

CONCORD'S SUSTAINABILITY GUIDE FOR HISTORIC AND OLDER HOMES

Abigail Ahern

THE TOWN OF CONCORD MASSACHUSETTS

UNH Sustainability Institute

PROJECT DESCRIPTION

The UNH Sustainability Institute Fellowship pairs students from across the United States with municipal, educational, corporate, and non-profit partners in New England to work on transformative sustainability initiatives each summer. Sustainability Fellows undertake challenging projects that are designed to create an immediate impact, offer a quality learning experience, and foster meaningful collaboration. Fellows work with their mentors at partner organizations during the summer, supported by a network of Fellows, partners, alumni, and the UNH Team. This summer, Abigail Ahern was chosen to work with the Town of Concord to develop a set of guidelines for historic homeowners interested in retrofitting their historic or older homes to become more sustainable.

Concord has long been committed to sustainability and has a goal of reducing greenhouse gas emissions by 80% by 2050. About 30% of community wide greenhouse emissions in Concord come from residential homes. Achieving Concord's 80% greenhouse gas reduction goal will require retrofitting the existing housing stock, much of which is located within an historic district or is subject to a Demolition Review bylaw, approximately 1,260 homes (14% of total buildings), to be more energy efficient and carbon-free.

Retrofitting historic buildings located in a designated Historic District presents unique challenges because replacing inefficient windows and/or installing rooftop solar panels requires approval by the Historic Districts Commission (HDC) and may be of concern to members of the HDC when such work changes the look or character of the building. Additionally, owners of older houses that are subject to the Demolition Review bylaw may believe that retrofitting their home may be cost prohibitive or less efficient than tearing down and building new.

Residents who have expressed an interest in adapting or retrofitting existing homes rather than demolish and rebuild do not always have access to the critical information needed to consider such an option. The goal of this project is to provide a resource for homeowners to make home improvements that reduce emissions while preserving historic character.

ACKNOWLEDGMENTS

I would like to thank my mentors Kate Hanley, Heather Gill, and Marcia Rasmussen for their patience, time, encouragement, and knowledge they gave throughout this project. I would also like to thank the UNH Team for their endless support and effort to continue to run this fellowship successfully amidst a global health crisis.

To learn the barriers and best practices of these retrofits I began this project by interviewing numerous people with a variety of different backgrounds and professions. I would like to thank all the Concord stakeholders, architects, preservationists, developers, engineers, community members, and Concord homeowners who were willing to be interviewed and share their experiences and knowledge with me.

Mentors

Kate Hanley
Sustainability Director

Marcia Rasmussen
Director of Planning &
Land Management

Heather Gill
Senior Planner

UNH Team

Megan Carney
Program Coordinator

Jennifer Andrews
Project Director

Interviewees

Jill Moonheron
Beth Williams
Melissa Simoncini
Jan Aceti
Peter Britz
Mari Brunner
Ben Silverman
Alexis Aldred
Don Kingman
Rick Detwiller
Dan Gainsboro
Shelbie McCormack
Tom Robinson
Dennis Fiori
Amy Latva-Kokko
Nancy Nelson
Maria and Jay Powers

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1. INTRODUCTION

The Town of Concord is filled with history and a large collection of historic and older buildings that define the character of the Town and establish a sense of place. Located 20 miles west of Boston, the Town of Concord was incorporated through a grant from the Massachusetts General Court on September 12, 1635 and is the first inland settlement in Massachusetts. The name Concord signifies agreement and harmony. Since its inception, the Town has played a significant role in regional, state, and national development and history. Concord was the original seat of local government in the area and the site of the first battle of the American Revolutionary War on April 19, 1775, where the "shot heard 'round the world" for liberty and self-government was fired, and is considered to be the birthplace of the nation. In the 18th and 19th centuries, Concord Center became the home of the District's Courts as well as a thriving commercial center. The Town is also renowned as the home of some of the greatest literary and transcendentalist minds in 19th century America including Ralph Waldo Emerson, Henry David Thoreau, Bronson Alcott, Louisa May Alcott, Nathaniel Hawthorne, and Margaret Fuller. Concord continues to be a leader in advocating for the environmental movement, the preservation of open space, and the continuance of local farms and agriculture.

Preserving the community's character is the foundation of the Town's planning policies, enacted primarily through the Historic District Commission's (HDC) Design Guidelines. The HDC established a review process that requires a "Certificate of Appropriateness" to ensure that historic properties are maintained and improved. Additionally, this process ensures that changes are compatible with the historic character of each district and appropriate for the time period and architecture of the structure.

Concord's 2020 Climate Action and Resilience Plan charts a course toward achieving the goal of reducing greenhouse gas emissions 80% by 2050 and preparing for the impacts of climate change on the community. This includes actions such as a major reduction in energy use and greenhouse gas emissions, progressive sustainability standards for new municipal buildings and schools, and a phased plan for deep energy retrofits to existing buildings.

Concord is home to 27 properties on the National Register of Historic Places. Beyond these recognized properties, much of the Town's existing building stock (approximately 1,260 homes) is subject to a Demolition Review by-law. The Demolition Review by-law may trigger a one-year demolition delay before one of these buildings can be demolished, during which time it is hoped that a way can be found to save the building. Concord has a total of 608 buildings located within its Historic Districts and another 2388 buildings within Concord's Historic Areas. Improving the performance of the Town's older building stock through green retrofits is a fundamental component to help Concord reach its GHG reduction goal. This guideline is intended to promote and facilitate sustainable retrofits of historic and older homes in a manner that will improve their performance and energy-efficiency while also being respectful to their historic character and the contribution the structure makes to the community and neighborhood character.

HOW TO USE THIS GUIDE

Steps for Planning a Retrofit

This guide was created to provide owners of historic and older homes with steps for planning a sustainable retrofit, strategies for improving performance and energy efficiency, and guidelines for preserving the historic character of these buildings. It details the evaluation, planning, and decision-making required to create an effective sustainable retrofit. This guide is focused on owners, tenants, and managers of historic and older homes; however the approach for evaluating and planning can be applied to other building types.

Chapter 2: Planning a Retrofit outlines a step-by-step approach to help evaluate your existing building and current energy performance. This chapter also helps you define your project goals and develop a coordinated and educated plan for making improvements. **Chapter 3: Retrofit Strategies** discusses a variety of sustainable retrofit strategies and is organized by building components. It provides you with a variety of options and lower and higher cost strategies that can be considered for each. **Chapter 4: Case Studies** provides examples of local and international projects that have successfully implemented green retrofit strategies into their building. **Chapter 5: HDC Review Process** provides a brief overview of the Historic District Commission's Review Process, including a list of projects that do and do not need to be reviewed by the Commission. Links to more information, including the HDC application forms, are also provided. **Chapter 6: Additional Resources** provides reliable and helpful links that can offer more in-depth information and research about the green retrofit process. It also offers resources to different incentive and rebate opportunities that can make your retrofit project easier to achieve. **Chapter 7: Future Considerations** discusses potential next steps in continuing the research and education involving sustainable retrofits for historic and older homes.

- **Step 1-** Know your Building
- **Step 2-** Evaluate Current Performance
- **Step 3-** Optimize Current Performance
- **Step 4-** Define your Goals
- **Step 5-** Develop a Strategy
- **Step 6-** Maintain and Monitor Performance

ENERGY CONSUMPTION IN CONCORD

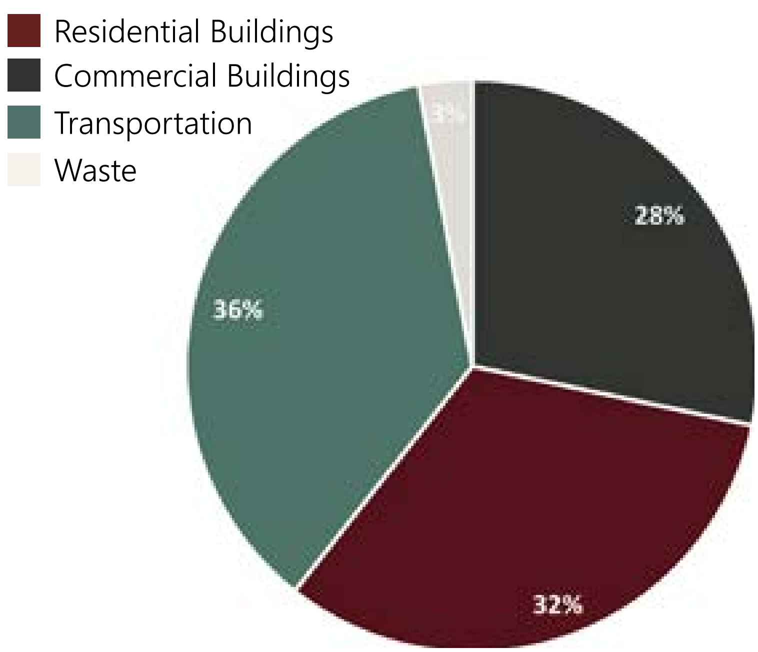
Sustainability of Historic Buildings

There is a common misconception that sustainability and green building design are incompatible with historic preservation. Preserving and retrofitting historic and older homes have many sustainability benefits.

- Reducing construction and demolition waste created by redevelopment
- Maximize the use and life of materials
- Reduce embodied carbon by reusing the existing building instead of constructing a new one
- Maintain affordability because the cost of rebuilding is significantly higher than a retrofit or remodel.
- Conserving raw materials by reusing existing resources
- Preserve the historic character of Concord and its neighborhoods

Although historic buildings are often dismissed as energy inefficient, we can actually learn a lot about sustainable design by looking to historic buildings. Because many historic buildings were designed with passive systems before the invention of electric lighting and powered heating and cooling, we find that many buildings constructed before 1920 use less energy per square foot than buildings constructed from 1920-2000. That is because these buildings were designed to take advantage of natural daylight, ventilation, and solar orientation. These methods are being used in new sustainable design today and are principles that we can use to retrofit existing homes.

While preserving existing structures have many inherent sustainability benefits, energy used in Concord's buildings is the largest source of community-wide greenhouse gas emissions. Success in reducing emissions from the built environment will require improving **energy efficiency**, beneficial **electrification** of heating and cooling systems, and increasing **renewable energy** sources.



Concord's greenhouse gas emissions breakdown for 2016.

Retrofitting the Town's existing housing stock to be more sustainable is a huge opportunity for reducing community-wide emissions. For example, the installation of 3,000 air source heat pumps in Concord (a more efficient heating method that does not rely on natural gas or heating oil) could reduce total community wide emissions by approximately 4%. Additionally, more energy efficient buildings could reduce emissions by another 4.6%; both strategies' reduction potential being further amplified by a shift to carbon-free electricity. You can find more information on this in **Concord's Climate Action and Resilience Plan** here.

Retrofitting existing historic and older buildings in the Historic Districts can also produce these following positive outcomes:

- Reduced energy costs for owners.
- Improved thermal comfort and quieter, more efficient systems for building occupants.
- Improved indoor air quality.
- Protection of the Town's older buildings, which preserves the unique character of buildings and neighborhoods.

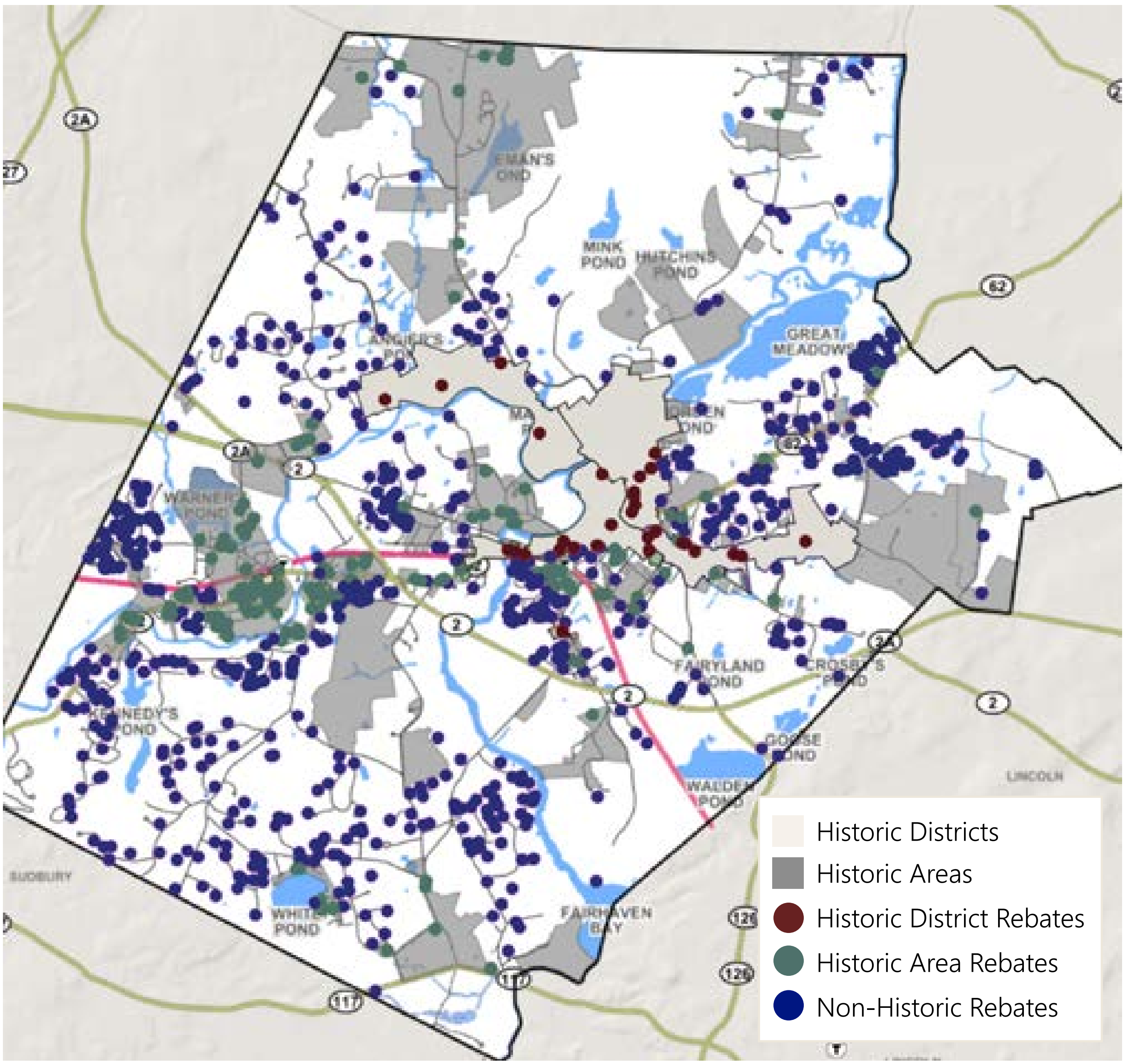
Sustainability Rebates in Concord

Concord Municipal Light Plant (CMLP) provides rebates for efficient lighting, heat pumps, solar, and electric vehicles. With the help of Concord's GIS analyst, we were able to create an interactive map that documents the homes that have used the Concord Municipal Light Plant Rebates program. The rebates that were studied included active solar, ground and air source heat pumps and weatherization. The map indicates whether these rebates are being used within the Historic District, Historic Areas, or in a non-historic area. The difference between Historic Districts and Historic areas is the guidelines and rules required in the renovation process.

