# Heat Recovery Ventilation Guide for Houses

British Columbia

Homeowner Protection Office
Branch of BC Housing

BC hydro powersmart

City of Vancouver

Canada

## Purpose of the Guide

This guide will assist designers, developers, builders,  renovators and owners gain a better understanding of heat recovery ventilators (HRVs) and energy recovery ventilators (ERVs) and how they can support healthy indoor living environments in single family, semi-detached and row housing (herein referred to as “houses”), including:

- Why ventilating houses is important;
- Existing residential 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 houses and existing house retrofits; and
- Important balancing, commissioning, maintenance and operation considerations.

This publication is not intended to replace the training materials developed for residential mechanical ventilation system design and installation contractors.

## Acknowledgments

This guide would not have been possible without the funding and technical expertise provided by BC Hydro Power Smart, the City of Vancouver, Natural Resources Canada – CanmetENERGY, and Canada Mortgage and Housing Corporation (CMHC). The Homeowner Protection Office (HPO) would like to thank the members of the Technical Steering Committee for their time and contributions. Acknowledgment is also extended to RDH Building Engineering Ltd. who was responsible for the development of the guide.


## 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 by-laws with respect to the design and installation of a residential ventilation system.

The greatest care has been taken to confirm the accuracy of the content. However, the authors, funders, publisher, members of the project 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.


Main entry under title:

Heat recovery ventilation guide for houses

ISBN 978-0-7726-6883-7





Homeowner Protection Office

Branch of BC Housing

1701—4555 Kingsway

Burnaby, British Columbia, V5H 4V8

Canada

# Table of Contents

# 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 oxygen 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 the young, 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 homes. 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. As housing has become better insulated and more airtight in an effort to conserve energy and reduce utility bills, mechanical ventilation has become the preferred ventilation strategy. Mechanical ventilation offers a more efficient, predictable and secure mannner of ventilation in comparison to open windows. Research has demonstrated that it is typically more cost effective to build housing to be more airtight and provide mechanical ventilation than it is to build leaky houses and rely on natural ventilation. For this reason, *"build tight – ventilate right"* has become one of the mottos of the energy efficient home building movement.

---

[1] https://www.canada.ca/en/health-canada/services/air-quality/residential-indoor-air-quality-guidelines.html

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

- Source Removal: For example, storing contaminants and pollutants outside the living space (such as cleaning products or paints), 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 of the house 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.

### 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 the house and, in so doing, draw air back into the house 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 house 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 house, 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 the supply air diffuser(s) 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 not objectionable 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, kitchen fans and/or whole house ventilators. 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 of the house from desirable locations in the quantities needed. Further, the outdoor air drawn back into the house represents a significant space heating and cooling load that can inflate utility bills. Perhaps one of the most pressing concerns is that exhaust-only systems can back-draft fuel-fired appliances, such as furnaces, water heaters and wood burning fireplaces, causing dangerous combustion gases to be drawn into the house.

Heat recovery ventilators were developed 20 to 30 years ago in Canada to meet the ventilation needs of super energy efficient housing demonstration projects underway at the time. HRVs were developed to overcome the shortcomings associated with conventional approaches to naturally or mechanically ventilate houses – 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 residential mechanical ventilation system requirements of most building codes. Further, they offer homeowners with a much more affordable, effective and efficient means of ventilating their houses. While there has been significant progress in the design and installation of HRV/ERV systems in both new and existing homes, careful planning is needed on the part of builders and renovators to ensure performance. This guide provides an overview of the considerations that can help ensure that HRV/ERV systems meet expectations.

# 2. Residential Ventilation Practices

## 2.1. Codes and Standards

The fabrication, design, and installation of mechanical ventilation systems and their components are guided by best practices and building code 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 and installation of 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 a designer's required code reviews.

Part 9 of the National Building Code (NBC), adopted by several provinces including the BC Building Code (with amendments, effective December 19, 2014), requires the use of a mechanical ventilation system in all new houses. The requirements with the most direct impact on the design of a house's ventilation system are outlined below as an illustration of what is now required in many jurisdictions.

- *Design and installation requirements for ventilation systems and indoor air quality:* Section 9.32 of the NBC requires a principal ventilation system that exhausts air from bathrooms and kitchens, and supplies fresh air to bedrooms and living areas. One fan must continuously exhaust air at a minimum prescribed rate. It also dictates minimum outdoor air supply and exhaust air quantities by room type.
- *Design requirements for energy performance:* Section 9.36 of the NBC requires a continuous air barrier to improve energy efficiency. Though this is not a ventilation system code requirement, a more airtight enclosure means less ventilation air can be pulled through the building envelope. The resulting reduction in air leakage is one of the key drivers for the requirement to provide a principal ventilation system. A relatively tight enclosure is also necessary for an HRV/ERV to be effective.
- *Performance of HRVs/ERVs:* Section 9.36 of the NBC 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.

| Code | Jurisdictions | Ventilation | Energy Efficiency | HRV Performance | HRV Installation |
|---|---|---|---|---|---|
| National Building Code 2010 | SK, MB, NB, NS, PEI, NFL, YK, NWT, & NV | 9.32 (Ventilation) | 9.36 (Energy efficiency) | 9.32.3.10 (Fan Ratings) and 9.32.3.12 (HRVs) | 9.32.3 (Single dwelling unit) |
| British Columbia Building Code | BC | 9.32 (Ventilation) | 9.36 (Energy efficiency) | - | 9.32.3 (Single dwelling unit) |
| Vancouver Building Bylaw 2014 | Vancouver | 9.32 (Ventilation) | - | - | 9.32.3 (Single dwelling unit) |
| Alberta Building Code 2006 | AB | 6.2.2.1 (All buildings) or 9.32 (Ventilation) | - | 9.32.3.10 (Fan Ratings) and 9.32.3.12 (HRVs) | - |
| Ontario Building Code 2012 | ON | 9.32 (Ventilation) | 12.2.1.1 (Energy efficiency) | 9.32.3.11 (HRVs) | 9.32.3.11 (HRV) and 9.32.3.13 (Installation) |
| Quebec Construction Code | QC | 6.2.2.1 (All buildings) or 6.2.2.8 (Dwelling units) | 11 (Energy efficiency) (references 9.32 of NBC) | 6.2.2.8 and 9.23.3.3 | 9.32.3.3(2) (All Group C buildings) |

ASHRAE 62.1-2001
ASHRAE 62.1-2004
ASHRAE 90.1-2007
CSA-F326-M91
CAN/CSA-C439
Ventilation rate based on the type and number of rooms
Exhaust rate based on the number of bedrooms

## 2.2. Traditional Ventilation Strategies

Ventilation systems in houses have historically relied on one or more of the following ventilation strategies:

- **Natural Ventilation**

  In many existing houses, natural ventilation through operable windows has been the primary means of ventilation. Natural pressure differences due to wind and stack effect can cause air movement through a house, particularly if it has an open floor plan. Natural ventilation can save energy by reducing fan power for ventilation, or providing "free" cooling in shoulder seasons in mild climates (typically spring and autumn, or at night during the summer, 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 house. However, natural ventilation can significantly increase space heating and cooling-related energy consumption. Opening windows in cool and cold weather can also lead to uncomfortable temperatures and represent a security concern particularly if left open overnight or when the house is vacant. Providing ventilation air through windows does not enable the tempering and filtration of air contaminants, as a mechanical system with filtration would. Further, natural ventilation is unpredictable and unreliable and may not be present when needed or in the quantities required.

- **Mechanical Exhaust-Only Systems**

  Exhaust-only systems rely on one or more fan(s) to exhaust stale air from the house. Replacement (or "make-up") air is provided through passive air inlets (such as trickle vents), operable windows, or by air leakage through the enclosure. The fans are usually manually controlled by the occupants. When exhaust fans are operating, the house will be under negative pressure compared to the outdoors. This type of system is no longer acceptable by many codes, including the NBC, and is not a recommended approach as exhaust-only systems can backdraft fuel-fired appliances, fireplaces and woodstoves; they provide no assurance that the make-up air will be delivered where needed, and they add to space conditioning costs.

- **Mechanical Supply-Only Systems (with Intermittent Exhaust)**

  Supply-only systems use one or more fans, typically a furnace fan, to automatically deliver outdoor air into the house and to each room. The house will likely still have occupant controlled exhaust fans in rooms where moisture and odours are generated, such as bathrooms, kitchens, and laundry rooms. In most cases, a supply-only system is simply an insulated duct installed to provide a path for outdoor air to enter the furnace return air duct, drawn by the negative pressure in the duct when the furnace fan is operating. The outdoor air is mixed with the return air and is then delivered to each room of the house via the forced air system. In houses without forced air systems, a dedicated ductwork system would be needed to distribute the air.

  Supply-only systems provide the advantage of being relatively simple and inexpensive to install and they can take advantage of an existing forced air system to deliver the ventilation air evenly throughout the house. They also provide an opportunity to filter and temper outdoor air before it is introduced into the occupied space. However, when the exhaust fans are not operating, the supply-only system can place the house under positive pressure and this condition can drive warm humid indoor air into building enclosure assemblies, or cause air to leak out through incidental openings or penetrations. In cold climates typical of Canada, positively pressurizing the building can increase the potential for condensation within wall assemblies, which may damage the building enclosure system and lead to mould growth.

  This type of system is no longer acceptable by many codes, including the NBC, and is not a recommended approach.

## 2.3. Balanced Mechanical Ventilation

Balanced mechanical ventilation systems use fans to simultaneously exhaust stale air and supply outdoor air in equal quantities. It is the preferred, and in many jurisdictions the only allowed, approach to ventilation.

Every ventilation system should strive toward a balance between supply and exhaust airflow to prevent pressurization or depressurization. Balanced systems not only reduce the infiltration and exfiltration related to exhaust- and supply-only systems, but also typically offer better indoor air quality, more ventilation control, and reduced opportunities for contaminant migration between adjoining spaces (e.g., secondary suites, garage and work spaces, and attics).

These systems can include the following configurations:

- A central HRV/ERV or air exchanger that continuously exhausts stale air from the bathrooms, kitchen and laundry rooms, and supplies air to bedrooms and living, dining and recreation rooms through dedicated ventilation ducts (see Fig. 2.1) or as part of a forced air heating system (see Fig. 2.2).
- A furnace or air handler fan with an outdoor air duct connected to the furnace return that is interlocked to a central exhaust fan so that both operate simultaneously (i.e., the furnace draws in as much outdoor air as is exhausted by the central exhaust fan). Though this approach can be made to work, it can be far more troublesome to design and install than a "packaged" HRV/ERV system.

Systems that utilize the furnace or air handler for distribution of ventilation air tend to use more energy than ventilation systems that use dedicated supply and exhaust ductwork because of the need to continuously operate the large furnace or air handler fan. If such an approach is used, ensuring the air handling fan motor is driven by an energy efficient brushless direct current motor will significantly reduce operating costs in comparison with conventional furnace motors.

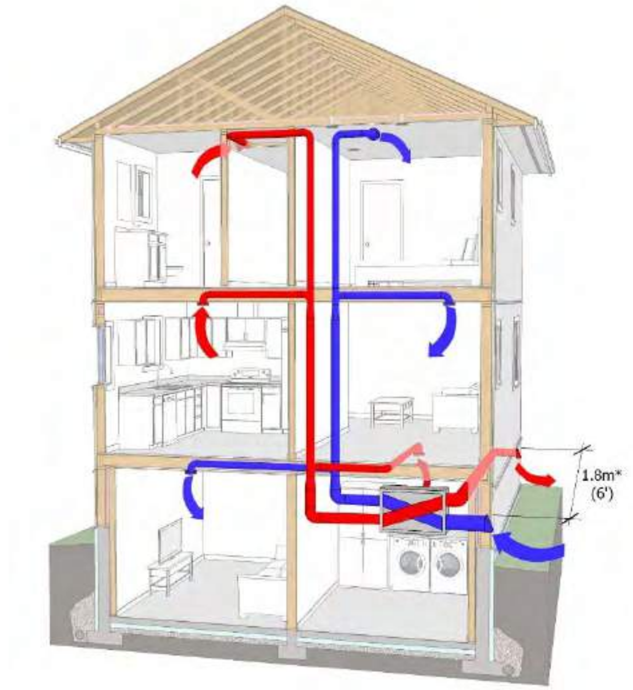



Fig. 2.1 Central HRV system. *Exhaust outlet and supply air inlet separation distance recommended by TECA.

