PLAYBOOK

# Ventilation Strategies for High-Performance Multi-Unit Residential Buildings

From ZEBx's Net-Zero Energy-Ready Playbook Series

March 2021

# Overview

High-performance multi-unit residential buildings (MURB) are becoming the norm in British Columbia. This shift in the building industry is the result of the increasing energy-related requirements mandated by municipal governments, as well as the need to satisfy the growing demand for high quality, sustainable developments. Many buildings are now designed to achieve Step 3 or 4 of the BC Energy Step Code ("Step Code") or the Passive House standard, greatly improving the energy performance, comfort and quality of our residential building stock. These high-performance MURBs are being built by forward-thinking developers, municipalities, housing providers, and educational institutions who are paving a path for the rest of the industry to follow.

Achieving higher levels of energy performance means rethinking the way many aspects of MURBs are designed and built, including ventilation systems. A number of innovative and energy-efficient ventilation solutions are now available to help support the achievement of net-zero energy-ready and other higher performance targets. This playbook provides an overview of the ventilation strategies used in net-zero energy-ready buildings and offers some guidance on making the right choice of ventilation system for the building.

> Part 3 buildings are those over three storeys in height or over 600 square metres in footprint. Part 3 also includes some buildings of three storeys or less in height or under 600 square metres in area that are of a specific use, such as public gatherings, residential care, detention, or high-hazard industrial activities.

Skeena Residence Rendering
PUBLIC Architecture + Communications

**By 2022,** the BC Building Code will be updated to require Step 2 for Part 3 buildings across the Province.[1]

**54%** of all GHG emissions in Vancouver are from buildings.[2]

**36%** of a building's annual energy use is from ventilation.[3]

# High-Performance Building Requirements

## The BC Energy Step Code

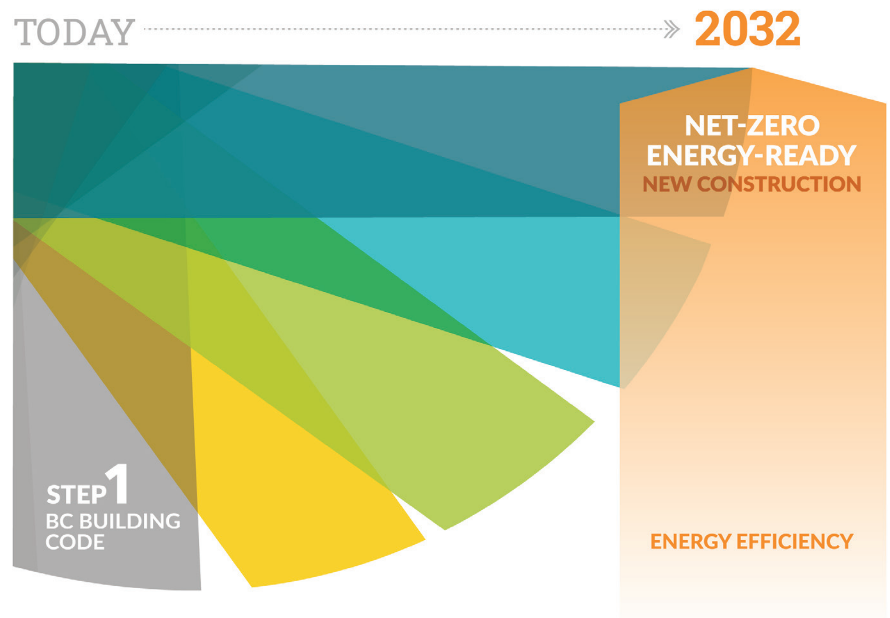
In 2018, BC's provincial government released the CleanBC Plan. The plan requires that by 2032, all new buildings mush achieve net-zero energy-ready levels of performance. For part 3 buildings, this equates to Step 4 of the Step Code. To reach this goal, the energy requirements outlined in the BC Building Code (BCBC) will increase over time. Starting in 2022, all new Part 3 buildings (including MURBs) must meet Step 2 of the Step Code. This corresponds to a 20% improvement in energy efficiency compared to the minimum requirements of the 2018 BCBC. By 2027, the target will increase to Step 3 (40% more energy efficient) and by 2032, the target will increase to Step 4 (80% more efficient or greater). Buildings that are constructed to the Passive House standard are deemed to meet the requirements of the 2032 target.

> Net-zero energy-ready is typically defined as a level of performance such that, with the addition of solar panels or other renewable energy technologies, the building can produce as much energy as it consumes over the course of a year.

## The City of Vancouver's Zero Emissions Building Plan

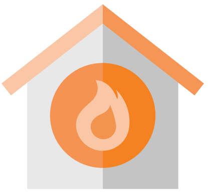
The City of Vancouver has authority to establish its own building code, the Vancouver Building Bylaw (VBBL). In 2017, it established its own green building plan called the Zero Emissions Building Plan. The plan was subsequently incorporated into the VBBL. In addition to setting energy requirements, the VBBL also sets targets for greenhouse gas (GHG) intensity.