There are 811 unique addresses that have used the CMLP rebates. Of those, only 30 homes were in the Historic Districts and 155 homes within the Historic Areas. To put these numbers in perspective, 14% of all Concord's homes have taken advantage of the CMLP rebates. Only 7.2% of homes in the historic district and 10.4% of the homes in the historic area received rebates compared to 16.2% of homes outside of these areas.

CMLP REBATES	# USED IN HISTORIC DISTRICTS	# USED IN HISOTRIC AREAS	TOTAL
Active Solar	15	63	**78**
Weatherization	5	30	**35**
ASGP	2	16	**18**
GSHP	0	3	**3**

This map was helpful in determining which rebates specifically were used in the Historic Districts and Areas to further the investigation about the barriers and best practices within historic homes. Within the Historic Districts and Areas, the most used rebate is Active Solar and Weatherization. The less common rebates being ground and air source heat pumps, which are newer rebate programs. This guide is here to provide a useful resource when thinking about implementing these rebates and other sustainable renovations within your historic or older home.



Location of Concord Municipal Lighting Rebates Used in Concord

2. PLANNING A RETROFIT

Step 1- Know your Building	Step 2- Evaluate Current Performance	Step 3- Optimize Current Performance	Step 4- Define your Goals	Step 5- Develop a Strategy	Step 6- Maintain and Monitor Performance

STEP 1: KNOW YOUR BUILDING

Before initiating a retrofit, it is crucial that you gain a better understanding your building. Answering the following questions will help you determine needs, project goals, financing, and the best strategies to incorporate into your retrofit.

Building Type and Use

The type of building, its use, and activities will play a large role in the type and amount of energy used and as a result, the best strategies to implement in your retrofit.

- Is your building use residential, mixed use, or commercial?
- If residential, is it single-family or multi-family?
- If commercial or mixed use, is it occupied by a retail store, restaurant, or office?

Location and Orientation

Location and orientation can influence a property's visibility, sun exposure, shading, potential moisture issue and more.

- How is your building oriented towards the sun?
- Where is it located on the block or in relationship to its neighbors? Is it detached, or semi-detached, part of a row?
- Where is it located in relation to a public street or way and rivers?

Construction

The most common building materials on older existing buildings in Concord are wood and brick. Different materials and construction methods will require different retrofit and upgrade strategies to reach the same energy efficiency levels.

- When was your building constructed and what are its primary materials?

Alterations may help you identify areas of flexibility or any areas that may need attention during the retrofit.

- Are there any noticeable alterations?
- How many stories is your building? Does it have a basement or attic? What is the roof shape and structure?

Different window materials and types may lend themselves to different retrofit strategies.

- What type of windows does the building have? What is the material? Are they functional? Are they double-hung, casement, fixed, or other?

Character Defining Features

Regardless of whether a building is designated historic, older existing buildings contribute to the character and diversity of Concord's neighborhoods. Character is defined by the elements that make a building unique or special, including distinctive materials, features and spaces, architectural styling or design, and unique construction methods or craftsmanship. These character defining features should be identified during the planning phase and preserved when implementing the retrofit.

- What is the unique character-defining features on your building?

Inherently Sustainable Features

Inherently sustainable features should be identified and incorporated into your overall plan, so they work in cooperation with other strategies implemented. The features can include operable windows, operable shutters, attic vents, storm windows, screens, awnings, porches, permeable surfaces, and landscaping. Maintaining and using these efficient features will improve sustainability and reduce unnecessary waste.

- What passive systems and inherently sustainable features exist on your building and what is their condition? Are there passive systems that could be integrated into the retrofit?

Existing Systems

- How do you heat and cool your house? Forced hot air, water pipes, or steam pipes?
- Are your existing systems operating effectively?
- Did you identify inherently sustainable features that you can take advantage of for passive heating and cooling?

Historic Status

- Is your property located within one of Concord's Historic Districts, or listed on the National Register of Historic Places?

You can find this information by searching for your property on the **List of Properties in Concord's Historic District**, accessible here.

Properties located within the Historic Districts require review by the Historic Districts Commission to assure that alterations and green retrofit strategies do not negatively impact the historic character of the structure and district.

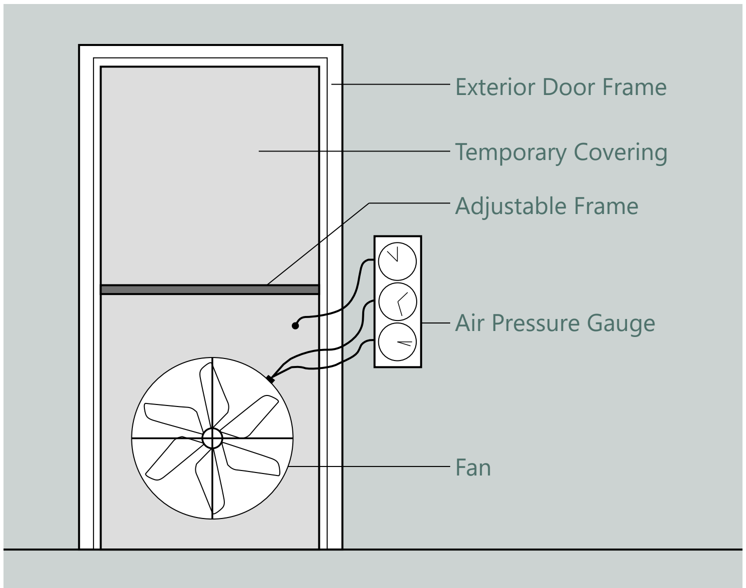
STEP 2: EVALUATE BUILDING PERFORMANCE

Evaluating the current performance of your building envelope and systems will identify inefficiencies and help determine your priorities and goals for your retrofit. Your home also may be eligible for rebates for making energy efficiency improvements. The evaluation can provide an understanding of how the building is operating and will help identify improper equipment performance. It can also determine what equipment or systems need to be rehabilitated, retrofitted, or replaced. In these cases there are opportunities for saving energy and money.

Home Energy Assessment

A home energy assessment can help you understand the whole picture of your home's energy use. An audit can help you determine how much energy your home uses, where your home is losing energy, and which problem areas and fixes you should prioritize to make your home more efficient and comfortable. A home energy assessment should be your first step before making energy-saving home improvements, as well as before adding a renewable energy system to your home. A professional home energy assessment will provide a thorough assessment of your home's energy use. In addition to a room-by-room examination of the home, an auditor may employ equipment such as blower doors, infrared cameras, and thermal imaging. You can find more information about receiving a free **Home Energy Assessment** here.

Blower Door Test



Blower door tests are performed by certified energy auditors to determine to what degree a home is airtight. A temporary "blower door" equipped with a powerful fan is fitted into the frame of an existing front or back door, and when the fan is turned on, it sucks the air out of the house and blows it outside. Digital gauges compare the difference in air pressure between the inside air and the outside air to determine how much air is leaking into the house. The goal is to learn where your home is leaking to make it as airtight as possible to conserve energy.

Thermal Imaging

Thermal imaging can be performed on the interior or exterior of a building to determine locations of air leakage or inadequate thermal insulation. Addressing these locations is a productive first step in a home retrofit.

STEP 3: WHAT ARE YOUR BUILDING GOALS?

Once you have evaluated your current performance it is important to define the goals and priorities you want to achieve your retrofit. This will determine which sustainable strategies you will begin to implement into your historic or older home. You should identify your goals with the concept of "do no harm", meaning you do not want to create new problems in the process of integrating your strategies like trapping moisture, creating condensation, or causing deterioration. There are several goals that you may want to achieve but choose the ones that apply directly to what you want and could apply to your building.

Building Goal Examples:

- Reaching a specific energy usage target or a specific percentage in reduction
- Meeting code requirements or specific standards such as LEED for Homes or Passive House.
- Reducing monthly energy costs
- Improving comfort
- Setting specific return on investment goals or payback periods for potential renovations
- Producing renewable energy
- Meeting project-specific air infiltration requirements
- Transitioning to electric systems and eliminating fossil fuel systems

STEP 4: DEVELOP A PLAN

Planning for Major Upgrades

When planning a retrofit and implementing sustainable strategies, keep in mind that there are ideal circumstances and points in time where major upgrades could save you money and time. By planning ahead for when these conditions occur or significant replacements are needed, you may be able to include additional energy-efficient improvements at a minimal additional cost.

- **Major Renovation or Improvements-** When planning a major renovation project or replacing mechanical equipment that is near the end of its service life, energy-efficient upgrades, such as a ground or air- source heat pump, could be incorporated at minimal additional cost.
- **Building Envelope Improvements-** When combined with major end-of-life equipment upgrades, like HVAC, improvements to the building envelope, such as improving wall and roof insulation and weatherstripping windows and doors, can offer opportunities for

reduced costs. Additional insulation and air-sealing that improve the efficiency of your building envelope could result in reduced heating and cooling loads and smaller less expensive mechanical equipment.

- **Life Safety and Code Requirements-** When implementing life safety or code requirement upgrades that require a high cost and effort, consider installing energy-efficient upgrades that could be incorporated with minimal additional investment. This can include improved insulation, ventilation, or the implementation of energy efficient mechanical systems.
- **Tenant Turnover-** In rental properties, tenant turnover may give an opportunity to improve efficiency and increase the value of the space.
- **Building Purchase or Refinancing-** When financing, a retrofit can be included in the transaction cost.

Consider Materials Lifespan and Impact

While considering strategies you should also recognize the lifespan of your building's materials and components, such as the following:

- Certain materials are intended to be repairable and have a long lifespan such as: masonry walls, slate roofs, and wood windows. You should try to minimize intrusions, alterations, and long-term impacts to these features.
- Passive and inherently sustainable features require little energy and maintenance to perform however, complex systems will require more maintenance to operate properly. Preserve and restore inherently sustainable features that provide daylighting and ventilation such as windows, shutters, attic vents, storm windows, and awnings/porches.
- Consider design systems that can allow repairs and replacements without disrupting the entire building or damaging historic features. Some improvements can be very intrusive to a home especially when installing mechanical systems, consider the consequences of installing these systems if repairs or replacements take place in the future. Simple repairs to inherently sustainable features can be very effective and are less invasive and damaging to the home.

Throughout the retrofit process, if new materials will be installed within your building it is important to be aware about the health and environmental impacts these materials may have. The following should be considered:

- Preserve existing materials when possible. Replace with similar materials that do not disrupt the building's character-defining appearance when needed.
- Try to use locally sourced materials when able. This makes the product "greener" by

reducing transportation distances, which lowers greenhouse gas emissions.

- Avoid building materials and products that are on the Red List, that contain toxins or have high VOC emissions.
- Select and specify healthy building products. Seek out materials and products that are free of toxins, socially responsible and respects the rights of workers, and is net positive and benefits both people and the environment.

Financing Opportunities

When planning for a retrofit it is important to consider the long-term savings and ease of maintenance when budgeting for a retrofit and energy-efficient upgrades. The initial cost of a product or design is only part of the true cost and homeowners should consider the costs and savings over the lifetime of the upgrade. Analyze prospective investments based on their expected financial and environmental benefits (maintenance savings, utility bills, comfort). There are a wide range of incentives, resources, and financing opportunities available to Concord residents for implementing green retrofits and energy-efficient upgrades. Chapter 6 includes a list of some available resources and opportunities.

Professional Services

Depending on the size and scope of your project, you may want to consider consulting a professional to address specific retrofits or design challenges. Larger projects require integrated teams that should be formed early in the planning process. It is also important when picking out consulting professionals that they have experience working with historic buildings AND sustainable design. You want someone who is willing to answer your questions and willing to let you be involved throughout the project. Typical professionals involved in green retrofits include:

Licensed Architect- Architects design basic to comprehensive renovations, advise on the construction process, and give guidance of material finishes. Make sure to hire professional architects that have experience working on high-performance, green building and/or historic renovations.

Historic Preservationist- Professional preservationists advise the treatments and planning that coincide with maintaining the character and integrity of the historic building throughout the upgrade.

General Contractor- Oversees the day-to-day activities on site during the construction phase and manages the subcontractors.

Energy Auditor- Inspects, surveys, and analyzes energy flows of the building to maximize comfort, efficiency, health safety, and durability. More information on the energy auditors' job is located in Step 2: Evaluation of Buildings Performance.

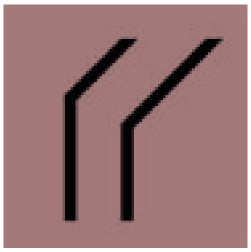
Structural Engineer- Evaluates the structural integrity of the building. A structural engineer may be necessary if rot is found within the structural members (not uncommon in historic homes) or if you are installing a green roof, solar panels or other upgrades that require structural support.

