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Municipal Corporate Energy Managers Network workshop

Gil Amdurski, CEM, CMVP.

Technical Coordinator, Toronto and Region Conservation Authority

October 7th, 2022

Outline

- Introduction to STEP
- Speaker introduction
- Past projects
- ASHP Campaign
- Future Projects (in the pipeline)
- Future Projects (long-term)
- Q&A

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- Non-profit
- Collaborative
- Research

- Pilots
- M & V
- Clean Tech

- Buildings
- Renewables
- Smart-grid

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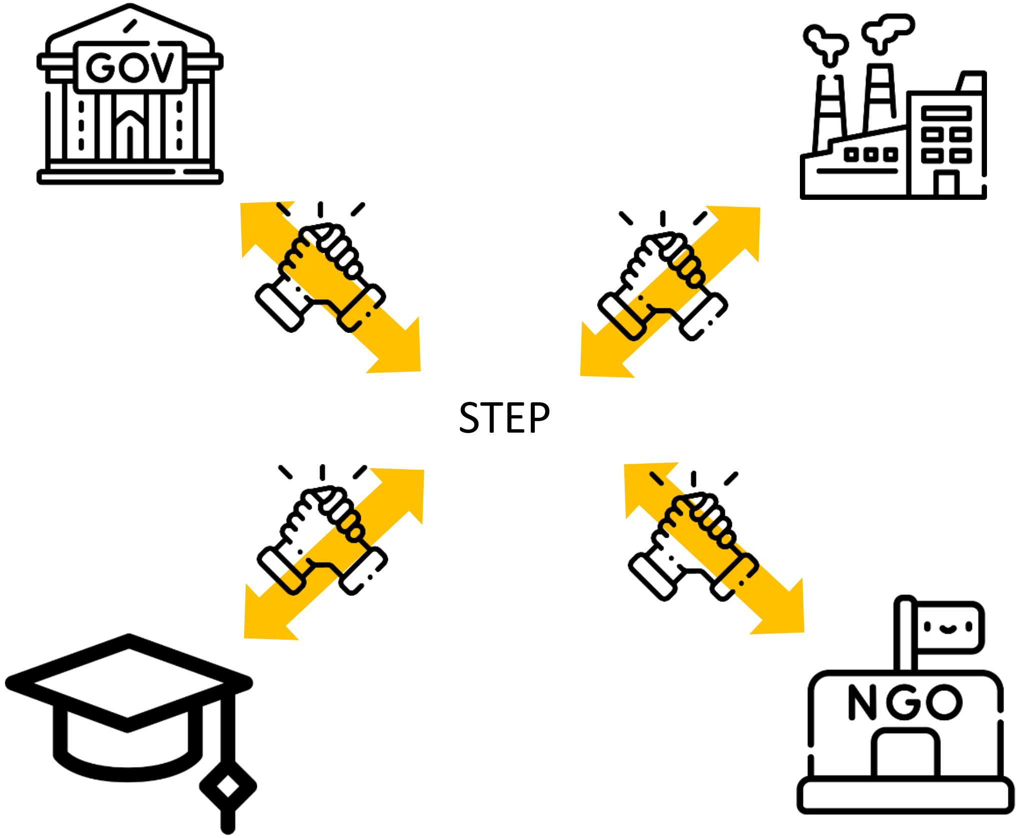
STEP



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- Collaborate with government, industry, academia, and NGOs
- Study sustainable solutions applicable ***locally***
- Disseminate findings to help governments and individuals make informed decisions
- Drive us collectively to a more sustainable society

Living Labs

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- Living Labs @ Kortright and TRCA buildings provide a friendly environment for vetting/testing prior to further deployment
- Open houses, group tours, meeting space, professional training, event space







Energy Trail

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Partners, Sponsors and Funders

TAF The Atmospheric Fund

uniongas

Government of Canada

Gouvernement du Canada

bloom

Region of Peel working with you

York Region

Toronto

Enbridge

Ontario

Ryerson University

Cricket Energy GROUP OF COMPANIES

OCC

DAIKIN

MITSUBISHI ELECTRIC

Jama Property Manageme

SNAP Sustainable Neighbourhood Retrofit Action Plan

Projects and Pilots

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TECHNICAL BRIEF

Residential Heat Pump Case Study 1: Hybrid Heating in a Semi-Detached House

The Sustainable Technologies Evaluation Program (STEP) is a collaborative non-profit research initiative within the Toronto and Region Conservation Authority (TRCA). Among other priorities, STEP partners with government, utilities, non-profits, academic institutions, and private companies, to pilot and evaluate emerging low-carbon technologies for buildings with the aim of providing real-world data, analysis, tools, and outreach that promotes effective technological solutions for climate change mitigation.