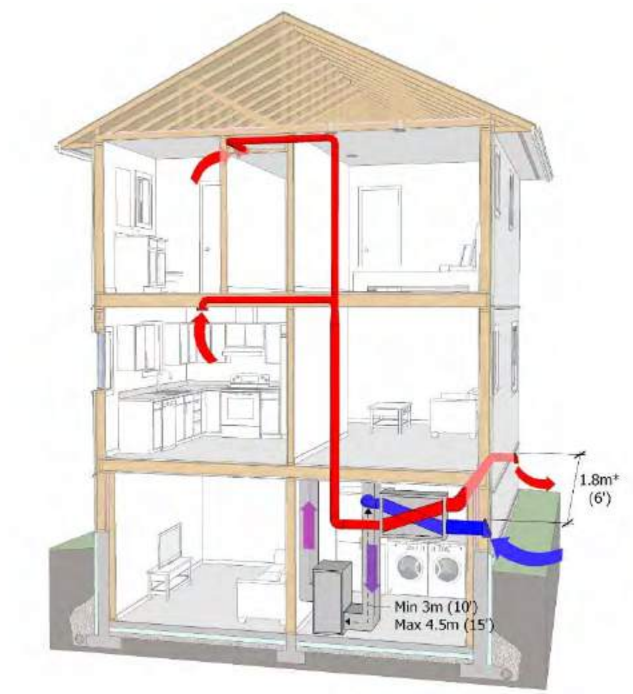



Fig. 2.2 Central HRV as part of furnace system.

# 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 houses. 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 house 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
- Condensation drain pan connecting to a drain
- Sensors and controls
- Removable /cleanable filters
- In some cases motorized dampers to aid in defrost

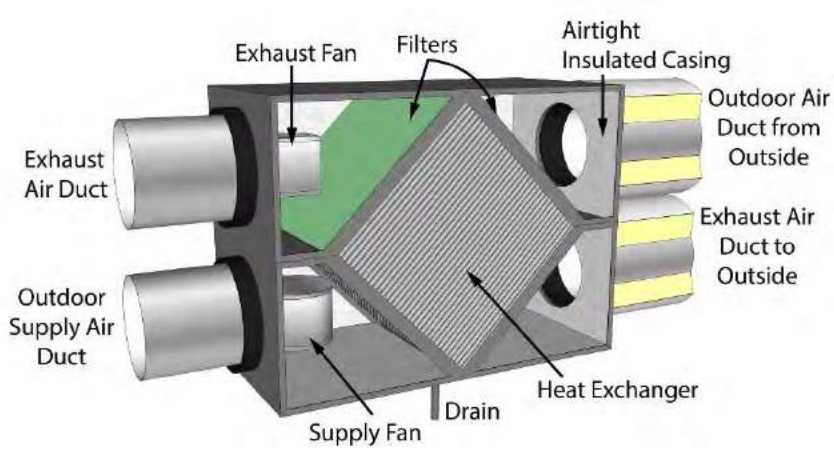



Fig. 3.1 Parts of a Heat Recovery Ventilator (condensate pan not shown).

The heat exchanger core of an HRV is constructed of 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.

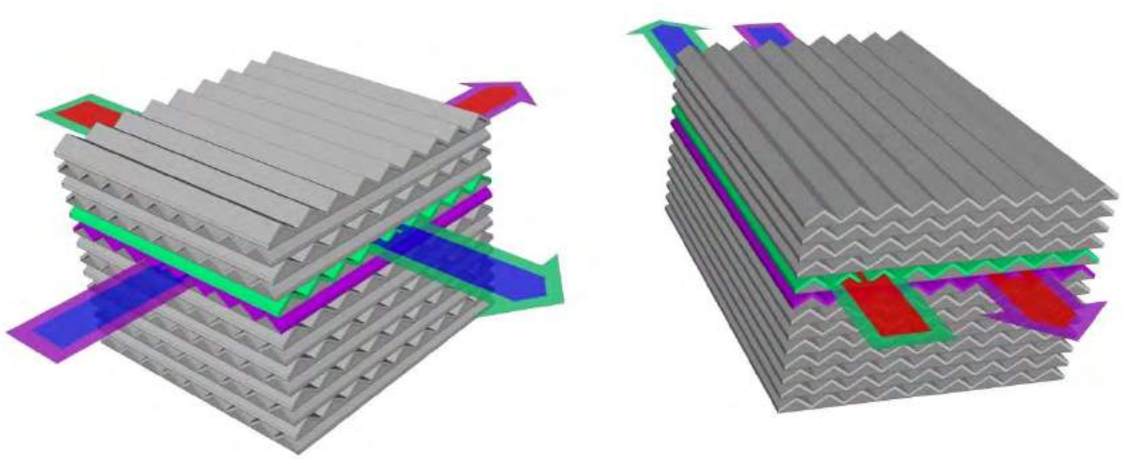


Fig. 3.2 Cross-flow core (left) and counter-flow core (right).

### 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, passes through the heat exchanger core (2), where it is preheated by heat transferred from the outgoing exhaust air (4). It is then supplied to the house via a supply fan and ductwork system (3). A separate duct system and exhaust fan draws exhaust air from the house 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 set up properly, create a balanced system with equal supply and exhaust airflows.

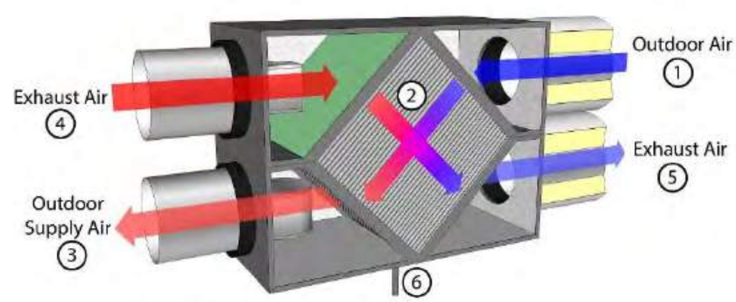



Fig. 3.3 HRV winter operation

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 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 house removes heat from the incoming warm outdoor air. In other words, the HRV pre-cools the outdoor air that is brought into the house. An HRV in a house 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). 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

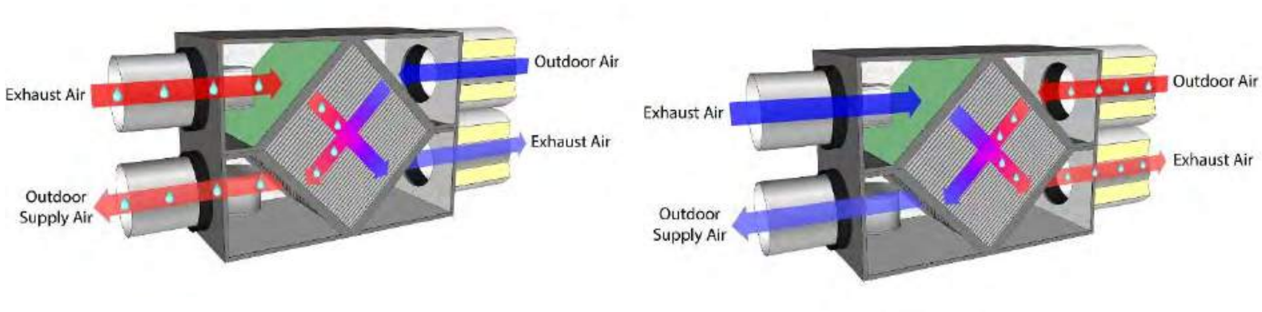
The components in ERVs are similar to those of HRVs. Since ERVs recover moisture, condensation does not typically form in the core. In many cases, ERVs have been installed without drains, although users should be aware that there may be circumstances under which an ERV will generate condensation (for 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.

### 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 3.4a). 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 3.4b). 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. 3.4 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 houses. 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 to and from a home, 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 room 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 and Soil Gas Safety*: In houses 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. Similarly, in houses with below-grade levels, soil gases can be drawn into the home during periods of depressurization. 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 building enclosure), space conditioning energy consumption can increase significantly.  A well-designed and controlled mechanical ventilation system in concert with an airtight enclosure will provide the amount of outdoor air needed for good indoor air quality and minimize the energy costs associated with ventilation.  Airtight homes equipped with HRV/ERV systems can operate in a far more cost-effective manner than in a less airtight house.

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 airstream 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/ERV can provide will vary with the home design, the system characteristics, quality of installation, climate, and occupant behaviour.  To give an indication of the savings possible, an energy analysis was completed for a typical 260 m² (2800 ft²) single family house in six locations across Canada representing different ASHRAE climate zones. These climate zones are illustrated for Canada in Fig. 3.5.

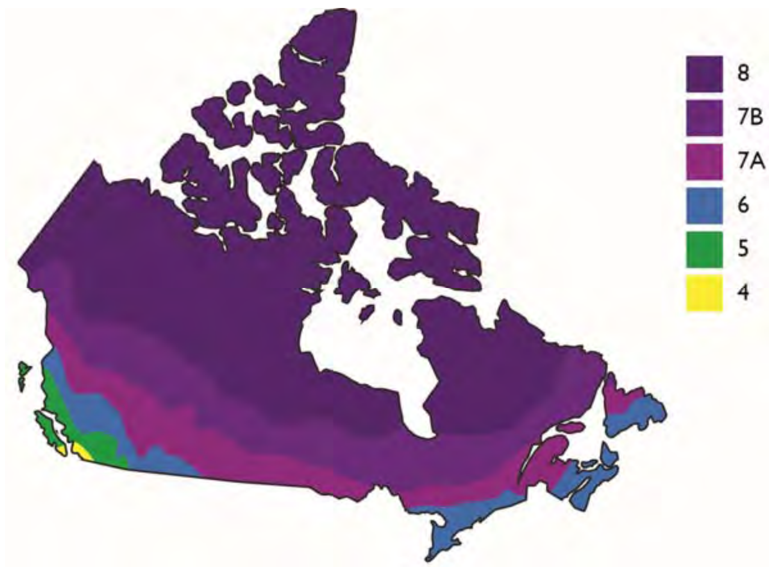



Fig. 3.5     Map of climate zones for Canada.

The results are summarized in Tables 3.1 and 3.2.  Table 3.1 represents a comparison of an HRV/ERV system to a typical existing house with intermittently operated exhaust fans. While this type of system is not supported by the NBC, it may still be used in jurisdictions that do not reference the NBC, and is common for many existing houses. Table 3.2 compares a balanced system with and without the HRV/ERV.  This is a more reasonable comparison for a typical new home.

Table 3.1 Modelled heating and cooling energy savings of an HRV compared to intermittent exhaust fans and a less airtight house.

| Location | Heating Degree Days† | Annual Energy Cost Savings and % Reduction in Annual Heating and Cooling Energy Due to HRV‡ | |
|---|---|---|---|
| | | Gas Furnace & Central AC | Electric Baseboard & No Cooling |
| Vancouver | 2825 | $50 (21%) | $120 (13%) |
| Toronto | 3520 | $100 (29%) | $340 (18%) |
| Montreal | 4200 | $70 (34%) | $220 (21%) |
| Winnipeg | 5670 | $180 (37%) | $360 (23%) |
| Fort McMurray | 6250 | $160 (41%) | $660 (25%) |

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

‡Modelling results are based on NBC 2010 Section 9.36 requirements for a 3-bedroom, 259 $m^2$ home (including conditioned basement); intermittent ventilation rate (125 L/s) per CAN/CSA-F326-M91; HRV *Sensible Recovery Efficiency* (SRE) of 65%; infiltration rate of 7.0 $ACH_{50}$ for the less airtight case and 2.5 $ACH_{50}$ for the HRV, based on NBC2010 modelling guidelines, and an assumed fan operating schedule.

