

# Build Better

A GUIDE TO ENERGY EFFICIENT CONCEPTS  
FOR NEW RESIDENTIAL CONSTRUCTION



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# Foreward

This guide was developed by the New York State Energy Research and Development Authority (NYSERDA) to help builders construct homes that use less energy. Rising energy costs is a growing concern to homeowners and communities. Energy efficient buildings can significantly reduce energy bills and create quieter, more comfortable homes with improved indoor air quality. Reducing energy use also decreases the amount of energy needed from power plants, lowers greenhouse gas emissions, improves air quality and helps New York State's economy by saving millions of dollars in energy costs.

This guide is one small component of NYSERDA's mission to advance innovative energy solutions in order to improve New York State's environment and economy. It is intended to be an informative tool used often by builders at the construction site and homeowners who are actively engaged in projects with energy components.

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# Acknowledgments

NYSERDA, a public benefit corporation, offers objective information and analysis, innovative programs, technical expertise, and support to help New Yorker's increase energy efficiency, save money, use renewable energy, and reduce reliance on fossil fuels. NYSERDA professionals work to protect the environment and create clean-energy jobs. NYSERDA has been developing partnerships to advance innovative energy solutions in New York State since 1975. To learn more about NYSERDA's programs and funding opportunities, visit [nyserderda.ny.gov](http://nyserderda.ny.gov) or follow us on Twitter, Facebook, YouTube, or Instagram.

This guide was an effort of NYSERDA's Codes and Standards Program. This program promotes best practices for compliance with the State's Energy Code within the design, construction and enforcement communities in order to provide more energy efficient and durable structures for the citizens of New York State.

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# Background

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# How to Use This Guide

This guide is, first and foremost, meant to assist New York State builders, contractors, subcontractors and designers improve the energy efficiency of small-scale residential construction. The guide is also useful for existing and prospective homeowners interested in developing an understanding of the importance and value of energy efficient construction techniques. For both audiences, the guide presents construction concepts for buildings that promote energy efficiency, safety, durability, comfort and economy.

This guide is designed as an easy-to-use reference that can be kept in tool boxes used on the construction site. While it incorporates information and illustrations consistent with good building science and construction practice, it is not intended to be a complete construction resource. Accordingly,

the guide addresses neither specific code requirements, which are subject to change, nor many other facets of residential construction beyond those associated with energy efficiency.

Despite a wealth of building science research over the past decade, there are many concepts for which no definitive recommendations are provided. This reflects the continuing evolution of energy efficient construction techniques, the advent of new materials and construction methods and ongoing debate on topics such as vented versus unvented attics or the presence and location of a vapor retarder. This guide leaves the final decision on such matters to the architect, engineer and/or contractor, based on the goals and construction approaches selected for a specific building.

## Energy Conservation: A Whole Building Approach

A whole building approach to building design and construction is the starting point of this guide. Every building is a complex assemblage of thousands of individual parts and systems that must interact with each other, the site and the environment. Building owners have a major but largely unrecognized role in how a building performs once occupied. Owners establish the priority given to energy efficiency, determine the level of acceptable comfort in a building,

and have the responsibility of operating and maintaining the building once construction is complete.

As buildings have grown in size and complexity, and as owners' expectations for comfort have increased, the number of design professionals and trades involved in a single project has multiplied. Carpenters, masons, roofers, plumbers, electricians, sheet rockers, insulators and others understand their work, but not necessarily

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the work of others on the job site. For example, the insulation installer unaware of all piping or duct penetrations made by the mechanical contractor and others, or the sequence and method of installing windows and doors, can leave significant gaps in the building envelope and paths for air leakage and moisture damage.

For proper operation of today's highly insulated buildings, which often use smaller, more efficient mechanical systems, a coordinated effort that treats the building as a whole and not as a collection of isolated components is essential.

## Building Quality and Durability

Homes should withstand the test of time. The use of quality materials and workmanship following the energy concepts suggested in this guide will help ensure a durable and safe home in which components and systems are built

to last. In addition to energy savings and increased comfort, quality construction achieved through the builder's attention to detail helps a home maintain its structural integrity and maximize its resale value.

## New York State Code Requirements

Codes set the legal minimum standard to which a building must be constructed. Construction requirements for detached one- and two- family dwellings (and townhouses not more than three stories in height with separate entrances and one-family dwellings converted to bed and breakfast dwellings) are found in the Residential Code of New York State (RCNYS), with possible references to the Plumbing, Fuel Gas, Mechanical and Fire Codes of New York. The Building Code of New York State (BCNYS) is applicable to all other structures. For energy conservation, all buildings must also meet the requirements of the Energy Conservation Construction Code of New York State (ECCCNYS).

New York State codes are based on, but not identical to, the family of model codes published by the International Code Council, Inc. (ICC). Preparation, adoption and administrative oversight of these codes are the responsibility of the New York State Department of State. Enforcement typically occurs at the municipal level.

For the small-scale homes addressed by this guide, general construction requirements are primarily found in the RCNYS. Energy requirements for efficient energy use in these buildings are found in either the RCNYS or the ECCCNYS. Alternate code paths to document compliance with the RCNYS or ECCCNYS

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are provided in order to provide flexibility of construction, including the use of innovative approaches and techniques.

In response to increasingly stringent federal and State policies establishing the minimum level of energy efficiency in buildings, builders and owners must confirm that the most current codes and standards are followed. (Codes are typically updated on a three year cycle,

although interim revisions of specific requirements are possible.)

Information on current and local requirements, including submission materials, inspections, testing, and any alternate requirements for municipalities that have adopted a More Restrictive Local Standard, can be obtained from the local code enforcement official or the NYS Department of State.

## **NYSERDA Support**

Program participation through NYSERDA and other agencies or local utility companies can make substantial differences in a building's energy efficiency and energy costs.

Resources to determine available programs and criteria include [nyserdera.ny.gov](http://nyserdera.ny.gov) and the Database of State Incentives for Renewables and Efficiency, [www.dsireusa.org](http://www.dsireusa.org).

## **ENERGY STAR® and More Restrictive Local Standards**

ENERGY STAR® is a reference to an advanced building energy efficiency program developed by the U.S. Environmental Protection Agency for new construction and renovations. The ENERGY STAR® label also refers to energy efficient consumer products and appliances that meet or exceed federal energy efficiency and quality guidelines. ENERGY STAR® has long served as a building block of NYSERDA's residential program.

Although in most New York State municipalities compliance with ENERGY STAR® building standards is optional, in recent years, select municipalities have adopted ENERGY STAR® as their More Restrictive Local Standard. Alternate approaches to establishing minimum requirements, such as the use of above minimum HERS ratings for new construction, are increasingly common.

For low-rise residential buildings, New York State programs have

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historically been based on the federal ENERGY STAR® platform. Although program offerings change, the following are currently available:

**New Construction:** The New York ENERGY STAR® Certified Homes program requires new buildings to be constructed to ENERGY STAR® standards, which represents a significant improvement in energy efficiency performance when compared to code-compliant new homes. All builders and owner-builders can participate in the program, which requires proposed plans to be reviewed by a

Home Energy Rater and the building to be performance tested at the completion of construction to ensure optimal performance and quality construction.

**Existing Buildings:** NYSEERDA's Home Performance with ENERGY STAR® program offers support to homeowners for retrofitting existing homes. To participate in the Home Performance with ENERGY STAR® program, contractors must be accredited by the Building Performance Institute (BPI).

## High Performance Buildings and Renewable Energy

This guide applies to the typical new home built to the State's minimum construction standards and incorporates many principles associated with high performance buildings designed to perform significantly above code. The following energy measures are not addressed in this guide:

- LEED certification
- Super insulated structures
- On-site energy (solar, wind, geothermal, low-impact hydro, biomass, biogas strategies)
- Zero Energy Buildings
- On-site water treatment
- Green roofs



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# Working with Architects and Engineers

Drawings and specifications for new construction must demonstrate compliance with applicable codes. These must be signed and sealed by a New York State licensed and registered design professional (architect or engineer) and submitted to the local code enforcement office for approval before construction can begin. For energy conservation purposes, the ECCCNY identifies specific information that must be included in the submission package. Interim and final field inspections are also required before a final certificate of occupancy is issued.

The architect and engineer can provide recommendations on design issues,

material selection and construction details to improve the building's aesthetics, functionality, energy use and occupant health and safety. As the intermediary between the contractor and owner, design professionals help owners make informed decisions, provide on-site inspections to ensure that work is performed as intended and assist the owner with administrative matters including payments to the contractor. Finally, for projects where competitive bids from potential contractors are solicited, the detailed construction documents prepared by the design professional are the means to ensure that bids received will be truly comparable.

## Inspections and Performance Testing

Codes require specific inspections and testing; additional visual inspections should occur throughout construction to ensure the quality of implemented work. For energy efficiency purposes, the most

common performance tests are associated with building envelope tightness (blower door test), and when mechanical system ductwork resides outside the building thermal envelope, duct tightness (duct blaster test).



Although not mandated by code, inspection using infrared imaging can also be useful to detect missing insulation in walls, roofs and ceilings; leaks at windows, doors and penetrations; and other gaps in the building thermal envelope. It is best to undertake testing during the construction process when corrections can be accommodated most easily.

At construction completion and prior to occupancy, all mechanical, plumbing and electrical systems should be tested

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to verify proper installation, calibration and operation. Test results should be reviewed by the design professional and maintained by the owner. Required adjustments and corrections should occur before project closeout when all trades

and subcontractors have been paid in full, although the need for minor adjustments immediately following occupancy and during the established warranty period should be anticipated.

## **Building Commissioning and Maintenance**

For high performance buildings, building commissioning is a formal process that occurs at the close of construction to verify proper and complete installation of building systems.

At construction completion, builders should provide guidance to owners on the appropriate scope and cycle of maintenance for various components and features. Maintenance and regular check-ups of energy efficiency measures is as essential for a building as it is for an automobile.

## **Owner's Manual and Homeowner Education**

Homeowners should receive from the builder an Owner's Manual that includes manufacturers' instructions and specifications and operating and maintenance requirements for all equipment. The builder should conduct a complete walk-through of the building with the homeowner to ensure a general understanding of how all systems work. Improper function of a single component can significantly impact the overall integrity of the house as well as occupant safety.

In addition to the certificates and postings on equipment required by code, the Owner's Manual should include basic information on R-values of insulation installed in walls, roof, foundation, slab and ducts; U-factors of fenestration; the types and efficiencies of mechanical equipment; manufacturers' technical materials on installed equipment; and contact information for all suppliers, and/or subcontractors responsible for installation.

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# Occupant Safety

Most indoor air quality problems in homes are associated with pollution produced from gases or particles emitted from construction materials, paints and other finishes, carpets and draperies, mechanical equipment, and cooking and other natural occupant functions. High temperature and humidity levels, improper selection and installation of air barriers or vapor retarders and unresolved maintenance and moisture issues can also increase the likelihood of pollutants such as mold.

Radon is one of the most significant safety issues affecting occupant safety. A naturally occurring, colorless and odorless radioactive gas, radon comes from the natural decay of uranium found in nearly all soils. Radon typically moves into homes through cracks and other holes in the foundation. If trapped inside and high levels of concentration are reached, life-threatening health issues can occur. Radon testing, and solutions to incorporate into a home's construction, are readily available.

High efficiency heating and cooling equipment rely on a tight and well insulated building envelope and mechanical ventilation in order to maintain a safe interior environment. Properly designed, installed and maintained ventilation equipment delivers outdoor air into the house to dilute emissions from indoor pollutants and transports indoor pollutants out of the home. Ventilation is a life safety feature that affects the operation of equipment, occupant comfort and the potential for condensation and mold growth.

As codes continue to require tighter buildings, provision of appropriate and managed mechanical and natural ventilation will become increasingly critical. Whole house mechanical ventilation is expected to be a requirement of the next energy and residential codes.

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# Further Reading and Additional Resources

The following resources provide detailed information on energy efficiency of buildings. Among these, the Building America Solution Center (U.S. Department of Energy Efficiency & Renewable Energy) is a particularly valuable resource providing greater information on the topics discussed in this guide.

NYSERDA  
[nyserdera.ny.gov](http://nyserdera.ny.gov)

NYS Department of State  
[www.dos.ny.gov/DCEA/energycode\\_code.html](http://www.dos.ny.gov/DCEA/energycode_code.html)

Building America Solution Center  
<http://basc.pnnl.gov/>

U.S. Environmental Protection Agency  
[www.epa.gov](http://www.epa.gov)

U.S. Department of Energy  
[www.energy.gov](http://www.energy.gov)  
[www.eere.energy.gov](http://www.eere.energy.gov)

Building Science Corporation  
[www.buildingscience.com](http://www.buildingscience.com)

Green Building Advisor  
[www.greenbuildingadvisor.com](http://www.greenbuildingadvisor.com)

Journal of Light Construction,  
The JLC Guide to Energy Efficiency.  
Hanley Wood (2011).

Krigger, J. and Dorsi, C.,  
The Homeowner's Handbook to  
Energy Efficiency. Saturn Resource  
Management (2008).

Krigger, J. and Dorsi, C., Residential  
Energy Cost Savings and Comfort for  
Existing Buildings, 6th Edition.  
Saturn Resource Management (2012).

Lstiburek, Joseph, Builder's Guide  
to Cold Climates. Building Science  
Press (2006).

# Site

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SITE

# Site Selection

**Site selection should occur before finalizing building plans. Sites should be chosen to best fit the building and cause the least environmental damage.**

**Incorporate proper site preparation techniques to lower environmental impact:**

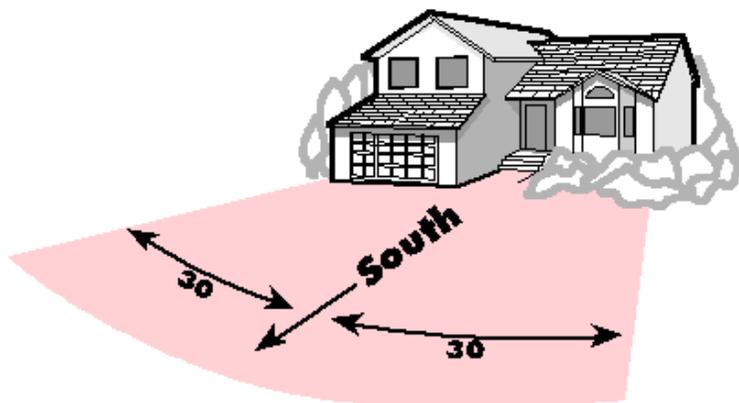
- Conserve and protect existing natural areas.
- Limit site disturbance, as feasible:
  - 40' from building perimeter.
  - 25' from built-up areas.
  - Distances that meet or exceed setbacks established by applicable regulation or by utilities.
- Minimize pollution during construction by controlling soil erosion, airborne dust and water-way sedimentation.
- Prepare an erosion and sedimentation plan prior to construction:
  - Plan for seeding and mulching.
  - Set up silt fences.
  - Provide earth dikes.
  - Create sedimentation traps.
  - Provide hay bales.
- Use excavated material, such as backfill to provide appropriate site drainage away from the building.
- Save valuable top soil for final landscaping over backfilled crushed stone.



# Building Orientation

**Proper building placement and orientation are among the most basic foundation blocks of the energy efficient building.**

- To optimize daylighting and solar heat gain, buildings should be designed and positioned so that south facing walls have the greatest window area with seasonal shading provided by deciduous plantings and shading devices. North and west facing windows, doors and skylights should be minimized.
- Where possible, building placement should take advantage of natural, cross ventilation provided by prevailing winds. In coastal areas, designing to capture cooling sea breezes must be balanced by the need to minimize vulnerability to high winds and flooding.
- Even if solar technologies are not included in initial construction, site selection and building orientation should anticipate addition of such technologies in the future.



# General

**Functional above and below grade drainage is required to create and maintain a dry and healthy building.**

### Proper drainage methods:

- Conduct a percolation test prior to construction to determine permeability of existing soil.
- If required, divert surface drainage to a storm sewer or other approved point of collection or disposal.
- Grade site at least 6" per 10' to drain away from foundation walls.
- Install perforated pipe covered with silt cloth in gravel/crushed stone at foundation footings.
- Properly size and install gutters and downspouts to drain away from building to daylight and/or a water retention area or rainwater collection system.
- Create a rainwater collection system to reduce the amount of potable water used for landscaping purposes.



# General

**Landscaping provides desirable shade for buildings and for natural cooling of hardscape paved surfaces, which absorb and retain heat.**

- Maximize landscaping with hearty plantings with minimal water needs.
- Limit cultivated grass areas.
- Plant deciduous trees around the building to provide shade in summer and allow solar heat gain in winter.
- Plant coniferous trees for year round shading and noise and wind control.
- Plant trees with strong, deep roots appropriate to soil characteristics to prevent land erosion and increase site stability.
- Save existing trees on the site.



# General

**Radon is an odorless, tasteless and invisible gas produced by the decay of naturally occurring uranium in soil and water. It is the second most common cause of lung cancer. For most Americans, the greatest potential for exposure to radon is in the home.**

Radon exists at varying levels throughout the United States. Radon is emitted from the ground to the outdoor air where it is diluted to an insignificant level by the atmosphere. Because radon is a gas, it can travel through the soil and into a building through cracks, joints and other openings in the foundation floor and wall.

Testing to determine the radon level at a specific site is relatively inexpensive and essential. Radon resistant new construction typically costs between \$250 and \$750. Some of these techniques are also beneficial for moisture control.

**A home with proper water management is likely a radon free home. Where high radon levels exist, the following measures are typically part of a radon mitigation plan:**

■ **Gravel:**

Use a 4" layer of clean, coarse gravel beneath the slab-on-grade.

■ **Vapor retarder:**

Place a vapor barrier (typically polyethylene sheet) atop the gravel to prevent soil gases from entering the house.

■ **Vent pipe:**

Run a 4" solid PVC Schedule 40 pipe vertically from the gravel through the roof to safely vent radon and other soil gases to the exterior of the house.

■ **Sealing and caulking:**

Seal all openings, cracks and crevices in the foundation slab (including at the slab perimeter) and walls with appropriately selected caulk to prevent radon from entering the house.

■ **Junction box:**

Install an electrical outlet in the attic if power venting is determined necessary after testing (following construction completion).

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## NOTES

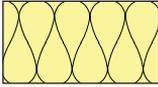
- See NY Radon Map: [www.epa.gov/radon/pdfs/statemaps/new\\_york.pdf](http://www.epa.gov/radon/pdfs/statemaps/new_york.pdf)
- See Joseph W. Lstiburek, *Water Management Guide* (Building Science Press, Inc., 2006).



# Material Basics

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# Illustration Key



Batt insulation



Foam insulation



Loose fill insulation



Rigid foam insulation



Sheathing (plywood, OSB)



Control layer (air, vapor, moisture)



Sealant (continuous)



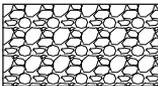
Gypsum board  
(wall or ceiling)



Wood blocking



Concrete



Gravel



Siding

# Climate Zones

Climates zones, used to categorize climatic concerns of temperature, moisture, wind and sun, including daily and seasonal patterns, determine code requirements for insulation and other building-related details. Climate zone maps are included in all building and energy codes.

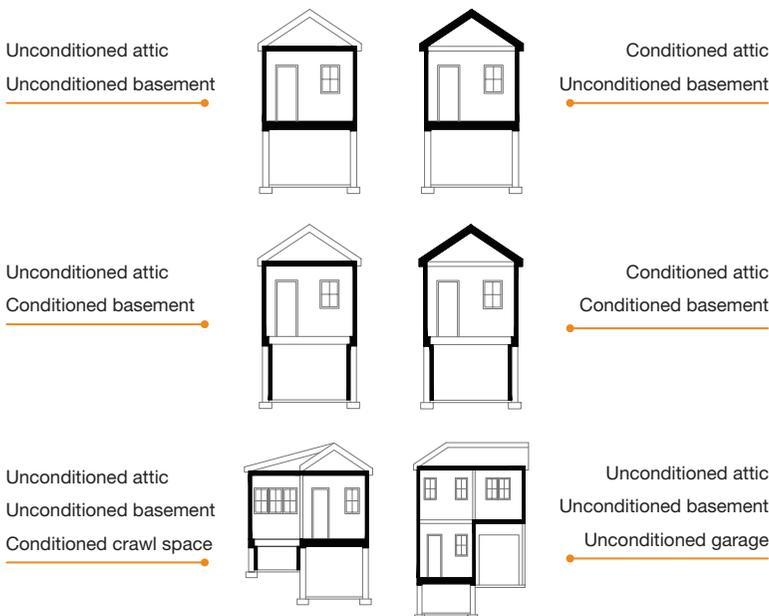
- All New York State counties are Category A (moist) and are classified as one of three climate zones.

Climate Zone 4			
Bronx	Nassau	Queens	Suffolk
Kings	New York	Richmond	Westchester
Climate Zone 5			
Albany	Erie	Ontario	Saratoga
Cayuga	Genessee	Orange	Schenectady
Chautauqua	Greene	Orleans	Seneca
Chemung	Livingston	Oswego	Tioga
Columbia	Monroe	Putnam	Washington
Cortland	Niagara	Rensselaer	Wayne
Dutchess	Onondaga	Rockland	Yates
Climate Zone 6			
Allegany	Franklin	Montgomery	Sullivan
Broome	Fulton	Oneida	Tompkins
Cattaraugus	Hamilton	Otsego	Ulster
Chenango	Herkimer	Schoharie	Warren
Clinton	Jefferson	Schuyler	Wyoming
Delaware	Lewis	St. Lawrence	
Essex	Madison	Steuben	

# General

The building envelope is the boundary between the building and the external environment that separates the conditioned (heated/cooled) building interior from unconditioned areas and/or the outdoor environment. The building thermal envelope must form a continuous, insulated enclosure around the conditioned space.

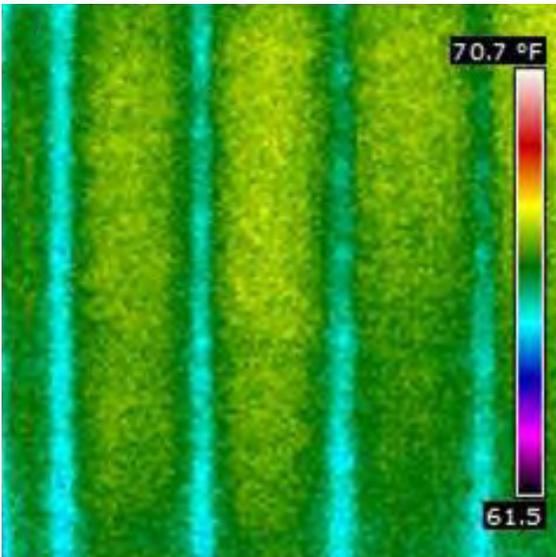
- All spaces that are heated or cooled are contained within the building thermal envelope.
- All above and below grade walls (including windows and doors), floors and ceilings that separate conditioned from unconditioned space are part of the building thermal envelope. These assemblies must be insulated depending on how the house is designed for use.
- The figures below illustrate how the building thermal envelope changes based on how the house is conditioned.



# Thermal Bridging

**Unwanted heat flow occurs through areas of minimum thermal resistance or high conductivity, causing heat loss, and/or moisture condensation.**

- Thermal bridging occurs through gaps in insulation or when high thermally conductive materials (e.g. steel, wood, concrete) create pathways for heat loss that bypass insulation (see photo).
- Thermal bridging creates an uninterrupted “short circuit” between the interior and exterior of a building, significantly lowering the effective R-value.
- This effect is most significant in cold climates during winter when the indoor-outdoor temperature difference is greatest.
- Thermal bridging is eliminated when continuous exterior foam insulation, coupled with full exterior or interior air sealing, is used. The exterior insulation keeps all materials, including piping and electrical boxes, on the warm side of the wall, reducing the likelihood of condensation within the foam and subsequent damage caused by deterioration or mold.



Courtesy of Newport Ventures

# Envelope Testing

**Buildings must be inspected and tested for air tightness and insulation installation. Beginning in 2014, an Envelope Air Leakage (blower door) test is likely to be required for residential construction in New York State.**

- The air tightness of a building can be evaluated through visual inspection and by a blower door test. Visual inspection throughout construction of all gaps, voids and intersections is the most effective means to ensure that code-required tightness will be achieved at construction completion without expensive removals to remediate concealed conditions. Envelope air leakage tests can occur on buildings with an exterior air barrier anytime after the barrier is installed and all penetrations of the building thermal envelope have been sealed, and at final inspection just before occupancy. An envelope air leakage test prior to final inspection is not useful if the interior surface is intended to function as the air barrier.
- Envelope air leakage door tests are typically conducted by installers and by energy efficiency experts such as HERS raters or certified through the Building Performance Institute.
- New York State requirements for building tightness are likely to be upgraded to approach the requirements of the model codes, currently 3 air changes per hour when conducted with a blower door at a pressure of 0.2 inches w.g. (50 Pascals).



**NOTE**

- Confirm current code requirements given ongoing efforts to increase air tightness of buildings.

# Infrared Thermal Imaging

**Thermal imaging provides the visual means to evaluate the quality and completeness of an insulation installation by graphically depicting differences in surface temperatures at the building exterior.**

- Thermal imaging (also referred to as Infrared or IR) is most valuable on new construction projects to verify the completeness of installations in enclosed cavities (dense pack or sprayed foam). In such instances, the image is most readable when conducted from the interior.
- Thermal imaging is not required for new construction since the quality of the insulation installation must be visually inspected (a more effective quality control process) before interior finishes are installed.



