Finding Ways to Say ‘Yes’[1]

Report of the Laurier Avenue Geothermal Project
to
Live Green Toronto
Toronto Environment Office, City of Toronto
September 30, 2010

Introduction:
The Laurier Avenue Geothermal Project was conceived in 2007 amidst the growing societal awareness that, if left to continue unabated, our carbon-based, energy-intensive economy would threaten health and wellbeing. In response, a group of residents on Laurier Avenue (a cul-de-sac in the Victorian neighbourhood of Cabbagetown), envisioned a project to research the potential of energy-efficient retrofits that would use renewable, low-carbon fuels. There was a desire to ‘do our bit’ toward stemming the problems of climate change and pollution, while preserving our quality of life. We wondered further whether the goals of energy-efficiency and reduced carbon intensity could be combined with the aim of reducing long-term operating costs of our houses.

Taking a lead from the City of Toronto’s *Climate Change Action Plan* and the *Live Green Toronto Community Investment Program*, this project reflects the perspective that there is more than enough science to warrant the adoption of the “precautionary principle” regarding renewable energy, conservation and reducing carbon intensity. With funding provided by the *Live Green Toronto* program, our project aimed to become an information resource and prototype for energy retrofits in the city.

As residents of a heritage district built in the 1880s, we could see the value of upgrading our old buildings for energy efficiency (such buildings are notoriously energy inefficient). These retrofits would not only improve the operation of the buildings, but they would also demonstrate that Toronto’s heritage architecture (built from the mid 19th century to the 1980s and all reflecting different aspects of the layered histories of this city), can be preserved and made energy-efficient while enhancing the City's unique character as a city of neighbourhoods. We realized that, if this approach to retrofitting heritage homes was successful in Cabbagetown, then it could be applied to heritage districts across the Greater Toronto Area (GTA).

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[1] The title of this report, *“Finding Ways to Say ‘Yes’”*, was inspired by Pam McConnell, our City Councillor, who convened and chaired a meeting with City staff from various departments regarding the Laurier Avenue Geothermal Project. She introduced the project as a citizen-initiated, forward-looking approach concordant with the aspirations of the City and then encouraged everyone to “find ways to say ‘YES’” to advance the project from an idea to a reality.

According to City plans, the goal has been set to reduce greenhouse gas emissions by 80%, below 1990 levels, by 2050. In a report produced by the Toronto City Summit Alliance, it was asserted the some 23% of Toronto's carbon emissions come from residential buildings. It would be hard to argue that the goal of an 80% reduction of GHG emissions can be achieved without the virtual elimination of fossil fuels for residential use. To this end, the Laurier Avenue project serves to help shine a light on the challenges and opportunities of conducting energy-efficient, low carbon retrofits in privately owned buildings that use fossil fuels for heating.

Who has been involved?
In the Summer of 2007, Douglas Worts asked Laurier Avenue neighbours about their interest in exploring geothermal heating/cooling systems for homes on the street. There was interest expressed by a number of neighbours, which lead to Worts arranging for a geothermal heating/cooling contractor to provide an evening seminar on the topic – that was held January of 2008. Sameer Dhargalkar, who works in the 'clean-tech' industry, joined with Worts to seize the funding opportunity presented by the City of Toronto's *Live Green Toronto* initiative. They also consulted with the City of Toronto's Office of Energy Efficiency, which was very encouraging of pushing forward with a proposal to explore the viability of using geothermal technology in residential retrofit applications.

Meanwhile, conversations with Lee Garrison, then President of the Don Vale Cabbagetown Residents Association (DVCRA), lead to a formal relationship being created that enabled the Laurier Avenue Geothermal Project to be submitted, under the name of the DVCRA, to the *Live Green Toronto Community Investment Program* for a project grant. This grant was awarded in October of 2008 for the undertaking of a feasibility study of geothermal retrofits, supplementary renewable energy systems, resurfacing the street with a permeable surface that would retain ground-water run-off, as well as exploring financing models for these types of retrofits. The Laurier Avenue Committee expanded to include representatives from the street (Douglas Worts, Mark Henschel, and Toby Barwick – as a result of a new baby in his family, Sameer Dhargalkar remained only marginally involved) and members of the DVCRA (Lee Garrison, Douglas Rowlands, and, later, Lee Matheson).

The project required engineering consultants and, after issuing a call-for-proposals, a team lead by ResCo Energy Inc (David Booz, Fidel Reijerse and Robert Mancini) was selected from amongst the submitting candidates.

Mark Henschel and Douglas Worts have worked closely with the consultants to arrive at the final technical report, see Appendix A.

Description of the Street:
Houses on Laurier Avenue are made up of two rows of row housing, all built in 1888. There is one set of 11 houses on the east side of the street and a mirror set on the west side – for a total of 22 houses. Each property has very little property in front. In fact, once

the street set-back of 16 feet from the centre of the street is calculated, each house has about 5.25 feet of private property fronting on Laurier Avenue. Because of this, the project was designed to explore the potential of drilling the 4" diameter, 540 foot-deep wells - one for each of the houses opting for a geothermal system - on city property. This would be under either the road or sidewalk.

All of the houses have virtually identical footprints – with the North-end houses being slightly different.

Opportunities Identified:
When the Laurier Avenue study began, it aimed to investigate the potential of retrofitting buildings with geothermal systems that would replace existing oil or natural gas furnaces as well as conventional air conditioning systems. Geothermal technology exploits the heat energy stored in the earth to warm buildings during cold months, and to cool them in summer. Along the way, we learned that a new generation of 'air-source heat pump' technology had become available. Air-source heat pumps are able to extract warmth out of minus 30 degree Celsius temperatures, and can obtain cooling out of plus 30 degrees Celsius air. As a result, we added this new technology to our project so that it could be compared to the geothermal systems and to high-efficiency gas furnaces.

The results of the study are clear… that geothermal systems offer:

1) the most efficiency in heating/cooling -- nothing beats three units of energy produced for each unit expended to deliver it;
2) geo-exchange can be as GHG free as the electricity used to run it; and
3) it is a commensurate means for safeguarding the valuable cultural capital the City has in its Heritage Districts which make an irreplaceable contribution to the City's unique character.

Essentially, the GHG emissions associated with geothermal come from two sources – the fuel spent in the drilling process and whatever portion of the electricity grid is powered by fossil fuels. The air-source heat-pumps do seem to work well in Toronto's climate, but they are not as efficient as geothermal options, which means that they use significantly more electricity to operate.

In recent years, all levels of governments have been convinced about the value of improving energy efficiency wherever possible, both through energy conservation strategies and through the use of efficient energy technologies. Accordingly, municipal, provincial and federal governments developed incentive programs to encourage Ontario citizens to become 'early adopters' of these technologies (Note: the Government of Canada has recently cancelled its eco-energy incentive program). These incentives, which are outlined in Appendix A, are significant for the geothermal systems, and quite small for the air-source heat-pumps, which will be a consideration for anyone considering retrofitting their home.

While the results of this study will certainly be helpful for Laurier Avenue residents, they are also of great value for all residential homeowners. Relevant information, guidelines and resources related to geothermal retrofits may be most valuable for those who can put drill-holes on private property. At this point in time, it is significantly more complex and expensive for those individuals considering geothermal but who cannot access private land on which to place the drill-holes. There are many obstacles to locating drill holes on City property (more on this below).

When considering the context of the City's goal of 80% reduction of GHG emissions by 2050, one opportunity that comes more clearly into focus as a result of having gone through the Laurier Avenue Geothermal process is that there is great potential for the City to build geothermal drill holes into the roadway infrastructure. Providing access to a system of geothermal wells would offer citizens an attractive option for weaning themselves off oil or gas based heating/cooling systems. The City has already established a precedent in this sort of enterprise – specifically its membership in the consortium that developed and implemented the Enwave deep-water cooling system. Enwave has won worldwide acclaim for its pioneering work in using the embodied energy stored in the deep waters of Lake Ontario as a source of cooling large buildings in the downtown core. Installing a system to take advantage of ground-source energy is a logical extension of the success of Enwave.

Obstacles:

There are several obstacles that have been scoped through this project, some of which have been referred to above. **High capital cost** of a geothermal systems is certainly a major impediment. However, existing government grants have helped to overcome this problem. The impact of these costs can also be managed through **financing options** that are based on paybacks that are tied to the increased efficiency and related cost savings of operating the heating/cooling systems. This means that the loan for a geothermal system can be set up so that a homeowner pays no more than what they were originally paying to heat/cool their house, with the increased efficiency of the new system generating the money that pays down the loan. It would be ideal to have the financing costs attached to the property tax for any home that undergoes this type of retrofit – to be paid down over time, after which the tax rate would return to its normal level. This remains a discussion that is underway within the City of Toronto, but at this moment it is not available. Until it is, financing will have to be found privately.

Perhaps the biggest impediment that lies ahead for Laurier Avenue residents is the array of **fees, approvals and studies** that are currently associated with installing a geothermal system that uses the road-allowance set-back for the drill holes. Because there is no existing framework for reviewing and approving this type of use of City property, the demands of a variety of departments combine to discourage even the most dedicated of enthusiasts for renewable energy. These fees are identified in some depth in Appendix A.

With regard to the potential use of solar or other renewable energy source to address the electricity needs of the geothermal systems, it was determined that the location and orientation of Laurier houses does not lend itself to the implementation of effective systems for collecting energy from solar or wind. While this may be true for Laurier Avenue, other communities might readily develop implementations that more closely approach the ideal of sustainability and self-sufficiency even to the point of producing more energy than they consume. What is an obstacle on Laurier Avenue may constitute an opportunity for many neighbourhoods across the City.

Next steps:

From the perspective of Laurier Avenue residents, the next step is to review in depth all the technical data presented in the technical study. This will lead naturally to discussing with the City how best to address existing obstacles to the installation of geothermal systems. If the obstacles to installing geothermal systems on Laurier Avenue can be removed in the short term, then those Laurier residents who are ready to proceed will need to do so before March 30, 2011, when the federal eco-energy program officially ends for those who have already had their eco-energy audit completed before March 30, 2010.

A new website is under construction that will ensure that the information available through the Laurier Avenue Geothermal Project is available to anyone who has an interest. It can be accessed through www.greenlaurier.ca.

Final Thoughts:

For those who have been involved in this project, it has been a very rewarding experience. Not only have we all learned a great deal about the complexities of heating/cooling buildings, but also how new technologies are providing many tools to address the emerging problems of the 21st century. The City of Toronto has provided many examples of leadership in how to transform a community from one that is clearly unsustainable to one that has a chance of being sustainable. We hope that others will find the work done by the Laurier Avenue Geothermal Project to be useful in bringing about meaningful and positive change.

The Laurier Avenue Geothermal Project Committee would like to thank the Don Vale Cabbagetown Residents Association for their help in facilitating the funding process of this report. From early stages of this project, DVCRA board members, especially Douglas Rowlands, Lee Garrison and Lee Matheson, provided essential and active support. We look forward to working with the DVCRA to help other Cabbagetown residents explore the potential of 'greening' our neighbourhood.

Prepared by Douglas Worts and Mark Henschel
September 2010

Appendix 1

RESCo Energy Inc

Laurier Avenue Geothermal Study

Final Report

For:

Don Vale Cabbagetown Residents Association, On behalf of the Laurier Avenue Geothermal Project Committee

17 Sackville Street
Toronto, Ontario

September 10, 2010

The Laurier Avenue Geothermal Study is supported by a Live Green Toronto Community Investment Program grant from the City of Toronto

This report is presented for the sole purpose of the Don Vale Cabbagetown Residents Association and the Laurier Avenue Geothermal Project Committee's evaluation and does not constitute a design nor does it endorse any of the proposals from vendors attached to this document. All information is based on information available at the time of reporting, which is subject to change. RESCo Energy Inc. assumes no responsibility or liability for decisions made by the Don Vale Cabbagetown Residents Association and the Laurier Avenue Geothermal Project Committee based on the contents of this document.

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EXECUTIVE SUMMARY

Laurier Avenue Residents, in collaboration with the Don Vale Cabbagetown Residents Association Inc., engaged RESCo Energy Inc. (RESCo), in partnership with Booz Engineering and R. Mancini & Associates, to prepare and deliver an engineering study on the feasibility of using GeoExchange heating and cooling for the heritage homes in the Laurier Avenue neighbourhood. This project has been made possible by a grant through the Live Green Toronto program, which is a project of the city's Environment Office.

The major objective of this study was to evaluate geothermal heating and other energy efficiency technologies for their applicability to the needs of the residents of a heritage neighbourhood in downtown Toronto. A secondary aspect of the study is to assess possible ways to retain ground-water run-off by providing permeable pavement solutions to road reconstruction. Aside from the comparative assessment of available technologies, there are political, bureaucratic, legal and financing dimensions of this project.

Baseline data was collected on the homes, and a number of homes had EcoENERGY audits. The energy efficiency of the homes is generally low, with heating systems that are not adequate to condition the upper stories. Because the houses are small and fully attached, however, utility costs are generally modest.

GeoExchange systems are efficient and effective, however they are capital intensive, and there currently are significant challenges to these systems in an urban environment. These challenges include bureaucratic challenges to using City property for borefields, heritage issues, archaeological preservation, and financing.

There are a number of additional energy efficiency technologies that have been explored here, including air source heat pumps, home air sealing and insulation upgrades, and high efficiency hot water systems. Site conditions significantly constrain the opportunities for electricity generation using renewable energy.

Within the context of Toronto's ambitious targets for achieving widespread energy-efficiency and reductions in greenhouse gas emissions, the City will have to find ways to reduce bureaucratic barriers to citizen initiatives like this one - replacing such barriers with incentives. This will take extraordinary resolve on the part of citizens, politicians and city employees - in imagination, policy innovation, and procedures that will help facilitate the implementation of novel ideas.

OBJECTIVES

The Don Vale Cabbagetown Residents Association Inc., on behalf of Laurier Avenue Geothermal Project Committee, engaged RESCo Energy Inc. (RESCo) and their partners Booz Engineering and R. Mancini and Associates Ltd to study the opportunities for geothermal systems for the Laurier Avenue community in Toronto. The objective of this study was to evaluate geothermal heating and other energy efficiency technologies for their applicability to the needs of the residents of a heritage neighbourhood in downtown Toronto.

This also included options for innovative financing solutions to help 'early adopters' shoulder the high capital costs of these energy efficiency solutions. Further, the study was to identify options for introducing permeable road re-surfacing on Laurier Ave, so as to help retain ground-water run-off and keep it out of the storm sewer system.

The additional objective of this study was to encourage the development of municipal policies that would support innovative energy efficiency technologies and projects that have the potential to improve the energy efficiency of heritage homes, thereby ensuring their viability in an energy and carbon-constrained society.

