Heat Recovery Ventilation Guide for Multi-Unit Residential Buildings

British Columbia

BC Housing

BC hydro powersmart

City of Vancouver

Canada

Purpose of the Guide

This guide will assist designers, developers, builders, contractors and owners gain a better understanding of heat recovery ventilators (HRVs) and energy recovery ventilators (ERVs) and how they can support healthy and comfortable indoor living environments in multi-unit residential buildings (MURBs). Topics include:

- Why ventilating MURBs is important;
- Existing ventilation system code requirements;
- How HRVs and ERVs work;
- The importance of early planning to facilitate HRV/ERV installation and to ensure efficient and effective operation;
- System design considerations for both new MURBs and existing MURB retrofits; and
- Important balancing, commissioning, maintenance and operation considerations.

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

Acknowledgments

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Disclaimer

This guide reflects an overview of current good practice in the design and installation of residential heat recovery ventilation systems; however, it is not intended to replace professional design and installation guidelines. 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. Use of the guide does not relieve designers and installers of their responsibility to comply with local building codes, standards, and bylaws with respect to the design and installation of a MURB ventilation system.

The greatest care has been taken to confirm the accuracy of the content. However, the authors, funders, publisher, members of the project Technical Steering Committee and other contributors assume no liability for any damage, injury, loss or expense that may be incurred or suffered as a result of the use of this publication, including products, building techniques or practices. The views expressed do not necessarily represent those of any individual contributor.

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1. Introduction

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

1. To provide fresh air for occupants to breathe.
2. To dilute or remove contaminants. These contaminants can include any of the following:
    a. Moisture generated by people, pets, and plants, and by activities such as cooking and showering.
    b. Contaminants and odours generated by interior sources including people, plants, cooking, household cleaners, and off-gassing of interior finishes and furnishings.
    c. Contaminants from exterior air including dust, particulates, allergens, and mould.

Poor indoor air quality has reported impacts on human health, particularly for the young, the elderly, and those with sensitivities. Impacts can include increased asthma, headaches, and fatigue. Health Canada publishes *Residential Indoor Air Quality Guidelines*, which advise on recommended exposure limits for a range of indoor pollutants, including benzene, carbon monoxide, fine particulate matter, formaldehyde, mould, naphthalene, nitrogen dioxide, ozone, and toluene[1] - all of which can be found in residences. While source control is an essential first step toward limiting exposure to indoor pollutants[2], adequate ventilation (paired with filtration) is a critical means of establishing and maintaining indoor air quality.

There are two traditional approaches to providing ventilation to a space:

1. Natural (passive) ventilation, where airflow is driven by natural pressure differentials through open windows, doors, grilles, and other planned penetrations.
2. Mechanical ventilation, where airflow is planned and controlled using fans and associated ductwork, grilles, diffusers and vents.

Natural ventilation can cause drafts, comfort problems, and higher space heating and cooling energy consumption and costs. Additionally, natural ventilation is unpredictable and not always available when and where needed. Mechanical ventilation offers a more efficient, predictable and secure mannner of ventilation in comparison to open windows. Many MURBs are designed to incorporate both mechanical and natural ventilation features, although most codes now require a mechanical ventilation system to achieve required ventilation rates.

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[1] http://healthycanadians.gc.ca/healthy-living-vie-saine/environment-environnement/air/guidelines-lignes-directrices-eng.php

[2] Sources of air contaminants and moisture can be addressed in three ways:

- Source removal: For example, storing contaminants and pollutants (such as cleaning products or paints) outside the living space and using appropriate filters to remove contaminants from the incoming air.
- Substitution: For example, selecting low-emitting interior finishes and furniture.
- Source containment: For example, storing contaminants and pollutants in sealed containers.

1.1. Objectives of Mechanical Ventilation

To be effective, mechanical ventilation systems must be able to:

1. Exchange indoor air with outdoor air;
2. Distribute ventilation air to most rooms and exhaust air from kitchens, bathrooms and laundry rooms;
3. Circulate ventilation air within the rooms; and
4. Treat the ventilation air so that it is acceptable to the occupants.

In a MURB, these objectives may be achieved by either a centralized system serving multiple suites, or a decentralized system serving individual suites.

1.1.1 Exchange

To exchange indoor air with outdoor air with any effectiveness and reliability, a motorized fan is needed. An exhaust fan (such as a bathroom fan, range hood, or cooktop fan) can be used to push air out of a suite or building and, in so doing, draw air back in to replace that which was exhausted. Alternatively, a supply air fan could be used to drive air exchange, but a supply-only approach can pressurize the building or suite and drive moisture-laden air into the building envelope, where it can lead to the deterioration of structural elements and finishes and potentially to mould growth.

1.1.2 Distribute

To distribute ventilation air to all the rooms of a suite, ventilation systems need ducts that run between the supply air fan and each room served. Where rooms are connected (e.g., a living room and dining room), one duct might be sized and installed to serve both rooms. Ventilation air is usually distributed to the rooms where occupants spend more time including bedrooms, the kitchen, living and dining rooms, family rooms, recreation rooms and workshops.

1.1.3 Circulate

When the ventilation air is delivered to the room, the ventilation system should be capable of fully circulating that air, meaning that it is delivered evenly throughout the occupied space. Circulation is achieved by careful placement of both the supply air diffusers and exhaust grilles, and ensuring that the air is delivered with sufficient speed and direction so that it spreads out into the room once delivered.

1.1.4 Treat

As ventilation air is drawn from outdoors, it may have to be treated to ensure that it is acceptable to the occupants. Treatment can include pre-heating or pre-cooling, filtering, humidification and dehumidification. This is an important and often under-appreciated element of ventilation systems; if occupants experience discomfort with ventilation air, they may take steps to alter or undermine the system.

1.2. Methods of Mechanical Ventilation

Traditionally, mechanical ventilation has been achieved through the provision of bathroom fans and kitchen fans. However, while an “exhaust-only” approach provides ventilation for the room where the exhaust fan is located, it offers no assurance that “fresh” air will be drawn into the other rooms from desirable locations in the quantities needed. Further, the outdoor air drawn into the building or suite to replace the exhausted air represents a significant space heating and cooling load that can inflate utility bills.

One of the most pressing concerns is that an improperly designed or installed exhaust-only system can back-draft fuel-fired appliances, such as furnaces and water heaters, causing dangerous combustion gases to be drawn into a suite.

HRVs were developed to overcome the shortcomings associated with conventional approaches to naturally or mechanically ventilating buildings – particularly those that were designed and constructed to meet improved energy efficiency and indoor air quality objectives. Over the years, the design and manufacture of HRVs has improved, performance and reliability have increased, standards have been developed, and training/education programs for design and installation contractors have been deployed.

HRV/ERVs provide a well-engineered and efficiently packaged means of meeting the relatively demanding mechanical ventilation system requirements of most building codes. Further, they offer a much more affordable, effective and efficient means of ventilating a building. This guide provides an overview of the considerations that can help ensure that HRV/ERV systems meet expectations.

2. MURB Ventilation Practices

2.1. Codes and Standards

The fabrication, design, and installation of ventilation systems and their components are guided by technical requirements that vary between jurisdictions.

The table on the following page provides a general outline of the main ventilation codes and standards that impact the design of ventilation systems for major jurisdictions in Canada. This table does not provide a complete review of code and standard requirements, and is not intended to replace the designer's required code reviews.

Part 6 of the National Building Code (NBC), adopted by most provinces, requires the use of a mechanical ventilation system in all new MURBs. The requirements with the most direct impact on the design of the ventilation system are outlined below:

- *Design and installation requirements for ventilation systems and indoor air quality (IAQ)*: Part 6.2.2 of the NBC requires a mechanical ventilation system in conformance with ASHRAE[1] 62 (or Section 9.32.3 for self-contained mechanical ventilation systems that serve only one dwelling unit).
- *Design requirements for energy performance*: ASHRAE 90.1 and/or the National Energy Code for Buildings (NECB) provide ventilation system requirements for energy efficiency, and are referenced by most provincial codes.
- *Performance of HRV/ERVs*: Section 5.2.10 of the NECB prescribes minimum performance requirements if an HRV/ERV is used. 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. Performance test standards define how a manufacturer determines energy efficiency and other performance characteristics.

HRV/ERV performance standards are also referenced by energy efficiency programs such as ENERGY STAR®[2]. The installation of an ENERGY STAR® qualified HRVs is often required when applying for energy efficiency incentives.

[1] Refers to a recognized standard developed by the American Society of Heating, Refrigerating and Air-Conditioning Engineers.

