TAF The Atmospheric Fund

HARVESTING HEAT WITH HEAT PUMPS

A Guide to Retrofitting Electrically-Heated Multi-Family Dwellings in Ontario with Heat Pumps

FEBRUARY 2018

TAF The Atmospheric Fund

About The Atmospheric Fund (TAF)

Founded in 1991 by the City of Toronto, TAF's mission is to invest in urban low-carbon solutions to reduce emissions and air pollution. To date, TAF has invested more than $50 million, helping Toronto save more than $60 million in energy costs and contributing to a city-wide carbon emissions reduction of 24 per cent below 1990 levels.

Visit **www.taf.ca** for more information or message Devon Calder, Heat Pump Researcher, at dcalder@taf.ca.

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The views expressed here are those of The Atmospheric Fund and do not necessarily reflect the views of the City of Toronto or the Province of Ontario.

Toronto

Ontario

Creation of this document was made possible through the financial support of the Independent Electricity System Operator.

Content

PURPOSE OF THE GUIDE

This document is intended for property owners and managers, engineers and contractors interested in learning more about why and how to retrofit an electrically heated multi-unit residential building with heat pump space heating systems.

To help you through the process, this document contains:

- Information about what a heat pump is and how it functions
- The business case for retrofitting an electrically heated building with heat pumps
- A step-by-step how to guide
- Information on available incentives and eligibility requirements
- Additional resources including educational materials, technology performance information, design and installation guidelines, key contacts, and a glossary of key industry terms

What is a heat pump?

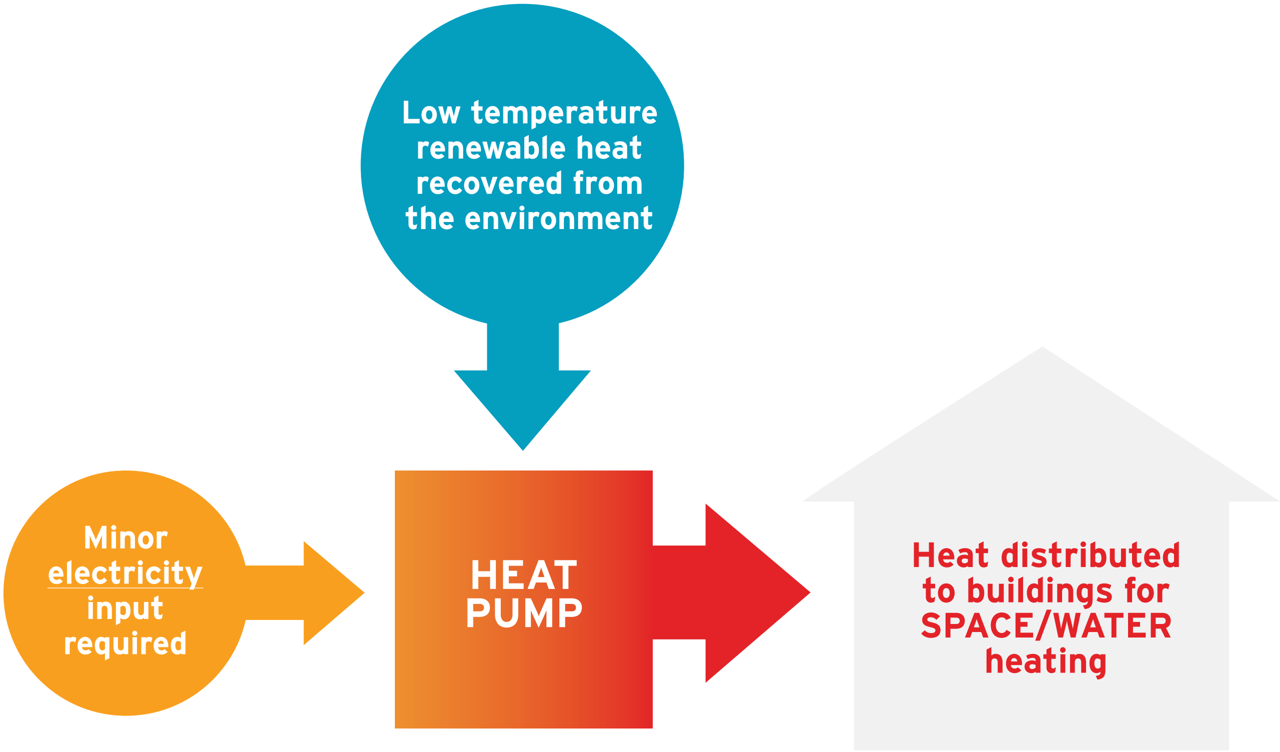
A heat pump is a mechanical device that harvests heat found in the outside environment (e.g. air, ground, water, waste heat). The pump upgrades recovered heat to a usable level for space heating and can also provide water heating and space cooling.

