ENERGY X CHANGE

FINAL REPORT

August 2015

With support from the Donner Foundation and others, TAF has explored, quantified and described how heat exchange systems in urban settings -- ground-source, air-source or other heat/cool sources -- are key to achieving a low-carbon future.

TORONTO ATMOSPHERIC FUND

EnergyXchange - Final Report to the Donner Foundation

Toronto Atmospheric Fund (TAF) is pleased to provide this report on the work we have undertaken over the past two years to advance heat exchange systems in urban settings. We appreciate the support provided by the Donner Foundation focused on understanding and communicating the value proposition of this technology and its potential to reduce greenhouse gas (GHG) emissions.

This report summarizes the results of several TAF-supported research, analysis and communications projects. The main conclusion is that energy exchange – whether ground-source, air-source or other heat/cool source – is a key and strategic technology for achieving a low-carbon future. Energy exchange technology can dramatically reduce the use of natural gas for space heating and reduce the summer cooling load all while using zero-carbon renewable energy.

The Donner Foundation's contribution of $10,000 towards this work came at a key time, while TAF was exploring the value proposition, identifying and engaging the key stakeholders, and framing the issue and next steps needed to truly maximize the GHG reduction potential of this technology. This support has been highly leveraged already and with a significant new contribution from the IESO and several others, TAF is now working on-the-ground to develop technical, financial and policy tools for deployment of heat pump technologies.

Round-up of TAF EnergyXchange Projects

Project 1: Dan Leckie Forum 2012- *What Lies Beneath: Incorporating Geoexchange in Building Retrofits*

TAF's 2012 Dan Leckie Forum convened a veritable think-tank of industry experts to deliberate the opportunities and barriers for retrofitting existing urban buildings with energy exchange systems.

These five key areas were identified to help accelerate energy exchange system uptake:

i. Increasing awareness amongst all stakeholder groups about the opportunities that energy exchange offers;
ii. Increasing the availability of performance and business case information;
ii. Establishing excellence in technology delivery through effective training and regulatory standards;
iii. Developing financing options that leverage economies of scale and efficient structures (e.g. on-bill financing);
iv. Generate scale-up strategies that initially support retrofits in sites with high energy demand densities (e.g. multi-unit residential buildings, district energy opportunities).

Project 2: Performance assessment of Urban Geoexchange Projects in the Greater Toronto Area

TAF worked with the Toronto & Region Conservation Authority (TRCA) to monitor the performance of ten energy exchange installation projects in the Greater Toronto Area: 3 commercial, 3 institutional, and 4 residential with 8 vertical, 1 horizontal and 1 combined ground loop used. Several methods for improving performance have been identified including:

- Design the system to distribute work evenly amongst all heat pumps to ensure an optimized lifespan for the system;
- Incorporate Time-Of-Use (TOU) controls into the system to leverage potential electricity savings of up to 20 – 25%. Additional benefits of TOU controls include benefits to utilities by reducing peak period demand.

Project 3: Closing the Loop: A Survey of Owners, Operators and Suppliers of Urban Geoexchange Systems in the Greater Toronto Area

Based on the monitoring results, TAF worked with the TRCA research team to conduct a survey with energy exchange system owners, operators, and suppliers in the GTA to:

- Enhance understanding among key stakeholders of the opportunities and challenges for developing and implementing energy exchange projects in the GTA and Ontario.
- Identify key technical factors that affect the planning, design, implementation, and ongoing operation of an energy exchange system.
- Establish a reasonable understanding of the business case (i.e. project costs, simple payback) for implementing energy exchange systems in the GTA and Ontario.

Several important findings from the survey include:

1. **Reasons for implementing an energy exchange project:**
   - Helps achieve environmental sustainability goals
   - Commercial respondents stated an energy exchange system sends a message that the organization is a "green" brand; provides a competitive edge
   - Long-term energy savings
   - Improved thermal comfort due to the efficiency of energy exchange technology

