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Electrifying Heating with Heat Pumps in Commercial Buildings

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Agenda

- An overview of heat pump technology and its application in the Ontario market
- Typical retrofit opportunities for commercial buildings including retail, offices, and other facility types
- Full fuel switch versus hybrid solutions
- Overview of the business case - what variables to factor in life cycle cost analysis using capital repair plans and building condition assessments for planning
- Tips on finding and working with contractors

An Overview of Heat Pump Technology Application in the Ontario Market

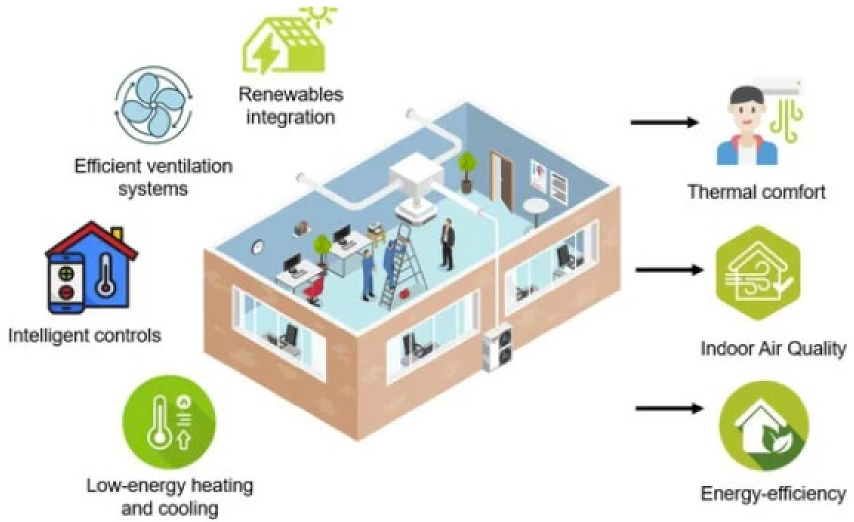
Why do we need heating, cooling and ventilation systems in buildings?

Comfort and Preservation of Property

1. **Temperature Regulation**: Heating systems ensure indoor temperatures remain within comfortable ranges during cold weather, while cooling systems maintain comfortable temperatures in hot weather.
2. **Humidity Control**: HVAC systems regulate indoor humidity levels, preventing discomfort from excessive moisture (high humidity) or dryness (low humidity).

Health, Safety and Well-being

1. **Air Quality:** HVAC systems filter and circulate indoor air, removing pollutants, allergens, and contaminants to maintain healthy indoor air quality.
2. **Ventilation:** HVAC systems provide fresh air intake and exhaust, ensuring adequate ventilation to dilute indoor pollutants and maintain oxygen levels.

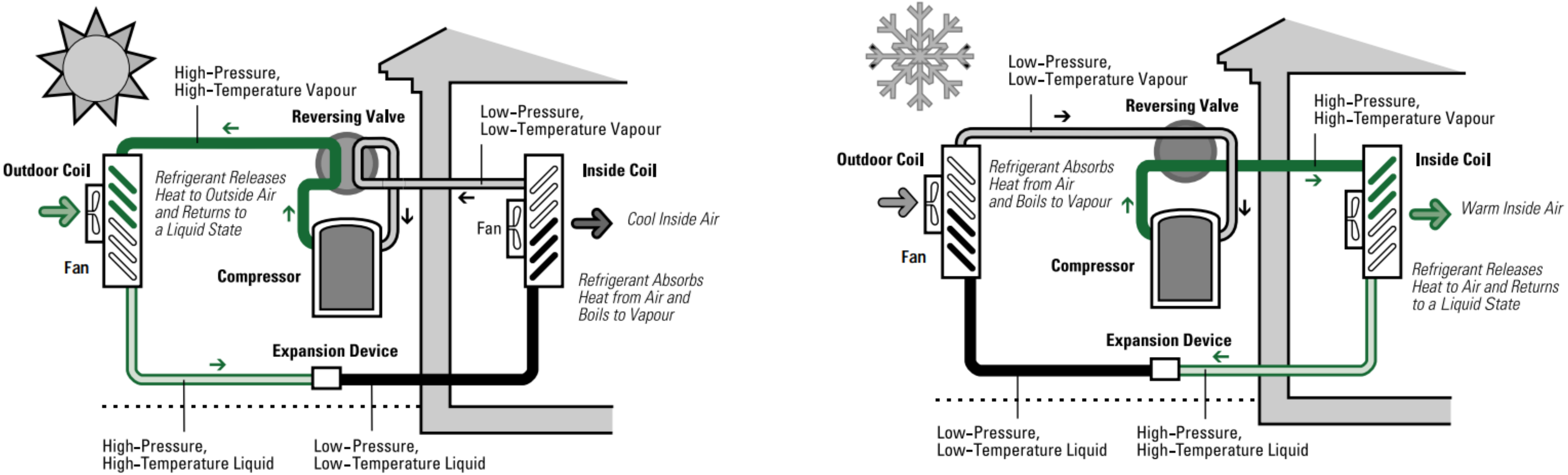


Heat distribution: air, water and refrigerants

Air	Water	Refrigerant
Most used in HVAC systems	Suitable for higher HVAC Loads	Suitable for any HVAC Systems
Lowest thermal conductivity and specific heat capacity	Higher Thermal Conductivity and Specific Heat Capacity	Highest Thermal Conductivity and Specific Heat Capacity
Larger ductwork or air handling units to transfer same amount of heat	Smaller Piping System	Compact System Design, Precise Temperature Control, Faster Response
Temperatures can vary depending on outdoor conditions, ventilation rates and system design	Temperature stability less affected by outdoor conditions	Minimal Energy Input, Versatile
Forced air Heating and Cooling	Hydronic Systems: Radiant Floor Heating, Chilled Beam or Water Source Heat Pumps	Heat Pumps

What are heat pumps?

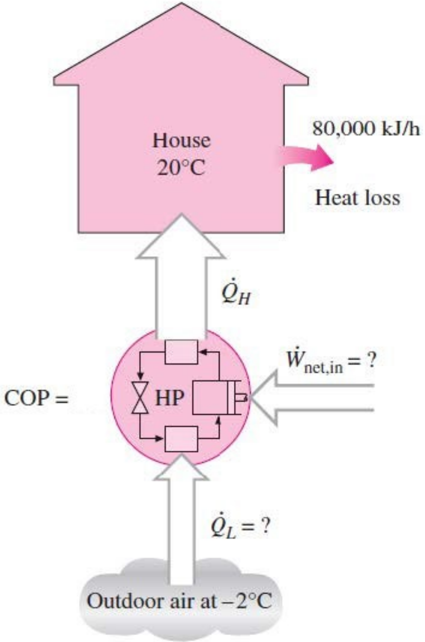
Heat pumps are highly efficient systems that transfer heat from one location (Source) to another (Sink), providing both heating and cooling capabilities.



Source: https://natural-resources.canada.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817

Dream heat pump efficiency!

A heat pump is used to meet the heating requirements of a building and maintain it at 20°C. On a day when the outdoor air temperature drops tc -2°C, the building is estimated to lose heat at a rate of 80,000 kJ/hr = 75,000 Btu/hr = 22 kW).



Coefficient of Performance of a Reversible Heat Pump:

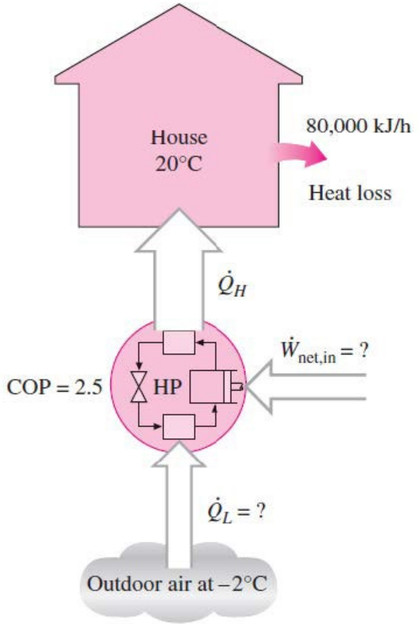
$$COP_{Reversible} = \frac{1}{1 - \frac{T_L}{T_H}} = \frac{1}{1 - \frac{-2+273}{20+273}} = 13.3$$

Power Consumption by Heat Pump:

$$W_{net,in} = \frac{Q_H}{COP_{Heat\ Pump}} = \frac{80{,}000\ kJ/hr}{13.3} = 6{,}015\ kJ/hr = 1.7\ kW$$

Why are heat pumps more efficient?

A heat pump is used to meet the heating requirements of a building and maintain it at 20°C. On a day when the outdoor air temperature drops to -2°C, the building is estimated to lose heat at a rate of 80,000 kJ/hr = 75,000 Btu/hr = 22 kW = 6.3 ton). If the heat pump under these conditions has a COP of 2.5:



Power Consumption by Heat Pump:

$$W_{net,in} = \frac{Q_H}{COP_{Heat\ Pump}} = \frac{80{,}000\,kJ/hr}{2.5} = 32{,}000\,kJ/hr = 8.9\ kW$$

Rate of heat transfer from outdoor air:

$$Q_L = Q_H - W_{net,in} = (80{,}000 - 32{,}000)\,kJ/hr = 48{,}000\,kJ/hr = 13.3\ kW$$

Heat Pump Efficiency in Steady State

Coefficient of Performance (COP): The COP is a ratio between the rate at which the heat pump transfers thermal energy (in kW), and the amount of electrical power required to do the pumping (in kW).

