# Home Energy Retrofit Program

# in the City of Vaughan

# Using Local Improvement Charges Financing

## - Business Case Study

## Acknowledgments

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This document is one of three reports that comprise Vaughan's study of the use of Local Improvement Charges to accelerate energy retrofits in private buildings. The three study reports are: a main study report; model by-law and forms; and a business case.


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## Contents

# Executive Summary

Improving the energy efficiency of Vaughan's residential building stock through a municipal retrofit program is one of the critical strategies to meet municipal GHG emissions reduction targets, help residents reduce their energy costs, and support local job creation. The potential Vaughan Local Improvement Charge (LIC) program is designed to finance consenting homeowners for the installation of qualifying energy and water conservation improvements, and may include related energy assessments, and then to secure payment by imposing a LIC on the private residential property.

A Study Report (under separate cover) lays out the details of how a City-wide, LIC-based residential energy efficiency retrofit program can be implemented. The study was also informed by a risk assessment workshop. The risk assessment identified success factors and barriers that will help to estimate potential program operation and uptake.

This report provides a comprehensive business case based on prior research and evaluation of similar programs in other jurisdictions. Primary focus areas of this business case are:

- the potential for uptake and retrofit rate
- energy savings and GHG reduction
- socioeconomic benefits, and
- an estimate of municipal staff time

## Summary of Findings

Results of the City of Toronto Home Energy Loan Program demonstrate average energy retrofit costs of $22,000 and typical energy savings of 30%, resulting in an average of $560 per year in energy bill savings.

Recommendations to ensure program uptake include suitable initial funding disbursement amounts (e.g. 30% of total financing) as well as overall financing totals (e.g. 10% of assessed value of the home), expansion of the program to include renewable energy and electric vehicle charging infrastructure, and allowing the cost of EnerGuide home evaluations to be an expense eligible for LIC financing.

Marketing to potential applicants should focus more on home improvement, better comfort and building performance as well as utility cost savings.

Full cost recovery of staff administration time will likely result in passing along a total interest rate, including an administration fee, that is higher than many applicants would be able to obtain through a secure line of credit. This is a consideration in transitioning from program start-up to full implementation.

# 1. Potential for Uptake and Retrofit Rate

An energy efficiency retrofit program is under consideration by the City of Vaughan utilizing Local Improvement Charges (LIC) financing. This approach provides financing to homeowners that is recovered by the municipality by applying charges to homeowners' property tax bills. It is critical to estimate the potential success of such a program before deployment. Success indicators include the number of projects, energy savings per project, and GHG emission savings per project. Additional associated metrics such as administrative costs, program expenditures, third party involvement, and participant satisfaction will define the success of the program.

The potential for uptake is a crucial metric to estimate the efficacy of such a program. In this work, an estimate of uptake potential has been derived. Due to similarities to the proposed LIC-based program, potential uptake has been estimated based on reported statistics from the City of Toronto's Home Energy Loan Program (HELP). This program has evolved over time and made amendments based on the success of other programs across North America.

## 1.2 Case Study: City of Toronto Home Energy Loan Program

The City of Toronto implemented the HELP initiative in January 2014, after City Council approval in 2013. The program provides homeowners with financing for energy and water efficiency home improvement projects with low, fixed interest rates (3.7 – 4.4%) over long payment terms (5 – 20 years). Homeowners repay the loans through LIC-based payments. These repayments are attached to the property, not the homeowner, and financial obligations are automatically transferred to a new homeowner at the time of sale. All data on the City of Toronto was obtained from the City of Toronto's numerous Reports for Action on the HELP (energy retrofits for low rise dwellings) and Hi-RIS (energy retrofits for multi-unit residential buildings) programs.

Initially, the program funded only building envelope improvements (window/door replacements, basement/attic/exterior wall insulation, air sealing), mechanical systems (including lighting), and water conservation improvements. In 2017, the program expanded to include renewable energy technologies (e.g. solar photovoltaics and solar hot water). In 2019, the initiative expanded further to include electric vehicle chargers, energy storage technology, and energy efficiency resilience measures.

At the time of its launch, the pilot program was intended to last three years (2014 – 2016). At this time, the program had committed $10M in funding for home energy improvements. The program had also set a participation target of 1000 homes during the first three years. Figure 1 shows the five-year uptake of the City of Toronto's HELP initiative in terms of both applications received and contracted projects. As of 2019, the HELP initiative was able to convert approximately 20% of applications into completed or committed projects.

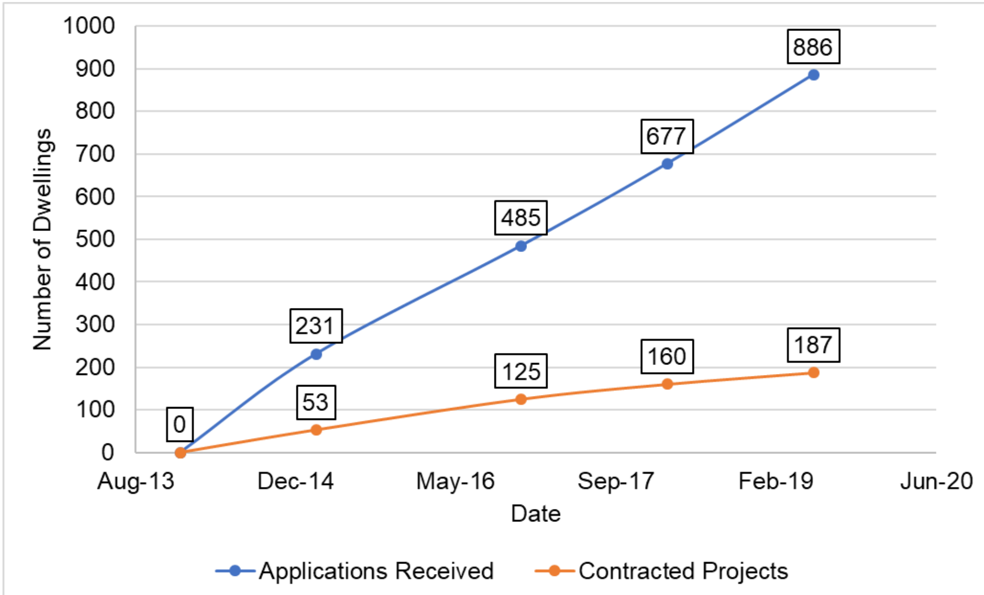



*Figure 1 - City of Toronto Home Energy Loan Program uptake.*

The actual rate of uptake is far lower than the program's initial goal of 1000 homes by the end of 2016. As of the summer of 2019, the program had also only committed $4.8M of the initial $10M in available funding. Due to these lower than expected projections, the program has been extended to December 31st, 2021.

As of 2019, the average HELP project cost was $22,000. Projects typically result in 30% energy savings, resulting in an average of $560 per year in energy bill savings. The program has produced cumulative savings of 550 tCO2 (tonnes of carbon dioxide emissions), or approximately 1 tCO2/household/year.

**$560**

Average annual energy savings

There have been many lessons learned throughout the implementation of the HELP initiative, which can help to strengthen future LIC-based energy efficiency retrofit programs. The strengths and weaknesses of the HELP initiative are described below.

### 1.2.1 Program Strengths

*1.2.1.1 LIC mechanism, low interest rates and repayment terms*

Homeowners found benefit in the fact that loans are attached to the property, and that charges are automatically transferred upon sale of the home. Low, fixed interest rates over extended periods minimize borrowing costs for homeowners, a considerable advantage over other means of obtaining financing. Initially, participants in the HELP initiative were limited to a 15-year repayment term. However, any projects that include solar, windows, geothermal and/or heat pumps are now eligible for 20-year terms.

*1.2.1.2 High-levels of customer support and satisfaction*

Customers reported high satisfaction when dealing with City and program staff. Almost all customers would recommend the program to friends and family. The HELP initiative is viewed as trustworthy, and homeowners have indicated that they experienced peace-of-mind when dealing with the City.

*1.2.1.3 Easy application process*

Most applicants found the application process to be straightforward. The City is currently working with its IT team to simplify further and automate the application process.

*1.2.1.4 Enabled multiple projects*

Program participants typically installed more than three energy and water efficiency measures per project. The program provides financial flexibility, covering additional work that enables energy improvements (e.g., maintenance upgrades, electric panel replacements, environmental remediation). It was noted that this type of flexibility was attractive to homeowners and helped to support increased participation.

### 1.2.2 Program Weaknesses

*1.2.2.1 Mortgage lender consent*

Half of all participants who submitted applications dropped out due to difficulties in obtaining consent from their mortgage lenders, which is a requirement under the City of Toronto's implementing LIC by-law to ensure that lenders do not consider a homeowner's enrollment a breach of their mortgage terms. Applicants had mixed experiences when dealing with their financial institutions, and issues identified include a lack of program awareness, conflicting information within organizations, and the lack of a clear policy to handle requests. These difficulties are on-going, and staff have been working with the Federal Government and other stakeholders to help address these issues. Hopefully, future programs can leverage the momentum that the City of Toronto has created in this regard.

*1.2.2.2 Marketing and promotions and staff support*

While participants have been very satisfied with staff support, the amount of support required has been far more than expected. Staff spend a considerable amount of time answering general inquiries. By the end of 2016, program expenditures (administrative costs and other expenditures, excluding loans provided) amounted to approximately $626,400. Divided across the 125 projects completed at this time yields $5,000 in additional costs per project. These costs are very high relative to the average loan per project amount of $22,000.