Heat pumps are energy efficient and environmentally sustainable. They harvest renewable thermal energy from the air, ground, or water, using a small amount of electricity to transfer heat and upgrade it to a higher temperature for space and water heating. Reversing this process provides space cooling.

WHY SHOULD I RETROFIT MY ELECTRIC HEATING SYSTEM WITH A HEAT PUMP?

Heat pumps offer multiple benefits:

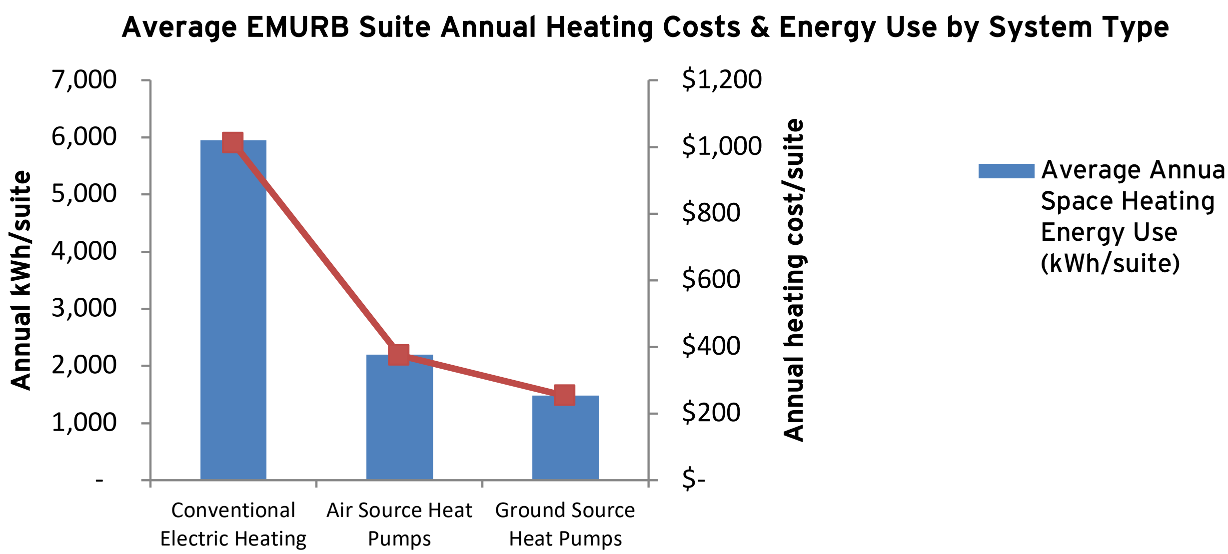
- Reduced energy costs;
- Reduced vulnerability to rising electricity prices;
- Improved comfort for residents;
- Reduced vacancy and turnover; and
- Reduced greenhouse gas emissions.



THE BUSINESS CASE FOR ONTARIO

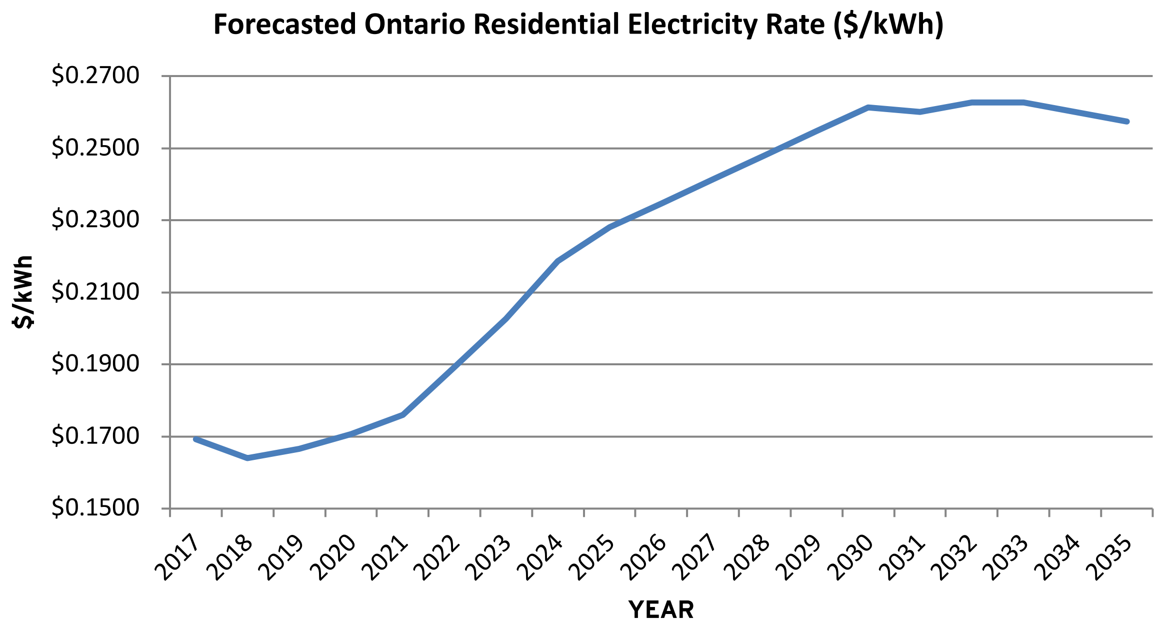
Electric heating costs have risen sharply with electricity prices in Ontario. Heat pumps have the potential to reduce costs by 40% - 75%, depending on the type of system chosen. Lower utility costs also translate into increased building value via an increase in net operating income. This is the case even in properties where tenants pay the heating bill. Electrically heated buildings with suite metering tend to have higher-than -average vacancy and turnover rates because of high utility costs for residents. A heat pump retrofit can reduce resident turnover and vacancy rates, thereby increasing rental income and building value.

