



HRV and ERV Guide for Multi-Unit Residential Buildings

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Purpose of the guide

This guide will assist designers, developers, builders, contractors and owners with the design, installation and operation of heat and energy recovery ventilation (HRV and ERV) systems in multi-unit residential buildings (MURBs) throughout Canada. The guide is organized into the following sections:

- **Chapter 1:** Introduction to ventilation and description of the various interactions among a building's components and systems that affect its overall comfort and performance
- **Chapter 2:** Background information on ventilation requirements in codes and standards, and current ventilation practices
- **Chapter 3:** Detailed description of HRV and ERV systems: how they work, as well as a cost-benefit comparison of HRVs/ERVs for climate zones across Canada
- **Chapter 4:** Design and installation guidance for HRVs/ERVs in new MURB projects
- **Chapter 5:** Guidance for ventilation and HRV/ERV upgrades for existing MURB projects
- **Chapter 6:** Guidance on balancing, commissioning and troubleshooting of HRVs/ERVs
- **Chapter 7:** Operation and maintenance guidance for owners, occupants and property managers

This guide does not discuss the detailed design of MURB ventilation systems. It assumes that a qualified engineer, building science consultant or qualified installer will be engaged in any MURB HRV/ERV project.

References for further information are noted throughout, with a compiled glossary included as an appendix. First appearances of each term in the glossary are indicated in [blue text with a dotted underline](#).

Disclaimer

The guide reflects current good practice in design and construction; however, it is not intended to replace professional advice. When information presented in this guide is incorporated into a specific building project, it must respond to the unique conditions and design parameters of that building, and be reviewed by the project architect or engineer. Use of the guide does not relieve designers of their responsibility to comply with local building codes, standards and bylaws with respect to the design and construction of the building. Readers should be aware that there are requirements under provincial Architects and Engineers Acts that determine when and for what type of projects the services of such registered professionals are legally required.



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1. Introduction

Ventilation is the process of supplying air to or removing air from a space for the purpose of controlling air contaminant levels, humidity or temperature within the space. It is an important contributor to the healthiness and comfort of an indoor environment. Specifically, ventilation serves three purposes:

1. Provide oxygen for occupants to breathe (and remove CO₂).
2. Dilute or remove contaminants (including odours and moisture generated within the building).
3. Cool the building.

The right amount of ventilation for the first and second purposes is typically determined by the rate of contaminant generation, and is regulated by code, while the ventilation rate for the third is determined by the building cooling demand. In MURBs, the amount of ventilation must specifically accomplish the following:

- Remove/dilute moisture generated by people, pets and plants, and by activities such as cooking and showering.
- Remove/dilute contaminants generated by interior sources, such as cooking, household cleaners and off-gassing of interior finishes and furnishings.
- Protect against specific pollutants and sources, including radon gas from the ground, combustion products from appliances, and vehicle exhaust fumes from attached garages.

A well-designed ventilation system will operate quietly, economically and without causing thermal discomfort (for example, through drafts).

There are two traditional approaches to providing ventilation to a space: mechanical (active) ventilation and natural (passive) ventilation. Mechanical ventilation is the intentional movement of air into and out of a building, using fans and associated ductwork, grilles, diffusers and vents. Natural ventilation is the flow of air, driven by natural pressure differentials through open windows, doors, grilles and other planned penetrations. Many MURBs incorporate both mechanical and natural ventilation features.

There is typically a trade-off between increased ventilation rates and energy consumption. As more ventilation is provided to maintain a healthy and comfortable interior environment, more energy is needed to condition this air. HRVs and ERVs are ventilation systems that significantly reduce this energy penalty by recovering energy from air that is being exhausted from the building.



1.1 Building as a system

MURBs are complex systems that operate through the interaction of various components, occupants and the exterior environment. When considering any one component of a building, such as the ventilation system, it is important to also consider the interaction of that component with other building elements such as the [building enclosure](#) and heating/cooling system. The following are a few examples of how the building and ventilation systems interact.

- Natural air infiltration and exfiltration through the relatively leaky building enclosures of older buildings may compensate for a lack of mechanical ventilation.
- Uncontrolled positive and negative [pressurization](#) caused by wind, [stack effect](#) and mechanical systems can lead to unintentional air movement, such as infiltration of soil gases; [air flow](#) between suites, corridors and common areas; and [backdrafting](#) of combustion appliances.
- Less-insulated building enclosure assemblies, such as windows, can develop cold interior surface temperatures that can lead to surface [condensation](#). Mould can grow when condensation conditions persist. Additional ventilation may therefore be required to limit interior humidity levels and reduce the potential for condensation.
- The layout of interior spaces, the placement of furniture, closets, bathrooms, etc., and the placement of heating, ventilation and air-conditioning ([HVAC](#)) equipment such as vents, radiant heaters and ducts can all affect whether heat and [outdoor air](#) is evenly delivered to all spaces. This can become problematic if heated air is unable to reach exterior walls (for example, if a wall is blocked by a sofa), creating the potential for condensation and mould growth.

Important interactions between ventilation systems and other building components are discussed in the following sections. Note that this guide does not focus on building enclosure design, but rather provides an overview of how the enclosure and other aspects of the building affect ventilation. Several documents are available for further information on building enclosure design, such as the [Building Enclosure Design Guide](#) published by BC Housing's Homeowner Protection Office (HPO).¹

1.2 Building enclosure airtightness

The control of air flow affects a building's performance and comfort, by managing water penetration, controlling moisture and condensation: reducing energy consumption for space heating and reducing drafts. Uncontrolled air leakage is common in MURBs and significantly increases annual heating energy consumption.

The building enclosures of new MURBs are becoming more airtight as a result of improved construction practices and building code requirements for a continuous [air barrier](#). Unplanned air, noise and odour transfer between interior spaces (such as neighbouring suites and corridors) is also being reduced by better [compartmentalization](#) of suites. As the [airtightness](#) of building enclosures improves, there is less incidental leakage through the enclosure. This increases the importance of providing adequate ventilation to indoor spaces.

¹ HPO, <http://www.hpo.bc.ca/>



1.3 Building pressurization

Air flow into, out of and within (that is, between rooms, suites and storeys) MURBs is driven by pressure differences between these spaces. The pressure differences are created by wind, stack effect and the fans of mechanical systems.

Wind creates pressure differences as it flows around a building. Stack effect (also called “chimney effect”) creates pressure differences when warmer, less-dense air rises and is replaced by cooler, denser air. Mechanical systems also develop pressure differences across the building enclosure and interior separators when they draw air out of or force air into building spaces (see figure 1.1).

The magnitude of pressure differences vary widely, depending on building type, mechanical system, occupancy and other factors. MURBs commonly experience varying positive and negative pressures throughout the building over the course of a single day. For example, bathroom fans and range hoods can significantly depressurize a suite when they exhaust air, but are typically operated intermittently. In some cases, significant depressurization can cause backdrafting of combustion products from naturally aspirated combustion appliances and can also reduce the effectiveness of exhaust systems. Codes and standards are designed to minimize these risks (see chapter 2).

The combination of wind, stack effect and mechanical systems, together with varying building enclosure airtightness levels, creates complex pressure profiles and air-movement patterns within MURBs. If uncontrolled, these patterns can create indoor air quality concerns, including insufficient ventilation and transfer of contaminants such as cooking odours and vehicle exhaust fumes.

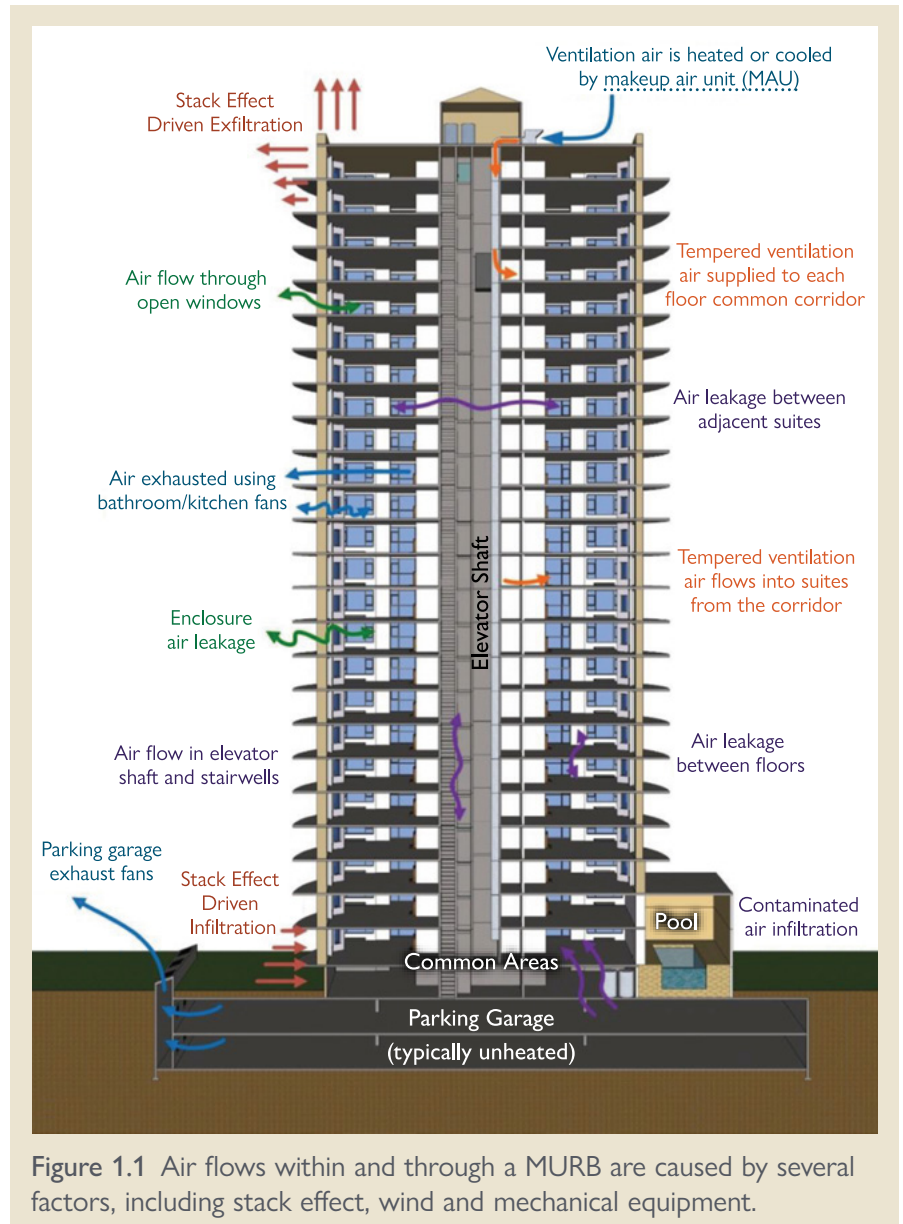


Figure 1.1 Air flows within and through a MURB are caused by several factors, including stack effect, wind and mechanical equipment.



1.4 Humidity

Moisture, in the form of water vapour, is always present in the air. Interior moisture is generated by occupants and their activities, such as cooking, showering, dish and clothes washing and even exhaling. Other sources of interior moisture include pets and plants. Since most sources of moisture originate in kitchens, bathrooms and laundry rooms, exhaust fans are typically located in these spaces. Sources of unusually high moisture from open-water sources, including indoor pools, ponds and aquariums, may require additional ventilation or dehumidification. Exterior moisture may also enter the building through outdoor air.

Indoor air is most comfortable and healthy in the range of 30 to 60 per cent [relative humidity \(RH\)](#), based on [ASHRAE](#) thermal comfort guidelines.² In some climates, mechanical systems are designed to humidify or dehumidify indoor air to maintain space comfort. Humidity control can be provided by a variety of mechanical methods; however, the most common method in MURBs is simply to use exhaust fans that remove moist air. Air conditioning can also provide dehumidification, though control is typically based on temperature rather than dehumidification requirements. Some MURBs have humidistats that automatically operate exhaust fans when the indoor air is above a certain humidity level. MURBs typically have no means to humidify air that it too dry.

Condensation occurs when air comes into contact with a surface that is colder than the [dew-point temperature](#) of the air. If a building located in a cold climate is not well insulated, then the interior surfaces of the building enclosure may become colder than the dew-point temperature, and condensation can occur on these surfaces. This is common at windows (see figure 1.2), which tend to have a low insulation value, as well as in corners of rooms and where furniture has been placed against exterior walls. Condensation moisture can damage interior finishes and building enclosure components, and can lead to mould growth. It is important, therefore, to consider acceptable humidity levels for health, comfort and building durability when designing ventilation systems.