COP is published by Air Conditioning, Heating, and Refrigeration Institute (AHRI) at two points:

- High-temp COP at 8°C (47°F) outdoor air temperature.
- Low-temp COP at -8 °C (17°F) outdoor air temperature.

For example, if a heat pump used 1kW of electrical energy to transfer 3 kW of heat, the COP would be 3.

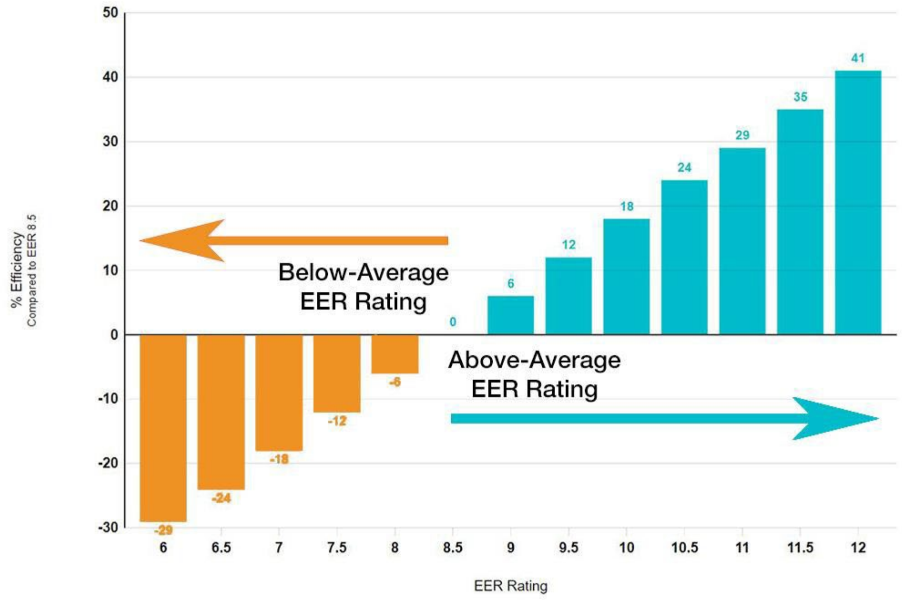
$$COP = \frac{\textbf{heat delivered by the heat pump (Btuh)}}{\textbf{energy supplied to the heat pump (Btuh)}}$$

Energy Efficiency Ratio (EER)

$$EER = \frac{\text{Cooling Capacity (Btu)}}{\text{Electrical Input (W)}}$$

The **EER** of a system is a ratio of the cooling output over the electrical power input.

Like COP, also a steady state measurement at a fixed operating condition.

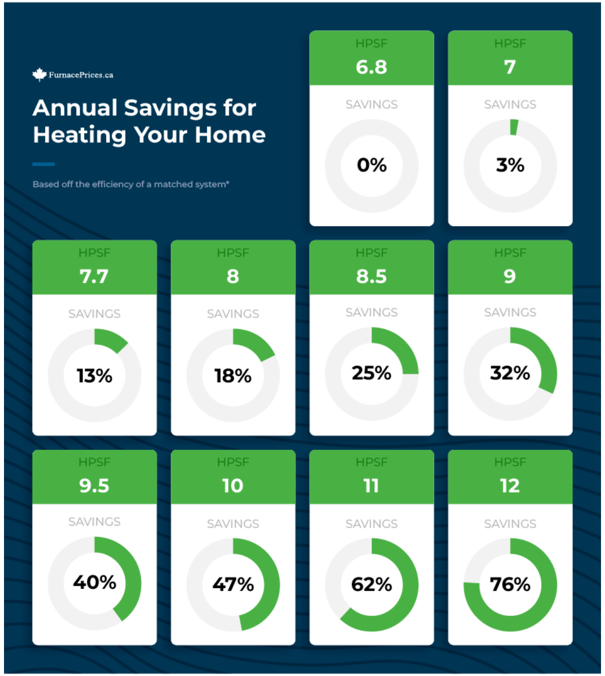


Heating Seasonal Performance Factor (HSPF)

$$\text{HSPF} = \frac{\text{Total Heating Output (Btu)}}{\text{Total Electrical Input (Wh)}}$$

The **HSPF** measures a heat pump's heating efficiency over an entire heating season.

HSPF is calculated by dividing the total heating output over the season by the total energy input for the same period.



Seasonal Energy Efficiency Ratio (SEER)

$$\textbf{SEER} = \frac{\textbf{Total Cooling Output (Btu)}}{\textbf{Total Electrical Input (Wh)}}$$

The **SEER** measures a heat pump's cooling efficiency over an entire cooling season.

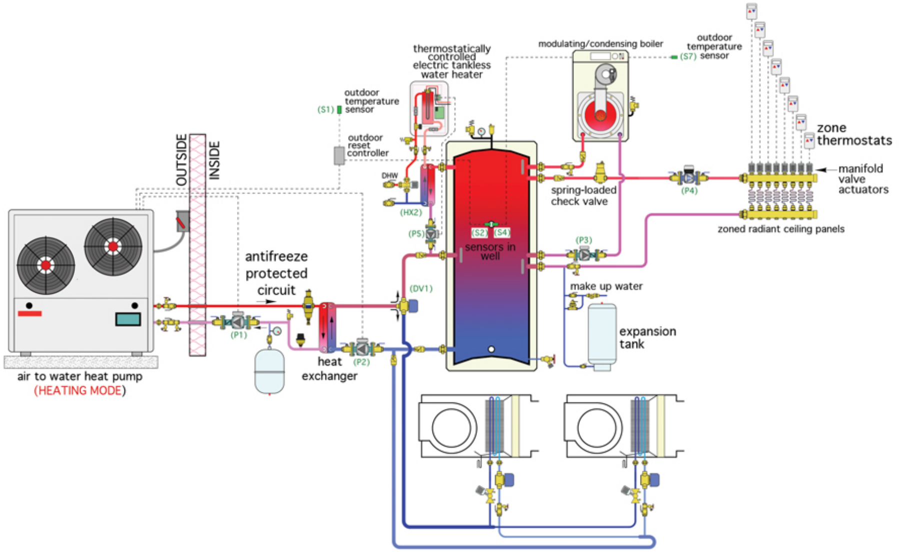
SEER is calculated by dividing the total cooling output over the season by the total energy input for the same period.

Air to water heat pumps

Air-to-water and water-to-water heat pumps have been intentionally designed for sustainable commercial buildings (offices to hospitals to schools).

These heat pumps feature energy-efficient technology, such as electronic vapor injection (EVI) compressors, while using refrigerants with low global warming potential (GWP).

When delivering heating and cooling simultaneously, these heat pumps can be 5 times more efficient than a boiler-chiller combination.



Heat pump retrofit process

- **Heat Source: Air or Ground**
- **Distribution: Air, Water or Refrigerant**
- **Sizing: Heating and Cooling Load**
  - **Supplementary Heat Sources**
- **Efficiency (HSPF)**
- **Defrost**
- **Installation**
- **Maintenance**

Types of heat pumps

Heat Pumps can be categorized based on their heat sources and configurations

- Air Source Heat Pumps
- Ground Source Heat Pumps
- Water Source Heat Pumps
- Hybrid Heat Pump Systems
- Absorption Heat Pump

Common commercial heat pump

Single-Split Systems
Multi-Split Systems
Packaged Terminal Heat Pump (PTHP)
Rooftop Terminal Units (RTU)
Variable Refrigerant Flow (VRF)
Hybrid Heat Pump Systems

Air source heat pumps

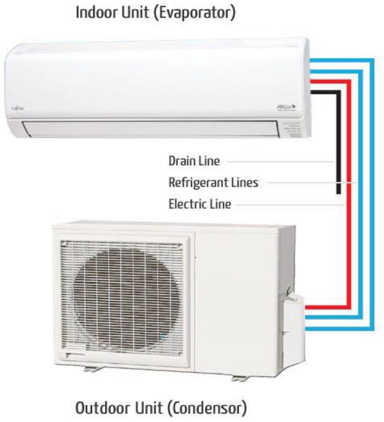
Standard/cold climate air source heat pumps

- **Function**: Transfer heat between indoor air and outdoor air.
- **Applications**: Residential and light commercial buildings.
- **Advantages**: Relatively easy and inexpensive to install.
- **Disadvantages**: Efficiency decreases in extremely cold temperatures.

Air source heat pumps

- Split System
  - Ductless Mini-Split
  - Multi-Zone Mini-Split
- Exhaust Air Heat Pump
- Packaged Air-Source
- Reverse Cycle Chiller
- Variable Refrigerant Flow (VRF) Systems

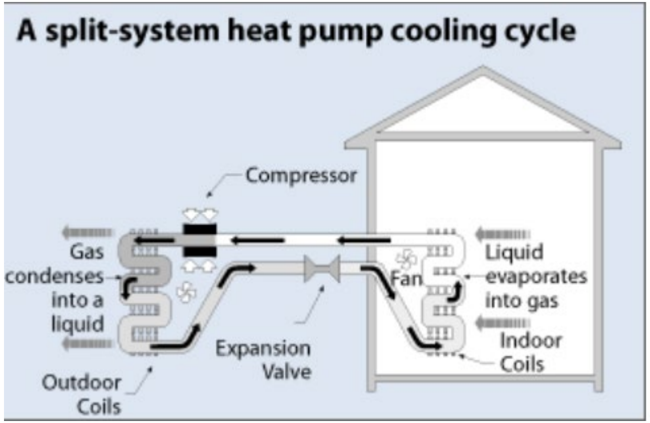
Multi Split

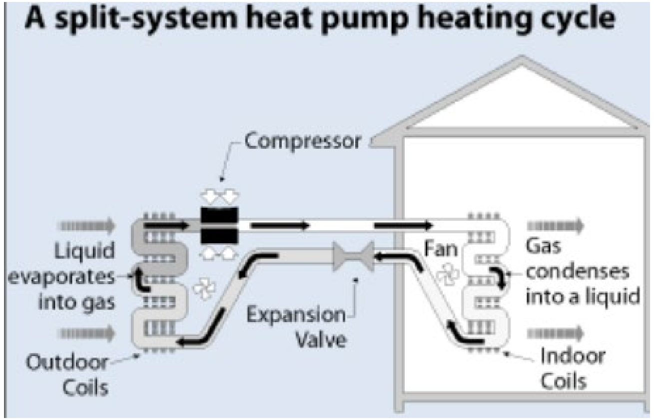


Single Split

Split system heat pumps

- **Components**: Consist of an outdoor unit (compressor and condenser) and an indoor unit (evaporator and air handler).
- **Applications**: Common in small to medium commercial buildings.
- **Advantages**: Flexible installation options, can be used for both heating and cooling, relatively easy to maintain and efficient.
- **Disadvantages**: Requires ductwork or ductless heads for distribution.