Program staff has also noted that in-person and direct marketing approaches have been the most effective; however, these methods of marketing are very labour-intensive. While the City initially intended to engage an external marketing consultant, staff instead updated their marketing capabilities and materials internally. The City also employed IT staff to develop a more automated application process, launched in 2018. The City of Toronto has also recently developed a website to share information and aid homeowners in finding incentive providers (https://betterhomesto.ca/rebates-incentives/).

Channel partners for the program include community groups, utility companies, energy advisors, renovation contractors, realtors and industry associations. Unfortunately, the effectiveness of each of these channel partners is not directly reported. However, staff noted that in 2017, 78% of HELP applicants received a Community Energy Conservation incentive through Enbridge. Since applicants can use utility incentives to help reduce overall project costs, integrated marketing campaigns with utilities would prove to be very beneficial to promote uptake. HELP staff had also engaged the former GreenON fund to include HELP information in GreenON's website, which was seen to contribute to a significant spike in uptake.

*1.2.2.3 Funding eligibility and disbursements*

When the program was created, homeowners were eligible for loans up to a maximum of 5% of the current value assessment (CVA) of their property. Homeowners felt that this maximum amount was too low and would struggle to cover many of the proposed projects. Additionally, the program would initially provide homeowners with a "deposit" of 10% of the project costs. Homeowners felt that this amount was too low, particularly when upfront project costs were high. To mitigate these issues, the program was amended such that the maximum funding eligibility is now the lesser of 10% of the CVA or $75,000. Initial disbursement amounts have also been increased to 30% of project costs.

*1.2.2.4 Home Energy Assessment costs*

Initially, the cost of Home Energy Assessments was not eligible to be included in project costs. However, in June 2019, the program was modified to allow the inclusion of energy assessment costs, less any applicable incentives, be included in overall project costs. It was indicated that pre and post EnerGuide evaluations were key in identifying retrofit measures and ensuring that those measures had been completed correctly and savings are realized.

*1.2.2.5 Emission reduction impact*

At the end of 2016, the program had seen a total of 125 projects completed or committed, with a total of $2.1M in funding provided. At this time, the program estimated that the funded retrofit measures would result in total emission reductions of 7,900 $tCO_2$ over the lifetimes of the funded projects. The cost of carbon associated with the HELP initiative investments is, therefore, calculated to be $265 per tCO2. This cost of carbon is five times greater than the Federal Government's intended price on pollution of $50 per tCO2. Some of the costs funded by the program are non-energy improvement costs (e.g., panel upgrades), and more targeted GHG reduction retrofit measures could help to deliver more emission savings per dollar invested.

## 1.3 Uptake Projections

Program uptake for a City of Vaughan energy efficiency program was based on uptake statistics from the HELP initiative and normalized by census dwelling data. According to the 2016 census, there are 619,650 and 84,445 low-rise dwellings in the City of Toronto and City of Vaughan, respectively. The fraction of private household homeownership is 52.7% in Toronto and 89.6% in Vaughan. Applying these fractions to the numbers of low-rise dwellings results in an estimated 326,880 and 75,696 *owned* low-rise dwellings in Toronto and Vaughan, respectively. These numbers were used to normalize HELP initiative uptake and apply projections to City of Vaughan owned low-rise dwellings. Normalization was applied based on the rate of homeownership since participants must own the property to be eligible for a loan.

Low-end projections used the same rates of uptake observed with the HELP initiative, normalized based on the number of owned low-rise dwellings in Vaughan compared to Toronto. The same relative rates of uptake were assumed to apply to the low-end projections since the lessons learned from the HELP initiative deployment should ensure that relative uptake in Vaughan is not less than in Toronto.

High-end projections are based on the most recent increase in HELP applications received (2018-2019), again normalized based on the relative number of owned low-rise dwellings in Vaughan and Toronto. This rate of received applications was assumed to represent the high-end of uptake, as it assumes that the rates of uptake in year one of deployment in Vaughan matches the year five rates of uptake in Toronto.

An average case is also presented, which is a simple average of the low and high-end cases. Figure 2 displays the projected results in terms of contracted projects.

Furthermore, a fourth case is presented, characterizing the average previously discussed while removing the obstacle of lender consent.

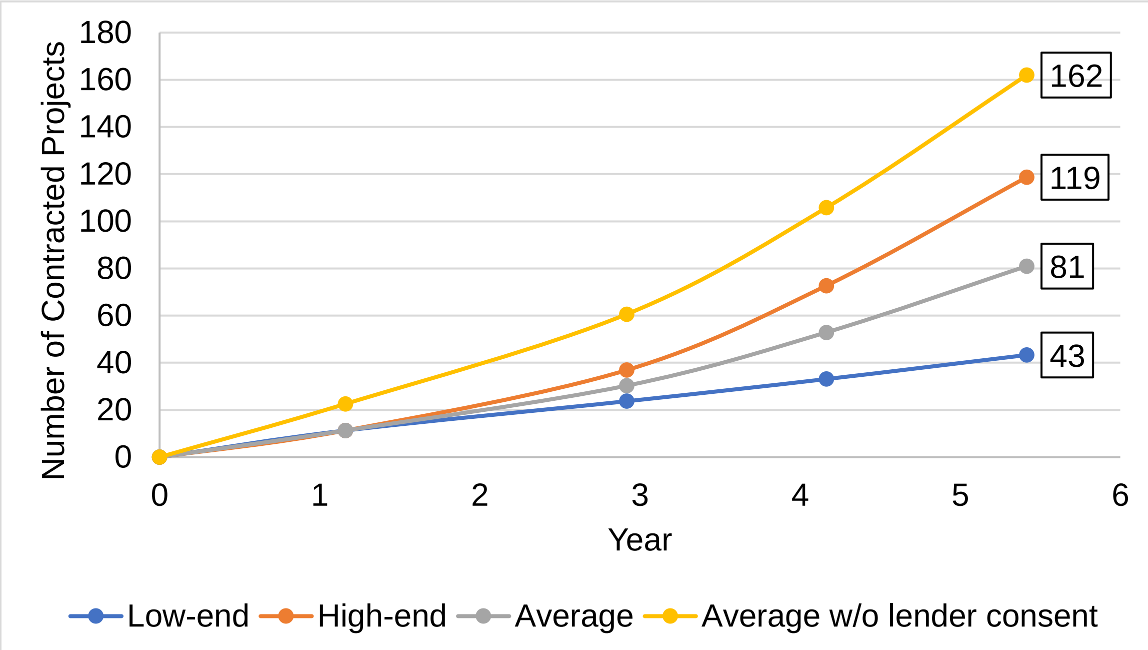



*Figure 2 - City of Vaughan projected LIC energy efficiency program uptake.*

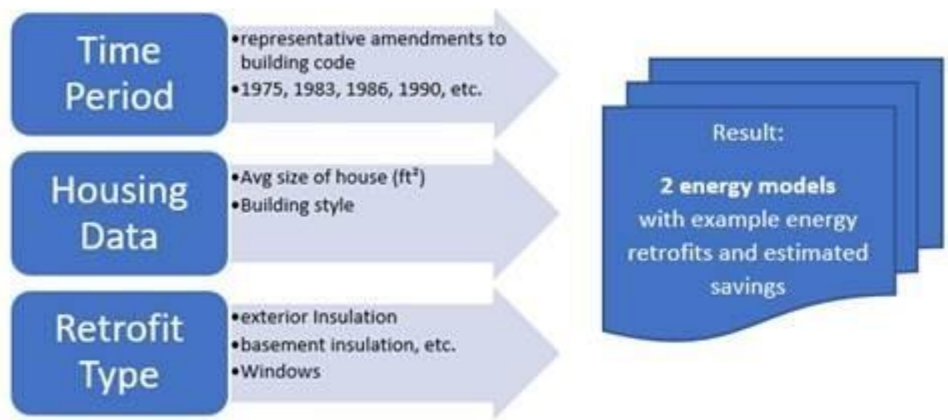
## 1.4 Recommendations

In order to maximize program effectiveness, program staff must analyze the lessons learned from the City of Toronto's HELP initiative implementation. Amendments to the HELP initiative should be incorporated at the design stage of a program proposed by the City of Vaughan. Some of these amendments have been summarized in this report and include increases to initial funding disbursement amounts and overall funding caps, and expansion of the program to include renewable energy and electric vehicle charging infrastructure. The program should also include EnerGuide home evaluations as eligible project costs, and help homeowners find incentive providers (e.g. utilities such as Enbridge, provincial and federal governments) to provide additional financial aid for pre and post evaluations. The City of Vaughan should also ensure that a detailed marketing strategy is developed along with the plan, and external expertise should be sought if required.

Unfortunately, one of the most significant hindrances to uptake, mortgage lender consent, is difficult for a City to address on its own. Any program developed and deployed by the City of Vaughan will benefit from the stakeholder outreach already conducted by the City of Toronto. However, if the City of Vaughan is to deploy a LIC-based program, it would be beneficial to join Toronto in their efforts to engage the Federal Government and other stakeholders.

