IMPROVING ENERGY EFFICIENCY AND OCCUPANT COMFORT IN MULTI-UNIT RESIDENTIAL BUILDINGS

Heating, ventilation and air conditioning (HVAC) systems each represent a systematic method for controlling the various aspects of the environment within an enclosure, whether it is a room, a group of rooms, or a whole building.

Property owners of MURBs can use this guide to better understand the benefits of improved HVAC systems and assist with their selection of measures and retrofit projects to increase energy efficiency and occupant comfort in their buildings.

MAINTAINING A COMFORTABLE ENVIRONMENT FOR OCCUPANTS INVOLVES CONDITIONING THE AIR BY:

- Heating/cooling to control temperature
- Humidifying/dehumidifying to control relative humidity
- Circulating air to provide movement
- Ventilating to supply fresh air
- Filtering to remove air contaminants

Providing HVAC to indoor spaces is the top source of energy use in residential buildings. Across different housing types, heating energy alone can account for 60 percent of all energy consumed by a residential building.[1]

[1] Natural Resources Canada Office of Energy Efficiency - National Energy Use Database

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COMMON PROBLEMS ASSOCIATED WITH HVAC IN MULTI-UNIT RESIDENTIAL BUILDINGS (MURBS)

Problem type	Potential causes	Impacts
Indoor air quality (IAQ)	Ineffective mechanical and natural ventilation fails to deliver sufficient fresh air, resulting in an inability to remove contaminated air and moisture from kitchens and bathrooms.	Poor IAQ affects human health, particularly the young, the elderly and those with sensitivities.
Thermal comfort	Incorrectly sized HVAC equipment, inefficient building enclosures and thermal bridging at balcony slabs cause occupant discomfort during periods of hot and cold weather.	Thermal discomfort can lead to difficulty sleeping and/or concentrating, leading to a higher likelihood of accidents.
High operating and maintenance costs	Inefficient building enclosures, hydronic or air distribution systems (e.g., leaky ducts, constant volume fans, single-stage pumps) can result in energy waste.	Energy waste increases operating costs, while non-durable materials and equipment (e.g., filters, gaskets, etc.) require excessive maintenance and repair.

THE V IN HVAC – WHY VENTILATION MATTERS

Ventilation is important in MURBs to maintain indoor air quality, enhancing the health and comfort of residents. Ventilation systems work to:

- **Remove pollutants:** Indoor air can be polluted from cooking, cleaning products and building materials that may off-gas, especially during periods of renovation.
- **Control odours:** Ventilation works to exchange polluted air with fresh air, eliminating odours that would otherwise accumulate.
- **Prevent mould and mildew:** Ventilation provides air flow, which prevents moisture from building up. Excess moisture can lead to mould and mildew growth, which can lead to respiratory issues and other health problems for residents.
- **Inhibit the spread of airborne contaminants:** Ventilation helps dilute and remove dust, allergens and pathogens from the air, reducing the risk of illness and improving overall air quality.
- **Allow occupants to breathe easier and sleep more soundly:** Healthy indoor air quality is linked to improved health and sleep quality.

COMMON DESIGN OPTIONS FOR MURB VENTILATION


Centralized ventilation


Decentralized ventilation

There are two common forms of MURB ventilation: centralized and decentralized. Centralized systems are commonly found in larger high-rise buildings with central heating and/or cooling plants. De-centralized ventilation is more commonly used in low-rise residential units, including townhomes and single family homes that were converted to apartments.

Centralized ventilation

How it works

- Supply ducts to each floor provide fresh air from a central make-up air (MUA) unit to pressurize common areas.
  - The purpose of MUAs is to keep hallways pressurized, healthy and comfortable. Pressurization is important for safety in the event of fire, and it helps to keep odours and humidity from daily domestic activities inside each dwelling unit.
  - Older conventional equipment is gas-fired and typically does not include a pre-heat function. Fresh air from outdoors must be heated before being supplied to common areas to maintain comfort indoors, using significant amounts of energy.

Opportunities

- Opportunities to improve comfort and efficiency in centralized ventilation systems:
  - Ensure individual suites are equipped with exhaust fans to remove contaminants and moisture (kitchen, bathroom, laundry).
  - Retrofit to high-efficiency equipment such as heat pumps with pre-heat functionality and air flow modulation based on occupancy schedules.