Ductless mini-split heat pumps

- **Components**: Comprise an outdoor unit and one or more indoor units connected by refrigerant lines.
- **Applications**: Ideal for retrofitting **older** buildings without existing ductwork, room additions, and individual zones.
- **Advantages**: Easy installation, high efficiency, independent zone control.
- **Disadvantages**: **Higher upfront** cost per unit compared to ducted systems.

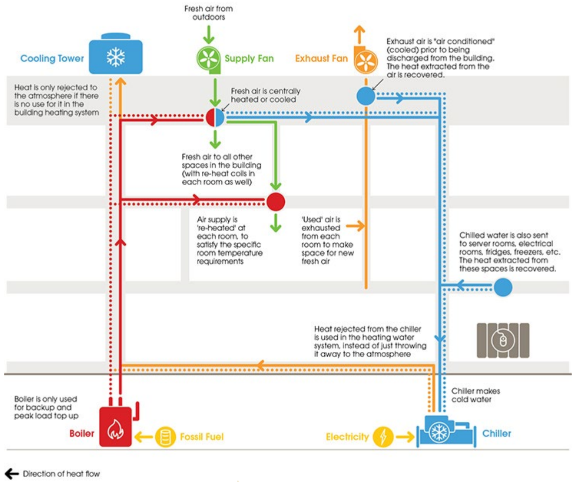
Multi-zone mini-split heat pumps

- **Components**: Similar to single-zone mini-splits but with multiple indoor units connected to a single outdoor unit.
- **Applications**: Larger offices, or buildings with multiple zones requiring independent temperature control.
- **Advantages**: Flexible zoning, energy-efficient, customizable comfort.
- **Disadvantages**: Higher initial cost and installation complexity.

Exhaust air heat pumps

- **Function**: Recover heat from a building's exhaust air to heat incoming fresh air or water.
- **Applications**: Buildings with high ventilation needs, such as offices, retail spaces, and hospitals.
- **Advantages**: Improves overall building efficiency by utilizing waste heat.
- **Disadvantages**: Limited heating capacity and often used in conjunction with other systems.

Setup for buildings with exhaust air heat pump heat recovery



Source: https://www.stantec.com/en/ideas/topic/buildings/turning-toasty-exhaust-air-into-usable-heat-that-s-sustainability

Packaged air-source heat pumps

- **Components**: All components (compressor, condenser, evaporator) are housed in a single outdoor unit.
- **Applications**: Small commercial buildings, rooftop installations.
- **Advantages**: Compact, easier to install in tight spaces, reduced indoor noise.
- **Disadvantages**: Limited to smaller capacities, less efficient than split systems.

Reverse cycle chiller heat pumps

- **Function**: Transfers heat to or from a water loop, which then heats or cools the building.
- **Applications**: Larger buildings with existing hydronic distribution systems.
- **Advantages**: Can leverage existing hydronic infrastructure, and provides consistent temperature control.
- **Disadvantages**: More complex installation and higher initial cost.

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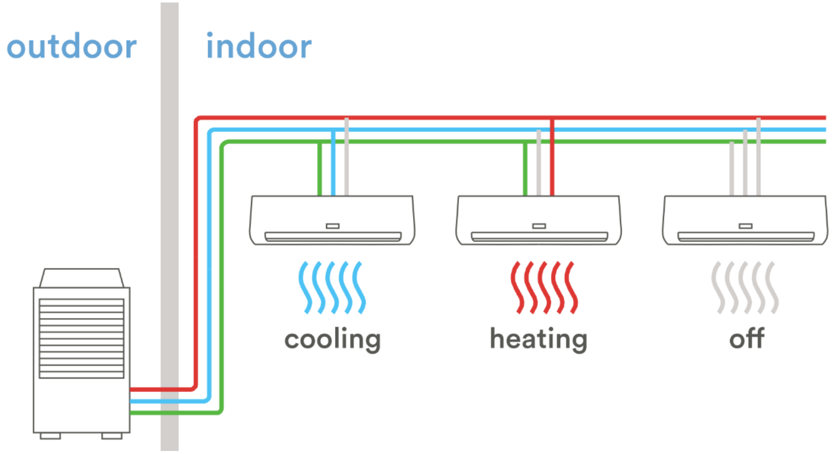
Variable refrigerant flow (VRF) heat pumps

- **Components**: Advanced type of split system that uses variable-speed compressors and multiple indoor units.
- **Applications**: Large commercial buildings, hotels, offices with diverse heating and cooling needs.
- **Advantages**: High efficiency, precise temperature control, simultaneous heating and cooling
- **Disadvantages**: Higher initial cost and complexity in installation and maintenance.



VRF heat pumps for commercial buildings

- Variable Refrigerant Flow (VRF) zoning systems
- Most popular technology for decarbonizing heating and cooling
- Lower carbon footprints
- Benefit: strategic electrification
- Reducing overall costs for commercial building owners
- Used for single zone applications or multi-zone applications where each zone has the same thermal profile.

REDUCED GHG EMISSIONS WITH VRF SYSTEMS

Source: Northeast Energy Efficiency Partnerships Variable Refrigerant Flow (VRF) Market Strategies Report (September 2019)

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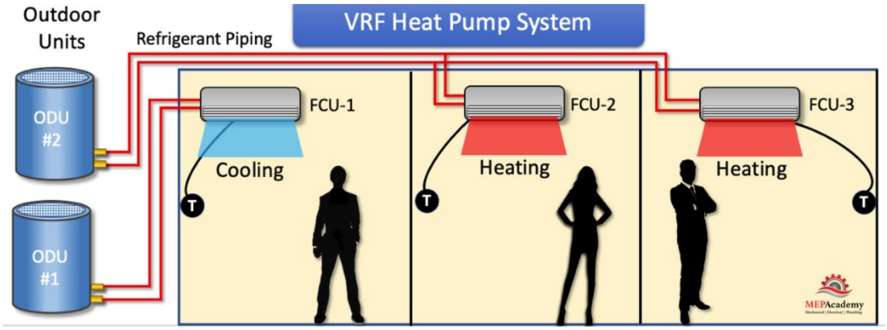
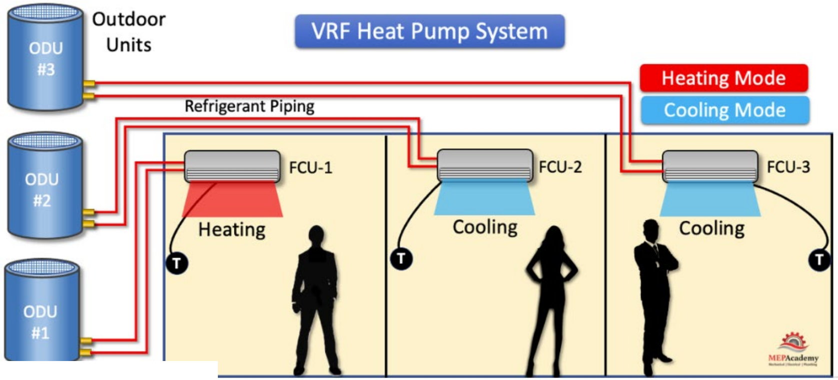
VRF heat recovery vs VRF heat pump



VRF Heat Pumps with Consolidated Zoning



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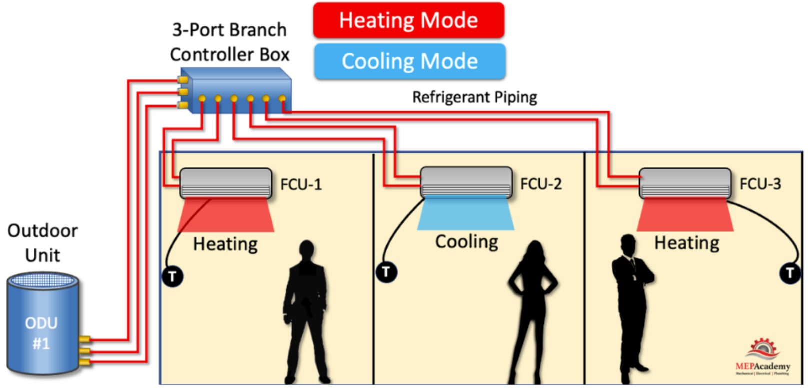


VRF Heat Recovery vs VRF Heat Pump (Heat Recovery System with 3-Port Branch Controller)

Source: MEPAcademy

Which VRF system to use

- Does the zone layout benefit from simultaneous heating and cooling by allowing the heat rejected from one space to be used by another?
- Is initial cost the determining factor, as VRF Heat Recovery often has the highest initial investment?
- Does the area have high moisture or relative humidity? This will require the use of additional equipment such as a dedicated outdoor air system (DOAS) unit to remove the moisture or latent heat.
- How will code required ventilation air be provided to the space?

