provided shade and places to catch breezes, while double-hung windows allowed for cooling breezes and ventilation, reducing the need for air conditioning. It is important to make optimal use of the building's inherent sustainable qualities and ensure that new energy measures are not counterproductive. Some energy-efficient features commonly found in historic properties include:

Creating a Whole House Plan

Keep in mind that all buildings operate as a system, so you should start with a "whole house" plan. Identify and assess existing energy-efficiency characteristics. Dealing with maintenance issues prior to energy improvements is crucial for success. For example, if you have a leaky roof and add blown-in cellulose insulation to your attic, moisture may collect in the new insulation, resulting in a mold problem. Any obvious holes in walls, ceilings, or the general building envelope should be sealed prior to starting an energy retrofit on a historic house. Finally, be sure to identify any hazardous materials such as lead paint, asbestos, and mold before crafting the best plan for your building. Get to know your building by doing some basic investigations: How old are the mechanical and electrical systems? What areas are insulated, and what is the type and the condition of the insulation?

Site Orientation

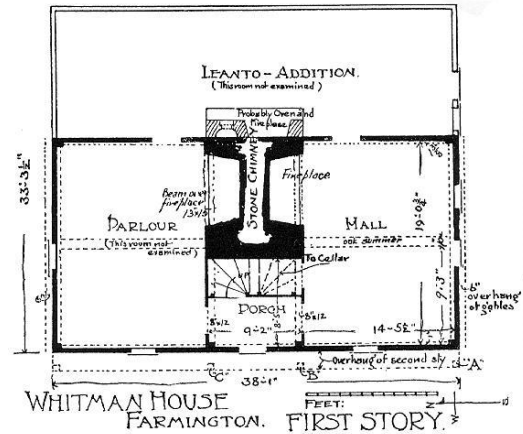
Site orientation was a major factor in the construction of early historic houses. Particularly in cold climates like Connecticut, buildings were oriented to protect them from northern winds during the winter months. Southern walls typically had more and larger windows to maximize heat from the

² <https://www.slideshare.net/petertroast/mallett-fcs-pres111611fin>

sun, while northern walls had fewer and smaller openings. Often, deciduous trees were planted on the southern side of a building to provide shade in the summer while allowing sun to warm the building in the winter. Similarly, evergreens were planted on the north side of the house to shield it from winter winds.

Plan

In New England, the floor plans of many early historic houses were designed for the cold climate. A common plan for a typical New England farmhouse had a series of small, low-ceilinged rooms around a central chimney to distribute the heat evenly. Walls and doors between rooms allowed them to be closed off when in use, conserving heat during cold weather, while keeping the rest of the house cool in warm weather. Along Connecticut's shoreline, many houses were built with deep porches to capture sea breezes, just as porches were used for ventilation in urban multifamily houses. Vestibules were also commonly used in historic buildings to provide a secondary "air lock" that reduces air infiltration between interior and exterior spaces.



Whitman House
Farmington, First Story.
Central chimney with multiple fireplaces.
Source: NPS Archives.

Roofs

Historic houses incorporate several common features in roof design depending on location and climate. Steeply pitched roofs with little or no overhangs at the eaves are common in colder climates, to allow snow to slide off freely and to increase solar gain through windows. Dark roofs also increase solar radiation. In warmer climates, wider overhangs help to minimize heat gain from the sun, and metal and light-colored roofs reflect sunlight, reducing heat gain from solar radiation.



Steeply pitched roof on the Joshua Hempstead House in New London.

Windows

Existing double-hung windows, clerestories, skylights, rooftop fan ventilators, and cupolas provide natural light and ventilation. These features all save energy by reducing the need for mechanical systems and artificial lighting. Historically, builders in cold climates limited the number of windows to those necessary for adequate light and ventilation. In historic buildings where the ratio of window to wall is less than 20 percent, the potential heat loss through the openings is minimal (see [NPS Preservation Brief 3](#)).³ Window sizes increased during the nineteenth and twentieth centuries, when energy was plentiful and cheap. As central HVAC systems became more commonplace in the mid-twentieth century, the need for functional windows lessened, particularly in commercial and institutional buildings.

Walls

Brick and stone masonry walls have intrinsic thermal features that keep buildings cooler in the summer and warmer in the winter. Thick walls reduce the rate of heat transfer through a process known as “thermal inertia.” When a thick masonry wall is warmed by the sun, it will absorb heat on the outside and slowly transfer that heat to the interior. Thermal inertia is the reason many older masonry buildings feel cool, without air conditioning, during the summer months. Heavy masonry walls reduce peak heat gains and losses, resulting in more moderate internal temperature cycles.

Identifying Historic Properties

Most people are familiar with Connecticut’s Colonial-period houses and nineteenth-century farmhouses found throughout the state, but are they all historic? What about a 1920s bungalow, or a ranch constructed in 1963? When reviewing “historic” properties for funding eligibility, it’s important to determine whether the site is eligible for listing on the National Register for historic places, State register of Historic places, or a local designation.

There are many reasons why a building may be eligible—it may be because of its architecture, its history, or even its association with a specific person or event.

National or State listing (as an individual property or as part of a historic district) does not restrict property owners from altering their buildings using private funds. However, if federal or state funds are used, then an environmental review process (described below) is used to ensure that projects will not adversely impact historic resources. Local designation has a separate process, also described below.

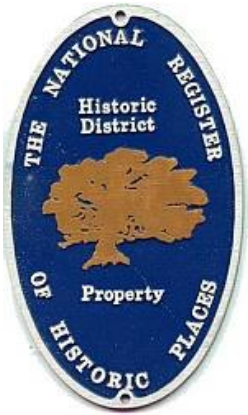
For example, when the Connecticut Green Bank supports a homeowner’s energy project using federal funds, houses over 50 years of age will receive an environmental review because a building over 50 years of age could be eligible for the National or State Register. (Occasionally, newer properties may also be listed if they are considered “exceptionally significant.”) Just because a property is 50 years old or more does not automatically mean that it is eligible. It be considered “historic” only if it is architecturally or historically significant, either as an individual property or as part of a district.

³ <https://www.nps.gov/tps/how-to-preserve/briefs/3-improve-energy-efficiency.htm>. This is one of a series of 50 Preservation Briefs that provide practical, easy-to-follow guidance for property owners on a variety of topics: <https://www.nps.gov/tps/how-to-preserve/briefs.htm>

National Register of Historic Places

The criteria used to evaluate whether a property is eligible for listing in the National Register of Historic Places are listed below.

The quality of significance in American history, architecture, archaeology, engineering, and culture is present in districts, sites, buildings, structures, and objects that possess integrity of location, design, setting, materials, workmanship, feeling, and association, and:



- A. *That are associated with events that have made a significant contribution to the broad patterns of our history; or*
- B. *That are associated with the lives of persons significant in our past; or*
- C. *That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or*
- D. *That have yielded or may be likely to yield, information important in history or prehistory.*⁴

Resources may qualify under one or more of the criteria. In addition to meeting at least one of the criteria, National Register-eligible resources must also possess “several” of the seven aspects of integrity (location, design, setting, materials, workmanship, feeling, and association). Properties can be listed individually or as a contributing resource to a historic district.

To see if a property is listed in the National Register, check the [National Park Service's NRHP Database](#).⁵ The database only contains listing up to 2013. You can contact the SHPO, which retains copies of all National Register nominations, for the most up to date information.

Connecticut[®]

Department of Economic and
Community Development

State Historic Preservation Office

The [State Historic Preservation Office](#) (SHPO) is a government entity responsible for managing the state’s historic and archaeological resources.⁶ The SHPO handles all environmental reviews, historic resource inventories, tax credits, and grant funding programs for the state. The SHPO also serves as repository for the State Register and National Register files.

⁴ See the National Register Bulletin 15: How to Apply the National Register Criteria for Evaluation: <https://www.nps.gov/nr/publications/bulletins/pdfs/nrb15.pdf>

⁵ <https://npgallery.nps.gov/NRHP>

⁶ <https://portal.ct.gov/DECD/Services/Historic-Preservation>



[Preservation Connecticut](#) is a nonprofit organization that is affiliated with the National Trust for Historic Preservation.⁷ Its mission statement: “The Connecticut Trust for Historic Preservation preserves, protects and promotes the buildings, sites, structures and landscapes that contribute to the heritage and vitality of Connecticut communities.”

State Register of Historic Places

The SHPO maintains the State Register of Historic Places (SR). The criteria for listing in the State Register closely follow that of the National Register. Connecticut’s State Register includes districts, sites, buildings, structures, and objects of national, state, or local significance. These resources possess integrity of location, design, setting, materials, workmanship, feeling, and association and:

1. *Are associated with events that have made a significant contribution to our history and the lives of persons significant in our past; or*
2. *Embody the distinctive characteristics of a type, period or method of construction; or that represent the work of a master; or that possess high artistic values; or that represent a significant and distinguishable entity whose components may lack individual distinction; or*
3. *Have yielded, or may be likely to yield, information important to prehistory or history.*



State Register listing in Connecticut does not result in any specific restrictions for homeowners, with effects to these properties receiving financial assistance reviewed in the same manner as those listed on the National Register. However, it still is important to know the architectural or historical significance of a property. A [State Register property database for the four coastal counties](#) is available now on the SHPO’s website.⁸ You can also contact the SHPO directly to check if your house is listed on the SR by

calling the Connecticut Department of Economic and Community Development at (860) 500-2300.

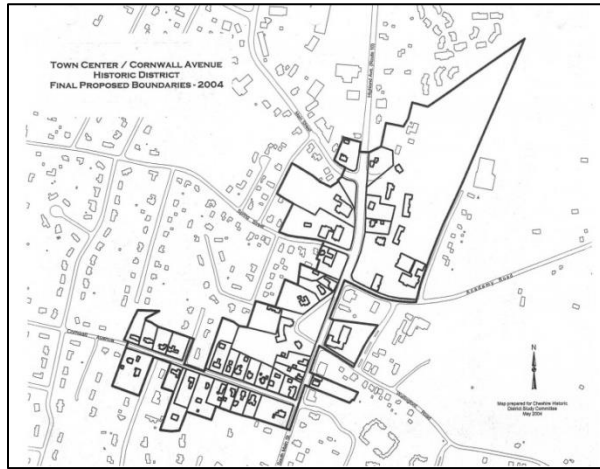
Local Historic Districts

Owners of buildings in Local Historic Districts (LHDs) are more than likely aware of the regulations or ordinances specific to that municipality. Some local historic districts are zoned differently from surrounding neighborhoods and require special permitting, or are subject to certain construction restrictions. Projects undertaken in LHDs must go through a Historic District

⁷ <https://www.preservationct.org/>

⁸ https://portal.ct.gov/DECD/Content/Historic-Preservation/01_Programs_Services/Historic-Designations/State-Registry-of-Historic-Places

Commission (LHDC) review prior to construction. If you are not sure if your property is in a Local Historic District, you can check your municipality’s website or the [CT Trust's Inventory of Local Historic Districts and Properties](#)⁹ or contact your local planning and zoning office.



Cornwall Avenue Local Historic District, Cheshire.
Source: CT Trust.

Municipal regulations for LHDs may prevent building owners from making renovations that will alter the appearance of any part of the building that is visible from the street. However, it is important to note that these regulations do NOT apply to the installation of solar energy systems unless those systems will impact the significance of the entire district.¹⁰ It is always best to consult with your LHDC before planning any kind of installation, but knowing this language up front can help make your argument for installation more effective. Additionally, understanding basic preservation standards and best practices prior to installation will make the process smoother for all involved. The Secretary of the Interior’s [Illustrated Guidelines on Sustainability for Rehabilitating Historic Buildings](#)¹¹ is an excellent resource, and the CT Trust and the SHPO are also good sources, if you need more information.

Contributing vs. Noncontributing Properties

It is also important to understand that properties in historic districts are categorized as “contributing” or “noncontributing,” and in many communities the regulations differ between the two categories. A contributing structure “adds to the historic associations or architectural qualities for which a property or district is significant,” while a non-contributing property does not. For example, if a rural district in Connecticut contains mostly nineteenth- and early twentieth-century houses and a few municipal buildings from the same period, these buildings would be considered contributing. If a modern grocery store was built in the historic district in the 1990s, it would be non-contributing.

⁹ <http://lhdct.org/maps/inventory-overview>

¹⁰ Section 7-147f of the Connecticut General Statutes states the following, “No application for a certificate of appropriateness for an exterior architectural feature, such as a solar energy system, designed for the utilization of renewable resources shall be denied unless the commission finds that the feature cannot be installed without substantially impairing the historic character and appearance of the district.”

¹¹ <https://www.nps.gov/tps/standards/rehabilitation/sustainability-guidelines.pdf>

If your property is non-contributing, alterations could still have an impact on surrounding



*Example of a noncontributing house in the Cannondale Historic District, Wilton.
Photo: NPS Archives.*

resources. For example, a 20-by-20-foot solar array placed in the front yard of a late twentieth-century house within a Local Historic District would likely be problematic. Although the house would not contribute to the historic or architectural character of the district, the solar installation would have a negative effect on the overall character of the street or “streetscape.” Again, it is always best to coordinate early and often with your LHD Commission when planning a major project.

Environmental Review Process for Historic Properties

If a house is over 50 years of age and will receive state or federal funding for a project, it is subject to review under Section 106 of the National Historic Preservation Act of 1966 (NHPA) and the Connecticut Environmental Policy Act. Many funding programs, such as the Connecticut Green Bank, use federal funds and require Section 106 review before releasing funds. Congress established a comprehensive program as part of the NHPA to preserve the historical and cultural foundations of the nation as a vital element of community life. Section 106 is crucial to that program because it requires review and consideration of historic properties affected by the multitude of federally funded projects that take place across the country every day.

The purpose of the Section 106 review is to ensure that no federal monies are used to harm historic resources. Identification of character-defining features and a general understanding of what could be considered an “adverse effect” are critical to success when introducing energy upgrades or renewable-energy projects. The Connecticut Environmental Policy Act adopts a similar process to evaluate effects to historic resources.

What is an Adverse Effect?

If a project will change the characteristics that make a property eligible for inclusion in the State or National Register (referred to as diminished integrity), that project is considered to have an “adverse effect.” Integrity is the ability of a property to convey its significance, based on its location, design, setting, materials, workmanship, feeling, and association.

Adverse effects can be direct or indirect, and include the following:

- Physical destruction, damage or alteration inconsistent with the Secretary of the Interior’s *Standards for the Treatment of Historic Properties* (these are explained below)
- Relocation of the property
- Change in the character of the property’s use or setting
- Introduction of incompatible visual, atmospheric, or audible elements
- Neglect and deterioration
- Transfer, lease, or sale of a historic property out of federal control without adequate preservation restrictions.

If a homeowner receives a notice stating that their proposed project would be an adverse effect, it does not mean the project cannot proceed. SHPO will work with applicants to come up with a solution that will meet the same goals while protecting the property’s historic character. The best way to avoid an adverse effect is to set realistic weatherization goals for a property and to plan a project from the outset with a good understanding of local guidelines and the *Standards*.

For more information on adverse effects and the Section 106 review process, see [A Citizen's Guide to Section 106 Review](#).¹² The review process for potential historic resources is straightforward and should not add significant time to the approval process. The Connecticut Green Bank takes care of the review along with the State Historic Preservation Office (SHPO). As long as the project will not result in the loss of a property’s designation eligibility, it can proceed without any issue. If the project will alter the significance of the historic building, the Green Bank and SHPO will work with the owner to try and find another way to meet the desired energy goals.

The Secretary of the Interior’s Standards: How They Apply to Your Project

The Secretary of the Interior’s *Standards for the Treatment of Historic Properties*¹³ were developed by the National Park Service to protect and preserve our nation’s historic resources. The four treatment standards or approaches provide a basic framework depending on the needs and goals of each individual project. The Secretary’s *Standards* provide guidance through which environmental review, grant funding, and other SHPO financial incentives are evaluated. Any

¹² <https://www.achp.gov/digital-library-section-106-landing/citizens-guide-section-106-review>

¹³ <https://www.nps.gov/tps/standards.htm>

program administered by the Secretary of the Interior through the National Park Service is required to use the *Standards* (including the Historic Preservation Fund).

The four treatment approaches are Preservation, Rehabilitation, Restoration, and Reconstruction, outlined below in order of preference:

Preservation retains historic fabric, especially character-defining features, through conservation, maintenance, and repair. It reflects a building's continuum over time, through successive occupancies, and maintains respectful changes and alterations.

Rehabilitation emphasizes the retention and repair of historic materials and character-defining features, but more latitude is provided for alterations necessary for continued or changing use of the property.

Restoration focuses on the retention of materials and character-defining features from the most significant time in a property's history, while permitting the removal of materials from other periods.

Reconstruction involves the recreation of a non-surviving site, landscape, building, structure, or object (or portions thereof) with new materials.

Most projects related to energy upgrades fall into the preservation or rehabilitation categories. Retention of historic materials and "character-defining features" is the key. That means making every effort to repair historic windows instead of replacing them, for example. If you know that your energy-efficiency upgrade or renewable energy project will be reviewed by your LHDC or SHPO (as a result of funding), then it is important to be familiar with the *Standards for Treatment of Historic Properties* and to follow their basic approach.

Frequently Asked Questions about Determining a Historic Property

As an owner of a historic building, what should I keep in mind when planning an energy project?

- 1) Find out if your property is in a Local Historic District. If so, be sure to consult with the municipal LHDC early on to clarify any restrictions that apply to your project. Consider projects that are reversible, rather than alterations that could permanently alter the historic fabric of your building.
- 2) Be sure to learn about your house, the mechanical systems, and their quirks. Each building is different, so if you do not feel confident doing so yourself, hire a preservation consultant. It could save time, money, and frustration if you begin with a complete understanding of your building.
- 3) Determine which improvements should be completed *first*, before other steps (for example, maintenance, followed by air-sealing and insulation improvements, before tackling renewable-energy projects). Which projects will be most efficient when paired with others? What is the payback time on each system and which are most cost-effective? Remember to develop a "whole house plan" for best results.

What are character defining features?

Character defining features include materials, design elements, finishes, and spaces that help to identify a building's use, age, and style. They include aspects of the building that can be assessed from a distance, such as a building's shape, openings, roof type, porches or other projections, trim, and setting. They also include features that are assessed at closer range, such as materials or a particular style or method of craftsmanship. Examples include ornate bracketing or trim, wood clapboard siding, wood windows and original doors; but, character defining features can include any design feature that speaks to the style or age of a



Character defining features on Lauralton Hall in Milford, CT: its asymmetrical roof, masonry walls, and porches. Source: NPS Archives.

building. For more information on identifying character-defining features, see the National Park Service's [Preservation Brief 17: Architectural Character – Identifying the Visual Aspects of Historic Buildings as an Aid to Preserving Their Character](#).¹⁴

Where can I find information about my building's original design or history?

If your house is in a LHD, members of the LHD Commission may have information related to your building. Commissioners are generally knowledgeable about local history, and they know where to find records and documents that may contain interesting information about your building. Your community may also have a historical society (or similar organization) that might have records or photographs related to your building. Depending on the age and history of your building, you may be able to dig up some interesting facts about its history, including information about traditional building methods and/or materials used. Many communities have completed a townwide Architectural and Historical Survey of historic buildings. Copies of these reports are often be available at local libraries, but you can also check the [Historical and Architectural Surveys by Town](#) at the Thomas Dodd Research Center at UCONN.¹⁵

Aren't older buildings always less efficient than newer buildings?

Not necessarily, given many of the inherent energy-saving aspects of early building design mentioned earlier, such as thick walls, central chimneys, building orientation, double-hung windows, shade, etc. If commonsense upgrades (such as air-sealing, insulation of selected areas, and new HVAC systems) have been made, and windows and doors have been properly weatherized and maintained, a historic building can be as efficient as new construction. If your house was originally heated with fireplaces and woodstoves, it was probably retrofitted with its current energy

¹⁴ <https://www.nps.gov/tps/how-to-preserve/briefs/17-architectural-character.htm>

¹⁵ <https://archives.lib.uconn.edu/islandora/object/20002%3A860267972>.

system sometime in the mid-to late twentieth century. These systems may be functioning at or near efficiency, or they may need updating. Get to know your house before you jump to conclusions about its efficiency.

As I begin to develop an energy-upgrade plan, are there passive or landscaping solutions to consider?

“Passive” energy-efficiency measures refer to strategies unrelated to mechanical systems. There are several options that could improve the passive heating and cooling properties of your building. Depending on the siting, you may be able to plant deciduous vegetation near the building to provide shade from summer sun, but allow winter sun to help warm it. It is always wise to consult with a landscape architect or Green-building professional to discuss these possibilities, since planting trees too close to a house can cause problems. Creating shade pockets near the house, through the installation of pergolas or canopies, will help to cool the yard and the house. In addition to landscaping, you might be able to install window awnings or shades (depending on local regulations), which will also help to reduce solar heat gain.

Why does my ranch built in 1963 have to go through a Section 106 Review? It’s not historic!

Hindsight is 20-20; at the time of the introduction of the National Historic Preservation Act of 1966, the fifty year rule was introduced to allow properties to be evaluated with appropriate context. If the ranch was built as part of a development that has a strong history or architectural significance, it could be eligible for listing in the National Register. An example is the Village Creek Historic District in Norwalk. This development was established in 1949 and was listed in the National Register in 2010 for its history as a racially inclusive community. The homeowner’s association encouraged a racially diverse composition at a time when such practices were uncommon and unpopular. The area is also listed for its architectural history, with several examples of Mid-century Modern houses. Village Creek is an unusual case, but it is likely that more mid-twentieth-century developments will be listed in the National Register in the years to come. While many houses dating from the 1950s and 1960s will not be considered “historic” owing to additions and/or replacement siding and windows, a cursory review is always required. These reviews are completed quickly and often go unnoticed by the homeowner. They are arranged by the lender (such as Connecticut Green Bank) and require no additional information or paperwork from the homeowner.

Resources

Secretary of the Interior's Standards

<https://www.nps.gov/tps/standards.htm>

For more information about the Section 106 process

<http://www.achp.gov/work106.html>

Connecticut State Historic Preservation Office

<http://www.ct.gov/cct/cwp/view.asp?a=3948&q=293806>

Connecticut Trust for Historic Preservation

<http://cttrust.org/>

Connecticut Trust for Historic Preservation – Local Historic District Database

<http://lhdct.org/>

National Park Service Database – National Register of Historic Places

<https://npgallery.nps.gov/nrhp>

National Park Service – Preservation Briefs

<https://www.nps.gov/tps/how-to-preserve/briefs.htm>

II. Improving Energy Efficiency

Once you have taken care of any important maintenance issues (such as a leaking roof), done some research to determine a building's historic status, given some thought to its character-defining features (such as wood windows), and identified any inherent energy-efficient features, you are ready to develop an energy-upgrade plan. This process should always start with an energy assessment, which will identify areas for improvement. Most often, there is no need for drastic measures—minor modifications can often help make a big difference to your energy savings. It is possible to check your appliance energy use without a professional; many local libraries have a household energy meter available for checkout. However, a full professional assessment will use a number of sophisticated techniques and specialized equipment to determine the best and most efficient improvements for your building. This section discusses the value of professional energy assessments, reviews typical assessment findings and recommendations, and provides funding sources for energy efficiency and renewable energy projects.

What Is an Energy Assessment?

Energy-assessment technicians determine how energy is used to heat, cool, and power a building. The technician spends several hours assessing a building and analyzing its energy performance which includes providing a blower-door diagnostics test which depressurizes your home to identify areas of air leakage. When testing is complete, the technician identifies potential problems and provides recommendations in a summary report for the homeowner. Assessment information helps owners to prioritize energy-upgrade projects and to make cost-effective decisions. An assessment provides a baseline of building performance data, so energy upgrades can be measured after completion. Historic houses often present unique challenges, and the more information provided by the assessment, the more smoothly any future upgrades are likely to go. The customer's small co-pay for the assessment is almost always recovered by implementing the recommended efficiency strategies.