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

Table 3.2 Modelled heating and cooling energy savings of an HRV compared to continuous balanced ventilation with no HRV/ERV

| Location | Heating Degree Days† | Annual Energy Cost Savings and % Reduction in Annual Heating and Cooling Energy Due to HRV/ERV‡ | |
|---|---|---|---|
| | | Gas Furnace & Central AC | Electric Baseboard & No Cooling |
| Vancouver | 2825 | $150 (48%) | $540 (40%) |
| Toronto | 3520 | $180 (47%) | $1,020 (41%) |
| Montreal | 4200 | $120 (50%) | $640 (44%) |
| Winnipeg | 5670 | $290 (50%) | $920 (44%) |
| Fort McMurray | 6250 | $230 (54%) | $1,730 (47%) |

†Heating degree days from 2010 National Building Code of Canada.
‡Modelling results are based on NBC 2010 Section 9.36 requirements for a 3-bedroom, 259 $m^2$ home (including conditioned basement); continuous ventilation rate (75 L/s) per CAN/CSA-F326-M91; HRV SRE of 65%; infiltration rate of 2.5 $ACH_{50}$ for both cases, based on NBC2010 modelling guidelines.
ERVs yield additional cooling energy savings if the home has air conditioning. However, because the Canadian climate is heating dominant, the difference in the energy performance between an HRV and ERV system is minor, and the results shown are for the HRV only.

Overall, significant energy savings can be realized in a typical Canadian house by building a relatively airtight house and installing an HRV or ERV. The percent 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 will lead designers, developers and builders toward a better understanding of the HRV/ERV system design and installation process to assist in the coordination of work with trained and certified ventilation subcontractors. This understanding will facilitate early planning and verification during design and installation, which is critical to ensuring the system operates as intended. A poorly designed or installed system will not provide the right amount of outdoor supply and exhaust air flows, may be too noisy for the occupants and may not save energy. Improperly installed systems can also be more difficult to operate and maintain and cause other unintended problems in the house.

Training and certification of system designers and installers is provided by organisations such as TECA[1], and HRAI[2].

## 4.1. System Design

The design process can be separated into four main steps, outlined in the inset.

**Overview of the Design Process**

Step 1: Code required ventilation rate calculation

Step 2: System configuration selection

Step 3: HRV/ERV selection

Step 4: Lay out and sizing of the ventilation system

A design checklist is included at the end of this section. The checklist can be used as a tool prior to beginning design, as well as a simple way to verify that key considerations have been addressed throughout the design process by the design and installation contractors.

### Step 1: Code required ventilation rate calculation

Minimum continuous ventilation capacity requirements are calculated based on the codes and standards outlined in Chapter 2. Factors that will have a major impact on the ventilation system size include local code and standard requirements, and the layout of the house (including number and types of rooms). Tips for calculating these requirements are provided in Table 4.1 below.

Table 4.1 HRV/ERV design tips: calculating ventilation requirements.

| Design Considerations | Design Tips |
|---|---|
| Codes and Standards | • The continuous ventilation rate should be used wherever a code or standard provides one.<br>• Some codes and standards provide separate calculations for ventilation outdoor air supply and exhaust rates; the higher rate should be used for both supply and exhaust to maintain a balanced system. |
| Floor Plan | • Consider which rooms will be supplied with outdoor air or exhausted by the HRV/ERV.<br>  • If bathrooms are connected to the HRV/ERV, the unit may require two modes of operation: continuous (low) flow, and occupied (high) flow. Some builders also install |

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

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

dedicated exhaust-only fans to provide extra ventilation when needed. Continuous exhaust of the kitchen is recommended via a high wall grille located at least 2 m from the cooktop. Additionally, an outdoor ducted dedicated range hood (with grease filter) can be installed to provide additional exhaust capacity as needed.

- Determine the capacities of any other exhaust fans and appliances that exhaust air other than the HRV/ERV. For houses with fuel-fired appliances or where soil gas is a concern, make-up air for large capacity exhaust devices such as high exhaust kitchen range hoods may be required to prevent house depressurization.

Below is an example ventilation rate calculation that conforms to CSA F326-M91, *Residential Mechanical Ventilation Systems*, which is referenced by the NBC and most provincial codes.

The example is a 3-bedroom, 2-bathroom house. The system would be sized with equal supply and exhaust, using the higher of the total calculated ventilation and exhaust capacities, i.e. for a minimum of 60 L/s (127 cfm). The HRV/ERV unit would then be selected such that this minimum rate is approximately 60% of the unit's airflow capacity, to allow boost capacity for intermittent kitchen, bathroom, and higher occupancy loads. Note that the Category B room types (kitchen, bathroom, laundry, utility room) typically pull the minimum ventilation capacity from other spaces and are not directly supplied with ventilation air.

Table 4.2 Minimum ventilation rate calculation.

| **Minimum Ventilation Air Requirements per CAN/CSA-F326-M91** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Number of Rooms** | **Minimum Ventilation Capacity Per Room** | | **Total Ventilation Per Room Type** | | **Continuous Exhaust Requirements Per Room** | | **Total Continuous Exhaust Per Room** | |
| Room Type | | L/s | (cfm) | L/s | (cfm) | L/s | (cfm) | L/s | (cfm) |
| **Category A** | | | | | | | | | |
| Master bedroom | 1 | 10 | 21 | 10 | 21 | | | | |
| Single bedrooms | 2 | 5 | 11 | 10 | 21 | | | | |
| Living room | 1 | 5 | 11 | 5 | 11 | | | | |
| Dining room | 1 | 5 | 11 | 5 | 11 | | | | |
| Family room | 1 | 5 | 11 | 5 | 11 | | | | |
| Recreation room | 1 | 5 | 11 | 5 | 11 | | | | |
| **Category B** | | | | | | | | | |
| Kitchen | 1 | 5 | 11 | 5 | 11 | 30 | 63 | 30 | 63 |
| Bathroom | 2 | 5 | 11 | 10 | 21 | 10 | 21 | 20 | 42 |
| Laundry | 1 | 5 | 11 | 5 | 11 | | | | |
| | | | | | | | | | |
| Total HRV / ERV System Ventilation Capacity* | | | | 60 | (127) | Continuous exhaust | | 50 | (105) |

| Minimum Ventilation Air Requirements per CAN/CSA-F326-M91 |
| --- |
| *While Category B room ventilation supply requirements are included in the total capacity calculation, they do not need to be supplied directly with outside air. They are typically exhausted only, with supply air achieved via transfer from other spaces. |

### Step 2: System Configuration Selection

There are two primary system configurations for an HRV/ERV system:

1. HRV/ERV in conjunction with a forced air heating system. In this configuration, the forced air system provides the air distribution. The HRV/ERV supplies outdoor air into the return side of the furnace ductwork and draws ducted exhaust air directly from spaces in the house, as shown in Fig. 4.1. Another option is to duct bathroom and kitchen exhaust separately, and pull return air from the furnace ductwork to the HRV, upstream of the outdoor air connection. Note that some codes, including NBC, require at least general exhaust to be ducted directly to the HRV/ERV.

   These systems typically use a trunk and branch ducting system, in which a main supply and a main exhaust duct is run centrally through the house, with branches off the mains to feed individual spaces. These systems can work effectively if properly designed and balanced. Balancing is usually achieved via manually adjusted balancing dampers, although adjustable diffusers may also be used to fine tune airflow at the outlet.

2. HRV/ERV as a standalone system. Fully ducted systems are completely separate from the space heating or cooling system and include separate ductwork for both supply and exhaust distribution. If used with a furnace system, the HRV/ERV will typically be interlocked with the furnace so that the furnace fan operates when the HRV/ERV does. The basic HRV/ERV with trunk and branch ducting is shown in Fig. 4.2.

   Another option for a standalone system is to use home run ducting, in which each grille/diffuser is connected to one or more dedicated ducts that run directly to and from the HRV/ERV unit, as shown in Fig. 4.3. Balancing is relatively simple because each duct is only connected to one diffuser or diffuser box. Fine tuning of airflow can be achieved by adjusting the nozzle of the supply diffuser. A mixing box is required between the home run ducts and the HRV/ERV unit to consolidate the air entering and leaving the main supply and return openings. Photos of the different ducting options are shown in Fig. 4.4 and Fig. 4.5.

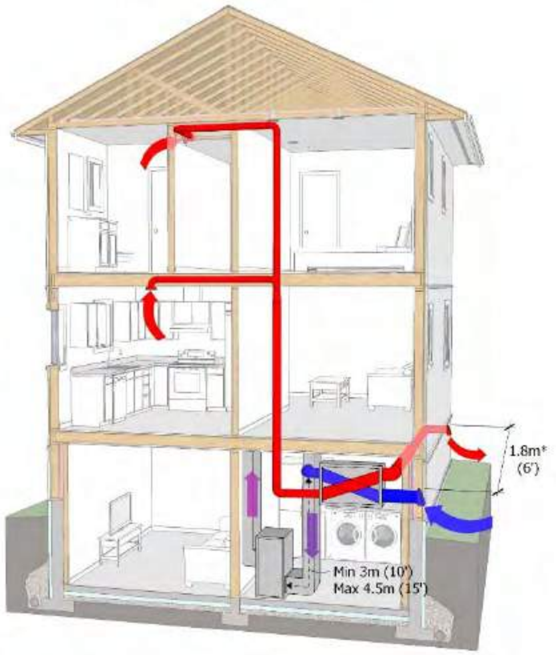



Fig 4.1 HRV/ERV installed with furnace system.

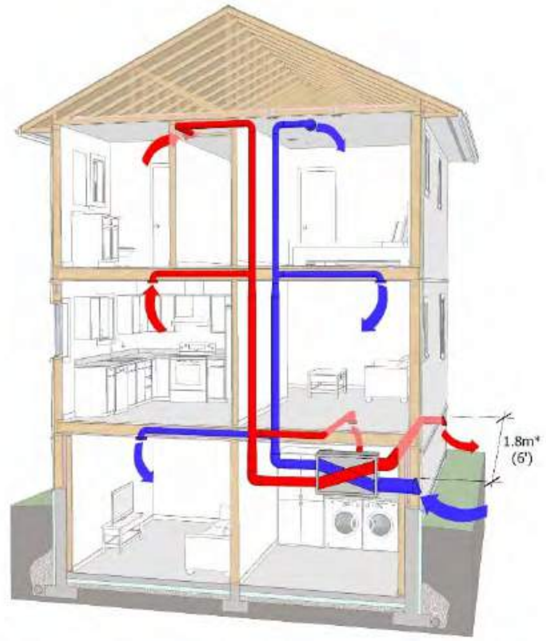



Fig 4.2 Independently ducted HRV/ERV.

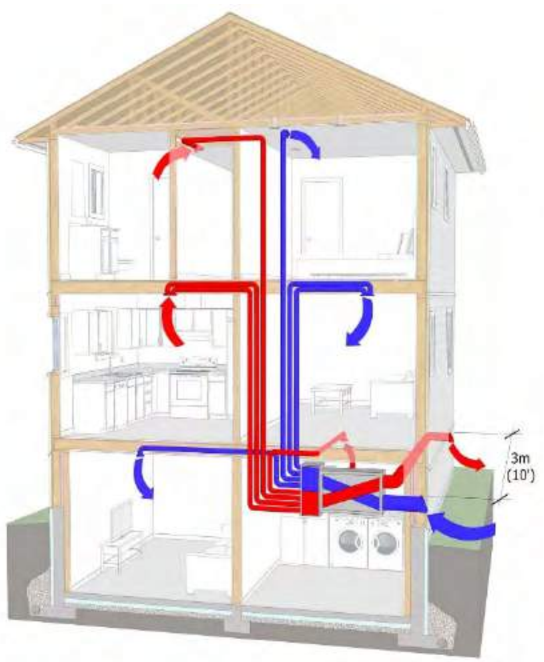



Fig. 4.3 Home run ducting system.

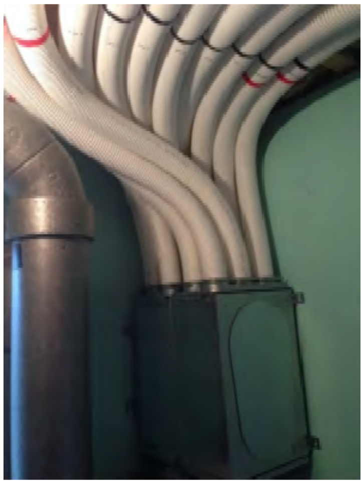


Fig. 4.4 Mixing box (above HRV not shown), with home run ducting (HDPE with smooth interior surface). Image courtesy of NZ Builders.

Fig. 4.5 HRV installation with trunk and branch ducting. Insulated ducts are to/from outside.

