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Builder Insight

TECHNICAL BULLETIN

Heat Recovery Ventilation

Important Considerations for Builders and Designers

Overview

Incorporating a heat recovery ventilator (HRV) or energy recovery ventilator (ERV) into the ventilation system is an effective means of meeting ventilation code requirements, reducing energy consumption and achieving a healthy indoor environment. HRVs simultaneously supply and exhaust equal quantities of air to and from a house while transferring heat between the two air streams.

This reduces the energy consumption associated with heating or cooling ventilation air, while also enhancing indoor air quality and thermal comfort.

This bulletin focuses specifically on HRV design for new Part 9 houses. For additional details – including builder checklists, information about ERVs (which transfer both heat and moisture between the two air streams), and system retrofits – refer to the HPO-published *Heat Recovery Ventilation Guide for Houses*. Another potential source of information is HPO's *Heat Recovery Ventilation Guide for Multi-Unit Residential Buildings*, which is focused on larger buildings and includes details for both centralized and compartmentalized ventilation systems.

Benefits of Heat Recovery Ventilation

HRV systems provide continuous, balanced, and energy efficient year-round ventilation to houses. During the heating season, an HRV preheats incoming outdoor air with exhaust air by passing both air streams through a heat exchanger, as illustrated in Fig. 1. In air-conditioned homes in the summer,

BC HOUSING

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the incoming outdoor air is pre-cooled when the outdoor temperature is higher than indoors. The system brings in an equal amount of supply and exhaust air, creating a balanced system that neutralizes the pressure in the house.

The new provisions of BCBC Section 9.32 (effective Dec. 19, 2014) ensure indoor air quality benefits regardless of the system used. There are, however, a number of benefits that are specific to HRV systems, including:

- Mechanical ventilation systems with separate supply and exhaust fans can become more easily unbalanced, and either pressurize or depressurize the building. HRVs are designed to provide balanced airflow, which results in enhanced indoor air quality and improved building envelope durability.
- HRV systems reduce drafts that can cause thermal discomfort by pre-conditioning outdoor ventilation air. The higher the efficiency of the HRV, the closer the incoming outdoor air is to the indoor temperature.
- HRVs save energy by recovering heat from the exhaust air stream in the winter, and reversing the process in the summer.

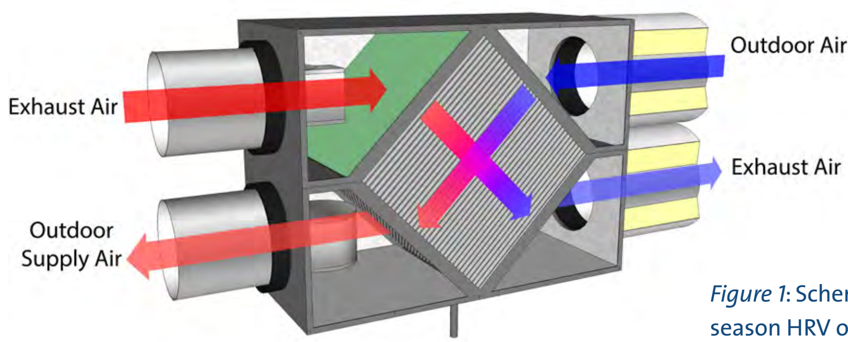

Figure 1: Schematic showing heating season HRV operation.

Ventilation System Design

Gaining a better understanding of the ventilation system design process 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 ventilation airflow, 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 can cause other unintended problems.

The design process can be separated into four main steps, outlined in the inset. 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[1] Canada or TECA[2].

Overview of the Design Process

Step 1: Code-required ventilation rate calculation

Step 2: System configuration selection

Step 3: HRV selection

Step 4: Layout and sizing of the ventilation system

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

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

Step 1: Code-required Ventilation Rate Calculation

Minimum continuous ventilation capacity requirements are based on BCBC Section 9.32, which also references CSA F326-M91, *Residential Mechanical Ventilation Systems*.

The system is sized with equal supply and exhaust, using the higher of the total calculated supply and exhaust ventilation capacities. The HPO-published *Heat Recovery Ventilation Guide for Houses* provides an example of a ventilation rate calculation.

Step 2: System Configuration Selection

BCBC 9.32.3.4 includes ventilation system requirements for five potential system configurations. The two that integrate HRVs are described below.

A good start towards getting a well-installed system is to select installers who have taken ventilation installer training.

1. Standalone HRV system: In this configuration, the unit is fully ducted to each room and the exterior, with separate ductwork for both supply and exhaust distribution. Fully ducted systems are typically distinct from the space heating or cooling system. The ducting can either be trunk-and-branch, or home-run, as shown in Figures 2 to 5.