Scheduling an Energy Assessment

A professional energy assessment can be scheduled through Energize Connecticut, which works with United Illuminating and Eversource to provide the assessment to their customers through two programs. The *Home Energy Solutions Core Services Program* conducts in-home energy assessments, performs HVAC and water heater safety checks, completes air-sealing, installs energy-saving lighting and water-saving products, and offers rebates and financing for more extensive upgrades. The second program is the *Home Energy Solutions Income-Eligible Program*, which provides the services mentioned above, plus a contractor who will install additional qualifying upgrades. The income-eligible program is free to those who qualify and can bring instant and long-lasting savings. For more information on these services and to sign up, call 877-WISE-USE or see the [Energize CT website](https://www.energizect.com/).¹⁶

¹⁶ <https://www.energizect.com/>

Preparing for an Energy Assessment

Once the assessment is scheduled, it is important to know what to do to prepare for the process. The team will be looking in every nook and cranny of the building, from basement to attic.

Preparation Checklist:

1. Make sure that the **building envelope** is solid. One of the most important tests during an assessment is of the building envelope. There cannot be any major holes in the walls, ceilings, floors, or exterior walls.
2. There can be no **asbestos or vermiculite present**—this includes asbestos duct or pipe wrap. Prior to 1978, many homes used asbestos to insulate furnace pipes and ducts. These must be removed by a professional remediator prior to an assessment (page 22). Similarly, if you have vermiculite insulation, the test of the building cannot be completed, since vermiculite may contain asbestos fibers that could be blown into living spaces by the test. Remediation of the vermiculite is crucial prior to the start your energy upgrade plan. If a technician comes to your house and identifies these issues, they will complete a partial assessment without completing the blower door test. A complete assessment can be rescheduled after the asbestos has been removed.
3. Clear areas near attic hatches to allow ladder access or extension of drop-down stairs.
4. **Remove belongings from knee walls, crawlspaces, or other wall access hatches to allow for inspection of these spaces.**
5. Clear areas near **combustion appliances** to ensure adequate access to all gas, propane, or oil-fired furnaces, boilers, or water heaters.
6. Remove or wet down ashes in **fireplaces and woodstoves** to prevent them being blown around during blower-door tests.
7. Close and latch all **windows and doors** and open curtains and window blinds.
8. Monitor **small children** and secure **pets**.
9. Provide the technician with copies of recent **energy bills**, showing a 12-month history, if you have them.
10. Any major issues with **mold** must be reported to the technician prior to the start of the testing. If excessive mold is found during an assessment, the blower-door test cannot occur.
11. Be sure to mention if any portion of your house has intact **knob and tube** wiring, as it could affect recommendations for wall insulation.

Expect the following questions:

- *Where are hot or cold spots in the house, if any?*
- *Does anyone living here have asthma or year-round allergies?*
- *Are there any moisture concerns?*
- *What year was the house built?*
- *What is the total square footage of the building?*
- *How long have you occupied the property, and how long do you intend to stay?*
- *Do you know the ages of your water heater, air conditioner, and furnace or boiler?*
- *Do you have any CO detectors and if so, how old are they? (5 years is life expectancy)*
- *How old are your major appliances?*

The Assessment Process

Energy assessments use special tools to evaluate the function, efficiency, and connections of the energy systems in a building. Infrared sensors are employed to find air leaks and insulation gaps. Manometers, combustion analyzers, and gas-leak detectors assess HVAC systems and water heaters to determine if they are operating at a maximum safety and efficiency. Watt-hour meters are used to monitor the performance of appliances such as refrigerators and freezers. A blower-door test identifies air leaks and measures the tightness of the building envelope. The blower door test uses a calibrated fan that is temporarily mounted in a doorway, and during the test, windows and doors are closed and the fan depressurizes the house.

The technicians may have questions, so it is important that an owner or representative be present to answer them as well as to provide access to all areas of the building. The technicians will ask if they can access your billing history, either online or by viewing copies of your utility bills.

Asbestos

Asbestos materials, such as paper pipe wrap, white duct tape, and vermiculite insulation can be found in many older homes. Asbestos was a popular material throughout much of the twentieth century, owing to its fireproofing and insulating properties. If left undisturbed, asbestos can be fairly stable, but once disturbed, the tiny fibers that make up the material can enter your lungs and cause serious health problems. If you find asbestos in your home, the best option is to call a professional to remove the material—do not attempt to remove it yourself. Technicians will look for asbestos before beginning the blower-door test. If it is found, the test will not be able to proceed, since the small particles associated with asbestos insulation can be pulled into living spaces as the house becomes depressurized.



Blower door test. Photo: Marguerite Carnell.

At the end of the process, the technicians will produce a report that includes a list of recommendations. The assessment will provide you with the information needed to develop a prioritized “whole house plan.” For example, if you plan to install a new HVAC system, the technician may suggest sealing air leaks throughout the house, as well as sealing the ductwork, to maximize performance as well as provide you with information on available rebate and financing programs.

Findings

An energy technician usually finds several easy and cost-effective opportunities to save energy. These small changes can add up to big savings over time. Recommendations for possible DIY solutions include:

Replace incandescent light bulbs with Light Emitting Diodes (LEDs). New LEDs have come down greatly in price when compared to early

models and can replace almost any bulb. They now are capable of producing a warm light that lasts (on average) 50 times longer than incandescent bulbs. Over their lifetime, they can pay back 30 times their initial cost. (In Connecticut, the technician may replace a number of bulbs as part of the assessment cost.)

Conserve electricity. It is as simple as it sounds! Turn things off when they are not in use and encourage other members of the household to do the same.

Use energy-saver settings on computers and office equipment. Shut down computers at night and set energy-saving functions to “sleep” mode if they have not been used in a while. Contrary to popular belief, screen-savers do NOT save energy.

Use power strips. Many items like phone chargers, TVs, and office equipment draw energy even when they are turned off. Over the course of a year, these “ghost” or “phantom” loads add up to a lot of money on your electricity bill. By using a power strip and shutting it off, the “ghost load” is eliminated.

Air-dry clothes. If the weather and location permit, this is often an easy way to save electricity.

Research and purchase energy-efficient appliances. Look for the Energy Star rating—tax credits or rebates are often available for purchasing Energy Star appliances. In many cases, the payback time for new appliances is short.

Adjust thermostats that control air conditioners, boilers, fans, freezers, water heaters, and refrigerators.

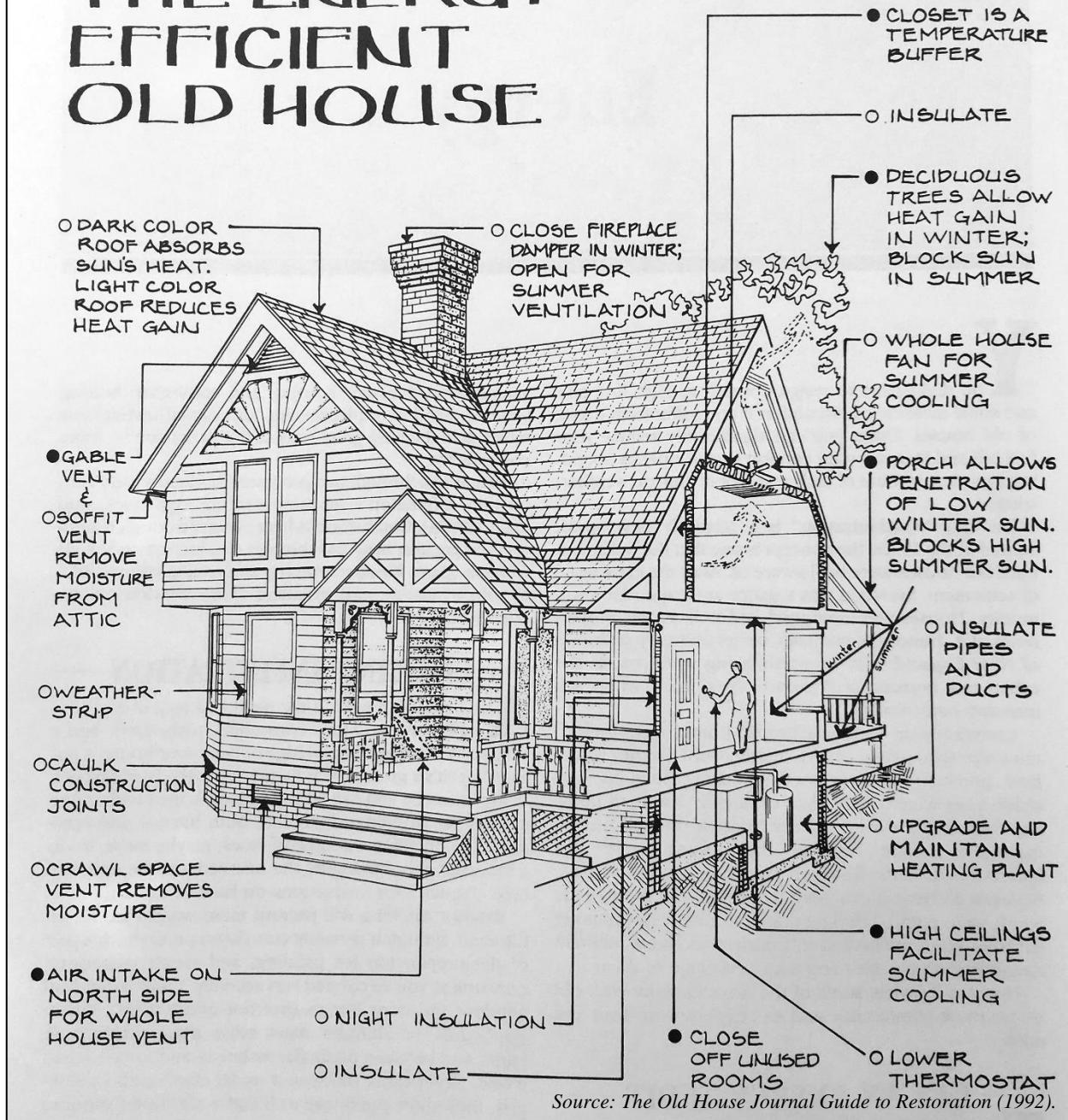
- Install modern electronic thermostats if recommended in the assessment.
- Set thermostats back a little. Just a slightly cooler or warmer temperature (even one degree Fahrenheit) can add up to significant savings over time.
- Programmable thermostats can be set to mirror your use. For example, if you are away all day, the temperature can be lowered slightly in the winter. They are easy to override as necessary.
- Fix water leaks and replace high-flow shower heads and faucets with good-quality, low-flow models.
- Insulate hot-water pipes and water-heater tanks.

According to the state-wide, non-profit organization Maine Preservation, the top three improvements with maximum payback and minimum cost are: attic insulation, weatherizing historic windows and doors, and sealing sources of air leakage. Explained briefly below, each of these improvements is discussed in-depth in their respective sections:

Insulate attics. Install at least R-38 attic floor insulation, if possible. Make sure to keep ventilation channels open between the rafters where they intersect the top wall plate. Incentives may be available through Energize CT if you complete an energy assessment in your home prior to insulating.

Repair and weather-strip historic windows and doors. The best type is draft-proof, interlocking weather-stripping made of zinc, bronze, or stainless steel. Add or tighten exterior or interior storm windows and doors with gaskets, allowing weep holes along the bottom rails to vent and drain condensed water vapor.

THE ENERGY-EFFICIENT OLD HOUSE



Seal Air Leaks and Areas of Air Infiltration. Open or poorly fitted chimney flue dampers can be a major source of heat loss, along with areas around exterior ducts, pipes, and other penetrations, attic hatches, unlocked double-hung sashes that fall open, and the joint between the foundation and the house frame (the sill plate).



Chimney before and after air sealing with mineral wool. Photos: Marguerite Carnell.

Beyond these three simple measures, there are many other ways to improve energy efficiency in older buildings. See Sections III through VII of this guide (arranged by subject), to learn more about the best practices for each type of improvement and renewable energy system.

Reversibility—Make improvements that are reversible. Newly developed materials have not been around long enough for assessment of their long-term impacts on historic materials. As a result, they may require unexpected replacement, or may damage historic fabric when removed. Spray-foam insulation is an example of a modern material with some unintended consequences; it can cause moisture problems and may even mask structural problems.

Funding Sources

Connecticut residents are fortunate to have a variety of funding options for energy-efficiency and renewable-energy projects. Two of the best online information sources for funding sources are:

Energize Connecticut, an information clearinghouse for energy-efficiency and clean-energy improvements. The website provides advice, resources, and funding as well as details on programs, rebates, financing, and contractors. Energy assessments can be scheduled from this website, and a search tool connects owners with lenders, depending on the type of project and amount of funding required. For more information, go to: [Energize CT's Find a Lender website](https://www.energizect.com/your-home/find-lender).¹⁷

Connecticut Green Bank, a quasi-public state agency that provides low-cost, long-term financing support to energy-efficiency and renewable-energy projects. It is the nation's first Green Bank to offers several financing options that link private investments with public funding. Below is a brief

¹⁷ <https://www.energizect.com/your-home/find-lender>

description of Connecticut Green Bank Funding residential programs. For more information, go to the [CT Green Bank website](#).¹⁸

The screenshot shows the Connecticut Green Bank website. The header includes the logo and navigation links: About Us, Road Map, Green Energy Solutions, Stories, News & Events, and Contact Us. A breadcrumb trail reads: You are here: Home / Green Energy Solutions / All Programs. The main content area is titled 'All Programs' and lists seven categories, each with a red plus icon: Homeowners, Building Owners, Multifamily Housing, Residential Contractors, Commercial Contractors, Towns and Cities, and Capital Providers. To the right, a 'STORIES' section features a photo of a man and a woman sitting at a table, with the text: 'Connecticut property owners are sparking a green energy movement.' Below the photo is a 'See How' button.

- **Smart-E Loans** from Connecticut Green Bank offer flexible, low-interest financing through participating lenders to help Connecticut residents make home energy improvements. Smart-E Loans are affordable, simple and quick to access. <https://ctgreenbank.com/programs/smart-e-loans/>
- Connecticut Green Bank’s **Residential Solar Investment Program** offers two incentive structures to help Connecticut homeowners go solar:
- **Expected Performance-Based Buydown (EPBB)** incentive (rebate) is available to homeowners choosing to purchase a solar photovoltaic (PV) system from an eligible contractor. Under this model, the contractor presents the rebate as an upfront cost reduction to the customer and is reimbursed by the Connecticut Green Bank when the project is complete.
- **Performance-Based Incentive (PBI)** is designed to allow homeowners to benefit from solar photovoltaic (PV) systems for little to no upfront cost. Under this model, an eligible third-party PV system owner has a contract with the homeowner. The PBI is paid to the system owner, based on actual performance over the course of six years, and is used to reduce the homeowner’s monthly cost. For more information, see www.GoSolarCT.com for [State Solar Incentives](#).¹⁹

¹⁸ <https://ctgreenbank.com/>

¹⁹ <http://www.gosolarct.com/2-Savvy-Solar-Shopper/State-Solar-Incentives>

Frequently Asked Questions about Energy Audits

I'm worried that if I get an energy assessment, I'll feel pressured to make lots of changes to my house.

If you have an energy assessment done for your house, it does not mean that you have to proceed with every recommendation. The assessment provides information, and when you are ready to start work on your house, you can do it in a well-informed, thoughtful manner. Professional assessments are always recommended, but there are ways homeowners can assess some aspects of energy use on their own. Some town libraries or facilities departments will lend out watt meters to assess the energy load of your appliances. While it will not give you as much information as a professional assessment, it is a way to get started. The following sites also offer energy calculators and additional advice on home energy assessments: [Energy.gov's Do-It-Yourself Energy Audit](#)²⁰ and [Energy Star Home Energy Yardstick](#).²¹

If I hire an energy technician, what certifications should the technician have?

In Connecticut, finding a good technician is easy because Energize CT works only with qualified contractors. All technicians have Building Performance Institute (BPI) certifications. In addition, technicians are required to disclose any financial interests they might have in the results of your assessment, since many technicians are also contractors or vendors of efficiency products.

What do I need to know about environmental hazards like radon, lead, and mold before I get started?

Radon is a radioactive gas that is naturally derived from decaying elements in the soil. It has no taste, odor, or smell, and it is a proven carcinogen in humans. Radon is prevalent in Connecticut. It usually moves from the ground beneath a building to the atmosphere, coming through cracks and gaps in the foundation and building envelope. Radon testing is simple and inexpensive, and remediation systems can be installed to effectively eliminate the problem. For more information, see the [EPA's radon website](#).²²

Lead was commonly used in house paints prior to 1978. Disturbance of lead-based paints can release toxic metals that are particularly harmful to small children. Federal law now requires that anyone performing renovation, repair, and painting projects that disturb lead-based paint in pre-1978 homes, child-care facilities, and schools follows lead-safe work practices. You should ask your contractor about lead hazards, and take the proper steps to protect your children by having them (and your house) tested. If you have a historic home, there is a very good chance that your windows and doors have been painted with lead-based paints. These areas, which produce the most friction from repeated opening and closing, need not always be removed if they test positive. There are several products that safely and effectively encapsulate impacted areas. For more information, see the [EPA's website on lead](#).²³

²⁰ <https://www.energy.gov/energysaver/home-energy-audits/do-it-yourself-home-energy-audits>

²¹ https://www.energystar.gov/index.cfm?fuseaction=home_energy_yardstick.showgetstarted

²² <https://www.epa.gov/radon>

²³ <https://www.epa.gov/lead>

Mold grows in damp and wet conditions. If your house has ventilation or moisture issues, mold may be a problem. Fixing moisture issues will usually solve any problems with mold; if the issue has been longstanding, mold remediation may be necessary. For more information, see the [EPA's mold website](#).²⁴

Resources

Energize Connecticut

<http://www.energizect.com>

Connecticut Green Bank

<http://www.ctgreenbank.com/>

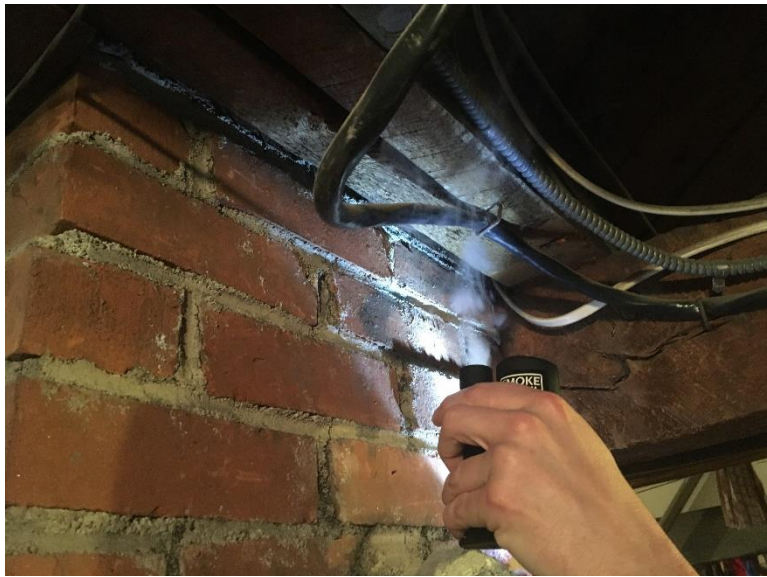
National Park Service – Preservation Briefs

<https://www.nps.gov/tps/how-to-preserve/briefs.htm>

²⁴ <https://www.epa.gov/mold>

III. Air Sealing

Reducing air leakage requires minimal changes, and it should be one of the first priorities of an energy-efficiency plan. Air leakage into a building can account for anywhere from 5 to 40 percent of heating and cooling costs. Air infiltration can be particularly troublesome in historic buildings because it can drive moisture into building materials, resulting in mold issues, peeling paint, and rotted wood. Just by caulking and weather stripping alone, it is possible to save 10 percent on energy bills! Air flows through cracks and gaps in buildings because of wind pressure, mechanical pressure, and the “stack effect,” which is air movement related to temperature and moisture differences. Outside air enters through loose-fitting windows, doors, and gaps in the building envelope, causing HVAC systems to work harder and consume more energy. For every cubic foot of heated or cooled air that leaves a building, one cubic foot of outside air enters and requires conditioning. This section reviews how to find air leaks in attics, basements, windows, doors, and other locations, along with recommended materials to eliminate them.



Smoke test to detect air leaks. Photo: Marguerite Carnell.

How to Detect Air Leaks

The first step in air sealing your historic building is to locate the gaps. The most effective way to test for air leaks is a building pressurization test—the “blower-door test”—which is completed as part of an energy assessment. Building owners can also complete their own visual inspections such as a candle test or “smoke test.” To do this, first close all of the windows and doors and turn on exhaust fans in the kitchen and bathroom (if you have them). This will create negative pressure in the house.

Next, light a candle or incense stick and hold it close to windows, doors, or any other places where you think there may be a leak. The smoke will be drawn inward by the air coming into the house.

Examine the following areas on your building exterior for gaps, particularly at joints between different building materials:

- Corners
- Outdoor faucets and utility inputs
- Joints between siding and chimneys
- Joint between foundations and siding materials
- Door and window frames

Inside the building, look for cracks or gaps at these locations:

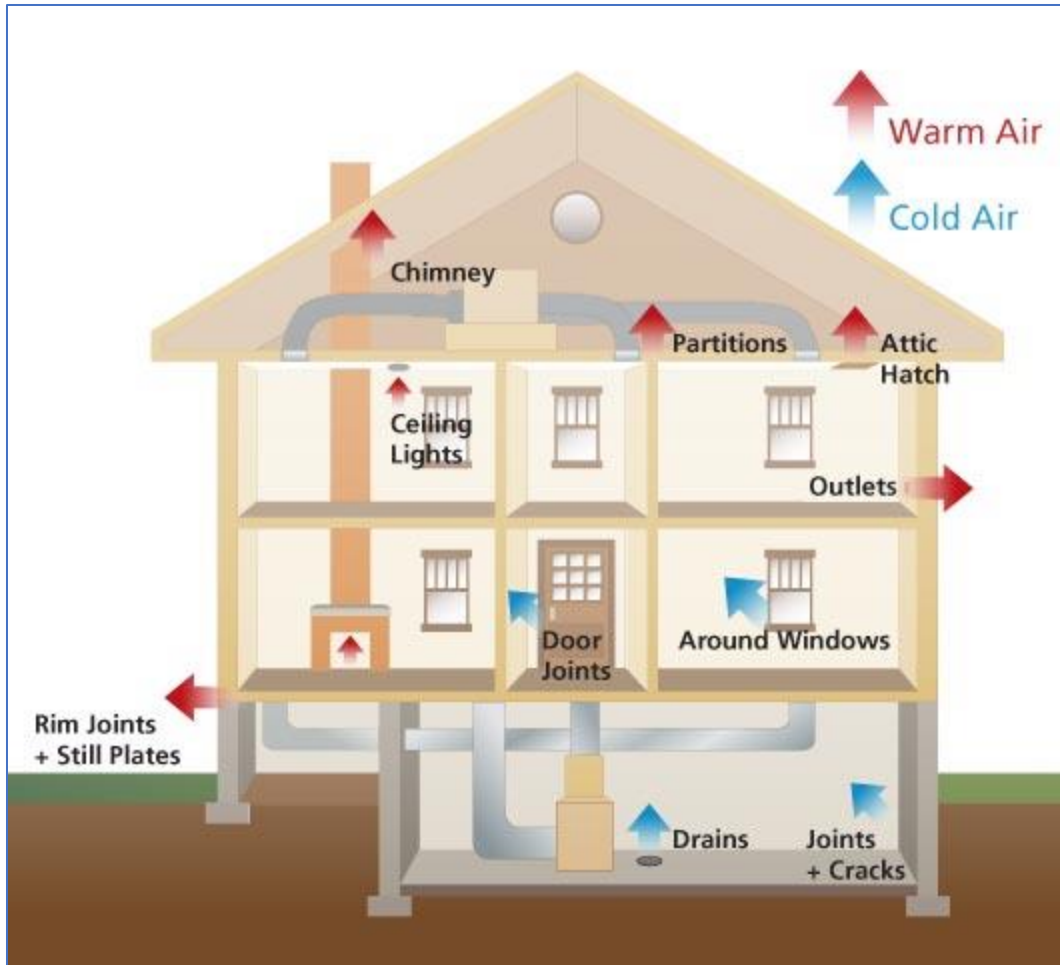
- Attic doors and hatches
- Attic and basement floors and ceilings penetrated by chimneys
- Vents (e.g., plumbing, stoves, exhaust fans)
- Corners and areas where floors, walls, and roofs meet
- Window frames
- Door frames and bottom edges of exterior doors
- Baseboards on exterior walls
- Fireplace dampers
- Wall- or window-mounted air conditioners
- Cable-TV and phone line connections
- Dryer vents
- Electrical outlets and switch plates
- Gaps around ducts, pipes, and wires leading from unconditioned basements to first floors
- Basement windows and bulkhead doors
- Electrical and gas service connections
- Basement structure: rim joists and sill plates where the first-floor structure meet the foundation

Stack Effect

One of the leading forces of convective losses (the transfer of heat in or out of buildings) is the “stack effect,” which is air movement related to temperature and moisture differences. The greater the temperature difference between the inside and outside, the stronger the stack effect. Building height also increases the stack effect. Since infiltration and exfiltration forces are greatest at the top and bottom of the building envelope, making sure that basements and attic floors are properly sealed is especially important. To put a stop to the stack effect, seal all cracks found along the top and bottom of the exterior walls, any openings between floors such as those drilled for wires or pipes, and all chases or shafts.