Recent updates to the VBBL have aligned the performance metrics for Part 3 residential buildings with Step 4 of the Step Code. By 2025, all new low-rise MURBs in the City of Vancouver must not emit any operational GHG emissions. The same requirement will apply to high-rise MURBs by 2030.



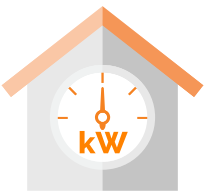

BC Energy Step Code Timeline

# Ventilation Performance Metrics



## Thermal Energy Demand Intensity (TEDI)

Thermal energy demand intensity (TEDI) refers to the total annual heating load being used throughout the building. These loads are associated with envelope losses, infiltration and air ventilation.



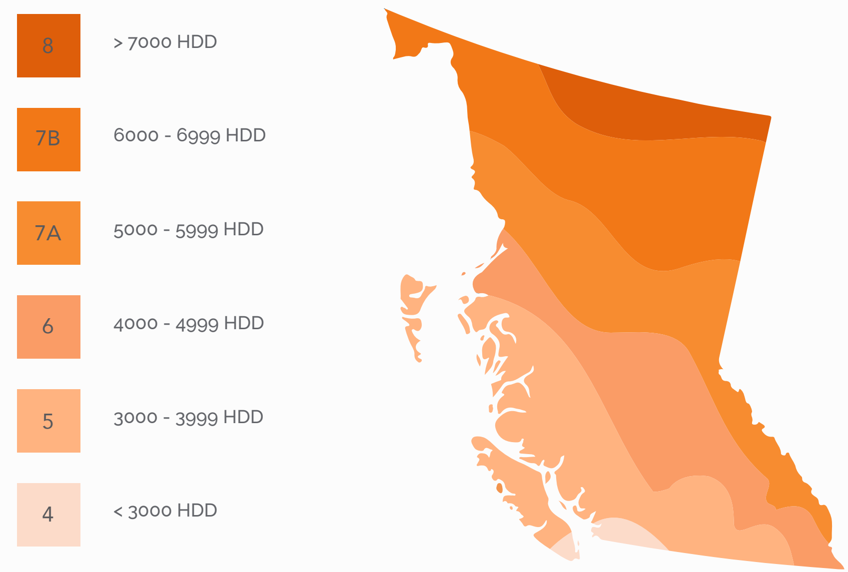

## Thermal Energy Use Intensity (TEUI)

Total energy use intensity (TEUI) refers to the total energy used on-site from sources such as electricity, district energy or natural gas. Common energy usages include space heating, cooling, domestic hot water, lighting, elevators and plug loads.

## Indoor Air Quality (IAQ)

Indoor Air Quality (IAQ) refers to the air quality within the building and suites, as it relates to the health and comfort of the occupants. Reducing pollutants in the air being delivered to the building will reduce potential risk to occupant health.

### British Columbia Climate Zones




| | TEDI ($kWh/m^2/year$) | | | TEUI ($kWh/m^2/year$) | | |
|---|---|---|---|---|---|---|
| Zone | Step 2 | Step 3 | Step 4 | Step 2 | Step 3 | Step 4 |
| 4 | 45 | 30 | 15 | 130 | 120 | 100 |
| 5 | 45 | 35 | 22 | 130 | 120 | 110 |
| 6 | 50 | 35 | 22 | 135 | 120 | 110 |
| 7A | 55 | 40 | 22 | 135 | 120 | 110 |
| 7B | 60 | 50 | 35 | 150 | 140 | 125 |
| 8 | 90 | 75 | 60 | 180 | 160 | 140 |

# Why is Ventilation Important?

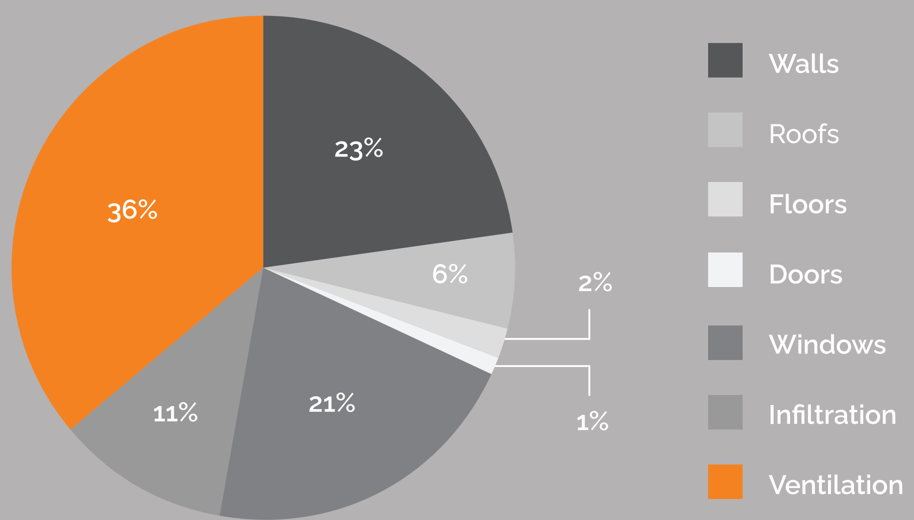
IAQ

The ventilation system is the most important design component that has a direct impact on **increasing indoor air quality** for the occupants. Ventilation systems must also be selected to meet the local codes and standards for airflow volumes and levels of filtration.