   Balancing for a trunk-and-branch system is usually achieved with manually adjusted balancing dampers, although adjustable diffusers may also be used to fine-tune airflow at the outlet. For a home-run system, 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 unit to consolidate the air entering and leaving the main supply and return openings (seen in Fig. 5).

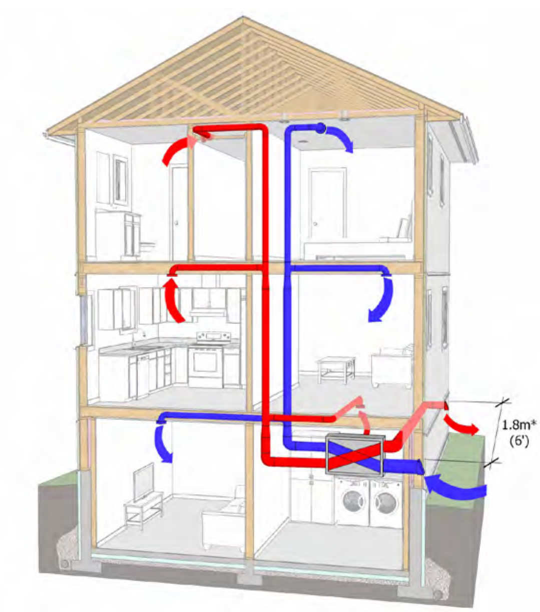

Figure 2: HRV system with trunk and branch system.

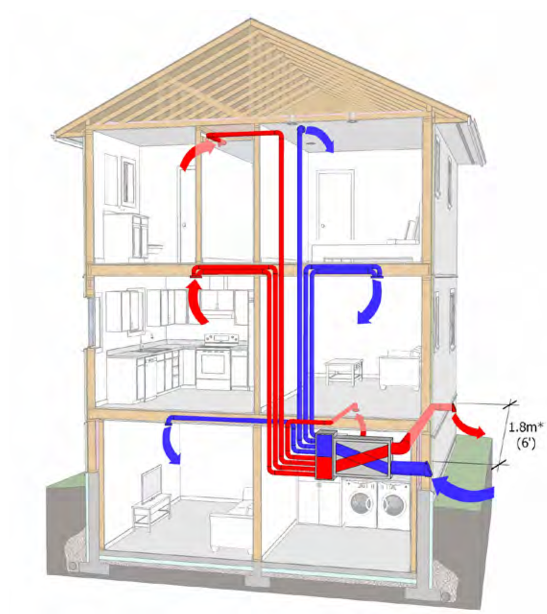

Figure 3: HRV system with home-run ducting system.

Figure 4: HRV installation with trunk-and-branch ducting. Insulated ducts are to/from outside.

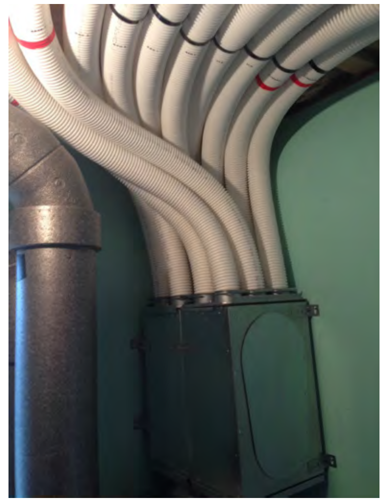

Figure 5: Mixing box (HRV not shown), with home-run ducting (HDPE with smooth interior surface). Image courtesy of NZ Builders.

2. HRV combined with a forced-air heating system: In this configuration, the forced-air system, typically a furnace, provides the air distribution. The HRV 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. 6. Section 9.32 requires at least general exhaust to be ducted directly to the HRV. There may also be separate bathroom and kitchen exhaust fans.

   These systems typically use a trunk-and-branch ducting system, and can work effectively if properly designed and balanced. Balancing is usually achieved via manually adjusted balancing dampers, although adjustable diffusers may also be used for the branches.

A well designed or installed system will provide the right amount of ventilation airflow and may save energy.

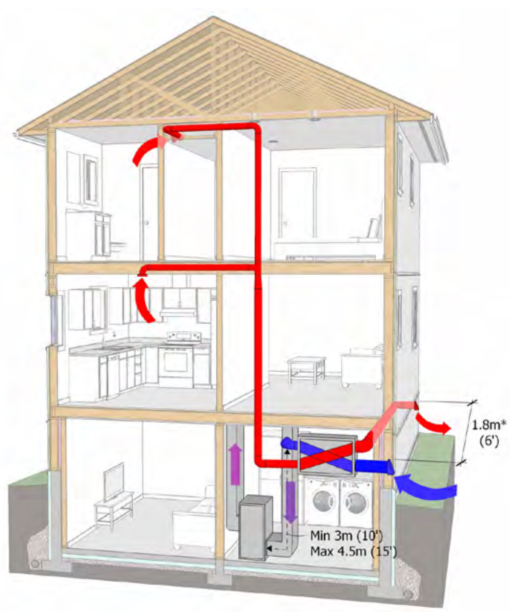

Figure 6: Forced-air system with integrated HRV.