BACKGROUND

LAURIER AVENUE COMMUNITY

Laurier Avenue is a distinctive community of 22 row houses on a cul-de-sac in the heart of Cabbagetown, built in 1888. With 11 identical, handsome homes on each side of the road, it is a very fine community of Victorian row houses, generally in good and apparently original condition.

The residents of Laurier Avenue are generally interested in sustainability and exploring the challenges and opportunities of making their homes more sustainable by adopting environmentally friendly heating and cooling opportunities such as GeoExchange systems. There is a high level of interest among the residents of Laurier Avenue, which makes the street a very good candidate for prototyping urban retrofits for sustainability.

The Laurier Avenue Committee, (Douglas Worts, Mark Henschel, Sameer Dhargalkar and Toby Barwick) made inquiries with the Toronto's Environment Office and its Energy Efficiency Office and developed a proposal for an engineering study to explore GeoExchange systems and other sustainable technologies. The proposed demonstration project supports the mandate of the City's Climate Change Action Plan, led by the Toronto Environment Office, and resonates with the mandate of the Energy Efficiency Office. With encouragement from both groups, an application was submitted to the Live Green Toronto Community Investment Program for a feasibility study project. Funding was approved for the Don Vale Cabbagetown Residents Association (DVCRA) to oversee the feasibility study project.

Figure 1 - Laurier Avenue

Building & Systems

The 22 homes of Laurier Avenue are row houses, with 11 on each side of the street. Each of the row houses has virtually the same footprint, with about 1,500 square feet of living space. The houses of Laurier Avenue have all been renovated to contemporary living standards, and all are heated with either natural gas or oil. Most of the houses currently utilize air conditioning systems.

The energy efficiency of the Laurier Avenue homes is generally low. These homes were originally built with little or no insulation, and fairly poor air sealing. Over time, many of the homes have had some insulation added and some air sealing.

Being row houses, most of the homes only have two outside walls, with the end units on each row having three.

Additional data was gathered on the heating, ventilating and air conditioning (HVAC) systems and insulation for each home. Several homes had EcoENERGY audits completed. This information is detailed below.

Heritage Conservation and Sustainability

Cabbagetown North is a ‘Heritage Conservation District’. A heritage conservation district is comprised of a collection of buildings, streets and landscapes that together give an area a special character that distinguishes it from other areas in a municipality. Cabbagetown North’s character is derived from the overall quality of the architecture, the integrity of form, the history of development, its residents, the aesthetic value of the public streetscape and the private landscapes.

As part of the HCD, Laurier Avenue homes are protected from changes that will change the heritage character of the street. HCD status protects anything that is visible from the public right of way, as well as maintaining the structural integrity of the homes.

While these homes are valuable heritage properties, the fact that they are energy inefficient poses a danger. As we move into a fossil fuel and carbon-constrained future, homes that are not energy efficiency will no longer be viable residences. Much of

Toronto is made up of heritage buildings in vibrant neighbourhoods that cannot, and should not, be demolished in order to build new structures. To preserve the heritage of the City, it is essential to upgrade these energy inefficient homes to ensure they remain viable in a fossil fuel and carbon constrained future.

RESCo Energy Inc. & DVCRA Project Partners

RESCo Energy Inc. (RESCo) is a turnkey provider of renewable energy systems for buildings. RESCo provides feasibility studies, design, construction management, supply, installation, and commissioning services to its partners and clients. RESCo has a strong history of providing these services to co-op, non-profit and corporate clients.

David Booz of Booz Engineering has extensive experience in renewable energy, home energy efficiency, and community energy projects. David is a LEED AP and has extensive knowledge of green buildings. David is a Mechanical Engineer with over 20 years of experience in capital equipment and project management.

Robert Mancini of R. Mancini and Associates Ltd has been designing GeoExchange heat pump systems since 1982. Mr. Mancini is well known to the industry both in Canada and the United States primarily serving the increasing demand for GeoExchange design and technical assistance across North America. This firm has been involved in the design of large single family residences, multi-family residences, schools, office buildings, theatrical/musical performance centers, prisons, large retail outlets, libraries, museums, utility service facilities, aircraft service facilities, etc.

Study Goals

The goals of this study as specified in the RFP documents included:

- Define baseline condition of homes on Laurier Avenue.
- Evaluate GeoExchange as a potential HVAC technology for urban retrofit applications.
- Evaluate air source heat pumps as another potential HVAC technology for urban retrofit applications.
- Explore opportunities for supplementary electricity generation.
- Explore other energy efficiency technologies applicable for heritage retrofits.
- Examine the potential for replacing asphalt with permeable road resurfacing.
- Identify and explore challenges and opportunities to energy-efficient retrofitting.
- Identify financing opportunities for retrofits.
- Explore challenges and opportunities of working with the City.
- Demonstrate that GeoExchange is a viable home heating & cooling technology for urban retrofit applications.
- Prototype energy efficiency retrofits to urban heritage neighbourhoods.
- Address challenges of the sustainability of heritage homes.
- Explore public benefit of sustainability in heritage homes.

This project was driven by a combination of hard and soft goals. The hard goals were to evaluate the feasibility of certain energy efficiency opportunities for an urban heritage community, including GeoExchange, air source heat pumps, supplementary energy generation, etc.

The soft goals were to explore the bureaucratic and administrative challenges and opportunities of upgrading heating/cooling systems in these homes to increase their sustainability – not just by decreasing their fuel requirements, but also by decreasing their environmental impact to ensure they remain viable residences in a carbon and fossil fuel constrained future.

Although there was considerable interest in geothermal technologies amongst Laurier Avenue neighbours, nobody was in a position to commit to such a retrofit until all the underlying issues were identified and a cost/benefit analysis was conducted. Once such an analysis was conducted, it was clear that residents across the GTA would benefit from the information in the report and be able to move towards addressing the widespread phenomenon of energy inefficiency within older Toronto buildings.

About This Report

The report represents the portion of the feasibility related to the technical, bureaucratic and financial aspects and specifically excludes any legal assessments. This report is presented in the following sections:

- Baseline Data
- GeoExchange Feasibility
- Air Source Heat Pump Feasibility
- Additional Opportunities
- Economics
- Conclusions
- Recommendations

BASELINE DATA

INTRODUCTION TO UNITS

The heating and ventilation industry in Canada uses both Imperial and Metric unit systems (and sometimes a combination of both). These different unit systems can be confusing to people who are not familiar with them.

We have used the metric system wherever practical, including kilowatt for power (kW) and kilowatt-hour for energy (kWh). There are, however, some other units that the reader should be familiar with.

Many HVAC systems are sized in British Thermal Units/hour, or Btu/hour.

- 3,413 British thermal units/hour (Btu/h) = 1 kW.

A commonly used unit in sizing air conditioning is the tonne of heating or cooling.

- 1 tonne of heating or cooling = 12,000 Btu/hour = 3.5 kW

Please note that the capacity of a heating or cooling system does not necessarily translate directly into energy consumption and/or carbon emissions due to the varying efficiency of the systems.

Large quantities of energy are measured in megawatt-hours, or MWh:

- 1 megawatt-hour (MWh) = 1000 kilowatt-hours (kWh)

The carbon content of the electricity coming from the grid can be difficult to determine, since the sources of electricity generation vary from time to time. The majority of the electricity in Ontario comes from nuclear and hydro, which are generally considered to be carbon free (or at least very low). According to the Independent Electricity System Operator, generation sources for electricity in April 2010 were:

Nuclear	6.1 Terawatt-hours	54%
Hydro	2.6 Terawatt-hours	23%
Coal	0.6 Terawatt-hours	5%
Other	1.6 Terawatt-hours	14%
Imports	0.4 Terawatt-hours	4%

Note that "Other" includes generation from natural gas, oil, and renewable energy (excluding hydro).

The carbon content of fossil fuel generation is:

- Natural Gas Generation: 0.491 tonnes CO_2/MWh equivalent
- Coal: 0.983 tonnes CO_2/MWh equivalent

The carbon content of grid electricity in Ontario is approximately 0.201 tonnes CO_2/MWh (1000 kWh), according to RETScreen 4, which is an industry standard renewable energy modeling tool published by Natural Resources Canada.

BASELINE DATA STUDY

A baseline data study was conducted in order to understand where the Laurier Avenue community is today with respect to energy efficiency. This section highlights the challenges and opportunities of upgrading these homes, showing which modifications make sense and which modifications are not justifiable.

To establish this baseline, the study included:

- Homeowner questionnaire
- EcoENERGY home audits

Additional background conversations were also had with representative of the City of Toronto on this type of project in order to determine what the residents of Laurier Avenue would need to do to proceed with implementing the results of this project. These conversations included:

- Meeting with the Department of Right of Way
- Speaking with Toronto Heritage
- Speaking with Toronto Archaeology

Details of these background data collection tasks are shown below.

HOME OWNER QUESTIONNAIRES

The Study Team, (David Booz, Robert Mancini, and Fidel Reijerse), working closely with the Laurier Avenue Study Project Committee, has collected and analyzed data on the current state of the Laurier Avenue homes.

A detailed questionnaire was developed and distributed to all residents of Laurier Avenue. This questionnaire included both subjective information, such as the general level of comfort in the home, as well as objective information, such as a summary of energy usage contained in utility bills. The challenge with such a questionnaire is that individual respondents likely have different technical levels of understanding. However, it is a very valuable snapshot of the community was gained by collecting this data, which provided useful information to the Study Team.

The key items in the questionnaire were:

Does your home feel comfortable? There were a range of responses to this question. One homeowner claimed their entire home was comfortable all of the time. Most homeowners claim the first and second floors are comfortable. Many, however, found their third floors hot in the summer and cold in the winter. Basements were generally comfortable in the summer; however, in the winter only half of the respondents said the basements were comfortable.

Type of Heating: All the homes have forced air heating.

Heating Fuel: 12 homes use gas, 2 homes use oil, 1 uses electric heat.

Air vents: Ranged from a low of 8 to a high of 15, with an average of 11. The condition of the existing ventilation system may have an effect on the viability of heating with a heat pump (either geoexchange or air source). A heat pump delivers lower temperature heat than a furnace, so it needs to deliver a higher quantity of conditioned air which can require a larger ducting system.

Air returns: Ranged from a low of 1 to a high of 4, with an average of 2.

Electrical Service: 5 homes have 100 amp electrical service, while 6 have 200 amp. Note that an 100 amp service is unlikely to be sufficient for a GeoExchange heat pump with electric resistance auxiliary heater (see below for details).

See the attachments for a detailed summary of all of the results.

The information on utility consumption (gas, oil, and electricity) was also very interesting.

Eight homes provided useful information on natural gas consumption. Natural gas consumption in 2009 varied from 1920 m3 up to 2778 m3, with an average of 2335 m3. Part of this was due to the varied uses of natural gas – specifically, gas is used to varying degrees for space heating, water heating, drying clothes, barbeques, etc.. Based on an estimated price of $0.386 per m3, the average house spent $901 in the year on natural gas. Gas consumption was high in the winter and low in the summer, which is consistent with gas-fired space and water heating. Consumption data from homes on the west side of the street was 24% higher than the homes on the east side of the street. This may be due to the prevailing winds coming from the west, causing these houses to lose more heat and need additional fuel to keep them at a reasonable temperature.

While two homes reported having oil-fired heat, only one reported their consumption: 1,208 litres of heating oil in 2009. Based on an estimated price of $0.804 per litre, they spent $971 in the year.

Twelve homes provided useful information on electricity consumption for 2009. There was a very wide range of electricity consumption reported, from a low of 3,483 kWh to a high of 11,181 kWh – a range of more than 320%! The average for the 12 homes was

6,755 kWh, representing a cost of $980 per year, based on an average price for electricity, including all charges, of $0.145 per kWh. Again, the west side of the street used more electricity than the east side, but only 8% more, a difference that we don't consider significant, especially given the wide range of individual home consumption.

As should be expected with a group of older homes, the condition of the homes varies widely. Some have had significant renovations in the recent past that significantly improves their energy efficiency. Others have had few upgrades to their building envelope (insulation, upgraded windows) or their utilities (furnace, electric service).

The existing HVAC systems in the homes generally are not adequate to heat or cool the top floor of these homes, most likely due to the inadequacies of the ductwork in the homes (see below). Another candidate for the cause of this is inadequate wall insulation and particularly ceiling/attic insulation. Basements also have inadequate insulation, which affects the level of comfort.

The forced air heating systems in many homes are not optimized for maximum comfort and ventilation. For optimal ventilation, each room in the home should have supply and return ducts to allow a free flow of conditioned air through each room. Few homes enjoy this level of ventilation, particularly old houses with retrofitted heating and cooling systems. This is seen most glaringly in the shortage of air returns, which serve to pull the air out of spaces, allowing newly conditioned air to flow in.

The condition of the ventilation system in each home may prove to be an additional challenge for retrofitting a heat pump based HVAC system into these homes. A heat pump delivers lower temperature heat than a furnace, so it needs to deliver a higher quantity of conditioned air.

ECOENERGY AUDITS

To supplement the questionnaire, it was encouraged that residents have a home energy audits performed under the EcoENERGY Retrofit – Homes program.

Seven homes had assessments performed. Four of these assessments were performed specifically for this study and three homes had audits performed by other home energy auditing firms and the results provided to the Study Team.

The EcoENERGY ratings for the seven homes evaluated ranged from 63 to 5, averaging 39.1. This is slightly higher than the average rating of 34.6 for the 108 homes evaluated by the HVRA HERO project.

Heating system upgrades were recommended for six of the seven audited homes – GeoExchange systems for the five homes audited after this study was started, and a high efficiency gas furnace one of the two homes audited before this study began. The energy efficiency improvement opportunity provided by replacing the heating systems is significant – an average improvement of 21.6 points for the GeoExchange systems, and a potential improvement of 21.7 points for the gas furnace, which is more than half of the average home rating (39.1)

After the heating system upgrades, the next most significant upgrade recommended was air sealing. As a rule, the homes were poorly sealed, with the air leakage rate at 50 Pa (equivalent to a wind blowing at 56 kilometers per hour on the home) ranging from 4.2 to 22.8 air changes per hour, with an average for the seven homes of 14.09 air changes per hour. Improving the air sealing of the homes would provide, on average, an 11 point increase, which is about one quarter of the average home rating of 39.1

It is important to note that while one of the homes audited was an end unit, the rest of the audited homes were middle units. It is impossible to determine what portion of the air leakage was from the outside and what portion was from the adjoining homes. The EcoENERGY software that is used to evaluate the homes does not consider row houses, and does not take into account the potential error introduced into the evaluation by row houses. From a practical standpoint, it is expected that air leaking from a neighbouring home will already be conditioned, however, outside air must be leaking into one of the homes somewhere along the row, so air leakage between homes will affect the overall energy efficiency of the complex. Nonetheless, it is always recommended to seal up between homes in a row house to minimize issues of air quality, smoke leakage during a fire, etc.

