Before we get started…

What are you hoping to learn from today's session?

Unmute or type in the chat!

JUNE 23, 2025

The importance of operator training in new heat pump installations

Presenters:

Michel Parent, Technosim

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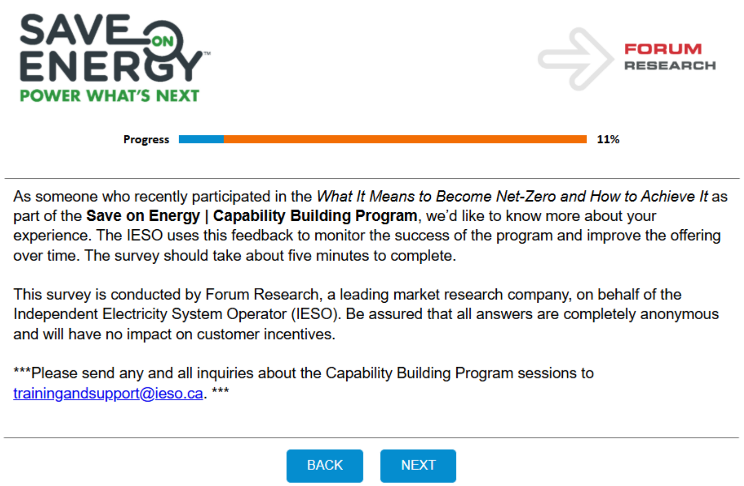
Upcoming survey: we want your feedback!



SAVE ON ENERGY POWER WHAT'S NEXT

FORUM RESEARCH

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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- Check your email! A survey is coming your way soon
- Why? Help us improve our training programs
- Who? Conducted by Forum Research on behalf of the IESO
- Time? It takes only 5 minutes to complete
- Confidentiality: your responses are anonymous and won't impact participation or incentives

The survey will be sent from: surveyinfo@forumresearch.com

Agenda

1. Welcome and introductions
2. Heat pump fundamentals
3. Heat pump system types
4. Installation and commissioning
5. Maintenance checklists for building operators
6. Questions and answers

Objectives

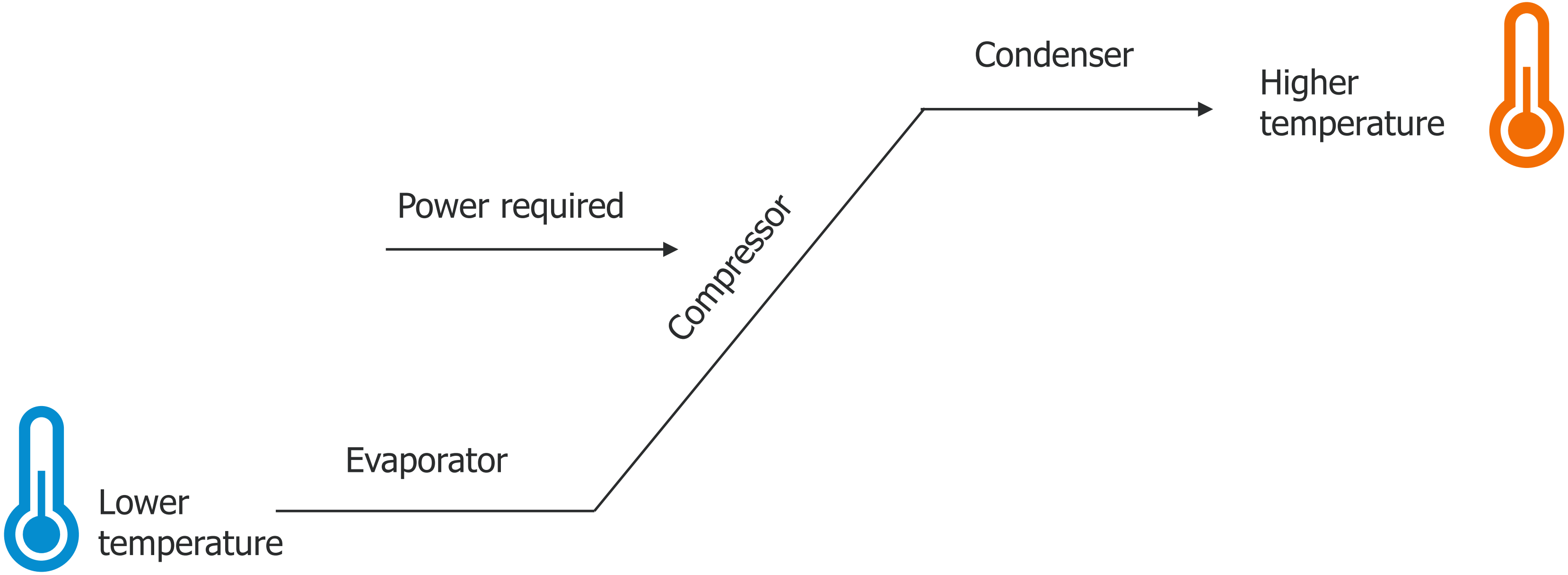
- Understand the fundamentals of heat pump operation
- Identify different types of heat pump systems
- Implement effective controls and setpoints to manage high performance of heat pumps
- Conduct routine maintenance and standard troubleshooting measures