Figure 1.2 Condensation on the interior surface of windows

1.5 Source control

While ventilation acts to remove and dilute air contaminants and moisture, it is also important to consider controlling the sources of these contaminants. Sources of air contaminants and moisture can be addressed in three ways:

- source removal – for example, by storing contaminants and pollutants (such as cleaning products or paints) outside the living space;
- substitution – for example, by selecting low-emitting interior finishes and furniture; and
- source containment – for example, by storing contaminants and pollutants in sealed containers.

While the focus of this guide is on ventilation, source control of contaminants and moisture is equally important to a healthy indoor environment.

² ASHRAE Standard 55 Thermal Environmental Conditions for Human Occupancy

2. Current MURB ventilation codes, standards and practices

2.1 Codes and standards

The fabrication, design and installation of ventilation systems and their components are guided by technical requirements that vary among jurisdictions. These include both regulated and “best practice” standards that relate to energy-efficient performance.

The codes and standards relevant to ventilation systems and HRVs/ERVs typically fall into four categories:

- **Design requirements for ventilation systems and indoor air quality:** Codes, or standards that are referenced by codes, are used to establish minimum ventilation air flow rates in buildings. Variations in the standards can often lead to different minimum ventilation rates, which can affect indoor air quality and energy consumption.
- **Design requirements for energy performance:** Standards that focus on improving whole-building energy performance often provide ventilation recommendations or requirements, because ventilation can have a significant effect on energy consumption.
- **Performance of HRVs/ERVs:** It is imperative that the HRV/ERV manufacturer has verified performance through testing by a Standards Council of Canada-accredited certification organization, such as CSA International or ULC. HRV/ERV performance test standards define how a manufacturer determines the energy efficiency and other performance characteristics.
- **Installation of HRVs/ERVs and ventilation systems:** Standards outline installation requirements for various components of ventilation systems, in addition to certifications required for the installation contractor.

HRV/ERV performance standards are also referenced by energy efficiency programs such as ENERGY STAR[®].³ The installation of an ENERGY STAR[®]-qualified HRV is often required when applying for energy efficiency incentives.

Adequate ventilation is needed to maintain good indoor air quality therefore it is important that the system meet all codes and standards. Before installing, modifying or maintaining any ventilation, heating or air-conditioning system, make sure that you know the building codes that apply to your province, territory or locality. These codes tend to be updated every few years; so make sure that you have the most recent codes.

As mentioned in the Introduction, this guide assumes that a qualified engineer, building science consultant or qualified installer will be engaged in any MURB HRV/ERV project. Qualified professionals will know the most recent codes and standards that apply to your building and can ensure that any new work on ventilation systems meets them.

³ ENERGY STAR[®] defines a qualified HRV/ERV as having a sensible heat recovery efficiency (SRE) of 65% at 0°C and 60% at -25°C under the Tier 2 specification that took effect on July 1, 2012, in Canada.
<http://www.nrcan.gc.ca/energy/products/for-participants/specifications/13695>



2.2 Mechanical ventilation strategies

Typical mechanical ventilation systems in MURBs use one or more of the following strategies:

Exhaust-only system

Exhaust-only systems rely on one or more fans to exhaust stale air from the suites (see figure 2.1). Replacement air is provided by transfer from the corridor, through trickle vents to the exterior, or through incidental [air leakage](#) through the enclosure. The suite is under negative pressure, compared with adjacent spaces when the fans are operating.

Supply-only system

Supply-only systems use fans to automatically deliver outdoor air into the suite (see figure 2.2). These suites will likely still have occupant-controlled exhaust fans in rooms where moisture and odours are generated, such as bathrooms, kitchens and laundry rooms.

Supply-only systems have the advantage of being able to filter outdoor air. However, when the exhaust fans are not operating, the ventilation supply places the suite under positive pressure and can drive air into building enclosure assemblies, or cause air to leak out through incidental openings or penetrations. In cold climates, positively pressurizing the building can increase the potential for condensation within wall assemblies, which may damage the building enclosure.

Balanced system

Balanced systems use fans to simultaneously exhaust stale air and supply outdoor air. These systems can include the following configurations:

- A central supply fan that supplies air to all suites and habitable rooms and is linked to a central fan that exhausts from bathrooms, kitchens and laundry rooms at the same time (air flow supply and exhaust can increase or decrease, depending on occupancy).
- A central HRV/ERV that continuously supplies air to all suites and habitable rooms, and exhausts from bathrooms, kitchens and laundry rooms.
- Individual suite supply and exhaust fans that operate at the same time.
- Individual HRVs/ERVs that operate continuously within each suite (see figure 2.3).

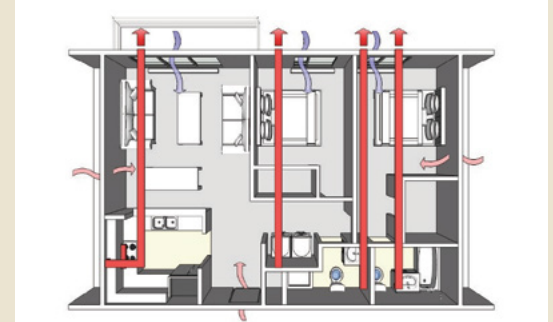


Figure 2.1 A basic exhaust-only ventilation system that consists of a bathroom exhaust fan and a kitchen range hood exhaust fan

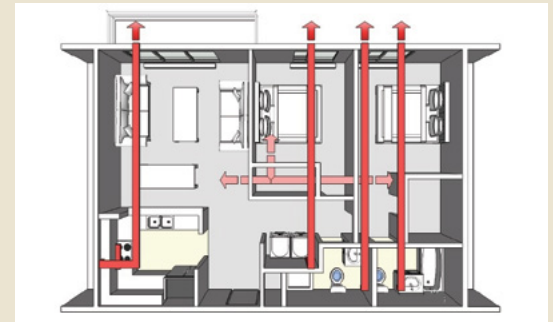


Figure 2.2 A basic supply-only ventilation system

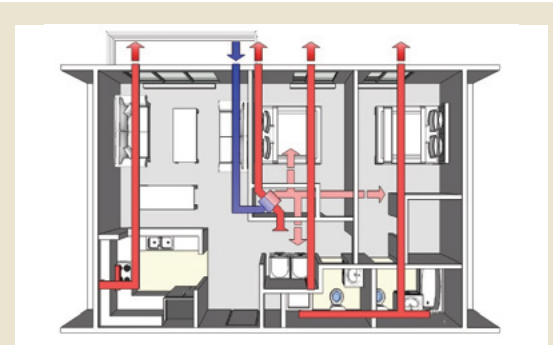


Figure 2.3 Balanced supply and exhaust from a fan system centrally located in each suite

Supply-only and exhaust-only systems can cause uncontrolled infiltration and exfiltration through the enclosure. A common strategy in the past has been to pressurize the corridor and then rely on leakage through the building enclosure and transfer under door undercuts to deliver air to individual suites. However, research has shown that much of the [supply air](#) from the central shaft does not penetrate the suites. A recent study of typical existing MURBs showed that only 20 per cent of the air that was supplied to a common corridor transferred into the suites. The remainder was lost to the elevator shaft, stairwell and garbage chute.⁴

Balanced systems not only reduce infiltration and exfiltration, but also typically offer better indoor air quality, more ventilation control and reduced opportunities for contaminant migration between adjoining spaces and suites.

Case study: Vancouver's Olympic Village

The Olympic Village neighbourhood, which housed athletes during the 2010 Olympic Games in Vancouver, uses a “passive supply, mechanical exhaust” strategy in many of its residential buildings. An exhaust fan in each suite operates continuously at low flow. Outdoor air is ducted to the back of the refrigerator in each suite through in-slab ductwork, allowing the air to be pre-tempered by passive means, using the waste heat from the refrigerator. The energy savings from this ventilation strategy were calculated to contribute almost 12 per cent of the project's overall energy savings.



2.3 Natural ventilation

Natural pressure differences, due to wind and stack effect, can cause air movement through a suite, particularly if it has an open floor plan. Natural ventilation can save energy by reducing fan power for ventilation or providing “free” cooling in shoulder seasons (typically spring and autumn, or at night during the summer in diurnal climates, when outside temperatures are cooler than interior spaces). A natural ventilation system can be as simple as a single operable window that can be used for local ventilation to one room or as complex as a group of operable windows and passive air vents strategically located to provide ventilation to an entire building or suite. In many MURBs, natural ventilation through operable windows is one of the primary means of ventilation.

While operable windows provide occupants with some control over the temperature and ventilation within a space, they can significantly increase energy consumption if they are open when it is too cold or too warm outside. Opening windows in cool and cold weather can also lead to uncomfortable temperatures and can reduce the effectiveness of an HRV or ERV system.

⁴ Ricketts, L. (2014) *A Field Study of Air flow in a High-Rise Multi-Unit Residential Building*.

3. Heat and energy recovery ventilation

Buildings are designed to be conditioned to a comfortable temperature and relative humidity for human occupancy. Space heating and ventilation together can account for over half of annual energy consumption in MURBs. Because ventilation systems introduce unconditioned outdoor air and exhaust conditioned indoor air, there is potential to save energy by incorporating heat transfer between the two air streams. This works both during the winter, when warm exhaust air preheats the intake air and during the summer, when cooler [exhaust air](#) pre-cools the intake air.

This chapter describes the components of HRVs and ERVs, how they work and their benefits. An energy- and cost-savings comparison for representative locations across Canada is also provided.

3.1 Heat recovery ventilation systems

HRVs simultaneously supply and exhaust air to and from a space, transferring heat between the two airstreams without actually mixing the air. This reduces the energy consumption associated with heating or cooling mechanically supplied ventilation air, while increasing indoor air quality and thermal comfort.

3.1.1 HRV components

Most HRVs have the following components (see figure 3.1):

- an airtight case
- supply and exhaust fan(s)
- ports (leading to ductwork) for outdoor air, supply air, return air, and exhaust air
- a heat exchanger
- a condensation drain pan, connected to a drain
- sensors and controls
- filters
- in some cases, motorized dampers to aid in defrosting

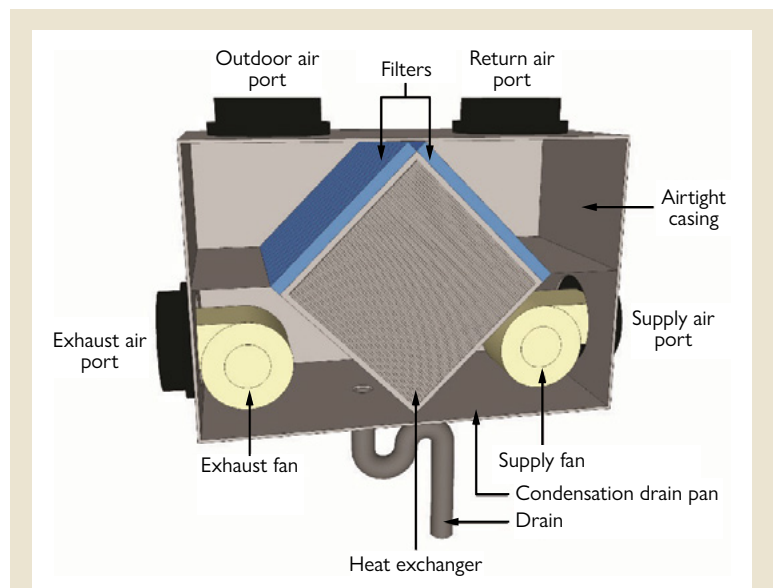


Figure 3.1 Parts of a heat recovery ventilator

The heat-transfer core of an HRV is constructed of a series of parallel plates that separate the exhaust and supply airstreams. These plates are typically made of metal or plastic. The airstreams can flow in perpendicular directions (cross-flow) or in opposite directions (counter-flow), as shown in figure 3.2. Counter-flow cores are more efficient at transferring heat but are more difficult to manufacture than cross-flow cores.