### Step 3: HRV/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 house is the first step.

- *Energy consumption*:
  - Summer considerations: If summers are hot and humid and the house 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. If moisture control is a bigger consideration (which it is in cold climates), an HRV will often be the better choice.
  - Brushless direct current motor fan sets 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*: Houses with significant moisture generation (such as densely occupied houses) 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. A basic understanding of the key 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 4.3 below can be used to identify these and other important parameters for a particular project. A careful review of equipment submittals and any substitution requests is recommended to ensure the project requirements are met.

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 4.3 Equipment selection parameters.

| Parameter | Description | Impact/Comment |
|---|---|---|
| **PERFORMANCE PARAMETERS** | | |
| Airflow Capacity | • Airflow rate, L/S (CFM), should match or slightly exceed the specification at design conditions. A good rule of thumb is to select the capacity such that the calculated continuous ventilation rate is a maximum of 60% of the unit capacity, to allow boost capacity for kitchens and bathrooms and a low setting for low occupancy. | • An undersized unit may not meet ventilation requirements, while an oversized unit adds unnecessary capital and energy costs.<br>• The capacity selected will be impacted by considerations such as whether the unit is providing bathroom ventilation in lieu of bathroom fans. |
| Heat Recovery Efficiency | • Sensible Heat Recovery Efficiency (SRE): Manufacturers test each HRV/ERV to determine the SRE. Since the efficiency changes at different temperature and humidity conditions, HRV/ERVs are tested to standard conditions to allow for comparison between products. In Canada, HRVs and ERVs are tested to Standard CSA-C439.<br>• Total Heat 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. | • A quiet unit is critical for house applications (there should be no audible noise at air outlets), although system installation practices also have a significant impact on vibration and sound transfer and airflow noise. Installing units with vibration isolation mounting, properly sizing ducts, grilles and diffusers, using smooth transitions, reducing number of unnecessary fittings |

| | | |
|---|---|---|
| | | and using short lengths of flexible ducting to connect the ducts to the four ports of the HRV/ERV will minimize sound transfer.<br>• Locating HRVs away from sleeping areas is recommended.<br>• Example sound data for a high quality HRV unit ranges from 36-73 dBA (for low to maximum airflow) at the supply air outlet of the unit. |
| Filtration | • Filters must be located to facilitate access and regular service. | • The fan-motor sets in most HRV/ERVs are not sized to overcome the external static pressure that higher performing filters may impose. If a high degree of filtration is needed, auxiliary filtration systems are available. |
| Control Options | • Control options determine how the occupants interact with the HRV/ERV system.<br>• 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. Many units have control panels that can be mounted in a central location such as where the thermostat is located. | • 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).<br>• 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, except BC's Lower Mainland (Climate Zone 4 in NBC).<br>• 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.<br>• 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.<br>• 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 can be selected with very flat or narrow dimensions to take up minimal square footage. |
| Casing Thickness, Material, and Construction Quality | • Stainless steel, aluminum, coated steel and plastic are common construction materials.<br>• The casing should be insulated. | • Thinner casing material will provide less sound damping and may be less durable.<br>• Joints should be sealed for airtightness. Poorly sealed joints will compromise energy efficiency through air leakage. |
| 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).<br>• 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. |

### Step 4: Lay Out and Sizing of the Ventilation System

The system sizing and layout will vary significantly based on the size of the house, the number and types of rooms, and other building-specific information. The layout and sizing process typically involves the following steps:

- *Locate the ventilation system equipment*: This involves choosing the appropriate locations for the HRV, all indoor supply diffusers and return grilles, and outdoor air intakes and exhaust(s).

  Locate the HRV within the heated space, accessible for filter cleaning and other maintenance, and near an exterior wall, so that the outdoor air duct run is short. The ducts to and from the outside will require thermal insulation to prevent condensation.

Locate interior supply diffusers so that the outdoor air is well circulated in each room. Diffusers should be mounted in the ceiling or preferably, linear grilles can be located high up in partition walls within 300 mm (12”) of the ceiling so that the supply air sweeps across the entire room before it exits under the door.

Locate exhaust grilles in bathrooms, kitchens, laundry rooms and walk-in closets: in the ceiling or high in a partition wall within 300 mm (12”) of the ceiling; and away from entry doors so that air moves under the door and across the entire room.

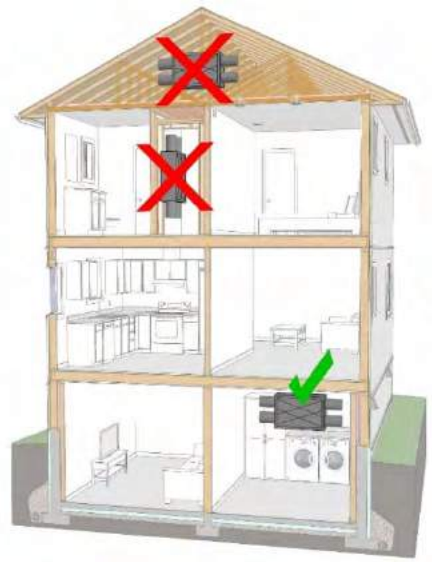
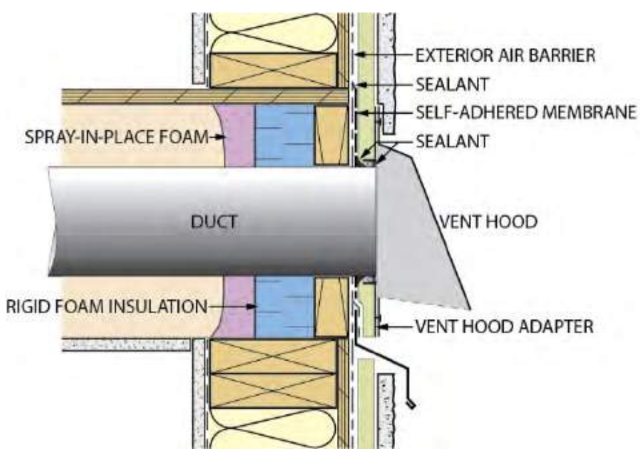


Fig. 4.6: Good and bad HRV locations. Avoid unconditioned spaces, and spaces such as bedroom closets where noise might be an issue.

The outdoor air intake hood is recommended to be located a minimum of 1.8 m (6’) from the exhaust outlet hood (per TECA and HRAI guidelines); at least 900 mm (36”) from all pollution sources; at least 450 mm (18”) above grade, or above the highest snow level, and so that it is accessible for cleaning (i.e., not located under decks). Other potential pollution sources may include plants/trees/pollens, emissions/exhaust from adjacent buildings, sources of odours and moisture, irrigation sprinklers, dog runs, garages/highways, and nearby industrial or commercial emissions. Additional filtration may be desired depending on the identified contaminants. Being aware of potential future decks and patios is also important.

- *Lay out the ductwork*: The ductwork should be sized and laid out to minimize the airflow resistance or friction. This can be accomplished by using the shortest path between the exhaust or supply grille and the HRV, and choosing duct materials with the smoothest possible interior surface, to minimize friction losses and buildup of contaminants (e.g. round sheet metal or medical grade HDPE). Minimize the number of turns in the ducts, and where they are unavoidable make them as gradual as possible. Flex duct is not recommended except for a short section for sound dampening at the connections to the HRV/ERV unit and for the insulated sections between the unit and outdoors.

  Keep ductwork inside the conditioned space of the house wherever possible, and avoid unconditioned attic spaces and crawlspaces. When ducts are located in unconditioned spaces they must be insulated as required by locally applicable building code and wrapped with a vapour barrier. Where ducts penetrate the air barrier, ensure that it is air sealed to the air barrier in a way that will last the life of the building. A sample detail of a duct penetration is shown in Fig. 4.9 below.



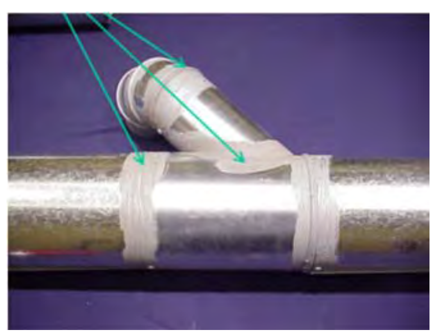



Fig. 4.9 Sample detail of duct penetrating the building's air barrier. Fig. 4.10 Duct sealing

The size, type and location of grilles and diffusers can impact occupant comfort. Undersized grilles restrict airflows and may be noisy.

Codes outline ductwork requirements, such as insulation, sealant and mounting. It is important to seal all seams and joints (such as those shown in Fig. 4.10) with a durable aluminum foil tape or a liquid sealer or mastic, to ensure that the ductwork supplies and exhausts the quantities of air per the design.

- *Size the ductwork*: The size of the ductwork required will depend on the layout and the volume of air that flows through each duct and the external static pressure rating of the fan motor set. Round or rectangular ductwork can be used, although round is more common in smaller applications such as household HRV/ERVs since it is less costly to manufacture.

  Builders should verify that the ductwork is sized using the simplified methods outlined in various codes, or recognized good engineering practice. The following codes provide simplified duct sizing methods:

  - National Building Code of Canada (NBC): Table 9.32.3.11.A provides the allowable duct size based on the length of duct and airflow passing through.
  - British Columbia Building Code (BCBC): Table 9.32.3.8 provides the allowable smooth or flexible duct sizes based on airflow.
  - Vancouver Building Bylaw (VBBL): Table 9.32.3.8 provides the allowable smooth or flexible duct sizes based on airflow.
  - Alberta Building Code (ABC): Table 9.32.3.11.A provides the allowable duct size based on the length of duct and airflow passing through.
  - Ontario Building Code (OBC): Tables 9.32.3.4B, 9.32.3.5, and 9.32.3.7A/B specify the smooth or flexible duct sizes for the principal exhaust duct, kitchen and bathroom exhaust ducts, and principal/branch supply ducts. The branch ducts are sized based on the number and types of rooms while the main ducts are sized based on the number of connecting branch ducts.
  - Quebec Construction Code: References the NBC.

  When using simplified duct sizing methods it should be understood that they are conservative and will tend to oversize the duct diameter compared to detailed design methods. Simple ductwork layout and sizing examples for both trunk-and-branch and home run systems are provided in the Appendix.

- *Confirm HRV/ERV fan capacity is adequate:* Once the duct layout and sizing is complete, the capacity of the fans within the HRV/ERV must be checked to ensure that they can overcome the total static pressure of the ventilation system.

- *Check combustion appliance and soil gas safety:* Exposure to potentially harmful gases is a concern in houses that have naturally aspirated combustion appliances, attached garages, and/or other potential sources. While HRV/ERVs are intended to provide balanced ventilation, they are not make-up air systems for unbalanced exhaust; they are not combustion air systems for non-sealed combustion appliances, and they are not soil gas prevention/remediation systems. Make-up air may be required for large capacity exhaust equipment if the house has appliances subject to back drafting or the house is located in an area classified as a concern for radon.

### 4.1.2 Design Checklist

The checklist below can be used as a tool prior to beginning design, as well as a simple way for the builder to verify that key considerations have been addressed by the design contractors.

Table 4.4 Design checklist.

| HRV/ERV System Design Checklist | |
|---|---|
| HRV/ERV unit manufacturer & model: | |
| HRV/ERV Rated performance at 0°C (32°F) and -25C (-13F), per CAN/CSA C439: | |
| Net air flow, L/S (CFM): | |
| Power consumed (Watts): | |
| Sensible Heat Recovery Efficiency (SRE)/ Total Recovery Efficiency (TRE): | |
| HRV Capacity, L/S at 100 pa (CFM at 0.4 ESP per TECA guideline) | |
| Design airflow, continuous mode, L/S (CFM) | |
| Design airflow, boost mode, L/S (CFM) | |
| Unit location is specified on plans | Y/N |
| Unit is located inside thermal envelope | Y/N |
| Filter can be easily replaced | Y/N |
| Outdoor supply and exhaust vents are marked on plans | Y/N |
| Min 1.8 m (6') between outdoor supply and exhaust | Y/N |
| Outdoor air supply duct (from outside) length & diameter: | |
| Outdoor air supply duct (from outside) insulation type & R-value: | |
| Exhaust duct (to outside) length & diameter: | |
| Exhaust duct (to outside) insulation type & R-value: | |
| Dedicated low-volume ductwork (or) forced-air heating ducts? | |
| Plans specify all ductwork inside thermal envelope | Y/N |
| If envelope penetrated, penetration details are indicated on plans | Y/N |
| If envelope penetrated, specify insulation value & type: | |
| Plans show outdoor air supply to all bedrooms and primary living areas | Y/N |
| Exhaust from all bathrooms, kitchens and laundry areas | Y/N |
| Boost mode controller is provided in each bathroom | Y/N |
| If not, secondary exhaust fan is provided in each bathroom | Y/N |

## 4.2. Installation Considerations

Proper installation techniques are as important as good design practice. Installation should be monitored throughout the construction process, and at construction completion. A good start towards getting a well-installed system is to select installers who have taken Ventilation Installer training, such as those offered by HRAI Canada or TECA.