Heat pump fundamentals

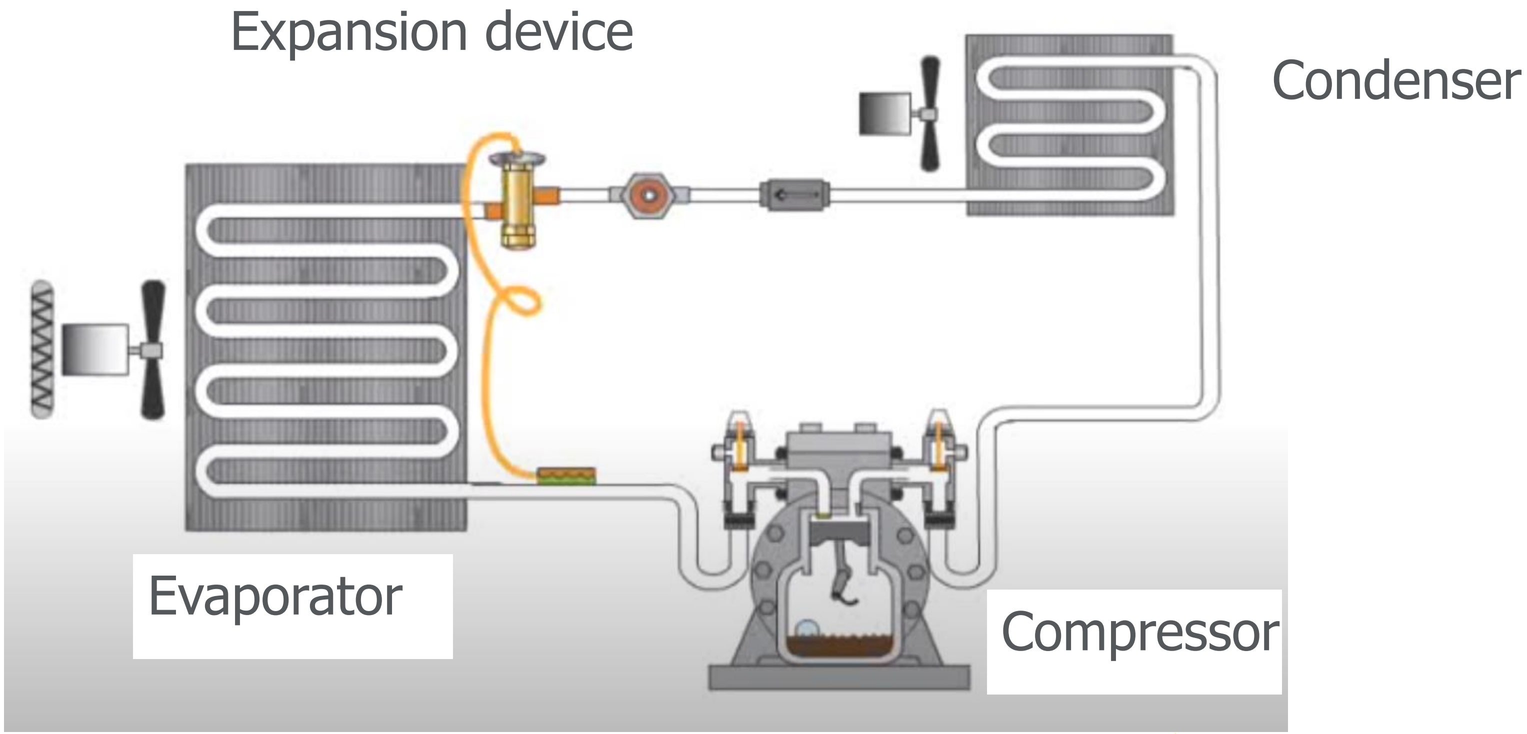
What is a heat pump?

- A device that transfers heat from one place to another
- Uses electricity and refrigerant cycle to move heat rather than burning fuel to create it
- Heat pumps can be used for both heating and cooling, making them a versatile heating, ventilation and air-conditioning (HVAC) solution
- Electric heat pumps deliver more heat energy than the electricity they consume