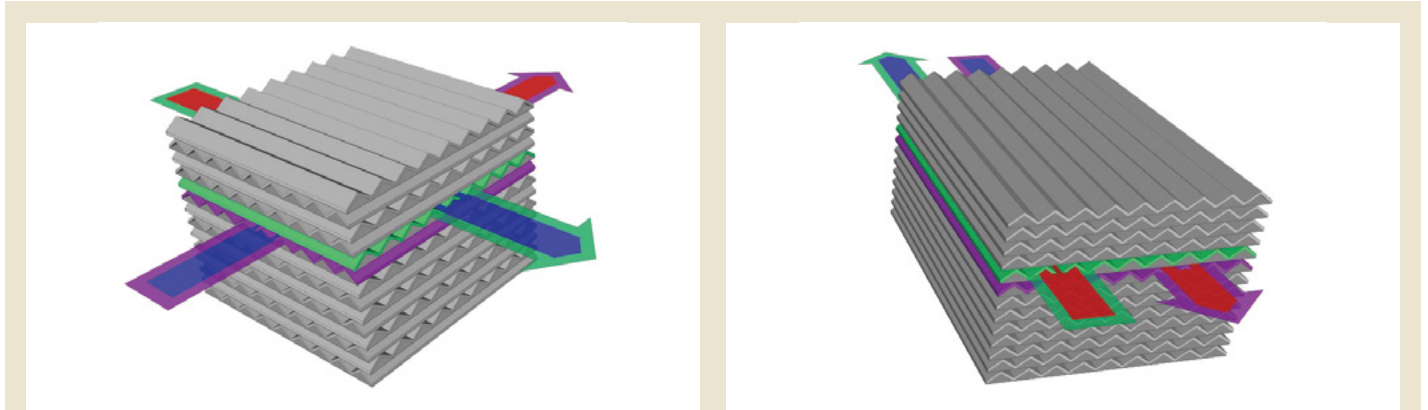


Figure 3.2 Cross-flow core (left) and counter-flow core (right)

3.1.2 HRV operation

The two air flow paths are illustrated in figure 3.3. Outdoor air enters the HRV (1), passes through the heat-exchanger core, where it receives heat from outgoing exhaust air (2), and is then supplied to the house via a supply fan and a ductwork system (3). A separate duct system and exhaust fan draw exhaust air from the space into the HRV (4), pass it through the heat exchanger, transferring heat to the supply stream, and exhaust it to the outdoors (5). These processes occur simultaneously, creating a balanced system with equal supply and exhaust air flow.

When heat is transferred from the exhaust to the supply airstream during the heating season, condensation can form inside the heat-transfer core. For this reason, drain pans are located inside the HRV to collect any water buildup, and the HRV is connected to a sanitary drain (6). This drain may limit the locations available to install HRVs in existing buildings.

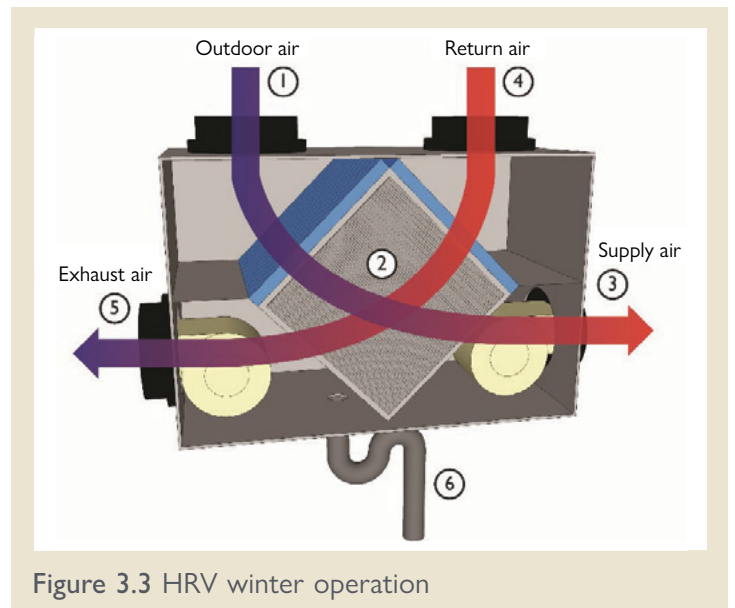


Figure 3.3 HRV winter operation

In colder winter conditions, the condensation inside the core can freeze and block the exhaust airstream. Some HRVs are designed to protect against freezing and clear the core of ice by going into defrost mode. This is typically accomplished by closing the outdoor air supply and drawing warm indoor air through the supply side of the core to heat the core and melt any ice, which can temporarily reduce indoor air quality. Another common method of defrosting is to use a preheater, especially in colder climates where constant defrosting is needed more often.

The heat-transfer process is reversed during the cooling season: cooler air being exhausted from an air-conditioned building removes heat from the incoming warm outdoor air. In other words, the HRV precools the outdoor air that is brought into the building. Many MURBs in Canada do not have air-conditioning systems, which can limit the ability of the HRV to precool outdoor air during warm temperature conditions (though the system still provides good indoor air quality by continuously ventilating the space).

Many HRV fans can operate at low, medium or high speeds, depending on the ventilation requirements. A common control strategy is to have the HRV run continuously at low or medium speed and switch to high speed when a higher ventilation rate is needed, such as when a bathroom is in use or during high-occupancy periods. The HRV system can be configured to operate in any number of ways with different mechanisms for control, including switches for manual operation by the occupants or sensors that automatically determine when more ventilation is needed.

3.2 Energy recovery ventilation systems

An ERV functions in a way similar to an HRV but, in addition to recovering heat, it also transfers moisture between the exhaust and supply airstreams.

3.2.2 ERV components

The components in ERVs are very similar to those of HRVs. An ERV typically has an airtight case, supply and exhaust fans, ductwork connections, a heat exchanger, sensors and controls, and filters. Because ERVs recover moisture, condensation does not typically form in their cores. In many cases, ERVs have been installed without drains, although users should be aware that there may be circumstances under which an ERV may generate condensation (for example, when the outdoor air is very cold and indoor humidity is high).

ERVs also require frost protection in cold climates, though an ERV's core typically freezes at a lower temperature than that of an HRV. The typical components of an HRV are shown in figure 3.4.

Many ERVs use heat-exchanger cores similar in design to HRV cores—except that, instead of metal or plastic, proprietary materials are used that transfer both moisture and heat. In general, these materials are specially designed so that moisture can transfer between airstreams, while contaminants such as odours and pollutants are blocked.

Another type of ERV core consists of a perforated wheel or drum (often referred to as an enthalpy wheel) that rotates between the exhaust and supply airstreams (see figure 3.5). Moisture and heat are deposited on the wheel, which then rotates into the opposite airstream, where the moisture and heat is released. These are more common in larger central systems than in individual-suite ones.

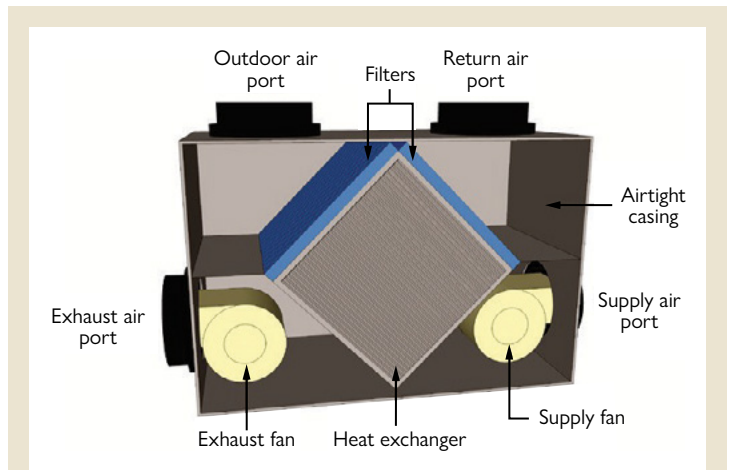


Figure 3.4 Typical components of an energy recovery ventilator



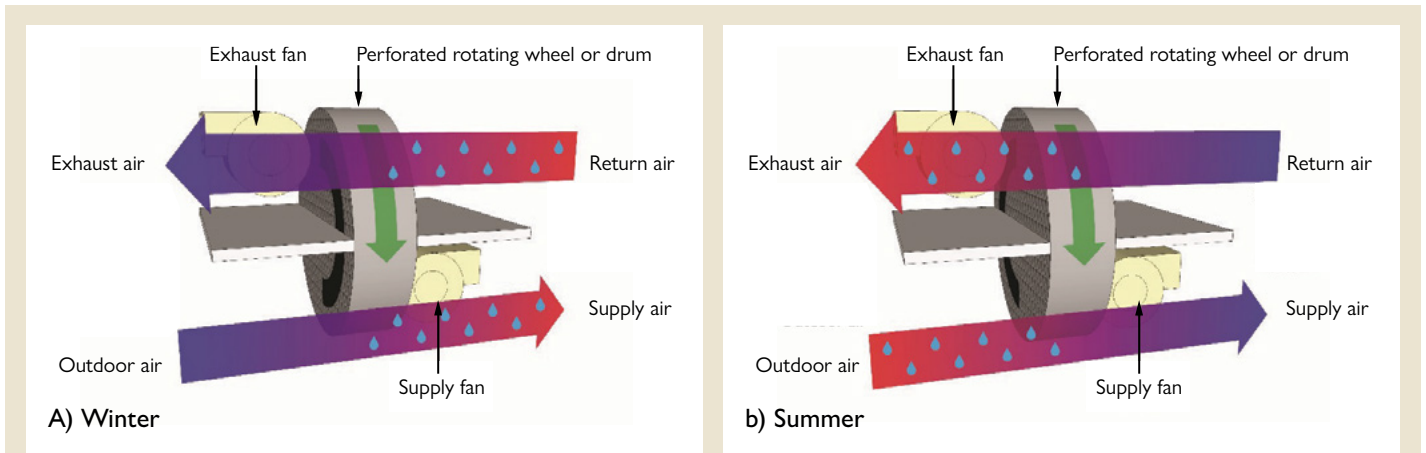


Figure 3.5 Enthalpy wheel ERV system operation during a) winter and b) summer

3.2.3 ERV operation

During the cooler months, an ERV will operate like an HRV, transferring heat from the exhaust to the intake airstream. An ERV can also raise the humidity in the intake air to a more comfortable level by returning a portion of the water vapour from the exhaust air to the incoming supply air (see figure 3.6). However, in suites that generate significant moisture from high occupancy, pets, plants or frequent cooking, ERVs may introduce too much moisture, as a result of this same effect.

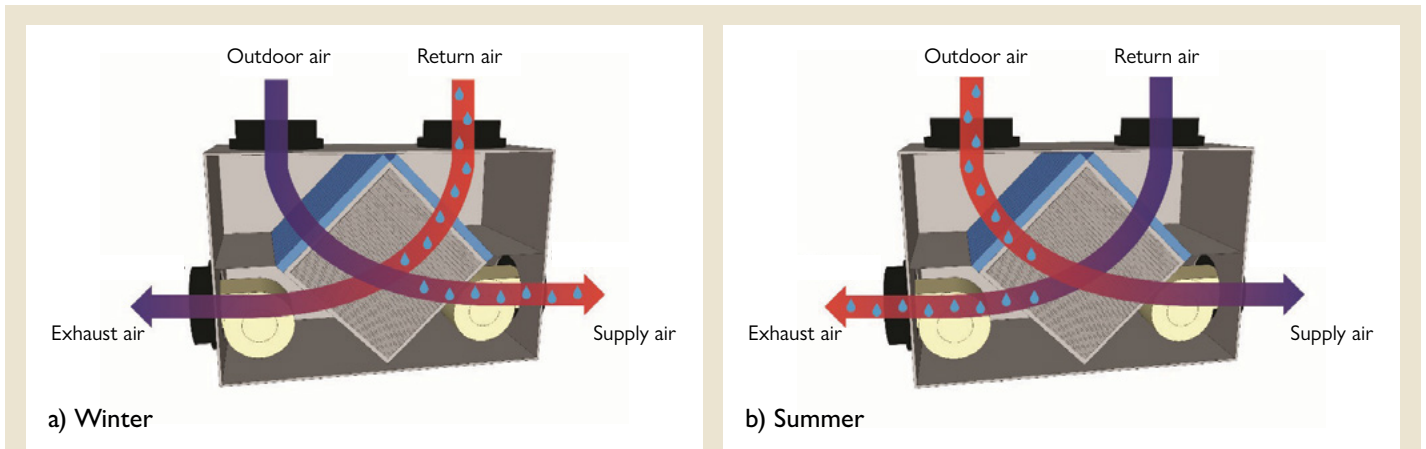


Figure 3.6 ERV operation during a) winter and b) summer, showing exchange of heat and moisture within the cross-flow core

During the warmer months, an ERV in an air-conditioned suite or building will both dehumidify and precool hot and humid outdoor air by transferring heat and moisture from the outdoor air to the cool exhaust airstream (see figure 3.6). If the building does not have air conditioning, these precooling and dehumidification benefits are not fully realized, though the system still provides constant ventilation to the space.

