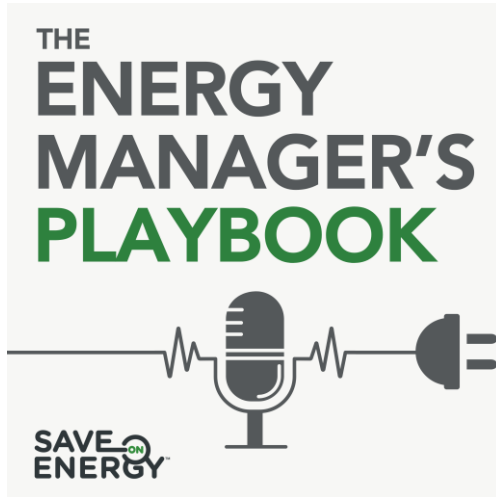


DATE: WED OCT 15, 2025

Hybrid heat pumps and heat recovery systems

Shahriar Ghahremanian, PhD, PMP, PEng, CEM, GBE, CEA, CMVP
Dr Energi Inc.

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Agenda

1. Introduction
2. Hybrid heat pump system fundamentals
3. Heat recovery system fundamentals
4. Optimization strategies
5. Integrated heat pump and heat recovery system case studies

Objectives

- Understand the principles of heat pump and heat recovery systems
- Know the common types of heat pumps and heat recovery systems
- Apply control and optimization strategies to improve the performance of hybrid heat pump and heat recovery systems
- Analyze real-world case studies to identify effective design, control and optimization strategies for hybrid heat pump and heat recovery systems

Why heat pumps and heat recovery



Heating and cooling account for about 40% of building energy use



Heat pumps improve energy efficiency



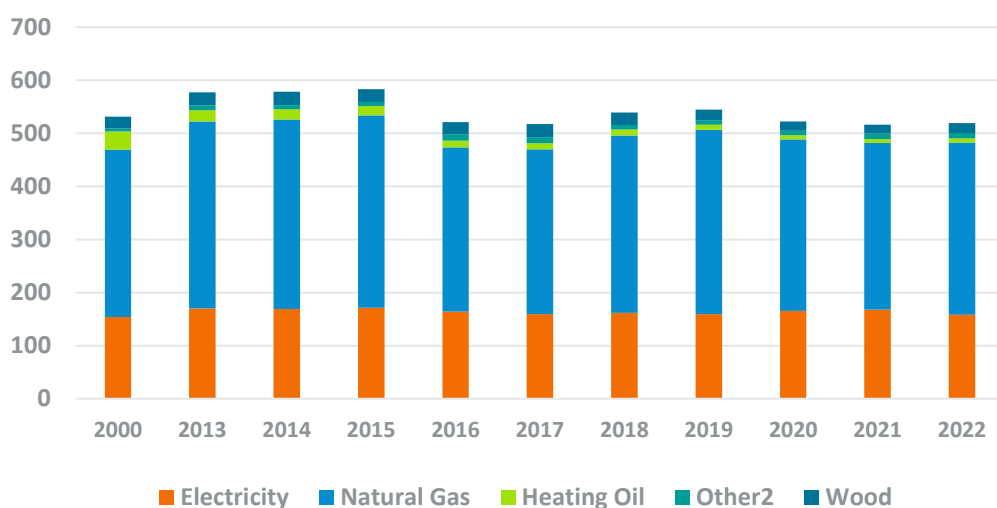
Heat recovery captures wasted energy (50-80% efficiency gains)



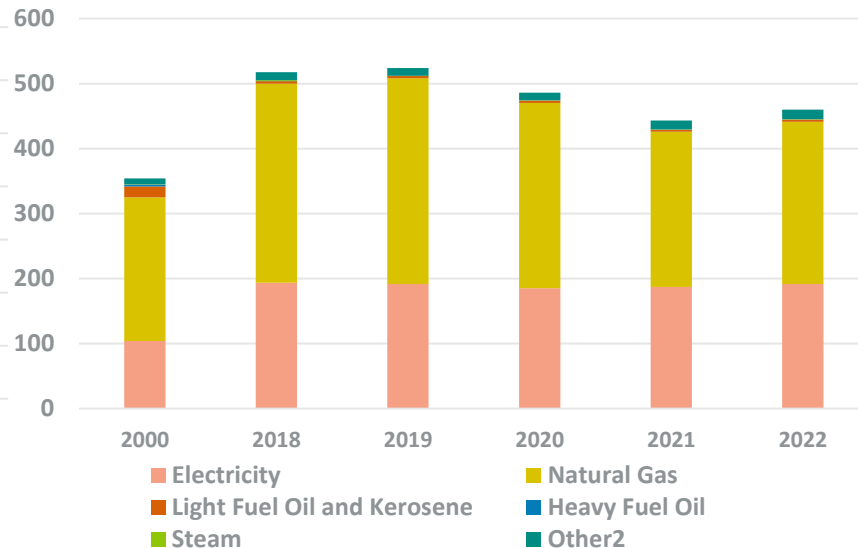
Both systems are essential for decarbonization and cost reduction

Energy use by energy source in Ontario

Residential
energy use by energy source (PJ)



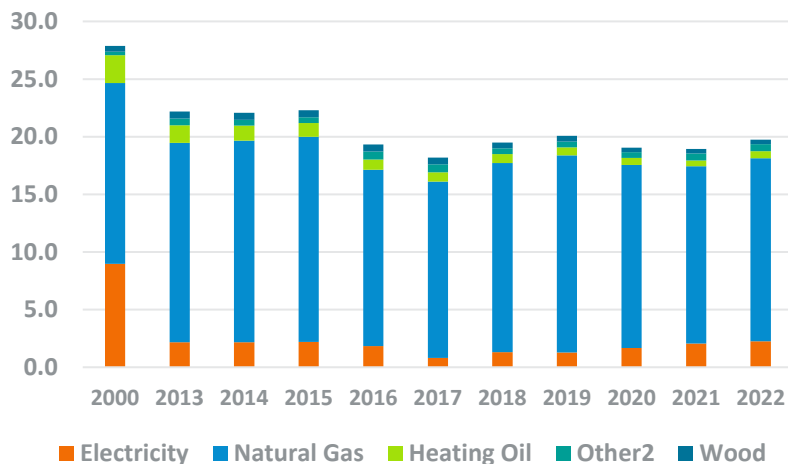
Commercial/Institutional sector
energy use by energy source (PJ)



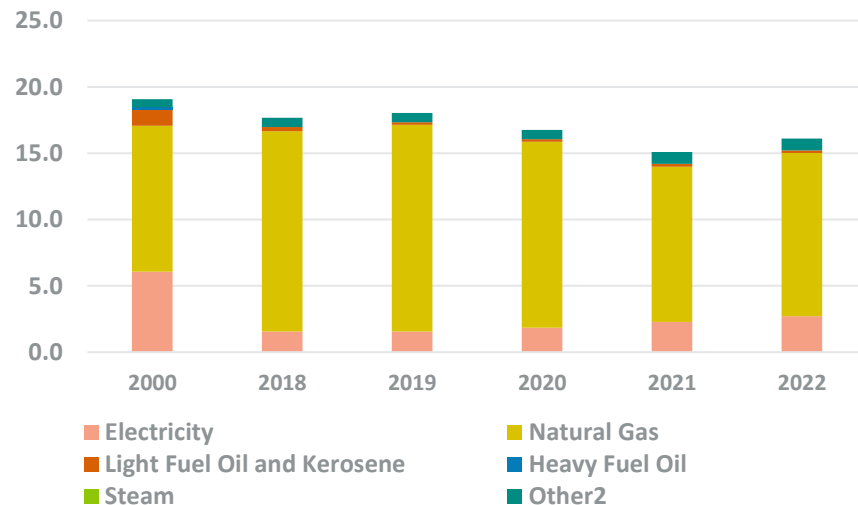
1 PJ = 10^{15} J, Natural Resources Canada