[2] 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. www.nrcan.gc.ca/energy/products/for-participants/specifications/13695

Table 2.1 HRV/ERV Codes and Standards for Major Jurisdictions in Canada

Code	Jurisdictions	Ventilation	Energy Efficiency	HRV Performance	HRV Installation
National Building Code 2010	SK, MB, NB, NS, PEI, NFL, YK, NWT, & NV	6.2.2.1 All Buildings or 9.32.3 Single Dwelling Unit	-	9.32.3.10 Fan Ratings and 9.32.3.12 HRVs	6.2.1.6 Small HRV Installation
National Energy Code for Buildings 2011	BC, MB, ON, NS	-	5.2.10 Heat Recovery and 5.2.10.4 (Single Dwelling Unit)	-	5.2.2.3 Duct Sealing and 5.2.2.4 Duct Testing and 5.2.2.5 Duct Insulation
British Columbia Building Code 2012	BC	6.2.2.1 All Buildings or 9.32.3 Single Dwelling Unit	10.2.1.1 Energy and Water Efficiency Design	-	6.2.1.6 Small HRV Installation
Vancouver Building Bylaw 2012	Vancouver	6.2.2.1 All Buildings or 9.32.3 Single Dwelling Unit	1.3.3.7 Energy Use Compliance	-	6.2.1.6 Small HRV Installation
Alberta Building Code	AB	6.2.2.1 All Buildings or 9.32.3 Single Dwelling Unit	12.2.1.1 Energy Efficiency	9.32.3.10 Fan Ratings and 9.32.3.12 HRVs	6.2.1.6 Small HRV Installation
Ontario Building Code	ON	6.2.2.1 All Buildings or 9.32.3 Single Dwelling Unit	12.2.1.1 Energy Efficiency	9.32.3.11 (HRVs)	6.2.1.6 Small HRV Installation
Quebec Construction Code 2010	QC	6.2.2.1 All Buildings or 6.2.2.9 and 9.32 Dwelling Units	11 Energy Efficiency 9.32.3.3 and 6.2.2.8 or Art. 136 (REENB-1983)	6.2.2.9 and 9.32.3.3 or Art. 139 (REENB-1983)	9.32.3.3(2) (Group C Buildings without central vent.) 6.2.2.9 (Group C buildings with central vent.)
ASHRAE 62-2001 ASHRAE 62-2004	MMAH SB-10 ASHRAE 90.1-2004	ASHRAE 90.1-2010 ANSI/AHRI-1060	CSA-F326-M91 CAN/CSA-C439	*Ventilation* rate based on type and number of rooms Exhaust rate based on number of bedrooms	

2.2. Mechanical Ventilation Strategies

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

- **Natural Ventilation**

  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 complicated as a group of operable windows and passive air vents strategically located to provide ventilation to an entire building or suite. While natural ventilation through operable windows may provide a complementary means of ventilation for MURBs, most codes require a mechanical ventilation system as the primary means.

  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 if one is present. Finally, providing ventilation air through windows does not enable the removal of exterior air contaminants, as a mechanical system with filtration would.

- **Exhaust-only system**

  Exhaust-only systems rely on one or more fans to exhaust stale air from the suite(s) (see Fig. 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 to adjacent spaces when the fan(s) are operating. This type of system is more common in Part 9 buildings. This approach is not supported by later versions of ASHRAE 62 (e.g., 62.1-2007), which require ventilation air to be delivered directly to bedrooms and living rooms, although several codes (including the 2012 BC Building Code) reference 62-2001, which only requires minimum bathroom and kitchen exhaust rates.

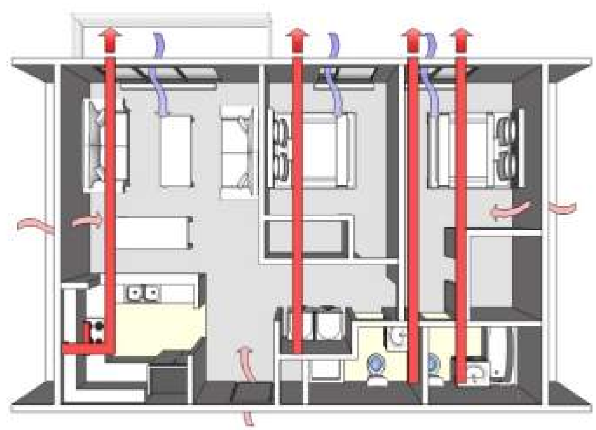


Fig. 2.1 A basic exhaust-only ventilation system that consists of bathroom exhaust fans and a kitchen range hood exhaust fan.

- **Supply-only system**

  Supply-only systems use fans to automatically deliver outdoor air into the suite(s) (see Fig. 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 provide the advantage of being able to filter outdoor air. However, when the exhaust fans are not operating, the ventilation supply places the suite under

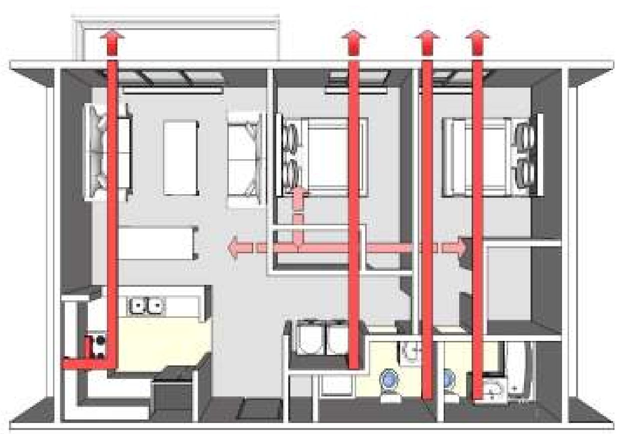


Fig. 2.2 A basic supply-only ventilation system.

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. Corridor pressurization has often been used as a means of supplying air to suites via door undercuts; however, research shows that very little corridor pressurization air finds its way into a suite and cannot be relied upon as an effective means of delivering ventilation air. A recent study of typical existing MURBs showed that only 20% 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.[3]

This approach is not supported by later versions of ASHRAE 62 (e.g., 62.1-2007), which require ventilation air to be delivered directly to bedrooms and living rooms, although several codes (including the 2012 BC Building Code) reference 62-2001, which only requires minimum bathroom and kitchen exhaust rates.

- **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 is linked to a central exhaust fan that exhausts from bathrooms, kitchens, and laundry rooms at the same time (airflow supply and exhaust can increase or decrease based on occupancy).

  > A central HRV/ERV that continuously supplies air to all suites, and exhausts from bathrooms, kitchens, and laundry rooms.

  > Decentralized in-suite supply and exhaust fans that operate at the same time.

  > Decentralized in-suite HRVs/ERVs that operate continuously within each suite (see Fig. 2.3).

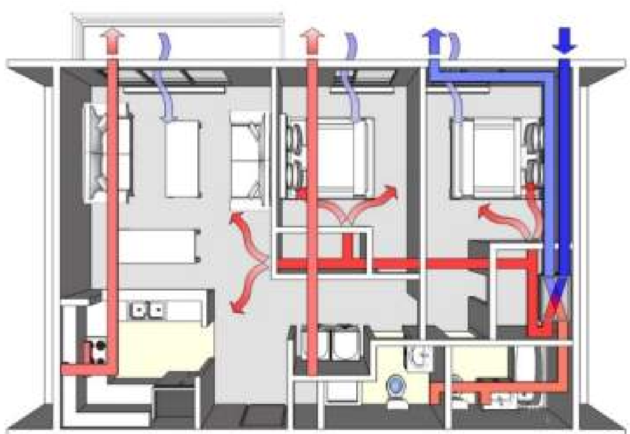


Fig. 2.3 Balanced supply and exhaust from HRV system centrally located in each suite

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.

[3] Ricketts, L. (2014) *A Field Study of Airflow in a High-Rise Residential Building.* http://rdh.com/wp-content/uploads/2015/01/CCBST-2014-A-Field-Study-of-Airflow-in-High-Rise-Multi-Unit-Residential-Buildings-LR-JS.pdf

3. Heat and Energy Recovery Ventilation

Buildings are intended to be conditioned to a comfortable temperature and relative humidity for human occupancy. Heating can account for over 50% of annual energy consumption in MURBs. Since typical ventilation systems introduce unconditioned outdoor air and exhaust conditioned indoor air, there is potential for energy savings by incorporating heat transfer between the two air streams. This can work both during the winter, when warm exhaust air pre-heats the intake air, and during the summer, when cooler air-conditioned 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 equal quantities of air to and from a building or suite while transferring heat between the two air streams (with minimal mixing of air in the two streams). This reduces the energy consumption associated with heating or cooling ventilation air while providing a balanced ventilation system. Heat recovery also helps condition the incoming outdoor air to temperatures that are more acceptable to the occupants.

3.1.1 HRV Components

HRVs typically consist of the following components (see Fig. 3.1):

- An airtight insulated case
- Supply and exhaust fans
- Outdoor air inlet from outside (shown with insulated duct connected)
- Outdoor supply air outlet (shown with duct connected)
- Exhaust air inlet (shown with duct connected)
- Exhaust air outlet to outside (shown with insulated duct connected)
- Heat exchanger
- Condensate drain pan connecting to a drain
- Sensors and controls
- Removable /cleanable filters
- In some cases motorized dampers to aid in defrost

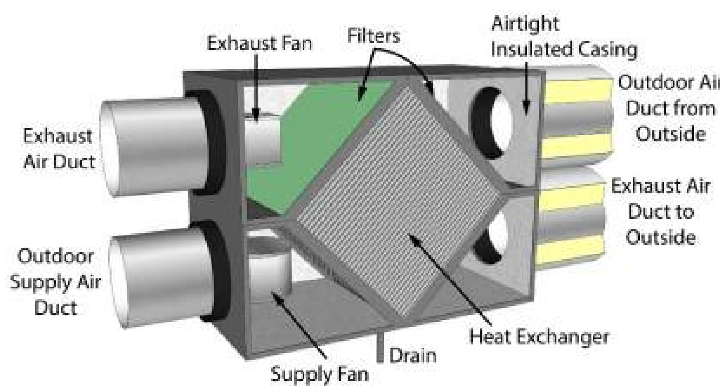


Fig. 3.1 Parts of a heat recovery ventilator (condensate pan not shown).

The heat exchanger core of an HRV is constructed from a series of parallel plates that separate the exhaust and outdoor air streams. These plates are typically fabricated of metal or plastic. The air streams can flow in perpendicular directions (cross-flow) or in opposite directions (counter-flow), as shown in Fig. 3.2. Counter-flow cores are more efficient at transferring heat but are more difficult to manufacture than cross-flow cores. As a result, cross-flow cores are more common.