Step 3: HRV Selection

Not all HRVs are created equal. Having a basic understanding of the key HRV unit selection variables will go a long way toward ensuring the unit that is ultimately installed meets expectations. Appropriate airflow capacity and high-rated heat recovery efficiency are two of the most important selection criteria. The table 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.

PERFORMANCE PARAMETERS	
Capacity	• Airflow rate (L/s [CFM]) should match or slightly exceed the specification of the design conditions. A good rule of thumb is to select an HRV with a ventilation capacity that is at least 40% greater than the code-required continuous ventilation rate, to allow boost capacity for kitchens and bathrooms and a low setting for low occupancy.
Heat Recovery Efficiency	• Units vary widely in their heat recovery efficiency (from less than 50% to greater than 90%), and should be selected at the highest possible efficiency that meets the project budget.
	• The Sensible Heat Recovery Efficiency (SRE) is the standardized value used to predict and compare HRV efficiencies. In Canada, HRVs are tested to standard conditions outlined in CSA-C439 to allow for comparison between products. The Home Ventilating Institute maintains a certified products directory that lists efficiency and other performance parameters (www.hvi.org/proddirectory/index.cfm).
Sound Performance	• A quiet unit is critical for house applications (there should be no audible noise at air outlets). System installation practices also have a significant impact on vibration and sound transfer. Installing units with vibration-isolation mounting; properly sizing ducts, grilles and diffusers; and using short lengths of flexible ducting to connect the ducts to the four ports of the HRV, will minimize sound transfer throughout the system.
Control Options	• 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.
	• 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	• Frost prevention is required in most of Canada, except B.C.'s Lower Mainland (Climate Zone 4 in BCBC).
	• Defrost is typically achieved automatically by the HRV 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, although this method can use considerable energy, decrease the efficiency of the heat exchange, and add cost to the design and installation.

ENERGY STAR qualified HRVs have been tested by a third party to ensure that they meet a set of specifications that promote increased heat recovery and efficient fan operation. For a list of ENERGY STAR qualified HRVs and ERVs, visit www.nrcan.gc.ca.

Step 4: Layout 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 characteristics. 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. This duct will require thermal insulation to prevent condensation.

  Locate interior supply diffusers so that the airflow is distributed through each room. Diffusers should be mounted in the ceiling, or 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 the room.

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

Layout and sizing of the ventilation system typically involves several steps.

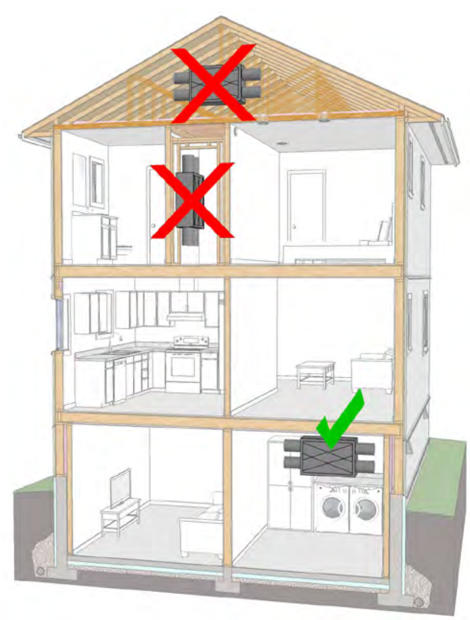

Figure 7: Good and bad HRV locations. Avoid unconditioned spaces, and spaces such as bedroom closets, where noise might be an issue.

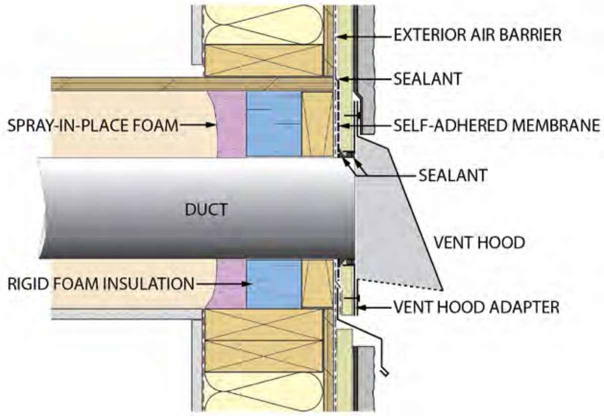

Figure 8: Sample detail of duct penetrating the building's air barrier.

Figure 9: Duct sealing: It is important to seal all seams and joints 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.