# 2. Energy Savings and GHG Reduction

Energy models were created using archetypes of homes within the City of Vaughan in order to estimate energy and GHG savings. Sample energy models were created to illustrate a representative sample of City of Vaughan homes. The models are arranged based on changes to building code and how these affect building energy use, in addition to aligning with the Region's housing data. Examples of energy retrofits are then applied to each of the models in order to estimate energy savings. Energy retrofits within the models include: High-efficiency furnaces, window/door replacements, basement/attic/exterior wall insulation, high-efficiency water heaters, tankless water heaters, drain-water heat recovery systems, rooftop solar photovoltaics (PV), etc.




## 2.1 Reference File Creation

To represent more of the building stock in Vaughan, a 1975 detached building and a 1990 attached unit were used for modelling purposes. The energy consumption of these two building types are affected by the upgrades in different ways because of the geometry of the building type. The 1975 model does not include cooling while the 1990 reference does, which will also affect window upgrades differently for the 1990 reference model. These differences will be noted in the upgrade discussion. The following table details the reference inputs for the modelling performed in HOT2000 v.11.6 in more detail.

| Description | Detached 1975 Reference | Attached 1990 Reference |
|---|---|---|
| *Envelope* | | |
| *Attic Insulation* | R-28 loose-fill insulation | R-32 loose-fill insulation |
| *Walls Above Grade* | 2x4 @ 16" o.c. R-12 cavity insulation | 2x6 @ 16" o.c. R-20 cavity insulation |
| *Walls Below Grade* | 2x4 @ 16" o.c. R-8 cavity insulation | 2x6 @ 16" o.c. R-20 cavity insulation |
| *Exposed Floor* | R-20 | R-26 |
| *Slab* | Not insulated | Not insulated |
| *Fenestration* | Single-glazed aluminum frame windows | U-1.8, SHGC 0.42 |
| *Doors* | Solid wood | R-3.97 |
| *Air Leakage* | "Loose (10.35 ACH @50 Pa)" | "Average (4.55 ACH @50 Pa)" |
| *Mechanical* | | |
| *Ventilation* | Fans as primary exhaust | Fans as primary exhaust |
| *Domestic Hot Water Heating* | Conventional tank 0.53 EF | Induced draft fan with pilot, 0.55 EF |
| *Space Heating* | Continuous pilot 77% steady state efficiency | Continuous pilot 77% steady state efficiency |
| *Cooling* | Not provided | SEER 10 |
| *Renewables* | | |
| *Drainwater Heat Recovery* | Not installed | Not installed |
| *Solar Photovoltaics* | Not installed | Not installed |
| *Electrical Upgrades* | | |
| *Lighting* | Compact fluorescent | Compact fluorescent |
| *Other* | None | None |

Inputs were based on the construction profile of the year built. Air tightness was modelled as the HOT2000 assumed values for "Loose" (1975) and "Average" (1990), which can be assumed as per the HOT2000 modelling guide for their age. The mechanical equipment efficiencies were assumed as the default for the equipment type, and not modelled to a specific equipment model. No renewable energy or electrical upgrades were modelled for either time period, however, these were applied as upgrades to examine the effects on energy consumption. The 1990 reference building includes air conditioning, while the 1975 model does not as it was less common during that time period.

The building types should be considered when examining the proposed upgrades. The volume and surface area of the semi-detached will result in upgrades affecting the envelope and domestic hot water consumption differently than when applied to the detached. The limitations of the software and implications of using Natural Resources Canada's (NRCan's) EnerGuide modelling protocol should also be considered. The software performs an annual energy simulation that is not capable of providing hourly calculations, therefore it is not practical to use to assess upgrades that are based on time of use rates. User behaviour and atypical loads are not accounted for in the modeling, which uses set parameters for inputs such as the number of occupants and water usage. Fuel costs have been adapted to reflect GTA rates.

## 2.2 Analysis of Proposed Upgrades

Upgrades were applied to both reference files to examine the impact on annual energy consumption, anticipated annual energy costs, and GHG emissions.

A complete table of retrofits can be seen in Appendix A which summarizes the upgrades by type with a focus on: envelope upgrades; mechanical upgrades; renewable energy upgrades, and; electrical upgrades including lighting and energy monitoring devices. The upgrades were applied incrementally, however if applied in an upgrade package, may not be additive in their impact. Incremental improvements can be useful when performing a cost benefit analysis to assist in retrofit decision making.

The following table summarizes Appendix A upgrades applied to the 1975's reference energy model by selecting several common retrofits. The results are shown as a percentage reduction in terms of both annual energy consumption, annual energy cost and GHG emissions reductions.

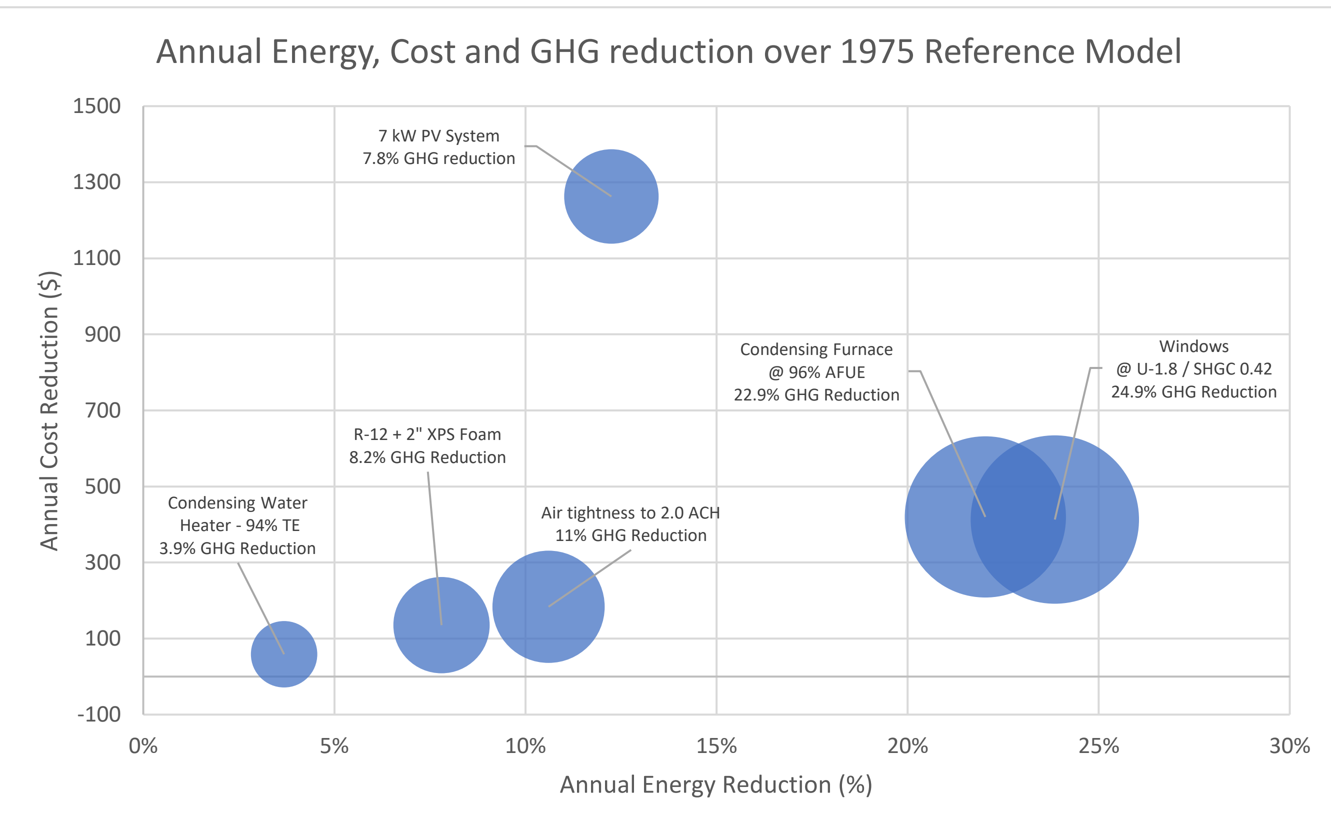



*Figure 3. Annual Energy, Cost and GHG reduction over 1975 Reference Model*

As shown in Figure 3, window upgrades have the greatest improvement on the annual energy consumption for the 1975 reference model. The reference model included single pane windows with no coating and included upgrades with a much higher U-value and solar heat gain coefficient. Once a U-1.8 window has been applied (typically double-pane with low-e coating), the impact on annual energy consumption between the upgrades is small relative to the initial upgrade from a single pane window. The same effect can be seen when upgrading the furnace to a high-efficiency unit. Older models tend to include pilot lights, which contribute to energy consumption while also having a low steady state efficiency compared to modern units. The primary source of energy consumption in the detached unit is heating, which lowers the impact of domestic hot water upgrades on energy consumption.

The addition of air conditioning resulted in a negative impact because air conditioning wasn't included initially, however it also shows that improving the SEER rating of the unit will improve the energy performance. The addition of an ASHP greatly decreases both the annual energy consumption and GHG emissions, which is due to the unit's efficiency relative to the furnace.

The following table summarizes Appendix B upgrades applied to the 1990 reference energy model by selecting several common retrofits. The results are shown as a percentage reduction in terms of both annual energy consumption, annual energy cost and GHG emissions reductions.