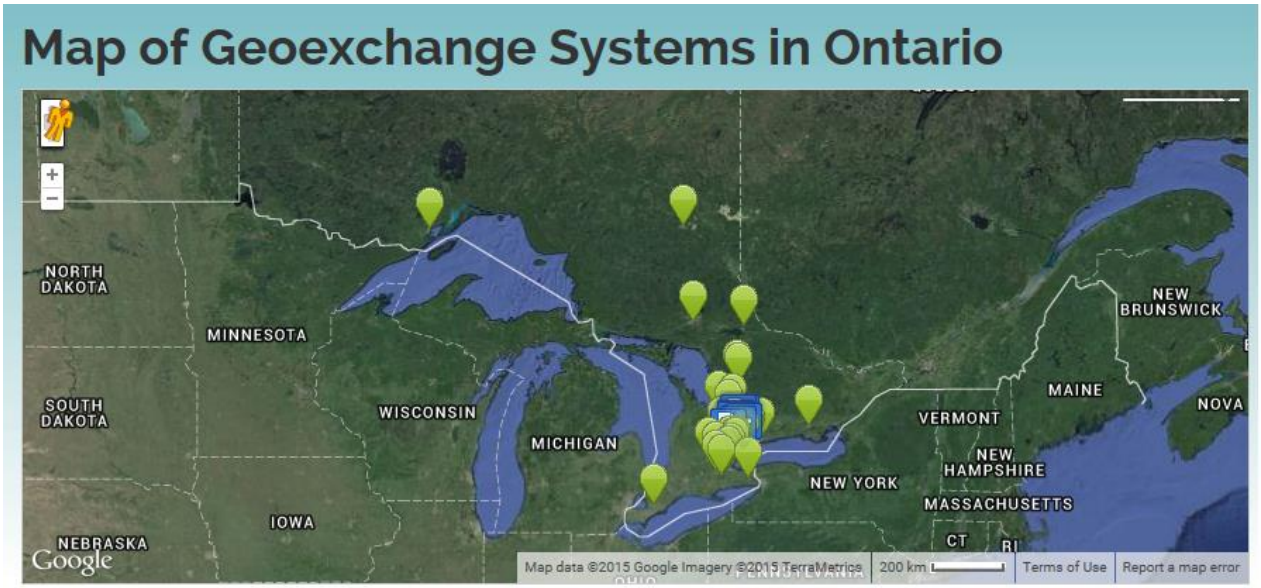
2. **Major risks to consider when implementing an energy exchange system:**
   - ***Environmental risk:*** What impacts will arise from drilling and long-term operation?
   - ***Financial risk:*** Will the real payback period become prohibitive?
   - ***Regulatory risk:*** How can one overcome the regulatory hurdles that might prevent a project from coming to fruition?

- ***Social risk:*** How can support be bolstered amongst all stakeholders?
- ***Technological risk:*** How much more efficient than conventional heating/cooling systems will the energy exchange system be?

3. **Key recommendations made based on challenges respondents faced or identified:**
   - Reduce costs by retrofitting an existing HVAC when it is due to be replaced
   - Size your system based on average load, not peak
   - Qualify your contractors/consultants expertise through references
   - Ensure system monitoring is conducted by qualified professionals. Proper post-project monitoring can result in significant savings. A crucial component of monitoring is to obtain pre-retrofit baseline data and compare that to the performance of the new energy exchange system. This can help to determine an appropriate operation plan.
   - An energy exchange system requires less maintenance than a conventional HVAC system. However inspecting and maintaining energy exchange systems regularly can prolong the life of the system.
   - Build capacity within the energy exchange industry through strategic collaborations and information sharing among regulatory bodies, energy exchange associations, academia, and industry that could foster training/apprenticeship opportunities and lead to the establishment of industry guidelines and standards.
   - Enhance outreach and communication to regulatory and municipal officials, innovative sectors (e.g. architecture), and utilities.
   - Improve existing regulations in order to limit market participation to only qualified professionals.
   - Strengthen the building code to require a higher energy efficiency standard.
   - Make operational energy exchange system data publicly available through a Ministry database to raise stakeholder faith in the business case of energy exchange and assess feasibility of their own planned project (e.g. size and type of system, borehole logs)
   - Develop robust incentive programs to support new energy exchange projects.

Project 4: Map of Ontario Energy Exchange Systems

To demonstrate that energy exchange is real and viable, TAF supported TRCA's development of the map below, which can be accessed here. It identifies the location of Ontario energy exchange systems along with short case studies on most of the Toronto area systems, which can be found here.



Project 5: Optimizing the Development of Earth Energy Systems in Urban Applications

TAF funded research by the Ryerson University Centre for Urban Energy (2014) to develop and validate a more rigorous, computational approach to optimizing the size and performance of a hybrid ground source heat pump (GSHP) system. Base load needs in a hybrid GSHP system are met with an energy exchange system, and peak demand is met with a conventional HVAC system.

