9

Heating, Ventilation and Air-Conditioning (HVAC)

Energy Code Requirements

The energy requirements of the building code that apply to HVAC installations (ECCCNYS Section 503) are in addition to any plumbing, mechanical, and fuel gas codes that apply to these systems. Although it is generally the HVAC installer's responsibility to follow these requirements, because they are in the building code it may be up to the builder to know what they are and to communicate them to the subs for a given project. Here's a summary of the HVAC requirements. Remember that these requirements generally apply to all residential buildings, but more complex mechanical systems typically found in multifamily residences may have to meet additional requirements—see ECCCNYS Section 503 for more detail.

- **Heat loss calculations and system sizing (ECCCNYS 503.3.1 and Chapter 3)**—Heating and cooling load calculations must be done according to a specified process.

> Air Conditioning Contractors of America (ACCA) *Manual J* (see Appendix B for ordering information) is required by the 2000 IRC One and Two Family Dwelling Code (see Section M1401.3). The design parameters used for these calculations are given in ECCCNYS Chapter 3.

- **HVAC system efficiencies**—The minimum efficiency requirements for HVAC systems are given in ECCCNYS 503.2. Note that code minimums for efficiency follow federal minimum efficiency standards. See following table and the next bullet for more information.

Equipment	Rating	Minimum
Boilers (oil and gas)	Annual Fuel Utilization Efficiency	80
Furnaces (oil and gas)	Annual Fuel Utilization Efficiency	78
Heat Pumps (air source)	Heating Seasonal Performance Factor	6.8
Central Air Conditioning	Seasonal Energy Efficiency Ratio	10

- **Heating system trade-offs**—Many boilers and furnaces are more efficient than the code minimums. You can take credit in any of the compliance methods for systems with higher than minimum efficiency. Get the equipment efficiency ratings from your HVAC installer (or subcontractors you have worked with) *before* you do the compliance analysis. As a designer or builder you can specify high levels of efficiency, which makes it easier to meet the code. However, be careful to know in advance what your requirements are, and how much the upgrade costs.
- **HVAC controls (ECCCNYS 503.3.2 and 503.3.3.5)**—Temperature controls must include the capacity to be set to 55 degrees or lower (for heating) and/or 85 degrees or higher (for cooling). Thermostats used to control heating and cooling simultaneously must have a temperature range (of at least 5 degrees) within which calls for heating and cooling are either suspended or reduced. Similarly, humidistats must have the capacity to prevent energy consumption (suspend operation) between 30 and 60% relative humidity. Heat pumps that include auxiliary electric resistance heaters must have controls that lock out the auxiliary heaters above a preset outdoor temperature.

  All mechanical ventilation systems must have controls to shut down when ventilation is not required. When the system is shut down, automatic or gravity-driven dampers at the points of intake and exhaust must be closed.
- **Duct and pipe insulation** is required for all HVAC ductwork and pipes in unconditioned spaces, as indicated in ECCCNYS 503.3.3. There are *exceptions* for return ducts in basements and ducts or pipes inside HVAC equipment. For most single family work, the insulation must meet the levels shown in the following table. Note that flex duct must have R-value labels on the outside jacket (ECCCNYS 102.5.3).

Table 9.1 Common Duct and Pipe Insulation Levels

Ducts in unconditioned space			Hydronic pipes in any unconditioned space		
Supply ducts	Return ducts in unconditioned attic or outside	Return ducts in all other unconditioned spaces	up to 2" pipe diameter	over 2" pipe diameter	runouts to individual terminals, up to 12' long
R-8	R-4	R-2	R-4 (1")	R-6 (1-1/2")	R-2 (1/2")

- **Duct sealing** is required on all low-pressure ductwork (ECCCNYS 503.3.3.4). All portions of stud bays or joist cavities used as ductwork must also be sealed. All connections and seams (except longitudinal joints that lock) must be sealed with either mastic or fibrous tape embedded in mastic (see Figure 9.1). Tapes meeting UL 181A may be used for rigid fiber ducts. Tapes meeting UL 181B may be used for flex ducts. **Duct tape is not allowed for duct sealing.**
- **Written materials** describing regular maintenance actions must be left with all HVAC and water heating equipment (ECCCNYS 102.3). A label with a reference to such material is also acceptable.