Other home energy efficiency upgrades recommended included basement insulation on five homes, new windows and/or doors on four homes, additional attic/roof insulation on two homes, wall insulation on one home, and an on-demand hot water heater and a solar domestic hot water heater on one home each.

The design heat loss calculation numbers are the key piece of information gathered by the audits. It is important to keep in mind that the heat loss calculation performed as part of the EcoENERGY audit is a simplified analysis and not a full-fledged heat loss calculation. The EcoENERGY program also requires that some standard assumptions be made on each home. While this allows for a comparison of various homes across the country, it may result in slightly skewed results for any particular home. Nonetheless, an EcoENERGY audit provides an easy and economical snapshot of the heat loss from the homes. Note also that the design heat loss and heat gain numbers are based on the homeowner performing the entire recommended building envelope upgrades (insulation and air sealing) listed in the report. The estimated design heat loss numbers are based on post-retrofit projections, not the current condition of the homes.

The design heat loss for the homes ranged from 14.95 to 21.54 kW (51,034 to 73,511 Btu/hour), with an average value of 18.64 kW (63,632 Btu/hr). The design heat gain values ranged from 8.76 to 11.89 kW (29,905 to 40,585 Btu/hr), with an average value of 10.49 kW (35,808 Btu/hour). The homes on the west side of the street had design heat losses on average 10% higher than the east side of the street, however, the sample size is too small for this to be statistically significant.

These heat loss and heat gain values are fairly high for homes of this size, demonstrating that even after some basic upgrades, these homes are relatively inefficient. This is an unfortunate fact of life for old homes. The only way to achieve very significant improvements in energy efficiency is to perform a top to bottom home upgrade, requiring the home to be essentially gutted to allow for full air sealing and insulation.

Converted to the common units for ventilation, the average heat loss is 5.3 tonnes of heating. This is a very large heat loss number for homes of this size, even relatively inefficient homes. We compared the EcoENERGY heat loss with the average natural gas consumption of 2,335 m3 per year and concluded that the calculated heat loss number is unreasonably large. It is important to note that the EcoENERGY home energy audit uses a simplified calculation to estimate heat loss. A true heat loss analysis, conducted in accordance with CSA Standard CAN/CSA-F280, is a much more sophisticated process than an EcoENERGY audit. Based on this, it is our opinion that the actual design heat loss for these homes should be somewhat smaller than that shown in the EcoENERGY audit reports.

The standard that regulates the installation of GeoExchange systems, CSA 448, requires that a GeoExchange heat pump be sized in such a way that their rated heating capacity is not less than 70% of the building's design heat load. The intent of this is to ensure that the heat pump supplies more than 90% of the building's annual space heating energy load. 70% of 5.3 tonnes is 3.7 tonnes (13.0 kW); however, since we believe these numbers are too high, we based this study on a heat pump size of 3 tonnes (10.5 kW).

SITE INFORMATION

Information on the layout of the Laurier Avenue site was collected in a number of ways. A real estate survey of one of the properties was provided to the Study Team. It is assumed that the information provided by this survey is representative of all of the homes in the community. This was confirmed by performing site measurements. This information was collected into a site drawing (see Attachments).

The general layout of the underground utilities was provided by the Laurier Avenue Study Project Committee and confirmed by Stephen Sudac of the City of Toronto Right of Way Management department, including illustrations of the community showing the utilities – see the Attachments. Some significant questions remain about whether the City actually has accurate locations for these utilities – some of which were installed over 100 years ago. In fact, the City has informed us that their information is considered accurate within a margin of error of plus or minus 7 feet – which, on lots that are only 15.5 feet wide, is a large margin of error. This is the nature of heritage properties.

According to Right of Way Management, the following utilities are located under the west side of the street:

- Natural gas
- Water service
- Combined sanitary/storm sewer.

Right of Way Management did not have any information on how deep they were buried; however, the average depth for a water main is 7-10 feet.

The combined sanitary/storm sewer is both at the front of the property and the back – it loops around between the west side of the street and the back of the houses on both sides of Laurier Avenue.

Anecdotal evidence from the Laurier Avenue residents suggests the actual location and composition of the sewers may not be exactly in accordance with the information provided by Right of Way Management. It has been suggested that the sewer in the streets may be a dedicated storm sewer, while the sewer at the back of the properties may be a dedicated sanitary sewer. Detailed information on utilities is available from the City of Toronto Survey and Mapping Services located at 18 Dyas Road, 4th Floor, (416) 392-7755. There are fees associated with obtaining this information.

It is recommended that before any actual construction work is commenced, that detailed information on the location of the utilities be obtained in the area where the work is planned. It is important to note that all utility information is likely to be incomplete, so all excavation or drilling activities must be undertaken with care. For the purposes of this study, however, this additional information is not required, so no additional work was done on this question.

Electrical power is located overhead at the front, on the west side of the street. Telephone and cable TV service are overhead at the back of the properties.

It is interesting to note that the backs of the properties are bounded by a 10' wide laneway allotment. While many of the homeowners have built fences and assumed control of this property, this area is a city-owned laneway that could potentially provide access to the backyards of the properties. While there might be some access to the rear of the properties on the east side of Laurier Avenue, the access to the rears of the homes on the west side of the street would be extremely difficult.

The geology of the Laurier Avenue area is expected to be overburden and then shale to about 300 feet below the surface. Below this we expect to find limestone bedrock.

COMPARISON WITH HERO RESULTS

The Harbord Village Residents' Association did a home energy efficiency project in 2009 called the Home Energy Retrofit Opportunity, or HERO. The project consisted of EcoENERGY audits on 118 homes, providing contact information for home upgrade contractors to the HERO participants, and a bulk purchase of 15 high efficiency gas furnaces.

The majority of the homes in Harbord Village are also Victorian, although there is substantially more variety of sizes, shapes and ages than the homogeneous homes of Laurier Avenue. Nonetheless, it is interesting to compare the EnerGuide rating results and recommendations of the Laurier audits with the results of the HERO project.

On average, the Laurier homes rate slightly better than the HERO homes, 39.1 for Laurier compared to 34.5 for HERO. The Laurier homes also have a higher average potential rating of 69.0 vs. 58.3 for HERO, however, GeoExchange was recommended for most of the Laurier homes, and essentially none of the HERO homes. The Laurier homes are slightly leakier, with an average of 14.9 air changes per hour vs. 14.1 for HERO, and a higher average opportunity for improvement due to air sealing.

The upgrade recommendations are similar, with the exception that most of the Laurier homes received a GeoExchange recommendation. Seventy one, or approximately 60% of the HERO homes, received a recommendation for a high efficiency gas furnace.

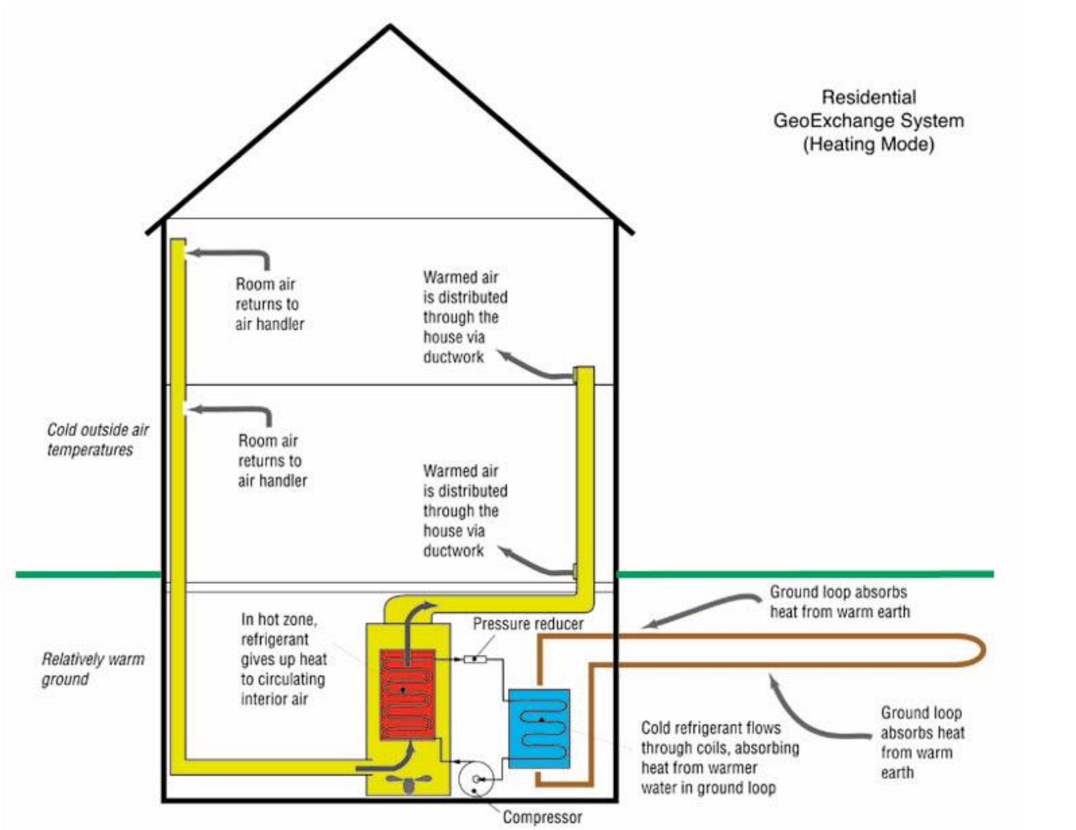
The other recommendations were similar for both projects – wall, basement, and attic insulation, on demand hot water, and new doors and windows.

GEO-EXCHANGE FEASIBILITY

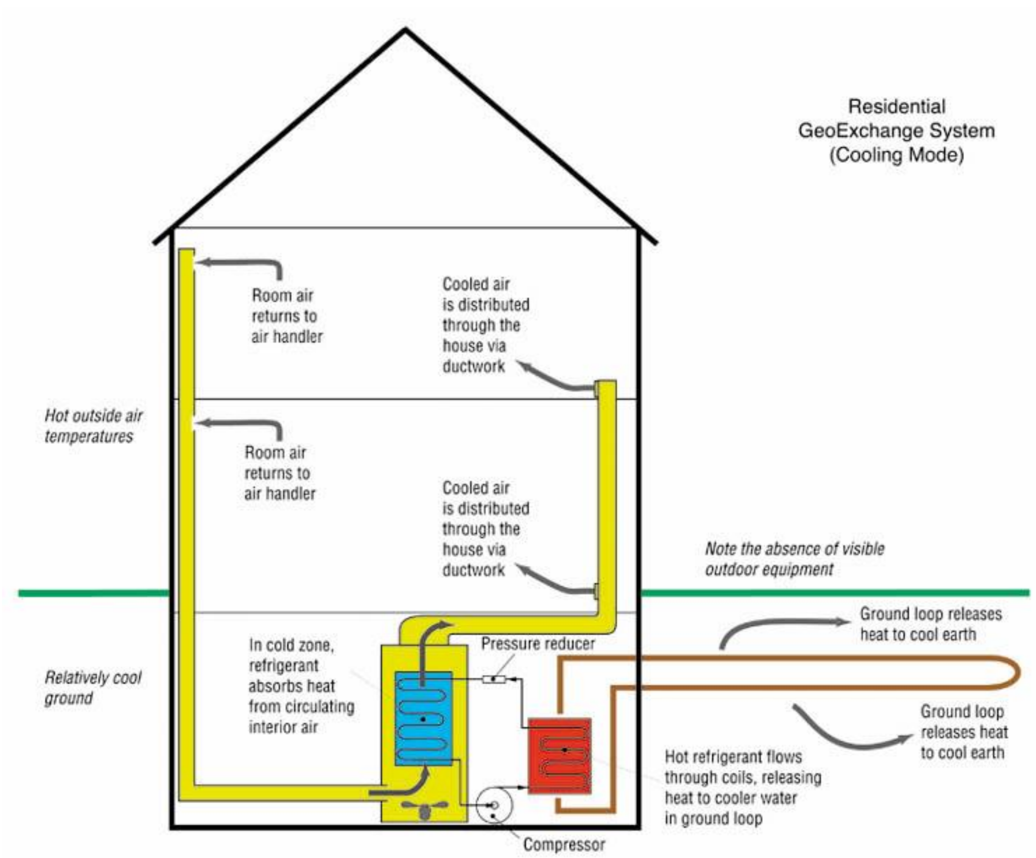
TECHNICAL

GeoExchange is a heating and cooling technology that provides space heating or cooling by moving heat from the ground into the home. GeoExchange takes advantage of the fact that, below the frost line, the temperature of the ground remains essentially constant at the yearly average air temperature. In Toronto, this is 8 to 10 degrees Celsius. To access this heat, a large loop of plastic pipe is buried in the ground, either in a horizontal loop (for properties where there is a large yard), or into vertical holes drilled into the ground (where space is limited). A non-toxic heat transfer solution of ethanol (beverage alcohol) and water is pumped through this loop to pick up heat from the ground.

To make the heat collected from the ground usable for heating a home, a heat pump is required. A heat pump is a device that moves heat energy from a cooler place to a warmer place, just like a refrigerator or air conditioner. The heat pump takes the heat from the heat transfer solution (at 8 degrees) and brings it up to 25 or 30°C to heat the home by moving the heat against up the thermal grade to the temperature required to heat the home.



During cooling season, the heat pump is reversed to pump the heat out of the home and into the heat transfer fluid to be pumped through the ground loop. Large commercial GeoExchange systems require a heat balance over the year – the amount of heat transferred to the ground needs to be balanced with the amount of heat removed from the ground. This is less of an issue with residential systems that see distinct heating and cooling seasons with a shoulder season in between. This allows the ground to "recharge" between heating and cooling seasons. Also, residential systems are generally small, with a large amount of undisturbed ground around the ground loop that can absorb and/or release heat. Accurate ground loop design, based on carefully estimated heating and cooling loads for the entire community, will ensure ground loops are sized correctly to ensure the ground temperature remains constant year to year.