Which VRF system to use cont'd

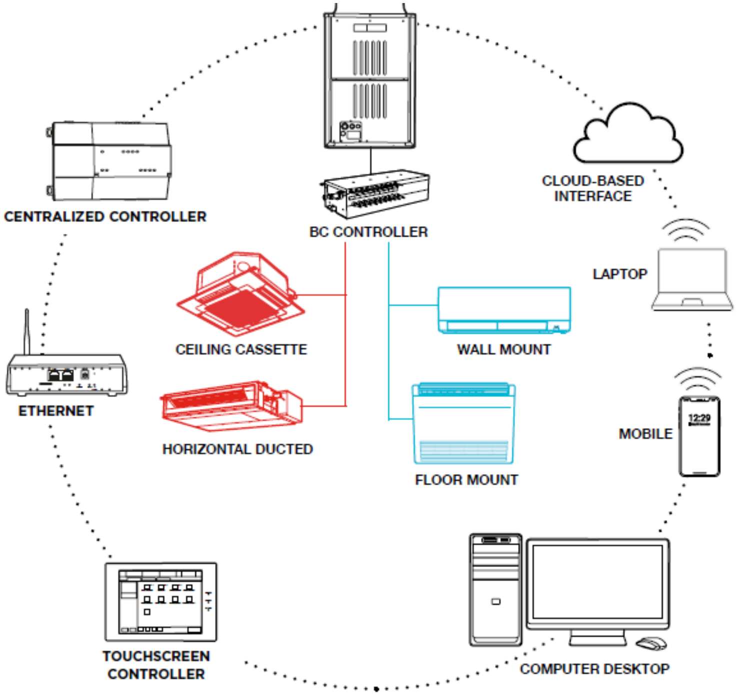
- Are the occupancy schedules of the various spaces similar?
- Is there space for the branch Selector Box if using a Heat Recovery System?
- Where can the outdoor units be located in relationship to the indoor units?
- Is refrigerant monitoring required and do the spaces meet the minimum volume for the ASHRAE 15 requirements?

VRF technology: all electric heating and cooling

Multizone system for offices, hotels, schools, multifamily buildings, indoor agriculture facilities and practically any commercial application

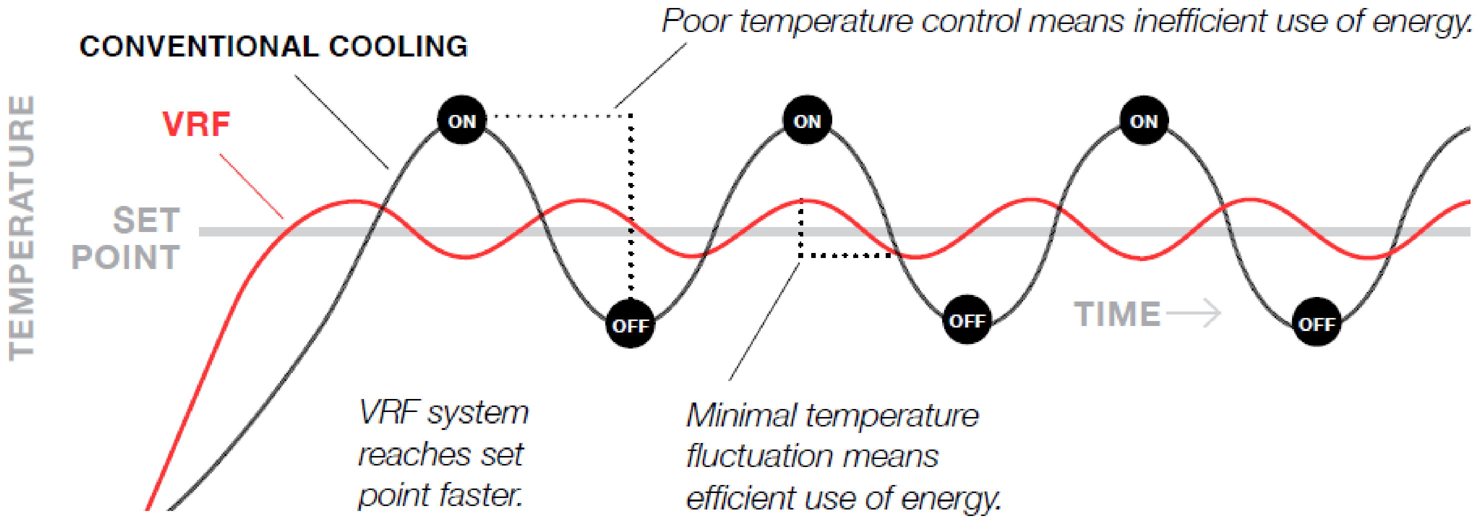
During Heating VRF heat pumps provide heating to zones by introducing ambient heat the outdoor unit extracts from the air or a nearby water source.

During cooling, VRF heat pumps reverse this process as indoor units transfer heat from zones to the outdoor unit which then rejects the heat



Source: MITSUBISHI, strategic electrification: satisfy the demand with VRF technology

VRF systems in cold-climate applications



Source: MITSUBISHI, strategic electrification: satisfy the demand with VRF technology

Office buildings

Selection of HVAC equipment and systems depends on whether the facility is new or existing.

Office HVAC systems generally range from small, unitary, decentralized cooling and heating up to large systems comprising central plants (chillers, cooling towers, boilers, etc.) and large air-handling systems.

HVAC systems such as single-zone constant-volume, water-source heat pump, and packaged terminal air conditioners (PTACs) with (VAV) systems.

High-rise office buildings

Perimeter fanpowered VAV terminals, induction, or fan-coil systems

In small to medium-sized office buildings, air-source heat pumps or minisplit systems (cooling only, heat pump, or combination) such as variable refrigerant flow (VRF) may be chosen

Source: ASHRAE HVAC Applications 2019, COMMERCIAL AND PUBLIC BUILDINGS

Applicability of systems to typical office buildings

Typical decentralized systems include the following:

- Water-source heat pumps
- Geothermal heat pumps
- Hybrid geothermal heat pumps
- Packaged single-zone and variable-volume units
- Light commercial split systems
- Minisplit and variable refrigerant flow (VRF) units

	Cooling/Heating Systems							Heating Only	
	Centralized			Decentralized					
Building Area/Stories	SZ[a]	VAV/ Reheat	Fan Coil (Two-and Four-Pipe)	PSZ/SZ* Split/ VRF	PVAV/ Reheat	WSHP	Geothermal Heat Pump and Hybrid Geothermal Heat Pump	Perimeter Baseboard/ Radiators	Unit Heaters
<25,000 ft^2, one to three stories				X		X	X	X	Special areas
25,000 to 150,000 ft^2, one to five stories	X	X	X	X	X	X	X	X	Special areas
>150,000 ft^2, low rise and high rise	X	X	X			X	X	X	Special areas

*SZ = single zone
VAV = variable-air-volume
PSZ = packaged single zone
PVAV = packaged variable-air-volume
WSHP = water-source heat pump
VRF = variable refrigerant flow

Source: ASHRAE HVAC Applications 2019, COMMERCIAL AND PUBLIC BUILDINGS

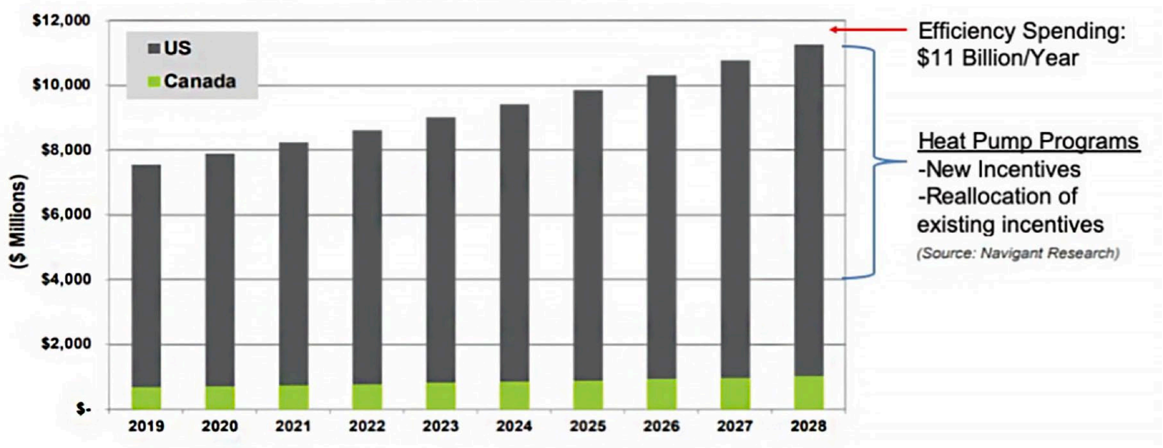
Solving electrification challenges with VRF technology