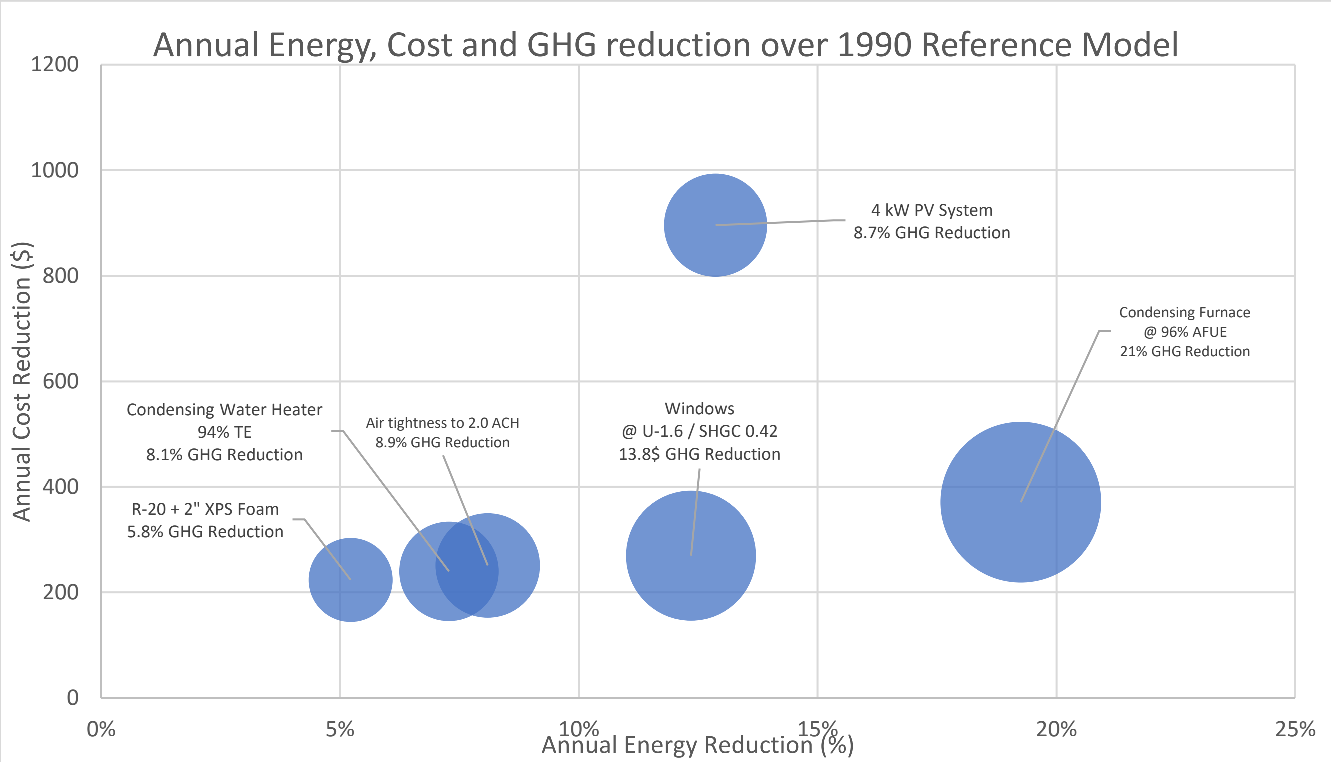



*Figure 4. Annual Energy, Cost and GHG reduction over 1990 Reference Model*

For the 1990 reference model, the impact of envelope upgrades should consider the wall system type. The 1975 model assumes a 2" x 4" wall, not a 2" x 6" which can accommodate higher interstitial insulation. Both the 1990 and 1975 models benefit from the addition of exterior insulation as it blunts the effect of thermal bridging. The impact of the window upgrades in the 1990 model is low in comparison to the 1975 model, as it uses a better performing window in the reference model.

The addition of solar PV is limited on the 1990 model as the semi-detached building has less roof space than the detached model to accommodate the panels. The semi-detached building benefits more than the detached building from upgrades that impact electricity consumption, which can be seen in the domestic hot water upgrades and the addition of the energy efficient lighting.

The impact on GHG emissions is similar to the detached model, where upgrades that reduce natural gas consumption result in a greater reduction in emissions.

Factors to Consider

The affect of the upgrade should consider both energy reduction and impact on the cost of operation. When considering upgrades, the return on investment or initial cost is also an important decision-making tool for homeowners. For example, the installation of a PV system can decrease energy consumption, however, the cost of the equipment and installation is quite high. For measures such as airtightness, the associated cost of the upgrade is difficult to assess as it is the result of labour hours to ensure “best practices”, rather than the direct application of a product.

Some energy works or water conservation improvements may require building permits. The cost of permits is recommended to be included as an eligible expense for LIC financing.

The impact on GHG emissions was included in the modeling, using the following conversion factors:

| | |
|---|---|
| GHG Elec (kgCO2/kWh) | 0.11 |
| GHG Natural Gas (kgCO2/m3) | 1.88 |

The reduction in GHG emissions typically results in a higher operating cost due to the cost of electricity in the GTA. Further analysis using an hourly simulation tool could be undertaken to examine how to incorporate energy measures like an air source heat pump (ASHP) into the mechanical design when considering time of use rates.

# 3. Socio-economic Benefits

Socio-economic benefits for energy retrofits can be described as the overall benefit, not just from the energy saved by the individual, but also broader benefits that include the general society. The socioeconomic benefits will be evaluated here as the following:

- Energy savings for tenants
- Home comfort (thermal, sound, and air quality improvements)
- Economic development
- Job growth

## 3.1 Energy Savings

Energy savings are derived here from previous estimations of uptake rates (Section 1) and estimates of energy savings (Section 2). Energy savings are directly related to the:

1. Age and construction of homes
2. Type of retrofits applied to the home

Energy savings have a direct correlation to costs savings for tenants and homeowners. The following charts and tables clearly list the cost savings estimates that may be achievable through home energy retrofits.

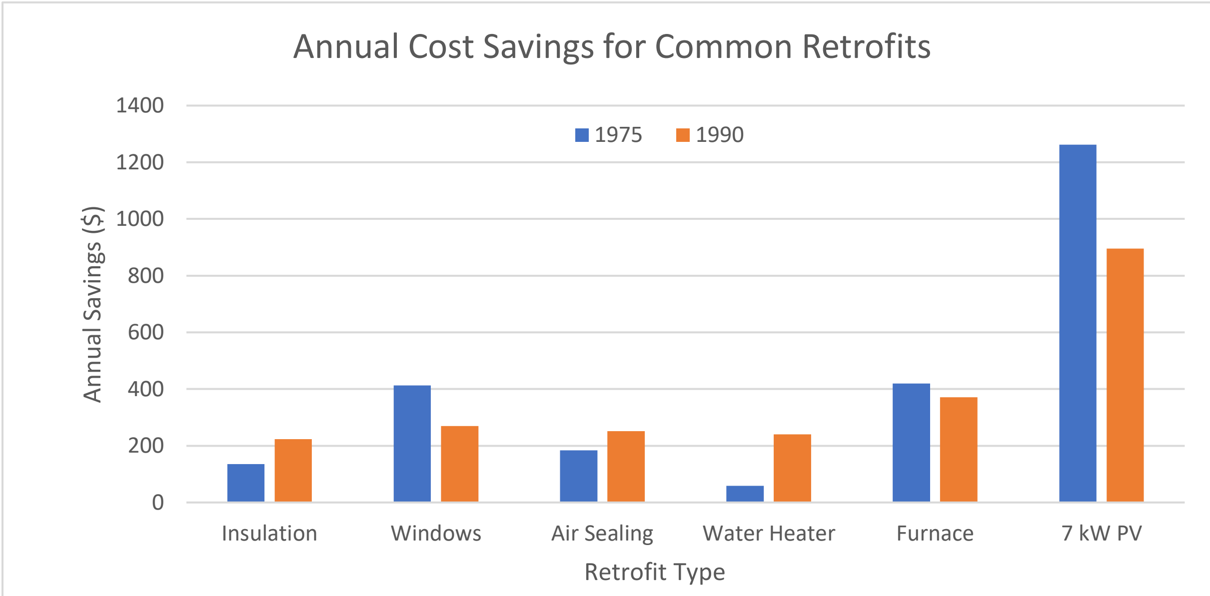



*Figure 5. Annual Cost Savings for Common Retrofits, referenced from the 1975 and 1990 energy models*

It is well documented here that certain home energy retrofits result in more significant energy (and thus cost) savings than others. Some home energy retrofits have a longer simple payback period. However, they may benefit from other non-energy benefits, which will be described in the sections below. This suggests that the marketing for an LIC-financed retrofit program not rely heavily on utility bill savings as an outcome but also focus on the opportunity for a comprehensive home improvement package and contribution to climate action.

In addition, cost savings can be attributed city wide as the total amount passed on to residents participating in the program. The table below shows estimated cumulative cost savings across all potential participants within the program referencing the uptake projections in Section 1.3, Figure 2.