GHG emissions by energy source in Ontario

**Residential
GHG emissions by energy source
(Mt of CO₂e)**



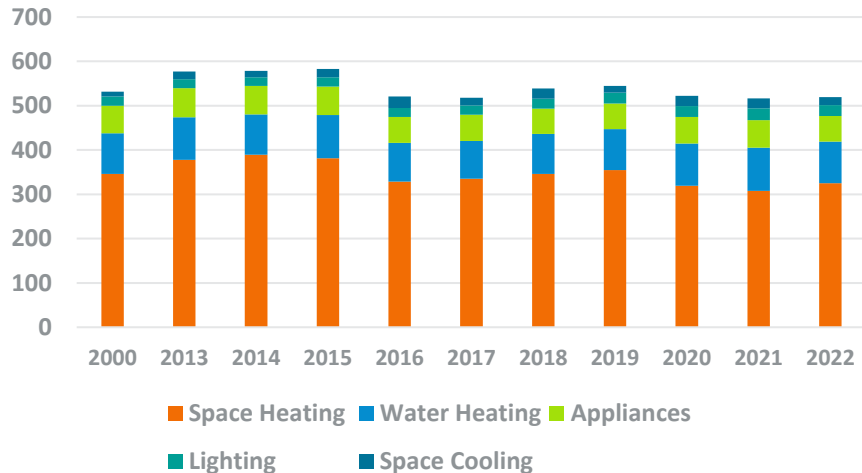
**Commercial/Institutional sector
GHG emissions by energy source
(Mt of CO₂e)**



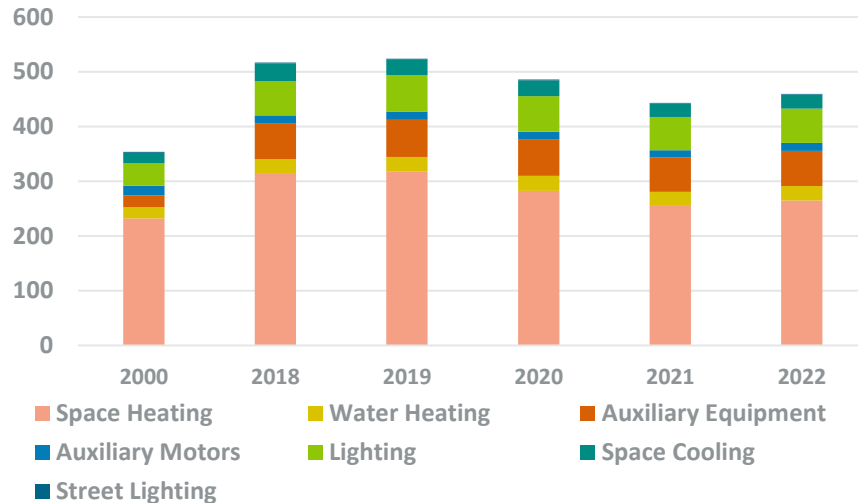
Natural Resources Canada

Energy use by end use in Ontario

**Residential
energy use by end use (PJ)**



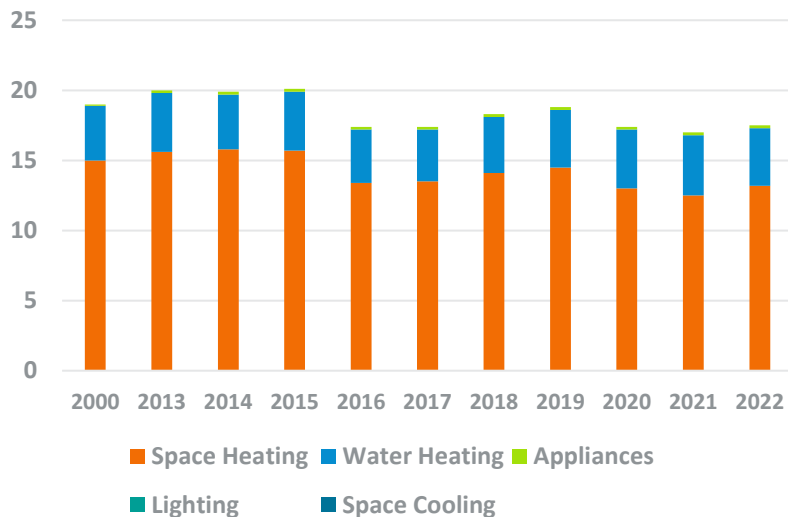
**Commercial/Institutional sector
energy use by end use (PJ)**



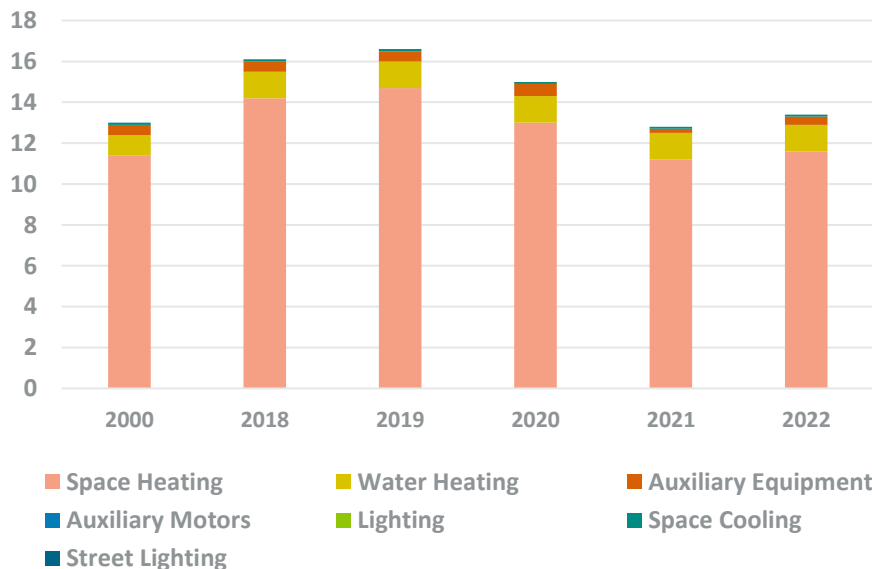
1 PJ = 10^{15} J, Natural Resources Canada