The following comparison shows that heating your property with any type of heat pump will save you money on your property's energy bill when compared with a conventional electric space heating system.



[1] Electricity Rate includes supply, transmission, distribution, and all other on bill charges (including tax) – based on Ontario's 2017 Long-Term Energy Plan: Delivering Fairness and Choice forecasted rate to 2020.

With energy costs expected to rise, there will be even greater opportunity for savings. Additionally, your property will be less susceptible to shocks from utility price changes, making it more energy independent.



Source: Ontario's 2017 Long-Term Energy Plan: Delivering Fairness and Choice

[2] Electricity Rate includes supply, transmission, distribution, and all other on bill charges (not including tax)

IS MY BUILDING A GOOD CANDIDATE FOR HEAT PUMPS?

Your property is a good candidate for a heat pump retrofit if it has the following characteristics:

- ☑ Electrically heated (e.g. electric resistance baseboards, Packaged Terminal Air Conditioner (PTAC) units, in-slab electric radiant, fan coils with supplementary electric resistance heating).
- ☑ Higher electricity bills during winter
- ☑ 20 years or older

In addition, it is recommended that you implement a heat pump retrofit along with other energy efficiency measures to optimize the system and maximize energy savings. The following make an even stronger case for a retrofitting your property with a heat pump system:

- ☑ Few or no energy efficiency retrofits within last 5 years
- ☑ Issues with maintaining a comfortable level of heating throughout the winter (and summer as heat pumps can provide both heating and cooling for year-round comfort)

Due to the low cost of natural gas compared to electricity, there is not a strong business case yet in Ontario to switch over from natural-gas heated properties to heat pumps. This may change in the coming years as carbon pricing and other factors increase the cost of natural gas.

Different types of heat pumps

Heat pumps can provide heating, hot water, and cooling for a fraction of the energy used by conventional heating systems.

WHAT ARE THE OUTDOOR HEAT SOURCES?

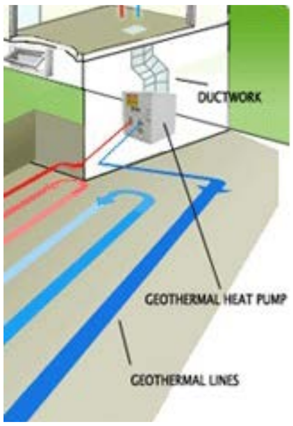
Two of the main kinds of heat pumps — air source and ground source — have been around for decades and have benefited from significant advances in technology.

Air source heat pumps extract low-temperature heat from outdoor air and send it indoors during cooler seasons, reversing this process during the warmer seasons for space cooling. Air source heat pumps used to have trouble operating in extreme cold conditions, but the new generation of cold climate heat pumps operates efficiently even in extremely cold conditions, eliminating the need for a backup heat source.

Ground (or water) source heat pumps absorb heat found in the ground or water and distribute the upgraded heat for space heating. During the summer, these systems send unwanted heat into the ground for space cooling. The ground retains that heat, allowing it to be used during the winter for space heating. Ground source heat pumps continue to be a highly reliable technology operating efficiently year round. There can be value in keeping existing electric heating systems in place as a full or partial backup as this offers redundancy and potentially reduces the size and expense of a new heat pump system.