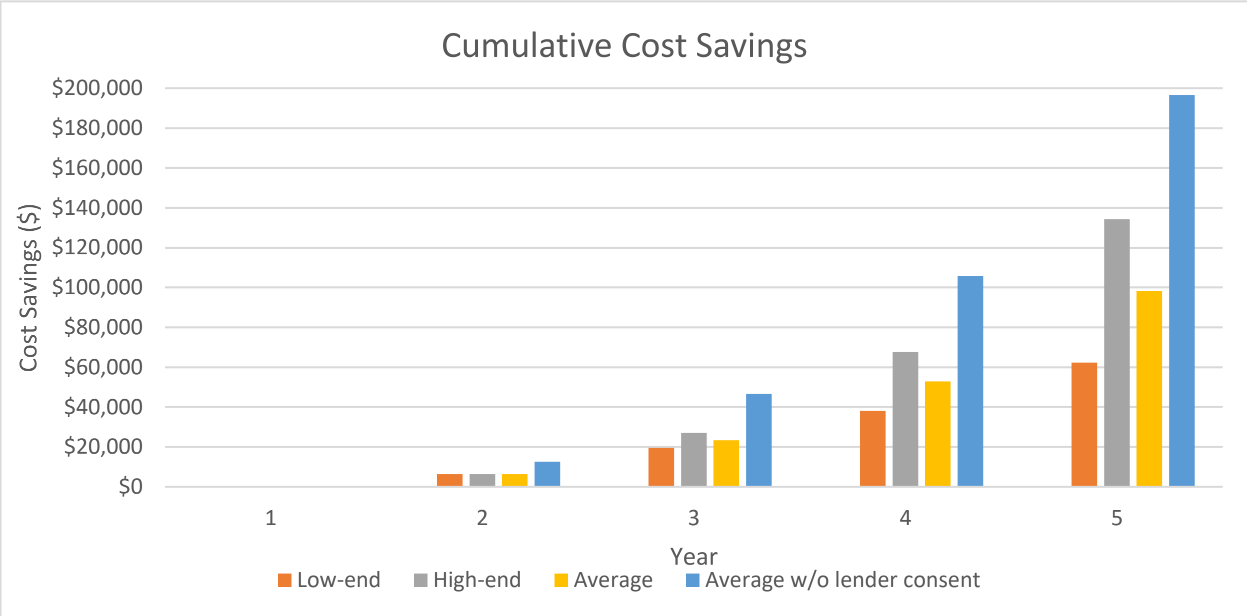



*Figure 6. Cumulative cost savings, program wide*

Furthermore, GHG emissions reductions are key in identifying measurable growth and the overall performance of the program. The table below shows estimated cumulative GHG reduction across all participants within the program referencing the uptake projections in Section 1.3, Figure 2.

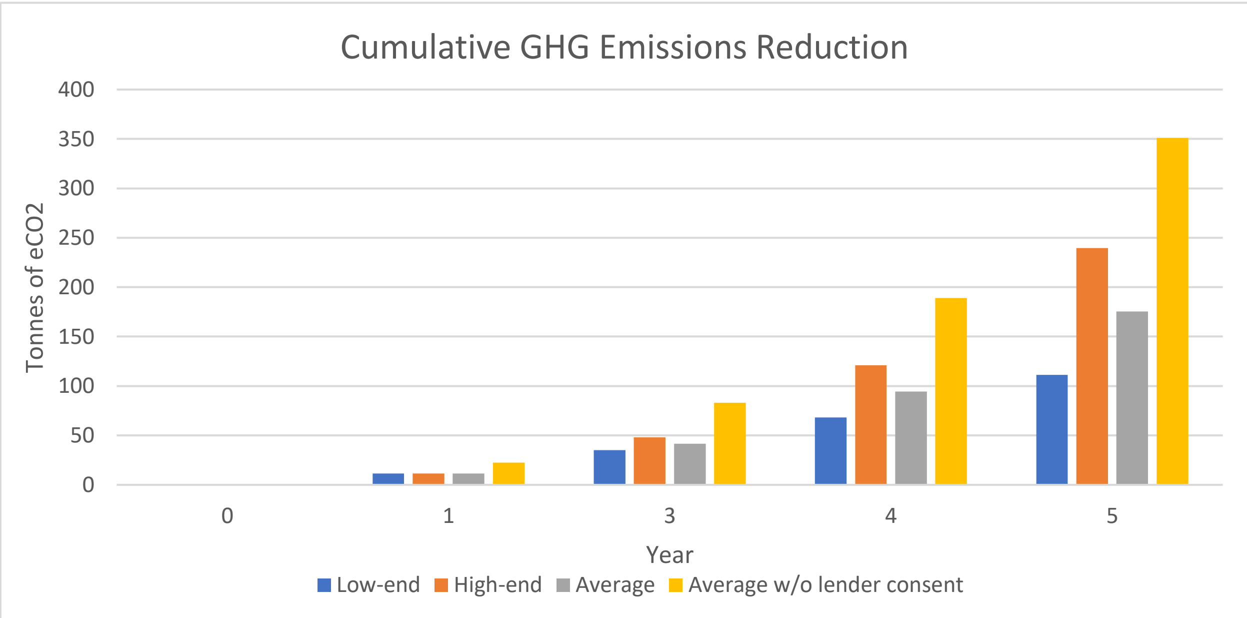



*Figure 7. Cumulative GHG Emissions Reductions, program wide*

## 3.2 Home Comfort

As we typically spend 95% of our time indoors, it is important to quantify the non-energy benefits of the interior space. While home comfort can be defined in many ways, three indicators are commonly highlighted when discussing comfort: thermal comfort, sound transmission, and indoor air quality (IAQ). Home comfort is recognized as a non-energy benefit, that will further improve the value of the home and the occupants within.

### 3.2.1 Thermal Comfort

Many factors contribute to quantifying thermal comfort, including: environmental factors such as air temperature, air speed (velocity) and humidity; and personal factors such as the type of clothing worn and Metabolic Heat (a measure of the amount of physical work done by a person). Home energy retrofits may improve thermal comfort by reducing drafts caused by air leakage, reducing radiative or convective temperature differences and better controlling humidity with upgrades in wall insulation, and mitigating temperature swings by providing more reasonably sized heating/cooling systems.

### 3.2.2 Sound Transmission Improvements

Residential households may be susceptible to many types of environmental noise, including sources such as transportation, construction, weather, industry, etc. There is overwhelming evidence that exposure to environmental noise has adverse effects on the health of the population (WHO, 2011). In fact, traffic noise is ranked high among environmental threats to public health, second only to air pollution (Ibid).

Sound Transmission Class (STC) is a number rating system used to express sound transmission in wall/material assemblies. An STC of 36.17 for exterior walls is recommended by the North American Institution for Insulation Manufacturers (NAIMA, 2019). Some older wall assemblies and windows may have an STC lower than this. Improvements and addition of insulation and air barriers will help to improve sound transmission properties. As we continue to urbanize and create community nodes of higher population densities to support transit, walking and cycling, reducing noise inside a home is a very significant co-benefit of improving wall insulation and the use of high-performance windows as components of building retrofits.

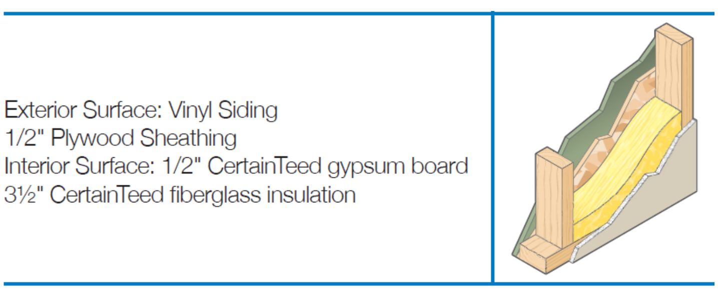



*Figure 8. A typical exterior wall assembly, having an STC of 38. CertainTeed Corporation (2018).*

### 3.2.3 Indoor Air Quality

Indoor air quality (IAQ) has a direct effect on the comfort, health and productivity for residents of homes and buildings. Serious and potentially fatal health impacts result from poor IAQ include: cancers, carbon dioxide poisoning, and Legionnaires' Disease

(ASHRAE, 2009). Other health impacts can include increased allergy and asthma from exposure to pollutants (specifically those associated with building dampness and mold), colds and other infectious diseases that are transferred through the air, and “sick building syndrome” symptoms due to elevated indoor pollutant levels as well as other indoor environmental conditions (Ibid).

Indoor air contaminants are pollutions that affect indoor air quality the greatest. They can be separated into 3 types: biological, chemical, and radiological. Biological contaminants are pollutants that come from living organisms like mould, bacteria, and dust mites. This type of IAQ can be controlled the most through home energy retrofits.


Figure 9. Mould on windowsill. Gil mo [CC BY-SA 3.0] https://upload.wikimedia.org/wikipedia/commons/2/28/Black_spots_on_window_sill.JPG

People living in homes with mould and damp conditions are more likely to have: eye, nose and throat irritation; coughing and phlegm build-up; wheezing and shortness of breath, and; worsening of asthma symptoms (Canada, 2018).

IAQ can become an issue in homes due to many factors: condensation on windows, walls and/or surfaces forming mould, VOC’s, ineffective or missing insulation, ineffective or missing vapour barriers, improper air sealing, etc.

Poor ventilation also can lead to increased indoor exposure to pollutants because there isn’t any exchange with outdoor air to dilute or remove the concentration of the pollutants: carbon monoxide; second-hand smoke; volatile organic compounds also known as VOCs. (EPA, 2016)

Home energy retrofits can aid in improving IAQ by applying some basic strategies related to source control and improved ventilation. Updating insulation, vapour barriers, air sealing, and retrofitting windows can all help in source control, preventing condensation buildup and mitigating the growth of mould. Improved ventilation is an important tool for supplying fresh air into buildings and can save energy and costs compared to opening windows.