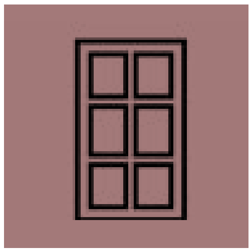
Sustainability Consultant- Helps measure and then improve the sustainability performance based on your goals. Their job is to facilitate an integrative design and work closely with you as a client to reach your goals.

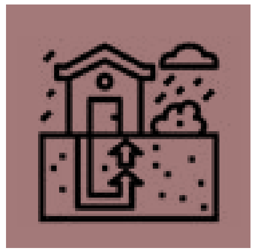
STEP 5: MONITOR PERFORMANCE

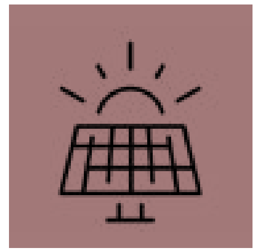
After the implementation of upgrades, your building should be regularly monitored for its performance to determine how the strategies are working and if adjustments still need to be made in the long-term. Existing buildings must be maintained regularly to preserve their historic character and maximize their reliability, performance, and efficiency.

3. RETROFIT STRATEGIES

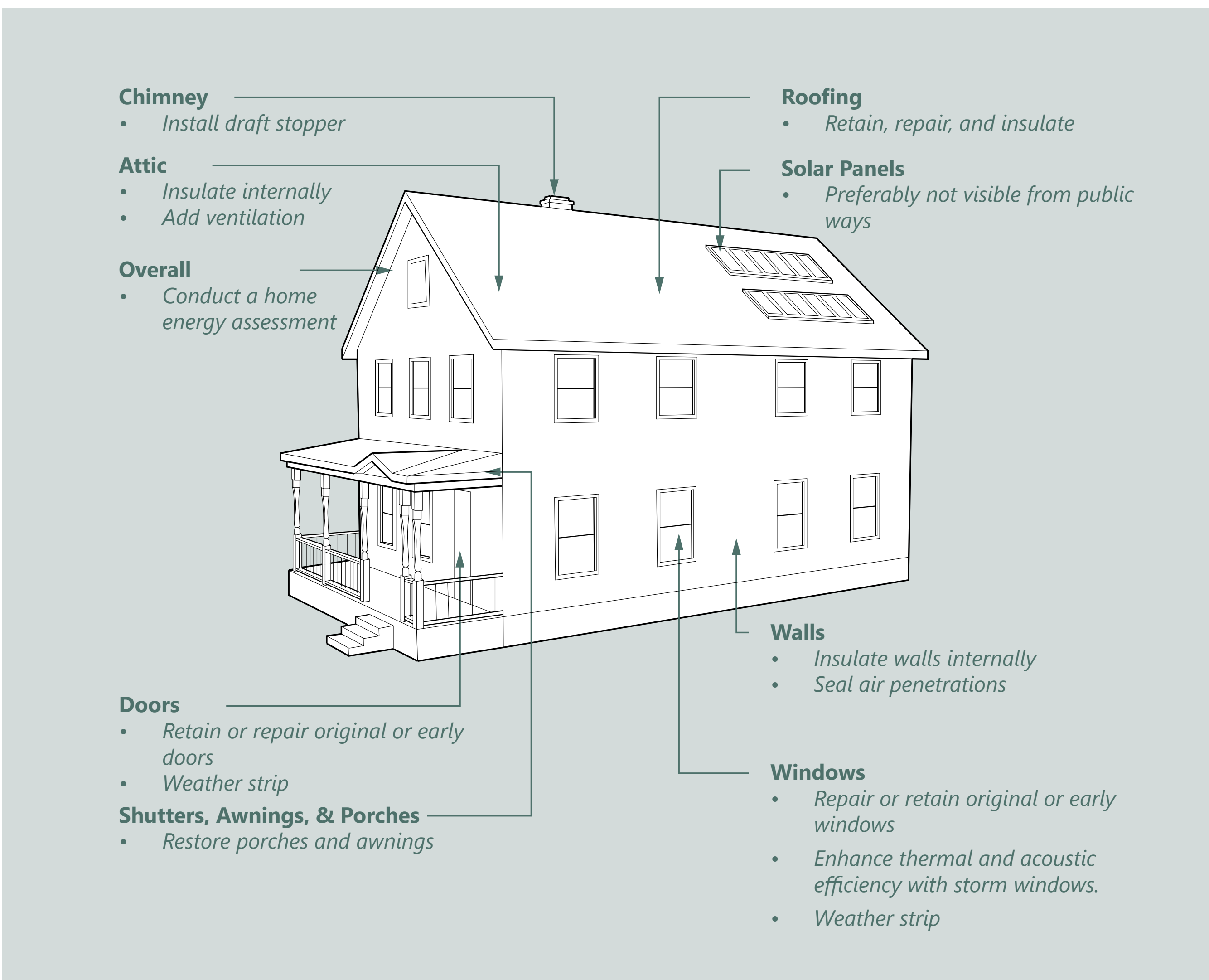

Walls & Roof


Windows & Doors


Mechanical Systems


Solar & Green Roof Installations


Landscape & Site Features



WALLS AND ROOF

Exterior walls and roofs are the most visible components of a building, and for historic buildings are also important aspects of the building's character. Typical wall materials of older buildings in the Historic Districts include brick and wood. Wood framed houses are generally covered with clapboard siding and shingles. Older brick buildings generally consist of multi-wythe walls, meaning a wall consisted of multiple thicknesses of brick. The typical interior wall finish for both construction types is plaster on lath unless later replaced with drywall.

Roofs are also often distinctive features of historic buildings. Their shape, materials, and detailing contribute to a building's appearance and character. Roofs can be flat, low-sloped, or steep-sloped and can be covered with metal, slate, asphalt, or woof shingles.

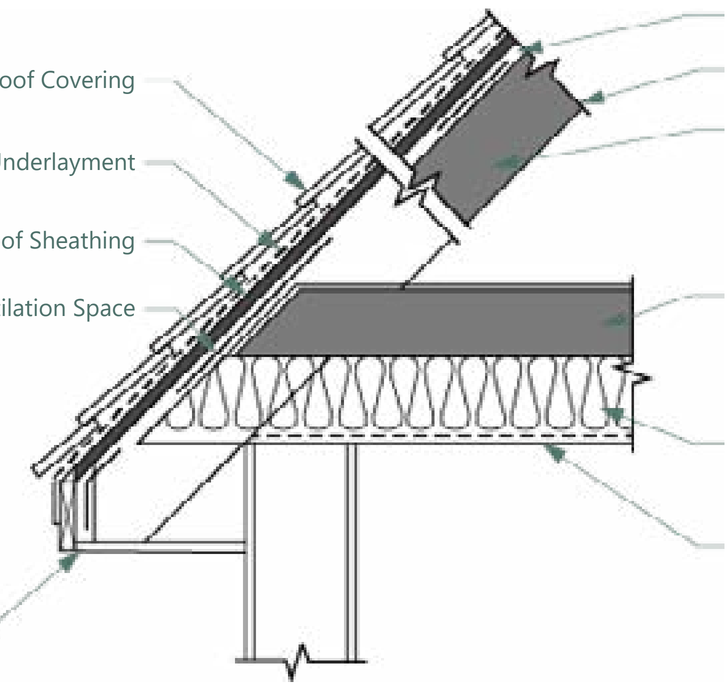
Providing proper ventilation and insulation for walls and roofs is one of the most cost-effective strategies for improving the energy efficiency of older buildings. Improving ventilation and insulation are also easy to do without impacting the exterior character of older and historic buildings.

Ventilation

A common problem that occurs when retrofitting historic homes is inadequate ventilation. Historic homes were built to "breathe" and designed to use passive ventilation but when they are sealed up for energy efficiency the stagnant air can cause an increase in moisture and heat build-up in interior spaces. This moisture and heat can flow into the attic when there is no dedicated air seal provided between the attic and living space below. A simple solution is venting the attic using louvers in gable ends, ridge vents, and soffit or eave vents which can increase air flow and help control moisture and heat build-up. However, venting can negate whole-building air sealing and result in energy loss from unwanted air exfiltration or infiltration.

Roof eaves and attics are common areas for thermal and air barrier inefficiencies, allowing for conditioned interior air to escape. Improving the air tightness of the ceiling assembly or providing a dedicated air barrier above the conditioned space can improve energy efficiency while maintaining passive ventilation.

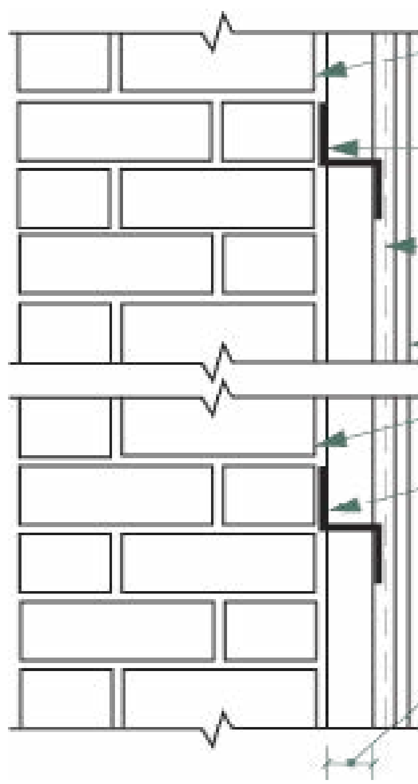
To avoid energy loss, one solution is to install air sealing and insulation to separate the attic from interior living spaces to prevent interior conditioned air from flowing into the attic. That way attic venting can be installed to prevent moisture build-up and keep the space cooler. Improving ventilation both to attics and interior living spaces, with a combination of appropriate natural (passive) and mechanical (active) ventilation can improve air circulation, keep the building cooler, and reduce moisture build-up.



Roof Ventilation

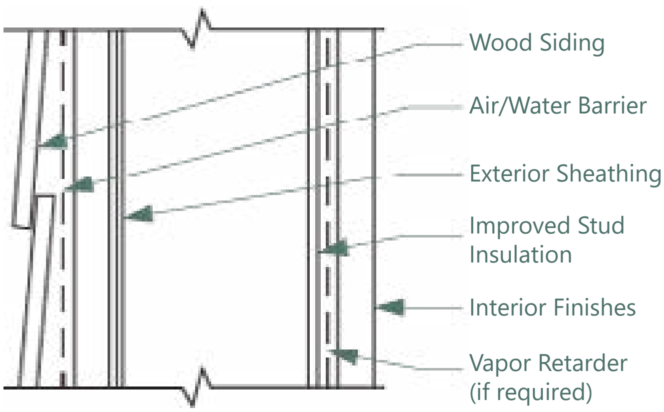
Wall Insulation

When adding insulation to your historic building it is important to preserve the exterior walls of your home as to not affect the historic appearance. Using continuous exterior insulation to walls may be an effective increase in thermal efficiency, however, this will typically have a harmful impact on the exterior aesthetic and character of a historic building and should not be undertaken on primary elevations. Installing insulation from the interior is the more appropriate option for older buildings. Before installing interior insulation, it is important to confirm that the installation will not cause damage to the existing historic materials.

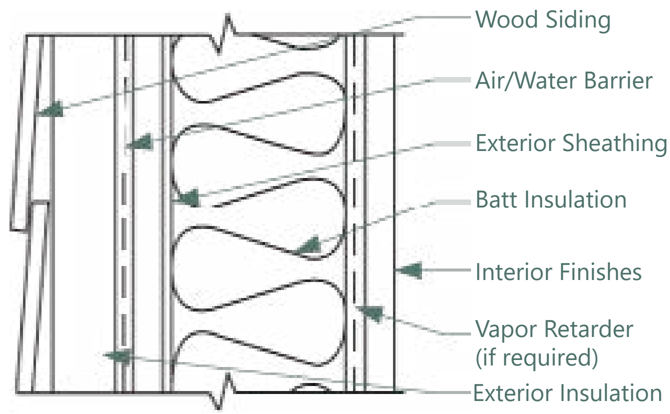


Mass Masonry Wall with Interior Insulation

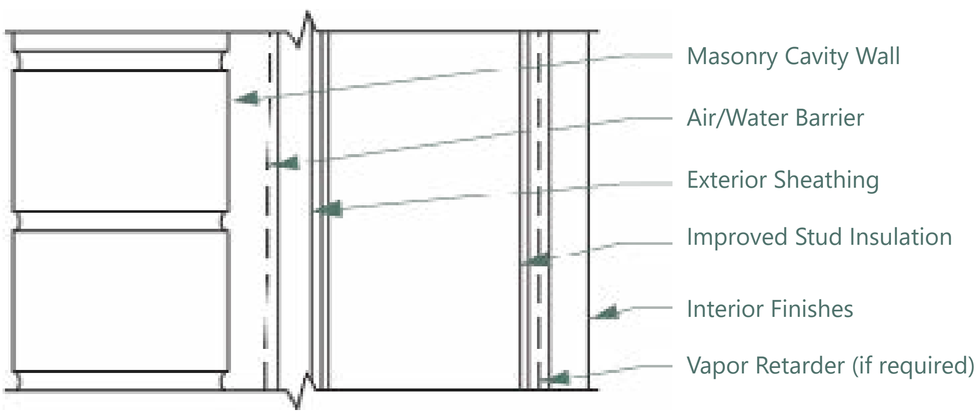
Before insulating the interior of masonry walls, you should have your home reviewed by a building envelope professional. Masonry walls are built to “breathe”, this allows them to absorb, store, and evaporate moisture on both the interior and exterior. Insulation on the interior may hinder needed evaporation, causing the wall to stay wet for a longer period and potentially leading to damage by the freeze/thaw cycle. A building envelope professional can evaluate whether an existing masonry wall is durable enough to allow for interior insulation.