## General

**Insulation materials are used to minimize heat transfer due to conduction (rate of heat flow) through the thermal envelope. In New York's climate, the goal is to retain heat in winter and to minimize heat entry or retain cooled air in summer.**

- Insulation typically comes in the following forms: batts and rolls, foam board (rigid foam), loose-fill or blown-in (fibers or pellets), and sprayed foam and foamed-in-place (used at small areas to control air leakage or to insulate an entire building).
- Insulation materials vary by thermal effectiveness, environmental impact, cost, complexity of installation, density, drying capacity, resistance to air leakage, and ability to provide other performance attributes such as fire resistance or minimize sound transmission (a function of material density).
- Insulation is most commonly described by its R-value (rate at which heat is lost through walls, roofs, and foundation); the higher the R-value, the better. In contrast, the U-factor, essentially the inverse of the R-value, is used to describe individual elements such as window or skylights, or to rate the overall wall or ceiling assemblies.
- R-values, expressed per inch, vary by material: overall R-value is a function of R-value/inch x thickness of insulation installation at wall, ceiling or roof assembly. Minimum R-values are established by code, and vary across the 3 distinct climate zones in New York State.
- Insulation materials can have environmental effects in manufacturing or installation, and can settle or deteriorate over time. For example, some types of foam (polyurethane and polyisocyanurate) are blown with heavy gases (CFCs or HFCs) that can, as they off gas over time, lose some of their effective R-value. Formaldehyde has lost favor as an insulating material due to health concerns.
- Because air leakage is another primary source of energy inefficiency, insulation must be either an air barrier itself or be in contact with a separate air barrier. Materials such as dense pack, blown in cellulose or sprayed foam have the inherent advantage of filling all holes when properly installed. Other materials, and specific locations (e.g., windows and doors) regardless of material selection, require a second step in sealing all intersections, gaps and voids. The most common material for voids is sprayed foam.
- Insulation efficiency and durability is also impacted by the need to protect against the movement of air and water (bulk or vapor) into the wall or roof assembly. This is achieved by addressing air leakage using a continuous air barrier system and proper selection and complete installation of vapor retarders, as determined necessary.

# Materials

TYPE	MATERIALS	WHERE APPLICABLE	INSTALLATION METHODS	ADVANTAGES
Blanket: batts and rolls	<ul style="list-style-type: none"> <li>•Fiberglass</li> <li>•Mineral (rock or slag) wool</li> <li>•Plastic fibers</li> <li>•Natural fiber</li> </ul>	<ul style="list-style-type: none"> <li>•Unfinished walls, including foundation walls</li> <li>•Floors and ceilings</li> </ul>	<ul style="list-style-type: none"> <li>•Fitted between studs, joists, and beams</li> </ul>	<ul style="list-style-type: none"> <li>•Do-it-yourself</li> <li>•Suited for standard stud and joist spacing that is relatively free from obstructions</li> <li>•Relatively inexpensive</li> </ul>
Foam board or rigid foam	<ul style="list-style-type: none"> <li>•Polystyrene</li> <li>•Polyisocyanurate</li> <li>•Polyurethane</li> </ul>	<ul style="list-style-type: none"> <li>•Unfinished walls, including foundation walls</li> <li>•Floors and ceilings</li> <li>•Unvented low-slope roofs</li> </ul>	<ul style="list-style-type: none"> <li>•Interior applications: must be covered with 1/2-inch gypsum board or other building-code approved material for fire safety</li> <li>•Exterior applications: must be covered with weatherproof facing</li> </ul>	<ul style="list-style-type: none"> <li>•High insulating value for relatively little thickness</li> <li>•Can block thermal short circuits when installed continuously over frames or joists</li> </ul>
Loose-fill and blown-in	<ul style="list-style-type: none"> <li>•Cellulose</li> <li>•Fiberglass</li> <li>•Mineral (rock or slag) wool</li> </ul>	<ul style="list-style-type: none"> <li>•Enclosed existing wall or open new wall cavities</li> <li>•Unfinished attic floors</li> <li>•Other hard-to-reach places</li> </ul>	<ul style="list-style-type: none"> <li>•Blown into place using special equipment, sometimes poured in</li> </ul>	<ul style="list-style-type: none"> <li>•Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions</li> </ul>
Rigid fibrous or fiber insulation	<ul style="list-style-type: none"> <li>•Fiberglass</li> <li>•Mineral (rock or slag) wool</li> </ul>	<ul style="list-style-type: none"> <li>•Ducts in unconditioned spaces</li> <li>•Other places requiring insulation that can withstand high temperatures</li> </ul>	<ul style="list-style-type: none"> <li>•HVAC contractors fabricate the insulation into ducts either at their shops or at the job sites</li> </ul>	<ul style="list-style-type: none"> <li>•Can withstand high temperatures</li> </ul>
Sprayed foam and foamed-in-place	<ul style="list-style-type: none"> <li>•Cementitious</li> <li>•Phenolic</li> <li>•Polyisocyanurate</li> <li>•Polyurethane</li> </ul>	<ul style="list-style-type: none"> <li>•Open new wall cavities</li> <li>•Unfinished attic floors</li> </ul>	<ul style="list-style-type: none"> <li>•Applied using small spray containers or in larger quantities as a pressure sprayed (foamed-in-place) product</li> </ul>	<ul style="list-style-type: none"> <li>•Good for adding insulation to existing finished areas, irregularly shaped areas, and around obstructions</li> </ul>

Extracted from DOE: <http://energy.gov/energysaver/articles/types-insulation>

**NOTE**

- Manufacturers offer numerous products with varying environmental impacts. Whenever possible, selections should be environmentally-friendly with respect to products used in the manufacturing process or as blowing agents.

# Comparing R-Values

## Relative R-Values

Material	R-value/inch (ave.)
Cellulose (dense pack)	3.2
Cellulose (loose blown)	3.7
Fiberglass (loose)	2.2 - 2.7
Fiberglass (batt)	3.1 - 4.3
Rock Wool	3.0 - 3.3
Expanded polystyrene board (bead board)	4.00
Extruded polystyrene board	5.00
Polyurethane board	5.00
Polyisocyanurate board (foil faced)	7.20
Open Cell Spray Foam	3.60
Closed Cell Spray Foam	6.50

## Fiberglass Batt Insulation: Total R-value by Cavity Depth

Fiberglass Batt Insulation	Framing Unit
R-13	2X4
R-15*	2X4
R-19	2X6
R-21*	2X6
R-24	2X8
R-30	2X10
R-38	2X12
* High density	

### NOTE

- Insulation values vary by location (e.g., wall vs. roof or ceiling) and effectiveness can diminish over time. For example, once out gassing has occurred the effective R-value of polyisocyanurate may decline to 6.0 – 6.5.

# Fiberglass Insulation

## General

Fiberglass insulation consists of extremely fine glass fibers most commonly manufactured into batts (blankets) or used as loose fill. The insulating properties of fiberglass come from the tiny air spaces between its glass fibers, which slow conductive heat flow.

- Most common and least expensive type of insulation.
- Does not act as an air barrier.
- Available with or without vapor retarder facings, such as foil or Kraft paper.
- Flame resistant facings available for areas where insulation will remain exposed.
- R-value of roughly R-3 per inch; manufactured in various depths and widths to fit typical framing cavities.
- Not recommended for gaps or in voids around windows and doors, except as a backer for foam or caulk air sealant.
- Loose fill and blown in insulation also available with growing acceptance.

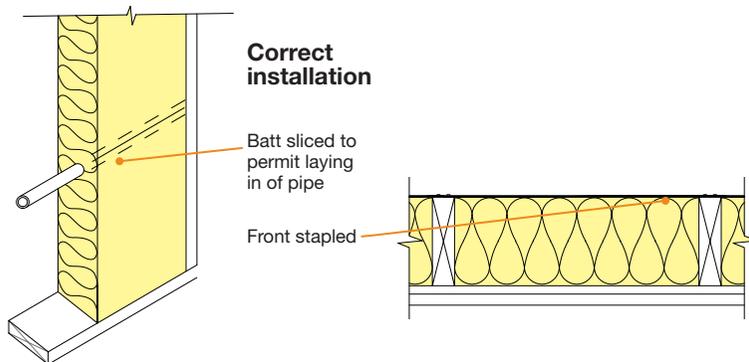
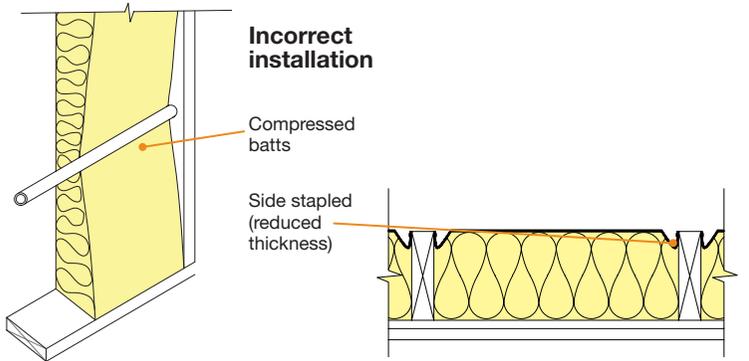


# Fiberglass Insulation

## Batts (Blankets)

To function as intended and retain its rated R-value, fiberglass insulation must not be compressed during installation.

- Batts must be installed to fully fill the framing cavity without gaps and air spaces, making complete contact with all six sides including sheathing and finished wall surface.
- Must be hand cut and trimmed to fit snugly around obstructions, such as plumbing and electrical features, to maintain full thickness.



**NOTE**

- Mineral wool, plastic fibers and natural fibers can also be used as batts.

## Flash and Batt Insulation

**Flash and batt insulation is a hybrid insulation method for framed walls that combines some of the benefits of fiberglass with those of spray foam. It can easily be incorporated into standard construction practice.**

- Fiberglass, which is not an air or vapor barrier, is used with spray foam, which contributes additional thermal performance and air tightness.
- The interior face of sheathing of 2x6 walls receives closed cell spray foam and typically 6" of fiberglass batt insulation. The depth of the spray foam (often 2" – 3") depends on the foam, climate zone, and code requirements.
- Because more labor is required, cost is greater than fiberglass batt insulation but less than a full foam installation. Additional time for curing of foam must be anticipated.
- Precautions followed for all foam and fiberglass insulation, including vapor retarders and other details, must be adhered to.



*Courtesy of IBTS*

# Cellulose Insulation

## General

**Cellulose insulation is primarily (80%) made from recycled newsprint and other paper sources. As compared with fiberglass and foams, it requires less energy to manufacture.**

- Cellulose insulation, used widely since the 1970s, is a low-cost insulation material, generally comparable in R-value to fiberglass or rock wool. Compared to closed cell and polyurethane foam insulation, cellulose has a lower R-value per inch but is much less expensive.
- The addition of up to 20% by weight of non-toxic borate compounds (may include ammonium sulfate) provides resistance to fire, insects and mold.
- While cellulose is a hygroscopic material able to soak up and hold liquid water, its vapor permeability supports drying of any moisture buildup. Use of a vapor retarder is often not recommended, and consideration should be given to the specifics of the proposed installation.
- Like other insulation materials, long term exposure to water is problematic. In cellulose, this can cause sagging or corrosion of metal fasteners, plumbing pipes or electrical wiring.
- Installation is typically dry spray, damp-spray, or dense pack (dry material under pressure installed with a fill tube).



### NOTES

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- Manufacturers are required by law to provide the “settled thickness” on their bags.
- Blown in insulation should completely fill cavities and be at an even thickness throughout the attic.
- Attic rulers appropriate to cellulose should be placed around the attic to verify depth: typically 1 ruler for every 300 sq.ft., evenly distributed around the attic and clearly readable from the attic access.

# Cellulose Insulation

## Dense Pack

**Dense pack cellulose is installed in a similar manner as other cellulose spray insulations although at a greater density (approximately 3.5 lb/cu.ft.).**

- Properly installed, dense pack cellulose has good resistance to settling.
- Dense pack cellulose in walls provides good thermal performance and, although not an air barrier, significant resistance to air leakage.
- Dense pack cellulose is not recommended for unvented cathedral ceilings or unvented flat roofs where the potential for desirable drying of the cavity to the exterior is less than at exterior walls.



### NOTE

- Fiberglass insulation can also be installed to comparable densities, although is typically subject to the same vulnerabilities as noted above. Spray fiberglass is becoming increasingly available, with fibers typically mixed with acrylic bonding agent.

# Cellulose Insulation

## Blown (Dry) and Sprayed (Damp)

**Qualified contractors should be used for both blown and sprayed installations. Precautions should be taken to protect against blowing fibers, including taping plastic sheets at windows, doors, electrical boxes, etc.**

- Blown cellulose is a good solution for attics where dry fiber is supported by the attic floor or in an enclosed wall cavity. Because of material settling, where possible (in floors), overspray should occur to provide desired thickness once settling occurs.
- Sprayed cellulose is typically used for open wall and floor cavities in new construction. The addition of water and/or adhesive during the installation process creates a sticky material that adheres to sheathing and fills the cavity, significantly reducing airflow.
- Sprayed cellulose is installed to fill wall or floor cavities, with any excess material scraped away. To confirm the correct amount of material has been installed, bag count required for the R-value for the installed area must be verified.

Following manufacturer instructions, including moisture content for spraying and temperature restrictions, is critical. Newly placed material is damp and must be permitted to dry or be dehumidified until the moisture content reaches 25% or as required by manufacturer. Moisture content should be checked prior to enclosure of cavity.



# Foam Insulation

## General

**Foam insulation provides a high R-value per inch of thickness and, when properly installed, reduces air infiltration.**

- Made from polystyrene (expanded or extruded), polyurethane, polyisocyanurate or phenol.
- Uniformly solid.
- Open cell foam allows water vapor to move through material more easily, but has lower R-value for a given thickness.
- Closed cell foam resists passage of vapor in both directions.
- Must follow manufacturer installation specifications and code requirements with respect to required fire protection coatings in certain applications.
- Following application, ventilation of house is recommended in order to minimize potential ill effects of out gassing.



*Courtesy of DOE*

### NOTE

- Numerous resources are available to address potential health issues associated with foam. These include the National Institute of Occupational Safety and Health, the Environmental Protection Agency (EPA), and various industry sources such as [www.spraypolyurethane.org](http://www.spraypolyurethane.org).

# Foam Insulation

## Rigid Board

**Insulation board is increasingly common for exterior applications to provide a continuous surface with thermal and vapor resistance and eliminate thermal bridging. To meet code, additional interior insulation (fiberglass, cellulose, or mineral wool) may be required between wall studs or roof rafters/attic joists.**

- Rigid board foam insulation is used at roofs, walls, foundation walls, and slabs, as well as at interior rim joists. Different foams are appropriate for each application, as recommended by manufacturer.
- Interior and exterior installations require precise fitting and/or sealing of all gaps and joints between rigid boards using compatible materials identified by the manufacturer.
- Installation requires supplementary use of small canisters of spray foam to seal larger or concealed voids.
- Rigid board insulation can improve overall thermal performance by eliminating thermal bridging through framing, and can be detailed and installed to act as an air, thermal and weather barrier (drainage plane).



# Foam Insulation

## Spray (Open or Closed Cell)

- Material can be polyisocyanurate or polyurethane.
- High R-value and effective air barrier can be achieved in a single application.
- Can be sprayed, poured or injected into almost any space. Once in place, material expands to completely fill the area. Because of the difficulty of ensuring a uniformly insulated surface within a concealed cavity, and the building damage possible from incomplete coverage, completed installations should be verified with thermal imaging.
- Open cell foam allows water vapor to pass through and has a lower R-value for a given thickness; depending on thickness, closed cell foam, with a higher R-value for a given thickness, can act as a vapor retarder.
- More expensive than other insulations.
- Installation by experienced crews is critical. Precise following of manufacturer recommendations will minimize the likelihood of shrinkage of materials, non-adherence to adjacent framing members, or other problems when the depth of a single lift exceeds manufacturer recommendation.
- To minimize potential ill effects following application, ventilation following application is recommended.



### NOTES

- May require an approved thermal barrier, such as drywall or fire rated coating.
- Urea formaldehyde (UF) foam, used in the 1970s, is no longer available for health reasons.

## Mineral (Rock or Slag) Wool

**Mineral wool insulation is a product made from molten rock that is manufactured (using blown air or steam, or spinning) to create mineral fibers which are used in building insulation.**

- Mineral wool is a durable insulation material that retains its insulation properties in very low and very high temperatures. Insulation is comprised of +/- 97% mineral materials: the remaining materials are binders (phenolic-formaldehyde resin) and/or impregnating oil.
- Because mineral fibers do not absorb water or moisture, under proper conditions, material that has been wetted will dry readily.
- Has good sound proofing characteristics resulting from the material's capacity to absorb sound.
- Naturally non-combustible, offering good fire resistance: the slow rate of heat transfer helps resist fire spread and does not contribute fire spread through the release of heat, smoke, or burning droplets.
- Can be installed loose-fill or as a batt product.



# General

- Any airtight interior or exterior surface is considered an air barrier. In addition to the variety of housewraps available, stucco, plaster, specific coatings, and properly installed and sealed exterior plywood, OSB, exterior closed cell foam board, and other sheathing materials, also provide protection from wind and material exposure during construction. Properly installed interior gypsum board (with full air sealing at windows, doors, floor/wall/ceiling junctions, electrical outlets and other penetrations) is also an effective air barrier.
- “Housewrap” is generically used to refer to synthetic materials (woven polyethylene-fiber paper and others) used as air barriers. These have generally replaced rosin-impregnated paper and asphalt saturated felt, which were traditionally placed over framing before installing siding. The primary function of this control barrier is to resist air infiltration and bulk water entry from the exterior.
- Housewrap products are relatively light weight and produced in wide rolls to allow for fast and continuous installation. Depending on application and material, housewraps can serve as the weather resistive drainage plane that protects inboard surfaces from water infiltration. Because these materials are permeable to water vapor, they permit drying of wall systems, helping to prevent mold growth within the wall assembly and to protect insulation materials.

# Air, Water, and Vapor Control

## General

Air, bulk water, and vapor control are essential to protect a building's structure. Depending on material and application, membranes, facings, coatings and foam insulation can protect against the infiltration of air, bulk water and vapor. Manufacturer recommendations must be followed for all installations.



Courtesy of DOE

# Air, Water, and Vapor Control Barriers and Vapor Retarders

Vapor retarders and barriers, rated by their permeability, slow vapor transmission through the building envelope. In New York State, before central air conditioning was common, vapor barriers were placed on the interior side of the building thermal envelope. As buildings have become tighter for energy efficiency and more commonly air conditioned, best practice on the use, position, and choice of vapor retarders (versus barriers) has evolved.

- Moisture enters a building assembly as bulk moisture (e.g., leaks), or in moisture-laden air, if an inadequate air barrier exists. Depending on climate and season, moisture enters from the exterior (hot humid summer conditions) or from the interior (generated from kitchens and baths).
- As a function of the interaction of humidity and temperature (both ambient and within the building assembly), moisture within the assembly can condense on colder surfaces. If this condensation cannot dry (in at least one direction), the thermal and structural integrity of building materials are compromised and can result in significant rot and mold damage.
- To reduce the likelihood of moisture and mold damage in all buildings, all installations require attention to detail to eliminate bulk moisture intrusion and moisture carried via air leakage.



# Air, Water and Vapor Control

## Selection of Vapor Retarders and Barriers

Examples of vapor retarders and barriers are as follows. Higher perm ratings permit greater (and desirable) vapor diffusion and drying of wall, ceiling, or floor assemblies.

Class	Perm Rating	Examples
Class I vapor retarder (barrier)	<0.1	<ul style="list-style-type: none"> <li>• On insulation facing: coated kraft paper, aluminum foil, vinyl</li> <li>• Polyethylene sheets</li> <li>• Polyisocyanurate insulation boards</li> <li>• Oil-base primers, vapor-barrier paints</li> <li>• Vinyl wall covering</li> </ul>
Class II vapor retarder	0.1 – 1.0 perms	<ul style="list-style-type: none"> <li>• All materials resisting water vapor diffusion</li> </ul>
Class III vapor retarder	1.0 – 10 perms	

- Vapor retarders that resist vapor movement into framed building assemblies and permit moisture penetrating the assembly to dissipate when conditions are cooler and dryer are recommended for above grade use in New York State. Generally, Class II and Class III retarders are recommended in New York State.
- Class I Vapor barriers should only be considered for New York State’s coldest climate, Climate Zone 6, where air conditioning is uncommon. Vapor barriers should never be used on both sides of a wall or ceiling assembly, or on the interior side of air-conditioned buildings. (The Climate Zone 6 home with central air conditioning can successfully use a Class I interior vapor retarder as the vapor drive will be reversed for only a short period of time.) When used, ventilation (mechanical or natural) should be provided to control humidity.

# Air, Water and Vapor Control

## Weather-Resistive, Air, and Radiant Barriers

**Weather-Resistive Barriers** that stop rain water from travelling through exterior cladding provide a narrow space (drainage plane) that permits any rain water entering the cavity to drain to the bottom of the wall and out. (A rain screen is a wider space between the exterior cladding and weather-resistive barrier that is even more advantageous for drying). Examples of weather-resistive barriers:

- Kraft paper with asphalt.
- Perforated asphalt felt.
- Woven polyethylene-fiber paper ‘housewrap.’

**Air Barriers** are materials that stop moisture-laden air from entering building assemblies, reduce air leakage and, when placed at the exterior, wind-driven air from entering into and through insulation. Air barriers can be separate from the vapor retarder/barrier, and require caulking or sealants at joints between materials, exterior outlets and switches, window and door frames, floor/wall/soffit junctions, plumbing chases, chimney enclosures, and all wire holes and other penetrations. Examples of air barriers:

- Interior drywall, fully sealed for continuity and air tightness.
- Exterior sheathing: plywood, OSB, fully sealed for continuity and air tightness.
- All airtight interior or exterior surfaces if fully sealed for continuity and air tightness.

**Radiant Barriers** reflect heat coming toward the barrier and retard heat flow. If used alone (fastened to bottom of roof rafters or sheathing), the barrier’s shiny surface faces the air space. When used in a fully insulated cavity without air movement (convection), the R-value of the assembly can be substantially improved. Radiant barriers are less common in new construction, instead providing the most benefit when used in existing, under-insulated buildings. Examples of radiant barriers:

- Aluminum foil, typically bonded to kraft paper or roof sheathing.

# Air, Water and Vapor Control

## Drainage Planes and Rainscreens

Drainage planes and rainscreens at exterior walls, located between the back of cladding and the face of weather resistive barrier, help to reduce the forces that draw water into the wall assembly. They provide great benefit in encouraging drainage of accumulated moisture and drying to the exterior.

Can be created using vertical wood or metal strapping attached to wall structure, or with manufactured materials such as the following to serve as a weather-resistive barrier and/or create a beneficial thermal break:

- Three dimensional, webbed matrix (approximately ¼” – ½” thick).
- Three dimensional matrix bonded to housewrap.
- Drainable housewrap with 3-dimensional coating (approximately 1 mm. thick).

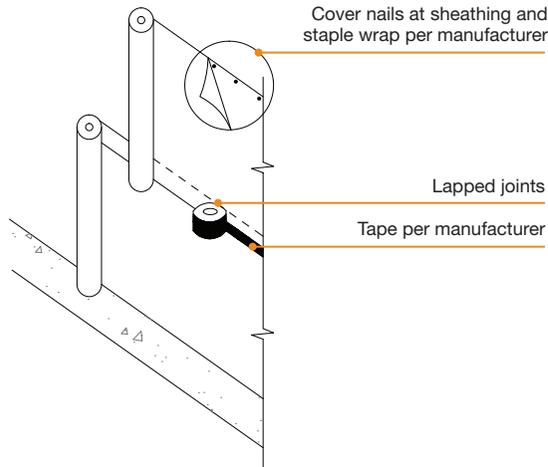


# Housewrap

## Installation

**Housewrap must be installed in shingle-lapped fashion, free of gaps or breaks, to provide complete protection. Always follow manufacturers specifications.**

- Housewrap acts as a drainage plane or backup barrier to keep moisture from wind driven rain or snow off the structural sheathing and framing.
- Serves as an effective air barrier if all seals, joints and penetration points are taped and sealed. Taping the seams also protects the building during construction (greater resistance to wind and tear).
- Housewrap must be secured to sheathing with ring-shank fasteners or per manufacturer instructions.



**NOTE**

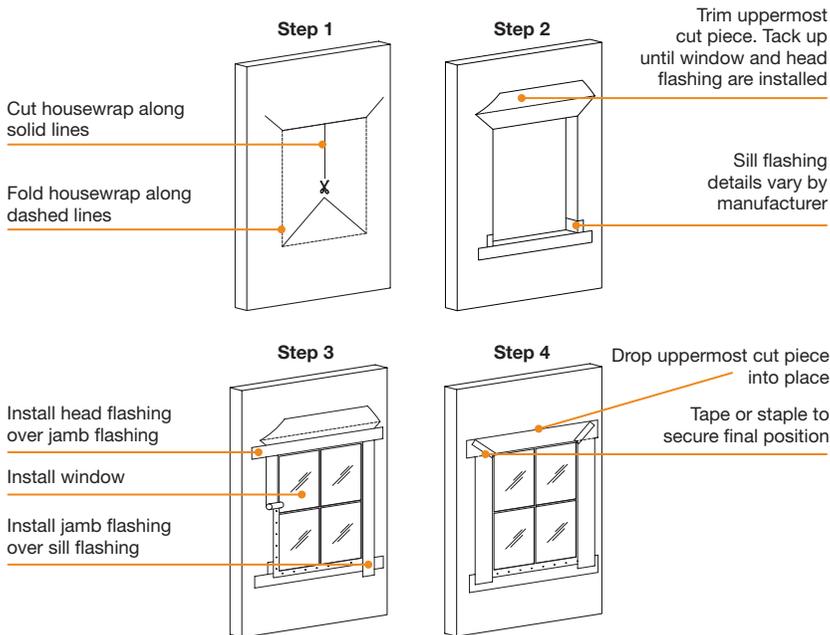
- Consult manufacturer product specifications for housewrap exposure limits prior to siding installation.