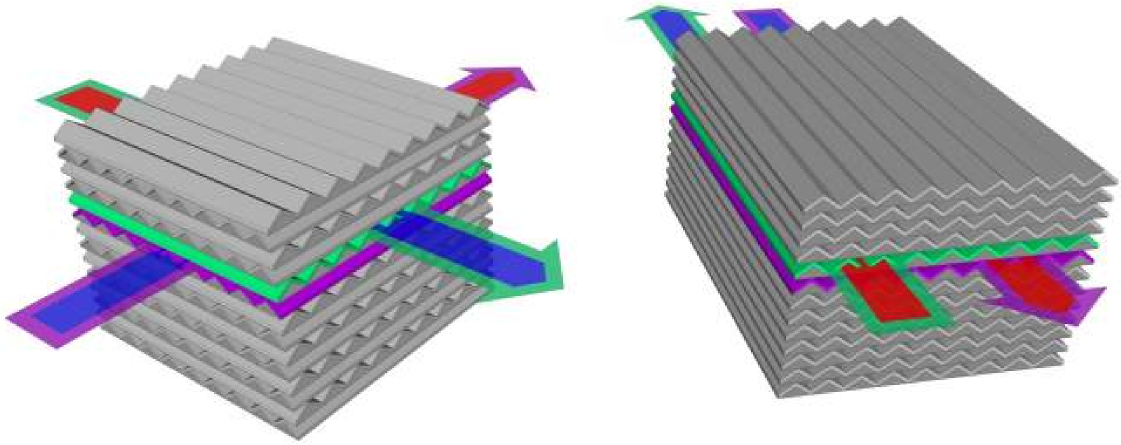


Fig. 3.2 Cross-flow core (left) and counter-flow core (right).

3.1.2 HRV Operation

The two airflow paths in a cross-flow core are illustrated in Fig. 3.3. Outdoor air (1), enters the HRV and passes through the heat exchanger core (2), where it is pre-heated by heat transferred from the outgoing exhaust air (4). It is then supplied to the suite or building via a supply fan and ductwork system (3). A separate duct system and exhaust fan draws exhaust air from the space into the HRV (4), passes it through the heat exchanger (2) (transferring heat to the supply stream), and exhausts it to the outdoors (5). These processes occur simultaneously, and, if the HRV is set up properly, create a balanced system with equal supply and exhaust airflows.

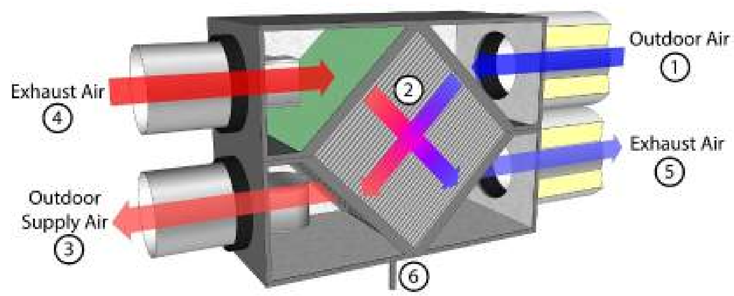


Fig. 3.3 HRV winter operation.

When heat is transferred from the exhaust to the outdoor air stream during the heating season, condensation can form inside the heat exchange 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).

In persistently colder winter conditions, the condensation inside the core can freeze and block the exhaust air stream. Some HRVs are designed to protect against freezing and to clear the core of ice by going automatically into defrost mode. This is typically accomplished by a damper that closes off the outdoor air supply and allows warm indoor air into the HRV to heat the core and melt any ice on the exhaust side. When operating in defrost mode, there is a temporary discontinuation in the indoor-outdoor air exchange, but this does not usually result in any noticeable reduction in indoor air quality. Another common method of defrost is to use a pre-heater, which is more applicable in colder climates where more constant defrost is required. Pre-heaters significantly increase energy costs and reduce the heat recovery efficiency of the HRV.

The heat exchange process is reversed during the cooling season. Cool air being exhausted from an air-conditioned building or suite removes heat from the incoming warm outdoor air. In other words, the HRV pre-cools the outdoor air that is brought into the suite. An HRV in a building without air conditioning will have limited ability to pre-cool outdoor air during warm temperature conditions (though the system still provides good indoor air quality by continuously ventilating the space). However, they can be equipped with a core bypass to avoid heat exchange when outdoor air is cooler than indoor air (for example, during summer nights that are cooler than the days). In either case, as the heat recovery efficiency is not 100%, the outdoor air is never raised to the temperature of the exhaust air during the winter and it is never lowered to the temperature of the exhaust air in the summer. Therefore, careful consideration must be given to the location of supply air diffusers to reduce the chance that the outdoor air results in comfort problems.

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 the bathroom is in use or during high occupancy periods.

3.2. Energy Recovery Ventilators

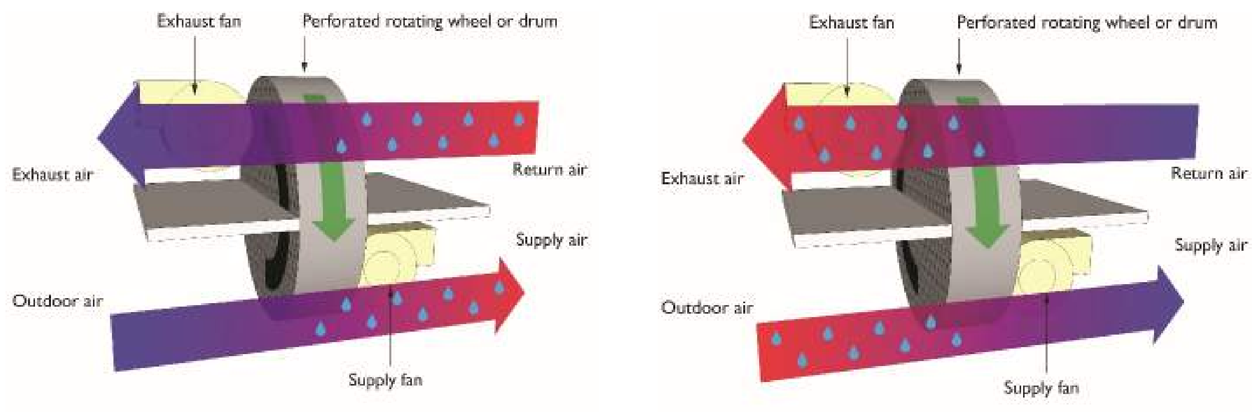
An energy recovery ventilator (ERV) functions in a similar way to an HRV, but in addition to recovering heat, it also transfers moisture between the exhaust and supply air streams. This can be advantageous when there is a need to maintain indoor relative humidity levels in the winter or to reduce the moisture in the incoming outdoor air in the summer (a concern in warm, humid climates).

3.2.1 ERV Components

The components in ERVs are similar to those of HRVs. Since ERVs recover moisture, condensation does not typically form in the core. In many cases, ERVs have been installed without drains, although users should be aware that there may be circumstances under which an ERV will generate condensation (for example, when the outdoor air is very cold and indoor humidity is high). ERVs also require frost protection in cold climates.

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 air streams, 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 air streams (Fig. 3.4). Moisture and heat is deposited on the wheel, which then rotates into the opposite air stream where the moisture and heat is released. These are more common in larger central systems than in decentralized suite systems.



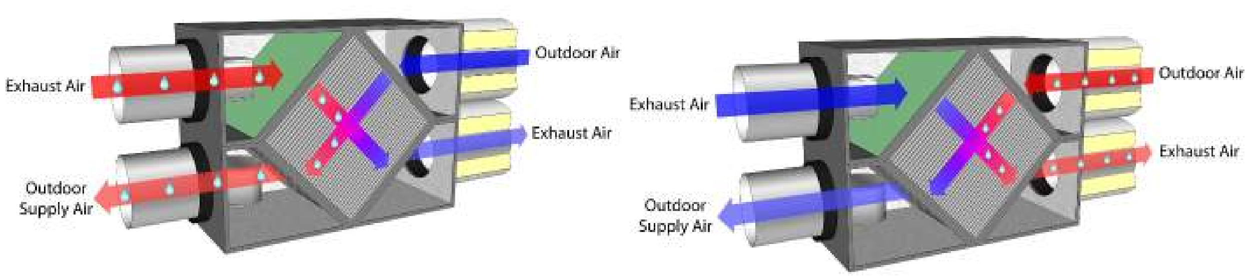
a) Winter b) Summer

Fig. 3.4 Enthalpy wheel-type ERV system operation during a) winter and b) summer.

3.2.2 ERV Operation

During the heating season, an ERV will operate like an HRV, transferring heat from the exhaust to the intake air stream. 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 Fig 3.5a). However, in houses that see significant moisture generation from factors such as high occupancy, pets, plants, or frequent cooking, ERVs may re-introduce too much moisture back into the house. In such cases, an HRV may be more appropriate.

During the cooling season, an ERV in an air-conditioned house will both dehumidify and pre-cool hot humid outdoor air by transferring heat and moisture from the outdoor air to the cool exhaust air stream (see Fig 3.5b). If the building does not have air conditioning these pre-cooling and dehumidification benefits are not fully realized, though the system still provides constant ventilation to the space.



a) Winter

b) Summer

Fig. 3.5 ERV operation during a) winter and b) summer, showing exchange of heat and moisture within the cross-flow core.