Stack Effect. Source: Blank Space, LLC.



Air Infiltration and Exfiltration. Source: Blank Space, LLC.

Materials and Treatment Options

With historic buildings, materials matter. The key element to look for when choosing an air-sealing treatment is reversibility—the ability to be removed without damaging historic building materials.

Some materials require solvents to remove, so be sure to read all labels carefully before beginning a project. It is also important to choose products that do not detract from the building's appearance by obscuring features, or staining or stripping historic finishes.

Caulking

Caulk is a flexible material used to seal air leaks through cracks, gaps, or joints that are less than one-quarter-inch wide.

- **Rubber caulks** are made with rubber compounds like butyl, butadiene isoprene, nitrile, and styrene. Rubber caulks have good adhesion and excellent water resistance, and they can be applied to damp surfaces. They are not appropriate for indoor use because the

solvents used to make them are flammable and dangerous to inhale. Rubber caulks are particularly difficult to tool and are extremely sticky. They will also shrink as they cure.

- **Latex caulks** are also known as acrylic or vinyl caulks. They are easy to use, can be applied to many different surfaces, and are often the least expensive option. However, many latex caulks are not as durable as silicone-based products. Some “siliconized” latex caulks contain small amounts of silicone to improve adhesion and durability. Latex caulks are easy to tool and do not pose fire or health hazards because they do not contain volatile solvents. A broad range of colors is available, and they can also be painted.
- **Silicone caulks** are completely waterproof, remain flexible at all temperatures, and adhere to a wide range of materials. They are most often used around tubs and shower stalls. Silicone is expensive and offers poor tear and abrasion resistance, so it is not a good choice in high-traffic areas. It is also generally unpaintable and difficult to tool (unless it is water-based silicone). Acetic acid, which is produced as silicone cures, can damage some metals and masonry surfaces.
- **Polyurethane sealants** are durable, abrasion- and tear-resistant, and highly adhesive. They are also waterproof and flexible, with minimal shrinkage. Most polyurethane formulations can be painted or stained. Polyurethane sealants are expensive and difficult to work with and clean up—solvents are needed for removal.

Spray Foams

Although polyurethane spray-foam sealants are frequently used for air sealing, especially in basements and attics, they are generally not recommended for use in historic houses. The reason is that spray foams are not reversible, meaning they are very difficult to remove without damage to historic building materials. Over time they can also mask developing maintenance issues, so that problems are not detected until they are more serious. Spray foams should generally be avoided in historic houses, except in small areas, such as around gaps cut for plumbing lines, for example. Off-gassing from spray foams can cause breathing difficulties if not used in areas with ventilation.

Application

The most important areas of your building to focus on air-sealing are the following:

Attics

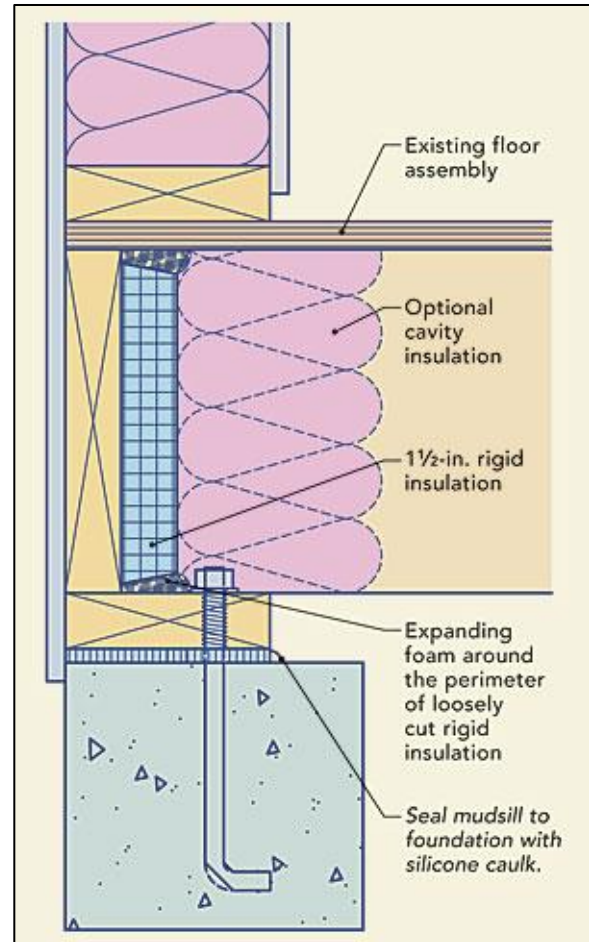
Sealing attic spaces is a priority, especially to prevent warm-air loss in cold weather. Every point of penetration in a ceiling or in the roof (fireplaces, pipes, vents, and recessed lights) should be sealed with a reversible material. To prevent moisture accumulation, be sure all exhaust fans from bathrooms and kitchens are vented to the exterior. Seal the attic door surround with weather stripping and the door itself with insulation or a ready-made foam cover, if possible. Attic air-sealing has the added benefit of preventing ice dams, the build-up of ice on the eaves of sloped roofs of heated buildings that results from melting snow under a snowpack and freezing over the eaves.

Basements

Warm air leaks out of attics, but basements and crawlspaces are where cold air infiltrates the building envelope. In many older homes, obvious issues can be found by simply turning off the basement lights during the day to see where light shines in. The most effective way to identify issues is through a professional assessment and blower test. Before sealing a basement, it is important to be sure that any combustion appliances are working properly and adequately vent through the flue or chimney. Sealing a basement too tightly can prevent harmful gases such as carbon monoxide from rising.

If basement walls are stone with mortar joints, repair of any damaged joints will fix an infiltration issues. If walls are cement, a silicone caulk can be used to seal cracks. On modern materials, rim joists can be sealed by using rigid foam insulation sealed with expanding foam. Cavity insulation can then be added behind the rigid foam.

Basement windows can be re-glazed or even covered with rigid foam if rarely used. Any door leading to the bulkhead should be well-fitted and tightly sealed with caulk or weather stripping. If there are any openings in the basement ceiling, seal them with rigid foam board or drywall and seal the edges with house wrap tape or caulk. Finally, even basement floors can let in air leaks. If the basement foundation is poured, there may be a crack around the perimeter that can be cleaned and caulked to prevent further infiltration. Any sump pump lids should have tightly-fitted lids.



Source: *FineHomeBuilding.com*.

Windows and Doors

Seasonal use of transparent plastic window insulation film, installed across window frames and sealed with hair-dryer heat for a snug, wrinkle-free fit, will help stop cold drafts and frost or condensation build-up.

Other seasonal options are rope caulk (applied by hand) or removable weather-stripping sealants (applied with a caulk gun). These products are easy to install, though they should be removed carefully to avoid paint and finish damage. Avoid using them near sash cords and chains.

There are several types of metal weather-stripping, such as spring bronze, that are appropriate for use on historic windows and doors. Some are more complicated than others, and could result in damage to windows and doors if not professionally installed. When installed properly, they require little or no maintenance to keep windows functioning with top efficiency. For the average

homeowner, the following options are better than unsightly “peel-and-stick” weather stripping, which isn’t as long-lasting and is often difficult to remove:

- **Window jamb flange weather-stripping** forms an integral seal with window sash and is found on many houses built between 1900 and 1950. It is made of zinc or bronze and often remains in perfect working order, even after more than 50 years of service. The bronze version is substantially more expensive than zinc, and can be more prone to damage if removed and reinstalled. This type of weather-stripping may be best installed by a professional.
- **Tension-seal weather stripping**, also known as V-strip weather stripping, provides an excellent seal to keep air, water, and insects out of your house. Spring bronze can be applied to door and window openings and is a durable and inexpensive material that can last generations without maintenance or replacement. This flexible V-shaped metal creates a seal by pressing against the sides of cracks. The weather stripping is usually nailed into place with small tacks. Avoid “peel-and-stick” versions of these products.
- **Felt weather-stripping** can be installed alone or reinforced with a flexible metal strip. It can be installed along and door and window surrounds with staples, tacks, or glue. It seals best if the staples are parallel to length of the strip. Keep in mind that felt weather-stripping can create moisture problems if installed in areas where water can collect.
- **Interlocking weather-stripping** is a bronze or zinc strip that is very durable and was commonly used on homes built around the turn of the twentieth century. Installation of interlocking weather-stripping is probably best left to professionals, as doors and frames must be properly aligned for the strips to interlock properly. Once in place, it will last indefinitely. [FineHomeBuilding](https://www.finehomebuilding.com/2007/04/01/interlocking-weatherstripping-techniques) has a step-by-step installation guide.²⁵

Door sweeps (also called threshold weather-stripping) are metal strips with rubber or plastic fins that are installed on the bottom edge of doors. When the door is shut, the fin forms a seal between the door bottom and threshold. See **Section IV: Windows and Doors** for more information.

Baseboards and Trim

Baseboards and trim are areas that often overlooked. In old houses, original baseboards and trim were often installed before the plaster walls. The walls were plastered up to the trim, often leaving an empty space. Many baseboards in older houses have been caulked and sealed by layers of paint, but if not, these gaps can be a significant source of hard-to-detect drafts. Use caulk to seal joints in the boards and gaps between trim and plaster.

Electrical Outlets and Switches

Electrical outlets and switches can have air leaks from wall cavities. Foam gaskets cost about 40 cents each, are easy to install, and can seal every type of outlet. They are much safer than spray foam, and are easily removed.

²⁵ <https://www.finehomebuilding.com/2007/04/01/interlocking-weatherstripping-techniques>

Do-It-Yourself Air-Sealing Measures

- Caulk gaps around doors and windows.
- Caulk and seal air leaks where plumbing, ducting, or electrical wiring comes through walls, floors, ceilings, and soffits over cabinets. Escutcheon plates often hide gaps in plumbing locations, so remove them to fill gaps and reinstall.
- Install foam gaskets behind outlet and switch plates on walls.
- Inspect dirty spots in existing insulation for air leaks and mold. Seal leaks with caulking, and repair or install house flashing if needed.
- Cover kitchen exhaust fan to stop air leaks when not in use. Plastic or metal covers in a variety of sizes are readily available online or in hardware stores.
- Check dryer vent to be sure it is not blocked.
- Keep chimney dampers tightly closed when not in use.
- Chimney flues may warp over time and can be a significant channel for air loss. Inflatable chimney balloons, made of durable plastic, can be used to seal drafty flues. They are easy to install and remove, and can be reused hundreds of times. If forgotten, the balloon will automatically deflate within seconds of contact with heat.
- Seal air leaks around fireplace chimneys, furnaces, and gas-fired water-heater vents with fire-resistant materials such as sheet metal and furnace cement caulk. Another alternative is to use a non-combustible mineral wool to seal spaces around furnaces.

Frequently Asked Questions about Air Sealing

Is it possible to make my historic home too airtight?

It is important to strike a balance between sealing air leaks to improve energy efficiency and making a building envelope too tight. Historic buildings were designed to “breathe,” and if sealed too tightly they can develop moisture problems.

Vented crawlspaces beneath the first floor are common, even in colder climates. These spaces are designed to allow air to circulate and eliminate moisture. When air-sealing your house, it is important to allow for some air circulation. If not, moisture can accumulate, attracting insects and cause or accelerate the deterioration of wood components. Installing a polyethylene vapor barrier along the perimeter of foundation walls (particularly in basements with earthen floors) and on earthen floors in crawlspaces will reduce the amount of water vapor moving through the house.

Using range hoods and bathroom fans that are vented to the outside will also help reduce moisture build up. (During your energy assessment, one of the questions asked is whether your bathroom mirrors fog up). Bathroom fans that operate automatically, based on ambient moisture levels, are now available.

Keep in mind that when air leaks are drastically reduced, mechanical ventilation could be necessary to get enough fresh air into living spaces. See [NPS Preservation Brief 39: Holding the Line: Controlling Unwanted Moisture in Historic Buildings](#).²⁶

How does moisture impact the weatherization process?

Moisture is a common problem in older homes. It causes problems such as mold and mildew, poor indoor air quality, and peeling paint. Excess moisture can even cause irreversible damage to your house, destroying plaster walls or even rotting important structural elements. Whether you know that you have preexisting moisture issues or not, you should check for and fix them prior to beginning of any renovation project—especially if the work will involve air sealing, insulation, or ventilation. Look for signs of water leakage such as discolored areas around windows and doors, spotting on walls and ceilings, visible mold and mildew, peeling paint, or flaking, damaged plaster. Also note areas that smell like mildew or mold. Check the basement, and look for areas of standing water or damp spots.

Be aware that if you seal the building envelope too tightly, a new moisture problem could develop. That is why it is essential that you contact a contractor, or other expert, who is knowledgeable about moisture management. See [NPS Preservation Brief 39](#).²⁷

My house is drafty. How can I tell where the air leaks are? How do I decide where to seal first?

It is possible that as much as 30 percent of the energy consumed by your home’s heating and cooling equipment is escaping through air leaks, so it is best to consult with a professional energy technician to find them. The energy technician will perform a blower test (described in Section II) to identify major air leaks. The technician might also walk through the house with a thermal camera, measuring the air leakage using infrared technology, making note of the places that require sealing and prioritizing them based on levels of infiltration. If air-sealing work is included in your energy assessment services, be sure that they use materials that you are comfortable with to fix the problem. Ask them to skip any measures that appear difficult to remove or irreversible (such as spray foam), and call your own handyperson to complete the task using materials that can be easily removed at a later date.

Are there contractors who have special expertise in weatherizing older buildings?

Your LHDC may be able to refer you to contractors who have experience working with historic houses, and are familiar with some of the issues that come up when weatherizing older structures. The [Preservation Connecticut Directory](#) is another useful source along with the SHPO, which maintains a list of architects and contractors who specialize in the renovation and rehabilitation of historic buildings.²⁸

²⁶ <https://www.nps.gov/tps/how-to-preserve/briefs/39-control-unwanted-moisture.htm>

²⁷ <https://www.nps.gov/tps/how-to-preserve/briefs/39-control-unwanted-moisture.htm>

²⁸ <https://www.cttrust.org/directory>

Resources

For more information on identifying and fixing air leaks visit:

Energy.gov

<https://energy.gov/energysaver/detecting-air-leaks>

Energy Advice for Owners Historic and Older Homes

<https://archive.epa.gov/region5/sustainable/web/pdf/energy-advice-for-owners-of-older-homes.pdf>

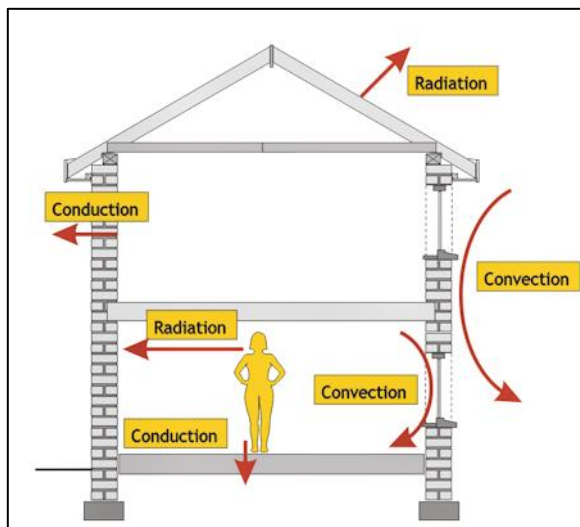
National Park Service's Preservation Brief 39: Holding the Line: Controlling Unwanted Moisture in Historic Buildings

<https://www.nps.gov/tps/how-to-preserve/briefs/39-control-unwanted-moisture.htm>

IV. Insulation

Upgrading the insulation of your house can make it more comfortable and save you money. Insulation conserves energy by reducing heat transmission. Adding attic and basement insulation to historic houses is often one of the easiest and least intrusive steps when starting a whole-house energy upgrade. Houses built before 1940 were not often insulated. If they were, many of the materials used (ranging from shredded newspaper to brick nogging) have limited efficiency that has likely decreased with age.

To understand how adding insulation reduces energy costs and improves comfort, it is helpful to understand how heat travels through the spaces in your building. Heat moves in three different ways: through conduction, convection, and radiation. It passes through solid materials through conduction; the more conductive the material, the faster the transfer of heat. Convection is the natural circulation of heat moving from warmer places to cooler places through gases and liquids. Heat moves through empty space through radiation (e.g., heat from the sun), and then that heat is



Conduction Radiation and Convection. Source: University of West England.

absorbed by materials in its path. Insulation works by slowing down heat transfer by forcing it to pass through air (or other gases), which are poor heat conductors.

Insulation's efficiency is expressed as R-value, which is a material's resistance to heat transmission. The higher the R-value, the better the insulation. R-value is typically expressed in inches. When installing multiple inches and layers of insulation, add them together to determine their total R-value.²⁹ Another aspect of insulation is its permeance, which is its ability to allow water vapor to pass through it. Permeance is expressed as a perm rating; the higher the perm rating, the more permeable the material. Permeance is important to consider when adding insulation to existing buildings.

International Energy Conservation Code (IECC)

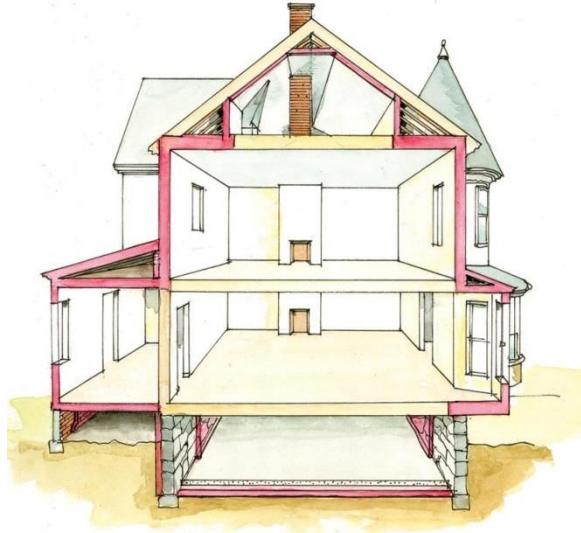
The 2012 International Energy Conservation Code (IECC), which Connecticut has adopted as its energy code, gives recommended R-values for various parts of new buildings. Existing buildings, and **buildings designated as historic, are exempted from the code**, but it is worth consulting for recommended levels of insulation for Connecticut's climate. In the IECC, Connecticut is located in Climate Zone 5. For more information, see the [IECC website](#).³⁰

²⁹ <https://energy.gov/energysaver/insulation>

³⁰ https://www.energycodes.gov/sites/default/files/becu/2012iecc_residential_BECU.pdf

Developing an Insulation Plan

The first step to upgrading the insulation in your building is identifying what types are already present, and to assess their effectiveness. The best way to do this is to have an energy assessment (see Section II). Energy assessments also include a building pressurization, or “blower-door test,” that will test for air leaks. Sealing air-infiltration leaks, as well as fixing other maintenance items such as moisture problems (see sidebar, below) should be completed before undertaking insulation upgrades.



*Where to insulate in an older house.
Source: oldhouseonline.com*

To develop an insulation strategy, consult with your energy technician or an experienced building contractor to determine which types will best serve your needs while avoiding damage to your historic building. There are many ways to insulate a building, but keep in mind that some insulation (such as dense-packed cellulose or spray foams) can be harmful to historic materials, like plaster.

Insulating several key places in historic structures—attics, basements and crawlspaces, as well as HVAC ducts and water pipes—provides the greatest benefit with the lowest risk of damage. These areas may already be insulated, but there is a good chance that if your building is over 50 years of age that the existing insulation is inadequate.

Your energy technician or building contractor can help you decide which areas to insulate, based on initial costs and returns on investment. Insulating unfinished basements and attics tend to be cost-effective because they do not involve disturbing finished construction. Adding insulation to exterior walls, however, is more invasive and can be very challenging in historic houses.

Insulation Types

Insulation is made from minerals, organic materials, or petroleum-based chemicals. It is available in a variety of forms: blanket or batts; loose fibers or granules; rigid boards; spray-applied materials; or specially made for applications, such as pipe insulation. The chart below provides an overview of insulation types, and is color-coded based on general suitability of use in historic structures. However, it should be noted that, just as every house is unique, each treatment plan, including materials and installation, will be unique to the house being insulated.