TEUI

Ventilation systems have contributed significantly to energy consumption in buildings for decades. Both the Passive House standard and the Step Code have targets for TEUI and TEDI. Due to the strict limits on the TEDI in high-performance buildings, **high-efficiency ventilation** has become a focus in the building industry.

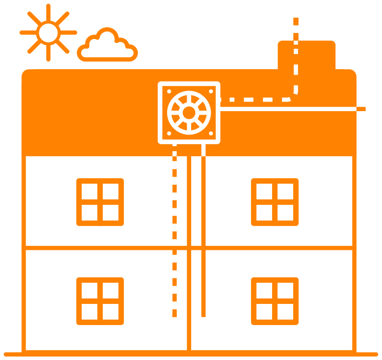
Achieving the TEDI and TEUI targets defined by the Passive House standard is more difficult than achieving these targets for Step 4 of the Step Code. In order to meet the targets, a highly efficient ventilation system is a must. By reducing the energy consumed by the ventilation system, the thermal performance requirements of the building enclosure can be relaxed slightly. A highly efficient ventilation system could allow for a slightly higher window to wall ratio or a slightly lower U-value for the fenestration or opaque wall assemblies.




*Typical breakdown of TEDI in Step 4 MURBs.*

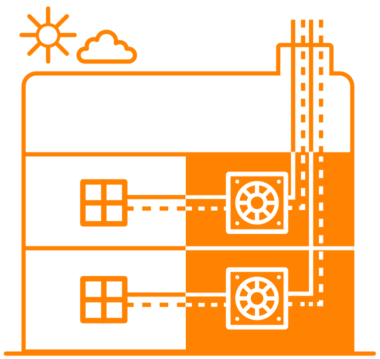
# Ventilation Systems

When choosing a ventilation system, there are numerous factors to consider that will assist in reaching a design solution that best suits the project. Designers and building owners will need to weigh the pros and cons of each ventilation system with the project-specific goals to come to the best solution for their unique situation.



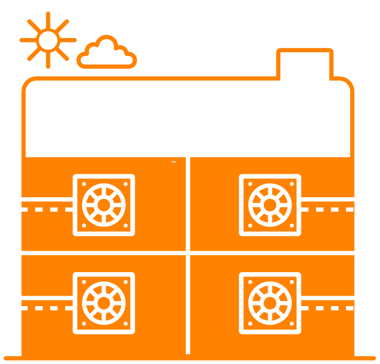
## Centralized Ventilation

A centralized ventilation system is one that uses a single heat recovery ventilator (HRV) that will serve the entire building. In some instances, a single unit may not be large enough to serve all of the suites. In this case, multiple units are used. Each suite is connected to the HRV through supply and exhaust air ducting. The HRVs for a centralized ventilation system can be located on the roof, in the parkade, or within a dedicated mechanical room in the building.



## Semi-Centralized Ventilation

A semi-centralized ventilation system is a cross between a centralized and decentralized system. The semi-centralized ventilation system is typically used to reduce ducting within the building by supplying the air from the HRV on a floor-by-floor basis or a vertical stack of suites. This solution is less common than the centralized or decentralized systems.



## Decentralized Ventilation

A decentralized ventilation system is one that uses a dedicated HRV to serve each individual suite within the building. Each HRV in a decentralized system requires its own dedicated ducting inside the suite and supply and exhaust terminations on the exterior of the building. Because each HRV is dedicated to the suite, the ventilation can be increased through a switch or a controller as desired by the occupant.

### Air Supply

Supply and exhaust air are not mixed in any of the three ventilation systems. All suites receive 100% filtered outdoor air for ventilation. All exhaust air is discharged to the outdoors.

### Occupant Comfort

Regardless of the choice of ventilation strategy and means of air distribution, each can provide a high level of occupant comfort and indoor air quality by providing 100% filtered and tempered supply air and exhausting all of it to the outdoors.

# Floor Space Ratio

Developers typically consider construction cost, high floor space ratio (FSR), and the number of suites in a building to maximize their return on investment. In municipalities where there are no exclusions for mechanical shafts in the FSR calculations, developers tend to prefer a decentralized ventilation system. This is due to the fact that centralized and semi-centralized ventilation systems require mechanical shaft space that results in the developer losing this valuable floor space.This may reduce overall sales revenue for the developer or rental income for the building owner.