Decentralized ventilation

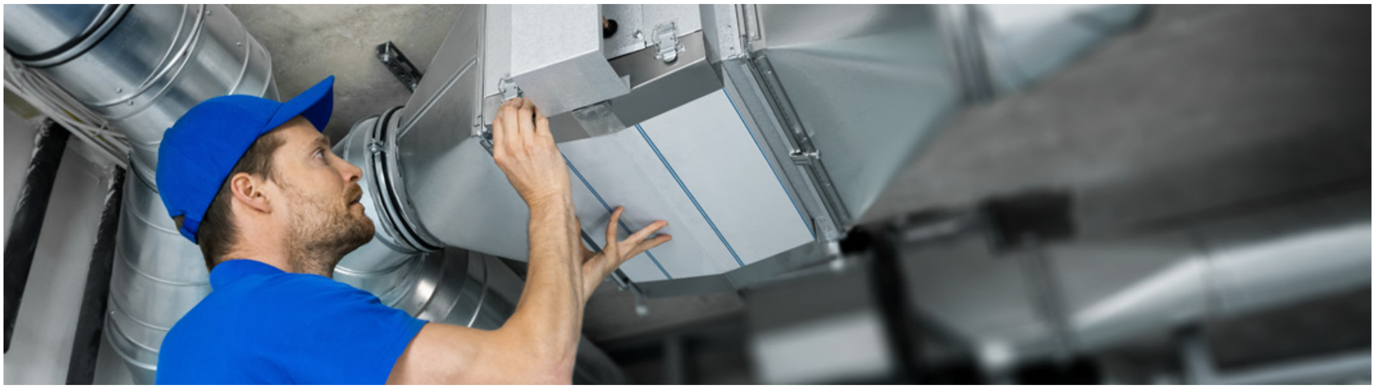
How it works

- Supply ducts inside each suite provide fresh air from individual air-handling units (AHU).
- Older conventional MURBs do not have decentralized heat recovery ventilation (HRV)/energy recovery ventilation (ERV).
  - HRVs and ERVs both use heat exchangers to recover heat from exhaust air, without the contaminants. ERVs can also recover humidity from the exhaust air.

Opportunities

- Opportunities to improve comfort and efficiency in decentralized systems:
  - Install individual ERVs inside each suite.
  - When upgrading, these solutions can be included in packaged supply systems or exhaust systems (kitchen, bathroom, laundry).

IMPROVE ENERGY EFFICIENCY ASSOCIATED WITH HVAC SYSTEMS



Building owners can implement no-cost and low-cost opportunities to eliminate energy waste associated with HVAC systems and to improve the efficiency of buildings and systems. These initiatives not only reduce energy consumption and operational costs, but also provide valuable non-energy benefits, such as improved occupant comfort and enhanced indoor air quality.

Following are examples of no-cost and low-cost opportunities to improve the energy efficiency of systems.

Maintenance

- Cleaning filters and coils reduces wear on equipment, reduces power consumption and improves heat distribution

Controls

- Timers for kitchen and bathroom ventilation
- Smart thermostats to reduce setpoints during unoccupied hours
- Variable frequency drives (VFDs) on HVAC equipment components such as fans, pumps and compressors
  - Modulate motor speeds to match the required load
  - Enable soft start of motors, reducing stress and extending their useful life
- Cascade control systems
  - Uses multiple units (e.g., boilers, modular chillers) as required to meet fluctuating heating/cooling demands
  - Maintains maximum efficiency by precisely matching the load
  - Whenever applicable, the most energy-efficient equipment is used first
  - Cascade control systems will modulate, stage and rotate equipment, as well as regulate equipment water and common supply temperature

Building enclosure improvements

- Improve air tightness and thermal resistance with:
  - Air sealing: caulking, weatherstripping, pressurized sealant applications
  - Thermal insulation upgrades (e.g., overcladding)
  - Energy-efficient windows (e.g., double or triple pane, low-e, argon filled)
  - Thermal bridge free design for new builds or extensive renovations