3.3. Benefits of HRVs and ERVs

HRV and ERV systems provide continuous, balanced, and energy-efficient ventilation to the suites of a MURB. These systems have several benefits beyond energy savings. Some of these benefits are specific to HRV and ERV systems, while others are simply a benefit of providing continuous ventilation air directly 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 used within or connected to the supply side of an HRV/ERV, further improving air quality. HRVs and ERVs also provide constant, balanced airflow, which provides more consistently good air quality than a standard supply-only or exhaust-only system that varies the airflow throughout the day.
- *Enhanced thermal comfort*: HRV and ERV systems reduce drafts that can cause thermal discomfort by preheating outdoor ventilation air. However, as the heat transfer is always less than 100%, the system must be carefully designed to ensure the outdoor air is introduced into each space in a way that does not cause comfort problems.
- *Quiet ventilation*: Properly designed and installed HRV and ERV systems operate more quietly than conventional exhaust fans. Many newer units are nearly inaudible.
- *Building enclosure durability*: Since HRVs and ERVs provide balanced airflow, they do not contribute to the pressurization/depressurization of the building. They also control indoor humidity levels by exhausting moist indoor air, reducing the risk of condensation on windows and cool indoor surfaces that could lead to mould growth and moisture damage.
- *Combustion appliance safety*: In suites with naturally aspirated combustion appliances, flue gas spillage or backdrafting can occur when negative pressure conditions (inward acting) on the building overcome the natural draft (outward acting) of the combustion appliances. HRVs and ERVs with balanced airflows do not contribute to the depressurization 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.

The ventilation system strategy and equipment selection will affect both the installation cost and the cost of energy to operate the ventilation system. Incorporating heat recovery may increase the initial cost of the ventilation system, but it can substantially reduce the annual energy costs compared to systems without heat recovery.

As discussed earlier in this chapter, HRVs and ERVs save energy by recovering heat from the exhaust air stream and pre-heating the incoming air in the winter, and reversing the process in the summer. In very cold climates, the potential for energy savings due to 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 provide 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 10-storey (6,500 m^2) MURB in six locations across Canada representing different climate zones. These climate zones are illustrated in Fig. 3.6. The results are summarized in Table 3.1 and 3.2 below. Table 3.1 represents a comparison of an HRV/ERV system to a typical existing MURB system with intermittently operated exhaust fans. Table 3.2 compares a balanced system with and without the HRV/ERV. This is a more reasonable comparison for a typical new code-compliant building.

Fig. 3.6 Map of climate zones for Canada.

Table 3.1 Modeled heating and cooling energy savings of HRV compared to 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‡**	
		Gas Furnace & Central AC	**Electric Baseboard & No Cooling**
Vancouver	2825	$280 (86%)	$640 (81%)
Toronto	3520	$300 (81%)	$1,090(78%)
Montreal	4200	$200 (82%)	$690 (80%)
Winnipeg	5670	$440 (85%)	$960 (82%)
Fort McMurray	6250	$370 (85%)	$1,800 (83%)

†Heating degree days from 2010 National Building Code of Canada.

‡ Modeling results are based on the 2011 NECB requirements for a 10-storey multifamily building with one- and two-bedroom suites. The baseline building has a pressurized corridor system with continuous ventilation to the corridors (7.5 L/s-m^2) and intermittent exhaust fans in suites per ASHRAE 62-2001 guidelines for intermittent exhaust ventilation systems, with an assumed fan operating schedule. The HRV cases use an infiltration rate of 0.25 L/s-m^2 based on NECB modeling guidelines; the baseline case with intermittent exhaust fans used an infiltration rate three times higher to account for natural ventilation to the space. The HRV Sensible Recovery Efficiency (SRE) is assumed to be 65%.

ERVs yield additional cooling energy savings compared to HRVs if the building has air conditioning. However, since the Canadian climate is heating dominant, the difference in the energy performance between an HRV and ERV system is minor, and the results shown are for the HRV only.

Table 3.2 Modeled heating and cooling energy savings of HRV compared to continuous balanced ventilation with no HRV

Location	Heating Degree Days†	Annual Energy Cost Savings Per Suite and % Reduction in Ventilation Heating and Cooling Energy Due to an HRV‡	
		Gas Furnace & Central AC	Electric Baseboard & No Cooling
Vancouver	2825	$170 (78%)	$300 (67%)
Toronto	3520	$170 (70%)	$580 (66%)
Montreal	4200	$120 (73%)	$360 (67%)
Winnipeg	5670	$250 (77%)	$510 (71%)
Fort McMurray	6250	$210 (77%)	$960 (73%)

†Heating degree days from 2010 National Building Code of Canada.

‡ Modeling results are based on the 2011 NECB requirements for a 10-storey multifamily building with one- and two-bedroom suites. Continuous ventilation is provided to each suite per ASHRAE 62.1-2001 (average 46 L/s per suite) and minimum ventilation to corridors for pressurization. The HRV Sensible Recovery Efficiency (SRE) is assumed to be 65%. Both cases use an infiltration rate of 0.25 L/s-m^2, based on NECB modeling guidelines, and an assumed fan operating schedule.

ERVs yield additional cooling energy savings compared to HRVs if the building has air conditioning. However, since the Canadian climate is heating dominant, the difference in the energy performance between an HRV and ERV system is minor, and the results shown are for the HRV only.

Overall, significant energy savings can be realized in a typical Canadian MURB by installing an HRV/ERV. The savings are higher in colder regions; however, HRV/ERVs can be beneficial in all areas of the country.

4. System Design and Installation

This chapter summarizes the primary HRV/ERV ventilation system configurations for new MURBs, and outlines the design considerations that will impact a project's performance, layout, aesthetics, and cost. 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 appropriate system choices for a particular MURB. The information is intended to supplement code requirements and best practice guidelines, such as those provided by ASHRAE and HRAI[1].

4.1. HRV/ERV Ventilation System Configurations

The two primary HRV/ERV ventilation 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. Fig. 4.1 below shows this arrangement in winter (heating) mode. The system will also deliver air to common areas (not shown in the graphic).

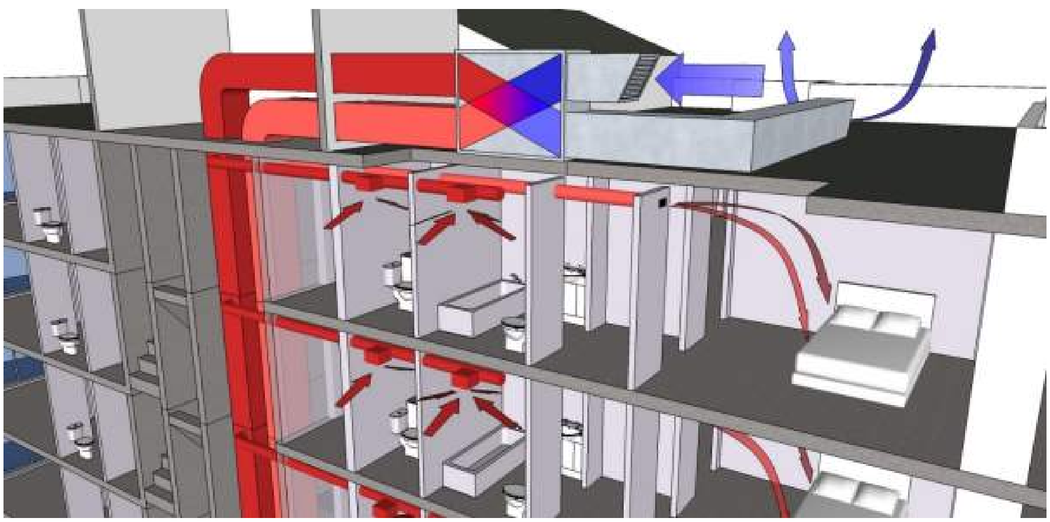


Fig. 4.1 Centralized HRV/ERV with ducted supply and return to each suite.

2. *Individual in-suite HRV/ERV*: The system details can vary (for example, 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 Fig. 4.2 and Fig. 4.3 below in winter mode. There are also emerging technologies such as point-source HRVs that can be installed without

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

ductwork, although a careful review of such systems with respect to code requirements for ventilation is advised.

In order 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 a continuous air barrier should be provided between each suite and between the suites and corridor, as well as at the building enclosure.

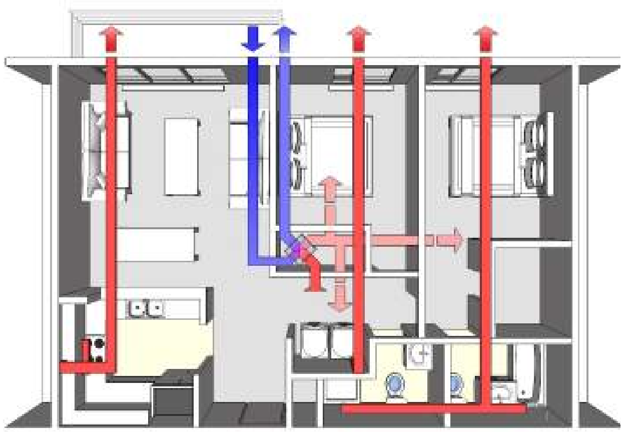


Fig. 4.2 Individual in-suite HRV/ERV with dedicated, intermittent kitchen/bathroom exhaust (in this scenario, the suite's pressurization will be unbalanced when the intermittent kitchen/bathroom exhaust fans are turned on).