## 3.3 Economic Development

Perhaps the most important socioeconomic indicators of this proposed program are related to the economic development potential. This describes the ability for LIC type programs to generate significant economic and fiscal improvements. The Pembina Institute, in a report to the City of Toronto titled “Benefits of actions to reduce greenhouse gas emissions in Toronto" (March 2019), identified that climate action can generate economic benefits in the following ways:

- *Generating direct, indirect and induced jobs*
- *Lowering household and business energy demand, thereby saving costs, freeing disposable income for re-investment in the economy and improving business competitiveness*
- *Protecting households and businesses against energy price volatility*
- *Generating overall economic output (GDP) and associated tax revenue*
- *Mitigating future climate impacts that will be costly to society and reducing the cost of adaptation by acting early*
- *Improving public health, and therefore, productivity, through improved indoor and outdoor air quality, reduced noise, improved building comfort, etc.*

Population growth in the GTA will require expanded energy infrastructure, including a proposed electricity corridor in the Kleinburg area in Vaughan. Energy efficiency and a move to distributed energy can delay major infrastructure upgrades and save costs for ratepayers and taxpayers.

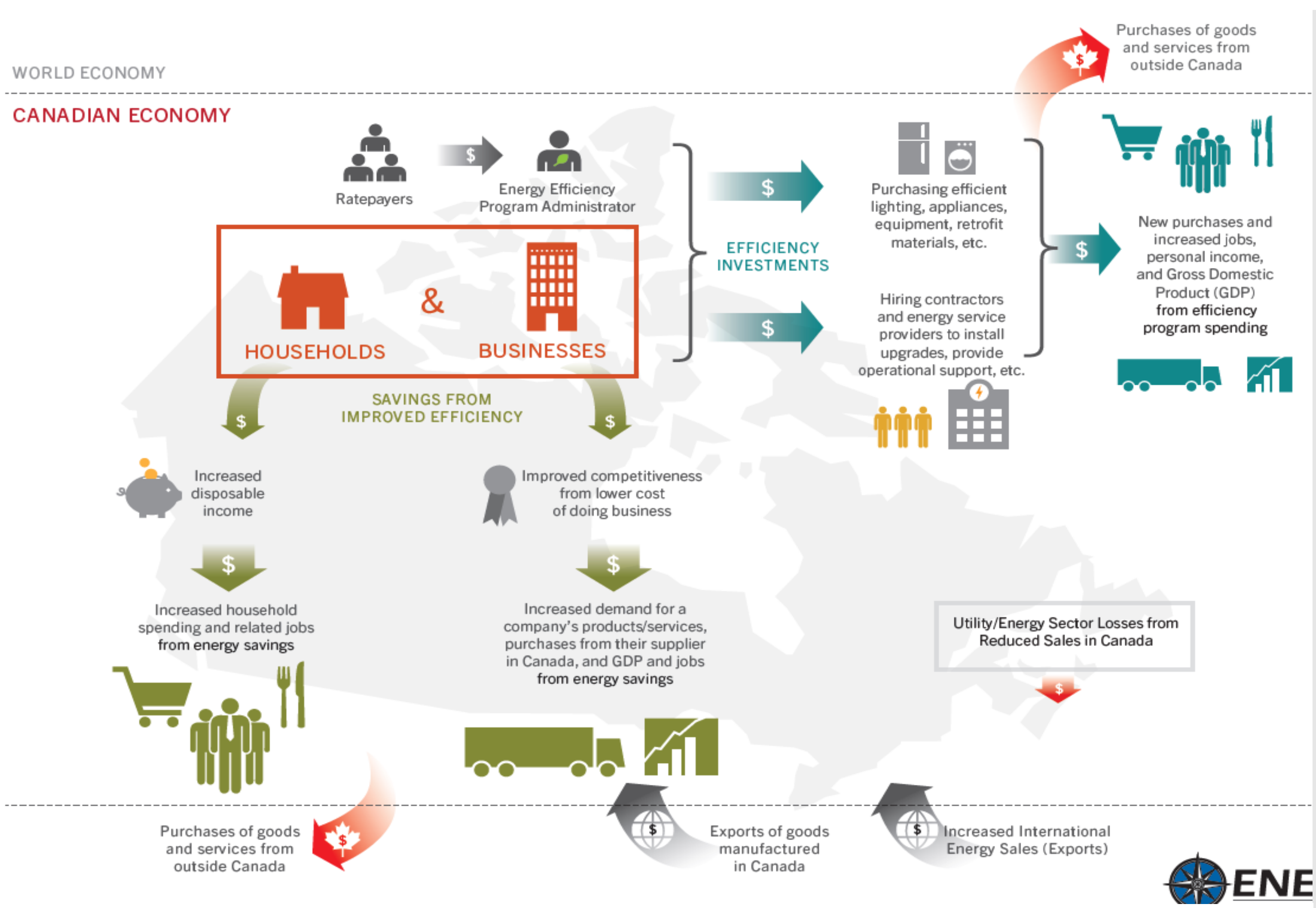


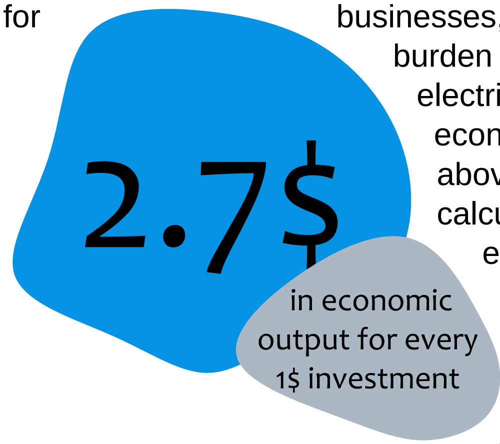

Figure 10. Macroeconomic impacts from investing in energy efficiency. (Environment Northeast, Inc. a.k.a Acadia Center, 2014)

### 3.3.1 Energy Savings

Energy, and thus, cost savings have been estimated in Sections 2 and 3.1. These cost savings help protect homeowners and tenants from the rising costs of utilities and ensure the decline of 'Energy Poverty'. Energy poverty (or fuel poverty) refers to individuals, households, or communities that are unable to access and afford adequate energy/fuel for the basic necessities of life, such as heating and cooling (The Canadian Observatory on Homelessness, 2015). In 2013, 7.9% of households in Canada were considered energy poor based on household energy consumption alone (Ibid). In addition, the cost of electricity and home heating fuels has continued to increase and is forecasted to continue outpacing the growth of average income and inflation, which will lead to further growth of energy poverty.

### 3.3.2 GDP Growth or Overall Economic Output

Investments in energy efficiency bring about savings for customers, generate revenue for businesses, create jobs, generate tax revenues, and ease the burden on utilities for purchasing and maintaining electric/fuel supply and infrastructure. These, among other economic benefits comprise GDP growth. Figure 10 above shows some of the inputs and outputs that are calculated with an in-depth approach to the varying economic impacts of investing in energy efficiency projects.




A review of three research papers from the U.S. and Canada revealed that on average around 2.73M$ of overall economic output could be attributed to an investment of 1M$ in energy efficiency retrofits. Furthermore, Canada's economy includes a large number of workers in the energy efficiency industry. A 2019 study found that an estimated 436,000 Canadians were directly employed in energy efficiency (Efficiency Canada, 2019).

## 3.4 Job Growth

Home energy retrofits have the capability of creating high-quality jobs with a wide variety of expertise levels and educational pre-requisites. Home energy retrofits can also greatly improve upon the growing need for skilled trades. Skilled trades jobs pay well. According to Statistics Canada, between 2000 and 2011, the average weekly wages of full-time workers aged 25 to 34 with trade certificates grew by 14%, while bachelor's degree holders saw their wage growth slow to 1% (Ontario, 2019). Skilled trades that may be involved in home energy retrofits include but are not limited to:

- Electrician
- General Carpenter
- Plumber
- Refrigeration and Air Conditioning Systems Mechanic

- Brick and Stone Mason
- Drywall Finisher and Plasterer
- Exterior Insulated Finish Systems Mechanic
- Construction trades helpers and laborer's

In quantifying economic development and job growth, full-time equivalent hours (FTEs) are generally accepted as an appropriate metric. An evaluation of five (5) separate research papers from the U.S. and Canada revealed that investments in energy efficiency retrofits could generate an estimate of between 8 and 19 full-time jobs for every 1$ Million invested in program administration and retrofits (see Appendix A for references). From the five research papers, an average of 12.6 FTEs per 1M$ was derived. If the average building retrofit costs $20,000, as derived from the City of Toronto experience, then only 50 projects represent a $1M investment that generates over 12 FTEs. Vaughan alone needs to scale-up well beyond 50 dwellings per year that undertake an energy retrofit project by 2030 in order to contribute to Paris Agreement targets and avoid dangerous climate change. Scaling up every year and across the GTA is a significant job growth opportunity.

**12.6**

FTEs per 1M$ Investment

# 4. Estimate of Municipal Administration Staff Time

The estimate of municipal staff time to understand resource allocation is based on two program models: City of Toronto's HELP program[1] and the Clean Energy Financing Program in Nova Scotia[2].

The Local Improvement Charges Study, in convening staff input from a number of City departments and preparing a model By-law and applicant forms, has completed many of the program start up tasks. Establishing the staff governance structure, finalizing the implementing LIC By-law and applicant forms, creating a dedicated web site for applicants, and translating the forms into writable web forms are some of the tasks yet to complete for program initialization. Ongoing or annual staff functions are described below.