Increase energy-efficiency

Power Thermal End Uses with Renewable Energy

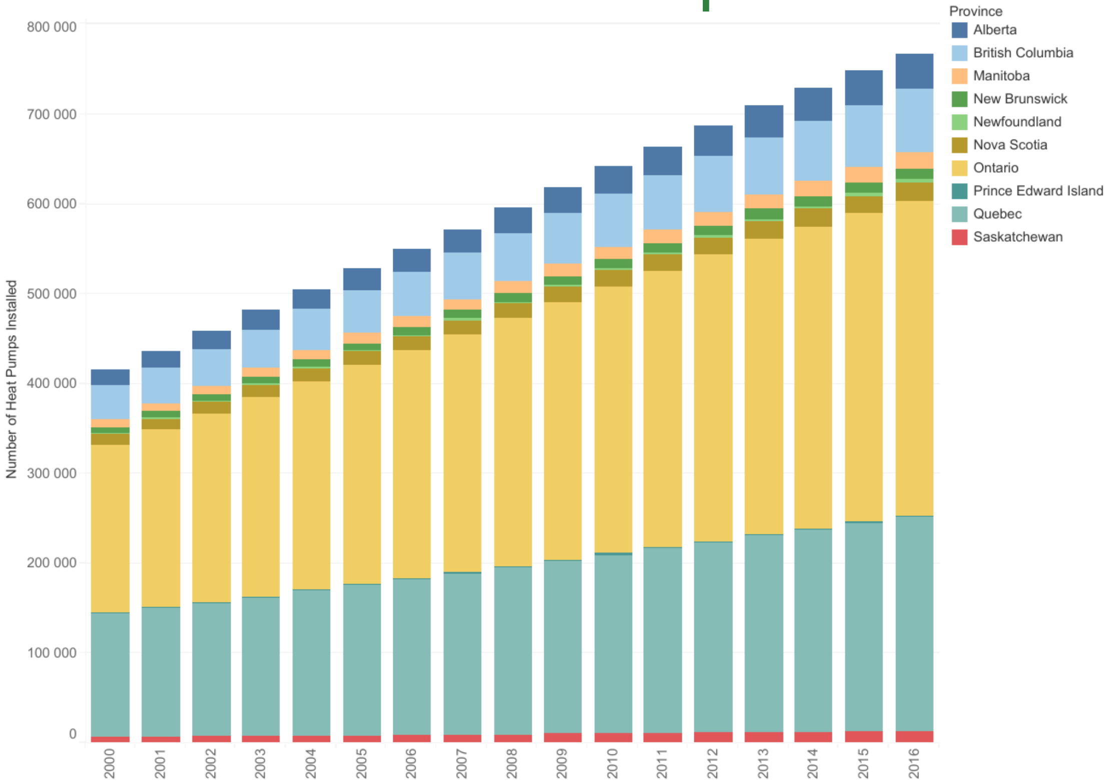
Decarbonize the Electric Grid

Heat pump spending in North America: 2019-2028



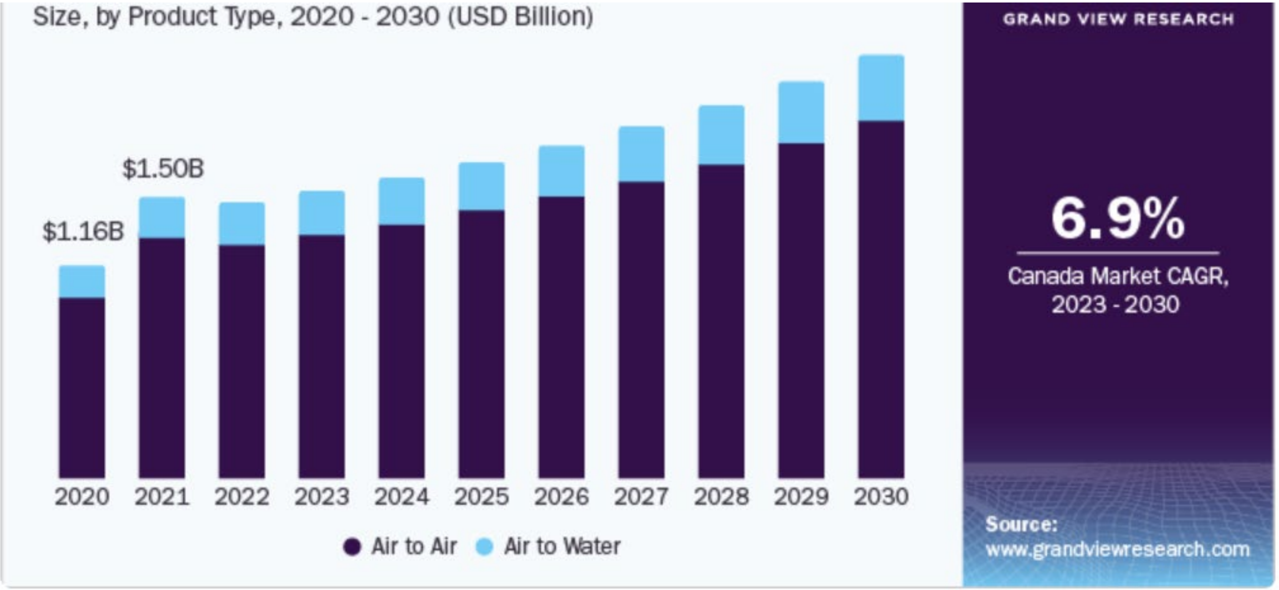
Source: MITSUBISHI, Strategic electrification: satisfy the demand with VRF technology

Number of Installed Heat Pumps In Canada



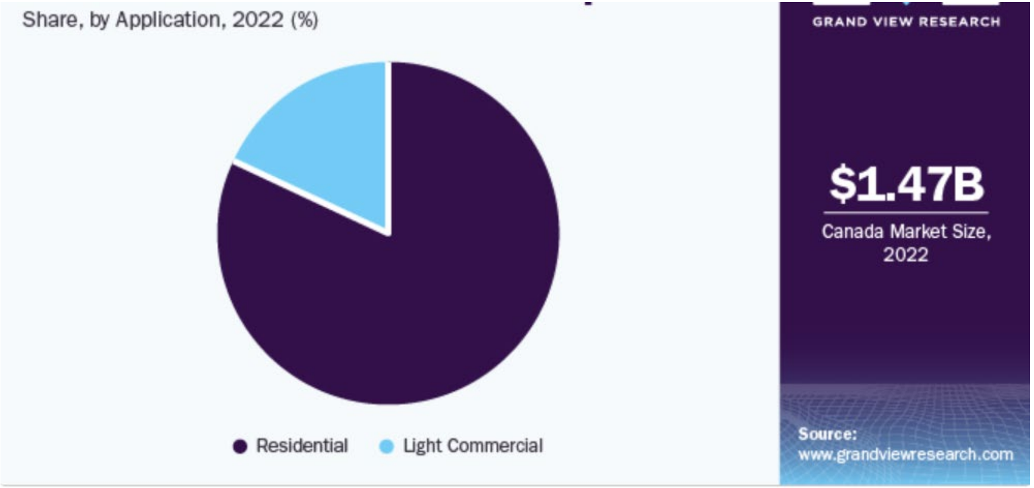
Source: https://www.cer-rec.gc.ca/en/data-analysis/energy-markets/market-snapshots/2019/market-snapshot-growing-heat-pump-adoption-how-does-technology-work.html

Canada air source heat pump market



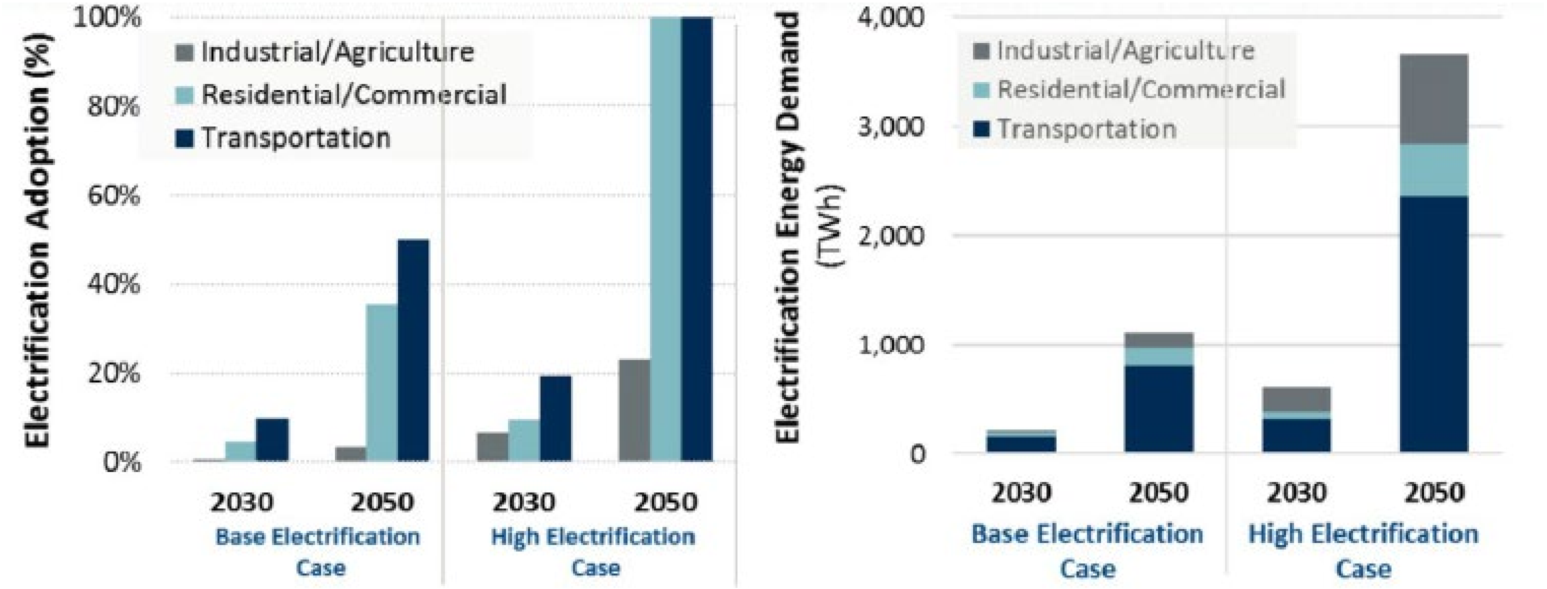
Source: Canada Outdoor Air Source Heat Pump Market Size, Share & Trends Analysis, 2023