NOTE: Water source heat pumps *can have two industry meanings. The first meaning is the first described above; another name for ground source heat pump – a system using heat pumps to draw/expel heat to and from outdoor water sources. The second industry definition describes a system where heat pumps distributed across a building (number demands on thermal needs) exchange heat with fan coils by drawing or expelling heat to and from a re-circulating water loop that runs throughout a building, with the water in the loop typically preconditioned first by either a boiler or chiller located at some point along the loop.*

HOW IS HEAT TRANSFERRED?

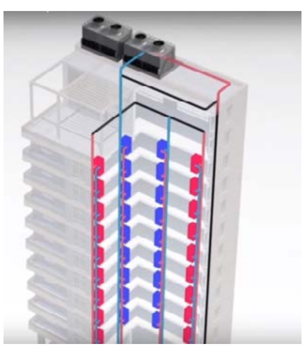


Ducted heat pump system[1]

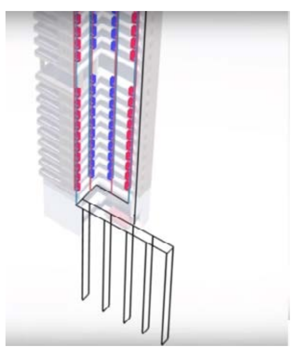
Air

Both air source and ground source systems can be used to distribute conditioned air through ducted systems. If a multi-unit residential building does not already have ductwork installed, new ductwork as part of a retrofit will not likely be a cost-effective option.

However, each business case will be context specific. Building size and wall construction will be important determining factors.



Air source to hydronic system[2]

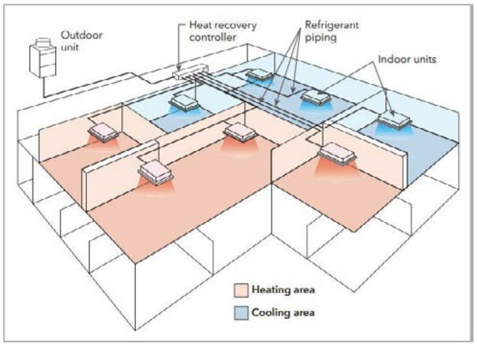


Ground source to hydronic system[3]

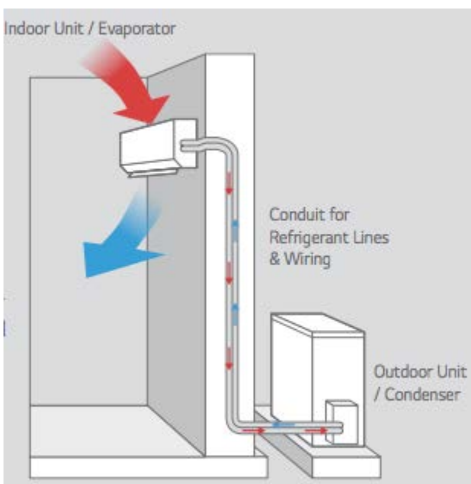
Water

Both air and ground source heat pump systems can be used to distribute heating and cooling through hydronic systems (e.g. recirculated hot/chilled water through pipes to in-suite fan coils). With a retrofit, it is most cost effective to utilize hydronic pipes that existed as part of an original hydronic fan coil or radiator system. Hydronic hybrid systems can be an alternative where centrally located heat pumps (such as on the roof or in a ground/ basement level mechanical space) can precondition the temperature of water in a recirculating loop that then gets adjusted to the appropriate temperature with distributed heat pumps located either in each suite or per floor. A hybrid system can benefit a building by reducing the number of rooftop units or size of a geothermal bore field.

[1] Adapted from: http://www.system-selector.ingramswaterandair.com/heatingandcooling.php
[2] https://www.youtube.com/watch?v=tJl2zehIUug&t=0s&list=WL&index=3
[3] https://www.youtube.com/watch?v=tJl2zehIUug&t=0s&list=WL&index=3



VRF system[4]



Ductless air source mini split system[5]

Refrigerant

If hydronic or ducted systems are not an option, variable refrigerant flow (VRF) or air source ductless mini-split systems can be a good alternative. Both air source and ground source heat pumps can transfer heat to refrigerant lines in a VRF system that travel to indoor fan coil units wherever heating and cooling is needed. A VRF system can be designed to service an entire building with special zone control units adjusting the flow of refrigerant between building areas so that heating and cooling can be provided at unique temperatures for areas/ rooms as needed.

Ductless air source mini-split systems are essentially a smaller VRF system, with a single outdoor air source unit typically suitable for one residential suite. There are larger air source mini-split systems (also known as ductless multi split heat pumps), which have sufficient capacity to service multiple residential suites (depending on suite size).