## 4.1 Case Studies: City of Toronto and Nova Scotia

### City of Toronto HELP

The HELP is an entirely municipal-run program. This involves setting up an in-house LIC program administration using local staff and/or assigning FTEs, and defining program administrator roles and responsibilities.

- Currently, the HELP program is administered by 1 full-time staff member who fields telephone calls and provides customer service support.
- There are also 3 support staff members who spend approximately 2-3 hours per month logging hours, handling customer calls, and other administrative tasks.
- Legal staff is also involved for adding the LIC charge to property tax bills and for signing-off projects.

### Nova Scotia Clean Energy Financing Program

The Clean Energy Financing Program model involves a third-party organization to address applicant intake and processing.

- The program is administered by 3 staff who work on the program part-time. Below is an approximate breakdown of the percent of their full-time positions (35 hr. work week) that is spent on administering the program:
  - Senior Lead – 20%
  - Customer Relations Specialist – 15%
  - Senior Technical Analyst – 10%
    - This is based on past participation levels (up to a maximum of 40 participants). As more municipalities join the program and the number of participants increases, the amount of staff time spent on the program will need to be adjusted as well.

Based on the case studies above, the City of Vaughan's key functions (without applicant intake and processing) include a focus on administrative processes and tracking financial flows.

- **Administrative processes:** implement by-law and contract document development per Property Owner Agreement, financial and technical underwriting. Staff capacity, including legal and technical expertise, will be required.
    - It is recommended that **one municipal staff member in the Legal Services department** be responsible to ensure the administration of these tasks.
    - **One or two staff members working part-time** may also be required to provide support (several hours per month depending on the number of applicants).

- **Financing:** servicing LIC assessments (billing, collections), paying property owners, and recording priority lien on the property. These functions can be performed by the municipal tax department.
    - It is recommended that **one municipal staff member in the Financial Services department** be responsible to ensure the administration of these tasks.

Estimates of staff time are dependent on the anticipated program uptake and the retrofit target rate set by the City of Vaughan. The staff time required may also change based on participation levels.

In 2013, Dunsky Energy Consulting prepared a sample budget (see table below) for a 3-year LIC/PACE pilot program in Ontario with 100, 250, or 500 participants per year.

| Expense Category | Expenses | 100 Participants per year | 250 Participants per year | 500 Participants per year |
|---|---|---|---|---|
| Program Initiation Fixed Costs (A) | Program Plan and Initiation<br>Legal and Financing | $ 80,000 | $ 80,000 | $ 80,000 |
| Program set up Costs (B) | Program Tools<br>Application Database<br>Marketing Materials<br>Documentation<br>($500-$700 per participant) | $ 70,000 | $ 150,000 | $ 250,000 |
| Annual Fixed Costs (C) | Human Resources<br>Debt Servicing<br>Marketing Overhead<br>LIC Collection<br>($140-$400 per participant) | $ 40,000 | $ 80,000 | $ 140,000 |
| Per Participant Costs (D) | Register Liens<br>Title Searches<br>Application Reviews<br>Documentation<br>($400 per participant) | $ 40,000 | $ 100,000 | $ 200,000 |
| **Total Program Set Up Costs (A+B)** | | **$ 150,000** | **$ 230,000** | **$ 330,000** |
| **Total Annual Operating Costs (C+D)** | | **$ 80,000** | **$ 180,000** | **$ 340,000** |
| **Total Admin. Costs (Per Participant)[11]** | | **$ 1,300** | **$ 1,050** | **$ 900** |

Source: Dunsky Energy Consulting. (2013). *Local improvement charge (LIC) financing pilot program design for residential buildings in Ontario.* Montreal, Quebec: Dunsky Energy Consulting. Retrieved from https://www.cleanairpartnership.org/wp-content/uploads/2016/08/CHEERIO-LIC-Program-FINAL-REPORT.pdf

Since the LIC Study recommends a Third Party delivery model, the estimate of staff time provided above is translated into the potential program options being considered by the City of Vaughan.

Table 1 Estimate of municipal staff administration time and other retrofit program costs based on procuring the service of a program administrator or opting into a Third Party program model.

| Expense Category | Expense Description | Responsibility | 100 Applicants per Year[a] | 500 Applicants per Year[b] |
|---|---|---|---|---|
| Start-up and Annual Costs (annual review) | Staff governance structure<br><br>Program Forms on Dedicated Web Site (OCIO)<br><br>Application Database (CSR)<br><br>Template Property Owner Agreement (Legal Services) | City of Vaughan<br>- Office of the Chief Information Officer<br>- Customer Service Representative<br>- Legal Services | $7,200 (based on 12 days of time @ $600/day) | $7,200 (based on 12 days of time @ $600/day) |
| Applicant Intake and Processing<br><br>(Ongoing – Procure the service of a delivery agent or 'concierge') | Applicant Guidance<br><br>Marketing<br><br>Review Home Energy Assessments<br><br>Review Funding Requests<br><br>Authorize application and prepare Property Owner Agreement<br><br>Estimate eligible utility rebates | Program Administrator / Delivery Agent | $70,000 per 100 applicants (based on an over-estimate of one day of time or $700 per applicant) | $200,000 per 500 applicants (based on an estimate of a half day of time or $400 per applicant) |
| Regulatory Requirements | Update Application Database<br><br>Prepare POA - City<br><br>Initial Disbursement - City<br><br>Review Certificate of Completion- City<br><br>Steps for Priority Lien Status<br>• Periodic certification of local improvement roll (Financial Services)<br><br>• Report to Council to adopt a by-law pursuant to Section 35.14 of O.Reg. 596/06 to impose the special charges on the participating properties - (Legal Services)<br><br>• For each property included in the by-law, the Treasurer will then add to the City's tax roll for that property each year that portion of the | City of Vaughan<br>- Customer Service Representative<br>- Financial Services<br>- Legal Services | About $30,000 per year (Based on 2 days per month for staff in each of Financial Services and Legal Services, or about $300 per applicant) | About $70,000 per year (Based on 5 days per month for staff in each of Financial Services and Legal Services, or about $150 per applicant) |

| Expense Category | Expense Description | Responsibility | 100 Applicants per Year[a] | 500 Applicants per Year[b] |
|---|---|---|---|---|
| | imposed special charge that is due in that year.<br><br>POA will require homeowners to sign up for the pre-authorized payment plan<br><br>LIC Disclosure<br>• posting on the City's website notice of the special charge by-law to impose the charge on the property in advance of its introduction and after its adoption (Legal Services) | | | |
| Overall Project Management | Secure Services of Program Administrator and ensure quality<br><br>Main point of contact with Program Administrator<br><br>Liaison between City departments | | About $15,000 per year (based on 2 days per month or 0.1FTE, or $150 per applicant | About $15,000 per year (based on 2 days per month or 0.1FTE, or $30 per applicant |

[a] 100 applicants per year is assumed to be program initiation or a pilot project.

[b] 500 applicants per year is assumed to represent opting in to a Third Party model.

Under the assumptions in Table 1 above and assuming the average retrofit cost is $20,000 (consistent with the City of Toronto experience), then the total municipal staff administration fee of about $450/applicant translates to an administration fee of about 2.25% when only considering 100 total applicants per year. In addition to an administration fee for a delivery agent or 'concierge' of about 3.5% for 100 applicants per year, this model is feasible only for the start-up situation or a pilot project. Experience is required to streamline the administration process. Otherwise, a total interest rate of 8% to 9% for LIC financing (e.g., staff administration fee + delivery agent fee + interest on the financing), based on full cost recovery, will reduce the number of applicants into the program even though spreading the payments over a long payment period of up to 20 years will be attractive.

Assuming efficiencies from economies of scale opting in to a Third Party model, the total municipal staff administration fee of about $180 per applicant translates to an administration fee of about 1% when considering 500 total applicants per year. The administration fee for a delivery agent or 'concierge' in the Third Party model is estimated to require $400 per applicant or translated to a 2% fee assuming an average retrofit cost of $20,000. Assuming financing of around 3%, the municipal administration fee and delivery agent fee could result in a total interest rate of around 6%.

Aiming for full cost recovery causes higher total interest rates for applicants than provided in the City of Toronto HELP program (fixed interest rates of 3.7 – 4.4% as noted in Section 1 of this report).

## References:

NAIMA (2019) Home Insulation: Insulating for Sound. Retrieved on Dec. 11, 2019, from: https://insulationinstitute.org/im-a-homeowner/why-insulate/insulating-for-sound/

Government of Ontario (2019). List of skilled trades in Ontario. Retrieved Nov. 19, 2019 from: https://www.ontario.ca/page/list-skilled-trades-ontario

World Health Organization (2011). Burden of disease from environmental noise. ISBN: 978 92 890 0229 5

Energy Poverty. 2015. The Canadian Observatory on Homelessness. Retrieved on Dec. 02, 2019
https://www.homelesshub.ca/povertyhub/basic-needs/energy-poverty

ENE, *Energy Efficiency: Engine of Economic Growth in Canada: A Macroeconomic Modeling and Tax Revenue Impact Assessment,* 2014 http://acadiacenter.org/wpcontent/uploads/2014/11/ENEAcadiaCenter_EnergyEfficiencyEngineofEconomicGrowthinCanada_EN_FINAL_2014_1114.pdf

Indoor Air Quality (IAQ): Energy, Weatherization and Indoor Air Quality (2016) United States Environmental Protection Agency (EPA) retrieved on Dec. 02, 2019 https://www.epa.gov/indoor-air-quality-iaq/energy-weatherization-and-indoor-air-quality

ASHRAE (2009) Indoor Air Quality Guide – Best Practises for Design, Construction and Commissioning. pp. 164.