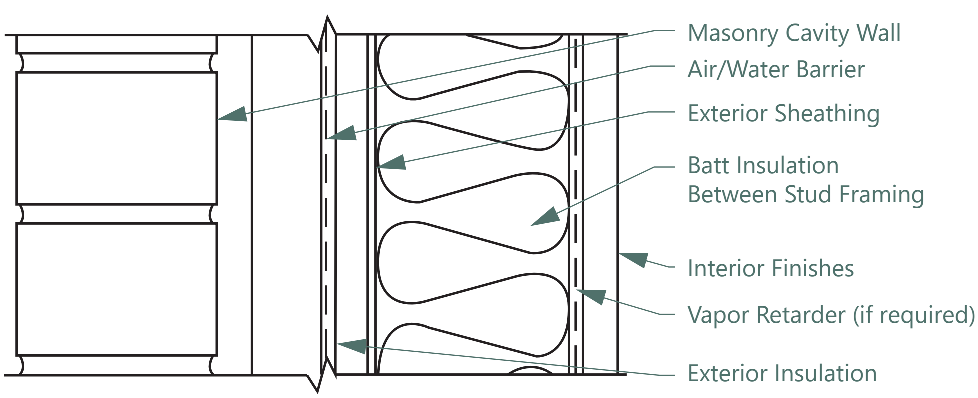
Framed Wall with Veneer



Framed Wall with Veneer



Framed Wall with Masonry Veneer

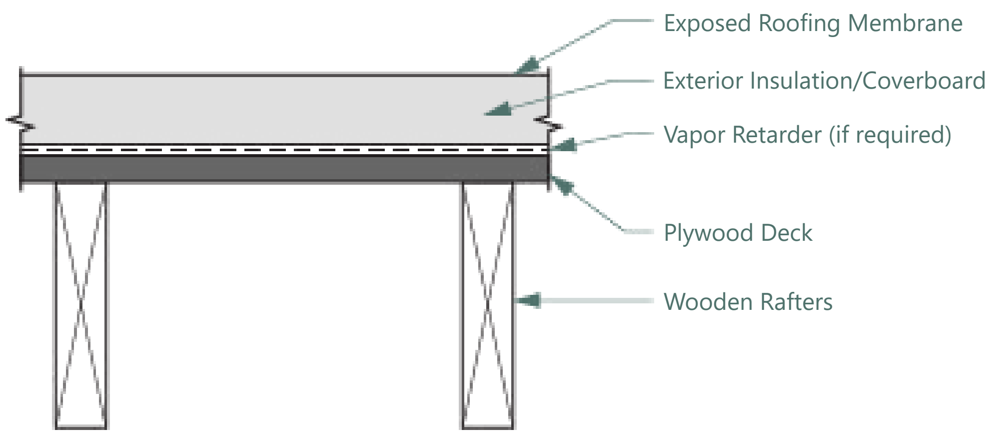


Framed Wall with Masonry Veneer

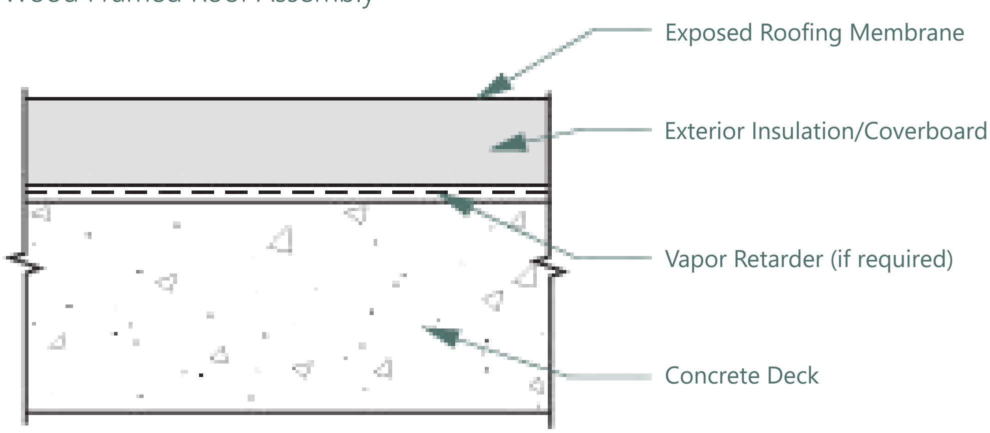
Roof Insulation

Insulating a roof or attic space is typically the most important step towards increasing energy efficiency within buildings. There are several options for adding additional insulation to existing roof assemblies including insulation above the roof deck, insulation below the roof deck, or insulation in the attic space below a roof. Installation of rigid insulation above a roof deck works best for low-sloped roof assemblies, a wood-framed structure typical of residential row houses. The insulation may also go below the roofing membrane.

Insulation installed below the roof deck is typically used on steep-sloped roof assemblies. Insulating along the underside of the roof deck between the rafters increases the total conditioned space in the building and is required when temperature or moisture-sensitive mechanical equipment is placed in the attic space. Alternatively, insulating the attic floor with batt insulation between the ceiling joists can be used when it is not necessary to condition the attic space. Regardless of the insulation arrangement, ventilating the space above the insulation by way of eave, gable and ridge vents is critical for passive ventilation.



Wood Framed Roof Assembly



Concrete Roof Assembly

Guidelines and Tips: Walls and Roof

- Coordinate strategies with information learned from a home energy assessment.
- Consider continuous or comprehensive insulation layouts and their appropriateness for repairs, additions, and new buildings.
- Identify and preserve inherent thermal properties of the building and determine appropriate insulating measure for the characteristic features and climate.
- Evaluate material durability and expected service life of existing and replacement materials when considering repairs, rehabilitation, or replacement of walls and roofing, For example a slate roofing shingle, which has a high upfront cost, can have a 75+ year lifetime, compared to an asphalt roofing shingle, which has a 10+ year lifetime.
- Retain, preserve and repair character-defining features of walls and roofs, including finish materials, functional elements, and decorative features.
- Avoid making new penetrations or cuts through primary elevations, limiting air intake and ventilation through secondary elevations or through the roof. Seal new penetrations appropriately to prevent air and water entry.
- Install insulation and ventilation features so that it will not damage or result in loss of character-defining features of the building.
- New exterior wall and roof finish materials should convey a similar scale, texture, and visual appearance to those originally found on the building.
- Properties with significant historic interiors, avoid changes to the proportional relationships of wall to trim and wall to window.

Low Cost Strategies: Walls and Roof

Roof Insulation	• Consider adding either batt insulation in the attic floor to prevent heat gain and loss through the attic space or insulation hung along a sloped roof deck (be sure to allow for ventilation) to have a conditioned attic space.
Roof Vents and Air Circulation	• Provide attic vents to allow for air flow within the attic so moisture and condensation does not build-up. This could include louvers in gable ends, ridge vents, or soffit vents. • Attic and ceiling vans can help vent and circulate air to improve the comfort of occupant.
Roof and Wall Air Sealing	• Evaluate areas that could have improper connections such as wall-to-roof connections. Improving these areas could reduce air leakage or heat transfer. • Replace interior and exterior perimeter sealant, weather stripping, or loose and missing wall and roof sheathing.

Higher Cost Strategies: Walls and Roof

Walls (Wood Framed Buildings)	• Provide additional wall insulation. Either from the exterior cavity insulation or interior insulation between the stud framing to increase thermal performance. When possible, provide continuous insulation without thermal breaks (such as studs or similar wall elements) interrupting the insulation.
Walls (Masonry Buildings)	• Repoint exterior masonry to provide increased wall durability and limit the air and water infiltration to your building. • Consult a building professional when considering insulation to avoid negative impacts to the durability of the masonry walls.
Rood Membrane	• Install a "cool-roof" membrane that reflects the sun and absorbs less solar radiation.
Roof Insulation	• Add roof insulation in conjunction with a roofing-membrane/ system replacement project.

WINDOWS AND DOORS

Windows and doors are important architectural features of older buildings in providing a sense of scale, craftsmanship, proportion, and architectural style. Historic windows come in a variety of styles and configurations and are typically constructed of wood with a painted finish. Windows require regular maintenance and repair. Replacement windows are a large expense and will only improve a limited area of the exterior enclosure. The typical ratio of fenestration to exterior wall surface area on historic buildings is around 20%, meaning the expense for full window replacements may not be a cost-effective solution given the long pay-back period based on the projected energy savings from the upgrade. Replacement windows may be justifiable if there is window failure. Upgrading the solid area of the exterior walls and roof and only performing moderate improvements to existing windows may provide better return on investment while preserving important character-defining features.

Windows

Typical concerns regarding windows include operability, air infiltration, maintenance and appearance. Generally, the appearance of a window that has not been properly maintained can seem significantly worse than its actual condition. Replacement of an entire window because of a deteriorated component, typically the sill or bottom rail, is rarely necessary. In many instances, selective repair or replacement of damaged parts and the implementation of a regular maintenance program is all that is required. It is generally possible to repair windows in fair or good condition relatively economically.

Maintenance

- Regularly review condition, repair and repaint windows

To Improve Operation

- Verify that sash cords, chains and weights are functional- Install metal sliders or sash tape, balances or operators at jambs if repair is not practical
- Repair or replace deteriorated components such as parting beads that separate window sash
- Remove built-up paint, particularly at jambs

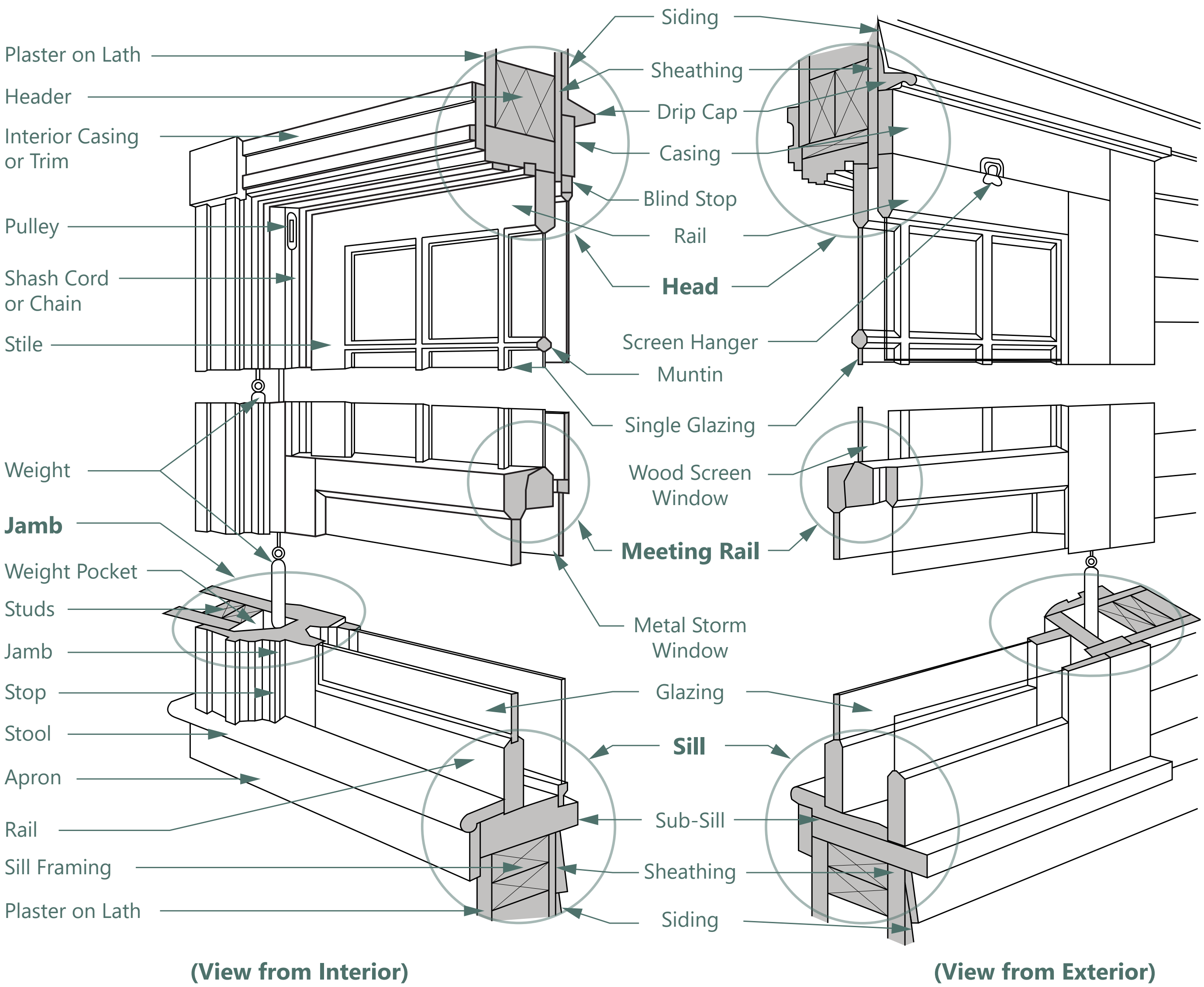
To Reduce Air Infiltration

- Replace broken glass (glazing)
- Install weather-stripping snugly between moving parts- Quality metal weather-stripping can last 20 years
- Re-caulk perimeter joints and remove and replace missing or cracked glazing putty

- Add sash locks to tighten windows
- Add interior or exterior storm window- A storm window can achieve similar R-values to a new thermal window

To Reduce Solar Heat Gain or Heat Loss

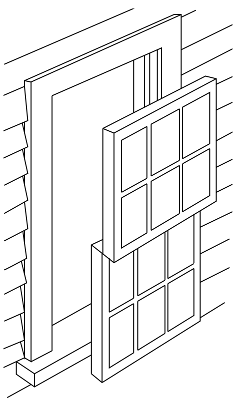
- Install and utilize operable exterior shutters where historically appropriate
- Install interior blinds, curtains or UV window shades
- Plant deciduous trees at south and west elevations to block summer sun and allow in winter sun, and plant conifer trees at north to reduce effect of winter winds



Double-Hung Window Components

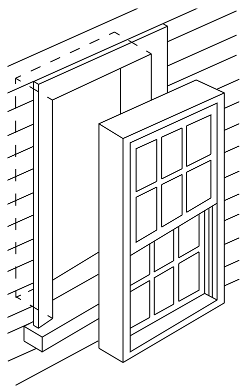
Repair or Replacement of Existing Window Components

Deteriorated sills, sash and muntins are repairable by craftsmen with wood consolidant or replacement parts, retaining original fabric and function. In-kind replacement sash components and sills can be custom-made to replace deteriorated elements if necessary. Property owners are strongly encouraged to explore repair and selective replacement parts options prior to considering whole sash or frame replacement, particularly at historically significant buildings.