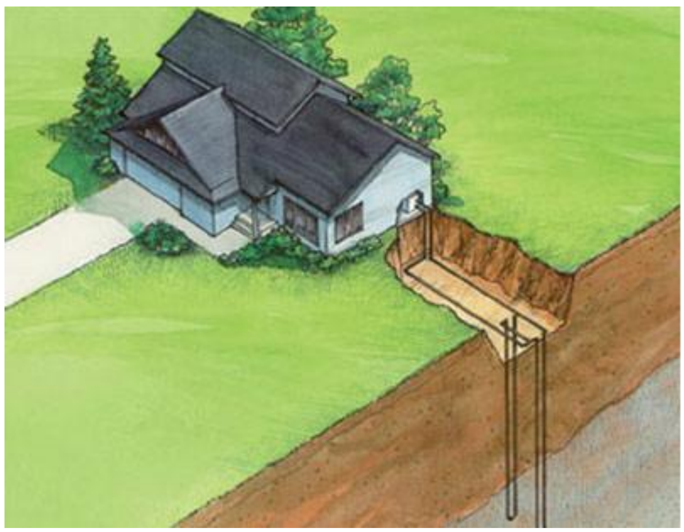


The reason that GeoExchange heating is so efficient is that for every kWh of electricity consumed by the system, 2 to 3 kWh worth of heat is moved from the ground into the home.

This technology is known by a number of different names including geothermal and ground source heat pumps. The term GeoExchange is useful to differentiate this technology from hot geothermal, the tapping of heat from deep in the earth's crust, usually by injecting cold water and pumping it back out at high temperatures.

GeoExchange systems can provide the heat for a number of different home heating arrangements, including forced air heating, hydronic in-floor heating, or hydronic heating with air handlers.

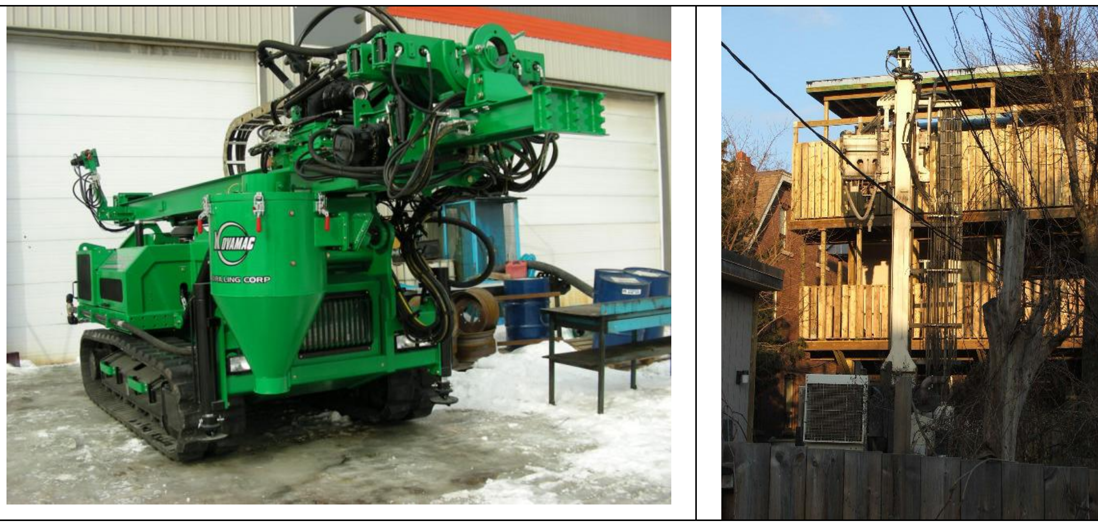
The ground loop is the key component of a GeoExchange system. For urban applications where properties are small, the most common configuration is a “vertical loop” which consists of one or more boreholes drilled into the ground. For the Laurier Avenue homes, the most suitable configuration for a 3 tonne ground loop would be a single borehole approximately 4 inches in diameter and 450 feet deep. The preferred location for the borehole would be in front of each house approximately 10 feet away from the foundation, roughly at the inside edge of the sidewalk. This would likely entail removing some of the sidewalk in this area. The borehole would most likely be vertical; however, an angled borehole can be beneficial for some applications. For the homes on the west side of the street the potential for interference with the existing hydro wires would need to be addressed. One possible solution would be to arrange with Toronto Hydro to have the power disconnected during the days that drilling is taking place (and reconnected overnight).



GeoExchange Vertical Loop

Borehole Drilling on Palmerston Avenue

Borehole during loop installation.



Drill Rigs

Drilling the boreholes and installing the ground loop can be intrusive and messy. The drilling rig is a large, noisy machine. Drilling time would be roughly one day per borehole. A trench would be required between the home and the borehole to run the ground loop pipes at least 4' below ground. Any landscaping would have to be replaced after the work is complete. While drilling is noisy, there is not significant vibration produced in the ground, and there is no risk to the existing homes or foundations.

GeoExchange heating has a number of advantages over a conventional natural gas furnace:

- Lower running costs compared to a gas furnace – in the range of 60% of the costs of gas heating (and even less compared to oil or electric heat).
- It is very safe – there is no combustion, no risk of carbon monoxide poisoning, and no fire/explosion risk.
- It insulates the homeowner from potential volatility in the price of fossil fuels, as dramatic price increases are predicted as the resource is depleted.
- It is very efficient, with the ratio of heat out to energy in the 2 to 3 range.
- These systems are highly reliable and require little maintenance.

- GeoExchange system can provide partial hot water heating, reducing hot water costs.
- Zero greenhouse gases (depending on the carbon content of the grid electricity).
- The systems include air conditioning with little or no additional capital cost.
- GeoExchange systems are very flexible, and can be adapted to a variety of built forms, and system configurations to provide optimum heating and cooling in a wide variety of applications.
- GeoExchange has the potential to extend the viable usage of heritage homes.

GeoExchange heating also has some disadvantages compared to a natural gas furnace:

- The systems have substantially higher installation costs.
- Installation is much more difficult, requiring drilling of boreholes, connecting the ground loop, etc.
- GeoExchange is a well proven technology over the past 50 years, yet it is a relatively new technology for urban HVAC applications, so there are significant barriers to its adoption, including: bureaucratic barriers with the authorities having jurisdiction; access to suitable contractors who are familiar with the challenges of urban GeoExchange; higher costs due to less competition; and a potential lack of understanding and therefore acceptance among homeowners and other end users.
- A GeoExchange system will require slightly larger ductwork to move larger quantities of lower temperature air around the home, so existing ductwork systems may need to be modified (see below for details).

There are a number of things that should be kept in mind when considering a GeoExchange system.

All heat pump systems must be sized based on a detailed heat loss calculation performed in accordance with CSA Standard CAN/CSA-F280 for residential dwelling units. The analysis performed during an EcoENERGY audit is an approximation and must not be used for sizing HVAC equipment. An independent heat loss calculation must be done for each home and the heating system for that home must be sized accordingly.

The electrical requirements and installation procedures for a GeoExchange system are not significantly different from a conventional HVAC system. In cooling mode, the heat pump unit will draw about 30% less power than a conventional air conditioner due to the lower temperature gradients. Also, since a heat pump is sized for heating, the condenser heat exchange that cools the indoor air tends to be larger than the condenser for a conventional A/C unit, which improves efficiency.

By code, all heat pump based heating systems (both GeoExchange and air source) must be supplied with a backup heater that can provide 100% of the required heating load. This code requirement is left over from when heat pumps were unreliable, and, interestingly, is not required for combustion based heating appliances. For forced air heating, the backup heater is usually an electric resistance element located in the central air handling unit or in the main distribution duct. The electric backup heater requires an independent power supply on a separate circuit so it can run when the heat pump is shut down for service. A licensed electrician must install all electrical wiring.

For homes with an existing combustion based heating system, it is possible to use the existing furnace or boiler to provide backup heat in lieu of the electric resistance heater. With hydronic systems that use water as a heat transfer fluid to move heat through the home, the backup heat can be provided with some kind of water heater, such as a gas fired on-demand unit.

A 3 tonne GeoExchange system would require a 45 amp circuit (120 VAC). An electric resistance backup heater would require a separate 60 amp circuit. A system with electrical loads of this size would likely require 200 A service to accommodate the heat pump and backup heater as well as the regular household appliances (30 A for an electric stove, 30 A for an electric drier, etc.). Should the backup heat be provided by a combustion appliance, the additional circuit would not be required and 100 A electrical service may be adequate.

Heat transfer fluid pumps are high efficiency and consume relatively small amounts of electricity.

Most heat pump systems are sized to provide less than 100% of the peak heating requirement. The standard that regulates the installation of GeoExchange systems in Canada, CSA 448, requires that a GeoExchange heat pump be sized so that their rated heating capacity is not less than 70% of the building's design heat load. The intent of this is to ensure that the heat pump supplies more than 90% of the building's annual space heating energy load. The use of an auxiliary heater eliminates the need to size the GeoExchange system and ground loop for the extreme heating loads that occur during unusually cold conditions that happen only a few hours per year. Even when the outside temperature is very cold, the GeoExchange system will continue to provide the majority of the heat a home requires. This is good design practice – sizing a GeoExchange system for 70% of the design load decreases the size of the equipment (and the capital cost) by roughly 30%, which is a significant savings for a capital-intensive technology like GeoExchange. The smaller GeoExchange system provides sufficient heat for all but a few hours per year. Filling that small heating gap with a very economical resistance heater is good system design.

The maintenance requirements for a GeoExchange system are minor. The heat transfer fluid in the ground loop should have the level of antifreeze checked every few years. The only significant risk to the homeowner is the risk of the system being engineered and sized incorrectly. Employing skilled and experienced contractors who are accredited by the Canadian GeoExchange Coalition can minimize this risk.

Ground loops must be designed in accordance with the guidelines outlined in the CSA-448 standard. This standard includes provisions to ensure that ground loops are sized correctly to ensure the average ground temperature does not increase or decrease on a year to year basis. These provisions include minimum spacing between loops to allow adequate heat storage and transfer without interfering with a similar ground loop on an adjoining property.

STATE OF THE INDUSTRY

GeoExchange systems have been around for many years and the technology has been improving and becoming more reliable and efficient. In Canada, the Federal Government supports the Canadian GeoExchange Coalition with a mandate to raise quality standards for GeoExchange systems and provide information on this technology to the Canadian market. GeoExchange heating systems are a mature technology that is becoming more popular as the price of heating with fossil fuels increases. New standards for system design and installation (CSA 448) help ensure systems are reliable and economical. Nonetheless, GeoExchange systems are relatively complex and expensive, so it is extremely important that customers ensure contractors are experienced and ethical in their dealings.

Recent growth in the industry is substantial. While Manitoba leads the country in installations, Ontario has 8,500 homes and 500 institutional and commercial buildings using geothermal systems and is growing rapidly with some companies reporting sales growth of 200 per cent in 2008 as oil prices have gone up, along with the burgeoning demand for low carbon heating/cooling.

In Ontario, the most significant residential market for GeoExchange systems is in rural settings. Many rural properties have large areas of land available for a horizontal ground loop, which is generally less expensive than a vertical loop. Many rural areas do not have natural gas service, so home heating uses electrical resistance heat, oil heat, or propane. This combination of relatively low installation costs and greater savings on home heating makes GeoExchange systems economically attractive for many rural properties.

In the urban and commercial markets where real estate is limited, many GeoExchange systems use vertical ground loops. Modern drilling methods produce little vibration in the ground and essentially no vibration risk to surrounding buildings. While most boreholes are vertical, some applications call for angle drilling. This can increase the size of the borefield below ground while minimizing the affected area at ground level, which can be beneficial for some applications.

Installer training has expanded and the linking of government incentive payments to GeoExchange membership has helped regulate the industry.

SYSTEM CONFIGURATION: DISTRICT SYSTEMS VS. INDIVIDUAL SYSTEMS:

GeoExchange is a very flexible technology, and there are many different ways it could be deployed on Laurier Avenue. The two basic system configurations that could be applicable to Laurier Avenue are:

- Community wide “district” system with shared ground loop
- Individual systems in each home

District Systems

A district GeoExchange system consists of a single system that provides heat and cooling to the entire neighbourhood. There are generally two different system configurations – distributed or centralized. With a distributed system, a complex of buildings would have a single large ground loop, sized to provide adequate heating for the entire complex. A heat storage tank might be included to provide small buffer between the ground loop and the homes. Each home would have a small sub loop (including send and return pipes) from the main loop to an individual heat pump in each unit. The sub loop would include isolation valves to allow the individual home to be isolated from the main loop for maintenance

The individual heat pump in each unit would provide the heating (or cooling) for that unit. One major advantage of this system is that each heat pump is independent, so some heat pumps could be heating while other pumps are cooling at the same time, allowing a large amount of individual control to each homeowner.

Another possible arrangement is a centralized system. With a centralized system, the ground loop would feed a single large water-to-water heat pump. The heat pump would upgrade the heat from the ground and distribute it to each townhouse unit. Fan coils or some other system would be used to condition the air in each townhouse.

The significant opportunity presented by a district system would be a reduction of the size of the ground loop required compared to individual systems on each home. This size reduction is possible because not all of the heat pumps would be running at any one time. A GeoExchange ground loop is sized for heat transfer (power), not total amount of heat exchanged (energy). Since only a portion of the heat pumps would be running at any one time, the ground loop can be downsized. As an illustrative example, a study was done on a commercial system consisting of a single large building with a large number of interior spaces. This building had a GeoExchange system with 97 individual heat pumps. The study showed that the maximum number of heat pumps running at any one time was only 17. Clearly, this was a very different system than that which is proposed for Laurier Avenue, however, it illustrates the design rule that the ground loop does not need to be sized to support all of the heat pumps in the system running at the same time.

For the Laurier Avenue project, the system would need to be fully modeled based on the heat and cooling needs of the entire complex, rather than the individual heat loss analyses of the individual homes. We anticipate that the ground loop could be downsized by approximately 25% compared to the total sizing of individual systems.

One challenge for this type of GeoExchange system would be organizing the business model of a community project. This is further complicated by the challenges of a retrofit project, with a number of existing homeowners with different priorities. There are a number of different business models that could be used for this system. The model that makes the most sense is to set up a Ground Loop Corporation as a co-operative, with each homeowner participating in the project owning an equal share in the co-op. The Ground Loop Corporation would own all of the common assets, including the ground loop, the circulation pumps, etc. One potential arrangement would be for each homeowner to pay a fixed monthly fee to the Ground Loop Corporation to cover the capital costs and the operating and maintenance costs for the common asset. The individual heat pump in each home would be connected to the electrical power in that home, so the energy cost of actually running the heat pump would be paid directly by the homeowner. This arrangement eliminates the complexity of metering the heat delivered to each home on the street.

A district system would have a number of advantages, including:

- Lower overall system costs since the overall ground loop size would be smaller than individual ground loops by approximately 25%. While this would be somewhat offset by higher installation costs due to a more complex system, the overall system costs would be less.
- The district system would require less maintenance than individual systems, since there is only one ground loop to maintain rather than one for each unit.
- High efficiency, since the system can be sized for the loads of the entire neighbourhood, rather than the product of the loads for 22 individual homes. Generally it can be assumed that not all of the homes would be demanding heat at the same time, so generally a district system could be sized smaller than the sum of an equivalent number of individual systems.
- The potential for a more favourable response from the City for a project of this type.