Vapour compression cycle: moving heat uphill

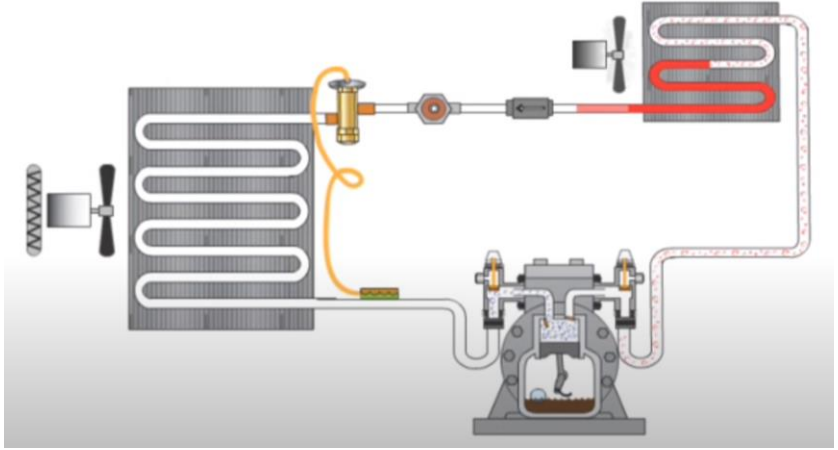


Quick review of the cycle



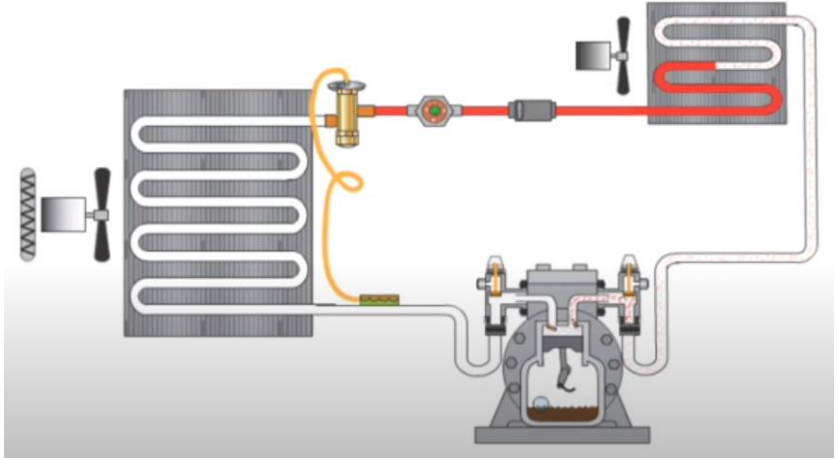
Compression

The compressor sends hot refrigerant gas to the condenser at high temperature and pressure.



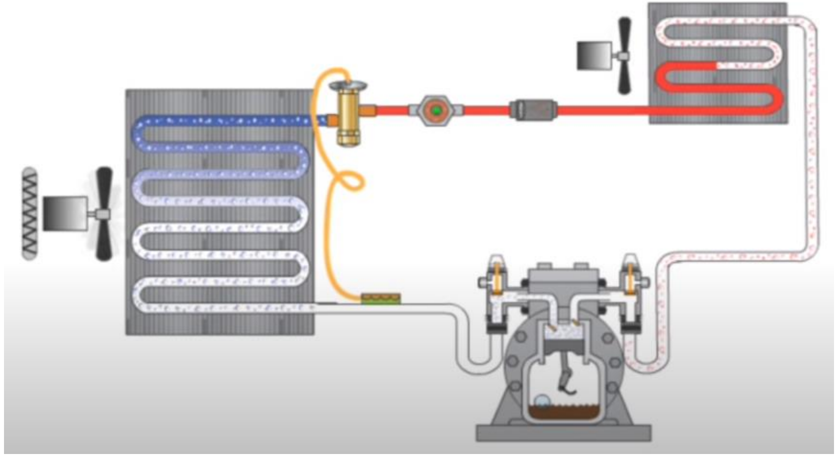
Condensation

The hot gas is turned into high pressure warm liquid at the exit of the condenser.



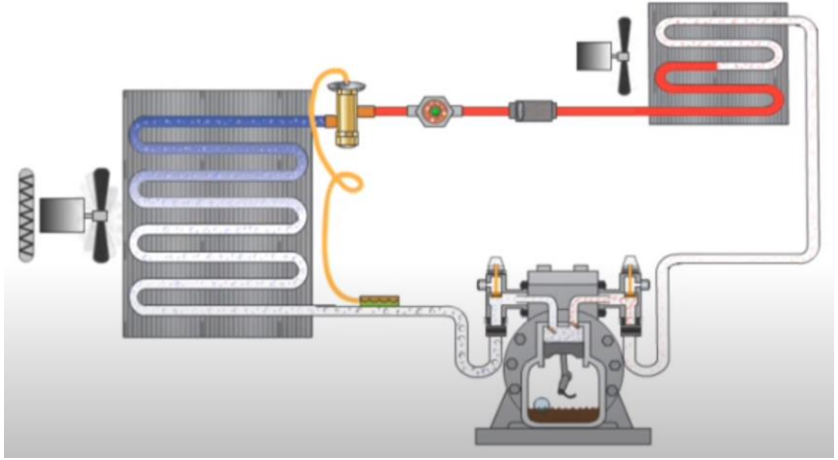
Expansion

The warm high-pressure liquid is pushed through the expansion device and becomes a mixture of low-pressure liquid and gas.