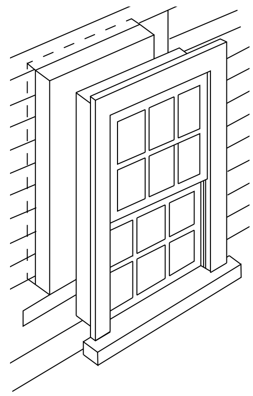
Shash-Only Replacement

Installation of new sash in existing frame. Can include new jamb liners.



Window Replacement Insert

Installation of new sash and frame unit within existing opening. This typically reduces the overall size of the sash and glass, reducing interior daylight.

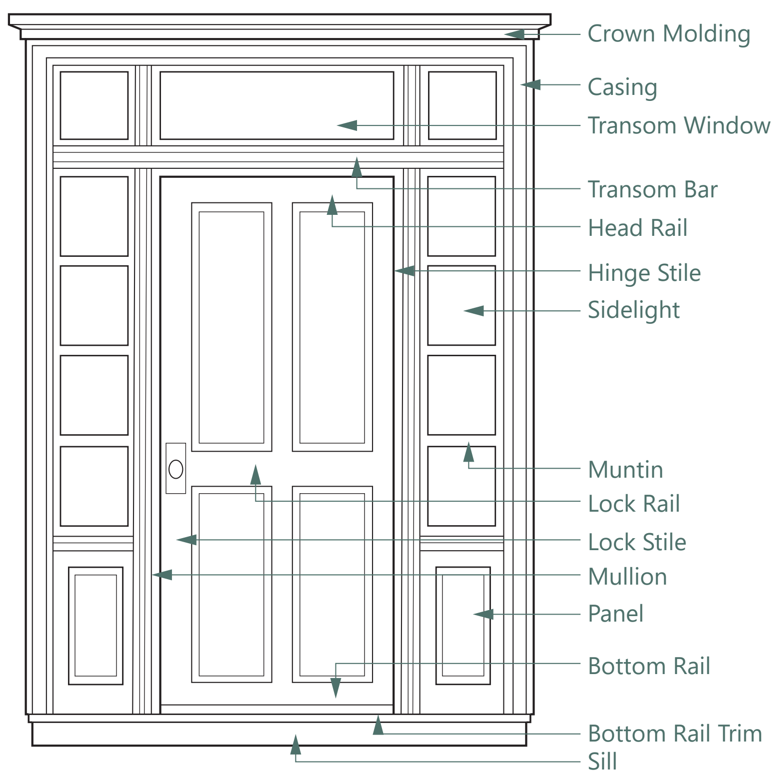


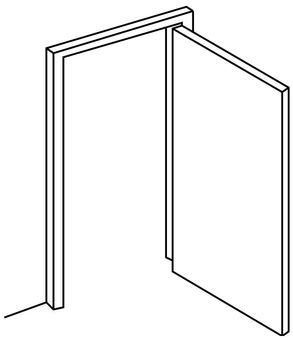
Full Window Replacement

Installation of new sash, frame and casing. The casing should be compatible with the building style. This approach may require modification of opening or siding.

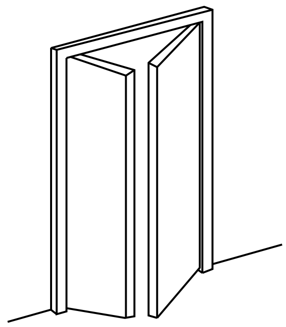
Doors

Historic wood doors are also significant features and should be retained where possible. Historic doors have similar maintenance as windows. Regular painting and renewed weather stripping are the most effective low-cost strategies for improving energy performance. Replacement doors may have more thermal resistance, but doors are only a small area of the total exterior wall surface meaning it may not have a significant effect on the overall building energy performance. Regular maintenance and replacement of interior and exterior perimeter seals, gaskets, and weather stripping around windows and doors can significantly improve their energy performance.

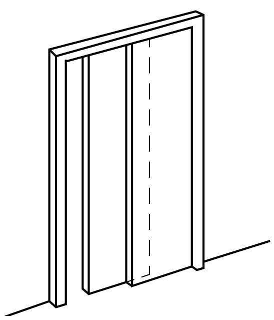




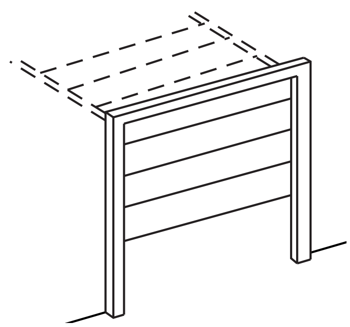
Hinged



Double or Paired



Sliding



Overhead

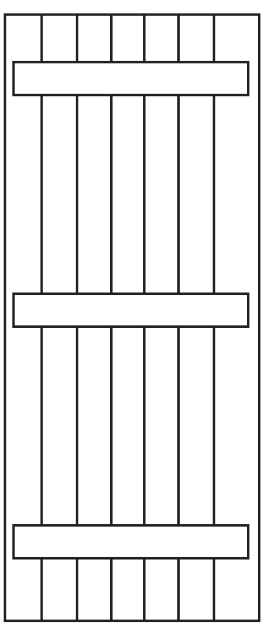
Common Door Types

Hinged: Swings to close at opposite jamb – almost always mounted at interior thickness of wall swinging inward

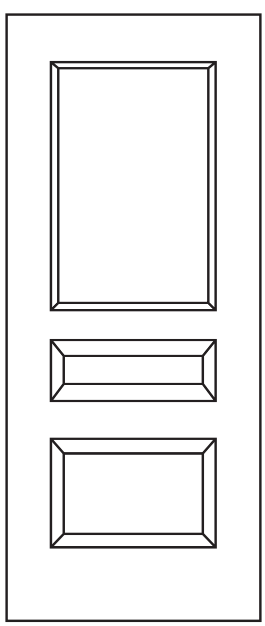
Double or Paired: A pair of swinging doors that close an opening by meeting in the middle – includes French doors

Sliding: Either a fixed panel with a horizontally sliding door or overlapping horizontally sliding doors – includes patio doors

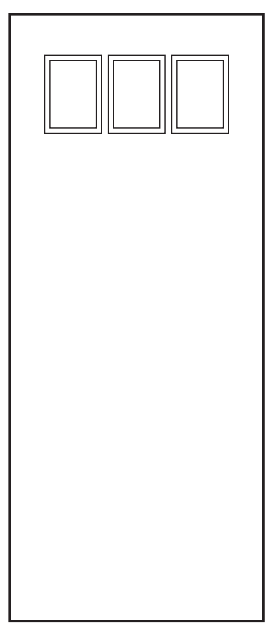
Overhead: Horizontal sections that open upward by sliding on tracks – most often found at garages



Batten



Paneled



Flush

Common Door Styles

All door styles can have glazing installed in different configurations.

Batten: Full height boards attached edge to edge with horizontal boards nailed to the verticals

Paneled: A frame of solid wood parts with either glass or wood panels

Flush: A single plain surface on its face, typically wood veneer

Guidelines and Tips: Windows and Doors

- Perform regular maintenance on older windows and doors to ensure functionality and weather tightness.
- Apply weather stripping, install storm windows and doors, and undertake basic repairs to windows and doors to improve thermal efficiency.
- Repair or reopen transoms to improve air flow and cross ventilation.
- Maintain, repair, or reinstall operational shutters and awnings.
- Retain, preserve, and repair original windows and doors unless repair is not a reasonable option.
- Replacement windows and doors on primary elevations should closely match the historic appearance. New windows and doors should fit properly within the original openings, replicate the pane configuration, dimensions and profiles of sash or door leaf, and match the finish and visual qualities of the historic windows and doors.

Low Cost Strategies: Windows and Doors

Weather Stripping	• Add weather stripping to existing windows, this can increase the energy efficiency of windows by up to 50%. • Tighten and seal around the window and between the upper and lower sash to make the windows more energy efficient. Most of the heat loss through older and historic windows occur around the perimeter of the sash. • Replace interior and exterior perimeter sealant and putty glazing, these components have significantly shorter lifespans than the wood and glass components. • Use joint filler, caulk, glazing putty and sealants to seal cracks and opening on non-moving parts such as around frames and glazing. • Use metal, silicone, rubber, or felt weather stripping on moving window elements to provide a tighter fit without sealing them shut.
Locking Mechanisms	• Repair or replace locking mechanisms to prevent excess air and heat loss through the window perimeter.
Window Treatments	• Add interior shading or drapes to minimize heat gain or loss through windows.

Higher Cost Strategies: Windows and Doors

Storm Windows/ Door	• Install storm windows on the interior or exterior of an older window to improve thermal efficiency. Storm windows provide additional insulation in the air space between the existing window and the storm window. To be effective, ensure proper seal between both the glass and the frame and the frame of the wall. • Install storm doors to improve the thermal performance of historic doors. Storm doors should be compatible with the appearance of the historic door, such as a fully glazed storm door with a frame that matches the existing door.
Window Replacement	• If original windows are deteriorated beyond repair, replace existing windows with new insulated windows. Replacement windows should closely resemble the existing windows. • When selecting replacement windows and doors considering choosing ones that are durable, repairable, and recyclable.
Window Restoration	• If original windows are not deteriorated beyond repair, restoring the window is the best option for historic homes within the historic districts with original windows.

MECHANICAL SYSTEMS

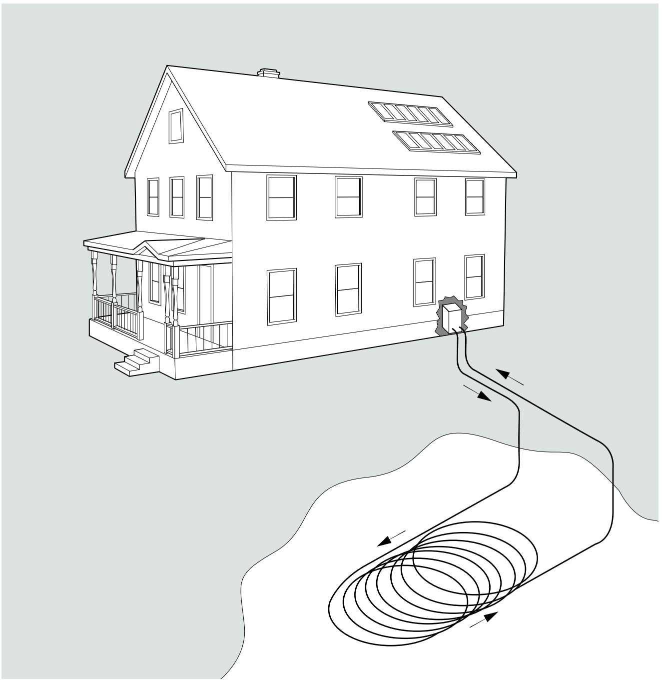
When considering installing or replacing mechanical systems in your historic home it is important to understand your options as mechanical system updates can have a large cost impact. Try to retrofit or update your mechanical systems when they are close to end of life use. Do not assume you have to replace an older system with the same type of older system. There are newer HVAC technologies that have significant benefits for historic buildings and the environment.

An air-source heat pump system is one option; these systems do not necessarily require ductwork, which can be helpful when trying to limit damage to existing walls, ceilings, and building structures. These systems are also extremely quiet, energy efficient and customizable for zoned operation. Both air-source and ground-source heat pump systems do not burn fossil fuels; they use electricity to run a compressor. Ground-source heat pumps take advantage of the stable, underground temperature of the earth (about 50 degrees Fahrenheit in Massachusetts), ground-source heat pumps are the most efficient heating and cooling system available.

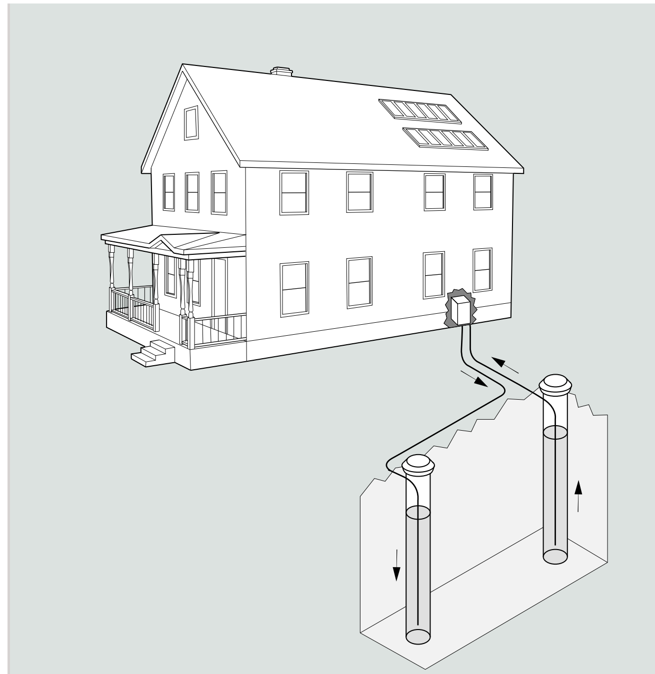
Ground-Source Heat Pumps

A ground-source heat pump (GSHP) is a central heating and cooling system that transfers heat to or from the ground. It uses the earth as a heat source or a heat sink. This design takes advantage of the moderate temperatures in the ground to boost efficiency and reduce the operational costs of heating and cooling systems. A ground loop is a heat exchanger, like a cooling coil, that either extracts or adds heat to the ground. There are four types ground loop systems: horizontal, vertical, and pond/lake (closed-loop systems), and open loop. The type of system used depends on the climate, soil conditions, available land, and installation costs. The most common system for historic homes is generally vertical, closed loop.