There would be a number of challenges to a district system, including:

- Additional complexities of installing the ground loop, including connecting a common borefield to all of the homes through a large community loop (involving trenching a path between all of the homes).
- Gaining cooperation from an adequate number of homeowners to make the district system viable and take advantage of the reduction of system size. While it would be necessary to fully model the system to confirm the minimum practical size for a project like this, we estimate that it would require at least 12 houses participating in the district system to make it worthwhile.
- Complexity of the business arrangements, including setting up a Ground Loop Corporation, arranging with all the homeowners to join the Corporation, administering the Corporation, and defining where individual responsibility/ liability begins and ends, compared to the responsibilities/ liabilities of the utility.
- This system has the potential to make the sale of a house more complicated since a new resident must become a member of the utility.

It is important to note that a study authored by Element Village in 2008 (“A Study of Cooperative Urban District GeoExchange for Heating and Cooling”) came to the conclusion that a shared district GeoExchange system would not reduce the per residence cost of installing a geo-exchange system. We disagree with the findings of this study, believing there would be appreciable cost savings over individual systems. We are not, however, convinced that the cost savings would compensate for the challenges of setting up a district system utility on a retrofit basis and the complexity of operating that utility. The Element Village report however, provides a very good starting point for those looking to start a neighbourhood co-operative. Additional resources can be sourced through the Toronto Renewable Energy Co-operative.

Individual Systems

The alternative model to a district system would be individual systems in each home, including dedicated ground loops and heat pumps for each home. The economy of scale would be captured by installing all of the ground loops at the same time and with a bulk purchase of multiple heat pumps for the same project.

Individual systems would have a number of advantages, including:

- Multiple simple, small systems.
- Individual system ownership, rather than complex condominium arrangements.
- Decreased system design and installation risk, due to the small system size and redundancy.
- Decreased operation risk due to the redundancy of multiple systems.

Further information regarding the societal benefits of district systems can be found in, "A Study of Cooperative Urban District GeoExchange for Heating and Cooling", prepared by Element Village for the Toronto Atmospheric Fund in June, 2008.

BUREAUCRATIC CHALLENGES

For the Laurier Avenue project, the GeoExchange system would use a vertical loop since there is very little available land in either the front of the homes or the back. It may be possible to sink the deep-wells on private property; however, the space between the houses and the property lines is only about 10' wide by 5' long, which is too small to locate a vertical loop. While the homes have back yards, they are small and essentially inaccessible, particularly for the homes on the West side of the street.

The opportunity exists to locate the GeoExchange ground loop on City property, either below the street, below the sidewalk, or below the City property between the sidewalk and the property line. There are a number of challenges to locating GeoExchange ground loops on City property. These include:

- The City's general position on this type of project is to minimize encroachment on City property.
- The City's reluctance to approve locating the GeoExchange ground loop on City property if there is room for the ground loop (or loops) on private property, either in front or behind the homes.
- The City has only had requests for laneway installations, which have been granted, establishing a precedent. At this time, there have been no applications for locating GeoExchange ground loops under sidewalks and boulevards (the area between the street and private property lines); however, Right of Way Management would prefer these to any street installations. Any and all street installation proposals are opposed and strongly discouraged by Transportation Services.
- To locate a ground loop under the City Street, it would be necessary to obtain a right-of-way permit.

- Currently, an encroachment agreement between the homeowner and the City, covering the use of the City property for ground loop for each home, would cost approximately $1000.
- Homeowners working on City property would require a Certificate of Insurance.
- The City requires a deposit to cover the potential restoration of the roadway.
- The payment of annual encroachment fees in the $160 to $240 range or more.
- An extensive requirement for sign-offs from varies utilities and other agencies, known as the PUCC.
- An extensive requirement for City of Toronto Internal Circulation sign-offs.
- The need for dealing with the special processes due to the Heritage Conservation District.
- The need for an archaeological study, entailing potentially significant cost and administrative requirements.

These challenges are detailed below.

City of Toronto Right of Way

The Laurier Study Team met with Stephen Sudac, an engineer from the Right of Way Management department, who is responsible for GeoExchange projects.

The City's current position on this type of project is to keep encroachment on City property to a minimum. Locating the GeoExchange ground loops on private property is preferred over locating the loops on city property. The City will be very reluctant to give approval for the putting the GeoExchange system under the street if there is room for the ground loop (or loops) on private property in the front or back of the properties.

Information provided by City of Toronto Right of Way management indicates that they have only had requests for laneway installations, which have been granted. At this time, there have been no applications for locating GeoExchange ground loops under sidewalks and boulevards (the area between the street and private property lines); however, Right of Way Management would prefer these to any street installations. Any and all street installation proposals are opposed and strongly discouraged by Transportation Services.

One reason the City would be reluctant to locate the ground loop under the street is that the GeoExchange piping would have to cross over (or under) the existing utilities to connect to the homes on the west side of the street. Should there be a water main or sewer breakage, there would be a significant risk that the city might have to remove the GeoExchange pipe to access the break. This removal and replacement would be at the homeowner's expense. Routing the GeoExchange piping under the utilities would decrease the risk of interfering with the services, however, locating the GeoExchange piping at a deeper level would cost more to install.

It was noted that laneways generally have fewer things buried under them – usually only water and sanitary /combined sewers.

To locate a ground loop under the City-owned street, it would be necessary to obtain a right-of-way permit. Should the Laurier Avenue residents organize a bulk purchase of individual GeoExchange systems, there are a number of things that each homeowner would need:

- Encroachment agreement between the Homeowner and the City, covering the use of the City property for a ground loop for each home.
- Certificate of Insurance.
- Deposit required for restoration of roadway.
- Payment of annual encroachment fees.

The application fee for an encroachment agreement is $480 per encroachment. There are also legal fees for setting up the encroachment agreement that would be about $600. There might be a savings with multiple applications at the same time.

There is an annual fee levied for the use of the City property under the street. This fee is based on the land appraisal files created by legal services.

The fee structure table from the City of Toronto website (www.toronto.ca/developing-toronto/pdf/rowfees.pdf) suggests the annual fee could be $15.28 plus GST per square metre of encroachment; however, it is not clear this is the correct fee for this application. It is also not clear how the City would calculate how much area a GeoExchange installation would use. A ground loop in the street could easily encroach by 10 to 15 square metres, requiring an annual fee in the $160 to $240 range or more. This fee amount could represent a significant portion of the annual savings from the GeoExchange system. Should the ground loop consist of a single borehole at the edge of the sidewalk, the encroachment area could be much smaller.

An encroachment agreement to use the Street would have to go to City Council or at least Community Council for approval since there is no by-law that covers private GeoExchange systems on City property. Having an agreement go to City Council should not be an issue, however, there is no guarantee that the City Councilors would look kindly towards an application.

It may be possible to obtain some relief from the fees, or at least a fee reduction, due to the green energy aspect of the project. There was, however, a precedent set on the GeoExchange system for the Planet Traveler Hotel project where it was deemed that the loop provided a private benefit to the hotel, and so the fee was applied. However, if the City hopes to achieve its current goal of 80% reduction of greenhouse gas emissions by 2050, and given the high percentage of Toronto's GHG emissions coming from buildings, it will have to find alternatives to fossil fuels for heating buildings, and geoexchange systems would be an effective way of doing this.

The alternative to drilling in the street would be locating the ground loops in the private property in the back yards. On private property, since there is no encroachment, only a standard building permit is required. This would eliminate the costs, hassles, and delays of obtaining an encroachment agreement. While locating ground loops in the back yards would cause damage to fences and landscaping, the cost to repair this damage could be less than the costs of using City property.

There are a number of steps in obtaining a right-of-way permit. A GeoExchange project would be considered as "Major Landscaping" because the excavation would be more than 0.61 m below grade. Requirements include providing 12 sets of drawings drawn in metric scale to a scale of 1:200 horizontal and 1:100 vertical.

It would also be necessary to get project sign-offs from members of the PUCC (Public Utilities Co-coordinating Committee). These are a number of utilities and other public organizations like the TTC and Canada Post that must sign off on this type of project. The four major utilities are: Bell Telephone, Toronto Hydro, Enbridge Gas and Rogers Cable TV. These utilities need to ensure that they know the pipes are there and that there are no conflicts with existing services. Contact must be made with each entity on a list of at least 11 utilities, with each one signing off on the project.

Project sign-offs are also required from another group of stakeholders, considered the “internal circulation” group. Right Of Way Management is responsible for internal circulation for sign-offs. The stakeholders in this group include:

- Bylaw inspection.
- Surface maintenance group – the project deposit covers potential repair.
- Trees.
- Toronto Water – water service mains and sewers.

The above covers the challenges for getting permits for individual homeowner systems. Should Laurier Avenue consider a community GeoExchange system, with a single shared ground loop, it may be more difficult to get an encroachment agreement with the City. The City legal department may feel that a community system may provide significant administrative risks in addition to the technical risks.

Currently, the City of Toronto has conflicting priorities. On the one hand, the City wants to achieve ambitious energy efficiency and greenhouse gas emission reductions in the coming years. On the other hand, there are many internal systems that create significant obstacles for citizens who aim to contribute what they can to achieving city targets. There is a need for the political and bureaucratic parts of the city to align their goals with the mechanisms to enable citizens to 'do their part'. These discussions have commenced through this project, with the significant support of Councillor McConnell who has convened meetings with a variety of city employees. The outcome of these discussions is not yet clear.

City of Toronto Policy on GeoExchange Loops on City Property

The City of Toronto is in the process of developing a policy on GeoExchange ground loops for private benefit on public property. This process started with the Planet Traveler Hotel project at 357 College Street, which is a small hotel whose goal is to be the greenest hotel in Canada. The owners of Planet Traveler believed that their best opportunity to achieve their carbon reduction goals was by using a GeoExchange HVAC system. Their challenge, however, was that the hotel is on a small piece of land, and the building extends all the way to the property line. The developer, Tom Rand, applied to the city to locate the ground loop in the adjacent lane, which was agreed to by the City.

The Planet Traveler project caused City Council to ask staff to explore policy options on GeoExchange, in particular on ground loops for private benefit on public land. A working group, chaired by Kirk Johnson, Portfolio Development Manager for the City of Toronto, has been set up to study this issue.

This group is in its early stages, however, some of the things that have been discussed include:

- Some people are in favour of having private ground loops in City property, some are ambivalent, and some are against it.
- The City would likely be interested in facilitating a project that includes a shared community ground loop.
- If Laurier Avenue residents pursue individual loops for each home, the group believes that there would not be a significant economy of scale for a project of this size, and the City would be less interested in a project with individual loops.
- Element Village, with the support of the Toronto Atmospheric Fund, produced a report on a community GeoExchange model in 2008 that stated that there are no economies of scale with a community project.
- If the Laurier Avenue Study Project Committee can demonstrate some concrete reasons why the City should explore this further, it will help.
- The Working Group is interested in learning what Laurier Avenue wants the City to do to help them. One potential barrier that the Study Team has identified is the administrative cost of about $1,000 per property.
- The bigger barrier would be the fee the City charges for the use of the City land, which could be in the $200 to $500 range. This is a significant portion of the savings generated by the system.
- The City was planning to pave the road anyway, so it would be nice if they would cover that cost after the system went in. It was noted that there would be a sequencing challenge/opportunity – the City digs up the road, the Geo vendor drills the holes, then the City backfills and paves.

Heritage Conservation District

Laurier Avenue is part of the Cabbagetown North Heritage Conservation District, and all of the properties on Laurier Avenue are designated under Part IV of the Ontario Heritage Act and listed in the City of Toronto Inventory of Heritage Properties. As designated Heritage properties, there are a number of additional issues that would need to be addressed for a GeoExchange system or systems on Laurier Avenue.

Any application for a building permit for a property on Laurier will require a Heritage Permit before the City will issue a building permit. The Heritage department will need to understand how the work is going to affect the building. Any modifications to the homes that are visible from the public right of way must comply with the Heritage guidelines. Note that St. James Cemetery is considered a public Right of Way, so modifications that can be seen from the cemetery also need to comply with the Heritage guidelines. Fundamentally, Heritage needs to be sure that the modifications have no visual impact.

While most of the work for a GeoExchange system will be below grade and out of sight, Heritage is also interested in any modifications that are done to the foundation of the homes. Drawings will need to be submitted that show how extensive the impact on the foundation would be, how large the alteration is, how much of the original foundation will be affected, and the structural implications, if any, on the foundation.

To satisfy these requirements, a permit application needs to include a drawing set that clearly shows the extent of the modifications below grade, including the structural implications.

The Heritage Conservation District plan also includes guidelines on landscaping, including lists of approved trees and shrubs and guidelines on how they should be laid out. Any GeoExchange system will require excavations, so it will be necessary to refer to the heritage landscaping guidelines when replacing the landscaping after backfilling. Note that this may result in a hidden additional cost for the GeoExchange systems should the homeowner(s) be required to do a more thorough landscaping job than they might consider otherwise.

Details on the Heritage requirements can be found in the City of Toronto publication: “Cabbagetown North Heritage Conservation District, Heritage Character Statement and District Plan, October 2003”. Guidelines on obtaining a Heritage permit are included in appendices.

Archaeological Preservation

Another potential challenge for installing a GeoExchange system is the need to confirm that the installation of the GeoExchange system poses no risks to the archeological heritage of the city.

Contact was made with Susan Hughes of the City of Toronto Archeological Office. It was noted that the potential areas of concern from an archaeological perspective are the areas of entry for the loops and the trenching that would connect separate properties.

It was reported that the area in question on Laurier Avenue (1-21 and 2-22 property addresses) is an area of archaeological potential; therefore Heritage Preservation Services would request that a Stage 1 archaeological assessment be completed.

A Stage 1 study is a background archival and land use review which determines whether archaeological resources may be encountered and defines areas for further testing in the form of test pitting survey and or test trenching. The test pit survey/test trenching (actual excavation) is the next step in the process since it relates to specific areas of disturbance based upon plans for the project.

A list of consultants who are qualified to complete such an assessment was provided. It was suggested that we contact a consultant to review the scope of work with respect to ground disturbances for this project.

Contact was made with David A Robertson, Senior Archaeologist & Manager of Archaeological Services Inc. ASI is the largest archaeological consulting company in the province, with a full time permanent staff of 40 individuals. ASI staff members are licensed by the Ontario Ministry of Culture to conduct archaeological research on sites of all time periods throughout the entire province. One of their current projects is the preparation of the large scale City of Toronto Archaeological Master Plan, so they are intimately familiar with the quality and extent of the available data sources, the overall project requirements, and the planning context in which this study will be undertaken.