INTRODUCTION

This is the first case study[1] in a series evaluating heat pump installations in single-family homes in Ontario, focusing on the Greater Toronto and Hamilton Area. The City of Toronto targets a 65% reduction in carbon emissions by 2030. Most of the emissions (57%) are from homes and buildings, primarily a result of natural gas used for space heating. Home energy retrofits on a massive scale are therefore needed. Hybrid heating systems are a promising cost-effective low-carbon heating solution. This case study evaluates upfront costs, carbon reductions, and utility bill impacts of an installation in a Toronto home.

SITE AND EQUIPMENT

The hybrid system was installed in late-2020 and commissioned in early January 2021 in a 2,100 ft² pre-1935 3-bedroom 2-storey semi-detached home in Toronto's East End. The hybrid system replaced the homeowner's A/C, which was at end-of-life, as well as a 12-year-old mid-efficiency furnace. The homeowner chose a high-efficiency two-stage air-source heat pump (ASHP) and a variable capacity gas furnace (AFUE 97%) for the hybrid system (Table 1). The system is controlled by a smart thermostat. It does not switch between furnace and ASHP at a preset outdoor temperature (as is often the case) but instead chooses the ASHP until it is no longer able to meet the thermostat setpoint within 30 minutes of turning on. Concurrently with the hybrid system retrofit, the homeowner also had the home professionally air-sealed and insulation was added to the rear basement wall, which had been identified within an energy audit as a source of heat loss.

Hybrid heating systems (also called dual fuel systems) look the same as conventional furnace and A/C systems. The difference is that, in a hybrid system, the A/C unit is "upgraded" to an air-source heat pump (ASHP). The ASHP provides both cooling and heating. It is driven by electricity and it is much more efficient than a furnace. It can be used for heating in milder outdoor conditions when it is generally more cost-effective than a furnace. The furnace is then used in very cold conditions. In jurisdictions with a low-carbon electricity grid, like Ontario, this can result in lower utility bills and significantly lower carbon emissions.

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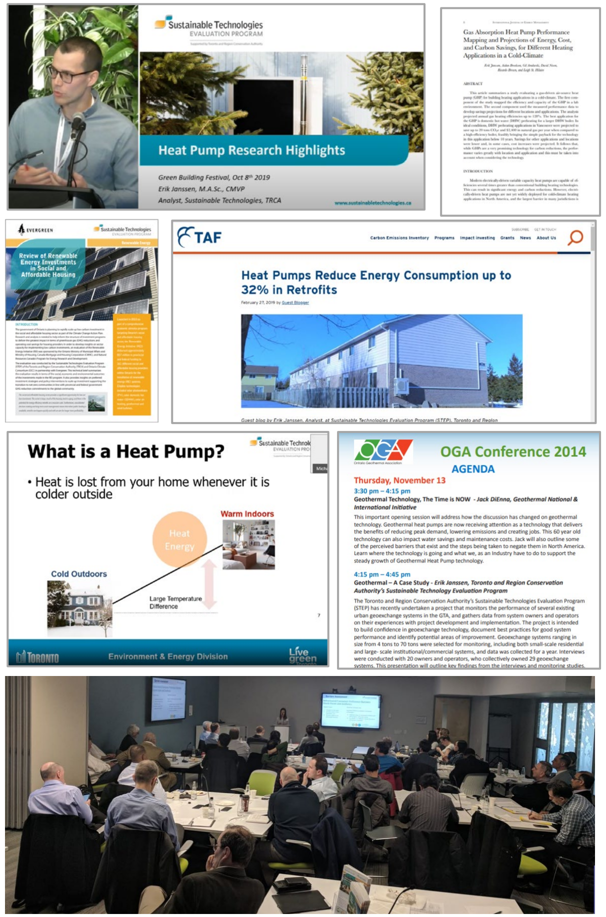
Communications & Outreach

- Homeowner and building-owner webinars
- Presentations to municipal energy management teams
- Industry conferences and publications
- Academic conferences and publications (through academic partners)
- Surveys
- Social Media Campaigns
- In-person symposium
- Social media
- Full reports and white papers (website)
- Stakeholder meetings