Canada air source heat pump market cont'd



Source: Canada Outdoor Air Source Heat Pump Market Size, Share & Trends Analysis, 2023

Electrification adoption and energy demand



Source: The Brattle Group and Wires: The Coming Electrification of the North American Economy

Typical Retrofit Opportunities for Commercial Buildings Including Retail, and Offices

Opportunities for Heat Pump Installation

- Add cooling to their HVAC system capability
- Replace cooling systems at or near end of life
- Replace heating systems at or near end of life
- Facilities with cold or hot spots or other occupant comfort issues

Case 1

Cloquet, Minnesota

5,000-square-foot office

-20° F = -28 ° C design temp

VRF + Heat Recovery

Result: VRF systems with heat-recovery make strategic electrification feasible in cold climates

Two side-by-side thermostats

Case 2

Building Type: Office
Floors: 1 Main plus Mezzanine
Square Feet: 11,000 sq. ft.
Engineer/Contractor: Kehoe Equipment LTD
Edmonton, Alberta, Canada

Existing system

- 7 outside condensing units with 7 indoor furnaces,
- A ceiling mounted water-cooled heat pump
- Ceiling hung furnace for the warehouse

Retrofit:

- single VRV heat recovery system that would include 9 zones and 25 fan coils

Before

After

VRV air-cooled condensing units installed in a climate controlled mechanical room equipped with dampers for maximizing all-year round heat pump performance in a cold climate application

Source: DAIKIN KEHOE EQUIPMENT LTD. OFFICE RETROFIT EDMONTON, ALBERTA, CANADA, www.daikinac.com

Case 3

Building Type: Hotel

Floors: Two main building

Queen Tower = 43

Richmond Tower = 11

Square Feet: Approximately 1,500,000 sq. ft. / 139,355 m2

Existing system

Two-pipe chiller system only allowed for either heating or cooling.

Retrofit:

Install VRV system

Benefits:

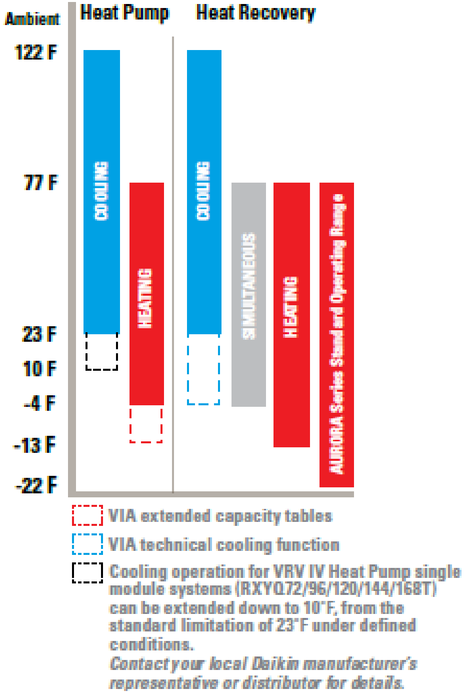
- lower sound levels,
- Competitive total installation cost
- Simultaneous heating and cooling (heat-recovery) between guest suites. When some guest suites are in heating mode, others can operate simultaneously in cooling mode

Source: DAIKIN SHERATON CENTRE TORONTO, www.daikinac.com

Case 4: VRV (Variable Refrigerant Volume)

Core benefits:

- Modular design
- Quick and easy to install
- High energy efficiencies even in extreme conditions
- Exceptional comfort control
- All control parameters remain



It is possible for heat pump and heat recovery systems to operate in cooling down to 10° F and -4° F ambient, respectively (conditions apply)

Source: www.daikinac.com

Case 5:
The Economics of Electrifying Medium-Size Commercial Retrofits

Case 5: Model Cases

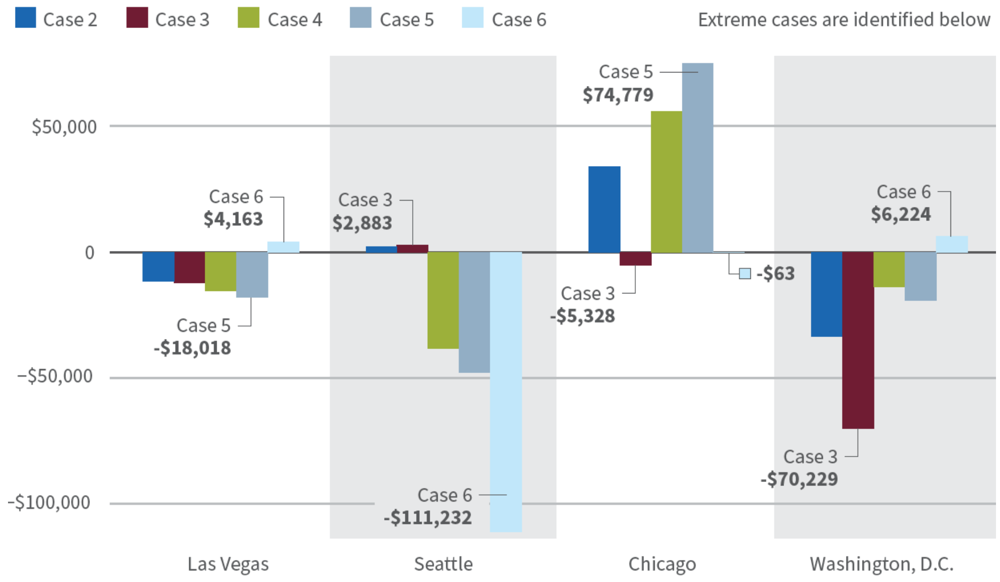
The case was modeled for four US cities (Washington, D.C., Chicago, Seattle, and Las Vegas) In cities with cold winters, such as Washington, D.C., and Chicago, ERV implemented as part of a heat-pump system, RTU provided significant annual energy savings, improving the economics of electrification.

Gas utility costs were a key factor in determining the economics of electrification. In Chicago, higher gas costs meant that electrification resulted in net positive savings over a 20-year lifecycle. In Washington, D.C., lower gas costs meant lower savings from electrification.

Case	Existing RTU replaced with	Efficiency details
1. No electrification	Conventional gas RTU	
2. Partial electrification	Heat-pump RTU with gas backup	
3. Full electrification	Heat-pump RTU with electric resistance backup	
4. Efficient electrification	Heat-pump RTU with electric resistance backup + ERV + efficiency measures	10% fan power efficiency improvement
5. Efficient electrification + demand management	Heat-pump RTU with electric resistance backup + ERV + demand management + efficiency measures	10% fan power efficiency improvement
6. Efficient electrification + demand management + PV	Heat-pump RTU with electric resistance backup + ERV + demand management + PV + efficiency measures	10% fan power efficiency improvement

Source: https://rmi.org/insight/economics-of-electrifying-buildings-medium-size-commercial-retrofits/

Case 5: 20-year Net Present Value of each case by city

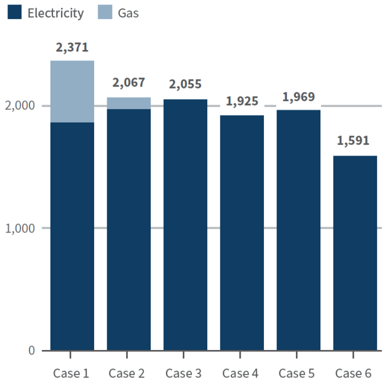


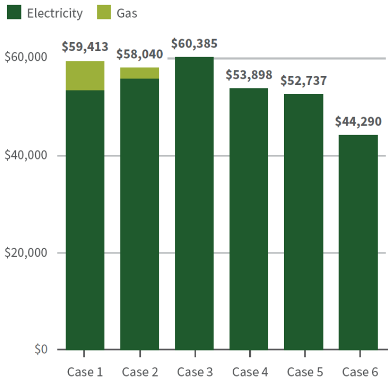
The broad economic viability of different options for each city.
Case 6 included solar PV

Source: https://rmi.org/insight/economics-of-electrifying-buildings-medium-size-commercial-retrofits/

Case 5: Annual Gas and Electricity Use Chicago

- Present annual gas and electricity use and cost for Chicago. For case 1, gas usage accounts for 21% of total annual energy use; however, due to the rate structure it only accounts for around 10% of total charges. Case 3 (full electrification) increases electricity use by 10%; however, it reduces total energy use by 13% compared to case 1. Overall, case 3 increases annual utility charges by 1.6% compared to case 1.