According to ASI, the Stage 1 Archaeological Resource Assessment includes the following tasks:

- Project initiation, background research and review of existing Archaeological and historical data.
- Reviewing pertinent provincial government files,
- Reviewing and compiling the results of a literature search including but not limited to archival material held at the City of Toronto Archives, the Archives of Ontario, and the Toronto Land Registry office,
- Determine archaeological potential of the subject property,
- Reviewing the former geomorphological and hydrological character of the study area, and the reconstructed locations of early settlement and industrial features on the basis of available project mapping to delimit zones of archaeological potential,
- Conducting a field review of the study area to confirm the research-based characterization of archaeological potential and to determine the degree to which recent construction disturbances may have affected archaeological potential,
- Stage 1 archaeological resource assessment report preparation.

A Stage 1 archaeological assessment report will address the project requirements, while at the same time addressing all of the archaeological and licensing concerns outlined in the Ontario Heritage Act, the Planning Act, or the Environmental Assessment Act, as applicable.

One of the outcomes of the Stage 1 archaeological assessment is a determination of whether to proceed with a Stage 2 assessment, which would consist of test digs throughout the Laurier Avenue community. Mr. Robertson stated that while he could not know for sure until the Stage 1 assessment was complete, it was his opinion that there was unlikely to be a need for a Stage 2 study in this area.

ASI's cost estimate for a Stage 1 study for the Laurier Avenue community was $3,250 plus taxes for approximately 8 days of effort. ASI's proposal stated that based on their understanding of the project, should a Stage 2 assessment be necessary, the cost would be approximately equal to the above cost for the Stage 1 study.

It is important to note that there have been some preliminary discussions with the City of Toronto Heritage department about the need for an archeological study. These discussions are based on some additional information on the actual amount of ground disturbance required for the proposed GeoExchange systems. The final results of these discussions are still pending.

Air Source Heat Pump Feasibility

Air Source Heat Pumps

Air source heat pumps can provide an alternative to the ground source heat pump systems used in GeoExchange systems. An air source heat pump is a heat pump that uses the air outside the building as the heat source (in the heating season) or the heat sink (for cooling).

An air source heat pump is similar to a conventional air conditioner, using a refrigeration unit to move heat against the thermal grade from a cooler place to a warmer place. The difference with an air source heat pump is that it is reversible – not only does it move heat from inside the home to outside for cooling; it can move heat from outside the home to inside for heating.

Air source heat pump.

An air source heat pump has two significant advantages over a GeoExchange system – because it uses the outside air as the heat source or sink, it does not require a capital intensive ground loop, which makes installing an air source heat pump much easier. Because of this, an air source heat pump system would be less expensive to purchase and install.

Another potential advantage is that since the heat source/sink surrounds the home on all sides, it is possible to employ multiple heat pumps around the home, including on the upper stories or roof.

Sketch showing multiple heat pumps in a single dwelling.

There are two significant disadvantages to an air source heat pump with respect to a GeoExchange system – efficiency and low temperature performance.

For heating, an air source heat pump is less efficient than a GeoExchange system because of the relatively large, negative temperature differences between the inside and outside air. The average outdoor ambient temperature in January is –4.2°C, which is about 13 degrees colder than the average ground temperature of 9°C. This means the air source heat pump has to do additional work to overcome the greater temperature difference between the inside and outside temperature (24°C) compared to the smaller temperature difference for the ground source heat pump (11°C).

Heating mode (January):	Air	Ground
Energy source temperature (warmer is better)	-4.2°C	+9°C
Target indoor temperature,	+20°C	+20°C
Temperature difference (smaller number is better)	24°C	11°C

There is a similar situation during the cooling season when the ground temperature is much cooler than the ambient air temperature and, so, is able to absorb or "sink" heat more readily. In this case, the average ambient temperature of the ground is cooler than the indoor temperature, so the heat pump has very little work to do to cool the interior of the home. The outdoor temperature is much higher, so more work has to be done to cool off the inside of the home. Of course, while the average outdoor temperature in July is 22.2°C, the ambient temperature is often much hotter, which means the air source heat pump must work even harder while the ground source system is not affected.

Cooling Mode (July):	Air	Ground
Energy sink temperature (colder is better)	+28.2°C	+10°C
Target indoor temperature	+24°C	+24°C
Cooling Challenge (smaller number is better)	+4.2°C	-14°C

Another factor that decreases efficiency is the tendency of the outdoor unit to frost up during the winter. The heat pump goes through a defrost cycle to remove this frost, a cycle that costs energy. The energy required to defrost the system is not reflected in coefficient of performance numbers.

The other significant disadvantage of air source heat pumps is that when the outdoor ambient air temperature falls below a certain temperature (between 0 and –15°C), most air source heat pumps shut themselves off to protect from damage. This is due to the fundamental thermodynamic limitations of the refrigeration cycle and the design of most heat pumps. The practical result of this is that most air source heat pumps require an auxiliary heat source that provides heat when the outdoor temperature gets very low. For forced air systems, this usually consists of an electrical resistance heater. For hydronic systems, an electric or gas fired boiler can be used.

Recently there have been developed a number of air source heat pumps that address this. Using special multi-stage compressor technology these units are able to continue to provide heat at reasonable levels of efficiency (co-efficient of performance at 2.0 or better) at ambient temperatures below –30°C.

There are some other things to keep in mind when considering an air source heat pump. The lifespan of the outdoor units tends to be in the 10 to 15 year range due to the wear and tear of being outside all day, every day. Also, the outdoor units can be physically large (particularly for some models of the cold climate heat pumps) which may pose a challenge for the small properties on Laurier Avenue. For example, the outdoor unit for a Hallowell Acadia cold climate heat pump is 48 ½” long by 31” wide by 27 7.8” high (see attached data sheets).

There are a number of potential configurations of air source heat pump, each with their challenges and opportunities.

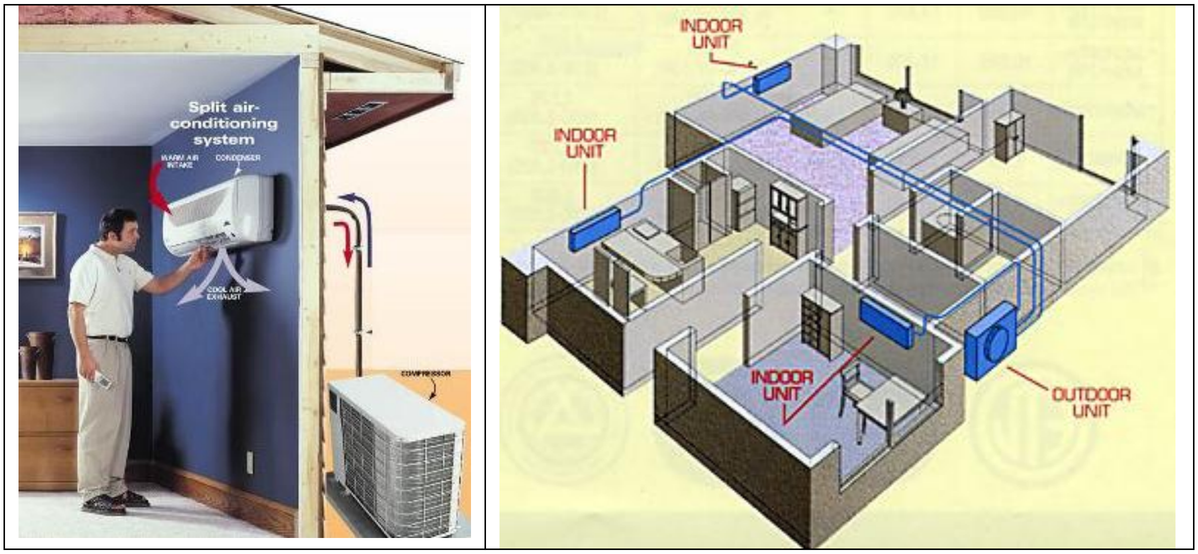
Central air-source heat pump with forced air heating

This configuration consists of a central air source heat pump with a central forced air indoor unit. The advantage of this configuration is that central cold climate heat pumps are available, such as the Hallowell Acadia and the Mitsubishi Zuba Central. These systems continue to provide heat at low outdoor ambient temperatures.

This system will provide a relatively simple installation, with no need for the cost or hassle of a ground loop. Since the unit is forced air, however, ductwork modifications will be required to ensure there is adequate airflow to provide heat (and cooling) to all areas of the home. More significantly, adequate airflow is required to ensure the heat is being transferred effectively from the heat exchanger or the efficiency of the heat pump is compromised. Air flow needs to be approximately 500 CFM/tonne of heating or cooling, which will probably require modifications to the ductwork in the home.

Distributed Heat Pumps (Ductless systems)

This configuration consists of multiple smaller heat pumps units distributed throughout the house. Each small “ductless” heat pump will provide both localized heating and cooling. These units can be located so that remote areas of the houses, such as the third floors and basements, can be heated or cooled directly, significantly improving home comfort. Localized heating and cooling can also be very efficient if the homeowner remembers to adjust the thermostats to reduce the heating and cooling to unoccupied parts of the home.



Distributed (ductless) heat pump systems

The most significant advantage of this system for retrofit applications is that it will not require modifications to the existing ductwork. While it will be necessary to drill holes through walls, ceilings, roofs, etc to feed the refrigerant piping, this should be much less intrusive than ductwork modifications.

The largest drawback of this system is that there are no ductless heat pump systems available that are suitable for cold climates. All of these systems will shut down at an outdoor ambient temperature of –15°C. This means that an auxiliary heating system, sized to heat the entire home, will be required. This could simply mean maintaining the existing gas fired furnace, however, maintaining the furnace is a cost that affects the return on investment for a system like this.

Please note that when making any significant change to a residential HVAC system, the building code requires the installation of a heat recovery or energy recovery ventilation system, even for poorly sealed homes. While this is not a problem when installing a central forced air heating system, this requirement needs to be kept in mind when considering replacing an existing heating system with a ductless heat pump system.

Central air-source heat pump with Hydronic Heating

This configuration consists of a central air to water heat pump with hydronic heating and cooling throughout the home. Instead of transferring the heat to the forced air, the air to water heat pump uses water to move the heat throughout the home. Small, localized heat exchangers with air distribution fans, commonly called fan coils, are used throughout the home to provide localized heating or cooling. In North America, 98% of all homes use forced air heating, while in Europe, 98% use the more efficient hydronic heating.

The significant advantage of an air-to water heat pump with hydronic heating is the opportunity to provide a system without significant modifications to the air ducts in the home. The water pipes that bring the heated water throughout the home are relatively small, and can be routed through the house with less impact than upgrading the duct systems.

The fan coils can be located throughout the home, wherever needed to provide localized heating or cooling, addressing localized home comfort issues. Again, localized heating and cooling can also be very efficient if the homeowner adjusts the thermostats to reduce the heating and cooling to unoccupied parts of the home. Studies have shown that zoned heating/cooling can save 30 % of energy in new construction

The drawback of this system is that there are no air-to-water heat pump systems available that are suitable for cold climates. All of these systems will shut down at an outdoor ambient temperature of –15°C. This means that an auxiliary heating system, sized to heat the entire home, will be required. For hydronic systems, however, an on-demand combination hot water heater/boiler can serve as a very energy efficient auxiliary heat source.

Air source hydronic heat pump and fan coils.

HEAT PUMP SYSTEM COMPARISON

We have prepared a summary table comparing the performance of a number of heat pump systems. This table is based on performance data provided by the equipment manufacturers. GeoExchange performance data is for a typical example, in this case from Next Energy.

For the air source heat pumps, it is important to note the outdoor temperature used to rate the system. The temperature used will vary by manufacturer. In heating mode, lowering the air temperature decreases the system efficiency.

The most important numbers for comparing system efficiencies are the coefficient of performance (COP) in heating and the energy efficiency ratio (EER) in cooling. Because of differences in the systems and variations in test conditions reported by the manufacturers, it is impossible to directly compare these heat pump systems. It is clear, however, that the GeoExchange system is significantly more efficient than the air source heat pump systems.

We are also including a high efficiency gas furnace in the table for contrast. The unit we have selected is a Goodman furnace, 95% annual fuel utilization efficiency, capacity 4 tonnes of heating. This is the furnace that was installed under the Harbord Village Residents' Association Home Energy Retrofit Opportunity (HERO) program by HERO's furnace contractor, Atlascare.

Type of System		**Geo-Exchange**	**Air Source, central**	**Air Source, central**	**Air Source, Split**	**Air Source, Hydronic**	**Hi-efficiency natural gas furnace**
Sample Make		**Next Energy**	**Mitsubishi**	**Hallowell**	**Mitsubishi**	**Aermec**	**Goodman**
Sample Model		**Tranquility 27 model 38**	**Zuba-Central**	**Acadia 036**	**Mister Slim MSZ-FD12NA**	**AN 0417**	**GMVC950 453BX**
Heating:							
Outdoor temperature	*°C*	Not applicable	Not specified	0	8	7	Not applicable
Capacity	*Btu/hour*	33,900	40,000	25,000	13,600	40,260	45,000
Capacity	*kW*	9.9	11.7	7.3	4.0	11.8	13.1
COP		4.26	2.75	2.89	3.09	2.56	0.95
Power draw	*kW*	2.34	3.67	2.54	0.98	4.6	~1.3
Cooling:							
Outdoor temperature	*°C*	Not applicable	Not specified	28	23	35	N/A
Capacity	*Btu/hour*	43,900	34,000	23,500	12,000	35,486	N/A
Capacity	*kW*	8.8	10.0	6.9	3.5	10.4	N/A
EER		26.5	12.0	16.6	12.5	9.2	N/A
Power draw	*kW*	1.66	2.865	1.46	0.96	3.86	N/A

An important consideration is the expected lifespan of the systems. Several studies have shown that a GeoExchange system lasts much longer than a conventional fossil fuel furnace and air-conditioning system, as the GeoExchange system is not exposed to rain, snow and extreme outdoor temperature changes. The earth loop, if installed to CSA standards, can be expected to perform well for 50 years or more. The expected lifespan of a GeoExchange heat up is 25 years (according to ASHRAE). Ground loop circulation pumps are usually good for 8 to 10 years of service.

With an air source heat pump, the lifespan of the outdoor units tends is expected to be in the 15 year range (according to ASHRAE).

Retrofitting

Retrofitting old homes is not easy. These homes were designed and built in a time when natural resources such as fossil fuels were readily available, and the insulation and air sealing technologies to make homes efficient were not. These homes were originally heated by passive furnaces located in the basements that produced hot air that rose through grates in the main floor, along with small coal/wood stoves on 2nd and 3rd floors. Also, the expectations of the people living in these homes were different – they put on a sweater in the winter (or sewed themselves into their long underwear from November to April) and, in the summer, they went outside and sat under a tree. What we consider a normal level of inside heating and cooling is much more energy intensive than what was imagined by the people building these homes. How do we adapt these homes to the current expectation of home comfort within the constraints of resource depletion?