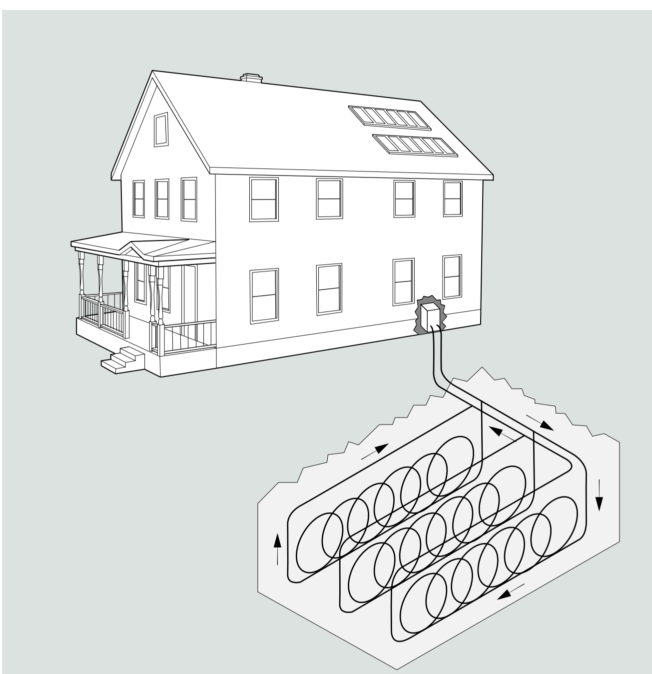
GSHPs are extremely efficient, last a long time, and are typically well suited for historic buildings because they require little equipment and are not visually intrusive to the historic character. GSHP's require less equipment, have fewer moving parts, provide better zone space conditioning, and maintain better internal humidity levels than traditional HVAC systems. GSHPs can cut energy bills by up to 65%. The cost for a ground-source heat pump system can be high as they require drilling and placement of wells deep below grade, though typically, energy cost savings allow the investment to be recouped within two to ten years. More information about GSHPs and available rebates can be found here.



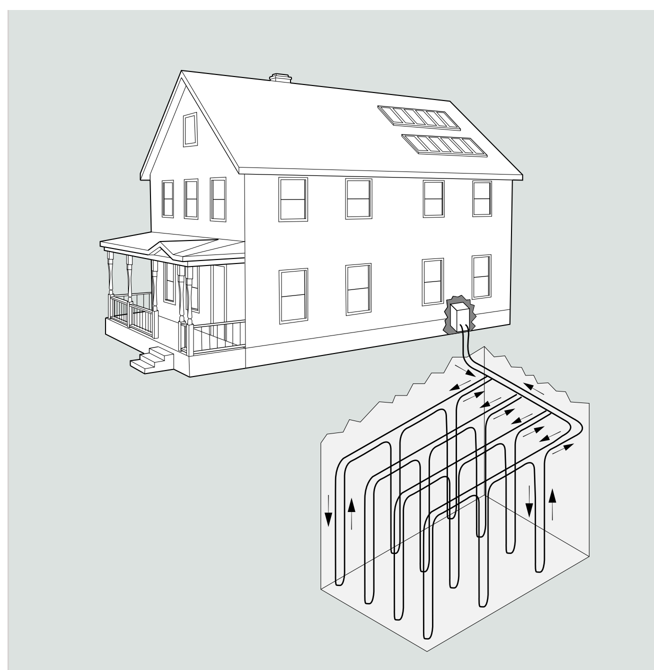
GSHP: Pond/Lake Closed Loop System



GSHP: Vertical Open Loop System



GSHP: Horizontal Closed Loop System



GSHP: Vertical Closed Loop System

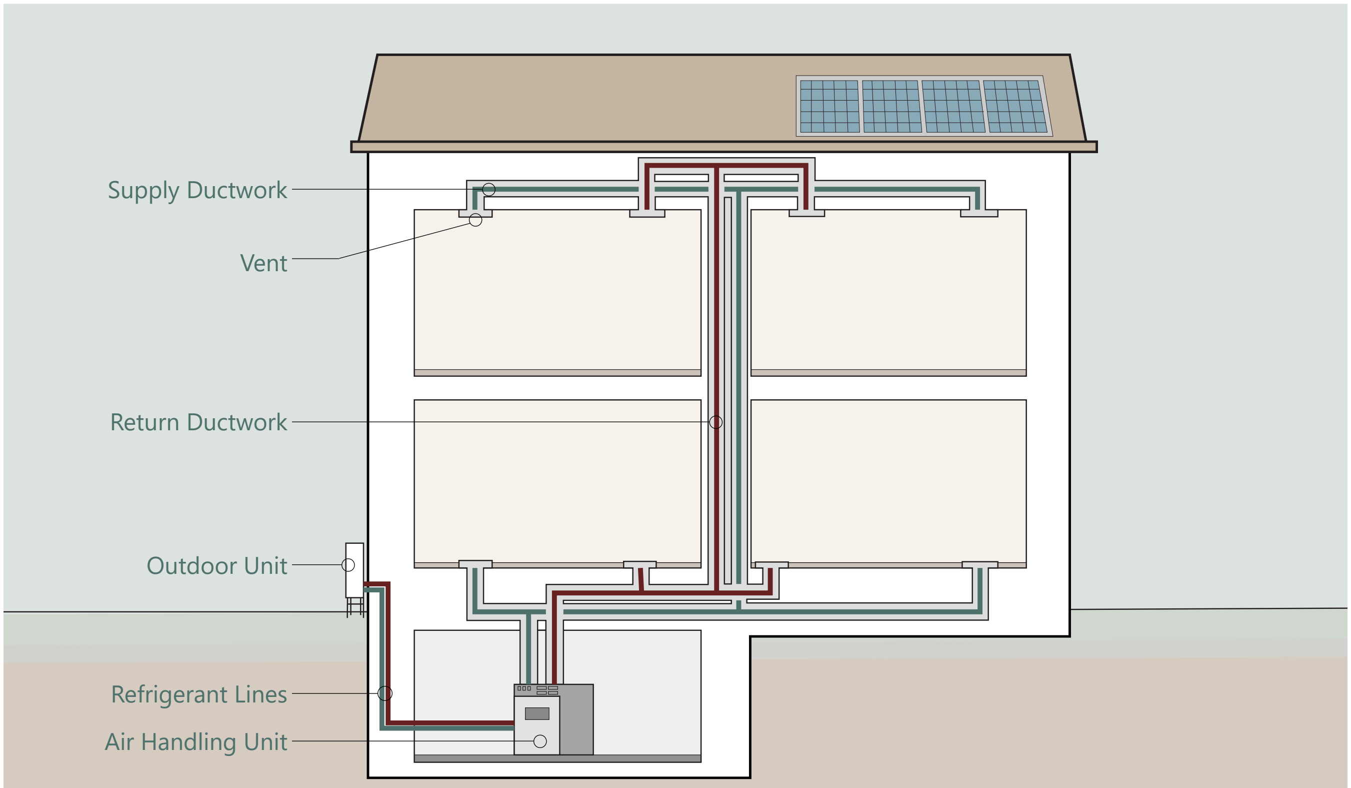
Air-Source Heat Pumps

Air-Source Heat Pumps (ASHP) are heating and cooling systems that move heat into a home in the winter and draw heat out of the home in the summer. Instead of burning fossil fuels, they operate on the same principle as your refrigerator: using a refrigerant cycle, powered by electricity, to move heat and to keep your home at a comfortable temperature year-round. They are much more efficient than electric resistance (electric baseboard) heating and provide highly efficient air conditioning.

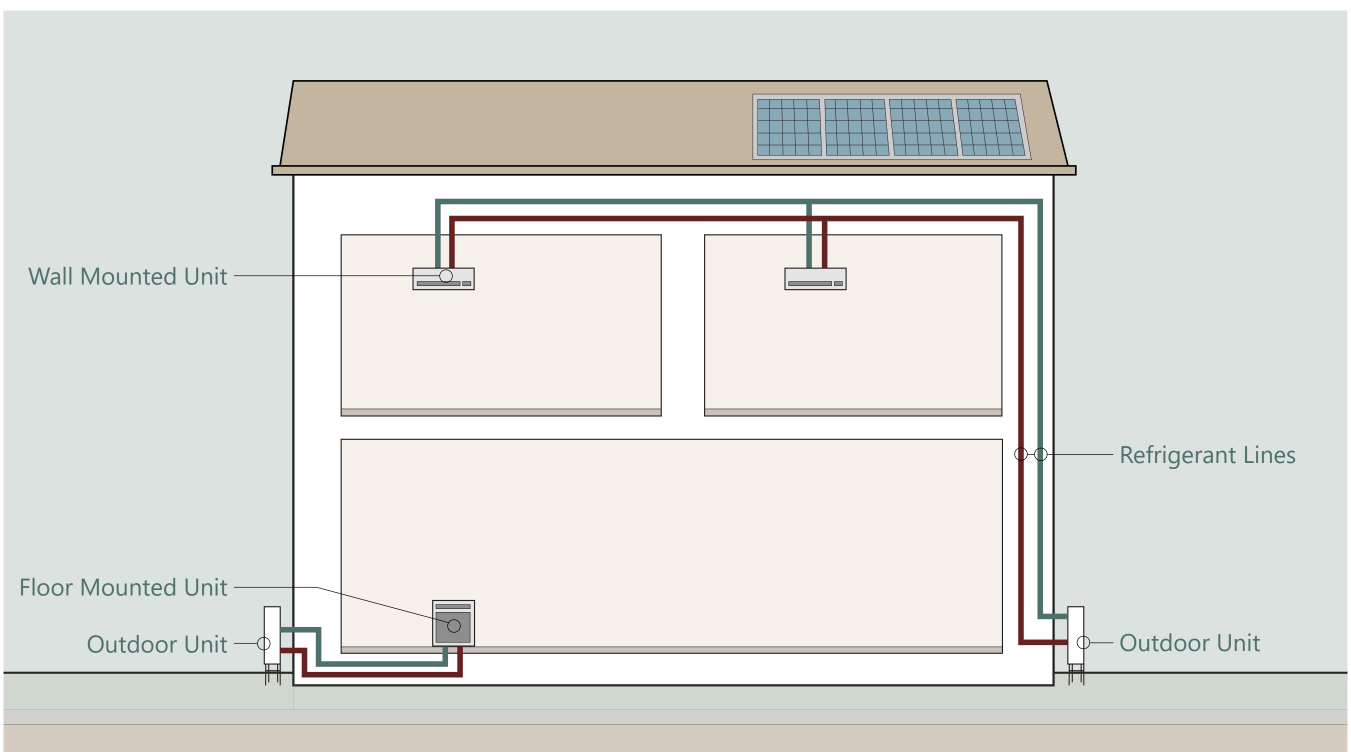
There are two main system types of air-source heat pumps: ducted or ductless. Ducted systems have an outdoor unit (like a central air conditioner), which is connected to an indoor air-handling unit that connects to the home's ductwork. Ducted systems can work well for homes that already have ducts or where the homeowner is planning to install ducts. A version of ducted systems known as "compact-ducted" uses much smaller air handlers that usually serve two to four rooms.

Ductless systems (including "mini-splits") have an outdoor unit which is connected to one or more indoor units (or "heads") by small copper refrigerant pipes. Each head typically serves one room or area of a house. Ductless heads can be mounted on a wall, mounted to the floor, or embedded in the ceiling. Ductless systems are a great option for houses that have no existing ductwork. Homes can be outfitted with a combination of ducted and ductless systems for a custom configuration that meets a home's needs.

The cost to install an air-source heat pump in your home will depend on the specific characteristics of the building, how much of your home's heating and cooling you want to cover with your heat pump system, the kind of system and the features you choose, and your installer. Air-source heat pumps have the lowest up-front installation cost of any low carbon heating or cooling solution and are also cost-competitive to operate compared to oil, propane, or electric heat. More information about ASHPs and available rebates can be found here.



Air-Source Heat Pump: Ducted System



Air-Source Heat Pump: Ductless System

Guidelines and Tips: Mechanical Systems

- Determine which mechanical system is the best fit for your home and your home energy priorities.
- Understand the costs of the mechanical system that is best for your home and plan how you will finance the project.
- Try contacting at least three installers to learn more about installing ground source or air-source heat pumps in your home. Installers may also give multiple quotes for different installation or unit configurations so you can understand all your options.
- If necessary, take preliminary measures to get your home ready for a new heating system, such as upgrading your electrical service or completing any weatherization work recommended in your home energy assessment, like sealing air leaks or installing insulation. If you are planning to improve the weatherization of your home, make sure your installer is aware so that they take the reduced heating and cooling needs of your home into account when designing your ground-source heat pump system.
- Talk to your installer about how long installation will take. Ground-source heat pump installations typically take between 2-4 weeks and air-source heat pump installations typically take between 3 days and 2 weeks, depending on home size, system complexity, and schedules of the driller and installer.

Low Cost Strategies: Mechanical Systems

Ductless Air Source Heat Pump	• If you're looking to use a ductless air source heat pump as your sole source of heating and cooling, an entire ductless system is going to be much more varied in cost because the required number of internal and external units will change based on the unique characteristics of your home. • These units will have to be installed throughout the home in each zone you are looking to heat, or cool, so overall costs can range considerably.