GHG emissions by end use in Ontario

**Residential
(Mt of CO₂e)**

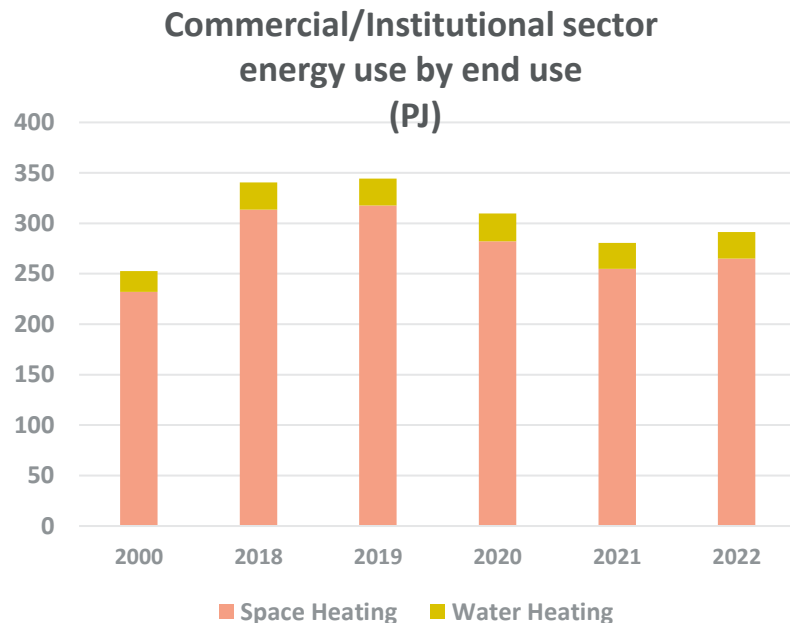
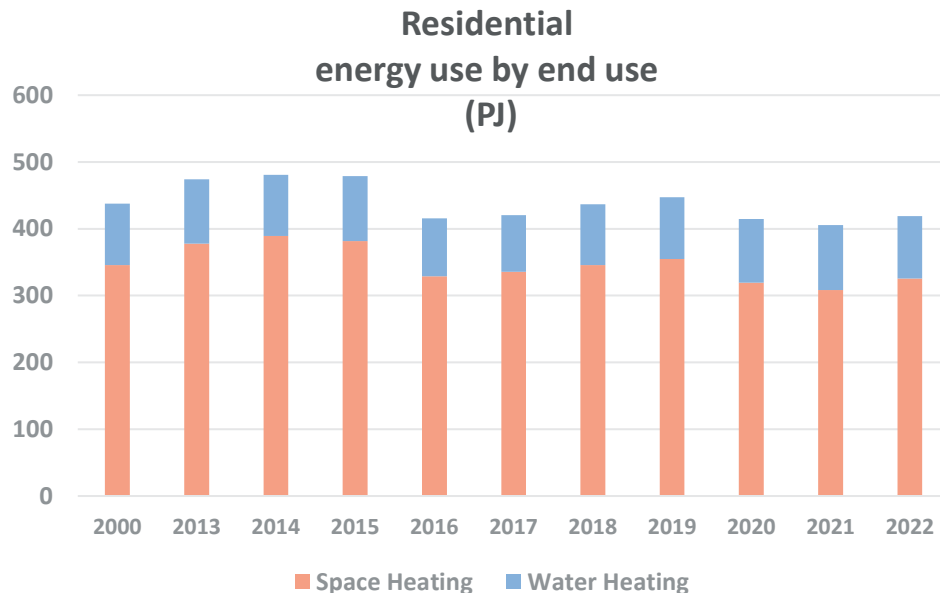


**Commercial/Institutional sector
(Mt of CO₂e)**



Natural Resources Canada

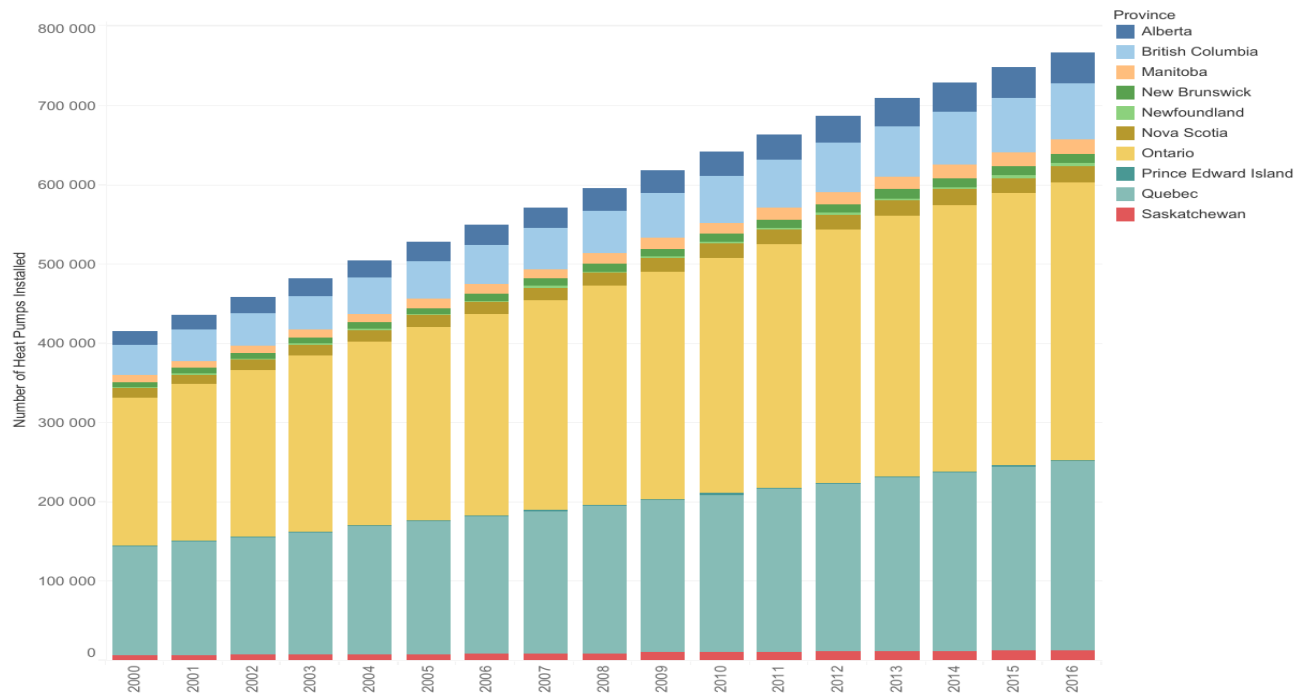
Energy use by space heating and water heating in Ontario



Number of installed heat pumps

In Ontario
102,960 heat pumps were
installed as of July 2025

Source: <https://natural-resources.canada.ca/energy-efficiency/home-energy-efficiency/canada-greener-homes-initiative/heat-pumps-uptake-glance-0>



<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>

What is a heat pump?

- A mechanical device that transfers heat from a source and rejects it to either an outside environment or indoors. Depending on if it's in heating or cooling mode.
- Outside environment
 - Air, ground, water, waste heat
- Primarily utilized for space/water heating or space cooling