Source: https://rmi.org/insight/economics-of-electrifying-buildings-medium-size-commercial-retrofits/

Case 5: Annual Gas and Electricity Use Chicago

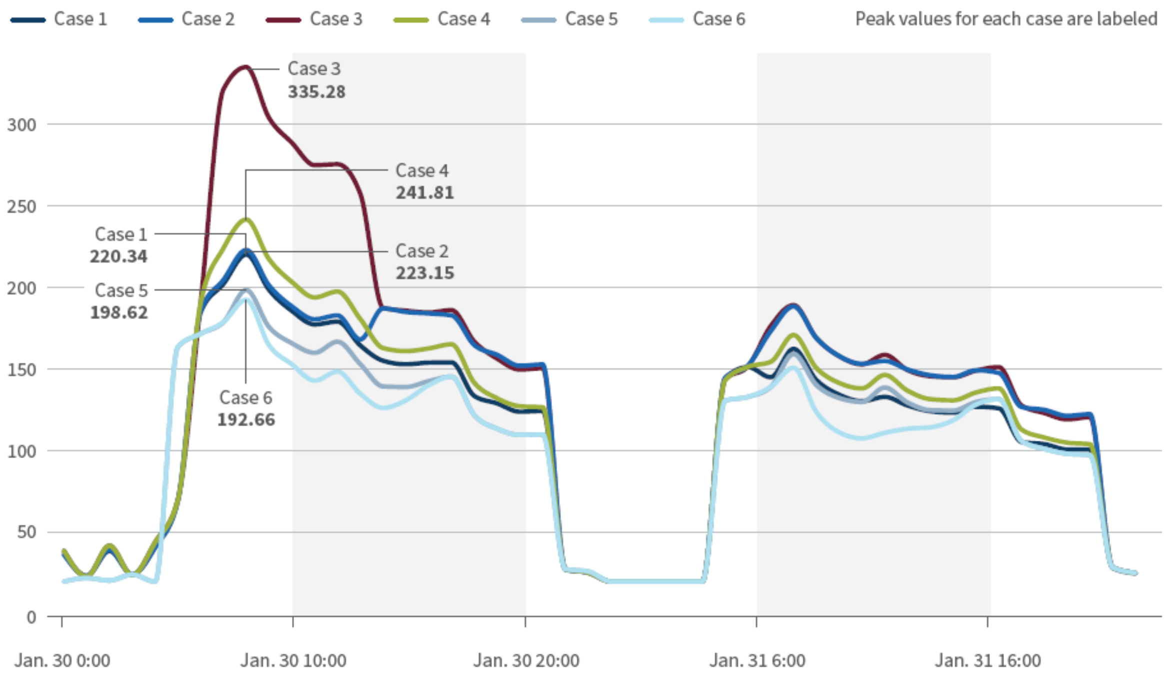
In Chicago, building owners who pursue installation of heat-pump RTUs with ERV and a winter peak demand management control sequence are likely to achieve a positive 20-year NPV.

In Chicago's harsh winter climate, the ERV system and peak demand management sequence are critical energy efficiency and peak load reduction strategies that provide robust cost savings.

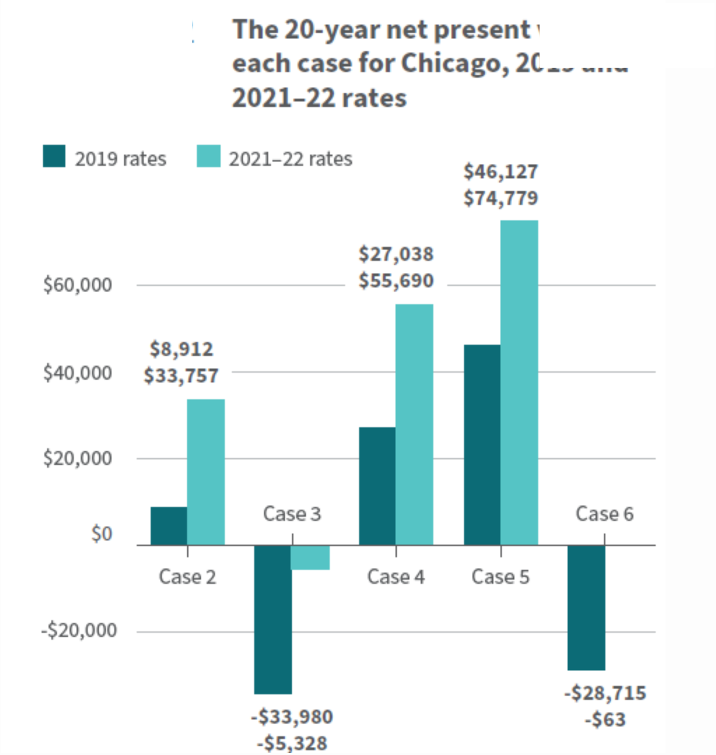
Chicago also has a relatively high per unit cost of gas relative to other cities modeled in this study. The prototypical building system used as the basis for this analysis, which uses electric resistance VAV reheat systems, is less common in Chicago than in the other three cities.

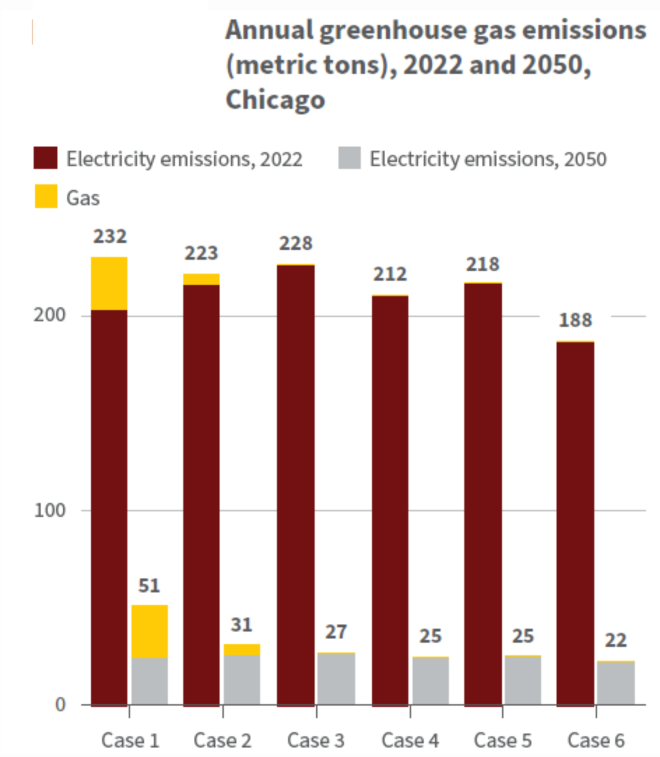
As such, the results should not be applied to the broad swath of the commercial office market that uses gas-fired terminal units for supplemental, zone-level heating. Regional existing building system surveys should be used to identify buildings with legacy electric resistance reheat, which offer major opportunities for economical heat pump electrification retrofits in the Midwest.

Electricity demand (kW) for two days in January 2019, Chicago



Source: https://rmi.org/insight/economics-of-electrifying-buildings-medium-size-commercial-retrofits/





Source: https://rmi.org/insight/economics-of-electrifying-buildings-medium-size-commercial-retrofits/

Case 5: Summary

The 20-year NPV is positive or neutral for commercial building electrification using cold-climate heat-pump RTU equipment.

These retrofits can be conducted as 1:1 equipment swap outs with limited system reconfiguration, reducing upfront costs.

Regional climate conditions and gas utility rates are primary drivers of the economics of decarbonization retrofits.

Electrification in commercial buildings can be paired with a suite of other energy retrofit measures, particularly ERV, peak heating load management, and on-site solar PV, to improve cost effectiveness and reduce grid impacts.

Increased availability and improved performance of cold-climate heat pump RTU equipment will make it easier and more beneficial to implement these retrofits.

Costs are likely to decrease over time with advancements in the heat pump product market and policy changes across states and at the federal level.

Case 6: System selection - strip malls & low-rise retail

What are some important factor to consider?

- Several tenant
- Lower budget
- No zoning
- Easy to change

What type of system?

Packaged Heat Pump Roof Top Units

- Low first cost
- Simple maintenance
- Simple control
- quick installation
- Unit per store

Case 6: Conclusion strip malls & low-rise retail

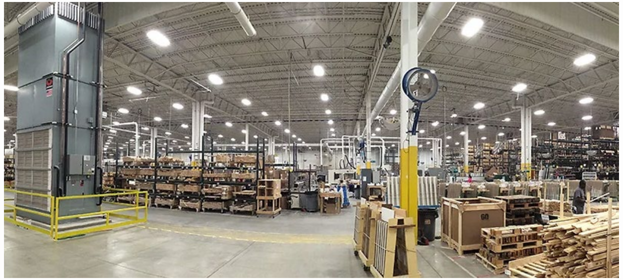
VAV Roof top unit

- Vary CFM while maintain a constant leaving air temperature
- Higher IEER
- Economizer controls
- Single zone VAV
- Low/bad turn down
- It is better to have unit for each store

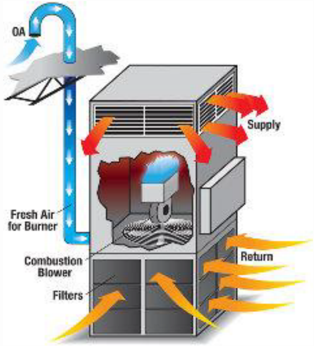
CAV Roof top unit

- Maintain constant CFM
- Simple controls
- Higher operational cost
- Unit cycle frequency
- Usually single zone

Case 7: System selection - warehouse & storage facilities



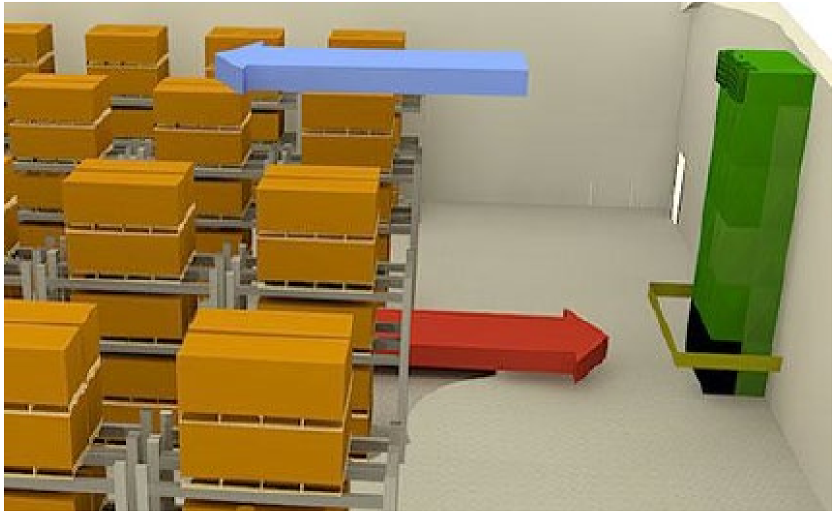
What are some important factor to consider?
- Large floor area
- Low no of people
- Uneven temperature distribution
- Poor air movement
- Nature of materials stored
- Stable temperature for sensitive material stored



What type of system?