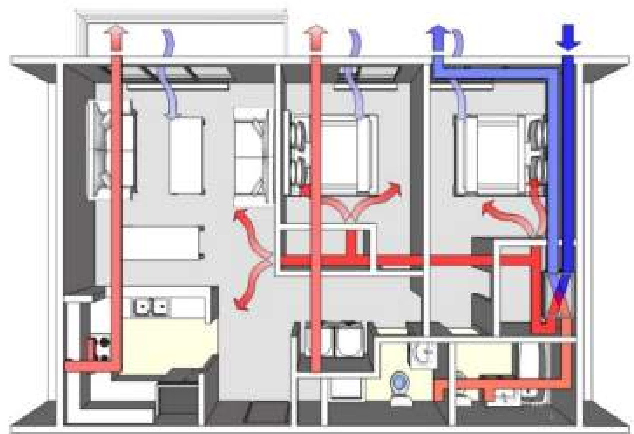


Fig. 4.3 Individual in-suite HRV/ERV integrated with bathroom exhaust (in this scenario, HRV/ERV airflows can be ramped up when the kitchen or bathroom requires additional exhaust).

4.1.2 HRV/ERV Ventilation System Design Considerations

As with any mechanical system, the final design, performance, and cost of a new MURB project will be impacted by choices related to the HRV/ERV system. When these impacts are understood and coordinated amongst the design team and stakeholders early in the design process, the project is more likely to successfully fulfil the expectations of the developer, owner(s), 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 list can be used by the project team as a checklist to identify the considerations that are most important for a specific project, and to guide the team toward the best solution. Photos of sample centralized and in-suite units are included in Fig. 4.4 and 4.5, following the table.

Table 4.1 Comparison of system design considerations for centralized vs. in-suite HRV/ERVs

<table>
<tr><th>Design Consideration</th><th>Centralized System</th><th>Individual In-Suite System</th></tr>
<tr><td>Code Requirements</td><td colspan="2">• Code requirements for ventilation must be satisfied. Requirements are independent of the system chosen to meet them. The mechanical designer will be well versed in locally applicable codes. Refer to Table 2.1 in Chapter 2.</td></tr>
<tr><td>Scale</td><td>• One large unit (or several large units if using a zoned system), with one power and condensate drain connection.</td><td>• Many smaller units, each requiring power and drain connections.</td></tr>
<tr><td rowspan="2">Space/Layout</td><td>• Larger shafts will be required to accommodate vertical supply and exhaust ducts between unit and suites.
• Main distribution ducts will require space in corridor ceiling (although they only need to be sized for outside ventilation air, which is much less than would be required for a centralized all-air system).
• Space within suite is not required for HRV/ERV.
• Main HRV/ERV can be located in conditioned space or outdoors (but must be selected accordingly).</td><td>• Shaft space not needed for suite ventilation (although if the building has an interior corridor, the shaft will need 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).</td></tr>
<tr><td colspan="2">• In-suite space (in ceiling, floor and/or wall) is required for ducting to bedrooms and primary living spaces, and from bathrooms/laundry rooms.</td></tr>
<tr><td></td><td colspan="2">• A separate kitchen exhaust for a gas-fired range is still required by most codes.</td></tr>
<tr><td rowspan="2">Fire/Smoke Separation and Envelope Penetrations</td><td>• 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).</td><td>• Fewer interior fire/smoke penetrations, but more envelope penetrations required for outside air and exhaust air for each suite.</td></tr>
<tr><td colspan="2">• Outdoor air inlet and exhaust locations need to be selected carefully to avoid contamination of outdoor supply air (and to meet associated code requirements).</td></tr>
</table>

Sound	• Sound performance of the unit is less critical, as 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). • Noise transfer between suites can be an issue with a centralized ducting system. Ducting should be designed to minimize sound transfer.	• 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.
	• Appropriately sizing and locating the ductwork and diffusers, and using limited flexible duct attachments, reduces unwanted noise caused by air movement.	
Ownership	• If a strata building, the system is part of the common property.	• If a strata building, ownership is transferred to individual owners.
Serviceability and Maintenance	• Single point of maintenance. • The building manager does not have to enter suites to maintain the system.	• Multiple points of maintenance, which can be challenging in a rental building. • If a strata, maintenance responsibilities are transferred to the individual owner. Can be more challenging to ensure that the units are maintained and operating as intended. Occupant education is crucial.
Controllability	• Lower degree of occupant control, which can benefit the overall performance of the building, but can also lead to occupant intervention if the system does not maintain comfort as intended (e.g., blocking diffusers). Occupant education is recommended.	• 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 (e.g., turning off the unit and allowing moisture to accumulate). Occupant education is recommended.

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

Fig. 4.5 Example of in-suite HRV unit, located at the top of a closet (Image courtesy of Bernhardt Contracting Ltd.).

4.1.4 HRV or ERV Selection

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

- *Airflow capacity:* HRVs and ERVs are available to meet a wide range of ventilation airflow requirements. Finding an HRV/ERV that can meet the airflow needs of the suite or building is the first step.
- *Energy consumption*:
    - Summer considerations: If summers are hot and humid and the building will be air conditioned, an ERV will reduce cooling energy, since it removes humidity from the incoming supply air stream (and effectively pre-cools the incoming air).
    - Winter considerations: When frost prevention is required on a consistent basis, an ERV can be the preferred choice, since 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.
    - Brushless direct-current motor fans reduce the amount of electricity consumed by HRV/ERVs.
- *Thermal comfort*: An ERV can return moisture into the supply air stream, which can improve thermal comfort in climates with very dry winters. Similarly, they can remove moisture from the supply air stream in climates with very hot, humid summers.
- *Moisture recovery*: Suites with significant moisture generation (such as densely occupied suites) may benefit more from an HRV, since it will not transfer additional moisture to the supply air stream.

Not all HRV/ERVs are created equal. When units are value-engineered to reduce capital cost, there are 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 that is ultimately installed meets expectations. Selecting a unit with the appropriate airflow capacity and at the highest rated heat recovery efficiency are two of the most important selection criteria. Table 4.2 below can be used to identify these and other 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 certified products directory of HRVs and ERVs. The directory compares efficiency and other performance parameters using a standardized testing protocol.

Table 4.2 Equipment Selection Parameters

Parameter	Description	Impact/Comment
PERFORMANCE PARAMETERS		
Airflow Capacity	• Airflow rate (L/S or CFM) should match or slightly exceed the mechanical engineer's specification at design conditions.	• An undersized unit may not meet ventilation requirements, while an oversized unit adds unnecessary capital and energy costs.
Heat Recovery Efficiency	• Sensible Recovery Efficiency (SRE): Manufacturers test each HRV and ERV to determine the SRE. Since the efficiency changes at different temperature and humidity conditions, HRVs are tested to standard conditions to allow for comparison between products. In Canada, HRVs and ERVs are tested to Standard CSA-C439. • Total Recovery Efficiency (TRE): This metric includes heat transfer through moisture, so only applies to ERVs. Manufacturers test ERVs to determine the TRE. This test is also completed at standard conditions to allow for comparison between products.	• Efficiency is impacted by the quality and construction of the unit components. Units vary widely in their energy recovery efficiency (from less than 50% to greater than 90%), and should be selected at the highest possible efficiency that meets the project budget.
Sound Performance	• Sound data of the unit is reported on the technical data sheet.	• Sound performance can vary widely among units. A quiet unit is critical for in-suite applications (there should be no audible noise at air outlets). • Other system installation practices also impact vibration and sound transfer. The mechanical designer should specify installation practices to minimize sound transfer (for example, installing units with vibration-isolation mounting, properly sizing ducts, grilles and diffusers, using smooth transitions, and reducing the number of unnecessary fittings). • Locating the HRV away from sleeping areas is recommended.

Control Options	• 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.	• High/low mode may be required by code (particularly if bathrooms or kitchens are connected to the HRV/ERV and no other exhaust is provided). • 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	• Defrost is typically achieved automatically by the HRV/ERV 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. Defrost can also be achieved by preheating outdoor air before it reaches the HRV/ERV.	• Frost prevention is required in most of Canada, excepting BC's Lower Mainland (Climate Zone 4 in NECB). • In general, an HRV will be designed to provide frost control below outside air temperatures of -5°C. ERV defrost temperatures may be lower, providing energy saving opportunities. • HRV/ERVs can be challenging to use in colder climate zones due to the potential for frost build-up; therefore, a unit with adequate defrost capability (such as an external heater) may be needed. • Defrosting by pre-heating air to the HRV/ERV can use considerable energy, decrease the efficiency of the heat exchange, and add cost to the design and installation.
PHYSICAL PARAMETERS		
Size (Dimensions and Weight)	• Units are available in a variety of dimensions.	• 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	• Stainless steel, aluminum, coated steel and plastic are common construction materials. • Units can be designed for indoor or outdoor conditions (although an outdoor unit must be specifically designed for outdoor use). • The casing should be insulated regardless of whether the unit is intended for indoor or outdoor installation.	• 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, compromising the equipment's performance.

Inlet and Outlet Locations	• Different units may 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.	• Outlet/inlet locations that are matched to the ducting design will minimize duct runs and ensure a smooth airflow pathway (thereby helping to ensure the desired airflow rates are achieved). • The heat exchanger configuration (cross-flow, counter-flow, heat wheel, or other) will impact the available port locations.
Access Door Locations	• Different units typically have options for the location of the access door (side, top, or bottom) for filter replacement and maintenance.	• The unit's location should enable easy access to regularly replace the filter and provide periodic maintenance. Allow enough space for the access door to be fully opened for servicing the HRV/ERV.