### 4.2.1 HRV/ERV System Installation Checklist

The following is an installation checklist that can be used for HRV/ERV systems. The goal of the checklist is to enable builders to review systems as they are installed and upon completion, and to verify that systems are installed following good practice.

Table 4.5 Installation checklist.

| Installation Checklist | Yes | No | N/A | Notes |
|---|---|---|---|---|
| **HRV/ERV Unit** | | | | |
| Model installed is same as that specified in design | | | | |
| HRV/ERV is located within conditioned space as shown on plans | | | | |
| HRV/ERV is hung from vibration isolating straps or is mounted on rubber or spring vibration isolators | | | | |
| HRV/ERV is fully accessible to open 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 waste water drain (with trap primer if necessary) | | | | |
| Operation and maintenance instructions are provided | | | | |
| Installer's name on HRV/ERV along with airflow balance confirmation | | | | |
| System balanced by:/ Date: indicated on unit | | | | |
| **Ductwork** | | | | |
| All four ducts running from the HRV/ERV incorporate a section of flexible duct to minimize vibration transmission | | | | |
| 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 | | | | |
| Supply and exhaust outlets are installed per plan | | | | |

| Installation Checklist | Yes | No | N/A | Notes |
|---|---|---|---|---|
| **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 hoods it terminates with a double walled ring and the exterior vapour barrier is taped to the outer wall of the ring | | | | |
| Where sheet metal ductwork passes through the air barrier, it is air sealed to the air barrier in a way that will last the life of the building | | | | |
| Where ceiling grille fittings pass through an exterior air barrier they are sealed in a way that will last the building's life | | | | |
| Exterior hood penetrations are sealed to the exterior wall air barrier | | | | |
| If envelope penetrated, a duct airtightness test was performed | | | | |
| Airtightness of the house at final ($ACH_{50}$ or Normalized Leakage Area): | | | | |
| **Exterior Air Intake & Exhaust Hoods** | | | | |
| Outdoor air intake incorporates a 6 mm (1/4") mesh to prevent pest entry | | | | |
| Outdoor air intake is a minimum of 1.8 m (6') from exhaust outlet; 900 mm (36") from all other pollution sources (combustion vents, plumbing vents, dog runs, dumpsters, etc.) | | | | |
| Outdoor air intake & exhaust are a minimum of 450 mm (18") above grade and above winter snow levels | | | | |
| Outdoor air intake & exhaust are accessible for cleaning | | | | |
| **Ventilation Grilles** | | | | |
| 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 | | | | |
| Kitchen HRV grille at least 2 m (6.5') from cooktop and is supplied with accessible grease filter | | | | |
| Exhaust grilles are located to ensure effective removal of indoor moisture and air pollutants | | | | |
| Strong exhaust airflow detectable at kitchen and bathroom grilles | | | | |

| Installation Checklist | Yes | No | N/A | Notes |
|---|---|---|---|---|
| **Controls** | | | | |
| A centrally located wall controller is installed and connected and enables occupants to switch the unit on and off | | | | |
| For multi-speed units, the central controller allows the occupants to switch between speeds | | | | |
| Timer switches and or humidistats are located and operational in all bathrooms serviced by the HRV/ERV | | | | |

# 5. HRV Retrofits for Existing Houses

An HRV/ERV can be considered for any ventilation retrofit solution, since it is intended to provide optimal levels of indoor air quality and energy efficiency. This chapter identifies the typical scenarios in which a ventilation upgrade involving an HRV/ERV would be undertaken for an existing house, 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 covered in Chapter 6.

**Overview of the Retrofit Process**

**Step 1**: Identify the need or opportunity: When is a ventilation upgrade necessary or desired?

**Step 2**: Understand the existing ventilation system

**Step 3**: Evaluate and select ventilation retrofit options

**Step 4:** Design and implement the solution

**Step 5:** Commission upgraded system and verify results

## 5.1. Identify the Need or Opportunity

A ventilation retrofit in an existing house 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 house 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 is occurring or mould is appearing on interior surfaces, it is possible that building enclosure components or assemblies are not providing adequate thermal resistance, causing interior surfaces to get too cold and create condensation. Other factors that may contribute to condensation on interior surfaces include poor distribution of air to exterior walls and windows, and 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.

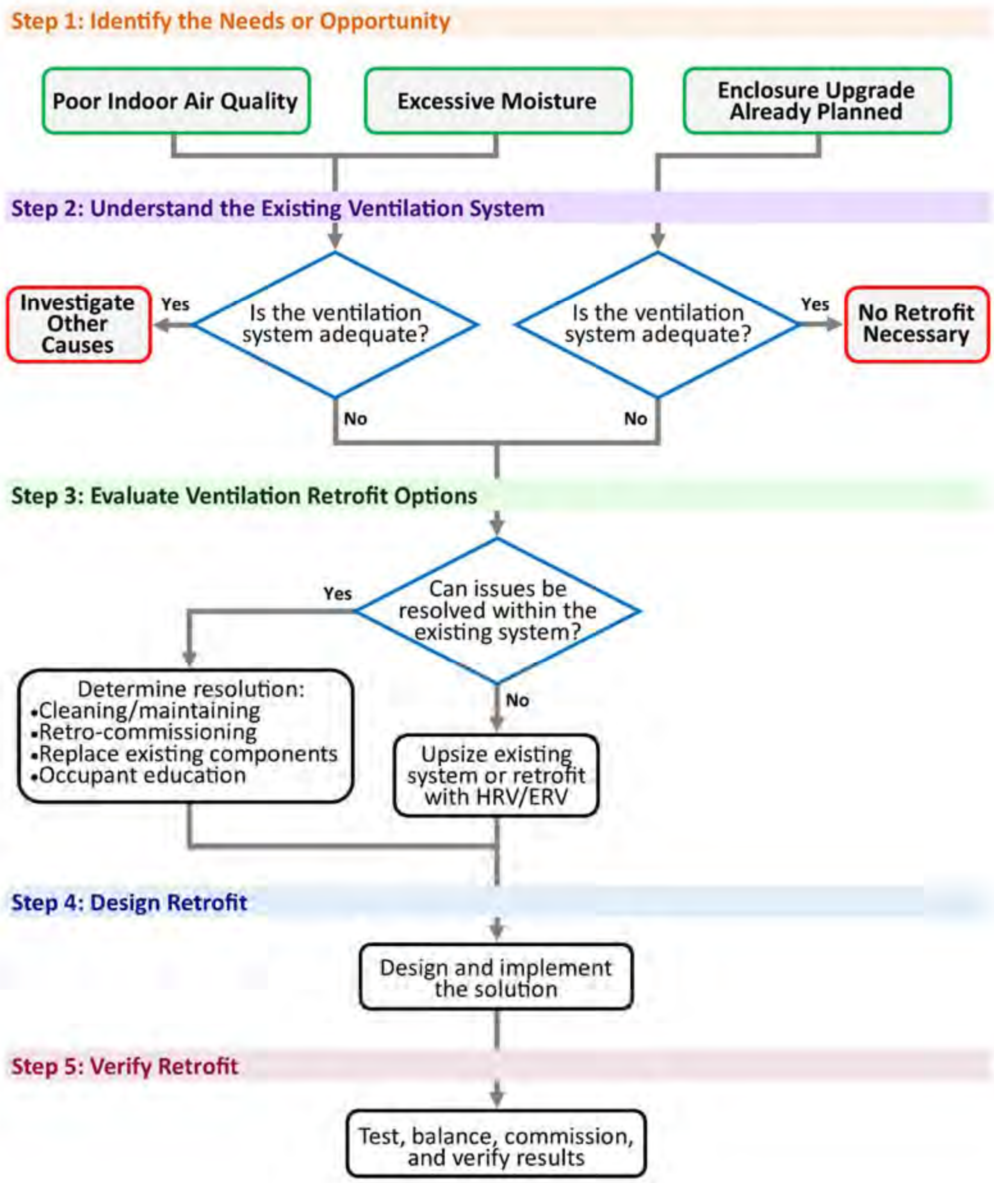



Fig. 5.1 Ventilation system retrofit process.

## 5.2. Understand the Existing Ventilation Strategy

> 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.

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

### 5.2.1 Existing Mechanical Ventilation System

The main ventilation system types are described in Chapter 2 (exhaust-only, supply-only or balanced). The majority of existing older houses will either rely on operable windows and/or will have intermittent exhaust-only systems (kitchen and bathroom fans), meaning that ventilation air is drawn in through the building enclosure when the occupant turns on an exhaust fan or opens a window. In these cases, there is no dedicated mechanical ventilation system. Some houses with forced air systems will incorporate an outdoor air inlet into the furnace ductwork and may or may not have exhaust-only fans.

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 must be taken at all exhaust outlets and air intakes while the system is in operation. The following table can be used to check and record flow rates along with automatic/manual operation and estimated operating hours per day to assist with the ventilation system design. Refer to the sample ventilation rate calculation in Chapter 4 to determine if the measured ventilation is adequate.

Table 5.1 Airflow measurement checklist for an existing house.

| Airflow Measurement | Measured Flow Rate, L/s (*cfm*)* | Automatic/Manual | Estimated Operating Hours/day |
|---|---|---|---|
| **Exhaust** | | | |
| Bathroom 1 Exhaust Fan | | | |
| Bathroom 2 Exhaust Fan | | | |
| Bathroom 3 Exhaust Fan | | | |
| Kitchen Exhaust Fan | | | |
| Additional Exhaust Fan(s) | | | |
| **Total Exhaust** | | | |
| **Supply** | | | |
| Supply Fan 1 | | | |
| Supply Fan 2 | | | |
| **Total Supply** | | | |
| **Passive** | | | |
| Passive Air Inlet(s) (#/inlet dimension(s)) | | | |
| Furnace Duct Air Inlet (size – diameter mm (in)) | | | |
| *NRCan's Heat Recovery Ventilators guide provides a low-tech method for measuring room-by-room airflow: http://aea.nt.ca/files/download/9ea593f131fa335 | | | |

### 5.2.2 Building Enclosure Airtightness Performance

Historically, Canadian houses have relied upon exhaust-only systems to provide acceptable air quality, typically relying upon some sort of air leakage through the enclosure. As discussed in previous chapters, the amount of either intended or unintended air exchange through the building enclosure can have a significant impact on the effectiveness of the ventilation system. Additionally, uncertainty of the source and quality of the air leaking into the house – and the uncontrolled nature of where it might actually end up – make exhaust-only systems questionable in terms of performance.

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

The airtightness of the building enclosure can be measured using a fan door air leakage test. This can be performed by a residential certified energy advisor (CEA), often done in conjunction with a Natural Resources Canada's EnerGuide for Houses evaluation. In Canada, the test will typically conform to CAN/CGSB 149.10-M86. This type of test is very common as part of weatherization work or government/utility incentive programs.

The test consists of installing a piece of specialized equipment known as a fan-door into an exterior door of the house and depressurizing/pressurizing the house. The resulting measurements of airflow and indoor-outdoor pressure differences provide an indication of the airtightness of the house enclosure. This airtightness can be expressed as a flow rate per unit wall area, as a leakage area (often referred to as Equivalent Leakage Area, ELA) to visualize the sum of all the building enclosure's holes in one combined dimension, or as an air exchange rate (often referred to as air changes per hour at 50 Pa, $ACH_{50}$). The $ACH_{50}$ value is a commonly used metric to compare the airtightness of houses. $ACH_{50}$, however, is neither a direct indicator of the airtightness of the enclosure nor a measurement of the house's ventilation rate in service. Houses operate at much lower pressure differences than those used for testing (typically 0 to 10 Pa) resulting in much lower natural air exchange rates. As an approximate conversion, the $ACH_{50}$ measurement can be divided by 20 to estimate the natural infiltration rate for the home under average conditions. More accurate estimates of natural infiltration can be performed by engineering calculations or simulations.