# Fire and Smoke Dampers

For residential buildings built in accordance with the BCBC, ducting that passes through a fire-rated wall requires a fire and smoke damper. This has implications for the centralized and semi-centralized ventilation system options, as they rely on a main duct serving multiple suites.

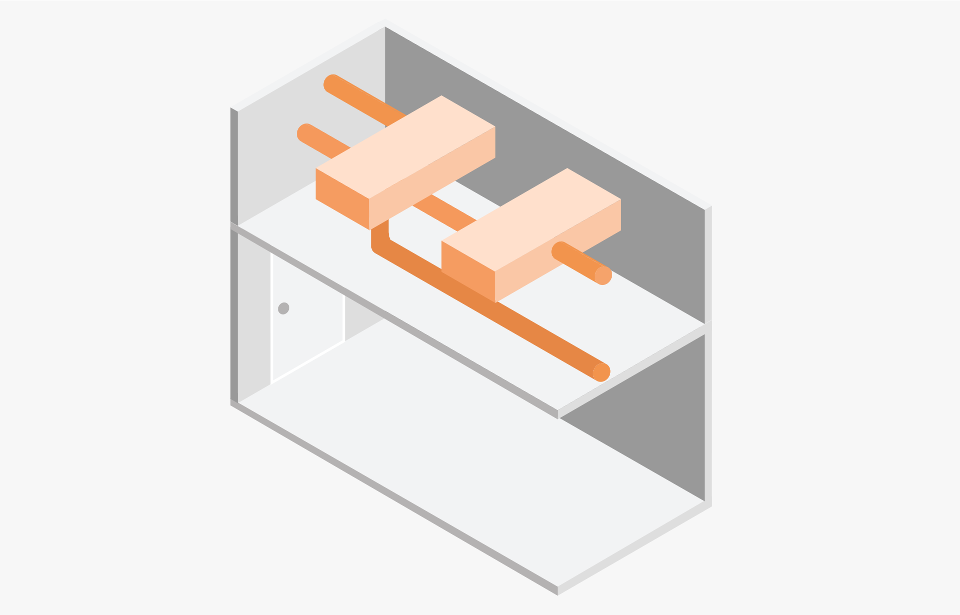
Although there may be other features of these systems that are less expensive than a decentralized ventilation option, the coordination required to install these combination fire-smoke dampers is significant. In addition to the work to install combination fire-smoke dampers, the fire-smoke dampers are mandated to be inspected annually by the BC Fire Code.

# Floor-to-Floor & Ceiling Heights

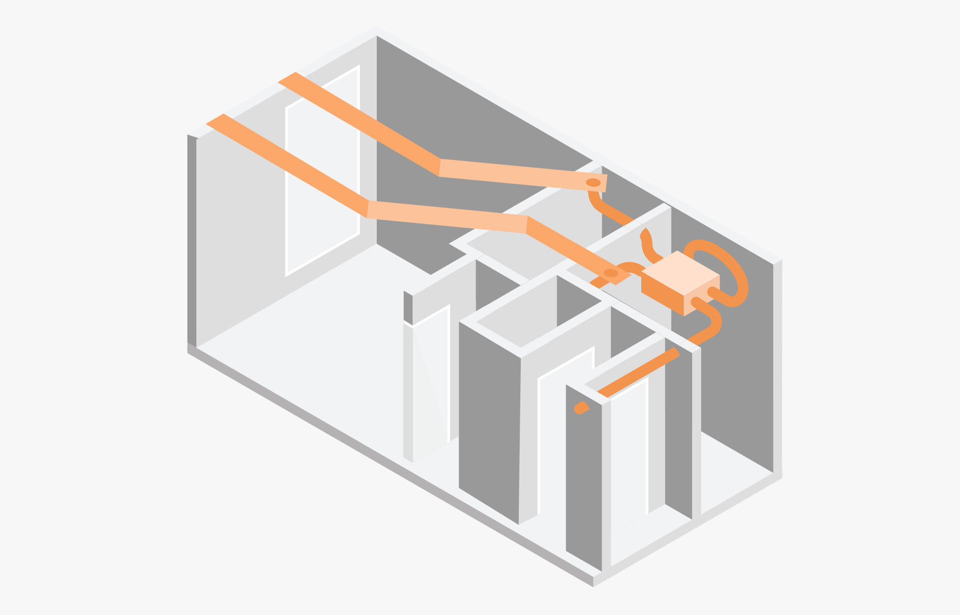
The market value of condos is affected by several factors including ceiling height. Considerations for centralized or decentralized systems will have different implications on floor-to-floor heights of the building and architectural aesthetics (i.e. bulkheads, exterior terminations etc.) which can affect the overall building form and architectural expressions.

Centralized systems often require large ductwork running down the corridors and branches off smaller ducts into each suite. This configuration lowers the ceiling heights within the corridor but can be utilized to maximize the available ceiling height within the suite.