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Speaker Bio: Gil Amdurski

- Technical Coordinator with STEP since 2010
- Technical lead/support for pilot projects evaluating renewable energy and energy-efficient mechanical systems for homes/buildings
- Diploma in Electro-mechanical Engineering
- Certified Measurement & Verification Professional (CMVP) with AEE
- Certified Energy Manager (CEM) with AEE
- Enthusiastic owner of a cold-climate air-source heat pump

Past Projects

Ductless ASHPs retrofits in MURBs

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Heating & Cooling

Case Study: Ductless Heat Pump Retrofits in an Ontario Rowhouse Complex

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INTRODUCTION

Electric baseboards are the main heating source for 24% of all multi-unit residential building (MURB) and rowhouse units in Ontario. In this sector, heat pump retrofits represent a significant opportunity to conserve electricity, reduce carbon emissions and reduce operating costs, while simultaneously promoting tenant comfort and safety.

Various heat pump options are available, including both air- and ground-source (i.e. geothermal). Multi-split ductless air-source heat pumps (ASHPs) are a potentially good option because they are simple to retrofit and may entirely displace an electric base-board heating system, while also providing a high-efficiency cooling system.

Multi-split ductless ASHPs have a single outdoor fan coil unit connected to multiple in-door fan coils through small diameter refrigerant piping that can be run on the exterior of a building or otherwise retrofitted into tight spaces within the building. This makes retrofits into an electrically-heated building straightforward.

This case study evaluated the performance of ductless multi-split air-source heat pump retrofits in a rowhouse complex located in Brantford, ON, during 2017/2018.

Air-source heat pumps (ASHPs) function on the same principle as an air-conditioner, in that a refrigeration cycle is used to "move" heat energy between a building's interior and the outdoor ambient air. However, unlike air-conditioners, ASHPs provide **both** cooling in the summer **and** heating in the winter. The key benefits of an ASHP in heating mode is that it supplements electrical energy used for space heating with heat energy extracted from the outside air to drastically reduce overall energy consumption.

- Replaced electric baseboards with ductless **multi-**split ASHPs in Brantford, ON, rowhouse complex
- IPMVP-adherent evaluation of energy/cost savings and tenant interviews

Key Lessons

1. Tenants were very positive about the heat pumps, but the business case was not strong.
2. A single **mini**-split used in conjunction with existing baseboards would likely have been a more cost-effective retrofit option for this type of building.

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Gas ASHPs

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Heating & Cooling

Gas Absorption Heat Pumps: Carbon, Energy and Cost Reductions for Heating Applications in a Cold Climate

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INTRODUCTION

Heat pumps achieve heating efficiencies beyond conventional limitations because they extract renewable heat energy from the air, ground or elsewhere. Natural gas heat pumps (GHPs) are of interest because they utilize a low-cost fuel. GHPs have been applied in Europe and Japan, but have not made significant inroads in Canada. This study analyzed the operation of a GHP installed at the Archetype Sustainable House (ASH) Lab in Vaughan, Ontario, during 2017/2018. The aim of the study was to characterize the GHP's performance for cold-climate conditions such that potential energy, cost, and carbon reductions could be estimated for different Canadian applications.

TECHNOLOGY

The GAHP-AR from Robur was evaluated. It is an "air-to-water" gas absorption heat pump that heats as well as cools. Nominal heating capacity and efficiency are 35.3 kW and 126% (HHV), respectively, and it supplies fluids up to 60 °C. A heating-only version (GAHP-A) is also available. The unit is single-packaged, installed outdoors on a pad or rooftop, and connected to a building via hydronics. It is well-sized for large homes, multi-unit residential and industrial-commercial-institutional (ICI) buildings.

Energy is stored in the chemical bonds that make up natural gas. The combustion of gas in furnaces, boilers and water heaters, releases that energy in the form of heat. Using conventional equipment, it is not possible for the heat energy output to exceed the gas energy input. In contrast, a heat pump can use the energy contained in gas to extract heat from the ambient outdoor environment and deliver an overall heat energy output that exceeds the gas energy input. In this way, heat pump "efficiency" can surpass 100% and less natural gas is consumed.

- Air-to-water gas absorption heat pump was used to heat and cool Archetype House Lab for 1 year
- Mapped capacity and efficiency against temp
- Extrapolated results for buildings/applications

Key Lessons

1. Little benefit for *space heating* across most of Canada. It should not be used for cooling because is much more carbon intensive.
2. Moderate carbon savings and potential good business case are possible for DHW preheating in MURBs.