4.1.5 Other Design Considerations

Other design considerations will impact the performance, layout, aesthetics, and cost of a new MURB HRV/ERV project. Key considerations include the following:

- *Ducting:* Ductwork needs to be selected for quality (sheet metal vs. flex duct), sized appropriately, and laid out with minimal transitions and bends. Poor layout and construction quality can lead to unwanted noise generation, increased fan energy use, and compromised durability. Early planning of HRV ducting is important to avoid complicated duct runs.
- *Grilles/diffusers:* The size, type and location of grilles and diffusers can impact the distribution of ventilation air and occupant comfort. They need to 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 aesthetics in mind.
- *Airflow balancing:* 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. Alternatively (or in addition to balancing dampers on main branches), supply diffusers and exhaust grilles can be specified that allow flow rates to be adjusted by turning a conical-shaped plug located in the centre of the grille.
- *Combustion appliances:* While HRV/ERVs are intended to provide balanced ventilation, they are not make-up air systems for unbalanced exhaust and they are not combustion air systems for non-sealed combustion appliances. Make-up air may be required for large capacity exhaust equipment. The mechanical system designer should understand and coordinate these requirements.

4.2. Installation Considerations

Proper installation techniques are as important as good design practice. 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 provides an installation checklist for HRV/ERV systems. This checklist is included as an illustration of the items that the designer 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 as shown on plans (if an indoor unit).				
HRV/ERV is hung from vibration-isolating straps or is mounted on rubber or spring vibration isolators.				
HRV/ERV is fully accessible for filter cleaning, core removal and servicing of fans and electronics.				
HRV/ERV internal filters are installed and clean.				
HRV/ERV is connected to power.				
Condensate pan is connected to a sanitary drain (if applicable).				
Operation and maintenance instructions are provided.				
Installer's name on HRV/ERV along with airflow balance confirmation.				
Date when system balanced indicated on unit.				
Ductwork				
All four ducts running from the HRV/ERV incorporate a section of flexible duct to minimize vibration transmission (for in-suite units).				
All ducts are run in conditioned space. Where ducts run through unconditioned space, they are insulated to the same level as exterior walls.				
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 airflow adjustable diffusers and grilles are used.				
Dampers and measurement ports are accessible for commissioning.				
Supply and exhaust outlets are installed per plans.				
Exterior Air & 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.				

Installation Checklist	Yes	No	N/A	Notes
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.				
Exterior louvre or hood penetrations are sealed to the exterior wall air barrier.				
Airtightness of the building at final (ACH_{50} or Normalized Leakage Area), if tested:				
Exterior Air Intake Louvers and & Exhaust Hoods				
Outdoor air intake(s) incorporate a 6 mm (1/4") mesh to prevent pest entry.				
Outdoor air intake(s) are a minimum of 900 mm (36") 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 intake(s) and exhaust(s) 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 and 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 and/or humidistats are located in all bathrooms serviced by the HRV/ERV (if applicable).				

5. HRV Retrofits for Existing MURBs

An HRV/ERV can be considered for any ventilation retrofit solution. This chapter identifies the typical scenarios in which a ventilation upgrade involving an HRV/ERV would be undertaken, and describes some of the design and installation considerations. The retrofit process can be summarized in five steps, shown conceptually in Fig. 5.1 on the following page and described in this chapter. Step 5 is explained more fully 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 building system

Step 3: Evaluate and select ventilation system retrofit options

Step 4: Design and implement the solution

Step 5: Commission the upgraded system and verify results

5.1. Identify the Need or Opportunity

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

1. *Indoor air quality is poor:* Any attempt at improving indoor air quality should start with the identification and removal of any source(s) of air contaminants. As described in Chapter 1, moisture and pollutant loadings within a suite are affected by occupant activities, interior and exterior moisture sources, interior finishes, furnishings, personal possessions, hobbies and lifestyles. When improving indoor air quality, opportunities for maintenance and operational changes within the existing ventilation system should also be considered.

2. *Condensation is collecting on interior surfaces:* If excessive condensation 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 other sources of moisture within the dwelling unit. The presence of condensation does not necessarily mean that inadequate ventilation is the problem. It is important that these other potential causes of condensation be assessed and addressed at the same time that ventilation system improvements are considered. A building science consultant can assist with this assessment.

3. *The building enclosure is being upgraded (e.g., window replacement, cladding renewal, air-sealing), which will result in an improvement in airtightness:* The decrease in air leakage through the building enclosure means that the overall natural ventilation rate may be inadequate, and new or upgraded mechanical ventilation capacity needs to be added.

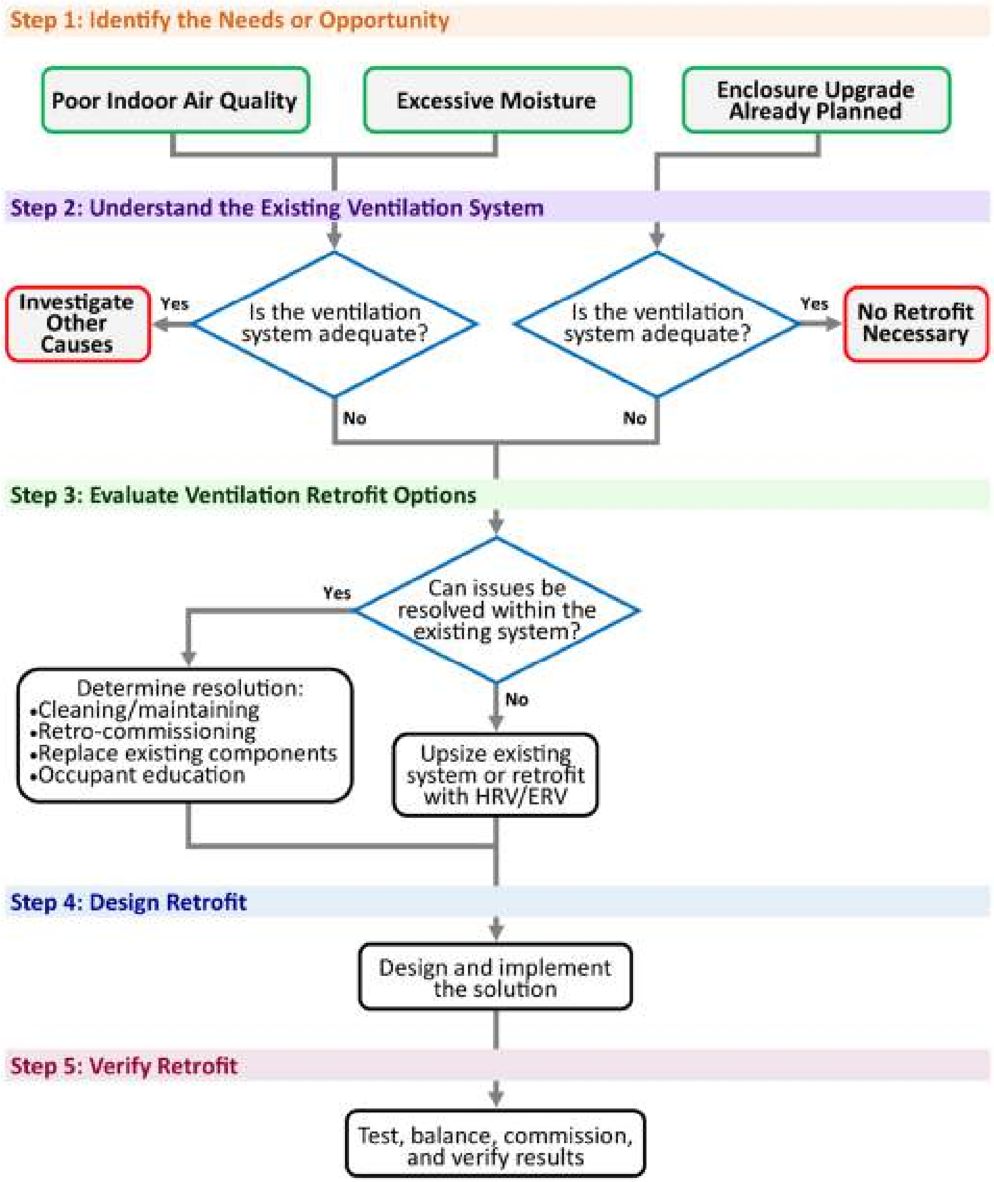


Fig. 5.1 Ventilation system retrofit process.

5.2. Understand the Existing Ventilation System and Building Performance

Many existing MURBs have poor ventilation and/or no mechanical ventilation system. Before a retrofit is undertaken, the existing system and 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

The main ventilation system types were described in Chapter 2 (exhaust-only, supply-only or balanced). The majority of MURBs constructed prior to the mid-1980s will have intermittent exhaust-only systems, meaning that ventilation air is drawn in through the (typically less airtight) building enclosure and/or corridor spaces 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 will have at least some minimal in-suite ventilation (e.g. 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. In order to understand actual flow rates, measurements should be taken at all exhaust outlets and air intakes while the system is in operation. A mechanical or building science consultant will be best suited to complete this investigation.

5.2.2 Building Enclosure Airtightness Performance

The airtightness of the building will have a significant impact on the potential effectiveness of a heat recovery system. A building that is less airtight and/or has poor compartmentalization between suites will potentially negate any benefit of an HRV/ERV due to unintended air losses. An HRV/ERV upgrade in an existing building should therefore be undertaken with a complementary effort to measure and improve the airtightness of the building enclosure.

While the airtightness of a single-family home can be easily measured, airtightness of a MURB is more complex due to the larger building size. Measuring airtightness for a single suite can be challenging due to 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 a 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 and/or to adjacent zones. Typically the test method performed will conform to CAN/CGSB 149.10-M86 (or CAN/CGSB 149.15) within Canada, and will be undertaken by a building science engineer or qualified tradesperson. The test consists of creating a pressure difference by forcing air into or out of the MURB or zone of the building with fans. The pressure difference created must be able to overcome naturally occurring zone pressure boundaries (i.e. stack effects).