Retrofitting old homes is not easy from a practical standpoint either. Doing a thorough job of upgrading these homes to modern standards essentially requires gutting the homes, air sealing the entire structure, replacing windows, and replacing the entire heating and cooling system with a modern, efficient, carbon-free (or at least low carbon) system. This can entail replacing the existing ductwork (which was usually installed in an ad hoc way) with a fully engineered ventilation system including supply and return ducts in each room or zone. Another option would be retrofitting with a more efficient hydronic system with in-floor heating, air handling units, and a ventilation system with a heat recovery ventilation system.

Retrofitting old homes can be risky. These homes are of frame construction, and the original siding and plaster could "breathe", so any moisture that got to the structure could work its way out of the walls without causing any damage. While air sealing and waterproofing is a good idea, a contractor who does not know what he or she is doing can cause moisture to be trapped inside the walls, potentially causing a lot of damage.

Regardless of the system to be installed, there are retrofit issues to be addressed. For any heat pump system with forced air heat delivery, the most significant issue is the suitability of the duct work in the home. While the ductwork in the Laurier Avenue homes may be adequate for the existing heating systems, optimal home comfort and best energy efficiency of the heat pump systems may require extensive duct work upgrades, particularly in the form of additional return ducts.

As noted above, heat pump systems require higher air flow rates than combustion based heating appliances due to their lower heat delivery temperatures. This is based on the requirements for instantaneous heat transfer from the heating system (either furnace or heat pump) to the air flow that is taking the heat into the home.

Conventional gas furnaces generate heat at a much higher temperature than a heat pump. This large temperature difference means the heat is transferred more quickly with a lower air flow rate.

Regardless of the heat source, when a home loses 36,000 Btu per hour of heat through the walls and air leaks, the heating system must transfer 36,000 Btu per hour of heat from the heat source (either combustion based or a heat pump) into the air inside the home to maintain a constant temperature. While heat pump systems are sized to match the heat lost requirements, combustion based heating systems are generally oversized. If a furnace generates 72,000 Btu per hour, it only has to run one half of the time to generate the required 36,000 Btu per hour to maintain the required indoor air temperature.

The air flow requirements are based on the following equation:

$$Q = 1.08 \times CFM \times \Delta T$$

Where

Q = heat transfer, in Btu/hour
CFM = air flow, in cubic feet per minute
ΔT = temperature change of the air, in degrees Fahrenheit.

Rearranged, the equation is:

$$CFM = Q/(1.08 \times \Delta T)$$

For a gas furnace where the air is heated to 140 degrees F and the ambient indoor temperature is 70 degrees, the required air flow for 3 tonnes of heating is:

$$CFM = 36{,}000/(1.08 \times 70)$$

CFM = 475 cubic feet per minute.

For a heat pump system, where the heat is delivered from the heat pump at 95 degrees F, the required heat flow for 3 tonnes of heating is:

$$CFM = 36{,}000/(1.08 \times 25)$$

CFM = 1335 cubic feet per minute, or approximately 450 cfm per tonne.

It is possible to run a heat pump at a lower air flow, however, this will reduce the heat transfer and therefore the efficiency of the heat pump (same energy in + less energy out = lower efficiency). In extreme cases, insufficient air flow can damage the heat pump.

Note that most central air conditioning systems require an air flow in the range of 300 cfm/tonne, which is somewhat lower than the air flow required for heating with a heat pump system.

Ductwork retrofits are not inherently difficult or expensive – ductwork modifications for the Laurier Avenue homes are likely to cost less than $1,000 per home. What can be expensive are the site specific requirements of the ductwork upgrades, particularly patching any holes in the plaster/drywall etc. The installation of $1,000 of ductwork could require $5,000 of patching. This site specific detail is beyond the scope of this study, and will require a detailed survey from a ducting specialist to confirm pricing.

One potential for improvement in both energy efficiency and home comfort is the move from conventional blower motors to high efficiency variable speed blower motors. The least efficient conventional blower motor is a single speed blower that cycles on when the furnace burner is on and then shuts down when the burner stops. These motors can be 10 to 60% efficient. A high efficiency variable speed blower motor, or ECM (electronically controlled motor) motor, maintains a good efficiency range of between 60 and 80% at all speeds. Because the motor is so efficient, it can run continuously, providing steady air circulation which improves home comfort.

One possible solution to the ductwork issue is a hydronic system with low temperature radiant heating (such as radiant floor heating) or air handling systems. Hydronic heating and cooling can be provided by either a GeoExchange system or an air source heat pump. Hydronic systems have the potential for zoned heating and cooling by locating the heat exchangers throughout the home. This can address the problem of inadequate comfort in the extreme areas of the home such as the third floors or basement. Hydronic systems offer the potential for a less intrusive retrofitting than ductwork replacement.

It is important to keep in mind that should any homeowner consider a major renovation on their home, energy efficiency upgrades, including high efficiency heating and cooling such as heat pump system, should be a key aspect of that renovation. Any renovation that includes the removal of interior finishes such as plaster or drywall should including careful attention to air sealing and insulation prior to replacing the finishes. Homeowners should put as much effort into energy efficiency during their renovation as they expend selecting cabinets and countertops.

ADDITIONAL OPPORTUNITIES

This study also looks at the applicability of additional opportunities for the Laurier Avenue row houses. These include:

- Renewable Energy;
- Energy Efficiency; and
- Permeable Road Resurfacing

RENEWABLE ELECTRICITY GENERATION

Solar Energy

The Study Team contacted Our Power to assist with a solar evaluation of the Laurier Avenue site. Our Power is a project of the Toronto Renewable Energy Co-op whose mission is to facilitate the installation of solar energy systems on residential rooftops in the GTA and across the province. Our Power invites people to join as Members and receive an on-line and telephone solar evaluation of their homes as a benefit of their membership. Since this program began in December 2009, the Our Power team has performed over 180 residential solar evaluations. David Booz of the Laurier Avenue Study Team serves on the Our Power steering committee.

The Our Power evaluation team was provided with information on the Laurier Avenue community, including the addresses of the homes, a layout of the community, and some information on the tree cover and other potential shading obstacles and asked to comment on the opportunities for photovoltaic and solar domestic hot water installations.

The report from Our Power said that “due to significant shading from trees and an unfavourable (due east-west) orientation of the homes on this block, the opportunities are limited”.

Our Power suggested that a wall-mounted system could be installed on the south walls of both number 1 Laurier and 2 Laurier, and a flat-roof system could be installed on number 1 Laurier, stringing along the roofs of numbers 3, 5, and 7. The total capacity for these roofs would be about 12 kW DC. Please see the complete roof assessment in appendix.

Like many neighbourhoods in downtown Toronto, Laurier Avenue boasts a number of fine trees that provide shade, shelter, animal habitat, air pollution reductions, and improve the appearance and livability of our neighbourhoods. The unfortunate aspect of large trees is that the shading they provide precludes the use of photovoltaic systems. PV systems are not shade-tolerant. A small amount of shading on the array can reduce the power yield of the array to practically zero. While the tariffs paid by the Feed-In Tariff program may appear at first glance to be generous, these systems are capital-intensive investments with long paybacks. Any reduction in system yield extends the payback period significantly. Our Power does not recommend PV installations on sites with any significant level of shading.

While there is some potential on the south end of the street, the solar potential for the rest of the community is poor.

Should the residents at the south end of Laurier Avenue elect to pursue a PV opportunity, Our Power can provide a significant level of support for the buying process. The solar assessments include estimated system costs and returns; including a return on investment calculation (please see the attached document). For Our Power members who wish to pursue a solar investment, Our Power provides access to a number of vendor partners who meet Our Power's criteria as reputable vendors for residential solar energy systems.

One technology that the Laurier Avenue Study Project Committee is interested in is concentrating solar photovoltaics. This technology uses some form of optical technology to concentrate the sunlight on a small area. The optical technology can be some form of focusing optics (see www.morgansolar.com) or a mirror based technology (see www.zenithsolar.com) to focus the sunlight on a small, highly efficient (and expensive) solar cell. The theory is that if you triple the amount of energy that hits a cell that is twice as efficient as a conventional solar cell, you can justify the significantly higher cost of this type of system.

One significant technological challenge to concentrating PV is the need for a two-axis tracking system to track the sun and ensure the sunlight enters the system at the correct angle to be focused on the high efficiency solar cell. The tracking system has to be very accurate and very reliable to ensure the energy hits the small target. This becomes even more challenging in the harsh Ontario climate.

While these technologies show some potential, there are no mainstream vendors in the Ontario market that have successfully applied these technologies. The Our Power team is particularly plugged in to the residential solar market in the GTA, and they are not aware of any vendors currently offering this technology for residential applications.

Wind Energy

Another potential renewable energy generation technology is wind energy. Wind energy has become a mainstream renewable energy technology. In the initial period of the Feed-In Tariff program, contracts were issued for 1,529 MW of wind energy projects.

Wind energy is a viable technology for large scale wind farms. It is not, however, suitable for urban residential applications.

The FIT tariff for wind, $0.135 per kWh, is a fair price for the energy produced by large scale wind farms. Small wind, however, costs a lot more per kW installed than large wind turbines. Small wind generating systems cost about the same amount as photovoltaics, and since the tariff is only about 1/6 the rate, the economics simply do not work.

Since the amount of energy in the wind is proportional to the cube of the velocity, a small increase in wind speed produces a significant increase in energy production. High relative wind speeds, and consistent wind speeds, produce the most energy. To harvest these winds, wind turbines are best positioned in large open areas with few or no obstructions to disrupt the wind, and on the tallest towers practical to capture the higher wind speeds found farther from the ground. In an urban environment, the difficulty of locating tall towers, and the turbulent wind caused by the many obstructions such as buildings and trees critically limit the productivity of urban wind turbines.

Rooftop mounting of wind turbines can be problematic. Wind turbines vibrate when they spin, and this vibration is transmitted into the building structure. Wind turbines exert strong reaction forces on their mounts, and the roof of a Victorian home may require significant reinforcements to ensure it can support the turbine. Should the wind turbine mount fail, the falling turbine could cause significant damage to persons and property.

Rooftop wind turbine in Harbord Village

For these reasons, we believe that wind is not a suitable technology for urban applications.

ENERGY EFFICIENCY

Energy efficiency upgrades are the most cost-effective ways to improve the energy efficiency of a home. Even if homeowners are considering an upgraded heating system, energy efficiency upgrades can potentially decrease the size of home heating system required and the cost of installing that system.

The EcoENERGY program provides a good framework for evaluating home upgrade opportunities and evaluating which upgrades would be effective and which make little contribution. Seven of the Laurier Avenue homes have had EcoENERGY home assessments, and it can be assumed that the findings from these homes would likely be applicable to the other homes in the neighbourhood.

As most of these assessments were connected with this project, the energy auditor recommended GeoExchange systems for the homes. Since GeoExchange systems are very efficient, they can produce a very significant increase in home efficiency. There was one home that was audited before this project was initiated. The auditor for that home recommended a high efficiency gas furnace, which also had a significant increase in efficiency. Clearly, new heating systems, either GeoExchange or something similar, are likely to be the key upgrade for improving the energy efficiency of the Laurier Avenue homes.

All of the Laurier Avenue homes tested were poorly sealed, with an average of 14.93 air changes per hour. Air sealing can be a simple, inexpensive and effective way of improving the energy efficiency and comfort of a home. Many air-sealing opportunities are good do-it-yourself projects, or you can use a contractor. These measures can include:

- Caulking around baseboard trims and moldings
- Sealing electrical outlets, switches, and ceiling fixtures
- Sealing penetrations for exterior wires and pipes
- Weather-stripping on doors and windows
- Sealing window and door frames
- Sealing attic hatches
- Sealing basement header (rim joists).

Please note that each air sealing opportunity may require specific materials and tools. Preference should be given to environmentally friendly sealing materials with low volatile organic compounds, both for the benefit of the environment as well as for improved indoor air quality. As a first step, we recommend the Natural Resources Canada publication “Keeping the Heat In”, which is available on the NRCan web site. Natural Resources Canada publishes a large library of information flyers on home improvement and home energy efficiency topics on their web site, which is a great place to start. A contractor who specializes in home energy efficiency, home insulation and air sealing would be another good resource.

After air sealing, improving insulation is the next best opportunity. Most homeowners on Laurier report little or no basement/crawl space insulation, which can have a significant impact on efficiency and comfort and is often relatively easy to install once any dampness issues are addressed. Wall insulation is also quite effective, however it can be challenging to upgrade finished walls without having to do significant upgrades such as removing and replacing exterior siding or interior finishes. Improving attic insulation can be relatively easy (depending on the attic configuration), especially in conjunction with attic air sealing. Homeowners should be careful to keep any soffit vents clear to ensure adequate attic ventilation to prevent excessive heat in the summer and condensation in the winter.

One other home upgrade opportunity is replacing windows and doors. On Victorian homes, the windows and doors are relatively small compared with the total wall area of the home. Even the best windows only have an R-value of 5, so as a general rule, replacing windows and doors provides less benefit than the marketing materials provided by the window manufacturers suggests. The exception, of course, are windows or doors that are leaking and generally in very poor condition. If a home needs new windows, homeowners should install the most efficient windows they can afford, however, replacing windows and doors should not be done purely as an energy efficiency upgrade. With heritage homes, of course, there are strict limits on what is acceptable for new windows and doors and these guidelines must be respected.

After space heating, the single largest home energy consumption is found in domestic hot water heaters. A basic gas fired hot water heater is not very efficient.

Should the residents of Laurier Avenue proceed with GeoExchange systems, the geoexchange systems can be equipped with a “de-super-heater” which can provide some high efficiency hot water pre-heating, particularly in the shoulder seasons. Otherwise, solar energy is a very efficient hot water pre-heating technology. While the homes on Laurier Avenue have too much tree shading for photovoltaics, solar hot water systems can still be effective and economical with a moderate amount of shading. We believe that most of the Laurier Avenue homes would have sufficient insolation for a small solar domestic hot water system. We suggest obtaining specific recommendations for each property from a reputable solar domestic hot water system installer.

Both GeoExchange and solar heating can provide pre-heating of hot water, however, an auxiliary heater is required to bring the water up to final temperature. There are a number of high efficiency hot water heating options including high efficiency condensing tank style hot water heaters and on-demand systems.

PERMEABLE ROAD RESURFACING

A significant cause of water pollution in Toronto is ground water runoff. Because of the large percentage of land surface that is covered with buildings or paved surfaces, only a small percentage of rainwater is absorbed into the ground where it falls.

Precipitation that percolates through the soil goes through a natural purification process, and recharges the local water table. When precipitation is collected on rooftops and on paved surfaces, it picks up the toxins that accumulate on roads and washes them into the storm sewer system and then into Lake Ontario, largely untreated.