Decentralized systems typically locate the HRV within a ceiling space above a washroom or storage closet. The efficiency requirements for HRVs are increasing, but more efficient HRVs are larger and require more space. Passive House-certified HRVs typically require more ceiling space and bulkhead depth than less efficient HRVs. A decentralized system will also require ductwork to and from the exterior wall of the suite. In concrete buildings, this is often minimized through the use of in-slab ductwork, however in wood construction this typically is accounted for with bulkheads through either living spaces or bedrooms.



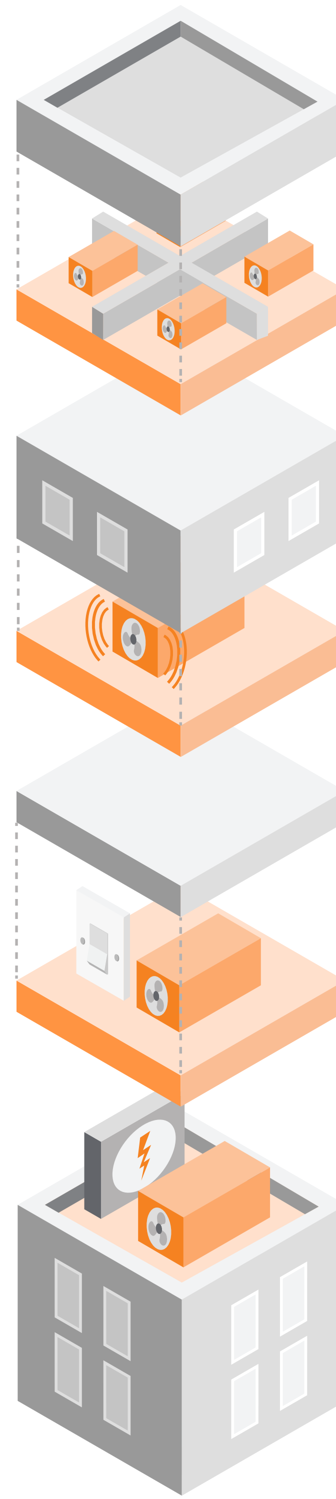
Centralized Duct Section



Decentralized Duct Section

# Redundancy

When using a decentralized or semi-centralized system, the redundancy in the ventilation system is greatly improved over that of a centralized option. In the event that a centralized HRV stops operating or is turned off for maintenance, all suites will be without mechanical ventilation. If redundancy is a concern for the building with a centralized ventilation system, efforts to add redundancy can be accommodated through the use of multiple HRV units acting in parallel or by utilizing a fan-array system.



# Noise

Centralized or semi-centralized systems are typically quieter than decentralized systems as the HRV is not located within the suite. One benefit of the more efficient HRVs required to reduce TEDI values is that they typically produce less noise than lower efficient HRVs as they utilize more efficient fans, have more insulation to dampen sound, and have a more robust casing construction that helps further reduce breakout noise.

# Occupant Control

A decentralized system gives the occupants more control without affecting the other suites. An occupant can boost the ventilation to their suite or bypass the HRV heat exchanger without causing a change in the ventilation to the other suites. This is often done through a wall switch in a washroom that increases ventilation rates. Providing occupant control with a centralized or semi-centralized system requires a more complex variable air volume control system for each suite which can be a costly addition to a project.

# Resiliency

It is less expensive to connect a central HRV or a few semi-centralized HRVs to emergency power than an HRV in each suite. Connecting HRVs to an emergency power supply improves the building's resiliency in the event of a power outage, but simply opening windows (if the outdoor conditions are appropriate) can achieve similar results. Unfortunately, opening windows during the winter months or during a smoke event can cause a reduction in indoor air quality and/or thermal comfort. This is an important consideration in buildings that house long-term care patients or similar residents where good indoor air quality has broader implications than just occupant thermal comfort.

# Operations and Maintenance

## Centralized and Semi-Centralized Ventilation Systems

In buildings where a landlord or strata corporation is responsible for maintenance of the ventilation system, centralized or semi-centralized ventilation systems are often preferred in order to facilitate maintenance of the system. Maintenance typically consists of filter replacement but can also include cleaning and/or repairing dampers and HRV components. It is easier (therefore, less expensive) to maintain one large HRV in a centralized system or several mid-sized HRVs in a semi-centralized system than it is to maintain many smaller HRVs inside each suite.

## Decentralized Ventilation Systems

If a decentralized ventilation system is chosen and the occupants are not responsible for maintenance of their HRV, HRVs can be located against a corridor wall so that they can be accessed from the corridor through a fire-rated access door. This eliminates the need to coordinate entry into each suite. The disadvantage to this approach is that the HRV would be located far from the exterior wall and this would result in longer duct runs and more thermal bridging. The consequences of this design is more pronounced in Passive House designs than in designs aiming for the upper levels of the Step Code, as Passive House designs account for all thermal bridging losses. Alternatively,  if a decentralized ventilation system is chosen and the owner/resident is responsible for the maintenance of their HRV, there is an increased risk that many HRVs would not be operating as intended as some owners are likely to neglect regular maintenance.