TECHNICAL CONSIDERATIONS FOR PLANNING HVAC RETROFITS

HVAC retrofits involve more capital-intensive projects, such as replacing major equipment with more energy-efficient options. There are many technical considerations for each technology when implementing building HVAC retrofits. To identify the most appropriate technology for any given building, it is important to determine the:

- Appropriateness of the technology for the building type and type of system it is replacing
- Cost-effectiveness of the technology (product and installation) compared to other options
- Benefits of the technology compared to other options

Such considerations generally include, but are not limited to, the following:

- Electrical service capacity available at the building
- Cold climate model availability for heat pump systems
- Envelope penetrations (thermal bridging)
- Difficulty overcoming distribution barriers
- Indoor unit placement for in-suite options
- Condensate management
- Operating noise
- Maintenance and reliability
- Equipment weight on rooftops or balconies
- Difficulty calculating savings estimates for budget approvals
- No dollar value assigned to quality-of-life improvements
- Potential increase in operating costs
- Rental or lease agreements where heat is included but electricity is billed directly to tenants create challenges in transferring heating costs to tenants
- HRV bypass to enable "free cooling"

An ASHRAE Level 2 energy audit is recommended to analyze historical energy consumption, identify retrofit opportunities, and provide financial analysis required to support investment decisions for implementing each recommendation.

BENEFITS OF RETROFITTING HVAC EQUIPMENT WITH HEAT PUMPS

Benefits of heat pump systems depend on the chosen system, but generally will improve the environment and occupant health with:

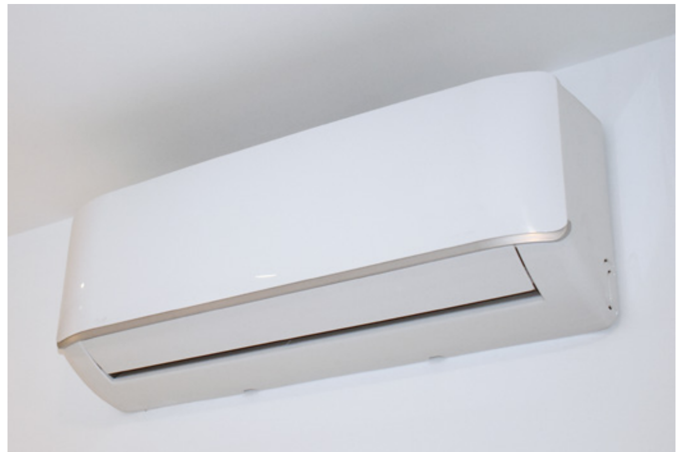
1. Higher efficiency than conventional systems
2. Reduced operations and maintenance costs
3. Significant greenhouse gas (GHG) reduction compared with natural gas systems
4. Improved indoor air quality
5. Improved thermal comfort and more even temperatures in suites

AVAILABLE TECHNOLOGIES: DECENTRALIZED SYSTEMS

The following pages provide a comprehensive overview of four different decentralized heat pump systems commonly used in multi-unit residential buildings. Each system is explored in detail, highlighting its unique features, benefits, and ideal applications. We will cover key considerations such as efficiency, performance and technical considerations, offering insights to help determine the most suitable option for specific residential needs.

Ductless mini-split air source heat pump (ASHP)

A mini-split air source heat pump system has an outdoor heat pump unit and one or more indoor units (indoor heads) that are connected by refrigerant lines. Each indoor mini-split unit has its own fan and evaporator coil and will independently service a single room or zone. Both ductless and ducted versions of multi-zone or multi-split systems are available to provide conditioned air to multiple rooms/zones. Some systems will allow up to eight rooms/zones to be heated by one outdoor unit, but typically only two to four indoor units are installed on each outdoor unit split system.