Green: Generally suitable for use in historic structures
Yellow: Caution should be used when installing in historic structures
Red: Not recommended for use in historic structures

	Material Type	R-Value per inch	Application	Comments
Blanket/Batt				
Fiberglass	mineral	R-3.2 to R-3.8	open floors, walls, ceilings	density varies
Mineral wool	mineral	R-3.2 to R-3.8	open floors, walls, ceilings	average 75% postindustrial recycled content, noncombustible
Sheep's wool	organic	R-3.5	open floors, walls, ceilings	naturally flame and pest resistant, can absorb and release moisture
Cotton fiber	organic	R-3.4 to R-3.7	open floors, walls, ceilings	recycled material, treated with borate for flame retardance and insect repellence
Plastic fiber	chemical	R-3.8 to R-4.3	open floors, walls, ceilings	made from recycled milk jugs
Loose Fiber				
Loose fiberglass	mineral	R-2 to R-2.5	open or closed floor and wall cavities	can fill irregularly shaped spaces more easily than batts
Dense-pack fiberglass	mineral	R-4.2	open or closed floor and wall cavities	can destroy wall plaster if too densely packed
Loose mineral wool	mineral	R-2 to R-2.8	floors, walls	average 75% postindustrial recycled content, can fill irregularly shaped spaces more easily than batts
Loose cellulose	organic	R-3.5	unfinished attics; walls	recycled newsprint, treated with borate for flame retardance and insect repellence
Dense-pack cellulose	organic	R-3.7 to R-4	open or closed walls, floor cavities	recycled newsprint, treated with borate for flame retardance and insect repellence; can destroy wall plaster if too densely packed
Loose Granule				
Vermiculite	mineral	R-2 to R-2.4	masonry wall cavities, historically used in unfinished attics	noncombustible, some older vermiculite contains asbestos
Perlite	mineral	R-2.4 to R-2.7	masonry wall cavities, under concrete slabs	noncombustible
Rigid board				
Expanded polystyrene (EPS)	chemical	R-3.6 to R-4.2	basement walls; exterior wall under finish materials	least expensive rigid foam, semi-permeable

	Material Type	R-Value per inch	Application	Comments
Graphite polystyrene (GPS)	chemical	R-4.4 to R-4.7	basement walls; exterior wall under finish materials	similar to EPS, graphite added to increase R-value, more common in Europe to date
Extruded polystyrene (XPS)	chemical	R-3.6 to R-5.4	basement walls; exterior wall under finish materials	semi-impermeable; subject to thermal drift
Polyisocyanurate (polyiso or ISO)	chemical	R-5.5 to R-5.7	basement walls; exterior wall under finish materials	subject to thermal drift (helped by foil facing); R-value lower in cold temperatures
Polyurethane foam panel	chemical	R-5.5 to R-6.5	basement walls; exterior wall under finish materials	subject to thermal drift, which is reduced by foil facing
Mineral wool panel	mineral	R-4 to R-4.6	basement walls; exterior wall under finish materials	flammable; repels insects; water-permeable and treated for water repellence
Expanded cork panel	organic	R-3.6 to R-4.2	exterior walls under finish materials	excellent sound insulation; more common in Europe to date
Straw	organic	R-1.4 to R-2	exterior walls under finish materials	typically 2-4" thick; faced with heavy kraft paper
Specialty				
Fiberglass	mineral	R-5 to R-6 total is best	HVAC ducts, pipes	faced with foil or paper, requires careful installation
Foam	chemical	varies	pipe insulation	available for varying pipe diameters, requires careful installation
Spray Applied (Not Recommended)				
Damp-Spray Cellulose	organic	R-3.7 to R-3.8	open wall cavities	75% cellulose, 25% water, 75-80% recycled newspaper
Spray-Applied Fiberglass	mineral	R-4.2	open wall and ceiling cavities	does not require netting; about 25% recycled content
Liquid Cementitious	mineral	R-3.9	open or closed wall, roof, ceiling cavities	made from magnesium oxide
Liquid Foam (closed cell)	chemical	R-5.5 to R-6.5	open wall and ceiling cavities, attics, hard-to-reach places like rim joist sealing in basements and top plates in attics	used for air-sealing as well as insulation
Liquid Foam (open cell)	chemical	R-2.6 to R-3.7	open wall and ceiling cavities, attics, hard-to-reach places like rim joist sealing in basements and top plates in attics	used for air-sealing as well as insulation, absorbs moisture easily

Blanket or batt insulations consist of fine fibers, often attached to a facing material that protects the fibers, holds them together, and serves as a fastening surface. Common facing materials include kraft paper, aluminum foil, and vinyl sheeting. Facing materials can act as air barriers, vapor barriers, and radiant barriers (e.g., reflective foil is a radiant barrier). The type of facing material needed will depend on where and how the insulation will be installed.



Mineral Wool Batt Insulation
Source: finehomebuilding.com.

Fiberglass batts and blankets are the most common types of insulation, made from very fine glass fibers, typically pink, yellow, or white. Fiberglass blankets come in varying densities (low, medium, and high). Depending on density, R-values range from R-3.2 to R-3.8 per inch.

Mineral wool batts and blankets are inherently fire-resistant and typically contain 75 percent post-industrial recycled content. There are two types: rock wool, fibers made from minerals such as basalt and diabase; and slag wool, fibers made from blast furnace slag, a byproduct of metal ore smelting. Mineral wool is usually gray or near-white, sometimes with black specks. Its R-values are comparable to fiberglass.

Cotton fiber batts are typically produced from recycled textiles such as denim. It costs about 15 percent to 20 percent more than fiberglass batt insulation, and its R-value is about R-3.4 to R-3.7 per inch. *Cotton batt insulation is treated with borate for flame*

retardance and insect/rodent repellence.

Sheep's wool batt insulation is capable of absorbing and releasing a great deal of water, an advantage in some installations. It has an R-value of about R-3.5 per inch. It is often treated with borates for insect/rodent repellence and flame retardance.

Plastic fiber batts are typically made from recycled milk bottles. They are similar to high-density fiberglass batts; R-values range from R-3.8 to R-4.3 per inch. They have limited availability in the U.S. at the time of this writing.

Loose fiber insulation also consists of fibrous materials that can be installed in varying densities. The most common types are fiberglass, mineral wool, and cellulose.

Fiberglass insulation can be installed as loose-fill or dense-pack. Its loose-fill R-value is about R-2.0 to R-2.5 per inch, depending on density. When dense-packed, its R-value can reach 4.2. If the density is at least 2 pounds per cubic foot, it will help to reduce air leaks as well as provide effective insulation, but it can cause problems when dense-packed inside exterior walls.

Mineral wool can also be installed as loose-fill insulation. Mineral wool's R-values are similar to fiberglass; denser loose mineral products could have an R-value up to R-2.8 per inch.

Cellulose insulation, made from recycled newsprint, consists of small gray fibrous pieces. It is treated with borates for flame retardance, mold retardance, and insect/rodent repellence. Cellulose has been used for insulation in New England for several decades. It is installed with varying densities.

Loose-pack or blown cellulose is often used to insulate unfinished attics, frequently installed over existing insulation to increase R-values. Blown-in cellulose installations typically have about 13 percent settling, so if 12 inches are needed, plan to install 14 inches. The R-value for loose-pack cellulose is about R-3.5 per inch. The quality of the installation is important—be installing loose-pack cellulose.



Installation of loose-pack cellulose insulation in an attic.
Source: Greenbuildingadvisor.com.

While it can be installed by homeowners with a rented blower machine, cellulose is often better installed by professionals. It is important to maintain an even density throughout for a consistent R-value.

Dense-pack cellulose is the same cellulose material installed with greater density. The R-value for dense-pack cellulose is about R-3.7 to R-3.8 per inch, with some claims of 4.0 per inch. When installed in open walls, a desirable density is about 3.5 lb. per cubic foot; netting keeps it in place. At 3 lb. per cubic foot it is soft; at 3.5 lb. it feels like a firm mattress; at 4 lb. it is quite hard. It can be installed in closed walls by drilling a hole at the top and bottom of each wall cavity and blowing material into each void. While dense-pack cellulose is not technically an air barrier, it will retard air flow through wall cavities.

Dense-pack fiberglass and cellulose installations are not risk-free. If plaster walls are packed too tightly, the pressure can break the “keys” that secure plaster to lath, resulting in catastrophic failure. Another potential problem is that with dense-packed insulations, wall masonry, or wood sheathing and cladding will stay colder and wetter for longer periods of time, particularly walls with many layers of old paint (which is not as vapor-permeable and flexible as newer paints). Over time, this can result in the deterioration of exterior wall materials. Vapor barriers might be recommended in some applications. It is best to consult a professional building scientist before installing dense-pack insulation.

Loose granule insulation is made from vermiculite and perlite, which are naturally occurring minerals. Vermiculite exfoliates (expands) when it is heated, becoming a lightweight material that is used as insulation and other applications. Gray or brown in coloration and sometimes glossy, the particles vary in size from grains of rice to almost an inch in length, often resembling worms. Vermiculite is treated with a water repellent for use as loose-fill insulation in wood-framed attics and walls, as well as cavities of masonry construction. Expanded vermiculite has an R-value of about R-2 to R-4 per inch. Similar to vermiculite, perlite is a naturally occurring siliceous rock that contains water. When it is heated, the water turns to steam and the perlite expands, becoming a lightweight, white material that is used for insulation inside masonry wall cavities, under concrete slabs, and other industrial applications. Its R-value is about R-2.7 per inch.

Vermiculite

Much of the vermiculite installed from the 1930s up until the 1990s was naturally contaminated with friable (brittle or crumbly) asbestos. Most was mined in Libby, Montana, and sold by the W.R. Grace Co. under the tradename Zonolite. (Check for bags that may have been left in the attic.) If a building has vermiculite insulation, it must be properly abated by a licensed contractor before blower-door testing or any work in the attic. It is not safe to simply cover vermiculite with another type of insulation.



Vermiculite attic insulation. Source: Greenbuildingadvisor.com.

Spray-applied insulations are available in a range of materials including cellulose, fiberglass, cementitious, and liquid chemical spray foams. **They are not recommended for installation in historic buildings.**

Damp-spray cellulose is used to insulate open walls, and with netting to keep it in place, in overhead cavities. It fills cavities and does not leave voids around pipes and wiring. It is treated with borate for fire resistance, which also protects it from mold as it dries. The cellulose is dampened (the ratio of water is about 25 percent of the dry cellulose weight). Generally, no binder is necessary, but sometimes is added. It takes about 24 hours to dry, before the wall can be closed up. Its R-value is R-3.7 to R-3.8 per inch, and density of 3.5 to 4.0 lb. per cubic foot (PCF) is best. Damp-spray cellulose provides both air sealing and insulation and is a good sound barrier.

Spray-applied fiberglass is a fairly new product developed as an alternative to damp-spray cellulose. Unlike cellulose, it does not require fire retardants and it can be applied to overhead surfaces. A small amount of an acrylic binder makes it adhere to surfaces, including overhead cavities. Its R-value is R-4.2 per inch, and recommended density is about 1.8 lb. per cubic foot (PCF). Spray-applied fiberglass provides both air sealing and insulation.

Cementitious spray foam is a mineral-based product made from magnesium oxide. It contains no toxic chemicals and is not flammable. Its R-value is about R-3.9 per inch. Unlike petroleum-based spray foams, it does not expand so it is less likely to over-pressurize closed wall cavities. Because it contains water, it can take longer to dry. Cementitious spray foam provides both air sealing and insulation.

Petroleum-based spray foams (e.g., polyurethane, phenolic, polyisocyanurate) consist of several compounds that are mixed on site; chemical reactions create the foam. They are available with “closed cell” and “open cell” formulations, which refer to the types of bubbles that they contain. The difference in cell structure can only be seen under a microscope. Depending on the type of foam, its thickness, the climate, and local building codes, vapor barriers may be required with spray-foam installations.

Closed-cell foams contain bubbles with fully formed walls, like cells or balloons. The cells are formed by blowing agents, such as carbon dioxide, pentanes, or hydrochlorofluorocarbons (HFCs). These gases increase R-value, but they are gradually replaced with air over time, resulting in “thermal drift,” which is a drop in R-value. Closed-cell foams have a firmer texture than open-cell foams and do not readily absorb moisture. Their initial R-value is about R-6.0 to 6.5 per inch.

Open-cell foams contain bubbles with openings, which allow the blowing agent to dissipate over time and to be replaced by air, which serves as the insulator. Open-cell foams have lower density,

resulting in a softer texture and a lower R-value than closed-cell foams, but they are better for sound absorption. They absorb and release moisture readily, with a permeance rating of up to 30-35 perms per inch. Their R-value ranges from R-3.5 to R-3.7 per inch. Open-cell foams are often used in conditioned attics.

Spray-foam insulation products can be problematic in historic buildings for several reasons. The first is that they expand as they cure, which can pressurize wall construction and damage historic materials. Another is that some (especially closed-cell types) will block the passage of moisture, which can cause it to collect within walls and cause damage. Equally important is that it is extremely difficult to remove and therefore doesn't qualify as a "reversible" treatment.

Environmental and health concerns with liquid spray foams

The brominated flame retardant HBCD is a persistent organic pollutant that is subject to a phased ban in Europe. Uncured MDI, a spray-foam component, and related polyisocyanurates are under an EPA action plan because they can cause lung problems. Long-term health effects are unknown.

Rigid board insulation is available in several types of petroleum-based rigid foam (EPS, GPS, XPS, ISO, and polyurethane), as well as several mineral-based and organic materials (mineral wool, expanded cork, and straw). The three most common types of rigid foam insulation are expanded polystyrene (EPS), extruded polystyrene (XPS), and polyisocyanurate (polyiso or ISO). They range from half an inch to 2 inches in standard thicknesses and can be ordered in greater thicknesses. They are available in faced or unfaced panels. Some rigid foam boards (particularly XPS and polyiso) lose a percentage of their R-value over time because of "thermal drift," as the low-conductivity gas in their cells is gradually replaced with air. Check manufacturers' warranties, which range in coverage from 80 percent to 100 percent of stated R-value.

Expanded Polystyrene (EPS) is the least expensive rigid foam insulation, typically white in color. The cells contain air (rather than a low-conductivity gas), and R-values tend to remain more stable than XPS or polyiso foam boards. EPS traps moisture less than XPS. It is mostly used as the main insulation in a building assembly; e.g., structural insulated panels and insulated concrete forms, as well as roof decks. EPS is also the most vapor-permeable option; one inch has a permeance of 2.0 to 5.8 perms, making it semi-permeable. Its R-value is 3.6 to 4.2 per inch, depending on density.

Graphite Polystyrene (GPS) is expanded polystyrene with graphite added to increase R-value, which gives it a gray color. GPS was developed in Europe and is more common there than the United States, to date. Its permeance is between 2.5 and 5.5m, depending on its density and thickness. Its R-value ranges from R-4.4 to R-4.7 per inch.

Extruded Polystyrene (XPS) has higher compressive strength and water resistance than EPS, so it is more often used to insulate foundation walls and to insulate slabs below grade. It is semi-impermeable; one inch has a permeance of 1.1, and 2 inches has a permeance of 0.55. Along with polyiso, XPS is also specified by architects for above-grade insulated sheathing. Its R-value is R-5 per inch. Depending on the facing material of the foam boards, XPS can be subject to thermal drift.

Note that polystyrenes have environmental concerns. The brominated flame retardant HBCD, which is used in polystyrenes, is a persistent organic pollutant that is subject to a phased ban in Europe. *Polyisocyanurate (polyiso or ISO)* has an R-value of R-5.7 per inch at room temperatures, but less (closer to R-4.5) in colder temperatures. It is the only insulation product that performs worse in lower temperatures than in higher temperatures. Manufacturers are working to improve cold-weather performances, so these numbers are subject to change. Polyiso can be subject to thermal drift. For example, an initial R-value of R-9 per inch would likely drop to R-7 per inch within two years; after that, it would likely remain at R-7. Reflective foils seem to reduce the likelihood of thermal drift. Along with XPS, polyiso used for above-grade insulated sheathing.

Polyurethane foam panels have an R-value of R-5.5 to R-6.5 per inch. Like polyiso, closed-cell polyurethane can be subject to thermal drift unless faced with reflective foil. Polyurethane foam is often used for structural insulated panels (SIPs) for walls and ceilings.

Alternatives to rigid foam insulation include expanded cork panels and mineral wool panels. Cork is the bark of a type of oak tree, primarily grown in Portugal. Expanded cork has been used in rigid insulation boards for many years in Europe. It is not inexpensive, but it is one of the “greenest” insulation products available, and it also provides excellent sound insulation. Expanded cork insulation has an R-value of about R-3.6 to R-4.2 per inch. Mineral wool panels are suitable for use below-grade and for exterior insulation, between siding and wall sheathing in lieu of rigid foam. It is not flammable, and it tends to repel termites and carpenter ants. Mineral wool is treated for water repellence; the boards are water permeable and have an R-value of R-4.0 to 4.6 per inch.

Another, less common alternative is straw (typically available in panels 2 to 4 inches thick and faced with heavyweight kraft paper). Realistic straw panel R-values are R-1.4 to R-2 per inch.

Where to Insulate

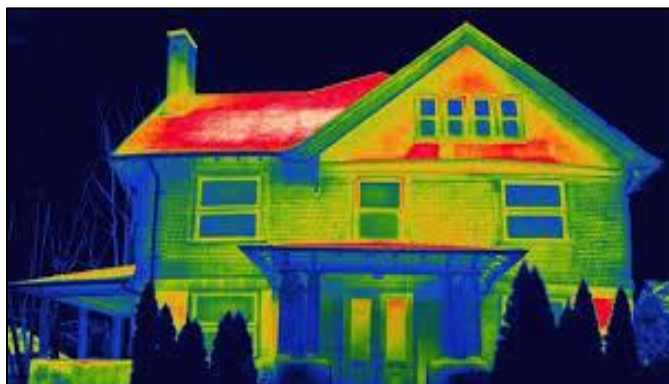
The insulation project and insulation type best suited to your home should be determined after undergoing a professional energy assessment. Insulating a few key places in historic structures such as attic spaces, crawlspaces, basements, around heating and cooling ducts and/or water pipes, provides a significant benefit with a low risk of harm to historic features. Insulating walls is a more invasive project and should be undertaken with the help of a professional to maximize efficiency and minimize potential damage to the historic fabric of your building.

Attic Insulation

Reducing heat transfer through the roof or attic should be one of the first steps in improving energy consumption. Adding insulation in unfinished attics is highly effective in improving comfort and reducing energy costs, is generally easy to install, and has minimal impact on historic building materials. Before beginning an attic insulation project, check for air leaks, water infiltration, or areas of deterioration. If a major repair or total roof replacement is required, rigid foam insulation can be installed on top of the roof deck before laying the new roofing material. This can be an effective solution on low-pitched roofs; however, the installation of rigid foam board should not alter the appearance of the intersection of the roof and eaves, dormers, or other architectural features.

The most effective place to install insulation is below existing attic floorboards. After any gaps are sealed, either blown-in cellulose or fiberglass batt insulation can be laid between the joists. The

National Park Service recommends using cellulose insulation treated with borates (as a fire retardant) instead of ammonium or aluminum sulfate, since sulfates can react with trapped moisture to create sulfuric acid. This can cause damage to wiring or plumbing as well as stone, brick, or wood.³¹ Installing batt insulation is often a “do-it-yourself” measure, but local contractors can also be found to do the job on the Energy Star website. If you choose to undertake this project yourself, be sure to follow the manufacturer’s instructions when insulating near chimneys, recessed light fixtures, and any wiring.



Thermal image showing heat loss through the attic. Source: ecohome.net.

In unfinished and unheated attics (“unconditioned” space), the insulation material (blown-in cellulose, batt, or rigid foam insulation) is typically placed between the floor joists. When using fiberglass batts faced with a vapor retarder, the vapor retarder should always face down, toward the heated interior.

If batt insulation is being added over existing insulation that is near or above the top of the joists, new unfaced batts should be placed perpendicular to the old ones to cover the top of the joists and reduce

thermal bridging (transfer of cold or heat) through the frame members. In buildings where installing batt insulation is difficult because of insufficient space, blown-in insulation may be a better choice. Unfinished attics must always be properly ventilated to allow excess heat to escape. Blocking the soffit, ridge, or gable vents may result in moisture issues.

What about moisture?

The issue of moisture in insulated spaces is the subject of much debate. While there is no way to predict all moisture problems, especially in historic buildings, experts seem to agree on a few basic tenets. Exterior materials in insulated buildings become colder in the winter and stay wet longer following a rain event. While the wetness may not pose a problem for robust materials, it may speed the deterioration of some building materials and lead to more frequent maintenance such as repainting of wood or repointing of masonry. Summer moisture problems are most commonly associated with excessive indoor cooling and the use of interior wall finishes that act as vapor retarders (paint buildup or vinyl wall coverings). Good air-sealing at the ceiling plane usually controls moisture in insulated attics.

Most problems are caused by poor moisture management, poor detailing which does not allow the building to shed water, or inadequate drainage. Therefore, a thorough assessment of the building’s ability to keep out unwanted moisture must be done before adding new insulation materials. See [Preservation Brief 39: Holding the Line: Controlling Unwanted Moisture in Historic Buildings](#)³²

³¹ National Park Service, *Preservation Brief Number 3 Improving Energy Efficiency in Historic Buildings*.

³² <https://www.nps.gov/tps/how-to-preserve/briefs/39-control-unwanted-moisture.htm>

for more information. Because of all the uncertainties associated with insulating walls, brick walls in particular, it may be advisable to hire a professional consultant who specializes in the many factors that affect the behavior of moisture in a building and can apply this expertise to the unique characteristics of a particular structure.

Sophisticated tools such as computer modeling are useful to predict the performance of building assemblies, but they require interpretation by a skilled practitioner and the results are only as good as the data entered. It is important to remember, there are no reliable prescriptive measures to prevent moisture problems (from [NPS Preservation Brief 3](#)).³³

When mechanical equipment and/or ductwork is installed in an attic, it is considered “conditioned” space. In conditioned spaces, insulation should be installed on the underside of the roof. While doing so increases the volume of the building’s thermal envelope, this treatment can prevent problems caused by condensation on the mechanical equipment and allows the equipment to operate more efficiently.

When insulation (typically fiberglass batt or rigid board) is installed under the roof in conditioned spaces, all vents in the attic and the intersection between the walls and roof rafters must be sealed. Rigid foam or batt insulation placed between the roof rafters is a common method of insulating the underside of a roof.

Blown-in or batt insulation should not be placed around old wiring. All knob-and-tube wiring should be removed and replaced prior to any insulation project. If you are unsure, it is best to have an electrician check the insulation on your wiring to see if it meets code.

Even in finished attics where there is no access to spaces under the floors or under the ceiling, it is possible to improve efficiency by air-sealing and adding insulation to knee walls or any other unfinished spaces. Trap- or access doors should also be insulated because they can be responsible for substantial heat loss. Kits specially designed to seal and insulate attic entries can be found at most major home-improvement stores.

Heating Duct Insulation

Fiberglass insulation is used to insulate ductwork. It is available in thickness ranging from 1 to 2 inches, with paper or foil facings; foil is a better choice because its reflectivity helps maintain treated air’s temperature. Choose an R-value of 5-6 or higher. It should be cut to fit snugly and carefully taped (using tape recommended by the insulation manufacturer), to fit without gaps, so that outside moist air cannot cause condensation in the ductwork, which can lead to mold and mildew problems. New insulation can be installed over an existing layer of insulation, as long as it is in good condition. It is important to check that the ductwork is tightly sealed with mastic before insulation is installed.

A newer product for spiral ducts is a wrap made of plastic bubble-pack in foil facing, lighter and thinner than fiberglass, with an R-value of R-5.6.

³³ <https://www.nps.gov/tps/how-to-preserve/briefs/3-improve-energy-efficiency.htm>

Pipe Insulation

Pipes can be insulated with fiberglass (faced with foil or vinyl), or with elastomeric foam tube products. Fiberglass wrapping needs fiberglass blankets and PVC fitting covers at elbow joints. For foam pipe insulation, miter the foam corners at piping elbows and tape them carefully, using tape recommended by the insulation manufacturer. With either type of insulation, sealing all joints carefully will maintain a vapor barrier and prevent condensation.

Vapor Retarders (Barriers): Vapor retarders are commonly used in modern construction to manage the diffusion of moisture into wall cavities and attics. For vapor retarders to work properly, however, they must be continuous, which makes their installation difficult in existing buildings, and therefore generally not recommended. Even in new construction, installation of vapor retarders is not always indicated. Formerly, the recommended treatment was to install a vapor retarder toward the heated side of the wall (toward the interior space in cold climates and toward the exterior in hot climates). The U.S. Department of Energy now recommends that if moisture moves both to the interior and exterior of a building for significant parts of the year, it is better not to use a vapor retarder (from [NPS Preservation Brief 3](#)).³⁴

Basement Insulation

Adding insulation to basements and crawlspaces can result in energy savings, but moisture can make it a challenge. Special consideration should be taken to resolve all moisture issues (which could involve installing exterior or interior drainage) prior to insulation. In older houses, basement walls can be earth, brick, fieldstone, cement or concrete (or any combination), which are all susceptible to water infiltration. To begin, make sure that foundation walls are in good condition. Properly sealing and pointing stone or brick walls will reduce drafts and moisture transfer. In instances where walls are simply too permeable and cannot be insulated, insulation can be installed on the basement ceiling.

Like attics, basements can be unconditioned or conditioned spaces. An unconditioned basement is an unheated space with no significant heat-producing appliances or devices, where the only heat comes from the living spaces above. In these spaces, the basement ceiling structure should be insulated to keep heat in the living space. Keep in mind that once the ceiling is insulated, the basement will be colder in the winter. All water pipes and ducts should be properly insulated, particularly those near the perimeter walls.