A decentralized ventilation system is often connected to a suite's electrical panel which in turn makes the occupant of the suite responsible for the operational costs of the ventilation system. Unfortunately, some owners might turn off the ventilation system in order to reduce their electricity bills, being unaware of the poor health effects of having no direct ventilation within their suites.

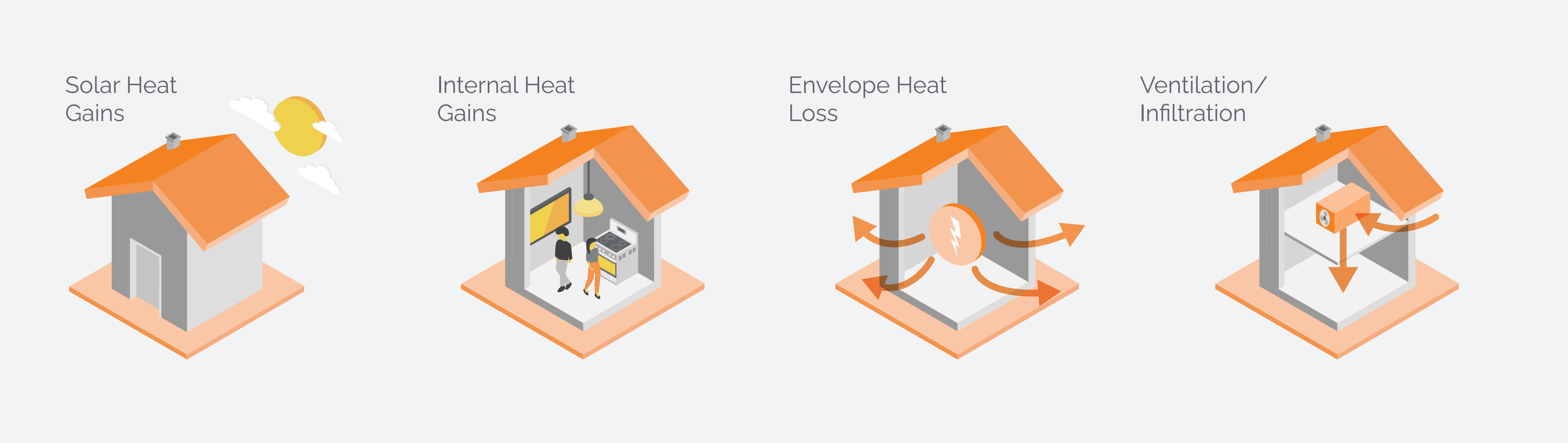
When the outdoor air quality is poor (e.g. due to smoke from forest fires), more frequent replacement of HRV filters is necessary but is unlikely to be done in a decentralized system due to the operational and maintenance costs.

# Planning and Design Checklist

**Use high-efficiency HRVs** to reduce the energy required for maintaining the indoor temperature setpoints within suites. The current market in BC for decentralized HRVs with over 80% heat recovery effectiveness is limited. Because of this, these HRVs come with a capital cost premium. Developers should make sure these additional costs are captured early in costing exercises.

Using a high-efficiency HRV typically reduces the reliance on the building envelope to achieve the TEDI targets. This could result in a greater window-to-wall ratio. The increase in cost for high-efficiency HRVs is commonly offset with the reduction in cost for the building envelope systems.

**Use passive design strategies** to keep peak building loads down. Some projects may consider heating or cooling the building by tempering the ventilation air. This is possible when solar heat gains and internal heat gains are minimized, and the design includes a high-performance building envelope with low air infiltration rates.




Building Heating and Cooling Load Design Considerations

**Reduce the ventilation rate for corridors to save energy.** With lower air infiltration rates in buildings and improved smoke seals at corridor suite doors, there is a reduced need for highly pressurized corridors. Corridors should still be ventilated in order to pressurize and counter the stack effect. By using an HRV with supply and exhaust connections inside each suite, migration of odours between suites is minimized. This issue can be further mitigated if corridor pressure is balanced slightly positive to suite pressure.

**Pay close attention to ducting layout.** The ducting layout and design has a big impact on the required fan power energy. A well-designed duct distribution system will minimize the size of the HRV, which in turn reduces capital and operational costs. Attention to duct sealing during construction is required to help limit duct leakage and achieve proper air balancing.

**Select a properly sized range hood.** If a recirculating range hood is being used, proper sizing and a high capture efficiency is of the utmost importance. Ensuring that there is a general exhaust outlet located near the recirculating range hood will limit heat and odour build-up in the kitchen. It is important to note that due to indoor air quality implications, all gas-fired ranges will require a direct exhaust range hood system.