System benefits

- Energy efficiency
- Cold climate models available
- Zonal heating and cooling controls
- Flexibility and options for indoor unit placement
- Capable of serving multiple zones with one outdoor unit
- Low electrical capacity models
- Operating noise is very low (25–35 decibels)
- Easy access for maintenance

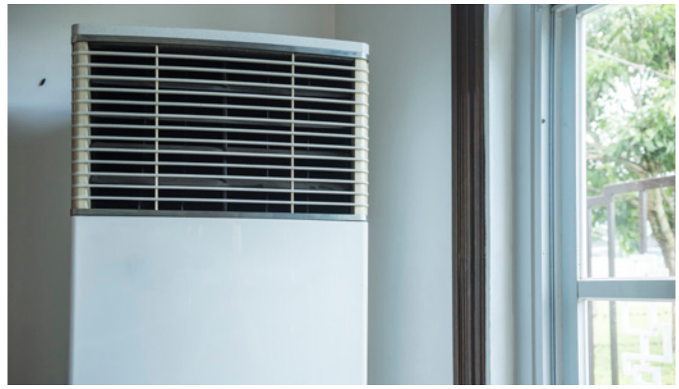
Technical considerations

- Whether heating capacity of indoor units can meet the heating loads of each zone
- Placement of indoor and outdoor units
- Challenges in transferring heating costs to tenants
- Placement and length of refrigerant lines
- Condensate management to avoid condensate buildup
- Envelope penetrations during installation must be properly sealed
- Potential need for auxiliary heating
- No advanced filtration or heat recovery
- May exceed the building's electrical service capacity

AVAILABLE TECHNOLOGIES: DECENTRALIZED SYSTEMS

All-in-one air source heat pump

All-in-one (AIO) systems are high-efficiency air source heat pumps in a single-package design with no outdoor unit. The indoor unit is mounted on an interior wall and sealed to two small vents that pass through penetrations in an exterior wall. Each indoor unit directly distributes heat into the room/zone where it is placed.



System benefits

- No outdoor unit
- Simple installation
- Low risk of refrigerant leakage
- Cold climate models available
- Multiple functions to provide heating, ventilation, air conditioning and domestic water heating
- Optional built-in electric heaters
- Operating noise is very low (approximately 20–35 decibels)
- Indoor unit directly distributes heat in the zone where it is placed

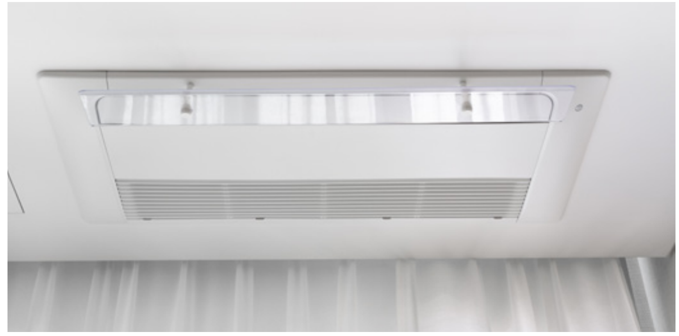
Technical considerations

- Envelope penetrations during installation must be properly sealed
- Unit placement
- Challenges in transferring heating costs to tenants
- Condensate management to avoid condensate buildup
- May exceed the building’s electrical service capacity
- Access for maintenance and reliability

AVAILABLE TECHNOLOGIES: DECENTRALIZED SYSTEMS

Ducted all-in-one heat pump

Ducted all-in-one (ducted AIO) systems are high-efficiency air source heat pumps with no outdoor unit. They are attached to an interior ducting system to distribute heat through diffusers in multiple rooms. The indoor unit is attached to two external vents and is typically ceiling mounted.



System benefits

- No outdoor unit
- Ducted full-suite solution
- Low risk of refrigerant leakage
- Cold climate models available
- Multiple functions to provide heating, ventilation, air conditioning and domestic water heating
- Optional built-in electric heaters
- Operating noise is very low (approximately 40–50 decibels)
- Indoor unit directly distributes heat in the zone where it is placed