The test zone is pressurized/depressurized to a standard test pressure differential using specialized equipment known as a fan door (see Fig. 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 (i.e. made equal to zero). In a test suite in a MURB, typical adjacent zones might include the suites above and below, adjacent suites on the same floor, and the corridor. Once all of the adjacent zones have been pressure neutralized with respect to the test zone, any remaining airflow from the test zone must be with the exterior.

Fig. 5.2 Fan door equipment setup (photo courtesy of Retrotec Energy Innovations Inc, Vancouver, BC)

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 evaluation can either be completed via air leakage testing, as described above, by tracer gas testing, or modeling by the building science consultant.

5.3. Evaluate Ventilation System Retrofit Options

If the existing ventilation rate has been found to be inadequate, upgrade options can then be considered. Simpler options, such as cleaning the existing ventilation system to re-establish rated airflows, replacing components (e.g., upgrading a fan, or section of ductwork), or modifying controls (e.g., automating fan operation to provide more ventilation over a 24-hour period) could contribute to better airflow and 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 compact and 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 in the building.

5.4. Design and Implement the Solution

If the decision has been made to install 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 listed below.

- *Airtightness improvements:* Consider installing weather stripping and sill sweeps on suite doors, and weather stripping on elevator doors. Eliminate the garbage chute if there is one. Air-seal at the top and bottom of the building (e.g., focus on reducing the size of openings at the elevator penthouse, smoke-sealing at separations, sealing/replacing doors at loading bays and parking garages).[1]

[1] Refer to CMHC's *Air Leakage Control Manual for Existing Multi-Unit Residential Buildings*, https://www.cmhc-schl.gc.ca

- *Airflow 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 airflow 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 aesthetics are less important. While unit sizes vary, plan for a space of about 20 ft^3 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 connect its drain pan to a sanitary pipe, whether by a gravity-fed connection or a connection via 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. Be sure to investigate existing damper type and operation, though. Some dampers, such as spring-loaded types, may not open when the HRV/ERV is operating in low mode.
    - Where possible, provide supply air to each of the bedrooms/living spaces and exhaust from bathrooms/kitchen/laundry room.
    - Conceal new duct runs in dropped ceilings, soffits, vertical chases, or existing walls.
- *Outdoor air inlets/exhaust outlets:*
    - The location of the outdoor air hood can be a challenge in a retrofit. Code intake requirements generally require avoiding any sources of contamination of the outdoor air.
    - If a building enclosure upgrade (particularly windows) is driving the ventilation system retrofit, consider designing the windows to incorporate the new outdoor air inlets and exhaust outlets.
- *Controllability:* If previous problems (e.g. excessive moisture) were caused or exacerbated by occupant behaviours, 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. Commissioning and Troubleshooting

This chapter provides guidance for the start-up of HRV/ERV systems including commissioning, balancing, and troubleshooting of common problems. It applies to both new MURBs and retrofits. 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 owner(s), the property manager, and/or the mechanical contractor.

6.1. 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 if the project is pursuing LEED certification. Guidance documentation is provided by LEED as well as ASHRAE, through its *Guideline 0-2005: The Commissioning Process* and the new *Standard 202-2013: Commissioning Process for Buildings and Systems*.

> **Commissioning** is defined by ASHRAE 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 ASHRAE.org.

An HRV/ERV system commissioning process will include at least the following:

- Review contractor submittals for the following equipment:
  - HRV/ERV unit
  - Interior diffusers and grilles, and exterior louvres
  - Control system (may be included with HRV/ERV)
- Inspect individual system components for proper installation. Verify that filters are easily accessed for servicing.
- Test and balance the ventilation system to establish compliance with design airflow rates.
- Perform functional testing of the system in all modes of operation, verifying that controls and sensors work, testing start-up and shut-down of major components, checking emergency and failure modes, and reviewing interlocks to other equipment. Document any outstanding issues.
- Provide relevant operations and maintenance information to owners and/or property manager, including a systems manual for the commissioned ventilation system. For larger MURBs that 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.

6.2. Measuring and Balancing Airflows

Balancing the ventilation system as part of building start-up (or re-commissioning for an existing MURB) will ensure that the appropriate airflow reaches each space. An air-balancing professional will measure the airflows at each outlet and adjust balancing dampers until the airflows match the original design. System supply and exhaust airflows 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 conical-shaped plug located in the centre of the grille.

A flow measuring station is typically used to measure the system airflow 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, analog pressure gauge or digital pressure gauge to provide a reading. This pressure difference is then converted to airflow 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 airflow readings.

Table 6.1 provides a list of items that the air balancer will typically check. Checked items may vary depending on the type of system installed (centralized vs. in-suite).

Table 6.1 Airflow measurement checklist

Airflow Measurement Checklist				
	Yes	**No**	**n/a**	**Notes**
Airflow measuring stations are installed according to the manufacturer's specifications.				
The HRV/ERV(s) incorporate accessible pressure taps for measuring gross system airflows.				
The HRV/ERV(s) incorporate balancing dampers.				
Balancing dampers are located in the main trunk ducts.				
Gross air supply and exhaust airflows have been measured, recorded and verified with the design.				
Airflows from all supply diffusers have been measured, recorded and verified with the design.				
Airflows 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.				

6.3. Troubleshooting Common Operational Issues

Common operational issues, along with common fixes, 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.	• Verify that the HRV/ERV control is turned on. • Ensure that the HRV/ERV is plugged in and the electrical cord is not damaged. • 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. • Check that the access door is fully closed. • Check that the safety switch is connected to the access door for proper operation.
The HRV/ERV is operating but there is little or no supply airflow.	• Check the exterior hoods and associated ductwork for blockage and clean as required. • Check the filters and clean or replace as required. • Check the indoor ducts and registers in rooms for blockage (closed dampers, lodged items, etc.) • Check the core for freezing/frosting. • Check all ducts for leakage or disconnection. Seal any loose joints with aluminum foil tape. • Check duct designs – sometimes adjustments made on-site to accommodate site conditions not anticipated at the design stage can impose more restriction in the duct system than planned. Alterations to reduce the number of elbows, transitions, or fittings may be required.
The core has frozen.	• Open the access panel and let any ice melt. Some cores can be easily removed and thawed in a sink. • Check the filters and clean or replace as required. • With some HRV/ERV models, the defrost mechanism or pre-heater can be checked by following the manufacturer's instructions in the owner's manual. • If problem persists, the system may need to be rebalanced, or additional heating may be required. • Sometimes core freeze-ups cannot be avoided due to cold outdoor conditions and/or the amount of moisture being produced in the suite/building. Checking the HRV from time to time to correct freeze-up may be needed.

HRV/ERV Operational Issue	Possible Solutions
A duct insulation jacket is damaged.	Light Damage • If the insulation is torn but not seriously damaged, use sheathing or foil tape to repair any punctures in the jacket. Major Damage • If the insulation is wet, has any ice build-up or if there is water on the floor, check if all seams and joints in the ductwork are air-sealed with aluminum foil tape or a mastic sealant. If not, replace the damaged insulation, air-seal all seams and seal the exterior vapour barrier.
There are cold drafts coming from the supply grilles.	• Check if the exhaust or return air stream is blocked as this reduces the amount of heat available to be transferred to the incoming outdoor air. • Check the core for freezing. • Check if any supply ducts are running within unconditioned or concealed cold spaces. If so, verify insulation and proper sealing. • If the problem persists, consider the following alternatives, as appropriate, which may require the installer's assistance: o Provide new horizontal linear diffusers to direct airflow along ceiling; o Relocate supply air outlets to high wall locations; or o Add a pre-heater, though this reduces the heat recovery effectiveness and increases operating costs.
There is poor air quality, excess moisture or high humidity throughout the suite/building.	• Adjust the humidistat (if any) to provide more dehumidification. • Ensure HRV is operating continuously or on sufficient cycle over a 24-hour period – adjust upwards in small increments so the right amount (and not too much) ventilation is provided. • Check the core for freezing as this blocks the exhaust airflow. • If an existing MURB, advise the occupant(s) to reduce sources of interior humidity through the following measures: o Don't hang laundry to dry inside. o Put lids on cooking pots and use the kitchen exhaust fan. o Ensure exhaust is on high during showers and baths. o Clean dryer lint traps and ensure dryer is properly vented outdoors. o For more tips on reducing interior moisture, visit the BC Housing website at: https://www.bchousing.org/research-centre • Ensure the HRV/ERV is operating properly. • Check location of outdoor air supply hood – ensure it is not close to dryer ducts, moisture and odour sources, etc. • Check that condensate pans in HRV housing are clean and are draining properly. Check condensate hose for mould and mildew – replace with clean tube if necessary. • If problem persists, the HRV/ERV's minimum continuous ventilation rate may be inadequate.

HRV/ERV Operational Issue	Possible Solutions
Air is too dry in the winter.	• Adjust the humidistat (if any) to provide less dehumidification. • Run the HRV/ERV on the lowest setting. • Run the HRV/ERV intermittently, or install controls to automatically run the unit intermittently on a reduced 24-hour cycle. • Consider installing an ERV instead of an HRV, which may increase winter humidity. Some HRVs can be converted to ERVs, at less cost than installing a new unit, by changing the core.
The air is too warm in the summer.	• Check that the core bypass is functioning properly.
The unit gives off unusual noise and vibrations.	• Oil the fan motors (if not self-lubricating) using non-detergent motor lubricating oil and as recommended by the manufacturer. • Inspect and clean the fan blades and heat-exchange core as required. • Ensure unit is properly mounted or hung with vibration-reducing straps. • Check filter and core condition – clean as necessary.
Suite occupant(s) complain of excessive airflow noise in rooms served by HRV/ERV.	• Verify that supply air diffusers are open. • Verify that airflow dampers are not disrupting flow too much. • Check duct system for fittings and transitions that may be causing too much turbulence within the duct, and replace with smoother transitions if needed. • Check to ensure duct sizes match design and are not too small. If too small, some sections of duct may need resizing/replacing. • Verify that the HRV/ERV is operating on the minimum continuous setting.