The research team's methodology was tested on ten buildings including 3 commercial (restaurant, office), 3 institutional (transit facility, hospital) and 4 residential (mid-rise and high-rise). Sixty percent of the cases had eighty percent or more of their heating and cooling demand met, with eighty percent of the cases having seventy percent or more of their thermal energy demand satisfied.

The optimization program was intended to reduce the total costs of developing and implementing a hybrid GSHP system, while increasing the heating and cooling capacity. The research team found that using an optimization program like theirs can reduce installation costs, operation costs and the payback period significantly, as well as ensure the system meets a majority of the base energy load.

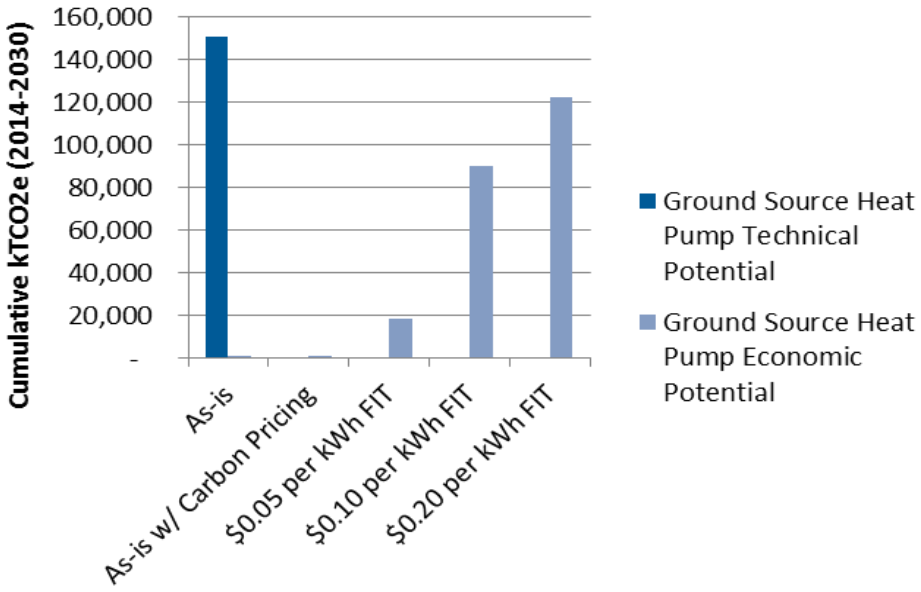
Areas for further research identified by the research team were questions regarding:

- What would happen if the optimization program was calibrated to be more sensitive to other criteria such as time-of-use electricity rates or annual weather data in varying locales?
- What potential savings would arise if multiple buildings in close proximity to each other shared one borefield via a district energy system?

Project 6: Quantifying the GHG Reduction Opportunity of Energy Exchange in Toronto

TAF, in partnership with Ernst & Young and ICF International, assessed the GHG reduction potential of deploying Ground Source Heat Pumps (GSHP) in Toronto. The technical potential (the level of GHG reduction that would occur if all technically feasible opportunities are applied) and the economic potential (the level of GHG reduction that would occur if all technically feasible projects achieve a particular economic threshold) were assessed. The latter included several market scenarios including: a "business as usual" scenario where no market interventions take place, one with carbon pricing, and another with a 'renewable heat incentive' at various levels.

This graph summarizes Toronto's technical and economic potential for energy exchange:



Project 7: Heat Pump Equipment Performance Assessment

A 6-person pro bono student consulting team from the Centre for Environment and Sustainability (CES) at Western University conducted a technology review of all manner of heat pump technology as their final year project. Their findings include the following:

- Potential for 66% GHG emission reductions by replacing conventional heating/cooling systems
- Due to spatial restrictions the most feasible option conducive to multi-unit residential building retrofits in urban areas (e.g. Toronto) would be water-to-air closed loop vertical systems
- Developing adjacent systems simultaneously would substantially reduce costs
- Incorporating time of use controls into the system design can potentially result in up to 25% additional electricity fuel cost savings
- Ground Source Heat Pumps (GSHP) have the highest operating efficiency but also the highest installation costs of any heat pump technology

Of particular interest to TAF was the report's identification of retrofitting electric baseboard systems in multi-unit residential buildings (MURB) as a highly viable short-term option for widespread heat pump implementation. Electrically-heated MURBs are an ideal entry point for heat pump system retrofits due to the relatively high cost of electric space heating, which improves the business case for heat pumps. Heat pumps can also provide air conditioning. This should make heat pumps even more important in the coming years as climate scientists estimate that summer temperatures in Ontario will rise due to climate change, increasing air conditioning demand. This will intensify issues of economic shocks from electricity price volatility (particularly with low-income groups), electricity grid strain, and increasing GHG emissions from natural gas "peaker plants" employed due to heightened need to meet growing peak demand.