Heating systems

Combustion Heating



Resistance Heating



**Heat Pump
Heating/Cooling**

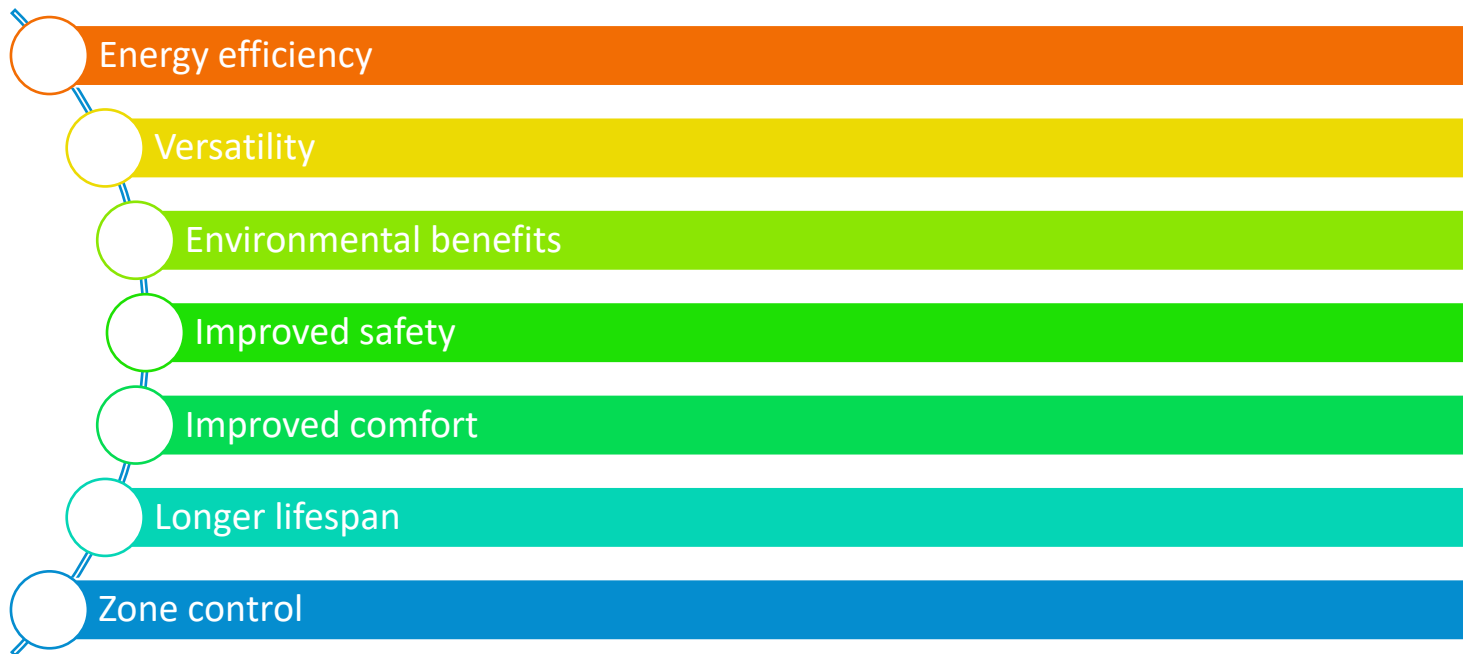


Efficiency	80% – 98%	Close to 100%	250 - 400% or 2.5 - 4.0 coefficient of performance (COP)
Energy cost	~\$0.30/m ³	\$0.15/kWh	\$10/GJ - \$20/GJ
Energy cost	\$15/GJ	\$41/GJ	\$10/GJ - \$20/GJ
Emissions	49 kg CO _{2eq} /GJ	8 kg CO _{2eq} /GJ (margin)	2 – 4 kg CO _{2eq} /GJ

All values are approximate for illustrative purposes

Why choose a heat pump system?

Heat pumps offer several advantages over other traditional heating and cooling systems.



Types of heat pumps

Heat pumps are categorized based on their heat sources and configurations:

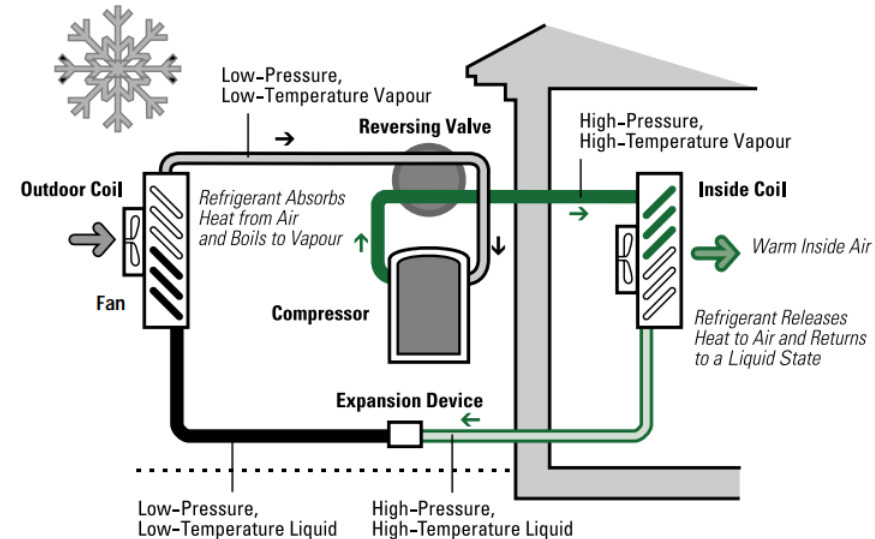
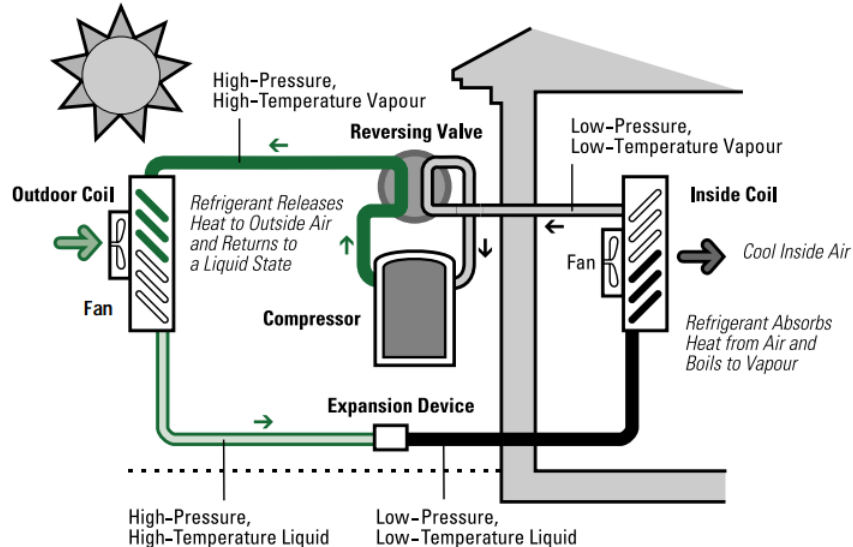
- Air source heat pumps
- Water source heat pumps
- Ground source heat pumps
- Hybrid heat pump systems
- Absorption heat pump



Air source heat pump

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

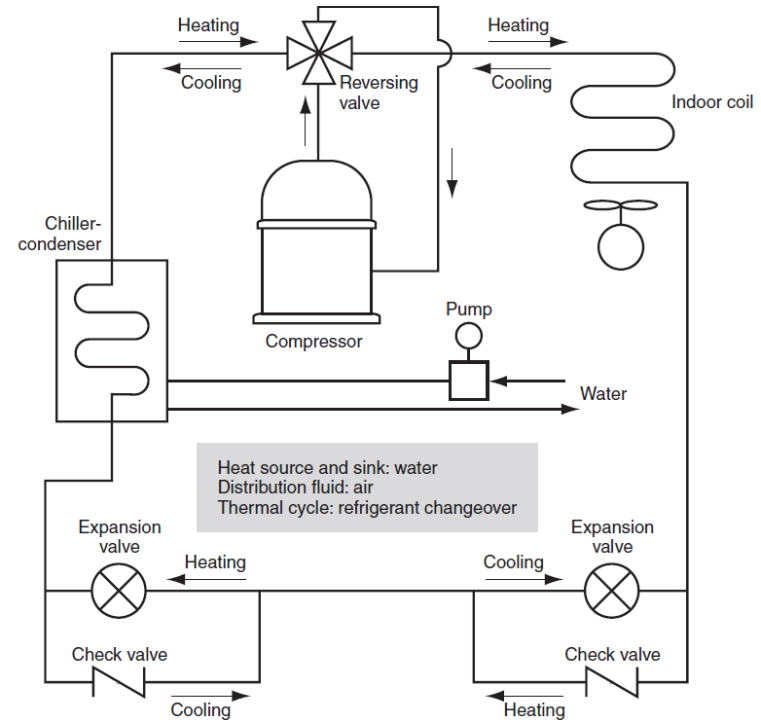
Air source heat pump: COP 2.5-3.5 (30-40% savings)