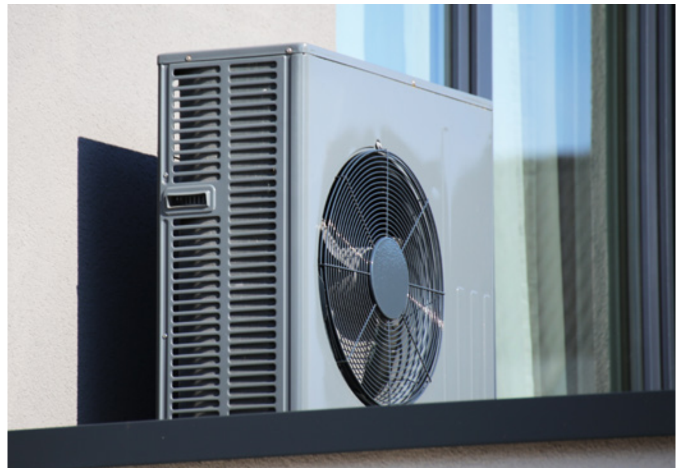
Technical considerations

- Envelope penetrations during installation must be properly sealed
- Unit placement
- Challenges in transferring heating costs to tenants
- Airflow and ductwork testing or redesign
- Condensate management to avoid condensate buildup
- May exceed the building's electrical service capacity
- Access for maintenance and reliability

AVAILABLE TECHNOLOGIES: DECENTRALIZED SYSTEMS

Window-mounted heat pump

Window-mounted heat pumps are a new heat pump product designed to be mounted over a windowsill to provide air conditioning and meet some, or all, of apartment heating loads, depending on the climate. Plugged into a standard 120-volt electrical outlet, these systems are designed to be simple to install, requiring no building envelope penetrations. One unit will typically serve a single room or zone.



System benefits

- Simple installation
- Lower cost than other systems
- Moderate efficiency
- Zonal heating and cooling controls
- Operating noise is very low (approximately 40–50 decibels)

Technical considerations

- Safety considerations or bylaws related to window-mounted AC units
- Placement of the unit/window compatibility
- Whether heating capacity can meet the heating loads of each zone
- Challenges in transferring heating costs to tenants
- Potential need for auxiliary heating
- May exceed the building's electrical service capacity

BENEFITS OF RETROFITTING HVAC EQUIPMENT WITH HEAT PUMPS

COMPARISON OF BENEFITS OF DECENTRALIZED HEAT PUMP SYSTEMS

	Benefits	Ductless mini-split ASHP	All-in-one ASHP	Ducted all-in-one ASHP	Window-mounted heat pump
1	Simple installation	√	√		√
2	Outdoor unit	√			
3	Moderate efficiency				√
4	Maximum efficiency	√			
5	Low cost				√
6	Cold climate models available	√	√	√	
7	Zonal heating or cooling controls	√			√
8	Flexibility and options for indoor unit	√			
9	Operational capacity of one outdoor unit	√			
10	Low electrical capacity models	√			
11	Low risk of refrigerant leakage	√	√	√	
12	Multi-purpose HVAC including domestic water heating		√	√	
13	Optional built-in electric heaters		√	√	
14	Ducted full-suite solution			√	

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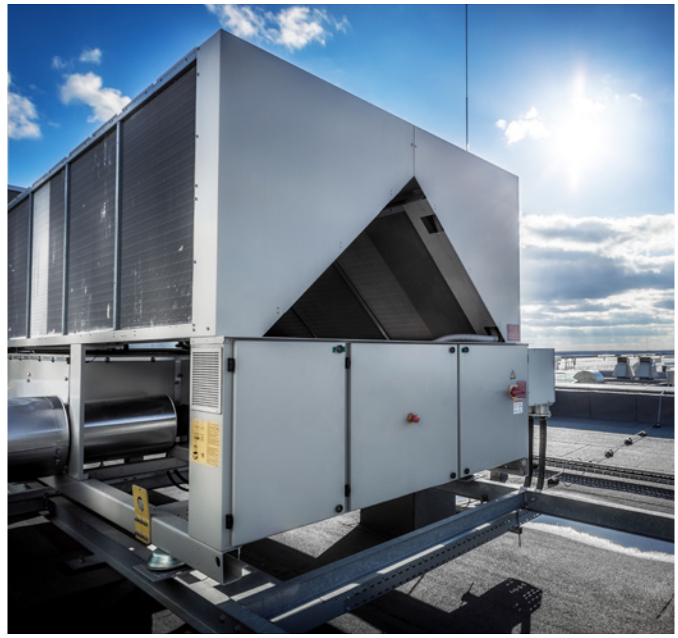
AVAILABLE TECHNOLOGIES: CENTRALIZED SYSTEMS

The following pages provide an overview of some centralized heat pump systems used in multi-unit residential buildings. These systems are explored in detail including system benefits, practical application in retrofit scenarios, and technical considerations prior to undertaking retrofit work including design, installation, and maintenance.