Renewables in Social Housing


EVERGREEN

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Renewable Energy

Review of Renewable Energy Investments in Social and Affordable Housing

INTRODUCTION

The government of Ontario is planning to rapidly scale up low carbon investment in the social and affordable housing sector as part of the Climate Change Action Plan. Research and analysis is needed to help inform the structure of investment programs to deliver the greatest impact in terms of greenhouse gas (GHG) reductions and operating cost savings for housing providers. In order to develop insights on sector capacity for implementing low carbon investments, an evaluation of the Renewable Energy Initiative (REI) was sponsored by the Ontario Ministry of Municipal Affairs and Ministry of Housing, Canada Mortgage and Housing Corporation (CMHC), and Natural Resources Canada's Program for Energy Research and Development.

The evaluation was conducted by the Sustainable Technologies Evaluation Program (STEP) of the Toronto and Region Conservation Authority (TRCA) and Ontario Climate Consortium (OCC) in partnership with Evergreen. This technical brief summarizes the evaluation results in terms of the social, economic and environmental outcomes of the investments made in the REI program. It also provides insights on preferred investment strategies and policy interventions to scale up investment supporting the transition to net-zero communities in line with provincial and federal government GHG reduction commitments to the global community.

The social and affordable housing sector provides a significant opportunity for low carbon investment. The sector is large, much of the housing stock is aging, and there is the potential for energy efficiency retrofits on a massive scale. Furthermore, consolidated decision-making and long-term asset management means that when public funding is available, retrofits can happen quickly and with an aim for longer-term profitability.

Launched in 2010 as part of a comprehensive economic stimulus program targeting Ontario's social and affordable housing sector, the Renewable Energy Initiative (REI) disbursed approximately $57 million in provincial and federal funding to 161 different social and affordable housing providers within Ontario for the installation of renewable energy (RE) systems. Eligible technologies included solar photovoltaics (PV), solar domestic hot water (SDHW), solar air heating, geothermal and wind turbines.

- Sponsored by MHO to evaluate Renewable Energy Initiative (REI) program in social housing
- Site visits, data review, and interviews

Key Lessons

1. Incentives should holistically consider different potential building energy upgrades – rather than targeting renewables alone.
2. Multiple examples of solar hot water systems not functioning effectively after installation.
3. Issues with housing provider capacity to manage new technologies. M & V needed to ensure systems function.

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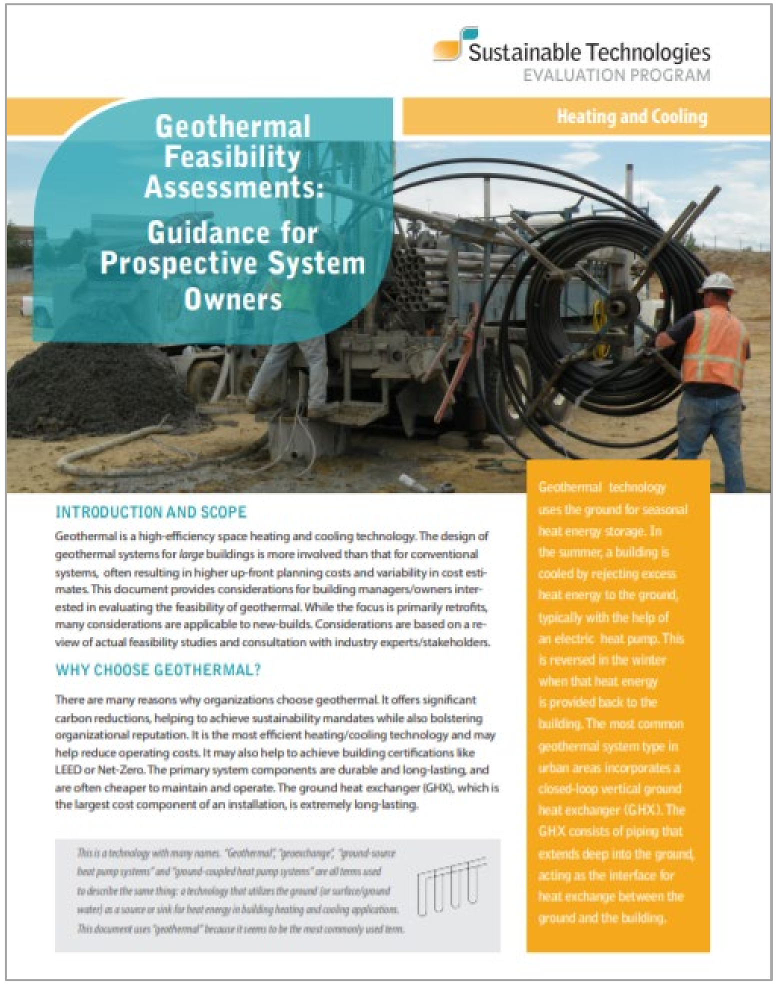
Geothermal Feasibility