The residents of Laurier Avenue are encouraging the City to use this small street to prototype one or more permeable paving systems that can be monitored and tested for its applicability more widely across the city.

Permeable paving systems reduce stormwater runoff by allowing precipitation to seep through the pavement system into the subsoil below, keeping the water in the immediate area for the use of the local foliage and ultimately replenishing the water table.

There are a number of permeable pavement technologies including:

- Permeable concrete or asphalt, consisting of concrete or asphalt with large voids that allow the water to flow through.
- Concrete unit paving systems, similar to interlocking brick, which allow water to seep between the blocks.
- Gravel or crushed stone

- Laurier Avenue residents have suggested that the City consider the installation of an 8” to 12” border along the edge of the roadway, beside the sidewalk. This would involve a layer of crushed gravel, topped by a permeable material. This would have similar maintenance and visual characteristics to the brick bordered side streets common in Toronto.

The most common applications for permeable pavement tend to be parking areas and walkways. It is not generally used for streets with vehicular traffic.

Permeable pavement can have some additional advantages:

- It can eliminate puddles, since stormwater seeps through the paving.
- If used over areas with underground utilities needing repair, pervious paving materials may be easily removed from over the repair area, pavement replacement is simplified and expensive asphalt or concrete cutting is eliminated.

There are, however, a number of challenges to implementing permeable paving systems:

- Installation costs can be higher than traditional impermeable pavement systems. While easier maintenance and reduced stormwater handling and treatment requirements offset some of this additional cost, these savings are difficult to quantify.
- A cold climate might be a challenge to the longevity of permeable pavements. Freezing and thawing cycles could cause damage to the paving system through the winter months. More study is required into these challenges.
- There is some question if the permeable paving systems in traffic areas have the strength and durability for regular vehicular traffic, even for a low traffic street like Laurier Avenue.
- Snow removal from pervious surfaces requires more care than from conventional paving.
- Some permeable paving systems require regular vacuum sweeping to prevent the voids from clogging with dirt and mud, which increases maintenance costs.

ECONOMICS

This section provides Laurier Avenue with an understanding of the costs of the system and available rebates and incentives, along with a financing strategy.

COSTS

<u>GeoExchange – Individual Homes</u>
For illustration, a single home GeoExchange system would provide 3 tonnes of heating/cooling and save 40-50% of the home's energy cost.

Assuming the neighbourhood comes together and affects the purchase of multiple systems, the system costs used for this purpose are:

Item	Estimate
Ground Loop (inc. trenching)	$11,250
Heat Pump	$5,000
Pumps and Piping	$2,500
Duct Modifications	$1,500
Total (before taxes)	**$20,250**

Some homes may need to upgrade to a 200A electrical service and the cost for this would be approximately $3,500.

The average Laurier home uses 2,335 kWh (eq.) of gas and 6,755 kWh of electricity. At rates of $0.386/kWh for gas and $0.145/kWh for electricity, the homeowner total energy cost is $1,881/yr.

At a savings of 40%, to be conservative, this would result in annual savings of $752.

Incentives for geothermal are limited to the following:

- Ontario Home Energy Savings grant for the installation of an earth-energy system that is compliant with CAN/CSA-C448 and certified by the Canadian GeoExchange coalition: $4,375
- Ontario Power Authority energy conservation grants offered through the City of Toronto: $250/tonne, or in the case of this example, $750.

It is assumed that most homeowners would be looking to GeoExchange as an option coincidently with the need to replace their existing furnace. A high efficiency natural gas furnace would cost approximately $5,500 installed. Taking this into consideration, the simple payback on an average Laurier home for an individual 3-tonne geothermal system is estimated at less than 13 years. A more rigorous approach would include the incremental electricity use escalated for future price increases, and the savings would similarly show an escalation in the cost of gas being offset. For the purposes of this report, these assumptions can be seen as netting out as the error in modeling these factors is greater than the accuracy of the model.

Item	Estimate
3-Tonne GeoEx Installed	$20,250
Ontario Home Energy Savings	($4,375)
Toronto Rebate	($750)
Replacement Furnace Credit	($5,500)
Total (before taxes)	**$9,625**
Total (before taxes w/EcoEnergy)	*$5,250*

Prior to the cancelling of the EcoENERGY program, an additional $4,375 in rebates would have been available to residents. Some Laurier residents that had EcoENERGY audits completed prior to March 31, 2010, and commit to the installation of the geothermal system prior to December 31, 2010, could still be eligible for this additional incentive.

A summary table of municipal charges as estimated in this report is provided below.

Encroachment Charges	Fees
Application Fee	$480
Legal Fees	$600
Annual Fees	$160-$240
Total Estimated Fees	$1,240-1,320

The following table provides the Laurier residents with an understanding of the necessary additional cost reductions that would be required to achieve a specific simple payback period. This table is only a guide, but if lower priced quotes, grants, or other incentives are forthcoming, it provides a sense of the time period required to capitalize the installation.

Payback Period (yrs)	Additional Cost Reduction Required
13	$0
10	$2,105
7	$4,361
5	$5,865

As can be seen from the above table, the EcoEnergy rebate (that is no longer available, unless an audit has already been completed) would bring the payback down to a just over 5 years. Without the rebate a 13 year payback should be expected.

GeoExchange – District Energy System

As discussed earlier in this report, a district energy system using GeoExchange can have a significant cost benefit. There are additional costs associated with the connections around the neighbourhood, and the administrative costs of setting up and managing a co-operative.

The key economy of scale is in the ground loop due to the ability to service all the homes, and recognizing that, especially on Laurier Ave, the daily use characteristics of the homes vary significantly. This allows the neighbourhood to benefit from a more even use of the system rather than a completely bi-modal distribution. It is expected that the ground loop could be as much as 25% smaller than the total of the individual loops. This would require a minimum of 12 homes to participate. Each additional home would increase the value to the group. For the purposes of comparison, an expected economy of scale of 15% is used to represent the lower end of the scale, and 25% is used for a 20 home participation.

Cost Item	Individual	District	District
	1 Home	12 Homes	20 Homes
Ground Loop	$11,500	$114,750	$168,750
Heat Pump	$5,000	$60,000	$100,000
Pumps and Piping	$2,500	$30,000	$50,000
Duct Modifications	$1,500	$18,000	$30,000
Coop Set-Up	$0	$7,500	$7,500
Total	$20,500	$230,250	$356,250
Unit Cost per Home	$20,500	$19,188	$17,813
Rebates	($10,625)	($10,625)	($10,625)
Municipal Charges	$1,300	$1,300	$1,300
Net Unit Cost	$11,175	$9,863	$8,488
Cost Savings	n/a	12% of individual	24% of individual
Simple Payback*	15 yrs	13 yrs	11 yrs

** after rebates and new furnace credit*

<u>Air-Source Heat Pumps</u>
Based on similar metrics to the analysis above, a 3-tonne air-to-air heat pump unit ranges from $16,000 - $19,500. Though highly efficient, both MitsAir (Zuba) and Hallowell (Acadia) concede that their systems cost more to operate than high-efficiency natural gas furnaces and are cost neutral to high-efficiency air conditioning. A 3-tonne Aermec system would cost $15,000 according to the representative. All of these costs do not include ductwork, supplemental heat options, or accessories. The market for these units is in off-setting the higher costs of electric resistance heating, oil or propane. Unless natural gas prices escalate rapidly, it is unlikely that a significant market for these units will exist where high-efficiency gas furnaces are viable.

As a comparison, the following table provides a base case furnace replacement cost using a high efficiency natural gas unit. The incremental cost for GeoExchange, or air-air, or air-water heat pumps is provided along with the relative savings to the base case. Negative savings indicate greater operating costs than the base case.

Base Case	Capital Cost	Savings
High Efficiency Gas	$5,500	n/a
Heat Pump Alternative	**Incremental Capital**	**Relative Savings**
Geothermal	+$9,625	12%
Air-to Air	+$10.5-$14,000	-9%
Air-to-Water	+$10,000	-20%

Source: correspondence with representatives for Zuba and Acadia

Grants

Over the years, various programs have supported the capital cost of GeoExchange systems. Currently, there is a gap in available grants for GeoExchange. However, where possible, it is encouraged that the Laurier residents pursue grant opportunities to bring down the capital cost of the system to a level that is no greater than a 10-year payback. These grants are best sought from those interested in urban development and community renewables. One such source is the Community Power Fund. Others could include City of Toronto resources like the Toronto Atmospheric Fund and Live Green Toronto. By using the City of Toronto as the lead, the residents may be able to build a test case that could be taken to the Canadian Federation of Municipalities of Canada Mortgage Housing Corporation. Additional opportunities may be available if the DVCRA were to apply to the Trillium Foundation. Most of these grant opportunities support community, environment, energy and infrastructure projects. However, in most cases they are open ended and are not focused necessarily on projects like this.

Financing

The best option for financing the remainder is the use of the City of Toronto's Sustainable Energy Fund, which will provide up to 49% of the project costs at 0% interest for up to 20 years. However, the minimum requirement is about $50,000 which would favour the district system over the individual project. The Laurier residents are encouraged, however, to approach the SEF as a group to discuss this further. This program is run through the City of Toronto Energy Efficiency Office.

Financing the remaining capital for an individual system is going to be limited to that which can be borne by the homeowner's credit. A third party owner, acting as a micro-utility, is unlikely to look at any projects with greater than a 10-year simple payback. Also note that the use of Local Improvement Charges, which is currently under investigation by the World Wildlife Fund, would have the effect of creating a property tax burden on the property for a period of at least the simple payback period. All third party financing would introduce a cost of borrowing which would be similar to a mortgage. It should be noted that third party financing will be dependent upon the equity in the home for an item like this.

CONCLUSIONS

A GeoExchange system is a very efficient and effective heating and cooling technology. Along with a number of other energy efficiency measures such as air sealing and insulation, these systems provide an exciting opportunity for Laurier Avenue residents to upgrade their homes, significantly reducing both the energy and carbon footprints of these homes.

Unfortunately, there still are significant barriers to the implementation of GeoExchange technology in an urban environment. These include:

- High capital costs
- Technical challenges due to small lot sizes
- Bureaucratic barriers to creative use of city property
- Heritage conservation and archeological preservation requirements
- Retrofitting advanced heating and cooling systems into existing heritage homes.

The homes of Laurier Avenue are relatively inefficient, however, they are small, and row houses have lower heat losses than detached houses. Relatively low utility prices result in relatively lower heating and cooling costs, even with low levels of home efficiency. While energy savings are a significant percentage, the dollar amounts are small, and the return on investment is long.

Nonetheless, it is important to continue to explore the technologies and address the bureaucratic barriers. The cost of fossil fuels and carbon emissions will continue to rise, making these residential efficiency measures more important and ultimately more economically viable. Laurier Avenue has a unique opportunity to pioneer the use of GeoExchange heating and cooling technologies in an urban environment, addressing both the economic and bureaucratic barriers to this type of home upgrade. This work has the potential to help make these technologies viable for other communities.

Air source heat pumps have the potential to provide a similar level of heating and cooling efficiency with less capital cost and a less intrusive installation. Unfortunately, this equipment is not cost competitive with natural gas at current natural gas prices. While we expect this to change as fossil fuel prices escalate, and air source heat pumps could provide other non-financial benefits to the Laurier Avenue community, the operating costs for this type of system are a subject of some concern.

Renewable energy technologies such as solar PV and wind power are becoming a significant part of Ontario's electricity supply mix. Unfortunately, the opportunities for installing systems on the Laurier Avenue homes are limited due to extensive shading for solar and poor siting for wind. Should the residents of Laurier Avenue be interested in investing in these technologies, we recommend investigating a renewable energy co-op such as TREC's Lakewind and SolarShare.

Home energy efficiency is almost always a good deal for heritage homes – the least expensive energy is the energy you don't have to purchase. As shown by the EcoENERGY home audits, there are a number of home energy efficiency opportunities that could be pursued by the residents of Laurier Avenue. One opportunity that is unique to Laurier Avenue would be for interested residents to get together to select energy efficiency upgrade vendors and negotiate a group purchase for multiple homes at the same time.

Permeable road resurfacing has the potential to help address the technical, environmental and economic challenges of storm run-off; however, these technologies are still relatively new and unproven for street applications in our climate. Laurier Avenue could be a useful test site for the City to explore the effectiveness of these technologies.

RECOMMENDATIONS

Based on the scope of this feasibility study, it is recommended that:

The Laurier Avenue committee continues to engage with the City of Toronto to encourage policy changes and other measures to remove barriers to GeoExchange systems and other energy efficiency and renewable energy technologies.

Once the Laurier Avenue committee and the City of Toronto have addressed the barriers to urban GeoExchange systems, it is recommended that the Laurier Avenue residents obtain technical proposals and pricing from GeoExchange system vendors, and share the preferred proposals with Laurier Avenue residents. This process should include detailed information on any required ductwork modifications.

Should the City be unable to remove sufficient barriers to make GeoExchange systems practical, the Laurier Avenue committee should explore opportunities with air source heat pumps. While the economics remain challenging, we are confident that these systems will become more attractive and economical as the technology improves and the price of fossil fuels increases.

Laurier Avenue should only consider a “decentralized” district style GeoExchange system, or individual systems on each home. A “centralized” district GeoExchange system is not recommended for Laurier Avenue, since this system would require common ownership of significantly more of the system (ground loop and large centralized heat pump), which could make the organization of the system more difficult. Also, this type of system must be switched from heating to cooling mode, so it would not be possible to provide heat to some homes and cooling to others at the same time.

Generation of renewable electricity using solar or wind energy is not recommended. The Laurier Avenue site is not suitable for either technology due to the large number of trees and other obstructions.

All Laurier Avenue residents should explore the energy efficiency upgrades recommended by EcoENERGY home audits. While the EcoENERGY program has been shut down, the Province of Ontario continues to subsidize home energy audits and provide grants for home energy efficiency upgrades. Laurier Avenue should explore a group purchase of insulation, air sealing, etc.

Permeable road resurfacing should be approached with caution. There is not enough information on the use of these systems for roadway applications in our climate to be confident that a solution would prove successful and economical.

APPENDIX

ATTACHMENTS TO THIS REPORT

- House Profiles Questionnaire
- House Profiles Summary Table
- Laurier Avenue Community Layout Drawings – Plan and Details
- Our Power House Assessment
- Community Layout with Utilities – City of Toronto
- Cabbagetown North Heritage Conservation District, Heritage Character Statement and District Plan, October 2003
- Proposal from Archaeological Services Inc.
- Product information for heat pump systems (geoexchange and air source)
- Element Village report: "A Study of Cooperative Urban District GeoExchange for Heating and Cooling"