3.3 Benefits of HRVs and ERVs

HRV and ERV systems provide continuous, balanced and energy-efficient ventilation to the suites in a MURB. These systems have several benefits beyond potential energy savings. Some of these benefits are specific to HRV and ERV systems, while others result generally from ventilation to rooms.

- **Enhanced indoor air quality:** HRV and ERV systems enhance the indoor air quality in a space by exhausting indoor air pollutants and replacing that air with filtered outdoor air. A range of filters can be added to the supply side of an HRV or ERV, further improving air quality. HRVs and ERVs also provide constant, balanced air flow to and from a suite, which provides more consistently good air quality than a standard supply-only or exhaust-only system that varies the air flow throughout the day.
- **Enhanced thermal comfort:** HRV and ERV systems reduce drafts that can cause thermal discomfort, by preheating outdoor ventilation air.
- **Quiet ventilation:** Properly designed and installed HRV and ERV systems operate more quietly than conventional exhaust fans do. Many newer units are nearly inaudible.
- **Building enclosure durability:** Since HRVs and ERVs provide balanced air flow (equal supply and exhaust), they do not contribute to the positive or negative pressurization of the building. HRVs and ERVs also lower indoor humidity levels by exhausting moist indoor air, reducing the risk of condensation, which could lead to mould growth on windows and cool indoor surfaces.
- **Combustion appliance safety:** In buildings with naturally aspirated combustion appliances, flue gas spillage or backdrafting can occur when negative pressure (inward-acting) conditions on the building overcome the natural (outward-acting) draft of the combustion appliances. HRVs and ERVs with balanced air flows do not contribute to the negative pressurization of a building.

3.4 Energy and cost savings from HRVs and ERVs

Energy is required to supply, condition, filter and distribute ventilation air, whether the air enters by forced or passive means. When the ventilation rate is not controlled (such as when the system relies on infiltration and exfiltration through the enclosure), space conditioning energy consumption can increase significantly. A well-designed and controlled mechanical ventilation system, paired with an airtight enclosure, will control the amount of outdoor air needed to provide good indoor air quality and minimize the energy costs associated with ventilation.

There are other costs associated with inadequate ventilation in MURBs. Poor indoor air quality can affect occupant comfort and health. In particular, failure to properly control moisture levels can lead to condensation and subsequent damage, such as mould. Occupant discomfort caused by drafts or odour migration is an indirect cost of inadequate or ineffective ventilation, which can directly affect owners' ability to rent or sell their suites. Because providing adequate ventilation is a building code requirement in Canada, any deficiencies may lead to warranty claims and other legal issues.

The ventilation system strategy and equipment selection will affect both the installation cost and the cost of energy to operate the system. Incorporating heat or energy recovery may increase the initial cost of the ventilation system, but it can substantially reduce annual energy costs.

As discussed earlier in this chapter, HRVs and ERVs save energy by recovering heat from the exhaust airstream and preheating the incoming air in the winter, and reversing the process in the summer. In very cold climates, the potential for energy savings from heat recovery increases; however, there will be an energy penalty from operating the defrost mechanism to prevent freezing of the core.

The annual energy savings that an HRV or ERV can achieve will vary with the building design, the HRV/ERV system characteristics, installation, climate and occupant behaviour. To give an indication of the potential savings, an energy analysis was completed for a typical ten-storey 6,500 m² (69,965 sq. ft.) MURB in six locations across Canada representing different climate zones. These climate zones are illustrated for Canada. The results are summarized in table 3.2 below. Table 3.1 is a comparison of an HRV/ERV system with a typical existing MURB system. Table 3.2 compares a balanced system with and without the HRV/ERV. This is a more reasonable comparison for a typical new building.

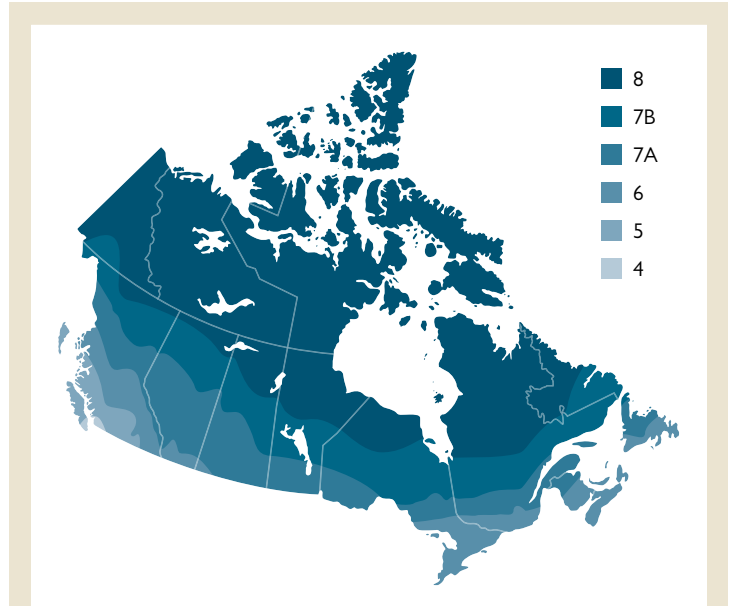


Figure 3.7 Map of climate zones for Canada

Table 3.1

Modelled heating and cooling energy savings of ERV/HRVs, compared with pressurized corridor system with intermittent exhaust fans in suites

LOCATION	HEATING DEGREE-DAYS [†]	ANNUAL ENERGY COST SAVINGS PER SUITE AND % REDUCTION IN VENTILATION HEATING AND COOLING ENERGY DUE TO AN HRV OR ERV [‡]	
		GAS FURNACE AND CENTRAL AC	ELECTRIC BASEBOARD AND NO COOLING
Vancouver	2825	\$280 (86%)	\$640 (81%)
Toronto	3520	\$300 (81%)	\$1,090 (78%)
Montréal	4200	\$200 (82%)	\$690 (80%)
Winnipeg	5670	\$440 (85%)	\$960 (82%)
Fort McMurray	6250	\$370 (85%)	\$1,800 (83%)

[†]Heating degree-days from the 2010 National Building Code of Canada

[‡]ERVs yield additional cooling energy savings compared with HRVs, if the building has air conditioning. However, because the Canadian climate is heating-dominant, the difference in the energy performance between an HRV and ERV system is minor.



Table 3.2

Modelled heating and cooling energy savings of ERV/HRVs, compared with continuous balanced ventilation with no HRV/ERV

LOCATION	HEATING DEGREE-DAYS [†]	ANNUAL ENERGY COST SAVINGS PER SUITE AND % REDUCTION IN VENTILATION HEATING AND COOLING ENERGY DUE TO AN HRV OR ERV [‡]	
		GAS FURNACE AND CENTRAL AC	ELECTRIC BASEBOARD AND NO COOLING
Vancouver	2825	\$170 (78%)	\$300 (67%)
Toronto	3520	\$170 (70%)	\$580 (66%)
Montréal	4200	\$120 (73%)	\$360 (67%)
Winnipeg	5670	\$250 (77%)	\$510 (71%)
Fort McMurray	6250	\$210 (77%)	\$960 (73%)

[†]Heating degree-days from the 2010 National Building Code of Canada.

[‡]ERVs yield additional cooling energy savings compared with HRVs, if the building has air conditioning. However, because the Canadian climate is heating-dominant, the difference in the energy performance between an HRV and ERV system is minor.

Overall, significant energy savings can be realized in a typical Canadian MURB by installing an HRV/ERV. The per cent savings are higher in colder regions; however, HRV/ERVs can be beneficial in all areas of the country. It is also important to realize that, while summer energy savings will be lower in buildings that do not have air conditioning, HRV/ERV systems will still provide heat exchange when outdoor temperatures are higher than indoor temperatures, creating a more comfortable interior environment.



4. Heat and energy recovery ventilation system design and installation

This chapter summarizes the primary HRV/ERV ventilation system configurations for new MURBs and outlines the design considerations that will affect the performance, layout, esthetics and cost of a new MURB project. It is not intended to replace the expertise of a design engineer (who will complete the detailed design, coordinate with the design team and prepare complete construction documentation), but rather to build an understanding of the design considerations that lead to an appropriate system choice for a particular MURB. The information is intended to supplement code requirements and best practice guidelines, such as those provided by ASHRAE, TECA⁵ and HRAI.⁶

4.1 HRV/ERV system configurations

The two primary HRV/ERV system configurations for new MURBs are as follows:

1. Centralized HRV/ERV system with ducted supply and return to each suite. The system can either be centralized as floor-by-floor (or other multiple-suite) zones or as a single unit serving the entire building. Figure 4.1 shows this arrangement in winter (heating) mode. The system will also deliver air to common areas (not shown).
2. Individual in-suite HRV/ERV. The system details can vary (for example, in how the exhaust path is ducted), but the basic concept is that the HRV/ERV is located within the suite and only serves that suite. In a MURB with central corridors, it is assumed that corridor ventilation (as required by applicable codes) is achieved independently of the suite ventilation. Two examples are shown in figure 4.2 and figure 4.3, in winter mode. For individual suite ventilation strategies to be effective, the suites must be compartmentalized to prevent air leakage to and from adjacent suites, the corridor and the exterior. This means that a continuous air barrier must be provided between each suite and between the suites and corridor, as well as at the building enclosure.

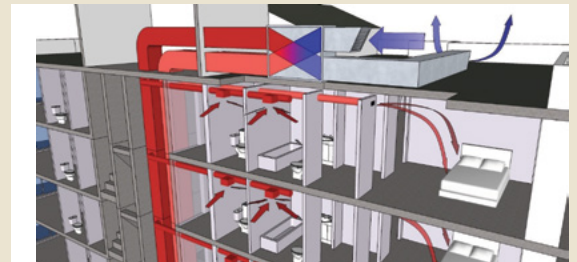


Figure 4.1 Centralized HRV/ERV with ducted supply and return to each suite

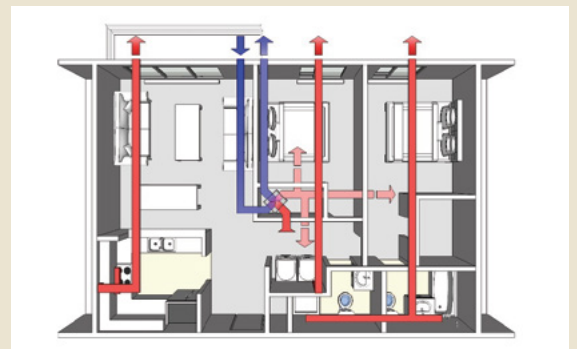


Figure 4.2 Individual in-suite HRV/ERV with dedicated, intermittent kitchen/bathroom exhaust. In this scenario, the suite's pressurization will be unbalanced when the intermittent kitchen/bathroom exhaust fans are turned on.

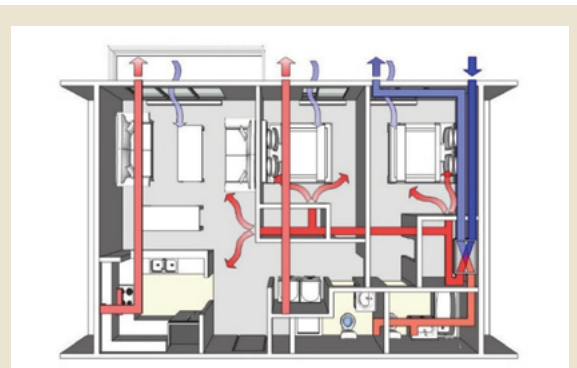


Figure 4.3 Individual in-suite HRV/ERV integrated with bathroom exhaust. In this scenario, HRV/ERV air flows can be ramped up when the kitchen or bathroom requires additional exhaust.