[4] Adapted from: http://www.seventhwave.org/new-technologies/variable-refrigerant-flow-vrf
[5] https://www.acgeothermaltn.com/mini-split/

Step-by-step guide

for retrofitting electrically heated buildings with heat pumps

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5
Preliminary assessment	In-depth investigation	Financing & procurement	Implementation	Post Retrofit

STEP 1 Preliminary assessment

Involvement	Task	Description	Check
DIY	Step 1.1	Pre-qualify your building based on property characteristics	☐
DIY	Step 1.2	Assess the business case using TAF Business Case Assessment Tool	☐

●	Consult an expert
●	DIY
●	Expert help required

Step 1.1 Prequalify your building based on property characteristics

If your property is electrically heated, experiences high electricity bills during winter, and is 20 years or older, then you could benefit from a heat pump retrofit. Further supporting characteristics would include: no energy efficiency retrofits conducted within last 5 years; issues with maintaining a comfortable level of heating throughout the winter and/or cooling throughout the summer; and air leaks or drafts.

Step 1.2 Assess the business case using the TAF Business Case Assessment Tool

TAF has developed a Business Case Assessment Tool for estimating the savings potential that your property could achieve from retrofitting with a heat pump. Download the tool at: taf.ca/publications/bcat

This is not intended to replace rigorous engineering assessments – it simply identifies potential retrofit benefits by entering some data about your property.

Please also note that choosing the right heat pump solution is context specific – an engineer could help you determine which solution is right for your property.

STEP 2 In-depth investigation

Involvement	Task	Description	Check
	Step 2.1	Engage professionals (feasibility study)	☐
	Step 2.2	Reassess the business case	☐

- Consult an expert
- DIY
- Expert help required

Step 2.1 Engage professionals

The next step is to engage a qualified professional to explore the technical and financial feasibility of retrofitting with heat pumps.

Speak with your local distribution company for advice on calculations, incentive options, measurement and verification requirements and for a list of engineers who can conduct your feasibility study.

Step 2.2 Reassess the Business Case

If, after reviewing your completed feasibility study, the business case still makes sense, proceed to Step 3.

STEP 3 Financing & procurement

Involvement	Task	Description	Check
	Step 3.1	Select project delivery approach	☐
or (RECOMMENDED)	Step 3.2	Apply for incentives through your utility	☐
	Step 3.3	Secure financing, if applicable	☐
	Step 3.4	Procurement	☐
	Step 3.5	Developing your Measurement & Verification plan	☐

- Consult an expert
- DIY
- Expert help required

Step 3.1 Select project delivery approach.

The type of heat pump solution best suited for your building will influence which project delivery approach makes the most sense. The engineer who conducted your feasibility study should be able to help you determine whether you can simply bid work out to HVAC contractors, or if you require a more elaborate project delivery approach like a design-tender or design-build approach with an engineer.

Step 3.2 Apply for incentives

Significant financial incentives for heat pump retrofits are available through Ontario's conservation programs. Contact your local distribution company to find out how you can apply to the programs and what the eligibility requirements are. Applying for incentives can be done by property owners but it is generally encouraged that people do this through their engineer or contractor.

Program	Incentive
Save On Energy – RETROFIT – Custom Track	$0.10/kWh up to 50% of project costs. For social housing providers this incentive is doubled to $0.20/kWh.
Save On Energy - Process & Systems Program	$0.20/kWh (eligible with retrofits achieving 100 MWh in annual savings). Up to 40% of project costs. Recommended approach where savings will be greater than 10% of whole building consumption.
Save On Energy - Energy Performance Program (EPP)	$0.04/kWh/year – currently available until 2020. NOTE: this may not be an option for many customers as it is for interval metered buildings only and the customer must have buildings in multiple local distribution company service areas.

Save On Energy – Retrofit Program
https://www.saveonenergy.ca/Business/Program-Overviews/Retrofit-for-Commercial.aspx

Save On Energy – Process & Systems Program
https://www.saveonenergy.ca/Business/Program-Overviews/Process-and-System-Upgrades.aspx

Save On Energy – Energy Performance Program Incentives for Multi-Site Customers
https://www.saveonenergy.ca/Business/Program-Overviews/Multi-Site-Customers/Energy-Performance-Program.aspx

Step 3.3. Secure financing, if applicable

If you're going to need help financing your retrofit project, there are a number of options to consider, including but not limited to:

- Energy Savings Performance Agreements: an innovative non-debt financing mechanism that provides properties with up to 100% of the capital needed for an energy efficiency project in exchange for your share of annual energy savings for up to 10 years. Learn more at: http://taf.ca/financing and http://www.efficiencycap.com

- Municipal Loan Programs: some municipalities, like the City of Toronto, offer low interest loans for eligible multi-family building retrofits. Check if your municipality has any active sustainable energy financing programs that you can benefit from.
- Commercial Lenders: standard property secured loans offer a viable option for financing heat pump retrofits for many buildings.
- HVAC Rental Service Providers: If buying equipment outright is not an option, HVAC equipment leasing providers exist that can offer a turnkey solution for a fixed monthly charge. Some even provide lease-to-own arrangements.