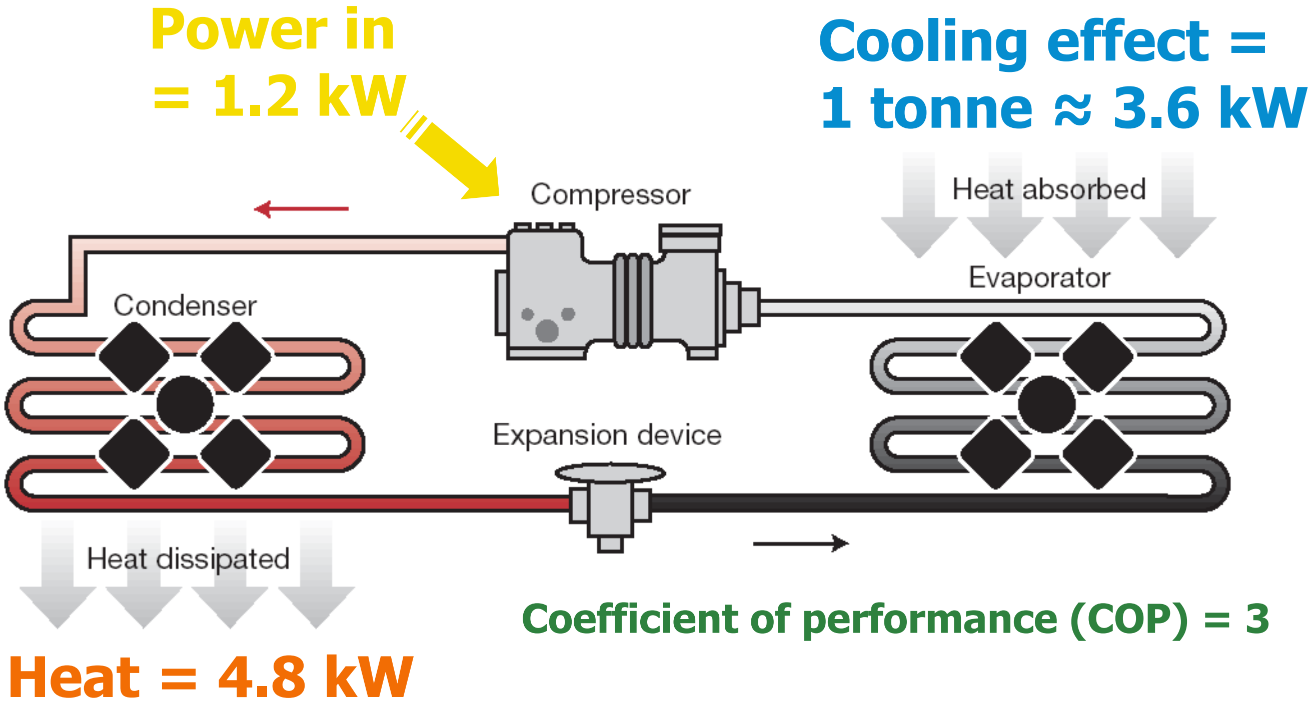


Evaporation

The low pressure and temperature liquid/gas is evaporated, producing cooling and the resulting low-pressure gas is compressed again.



In summary



Coefficient of performance (COP) = 3

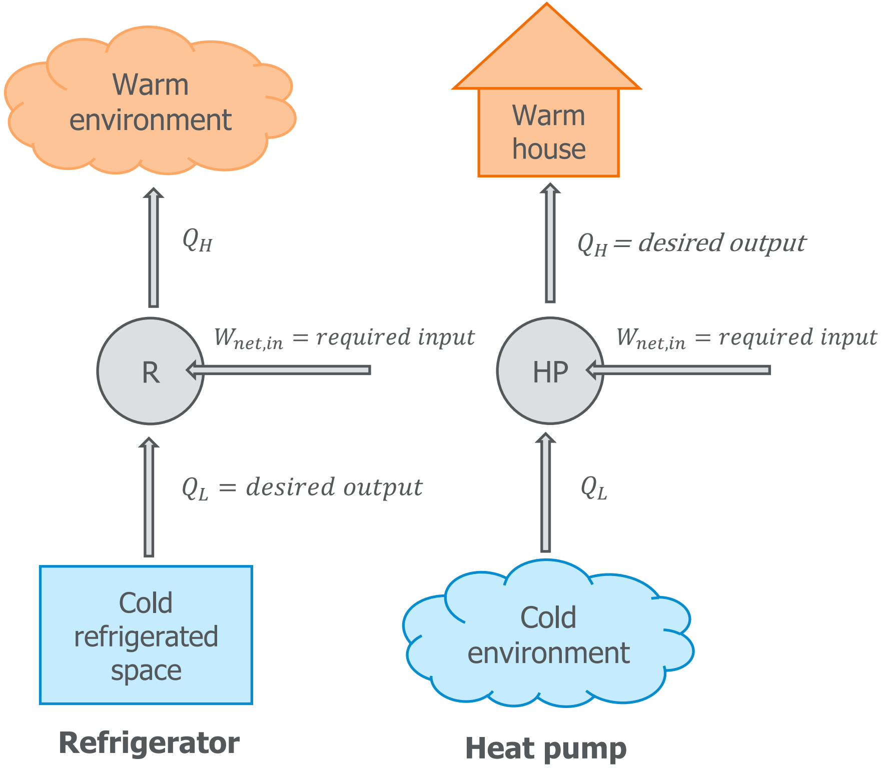
Reference: GPG 279

Coefficient of performance

Refrigeration (R) and heat pumping (HP)

$$COP_R = \frac{\text{Desired output}}{\text{Required input}} = \frac{\text{Cooling effect}}{\text{Work input}} = \frac{Q_L}{W_{net,in}}$$