Most new houses in Canada will have $ACH_{50}$ values of between 2 and 5, with older houses in the range of 5 to 10 or higher. Experience has shown that houses with $ACH_{50}$ values of less than approximately 3 (depending on exposure, occupancy, house size, etc.) will generally not have enough leakage through the building enclosure for natural ventilation to provide adequate indoor air quality – and the natural ventilation rate will be intermittent and difficult to predict. Therefore, 3 $ACH_{50}$ is often used as an approximate cut-off point below which a balanced continuous ventilation system such as an HRV/ERV system is recommended. In less airtight houses, HRV/ERV systems will improve indoor air quality, but will not have as tight control over the whole house ventilation rate resulting in a lost energy recovery opportunity.

The $ACH_{50}$ and ELA values measured by the fan door test can also be used to evaluate the combustion safety and potential for backdrafting of fuel-fired appliances when exhaust fans are operating. Additional guidance on balancing primary exhaust fans and make-up air for larger equipment can be found within Section 9.32 of the NBC and in provincial building codes.

If the building enclosure is being upgraded, then the airtightness test should occur before the upgrade to establish the air leakage “before” condition and to locate leakage points, and again after the upgrades have been completed so the overall improvement can be assessed. In most cases, the new enclosure will be more airtight than the older one. If a supply or exhaust-only mechanical system was in place, a balanced HRV/ERV ventilation system should be considered for the retrofit, particularly if the airtightness is below 3 $ACH_{50}$. If unsealed combustion appliances are present in the house (e.g., fireplaces, wood stoves, gas water heaters, unsealed furnace), a combustion safety test should always be performed after a building enclosure or ventilation system retrofit to assess the need for additional protective measures such as a dedicated make up air system.

## 5.3. Evaluate and Select Ventilation System Retrofit Options

Once the ventilation system airflow and airtightness have been determined for a house, then the overall ventilation rate can be calculated. If the existing ventilation rate has been found to be inadequate, upgrade options can then be considered. Simpler options, such as cleaning the existing 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.

Many occupants of houses that have an exhaust-only ventilation system do not use the exhaust fans to improve overall indoor air quality. If exhaust-only systems are to be relied upon for ventilation, homeowner education may be required.

### 5.3.1 Benefit Threshold

As shown in Table 5.2 below, HRV/ERV systems are recommended for more airtight houses. This is because, in order to gain the energy recovery benefits that justify the cost and effort of installing an HRV/ERV system, the majority of the home’s ventilation air must pass through that system. When the airtightness of a home is poorer than approximately 3 $ACH_{50}$, the energy benefit is less, although an upgraded ventilation strategy may still be required or desired for other reasons, such as improved indoor air quality. Furthermore, energy savings aside, in order to achieve the same airflow performance of an HRV/ERV system, a more complicated system of interconnected and controlled supply air fans, exhaust air fans would have to be designed, installed and commissioned – at a cost that may equal, or be more than, the well-engineered packages offered by HRV/ERV manufacturers.

Table 5.2 below provides suggested ventilation system options for existing houses, assuming that excessive moisture and pollutant sources are not present and that all building enclosure elements are insulated and windows are, at a minimum, double-glazed (to reduce condensation potential). Additional health and safety issues related to combustion gas safety and entry of soil gases, including radon, are not addressed by this table.

Table 5.2 Minimum ventilation strategies depending on airtightness and climate zone.

| Climate | Airtightness [ACH @ 50 Pa] | Minimum Control Strategy | Minimum Ventilation Strategy |
|---|---|---|---|
| Coastal /Maritime Climate Zones (Higher Humidity Winters) | ≤ 3.0 | Continuous low speed with manually operated high speed | Continuously operating HRV/ERV system |
| | 3 to 5 | | |
| | 5 to 7 | Time-of-day timer with ability to operate continuously | Central low-noise fan (rated for continuous operation), outside air supply (passive air inlets or in-line furnace duct) or building enclosure leakage for supply air |
| | ≥ 7 | On/Off, time-of-day timer | |
| Non-Coastal / Continental Climate Zones (Lower Humidity Winters) | ≤ 3.0 | Continuous low speed with manually operated high speed | Continuously operating HRV/ERV system |
| | 3 to 5 | Time-of-day timer with ability to operate continuously | Central low-noise fan, outside air supply (passive air inlets or in-line furnace duct) or building enclosure leakage for supply air |
| | ≥ 5 | On/Off, time-of-day timer | |

## 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 house. An HRV/ERV installer who specialized in retrofits should be involved in the project. Some design considerations and suggestions for HRV/ERV retrofits are listed below:

*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.
- A reasonable approach is to target 0.3 ACH room by room as a starting point, and consult with a qualified mechanical contractor.

*HRV/ERV location*

- If there is a furnace in the house, locate the HRV/ERV in the same room to provide access to connect the HRV/ERV supply and exhaust ducts to the existing trunk ducts.
- If the house is heated by baseboards or in-floor heating (i.e., no existing central duct system) consider locating the unit in an existing service space (e.g., basement or laundry room) where aesthetics are less important. While unit sizes vary, plan for a space of at least 1.5m x 1m x .6m (5’ x 3.3’ x 2’) to accommodate the unit and ductwork entering and leaving the unit.
- Alternatively, a drop ceiling in a bathroom or closet could be used to help conceal the unit (note that an access hatch would be required for maintenance). Never install an HRV/ERV in an unheated attic.

- Consider how the unit will connect its drain pan to a sanitary pipe, whether 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.
- Ensure enough space so the unit can be easily inspected and serviced and if necessary, removed.
- Try to locate the unit as close to an exterior wall as possible to limit the amount of insulated cold-side flex duct needed.
- Do not install the unit near bedrooms as they can produce a small amount of vibration and airflow noise that some may find disturbing.

*Ductwork runs*

- Where possible provide supply air to each of the bedrooms/living spaces and exhaust from the bathrooms/kitchen/laundry room either through the existing forced air system or through a dedicated duct system.
- Conceal new duct runs in dropped ceilings, vertical chases, or by opening existing walls.
- If the house has a furnace, it is possible to simply interconnect the HRV with the return air duct and operate the furnace fan continuously or on a set 24 hour schedule to achieve the desired air change rate. The exhaust side may be run from basement bathrooms or first floor bathrooms and the kitchen, while connecting the outdoor air duct to the furnace return.

*Outdoor air inlets/ exhaust outlets*

- The location of the outdoor air hood can be a challenge in a retrofit. Review code intake requirements, which generally require avoiding any sources of contamination of the outdoor air.

# 6. Commissioning, Balancing and Troubleshooting

This chapter provides guidance for builders and renovators so they understand the start-up of HRV/ERV systems including balancing and troubleshooting of common problems. It applies to both new house systems and retrofits. While these issues could occur during start-up, they could also occur at any time during regular operation of the house. This information is therefore relevant to both the installer and owner.

## 6.1. Measuring and Balancing Airflows

It is important to ensure that the HRV installer balances the ventilation system as part of the start-up in order to ensure that:

- The amount of air entering the house is the same as the amount of air leaving the house;
- The appropriate outdoor supply airflow reaches each space; and
- An appropriate amount of exhaust air is drawn from the kitchen and bathrooms.

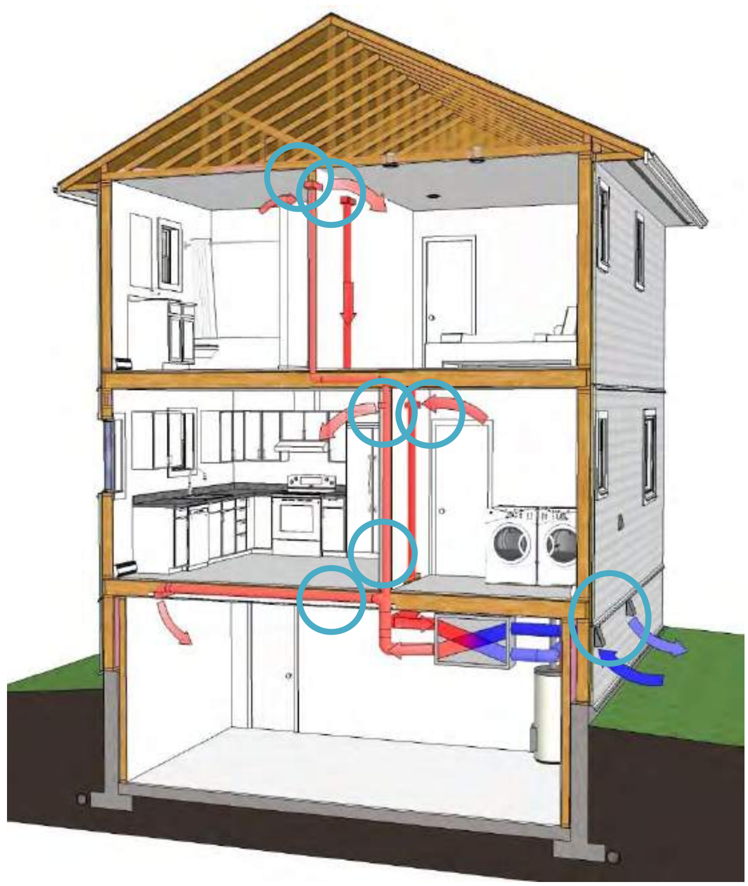


Fig. 6.1 House indicating example locations of where balancing dampers and diffusers can be used to adjust airflow rates.

System outdoor air supply and exhaust airflows through major trunk ducts (if present) leaving and entering the HRV/ERV are typically where airflows should be measured to verify that the system matches the design and meets code requirements. 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. Airflow stations must be installed in straight duct runs and away from the turbulent air that develops in proximity to duct elbows and fans. It is important that sufficient room in the duct system be allocated for flow measuring. Some HRV/ERVs incorporate pressure taps right on the housing that can be used in place of the flow measuring stations to obtain airflow readings.

In addition, the airflow from each supply grille and diffuser and to each exhaust grille or diffuser must be verified, for example by using a smoke pencil. The HRV/ERV contractor will read the outdoor air supply and exhaust airflows and balance them at the desired setting. Often, a record of the airflow settings is affixed to the HRV/ERV housing along with the installer's information.

Table 6.1: Airflow measurement checklist.

| Airflow Measurement Checklist | | | | |
|---|---|---|---|---|
| | Yes | No | N/A | Notes |
| Airflow measuring stations are installed according to the manufacturers specifications | | | | |
| The HRV/ERV incorporates pressure taps for measuring gross system airflows | | | | |
| The HRV/ERV 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 grilles/diffusers have been detected, recorded and verified with the design | | | | |
| Airflows from all exhaust grilles/diffusers have been detected, recorded and verified with the design | | | | |
| Duct airtightness has been tested and verified with the minimum leakage requirements, or at a minimum visual inspection has confirmed that ducts are sealed with foil tape or duct sealing mastic | | | | |

## 6.2. Troubleshooting Common Operational Issues

Table 6.2 outlines several common operational issues, along with common fixes, intended to assist the contractor/installer.