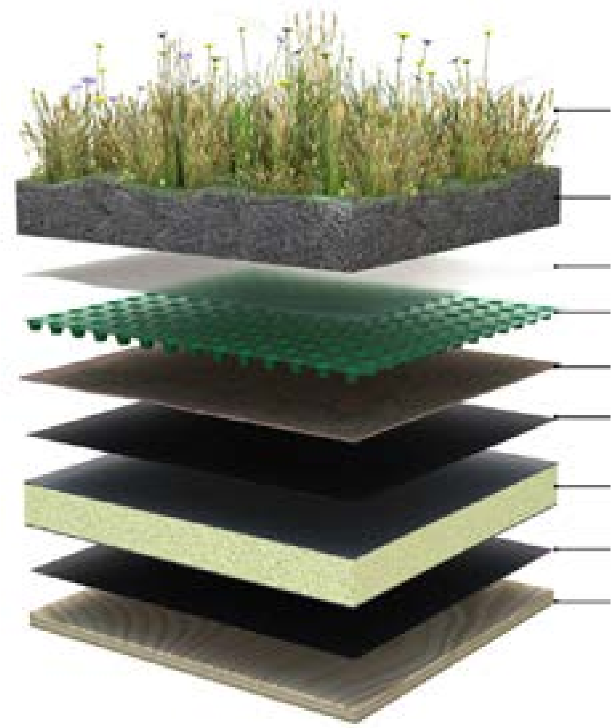
Higher Cost Strategies: Mechanical Systems

Ducted Air Source Heat Pump	• IDucted (or central) systems tend to be more expensive, but more standardized in cost since the installer will simply need to replace your old air handling unit that is already connected to your existing ductwork with an air source heat pump. • If your home does not have a duct system already, installing a complete duct network in your home will add a significant extra cost.
Ground Source Heat Pump	• Geothermal heating systems price varies depending on the type of loop system, vertical or horizontal are most common depending on available space. Horizontal loops are typically more cost effective than vertical loop systems, but you need adequate space to have a horizontal loop system installed.

SOLAR & GREEN ROOF INSTALLATIONS

There are a few different roof installations that can be implemented into your historic home that can be used to capture storm water or to generate renewable energy. Installations of such systems need to consider the building's structural capacity and architectural character.

Green Roofs



Green roofs can have many environmental benefits, they capture and slow storm water run-off, provide insulating qualities to a building, and reduce urban heat-island effect. A green roof typically includes the following components: a supporting structure, continuous waterproofing membrane, root barrier, a drainage layer/ moisture retention mat system, insulation, and soil and plantings. In order to provide a durable watertight long-term roofing assembly, the selection of an appropriate waterproofing membrane and the proper construction of detailing and base flashing is crucial. The soil media, insulation, and drainage/moisture retention systems must all be designed to reduce the volume of runoff.

It is important to consult a licensed architect or engineer as a first step to determine whether the structural capacity of the existing roof can support the green roof installation. It may be necessary to supplement the existing structure. Additionally, a licensed roofing contractor or vegetative roofing supplier should be involved to assist in reviewing the relevant details, drainage, installation, and any suggested quality control measures for testing of the system.

Solar Photovoltaic (PV) Systems

Solar photovoltaic (PV) systems capture sun rays and convert the sunlight into electricity. These systems have the potential to be cost-effective and reliable producers of electricity for your home. The PV system is built from solar cells, which consist of semiconductor materials that absorb sunlight and convert it into energy for immediate use of storage in batteries. There are a variety of solar cell materials available which vary in their appearance and efficiency.

Within the historic districts there may not be a perceptible change in the building's massing, height or roofline, as seen from public street view, and such systems cannot cover or obscure distinctive roof features or finishes on primary elevations, making it difficult for certain homes to install this system.

PV systems can be designed to meet the specific energy needs of a building and its users. Solar cells are interconnected with other cells to form flat-plate panels or modules that are installed on a building or in a rack to form a PV array. Panels can either be fixed in place or installed to track the movement of the sun throughout the day. Thin-film PVs make it possible for solar cells to double as roof shingles, roof tiles, building facades, and even glazing for skylights. These systems are new to the residential market but are increasing in popularity and effectiveness. Products such as solar roof shingles have the potential to integrate renewable solar energy in a subtle and attractive way on older existing buildings. More information about solar panels and available rebate programs can be found here.

Example of a solar array mounted onto roof of historic home.

Solar shingles implemented into the roof of a home. These shingles are still located in a discreet area.

Guidelines and Tips: Solar and Green Roof Installations

- Consult a structural engineer or architect to assess the roof's structural capacity when considering installing a green roof or roof-top solar array.
- Consult a specialist in green roofs or solar installations to ensure that the system is professionally designed and scaled for your building.
- Consider the life-expectancy of the existing roof and whether replacement should be undertaken prior to installing a green roof or solar array. The roof should be watertight and have adequate slope and drainage.
- When implementing roof installations retain original character-defining roof features and finish materials.
- Install green roofs and solar panels so that they do not result in a perceptible change in the building's massing, height or roofline, as seen from public street view, and do not cover or obscure distinctive roof features or finishes on primary elevations.
- For buildings with flat roofs, locate green roofs and solar installations back from the front edge of the roof (and from the exposed side edge for corner properties) to minimize their visibility from public street view.
- For buildings with sloped roofs, locate solar installations on secondary elevations to minimize their visibility from public street view, away from roof edges and ridges. Use low-profile panels set flush with the roof and in a complementary color with the roof finish to avoid a discordant or visually obtrusive appearance.

Low Cost Strategies: Solar and Green Roof Installations

Roof Finish	• Install a white roof finish to deflect solar rays and reduce heat gain.
Green Roof	• Install a green roof on a secondary building, such as a shed or garage.

Higher Cost Strategies: Solar and Green Roof Installations

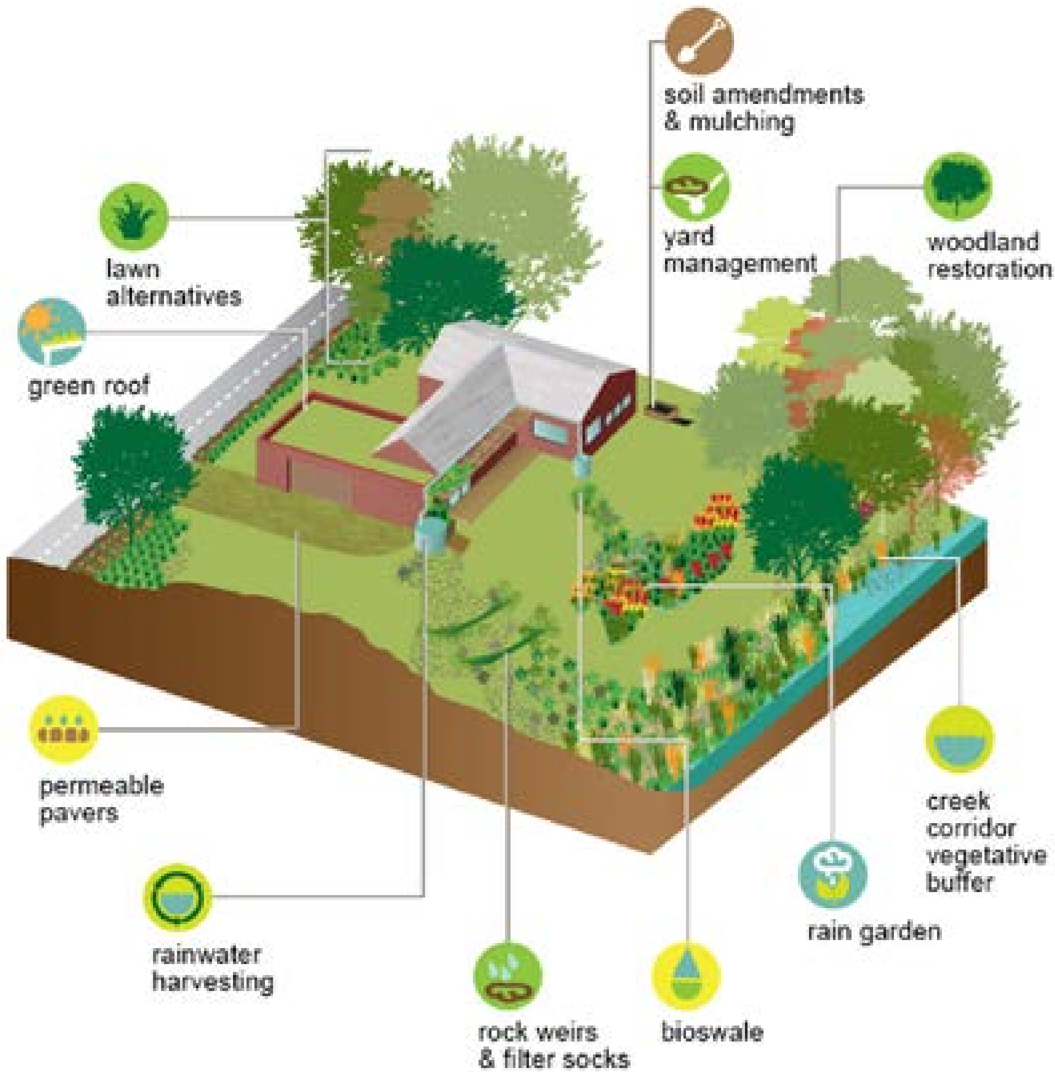
Green Roof	• Install a green roof on the primary building.
Solar	• Install a solar photovoltaic system and/or solar thermal system.

LANDSCAPE & SITE FEATURES

Landscape and site features can cost effectively reduce energy use, resource consumption, and heating and cooling costs as well as improve the appearance of a property. These features can also help manage storm water and reduce heat island effect. Heat island effect is a phenomenon where extensive paved surfaces in urban areas raise the ambient temperature above the surrounding region. As a result, downtown is sometimes 10-15 degrees hotter than surrounding neighborhoods. Incorporating more vegetation in dense areas can reduce this effect.

Existing landscape and site features that enhance building performance, manage storm water, and improve interior comfort should be maintained and supplemented. Strategies could include removal of impervious paving and/or installation of permeable paving, installation of green roofs, reestablishment of tree canopy, incorporating bioswales or rain gardens and planter boxes, and rainwater harvesting. Bioswales are landscape elements designed to concentrate or remove debris and pollution out of surface runoff water. They consist of a swaled drainage course with gently sloped sides (less than 6%) and filled with vegetation, compost and/or riprap. As the roofs of most buildings drain to the rear (rather than to the front) rainwater harvesting and the installation of bioswales and cisterns are most appropriate in side or rear yards. Paving should be limited in front yards to reduce impervious surfaces and to retain neighborhood character.

For more information about landscape and site features **Concord's Sustainable Landscaping Handbook** can be found here.



Example of several landscape and site features that can be integrated into your historic property to help reduce energy use and manage storm water.

Guidelines and Tips: Landscape and Site Features

- Identify and retain existing sustainable features such as permeable paving and mature trees that block summer sun or serve as a wind break.
- Place new trees and landscaping away from foundations or basement walls to avoid moisture infiltration and damage from roots.
- Select plant and tree species according to their mature size to account for the long-term impact of mature growth.
- Prevent vines, ivy, and other plants from growing directly on the building as they can cause damage to the underlying materials.
- Consider permeable paving options when installing new or replacement paving. Avoid paving up to the building foundation with impermeable surfaces as this can increase building temperature, cause damage to the foundation, and trap moisture.
- Ensure protection of nearby buildings, trees, site features, and known archaeological features when undertaking excavation or regarding for the installation of an underground cistern.
- Identify, preserve, and repair character-defining landscape features such as masonry walls, walkways, topographical features, plantings, or other man-made and natural features.
- Install new paving that is compatible with the character of the building and surroundings, using permeable paving if appropriate, for walkways, driveways, and patios.
- Install rain gardens, bioswales, and cisterns or other rainwater harvesting systems in a manner that is compatible with the landscape character of the property and surrounding context. Side and rear yards are typically the most appropriate place for larger landscape features that require substantial excavation or changes in topography.

Low Cost Strategies: Landscape and Site Features

Landscaping	• Preserve existing trees and plants, particularly mature trees. • Use native plants, shrubs, and well-placed trees to reduce water consumption and provide shade and wind protection. • Maintain trees to promote health and avoid property damage.
Composting	• Compost food and yard scraps to enrich soil instead of using store-bought chemical fertilizers.
Rainwater Harvesting	• Collect and store rainfall from rooftops or other impervious surfaces in rain barrels or below ground cisterns for on-site use. • Non-potable uses include irrigation, washing sidewalks cars or pets, refilling water features or swimming pools.
Water Efficient Irrigation Systems	• Install systems that reduce water consumption such as drip irrigation, soaker hoses, moisture sensors, and timers.

Higher Cost Strategies: Landscape and Site Features

Permeable Paving	• Install permeable paving materials to allow stormwater to filter through voids or pervious joints in the surface where it is captured in underground layers of soil and gravel. • Examples include porous asphalt, porous concrete, brick pavers, vegetated permeable pavement, and interlocking pavers.
Rain Gardens and Planter Boxes	• Use shallow vegetated basins or planter boxes to capture and store stormwater runoff and pass it through a filter bed of engineered soil composed of sand, soil, and organic matter. Filtered runoff may be collected and returned to a storm sewer or allowed to infiltrate into the soil.
Rainwater Harvesting-Underground Cisterns	• Install an underground cistern to collect and store rainfall from rooftops or other impervious surfaces for later use. • Residential cisterns typically have a capacity between 1,500-5,000 gallons. Most cisterns have a standard pressurized plumbing system that conveys water to the house or wherever needed for use.

4. CASE STUDIES

The case studies featured below and a growing number of historic rehabilitation work across the nation demonstrate that green building technologies are compatible with the preservation of historic buildings. While some of the components of historic buildings may seem to conflict with sustainable strategies, most issues can be resolved by early consultation with qualified preservation designers, understanding the issues, and becoming familiar with the process. Early guidance from qualified professionals with experience in applying the energy efficiency strategies to rehabilitation projects will result in projects that meet sustainability goals while preserving historic buildings and neighborhoods.

PRIVATE RESIDENCE

Walla Walla, WA

This private residence in Walla Walla was built in 1917 and is listed on the Walla Walla Register of Historic Places. The rehabilitation earned a 4-Star Built Green certification, which began with a comprehensive plan that was put into place before the project began to ensure that all goals were met. These included blower door testing which determines the airtightness of a building to determine where improvements can be made. All new materials were required to be low VOC (volatile organic compounds) that are both healthier for the environment and indoor air quality of the home. All materials on site were either carefully sorted and reused or were used for other purposes off site. The advanced planning paid off in energy efficiency and comfort for the homeowners.