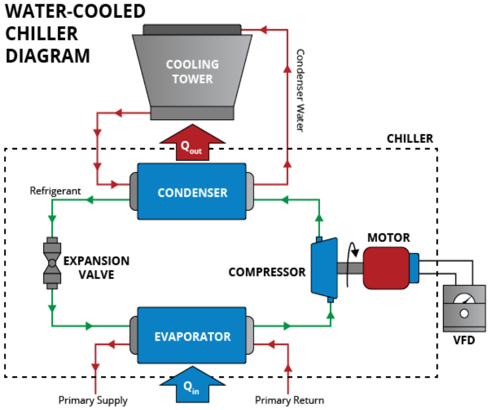
$$COP_{HP} = \frac{\text{Desired output}}{\text{Required input}} = \frac{\text{Heating effect}}{\text{Work input}} = \frac{Q_H}{W_{net,in}}$$

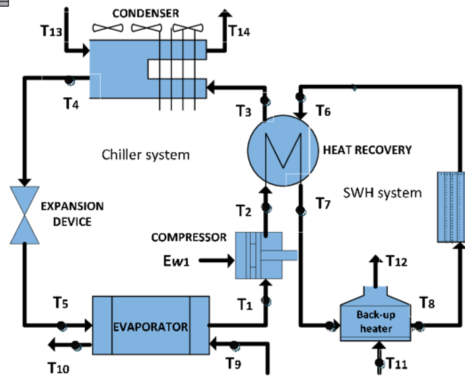


Heat pump system types

Heat recovery chillers

- Revisiting an old concept:
  - Use condenser heat for a low-temperature building loop
    - Reheat loop
    - Air handling unit (AHU) loop
- Two common configurations:
  - Double bundle
  - Auxiliary plate exchanger
- **Stop** using free cooling





Heat recovery chillers: typical application

- Medium to large office and institutional buildings with hydronic heating and cooling:
  - Large office buildings
  - Hospitals
  - Large schools/universities
  - Data centres
  - Large shopping malls
- Presence of low temperature loops

Heat recovery chiller pros and cons

Pros

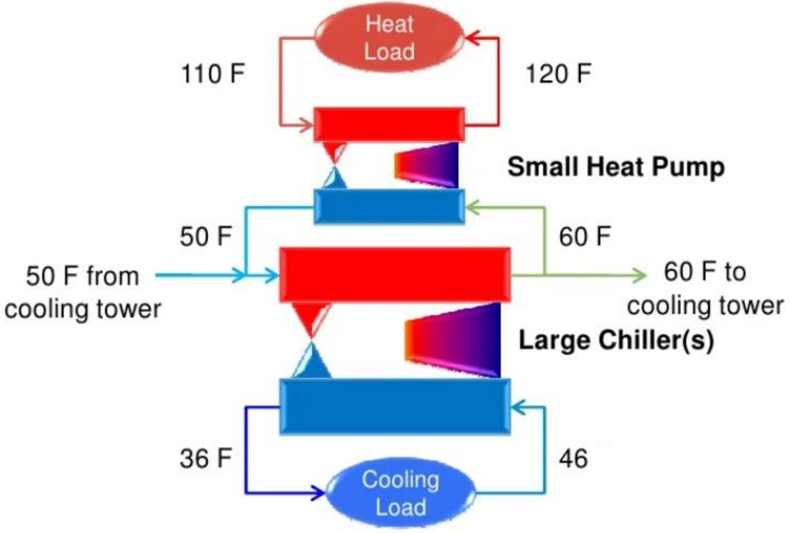
- Retrofit is not too intrusive – can keep the existing distribution system
- Can be used to recover internal heat loads such as server rooms
- Easy to integrate in existing control system

Cons

- Limited in supply temperature, typically around 45 °C , but 60 °C is possible
- Dependent on the available cooling load during the heating season
- Additional chillers often needed for cooling-only operation

Cascade heat pumps

- Chillers or heat recovery chillers may not provide the temperature levels needed
- For medium temperature loops, the use of a heat pump to boost the condenser water temperature can be considered
- A secondary heat pump uses the condenser water from the main chiller to produce hotter water



Cascade Arrangement

Cascade heat pumps: typical application

- Identical to heat recovery chillers:
  - Require hydronic loops
- No need for low temperature loops:
  - Cooling load during the heating period must be significant

Cascade heat pump pros and cons

Pros

- Retrofit is not too intrusive – can keep the existing distribution system
- Can be used to recover internal heat loads such as server rooms
- Can provide water typically in the 60 °C to 80 °C range

Cons

- Significant reduction in overall system COP
- Higher cost than standard heat reclaim chillers
- Requires a significant cooling load during the heating season

Central air-source hydronic heat pumps

- A true heat pump system providing hot water heating.
- Can be installed in existing boiler plant to replace or supplement existing boilers.
- Does not replace the existing cooling system.
- Always verify the ambient temperature range and supply temperature range.