Step 3.4 Procurement

Your selected project delivery approach will help you decide how to go about procuring equipment and service providers. A project manager controlling the entire design/build process can be a more expensive option. However, opting for a seasoned professional to coordinate all aspects of project procurement can end up being worth it in the long run. This can be for a number of reasons, including but not limited to: accountability, streamlining of project logistics, and reduction of resident hassles. You may wish to develop bid documents for competitive quotes.

Step 3.5 Developing your Measurement & Verification plan

Measurement & Verification (M&V) is the process of confirming how well your new system performs against historical energy usage prior to the retrofit. This step is important to help ensure the retrofit is achieving the desired results. It's also required as part of any conservation incentive program. Some M&V approaches are more robust (and complex) than others. Ask your local distribution company about the different M&V requirements for each of the incentive programs. A common option is to have your retrofit project manager/engineer design and implement your M&V plan. See also Step 5.1.

STEP 4 Implementation

Involvement	Task	Description	Check
	Step 4.1	Detailed project design	☐
	Step 4.2	Construction	☐
or (RECOMMENDED)	Step 4.3	Verify project completion	☐
	Step 4.4	Commissioning	☐

Consult an expert
DIY
Expert help required

Step 4.1 Detailed project design

Depending on the size and complexity of your system, you may need to prepare engineering designs and/or specifications. Assuming no issues are found during the design process, your next step will be to implement the plan.

Step 4.2 Construction

Your engineer or contractor will manage and review the construction process and either you or your project manager will oversee contract administration.

Step 4.3 Verify project completion

You will need to verify installation for your local distribution company to qualify for incentives. You must apply before construction, but then send certain materials after construction to verify installation. There's value in having an engineer/contractor take responsibility of the incentive application process on your behalf.

Step 4.4 Commissioning

Commissioning is a process of testing your new heat pump system after it has been successfully installed (typically in larger buildings). It is a critical step of verifying that the heat pump system, and all supplemental systems, are operating at the level of performance as designed by the engineer/contractor. Make sure you receive an installation/commissioning certificate to verify this step has been performed.

STEP 5 In-depth investigation

Involvement	Task	Description	Check
Expert help required (yellow)	Step 5.1	Measuring the benefits	☐
DIY (orange)	Step 5.2	Report back to stakeholders	☐

(blue)	Consult an expert
(orange)	DIY
(yellow)	Expert help required

Step 5.1 Measuring the benefits

The implementation of your Measurement & Verification (M&V) plan will provide critical information about how much energy is being saved as a result of the heat pump retrofit. You will need to submit post project documentation and an M&V report for utility incentives. Once your local distribution company has reviewed and approved the M&V results, they will issue a cheque for the incentive(s) your project was eligible and prequalified for. ***Please note: you should begin preparing implementation of an M&V plan before your retrofit starts***. See Step 3.2 & 3.5 for further clarification on the need for M&V.

Step 5.2 Report back to stakeholders

After your project has been successfully implemented and the performance results are in, it's time to update your residents and other stakeholders. Let them know how much money and energy your building is saving, and inform them of additional benefits like contributions to carbon emission reductions. Look at this as an opportunity for ongoing dialogue with your residents – you can continue to remind them of the benefits of living in your property and prepare them for the next energy efficiency project.

Additional Resources

INCENTIVE PROGRAMS

Save On Energy – Retrofit Program
https://www.saveonenergy.ca/Business/Program-Overviews/Retrofit-for-Commercial.aspx

Save On Energy – Process & Systems Program
https://www.saveonenergy.ca/Business/Program-Overviews/Process-and-System-Upgrades.aspx

Save On Energy – Energy Performance Program Incentives for Multi-Site Customers
https://www.saveonenergy.ca/Business/Program-Overviews/Multi-Site-Customers/Energy-Performance-Program.aspx

NORTH AMERICAN CASE STUDIES

Mini-Split Heat Pumps Multifamily Retrofit Feasibility Study
https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/minisplit_multifamily_retrofit.pdf