⁵ The Thermal Environmental Comfort Association (TECA) provides publications and courses; more information is available at www.teca.ca

⁶ The Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI) provides guidelines and training; more information is available at www.hrai.ca



4.1.2 HRV/ERV system design considerations

As with any mechanical system, the final design, performance and cost of a new MURB project will be affected by choices related to the HRV/ERV system. When these effects are understood and coordinated among the design team and stakeholders early in the design process, the project is more likely to successfully fulfill the expectations of the developer, owner, designers and occupants.

4.1.3 Centralized or in-suite system

Centralized and in-suite HRV/ERV systems are compared in table 4.1 below. This table can be used by the project team as a checklist to identify the considerations that are most important for a specific project and guide the team toward the best solution. Photos of centralized and in-suite units are included in figure 4.4 and 4.5 after the table.

Table 4.1

Comparison of system design considerations for centralized versus in-suite HRV/ERVs

DESIGN CONSIDERATION	CENTRALIZED SYSTEM	INDIVIDUAL IN-SUITE SYSTEM
Code requirements	<ul style="list-style-type: none"> Code requirements for ventilation must be satisfied. Requirements are independent of the system chosen to meet them. The mechanical engineer will be well versed in locally applicable codes. See chapter 2. 	
Scale	<ul style="list-style-type: none"> One large unit (or several large units if using a zoned system), with one power and condensate drain connection (if required). 	<ul style="list-style-type: none"> Many smaller units, each requiring power and drain connections (if required).
Space/layout	<ul style="list-style-type: none"> Larger shafts will be required to accommodate vertical supply and exhaust ducts between the unit and suites. Main distribution ducts will require space in the corridor ceiling (although they need to be sized only for outside ventilation air, which is much less than would be required for a centralized all-air system). Space within the suite is not required for the HRV/ERV. The main HRV/ERV can be located in conditioned space or outdoors (but must be selected accordingly). 	<ul style="list-style-type: none"> Shaft space is not needed for suite ventilation (although if the building has an interior corridor, the shaft will have to accommodate the corridor ventilation system). No ventilation distribution ducts are required in the corridor ceiling. Space is needed within the suite to locate the unit (can be on the floor or mounted on a wall—for example, above the washer/dryer). For buildings with very aggressive window-to-wall ratios, in-suite units/systems may be a preferred option.
	<ul style="list-style-type: none"> In-suite duct distribution space (in ceiling, floor and/or wall) is required to bedrooms and primary living spaces, and from bathrooms/laundry rooms. 	
	<ul style="list-style-type: none"> A separate kitchen exhaust for a gas-fired range is still required by most codes. 	



DESIGN CONSIDERATION	CENTRALIZED SYSTEM	INDIVIDUAL IN-SUITE SYSTEM
Fire/smoke separation and envelope penetrations	<ul style="list-style-type: none"> • Shaft fire/smoke separations are penetrated at each floor by two larger ducts. Ducts penetrating these or other fire/smoke separations must include fire/smoke dampers (as required by code). • Fire/smoke separations are penetrated at each suite by both supply and return ducts. Ducts penetrating fire/smoke separations must include fire/smoke dampers (as required by code). 	<ul style="list-style-type: none"> • Fewer interior fire/smoke penetrations, but more envelope penetrations required for outside air and exhaust air to each suite.
Sound	<ul style="list-style-type: none"> • Sound performance of the unit is less critical, as the unit is located outside the occupied space. The base/equipment pad should be designed to minimize vibration and sound transfer through the roof (if applicable). 	<ul style="list-style-type: none"> • Sound performance of the unit is critical, as units are located within suites. Units are available that are virtually inaudible, and mounting configurations can further reduce noise. Louder units are at risk of being turned off by occupants.
Ownership	<ul style="list-style-type: none"> • In a strata building, ownership is part of the common element. 	<ul style="list-style-type: none"> • In a strata building, ownership is transferred to individual owners.
Serviceability and maintenance	<ul style="list-style-type: none"> • Single point of maintenance. In a rental building, the building manager does not have to enter suites to maintain the system. 	<ul style="list-style-type: none"> • Multiple points of maintenance, which can be challenging in a rental building. • In a strata building, maintenance responsibilities rest with the individual owner. This can be more challenging to ensure that the units are maintained and operating as intended. Occupant education is crucial.
Controllability	<ul style="list-style-type: none"> • Lower degree of occupant control, which can benefit the overall performance of the building, but can also lead to occupant intervention if this system does not maintain comfort as intended (for example, blocking diffusers). Occupant education is recommended. 	<ul style="list-style-type: none"> • Higher degree of occupant control, which can be perceived as a benefit to occupants, but can also lead to behaviours that are detrimental to overall building performance (for example, turning off the unit and allowing moisture to accumulate). Occupant education is recommended.





Figure 4.4 Custom centralized HRV for an 11-storey MURB. The unit supplies ~6000 cfm to 90 units.

4.1.4 HRV or ERV

The choice of an HRV versus an ERV depends primarily on the following factors:

- **Energy consumption:**
 - **Summer considerations:** If summers are hot and humid and the building is to be air-conditioned, an ERV will reduce cooling energy, because it removes humidity from the incoming supply airstream (and effectively precools the incoming air).
 - **Winter considerations:** When frost prevention is required consistently, an ERV can be the preferred choice, because its core typically freezes at a lower temperature than that of an HRV. In short, an ERV operates more efficiently at lower temperatures, using less heating energy for frost prevention.
- **Thermal comfort:** An ERV can return moisture into the supply airstream, which can improve thermal comfort in climates with very dry winters. Similarly, it can remove moisture from the supply airstream in climates with very hot, humid summers.
- **Unit size and location:** Some ERVs do not require a condensate drain connection, which may benefit a very space-constrained building. Both ERVs and HRVs can be selected in a range of dimensions to suit the project conditions.
- **Moisture recovery:** Suites with significant moisture generation, such as densely occupied suites, may benefit more from an HRV, because it will not transfer additional moisture to the supply airstream.



Figure 4.5 Examples of in-suite HRV units serving multiple zones. The unit on the left is actually serving an extended family home, so it has many more duct connections (one per room) than a typical MURB suite would have. The size of the unit is comparable to what would be used in a suite (images courtesy of Bernhardt Contracting Ltd.).



4.1.5 Unit selection

Not all HRV/ERVs are created equal. Units are often value-engineered to reduce first cost, with consequences to their performance in many cases. A basic understanding of the key HRV/ERV unit selection variables will go a long way toward ensuring that the unit meets expectations. Table 4.2 can be used to identify the most important equipment parameters for a particular project. After the parameters have been agreed upon, a careful review of equipment submittals and any substitution requests is recommended.

Refer to the appendices for a sample technical data sheet for an HRV/ERV. Also refer to the Home Ventilating Institute (<http://www.hvi.org/proddirectory/index.cfm>), which maintains a directory of certified HRVs and ERVs. The directory compares efficiency and other performance parameters, using a standardized testing protocol.

Table 4.2

Equipment selection parameters

PARAMETER	DESCRIPTION	EFFECT/COMMENT
PHYSICAL PARAMETERS		
Size (dimensions and weight)	<ul style="list-style-type: none"> Units are available in a variety of dimensions. 	<ul style="list-style-type: none"> Units for in-suite application can be selected with very flat or narrow dimensions, to take up minimal square footage within a suite.
Casing thickness, material and construction quality	<ul style="list-style-type: none"> Stainless steel and aluminum are common construction materials. Units can be designed for indoor or outdoor conditions. 	<ul style="list-style-type: none"> Stainless steel is thicker and more durable than aluminum. Thinner casing material will provide less sound damping and may be less durable. Joints should be sealed for airtightness. Poorly sealed joints will compromise energy efficiency through air leakage. Outdoor units should have casings rated for exterior conditions. Inadequately protected units could experience air or water leakage, reducing the equipment's performance.
Inlet and outlet locations	<ul style="list-style-type: none"> Units can have inlet and outlet ports located on any of the six faces of the unit, to suit the particular access and duct-routing requirements of the project. 	<ul style="list-style-type: none"> Outlet/inlet locations that are matched to the project design will minimize duct runs and ensure a smooth air flow pathway, increasing the efficiency of the system. The heat-exchanger configuration (cross-flow, counter-flow, heat wheel or other) will affect the available port locations.
Access door locations	<ul style="list-style-type: none"> Units typically have options for the location of the access door (side, top or bottom) for filter replacement and maintenance. 	<ul style="list-style-type: none"> The access door should be located to match the unit's installation location.
PERFORMANCE PARAMETERS		
Capacity	<ul style="list-style-type: none"> Air flow rate (L/s or cfm) should match or slightly exceed the mechanical engineer's specification at design conditions. 	<ul style="list-style-type: none"> An undersized unit might not meet ventilation requirements, while an oversized unit adds unnecessary first and energy costs.



PARAMETER	DESCRIPTION	EFFECT/COMMENT
Heat recovery efficiency	<ul style="list-style-type: none"> • Sensible recovery efficiency (SRE): Manufacturers test each HRV and ERV to determine the SRE. Because the efficiency changes at different temperature and humidity conditions, HRVs are tested to standard conditions, to allow for comparison among products. As of this publication, HRVs and ERVs in Canada are tested to Standard CSA-439. • Total recovery efficiency (TRE): This metric applies only to ERVs. Manufacturers test ERVs to determine the TRE. This test is also completed at standard conditions to allow for comparison among products. 	<ul style="list-style-type: none"> • Efficiency is a function of the quality and construction of the unit components. Units vary widely in their energy recovery efficiency (from less than 50 per cent to greater than 90 per cent), and should be selected at the highest possible efficiency that meets the project budget.
Sound performance	<ul style="list-style-type: none"> • Sound data of the unit is reported on the technical data sheet. 	<ul style="list-style-type: none"> • Sound performance can vary widely among units. A quiet unit is critical for in-suite applications. • Other system installation practices also affect vibration and sound transfer. The mechanical engineer should specify installation practices to minimize sound transfer (for example, by installing units with vibration isolation mounting).
Control options	<ul style="list-style-type: none"> • Control options determine how the occupants interact with the HRV/ERV system. • Units can have varying levels of control at both the unit and at remote manual locations. Examples include manual timed controllers in bathrooms and kitchens that increase the unit operation from low to high mode, and automatic humidistat controls at the unit. 	<ul style="list-style-type: none"> • High/low mode may be required by code (particularly if bathrooms or kitchens are connected to the HRV/ERV). • Control options should be chosen carefully to give occupants the desired level of control, while also ensuring that the overall system operates as intended (maintaining comfort, indoor air quality and appropriate humidity levels).
Frost prevention	<ul style="list-style-type: none"> • Defrosting is typically achieved by recirculating internal (exhaust) air across the core; some units are designed just to exhaust air (stopping intake of the cold, outdoor air); however, this causes an imbalance between supply and exhaust air that is less desirable. Defrosting can also be achieved by preheating outdoor air before it reaches the HRV/ERV. 	<ul style="list-style-type: none"> • Frost prevention is required in most of Canada, excepting B.C.'s Lower Mainland (climate zone 4 in National Energy Code for Buildings). • In general, an HRV will be designed to provide frost control below outside air temperatures of 2°C. ERV defrost temperatures may be lower, providing energy-saving opportunities. • HRV/ERVs can be challenging to use in colder climate zones, given the potential for frost build up; therefore, a unit with adequate defrosting capability (such as an external heater) must be selected. • Defrosting by preheating air to the HRV/ERV can use considerable energy and decrease the efficiency of the heat exchange.



4.1.6 Other design considerations

Other design considerations that can affect the performance, layout, esthetics and cost of a new MURB project include the following:

- **Ducting:** Ductwork must be selected for quality (sheet metal versus flex duct), sized appropriately and laid out with minimal transitions and bends. Poor layout and construction quality can lead to unwanted noise generation and compromise durability.
- **Grilles/diffusers:** Grilles are the louvred or perforated covers over heating and ventilation system air inlets and outlets. Diffusers are grilles designed to diffuse or spread supply air throughout a space. The size, type and location of grilles and diffusers can affect the distribution of ventilation air and occupant comfort. They should be located to deliver air across the entire occupied zone of a given room. They are also the most visible component of the ventilation system and should be selected with esthetics in mind.
- **Combustion appliances:** Specific [makeup air](#) requirements apply to suites/buildings that have naturally aspirated combustion appliances, which must be accounted for in the ventilation system. The mechanical system designer will understand and coordinate these requirements.
- **Additional space heating:** In most of Canada, additional space heating, beyond what the ventilation system can provide, will be required for the coldest days. The mechanical designer will determine how much is required, considering the project location, air volume, capacity of the HRV/ERV and interior loads. It can be provided within the HRV/ERV unit (for example, a hot-water heating coil), in distributed fan coils or independent of the ventilation system (for example, hot-water radiators).