1917 Private Residence located in Walla Walla, WA that underwent a sustainable retrofit.

FEATURES

- Recycled insulation added to attic, floor, and walls.
- Ceiling fans installed to redistribute air on hot days.
- Storm windows restored and weather stripping added around window to reduce infiltration.
- Ground source heat pump installed in back yard and feeds new radiant floor heating system, so no source fuel is needed.
- Old concrete and 3-gallon toilets crushed and used for fill under new patio.
- 100% recycling from construction waste to either new uses or recycle plants.
- Indoor air quality emphasized with no formaldehyde and low VOC (volatile organic compound) products.
- New drought resistant plants and impervious materials to help reduce storm water runoff.
- Low flow plumbing fixtures installed such as dual-flush toilets and 18 Energy Star qualified fixtures which contribute to reduced consumption.

Storm windows were restored and windows were eather stripped to reduce air infiltration.

A ground-source heat pump horizontal closed-loop system wall installed in the backyard so no source fuel is needed.

THE PEARL APARTMENTS

Spokane, WA

Built in 1911 of brick masonry, the Pearl Apartments in Spokane contribute to the West Downtown Historic District. SMR Architects of Seattle was hired by the Spokane Housing Authority to rehabilitate the former apartment complex into affordable housing. The project used the Federal Historic Preservation Tax Incentive program, as well as met the criteria for the Built Green Multi-Family certification. Historic features were maintained and restored while advanced testing informed project needs on moisture protection, insulation requirements and efficient energy system upgrades.

The Pearl Apartments located in Spokane, WA is a 1911 brick masonry building that was sustainably retrofitted to make affordable housing.

FEATURES

- Rigid insulation added to exterior masonry walls for higher performance; blown-in insulation at roof.
- Energy Star fixtures and bulbs installed throughout.
- Heat-recovery ventilator and high efficiency heat pumps installed in units.
- Doors and windows weather-stripped to reduce infiltration.
- Spokane bio-based tile and linoleum used for better indoor air quality.
- Light interior finishes add reflectivity of natural light.
- Recycling stations at each floor for occupants.

The doors and windows were weatherstripped to reduce infiltration and the exterior lighting was replaced with Energy Star fixtures.

HARVARD HOUSEZERO

Cambridge, MA

The Harvard Center for Green Buildings and Cities at the Harvard Graduate School of Design has completed the retrofit of a pre-1940s building in Cambridge into a living laboratory to be used as an energy-positive prototype that can help us to understand buildings in new ways. HouseZero creates a blueprint for reducing energy demands and increasing cost savings for property owners. The building will adjust itself seasonally, and even daily, to reach thermal comfort targets. 285 sensors embedded within the building collect millions of data points each day. This data infrastructure enables the building to immediately self-adjust in response to both internal and external variables such as outdoor air temperature or rain, and indoor CO2 levels and air temperature.

The Harvard Center for Green Buildings completed a green retrofit on a pre-1940s building in Cambridge, MA.

The interior of the home was designed so no artificial light is required during daylight hours.

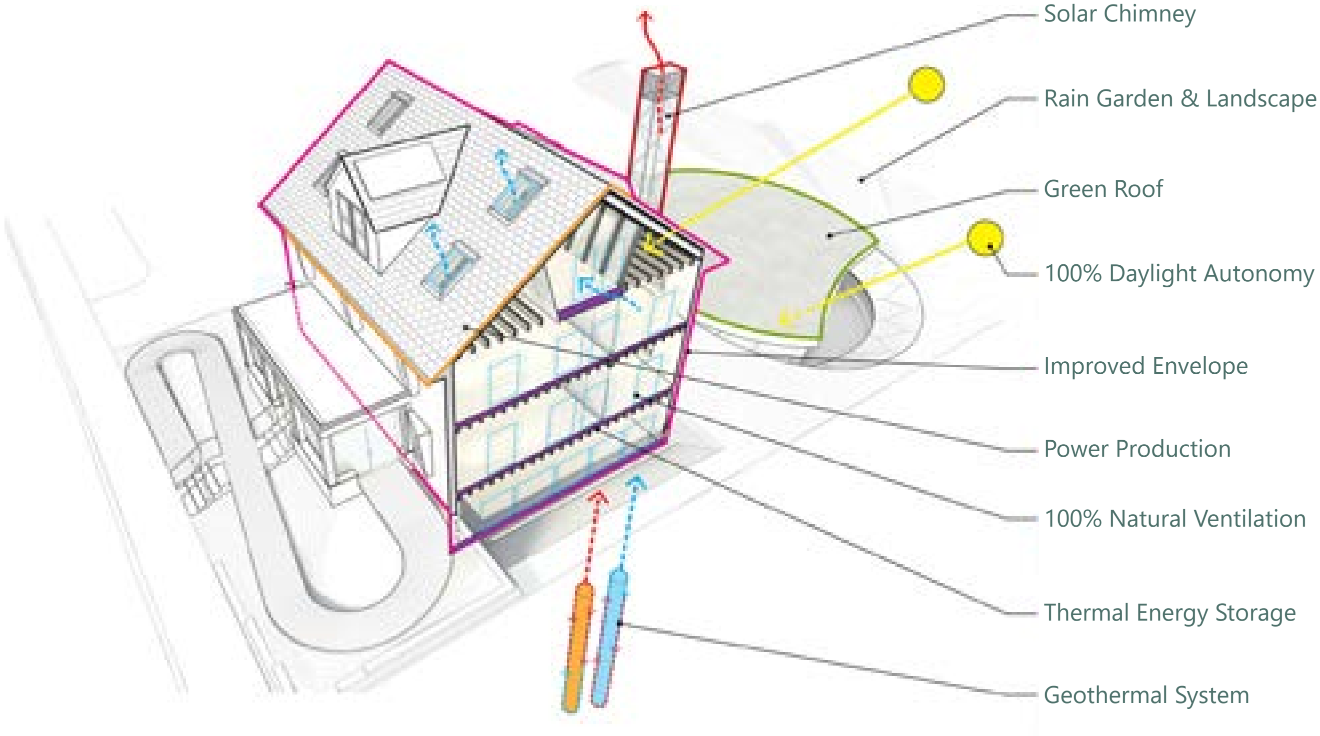


Diagram of where the sustainable strategies were implemented within the building.

FEATURES

- A solar chimney was installed that uses air heated by the sun to pull air from basement spaces below to properly ventilate meeting spaces that have more occupants.
- Replaced an existing parking lot with rain gardens and landscape that mitigates stormwater.
- Green roof installed to help control storm runoff, reduce solar gain on roof and reduce visual impact by blending in with landscape.
- Designed so no artificial light is required during daylight hours on non-cloudy days. Roof and window treatments are shaped to allow maximum light during winter and no direct daylight during the summer.
- Insulation, air tightness, and waterproofing are substantially increased through improvements to the existing walls and roof.
- Minimal on-site power needs are met by photovoltaic shingles on roof and stored via batteries in the house.
- All heating and cooling energy is exchanged in the ground through geothermal wells and released through radiant slabs in the house. A solar thermal panel on the roof provides all domestic hot water and can switch to heat certain areas of the house.

THE ORCHARD HOUSE

Concord, MA

The Orchard House built in 1660, (where Louisa May Alcott famously wrote Little Women) is a historic house museum in Concord that is leading the way in sustainable innovations that will ensure the house is enjoyed for generations to come. The number one priority is to preserve the historic character of the Orchard House and its collections; however, the property managers have implemented a wide range of sustainability initiatives. These initiatives have enhanced the energy and water efficiency, reduced the carbon footprint, and made sure the building is physically resilient.

The Orchard house was 1660 wood framed home that underwent a sustainable retrofit in 2010.

FEATURES

- Installed geothermal heat pumps which reduced the electric bills by 60-70%, reduced noise pollution, maintained the buildings historical character, and made it so there is no burning of fossil fuels on site.
- Updated bathrooms with WaterSense toilets which use 20% less water than a standard toilet.
- Went paperless, utilizing digital memberships and e-newletters.
- Transitioned to LED lighting by replacing old bulbs and fixtures in both the interior and exterior of the building.

Ground-source heat pumps were installed in the back of the house and they also restored the foundation at the same time.

5. HDC REVIEW PROCESS

The Historic Districts Commission (HDC) is a volunteer board of Concord residents appointed by the Board of Selectmen to implement the Concord Historic Districts Act. The purpose of this Act is to promote the educational, cultural, economic, and general welfare of the public through the preservation and protection of buildings, places, and districts of historic or literary significance. The HDC members' expertise may include architecture, design, law, and the experience of having lived in a historic home or a historic district.

An approval from the HDC may be required if your property is listed within the Concord's Historic Districts Listed. The Historic Districts include the following:

- **The American Mile**
- **Barrett Farm Historic District**
- **Church Street Historic District**
- **Hubbardville Historic District**
- **Main Street Historic District**
- **Monument Square/North Bridge Historic District**

Changes to exterior architectural features visible from a public way are subject to review by the Commission. Interior changes, landscaping, replacement in-kind/ordinary maintenance and changes to exterior features not visible from a public way are not reviewed. The HDC considers architectural significance, historical significance, general design, material, size, massing, shape in relation to its site, its surroundings, and to existing buildings and their arrangement, and how the changes affect landscaping. Decisions are made on a case-by-case basis. The following lists are projects that DO or DO NOT require the HDC review process. It is important to note that you should **ALWAYS** check with the Planning Division staff before embarking on any of these projects.

Historic District Commission Resources

Historic District Design Guidelines

New Construction Policy

Properties Listed In Concords Historic Districts (Please check with Planning Division staff if you do not know if your property is located within a historic district.)

HDC Application Materials (Please check with Planning Division staff if you do not know if your proposed project requires an application.)

PROJECTS THAT REQUIRE REVIEW

- Any exterior changes visible from a public street, way, or place including the Concord, Assabet, and Sudbury Rivers and Town-owned land.
- The erection or demolition of any building or structure visible from a public street, way, or place.
- Any change of exterior paint, roof, or other material color.
- Any change in existing material or design of existing exterior elements.
- Any changes to existing signage or installation of new signage.
- Changes to any landscaping structures or hardscaping (paving, walkways, retaining walls, etc.).
- Changes to vegetation or plantings, if the vegetation was specifically required as screening necessary to obtain a Certificate of Appropriateness.

PROJECTS THAT DO NOT REQUIRE REVIEW

- Ordinary maintenance and repair of any exterior architectural feature of buildings and structures within the Historic Districts. ("Ordinary maintenance and repair" does not include replacement, or changes in the color, materials, design, or size of the existing feature.)
- The addition or removal of landscaping plant material does not require a hearing unless that material is referred to in a Certificate of Appropriateness as a condition of the granting of that Certificate.
- Temporary signs or structures for official celebrations, charitable drives, or other purposes that the Commission determines do not derogate from the purposes of Historic Districts Act. Temporary signs and structures must be removed within three days following the event under the Historic Districts Act.

6. ADDITIONAL RESOURCES

Sustainability in Concord

Concord's History of Sustainability

Concord's Climate Action and Resilience Plan

Building Standards

LEED

Passive House

The Red List

Financing Opportunities and Rebates

Rebates Available for Concord Homeowners

Concord Rebates- Concord Municipal Utilities

Free Home Energy Assessment

Ground-Source Heat Pump Rebates

Air-Source Heat Pump Rebates

Solar Rebates

Weatherization Rebates

Mass Save

Federal Historic Preservation Tax Incentive Program

Incentives and Financing for Energy Efficient Homes

Walls and Roof

EnergyStar Seal and Insulation Guide

Windows and Doors

Guide to Weatherstripping

Energy Saver- Weatherization

Guidelines for Windows and Doors- Plan Portsmouth

Solar and Green Roof Installations

Learn About Concord Solar

Mechanical Systems

Learn More About Ground-Source Heat Pumps

Learn More About Air-Source Heat Pumps

Mass Clean Energy Center: Guide to Air-Source Heat Pumps

Mass Clean Energy Center: Guide to Ground-Source Heat Pumps

Energy Saver- Heat Pump Systems

Landscape and Site Features

Sustainable Landscaping in Concord

Concord's Sustainable Landscape Handbook

Water Conservation

Native Plants for Sustainable Landscaping Guide

Case Studies

Harvard House Zero- Cambridge, MA

The Orchard House- Concord, MA

Historic Home in Deerfield, MA Gets Retrofit and Restoration

107 Year Old Net Positive Victorian Retrofit

Kent Hicks Construction Company

Historic District Commission Resources

Historic Districts Map

Historic District Design Guidelines

New Construction Policy

Properties Listed in Concord's Historic Districts

HDC Application Materials

Additional Resources

Whole Building Design Guide: Retrofitting Existing Buildings to Improve Sustainability and Energy Performance

Whole Building Design Guide: Sustainable Historic Preservation

Historic Preservation and Green Building

Preservation and Sustainability

Guidelines for Preserving Historic Buildings

Sustainability Guide for Existing and Historic Properties

7. FUTURE CONSIDERATIONS

The role of historic preservation in sustainability strategies and reducing carbon emissions is rapidly changing. A growing body of research and the completion of green historic rehabilitation projects keeps the topic one of expanding interest and lively debate. However, much remains to be done to ensure that existing buildings and communities, both urban and rural, are fully utilized to reach sustainability goals as well as enriching quality of life.

Next Steps

1. New innovative **BUILDING CODES** should be developed that better integrate preservation with energy efficiency based on performance.
2. **NEW PARTNERSHIPS** and collaboration should be established between historic preservation groups, government officials, policy makers and green designers and builders to create more successful sustainable historic preservation projects.
3. Expand **EDUCATION** efforts that present preservation technology as sustainability techniques and practices to all levels of educational institutions, including continuing professional education.
4. Historic building energy performance needs **MORE RESEARCH** so that decisions to repair and maintain rather than replace are based on both hard data and historic character.
5. Expand **PLANNING** for sustainable development to include not only rehabilitating historic buildings, but also conservation of existing neighborhoods, commercial centers, and rural landscapes.