Blanket (batt and roll) insulation, rigid foam board, and blown-in or loose-fill insulation are all suitable for basement ceiling installations in older houses. Unfaced fiberglass batts or blankets installed between the first-floor joists are also easy to install. They are held in place with wire, fishing line, or spring-metal supports called “tiger claws.” Rigid foam insulation can also be attached to the underside of the first-floor joists, which lessens the effect of thermal bridging. All gaps between the unconditioned and conditioned areas of the building, including the band joists, should be air-sealed to prevent unconditioned air moving into the living spaces above.³⁵ Loose-fill or blown-in cellulose can also be used and is highly effective, but can be difficult to install without a professional.

³⁴ <https://www.nps.gov/tps/how-to-preserve/briefs/3-improve-energy-efficiency.htm>

³⁵ The band joist is located around the building perimeter and encloses the end of the floor joists. The band joist and the exterior siding are all that stands between the basement interior and the outdoors.

A conditioned basement is one that is heated, either intentionally or through the presence of mechanical equipment such as a heating system or water heater. If the basement is finished or intentionally heated, the temperature will be close to that in the living space. In a basement heated only by equipment, the temperature can range somewhere between that of the living space and the outdoors. In either case, the objective should be to contain whatever heat is there by insulating the basement walls.

If your house has concrete basement walls, wood framing can be installed along with fiberglass batts between the studs. Alternatively, several inches of rigid foam insulation board can be installed directly against the concrete wall. The insulation should extend below the frost line (the depth to which the ground freezes in winter) or to the basement floor. Above-grade walls in the basement should be insulated with fiberglass batts or rigid board insulation. Keep in mind that interior wall insulation will not prevent moisture from entering the basement. If the perimeter drainage is poor, the insulation may become wet from moisture seeping through the foundation walls. The best way to insulate brick or stone basement walls is to make sure that they are as sound as possible. Inspect mortar and repair and replace any loose or missing joints, and do not add insulation materials.

In basements with exposed earth floors, ground moisture can enter the building envelope. Consult your contractor or a building professional to determine the best option to manage moisture. Some common recommendations include pouring a concrete slab or installing a vapor barrier (usually a heavy-duty polyethylene sheet). In all instances, running a dehumidifier can help alleviate moisture issues in basements.

Exterior Walls

Wall insulation in historic houses must be evaluated as part of a “whole house” plan to improve energy efficiency, and should only be considered after insulation of attic and basement spaces. Wall insulation is controversial. Some preservation experts believe that it is unnecessary and more often than not damages the building rather than improving it. Even the least-invasive methods, such as blown-in cellulose or fiberglass, can have a catastrophic effect on plaster walls, including, but not limited to:

- Breakage of keys
- Cracks in walls, and/or
- Total detachment of wall sections from lath

if not installed properly. It is important to determine whether wall insulation can be added without causing significant damage or loss of historic materials, like removing historic plaster walls and woodwork. The loss of historic fabric needs to be weighed against short term energy savings. Ultimately, the addition of wall insulation is only a small portion of a whole house energy plan, and, like window replacements, its use should be carefully evaluated.

Wall insulation can be difficult to install properly. Insulating walls may require a contractor, but the added expense is worth it since proper installation is crucial. Historic construction is not formulaic—there are often firestops, blocking, or chases where cold pockets can remain. Once insulation is installed, these uninsulated areas can create thermal bridges where cold pockets may cause moisture to condense. With moisture comes the increased possibility of mold, mildew, and decay. It is important to address any problems with moisture prior to beginning a wall insulation project.

Wood-framed walls typically include a cavity that slows the transfer of heat between the interior and exterior of a house. Uninsulated historic wood-framed buildings have a higher rate of air infiltration than modern insulated buildings, which keeps interior wall assemblies dry. When insulation is added, wall cavities are susceptible to moisture damage because water vapor can condense in them, much like water on the side of a cold glass. Moisture can ruin insulation and damage wood framing. The proper use of air and vapor barriers will help to solve or prevent these problems.

There are many factors, such as condition of building materials and climate that influence how added insulation will impact air flow. Although unusual in northern climates, walls built without sheathing between the siding and studs can let in moisture through cracks in the joints. In these cases, added insulation could become damp from wind-driven rain or capillary action. In colder climates, the production of moisture from cooking or bathing in living spaces can also cause problems when it diffuses into walls and condenses. As moisture collects, it can cause loose-fill insulation to settle at the bottom of the wall cavity. As each situation is unique, consult your insulation manufacturer for the proper placement of air or vapor barriers. Wherever possible, be sure to install fans or vent hoods to ventilate properly kitchens and bathrooms.

After any moisture-related issues have been identified and solved, wall insulation can be considered. Dense-pack or blown-in fiberglass insulation is recommended for existing wood-framed walls because it generally causes the least amount of damage to historic materials and finishes, it carries a high R-value, it is cost-efficient, and it is moisture-permeable.

Cellulose insulation is also commonly used in historic homes, but as noted above it should be used with great caution in plaster walls. The pressure needed to blow the insulation into the wall cavity can cause expansion of the wall cavity, resulting in damage to plaster or other historic finishes. Be sure to use cellulose insulations that are free of sulfates, which can deteriorate and damage historic framing connections. Use “borate only” insulation (which is treated only with boric acid).

Blown-in insulation requires access to the wall cavity through the interior or exterior wall surface. If historic interior finishes like plaster or wood paneling are in good condition, the wall cavity should be accessed from the exterior. Siding boards at the top of each wall cavity can be removed to blow in the insulation material, or individual wood shingles can be removed. These methods avoid the need for drilling holes in the exterior walls.

The use of batt or rigid foam insulation in walls is not recommended if historic finishes remain intact, because installation requires extensive access to the wall cavity. Historic siding and interior finishes should not be removed to install insulation because even if it is done with care, it will result in some damage. In cases where interior finishes are beyond repair or have already been removed, unfaced batt insulation that fills the entire wall cavity is recommended. Unlike blown-in insulation, batt insulation does not create an air seal. Batt insulation must be installed with no air gaps left between structural members. Empty spaces can result in convection, while unevenly installed batts can create air pockets that are cold spots. In either case, thermal performance is greatly reduced. Batt should be split for installation around ducts, pipes and wiring, rather than compressed. The band joist area between floors should be insulated as well, equal to or greater than the R-value of the insulation in adjacent wall cavities. Other options for walls that have already been opened include damp-spray cellulose and spray-on fiberglass insulation.

Rigid foam insulation should not be added to the exterior of historic wood-frame buildings, since this would require removal of the existing siding and trim. Even if the materials could be removed

and reapplied without significant damage, the relationship between the walls and the windows, eaves, and trim would be altered. This change would compromise both the appearance and the architectural integrity of the historic building.

Spray-foam or foamed-in-place insulation is generally not recommended in historic buildings. Despite advantages such as ease of installation and high R-value, spray foam is problematic for several reasons. It obscures the method of construction, it can trap moisture, and the foam bonds tightly to building materials, making reversibility almost impossible.

Masonry walls pose different problems when it comes to insulation. Moisture is a more complex problem with masonry walls because they can absorb moisture, especially from rainfall. The amount of absorption varies depending on the type of masonry; soft brick absorbs more than granite. Masonry walls dry both toward the exterior and the interior. When insulation is added to the interior side of a masonry wall, it can cause the wall to stay wet for longer periods of time and cause moisture problems.

Before insulating a historic masonry building, be sure that it is in the best condition possible. Repoint as needed and replace damaged materials in kind. Make sure all moisture-removal systems are intact and functioning, such as gutters, flashing, and drip moldings, to keep as much moisture as possible away from wall surfaces.

There are two basic types of masonry walls: solid walls, and masonry veneer walls with internal cavities. Adding insulation to the interior side of a solid masonry wall decreases its ability to transfer heat between the interior and exterior spaces. This means that the exterior may stay warmer in summers or colder in winters. This can lead to larger swings in the freeze-thaw cycle, which in turn may cause wall components to expand and contract at a faster rate, leading to potential deterioration.

Buildings with masonry veneer and internal wall cavities generally date from after 1900. The wall cavities provide a thermal break between interior and exterior temperatures and were built with systems in place to avoid moisture problems. Internal drains, known as weep holes, were installed in cavities to allow moisture to drain to the exterior. Even with drainage systems and thermal breaks, masonry walls with interior cavities can be susceptible to problems related to “over-insulation” if proper vapor and air barriers are not maintained. All insulated masonry walls should be monitored periodically for moisture problems.

Frequently Asked Questions about Insulation

Should I remove the old insulation in my building?

That depends on the type of insulation that is in your building and its condition. If you have vermiculite or other asbestos-based insulation, it should be removed and remediated by a professional. If your insulation has lost efficacy because of settling in a wall or floor cavity, then it may not be necessary to remove it. If there are no moisture issues or problems with vermin, then new insulation can be added without removing the old material. If the old material has mold or mildew, then it should be removed and the moisture problem solved before new insulation is added.

I have exposed ledge in my basement. Does that change my insulation or air-sealing options?

Exposed ledge (bedrock) could mean that there is radon in the basement. You should have radon levels assessed and mitigated, if necessary, before proceeding. Ledge is also a direct conduit for groundwater to enter your basement. Many building scientists have found that the best solution is a polyethylene ground-moisture barrier, sealed above the ledge, which is then foamed with insulation. Make sure your contractor knows about the ledge in your basement, and ask them to explain how the ledge affects the insulation plan.

How does moisture impact the weatherization process?

Moisture is a common problem in older houses. It can lead to mold and mildew, poor indoor air quality, and peeling paint. Whether or not you know that you have moisture problems, you should *definitely* check prior to the beginning of any renovation project. This is especially true if the work will involve air-sealing, insulation, or ventilation. Be aware that if you seal the building envelope too tightly, that your home could develop a new moisture problem. It is essential to have a contractor or other expert who is knowledgeable about moisture management.

Look for leaks around windows and on ceilings, peeling paint, and discoloration or warping of materials. Note any areas that smell musty or like mold or mildew. In the basement, look for areas of standing water, wetness on the walls and damp spots, which might not be present at the time of your contractor's visit. By informing your contractor of problem areas, you can work together to formulate the best insulation strategy for your house. Every building will be different based on moisture issues and energy-improvement needs.

If I install additional attic insulation, will I need to install wall insulation to achieve the projected energy savings?

In this case, one solution does not presuppose the other. Many owners of older houses with original plaster and lath in place find it prohibitively expensive to retrofit wall cavities with insulation. About half the heat loss in the average home is from the attic and basement, and insulating these spaces is cheaper and less problematic than wall solutions. In many situations, attic insulation can be installed to a level of R-40 or greater, achieving bigger energy savings for less money than a typical wall insulation retrofit. Additionally, there is the possibility that installing wall insulation will require the removal or damage of historic wall materials. Ask your contractor to help you understand your home's unique circumstances.

Resources

Adding Insulation to an Existing House

<https://web.ornl.gov/sci/buildings/tools/insulation/r-value/existing/>

Barry, Nancy E. “7 Insulation Tips to Save Money & Energy,” *Old House Online*, 2011

<http://www.oldhouseonline.com/articles/7-insulation-tips>

Carroon, Jean. *Greening Existing Buildings*, Hoboken, New Jersey: John Wiley & Sons, Inc. 2010, p. 401.

Energy Star’s A Do-It-Yourself Guide to Sealing and Insulating with Energy Star

https://www.energystar.gov/ia/partners/publications/pubdocs/DIY_Guide_May_2008.pdf

Energy Star’s Rule Your Attic Program

https://www.energystar.gov/newhomes/rule_your_attic

Forsyth, M. *Historic Building Conservation: Structures and Construction*. Oxford (U.K.): Blackwell Publishing, 2007, p. 37.

Energy.gov’s Insulation Materials

<https://energy.gov/energysaver/insulation-materials>

Lord, Noelle “Co-Existing with Energy Efficiency.” *Old House Journal*, October 2007.

National Park Service’s Weatherizing and Improving the Energy Efficiency of Historic Buildings

<https://www.nps.gov/tps/sustainability/energy-efficiency/weatherization.htm>

National Park Service’s Preservation Brief 39: Holding the Line: Controlling Unwanted Moisture in Historic Buildings

<https://www.nps.gov/tps/how-to-preserve/briefs/39-control-unwanted-moisture.htm>

Energy.gov’s Where to Insulate in a Home

<https://energy.gov/energysaver/where-insulate-home>

Yapp, Bob. Myths About Insulating Old Houses

<http://bobyapp.com/blog/2009/06/myths-about-insulating-old-house-walls>

Zimmerman, Sally. Energy Costs in an Old House: Balancing Preservation and Energy Efficiency.

https://static1.squarespace.com/static/56b74bc427d4bd8d3cff12f6/t/56dbff51356fb0dac9d8ad5e/1457258321349/Energy_Costs_in_an_Old_House_Balancing_Preservation_and_Energy_Efficiency.pdf

V. Windows and Doors

Windows

Windows are among a building's primary character-defining features. They are often romantically described using a reversed idiom as the "eyes to the soul" of a building. A well maintained historic window properly fitted with a corresponding storm widow has a comparable insulation factor as an insulated window unit. According to the National Park Service's [Preservation Brief 9: The Repair of Historic Wooden Windows](#)³⁶ windows are considered historically significant if they:

- Are original to the building; or
- Reflect the original design intent for the building; or
- Reflect period or regional styles or building practices; or
- Reflect changes to the building resulting from major periods or events
- Are examples of exceptional craftsmanship or design

On a more basic level, windows admit light into interior space, provide fresh air and ventilation to the interior, provide a visual link to the outside world, and enhance a building's physical appearance. Windows can begin to wear over time, but there are a number of strategies that can be employed to repair rather than replace historic windows. This section explains why it is better to repair than replace historic windows and doors; discusses DIY strategies versus work that requires professionals; and how to choose appropriate replacements when the originals have already been removed.

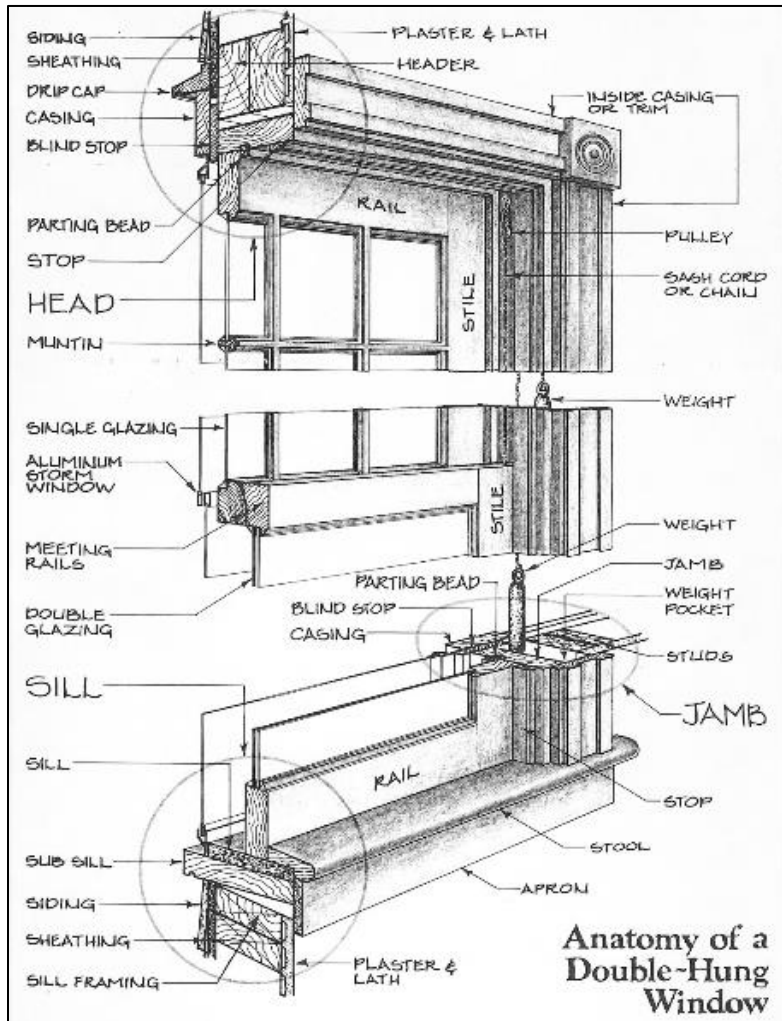
The earliest houses in Connecticut had casement windows, which hinged at the side to open. Single- and double-hung sash windows were introduced at the beginning of the eighteenth century. Connecticut has a wide range of architectural styles: Colonial houses built in the late seventeenth through the late eighteenth centuries; Greek Revival, Gothic Revival, Victorian, Queen Anne, and other eclectic revivals of the nineteenth century; Colonial Revival houses from the late nineteenth century through the mid-twentieth century, as well as Mid-century Modern houses. Windows and window trim contribute to the identification of each one of these styles. For instance, pointed arches indicate the Gothic Revival style, while Colonial Revival windows are often seen in pairs or triplicate, with small panes of divided light meant to mimic 18th century glass. Each of these styles may have windows and doors that are specific to that style or time period.



Double-hung windows on a Gothic Revival cottage, Suffield. Photo: Lucas Karmazinas

³⁶ <https://www.nps.gov/tps/how-to-preserve/briefs/9-wooden-windows.htm>

Why it's Better to Repair than Replace Historic Windows



Source: *Old House Journal*.

The National Park Service's Technical Preservation Services Division, Preservation Connecticut, and the Connecticut State Historic Preservation Office all recommend keeping and repairing original windows whenever possible. Repair and weatherization of old windows is a practical solution: Windows that are repaired and properly maintained will function efficiently with a few simple modifications. Preserving historic windows means preserving an important element of your building's historic significance while expending less energy and keeping materials out of landfills. The [New England Window Restoration Alliance \(NEWRA\)](http://www.windowrestorationne.org/)³⁷ is a trade organization that helps educate building owners, architects, preservationists, and others about the value of original windows.

³⁷ <http://www.windowrestorationne.org/>

Here are their “top 10” reasons (lightly edited) why it is better to keep your historic windows:

1. Because you really can save 30 percent to 40 percent on heating costs without replacing your old windows. The estimated first-year energy savings between a restored wooden window with a good storm window vs. a replacement window was 60 cents, according to the *Field Study of Energy Impacts of Window Rehab Choices* conducted by the Vermont Energy Investment Corporation, the University of Vermont School of Civil and Environmental Engineering, and the U.S. Army Cold Regions Research and Engineering Laboratory. That is less than a dollar for what is often a multi-thousand-dollar job. Small maintenance issues such as broken glass, failed glazing, no weather stripping—these repairable items are what have the most impact on energy efficiency in old windows.

2. Because your windows were designed to fit your house. Windows in historic houses were designed to match the style of the building, the trim, etc. The windows have expanded and contracted with the seasons for many decades. With proper weather stripping, historic windows can be made to fit and seal even better. Replacement windows have a rigid structure that fits within your existing window openings. Old houses move and shift over time, and frequently the gaps that open up around replacement windows result in more drafts, rather than increased energy efficiency.

3. Because you appreciate good craftsmanship. The true mortise-and-tenon construction of wood windows is incredibly strong, and even when it begins to weaken, it is easily repaired. Many unique window shapes were created because of craftsmanship with wood joinery. Similarly, steel windows, popular in some Revival-style houses from the 1920s and 1930s, were also built to last.

4. Because old windows were constructed using old-growth timber. Old-growth wood is much denser and more weather-resistant than the softer farmed woods available today. Because of old wood’s density, even delicate muntin profiles can be maintained without aluminum cladding.

5. Because antique glass has character. Even the glass in antique windows tells a story. It may be roundel or cylinder glass, each indicating a certain era of manufacturing. Old glass has pleasing variations of color and texture. While it is true that two layers of glass are more energy efficient than one, in a historic house the second layer of glass should be the storm window that protects the original window.

6. Because you think a warranty should be more than 20 years. Chances are your windows have done their job for 50 or more years already. Sure, they may be a little creaky and may not be as attractive as they once were, but it is a far better investment to repair a proven performer than to sink money into a new window that only has a 20-year warranty at best. With proper repair and maintenance, your antique windows could last another 100 years.

7. Because vinyl is not the best choice for your house. The production of polyvinyl chloride (PVC) is damaging to the environment, and the gases it emits during its lifecycle have been shown by the EPA to be a health hazard. In the case of a house fire, PVC will release toxic levels of dioxin.

8. Because you want more light. Replacement windows are set into the window opening, and the sash is smaller than the originals. This results in a reduced viewing area and less light.

9. Because windows are a functional part of your house. Weights and pulleys are the best balance systems ever invented. There is a common myth that a lot of cold air comes in through the weight pocket. If there is cold air in the weight pocket, it is generally because there is a gap between the outside trim of the house and the siding. It may also indicate a poor seal at the floor joists. These

issues can easily be fixed. Replacing easily serviceable weights and pulleys with vinyl jamb liners or invisible balance systems means installing a system that has a maximum lifespan of 10-20 years. Old windows will open and close easily with one hand—when they are restored to the way they were designed to work.

10. Because as the National Trust for Historic Preservation has been saying for decades, the greenest building is one that is already built. Replacement windows are pushed as a quick fix and an easiest way to save energy. However, when the entire production, shipping, installation, and removal processes are taken into account, replacing windows consumes a lot of energy. Viewed another way, an older building has a great deal of embodied energy. If the total energy expenditure to manufacture replacement windows is considered, the breakeven period stretches to 40-60 years. Repairs and restoration work are done by local craftspeople paying local taxes. They use a minimum of materials and resources and a maximum of labor. Restoring windows is the best way to make use of existing materials and an excellent way to support the local economy.

Lead

Lead-based paint was commonly used on building exterior and interior surfaces until 1978. Lead improved paint durability, and it was used as a white pigment. Lead paint is not dangerous when painted surfaces remain intact, but when it begins to chip or peel—which happens frequently on friction points of windows and doors—it can be a serious health hazard if lead dust is inhaled or chips are ingested. But just because you have windows and doors with lead paint does not mean that you need to replace them. It just means that you have to be “lead smart.” There are several state and federal laws governing lead abatement. Before beginning any work, consult the [Connecticut Department of Public Health on Lead Poisoning Prevention and Control Program](#), which features a video showing how to work safely with lead in older houses as well as resources and a list of qualified contractors.³⁸ For more information on how to deal with lead paint, see the EPA’s [Lead Renovation, Repair and Painting Program Rules](#).³⁹

DIY Strategies

Easy (and Reversible) Ways to Improve Energy Efficiency:

- **Window draft stoppers (“snakes”)** can be used to stop drafts along the sill edge.
- **Insulating cellular shades** and curtains are one of the least intrusive measures that can be taken to reduce window drafts.
- Basement and attic windows that do not require visibility can be covered with a piece of **foam board**, cut to size, and glued to ¾-inch drywall. The boards can be easily removed as necessary.