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

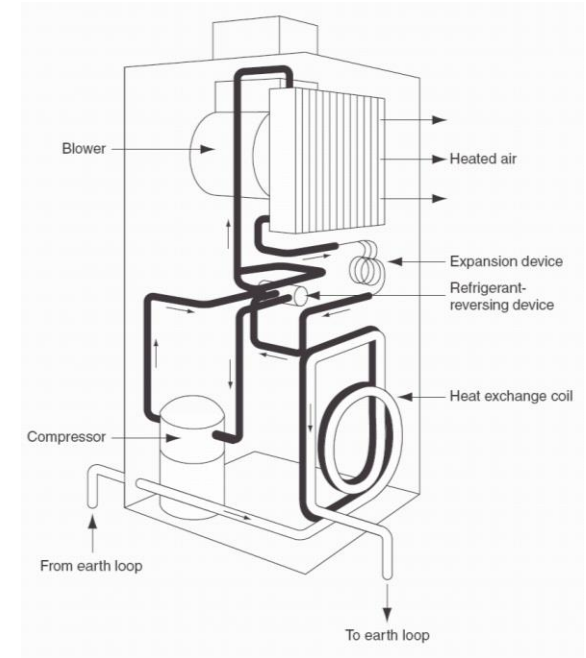
Water source heat pumps

- Water source heat pumps are preferred as they are less dependent on outdoor air temperature due to water's high heat capacity.
- No defrost cycle is needed with water source heat pumps
- Provide excellent efficiency
- Compressor life benefits
- Are widely popular in residential applications



Water source heat pumps continued

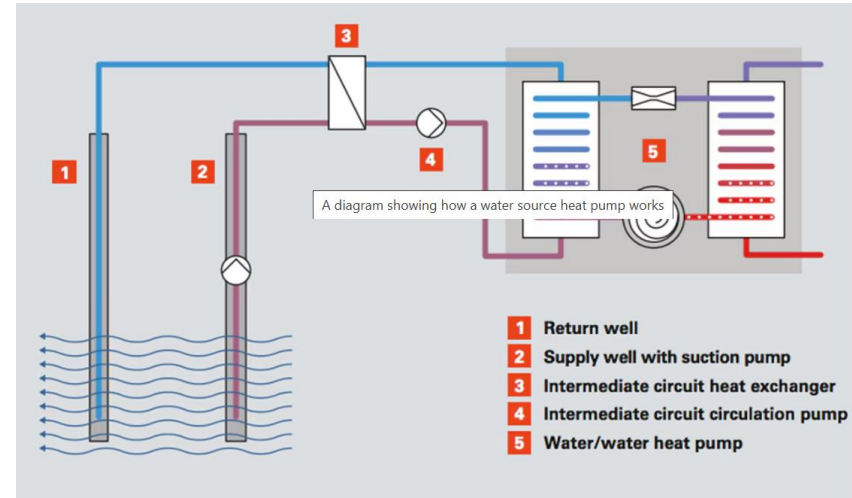
- Water source equipment is available based on several different design strategies.
- These units may be separated into two broad categories, open-loop systems and closed-loop systems.



Water source heat pump systems

Closed-loop system

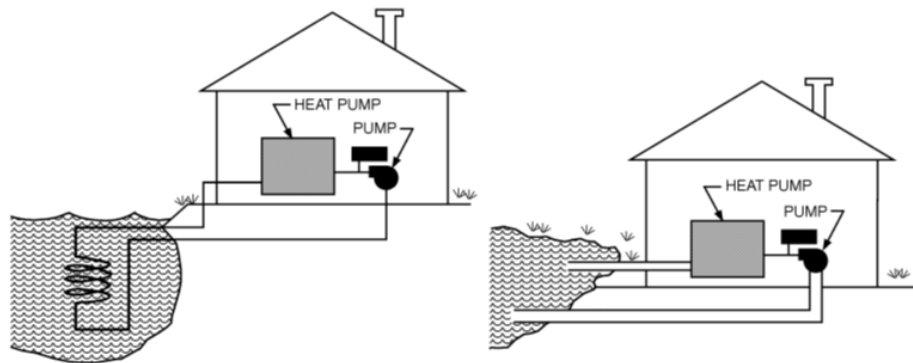
- Heat is transferred from the body of water and delivered to the heat pump.
- Heat exchanger panels submerged in the water source transfer heat to/from system.
- Fluid is continuously recirculated through underground loops (horizontal or vertical), lake coils or ground wells.



Water source heat pump systems continued

Open-loop system

- Pumps water directly from lake/water source to heat pump
- Cooled water then pumped back into the water source
- COP 3.5-4.5 (40-60% savings)



Heat pump systems

Single-split systems



Multi-split systems



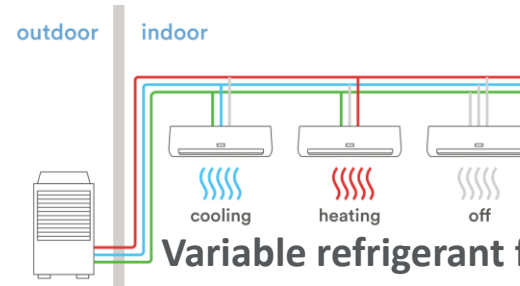
Packaged terminal heat pumps (PTHPs)



Rooftop terminal units (RTU)



Hybrid heat pump systems



Variable refrigerant flow (VRF)

Variable refrigerant flow (VRF) heat pump

- During heating, VRF heat pumps provide heating to zones by introducing ambient heat that 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 that then rejects the heat.
- VRF heat pump systems are used for single-zone applications or multi-zone applications where each zone has the same thermal profile.

Technology highlights - heat pumps

- Heat pumps provide a COP of 3-4 at mild temperatures.
- Performance drops in very cold conditions.
- Controls switch between sources for efficiency.
- Hybrid systems ensure steady performance year-round.
- Lower carbon emissions.
- Cost is optimized through fuel switching.
- Heat pumps are reliable and resilient in all weather conditions.
- They offer flexibility for retrofits.
- They are eligible for incentives and are compliant with most requirements.

Control options/strategies for hybrid systems

- Controls determine when the heat pump runs versus when the backup runs
- Temperature-based switchover (setpoint control switches to backup in cold)
- Load-based control (smart thermostats and sensors optimize use)
- Building automation systems (BAS) for advanced control
- Time-of-use/cost-based (time-of-use shifting to reduce costs)
- VRF zoning systems
- Carbon intensity-based
- **Highlight:** optimize utility cost, reduce GHG emissions, and improve comfort

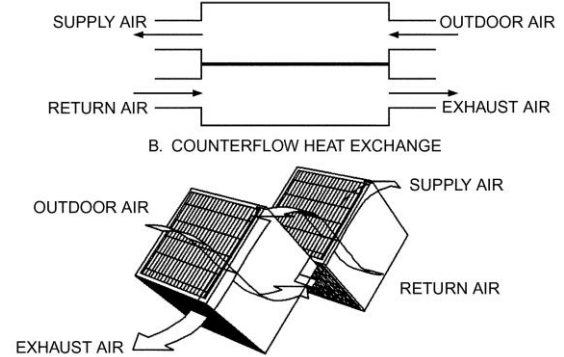
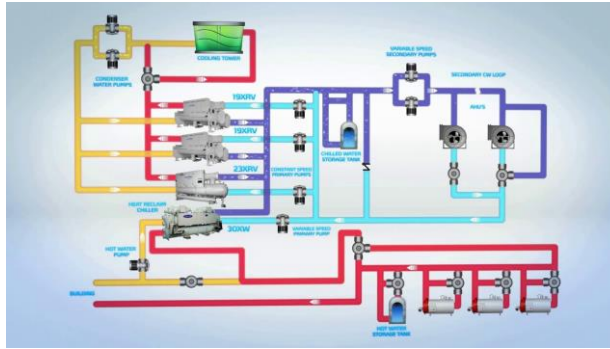
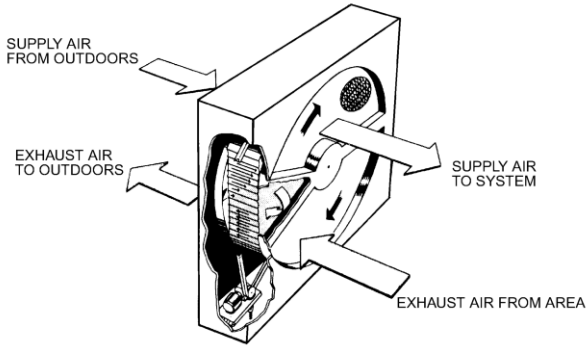
Control options/strategies: advanced BAS integration