4.2 Installation considerations

Proper installation techniques are as important as good design practices. Installation techniques should be verified by the mechanical engineer throughout the construction process, and the final installation reviewed at construction completion.

4.2.1 HRV/ERV system installation checklist

Table 4.3 is an installation checklist for HRV/ERV systems. These are items that the mechanical engineer will verify in the field to ensure that the system has been installed as intended and following good practice.



Table 4.3

Installation checklist for HRV/ERV systems

INSTALLATION CHECKLIST	YES	NO	N/A	NOTES
HRV/ERV UNIT				
HRV/ERV is located within conditioned space (if an indoor unit).				
HRV/ERV is hung from vibration-isolating straps; OR HRV/ERV is mounted on rubber or spring vibration isolators.				
HRV/ERV is accessible for filter cleaning, core removal and servicing of fans and electronics.				
HRV/ERV internal filters are installed.				
HRV/ERV internal filters are clean.				
HRV/ERV is connected to power.				
Condensate pan is connected to a wastewater drain (if applicable).				
DUCTWORK				
All four ducts running from the HRV/ERV incorporate a section of flexible duct to minimize vibration transmission.				
All sheet metal ductwork is sealed with a durable aluminum tape, liquid sealer or mastic at all joints, connections and seams.				
Outdoor-air ducts are insulated per the appropriate code.				
Balancing dampers are located along all branch ducts per the design; or air flow-adjustable diffusers and grilles are used.				
EXTERIOR AIR- AND VAPOUR-BARRIER CONTINUITY				
Where pre-insulated, flexible ducting is connected to the HRV/ERV, the exterior vapour barrier is taped to the outer ring of the double-walled port.				
Where pre-insulated flexible ducting connects to the exterior louvre or hood, it terminates with a double-walled ring and the exterior vapour barrier is taped to the outer wall of the ring.				
Where sheet metal ductwork passes through the air barrier, it is air sealed to the air barrier in a way that will last the life of the building.				



INSTALLATION CHECKLIST	YES	NO	N/A	NOTES
Exterior louvre or hood penetrations are sealed to the exterior wall air barrier.				
EXTERIOR AIR-INTAKE AND EXHAUST LOUVRES/HOODS				
Outdoor-air intakes incorporate a 6-mm (1/4 in.) mesh to prevent pest entry.				
Outdoor-air intakes are a minimum of 900 mm (36 in.) from all pollution sources (exhaust louvres or hoods, combustion vents, plumbing vents, dog runs, dumpsters, etc.) or as required by local codes.				
Outdoor-air intake for each suite is located as far from other suites' balconies, exhausts and operable windows as possible.				
Outdoor-air intakes and exhausts are accessible for cleaning.				
VENTILATION GRILLES AND DIFFUSERS				
Grilles and diffusers are specifically designed for ventilation use.				
Supply grilles or diffusers are located in the ceiling or high in partition walls.				
Supply grilles or diffusers are selected and located to ensure complete distribution across the entire room.				
Exhaust grilles are located to achieve effective removal of indoor moisture and air pollutants.				
CONTROLS				
A centrally located wall controller is installed and connected to the HRV/ERV.				
The central controller allows the occupants to switch the HRV/ERV on and off (if applicable).				
For multi-speed units, the central controller allows the occupants to switch the HRV/ERV between speeds (if applicable).				
Timer switches are located in all bathrooms serviced by the HRV/ERV (if applicable).				



5. Ventilation retrofits for existing MURBs

An HRV/ERV can be considered for any ventilation retrofit solution, because it is intended to provide optimal levels of indoor air quality and energy efficiency. This chapter identifies the typical scenarios in which a ventilation upgrade would be undertaken and describes some of the design and installation considerations particular to existing MURBs. The retrofit process can be summarized in five steps, shown conceptually in figure 5.1 on the following page and described in this chapter. Step 5 is covered in chapter 6.

Overview of the retrofit process

- **Step 1:** Identify the need or opportunity: When is a ventilation upgrade necessary or desired?
- **Step 2:** Understand the existing ventilation system.
- **Step 3:** Evaluate ventilation system retrofit options.
- **Step 4:** Design and implement the solution.
- **Step 5:** Test, balance, commission upgraded system and verify results.

5.1 Identify the need or opportunity for a ventilation retrofit

A retrofit in an existing MURB could be initiated for several reasons; however, the three most common reasons are as follows:

1. Indoor air quality is poor.

Any attempt at improving indoor air quality should start with the identification and removal of any sources of air contaminants. As described in chapter 1, moisture and pollutant loadings within a suite are affected by occupant activities and interior finishes. When improving indoor air quality, opportunities for maintenance and operational changes within the existing ventilation system should also be considered.

2. Excessive moisture (condensation) is collecting on interior surfaces.

If excessive condensation is occurring or mould is appearing on interior surfaces, it is possible that building enclosure components or assemblies are not providing adequate thermal resistance, causing interior surfaces to get too cold and create condensation. Other factors that may contribute to condensation on interior surfaces include poor distribution of air to exterior walls and windows, and unusual sources of moisture within the dwelling unit. The presence of condensation moisture does not necessarily mean that inadequate ventilation is the problem. It is important that these other potential causes of condensation be assessed and addressed while considering improvements to ventilation systems. A building science consultant can assist with this assessment.

3. The building enclosure is being upgraded.

Upgrades such as window replacement, cladding renewal or air sealing can improve airtightness. The decrease in air leakage through the building enclosure means that the overall natural ventilation rate may be inadequate and that new or upgraded mechanical ventilation capacity should be added.



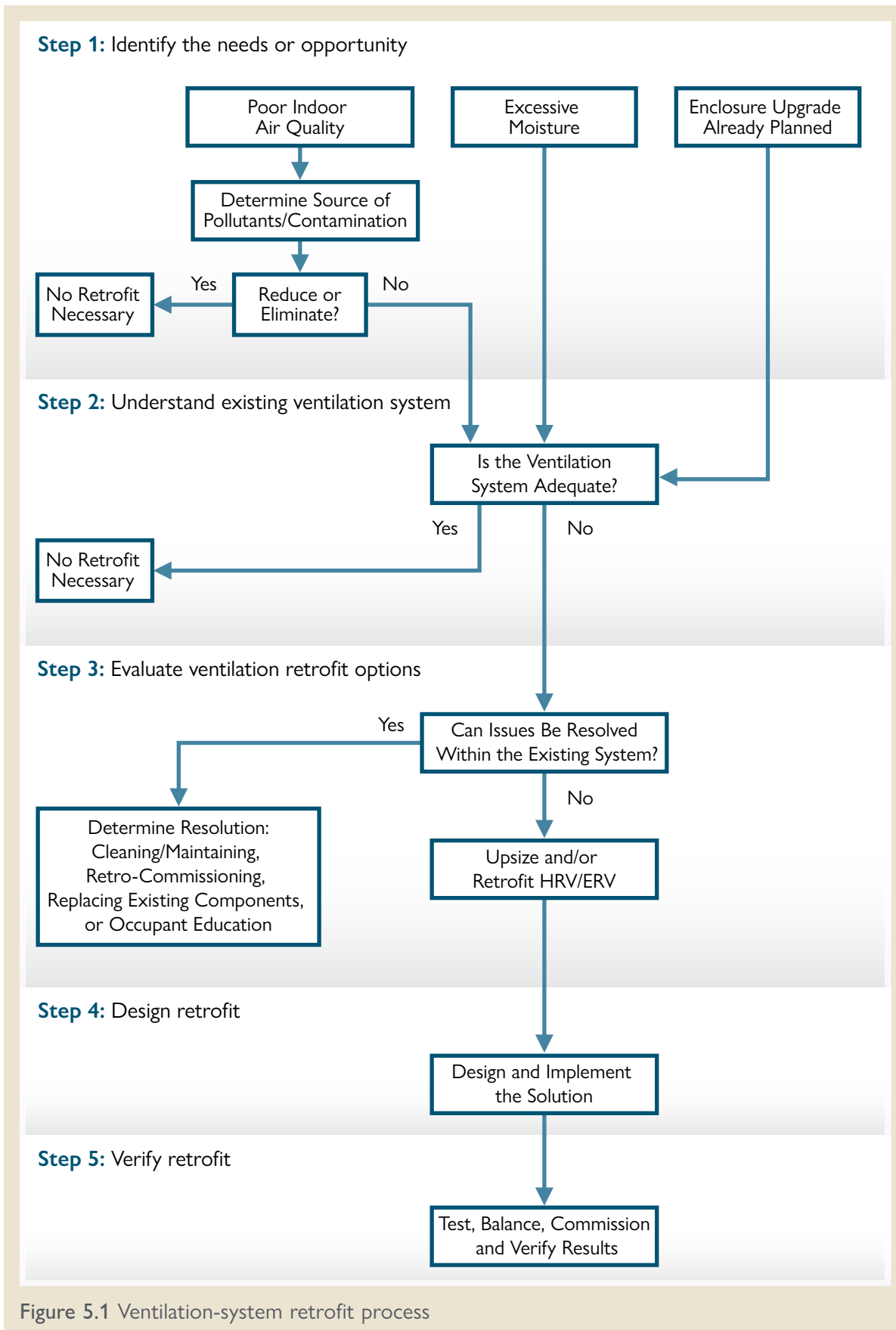


Figure 5.1 Ventilation-system retrofit process

5.2 Understand the existing ventilation system

Many existing MURBs have poor ventilation or no mechanical ventilation system. Before a retrofit is undertaken, the existing system's performance must be evaluated to inform the appropriate solution. This investigation includes assessing the performance of the existing mechanical fans and distribution system (if applicable), the airtightness of the building enclosure and the resultant ventilation rate to various interior spaces.

The **ventilation rate** within a space is the rate of exchange of indoor air to outdoor air inside a building or room. The rate is primarily determined by the mechanical ventilation system; however, the airtightness of the building enclosure plays an important role.

5.2.1 Existing mechanical ventilation system

Three main ventilation system types are described in chapter 2 (exhaust-only, supply-only or balanced). The general ventilation strategy must be understood before any upgrades can be evaluated and considered. Most MURBs constructed before the mid-1980s have intermittent exhaust-only systems, meaning that ventilation air is drawn in through the (typically leaky) building enclosure or corridor spaces, and only when the occupant turns on an in-suite exhaust fan or opens a window. In these cases, there is no dedicated mechanical ventilation system. Buildings constructed later typically have at least some minimal in-suite ventilation (for example, an exhaust fan controlled by a humidistat) and corridor pressurization.

The existing ventilation system's intended design capacity can be determined from the original mechanical drawings, equipment tags/labels or maintenance manuals. To understand actual flow rates, measurements must be taken at all exhaust outlets and air intakes while the system is in operation. A mechanical engineer or building science consultant is best suited to complete this investigation.

5.2.2 Building enclosure airtightness performance

While the airtightness of the building enclosure of a single-family home can be easily measured, airtightness of the building enclosure of a MURB is more complex, given the larger building size. Measuring airtightness for a single suite can be challenging because of the complexity of air leakage through adjacent interior walls and floors, as well as the exterior building enclosure. As a result, airtightness testing is frequently achieved by identifying a test zone or series of test zones, such as single floor of a MURB.

The airtightness of the building enclosure of a MURB is obtained by pressurizing or depressurizing the building, or a zone of the building, relative to the exterior building enclosure or adjacent zones. As of this publication, a typical test method in Canada must conform to CAN/CGSB 149.10-M86, and be undertaken by a building science engineer or qualified tradesperson. The test consists of creating a pressure difference by using fans to force air into or out of the MURB or zone of the building. The pressure difference created must be able to overcome naturally occurring pressure boundaries (for example, stack effects).



The test zone is pressurized/depressurized to a standard test pressure differential, using specialized equipment known as a fan door (see figure 5.2). Additional fans are set up to pressurize/depressurize zones adjacent to the test zone, such that the pressure difference across the boundary between these zones can be neutralized (that is, made equal to zero). In a test suite in a MURB, typical adjacent zones might include the suites above and below the test suite, suites on the same floor adjacent to the test suite and the corridor. Once all of the adjacent zones have been pressure-neutralized with the test zone, any remaining air flow from the test zone must be with the exterior.