Lessons and Insights

Based on TAF's work to advance and accelerate heat exchange systems in the urban context, we have identified several key lessons, challenges and areas for leveraging further understanding and deployment opportunities:

1. **Efficacy**
   - Heat exchange systems yield higher efficiencies than conventional HVAC systems.
   - Market stakeholders are calling for more technical and economic data regarding system performance in order to understand the business case and level of risk associated with developing/implementing heat exchange systems.

2. **Business Case**
   - Despite their high upfront costs heat exchange systems will generate long-term energy savings compared to conventional heating and cooling systems.
   - More education is needed regarding the value proposition of converting existing HVAC system to heat exchange systems.

3. **GHG Reduction Potential**
   - Ontario has a significantly underutilized ground- and air- resource, which has significant potential to reduce GHG emissions associated with building heating and cooling.

4. **Deployment Plan**
   - A particular segment of the existing building stock that shows promise for offering high levels of energy costs savings and GHG emission reductions is the electrically-heated multi-unit residential building sector.
   - More research and demonstration is needed regarding the opportunities and barriers for widespread adoption of energy exchange systems in Ontario, for instance documentation of real projects to leverage knowledge/understanding
   - Incentives and/or procurement (like a Feed-in-Tariff for heat) are needed, at least at the front end, to accelerate heat exchange systems in Ontario.

5. **Implementation Capacity and Oversight**
    - Academia and industry need to provide better learning, training, internship, and apprenticeship opportunities that would allow future heat exchange professionals to become recognized as being part of a specialized field of practice.
    - Regulatory bodies must set standards for the heat exchange industry (especially geoexchange) so that academia and industry will respond and adjust to enhanced requirements.

Financial Report

The Donner Foundation grant of $10,000 was utilized as follows:

- $5,000 to assess the energy/GHG reduction opportunity through our work with Ernst & Young and ICFI
- $5,000 for development of presentations, proposals, convening and dissemination of the case/value proposition for energy exchange, which assisted in leveraging significant additional funding and generated interest amongst key stakeholders

Tours of energy exchange facilities were conducted by TRCA, which did not require expenditure of the funds budgeted for this activity ($2,000).

TAF's Next Steps to Advance the Low-Carbon Potential of Heat Pumps

TAF is committed to further investigating and advancing heat exchange in the context of a low-carbon economy. Leveraging the expertise and insights we've accumulated with support from the Donner Foundation, as well as from Hydro One, TAF has developed and secured almost $400,000 in funding for a project to actually plan, cost and analyze the technical and business case for retrofitting eight electrically-heated multi-unit residential building (EMURBs) with heat exchange systems, and propose programs (technical, financial, etc.) that would assist in accelerating uptake in this sector. "Pumping Energy Savings: Advancing the Conservation Opportunities of Air &Ground Source Heat Pumps in Electrically-heated Multi-unit Residential Buildings (EMURBs)" is funded by IESO Conservation Fund ($260,700), and several utilities (Horizon, Toronto Hydro) and Ontario Property Management Group (totalling $120,000).

TAF, along with the City of Toronto, have launched a new initiative focused on positioning and guiding Ontario's largest city towards its target of reducing carbon emissions by 80 percent by 2050. TransformTO will employ long-range greenhouse gas reduction modelling to identity key actions that would result in significant carbon cuts and mobilize all stakeholders in implementation. A review of low-carbon plans from cities around the world indicated that energy exchange is a key mechanism for achieving ambitious reduction targets because it is an efficient energy system utilizing renewable resources (latent heat). Energy exchange is well-suited to become a major asset to Toronto's low carbon future.

The Ontario government's climate change action plan is another opportunity to accelerate energy exchange, and Minister Glenn Murray is a strong champion of this technology, having been involved in Manitoba's program when he was Mayor of Winnipeg. Similarly, deployment of heat pumps is one way to implement the Minister of Energy's direction to the Ontario Energy Board to implement the "Conservation First" policy and to integrate gas and electricity conservation.

Thank-you

Toronto Atmospheric Fund is committed to pursuing the researching, knowledge-sharing, policy reform and financial innovation related to implementation of energy exchange in order to dramatically reduce carbon emissions associated with existing buildings. The Donner Foundation's support in the early stages of this work is very much appreciated.

Sincerely,

Julia Langer, CEO