- BAS integrates outdoor temperature, pricing and occupancy
- Demand-limiting to avoid peak utility charges
- Coordinates with heat recovery chillers and loops
- Enables dynamic optimization

Benefits of smart controls

- Economic: lower utility costs
- Environmental: lower greenhouse gas (GHG) emissions
- Operational: longer equipment life
- Resilient: reliable in extreme weather

- Waste heat (industrial processes, data centers)



Typical efficiency ranges

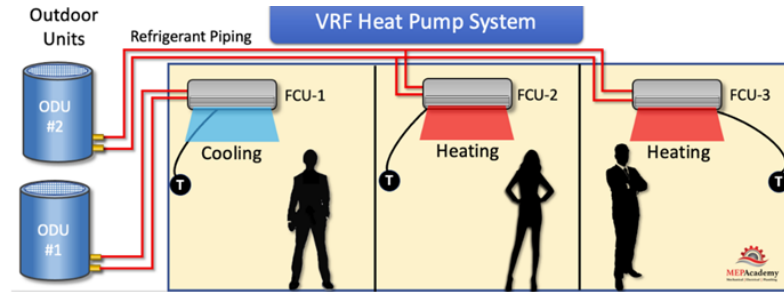
Systems	Savings
Plate heat exchangers	50–70%
Energy recovery wheels	65–85%
Run-around loops	40–60%
Heat recovery chillers	COP 6–8
VRF with recovery	20–40%

Savings potential

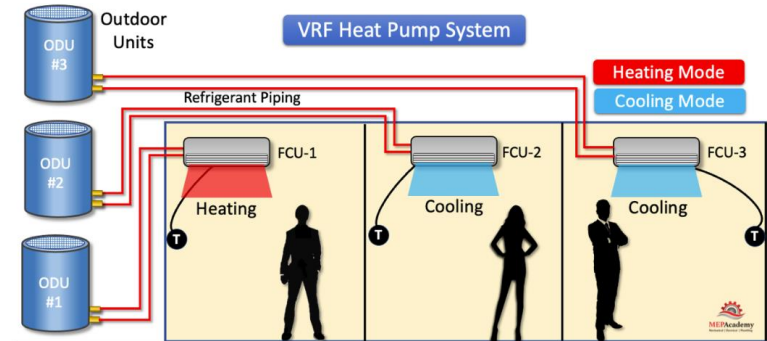
Building type	System	Savings
Offices	Energy recovery ventilators (ERVs)	20–30% reduce energy consumption
Hospitals	Heat Recovery chillers	\$100,000+/yr savings
Multi-family	VRF recovery	25% utility costs

*GHG reductions: 20%–40% lower than conventional

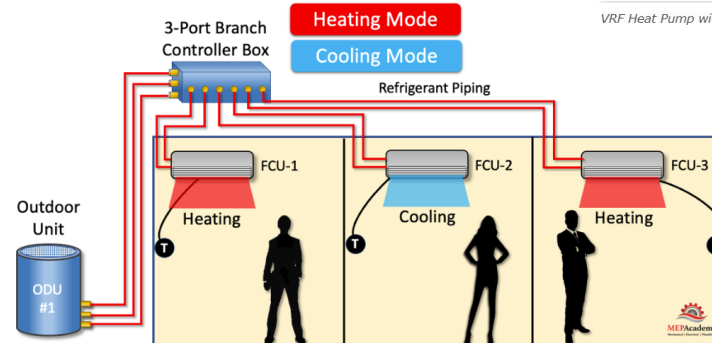
VRF heat pump versus VRF heat recovery 1/2



VRF Heat Pumps with Consolidated Zoning

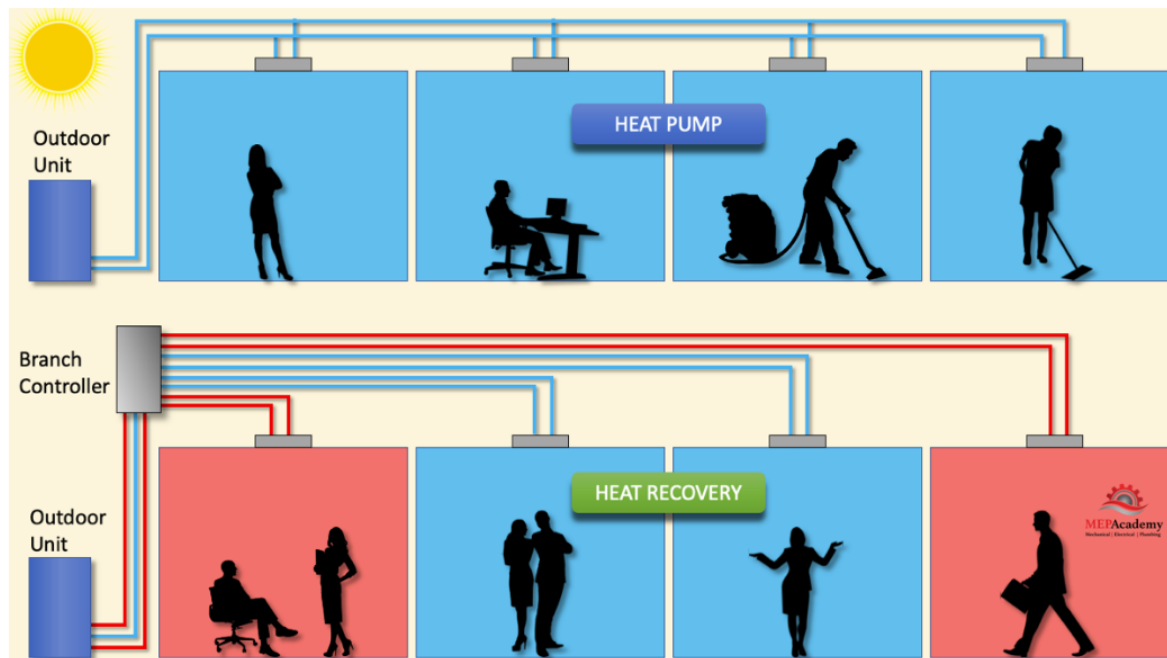


VRF Heat Pump with Individual Zones



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

VRF heat pump versus VRF heat recovery 2/2



VRF System Comparison

MEPAcademy

Integrated technologies

- Integration of heat pump + heat recovery
- May include gas boiler, solar thermal, etc.
- Controls select optimal source based on load, temp and rates
- Repurpose for space heating, preheating or domestic hot water (DHW)
- Improve efficiency, reduce operating costs and lower GHG emissions
- Year-round efficiency, lower bills and redundancy

Benefits of heat recovery and a heat pump

- Heat recovery and a heat pump maximize energy savings
- Reduce HVAC load and lower energy bills
- Better indoor air quality
- Due to pre-conditioned air, smaller heating equipment size
- Ideal for residential and commercial such as homes, schools and offices due to decentralized/compact systems