ENERGY STAR

Mechanical Ventilation

There is little emphasis on indoor ventilation in building codes. Most builders meet requirements for "natural" ventilation by accident, with ordinary window and door openings. **In New York however, every ENERGY STAR Labeled New Home must be equipped with a mechanical ventilation system.** Controlled mechanical ventilation provides the following benefits:

- **Healthier indoor air**—ASHRAE recommends that residential buildings be maintained at 30 to 60% relative humidity for optimum health. Why? Some biological contaminants thrive in low or high humidity, but most are minimized in this range. How do you control the humidity? In any climate and in any season, the first step is to control the air exchange rate. In the winter, dryness is caused by excess air leakage; when dry outdoor air is heated, the relative humidity drops. High humidity on the other hand, is often caused by underventilation, and poor source exhaust for moisture-producing activities such as cooking and bathing. Control the dryness by limiting air leakage, and control the moisture by ventilating the house. In the summer, the only way to control humidity is with mechanical dehumidification or properly sized air conditioning systems (see pages 113-114).

  Leaving ventilation to random air leaks doesn't work. How do you know the building is leaky enough? Even leaky buildings tend to be underventilated in the spring and fall, when there's little driving force for air movement. They are also overventilated in the winter when the driving forces are large, and when it costs more money to heat up the leaking air. Leaving ventilation to operable windows and doors doesn't work; people don't like to open windows and doors in the winter when it's cold. Build the house tight enough to limit the air leakage, then give the occupants control over background ventilation rates.
- **Reduced moisture**—As well as healthier indoor air, controlled ventilation helps to limit moisture problems in the building. Every bath-

room should have a fan that exhausts to outdoors. Be sure the fan actually works; use rigid or flexible metal ducts and keep runs as short as possible. Kitchen range hoods should be exhausted to outdoors, especially if there is a gas range. Don't use dryer hose. Keep duct runs as short as possible. Of course, ventilation may not be adequate if moisture is getting into the house because of improper foundation drainage, roofing, or siding details.

- **Improved comfort**—Sealing air leaks in the building limits overventilation and drafts. Ventilation contributes to improved comfort in several ways. Controlling background ventilation rates reduces cooking odors, damp musty smells, "stale air," and elevated levels of carbon dioxide. Ventilation also helps reduce concentrations of airborne contaminants from building materials and household activities. By controlling indoor humidity, air sealing and ventilation work together to improve comfort.
- **Fewer callbacks**—A newly built house has a lot of moisture in it. Foundations, frames, drywall, plaster and paint all bring water into a new home. Depending on the weather and other conditions, there may be a lot of water, or even more water. The most likely time to get a moisture-related callback is in the first winter of occupancy. When a new homeowner calls you to say "Our windows are sweating and there's mildew in the bathroom," what will you tell them? "Open a window?" How about, "Set your ventilation system to run more often (or at a higher speed)." Presto, the moisture problem is gone. Healthier, more comfortable people are less likely to complain and more likely to provide referrals.

How Much Ventilation?

The New York Energy Smart program uses a combination of ASHRAE Standard 62-2003 and the requirements contained in NYS Codes for determining mechanical ventilation rates. The table on page 73 outlines the minimum ventilation requirements required by the program.