Hot Water Delivery Temp °C	Nominal Ambient Operating Temperature - °C (Minimum)	
	Refrigerant Listed	
	R410 A	R407C
60	8	14
54	4	11
49	1	7
43	-3	3
38	-9	-1
32	-16	-7
27	-20	-10

Central air-to-water heat pumps: typical application

Small to medium commercial buildings.

Multi-unit residential buildings (MURBs).

Distribution systems such as radiant floor heating, low temperature hydronic loops or fan coil units.

Central air-to-water heat pump pros and cons

Pros

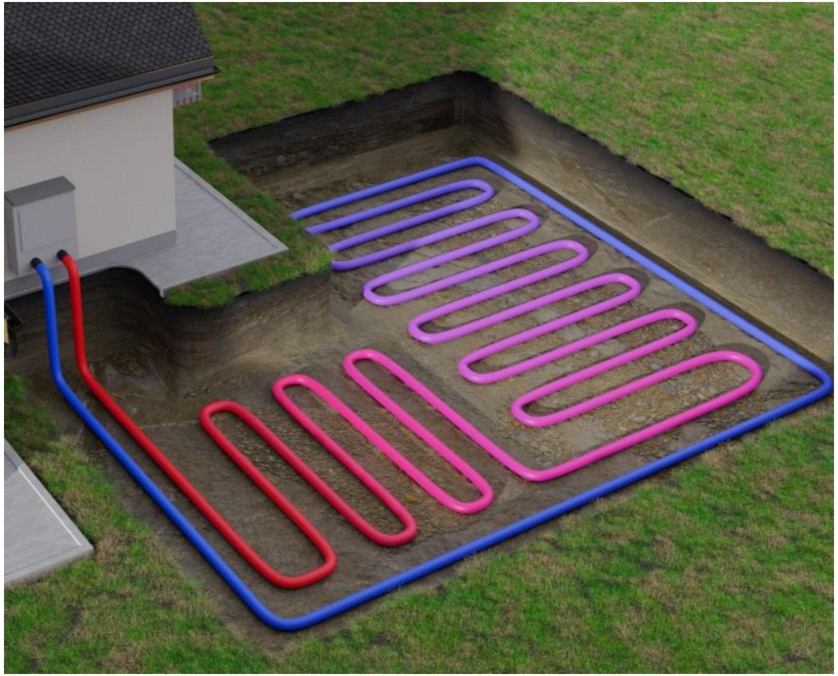
- Retrofit is not too intrusive – can keep existing distribution system
- Does not rely on internal loads to provide heating
- Applicable to a wide-range of buildings, unlike heat reclaim chillers

Cons

- No simultaneous heating and cooling, like a heat recovery chiller
- Loss capacity and efficiency with lower ambient
- Limited low temperature loops, maximum of typically 60 °C
- Rarely the only heating source due to ambient temperature limitation

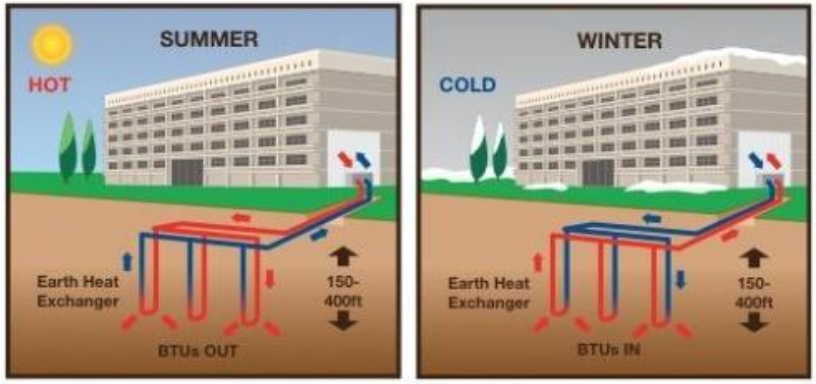
Central ground-source heat pumps (GSHPs)

- A central heat pump that typically provides hydronic heating in the winter and chilled water for cooling in the summer
- The ground heat exchanger is usually composed of a series of vertical wells but can be horizontal trenches for smaller buildings or even open wells
- Supplemental heating may be required for managing the cost of the ground heat exchanger



Central GSHPs: typical application

- Small to large commercial and institutional buildings with hydronic heating and cooling loops including:
- Schools
- Hospitals
- University campuses
- MURBs



Central GSHP pros and cons

Pros

- Capable of high efficiencies
- Does not rely on internal loads to provide heating
- Efficiency is not impacted by ambient temperatures
- Can be designed as standalone system (no supplemental heating)

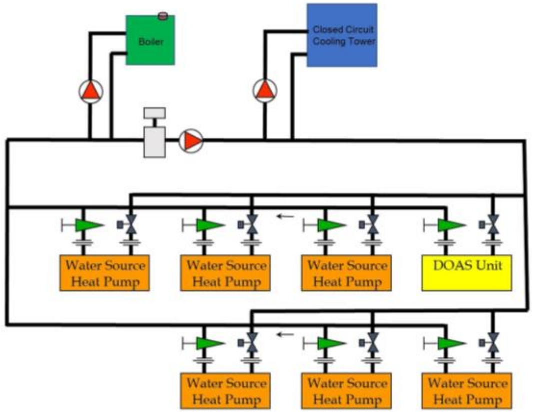
Cons

- One of the more expensive heat pump options
- Requires access to sufficient land area for wells and is a major undertaking
- Limited to low temperature loops, maximum of typically 55 °C