This type of evaluation is not critical if the ventilation upgrade is intended to resolve deficiencies in the mechanical ventilation system. However, if the upgrade is being undertaken in tandem with a building enclosure upgrade, it is essential to understand the change in air leakage across the enclosure. The mechanical ventilation system can then be sized (or upgraded) to reflect this change. The evaluation can either be completed through air leakage testing, as described above, or modelling by the building science consultant.

5.3 Evaluate ventilation system retrofit options

If the existing ventilation rate is found to be inadequate, upgrade options can then be considered. Simpler options, such as cleaning the existing ventilation system, replacing components (for example, upgrading a fan or section of ductwork) or modifying controls (for example, automating fan operation) could contribute to better indoor air quality. However, if the building has an airtight enclosure and a balanced system is required, or if simpler options will not solve the problem, an HRV/ERV should be considered.

Finding space for the unit(s) and associated ductwork is likely the biggest challenge in retrofitting an existing MURB. In this scenario, it is typically more feasible to install individual in-suite systems than a centralized system. An in-suite system is self-contained; its ductwork does not need to cross interior fire/smoke separations, nor fit into typically tight corridor-ceiling space and vertical shafts; and there is no need to find space for a large, centralized unit.



Figure 5.2 Fan-door equipment setup (photo courtesy of Retrotec Energy Innovations Inc., Vancouver, B.C.)

5.4 Design and implement the solution

Once it has been established that an existing MURB will benefit from an HRV/ERV system, many of the same considerations for new construction (detailed in chapter 4) apply to a retrofit. However, there are challenges particular to retrofitting a ventilation system in an existing MURB. Some design considerations and suggestions for HRV/ERV retrofits are as follows:

- Air flow rates
 - A new, balanced HRV/ERV system will provide continuous ventilation to a space. Depending on the local code and standard requirements (see chapter 2), this will allow lower ventilation air flow rates than those required when fans are intermittently operated.
- HRV/ERV location
 - Consider locating the in-suite unit in an existing service space or laundry room, where esthetics are less important. While unit sizes vary, plan for a space of about 20 cu. ft. to accommodate the unit and ductwork entering and leaving the unit.
 - Otherwise, a ceiling in a bathroom or closet could be removed to help conceal the unit. Note that an access hatch would be required for maintenance.
 - Consider how the unit will move condensate from its drain pan to a sanitary pipe, whether by gravity or a condensate pump. If this proves prohibitive, consider an ERV, as some units in some applications will not require a drain.
- Ductwork runs
 - Where possible, use existing ductwork runs. For example, attach the HRV/ERV exhaust ports to existing exhaust ducts in bathrooms.
 - Where possible, provide supply air to each of the bedrooms or living spaces and exhaust from bathrooms, the kitchen and laundry room.
 - Conceal new duct runs in dropped ceilings, vertical chases or by opening existing walls.
- Outdoor-air inlets and exhaust outlets
 - If a building enclosure upgrade (particularly a window upgrade) is driving the ventilation system retrofit, consider designing the windows to incorporate the new outdoor-air inlets and exhaust outlets.
- Controllability
 - If previous problems (for example, excessive moisture) were caused or exacerbated by occupant behaviour, consider solutions that will minimize occupant discomfort and resultant intervention. For example, if a new HRV/ERV is very quiet and efficient, and runs automatically and continuously, occupants will be less likely to disable the system. Occupant education can accompany these efforts.

6. Balancing, commissioning and troubleshooting

This chapter provides guidance for the start-up of HRV/ERV systems, including balancing, [commissioning](#) and troubleshooting of common problems. While these issues could occur during start-up, they could also occur at any time during regular operation of the building. Depending on the system type (centralized or in-suite) and building type (rental or strata), this information will be useful for the owners, the property manager and the mechanical contractor.

6.1 Measuring and balancing air flows

Balancing the ventilation system as part of building start-up (or recommissioning for an existing MURB) will ensure that the appropriate air flow reaches each space. An air-balancing professional will measure the air flows at each outlet and adjust balancing dampers until the air flows match the original design. System supply and exhaust air flows through major trunk ducts will also be verified. Some codes and standards also require testing of duct airtightness.

Balancing dampers are used to adjust the flow rates of the HRV/ERV. They are located in main branches, and sometimes also in each of the branch ducts, to adjust the flow rates to each diffuser. Typically, once the system has been adjusted and balanced, the dampers are fixed in position. Alternatively, supply diffusers and exhaust grilles can be specified that allow flow rates to be adjusted by turning a cone-shaped plug located in the centre of the grille.

A flow-measuring station is typically used to measure the system air flow in the main trunk ducts. This device uses averaging pitot tubes that measure the average pressure across the duct and are connected to a manometer or an analog or digital pressure gauge to provide a reading. This pressure difference is then converted to air flow, using tables provided by the manufacturer. Some HRV/ERVs incorporate pressure taps that can be used in place of the flow-measuring stations to obtain air flow readings.

Table 6.1 is a list of items that the air balancer will typically check. The items that should be checked may depend on the type of system installed (centralized versus in-suite).



Table 6.1

Air flow measurement checklist

INSTALLATION CHECKLIST	YES	NO	N/A	NOTES
Air flow measuring stations are installed according to the manufacturers specifications.				
HRVs/ERVs incorporate pressure taps for measuring gross system air flows.				
HRVs/ERVs incorporate balancing dampers.				
Balancing dampers are located in the main trunk ducts.				
Gross air supply and exhaust air flows have been measured, recorded and verified with the design.				
Air flows from all supply diffusers have been measured, recorded and verified with the design.				
Air flows from all exhaust grilles have been measured, recorded and verified with the design.				
Duct airtightness has been tested and verified with the minimum leakage requirements.				

6.2 Commissioning an HRV/ERV system

Commissioning is the process through which a building or system is verified and adjusted so that it performs per the original design intent and the owner’s requirements. It is recommended for all new MURBs and all existing ones undergoing significant system changes. It is required of members of TECA and is required if the project is pursuing **LEED** certification. Guidance documentation is provided by these two organizations, as well as ASHRAE, through Guideline 0-2005: The Commissioning Process and Standard 202-2013: Commissioning Process for Buildings and Systems. Check the organizations’ websites for the most recent documentation.

Commissioning is defined by ASHARE Standard 202-2013 as “A quality-focused process for enhancing the delivery of a project. The process focuses upon verifying and documenting that all of the commissioned systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner’s Project Requirements.” For more information, visit www.ASHRAE.org.



A simplified HRV/ERV system-commissioning process will include at least the following:

- Review contractor submittals for:
 - the HRV/ERV unit;
 - interior diffusers and grilles, and exterior louvres; and
 - the control system (which may be included with the HRV/ERV).
- Inspect individual system components for proper installation.
- Test and balance the ventilation system to establish compliance with design air flow rates.
- Perform functional testing of the system in all modes of operation, verifying that the controls and sensors work, testing start-up and shutdown of major components and checking emergency and failure modes and interlocks to other equipment. Document any outstanding issues.
- Provide relevant operation and maintenance information to the owners or property manager, including a manual for the commissioned ventilation system. For larger MURBs that will have a building operator/manager, provide any necessary training to the operator/manager and unit-operation manuals to individual suite owners/tenants.
- Complete a summary report or checklist, indicating that all components of the system have been commissioned and are functioning per the design. Provide a plan for system measurement and verification and/or monitoring.

6.3 Troubleshooting common operational issues

Common operational issues and solutions are presented in table 6.2 below. Some basic troubleshooting may be performed by an owner in a strata building. In most cases, though, these issues will be addressed by either the qualified installer or the property manager.

Table 6.2

HRV/ERV operational issues and possible solutions

HRV/ERV OPERATIONAL ISSUE	POSSIBLE SOLUTIONS
The HRV/ERV is not operating.	<ol style="list-style-type: none"> 1. Verify that the HRV/ERV control is turned on. 2. Ensure that the HRV/ERV is plugged in and the electrical cord is not damaged. 3. Check for a tripped circuit breaker or blown fuse. If either has occurred, call a contractor. Do not reset the breaker or replace a fuse before determining what caused the electrical problem, as this is a fire or shock hazard. 4. If the problem persists, contact the installer.
The HRV/ERV is operating, but there is little or no supply air flow.	<ol style="list-style-type: none"> 1. Check the exterior hoods and associated ductwork for blockage and clean as required. 2. Check the filters and clean or replace as required. 3. Check the indoor ducts and registers in rooms for blockage (closed dampers, lodged items, etc.). 4. Check the core for freezing/frosting. 5. Check all ducts for leakage or disconnection. Seal any loose joints with aluminum foil tape. 6. If the problem persists, contact the installer.
The core has frozen.	<ol style="list-style-type: none"> 1. Open the access panel and let any ice melt. Some cores can be easily removed and thawed in a sink. 2. Check the filters and clean or replace as required. 3. With some HRV/ERV models, the defrost mechanism or preheater can be checked by following the manufacturer's instructions in the owner's manual. 4. If the problem persists, contact the installer. The system may have to be rebalanced or additional heating may be required.
A duct insulation jacket is damaged.	<p>Light damage</p> <ul style="list-style-type: none"> • If the insulation is torn but not seriously damaged, use aluminum foil tape to repair any punctures in the jacket. <p>Major damage</p> <ul style="list-style-type: none"> • If the insulation is wet, has a buildup of ice or if there is water on the floor, check that all seams and joints in the ductwork are air sealed with aluminum foil tape or a mastic sealant. If not, air seal all seams and joints and then replace and seal the damaged insulation and exterior vapour barrier.



HRV/ERV OPERATIONAL ISSUE	POSSIBLE SOLUTIONS
<p>There are cold drafts coming from the supply grilles.</p>	<ol style="list-style-type: none"> 1. Check if the exhaust or return air stream is blocked. 2. Check the core for freezing. 3. Check placement of supply air ducts and insulation, if they are running within unconditioned or concealed cold spaces. 4. If the problem persists, consider the following alternatives, as appropriate, which may require the installer's assistance: <ol style="list-style-type: none"> a. Provide new diffusers. b. Relocate supply air outlets. c. Add additional supply air outlets. d. Add a preheater.
<p>There is poor air quality, excess moisture or high humidity throughout the suite/building.</p>	<ol style="list-style-type: none"> 1. Adjust the humidistat (if applicable) to provide more dehumidification. 2. Check the core for freezing. 3. Reduce sources of interior humidity through the following measures (to be coordinated with suite occupants): <ol style="list-style-type: none"> a. Don't hang laundry to dry inside. b. Put lids on cooking pots and use the kitchen exhaust fan. c. Clean dryer lint traps. d. For more tips on reducing interior moisture, visit the Homeowner Protection Office website at http://www.hpo.bc.ca 4. Run the HRV/ERV at a higher speed.
<p>Air is too dry in the winter.</p>	<ol style="list-style-type: none"> 1. Adjust the humidistat (if applicable) to provide less dehumidification. 2. Run the HRV/ERV on the lowest setting. 3. Run the HRV/ERV intermittently or install controls to automatically run the unit intermittently. 4. Consider installing an ERV, which will increase winter humidity, instead of an HRV. Some HRVs can be converted to ERVs, at less cost than installing a new unit, by changing the core.
<p>The unit gives off unusual noise and vibrations.</p>	<ol style="list-style-type: none"> 1. Oil the fan motors (if not self-lubricating) using non-detergent motor lubricating oil and as recommended by the manufacturer. 2. Inspect and clean the fan blades and heat-exchange core as required.



7. Operation and maintenance of HRVs and ERVs

This chapter provides guidance on the operation and maintenance of HRV/ERV systems. Operational responsibilities will vary, depending on the system configuration, although most occupants will have at least some level of control. In most MURBs, maintenance will be performed by the property manager or a service contractor, particularly for centralized systems. For in-suite systems in strata buildings, owner occupants may undertake simpler maintenance tasks.

Regardless of the system type and ownership model, all occupants should be educated on the purpose of the system, how it operates and how to interact with it. One of the biggest factors in consumer satisfaction with ventilation systems is the consumers' own understanding of how to operate and maintain their systems. The builder's representative, property manager or service contractor can facilitate this understanding and explain any occupant responsibilities at move-in or project completion. Details of this process are described below.