As an alternative, the mechanical ventilation requirement can be met by using the larger result of Equation 1 and Equation 2 as follows:

Equation 1: (# of Bedrooms + 1) x 15 CFM

Equation 2: ((# of Bedrooms + 1) x 7.5 CFM) + (Conditioned Floor Area x 0.1 CFM)

Other Ventilation Rate Considerations

The New York ENERGY STAR Labeled Homes program recommends spot ventilation in all kitchens and bathrooms. When installed, kitchen exhaust fans shall have a minimum ventilation rate of 100 CFM intermit-

Table 9.2 **New York ENERGY STAR Labeled Homes 2005 Minimum Ventilation Requirements (CFM)**

House Square Footage	Number of Bedrooms 2	3	4	5	6	7
<1000	45	60	75	90	105	120
1000-1500	45	60	75	90	105	120
1501-2000	45	60	75	90	105	120
2001-2500	48	60	75	90	105	120
2501-3000	53	60	75	90	105	120
3001-3500	58	65	75	90	105	120
3501-4000	63	70	78	90	105	120
4001-4500	68	75	83	90	105	120
4501-5000	73	80	88	95	105	120
5001-5500	78	85	93	100	108	120
5501-6000	83	90	98	105	113	120

Notes: This chart represents a conservative combination of the ventilation requirements as included in the Residential Code of New York State, the Mechanical Code of New York State and the ASHRAE Standard 62-2003. It includes the minimum ventilation requirements for New York ENERGY STAR Labeled Homes for 2005.

tent or 25 CFM continuous and bathroom exhaust fans shall have a minimum ventilation rate of 50 CFM intermittent or 20 CFM continuous.

Types of Ventilation Systems

- **Bath fan system**—The easiest type of ventilation system to install is a simple exhaust fan system. All bath fans should be ENERGY-STAR-rated models that are quiet (less than 1.5 sone, preferably). People won't use a fan that sounds like an airplane. Choose a model that is rated for continuous operation (typically 30,000 to 50,000 hours). This is to make sure it doesn't break after a year or two. The fan must be ducted to outdoors, with an insulated duct and a damper at the building envelope. Put a 24 hour timer on the electrical circuit, so the fan can run full time or part time, and so people can leave it off when they are not home. One type of timer is just like the one that plugs into the wall to turn lights on and off in the evening, except it is hard-wired in a single-gang box. You can also provide a switch or wind-up timer so that someone using the bathroom is able to turn the fan on regardless of the timer program. To use the kitchen range exhaust as the "boost" fan, be sure it is ducted to the outdoors. This type of system is inexpensive; makeup air comes in through small leaks that exist even in a very tight building. It is not as effective at getting fresh air to upstairs rooms as a fully ducted supply air system, such as a heat recovery system (see below).

- **Central exhaust**—This is a middle-of-the road type of system. You can run ducts from the bathrooms and kitchen to a central exhaust fan, which has a 24-hour timer or variable speed control. Be careful to size the ducts for adequate airflow, to balance the system properly, and to get adequate airflow from each bathroom for moisture removal. Most exhaust fans are not rated for range hood duty, so don't place the kitchen exhaust register right over the stove! This system also gets its makeup air through leaks in the building shell.
- **Return makeup air**—Return makeup air systems pull fresh air into the home through the return duct of a forced-air distribution system (see Figure 9.2). These systems are better than exhaust type systems at getting fresh air into all the rooms in a house. However, it is necessary to limit incoming airflow, and also to ensure adequate ventilation is provided when heating loads are small.
- **Energy recovery ventilation (ERV)** systems pull exhaust air from the bathrooms and kitchen, and deliver fresh air to the living area and bedrooms, or to the return plenum of a whole-house air handler (see Figure 9.3). The two air streams run through an exchange core where heat and humidity are transferred from one stream to the other. Be aware that even a large ERV may not adequately remove moisture from bathrooms if the exhaust ducts are run to many locations; it may be better to use a smaller ERV unit and to install separate bath fans for fast removal of steam. **Heat recovery ventilators (HRVs)** do not transfer moisture between the two air streams and are more appropriate in homes without air conditioning.