Performance Assessment of Urban Geoexchange Projects in the Greater Toronto Area
http://www.sustainabletechnologies.ca/wp/wp-content/uploads/2015/03/GeoExchangeMonitoring_Final_Feb2015.pdf

Closing the Loop: A Survey of Owners, Operators and Suppliers of Urban Geoexchange Systems in the Greater Toronto Area
http://www.sustainabletechnologies.ca/wp/wp-content/uploads/2015/03/GeoexchangeSurvey_Final_Feb2015.pdf

Efficiency Maine Low-Income Multifamily Weatherization Evaluation Report
https://www.efficiencymaine.com/docs/Low-Income-Multifamily-Final-Evaluation-Report-2016.pdf

Impact and Process Evaluation of the 2014 Illinois Power Agency All-Electric Homes Program
http://ilsagfiles.org/SAG_files/Evaluation_Documents/Draft%20Reports%20for%20Comment/DCEO_EPY7-GPY4/IPA_PY7_All-Electric_Homes_DRAFT_2016-01-04.pdf

TECHNOLOGY COMPARISON

NEEP – Cold Climate Air Source Heat Pump Database
http://www.neep.org/initiatives/high-efficiency-products/emerging-technologies/ashp/cold-climate-air-source-heat-pump

Consortium for Energy Efficiency Inc. – Directory of Efficient Equipment
http://www.ceedirectory.org/site/1/Home

STANDARDS & CODES

CAN/CSA-C448 SERIES-13 - Design and installation of earth energy systems
http://shop.csa.ca/en/canada/energy-efficiency/cancsa-c448-series-13/invt/27014712013

CAN/CSA-C273.5-11 (R2015) - Installation of air source heat pumps and air conditioners
http://shop.csa.ca/en/canada/energy-efficiency/cancsa-c2735-11-r2015/invt/27008482011

CONSUMER GUIDES

Commercial Earth Energy Systems: A buyer's Guide
http://publications.gc.ca/collections/Collection/M92-251-2002E.pdf

Heating and Cooling With a Heat Pump | Natural Resources Canada
http://www.nrcan.gc.ca/sites/oee.nrcan.gc.ca/files/pdf/publications/infosource/pub/home/heating-heat-pump/booklet.pdf

RESEARCH REPORTS

Performance Assessment of Urban Geoexchange Projects in the Greater Toronto Area
http://www.sustainabletechnologies.ca/wp/wp-content/uploads/2015/03/GeoExchangeMonitoring_Final_Feb2015.pdf

Global Heat Pump Performance Review
http://taf.ca/wp-content/uploads/2015/06/TAF-Heat-Pumps-Final-Report-2015.pdf

CONTRACTOR & MANUFACTURERS DIRECTORY

HRAI contractor directory:
http://portal.hrai.ca/HRAI/Contractor_Locator/HRAI/Contractor_Locator/Contractor_Locator.aspx

HRAI Manufacturers Product Directory
http://portal.hrai.ca/HRAI/ProductDirectory/HRAI/Directories/HRAI_Manufacturers_Product_Directory.aspx

MANUFACTURER INFORMATION

Heat pumps, ground source (MANUFACTURER INFO)
http://oee.nrcan.gc.ca/pml-lmp/index.cfm?action=app.search-recherche&appliance=HP_GS

PRODUCT DIRECTORIES

ENERGY STAR Certified Non-AHRI Central Air Conditioner Equipment and Air Source Heat Pump
https://data.energystar.gov/Active-Specifications/ENERGY-STAR-Certified-Non-AHRI-Central-Air-Conditi/cker-n33t

Directory of Certified Product Performance
https://www.ahridirectory.org/ahridirectory/pages/home.aspx

Cold Climate Air Source Heat Pump Specification Listing
http://www.neep.org/initiatives/high-efficiency-products/emerging-technologies/ashp/cold-climate-air-source-heat-pump

CEE Directory of Efficient Equipment
http://www.ceedirectory.org/site/1/Home

ASSOCIATIONS/INSTITUTES

Canadian GeoExchange Coalition
http://www.geo-exchange.ca/en/

Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI)
http://www.hrai.ca/

Ontario Geothermal Association
http://ontariogeothermal.ca/index.html

Ontario Refrigeration & Air Conditioning Contractors Association
http://orac.ca/

Glossary

Air Source Heat Pump: a system which transfers heat from outside to inside a building, or vice versa. Under the principles of vapour compression refrigeration, an air source heat pump uses a refrigerant system involving a compressor and a condenser to absorb heat at one place and release it at another.

Borehole: a vertical hole drilled in the earth to insert pipe to transfer heat from the soil.