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Heating and Cooling

Geothermal Feasibility Assessments: Guidance for Prospective System Owners

INTRODUCTION AND SCOPE

Geothermal is a high-efficiency space heating and cooling technology. The design of geothermal systems for *large* buildings is more involved than that for conventional systems, often resulting in higher up-front planning costs and variability in cost estimates. This document provides considerations for building managers/owners interested in evaluating the feasibility of geothermal. While the focus is primarily retrofits, many considerations are applicable to new-builds. Considerations are based on a review of actual feasibility studies and consultation with industry experts/stakeholders.

WHY CHOOSE GEOTHERMAL?

There are many reasons why organizations choose geothermal. It offers significant carbon reductions, helping to achieve sustainability mandates while also bolstering organizational reputation. It is the most efficient heating/cooling technology and may help reduce operating costs. It may also help to achieve building certifications like LEED or Net-Zero. The primary system components are durable and long-lasting, and are often cheaper to maintain and operate. The ground heat exchanger (GHX), which is the largest cost component of an installation, is extremely long-lasting.

This is a technology with many names. "Geothermal", "geoexchange", "ground-source heat pump systems" and "ground-coupled heat pump systems" are all terms used to describe the same thing: a technology that utilizes the ground (or surface/ground water) as a source or sink for heat energy in building heating and cooling applications. This document uses "geothermal" because it seems to be the most commonly used term.

Geothermal technology uses the ground for seasonal heat energy storage. In the summer, a building is cooled by rejecting excess heat energy to the ground, typically with the help of an electric heat pump. This is reversed in the winter when that heat energy is provided back to the building. The most common geothermal system type in urban areas incorporates a closed-loop vertical ground heat exchanger (GHX). The GHX consists of piping that extends deep into the ground, acting as the interface for heat exchange between the ground and the building.

- Large variation in findings of geothermal feasibility studies performed by different consultants
- Worked with Toronto and leading geothermal designers to harmonize RFP/RFQ requirements

Key Lessons

1. Many consultants are available to provide low-cost (low-quality) assessments.
2. Quality can be safeguarded through RFP/RFQ requirements.
3. Leading designers follow an iterative design procedure that provides a cost-optimized ground heat exchanger (GHX).

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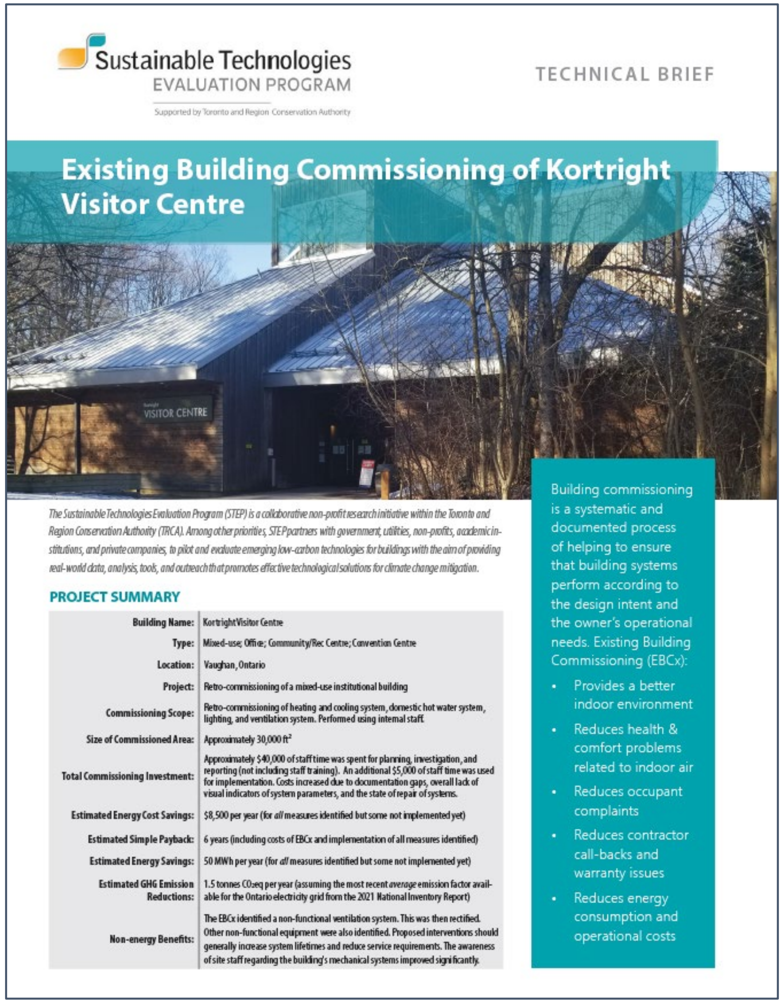
Existing Building Commissioning (EBCx) Kortright Visitor Centre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TECHNICAL BRIEF