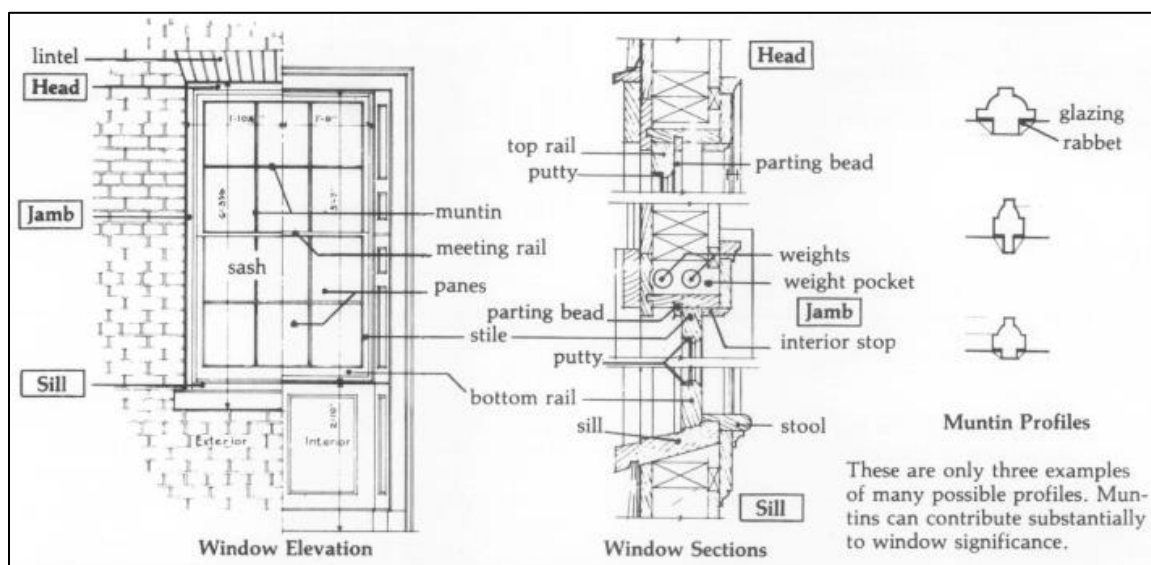
³⁸ <https://portal.ct.gov/DPH/Environmental-Health/Lead-Poisoning-Prevention-and-Control/Lead-Poisoning-Prevention-and-Control-Program#47067>

³⁹ <https://www.epa.gov/lead/lead-renovation-repair-and-painting-program-rules>

- **Transparent plastic window insulation film** can be applied with double-sided tape and sealed using the heat from a hair dryer. This inexpensive film will help stop cold drafts and frost or condensation buildup.
- Seasonal options are **rope caulk** (applied by hand) or **removable weather-stripping sealants** (applied with a caulk gun). These products are easy to install, although they should be removed carefully to avoid paint and finish damage. Avoid using them near sash cords and chains.
- **Window draft seals** can be installed on double-hung windows at the meeting rail/parting bead junction, to seal what is often the largest gap. They are small, unobtrusive bronze plates with a felt gaskets. They will fit most double-hung windows, are easy to install, and leave windows operable.

Basic Maintenance is also a logical step to improving the energy efficiency of historic windows. The average handy person can employ the following measures to keep older windows functioning for many years. A list of resources is included at the end of this section.

- Keep the exterior surfaces painted, including the glazing putty. Paint extends the service life of wood and putty by protecting them from the elements. Horizontal surfaces where water collects are particularly vulnerable and should be monitored regularly.
- Spot-repair glazing putty as needed, and re-glaze the entire sash when you see that it has dried out. Glazing putty is meant to be periodically replaced.
- Keep the sash sliding freely by keeping movable surfaces, such as the inside jamb, free of paint buildup.
- If your sash are hung with cord, keep the cords free of paint to retain the window's operability. Cord will eventually dry out and break, but can easily be replaced. Missing window weights can be replaced to rebalance the sash when cords are replaced.



Source: NPS Preservation Brief 9: The Repair of Historic Wooden Windows.

Work that May Require a Professional

Metal Weather Stripping. There are several types of metal weather-stripping, such as spring bronze, that are appropriate for use on historic windows and doors. Some are more complicated than others, and could result in damage to windows and doors if not professionally installed. When installed properly, they require little or no maintenance to keep windows functioning with top efficiency. See **Section III: Air Sealing**.

Interior Storm Windows. Install interior storms when exterior storm sash would obscure especially attractive windows, or for casement windows. Interior storms are usually made of Plexiglas (for safety) set in a frame, which attaches to window sash with small magnets or fabric hook and loop fasteners. (Sometimes screws are used, but they are not recommended since they can damage old windows.) Drawbacks to interior storms include: window access (they are difficult to open quickly for ventilation or safety purposes); there is no exterior protection of the prime sash; and condensation can become trapped between the storm and the window sash, which can cause damage. Appropriate gaskets must be used to ensure condensation buildup. (Check with your local hardware store to find the correct one.) Removing the interior storm windows after the winter season also helps to avoid condensation problems.

Interior storm windows can be highly effective when installed and monitored correctly. A growing number of companies are specializing in interior storms, and some hardware stores and glass companies will custom-make them to fit your windows.

Exterior Storm Windows. Adding exterior storms is an excellent way to improve energy efficiency. They are reversible (easily removed without damaging the old windows or the building), and they are easier to install and less expensive than replacement windows. Storm windows also avoid insulated replacement windows' problems with seal failures, which causes chronic fogged glass.

Storm windows provide additional insulating air space and an added barrier to air infiltration. Using clear, non-tinted low-E glass in storm windows can further increase thermal performance. Storm windows must be tight fitting and include a sealing gasket around the glass. During installation, storm windows must be caulked around the frame to reduce air infiltration (without blocking weep holes, which allow rain and condensation to dissipate). To be visually compatible, multiple-track storm windows should align with the primary windows' meeting rails and match the sash color.

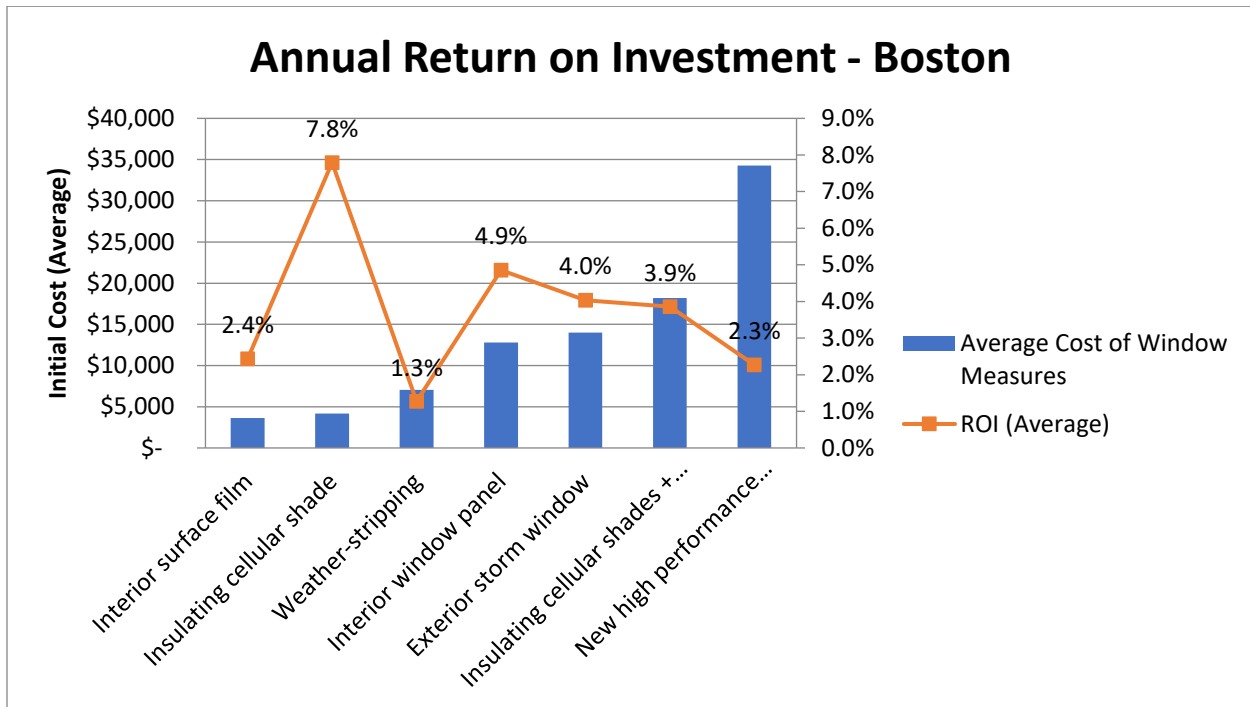
Triple-track aluminum storms are frequently used on older houses. Most do an adequate job of preventing air infiltration, but older sash used cam locks to tighten the frames rather than relying on integral weather stripping. These cam locks tend to have a long operating life. Older storms that were manufactured using thin-pile weather stripping often need to have the pile replaced. Replacing glass and screens in a storm sash is economical, and there are many hardware stores and glass companies that specialize in this work. However, if both the screen and glass are beyond repair, it usually makes sense to purchase new storm window sash.

There is also growing interest in traditional wood storm windows because wood frames transfer less heat than aluminum storm windows.

The Myth of Replacement Windows

As stated at the outset of this chapter, together with a good storm window, a well maintained single-glazed historic window can have about the same thermal performance as a typical new vinyl window. A 2010 Boston-area study determined that a typical double-hung wood window, combined with a low-E storm window, had a similar thermal performance to a vinyl replacement window—and a much lower life-cycle cost over a 100-year period.

There is tremendous market pressure on homeowners to replace their windows—telephone calls, emails, flyers, and kiosks in local malls all offer “tremendous energy savings” and “increased comfort” from new windows. These claims are often misleading.



For more information, see the Nation Park Service’s [Sustainability Research](https://www.nps.gov/tps/sustainability/research.htm).⁴⁰

Last Resort

Windows are among the most significant character-defining features of historic buildings. Their replacement is irreversible, and the replacement costs are often higher than repair or restoration. Once historic windows are dumped in a landfill, they are gone forever, and many owners are left with regret over the changed appearance of their house. Clearly, the more sustainable choice is to maintain and upgrade existing windows whenever possible.

If repair is impossible due to their condition, replacement windows may be considered. If window sash are severely deteriorated but the frames are repairable, then replace just the sash. It is important that replacements match historic windows in size, design, number of lights (panes) in each sash, muntin profile, and glass color and reflectivity.

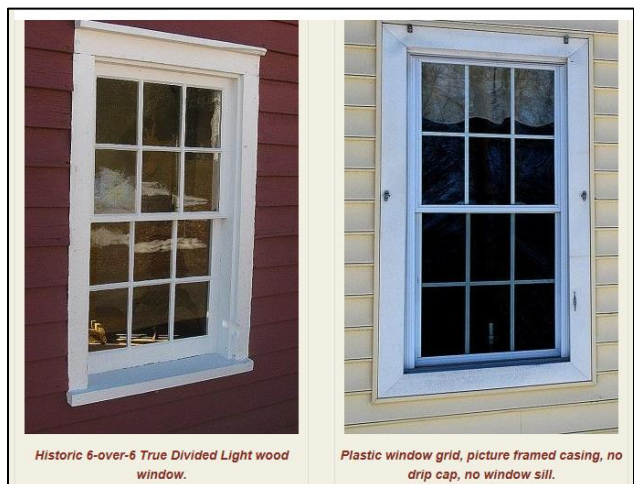
⁴⁰ <https://www.nps.gov/tps/sustainability/research.htm>

Keep in mind that even high-quality replacement windows typically have wider rails and stiles than historic windows, so the size of the glass lights is often reduced. Most insulated windows are difficult to repair. The lifespan of insulated glass units (IGUs) depends on the quality of the seal and other factors, but it is unrealistic to expect more than 25 years. Once the seal fails—causing the window to become cloudy—the entire sash will usually need to be replaced, since repairing the seals is expensive (if not impossible).

When Replacement is the Only Option: Choosing Appropriate New Windows

When choosing an appropriate replacement window, it is important to note the guiding principle of the Secretary of the Interior’s *Standards for Rehabilitation*, which states:

“Deteriorated historic features shall be repaired rather than replaced. Where the severity of deterioration requires replacement of a distinctive feature, the new feature shall match the old in design, color, texture, and other visual qualities and, where possible, materials. Replacement of missing features shall be substantiated by documentary, physical, or pictorial evidence.”



Historic vs. Replacement Window. Source: Old House Guy.

The location of the window is a key factor in determining how critical it is to match the original. Windows on a building’s street-facing façade may be more important than those on a rear elevation, hidden from street view. Windows on the lower levels of a tall building, clearly visible from street level, may be more crucial than upper-story windows. On buildings where the interior finishes are as important as the exterior (such as individually-listed National Register of Historic Places properties), interior details should be replicated to match the original, including

hardware. The operation of historic windows is an important factor in their design and appearance, and it is best for replacement windows to operate in the same manner.

Factors to consider in evaluating the match of a replacement window:

- **Location of window unit in relation to the wall.** The location of window sash within a wall affects a building’s three-dimensional appearance, creating highlights and shadows that are subtle—yet important—elements.
- **Window frame size and shape.** For a wood window, this would include the brick mold, blind stop, and sill. In industrial and commercial buildings, curtain wall windows have so little frame exposed that any replacement window options necessitate some addition to this dimension.
- **Glass size and divisions.** Traditional divided-light windows are always preferred, but the National Park Service says that muntins reproduced as simulated divided lights—consisting of a three-dimensional exterior grid, between-the-glass spacers, and an interior grid—may provide an adequate match when the dimensions and profile of the exterior grid

are equivalent to the historic muntins, and the grid is permanently affixed tightly to the glass.

- **Sash elements' width and depth.** With wood windows, this includes the rails, stiles, and muntins; with steel windows, it includes operator frames and muntins. The depth of the sash, the muntin size and shape, and the alignment of the stiles and meeting rails all have a major impact on a window's appearance.
- **Sash materials and finishes.** Choice of material affects finishes profiles, dimensions, and details. Vinyl-clad or enameled aluminum-clad windows may have conspicuous joints in the cladding, very different from painted wood windows. Secondary window elements (such as white vinyl tracks) that do not match window finish or color can also weaken the match.
- **Glass characteristics.** Color, clarity, and reflectivity all vary in old glass. These characteristics should be matched as best as possible. Old glass tends to be less reflective than new glass. (When coatings are used to enhance the color of new glass, they can add to its reflectivity.) Opaque or translucent glass may be replaced with clear glass as long as some evidence of the historic glazing remains, either in parts of the window or in selected units. Insulated glass is generally acceptable for new windows, as long as it does not compromise other important aspects of the window sash.

Replacement Windows Where No Historic Windows Remain

In buildings where windows are missing, or buildings that have non-historic replacement windows, re-creation of the absent historic windows is not required to meet the Secretary of the Interior's Standards. The appearance of the replacement windows should, however, fit the general characteristics of a historic window of the type and period. In selective cases, this may be accomplished using substitute materials (such as aluminum-clad wood). When receiving financial incentives from the State Historic Preservation Office, replacing existing incompatible, non-historic windows with similarly incompatible new windows does not meet the Standards and is generally not acceptable, although occasionally LHDCs will accept such replacements in-kind.

Doors



A typical Connecticut River Valley Doorway, South Windsor. Source: SHPO Archives.

A front door is usually the focal point of a building's façade, and is often the first feature encountered by a person experiencing a historic home. Like windows, homes constructed in distinct architectural styles have character-defining features expressed in their doors: Colonial-era houses of high style often have ornate surrounds, such as a swan's neck pediment, Greek Revival Doors are often multi-paneled, with a transom above and sidelights on either side, Italianate often have a pair of rounded arched door with deep recessed panels, and Colonial Revival entries can incorporate many or all of these features to create a bold, central statement. Whenever possible, historic doors should be maintained. Insulated replacement doors might have higher R-values, but doors represent such a small percentage of a building envelope that actual energy savings of replacements are minimal. There are several strategies that can make historic doors more energy efficient:

- Regular Maintenance of doors and frames (including filling small cracks and painting).
- Weather-stripping can be added to close gaps and minimize air leaks. Bronze and zinc weather-stripping are the most durable options. See **Section III: Air Sealing**.

Storm doors can improve the thermal performance of older doors, particularly during Connecticut's winters. It is important that the design of the storm door is compatible with the historic door. A fully glazed storm door with a frame that matches the color of a historic door is often appropriate. It might not be appropriate to install a storm door on a highly significant entrance door; original features will be hidden. Keep in mind that a storm door can add significant heat gain on southern and western exposures, which could eventually damage the historic door itself.

Frequently Asked Questions about Windows and Doors

Where can I learn more about how to fix historic windows myself?

The Preservation Connecticut periodically runs wooden window restoration workshops. Check their [Events](#) to see when the next workshop is scheduled.⁴¹

Several training videos provide step-by-step window repair instruction for owners of historic houses. They are available on YouTube and are approved by the National Park Service.

[Simple Steps to Working Windows](#) are a series of how-to videos produced by the Michigan Historic Preservation Network.⁴²

[Wood Windows: Sash Cords Repaired with Mike Goans](#) is produced by the Kansas Historical Society, and demonstrates how to repair missing or broken sash cords.⁴³

Should I replace my windows as part of my energy-efficiency upgrade?

No. If you have wood or steel windows dating from the mid-twentieth century or earlier. Historic wood windows are made from old-growth wood, which is denser and more durable than the wood available today. Window replacement is generally not cost-effective; replacement windows are expensive, and the amount of energy saved takes a long time to pay back. Historic windows contain a significant amount of embodied energy, and the environmental life-cycle costs of replacement are high. There are many ways to improve the performance of your historic windows, and replacement should be last on your list of options.

If your windows are too deteriorated to repair and you must replace your historic windows, be mindful that many of today's energy-efficient windows have a relatively short lifespan, in part because they are typically not repairable. If a window breaks, it is often necessary to buy an entire new unit, and the broken one goes to a landfill. If it becomes necessary to replace windows, it should be done during the last phase of an energy upgrade.

If your property is located in a Local Historic District, you may find that your LHDC will advise owners not to replace historic windows. Some HDCs may not allow window replacements at all, or may have stringent guidelines for window design and materials. It is important to check with your HDC early in your project planning. If your HDC does allow window replacements and you decide to move forward, there are architectural reclamation organizations that will recycle or repurpose old window sash. At the very least, the embodied energy of the historic windows can be preserved—even if not in place.

⁴¹ <https://www.preservationct.org/events>

⁴² <https://www.youtube.com/watch?v=WUSGILSfzwE&feature=youtu.be>

⁴³ <https://www.youtube.com/watch?v=DsvwtWZR-R4&feature=youtu.be>

Resources

New England Window Restoration Alliance

www.windowrestorationne.org

Window Preservation Alliance

<http://windowpreservationalliance.org/AboutWPA>

National Park Service's Preservation Brief 9: The Repair of Historic Wooden Windows

<https://www.nps.gov/tps/how-to-preserve/briefs/9-wooden-windows.htm>

National Park Service's Preservation Tech Notes

<https://www.nps.gov/tps/how-to-preserve/tech-notes.htm>

National Park Service's Replacement Windows that Meet the Standards

<https://www.nps.gov/tps/standards/applying-rehabilitation/successful-rehab/windows-replacement.htm>

The Old House Guy's Window Designs & Curb Appeal

<https://www.oldhouseguy.com/window-designs/>

This resource provides an in-depth look into why it is so important to maintain your historic windows; what elements give a historic window its character, and examples of bad window replacements.

For contractors in your area, see Preservation Connecticut's Services Directory

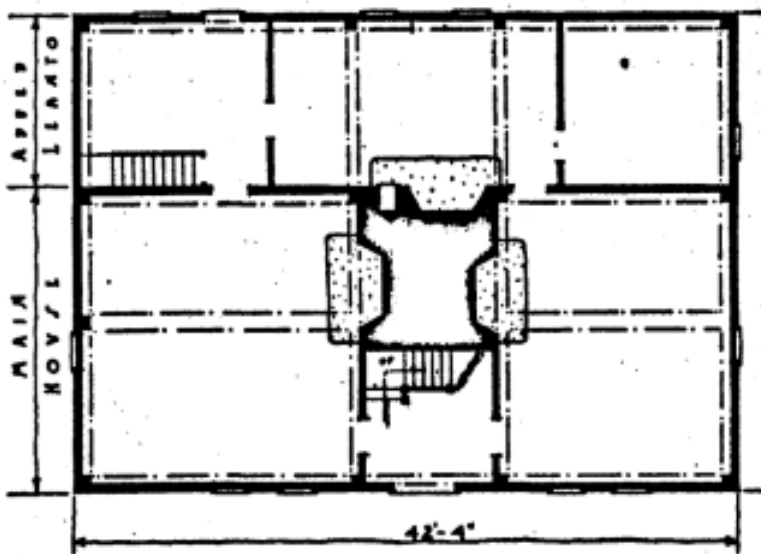
<https://www.preservationct.org/directory>

V. Heating, Ventilation, and Air-Conditioning (HVAC) Upgrades

As technology evolves, heating, ventilation, and air-conditioning (HVAC) systems become outdated relatively quickly. Installing new climate-control systems improves comfort but can come at a cost to historic buildings. Structural systems can be weakened by additional weight and vibration from new equipment, and moisture from improperly planned or installed systems can cause damage. If not well designed, mechanical systems can result in poorly placed grills and registers, or worse, the all-too-common dropped ceiling. It is important to understand which spaces and features in your building are historic and “character defining,” and to plan for realistic climate-control goals. As with any energy improvements in a historic building, a thoughtful approach can ensure that systems are upgraded while maintaining the building’s historic integrity.

This section discusses historical building technologies, how to plan an HVAC upgrade, and various types of systems. Prior to undertaking HVAC system work, make sure you complete all necessary weatherization measures in your building. After taking care of air sealing and insulation improvements, you can plan more accurately for mechanical system upgrades

History of Mechanical Systems



Thomas Lee House, East Lyme. Source: Kelly, J. F. Early Domestic Architecture of Connecticut.

Eighteenth-century builders relied on common-sense planning, like siting buildings to maximize sun exposure in winter and shade and breezes in summer. Windows and doors were placed with cross-ventilation in mind. Fireplaces and stoves were the primary sources of heat. In Connecticut, many Colonial-era houses had central chimneys and fireplaces that provided heat for surrounding rooms on each story.

Many nineteenth-century innovations in building technology resulted in increased comfort and healthier indoor environments. Early central-heating systems distributed heated air

or steam through metal ducts or pipes. Wrought-iron steam boilers and low-pressure hot-water radiator systems were in use in commercial and residential buildings by the middle of the nineteenth century. By the end of the nineteenth century, floor and ceiling grilles delivered gravity-forced hot air in some buildings, but most late nineteenth-century houses were heated with boilers and radiators. Health and sanitation movements in the late nineteenth and early twentieth centuries recognized the health benefits of well-ventilated spaces and fresh air circulated through architectural features such as porches, transoms, clerestory windows, cupolas, and roof monitors.

By the turn of the twentieth century, new technologies made oil and gas furnaces, first introduced in the nineteenth century, more efficient. Forced-hot air systems with ducts and registers became popular. Central air-conditioning was introduced in commercial buildings in the 1920s, and by the

1950s forced-air systems combining heating and cooling in the same ductwork were common in residential construction. By the end of the twentieth century, HVAC systems had become better integrated and more energy-efficient. Insulation, double-glazed windows, and the use of vapor barriers created conditioned spaces that were comfortable and moisture-controlled.

Electrical Systems

Electricity did not become commonplace in cities until the 1890s. The Rural Electrification Act was passed in 1936 to provide power to outlying areas. As a result, most historic houses have been wired for electricity. Many older houses have several generations of electrical wiring in their walls. Knob-and-tube wiring was the earliest system commonly used in residential construction from ca. 1880 to 1930. To improve efficiency and ensure safety, all wiring systems should be assessed and upgraded as necessary prior to improving any mechanical systems.



Photo: Old House Web.

By design, eighteenth-, nineteenth-, and early twentieth-century building materials expanded and contracted according to fluctuations in interior and outside temperature and humidity. As HVAC technology in the mid-twentieth century led to increased comfort—and more extreme differences between outside and interior temperature and humidity levels—it came at a cost to historic building fabric. The greater the difference between the interior and exterior temperature and humidity levels, the greater the potential for damage to building materials because of “vapor pressure.” In this context, vapor pressure is the action of warm, moist air moving toward a cooler, drier area, resulting in condensation on the cooler building materials. Condensation can cause deterioration of wood windows and other structural elements. In variable climates like Connecticut’s, excessive moisture in walls can result in a freeze-thaw cycle, wet insulation, and other moisture-related problems. Installing an effective vapor barrier or improving air flow in key areas can help to manage these issues. For more information, see **Section V: Insulation**.