Central hydronic systems

Central hydronic heat pump systems are composed of a central heating source that distributes heat energy by running heated water through a piping loop around the building. Heat energy is then delivered to heat-emitting zone terminal equipment, which may consist of baseboards, wall/floor radiators, in-floor pipes or fan-coil units. In most cases, the heat-emitting equipment in central hydronic systems will be floor-mounted baseboards or radiators. Traditionally, central hydronic systems or boilers were fueled by gas or fuel oil. Theoretically, electrifying a gas or fuel oil boiler could be done simply by replacing the heating source with a central heat pump. However, there are other considerations to keep in mind, such as the following:



System benefits

- Avoid or limit work in the suites
- Radiant heat rather than forced air
- Reduce amount of enclosure penetrations
- Central electrical connection

Technical considerations

- System must be capable of delivering high water temperature
- Challenges adding cooling solutions
- Potential auxiliary heating requirement
- Outdoor units are large and heavy
- Condensate management
- Issues with existing hydronic piping, such as leakage or scaling
- May exceed the building's electrical service capacity
- Access for maintenance and reliability

AVAILABLE TECHNOLOGIES: CENTRALIZED SYSTEMS

Variable refrigerant flow

Variable refrigerant flow (VRF) heat pumps consist of an outdoor compressor unit connected to multiple indoor fan coil units. These units vary the refrigerant flow using variable speed compressor(s) in the outdoor unit and the electronic expansion valves in each indoor unit. The ability to control the refrigerant mass flow rate according to the heating and/or cooling load allows for the use of individual temperature control in 60 or more indoor units of different capacities with one single outdoor unit.

There are two common types of VRF systems:

1. Heat pump systems that can be used for either cooling or heating, but not simultaneously.
2. Heat recovery systems that can deliver simultaneous heating and cooling to different zones by transferring heat between the cooling and heating indoor units. This generally occurs in the shoulder seasons in medium-sized to large-sized buildings with substantial heat gain loads on elevations of the building oriented toward the sun—typically south and west, sometimes east.

System benefits

- Zonal heating/cooling provided by a centralized system
- Potential for heat recovery among zones
- Flexible configuration
- Central electrical connection
- Sophisticated controls

Technical considerations

- Refrigerant issues such as leakage
- Higher capital cost than other options
- Potential auxiliary heating requirement
- Condensate management
- Outdoor units are large and heavy
- Each outdoor unit has relatively low noise levels (approximately 40–60 decibels)
- Repair and troubleshooting can be more complex
- Access for maintenance and reliability

AVAILABLE INCENTIVES FOR RETROFIT PROJECTS

The Save on Energy Retrofit Program throughout offers incentives to upgrade to higher-efficiency equipment, reduce energy consumption, reduce utility bills and lower greenhouse gas emissions. Owners of MURBs can participate in either or both of the custom or prescriptive stream.

Custom stream – Often used for more complex retrofit projects.

Prescriptive stream – For more common upgrades, including lighting controls and HVAC.

The following are some common heat pump incentives that owners of MURBs may consider for their retrofit projects.

Unitary ASHP equipment size: split or single-package systems

Tons	Btu/h (kW)	Incentive (per unit)
3.0 to <5.4	36,000 to <65,000 (11 to <19) =	$400
5.4 to <11.25	65,000 to <135,000 (19 to <40) =	$3,000
11.25 to <20	135,000 to 240,000 (40 to <70) =	$5,000
20 to <63	240,000 to <760,000 (70 to <223) =	$18,000

For air-to-water or VRF systems, the custom program stream is recommended. You should work with a licensed energy or HVAC professional to support your estimated savings calculations.

For more information on the Retrofit program, including equipment performance requirements, visit SaveOnEnergy.ca/Retrofit. The incentives are capped at 50 percent of the project's total eligible cost.

For further information on the benefits of heat pumps, visit SaveOnEnergy.ca/Training.

[2] About the Retrofit program: SaveOnEnergy.ca/Retrofit.