# Housewrap

## Installation at Openings

To eliminate water entry into the building, fastidious design detailing and installation technique at windows and doors is required. These locations are arguably the most common sources of failure in buildings.

- Openings must be properly taped, sealed and flashed following manufacturer instructions.
- All water must be directed outward by proper lapping of materials: upper materials slip over lower.



**NOTE**

- Consult manufacturers' instruction for installing housewrap around windows, doors and other openings.

# General

Sealing joints and penetrations in the thermal envelope prevents air leaks and interior and exterior damage and discomfort. Locations requiring sealant include plumbing and electrical fixtures, pipes and wiring, and other penetrations and gaps at HVAC and ventilation equipment and around doors and windows.

- In a 100 sq. ft. wall, one cup of water can diffuse through drywall without a vapor barrier in a year, but 50 cups can enter through a ½” round hole.
- Air sealing and moisture control make insulation more effective and protect the building assembly from condensation and mold.

## Common envelope air leakage points



Courtesy of EPA

### NOTE

- See [www.efi.org](http://www.efi.org) for information on sealants and related products.

# Sealant Chart

Given the importance of sealants in long term energy performance, always select the best sealant for for a given material and follow manufacturer recommendations. New materials such as tapes are continually being improved for longevity and performance.

Material and Relative Cost Factor	Exterior	Interior	Typical Use	Benefits	Drawbacks	Estimated Lifetime (Years)
Acrylic Latex Silicone Caulk \$\$	■	■	Use where slight movement is expected	Flexible and durable	Difficult to paint	10–25
Fire Rated Acrylic Intumescent Caulk \$\$\$	■	■	Sealing penetrations through fire rated assemblies or penetrations through floors. Use at high temperature areas such as around chimneys	Fire rated (must meet UL 1479 and ASTM E814), flexible, easy to install and finish. Good adhesion to most building materials.		10–15
Urethane Foam Sealant: One Part \$\$	■	■	Around window and door openings. Must use fire rated version in required areas	Provides tight air seal and conforms to opening	Must be careful not to overfill the opening	10–20
Urethane Foam Sealant: Two Part \$\$\$	■	■	Rim Joists, tops of plates in attic flat, at soffit/eaves to provide wind dam	Provides a tight air seal, high expanding, covers larger areas	Will outgas initially, can be messy	10–20
Silicone Caulk \$\$\$	■	■	Gaps ¼" or less	Flexible and durable	Difficult to paint	10–35
Acrylic Latex Caulk \$\$		■	Interior projects with gaps ¼" or less	Flexible, fast drying and paintable	Difficult to clean up	10–15
Acoustical Sealant \$		■	Sealing polyethylene air barriers	Best for providing tight seal	Difficult to clean up, can be messy	> 20
Latex Caulk \$		■	Gaps ¼" or less	Easy to clean, paintable, inexpensive alternative	Inflexible and not very durable	2–10
Acrylic Caulk \$\$	■		Exterior applications	Very flexible and durable over extreme temperature ranges	Messy, difficult to clean up	10 +/-
Butyl Caulk \$\$	■		Masonry or intersections of masonry to other materials	Flexible, can span bigger gaps (maximum gap should be less than ¾"), usually is color matched	Difficult to work with, messy, high shrinkage factor	8–10

# Sealants

## Caulk

Specific caulking compounds are made specifically for concrete, brick, wood, glass and metal and are intended to form a flexible seal for cracks, gaps and joints less than 1/4" wide.

- May be pure latex, siliconized latex, polyurethane and other modern materials.
- When selecting caulk, consider life expectancy, shrinkage over time, paintability and clean up (soap and water or solvent).
- Prep surfaces to ensure they are clean and free of debris.
- Apply in one straight, continuous bead and tool to finish if necessary.
- Completely fill crack, gap or joint; reapply where shrinkage occurs.
- Backer rod must be used for areas greater than 1/4".



### NOTE

- The terms caulk and sealant are often used interchangeably. Caulks or caulking compounds are non-elastomeric, do not return to their original sizes after being stretched or compressed, and are used for filling small joints (1/4" less) where little or no movement is expected. Sealants are elastomeric materials used to seal joints where movement (typically 25% to 50%) is expected.

# Sealants

## Spray Foam

**Spray foam is a readily available, easy to use material to effectively air seal gaps and openings greater than 1/4" wide. Both 1-part and 2-part foam materials are available.**

- Openings to be sprayed with foam must be clean for proper adhesion. 1-part foam is more forgiving and can be used under dusty conditions in an attic and basement.
- To obtain an effective seal, foam must be sprayed in a continuous motion with no voids or breaks.
- To fill openings around windows and doors, a non-expanding, 2-part foam is recommended. If a 1-part foam is used, the gap should be filled no more than half way in order to reduce waste and prevent bowing and warping of surrounding materials as foam expands during the curing process.
- At top plates and when sealing large by-passes (e.g., at drop soffits) where a rigid backing material such as insulation board, rolled fiberglass batt, drywall, or radiant bubble wrap will be installed first and later sealed, the natural tendency of 1-part foam to expand to close large gaps is beneficial.
- Once cured, foam can be trimmed so that finish materials can be installed on top. Generally, foam cannot be successfully sanded or smoothed to blend with finish surfaces such as drywall or wood trim.

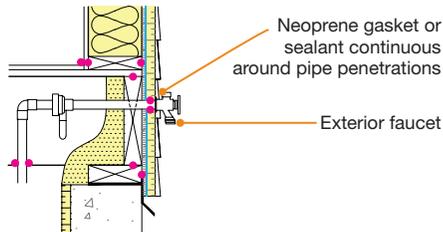
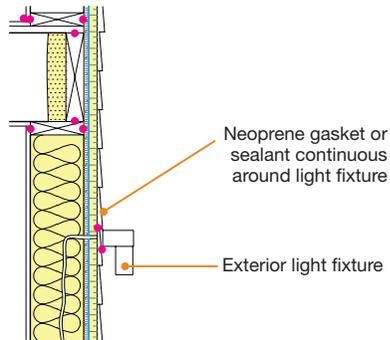
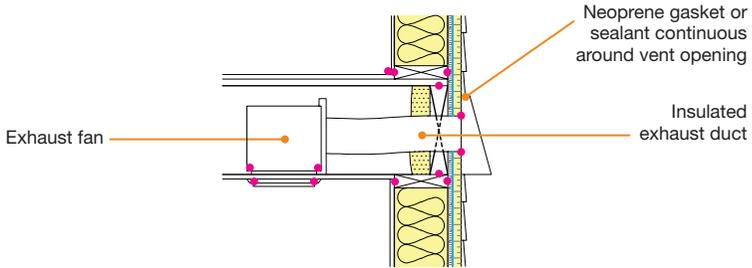


**NOTE**

- Choose appropriate foam for specific application; see sealant chart on page 42.

# Exterior Wall Penetrations

■ All penetrations through the building thermal envelope must be sealed.

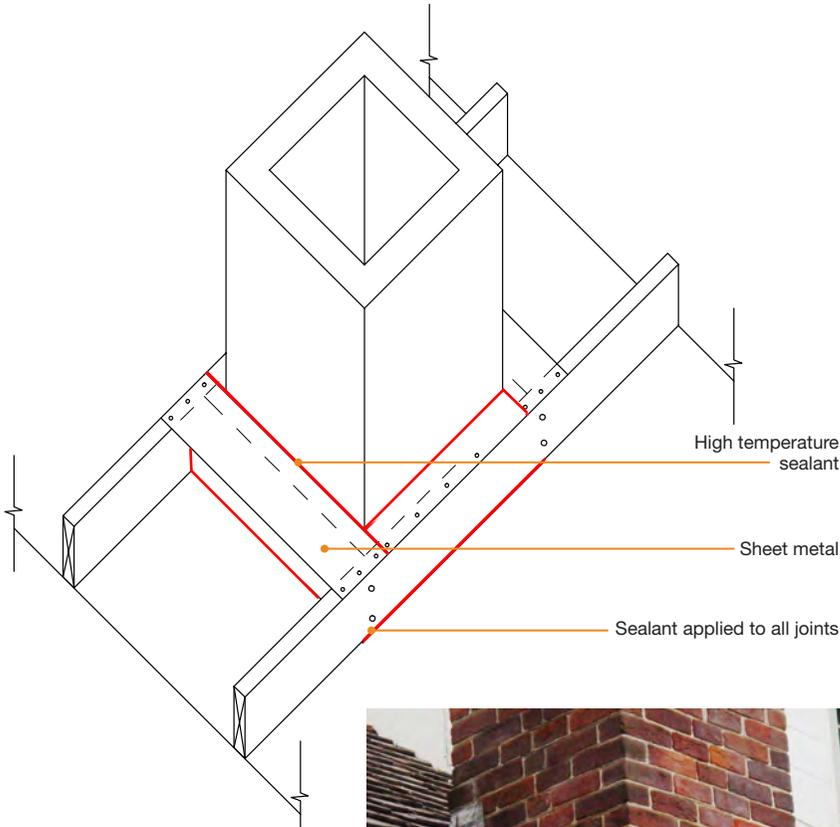


## NOTES

- Completely seal penetrations with gaskets, spray foam or tape. Use products appropriate to materials, following manufacturer recommendations.
- Because of deterioration due to exposure to the elements, monitoring and maintenance of sealed penetrations is essential.

# Chimney Penetrations

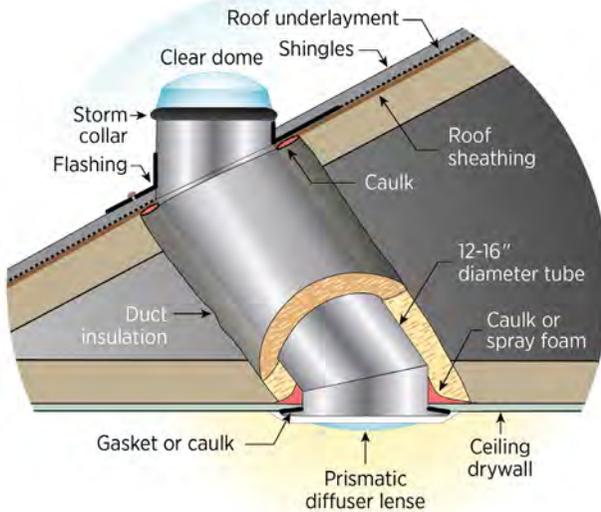
Chimneys run vertically through the entire building and penetrate the building thermal envelope at the attic floor or roof level (depending on whether or not the attic is conditioned). Sealant is required where the chimney penetrates the building thermal envelope.



# Other Roof Penetrations

**All roof penetrations, including skylights, light tubes, vents, and other holes created for plumbing, mechanical and electrical equipment, must be made watertight.**

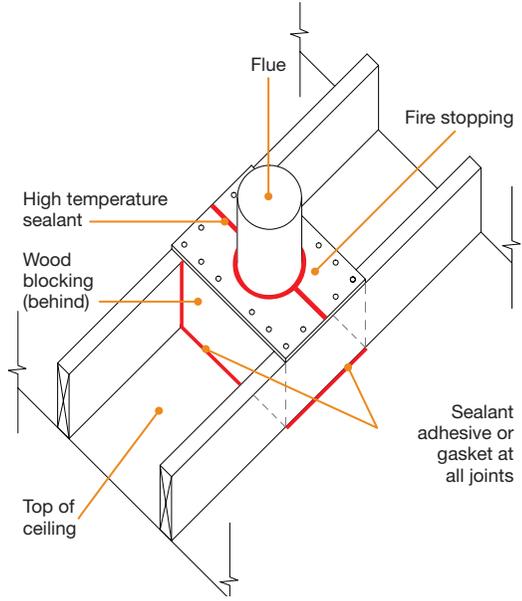
- Materials selected for flashing penetrations should follow manufacturer requirements and be evaluated for compatibility with adjacent materials.
- Given the vulnerability of roof penetrations and the potential damage if leakage occurs, always select the best available material and ensure proper installation. Monitoring and maintenance is essential.



*Courtesy of the Department of Energy*

# Flue Shaft Penetrations

- Flue shafts vent combustion air from appliances such as furnaces and water heaters, creating building thermal envelope penetration points in most homes.
- Seal flues with high-temperature, flexible sealant to allow for pipe expansion.
- Confirm code-required clearances to combustibles before installing or completing air barriers around heat sources.



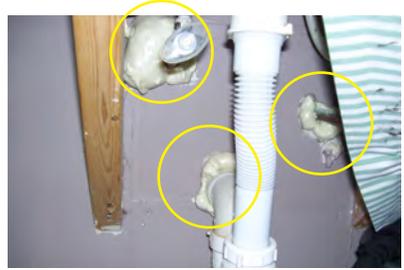
# Exhaust Fan and Dryer Penetration

- Exhaust fans and dryer vents must vent directly to the exterior and not into attics, basements, or buffer spaces such as garage or between floors. Because these carry warm moist air, these should be completely sealed and insulated to prevent condensation, in particular when contained in unconditioned spaces.
- Exhaust hood systems capable of exhausting more than 400 cfm require make up air at approximately the same rate. Make up air system requires a means of closure and an automatic start when the exhaust system is operated.



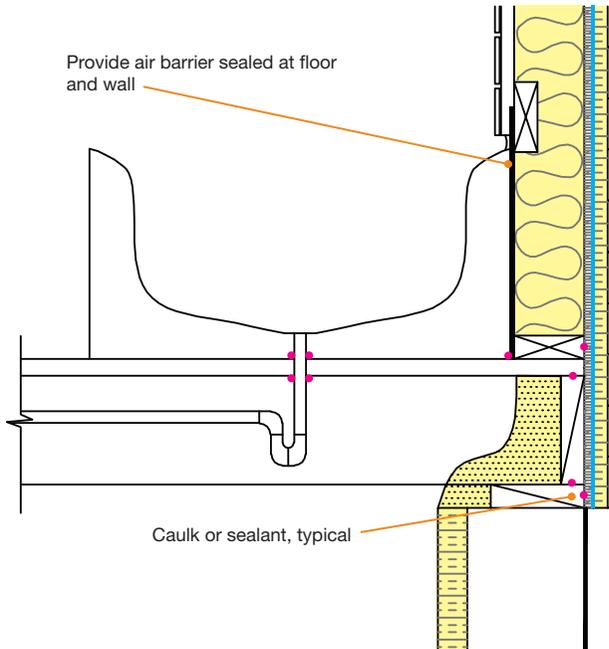
# Plumbing Penetrations

- Seal all plumbing penetrations at building thermal envelope and at interior locations such as under cabinets and by water heaters.



# Bathtub and Shower Penetrations

- Tubs and showers at exterior walls are common areas of significant air leakage. Air barriers should be placed and sealed before installation of the tub or shower, extended beyond the insert, and attached and sealed to the surrounding air barrier.



# Heating and Electrical Penetrations

- Seal all plumbing and electrical penetrations, including receptacles, switches and junction boxes.



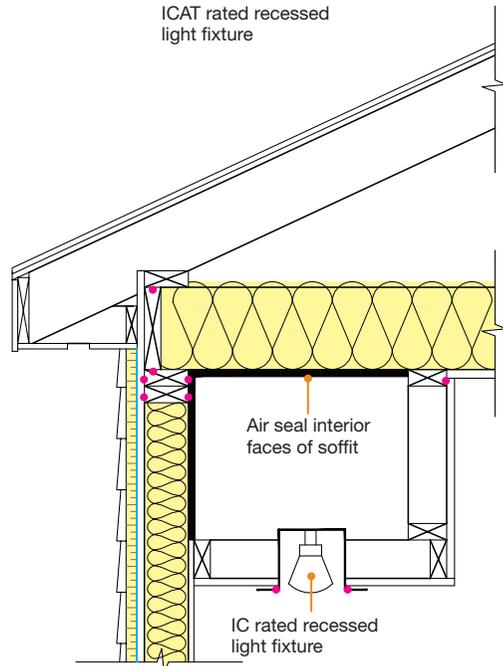
Courtesy of the Environmental Protection Agency

## Recessed Lighting Penetrations

- Recessed lighting fixtures are sources of potential air leakage through the thermal envelope. Sealing of fixtures can occur at the fixture or (if located within a soffit) above the fixture.
- IC (insulation contact) fixtures (typically up to 100 watts of light output) can make direct contact with ceiling insulation but may not be air tight. ICAT (insulation contact and air tight) fixtures (light output capacity posted on housing) are also sealed, stopping the passage of air through the fixture and into a ceiling or attic.



ICAT rated recessed light fixture



Air seal interior faces of soffit

IC rated recessed light fixture

# Interior Bypass Penetrations

- Sealing penetration points (bypasses) in walls, floors and ceilings between adjacent floors and rooms prevents unwanted heat loss and gain by minimizing stack effect.



Duct chase between floors.



Plumbing, electrical and HVAC penetrations between floors.



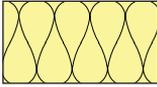
Plumbing penetrations between floors.



# Below Grade Construction

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# Illustration Key



Batt insulation



Foam insulation



Loose fill insulation



Rigid foam insulation



Sheathing (plywood, OSB)



Control layer (air, vapor, moisture)



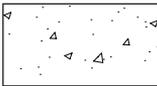
Sealant (continuous)



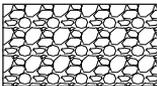
Gypsum board  
(wall or ceiling)



Wood blocking



Concrete



Gravel



Siding

# General

Effective foundation design can create more comfortable above grade and below grade spaces, reduce utility bills, prevent moisture and structural problems and control the effects of radon.

Foundations are supported by footings that spread the weight of the building below grade to minimize movement. The size, depth, reinforcement and design of foundations and footings are determined by code. Three types of residential foundations are common in New York State:

- Slab-on-grade.
- Crawl space.
- Full basement.



*Courtesy of IBTS*

## NOTES

- Radon control should be considered when testing determines high levels of radon present.
- Other foundation types, such as pile, monolithic or thickened edge slab, are less common, in part due to New York State's cold weather conditions.

# Foundation Types

**Different materials systems are available for residential foundations. The choice of foundation is often regional or based on contractor preference.**

The most common foundations for homes include:

■ **Poured reinforced concrete:**

Wall type, poured reinforced concrete foundations are among the most common. These require formwork, steel reinforcement, and applied insulation but are the least labor intensive. Poured reinforced concrete is typical for piers for porches, decks and other small structures and additions.

■ **CMU (Concrete Masonry Unit):**

Laid-up blockwork is more labor intensive than poured concrete. One advantage, in particular for more complicated foundation designs, is its ability to be easily altered during construction. Applied insulation is required.

■ **ICF (Insulated Concrete Forms):**

A newer type of foundation consisting of stacked insulated forms. Reinforcement is placed inside of hollow forms and concrete is poured inside to bond the structure. ICFs have the benefit of forming an integral and continuous insulated foundation, although by isolating the thermal mass of the concrete from the inside of the building envelope, some of the positive effect is negated.

■ **Pre-engineered concrete:**

Panels are fabricated off-site and shipped to the job site for assembly per manufacturer specifications. Panels require absolute water-sealing, positive drainage and bulk water control on the exterior and underneath.

## NOTES

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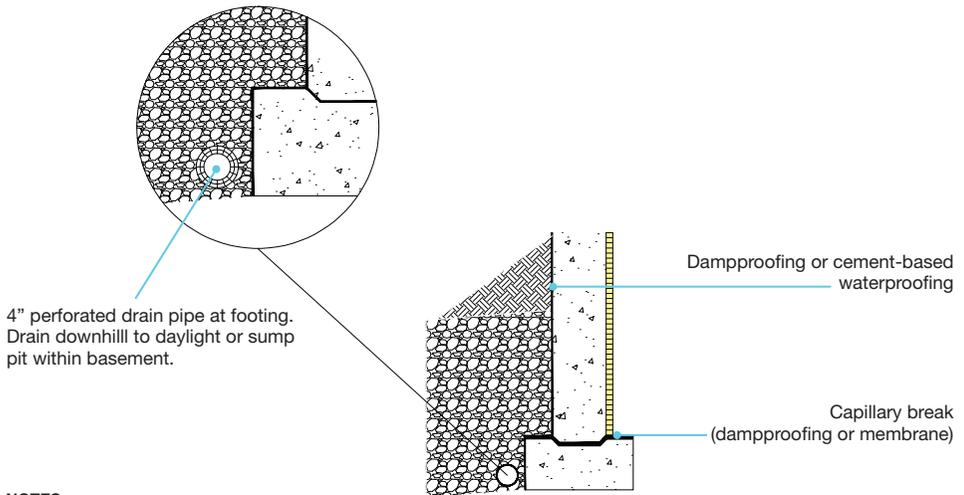
- At all locations, seal interface between the foundation and the exterior wall to reduce infiltration into the home.
- Insulate foundations per code and ensure insulation coverage is continuous and complete. Use only insulation approved for below-grade use.

# Foundation Drainage

Managing water at the foundation is key to keeping groundwater and roof water collected through flashing and gutter systems out of the building.

Primary construction techniques to prevent the buildup of water at the foundation include:

- Drain water at the foundation footing with a perforated drainage pipe embedded in gravel, covered with filter fabric and located at the lower perimeter of the foundation footing.
- Sloped pipe around the building should direct water away from the building or to a collection point of daylight. Design should include drainage at basement window wells.
- In areas or sites prone to water problems, include provisions for secondary interior drains and/or a sump pump. Secondary interior drains should be enclosed, where possible.
- Slope grade away from building perimeter between 5% and 15%. Greater slopes pose the risk of causing erosion to occur.
- Ensure roof water is directed away from building perimeter a minimum of 2'. May require downspouts (leaders) with extensions at grade or with subgrade connections to below grade piping.



**NOTES**

- See dampproofing basement walls on page 57.
- See Ltsiburek, Joseph. *Water Management Guide*. Somerville: Building Science Press, Inc., 2006.

# General

**Basements are commonly used for living space, mechanical equipment, laundry or storage. A basement may be conditioned or unconditioned based on intended use.**

**Basements can be either conditioned (heated or cooled) or unconditioned:**

**Conditioned basements:**

- Foundation walls part of the thermal envelope must be insulated on the exterior or interior.
- Mechanical ductwork and pipe insulation is not required although is considered best practice.

**Unconditioned basements:**

- Not part of the thermal envelope.
- Ceiling must be insulated.
- Mechanical ductwork and piping must be insulated.



*Courtesy of Conservation Services Group*

**NOTE**

- Many basements have both conditioned and unconditioned sections. Walls and doors separating conditioned from unconditioned spaces must be insulated.

# Dampproofing Basements

**Damp basements are common. While it is difficult to absolutely waterproof a basement, there are ways to minimize dampness.**

Masonry materials are inherently porous; moisture in the soil will penetrate masonry walls or floors and make its way into the building. Any moisture absorbed by masonry walls must be permitted to dry. Waterproof but non breathable coatings are likely to fail in areas exposed to excessive moisture.

## Dampproofing:

- A coating or membrane directly applied to below grade masonry foundations as a capillary break to minimize absorption of moisture into the masonry.
- Applied or installed to exterior walls and at the joint between the foundation footing and perimeter foundation walls.
- Historically, bituminous/tar coatings were used. Many choices are now available, including cement-based materials, synthetic coatings and membranes.

## Below Grade Slabs:

- For normal installations, concrete slab should be placed over XPS (extruded polystyrene) rigid board insulation over a 6 ml polyethylene vapor barrier over coarse gravel. The rigid board insulation can act as the vapor barrier if joints are well sealed, although many find sealing of the polyethylene barrier easier to accomplish.



## NOTE

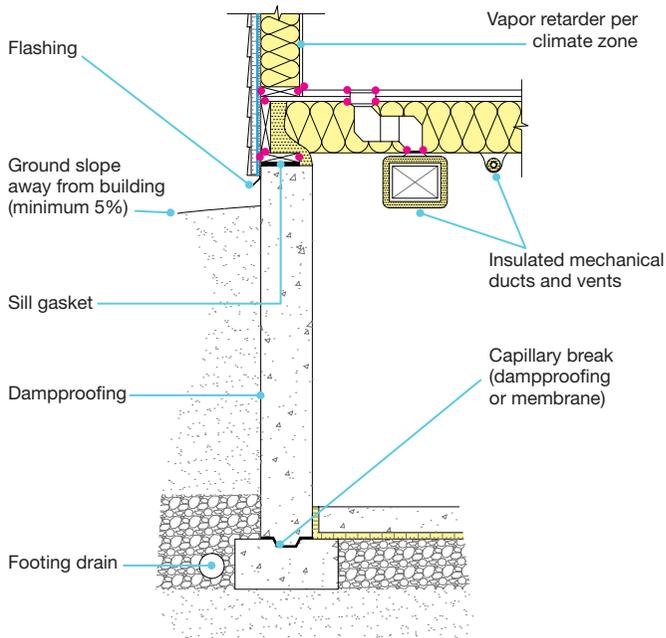
- Basements on soil with a high water content or at the foot of a hill may require sump pumps.

# Unconditioned Basements

Unconditioned basements can increase moisture challenges and limit the opportunity to use this space.

## Disadvantages of unconditioned basements:

- May be more expensive than conditioned basements since the basement ceiling must be insulated, all penetrations sealed, and mechanical ductwork and piping insulated.
- May be more vulnerable to moisture issues and deterioration due to freeze-thaw since the foundation wall is uninsulated.
- Because the uninsulated foundation wall is vulnerable to moisture issues and deterioration due to freeze-thaw, proper drainage at the foundation must be provided.



## NOTES

- Perimeter footing drain system is essential.
- If basement may be finished in the future, construction details should anticipate this future conversion.