7. Operation and Maintenance

This chapter provides guidance on the operation and maintenance of HRV/ERV systems. Operational responsibility 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 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 they will interact with it. One of the biggest factors in occupant satisfaction with ventilation systems is the occupants' own understanding of how to operate and maintain their system. 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 and/or service contractor with product data, warranty information, and the HRV/ERV operation and maintenance (O&M) manual, and provide any training particular to the unit. Information should be included about local service providers and suppliers of serviceable components.

7.2. Training for New Owners/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 source 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) on a continuous basis 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 build-up of indoor air pollutants and humidity, and can also potentially void warranties on the system.

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 suite.
- *Programming the humidistat:* If a central humidistat is used to raise or lower the ventilation rate of an HRV system, it can be programmed and/or manually adjusted to respond to seasonal changes. For example, the humidistat can be set to high during warmer months to avoid having the HRV attempt to reduce interior moisture with warmer moist outdoor air. 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% 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 savings time will require reprogramming twice per year.

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 or to operate it temporarily at higher speeds as needed. 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.

One question often raised by occupants is whether moisture is being cleared from bathrooms quickly enough after showers. In typical HRV/ERV systems, the low-volume continuous ventilation rate in bathrooms is 10 L/s (21 CFM). This rate is typically doubled when the HRV/ERV is switched to high speed. This may not clear humidity from the bathroom as quickly as some bathroom exhaust-only fans, but due to the continuous ventilation provided by an HRV/ERV system, the bathroom will be more effectively dried over time than with a bathroom exhaust fan. If faster performance is needed, an independent exhaust-only fan can also be installed.

7.3. Maintenance

HRV/ERV systems are intended to operate 24/7 and, like all mechanical equipment, will require ongoing preventive maintenance. Maintenance tasks are similar for centralized and in-suite units, and will typically be performed by the property manager or service contractor. Owner occupants with in-suite units may undertake simpler maintenance tasks, and should be trained accordingly. It is recommended that all systems receive an annual servicing by a mechanical contractor accredited by the Heating, Refrigeration and Air Conditioning Institute of Canada or the Thermal Environmental Comfort Association.

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

- *Check and clean or replace dirty filter(s):* Filters should be checked and cleaned or replaced roughly every three months, although the frequency will depend on a number of factors, including whether the bathroom fans are part of the HRV/ERV system, and the level of pollutants in the outdoor supply air. Check filters more regularly for the first year of operation to establish the required schedule.

- *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 via a clear plastic tube either to a plumbing drain or condensate pump. For a new building during its first year after construction is completed, the unit will generate more condensate than normal as the building's interior finishes and structure dry. The tube should be tested annually by pouring two litres of warm clean water in the drain pan and ensuring that the water drains freely.
- *Check the outdoor air intake and exhaust hoods for blockage:* The metal screen located in the air 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. The position of the grille or diffuser should be noted or marked before they are removed, to ensure that the airflow volume is not changed.
- *Clean unit fan blades:* With the unit shut off and power disconnected, remove dirt that has accumulated on 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. The product manual should be referenced to cover this eventuality.

Table 7.1 below 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, and/or used by the primary servicer to schedule and record maintenance tasks that will keep the unit(s) operating in prime condition. Blank rows are provided for additional related maintenance activities for a specific system.

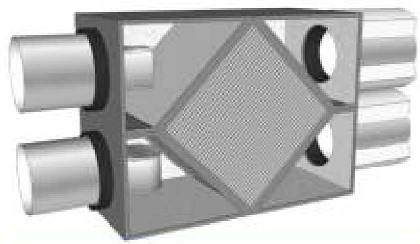
Table 7.1 HRV/ERV Maintenance Checklist

HRV/ERV Maintenance Checklist						
Maintenance Task	**Recommended Frequency**	**Date Maintenance was Performed**				
Clean and check exterior intake hood	3 months					
Check condition of exterior exhaust hood (ensure no nesting birds, rodent intrusion, etc.)	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					

Appendix A - Sample HRV/ERV Product Data Sheet

BEST HRV/ERV MANUFACTURER

Model XY1000 ERV



Specifications provide 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 26.7 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 provides data regarding the ventilation rates at various static pressures

Ventilation Performance

Ext. Static Pressure in wg (Pa)	Net Supply Airflow cfm (L/s)	Gross Airflow Supply cfm (L/s)	Gross Airflow 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)

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Relevant certifications and memberships

Energy Performance

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			**Total Recovery Efficiency**		
95 (35)	29 (14)	70	54		

Percentage of outgoing heat recovered by the unit (SRE)

Energy performance provides data regarding the energy used by the unit and the energy transferred in the core of the unit

BEST HRV/ERV

BestHRV.com

Appendix B - References

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Thermal Environmental Comfort Association. https://teca.ca/

Appendix C - Glossary

air barrier	Refers to the materials and components of the building enclosure or of compartmentalizing elements that together control airflow through the assembly.
air changes per hour (ACH)	Refers to the number of times per hour that a volume of air (room, suite, etc.) is replaced in an hour. Provides an indication of ventilation rates.
air leakage	Refers to air which unintentionally flows through building enclosure or compartmentalizing elements. This is often quantified as "normalized leakage rate" [cfm/ft² or L/s·m²] or simply "leakage rate" [cfm or L/s].
airtightness	Refers to the ability of a building enclosure or compartmentalizing element to resist airflow. A system which is more airtight has higher resistance to airflow. This is often quantified as "normalized leakage rate" [cfm/ft² or L/s·m²] or simply "leakage rate" [cfm or L/s].
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
ATTMA	Airtightness Testing and Measurement Association
airflow	Refers to the movement of air from one space to another. Usually measured in cfm or L/s at a specific reference pressure.
backdrafting	Refers to the situation when a space becomes sufficiently depressurized that products of combustion of fuel-fired appliances are drawn into the occupied zone.
below-grade	Refers to the portion of the building that is below the level of the ground surface.
building enclosure	Refers to the part of a building which separates the interior environmental conditions from the exterior environmental conditions, including the control of precipitation, water vapour, air, and heat.
cfm	cubic feet per minute (ft³/min)
CGSB	Canadian General Standards Board
compartmentalizing elements	Refers to any interior element of the building that is intentionally designed to limit the flow of air between adjacent spaces. Typically this would include walls between suites, walls between suites and the corridor, and floors.
condensation	Refers to 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 (v.)	Refers to the process of heating, cooling, humidifying, dehumidifying, and cleaning (i.e. filtering) the air in a space such that it is of the desired temperature, humidity, and quality.
depressurization	Refers to 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	Refers to the temperature at which the air would be saturated with water vapour (100% relative humidity).

driving forces of airflow	Refers to natural phenomena and mechanical systems which create pressure differentials and thus create airflow. Includes stack effect, wind, and ventilation equipment.
Equivalent Leakage Area (EqLA)	Quantitative expression of the airtightness of a building enclosure. EqLA is the method set by the CGSB in which a blower door depressurizes the building enclosure to 10 Pascals and the leakiness of the enclosure is expressed as a summary hole in square centimeters.
exhaust air	Refers to air which is removed from a space by a mechanical system (fan) as part of the ventilation strategy.
external static pressure	Refers to the resistance of the ventilation system to airflow, including resistance of ductwork, grilles, louvres, diffusers, filters, heating and cooling coils, dampers, etc.
HVAC	Heating, Ventilation, and Air Conditioning. Refers to the equipment used to condition the interior spaces of a building.
IBC	International Building Code
IECC	International Energy Conservation Code
IGCC	International Green Construction Code
indoor air quality	Refers to the nature of air inside a building that affects the health and well-being of building occupants.
ISO	International Organization for Standardization
latent heat	Refers to the movement of energy that occurs during a constant temperature process, as a result of phase change (for example, evaporation and condensation).
LEED	Leadership in Energy and Environmental Design
leakage rate	Refers to the rate at which air unintentionally flows through the building enclosure.
make-up air	Refers to air that is brought into a space to maintain the mass balance of air in a space when air is exhausted.
make-up air unit (MUA)	An air handling unit that conditions and supplies 100% 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	Refers to combustion appliances that draw their combustion air from the surrounding air (vs. 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.
NBC	National Building Code of Canada
NECB	National Energy Code for Buildings
outdoor air	Ambient air from the exterior that enters a building through a ventilation system, through intentional openings for natural ventilation, or by infiltration.
pascal (Pa)	A metric unit of measure for pressure. 1 inch H_2O = 249 Pa.

pressurization	Refers to the process of creating positive pressure inside a building or space relative to the surrounding conditions by removing air from the space with a fan.
Relative Humidity (RH)	Refers to the proportion of the moisture in the air compared to the amount of moisture the air could potentially 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 air streams 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.
sensible heat	Refers to the amount of heat energy absorbed or released due to a change of temperature.
stack effect	Refers to the natural pressure differentials that are developed across the building enclosure as a result of buoyancy forces due to difference in temperature between the interior and exterior of a building.
supply air	Refers to air which is provided to a space by a mechanical system (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 air streams 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.
ventilation rate	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.