Existing Building Commissioning of Kortright Visitor Centre

The Sustainable Technologies Evaluation Program (STEP) is a collaborative non-profit research initiative within the Toronto and Region Conservation Authority (TRCA). Among other priorities, STEP partners with government, utilities, non-profits, academic institutions, and private companies, to pilot and evaluate emerging low-carbon technologies for buildings with the aim of providing real-world data, analysis, tools, and outreach that promotes effective technological solutions for climate change mitigation.

PROJECT SUMMARY

Building Name:	Kortright Visitor Centre
Type:	Mixed-use; Office; Community/Rec Centre; Convention Centre
Location:	Vaughan, Ontario
Project:	Retro-commissioning of a mixed-use institutional building
Commissioning Scope:	Retro-commissioning of heating and cooling system, domestic hot water system, lighting, and ventilation system. Performed using internal staff.
Size of Commissioned Area:	Approximately 30,000 ft^2
Total Commissioning Investment:	Approximately $40,000 of staff time was spent for planning, investigation, and reporting (not including staff training). An additional $5,000 of staff time was used for implementation. Costs increased due to documentation gaps, overall lack of visual indicators of system parameters, and the state of repair of systems.
Estimated Energy Cost Savings:	$8,500 per year (for *all* measures identified but some not implemented yet)
Estimated Simple Payback:	6 years (including costs of EBCx and implementation of all measures identified)
Estimated Energy Savings:	50 MWh per year (for *all* measures identified but some not implemented yet)
Estimated GHG Emission Reductions:	1.5 tonnes CO_2eq per year (assuming the most recent *average* emission factor available for the Ontario electricity grid from the 2021 National Inventory Report)
Non-energy Benefits:	The EBCx identified a non-functional ventilation system. This was then rectified. Other non-functional equipment were also identified. Proposed interventions should generally increase system lifetimes and reduce service requirements. The awareness of site staff regarding the building's mechanical systems improved significantly.

Building commissioning is a systematic and documented process of helping to ensure that building systems perform according to the design intent and the owner's operational needs. Existing Building Commissioning (EBCx):

- Provides a better indoor environment
- Reduces health & comfort problems related to indoor air
- Reduces occupant complaints
- Reduces contractor call-backs and warranty issues
- Reduces energy consumption and operational costs

- Partially funded through NRCan
- Used existing TRCA staff to execute commissioning
- Provided staff with EBCx training

Key Lessons

1. Estimated energy savings of 25 MWh; GHG emission reduction of 7 tonnes eCO2/yr
2. Costs were reduced by an estimated $4,250 per year as a result of initial measures taken to address findings of the EBCx.
3. Further cost-savings are anticipated as implementation progresses.
4. Additional benefit of the internally led EBCx, engagement and capacity building of staff. Through project, staff gained understanding of site systems, which will result in increased operational efficiency moving forward

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Monobloc Heat Pump for Multi-Unit Residential Buildings

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TECHNICAL BRIEF

Real-world Efficiency of a Monobloc Heat Pump for Multi-Unit Residential Buildings

The Sustainable Technologies Evaluation Program (STEP) is a collaborative non-profit research initiative within the Toronto and Region Conservation Authority (TRCA). Among other priorities, STEP partners with government, utilities, non-profits, academic institutions, and private companies, to pilot and evaluate emerging low-carbon technologies for buildings with the aim of providing real-world data, analysis, tools, and outreach that promotes effective technological solutions for climate change mitigation.