# Conditioned Basements

## General

**Conditioned basements require insulation that is installed at the interior or exterior. Both approaches create habitable space and do not require mechanical ductwork and pipes to be insulated.**

**There are many advantages of exterior rigid board insulation:**

- Easy to achieve continuous thermal and air leakage boundary that minimizes thermal bridging and reduces heat loss through the foundation.
- Locating masonry mass inside of the building thermal envelope helps to regulate heating/cooling and increase comfort.
- Serves as a capillary break to moisture intrusion.
- Protects exterior dampproofing from damage during backfilling.
- Protects foundation from the effects of freeze-thaw cycle; reduces the potential for condensation on surfaces when basement is properly drained.
- Conserves room area relative to interior insulation.

**Disadvantages of rigid insulation on basement wall exterior:**

- Some exterior insulation materials are particularly susceptible to insect infestation.

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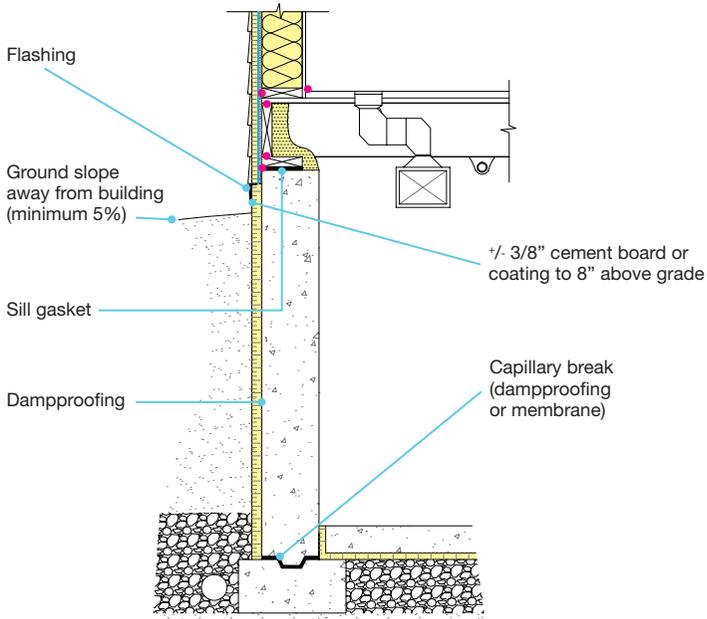
### NOTES

- Proper detailing to match manufacturer recommendations is critical.
- If radon gas is present, a mitigation system beneath the basement floor is required.

# Conditioned Basements

## Exterior Insulation Details

Exterior wall insulation protects dampproofing applied to the exterior of foundation walls.



### NOTES

- Perimeter footing drain system is essential.
- Proper details for insect control and/or termite-insect barrier required.
- On interior side of the basement wall, moisture resistant, breathable coating and/or air space between foundation and new wall framing is recommended.

# Conditioned Basements

## Interior Insulation

### Advantages of interior basement wall insulation:

- Mechanical ductwork and pipes do not require insulation.
- Wider choice in insulation materials, since it will not be exposed to the elements.
- Threat of damage from insect infestation is minimized.

### Disadvantages of interior basement wall insulation:

- Higher likelihood of moisture weeping through foundation walls.
- Requires superior air sealing details and vapor retarder installation.
- Room area diminished by thickness of insulation and wall framing.



### NOTES

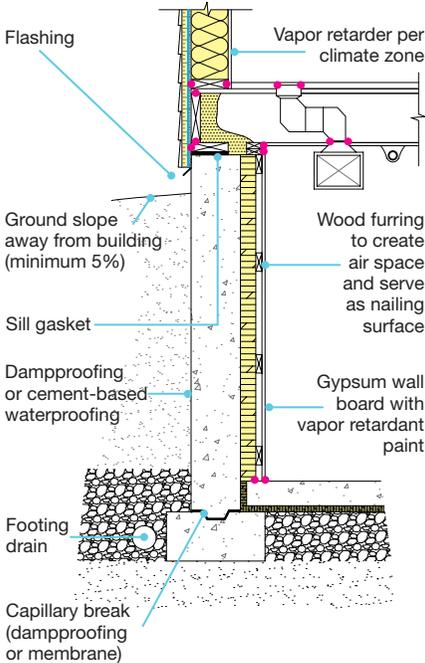
- Only rigid insulation rated for exposed application can be used without drywall.
- Vapor barriers (vinyl wall coverings, flooring or vapor impermeable paints) are not recommended at walls or floor.

# Conditioned Basements

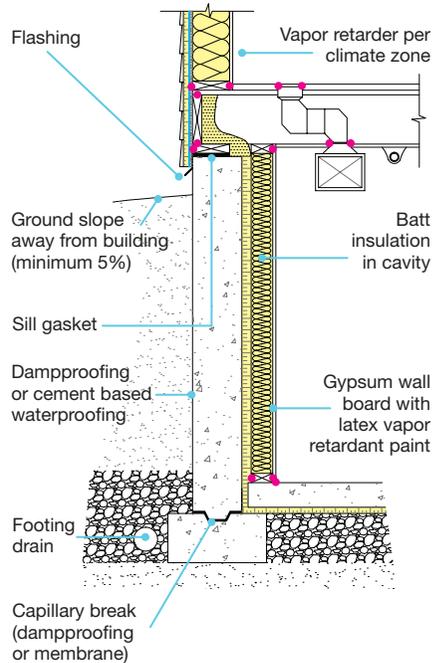
## Interior Insulation Details

Options for interior basement wall insulation:

### Rigid board insulation



### Rigid board and batt insulation



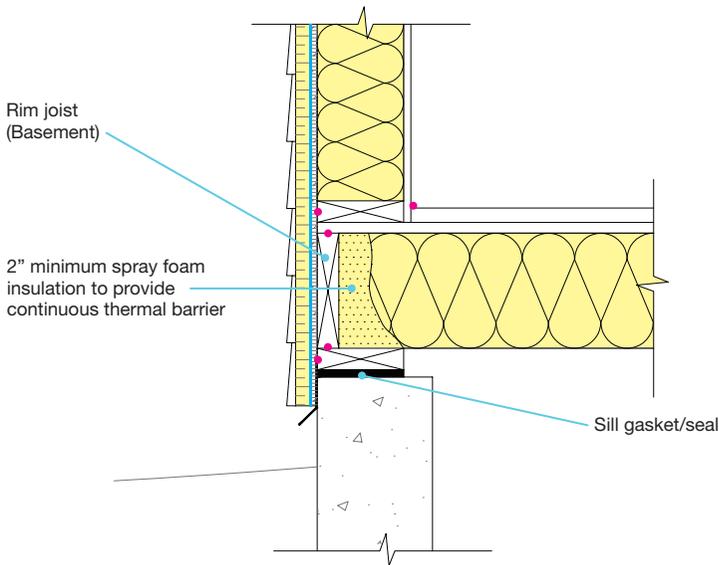
**NOTE**

- Due to the possibility of trapping moisture behind drywall and finish assembly, permitting mold growth, details must be carefully resolved and accurately implemented. Means to allow drying to the inside and dehumidification may be required.

# Rim Joists

Rim joists (or rim/band joists), located at the perimeter of floor framing, are often overlooked when insulating building walls. When poorly insulated or sealed, these are significant points of heat loss/gain. Because rim joists are always part of the building thermal envelope, they must be insulated whether the basement is unconditioned or conditioned.

- Spray foam is frequently used for rim joist insulation, especially at plumbing and electrical penetrations.
- Rim joist insulation must be continuous with wall insulation and have the same R-value to maintain the building thermal envelope.
- A coating for fire protection (thermal barrier) may be required for foam applied to sill plates, box headers, and rim joists unless the foam meets the thickness, density, and flame spread rating required by code.



**NOTE**

- Rim joists (or top plate) at attic are also part of the building thermal envelope and require similar treatment.

## General

Crawl spaces below buildings have insufficient height, as determined by code, for most people to stand upright. Crawl spaces often have dirt floors and can be vented or unvented. Exposed materials, including framing members, may be susceptible to deterioration through contact with the earth or moisture moving upward from unprotected ground or inward from the exterior.

For both vented and unvented crawl spaces:

- Install a capillary break, such as an EPDM membrane, between masonry and any wood framing to reduce water movement. A membrane can also serve as a termite shield.
- Dampproof the below grade portion of the foundation wall to prevent absorption of ground moisture.
- Install an exterior foundation drainage system at the footing (perforated drain pipe sheathed in filter fabric and embedded in gravel).
- Install a vapor barrier (EPDM or polyethylene sheet) across the crawl space floor to prevent soil moisture from migrating into the crawl space. Overlap and tape all seams, extend up the crawl space walls and seal completely to achieve air-tightness.
- Recommended option: pour a thin concrete slab over the polyethylene vapor barrier.



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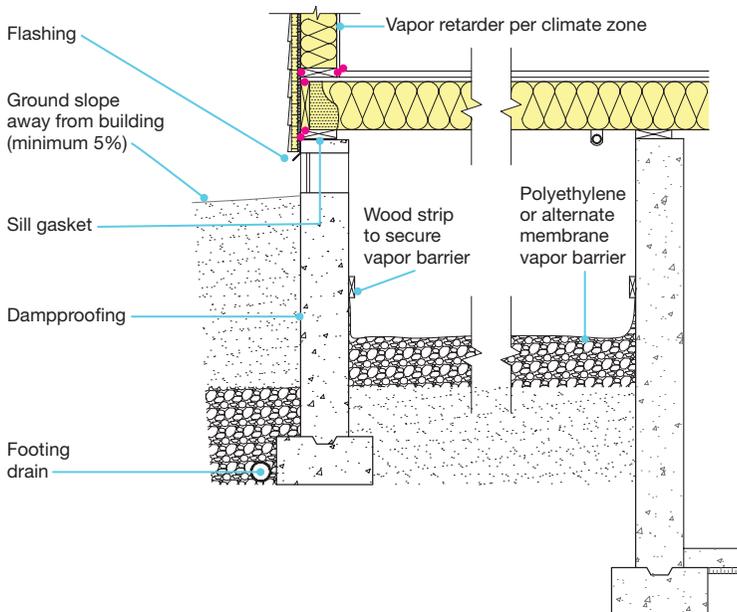
### NOTE

- Where required, radon mitigation systems require a passively or mechanically ventilated crawl space.

# Vented Crawl Spaces

Crawl spaces were traditionally vented to mitigate moisture, requiring seasonal maintenance.

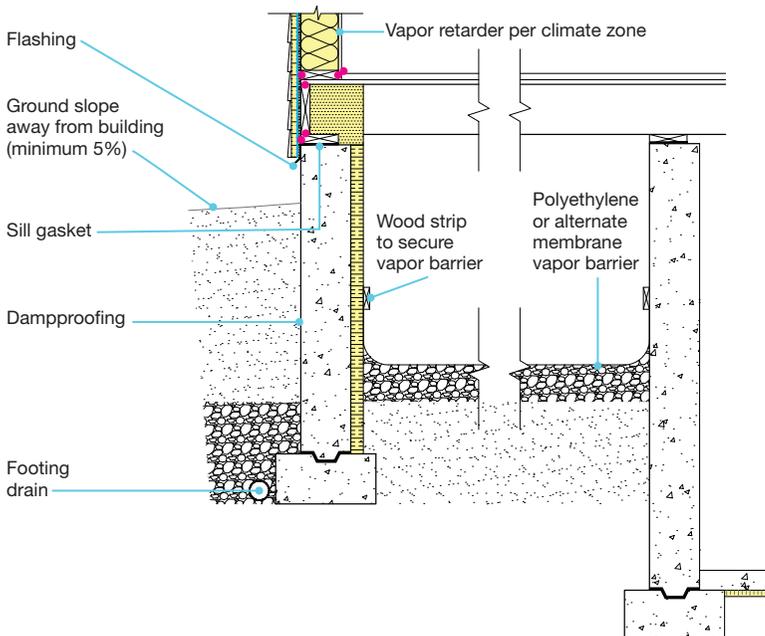
- Vented crawl spaces are losing favor in New York State since, in summer conditions, moist moisture-laden air moving into vented crawl spaces can condense on cold concrete or other surfaces.
- To minimize adverse effects where vented crawl spaces are used, vapor barrier should be installed at grade and firmly secured to the wall, and vents sized to meet code requirements. Blocking in or closing of vents is recommended in winter to prevent freezing.
- The floor above a vented crawl space is part of the building thermal envelope and must be sealed and insulated.
  - Support insulation with mechanical fasteners to maintain contact with the floor above.
  - Cover the insulation with housewrap or other material to protect insulation.



# Unvented Crawl Spaces

In buildings with proper exterior drainage and moisture control and a relatively low water table, unvented insulated crawl spaces are a good, energy efficient option.

- Insulating crawl space walls with rigid insulation can be easier and less expensive than insulating the floor of the conditioned space above.
- Properly insulated and sealed crawl space walls can save energy costs and increase comfort.
- Heat transferred through the uninsulated floor above keeps the crawl space from freezing, allowing placement of plumbing and ductwork within the crawl space.



## NOTES

- An access hatch should be located through the floor above or through an insulated access door in the perimeter wall.
- Vapor barrier should not extend up the full height of the crawl space wall.

# General

**A foundation with a slab-on-grade floor is often the least expensive foundation system. Floors consist of a concrete slab poured over rigid board insulation over vapor barrier over gravel.**

- Slabs-on-grade lose energy primarily as a result of heat conducted outward and through the slab perimeter.
- Only the perimeter slab edge requires insulation; the thermal mass of the earth serves as a natural insulator at the underside of the slab.
- Slab edges must be insulated from the top of the slab (on the inside or outside of the foundation wall) downward.

## Keys to an effective slab foundation:

- **Moisture control:**  
Use a site and building drainage system to direct rainwater and groundwater away from the foundation.
- **Airtight construction:**  
Seal interface between the slab, foundation and exterior wall to reduce air leakage.
- **Complete insulation coverage:**  
Properly install the correct insulation levels and ensure the insulation coverage is continuous and complete.
- Use insulation products approved for below grade use.



*Courtesy of DOE*

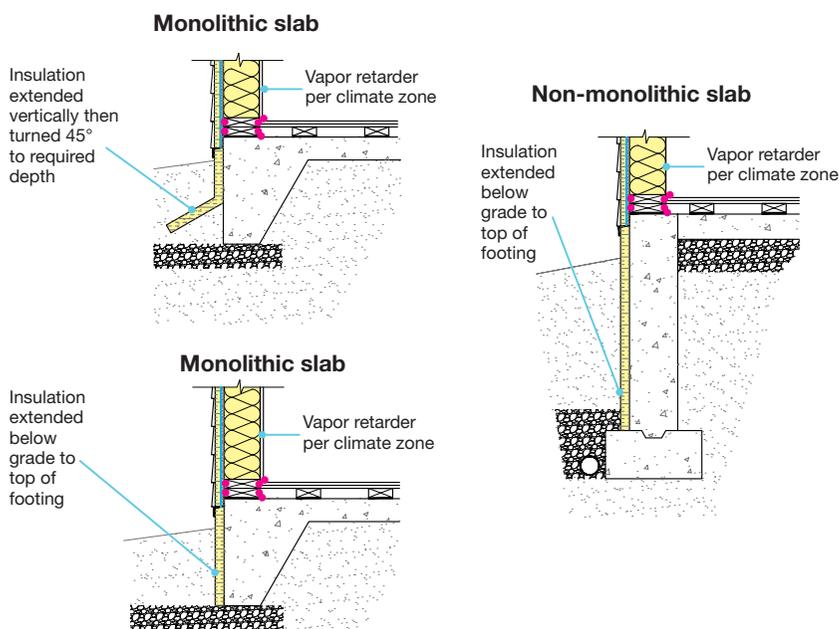
## NOTE

- When a building is designed to optimize solar or mass storage, insulation is required under the slab.

# Exterior Insulation

**Rigid insulation is installed directly around the exterior perimeter of the slab and footing to a depth required by code.**

- Insulation can be installed either vertically, vertically then under the slab, or vertically and diagonally outward from the foundation.
- Extending the insulation outward beyond the foundation helps protect the footing from freezing.
- The above-grade portion of the insulation exposed to outside elements must be covered with metal, masonry, cement parging, or another approved membrane or material to protect it from damage.
- Exposed edges of the insulation (above and below grade) should be covered with a protective membrane to serve as a capillary break and to protect the insulation from termites and physical impacts.



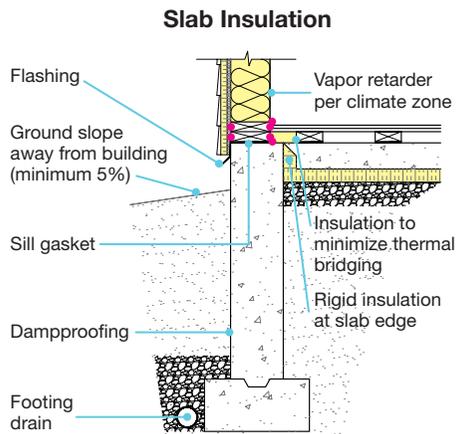
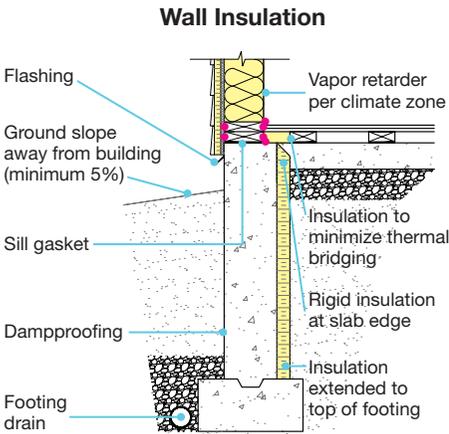
## NOTE

- Protect diagonal or horizontal insulation with gravel or a minimum of 10" of soil.

# Interior Insulation

Rigid insulation is installed against the interior side of the foundation wall or horizontally under the slab to a depth required by code.

- Insulation can be installed vertically from the top of the slab edge to the foundation footing or vertically from the top of the slab edge then horizontally underneath the slab.
- Interior and exterior insulation have similar thermal performances.
- Interior insulation is less expensive to install than exterior insulation, does not require exterior protection for long term durability, and may offer better protection from insect damage.

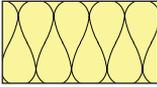




# Above Grade Construction

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# Illustration Key



Batt insulation



Foam insulation



Loose fill insulation



Rigid foam insulation



Sheathing (plywood, OSB)



Control layer (air, vapor, moisture)



Sealant (continuous)



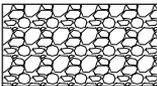
Gypsum board  
(wall or ceiling)



Wood blocking



Concrete



Gravel



Siding

# Sheathing

**Sheathing provides a continuous surface at the exterior face of the building envelope that contributes to building stability and durability, resistance to air movement, and, when insulated, thermal resistance.**

- Insulated sheathing (top photo), typically used in addition to insulation installed from the interior within the wall cavities, provides an ideal continuous thermal barrier. The most common types of insulated sheathing are Expanded Polystyrene (EPS), Extruded Polystyrene (XPS), and Polyisocyanurate (Polyiso).
- Taping of joints between panels (bottom photo) is required for air and water tightness and proper performance. Careful attention to details and installation, as recommended by manufacturer and appropriate for local conditions, is essential.



Courtesy of IBTS



## Wood Framing

**Wood is readily available and in New York State remains the material of choice for most exterior walls, floors and roofs in residential construction.**

- Material selection (including species and grade) and detailing are critical due to wood's vulnerability to rot and insect or termite attack.
- Although wood is a fair insulator at approximately R-1 per inch, it is much less insulative than other insulation materials.
- Standard wall framing makes up 20–25% of the total wall area. The reduction in overall R-value resulting from wood framing can be mitigated by exterior continuous insulation and advanced framing techniques.



*Courtesy of IBTS*

## Metal Framing

**Metal is an alternative to wood for residential construction. Although more expensive and conductive, metal has greater spanning capacity and is not susceptible to insect attack.**

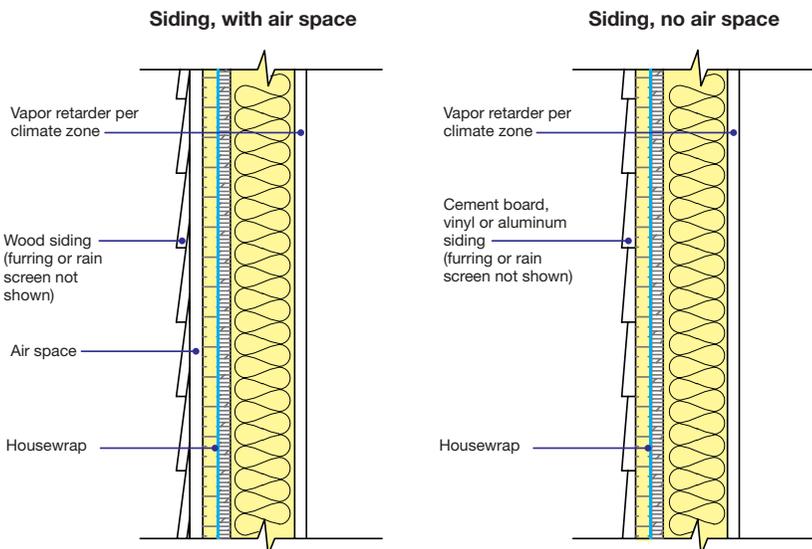
- Metal or steel framing is highly conductive. Although there is less mass than wood, the conductivity of metal makes a building more prone to energy loss and condensation issues.
- High conductivity reduces the effective performance of insulation in metal frame assemblies.
- Cavity insulation alone is not adequate to insulate a metal framed house. Continuous rigid insulation on the exterior wall is required.

# Cladding

## Wood, Cement Board, Aluminum, and Vinyl

Exterior cladding acts as the outward component in a rainscreen assembly, helping to prevent water from entering exterior wall assemblies.

- Wall cladding may be wood, cement board, stucco, vinyl or aluminum.
- With the exception of vinyl and metal, all cladding gets saturated. In all claddings, open joints and gaps can develop over time, allowing wind driven rain to enter the wall system.
- Most cladding systems are installed with vent and weep holes, providing intentional air movement that permits walls to dry properly.
- Air spaces also contribute to thermal performance and wind pressure equalization, as well as accommodate natural movement in buildings due to settlement and seasonal changes.



**NOTES**

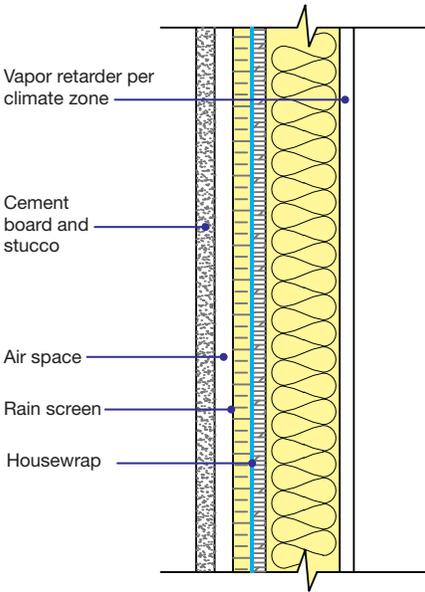
- Some cladding types, such as vinyl and aluminum siding, do not require venting.
- Always provide air space if recommended by manufacturer.

# Cladding

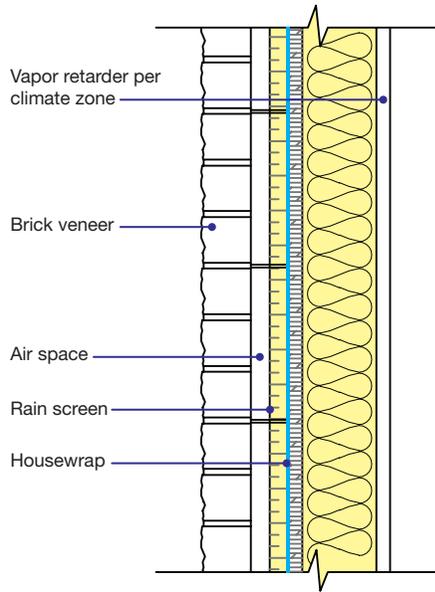
## Stucco and Masonry

While ventilated rainscreens benefit all cladding types, they are essential for masonry and strongly recommended for cement board. To permit full drying of the wall assembly, follow manufacturer recommendations for position, material and detailing.