Planning an HVAC System Upgrade

Modern standards for climate control—developed for new construction—may not be achievable or even desirable for historic buildings. In each case, the system that requires the least amount of alteration to the historic building should be chosen. Prior to choosing a new system:

Assemble a qualified team. This team ideally should consist of a preservation architect, mechanical engineer, electrical engineer, and structural engineer. If a team approach is too costly, find a qualified contractor who is familiar with older structures. Be sure your team members are familiar with local fire and building codes, and that they understand the importance of your building's historic features.

Complete a conditions assessment of the existing building and its systems. What are the construction materials? Where are HVAC system components located, and what is their condition? Consider the condition of building systems that may benefit from being integrated into a new system, such as electrical or fire suppression systems (particularly in commercial applications). Has the building been retrofitted to improve energy efficiency by installing new insulation, reducing air infiltration, and repairing windows and doors? Updating HVAC systems should be one of the last items on an energy-efficiency improvement list.

Prioritize architecturally significant spaces, finishes, and features to be preserved. Features such as wall and window trim are obviously character-defining features, but early decorative radiators, grilles, and electrical switches can also add to the historic significance of a space. Be sure to take a look at all of the elements that make a house historic before removing them to install new equipment.

Check for hazardous materials. Many late nineteenth- to mid-twentieth-century hot-water pipes were wrapped in asbestos insulation, and asbestos panels were often used to shield ductwork. Asbestos and other hazardous materials should be removed or encapsulated prior to the start of any HVAC work.

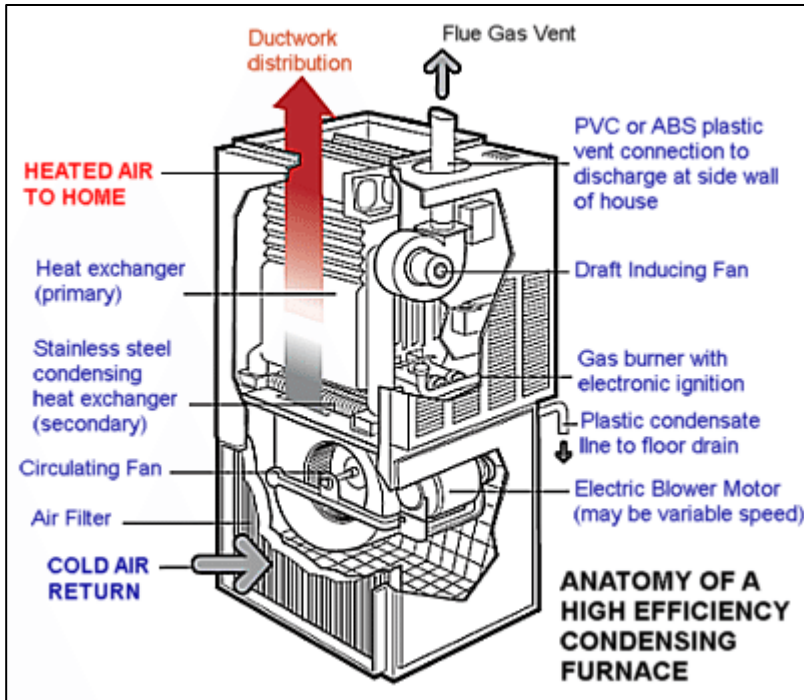
Preserve exterior spaces. Exterior equipment, such as condensers, should be placed in inconspicuous areas that will not detract from the historic appearance of the building or setting. For houses dating to the mid-nineteenth century or earlier, be aware that undisturbed soils near the house have the potential to contain archaeological artifacts. Care should be taken when digging trenches or excavating to install underground equipment.

Types of HVAC Systems

Most residential or small commercial systems installed in the second half of the twentieth century consist of a basic furnace with a cooling coil and a refrigerant compressor, or a condenser located outside the building. Heating and cooling ductwork is commonly shared. Over the past decade, however, technological advances have produced smaller, more efficient systems that are better for historic buildings.

Furnaces

Warm-air furnaces are powered by natural gas, propane, or oil, which is mixed with outside air and burned, heating a metal heat exchanger that transfers heat to air. Air is pushed through the heat exchanger by a fan, then forced through ductwork. Warm air is delivered to rooms throughout the house via air registers or grilles. This type of heating system is called a ducted warm-air or forced warm-air distribution system.



Source: *The Spruce.com*.

reclaims much escaping heat, while exhaust is vented through a side wall with a small (typically 3-inch) plastic pipe rather than through a chimney.

In a traditional furnace system, combustion products are vented out of the building through a flue pipe.

“**Atmospheric**” furnaces vent directly to the outside, using about 30 percent of the fuel consumed to heat the exhaust so that it will rise safely out of the chimney. Newer minimum-efficiency furnaces reduce the amount of fuel wasted during this process significantly by using an “inducer” fan to pull the exhaust through the heat exchanger and into the chimney.

“**Condensing,**” or high-efficiency furnaces are designed to cool exhaust gases below 140°F, a temperature at which water vapor condenses into water. This process

Measuring Efficiency

There are two ways to measure the efficiency of a fossil-fuel-powered furnace: Combustion Efficiency (CE) and Annual Fuel Utilization Efficiency (AFUE). CE measures the system’s efficiency while running at peak performance. The AFUE is more complex and measures the average efficiency rather than peak efficiency. (This includes the energy used when the system stops and starts back up over several seasons.) The higher the AFUE, the more efficient the furnace or boiler. See [Energy Star's Certified Products](https://www.energystar.gov/products?s=mega) for guidance on selecting an energy-efficient system.⁴⁴

Boilers

Systems that use water instead of air are called hydronic systems, typically fueled by oil or natural gas. Hydronic systems use a network of pipes to deliver hot water to radiators, to radiant pipes set into floors, or to fan coil units (which can produce both heating and cooling). Water is returned to the boiler to be reheated. In steam boilers, commonly used in historic houses, steam is carried through the house into radiators, where it condenses as it cools and is recirculated. When upgrading a boiler system, it is important to understand the types of systems available:

⁴⁴ <https://www.energystar.gov/products?s=mega>

Regular boilers (sometimes known as traditional, conventional, or heat-only boilers) are best suited to buildings that already have a traditional heating-and-hot-water system linked to a separate hot-water cylinder. These boilers need a cold-water storage tank in the attic to feed the hot-water cylinder, as well as a tank to maintain the water level of the central heating system. In an upgrade project, portions of the system may be left in place, but it is important to make sure that all reused components are intact and functioning to avoid leaks in ceilings or walls. A traditional boiler may be the best option for replacing an existing boiler if the property has an older radiator system, since the radiators and other components of the system may not be able to handle the increased water pressure delivered by a “system” boiler.

“System” boilers can be a good choice for new installations in historic buildings. Although system boilers require cylinders for storing hot water, the majority of the heating and hot-water system components are built into the boiler. This type of system may produce too much pressure to be used with older radiators, but it requires less room and does not need a cold-water tank in the attic. System boilers are also compatible with solar water heating systems.

Condensing units, similar to those found on furnaces, can greatly improve energy efficiency with minimal changes to an existing boiler system. A condensing boiler features a second heat exchanger, where gas fumes formed in the first heat exchanger are recycled through the second to produce more heat. As with furnaces, condensing gas-fired boilers are significantly more efficient than non-condensing boilers.

Radiators

Radiators or baseboard radiators are components of a boiler system that are looped together and usually set under windows or along perimeter walls. Historic radiators can be reconditioned and kept in use with an updated boiler system.

Fan Coil Units

Fan Coil Units (FCUs) deliver heating or cooling to a room through a series of pipes (approximately 1 ½ inches in diameter). Each unit contains a coil and a fan to recirculate indoor air. A fan blows air over the coils, which are serviced by hot or chilled water, directly into the room rather than through ductwork. Four-pipe fan coils can provide both heating and cooling year-round. Although they do not require concealed ductwork, individual units must be concealed in most historic interiors.

Heat Pumps

Heat pumps are essentially two-way air conditioners. During the heat of summer, an air conditioner works by transferring heat from the building interior to outside. In winter, heat pump function in reverse, transferring heat from outdoor air with the help of an electrical system and discharging heat inside the house. Traditional heat pumps typically use ducted delivery systems to move heated air, so they may not be the best choice for a historic building without space for ductwork.

Air-source heat pumps are the most common type and use the variable outside temperature to produce heating or cooling. Ground-source heat pumps, which absorb heat from underground, rely on temperatures that are more constant year-round (see **Section VII: Renewable Resources** for more information). Air-source heat pumps are more common because they are less expensive and easier to install. They are installed much like a central air-conditioning system. Condenser units

should be placed at the side or rear of the building, where they are not visible from the public right-of-way.

Ductless Mini-Split Heat Pumps use refrigerant lines instead of water or air to distribute energy. Like standard air-source heat pumps, mini-splits have two main components: an outdoor compressor/condenser and an indoor air-handling unit. A conduit, which houses a power cable, refrigerant tubing, suction tubing, and a condensate drain, links the outdoor and indoor units. Ductless mini-splits make good retrofit add-ons to houses with non-ducted heating systems. They can be a good choice for additions, where extending or installing ductwork is not feasible. They also allow for zoning or heating and cooling individual rooms with their own thermostat. Many models can have as many as four indoor air-handling units (for multiple zones or rooms) connected to one outdoor unit.

Ductless mini-split systems are easy to install. The connection between the outdoor and indoor units generally requires only a three-inch hole through a wall for the conduit. Since the distance between the interior and exterior units can be quite long, most compressor units can be placed in inconspicuous locations at the side or back of a building. Interior air handling units, which are typically installed on walls or ceilings, are about 7 inches deep.



Ductless Mini-Split Unit. Source: Wisconsin History.

Individual Air Conditioners

Most individual air conditioners are set into windows or exterior walls. When permanently set into walls, they are visually intrusive and can cause extensive damage. When they are set into windows, seasonal installation and removal can damage window frames and sash. Exposure to moisture from window units can also cause damage. Portable air conditioners are a less intrusive alternative. Floor or tabletop models can be placed almost anywhere, exhausting warm, humid air directly outside through unobtrusive window vent kits. These units are energy-intensive, however, and can greatly increase your energy costs.

Portable Fans

Fans can be placed in attics, at the top of stairs, or in individual rooms to improve ventilation. In some areas with moderate or breezy climates, such as coastal Connecticut, well-placed fans may eliminate the need to install central air systems.

Dehumidifiers

Seasonal use of dehumidifiers can remove moisture from damp basements and reduce fungal growth, even in houses with central air-conditioning.

Summary

There is no such thing as a perfect HVAC system. For best results, hire professionals who understand preservation and mechanical systems' impacts on historic materials. They can design a system that best serves your historic building's needs. Reversibility is key, since most mechanical systems last only 15 to 30 years.

The National Park Service has developed a helpful series of Do's and Don'ts in *Preservation Brief 24: Venting and Cooling Historic Buildings*:

Do	Don't
<ul style="list-style-type: none"> • Use shutters, operable windows, porches, curtains, awnings, shade trees and other historically appropriate nonmechanical features of historic buildings to reduce the heating and cooling loads. Consider adding sensitively designed storm windows to existing historic windows. • Retain or upgrade existing mechanical systems whenever possible: for example, reuse radiator systems with new boilers, upgrade ventilation within the building, install proper thermostats or humidistats. • In major spaces, retain decorative elements of the historic system whenever possible. This includes switch-plates, grilles and radiators. Be creative in adapting these features to work within the new or upgraded system. • Use space in existing chases, closets or shafts for new distribution systems. • Design climate control systems that are compatible with the architecture of the building: hidden system for formal spaces, more exposed systems possible in industrial or secondary spaces. In formal areas, avoid standard commercial registers and use custom slot registers or other less intrusive grilles. • Size the system to work within the physical constraints of the building. Use multi-zoned smaller units in conjunction with existing vertical shafts, such as stacked closets, or consider locating equipment in vaults underground, if possible. • Provide adequate ventilation to the mechanical rooms as well as to the entire building. Selectively install air intake grilles in less visible basement, attic, or rear areas. • Maintain appropriate temperature and humidity levels to meet requirements without accelerating the deterioration of the historic building materials. • Design the system for maintenance access and for future systems replacement. • Have a regular maintenance program to extend equipment life and to ensure proper performance. 	<ul style="list-style-type: none"> • Don't install a new system if you don't need it. • Don't switch to a new type of system (e.g. forced air) unless there is sufficient space for the new system or an appropriate place to put it. • Don't over-design a new system. Don't add air conditioning or climate control if they are not absolutely necessary. • Don't cut exterior historic building walls to add through-wall heating and air conditioning units. These are visually disfiguring, they destroy historic fabric, and condensation runoff from such units can further damage historic materials. • Don't damage historic finishes, mask historic features, or alter historic spaces when installing new systems. • Don't drop ceilings or bulkheads across window openings. • Don't place condensers, solar panels, chimney stacks, vents or other equipment on visible portions of roofs or at significant locations on the site. • Don't overload the building structure with the weight of new equipment, particularly in the attic. • Don't place stress on historic building materials through the vibrations of the new equipment. • Don't allow condensation on windows or within walls to rot or spall adjacent historic building materials.

Frequently Asked Questions about HVAC Systems

How do I determine if an upgrade to my 20-year-old furnace will achieve enough energy savings to make the investment worth it?

During an energy assessment, your technicians will let you know how well your furnace is functioning. They should also calculate the “payback period,” or amount of time it will take to recover the costs of a new system before you start saving on your bills. By comparing your current system’s performance against the payback period, you can make an informed decision. If an upgrade does not make financial sense, ask your contractor about boiler control options. You can increase the efficiency of your boiler (within your current furnace) by installing outdoor reset controls. These controls lower boiler water temperature when the outdoor temperature is warmer, and increase it when the outdoor temperature is colder. Outdoor reset controls can save up to 30 percent of energy use, by continuously adjusting the boiler temperature for outdoor conditions.

I want to add central air conditioning to our house that is heated using a boiler and radiators. How can I do this efficiently, without ruining the character of my historic interior?

Standard central air-conditioning systems use ducts to move air through large grilles into rooms through a house. These ducts are most commonly run through closets, whenever possible, to minimize visual impacts. If you do not mind losing some storage space, then a traditional system may be the solution for you. Sacrificing closets can be a problem in older houses, however, where storage is already at a premium.

Another option is a high velocity mini-duct system, which moves air through smaller (3-inch-diameter) ducts. The ducts are flexible, can be placed almost anywhere, and can be painted or stained to blend into historic finishes. High-velocity mini-duct systems remove up to 30 percent more humidity than a traditional system. Since drier air feels cooler than humid air at the same temperature, the thermostat can be set higher to save energy costs. Mini-duct systems can also operate on dehumidify mode, another way to reduce energy costs while improving comfort.⁴⁵ For more information on two of the more popular high velocity mini-duct systems, see [Unico System](#) or [Spacepak](#).⁴⁶

⁴⁵ Kolle, Jeffery. An Easy HVAC Retrofit for Old Houses Old House Online October 17, 2011. <http://www.oldhouseonline.com/articles/easy-hvac-retrofit-for-old-houses>

⁴⁶ <https://www.unicosystem.com/>; <http://spacepak.com>

Resources

National Park Service's Preservation Brief 24: *Heating, Ventilating, and Cooling Historic Buildings*

<https://www.nps.gov/tps/how-to-preserve/briefs/24-heat-vent-cool.htm>

Whole Building Design Guide's Updating Building Systems Appropriately

<https://www.wbdg.org/design-objectives/historic-preservation/update-building-systems-appropriately>

VI. Renewable Energy

Fossil fuels such as coal, petroleum, and natural gas are non-renewable resources. When fossil fuels are burned, harmful greenhouse gases such as carbon dioxide and methane are released. Most electrical plants are powered by fossil fuels. As a result, global warming caused by greenhouse gases is affecting the planet and human health.

Renewable energy sources such as geothermal, hydropower, wind, solar, and biomass are inexhaustible and have fewer, if any, harmful emissions. Connecticut lawmakers have set a mandatory amount of renewable energy for electrical generation in the state, known as a Renewable Portfolio Standard (RPS). The minimum in 2020 is 29 percent, which will increase annually to 48 percent in 2030.⁴⁷ To reach these goals, several public and private entities such as the Connecticut Green Bank currently offer incentives to offset the installation of renewable energy systems. (See Section II for more information.) Renewable resources will provide the greatest economic benefit to a historic building that is already as energy-efficient as possible, and should be considered one of the last steps in your whole-house plan. Renewable energy systems can be installed independently or used to support a fossil fuel system. When renewable technologies are combined, or used with a fossil fuel system, the result is called a hybrid system.

Renewable energy systems should be added in a manner that has minimal impact on your property's character.

Choosing the Best Renewable Energy Technology

To choose the best renewable energy system for your property, you need a basic understanding of how each technology works, as well as the following information:

- **Energy resource availability:** Do you have enough hours of sun or wind to make an installation feasible?
- **Costs and payback time frame:** How long will it take for you to recoup your initial investment? What funding programs are available?
- **System siting:** Do you have the right conditions to make a solar or wind system work? For example, will trees need to be removed before installing a solar system? If so, how will the loss of those trees impact the setting?
- **System size:** What size is most appropriate for your electric usage?
- **Local codes and regulations:** Will a septic system or a well be an issue? What about Local Historic District regulations or design guidelines?
- **Installation and maintenance considerations:** Be sure the system is located where it can be easily serviced or replaced, if necessary, with minimal impact to your historic building.
- **The overall impact of the project on historic and archaeological resources:** What will it look like? How will it impact the setting of the property or district where it is located?

⁴⁷ "CT Renewable Energy Standards": <http://www.energizect.com/compare-energy-suppliers/cts-renewable-energy-standards>

Solar Energy

For centuries, “passive” solar design and construction techniques have been used to collect, store, and release heat from the sun. Many historic buildings include passive solar features that should be retained and even enhanced. Such building features often include strategic orientation toward the sun, large windows on south-facing walls, and masonry walls and floors that store and distribute solar heat. Initial attempts to harness solar energy were made in the late nineteenth century, but it was not until the 1950s that solar cells were developed for residential use. With fossil fuel shortages in the 1970s the idea of photovoltaic panel (PV) technology became popular. In 1977 the federal government created the National Renewable Energy Laboratory (NREL) to further the development of solar technology. In the 1990s the discovery of new materials improved solar efficiency and reduced solar panel thickness and weight, increasing their popularity. In recent decades innovations have been made to further improve PV panel efficiency and appearance, making it easier to reduce their impact on historic buildings. The current life expectancy for PV panels is about 25 to 30 years.

There are two major types of solar collectors: photovoltaic panels and building-integrated photovoltaics (BIPV). PV cells contain semiconducting material such as silicon. When sunlight is absorbed by a semiconductor, the electrons within the material are let loose. The flow of electrons creates a current of electricity. An inverter transforms the direct current (DC) into alternating current (AC), and excess electricity generation is stored in the grid. Thanks to Connecticut’s Net Meter Law, any excess energy sent back to the grid must be purchased by the local power company at full retail rate.

PV systems work best in areas where they will be exposed to at least six hours of sun a day. Typically, BIPV systems are less visually intrusive. Some technologies now allow PV collectors to be hidden entirely within the roof structure. However, this technology is still new, and is not as efficient as conventional PV panels.

If your property is located in a Local Historic District, be sure to coordinate with the LHDC at an early date to reduce the possibility of project delays. Chapter 97, Sec. 7-147f of the Connecticut statutes prohibits a commission from denying an application for a certificate of appropriateness for a “solar energy system designed for the utilization of renewable resources” unless “the commission finds that the feature cannot be installed without substantially impairing the historic character and appearance of the district.” The commission can impose conditions on the issuance of the certificate of appropriateness, including design modification and limitations on the location of the feature, provided that the effectiveness of the system is not significantly impaired.

The National Park Service has acknowledged that photovoltaic panels help to enhance the energy efficiency of historic buildings, but they should be installed in a sensitive manner:

- Install in visually unobtrusive ground-mount arrays, if possible.
- Use vegetation or a compatible screen to further reduce the visual impact of installations.
- If ground-mounted installations are infeasible, site roof-mounted arrays with either no or minimal visibility from nearby streets, sidewalks or public spaces.
- Avoid altering the historic character of the building.
- Avoid damaging historic roof materials.

The National Park Service provides examples based on installation:

[Installing Solar Panels and Meeting the Secretary of the Interior's Standards](#)

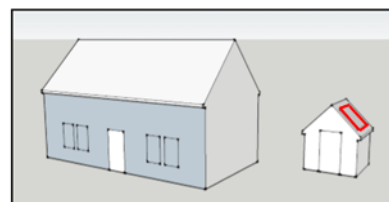
[Incorporating Solar Panels in a Rehabilitation Project](#)⁴⁸

Solar Panel Placement

Ideal solar panel locations will have no physical impact on the primary structure and negligible visual impact on the site as a whole. Visibility is the biggest concern when introducing a solar collection system on or near a historic building. Solar panel locations and methods are described below, in order of least to greatest impacts on historic properties.⁴⁹

Ground- or pole-mounted arrays. These options are preferred because they do not impact historic buildings, and they are easily reversible. If installed in a side or rear yard, they can be even less inconspicuous when they are sited carefully. For instance, if a farmhouse has sweeping views of a nearby field, install the array on the opposite side to preserve the visual continuity of the house and associated property. Arrays should be close to the ground and screened with plantings, whenever possible, to limit visibility.

New construction or additions. Installing solar panels on a new or non-historic accessory building, such as a garage, provided it is compatible in design, avoids direct impact to a historic building. Even on new construction, panels should be placed on rear or side elevations.



On historic buildings - Roof-mounted solar panels. Roof mounts are the most common types of installations, and they can often be accomplished sensitively. Be sure that the installation is not visible, or only minimally visible, from the public view, with panels on side or rear roof slopes. Optimal placement is on a nonpublic facing slope. Installations should match the basic slope and color of the existing roof, and the panel profile should be as low as possible. The installation should not damage historic roofing materials. On flat roofs, panels should be set back to screen them from street view. Roof structures may require repairs or reinforcements to support the weight of a solar panel system.

⁴⁸ <https://www.nps.gov/tps/standards/applying-rehabilitation/its-bulletins/ITS52-SolarPanels.pdf>

⁴⁹ Illustration of solar panel placements in this section are courtesy of *Sustainable Preservation: An Addendum to Building with Nantucket in Mind* by Ginny Way.



Do: Place panels on a nonpublic facing slope



Don't: Place panels on façade



Solar roof shingles. These are less visually obtrusive than traditional PV panels, but their installation can have a greater impact on historic building materials. For instance, each solar shingle requires a screw into the sub-roofing. Currently, solar roof shingles are not generally as efficient as conventional PV panels, but solar technology is progressing at a rapid pace and new products are being produced each year.

Solar thermal systems. These systems, typically roof-mounted, harness the power of the sun to heat liquids for specific applications. They are similar in appearance to PV panels. They are used to provide hot water, space heating, cooling, and pool heating for residential, commercial, and industrial applications. The sun's energy heats a fluid in the solar collectors, and the heated fluid passes through a heat exchanger in a storage tank, transferring heat to water. The fluid is cycled back to the collectors. Installation of solar thermal panels should follow the same guidelines used for PV panels, and exterior storage tanks should be placed in a rear or side yard and appropriately screened from view.

Most electrical plants in Connecticut are powered by fossil fuels. Every new solar energy system placed into service works directly to reduce harmful emissions. By understanding and minimizing potential impacts to historic materials, historic building owners can do their part to work toward reduction in fossil fuel consumption.

Common Terms Used in Solar Installations

Active System – A solar system that uses mechanical and electrical equipment to collect, store, and transport solar energy. Examples include photovoltaic and solar thermal systems.

Array – A set of connected photovoltaic modules or panels that function as a unit.

Cell – The smallest component of a solar panel, which converts sunlight into electricity.