Case study 1: heat pump + heat recovery – technology

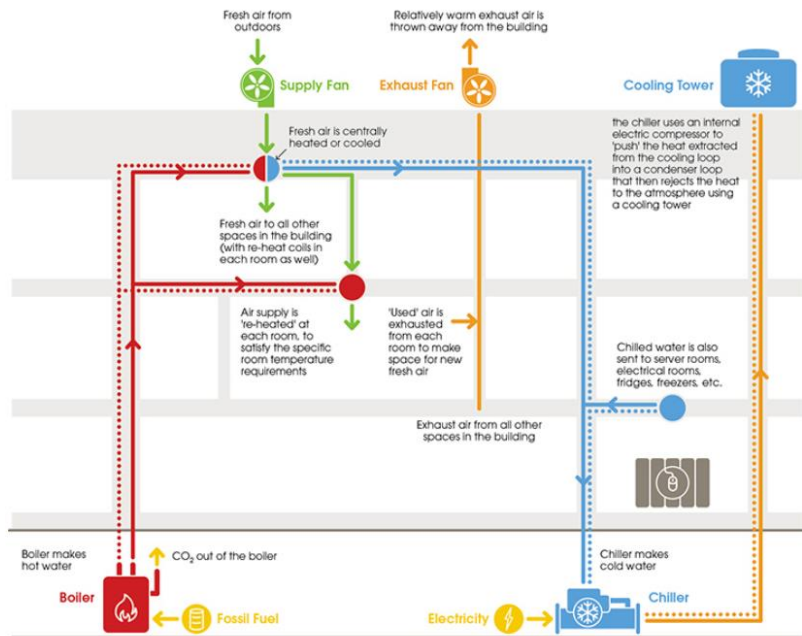
- Captures and reuses waste heat
- Common sources: exhaust air, wastewater, industrial processes
- Efficiency: HRVs 60–80%, wastewater up to 95%
- A lot of savings when paired with heat pumps
- Capture waste heat from exhaust, water or processes
- Repurpose for space heating, preheating or DHW
- Improve efficiency and reduce operating costs



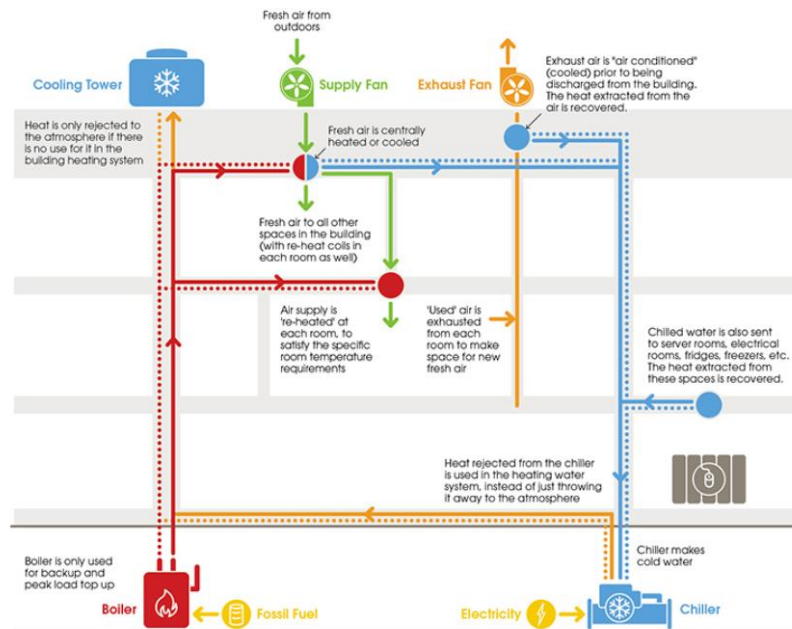
Source: Exhaust air heat pump recovery system, <https://www.stantec.com>

Exhaust air heat pump heat recovery

*Exhaust air heat pump recovery offers up to 400% efficiency



Common heating and cooling system

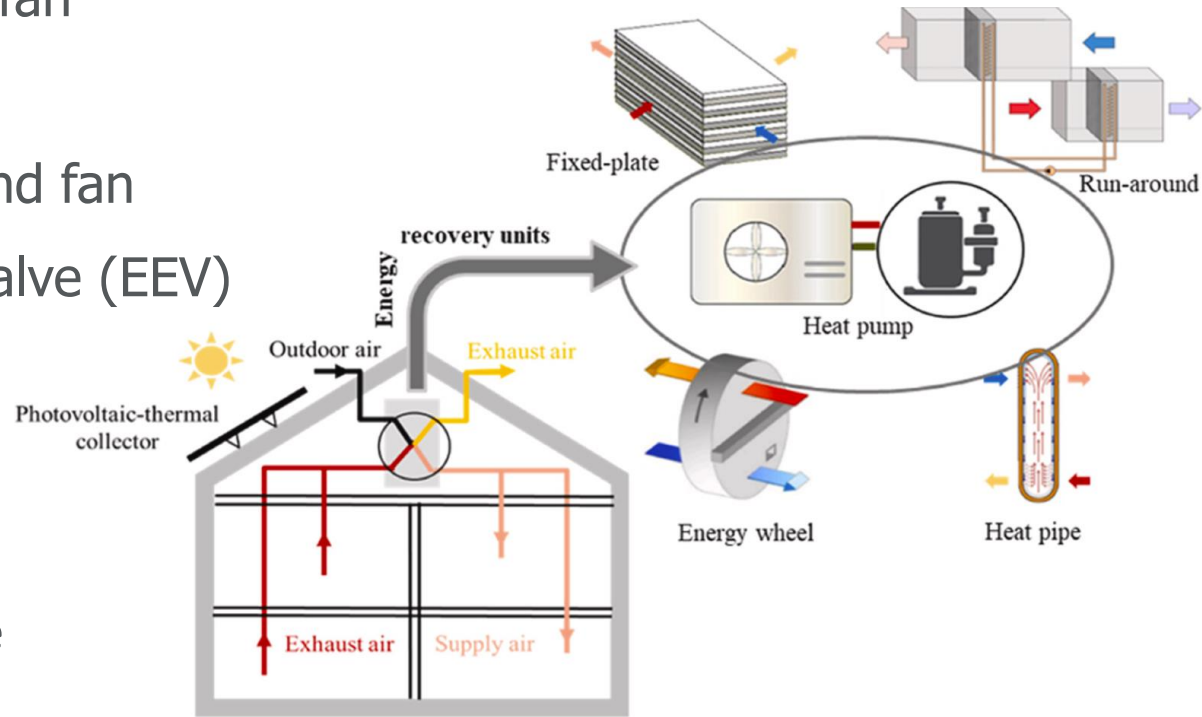


Exhaust air heat pump heat recovery

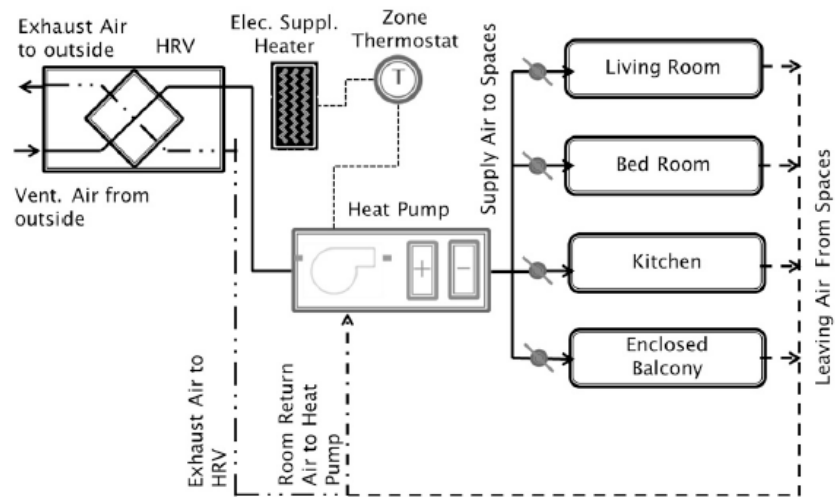
Case study 2: heat pump energy recovery ventilation