Cement board or stucco



Brick masonry veneer



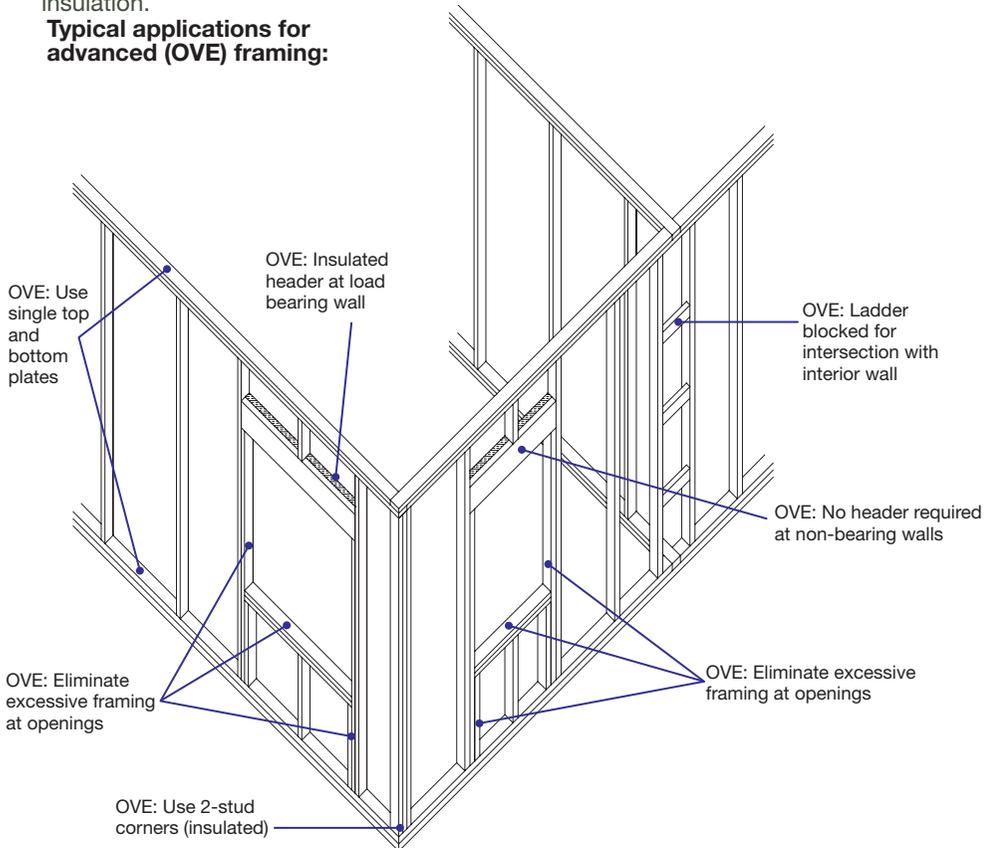
# Advanced Framing

## General

**Advanced framing, also known as Optimal Value Engineering (OVE), is a technique that reduces the amount of wood used to frame a building without compromising structural integrity.**

- The goal of advanced framing is to reduce unnecessary wood around windows, headers, corners, wall intersections, etc. Among other details, this typically includes an increase in stud spacing (to 24" o.c.) and use of 2x6 wood framing.
- Can reduce thermal bridging by up to 25% by allowing more room for cavity insulation.

**Typical applications for advanced (OVE) framing:**



## Advanced Framing Corner Connections

Traditional corner framing with 3 and 4 studs wastes wood and reduces the total wall R-value. 2-stud corner framing is preferable to minimize pockets of uninsulated voids after exterior sheathing is installed.

Use of 2-stud corners requires use of wood backup cleats, metal drywall clips or other devices to serve as backing for finish material.



# Advanced Framing

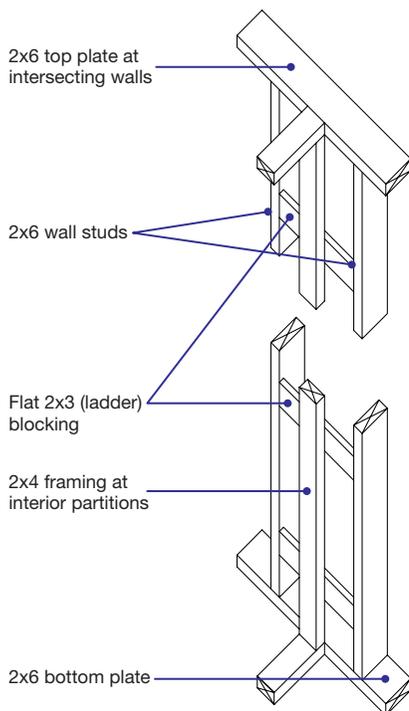
## Junctions with Interior Partitions

Extra studs used in exterior walls at junctions with interior partitions to provide solid nailing for drywall results in locations that lack insulation.

Alternative techniques can reduce the number of studs while providing strength and nailing surfaces:

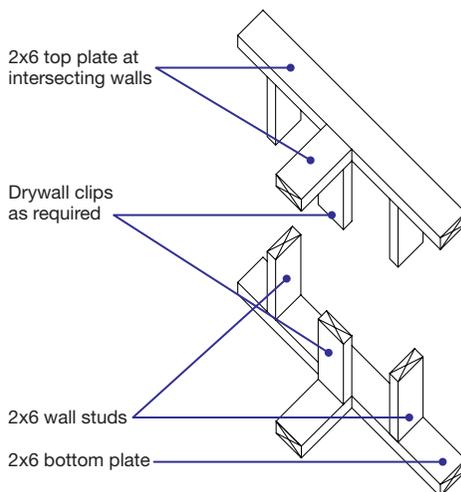
**Ladder blocking at wall junctions:**

Install horizontal (ladder) blocking where the partition will be secured to add support for the interior wall.



**Drywall clips at wall junctions:**

Install clips before installing the next sheet of drywall.

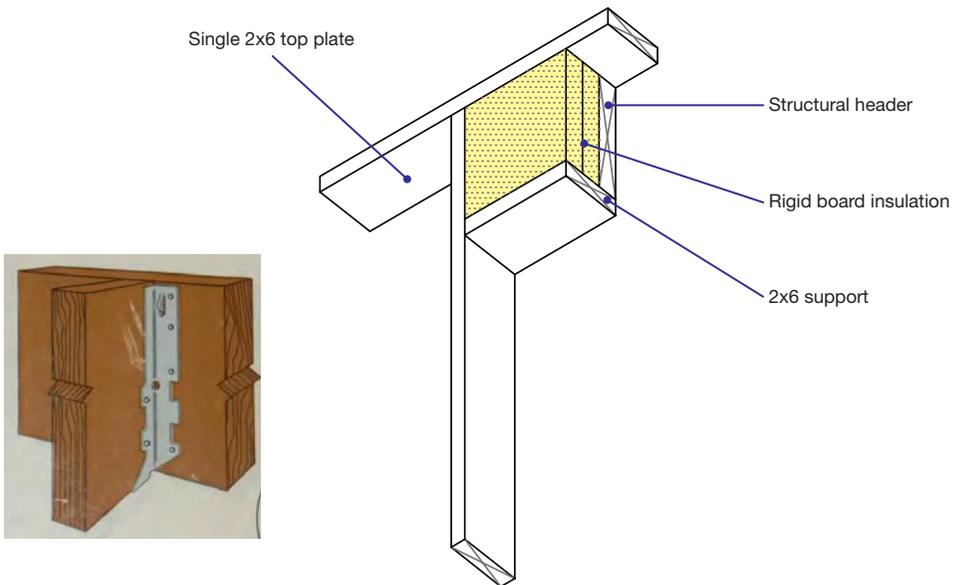


Drywall clip

# Advanced Framing Headers

**A single header can be used in most locations instead of a double header.**

- Advanced framing permits elimination of window jack studs, thus creating the opportunity for additional wall insulation. Headers can be notched to connect to the single stud or attached with a metal header hanger.
- At non-bearing walls, insulation can be maximized since no (structural) headers are required. Framing need only be sufficient to create appropriate window or door openings.

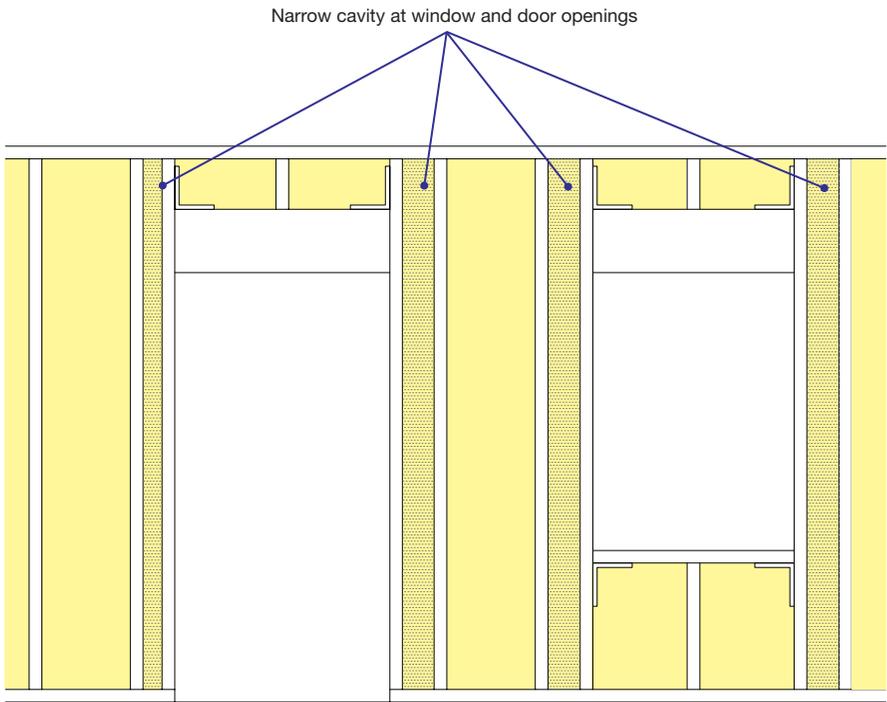


# Narrow Cavities

**Narrow cavities must be sealed and insulated to eliminate air infiltration into the building.**

Where possible, without compromising structural concerns or placement of windows and doors, framers should avoid narrow cavities.

- To minimize the number of narrow cavities, careful attention to wall framing design should be paid by the design professional and the builder.
- Narrow cavities can best be avoided when placement of vertical framing members is kept on a modular schedule (although modification for placement of windows and doors may be necessary) and when advanced framing techniques are used.
- Spray foam insulation with appropriate backers should be used to seal and insulate where narrow cavities are unavoidable.



# Mass Walls

**Mass walls provide energy efficiency through mass rather than insulation. Exterior walls constructed of concrete block, concrete, insulated concrete form, masonry cavity, brick, earth, adobe and solid timber or logs, are heavier per cubic foot than traditional frame walls and specifically designated as mass walls (by weight) by the code.**

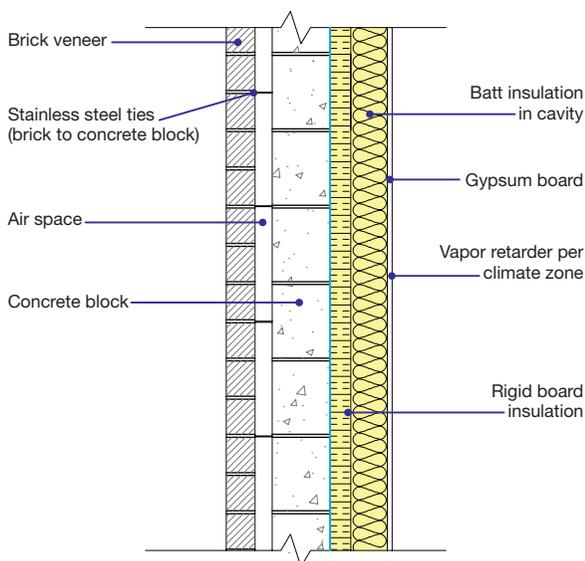
Mass walls can supplement both heating loads in the winter and cooling loads in the summer if carefully designed.

- In a heating climate, the sun's energy is collected and stored during the day and released at night. Because mass walls absorb heat from the sun and radiate it to the interior, less insulation is required than for a frame wall. If the mass wall will receive direct summer sun, shading should be provided.

Insulation requirements are dependent on how the insulation is distributed between the interior and exterior walls.

- If more than half of the insulation is on the exterior, mass walls are permitted to have a lower R-value than permitted for other wall systems.
- If at least half of the insulation is on the interior (limiting the ability of the building to use stored heat) additional interior insulation, approaching that required for a frame wall, is required.

**Mass wall with interior insulation**



# Structural Insulated Panels (SIP)

- SIPs are factory-built, insulated wall assemblies with insulation sandwiched between plywood or OSB sheets. Wall panels are assembled in the field.
- By providing a continuous insulation/thermal barrier at the building exterior, SIPs ensure minimal thermal bridging and avoid gaps, voids or compression often found in standard cavity insulation installations.
- Installation requires detailed joint sealing and proper water- and weather-resistive barriers.



---

**NOTE**

- Can be manufactured with precut openings for windows and doors or with grooves and voids for electrical wiring and heating/cooling ducts and pipes.

# Insulated Concrete Forms (ICF)

**ICFs are factory-made forms constructed from rigid insulation boards designed to be assembled onsite and filled with concrete.**

- Steel reinforcement and concrete poured into the voids result in an airtight, well insulated, sturdy wall.
- Continuous interior and exterior insulation eliminates thermal bridging, with no voids, gaps or compression often found in standard cavity insulation installations.
- Most typically used for foundation walls, although gaining favor for above grade exterior walls.
- Below- and above- grade ICFs must be protected like other board insulation to prevent physical damage to the insulation, as well as be treated with a weather-resistant barrier.



## General

**Windows, skylights, and doors transmit a substantial amount of heat. Even a high performance window has less than 15% the insulating value of a code-compliant frame wall.**

Modern glass and glazing systems are much improved over glass historically used in residential construction.

- Low-E-coatings, triple glazing and sealed gas between glass layers improve the insulating qualities of glass.
- High performance glass reduces UV (ultraviolet) radiation, beneficial for energy performance and for color protection of interior finishes and fabrics.
- Proper installation including head and sill flashing and sealing is essential to protect glazed units and interior and exterior finishes.



*Courtesy of IBTS*

# Window Frames

- **Material choice and manufacturer details have a significant effect on window performance.**
- Wood is a better insulator (and less conductive) than metal and a good choice for window, door and skylight frames.
- Metal frames must have thermal breaks to stop transfer of heated or cooled air across the assembly.
- Most manufactured window assemblies come with a label indicating energy performance rating by the National Fenestration Rating Council (NFRC).



# Window Labels

The National Fenestration Rating Council (NFRC) presents independent results on four areas of energy performance from NFRC-certified laboratories.

		<b>World's Best Window Co.</b> Millennium 2000™ Vinyl Clad Window Program Double Glazing - Argon Fill - Low E Product Type: Vertical Slider	
<b>ENERGY PERFORMANCE RATINGS</b>			
U-Factor (U.S./F.P.)		Solar Heat Gain Coefficient	
<b>0.35</b>		<b>0.32</b>	
<b>ADDITIONAL PERFORMANCE RATINGS</b>			
Visible Transmittance		Air Leakage (U.S./F.P.)	
<b>0.51</b>		<b>0.2</b>	
Condensation Resistance			
<b>51</b>			
<small>                     INFORMATION CONCERNING THE WINDOW RATING SYSTEM IS AVAILABLE FROM THE NFRC WEBSITE FOR DOWNLOADING UNDER LIMITED PERMISSIONS. NFRC ratings are measured for a range of environmental conditions and do not represent product field conditions. For more information, visit <a href="http://www.windowratings.org">www.windowratings.org</a>.                 </small>			



## Understanding the NFRC Label



**U-factor** measures the heat from **INSIDE** a room that can escape. The lower the number the lower the potential for wasted heating expenses.

**Solar Heat Gain Coefficient** measures the amount of **OUTDOOR** heat that can enter a room. The lower the number, the lower the potential for wasted cooling expenses.

**Visible Transmittance** measures how much natural light can come into a room – a **HIGH** number means more natural light.

**Air Leakage** measures how much air will enter a room through the product. The lower the number, the lower the potential for draft through the product.

**This image mirrors the four sections of the certified NFRC Label, providing the consumer with visual illustrations of what the label ratings mean. More in-depth information on the NFRC Label and purchasing the best possible windows, visit [www.WindowRatings.org](http://www.WindowRatings.org)**

Courtesy of NFRC

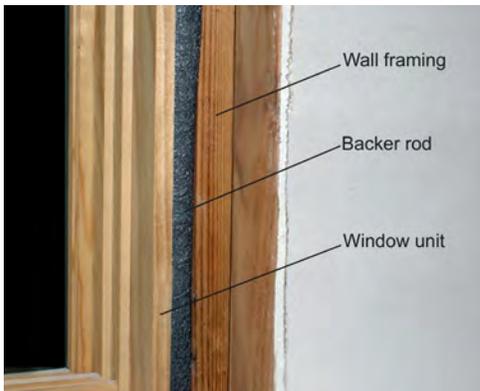
**NOTE**

- For additional information, see websites of the American Architectural Manufacturers Association (AAMA) and the Window and Door Manufacturers Association.

# Window Installation

**Always install the best performing windows possible: as operable units, they receive much wear and tear over the building's lifetime. Their inherent energy inefficiencies (low thermal resistance, installed with an open perimeter until sealed) must be compensated for with excellent and appropriate installation techniques.**

Perimeters are a potential source of air leakage and water intrusion. For energy performance and durability, seal and flash properly.



*Courtesy of the Department of Energy*

## NOTES

- See section on Housewrap: Installation at Openings, page 40.
- See Building Science Corporation, *Water Management Details for Residential Buildings*.

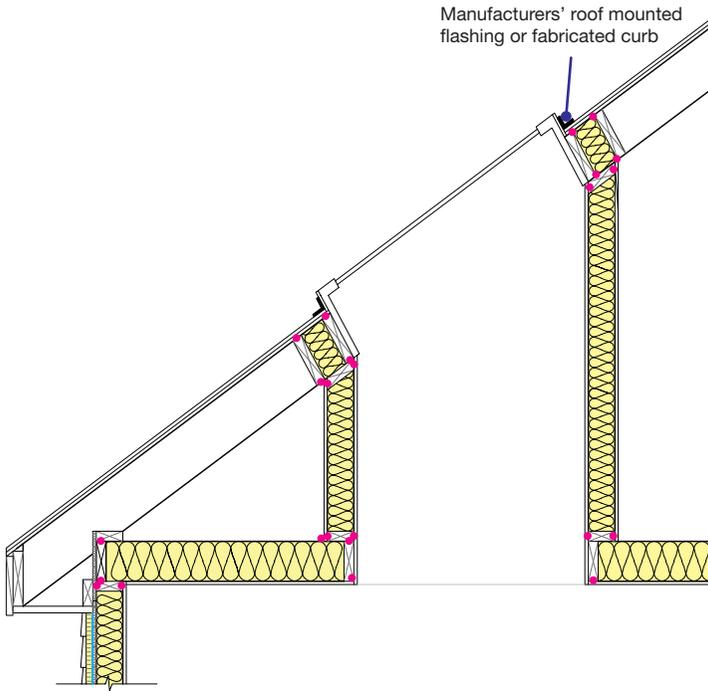
## Door Installation

Exterior doors are a potential source of heat loss. Doors must be properly installed with careful attention to the sill, where water entry is most likely. Doors must be tight when closed with all weather stripping at jambs and threshold engaged.



# Skylight Installation

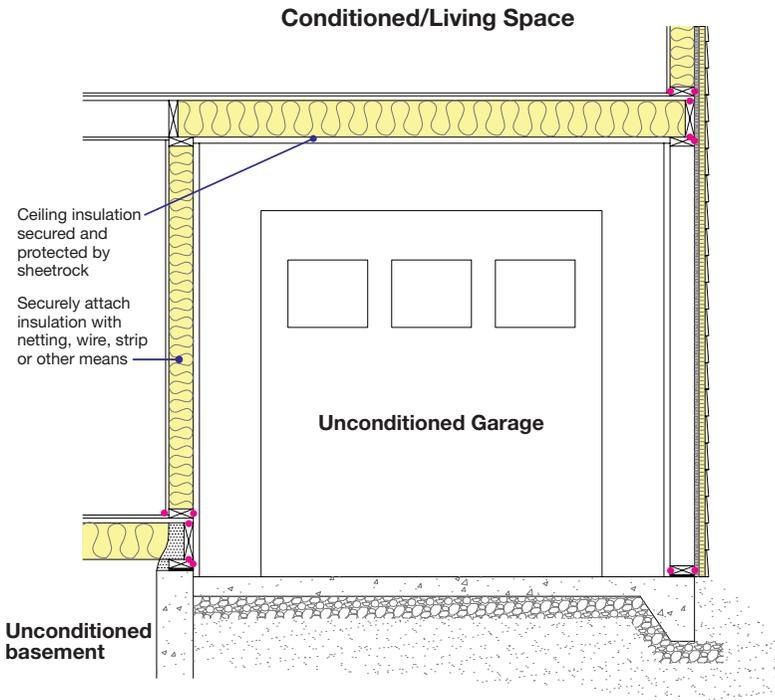
Skylights increase the opportunity for a space to benefit from natural daylight. However, they are vulnerable to water infiltration and must be properly flashed and sealed. Walls framing the skylight must be insulated as part of the building thermal envelope.



# Separating Conditioned and Unconditioned Spaces

**Floors between conditioned and unconditioned spaces, such as between a garage and second floor bedroom, are part of the building thermal envelope.**

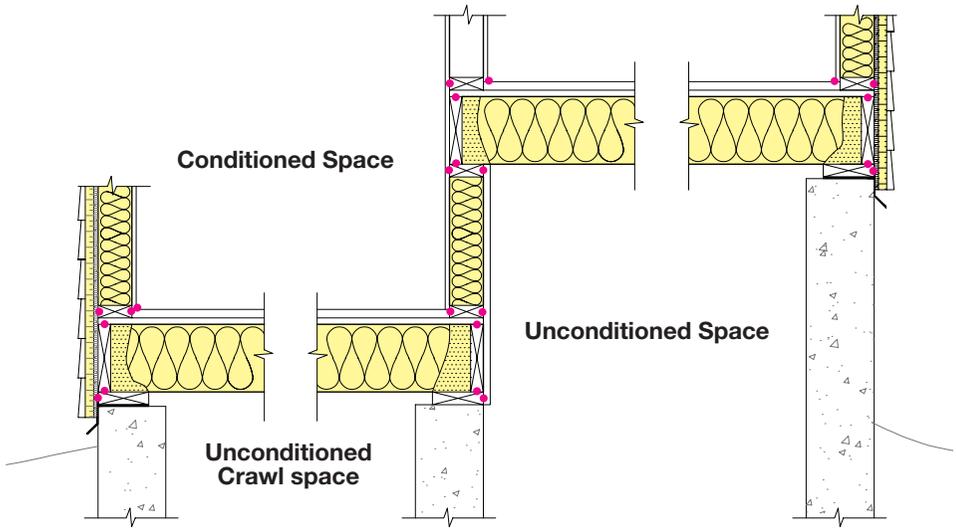
- The entire floor cavity must be filled to full depth with insulation that is held in place with netting, wood, wire, staples, etc. To be effective, insulation must stay in contact with the warm surface.
- The wall between the garage and the house, and the ceiling above it that may be below the house, should be air sealed as with all exterior walls, and to protect building occupants from the products of combustion or entry of other airborne pollutants from the garage. After parking and turning off the car motor, timed mechanical ventilation of garage can provide additional protection from potential movement of carbon monoxide into the home.





# Level Changes

Floors and their vertical connections exposed to outside air or unconditioned space in split level houses must be insulated and air sealed as part of the building thermal envelope.



# Vented Attics

## General

**While attics are traditionally vented, unvented attics have many advantages. Codes allow for both options.**

In a vented attic, the building thermal envelope is located at the attic floor/ceiling of the conditioned space below and must be insulated and fully air sealed. Ventilation is provided at soffits, roof ridges, knee walls, and /or vertical walls.

**In winter:**  
Maintains cold roof temperature to control ice dams created by melting snow if the ceiling below is completely air sealed.

**In summer:**  
Natural ventilation provides opportunity for moisture removal.



### Vented attic disadvantages:

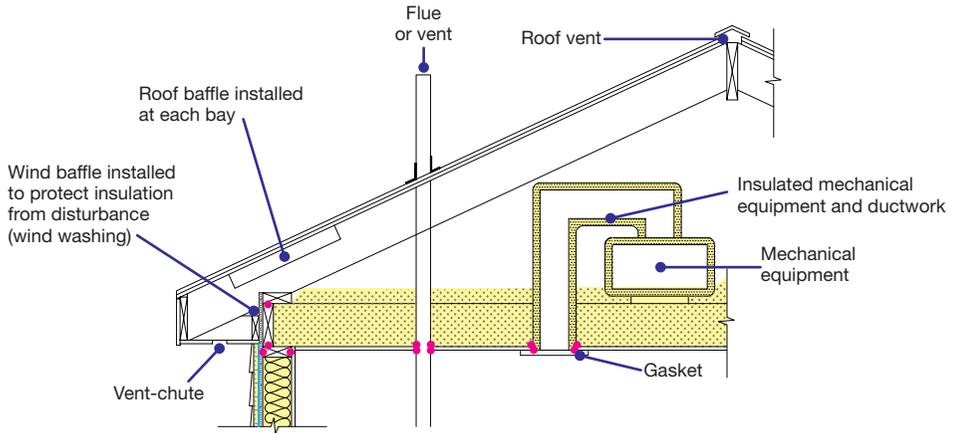
- Ductwork and mechanical equipment must be insulated.
- Access doors to attic through ceiling below must be airtight and sealed.
- Soffit and other vented attic details (blocking, venting, sealing, insulation depth and location) are often done wrong and create problems, primarily at the roof edge.
- Can increase air leakage if not fully air sealed.