Other HVAC recommendations

- **Bring ducts and pipes inside**—Ducts and pipes in unconditioned attics, garages, basements and crawlspaces must be insulated. Locating ducts and pipes in unconditioned spaces can lead to higher heat loss, discomfort, and ice dams. *Whenever* possible, bring the mechanicals inside the insulated envelope of the house. Builders and designers can help make sure that framers leave room to run the heating and cooling distribution system inside the thermal envelope.
- **Avoid ducts in outside walls**—If you must put a heating duct in an outside wall cavity, install *at least* R-14 rigid insulation between the duct and the exterior sheathing.
- **In New York, high efficiency heating systems are required for participation in the ENERGY STAR labeled homes program.** All heating systems shall meet or exceed the following minimum standards.

Table 9.3 Minimum heating system efficiencies

Heating System	Minimum AFUE	
	Gas	Oil
Furnace	90	84
Boiler	84	84

This table illustrates minimum heating system efficiencies required for participating in the New York ENERGY STAR Labeled Homes program.

Additional HVAC requirements: Central air conditioners installed in the LIPA service territory must have a SEER rating of 13 or higher and a minimum EER of 11. It is recommended that all central air conditioning equipment installed in ENERGY STAR homes throughout New York State have a SEER rating of 13 or higher and a minimum EER of 11.

- **Use sealed combustion** to avoid backdrafting and carbon monoxide (CO) in the home. Figure 9.4 shows one typical backdrafting scenario; any large exhaust fan can backdraft atmospheric vented combustion appliances. Installation of sealed combustion boilers, furnaces, and water heaters may avoid the expense of building a chimney; many of them can vent through the side wall (see Figure 9.5). **Every New York ENERGY STAR Labeled Home must pass a combustion safety test.** All combustion appliances are tested for the presence of CO. Additionally, all non-sealed combustion appliances or systems must undergo a worst-case depressurization Combustion Air Zone (CAZ) test.
- **Use integrated systems**—Integrated heating/hot water systems can save energy and also save on installation costs. If you have a boiler, using an indirect fired water storage tank is much more efficient than a stand-alone tank, uses only one burner to do both jobs, and needs only one venting system. If forced air is desired, a boiler can provide heat through a "hydro-air" fan coil. In a house with small heating loads, the fan coil can be supplied by a small, high efficiency, stainless steel water heater with a heat exchanger. This approach also saves space. Avoid tankless coils that are built into boilers for water heating; they have the lowest efficiency of all.
- **Proper sizing** of heating systems may save only a little money on the boiler or furnace itself. However, proper sizing of the distribution system, or sizing cooling systems 1/2 to 1 ton smaller, can save hundreds of dollars in a typical house. Heating and cooling loads should be calculated on a room-by-room basis. Ducts, air handlers, hydronic baseboard and circulating pumps should also be sized to actual loads,

rather than rules of thumb. Efficient homes with low-e glazings and no drafts need less heating and cooling and smaller distribution systems than rules of thumb typically indicate. Occupants may be comfortable with registers or baseboards located closer to the center of the building, rather than the standard practice of delivering heating and cooling near exterior walls. Properly sized air conditioning may be healthier for the occupants as well (see page 114).

Properly sized heating and cooling systems are required for participation in the New York ENERGY STAR Labeled Homes program. In addition to complying with the associated code requirements listed earlier in this chapter, equipment must also be sized to no more than 115% of the heating or cooling load as calculated, or the next available size if no properly sized unit is available in the market. This calculation should be consistent in inputs with the actual construction of the building.

- **Every New York ENERGY STAR Labeled Home must comply with a prescribed maximum duct leakage rate.** For a given house, the duct leakage (measured in CFM to outside at a test pressure of 25 Pascals) cannot exceed 6% of the conditioned floor area of the house (e.g., 120 CFM at 25 Pascals for a 2000 square foot home). The HERS rater that is hired to certify the house typically performs a duct leakage test at one of the inspections that is performed to verify compliance with ENERGY STAR standards.