Building load (heating or cooling): the heating or cooling power required to maintain building indoor spaces at their selected temperatures. This power is calculated based on the heat transfer for each room, the simultaneous heat transfer for the whole building and the difference between the indoor and outdoor temperature.

Cash-flow analysis: a study of the economics of owning a heat pump system that takes into account the cost of purchasing the system (including interest paid on money borrowed to purchase it) and the cost of energy used to operate it.

Climate change: a change in the average weather of a given region. Average weather includes all features associated with climate such as temperature, wind patterns, and precipitation. Climate change on a global scale refers to changes to the climate of the Earth as a whole.

Closed-loop system: *see* Loop: closed loop.

Coefficient of performance (cooling) (COPc): a measure of the efficiency of an air-conditioning appliance, calculated by dividing the cooling output by the energy input.

Coefficient of performance (heating) (COPh): a measure of the efficiency of a heating appliance, calculated by dividing the heat output by the energy input.

Compressor: a device used to compress refrigerant gas in a heat pump. Compressing a gas raises its temperature and makes it more useable to heat either a home or domestic water.

Conventional heating/air-conditioning system: a system using the prevalent fuels (fossil fuel, electrical resistance, air-cooled condensing units) to provide heating and cooling to most homes is often referred to as conventional.

Desuperheater: a heat exchanger installed in a heat pump directly after the compressor and designed to remove a portion of the heat from hot, gas refrigerant in a ground source heat pump. It is typically intended to heat domestic water.

Distribution system: a system that distributes the heated (or cooled) air (or water) supplied by a heating system in a home. Ductwork is normally used in a forced-air system, and water piping is used in a hydronic heating system.

Energy efficiency ratio (EER): a measure of the cooling or air-conditioning efficiency of an appliance, calculated by dividing the cooling output in Btu/h by the energy input in watts.

Ground Source Heat Pump (GSHP): a system designed to transfer heat to and/or from the soil and a building, consisting of a heat pump that is connected to a closed or open loop and a forced-air or hydronic heat distribution system.

Greenhouse gases: the combustion of fossil fuels releases gases, such as carbon monoxide (CO), carbon dioxide (CO2), sulphur dioxide (SO2), nitrous oxides (NOX) etc., that are commonly referred to as greenhouse gases because they allow the sun's radiation to pass through but block the radiation of the earth's heat back into space (also see Climate change; Combustion, products of; Emissions; Global warming).

Heat pump: a device at the heart of an air source or ground source heat pump system, designed to extract heat from a low-grade source (such as the earth) by way of a loop (open or closed) and concentrate it for use to heat a space. Consists of a compressor, a blower motor, and a circulation pump. A reversing valve enables it to switch functions to provide air-conditioning as well as heat for a home. May be either a console-type or water-water heat pump.

Heating/air-conditioning system, Conventional: *see* Conventional heating/air-conditioning system.

Heating Seasonal Performance Factor (HSPF): HSPF is the total space heating required in region IV during the space heating season, expressed in Btu, divided by the total electrical energy consumed by the heat pump system during the same season, expressed in watt-hours.

Life-cycle cost analysis: similar to a cash-flow analysis. Used to calculate the economics of owning a heat pump system (aka an energy-earth system or EES), the life-cycle cost analysis also takes into account the cost of maintaining and/or replacing the equipment as it deteriorates over time; probably the most accurate method of determining the true cost of owning a heat pump system.

Load: *see* Building load.

Loop: a heat exchanger used to transfer heat between a ground source heat pump and the earth, using liquid as a heat-transfer medium. Types of loops used in ground source heat pump systems include the following:

Closed loop: a continuous, sealed, underground or submerged system, through which a heat-transfer fluid (refrigerant) is circulated.

Ground (also earth) loop: a sealed underground pipe through which a heat-transfer fluid is circulated to transfer heat to and from the earth.

Horizontal: pipes are buried on a plane parallel to the ground.

Lake (also ocean, pond) loop: sealed pipes arranged in loops and submerged in a lake (ocean or pond), through which a refrigerant passes to absorb or release heat from or into the water.

Open loop: designed to recover and return ground or surface water with a liquid-source heat pump; usually requires two wells – one from which to draw the water (primary well) and a second to receive the circulated water (return well).

Vertical loop: pipes are buried on a plane at 90 degrees to the ground.

Low-grade heat: a source of heat that is not hot enough to heat a living space by itself.

Seasonal Energy Efficiency Ratio (SEER): SEER is the total heat removed from the conditioned space during the annual cooling season, expressed in Btu, divided by the total electrical energy consumed by the air conditioner or heat pump during the same season, expressed in watt-hours.