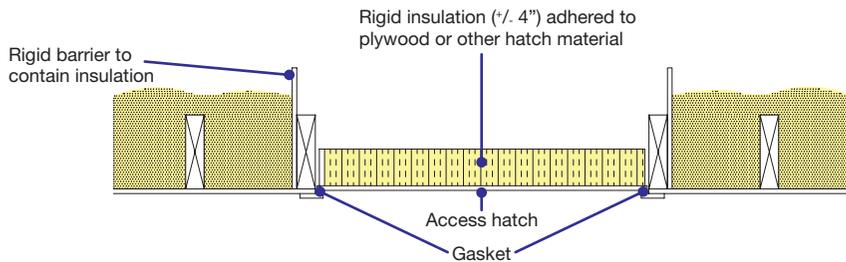
# Vented Attics

## Loose Fill (or Batt) Insulation

### Unconditioned Attic

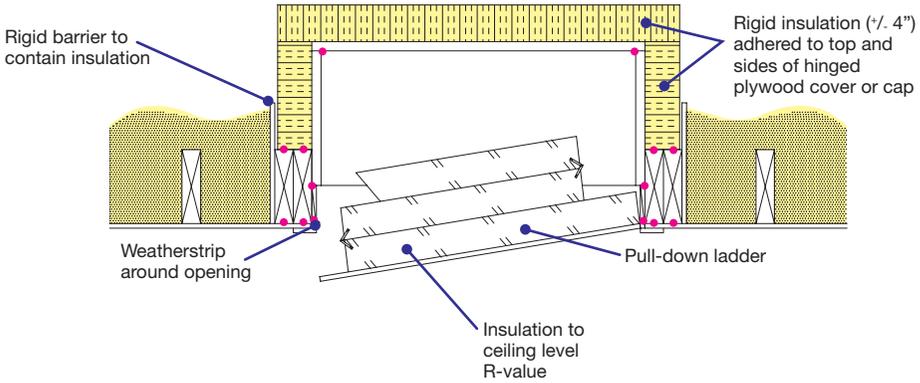


## Access Hatch

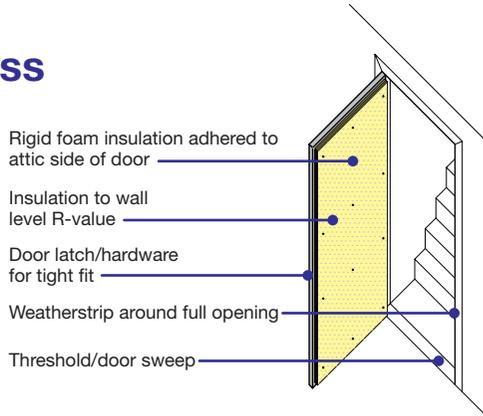


# Vented Attics

## Pull-Down Ladder



## Full-Height Door Access



# Unvented Attics

## General

**Insulating the roof and eliminating ventilation brings an attic into the conditioned space.**

### Unvented attic advantages:

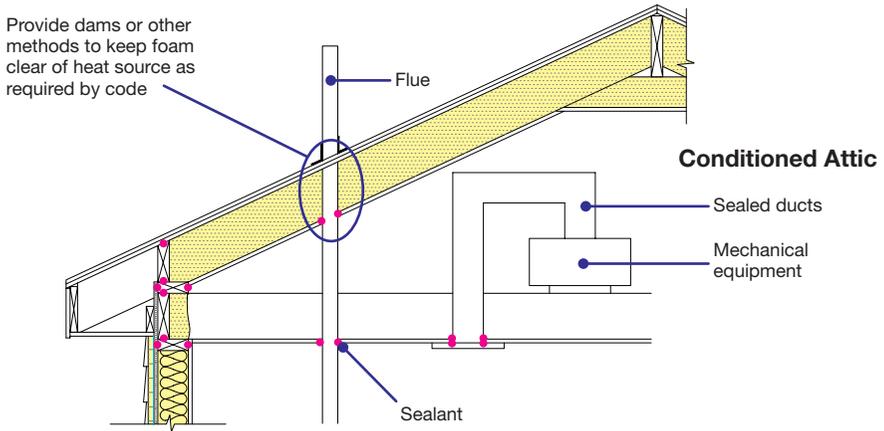
- Increases a home's livable space.
- Mechanical equipment located in the attic may not require insulation.
- May be preferable to vented attics in complex roofs.
- Temperature and humidity can be controlled.

### Unvented attic disadvantages:

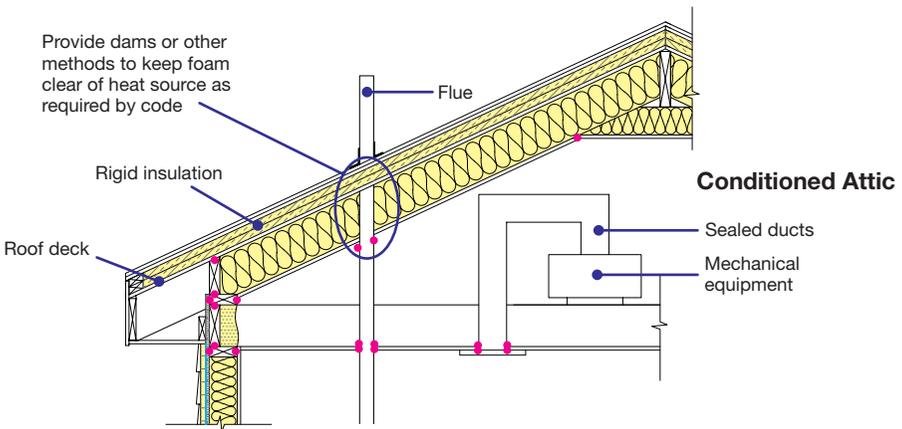
- Hotter in summer than vented attics, causing an increase in cooling demand.
- More difficult to see or trace (future) roof leaks.

# Unvented Attics

## Spray Foam Roof Insulation



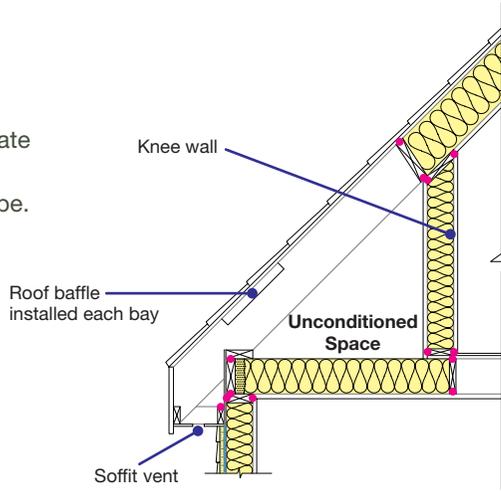
# Fiberglass Batts and Rigid Board Insulation



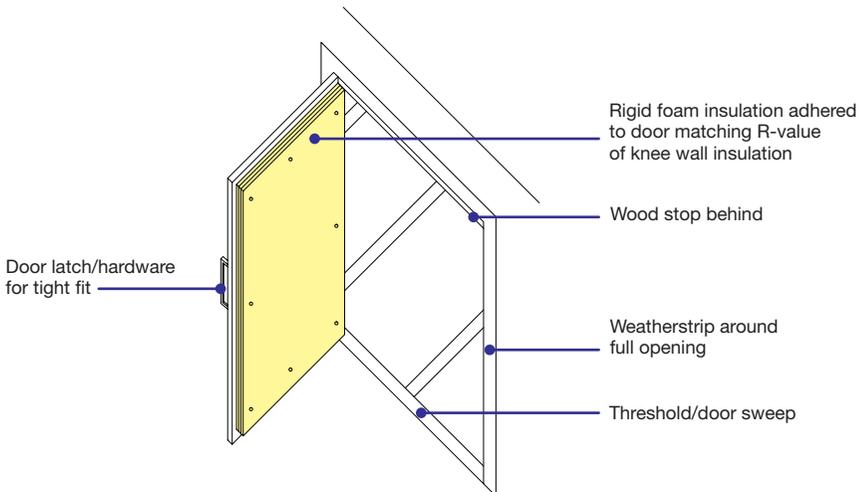
# Unvented Attics

## Knee Walls

■ Low knee walls provide vertical surfaces in attic that increase space usability and may facilitate the continuity of the building thermal envelope.



## Knee Wall Access Door



## General

**Sunrooms are specifically defined by code as one-story structures attached to the home with glazing (windows, skylights, and/or doors) covering more than 40% of the area of the exterior walls and roof.**

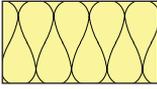
- Sunrooms that are heated or cooled, do not exceed 500 sf, and are thermally isolated from the rest of the home are permitted to have reduced R-values at walls and ceiling.
- Walls, doors, and any windows separating the sunroom from the home are treated as exterior and must meet the building thermal requirements of the code.
- Mechanical systems for heating or cooling should be separately zoned.



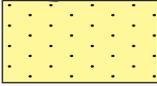
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# Illustration Key



Batt insulation



Foam insulation



Loose fill insulation



Rigid foam insulation



Sheathing (plywood, OSB)



Control layer (air, vapor, moisture)



Sealant (continuous)



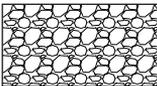
Gypsum board  
(wall or ceiling)



Wood blocking



Concrete



Gravel



Siding

# Conditioned Spaces

## Heating and Cooling

**The most energy efficient heating system will only save money when properly installed and maintained. Installations should conform to the latest version of ACCA 5 HVAC Quality Installation Specification.**

- Properly sized and installed systems provide steady, even and energy efficient heating/cooling. Right-sizing permits a building's system to be based on the rate at which the building is predicted to lose heat.
- Oversized units quickly meet thermostat set points and then shut down. This short cycling, which uses more energy, wears out components and creates excess noise.
- Heating and cooling equipment typically is designed in accordance with the latest versions of ACCA Manual J (building loads) and Manual D (duct design), as required by code. ACCA Manual S (equipment sizing) and Manual T (air distribution) also help ensure properly designed systems.
- Proper installation, system commissioning, testing and customer education are the best assurances for energy efficiency and occupant safety. Testing ensures that all equipment, connections, flues, ducts and other associated items are tightly sealed for energy efficiency and occupant safety.
- Code may require ventilation and/or makeup air for combustion and to prevent backdrafting of gas appliances.

### Common fuel types:

#### Natural gas:

- Clean and economical.
- Direct utility connection.
- Not available in all areas.

#### Oil:

- Although costs fluctuate, less expensive than LP but more expensive than natural gas.
- Does not burn as cleanly as gas, thus requiring yearly maintenance.

#### Liquid Propane (LP):

- Clean burning.
- Requires delivery and storage.
- Costly.

#### Wood:

- Not available for use in all areas.
- Quality and maintained stoves, proper ventilation, and sustainably harvested wood are essential. Flue must be properly sized and outside combustion air may be required.

### NOTE

- Mechanical ventilation is critical in tight buildings for life safety, building protection, and proper operation of equipment.

# Boilers

- Typically used to produce hot water (or steam) which is distributed via piping and radiators to create heat (hydronic system). Can also be used with a ducted system via the installation of a hydronic heating coil, and to produce domestic hot water.
- Fuel sources: typically gas or oil; some wood boilers used, typically in rural areas.
- ENERGY STAR® boilers with AFUE ratings 85% or greater use about 6% less energy than standard boilers. These have new combustion technology which extracts more heat from the same amount of fuel.
- Condensing boilers: convert latent heat from water vapor into condensing gases instead of losing it to atmosphere. Flue gases are used to preheat water returning to the boiler. Generally work best with low temperature heat sources.
- Non-condensing boilers are less expensive and require venting into a chimney.
- High efficiency sealed-combustion boilers use outside air to fuel the burner without relying on a chimney draft to vent. In particular, in buildings with tighter thermal envelopes, these boilers reduce unwanted interior drafts and are safer since not subject to backdrafting. No chimney is required.

# Furnaces

- Fuel Source: typically gas or oil; some wood furnaces used, typically in rural areas.
- ENERGY STAR® furnaces with AFUE ratings 85% or greater use about 15% less energy than standard furnaces.
- Condensing gas furnaces can vent directly to the outside with PVC pipe, versus a lined masonry chimney.
- A two stage furnace operates most of the time on a lower burner setting. Variable speed blower motors are more expensive but operate more efficiently and have an auxiliary terminal for air cleaner, dehumidification and multistage air conditioning without the need for separate controls.
- Hot air systems typically use some ductwork for heating and cooling. Ductwork must be sealed throughout the house and insulated if it is located in unconditioned spaces.
- High efficiency sealed-combustion furnaces use outside air to fuel the burner without relying on a chimney draft to vent. In particular, in buildings with tighter thermal envelopes, these boilers reduce unwanted interior drafts and are safer since not subject to backdrafting. No chimney is required.



# Heat Pumps

**Heat pump systems are used for heating, cooling, and/or producing heated water. Some systems can accomplish all, and/or be used in combination with other heating/cooling equipment (e.g., used with conventional storage water heater).**

- Although heat pumps have higher initial costs, operating costs can be reduced 15% - 25%. Geothermal heat pumps are typically more efficient than air source heat pumps, although more costly to install.
- Because of limited output in extremely cold weather, heat pumps typically have a back-up heating system (electric strip heating or furnace).

### Two primary types of heat pumps:

#### Air Source Heat Pumps:

- Mini-splits. System that incorporates ductless fan coils, most often wall mounted, to condition individual rooms. Multiple indoor fan coils can be used with one outdoor unit. Typically use inverter-driven technology which allows for variable capacity and very high efficiency equipment.
- Ducted mini-splits. Compact systems that use short, low-friction duct runs to deliver air to 1-3 rooms. Multiple indoor fan coils can be used with a single outdoor unit. Typically use inverter-driven technology.
- Central Ducted. System that delivers air to an entire home using a single air handler and a conventional duct system with supply and return ducts. Inverter-driven technology is available only from a limited number of manufacturers.

#### Geothermal Heat Pumps:

- Closed loop. Circulates an antifreeze and/or water solution through a closed loop (typically plastic tubing) buried in the ground vertically or horizontally or submerged in water (pond or lake).
- Open loop. Uses well or surface body water as the heat exchange fluid that circulates directly through the heat pump and returns the fluid back to the source.
- Direct exchange. Refrigerant in ground loops (copper pipes) used to transfer the heat.

# Cooling

**Cooling technologies include ventilation, air conditioning, evaporative and absorption cooling, and radiant cooling. Equipment varies greatly in quality and energy efficiency, and maintenance is essential to maximize performance and efficiency. Proper siting, deciduous vegetation and natural ventilation are also planning techniques that can minimize cooling loads.**

- Central air conditioners circulate cool air from the air conditioner through supply ducts located throughout the building. As cooled air is warmed, it is circulated back to the air conditioner through return ducts and registers. Equipment includes outdoor compressors or condensers connected to an indoor air-handling unit.
- Ductless, mini-split systems, like central air conditioners, have outdoor compressors or condensers and an indoor air-handling unit. These are often used in buildings with non-ducted heating systems (i.e., hydronic heating). Systems are available with a single outdoor unit and multiple indoor heads for zoning applications.
- Other technologies (evaporative cooling in dry climates; absorption).

# Programmable Thermostats

**Proper use of a programmable thermostat, as required by code, can save up to 25% of heating costs.**

Three primary types, each with four temperature settings per day:

**7 day model:**

- For schedules that change daily.

**5 + 2 day model:**

- Same weekday schedule and another for weekends.

**5 + 1 + 1 day model:**

- Same weekday schedule, separate schedules for Saturday and Sunday.

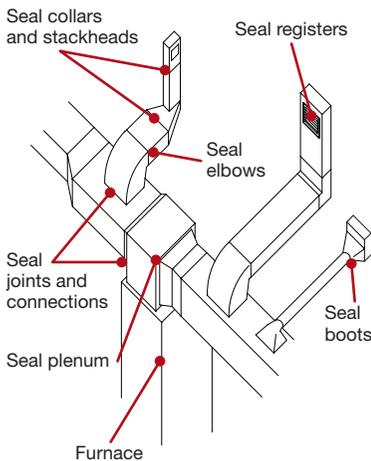


# Duct Sealing

**Properly sealed duct systems can save energy, improve occupant comfort and increase the life of heating and cooling systems.**

- Seal all joints, connections, collars, sleeves, boots, elbows, supply/return registers, and other components of the system.
- Seal all penetrations in building thermal envelope where ductwork transitions from conditioned space to unconditioned space (e.g., ductwork that runs through an unconditioned attic into a bedroom).
- Use UL181A or 181B rated tape or duct mastic; do not use duct tape. Joints should be held with sheet metal screws. Mastic may require fiberglass mesh prior to application of mastic. Follow all manufacturer recommendations specific to material used for ducts and mastic.
- Standard tests are available and required by code to evaluate duct sealing completeness.

## Duct Sealing Locations



# Duct Insulation

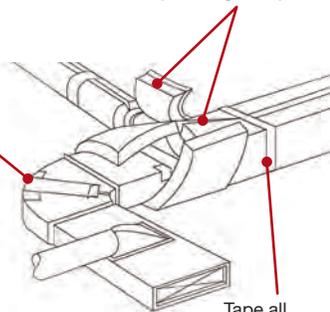
**Where possible, install duct system within the building thermal envelope. Insulate all ducts outside the building thermal envelope per code.**

- Properly seal duct system before insulating.
- Cover all exposed portions of ducts with properly selected and installed insulation.
- Tape seams and eliminate all voids.
- Fasten with mechanical means, such as plastic straps or UL-rated metal tape, per manufacturer instructions.

## Warm Air Duct

Seal duct seams and openings with UL approved tape or mastic

Square cut insulation; butt joint edges at joints



Tape all insulation seams with manufacturer approved material

# Natural Ventilation

**Well designed, natural ventilation can be the least expensive and most energy efficient way to provide cooling. Natural ventilation can improve indoor air quality and maintain a healthy and comfortable indoor climate.**

- Fresh air moves through a building via pressure differences caused by prevailing winds or the buoyancy effect created by temperature or humidity differences. Design for natural ventilation must give equal consideration to supply and exhaust.
- A successful ventilation design considers numerous factors for windows and doors including type of operability (e.g., double hung versus casement window) and size and placement of window and door openings at exterior walls.
- To complete the airflow circuit, interior features that are part of the design include transom windows, louvers and grills, open floor plans, vertical air movement, ceiling or window fans, and roof or upper level exhaust.
- Because a house's natural ventilation rate is unpredictable, ventilation may not be uniform 100% of the time.



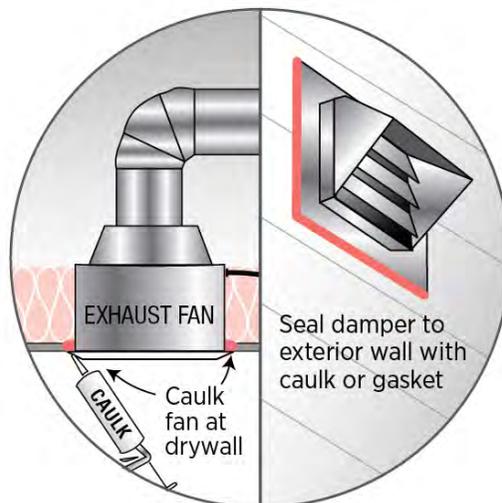
*Courtesy of IBTS*

# Mechanical Ventilation

## General

**Mechanical ventilation systems use ducts and fans rather than windows, doors or vents alone to serve individual spaces or whole houses. Individual spaces such as bathrooms, kitchens, and laundry rooms typically use a ceiling or wall mounted exhaust fan.**

- Provide consistent levels of comfort and air quality through controlled air movement and removal of allergens, pollutants and moisture that can cause mold. Systems can be supplemented with filtration and dehumidification.
- Systems consist of single or multiple fans, ducts and equipment located at appropriate intake and exhaust locations. Quiet, high efficiency fans designed for extended or continuous operation at source point can preclude the use of more complicated systems.
- Fans must be properly sized for individual spaces. ASHRAE recommendations:
  - **Bathrooms**  
50 cfm for intermittent fans; 20 cfm for continuous ventilation.
  - **Kitchens (based on room volume)**  
Exhaust independent of range: Continuous rate of 5 ACH min. or intermittent rate of 100 CFM min.  
Exhaust integrated with range: 5 ACH min.



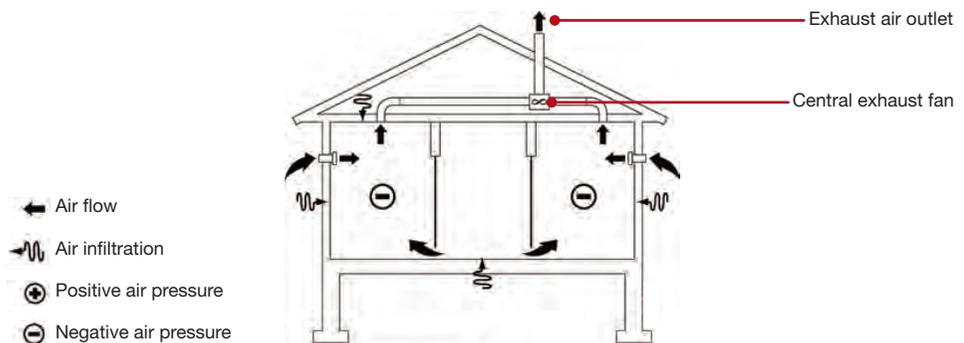
# Mechanical Ventilation

## Whole-House Ventilation: Exhaust

**Exhaust ventilation systems work by depressurizing the building. By reducing the inside air pressure, air can move through the building via intentional paths such as windows and vents.**

- Typically composed of a single fan connected to a centrally located, single exhaust point in the house.
- Advanced design connects the fan to ducts from several rooms, including kitchens, bathrooms and laundry rooms where pollutants are generated.
- Adjustable, passive vents through interior or exterior window or wall openings can be installed to introduce fresh air, although may be ineffective when interior/exterior pressure difference is inadequate.
- Relatively simple and inexpensive to install as part of initial construction. Whole house fans work best in colder climates. In climates with warm, humid summers, depressurizing can draw moist air into building wall cavities where condensation and moisture damage may occur and cause gas appliance backdrafting.

**Exhaust Ventilation**

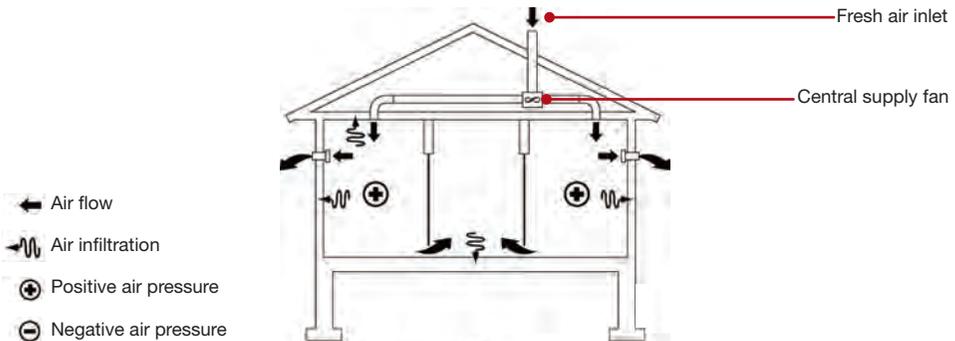


# Mechanical Ventilation

## Whole-House Ventilation: Supply

- **Supply ventilation systems work by positively pressurizing the building.**
- Fan and duct system introduce fresh air into one or more rooms most often occupied (bedrooms, living room, etc.). May include an adjustable interior or exterior window or wall opening in other rooms.
- Fan draws outside air into the building; air escapes through holes in the envelope, bath and range fans and ducts, and other intentional vents.
- Relatively simple and inexpensive to install as part of initial construction.
- System can be enhanced to filter air to remove pollen and dust or to provide humidity control.
- Ideal in hot or mixed climates: may cause moisture problems in cold climates. If excessive moisture exists in air entering the house, cooling costs may be increased. Outdoor air may require mixing with indoor air to avoid drafts at cooler temperatures and/or removal of moisture.

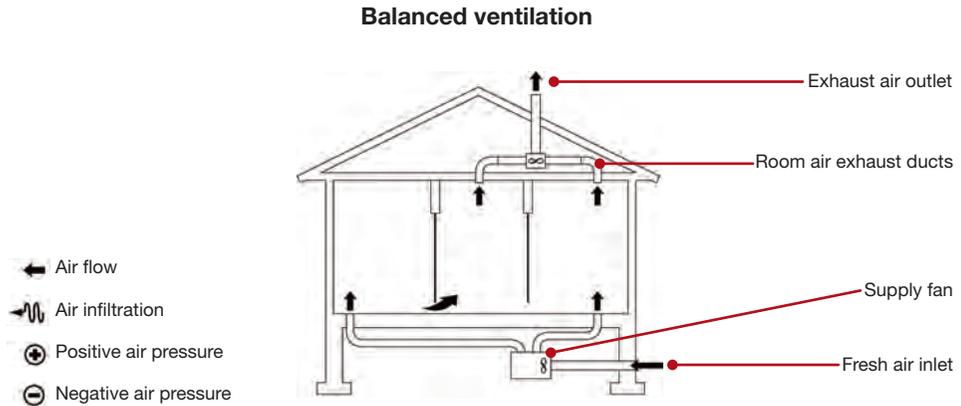
Supply Ventilation



# Mechanical Ventilation

## Whole-House Ventilation: Balanced Systems

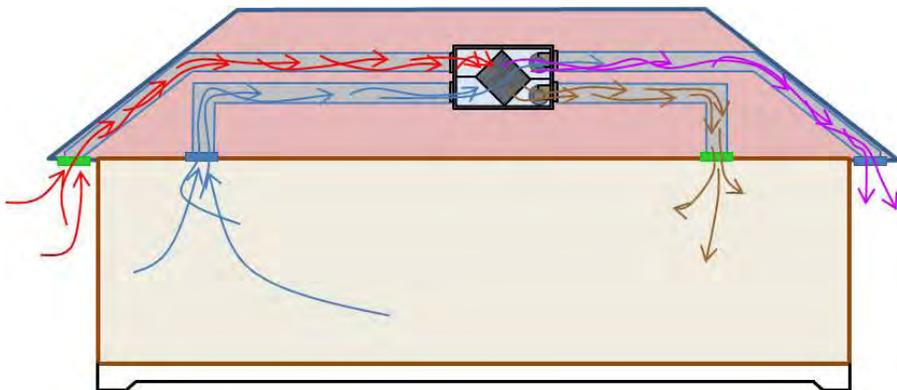
- Balanced ventilation systems introduce and exhaust approximately equal quantities of fresh outside air and inside air.**
- Balanced ventilation systems are appropriate for all climates, although are usually more expensive to install and operate than supply or exhaust systems.
- Balanced ventilation systems typically have two fans, two duct systems and appropriately located exhaust vents. Distribution of fresh air is facilitated by placing supply and exhaust vents in spaces most often occupied (bedrooms, living rooms, etc.). Air is exhausted from rooms where most moisture and pollutants are generated (kitchen, bathrooms and laundry). Filters can mitigate dust and pollen from outside air before introduction into the house.
- Unlike energy recovery ventilation systems, moisture and heat are not removed from air before entering the house. This may contribute to higher heating and cooling costs. Outdoor air may require mixing with indoor air before delivery to avoid drafts at cooler temperatures.