7.1 Start-up

At project completion, the system installer should provide the building or suite owner, property manager or service contractor with product data, warranty information and the HRV/ERV operation and maintenance (O and M) manual, and provide any training particular to the unit. Information should be included for local service providers and suppliers about serviceable components.

7.2 Training for new owners or occupants

For new occupants of both strata and rental buildings, the builder's representative or property manager can explain that the ventilation system is the primary supplier of outdoor air in the suite. Include the following key points:

- Although windows can be opened at any time of the year, they will not necessarily enhance indoor air quality and in many cases will lead to increased heating and cooling costs.
- The HRV/ERV is intended to operate (at least at low speed) continuously to remove moisture and pollutants generated by normal human activities and to maintain good indoor air quality.
- Shutting off the HRV/ERV for prolonged periods can lead to a buildup of indoor air pollutants and humidity, and could also void warranties on the system.

MODES OF OPERATION

- **Manual operation** requires the occupant to turn the ventilation system on and off.
- **Automatic operation** uses controls such as timers, humidistats and occupancy sensors to operate the ventilation system. The occupant needs to understand which sensor or timer is activating the system.
- **Continuous operation** ensures that the suite is always ventilated, but may result in over- or under-ventilation at times. All ventilation systems must include manual controls, even if the occupant installs automatic controls or plans to operate the ventilation system continuously.
- **High/low operation** uses a two-speed fan that normally operates on low speed, but switches to high speed when increased ventilation is called for. High-speed operation may be initiated by manual or automatic controls.



- Below are basic operational topics that should be covered with all new occupants:
 - **Basic operating modes:** Units can be specified with a range of operating modes (see inset). The occupant should understand which operational options are available for the system, and what they can control within their suites.
 - **Programming the humidistat:** If a central humidistat is used to raise or lower the ventilation rate of an HRV system, it can be programmed or manually adjusted to respond to seasonal changes. For example, the humidistat can be set to high during warmer months. The setting should be based on what the occupants find comfortable, but should always be low enough to prevent condensation from forming on the windows. The typical range is between 30 and 60 per cent relative humidity (RH).
 - **Scheduling:** If a timer is used and programmed to occupants' schedules, occupants should be shown how to program the timer. For hourly schedules, daylight saving time may necessitate reprogramming twice per year.

One question that occupants often raise is whether the system clears moisture from bathrooms too slowly after showering. In typical HRV/ERV systems, the low-volume continuous ventilation rate in bathrooms is 10 L/s. This rate is typically doubled when the HRV/ERV is switched to high speed. This might not clear humidity from the bathroom as quickly as some bathroom exhaust-only fans do. However, the continuous ventilation provided by an HRV/ERV system will dry the bathroom more effectively over time than an exhaust fan would.

7.3 Maintenance

HRV/ERV systems are intended to operate 24-7 and, like all mechanical equipment, will require regular preventive maintenance. Maintenance tasks for centralized and in-suite units are similar and will typically be performed by the property manager or a service contractor. Owner occupants with in-suite units may undertake simpler maintenance tasks and should be trained accordingly. Annual servicing by a mechanical contractor accredited by HRAI or TECA is recommended for all systems.

Below are listed common preventive maintenance tasks for HRV/ERVs:

- Check and clean or replace dirty filters.
- Check and clean the drain pan (if applicable), as dirt and insects can accumulate. The drain pan at the bottom of the unit will be connected by a clear plastic tube either to a plumbing drain or condensate pump. During a new building's first year, the unit will generate more condensate than normal, as the building's interior finishes and structure dry. The tube should be inspected annually by pouring two litres of warm clean water in the drain pan and ensuring that the water drains freely.
- Check and clean or replace the HRV/ERV core.
- Check the outdoor-air intake hood for blockage. The metal screen located in the intake hood may become blocked with grass, dirt, leaves and other small debris, and should be checked and cleaned at least twice a year.



- Check and clean grilles/diffusers. Over time, dirt can accumulate on exhaust and supply grilles/diffusers. In most cases, they can be pulled out of the end of the duct, washed with a mild soap solution and dried before being reinserted. While the end of the duct is exposed, the inside of the duct can also be vacuumed.
- Clean fan blades. With the unit shut off, remove dirt that has accumulated on the fan blades with a brush or soft cloth.
- Lubricate fan components. Most HRV/ERV fans are designed to run continuously without lubrication, but some may require occasional attention. Refer to the product manual for the correct procedure.

Table 7.1

Table 7.1 is an example of an ERV/HRV maintenance checklist, with the suggested frequency for performing each task. The list can be photocopied and attached to the unit or used by the primary servicer to schedule and record maintenance tasks that will keep the units operating in prime condition. Blank rows are provided for additional related maintenance activities for a specific system.

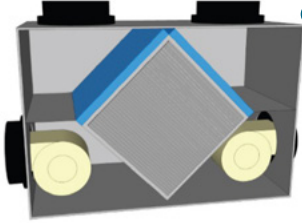
HRV/ERV MAINTENANCE CHECKLIST						
MAINTENANCE TASK	RECOMMENDED FREQUENCY	DATE MAINTENANCE WAS PERFORMED				
Clean exterior intake hood.	3 months					
Clean or replace internal HRV/ERV filters.	3 months					
Replace external HRV/ERV filters, if filter box is used.	3 months					
Inspect HRV drain tube.	3 months					
Clean fan blades.	6 months					
Clean HRV/ERV drain pan.	6 months					
Clean exhaust and supply grilles.	12 months					
Lubricate fans, if required.	12 months					

Appendices

Sample HRV/ERV product data sheet

Manufacturer **Image of unit** **Model**

BEST HRV/ERV MANUFACTURER **Model XY1000 ERV**



Specifications: General information about the HRV/ERV

Specifications:




Model: BEST HRV/ERV XY1000
Total Assembled Weight: 50 lbs (22.7 kg)
Shipping Dimensions: 29-1/2" x 21-1/2" x 14 1/2" (75.0 cm x 54.5 cm x 291.0 cm)
Cabinet: 20 ga. Pre-painted steel
Filters: MERV 8, spun polyester media 7-1/2" x 10 1/2" x 1" (191 mm x 267 mm x 25 mm)
Collar Size: Round, 5" (127 mm)
Electrical: 120V, 60 Hz, 84W, 0.7A
Energy Recovery Core: Cross-flow, washable foam 8-3/4" x 6-3/4" x 1/2" 222 mm x 171 mm x 13 mm

Heat Exchange Surface Area: 56 ft² (5.2 m²)
Fans/Motors: High-efficiency PSC motors
Mounting: Suspended by chains and springs

Ventilation Performance: Data on the ventilation rates at various static pressures

Ext. Static Pressure in wg (Pa)	Net Supply Airflow cfm (L/s)	Gross Airflow	
		Supply cfm (L/s)	Exhaust cfm (L/s)
0.1 (25)	116 (55)	119 (65)	125 (59)
0.2 (50)	113 (53)	116 (55)	121 (57)
0.3 (75)	107 (50)	111 (52)	115 (54)
0.4 (100)	104 (49)	107 (50)	112 (53)
0.5 (125)	98 (46)	101 (48)	105 (50)
0.6 (150)	94 (44)	97 (46)	100 (47)
0.7 (175)	88 (42)	91 (43)	95 (45)
0.8 (200)	82 (39)	84 (40)	90 (42)

Relevant certifications and memberships

Energy Performance: Data on the energy used by the unit and the energy transferred in the core of the unit

Supply Air Temperature °F (°C)	Net Supply Airflow cfm (L/s)	Power Consumed Watts	Sensible Recovery Efficiency %	Apparent Sensible Effectiveness %	Latent Recovery/Moisture Transfer
Heating					
32 (0)	28 (13)	73	69	94	0.68
32 (0)	96 (45)	137	62	74	0.48
-13 (-25)	54 (25)	102	54		0.58
Cooling					
95 (35)	29 (14)	70		54	
			Total Recovery Efficiency		
			54		

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 Efficiency Town, Ontario
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 Fax: (800) 7654-321
 E-mail: sales@bestHRVERV.com

BEST HRV/ERV

BestHRV.com

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Glossary

Air barrier - The materials and components of the building enclosure or of compartmentalizing elements that together control air flow through the assembly.

Air leakage - Air that unintentionally flows through a building enclosure or compartmentalizing elements. This is often quantified as the “normalized leakage rate” [cfm/sq. ft. or L/s·m²] or simply the “leakage rate” [cfm or L/s].

Airtightness - The ability of a building enclosure or compartmentalizing element to resist air flow. A system that is more airtight has higher resistance to air flow. This is often quantified as the “normalized leakage rate” [cfm/sq. ft. or L/s·m²] or simply the “leakage rate” [cfm or L/s].

ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers.

Air flow - The movement of air from one space to another. Usually measured in cfm or L/s at a specific reference pressure.

Backdrafting - The situation when a space becomes sufficiently depressurized that products of combustion of fuel-fired appliances are drawn into the occupied zone.

Building enclosure - The part of a building that separates the interior environmental conditions from the exterior environmental conditions, including the control of precipitation, water vapour, air and heat.

Commissioning - A quality-focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that all of the commissioned systems and assemblies are planned, designed, installed, tested, operated and maintained to meet the owner’s project requirements (ASHRAE Standard 202-2013).

Compartmentalization - Separating a volume (floor, room, suite, office, etc.) within a larger building volume with the primary intention of controlling air flows into and out of the space. Compartmentalization is typically performed for fire, smoke, odours and acoustic separation; however, it can also be important for HVAC control.

Condensation - The change in state of water from vapour to liquid. Often materializes as water on a surface that is below the dew-point temperature of the air.

Condition - The process of heating, cooling, humidifying, dehumidifying and cleaning (that is, filtering) the air in a space such that it is of the desired temperature, humidity and quality.

cfm - cubic feet per minute (cu. ft./min).

CGSB - Canadian General Standards Board.

Depressurization - The process of creating negative pressure inside a building or space relative to the surrounding conditions, by removing air from the space with a fan.

Dew-point temperature - The temperature at which the air would be saturated with water vapour (100 per cent relative humidity).

Exhaust air - Air that is removed from a space by a mechanical system (such as a fan) as part of the ventilation strategy.

HVAC - Heating, ventilation and air conditioning. Refers to the equipment used to condition the interior spaces of a building.

Indoor air quality - The nature of air inside a building that affects the health and well-being of building occupants.



LEED - Leadership in Energy and Environmental Design.

Makeup air - Air that is brought into a space to maintain the mass balance of air when air is exhausted from that space.

Makeup air unit (MUA) - An air-handling unit that conditions and supplies 100 per cent outside air with no recirculation. Used to replace air that is drawn out of a building by exhaust fans or other means.

Mechanical ventilation - The process of supplying and removing air through an indoor space via mechanical systems such as fans and air-handling units. Also referred to as a “forced air” system.

Naturally aspirated - A feature of combustion appliances that draw their combustion air from the surrounding air (as opposed to an appliance that has combustion air ducted directly to it).

Natural ventilation - The process of supplying and removing air through an indoor space without using mechanical systems such as fans. It refers to the flow of external air to an indoor space as a result of pressure or temperature differences.

Outdoor air - Ambient air from the exterior that enters a building through a ventilation system, through intentional openings for natural ventilation, or by infiltration.

Pressurization - The process of creating positive pressure inside a building or space relative to the surrounding conditions with a fan.

Relative humidity (RH) - The proportion of the moisture in the air compared to the amount of moisture the air could hold at that temperature.

Sensible recovery efficiency (SRE) - Standardized value used to predict and compare energy performance of HRVs and ERVs. It is equivalent to the ratio of sensible energy transferred between the two airstreams, compared with the total energy transported through the heat exchanger. It corrects for the effects of cross-leakage, purchased energy for fan and controls, as well as defrost systems.

Stack effect - The natural pressure differentials that develop across the building enclosure as a result of buoyancy forces, due to the difference in temperature between the interior and exterior of a building.

Supply air - Air provided to a space by a mechanical system (such as a fan) as part of the ventilation strategy.

Total recovery efficiency (TRE) - Standardized value used to predict and compare energy performance of ERVs. It is equivalent to the ratio of total (sensible + latent) energy transferred between the two airstreams, compared with the total energy transported through the heat exchanger. It corrects for the effects of cross-leakage, purchased energy for fan and controls, as well as defrost systems.

Ventilation - Refers to the supply and exhaust of air from spaces to maintain indoor air quality by diluting and extracting contaminants.





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