- A supply air (SA) coil and fan
- A compressor
- An exhaust air (EA) coil and fan
- An electronic expansion valve (EEV)
- A four-way valve

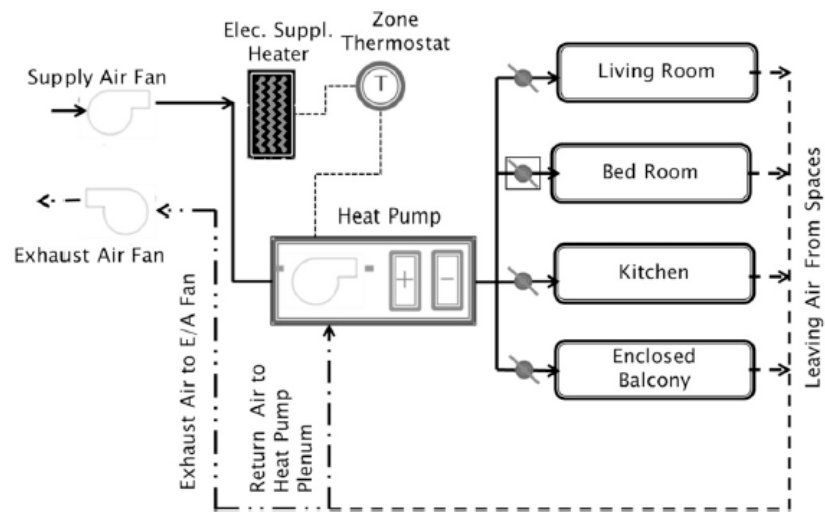
With the use of a heat pump plus an energy wheel system, the heat recovery rate can be increased by 24%.



Case study 3: air source heat pump with and without HRV

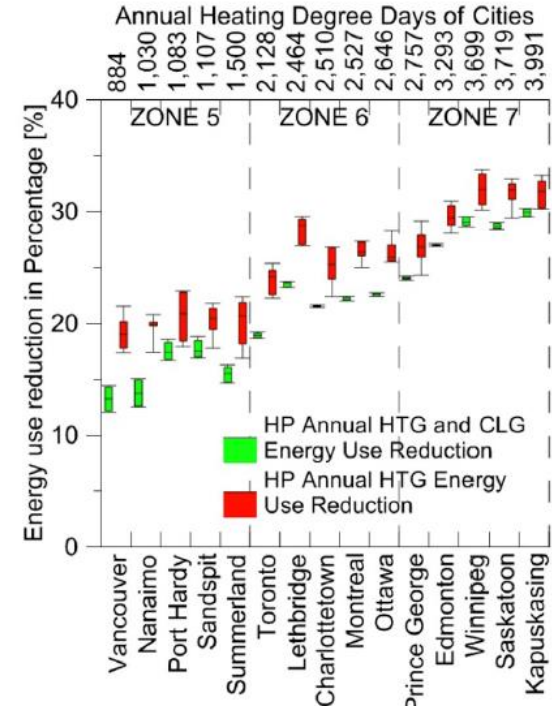
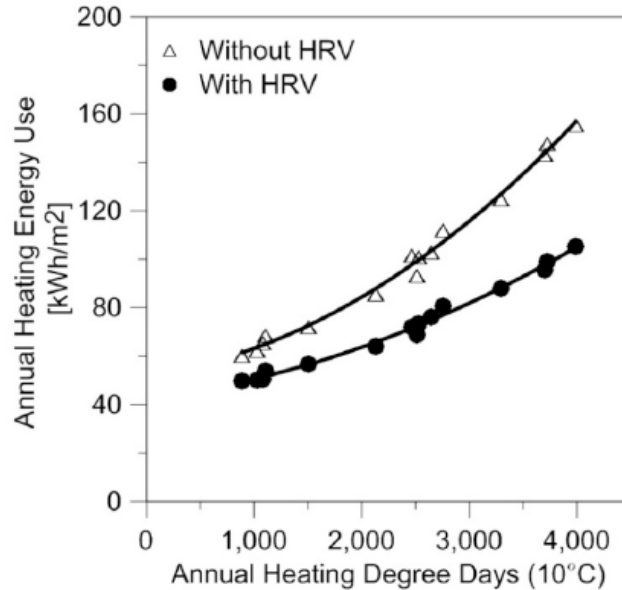


Schematic of air source heat pump with HRV

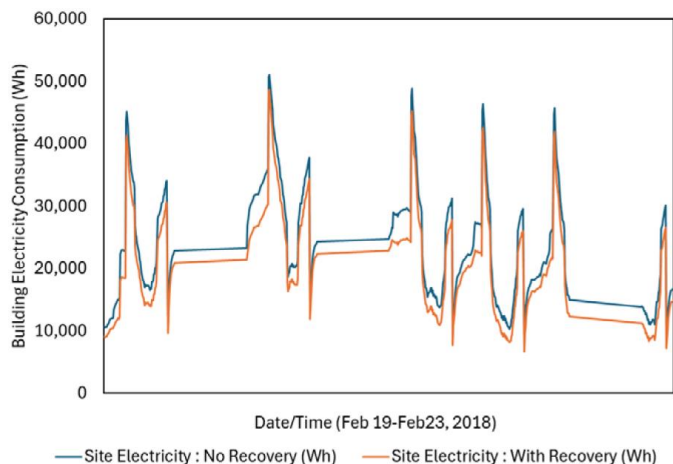


Schematic of air source heat pump without HRV

Case study 3: heating and cooling energy use of heat pump without HRV



Case study 4: heat pump rooftop units with energy recovery



	Natural Gas (KBtu)	Electricity (KBtu)	Total Site Energy (KBtu)
Baseline	855,869	526,304	1,382,173
HP-RTU, No ER	0	807,095	807,095
HP-RTU, with ER	0	733,023	733,023

Summary – why heat recovery and a heat pump

- Combine strengths of multiple technologies
- Energy savings and GHG reductions
- Heat recovery achieves 50-85% energy recovery
- Flexibility for climates and building types
- Smart controls enable year-round efficiency
- Smart controls maximize cost and carbon savings
- Hybrid systems balance efficiency and resilience

- Highlight: integration and operation = where true value lies

Questions and discussion

- What type of system might suit your building?
- Any challenges in implementation?
- Challenges in complex adoption?
- Lifecycle cost versus carbon emissions versus climate resilience – which matters most?



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Progress  11%

As someone who recently participated in the *What It Means to Become Net-Zero and How to Achieve It* as part of the **Save on Energy | Capability Building Program**, we'd like to know more about your experience. The IESO uses this feedback to monitor the success of the program and improve the offering over time. The survey should take about five minutes to complete.

This survey is conducted by Forum Research, a leading market research company, on behalf of the Independent Electricity System Operator (IESO). Be assured that all answers are completely anonymous and will have no impact on customer incentives.

***Please send any and all inquiries about the Capability Building Program sessions to trainingandsupport@ieso.ca. ***

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- Who? Conducted by Forum Research on behalf of the IESO
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Thank you!

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