- *Lay out the ductwork:* The ductwork should be sized and laid out to minimize 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 interior surface (e.g., sheet steel or medical grade HDPE).

  Minimize the number of turns in the ducts, and where they are unavoidable, make them as gradual as possible.

  Keep ductwork inside the conditioned space of the house wherever possible. When ducts are located in unconditioned spaces, they must be insulated to the same level as the exterior walls (BCBC 9.36.3.2). Where ducts penetrate the air barrier, ensure that they are 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. 8 above.

- *Size the ductwork:* The size of the ductwork required will depend on the layout and the volume of air that flows through each duct. Round, oval, or rectangular ductwork can be used, although round is more common in smaller applications such as household HRVs.

  Size the ductwork using the simplified methods outlined in BCBC Table 9.32.3.8 or Vancouver Building Bylaw (VBBL) Table 9.32.3.8.

- *Confirm HRV fan capacity is adequate:* Once the duct layout and sizing is complete, the capacity of the fans within the HRV 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 HRVs are intended to provide a balanced ventilation system, they are not make-up air systems for unbalanced exhaust or for non-sealed combustion appliances, nor are they soil gas prevention/remediation systems. Make-up air may be required for large-capacity exhaust equipment if the house has appliances subject to backdrafting or if the house is located in an area that is classified as a concern for radon.

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 and installation contractors. Proper installation techniques are as important as good design practice. Installation should be monitored throughout the construction process, and at construction completion.

Use this checklist as a tool prior to design, and also to verify that key considerations have been addressed.

HRV SYSTEM DESIGN CHECKLIST	
HRV unit manufacturer & model:	
HRV rated performance at 0°C (32°F) and -25C (-13F), per CAN/CSA C439:	
Net airflow, L/S (CFM):	
Power consumption rating(watts):	
Sensible Heat Recovery Efficiency (SRE):	
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 marked on plans:	Y/N
If ductwork runs outside, specify insulation value & type:	
Plans show outdoor air supply to all bedrooms and primary living areas:	Y/N
Plans show 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

Commissioning

It is critical to verify that the system is operating as intended as part of the start-up process. Of primary importance is 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.

An airflow measuring checklist is provided in HPO's *Heat Recovery Ventilation Guide for Houses* to assist with this commissioning process.

Occupant Handover

One of the biggest factors in occupant satisfaction with ventilation systems is the occupants' own understanding of how to operate and maintain their system. The builder's representative or service contractor can facilitate this understanding and explain any owner responsibilities. In addition, the owner should be provided with product data, warranty information, the HRV Operation and Maintenance (O&M) Manual, and training particular to the unit. Information should be included for local service providers and suppliers for serviceable components.

New owners need to be aware of the following key points related to a new HRV system:

- 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 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 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 is interconnected with the furnace system, the furnace fan should be set to operate continuously as well.

The following 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, including automatic or manual high/low operation. The owner should understand what operational options are available for the system, and what they can control.
- Programming the humidistat (if applicable).
- Scheduling (if applicable).
- Maintenance: HRV 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.

Operation and maintenance information for homeowners is provided in HPO's *Maintenance Matters – Maintaining Your Heat Recovery Ventilation System*. It includes a checklist of maintenance tasks and suggested frequency. 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.

HRV systems provide continuous, balanced, and energy efficient year-round ventilation to houses.

Key Points

- Incorporating a heat recovery ventilator (HRV) or energy recovery ventilator (ERV) into a home's ventilation system is an effective means of meeting code ventilation requirements and achieving a healthy indoor environment, while also reducing energy consumption.
- Early planning and careful design are critical to ensuring the system works as intended. Duct layout and sizing, diffuser layout and sizing, as well as HRV unit selection and installation methods will all impact user satisfaction, energy efficiency, and overall performance of the system.
- Commissioning is critical to ensure that the system operates as intended after installation, while ongoing maintenance and cleaning will ensure the system continues to operate properly.

For More Information

- BC Building and Safety Standards Branch Information Bulletin No.B14-05: 9.32 Ventilation, available at: www.housing.gov.bc.ca
- *Heat Recovery Ventilation Guide for Houses*, Homeowner Protection Office, available at www.hpo.bc.ca
- *Heat Recovery Ventilation Guide for Multi-Unit Residential Buildings*, Homeowner Protection Office, available at www.hpo.bc.ca
- *Maintenance Matters – Maintaining Your Heat Recovery Ventilation System*, Homeowner Protection Office, available at www.hpo.bc.ca
- 2012 BC Building Code, sections 9.32 (Ventilation) and 9.36 (Energy Efficiency), available at www.bccodes.ca.
- *Quality First Ventilation Guidelines:* A Simplified Guide to Section 9.32-Ventilation of the 2012 BC Building Code, produced by TECA. Available at: www.teca.ca

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