INTRODUCTION

The Atmospheric Fund (TAF) has estimated that nearly a quarter of all multi-unit residential building (MURB) suites in Ontario are heated with electricity, primarily with electric resistance baseboards.[1] These systems are much less efficient than other electric heating options. Their low efficiency creates high operating costs for owners and reduces the grid capacity for the electrification of other buildings and sectors. Many of these buildings also have no central cooling or have relied on window air-conditioners, but window air-conditioners are now banned in some MURBs due to the risk of them falling from the window and causing injury or death. A compounding issue is that cooling is becoming increasingly critical for the health of MURB occupants as the number of heat waves and related health impacts are on the rise.

Retrofitting electrically-heated MURBs with heat pumps is a significant opportunity to drastically decrease utility bills for owners, reduce the demand on the electricity grid, and ensure occupant well-being. This study evaluated the heating efficiency of a new monobloc air-source heat pump (ASHP) for MURB applications. The heat pump was installed at the MURB Test Suite of the Archetype Sustainable House (ASH), located in Vaughan, ON (pictured above). The MURB Test Suite is 300 ft^2 and sits above a garage. It has a heat loss on the scale of an actual MURB suite and is used as a platform for evaluating suite-level MURB heating and cooling technologies. Using performance data collected at the MURB Test Suite during Winter 2021/2022, the ASHP efficiency was determined and used to predict the energy savings of retrofits in different cities across Canada.

Air-source heat pumps (ASHPs) provide high-efficiency heating and cooling for homes and buildings. In heating mode, they operate by extracting renewable heat energy from the outdoor air. In cooling mode, they function similarly to an air-conditioner. While many ASHPs are "split" systems, meaning there is an outdoor coil and an indoor coil, monobloc ASHPs package the components into one unit. In a multi-unit residential context, it typically sits on the inside of a suite with outside air ducted in and out. There are several advantages to this approach, especially when there is no balcony to place an outdoor coil.

- Tested at Archetype House, small 300ft2 unit above garage
- Monobloc – self contained unit, only 2 penetrations through building assembly
- Innova – from Italy, local distributor

Key Lessons

1. Not cold-climate; -10°C cut-off
2. Average seasonal COP of 1.66, Avg heating energy savings of 40%. Calculated over previous 10 yrs

- We are currently working with TAF on evaluating a larger MURB retrofit

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Current Projects

FQSF – TAF Contracted Chiller to Heat Pump Retrofit M&V

- First system of its kind in Ontario
- 2 MBTU (~166 ton) chiller. Replaced with 2 Mitsubishi Climaveneta Air-to-water heat pumps
- 86 Tons CO_2e Offset Annual Compared to NG Boiler

- Intent of influencing market actors and direct impact on uptake

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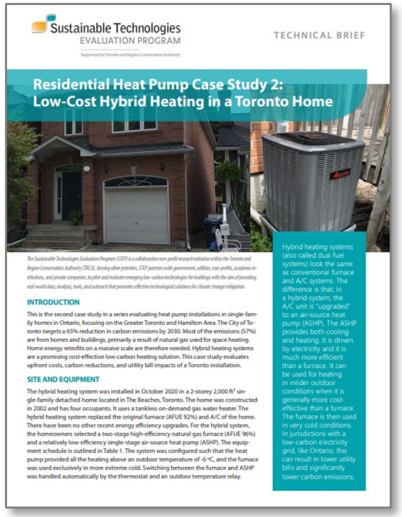
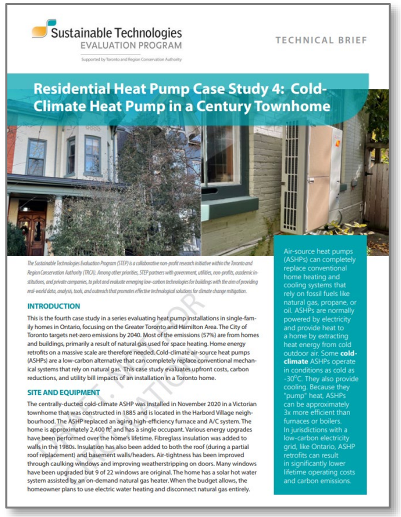
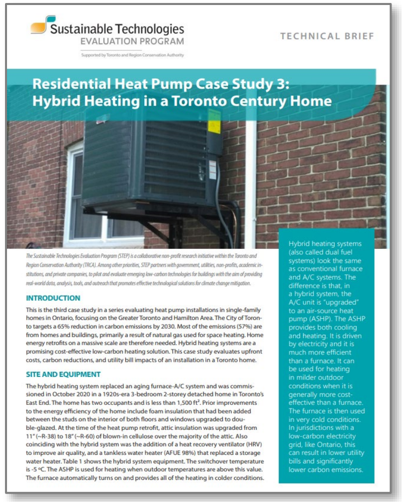
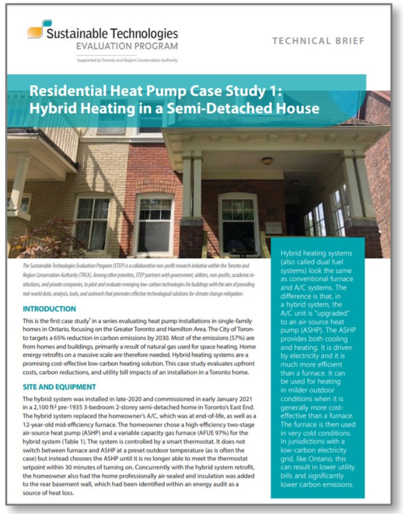
Residential ASHP Communications Campaign