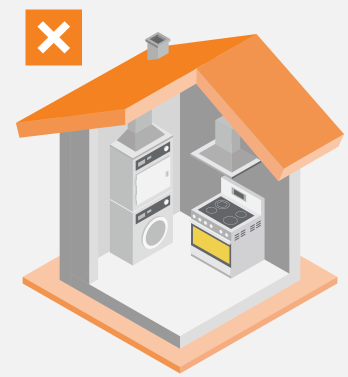
**Select a ventless dryer.** These dryers are more energy-efficient than conventional vented dryers and do not exhaust directly to the outdoors. Eliminating this exhaust duct reduces overall air infiltration rates. Similar to the recirculating range hoods, the ventless dryers discharge heat into the suite. This should be considered when designing both the ventilation and cooling systems.

**Allow for occupant control.** Enable the occupant to increase ventilation and exhaust from their suite. This is a simpler solution for a decentralized ventilation system than it is for the semi-centralized or centralized system options.

**Commission the ventilation system.** Commissioning is intended to ensure that the ventilation system performs as designed. The Passive House standard requires commissioning of the HRV. The Step Code does not require commissioning of ventilation systems, although commissioning can be specified in design documentation.

**Avoid using Passive House and ASHRAE standards interchangeably** throughout the design phase. The two standards specify different ventilation rates, with the Passive House standard typically being lower than those in ASHRAE. At low airflow rates, the ventilation systems can be difficult to balance, and care should be taken to avoid outlets that are balanced below 7 L/s (15 cfm).

**Avoid using direct exhaust air systems (range hoods, dryers) where possible.** These direct exhaust systems can exhaust a significant amount of conditioned air out of the suite, which results in an increase in energy usage. Condensing and heat pump dryers do not require ducting to the exterior of the building and are becoming more widely available and should be strongly considered. Recirculating range hood systems require additional maintenance and can temporarily increase indoor temperatures when in use. Although this may be acceptable in the winter, it is less desirable in the summer.



# Using Ventilation Systems for More than Just Fresh Air

## Heating and Cooling Loads in High-Performance Buildings

Given the thermal efficiency of the building envelope in high-performance buildings, the heating and cooling loads are significantly lower than buildings of the past. Cooling loads are also often significantly reduced in these types of buildings through the use of proper exterior shading (fixed or operable), glazing with a low solar heat gain coefficient and other design strategies. Given these reduced loads, it may be possible to address most of the heat loss and gains by integrating some heating and cooling with the ventilation system (HRV) to temper the supply air being provided to the suites. This strategy is most often incorporated in centralized or semi-centralized ventilation systems, as it is much more cost effective than introducing separate heating and cooling to the individual HRVs of a decentralized system.

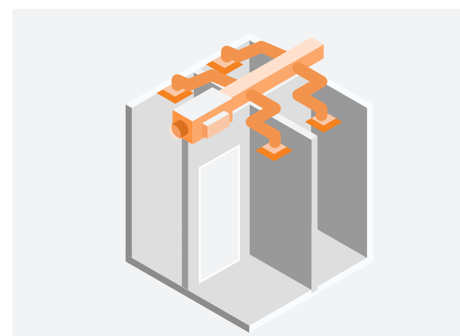
## Heating and Cooling Ventilation Strategies

If attempting to address all of the building's heating and cooling requirements through the ventilation system, it may be more appropriate to adopt a semi-centralized strategy. This is because the annual heating and cooling loads may vary from suite to suite. For example, the suites that are exposed to more solar radiation on the south and west elevations could be connected to one ventilation system with a higher cooling capacity. This could allow for the system supply air to be reset based on demand for similar suite types and exposures to limit discomfort (overheating or overcooling). An alternative to this strategy is the the use of variable air volume (VAV) dampers for the supply air to each suite that operates to increase ventilation when additional cooling is required. This strategy can increase capital costs, but VAV systems require less maintenance than a decentralized approach.

Given the low airflow rates of HRVs, the peak heating and cooling loads may need to be addressed using dedicated (separate) heating and cooling systems such as baseboard heaters, heat pump systems or fan coils. An alternative approach to a dedicated heating or cooling system is to increase the peak ventilation rates as required to address any potential overheating.

Incorporating cooling in an HRV will reduce the amount of overheating experienced by building occupants and is often considered to be "partial cooling". Typically, those living in condominiums or apartments with glazing on the south and west elevations are the most affected in buildings with no cooling.