# Mechanical Ventilation

## Heat Recovery Ventilation (HRV) and Energy Recovery Ventilation (ERV)

- To reduce heating and cooling loads caused by outside ventilation air and provide energy efficiency, HRVs and ERVs exchange heat (sensible) and moisture (latent) between the two airstreams.
  - HRVs exchange only heat (sensible).
  - ERVs exchange both heat (sensible) and moisture (latent).
- To achieve balanced air flows, HRV or ERV ventilation systems have two fans: one brings outside air into the building, and the other exhausts stale interior air. These systems also filter incoming air, provide spot ventilation for bathrooms (eliminating separate fans) and deliver ventilated air throughout the house.
- HRV/ERV can be installed using an existing HVAC duct system and/or as a complete stand alone, fully ducted system.
- Proper design, system installation, commissioning, testing and customer education is required.



Courtesy of DOE

# Hot Water Heaters

## Storage

**Traditional water heaters maintain heated water in insulated tanks at a constant temperature. High efficiency units and insulation jackets are recommended to counteract any inherent inefficiency and heat loss.**

- Traditional fuel sources for storage water heaters include natural gas, oil, propane and electric. Heat pump storage water heaters that use electricity to transfer heat (instead of generating heat directly) can be two to three times more energy efficient than a conventional electric resistance water heater.
- High efficiency sealed-combustion hot water heaters use outside air to fuel the unit. In particular, in buildings with tighter thermal envelopes, these boilers reduce unwanted interior drafts and are safer since not subject to backdrafting.
- Water heaters should be selected based on the Energy Factor (EF), an annual measure of the useful energy coming out of the water heater divided by the amount of energy used to heat the water. The higher the energy factor, the better. However, due to varying rates for fuel sources, higher energy factor values don't guarantee lower annual operating costs.
- Storage water heaters should be sized based on peak-hour demand (the busiest one-hour) as determined by use of the GAMA Water Heater Sizing Tool. The unit's first hour rating should match within 1-5 gallons of peak-hour demand.
- Additional uses of storage hot water heaters can include providing hot water for heating or radiant floors in small spaces, or where supplemental or back-up heat is required.
- Because large bathtubs/spas have a significant impact on storage capacity, instantaneous water heaters should be considered for these applications.

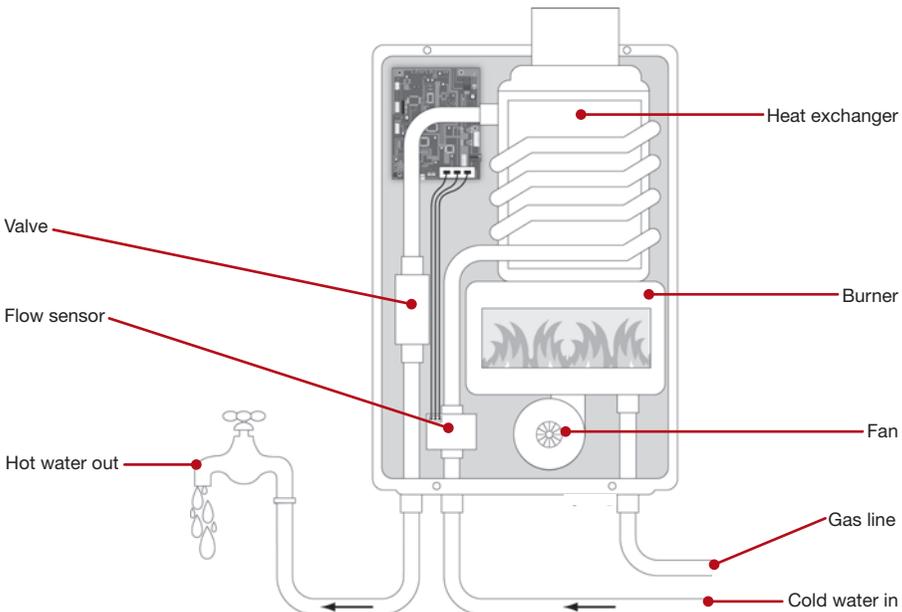
# Hot Water Heaters

## Tankless (Instantaneous)

**Tankless or Instantaneous water heaters deliver a constant supply of hot water on demand without standby energy loss. These are smaller in size and more efficient than conventional storage water heater when hot water demand is less than 40 gallons per day. Separate units are installed for different areas of demand.**

- Traditional fuel sources include natural gas, propane or electricity. Gas models produce a higher flow rate than electricity, but may require a constantly burning pilot light.
- Initial cost is greater than conventional storage models.
- Should be sized based on match of estimated peak-hour flow rate GPM and design temperature rise (difference between coldest inlet water temperature and outlet water temperature) with manufacturer rated flow rate.

**Tankless (Instantaneous) Water Heater**

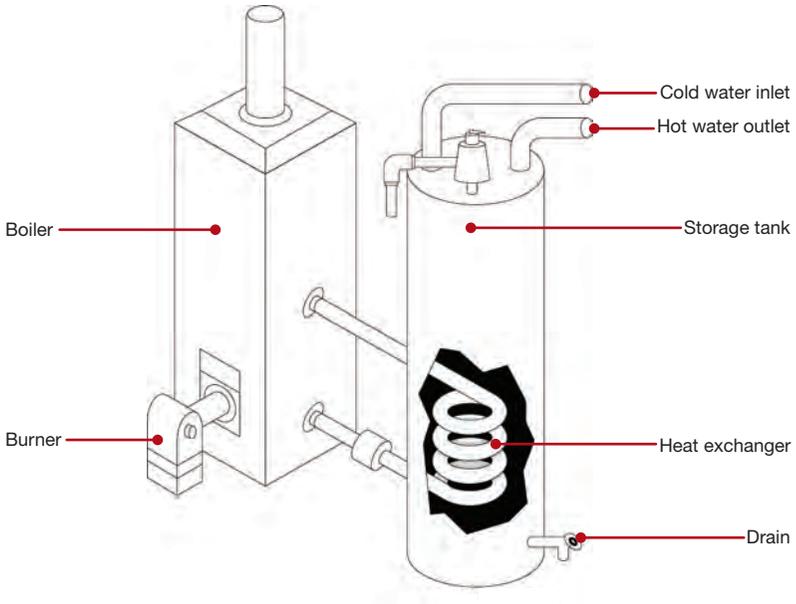


# Hot Water Heaters

## Tankless Coil (Indirect)

- Uses main furnace or boiler to heat a liquid circulated through a heat exchanger in a storage tank.
- When well insulated and used with a high efficiency boiler or furnace, can be the least expensive means to provide hot water.
- Works most efficiently when heating system is in use. Summer usage may not be cost effective.

Indirect Water Heater



# Hot Water Heaters

## Insulation

- Hot water temperature should be maintained at 115°–120° F.
- Storage tanks with an integral R-value < 20 should have an insulation blanket (jacket) to reduce standby heat loss.
- Insulation blanket must be taped in place without compressing or blocking the flue draft collar.



## Pipe Insulation

- Reduces heat loss and can maintain a 4° F higher water temperature than uninsulated pipes.
- Typically closed cell foam purchased in pre-cut lengths; seams must be taped.
- Prefabricated fitting insulation is best, but may be most expensive.
- At gas heaters, insulation must be kept away from combustion heat per manufacturer recommendations, approximately 6".



# Plumbing Fixtures

**Products with the WaterSense® or other energy efficient labels often perform better and are up to 20% more water efficient.**

- WaterSense® is a federal program that encourages the use of water and energy efficient products, including bathroom sink faucets and accessories, showerheads and other accessories or equipment.
- The average household could save more than 2,300 gallons per year by installing WaterSense® labeled showerheads alone, as well as reduce operational demands on water heaters.



# Appliances

**ENERGY STAR® qualified appliances incorporate advanced technologies and use 10–50% less energy than standard appliances. Every appliance is labeled to indicate purchase and operational costs.**

ENERGY STAR® is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy.



■ **Refrigerators and freezers:**

ENERGY STAR® qualified refrigerators use up to 40% less energy than conventional models.

■ **Dishwashers:**

ENERGY STAR® qualified dishwashers use at least 40% less energy than the federal minimum standard for energy consumption.

■ **Clothes washers:**

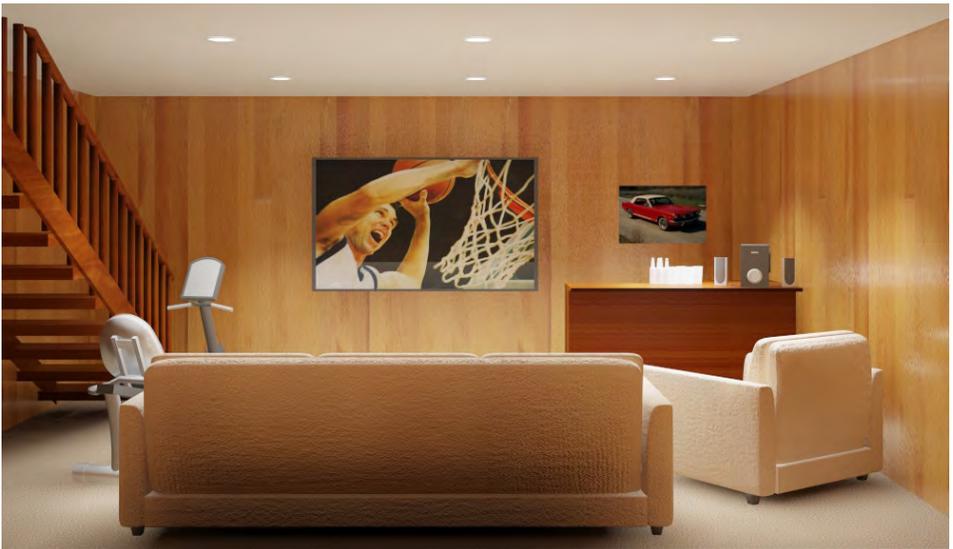
ENERGY STAR® qualified clothes washers use up to 50% less energy and 55% less water than standard washers.



# Interior Lighting

**Energy (kWh) = power (kilowatts) x time (hours).**  
**Given the great opportunity to save energy through the selection and location of lighting equipment, codes specifically establish which fixtures and lamps are minimally acceptable. There are several ways to reduce energy used for lighting purposes:**

- Use energy-efficient fixtures and lamps.
- Select and lay out lighting fixtures to maximize task (vs. general) lighting.
- Locate windows to maximize daylight.
- Use occupancy sensors to control fixtures automatically.



Courtesy of the Lighting Research Center

# Interior Lighting Controls

**People are good at turning lights on when they enter a room but less reliable in turning lights off when they leave.**

- **Occupancy Sensors:**  
Ceiling or wall mounted units turn lights on or off based on detected movement in a room.
- **Manual on/auto-off (Vacancy) Sensors:**  
Occupants must turn lights on manually on entering a space; lights turn off automatically when no motion is detected.
- **Dimming Switches:**  
Provide energy savings by giving occupants control over light output in a room versus a standard switch. Dimmers may not be compatible with all fixtures, with particular concern given to CFLs.



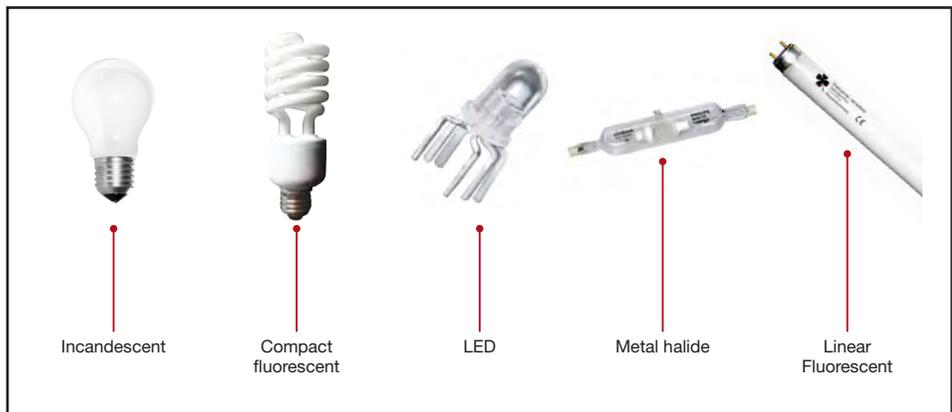
# Interior Lamps

## Bulbs

Homes will soon be required to have at least 75% of the lamps in permanently installed lighting fixtures be high-efficacy lamps, although this does not require the use of low-voltage lighting.

### Cost savings:

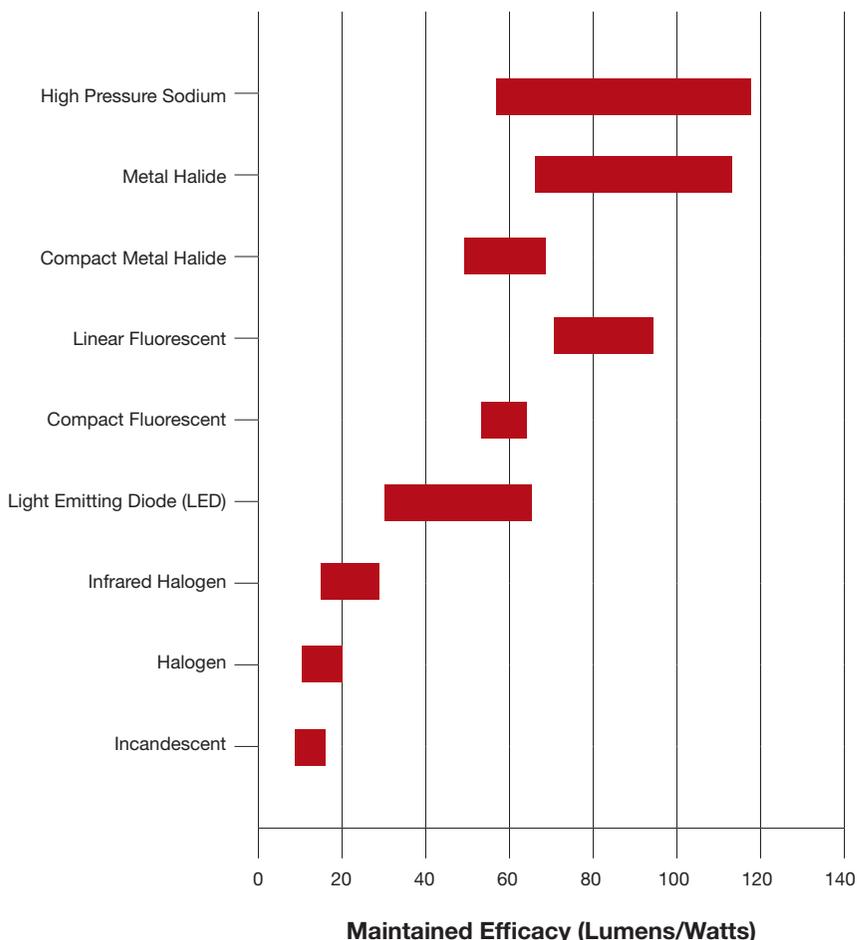
- An ENERGY STAR® qualified compact fluorescent light bulb (CFL) uses about 75% less energy than a comparable standard incandescent bulb. Replacing a 60-watt incandescent with a 13-watt CFL can save more than \$30 in energy costs over the life of the bulb.
- Compared to standard incandescent bulbs, ENERGY STAR® qualified CFLs generate about 75% less heat. They are cool to the touch and can help reduce home cooling costs.
- When comparing bulb types, the higher efficacy bulb may not always be the best choice or even the most efficient. Factors including color and temperature should be considered.
- Rapid advances in code requirements and manufactured products ensure an increased use of energy efficient bulbs in residential construction.



# Interior Lamps

## Comparing Bulbs

**Efficacy, or lumens per watt, is an indication of a bulb's efficiency. High efficacy bulbs may have unacceptable color rendering, a measure of how colors are represented.**



# Exterior Lighting

**Lighting gardens, driveways, walkways and entry doors is important for safety and aesthetics. However, too much lighting or lighting in the wrong locations wastes energy and causes “light pollution.”**

Exterior lamps should be either:

- Low voltage.
- High efficiency fixtures or lamps.
- Photovoltaic.

Exterior lighting should be controlled using either:

- Timeswitch control.
- Photosensor.



*Courtesy of the Lighting Research Center*

# Snow and Ice Melt Systems

**Snow and ice melt systems are used to remove snow and ice from walkways, driveways and roof eaves via embedded electric cables or hydronic piping.**

Snow melt systems should be equipped with controls that are either:

- Automatic shutoff when the pavement temperature is above 50° F degrees and no precipitation is falling.
- Automatic or manual shutoff when the outdoor temperature is above 40° F.

Shutoffs should be readily accessible and turned off when not needed.



*Courtesy of IBTS*

# Pool Heaters

**Many swimming pools located in New York State are heated. Without proper oversight, these are a substantial and unnecessary source of energy use.**

Requirements for pool heaters include:

- An accessible manual on-off switch to permit shutting off of heater without adjusting the thermostat setting.
- Time switches that automatically turn on and off heaters and pumps according to a preset schedule, except for solar- pool heating systems.
- Heaters fired by natural gas or LPG are not permitted to have continuously burning pilot lights.

Pools must also be equipped with a vapor-retardant cover: those heated to more than 90° F require a cover with a minimum insulation value of R-12.





# Glossary and Index



# Glossary

**Advanced framing:** Strategy for reducing thermal bridging by minimizing wall framing needed for structural support, thus permitting additional insulation. Common techniques include 2x6 inch framing at 24 inch on-center spacing, single top plates where trusses align with wall framing below, insulated headers, 2 or 3-stud corners, lattice (ladder) strips at exterior/interior wall intersections, and the elimination of redundant fire blocking and excessive window and door framing.

**Air barrier:** Any material that restricts air flow. In wall assemblies, the exterior air barrier is often a combination of sheathing and either building paper, housewrap, or rigid foam insulation. The interior air barrier may be fully sealed gypsum board.

**Air changes per hour (ACH):** Number of times per hour that the air equal to the volume of a space is changed. ACH depends upon the efficiency of the ventilation method and the building tightness.

**Air conditioning:** Process of modifying air to meet the requirements of a conditioned space by controlling its temperature, humidity, purity, and distribution.

**Air-impermeable insulation:** See Insulation, air-impermeable.

**Alignment:** Condition where the air barrier and thermal barrier (insulation) are contiguous (touching) and continuous across the entire building envelope.

**Ambient air:** Air external to a building or device.

**Annual fuel utilization efficiency (AFUE):** Measure of the amount of fuel converted to space heat in proportion to the amount of fuel entering the furnace, expressed as a percentage. A furnace with an AFUE of 90 is considered to be 90% efficient.

**ASHRAE:** Membership organization previously known as the American Society of Heating, Refrigeration, and Air-Conditioning Engineers. ASHRAE's Standard 90.1 is a commonly used code path applicable to residential buildings greater than three stories in height.

**Assembly:** For the purposes of this document, assembly refers to the composite of materials used in the building thermal envelope. For example, an exterior wall assembly may include gypsum board, vapor retarder, wood framing, sealed rigid board insulation, exterior sheathing, and exterior cladding.

**Attic, vented:** In an insulated building, an unconditioned attic space insulated at the floor level with natural ventilation typically provided through soffit and ridge vents.

**Attic, unvented:** In an insulated building, a conditioned attic space insulated at the roof level (within or above roof cavity), with no ventilation provided to this space.

**Batt insulation:** See Insulation, batt.

**Blower door test:** See Envelope Air Leakage.

**Boiler:** Self-contained appliance where heat produced from the combustion of fuels (natural gas, fuel oil, wood or coal) is used to generate hot water, which is circulated for space heating and/or heating of domestic hot water.

**Boiler rating:** Heating capacity of a steam boiler expressed in Btu per hour (Btu/hr), horsepower or pounds of steam per hour.

**British thermal unit (Btu):** Amount of heat (energy) required to raise the temperature of one pound of water one degree Fahrenheit. This is a standardized unit of measurement to describe capacity of heating appliances.

**Building Code of New York State (BCNYS):** One in a family of codes in New York State that establishes minimum requirements for construction for buildings, including residential structures greater than three stories in height. Published by the NYS Department of State, the BCNYS is based on the International Building Code.

**Building envelope:** Components (walls, roof, floor, and foundation) of a building separating the inside living space from outside elements. Unconditioned spaces, such as an attached garage, are part of the building envelope.

**Building thermal envelope:** The basement walls, exterior walls, slab, roof, ceilings, and/or other building components that enclose conditioned space and serve as the boundary between conditioned and unconditioned space.

**Building system:** Combination of equipment, components, controls, accessories, and interconnecting means that transforms energy to perform a specific function, such as heating, ventilation, air conditioning, hot water heating, or lighting.

**Cantilever:** Overhang where one floor extends beyond a wall below, exposing the underside of the floor to exterior conditions.

**Cathedral ceiling:** Finished ceiling that follows the roof line.

**Cavity:** Space between inner and outer, or upper and lower, surfaces of wall, ceiling, floor, or roof sheathing that can be filled with insulation to reduce heat loss.

**Cellulose insulation:** See Insulation, cellulose.

**Central air conditioning system:** System that provides cooling to all areas of a building from a single appliance through a network of ducts. May be integrated with a ducted central heating system.

**Central heating system:** System that provides heat to all areas of a building from a single appliance through a network of ducts or pipes. Ducted systems may be integrated to central air conditioning systems.

**Chimney:** Masonry or metal stack that creates a draft to bring oxygen to a fire and removes the gaseous byproducts of combustion safely out of the building.

**Chimney Effect:** See Stack effect.

**Cladding:** See Siding.

**Climate zone:** Zone that describes exterior design conditions for a building. New York State has three climate zones (4, 5, and 6) which are defined in the NY State Energy Code. Requirements for building materials, systems, and equipment are based upon the climate zone in which the building is located.

**Codes:** Laws that regulate construction to protect public health, safety, and welfare and establish a minimum standard of construction. Prescriptive codes detail specific and mandatory requirements, while performance codes establish a mandatory performance level and permit greater design flexibility.

**Combustion air:** Air providing necessary oxygen to appliances for combustion. A specific quantity of air is required to ensure complete and clean combustion.

**Commissioning:** A process that ensures the as-built building, including mechanical and electrical systems, are installed, tested and functioning according to building design. A commissioning report that records the results of the commissioning process is typically provided for above-code energy construction projects.

**Compact fluorescent lamp (CFL):**



Lamp that operates when electric current is conducted through mercury gas, causing the phosphor-coated glass tube of the lamp to emit light. An alternative to the standard incandescent lamp (light bulb), CFLs can use one-fifth to one-third the electricity and last 8 to 15 times longer.

**Compressor:** Device in air conditioners, heat pumps and refrigerators that pressurizes refrigerant, enabling it to flow through the system.

**Condensate:** Liquid that separates from a gas due to a reduction in temperature, such as water that condenses from flue gases or air circulating through the cooling coils in an air conditioning unit.

**Condensation:** Water droplets formed on a surface when humid air encounters a cooler surface. Condensation is undesirable because it can encourage mold growth and create a desirable microclimate for insects.

**Condenser:** Device in air conditioners or heat pumps in which the refrigerant condenses from a gas to a liquid when it is depressurized or cooled.

**Conditioned space:** Interior space within the building thermal envelope that is insulated and heated or cooled (new construction).

**Conductivity:** Measure of a material's ability to conduct heat. Materials of low thermal conductivity are used for thermal insulation because heat transfer across materials of low thermal conductivity occurs at a lower (more desirable) rate than across materials of high thermal conductivity.

**Construction documents:** Drawings and specifications, typically prepared by an architect or engineer, that describe construction requirements for a building. Construction documents are a part of required submittals for obtaining a building permit from the municipal building department.

**Convective air flow:** Air flow that occurs in gaps between insulation and the air barrier due to temperature and pressure differential in and across the gap. Occurs at locations of thermal bypass, resulting in energy inefficient heat loss or gain.

**Crawl space:** An area under a building not high enough to walk under, which may be used for passage of building system components.

**Department of Energy (DOE):** Federal agency that provides technical information and a scientific and educational foundation for technology, policy, and leadership to achieve energy efficiency, diversity in energy sources, a productive and competitive economy, improved environmental quality, and a secure national defense.

**Dense packed insulation:** See Insulation, dense packed.

**Design professional:** A licensed and registered architect (RA) or professional engineer (PE).

**Dew point:** Temperature at which saturated air that can no longer hold moisture turns water vapor into liquid water, creating condensation on colder surface.

**Direct vent:** See Vent, direct.

**Double-pane or double-glazed window:** Window with two layers (panes or glazing) of glass separated by an air space that is typically hermetically sealed and filled with gaseous material to improve thermal resistance. The thermal resistance of a window is identified by its U-factor.

**Door assembly:** Includes the door, hinges, frame, and saddle. The thermal resistance of the door assembly is identified by its U-factor.

**Door sweep:** Metal or plastic strip typically with vinyl, felt-back, or foam applied to the bottom of a door to reduce air infiltration. Also referred to as weather-stripping.