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.<br>• Ensure that the HRV/ERV is plugged in and the electrical cord is not damaged.<br>• Check for a tripped circuit breaker or blown fuse.<br>• Check access door is fully closed.<br>• Check safety switch connected to access door for proper operation. |

| HRV/ERV Operational Issue | Possible Solutions |
|---|---|
| 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.<br>• Check the filters and clean or replace as required.<br>• Check the indoor ducts and registers in rooms for blockage (closed dampers, lodged items, etc.)<br>• Check the core for freezing/frosting (see next issue).<br>• Check all ducts for leakage or disconnection. Seal any loose joints with aluminum foil tape.<br>• 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, 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.<br>• Check the filters and clean or replace as required.<br>• With some HRV/ERV models, the defrost mechanism or preheater can be checked by following the manufacturer's instructions in the owner's manual.<br>• If problem persists, the system may need to be rebalanced.<br>• Sometimes core freeze-ups cannot be avoided due to cold outdoor conditions and or the amount of moisture being produced in the house. Checking the HRV from time to time to correct freeze-up may be needed. |
| A duct insulation jacket is damaged. | Light Damage<br>• If the insulation is torn but not seriously damaged, use sheathing or foil tape to repair any punctures in the jacket.<br>Major Damage<br>• 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. |

| HRV/ERV Operational Issue | Possible Solutions |
|---|---|
| There are cold drafts coming from the supply grilles. | • Check to see 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.<br>• Check the core for freezing.<br>• Check if any supply ducts are running within unconditioned or concealed cold spaces. If so, verify insulation and proper sealing.<br>• If the problem persists, consider the following alternatives, as appropriate:<br>o Provide new horizontal linear diffusers to direct airflow along ceiling;<br>o Relocate supply air outlets to highwall locations; or<br>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 house. | • Adjust the humidistat (if any) to provide more dehumidification.<br>• Ensure HRV is operating continuously or on sufficient cycle over 24 hour period – adjust upwards in small increments so the right amount (and not too much) ventilation is provided.<br>• Check the core for freezing as this blocks the exhaust air flow.<br>• If an existing house, advise the owner to reduce sources of interior humidity through the following measures:<br>o Don't hang laundry to dry inside.<br>o Put lids on cooking pots and use the kitchen exhaust fan.<br>o Ensure exhaust is on high during showers and baths.<br>o Clean dryer lint traps and ensure dryer is properly vented outdoors<br>o Store fireplace wood outdoors.<br>o For more tips on reducing interior moisture, visit the BC Housing website at: http://www.bchousing.org/<br>• Ensure the HRV/ERV is operating properly.<br>• Check location of outdoor air supply hood – ensure it is not close to dryer ducts, moisture and odour sources, etc.<br>• Check that condensate pans in HRV housing are clean and are draining properly. Check condensate hose for mold and mildew – replace with clean tube if necessary.<br>• If problem persists, the HRV/ERV's minimum continuous ventilation rate may be inadequate. |
| Air is too dry in the winter. | • Adjust the humidistat (if any) to provide less dehumidification.<br>• Run the HRV/ERV on the lowest setting.<br>• Run the HRV/ERV intermittently, or install controls to automatically run the unit intermittently on a reduced 24 hour cycle.<br>• Consider installing an Energy Recovery Ventilator (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. |

| HRV/ERV Operational Issue | Possible Solutions |
|---|---|
| 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.<br>• Inspect and clean the fan blades and heat-exchange core as required.<br>• Ensure unit properly mounted or hung with vibration reducing straps.<br>• Check filter and core condition – clean as necessary. |
| Homeowner complains of excessive airflow noise in rooms served by HRV/ERV | • Verify that supply air diffusers are open.<br>• Verify that air flow dampers are not disrupting flow too much.<br>• Check duct system for fittings, transitions that may be causing too much turbulence within the duct, and replace with smoother transitions if needed.<br>• Check to ensure duct sizes match design and are not too small. If too small, some sections of duct may need resizing/replacing.<br>• Verify that HRV/ERV is operating on the minimum continuous setting. |

# 7. Operation and Maintenance Information for Homeowners

This chapter provides guidance on how to educate homeowners on the operation and maintenance of HRV/ERV ventilation systems. 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 or renovator's representative or service contractor can facilitate this understanding and explain any owner responsibilities at project completion. Details of this process are described below.

## 7.1. Start-up

At project completion, the system installer should provide the owner 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 for local service providers and suppliers for serviceable components.

## 7.2. Training for New Owners

For new owners, the builder's representative or installer can explain that the ventilation system is the primary source of outdoor air for the house. 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 buildup of indoor air pollutants and humidity, and can also potentially void warranties on the system.
- In cases where the HRV/ERV is interconnected with the furnace system, the furnace fan should be set to operate continuously as well.

Below are basic operational topics that should be covered with all new owners:

- Basic operating modes: Units can be specified with a range of operating modes (see inset). The owner should understand which operational options are available for the system, and what they can control.

**Modes of Operation**

- **Manual Operation** requires the occupant to turn the ventilation system on and off. High speed operation may be also be initiated by manual controls.
- **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 house 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.

- Programming the humidistat: If a central humidistat is used to raise or lower the ventilation rate of an HRV/ERV system, it can programmed and/or manually adjusted to respond to seasonal changes (in climates where humidity control is a concern). 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. Similarly in the winter, the humidistat can be set lower to avoid having the HRV trying to reduce moisture if not needed. 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 reprograming twice per year.

One question raised by owners is whether the speed with which moisture is cleared from bathrooms after showering is too slow. 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. Owners may undertake simpler maintenance tasks, and should be trained accordingly. An annual servicing by a mechanical contractor accredited by HRAI or TECA is recommended for all systems.

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

- Check and clean or replace dirty filter(s).
- 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 plastic tube either to a plumbing drain or condensate pump. For a new house during its first year after construction is completed, the unit may generate more condensate than normal as the building's interior finishes and structure dry. The tube should be inspected annually by pouring two liters 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 duct can also be vacuumed. The position of the grille or diffuser should be noted or marked 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 Example of an ERV/HRV 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) |

HVI 2100 CERTIFIED

C SA US

HRAI MEMBER COMPANY

**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 - Example Ductwork Layout and Sizing

Below are sample ducting plan layouts for a 2-storey house, showing supply and exhaust ductwork layout and sizing. A home run ducting system is shown below (Figs. A and B), followed by a trunk and branch ducting system (Figs. C and D).

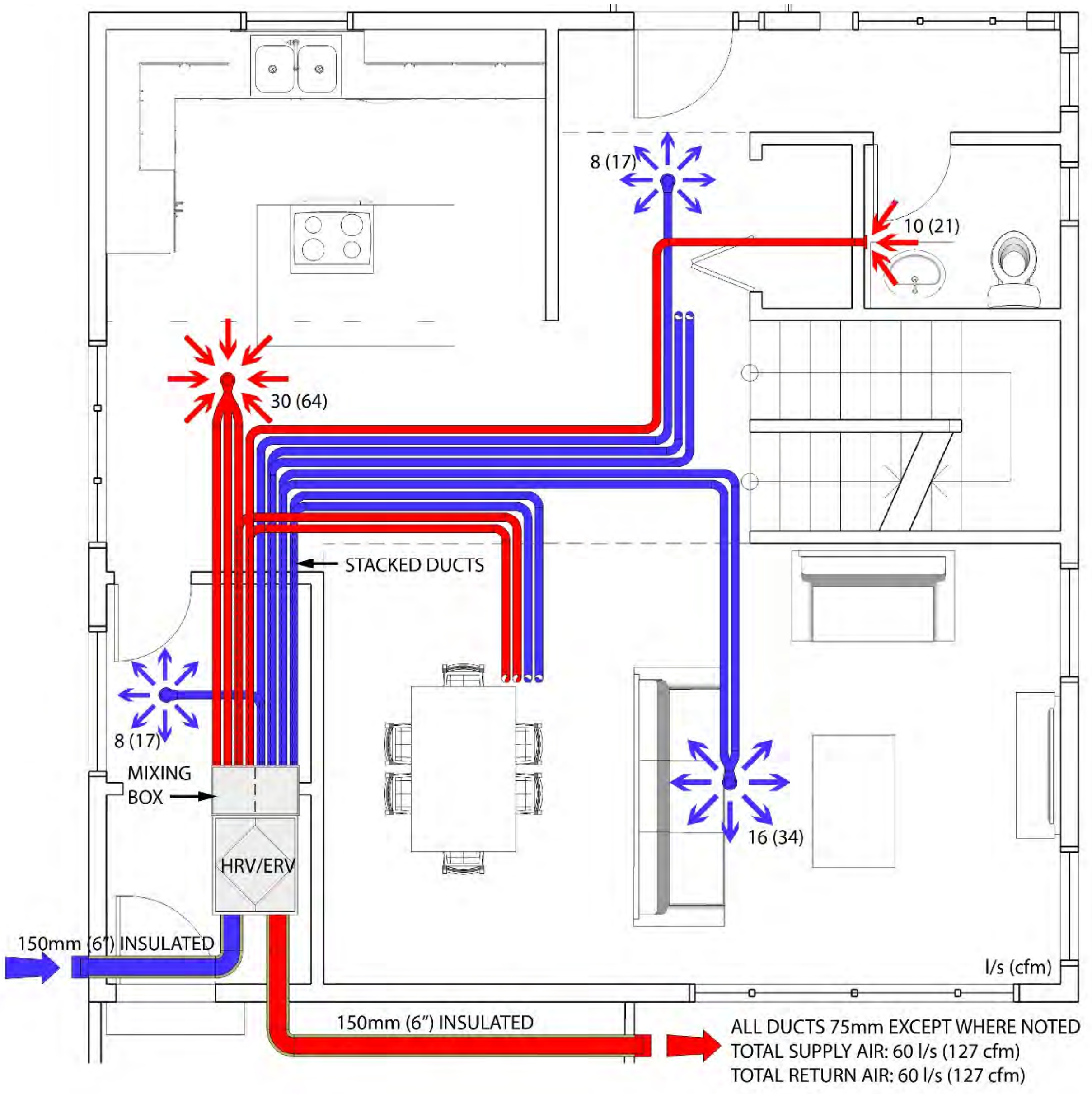



Fig A: Example schematic HRV / ERV home run ducting system layout, main floor.

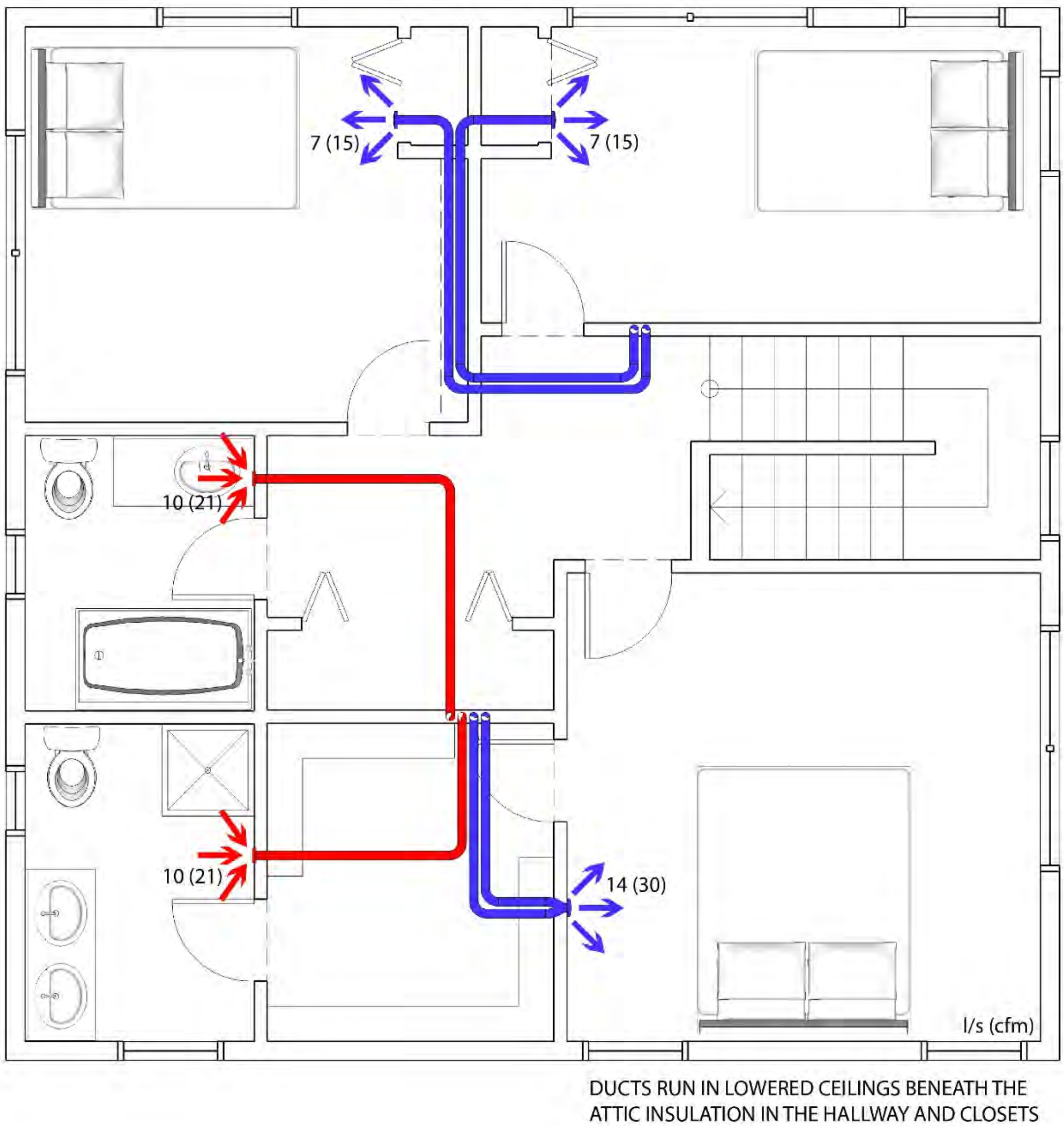



Fig B: Example schematic HRV / ERV home run ducting system layout, upper floor.