Centralized HRV with Heat Pump



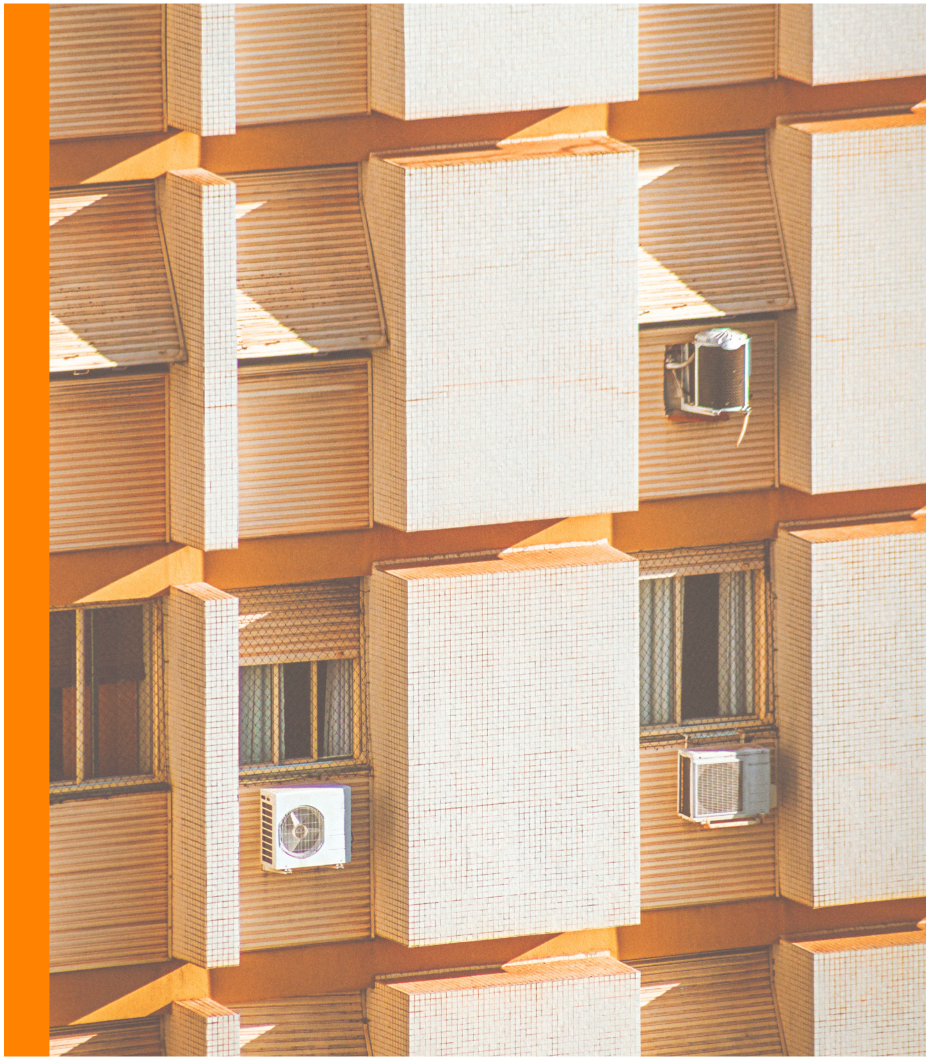
Suppy Air Ducting with VAV Dampers

# Cooling for Social Housing

If housing is intended for vulnerable populations, the overheating potential needs to be more closely monitored and further reduced over the BCBC requirements. In these instances, the *BC Housing Design Guidelines and Construction Standards*[4] for overheating should be used for minimizing overheating hours. Typically, this will require the use of a dedicated cooling system unless a detailed thermal comfort analysis confirms that the mechanical design is compliant with the BC *Housing Design Guidelines and Construction Standards* without cooling.

# Bypass Mode for Occupant Comfort

HRVs with a bypass mode are more likely to provide better occupant comfort than those without bypass mode. When the outdoor temperature is closer to the desired indoor temperature, the bypass mode allows the suite to reach the desired temperature more quickly than if the air was passing through the heat exchanger of the HRV. An example of this is flushing a warm suite with cool air at night to reduce the indoor temperature without requiring active cooling (i.e. air conditioning). This is commonly known as "night-flushing" and it is a more effective way to cool rather than simply opening windows at night after a hot summer day.



## Additional Resources

To learn more about the topics covered in this playbook, please consult the following publications:

- Improving Ventilation in Existing or New Buildings with Individual Ventilation Systems. National Center for Healthy Housing. Winter 2009.
- Practical Guidance for Epidemic Operation of Energy Recovery Ventilation Systems. ASHRAE TC 5.5. June 2020.
- Spending Through the Roof. Urban Green Council, prepared for NYSERDA. March 2017.
- There are Holes in Our Walls. Urban Green Council and Steven Winter Associates. April 2011.
- The Facts About Energy Recovery Ventilators. Architect Magazine. July 2009.
- Heat Recovery Ventilation Guide for Multi-Unit Residential Buildings. BC Housing. 2015.

## Endnotes

1 Source: https://energystepcode.ca

2 Source: City of Vancouver Climate Emergency Action Plan https://council.vancouver.ca/20201103/documents/p1.pdf

3 Source: AME Consulting Group Ltd. projects, assuming residential building, with natural gas heating and electricity for other usages, and no HRV: approximately 25% of TEUI is from space heating, 40-60% of total heat loss is from ventilation

4 Source: BC Housing Design Guidelines and Construction Standards https://www.bchousing.org/partner-services/asset-management-redevelopment/construction-standards

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