Electrical Grid – The system in a discrete geographical area that distributes electricity to buildings, structures, and sites. A “grid-connected” solar energy system uses the grid as a backup power source. In Connecticut, service providers are required to purchase any excess power generated by residential solar systems.

Inverter – The device used to convert direct current (DC) into alternating current (AC).

Mount – Method of attaching solar panels to the roof or ground.

Net Meter – An electrical meter that spins both forward and backward, depending upon whether electricity is flowing in or out of the grid.

Passive Solar System – Collecting and storing solar heat through building siting, design, and materials rather than technological systems.

Photovoltaic (PV) System – Technology that converts solar energy into electrical energy.

Solar Module – Several connected solar cells; also called a solar panel; usually measuring several feet per side.

Solar Panel – several connected solar cells; a general term for the discrete unit of a system that captures solar energy, usually measuring several feet per side; sometimes also called a solar module.

Solar thermal systems – systems that produce heat by using sunlight to heat water or another fluid such as antifreeze.

Tilt – the angle of a solar panel arranged optimally to collect the most sunlight.

Tracking panels – panels that change orientation to follow the sun’s path.

Funding

There are four financing options for installing solar in Connecticut: Power Purchase Agreement (PPA), cash purchases, solar leases, and solar loans. Visit [Understanding Financing Options](#) to see which option would work best for you.⁵⁰ If part of a larger rehabilitation project of a historic property solar installations can be an eligible expense, provided they are installed according to the guidelines of the [Homeowner Rehabilitation Tax Credit Program](#)⁵¹.

In 2017, Connecticut was given an A and ranked the seventh-best state in the U.S. to install solar panels. For more information on their assessments, see [Welcome to Solar Power Rocks](#).⁵²

⁵⁰ <http://www.gosolarct.com/Savvy-Solar-Shopper>

⁵¹ https://portal.ct.gov/DECD/Content/Historic-Preservation/02_Review_Funding_Opportunities/Tax-Credits/Historic-Homes-Rehabilitation-Tax-Credit

⁵² <https://solarpowerrocks.com>

Geothermal Heat Pumps

The top 10 feet of the earth's crust retains a constant temperature between 50 to 60 degrees Fahrenheit: warmer than the air above in the winter and cooler in the summer. Geothermal heat pumps that rely on the constant temperature of the earth were first developed in the late 1940s. Also known as geo-exchange, earth-coupled, ground-source, or water-source heat pumps, they are more efficient than conventional heat pumps because they do not require electric backup heat sources during prolonged cold weather.

There are two main types of geothermal systems. Closed-loop geothermal systems circulate antifreeze solution through a closed system of plastic tubing. The tubing is installed underground (horizontally or vertically). A heat exchanger transfers heat between the refrigerant in the heat pump and the solution in the closed loop. Less common are open-loop systems, which use wells

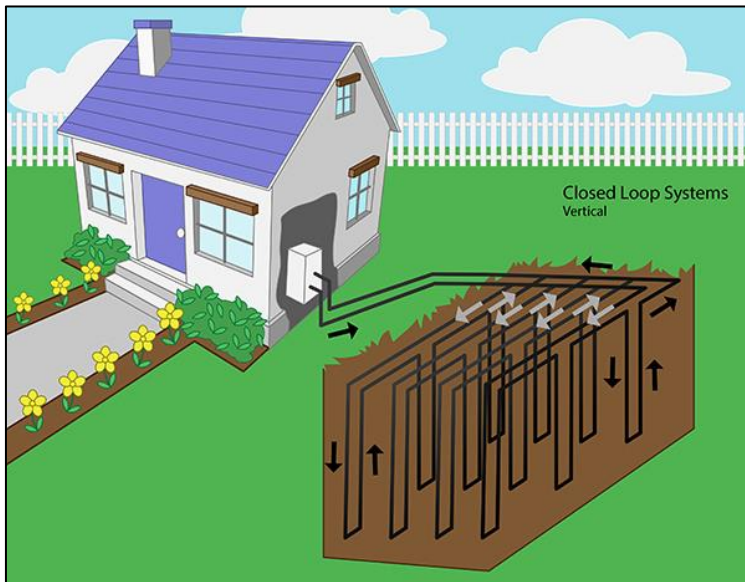


Image: wellowner.org.

or bodies of clean water as the heat exchange fluid that circulates directly through the system. After circulating through the system, water returns to the ground through the well, a recharge well, or surface discharge.

Geothermal heat pumps are often appropriate for historic properties. While the cost of geothermal installations is higher than conventional oil-burning furnaces, other advantages are that they need little space and do not require external compressors.

Geothermal systems maintain more consistent humidity levels and are capable of providing better-zoned space heating than conventional furnaces. Since they work with the constant temperature of the earth, geothermal heating and cooling systems can use 40 percent to 60 percent less energy than conventional ducted furnace systems. Depending on the geology of the property, a geothermal system might be appropriate for your historic building. The benefits of geothermal heating are best realized after a building has been upgraded for maximum energy efficiency, including air sealing and insulation.

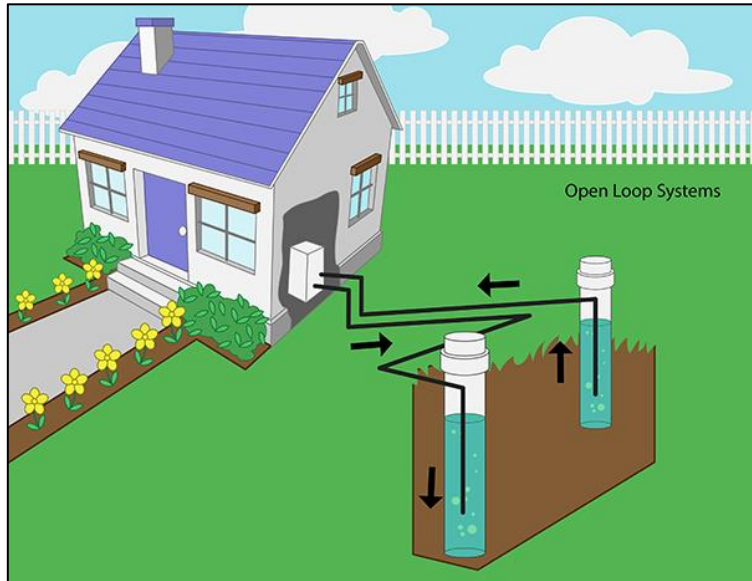
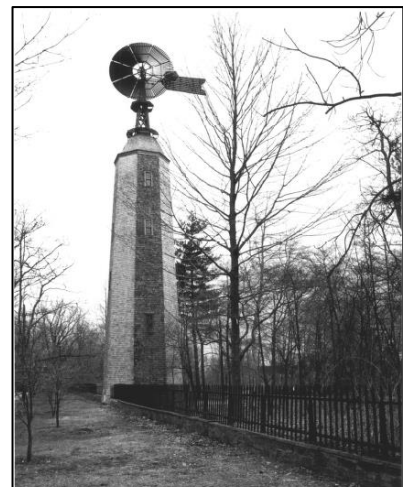


Image: wellowner.org

Although geothermal installations do not have above-ground impacts, there can be archaeological concerns when they are located near houses that date to the mid-nineteenth century or earlier. The State Historic Preservation Office has a 30-day review process to determine whether an Archaeological Reconnaissance Survey is required. (This is fairly rare.) The process ensures that no archaeological resources are harmed during excavation. Note that it is also important to check local septic regulations with your municipality.

Wind Energy

There is a long history of windmills along the Connecticut shore, such as the Bronson windmill in Fairfield, originally used to draw water from the first deep-drilled well in the area.⁵³ In rural areas where wind power was used historically, installation of a windmill or wind turbine could be a suitable and cost-effective measure to produce renewable energy on historic properties. Average wind speeds of 10 mph or higher are required to make this type of installation practical. In 2015 the National Renewable Energy Laboratory estimated that only about 23 square miles of land in Connecticut can support wind energy systems.⁵⁴ Wind energy is not practical in Connecticut's more densely populated areas that are sheltered from winds, or where winds are inconsistent. When considering a wind energy installation, it is



Bronson Windmill, 1971. Source: NPS.

⁵³ Constance Luyster (1970). "National Register of Historic Places Inventory-Nomination: Greenfield Hill Historic District". *National Park Service*. <https://npgallery.nps.gov/GetAsset/34a10efa-0c69-4d68-857e-2a1e3fd5ef7e/>.

⁵⁴ Ryan Caron King, "Does Wind Energy Have a Future in Connecticut?" *WNPR News* August 29, 2016 <http://wnpr.org/post/does-wind-energy-have-future-connecticut>

important to measure the potential benefit against impacts on the historic character of the building, the site, and the surrounding historic setting.

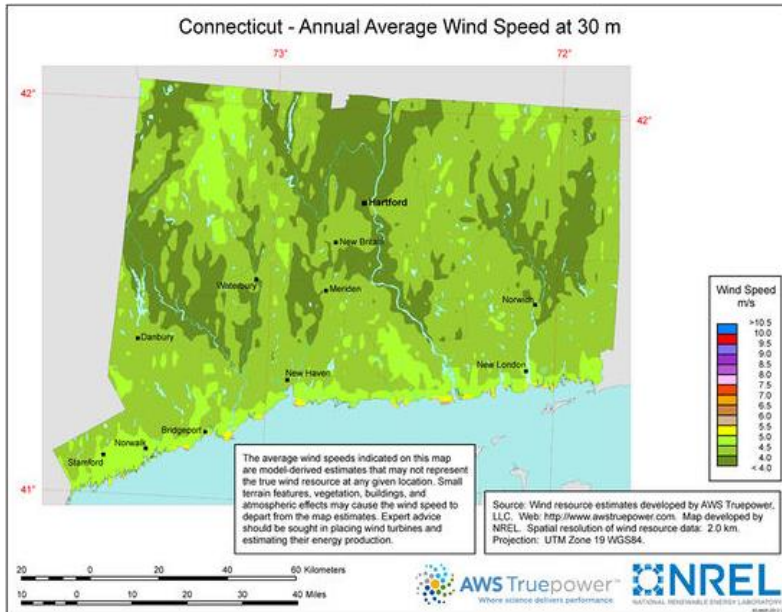
There are currently three primary types of wind energy production: utility-scale wind, distributed wind (residential or small-scale production), and offshore wind.

Utility-scale wind refers to turbines that produce 100 kilowatts or more, for the power grid or to power large buildings. These turbines are typically large horizontal-axis wind turbines (HAWTs),

often installed in groups called wind farms or wind banks. HAWTs look like giant pinwheels, usually with three rotating blades. They range from 50 feet to more than 500 feet tall.

The other main type is a vertical-axis wind turbine (VAWT). VAWTs, which resemble eggbeaters, work better in variable wind directions than HAWTs, but are less efficient.

Offshore wind refers to wind farms off the coastline that capture strong ocean winds. In Connecticut, consistent wind speeds rarely reach above 5 mph inland (see map). Current wind



Connecticut Wind Resources Map. Source: Energy.gov.

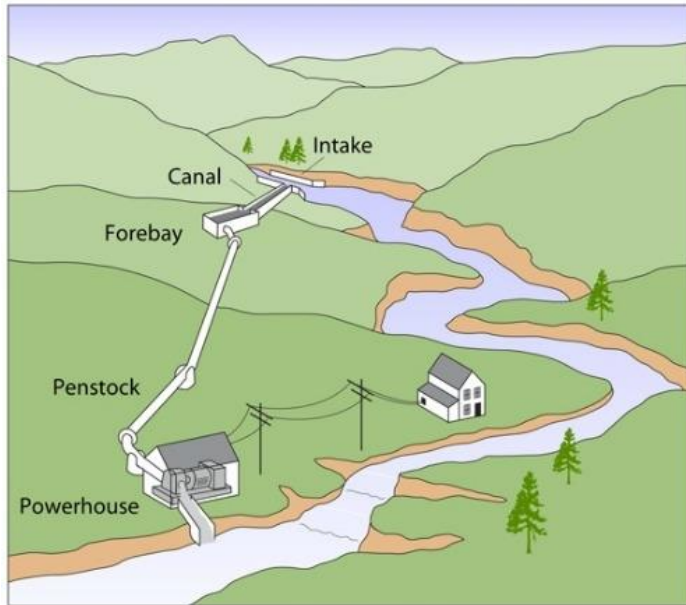
speeds along Long Island Sound are also much lower than in neighboring states such as Rhode Island, Massachusetts, and New York. The Block Island Wind Farm, located three miles off the coast of Rhode Island, is the first offshore wind farm in the nation and provides enough electricity to power 17,000 properties.⁵⁵ If technology develops to make Connecticut's shoreline practical for turbine installation, potential projects that affect views from historic properties in Connecticut would require Section 106 review by the SHPO to evaluate all potential impacts.

Distributed wind refers to turbines that produce fewer than 100 kilowatts. They are generally used to power residential properties, farms, or small businesses. A prominent example is the privately funded single-turbine installation located along I-95 in New Haven (affectionately known as "Gust"), which provides power to Phoenix Press. Small rooftop turbines can sometimes be installed on tall city buildings with little impact on their setting, since they are usually invisible from the street. Because of wind turbines' initial cost and size, it is generally more practical to purchase wind power from an offsite wind farm through a local utility company. Connecticut has limited wind speeds compared to neighboring states. Even if wind energy is available, it is not always cost-effective, so research thoroughly before investing in a wind energy system.

⁵⁵ Tatiana Schlossberg, "America's First Offshore Wind Farm Spins to Life," *New York Times*, December 14, 2016. <https://www.nytimes.com/2016/12/14/science/wind-power-block-island.html>. Accessed 8/16/2019.

Hydropower

Connecticut's streams and rivers powered thousands of mills, beginning with the earliest European settlers' small gristmills and sawmills in the late seventeenth and early eighteenth centuries. During the Industrial Revolution of the nineteenth century, many Connecticut towns saw the introduction of large-scale commercial operations; manufacturing cities such as Norwich and Waterbury were booming at the turn of the twentieth century. Most of these factories had ceased operation by the 1950s, but their mill ponds and dams remained. For more information, see Energy.gov's [History of Hydropower](#).⁵⁶



Run-of-River Mill. Source: Energy.gov.

Today, the power from Connecticut's historic mill ponds and dams can be harnessed for power generation. Hydropower is the United States' largest source of renewable energy, yet it generates just 7 percent of its electricity.⁵⁷ [Micro-hydropower systems](#) can generate up to 100 kilowatts of electricity through a 10-kilowatt system, enough for a large house or small farm.⁵⁸ If you have water flowing on your property and want to investigate the possibility of a micro-hydropower system, see Energy.gov's [Planning a Microhydropower System](#).⁵⁹

Impoundment is the most common form of hydropower. When a dam is built on a stream or a river, it creates a reservoir. Energy from pressure of the reservoir behind the dam and the water flow powers the hydro turbine, and a generator converts the energy into electricity.

Run-of-river or **diversion** mills rely on the natural flow of a river to produce power, without a dam or reservoir. Run-of-river facilities divert water with a canal or penstock to a generating house or powerhouse. The spinning turbines in the powerhouse, powered directly by the water flow, run the generator that produces electricity.

Pumped storage systems move water between two reservoirs at different elevations. When electrical power is needed, water in the higher reservoir is released to power hydro turbines and produce electricity, as it flows to the lower reservoir. During periods of less demand, the water is pumped back up to the higher reservoir (using a different energy source, often solar, wind, or nuclear), where its potential energy is stored like a battery.

⁵⁶ <https://www.energy.gov/eere/water/history-hydropower>

⁵⁷ Energize CT "Hydropower" <http://www.energizect.com/events-resources/energy-basics/hydropower>

⁵⁸ <https://www.energy.gov/energysaver/buying-and-making-electricity/microhydropower-systems>

⁵⁹ <https://www.energy.gov/energysaver/planning-microhydropower-system>

Applications for hydropower systems located on historic dams are reviewed by the Connecticut SHPO, along with the Federal Energy Regulatory Commission (FERC). For more information about the Small/Low Impact Hydropower Program in Connecticut, visit Energize CT's [Hydropower: Leading the Way in Renewable Power](#) or the FERC's [Small/Low Impact Hydropower Projects](#).⁶¹

Archimedes Screw Turbine

At the Hanover Pond Dam in Meriden, a small-scale hydropower system is generating electricity at the site of a historic cutlery factory on the Quinnipiac River. This system uses an Archimedes screw, the first of its kind in the United States to send water down through a shaft to rotate a turbine (which looks much like a large screw). This ancient technology also functions as a fish ladder, so that fish can pass through without harm. New England Hydropower Company anticipates that this hydropower system, installed in 2016, will save the city approximately \$20,000 a year.⁶⁰



Image: Hartford Courant.

Biomass Energy

Biomass energy, or bioenergy, are generic terms for organic materials such as wood, pellet fuels, other plant matter, and organic waste that can be burned, converted into other fuel types, or transformed into chemicals to make products traditionally derived from petroleum. Biomass energy has gained popularity because these fuels can be replenished and/or make good use of waste products. Biomass fuel is an excellent option for historic houses already equipped with a wood-burning stove, though new wood and pellet stoves are more efficient and produce far less pollution. For more information about energy-efficient stoves, including a list of EPA Certified models, see the EPA's [Frequent Questions About Wood-Burning Appliances](#).⁶²

More information on biomass energy can be found on the Connecticut DEEP's [Biomass webpage](#).⁶³

⁶⁰ Hladky, Gregory. "Archimedes Screw Being Used to Generate Power at Meriden Dam" *Hartford Courant* December 29, 2016.

⁶¹ <https://www.energizect.com/events-resources/energy-basics/hydropower>
<https://www.ferc.gov/industries/hydropower/gen-info/licensing/small-low-impact.asp>

⁶² <https://www.epa.gov/burnwise/burn-wise-frequently-asked-questions>

⁶³ http://www.ct.gov/deep/cwp/view.asp?a=2708&q=323872&deepNav_GID=2121

Frequently Asked Questions about Renewable Energy

My house is in a Local Historic District. Won't they tell me that I cannot install renewable energy on my historic property?

Applications submitted to LHDCs are reviewed on a case-by-case basis. As long as the proposed work does not “substantially [impair] the historic character and appearance of the district,”⁶⁴ it will likely be approved. LHDCs can, however, deny certificates of appropriateness if the installation is poorly designed. If you follow the general guidelines above, then there should be little concern with the installation of a solar energy system. For other renewable energy resources, it is important to understand your local regulations. Get acquainted with them early in the planning process, and research all potential impacts on your project. By working with your LHDC, you might end up planning a project that serves as a model for your community.

Are there any examples of historic properties that have successfully integrated renewable energy sources?

In 2016 Preservation Connecticut installed photovoltaic panels on the roof of the Eli Whitney Boarding House. This ca. 1827 Greek Revival building is listed in the National Register of Historic Places and serves as the Trust's main office. The staff and board of trustees wanted to make the Trust more environmentally sustainable, defray rising energy costs, and improve comfort for staff. Sustainability has been an important aspect of the Connecticut Trust as well as the National Trust's preservation philosophies for many years. This project provided an opportunity to evaluate the process first-hand, and to use the Trust's experience for public education.



The Whitney Boarding House, Hamden.

Photo: Stacey Vairo.

Following an energy assessment in 2011, the Trust began a series of upgrades, beginning with replacing the roof and drainage. Then dense-pack, blown-in insulation was added in the walls, attic, and basement spaces. Next, the Trust restored the single-glazed windows (reproductions installed in 1989) and installed wood storm windows. Small but significant changes were made to interior spaces as well, such as switching from incandescent to LED bulbs. These changes had minimal impact on the historic building materials, yet reduced electricity bills while significantly increasing comfort levels for the staff.

⁶⁴ Conn. Gen. Stat. § 97a Sec. 7-147f. a. (2012) Considerations in determining appropriateness. Solar energy systems.

Adding a solar PV system proved to be a bit more challenging. The central mission of the Trust is to help preserve historic places throughout the state, so it was crucial that the installation move forward in a way that did not detract from the overall setting of the building. The SHPO also holds an easement on the building and needed to review all plans before the project could move forward. Structural support was added to the roof trusses to ensure it would be able to support additional weight of the panels.



Structural reinforcements added to support the weight of solar panels.

Photo: Stacey Vairo.

The Trust was fortunate that the optimal placement for the panels, on the south-facing roof slope, was also the least visible from the public road.



Solar panels on the south-facing roof of the Whitney Boarding House.

Photo: Stacey Vairo.

The low profile of the panels also ensured that the overall shape of the roofline remained unchanged. In an interview with Patrick Skahill of WNPR, Deputy Director Christopher Wigren noted the connection between the boarding house, a place associated with the historical innovations of Eli Whitney and the innovative technologies in place at the property today. Wigren summed up how these “new” technologies will likely soon become a part of everyday life: “There’s a long history of adopting buildings to new needs and new technologies. We put heat in buildings, we put electricity we put plumbing—all changes that once you get used to then become more or less invisible to us.”

Resources

National Renewable Energy Lab

<http://www.nrel.gov/>

Energize Connecticut's Renewable Energy Basics

<http://www.energizect.com/events-resources/energy-basics/renewable-energy/>

Go Solar CT

www.GoSolarCT.Com

Geothermal Energy

<http://geothermalconnecticut.org/>

Wind Energy

<https://energy.gov/energysaver/planning-home-renewable-energy-systems>

Checklist: Energy Efficiency for a Historic House

- Get to know your house (site, plan, roof, windows, etc.).
- Determine its historic status (National Register, State Register, Local Historic District).
- Identify the house's character-defining features.
- Schedule an energy assessment.
- Check for asbestos, vermiculite, radon, and lead.
- Check for unwanted moisture problems and mold.
- Develop a realistic "Whole House Plan" for improving energy efficiency.
- If you live in a Local Historic District, obtain a "Certificate of Appropriateness" for any projects that affects the house's exterior.
- Explore funding sources.
- Undertake additional air sealing (attic, basement, windows, doors, electrical outlets and switches).
- Consider insulation (heating ducts, pipes, attics, basements; not recommended for exterior walls).
- Evaluate windows (if historically significant, repair rather than replace; air sealing; storm windows).
- Evaluate exterior doors (if historically significant, repair rather than replace; air sealing; storm doors).
- Consider HVAC upgrades.
- Consider renewable energy (solar, geothermal, wind energy, hydropower, biomass).

Conclusion

There is a false dichotomy that the preservation and environmental communities are separate groups. In fact, they share the same goal, approached from different angles. Historic resources are environmental resources, an assertion enshrined in both the National Historic Preservation Act, and the Connecticut Environmental Policy Act. The adage “the greenest building is the one already built,” is still true. If you own a historic house, you are already a green homeowner. Through this booklet, you have learned that many historic homes were designed to be as energy efficient as possible, and that retaining historic fabric not only preserves the integrity of your historic home, but is also often the most environmentally-friendly choice. You have also learned that it is possible to introduce new energy-saving measures without making permanent, irreversible changes to your historic home.

Before embarking on making energy improvements, remember these general principles:

- Start with the included checklist to determine your resources, your needs, and your goals.
- Consider your house as a whole, rather than piecemeal projects. This will help you determine which interventions are necessary and which should be avoided.
- Look to see if your project qualifies for financial incentives from either CT Greenbank or SHPO.
- Determine if your project requires local or state approval, and seek guidance before finalizing plans. SHPO also offers guidance and resources for projects not requiring review.

With some carefully considered actions, your home can be even greener without harming its historic character. We hope you found this booklet useful.

Disclaimer

This guide is made available by the Connecticut Green Bank and State Historic Preservation Office for educational purposes only, to give you general information and a general understanding of historic preservation requirements in Connecticut as they relate to clean energy improvements, not to provide specific legal advice. By using this guide, you also understand that there is no attorney/client relationship between you and the guide or its representatives. The guide should not be used as a substitute for competent legal advice from a licensed professional attorney in Connecticut. This text is as of March 2020, and subject to change and/or revision.