Air turnover unit
- Air distribution through the aisles
- Custom option (economizer, special filters)
- Heat 150,000 sq ft or cool 125,000 sq ft
- Up to 170,000 cfm

Case 7: System selection - warehouse & storage facilities



Vertical Heat Pump units versus Roof Top Units

- Reduced installation costs
- Reduce operating cost
- Reduce maintenance
- Longer product life
- Increase portability
- Higher first cost
- Take up floor space (indoor or outdoor)

Case 7: Conclusion- warehouse & storage facilities

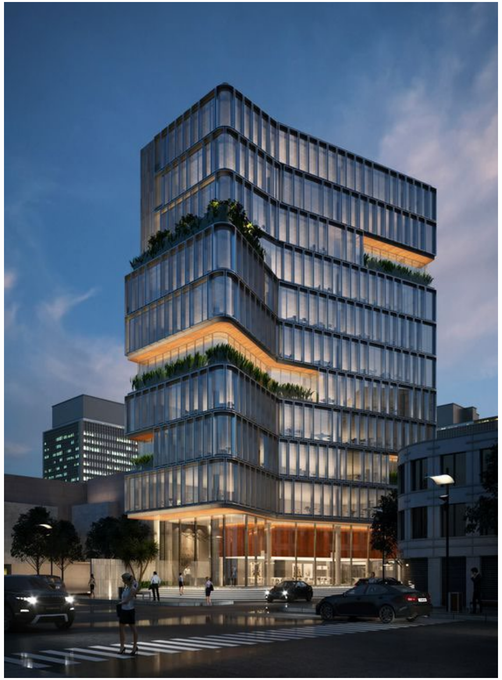
What are some important factor to consider?

- Higher engineered solutions
- Air rotation units seems to solve indoor thermal environment issues
- Depending on the application, simpler solution may work

Case 8: System selection - office building

What are some important factors to consider?

- Occupants Comfort = more productivity
- Rental floor space



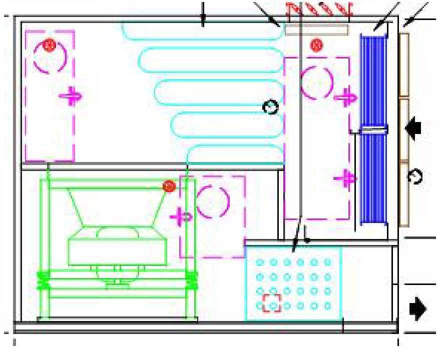
Case 8: Why use a self-contained unit or compartment unit?

Self-Contained Unit?

- One unit per floor (or tenant)
- Decentralized mechanical space
- Conditions outside air and room air
- Simplified ductwork and piping layout
- Typically, large capacities (>23-130 tons) (> 8000-42000 cfm)

Compartment Unit

- Custom unit
- No compressor
- Large units
- Sound options
- Floor by floor vertically oriented air handling units



Case 8: Conclusion – office building

	Roof top Units	VRF	Compartment Unit	Self-Compartment Units	Chilled Beams
Efficiency	Medium	High	Medium	Medium	High
First cost	Depend on size	Depend on size	Depend on size	Depend on size	Depend on size
Comfort	Similar	Similar	Similar	Similar	Similar
Tenant billing	Easy	Medium	Hardest	Easy	Hardest
Tenant Maintenance	Low	Medium	Low	High	Low
Architectural Flexibility	High	Medium	High	High	Low

Tips on Finding and Working with Designers and Installers

Installation

It is a best practice to follow all manufacturer recommendations when installing new heat pump equipment.

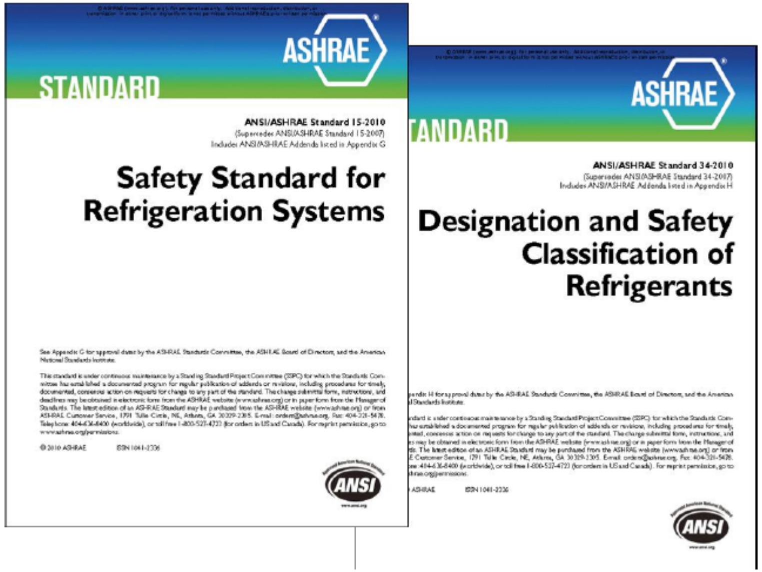
All local, provincial, and national codes must be met.

Equipment performance must be verified using published product data.

The jobsite must be clean and presentable when the installation is finished.

ASHRAE Standard 15 and 34

Considerations for VRV/VRF Systems
The ASHRAE Standard provides safeguards for life, limb, health, property, and prescribes safety requirements for both Residential, and Commercial



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Front cover of ASHRAE Standard 34-2010 is reprinted with permission. ©ASHRAE, www.ashrae.org. 2010 ANSI/ASHRAE Standard 34.

Selected Codes and Standards Published

Heat Pumps	Commercial Systems Overview	ACCA	ACCA Manual CS-1993
	Geothermal Heat Pump Training Certification Program	ACCA	ACCA Training Manual
	Heat Pumps Systems, Principles and Applications, 2nd ed.	ACCA	ACCA Manual H-1984
	Residential Equipment Selection, 2nd ed.	ACCA	ANSI/ACCA 3 Manual S-2014
	Industrial Ventilation: A Manual of Recommended Practice, 29th ed. (2016)	ACGIH	ACGIH
	Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment	AHRI	ANSI/AHRI 210/240-2017
	Commercial and Industrial Unitary Air-Conditioning and Heat Pump Equipment	AHRI	ANSI/AHRI 340/360-2015
	Single Package Vertical Air-Conditioner and Heat Humps	AHRI	ANSI/AHRI 390-2003
	Direct Geoexchange Heat Pumps	AHRI	ANSI/AHRI 870-2016
	Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment	AHRI	ANSI/AHRI 1230-2014
	Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment	ASHRAE	ANSI/ASHRAE 37-2009
	Methods of Testing for Rating Seasonal Efficiency of Unitary Air-Conditioners and Heat Pumps	ASHRAE	ANSI/ASHRAE 116-2010
	Method of Test for Direct-Expansion Ground Source Heat Pumps	ASHRAE	ANSI/ASHRAE 194-2017
	Method of Testing for Rating of Multi-Purpose Heat Pumps for Residential Space Conditioning and Water Heating	ASHRAE	ANSI/ASHRAE 206-2013
	Performance Standard for Split-System and Single-Package Central Air Conditioners and Heat Pumps	CSA	CAN/CSA C656-14
	Installation of Air-Source Heat Pumps and Air Conditioners	CSA	CAN/CSA C273.5-11 (R2015)
	Performance of Direct-Expansion (DX) Ground-Source Heat Pumps	CSA	C748-13
	Water-Source Heat Pumps—Testing and Rating for Performance, Part 1: Water-to-Air and Brine-to-Air Heat Pumps	CSA	CAN/CSA C13256-1-01 (R2016)
	Part 2: Water-to-Water and Brine-to-Water Heat Pumps	CSA	CAN/CSA C13256-2-01 (R2015)
	Heating and Cooling Equipment (2011)	UL/CSA	ANSI/UL 1995/C22.2 No. 236-15

Applying Standard 15 When Designing A VRV System

First Step
Preliminary layout of the system

↓

Second Step
Determine the amount of refrigerant

↓

Third Step
Verify that the *VRV* system layout complies with Standard 15 requirements

↓

Fourth Step
Actions if a room is too small

First Step
Preliminary layout of the system

Second Step
Determine the amount of refrigerant

Third Step
Verify that the *VRV* system layout complies with Standard 15 requirements

Fourth Step
Actions if a room is too small

Questions?

Stay connected with tools and resources

- Virtual one-on-one coaching: post-webinar support intake form for tailored support for organizations to manage energy resources effectively.
- Monthly bulletin: sign up to receive monthly training updates on all Save on Energy training and support new tools and resources.
- Live training calendar: visit this page to easily register for upcoming events and workshops.
- Training and support webpage: visit this page to access all training and support materials.

Thank you!

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