**Ducts:** Conduits for distribution of heated or cooled air in buildings, usually round or rectangular in shape, constructed of sheet metal, fiberglass board or a flexible plastic-and-wire composite located within a wall, attic, floor or ceiling, or exposed. Ducts outside conditioned spaces require insulation.

**Duct pressurization leakage:** Diagnostic tool designed to measure the air tightness of ductwork and to help locate leaks. Duct leakage can increase heating and cooling costs up to 30% and adversely affect occupant comfort, health and safety.



**Duct return:** Duct(s) through which heated or cooled air passes on its way back from the conditioned space to the heating or cooling unit.

**Duct supply:** Duct(s) through which heated or cooled air passes on its way to the conditioned space from the heating or cooling unit.

**Duct system:** Continuous passageway to transmit heated or cooled air in a building. In addition to ducts, the duct system includes duct fittings, dampers, fans, and accessory air-handling equipment and appliances.

**ECCCNYS:** Energy Conservation Construction Code of New York State. See Energy Code.

**Economizer, air:** Duct and damper arrangement and automatic control system that allows a cooling system to use outside air to reduce or eliminate the need for mechanical cooling during mild or cold weather.

**Economizer, water:** Component of a cooling system that permits supply air to be cooled by indirect contact with water that has been cooled (by heat or mass transfer to the environment) without the use of mechanical cooling.

**EDPM (ethylene propylene diene monomer):** Synthetic rubber membrane used for low slope roof applications and, on a limited basis, for vapor barriers at crawl space locations.

**Energy (use):** Quantity of onsite electricity, gas or other fuel required by building equipment to meet building heating, cooling, lighting, hot water, and other loads including refrigeration, cooking, and plug loads.

**Energy audit:** Inventory and descriptive record of features, undertaken by an energy professional, impacting energy use in a building. This includes but is not limited to: building component descriptions (locations, areas, orientations, construction attributes, and energy transfer characteristics); energy using equipment and appliance descriptions (use, make, model, capacity, efficiency, and fuel type); and any additional energy features.

**Energy Code (Energy Conservation Construction Code of New York State, ECCCNYS):** One in a family of codes in New York State that establishes minimum energy conservation requirements for all buildings. Published by the NYS Department of State, the Energy Code is based on the International Energy Conservation Construction Code.

**EnergyGuide labels:** Labels placed on appliances that permit comparison of energy efficiency and energy consumption.

**Energy rater:** See HERS and HERS score.

**Energy recovery ventilation system (ERV):** Systems that employ air-to-air heat exchangers to recover energy from exhaust air for the purpose of preheating, precooling, humidifying or dehumidifying outdoor ventilation air prior to supplying the air to a space, either directly or as part of an HVAC system.

**ENERGY STAR® Home:** A home that is documented to meet a prescribed standard more energy efficient than homes constructed to minimum code. ENERGY STAR® is trademarked by the U.S. Environmental Protection Agency.

**Envelope Air Leakage:** Diagnostic tool designed to measure the air tightness of buildings and to help locate air leakage points. Air tightness is a code requirement for residential buildings in New York State.

**EPA Indoor airPLUS® specifications:** Construction specifications from the U.S. Environmental Protection Agency for moisture control systems; heating, ventilating, and air conditioning systems; combustion venting systems; radon resistant construction; and low-emitting building materials.

**EPA WaterSense®:** Program from the U.S. Environmental Protection Agency to promote water efficiency through water efficient products, programs, and practices.

**Exfiltration:** Uncontrolled outward flow of air from a building through unintentional gaps, voids or cracks in the building envelope caused by wind, inside and outside pressure, and temperature differences and/or imbalanced supply and exhaust airflow rates. Exfiltration is likely to occur at points of intersection of framing and sheathing members, at perimeters of windows and doors and at penetrations.

**Exhaust air:** Air discharged from a conditioned space to the outside of a building either by mechanical or natural ventilation.

**Fenestration:** Window and door openings in the building envelope.

**Fiberglass insulation:** See Insulation, fiberglass.

**Flash and batt:** See Insulation, flash and batt.

**Floating slab:** See Slab, floating.

**Flue:** Metal or masonry passageway from heating appliances used to contain combustion gases until they are emitted to the building exterior.

**Foam Insulation:** See Insulation, spray foam.

**Forced ventilation:** See Ventilation, mechanical.

**Freeze-Thaw Cycle:** In buildings, the cycle of water freezing and thawing. Water expansion on freezing can cause permanent damage to building materials, in particular masonry.

**FSK radiant barrier:** Foil-coated insulation providing fire protection, commonly used in high heat areas of a building such as behind fireplaces. FSK stands for the foil, scrim, and kraft components of the material.

**Geothermal heat pump:** See Heat pump, geothermal/ground source.

**Glazing:** Material, usually flexible, to cushion and seal glass against the window or door stop and frame.

**Heat gain:** Increase in temperature of a space due to conduction, convection or radiation, typically desirable for winter (heating) and undesirable for summer (cooling).

**Heat load:** Quantity of heat added to or removed from the building (or hot water tank) in order to maintain temperatures at a specified thermostat setting.

**Heat loss:** Decrease in temperature of a space due to conduction, convection or radiation.

**Heat pump:** Device used for heating, cooling (in reverse mode) and water heating that primarily uses energy from the external environment.

**Heat pump, air-to-air:** Type of electrically driven heat pump that transfers heat from outdoor to indoor air where it is used for heating and cooling (in reverse mode). Air-to-air heat pumps are the most common type used in residential applications. Available for individual rooms (most efficient) or as centralized, ducted units serving more than one space. Most are split systems with outdoor condensers and indoor air handlers and evaporators.

**Heat pump, air-to-water:** Type of electrically driven heat pump that transfers heat from outdoor air to the indoors where it is used for heating and cooling (in reverse mode). Available for individual rooms (most efficient) or as centralized, ducted units serving more than one space. Most are split systems with outdoor condensers and indoor air handlers and evaporators.

**Heat pump, geothermal/ground source:** Type of electrically driven heat pump that transfers heat collected from the ground (via circulated water in buried pipe) to the indoors where it is used for heating and cooling (in reverse mode). The ground acts as both a heat source and heat sink. Typically more efficient and expensive than air-to-air heat pumps. Also known as closed-loop or ground-coupled systems.

**Heat pump, geothermal/water source:** Type of electrically driven heat pump that transfers heat collected from groundwater wells (via circulated water in buried pipe) to the indoors where it is used for heating and cooling (in reverse mode). The groundwater acts as both a heat source and heat sink. Typically more efficient and expensive than air-to-air heat pumps. Also known as open-loop or groundwater systems.

**Heat recovery ventilator (HRV):** Energy efficiency device that captures the heat from a building's exhaust air to preheat air entering the mechanical ventilation system or the fresh air supply.

**Heat trap:** Arrangement of piping and fittings or a commercially available manufactured unit that prevents thermosiphoning of hot water during standby periods.

**HERS (Home Energy Rating System):**

Standardized system developed by the Residential Energy Services Network (RESNET) to rate the energy efficiency of a home. HERS rating may establish eligibility for programs (e.g., ENERGY STAR®) or, in some communities, code compliance.

**HERS score:** Value between 0 and 100 that indicates the relative energy efficiency of a given home compared with the user defined Reference Home. The lower the score, the more efficient the home.

**High efficiency lamps:** Compact fluorescent lamps and other emerging new technologies with greater efficacy than traditional incandescent lamps.

**Housewrap:** Pliable fabric used for wrapping the exterior of the building envelope to provide a water resistant barrier between the exterior cladding and sheathing material. When fully sealed, may also serve as an air barrier. Wraps vary by material, permeability and manufacturer installation requirements.

**HSPF (Heating Season Performance Factor):**

A measure in Btu/Wh of total seasonal electric power input in watt hours of the seasonal efficiency of an electric heat pump.

**HVAC (Heating, Ventilation, and Air-Conditioning):** Term used to describe building trades or elements associated with mechanical systems.

**Hydronic system:** Heating system that uses water instead of air as the heat transfer medium.

**IAQ:** See Indoor air quality

**IC:** See insulated contact lighting fixture.

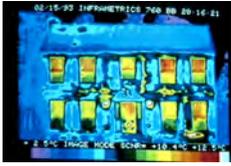
**Impervious material:** Ground covering, or surface or building material that absorbs little water. Can benefit or detract from a site's need for water run-off and collection. Impervious soil may create adverse conditions for sub-grade tree roots.

**Incandescent:** Lights using an electrically heated filament to produce light in a vacuum or inert gas-filled bulb. Largely phased out in favor of high efficiency lamps.

**Indoor air quality (IAQ):** Quality of air within a building that affects the health and comfort of occupants.

**Infiltration:** Uncontrolled inward flow of air into a building through unintentional gaps, voids or cracks in the building envelope caused by wind, temperature, and pressure differentials between inside and outside and/or imbalanced supply and exhaust airflow rates. Infiltration is likely to occur at points of intersection of framing and sheathing members, at perimeters of windows and doors, and at penetrations.

**Infrared thermal imaging (IFR):** Images taken by a heat-sensing camera that reveal missing or improperly installed insulation including thermal



bypass conditions at voids and openings that allow unintended thermal, air, and moisture movement. The thermal image graphically distinguishes between hot and cold surface temperatures.

**Insulated concrete forms (ICFs):** Factory made wall or foundation system comprised of interlocking empty blocks intended to be filled onsite with concrete and steel reinforcement. ICFs create an air-tight, well-insulated and sturdy system with insulation inherently aligned with the interior and exterior air barriers.

**Insulated contact lighting fixture (IC):** Rating for recessed light fixtures that can be installed in insulated cavities with direct contact with insulation.

**Insulation (thermal):** Materials which prevent or slow down the transfer of heat.

**Insulation, air-impermeable:** Insulation which provides thermal resistance and an air barrier when installed properly. Air-impermeable insulation (typically foam) is commonly used to insulate roofs in unvented attics.

**Insulation, batt:** Insulation available in batts (or rolls) sized for typical wall, floor and ceiling framing bays that can be manually fitted into place. Typical materials are fiberglass, cellulose, mineral (rock or slag) wool and plastic and natural fibers. Also known as blanket insulation.

**Insulation, blanket:** Pre-cut layer of insulation applied around a water heater storage tank or other appliance to reduce heat loss from the tank. Also used in reference to batt insulation.

**Insulation, blown-in:** Insulation made from fiberglass, cellulose, mineral wool, or other materials that is blown dry or wet into construction assemblies. Blown-in insulation fills the entire framed assembly without gaps, voids, compression, or misalignment. Term typically excludes spray foam insulation, which uses alternate equipment to blow in plastic foam materials.

**Insulation, cellulose:** Type of insulation composed of recycled newspaper, cardboard or other forms of paper. Available as batts, loose fill, or blown-in (damp or dry spray), including dense-pack. A separate vapor retarder is typically required on the interior unless the exterior sheathing or siding is impermeable.

**Insulation, dense packed:** The process of completely filling a building cavity with blown-in insulation material, such as cellulose or fiberglass, creating a densely insulated space free of voids. Common in the retrofit of existing buildings, this can also be used in new construction.

**Insulation, fiberglass:** Type of insulation, composed of small diameter glass fibers, formed into blankets or batts, or used in loose-fill and blown-in applications.

**Insulation, flash and batt:** Insulation method for exterior walls where cavities are filled with a combination of spray foam and batt insulation. Using higher R-value and air sealing foam creates a better building, and using less expensive batt insulation at the interior face of the cavity saves money.

**Insulation, foam:** High R-value insulation product made from a variety of plastic materials (polyurethane, polystyrene, extruded polystyrene, expanded polystyrene, polyisocyanurate). Available in boards or spray onto roofs, floors, rim joists, and gaps such as at penetrations and window and door frames. A less common application is injection into closed wall or floor cavities. R-value, expansion rates, permeability, and setting times vary by material.

**Insulation, loose fill:** Insulation made from fiberglass, cellulose, or other materials composed of loose fibers or granules, which can be applied by pouring directly from the bag or with a blower unit.

**Insulation, rigid board:** Plastic foam insulation product, pressed or extruded; typically used as insulation for interior basement or crawl space walls, beneath basement or crawl space slabs, and at exterior below-grade or above-grade walls. Panel dimensions and thicknesses vary. R-values typically range from 3.2 to 7 per inch. At exterior walls, it can provide contiguous insulation that creates the building thermal envelope (foundation, exterior walls, and roof).

**Insulation, spray foam:** Foam insulation (open cell/low density or closed cell/high density) for spray application and/or injection into closed cavities. Installation includes mixing of polyurethane resin with a blowing agent using specialized equipment, causing foam to expand to fill cavity and encapsulate tiny gas cavities. Must be separated from the interior of a building by an approved thermal barrier or approved finish material unless rated for exposure. A less common application is injection into closed wall or floor cavities.

**Insulation, spray foam-open cell:** Open or low density foam (approximately .5 lb/ft<sup>3</sup>) that is sprayed or injected. R-value approximately 3.6 per inch. One advantage of open cell spray foam is that alternate blowing agents with less adverse environmental impact and greater durability are available. Considered an air barrier. when minimum thickness is 5 inches.

**Insulation, spray foam-closed cell:** Closed or high density foam (approximately 2.0 lb/ft<sup>3</sup>) that is sprayed or injected. R-value approximately 6.0/inch, although decreases over time as air replaces hydrocarbon gas used as the blowing agent. Considered an air barrier; has good adhesion and structural strength.

**Light pollution:** Excessive artificial light from a building site that exceeds occupant needs and produces glare.

**Low-E coating:** A thin, metallic oxide coating for high performance glass (“E” stands for emissivity or radiated heat flow) that increases the U-factor of a fenestration product by reducing heat flow. Low-E coatings allow short wavelength solar radiation to travel through glazing but reflect back longer wavelengths of heat.

**Low voltage lighting:** Lighting equipment powered through a transformer such as a cable conductor, a rail conductor, or track lighting.

**Lumen:** Measurement of how much light a lamp (bulb) creates. The more lumens produced per watt of power, the more efficacious (efficient) the light source.

**Manual D:** Standard method used to size and design a duct system that matches equipment blower capabilities. Published by the Air Conditioning Contractors of America (ACCA).

**Manual J:** Standard method used to calculate residential heating and cooling loads developed by the Air-Conditioning and Refrigeration Institute (ARI) and the Air Conditioning Contractors of America (ACCA).

**Manual S:** Standard reference developed by ACCA for selection of residential equipment based on load calculations. Includes sizing strategies and manufacturers performance data.

**Manual T:** Standard reference developed by ACCA for residential equipment for selection, sizing and location of supply air diffusers, grilles, and registers and return air grilles.

**Mechanical ventilation:** See Ventilation, mechanical.

**Misalignment:** Condition where air barrier and thermal barrier (insulation) are not contiguous (touching) and not continuous across the entire building envelope.

**Natural ventilation:** See Ventilation, natural.

**Net-zero energy building:** A building that produces as much energy as it uses over the course of a year

**Occupancy sensor:** Optical, ultrasonic or infrared sensor that turns lights or other equipment on or off when occupancy is detected.

**Off-gassing:** The evaporation of volatile organic compounds (VOCs) from non-metallic synthetic and natural materials. Off-gassing, in particular for new products, is a potential issue associated with IAQ.

**Penetration:** Point at which unintended air infiltration and exfiltration occurs between conditioned and unconditioned spaces. Common penetration points include, but are not limited to, holes created for exhaust stacks and vents, chimneys, electrical conduit, and plumbing lines.

**Performance test:** An on-site measurement of the energy performance of a building energy feature or appliance conducted in accordance with pre-defined testing and measurement procedures. Should occur prior to building occupancy.

**Perm:** A unit of measure of water vapor permeance. The greater the number, the greater the amount of water vapor that will pass through a given material.

**Pervious material:** Ground covering, or surface or building material, that allows the passage of water. It can benefit or detract from waterproofing and damp proofing of below-grade building components.

**Phantom load:** Electrical power consumed by appliances when turned off.

**Photovoltaic (PV):** Method of generating electrical power by converting solar radiation into direct current electricity using solar panels (solar cells containing a photovoltaic material).

**Power vent:** See Ventilation, power.

**Pressure boundary:** The point in a building at which inside air and outside air are separated. Unequal interior and exterior pressures contribute to air infiltration and exfiltration.

**Programmable thermostat:** Thermostat that allows the user to program a pre-set schedule of times to turn HVAC equipment on and off.

**PV:** See Photovoltaic.

**Radiant barrier:** Thin, reflective foil sheet that exhibits low radiant energy transmission and blocks radiant heat transfer, usually installed in attics.

**Radiant heat:** Heat emitted from a warm object, such as a floor or wall, which warms people and objects rather than heating the air (as in convection heating). Exterior applications include snow melt, gutter and roof de-icing, and patio heating.

**Radon:** A naturally occurring, colorless and odorless radioactive gas that comes from the natural decay of uranium found in nearly all soils. Radon typically moves up through the ground into homes through cracks and other holes in the foundation. A known carcinogen, radon must be captured or prevented from entering a house.

**Rain screen:** An intended space inboard of building siding or cladding that drains to the exterior and permits drying of the assembly. Position, material, and detailing vary by application.

**Re-circulated air:** Return air re-used as supply air.

**Registered design professional:** See design professional.

**Renewable energy source:** Source of energy (excluding minerals) derived from incoming solar radiation including natural day lighting and photosynthetic processes, wood, wind, waves and tides, lake or pond thermal differences and from the internal heat of the earth.

**Residential Code (Residential Code of New York State, RCNYS):** One of a family of codes in New York State that establishes minimum requirements for construction of most residential buildings not more than three stories in height. Published by the NYS Department of State, the RCNYS is based on the International Residential Code.

**Rigid board insulation:** See Insulation, rigid board.

**R-value:** A measure of how well a material, or series of materials, retards heat flow (thermal resistance). As R-value increases, the heat loss or gain through the material decreases. The effective R-value of a wall, ceiling, or floor assembly is reduced by gaps, voids, compression, moisture, settlement, and misalignment.

**Sealed combustion:** Combustion occurs in a sealed combustion chamber using air brought in from the outside. Combustion products are vented to the outside through a separate, dedicated sealed vent. Sealed combustion with high-efficiency furnaces and boilers are the safest alternative for increasingly airtight buildings.

**Seasonal Energy Efficiency Ratio (SEER):**

A measurement of the seasonal cooling efficiency of an electric air conditioner or heat pump.

**Semi-permeable:** Description of a material's permeability or ability to transfer water vapor (expressed as a numerical value between 1 and 10 perms). Semi-permeable materials allow water vapor to pass through at a slow rate.

**Sheathing (exterior):** Construction material used to cover the exterior of wall framing and roof structures, not intended for long term exterior exposure.

**Siding (cladding):** Material that covers the exterior of a building envelope that is in direct contact with outside elements. May be wood, manufactured wood product, cement board, or other manufactured material including vinyl or aluminum. Siding selection will impact choice and location of exterior or interior air barriers and vapor retarders.

**SIPs:** See Structural insulated panels.

**Skylight:** Fenestration located on a roof that provides natural daylight and/or heat and ventilation (when operable) to interior building spaces.

**Slab, floating:** An economical means of constructing a slab foundation. The slab "floats" on a gravel base above the soil, with thickened concrete at the edge to hold the slab in place. Rigid insulation can be placed between the thickened edge and the slab to provide slab-edge insulation.

**Slab, radiant:** Concrete floor slab with integral piping or electrical conduit to provide radiant heat.

**Soffit, exterior:** Enclosed, horizontal exterior area that connects lowest portion of roof with exterior building wall.

**Soffit, interior:** Interior area in a ceiling that is dropped, usually to hide plumbing or electrical services. Often found above kitchen cabinets or bathroom showers and bathtubs.

**Solar Heat Gain Coefficient (SHGC):** Measure of how well a window or skylight blocks the heat from sunlight. Expressed as a number between 0 and 1, the lower the SHGC, the less solar heat is transmitted and the greater the energy efficiency.

**Solar heater, active:** Solar water or space heating system in which solar energy is collected and/or moved from the solar collector to a storage tank subsystem using pumps or fans to circulate water or heat transfer fluid.

**Solar heater, passive:** Solar water or space heating system in which solar energy is collected and/or moved from the solar collector to a storage tank subsystem by natural convection without the use of pumps or fans.

**Solar power:** The conversion of sunlight into electricity using photovoltaic materials.

**Split system:** An air conditioning system that splits the hot side of the system (condensing unit, located outside) from the cold side (air handler, located inside). May use ducts within the building to circulate air.

**Spray foam insulation:** See Insulation, spray foam.

**Stack effect (chimney effect):** The upward movement of air through a building caused by the normal buoyancy of warm air. As warm air escapes through unintentional openings high in the building, cold air is pulled in through openings low in the building.

**Storm door:** Secondary door, often glass or plastic panels in wood, metal, or plastic frame, used to create an insulating air space between itself and the primary door. Creates a secondary seal at the exterior wall to reduce air infiltration and exfiltration.

**Storm window:** Secondary layer of glazing, constructed of glass or plastic panel in wood, metal or plastic frame, used to create an insulating air space between layers of glazing. Creates a secondary seal at the exterior wall to reduce air infiltration and exfiltration.

**Structural Insulated Panels (SIPs):** Factory-built insulated wall panels comprised of insulated foam board sandwiched between interior and exterior layers of sheathing, typically oriented strand board (OSB) or plywood. May be manufactured with precut window and door openings and conduits for electrical circuits and piping.

**Sunroom:** As defined by the Energy Code, a structure attached to a dwelling with a glazing area exceeding 40 percent of the gross exterior walls and roof.

**Tankless water heater:** Energy-efficient water heater that heats water on demand.

**Thermal barrier:** Fire protection barrier installed over foam plastic insulation.

**Thermal break (barrier):** Material (such as rubber) with low thermal conductivity placed in a construction component, such as a window, to reduce or prevent the flow of heat between conductive materials.

**Thermal bridging:** Rapid heat conduction caused by the contact of very conductive materials, such as metal studs and drywall, that are poor insulators. The result is unwanted heat loss or gain or conditions where condensation can occur.

**Thermal bypass:** Movement of heat around or through insulation that occurs when gaps exist between the air barrier and insulation or where air barriers are missing.

**Thermal conductivity:** Quantity of heat transferred through a material due to the difference in temperature on both sides of the material.

**Thermal isolation:** Space that is heated and/or cooled by a system separate from the other conditioned spaces of the building or controlled as a separate zone.

**U-factor:** The measure of how much heat a building element conducts or thermally transmits. The lower the U-factor, the more energy efficient the building element. Window and door performance labels include U-factors to help compare different fenestration products.

**Unconditioned space:** Interior space outside the building thermal envelope that is neither heated or cooled.

**Vapor barrier:** Material that prohibits or severely limits the entry of water vapor into and out of building assemblies. Because a vapor barrier traps moisture, use is limited to at-grade applications over dirt and below slabs. Interior vinyl coverings can act as vapor barriers and should be avoided, particularly in air conditioned structures.

**Vapor diffusion (transmittance):** The process by which moisture moves from areas of higher vapor pressure or temperature to areas of lower vapor pressure or temperature.

**Vapor retarder:** Material used to control the entry of water vapor into and out of building assemblies through the mechanism of vapor diffusion.

**Vent:** A device that is part of a heating or ventilation appliance or system that conducts fresh air into, or waste air or combustion gases out of, the appliance or interior space. Examples include flue vents and fresh air vents.

**Vent chute:** Elements placed between low sides of roof rafters in buildings, typically with vented attics, to permit air entering soffit vents to move freely above the insulation, through the attic, and exit at ridge vent or other roof-mounted vents. May also protect insulation at low side of roof rafters from displacement due to wind exposure.

**Vent damper:** In a heating system, device that causes a vent to close when the heating unit is not firing in order to trap heat rather than allow its updraft and escape through the vent system.

**Vent, direct:** Component of a combustion appliance installation that draws combustion supply air from the outside and vents combustion exhaust directly to the outside. May be combined with power vent exhausts.

**Vent pipe:** A duct, usually round, in which combustion gases from an appliance are vented to the outside.

**Vent, power:** Sealed exhaust ventilation system for combustion appliances that uses a fan to move combustion exhaust outside the building. Depending on the appliance, may be located at roof or walls.

**Ventilation:** The natural or mechanical process of supplying or removing conditioned or unconditioned air to a space.

**Ventilation, mechanical:** Process of supplying or removing air to or from an indoor space by powered equipment such as air handlers, motor-driven fans and blowers. Typically excludes devices such as wind-driven turbine ventilators and mechanically operated windows.

**Ventilation, natural:** Ventilation of a building without the use of fans or mechanical systems.

**Weatherization:** Process of improving a building to reduce its energy usage, may include sealing gaps and penetrations in a building to reduce air infiltration and exfiltration using sealants, caulks, foam, and weather-stripping.

**Weather-stripping:** Material used to seal gaps around perimeters and moving parts of windows, exterior doors, and skylights. May be metal, foam, felt, or vinyl.

**Whole house fan:** Mechanical device used to pull air through an interior space and exhaust it to a vented attic or directly to the outside.

**Wind baffle:** Elements placed between low sides of roof rafters in buildings, or at other required locations, to protect insulation from displacement due to wind exposure.

**Wind washing:** Process of wind-driven air moving through insulation. Wind washing occurs most commonly in attic spaces when air enters through soffit vents and directly encounters insulation. Insulation at the eaves of vented attics should be protected from wind washing using baffles to allow unobstructed airflow through the soffit vents without disturbing insulation. Wind washing reduces the effective R-value of insulation.

**Window assembly:** Includes the window glazing, sash and frame. Windows are U-factor rated for the whole assembly.

**Zero energy building:** See Net-zero energy building.

**Zone:** A space or group of spaces within a building with similar heating or cooling requirements that permit desired indoor air conditions to be maintained throughout using a single control device.

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