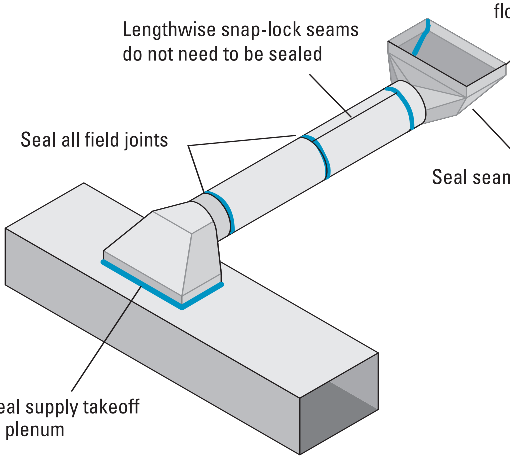
Going Further

There are a number of references listed in Appendix B specifically related to indoor air quality, ventilation, and HVAC systems.

FIGURE 9.1

Sealing duct runs within unconditioned spaces

Use mastic to seal all the locations shown here. Use fiberglass mesh as reinforcement for gaps larger than 1/8".



Leaky ductwork in unconditioned basements and attics is a major source of heating and cooling losses. Run ducts inside the conditioned envelope wherever possible; duct sealing is not required in conditioned spaces.

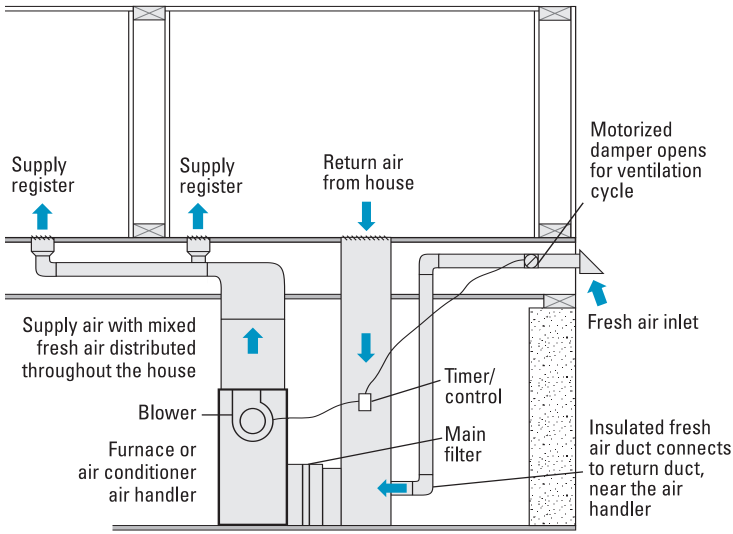
To apply mastic, use vinyl gloves and smear it in place by hand. Pay close attention to:

- folded corners on end caps, boots and takeoffs;
- plenum connections;
- filter racks;
- swivel elbows; and
- finger-jointed collars

TIPS: Mastic is much faster to install and more reliable than the more common aluminum tapes, and is the only sealant that is pre-approved in the energy code.