Distributed heat pumps

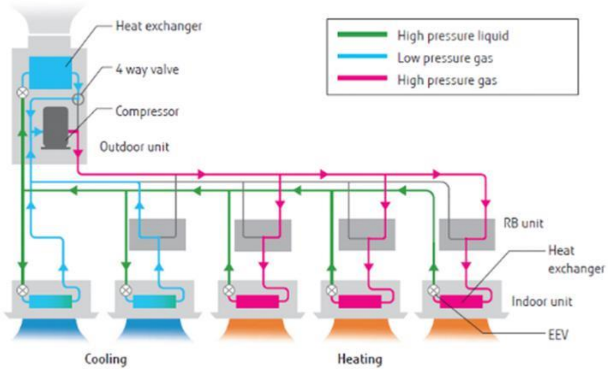
- Water-loop heat pumps (WLHPs): heat pumps located throughout the building:
  - Can be ground-source, air-source or boiler supplemented with cooling towers
  - Capital-intensive in a retrofit case
- Retrofit is sometimes done using variable refrigerant flow (VRF) systems for mid-size or small buildings:
  - Two types: heat pump (two-pipe) and heat recovery (three-pipe)

Distributed heat pumps: typical application



Water-loop heat pumps (WLHPs)

- Medium to large commercial and institutional buildings with existing water-loop distribution



Variable refrigerant flow (VRF) systems

- Small to medium commercial buildings
- No requirement for a hydronic system

Distributed heat pump pros and cons

Pros

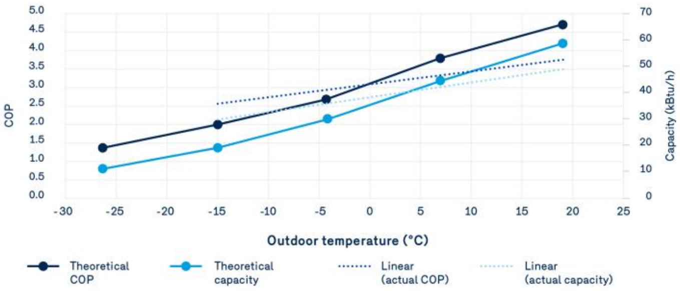
- Water loop heat pumps (WLHP) - one of the most efficient systems
- Variable refrigerant flow (VRF) systems can be implemented in a variety of settings
- WLHPs and VRF can recover internal heat loads for useful heating
- Existing WLHPs can be converted from gas supplemental to heat pump supplemental

Cons

- More maintenance intensive due to distributed nature of the systems
- Can be difficult to integrate in a building automation system (BAS), some require gateway or are not integrable
- Large amount of refrigerant for VRF and efficiency drops with length of refrigerant piping

Air-to-air heat pumps and rooftop units (RTUs)

- Very common in smaller commercial applications:
  - Capacity and COP vary with outdoor air temperature (OAT)
  - Modern systems can operate at low OAT (e.g. -15 ^{o}C)
  - Almost always associated with a supplemental heating source
- Mini-split
  - Can be very efficient and low OAT
  - Controls can be problematic with existing heating



https://informatech.energir.com/

Air-to-air heat pumps and RTUs: typical application

- Small to large commercial and institutional buildings:
  - No need for hydronic loop
  - Direct retrofit of existing RTUs
- Add-on heating and cooling for specific spaces

Air-to-air heat pump and RTU pros and cons

Pros

- Easy retrofit assuming electrical supply is sufficient/available
- Can provide high efficiency even at low ambient
- Lower cost than GSHPs

Cons

- Limited in capacity range
- Can be more challenging to integrate in a BAS, particularly mini-splits
- Performance is maintenance dependent (to minimize lift)

Heat pump water heaters

- Two or three times more efficient than an electric tank
- Packaged: uses the room air as a heating source while cooling the space:
    - Packaged systems are easy to retrofit and have higher efficiency but preferably installed in a space with large heat load (e.g. boiler room)
- Split system: uses ambient air as a heat source, lower winter efficiency

Installation and commissioning

Commissioning – key to your success

- First and foremost – a quality assurance process
- Commissioning: a process that serves to verify whether the service provided by the system not only meets the requirements of the building owner, but also the intent of the design
- Successfully demonstrating that a heat pump system is operating correctly is a key component of the process led by the commissioning authority (CxA)

Commissioning steps

- From project conception to final delivery
- A third-party CxA is an asset, but in-house commissioning is possible if done in a structured and well documented manner
- The phases of commissioning (Cx) are:

Design	**Construction**	**Acceptance**	**Warranty period**

Know your objectives and requirements

- Commissioning heat pump systems requires having a clear idea of the service to be provided:
  - Owner's project requirements (OPRs) must define specific heat pump performance that can be measured during commissioning, such as:
    - COP, typically under various conditions (such as outdoor temperature)
    - Performance of a supplemental heating source
    - Control sequence for the use of supplemental heating
    - Impact on building peak demand
  - Compare the results to the basis of design (BOD), which is basically what the contractor installed/proposed to the owner

Prior to installation

- The submittal review phase is a necessary part of commissioning:
    - Submittals: a basis for developing commissioning pre-functional checklists (PFC) and functional performance test (FPT) plans
- Equipment specifications provide an overview of how the system is intended to function, and sequence of operation must also be reviewed
- Commissioning authority will review to ensure compliance with OPRs and BOD

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Checks during construction

- Checklist: fundamental component of the commissioning process; typically provided by the contractor and includes electrical and mechanical verification to confirm that the heat pump system has been fully installed
- All required balancing work is to be completed (air, hydronic, geothermal)
- Once the checklist is complete and verified by the commissioning authority, the system is ready for performance testing

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Verify the performance

- The commissioning authority must be present for heat pump system performance tests
- Demonstration of the expected sequence of operation as specified, switch-over to supplemental heating, alarms and safeties, schedules and setpoints
- System COP may extend to the warranty period as more than one season is required to test heat pump performance

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Issues log

- The commissioning authority keeps an issues log throughout the process
- Issues are reported to the contractor and often need to be resolved prior to moving to the next commissioning phase
- Items are tracked until resolved:
  - Full payment of the project is not recommended until all performance testing is completed and issues log is clear

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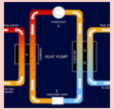
Maintenance

Maintain performance through maintenance

Heat pumps can be severely and negatively impacted by poor maintenance, more so than many conventional heating systems.



Similarly to chillers, the COP and capacity of heat pumps will drop due to factors such as heat exchange surface fouling, improper refrigerant charge, improper temperature settings, flow imbalance (e.g. ground), etc.

Adapt the building O&M program for newly installed heat pumps.

Example maintenance list – air source

Typical tasks include:

- Cleaning coils and condensers
- Replacing filters
- Checking for leaks
- Clearing drain lines
- Clearing outside unit of any debris
- Checking thermostats
- Checking refrigerant charge, presence of moisture
- Checking connections
- Inspecting air ducts
- Checking fan motors and oiling as needed

Questions and answers

- Any questions?
- Training and support webpage: visit this page to access all training and support materials

Save on Energy's Capability Building Program

- Save on Energy's Capability Building Program helps increase awareness about energy-efficiency opportunities, enhances knowledge and develops skills in organizations and communities across Ontario so they can undertake energy-efficiency actions and participate in Save on Energy programs
- The program includes tools such as workshops, webinars, training courses, coaching, peer learning and information resources, including guides and videos

Learn more at https://saveonenergy.ca/Training-and-Support
Register at www.saveonenergytraining.ca

Training courses – incentives

Save on Energy offers incentives of up to 50% for ~20 training courses plus certification exam fees, including:

- Achieving Net-Zero Buildings
- Energy Management and the ISO 50001 Standard
- HVAC Optimization for High Performance Sustainable Buildings
- Certified Energy Manager (CEM)
- Certified Measurement and Verification Professional® (CMVP)

Learn more at https://saveonenergy.ca/Training-and-Support/Training-Courses

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Training courses – incentives for Enbridge customers

Enbridge customers are eligible for incentives of up to 75% for three courses:

- Dollars to $ense Workshops: up to $500 per day
- Certified Sustainable Building Operator® (CSBO): up to $2,250 of course fees
- Certified Energy Manager® (CEM): up to $2,500 of course fees

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

Post-webinar support

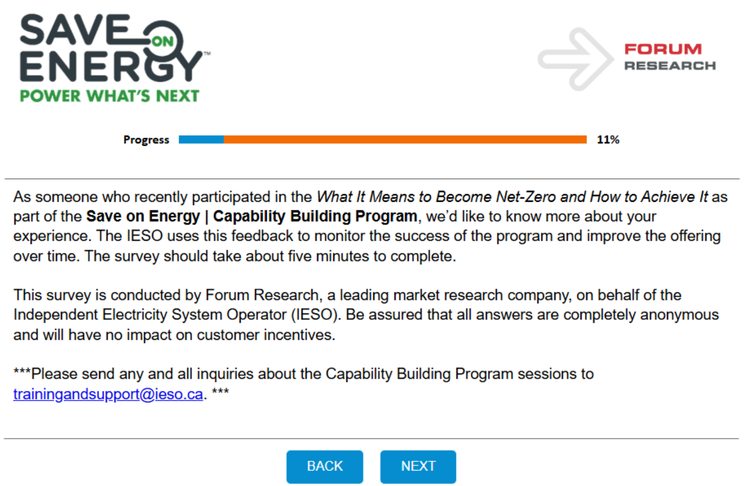
One-on-one coaching: tailored support for managing energy resources effectively

Post-webinar support intake form

Coaching sessions conducted virtually: phone, video calls and email

Designed for organizations, new or old, seeking guidance

Upcoming survey: we want your feedback! - 2



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