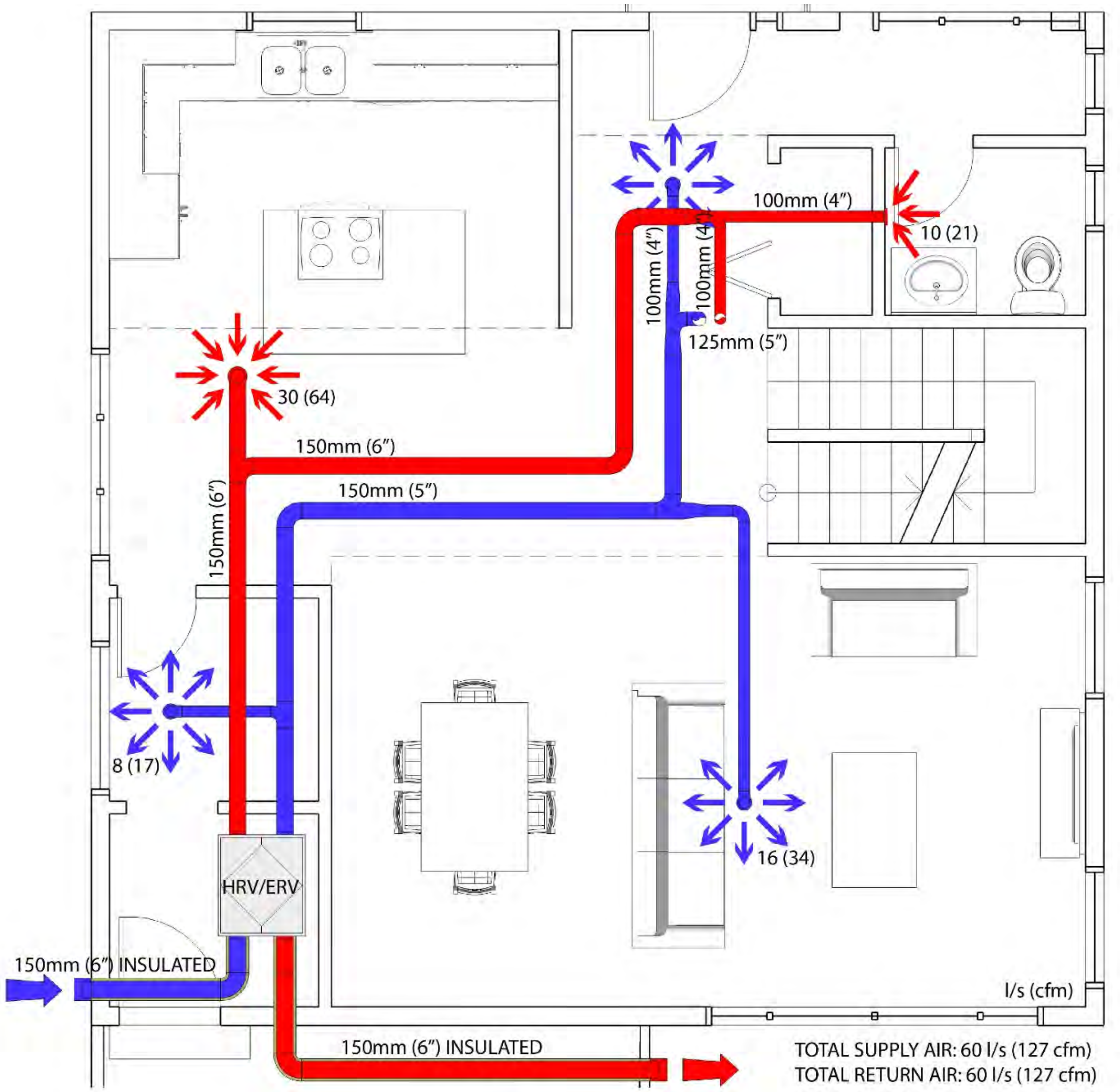



Fig C: Example schematic HRV / ERV trunk & branch ducting system layout, main floor

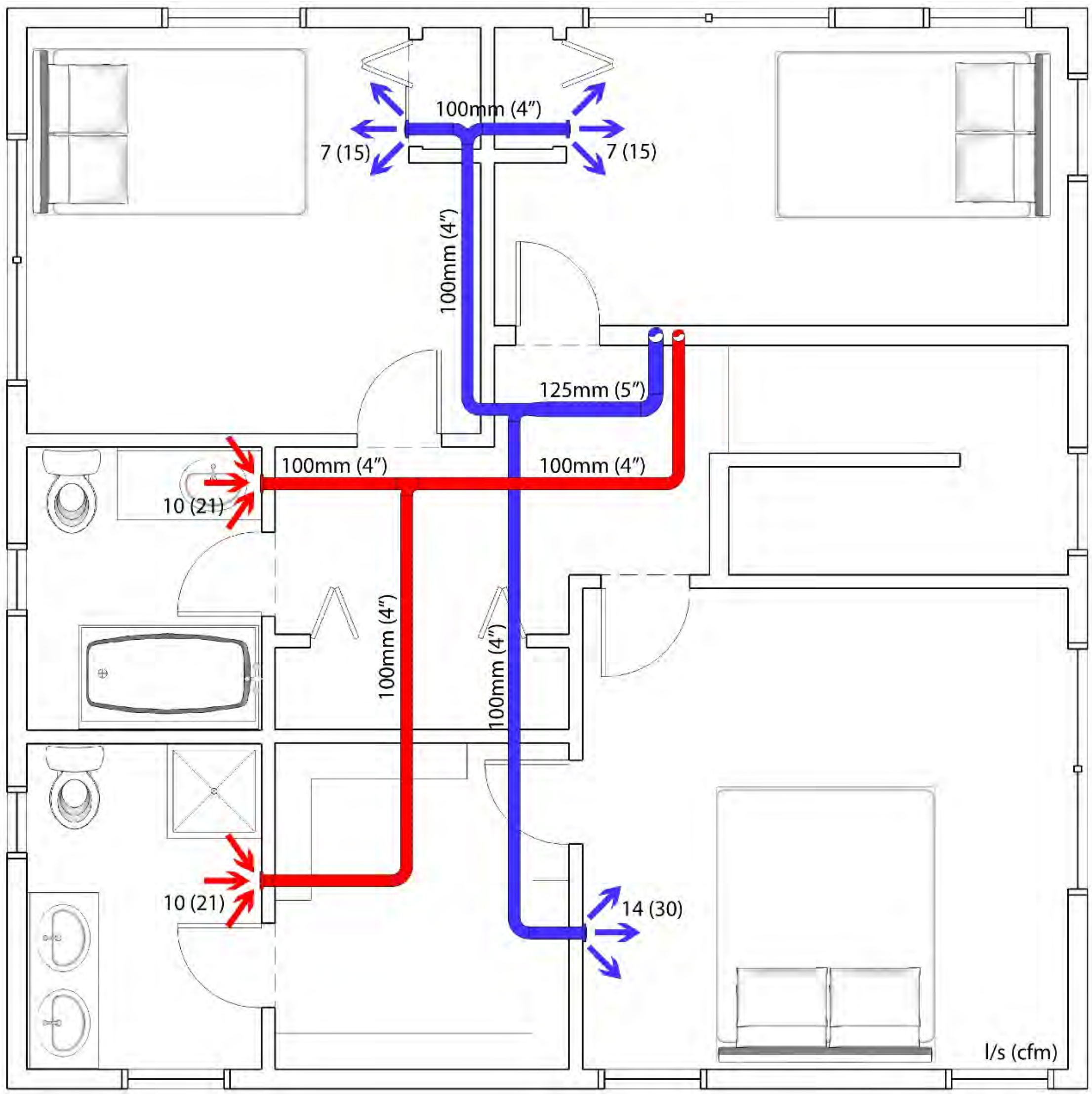



Fig D: Example schematic HRV / ERV trunk & branch ducting system layout, upper floor

## Appendix C - References


American Society of Heating, Refrigeration and Air-Conditioning Engineers. (2001). *Standard 90.2-2001, Energy-Efficient Design of Low-Rise Residential Buildings.*

American Society of Heating, Refrigeration and Air-Conditioning Engineers. (2004/2007). *Standard 62.1-Ventilation for Acceptable Indoor Air Quality.*

American Society of Heating, Refrigeration and Air-Conditioning Engineers. (2004/2007). *Standard 62.2-*

*Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings*.

Canada Mortgage and Housing Corporation. https://www.cmhc-schl.gc.ca

Canadian Home Builder's Association. (2001). *Builders Manual: Chapter 18, Ventilation Systems.*

Canadian Standards Association. (Reaffirmed 2010). *CAN/CSA-F326-M91 - Residential Mechanical Ventilation Systems.*

City of Vancouver, Light House Sustainable Building Centre, Wimmers. (2009). *Passive Design Toolkit For Homes*,

http://vancouver.ca/sustainability/documents/58346PassiveKitBookPrt9.pdf

International Eco-House Inc., Mattock, Ito. (1997). *Dealer ERV Installation Manual.*

Heating Refrigeration and Air Conditioning Institute of Canada. (1996). *Residential Mechanical Ventilation.*

BC Housing. *Building Envelope Guide for Houses.* https://www.bchousing.org/research-centre

Homeowner Protection Office, Canadian Home Builder's Association, Canadian Mortgage and Housing Corporation. (1997). *Building Envelope Solutions- Theory and Practice.*

Home Ventilating Institute (HVI)-Certified Products Directory. http://www.hvi.org/proddirectory/index.cfm

Natural Resources Canada (NRCan), Office of Energy Efficiency (OEE). (2012). *Heat Recovery Ventilators* http://aea.nt.ca/files/download/9ea593f131fa335

Passive House Institute. (2003). *Types of Ventilation* https://passipedia.org/start

Province of British Columbia. (2010). *File #42: Radon in Homes and Other Dwellings* http://www.healthlinkbc.ca/healthfiles/hfile42.stm

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

Thermal Environmental Comfort Association. (2008). *Ventilation Guidelines Manual: A Simplified Guide to Section 9.32 – Ventilation of the 2006 British Columbia Building Code.*

## Appendix D - 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 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 as an air change rate at a specified building pressure (e.g., at 50 Pa, $ACH_{50}$). |
| **ASHRAE** | American Society of Heating, Refrigerating and Air-Conditioning Engineers. |
| **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. |
| **commissioning** | Per ASHARE Standard 202-2013: "A quality-focused process for enhancing the delivery of a project. The process focusses 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." |
| **condensation** | Refers to the change in state of water from vapour to liquid. Often materializes as water on a surface that is below the dewpoint temperature of the air. |
| **condition (v.)** | Refers to the process of heating, cooling, humidifying, dehumidifying, and/or 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% RH). |
| **Equivalent Leakage Area (ELA)** | 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, and dampers. |
| **furnace** | Refers to an appliance which use energy (typically electricity or natural gas) to provide heat and then delivers this heat to building spaces using forced air. |
| **HVAC** | Heating, Ventilation, and Air Conditioning. Refers to the equipment used to condition the interior spaces of a building. |
| **indoor air quality** | Refers to the nature of air inside a building that affects the health and well-being of building occupants. |
| **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). |
| **leakage rate** | Refers to the rate at which air unintentionally flows through. |
| **make-up air** | Refers to air that is brought in to a space to maintain the mass balance of air in a space when air is exhausted. |
| **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. |
| **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)** | Is a metric unit of measure for pressure. 1 in $H_2O$ = 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 heat** | Refers to the amount of heat energy absorbed or release due to a change of temperature. |
| **Sensible Heat 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. |
| **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 Heat 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 contaminates. |
| **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. |