- Partially funded through TAF and City of Toronto
- Ongoing project; Jan 2022 – Dec 2023
- Multi-faceted approach towards communicating the benefits of ASHPs and encouraging uptake
  - Homeowner, Energy Advisor and HVAC Contractor Surveys
  - Case Studies
  - Homeowner testimonial videos
  - Webinars for: Homeowner, Architect/Designer, HVAC Contractor, Decision Makers, etc.
  - Tutorials, Guidance documents for varied audiences
  - News-media articles
  - Social media push, including paid campaigns
- Intent of influencing market actors and direct impact on uptake

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Green Home Heating in the GTHA

Raising Awareness for Heat Pump Deployment in GTHA and Ontario Single-family Homes

Home energy retrofits are urgently needed on a massive scale to meet the ambitious carbon reduction targets being formulated by municipalities in the Greater Toronto and Hamilton Area (GTHA). Towards this end, air-source heat pumps (ASHPs) are a key retrofit technology capable of replacing or offsetting conventional carbon-intensive home heating systems.

Throughout 2022 and 2023, The Sustainable Technologies Evaluation Program (STEP) is leading a communications campaign to support the deployment of ASHPs in existing homes within the GTHA. Primary funding for this initiative is being provided by The Atmospheric Fund (TAF) with additional base funding support from The City of Toronto, Region of Peel, and York Region. Additional project partners include Enbridge, Durham Region, The Heating Refrigeration and Air-conditioning Institute of Canada (HRAI), The Clean Air Partnership (CAP), Windfall Ecology Centre, Imperial Energy, and the Sustainable Neighbourhoods Action Program (SNAP).

The initiative consists of three stages. In the first stage the STEP team will create cases studies of actual GTHA ASHP home retrofits from early adopters of the technology. The case studies will analyze pre- and post-retrofit utility bill data to calculate the energy savings, cost savings, and carbon reductions, as well as the overall business case for ASHPs. They will also document the homeowners experience with the retrofit process

Tell us Your Experience

Heat Pump Owner Survey
Please fill out this survey if you own a heat pump in the GTHA

Case Studies

Residential Heat Pump Case Study 1
400 KB PDF

Residential Heat Pump Case Study 2
1.5 MB PDF

Residential Heat Pump Case Study 3
400 KB PDF

Residential Heat Pump Case Study 4
500 KB PDF

Webinars

Air Source Heat Pump Webinar for Homeowners
Delivered to the Pocket Change Project

Air Source Heat Pump Webinar for Green Professionals
Delivered to the PEO Climate Change Group

Air Source Heat Pump Webinar for Contractors

Future Projects

Upcoming and Future Project Ideas

Hybrid ccASHPs

Hybrid ASHP with Hydronic Back-up

And/or CSA p.9-11

Heat Pump RTUs
Potentially Including Hybrid Options

Residential Thermal or Electric Demand
Shifting and Storage Technologies

Upcoming and Future Project Ideas

Heat Pump Pool Heaters

Commercial Air-to-water CO^2 DHW heat pumps

Heat Pump Water Heaters

High Temperature GSHP

Thanks!
Questions?
Ideas?

Gil Amdurski
Gil.Amdurski@trca.ca

For more information:
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