FIGURE 9.2

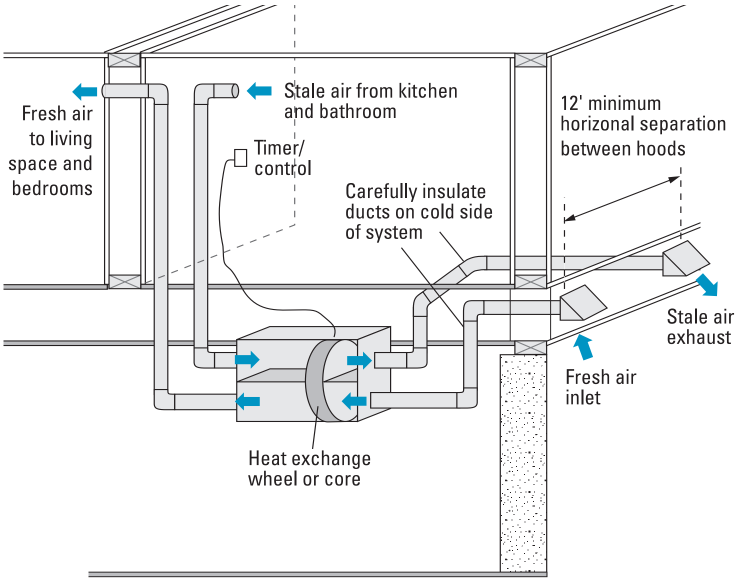
Return duct fresh air



TIP: Although the return duct fresh air system can filter and distribute fresh air throughout the house, the air handler blower may consume substantially more electricity. Low-energy, variable speed blower motors are recommended.

FIGURE 9.3

Energy (or heat) recovery ventilation

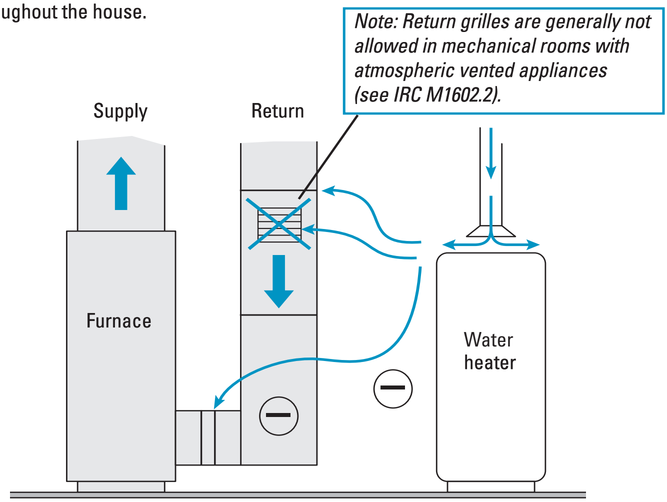


TIP: As an alternate, fresh air may be ducted to the return side of a central air handler for distribution throughout the house.

FIGURE 9.4

Depressurization and backdrafting

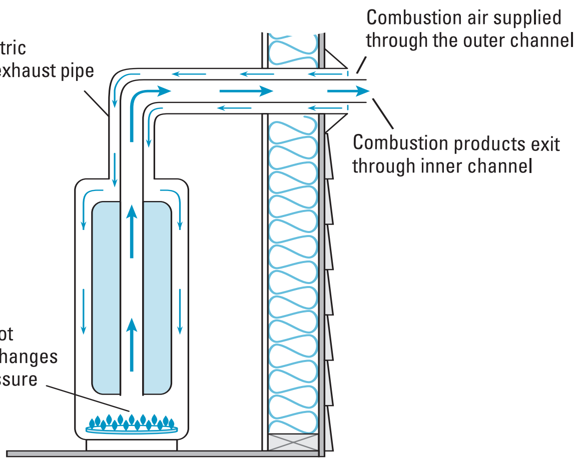
This figure shows a typical scenario. Leaks in return ducts depressurize the basement. Depressurization can backdraft the water heater vent or the furnace burner. Backdrafted combustion products, which may include deadly carbon monoxide, are then circulated throughout the house.



Depressurization that causes backdrafting can be created by any exhaust appliance. The large ones that are most likely to create depressurization include range vents, whole house fans, dryers, central vacuum, and fireplaces without outdoor air supply. Leaks in return ducts and/or the presence of return air registers in the vicinity of a combustion appliance can also cause backdrafting (as shown in the diagram above). **Mechanical code requirements for passive combustion air inlets or volume of air space do not guarantee against backdrafting**, yet they add to building heat loss.

FIGURE 9.5

Direct vent water heater



TIP: The placement of a direct vent appliance is limited by the allowable length of the intake/exhaust pipe. Plan carefully for locating these appliances.

The direct vent water heater is completely sealed from indoor air, so backdrafting into the living space cannot occur. Similar arrangements are available for furnaces, boilers, and gas or wood fireplaces and stoves.

FIGURE 9.6

Duct problems to avoid