City of Toronto, EI6.5; Extending Successful Energy Retrofitting Programs, June 13, 2019.

## APPENDIX A. - Upgrades applied to the 1975's reference energy model

1975 Detached Model

| Upgrade Description | Annual Energy Reduction (%) | Annual Energy Cost Reduction ($) | GHG Emissions Reduction (%) |
|---|---|---|---|
| Envelope Upgrades | | | |
| Walls Above Grade | | | |
| 2"X4" @ 16" O.C. R-14 Batt | 0.93% | $16.20 | 0.97% |
| 2"X4" @ 16" O.C. R-12 Batt + 1" XPS | 4.42% | $76.51 | 4.62% |
| 2"X4" @ 16" O.C. R-12 Batt + 2" XPS | 7.80% | $135.22 | 8.16% |
| 2"X4" @ 16" O.C. R-14 Batt + 1" XPS | 5.36% | $92.87 | 5.60% |
| 2"X4" @ 16" O.C. R-14 Batt + 2" XPS | 8.09% | $140.23 | 8.46% |
| Walls Below Grade | | | |
| R-20 Continuous Blanket | 2.60% | $45.01 | 2.72% |
| 2"X4" @ 16" O.C. R-14 Batt + 1" XPS | 1.66% | $28.79 | 1.73% |
| 2"X4" @ 16" O.C. R-14 Batt + 2" XPS | 2.68% | $46.45 | 2.80% |
| Roof - Attic | | | |
| Attic @ R-40 | 0.80% | $13.78 | 0.83% |
| Attic @ R-50 | 1.15% | $19.89 | 1.20% |
| Attic @ R-60 | 1.29% | $22.38 | 1.35% |
| Roof - Flat / Sloped | | | |
| Flat / Sloped @ R-31 | 0.05% | $0.80 | 0.05% |
| Flat / Sloped @ R-40 | 0.04% | $0.74 | 0.04% |
| Exposed Floor | | | |
| Exposed Floor @ R-31 | 0.28% | $4.93 | 0.30% |
| Exposed Floor @ R-40 | 0.32% | $5.61 | 0.34% |
| Slab | | | |
| Underslab @ Full R-5 | 0.45% | $7.79 | 0.47% |
| Underslab @ Full R-10 | 0.87% | $15.10 | 0.91% |
| Fenestration | | | |
| Fenestration @ U-1.8 / SHGC 0.42 | 23.85% | $412.98 | 24.93% |
| Fenestration @ U-1.6 / SHGC 0.42 | 25.03% | $433.49 | 26.16% |
| Fenestration @ U-1.4 / SHGC 0.42 | 26.16% | $452.88 | 27.34% |
| Fenestration @ U-1.2 / SHGC 0.42 | 27.47% | $475.75 | 28.71% |
| Doors | | | |

| | | | |
|---|---|---|---|
| Doors @ R-3.97 (OBC SB-12 2017) | 0.32% | $5.64 | 0.34% |
| Doors @ R-4.83 (Fibreglass Polystyrene Core) | 0.40% | $6.89 | 0.41% |
| Doors @ R-5.57 (Steel Polystyrene Core) | 0.44% | $7.67 | 0.46% |
| Doors @ R-6.47 (Steel Medium Density Spray Foam Core) | 0.48% | $8.37 | 0.50% |
| Air Tightness | | | |
| 8.0 ACH | 2.13% | $36.83 | 2.22% |
| 6.0 ACH | 5.56% | $96.22 | 5.81% |
| 4.0 ACH | 8.45% | $146.28 | 8.83% |
| 2.0 ACH | 10.60% | $183.57 | 11.08% |
| **Mechanical Upgrades** | | | |
| HRV | | | |
| HRV 75% Efficiency | 0.78% | $25.40 | 0.76% |
| HRV/ERV 81% Efficiency (w/ ECM) | 0.94% | $28.21 | 0.93% |
| HRV/ERV 84% Efficiency (w/ ECM) | 1.01% | $28.64 | 1.00% |
| Domestic Hot Water | | | |
| Instantaneous Condensing @ 0.96 EF | 3.80% | $60.03 | 4.00% |
| Instantaneous Condensing @ 0.99 EF | 3.90% | $61.73 | 4.11% |
| Condensing Tank @ 90% TE | 3.57% | $57.04 | 3.75% |
| Condensing Tank @ 94% TE | 3.68% | $58.74 | 3.88% |
| Space Heating | | | |
| Condensing Furnace @ 96% AFUE | 22.03% | $419.87 | 22.85% |
| Condensing Furnace @ 98% AFUE | 22.83% | $432.61 | 23.68% |
| Cooling | | | |
| Air Conditioner @ 14 SEER | -3.67% | -$360.12 | -2.44% |
| Air Conditioner @ 16 SEER | -3.50% | -$341.68 | -2.33% |
| Air Conditioner @ 21 SEER | -3.16% | -$305.46 | -2.11% |
| Heat Pump @ 8 HSPF and 14 SEER | 13.31% | -$553.00 | 17.61% |
| Heat Pump @ 8 HSPF and 16 SEER | 13.48% | -$534.58 | 17.72% |
| Drain Water Heat Recovery | | | |
| DWHR @ 42% (2 Showers) | 0.80% | $12.97 | 0.84% |
| DWHR @ 50% (2 Showers) | 0.93% | $15.03 | 0.98% |
| DWHR @ 54% (2 Showers) | 1.00% | $16.22 | 1.06% |
| Solar Photovoltaics | | | |
| 1 kW Photovoltaic (PV) system | 1.75% | $180.66 | 1.11% |
| 4 kW Photovoltaic (PV) system | 6.98% | $719.97 | 4.47% |
| 7 kW Photovoltaic (PV) system | 12.25% | $1,262.48 | 7.85% |
| Electrical Upgrades | | | |

| | | | |
|---|---|---|---|
| 25 - 75% Energy Efficient Lighting | 0.06% | $49.67 | -0.17% |
| >75% Energy Efficient Lighting | 0.14% | $99.63 | -0.32% |
| All Off Switch (-0.3 kWh/d) | 0.02% | $15.01 | -0.04% |

## APPENDIX B. - Upgrades applied to the 1990's reference energy model

**1990's Attached Model**

| Upgrade Description | Annual Energy Reduction (%) | Annual Energy Cost Reduction ($) | GHG Emissions Reduction (%) |
|---|---|---|---|
| Code Reference Building 1975 | - | - | - |
| **Envelope Upgrades** | | | |
| **Walls Above Grade** | | | |
| 2"X6" @ 16" O.C. R-20 Batt | 0.05% | $176.14 | 0.06% |
| 2"X6" @ 16" O.C. R-22 Batt | 1.00% | $184.70 | 1.16% |
| 2"X6" @ 16" O.C. R-24 Batt | 1.62% | $190.29 | 1.78% |
| 2"X6" @ 16" O.C. R-20 Batt + 1" XPS | 3.14% | $204.60 | 3.47% |
| 2"X6" @ 16" O.C. R-20 Batt + 2" XPS | 5.22% | $223.68 | 5.76% |
| 2"X6" @ 16" O.C. R-22 Batt + 1" XPS | 3.74% | $210.23 | 4.13% |
| 2"X6" @ 16" O.C. R-22 Batt + 2" XPS | 5.62% | $227.33 | 6.20% |
| 2"X6" @ 16" O.C. R-24 Batt + 2" XPS | 6.13% | $232.06 | 6.76% |
| **Walls Below Grade** | | | |
| R-20 Continuous Blanket | 1.60% | $190.78 | 1.76% |
| 2"X6" @ 16" O.C. R-20 Batt | 0.66% | $181.95 | 0.73% |
| 2"X6" @ 16" O.C. R-20 Batt + 1" XPS | 1.71% | $191.79 | 1.88% |
| **Roof - Attic** | | | |
| Attic @ R-40 | 0.75% | $182.67 | 0.82% |
| Attic @ R-50 | 1.21% | $187.02 | 1.33% |
| Attic @ R-60 | 1.61% | $190.64 | 1.77% |
| **Exposed Floor** | | | |
| Exposed Floor @ R-31 | 0.01% | $175.69 | 0.00% |
| Exposed Floor @ R-40 | 0.02% | $175.82 | 0.02% |
| **Slab** | | | |
| Underslab @ Full R-5 | 0.32% | $178.73 | 0.36% |
| Underslab @ Full R-10 | 0.59% | $181.23 | 0.65% |
| **Fenestration** | | | |
| Fenestration @ U-1.6 / SHGC 0.42 | 12.35% | $269.66 | 13.80% |
| Fenestration @ U-1.4 / SHGC 0.42 | 13.38% | $277.91 | 14.94% |
| Fenestration @ U-1.2 / SHGC 0.42 | 14.72% | $289.00 | 16.45% |

| | | | |
|---|---|---|---|
| Doors | | | |
| Doors @ R-4.83 (Fibreglass Polystyrene Core) | 0.54% | $180.59 | 0.60% |
| Doors @ R-5.57 (Steel Polystyrene Core) | 0.83% | $183.18 | 0.92% |
| Doors @ R-6.47 (Steel Medium Density Spray Foam Core) | 1.13% | $185.81 | 1.24% |
| Air Tightness | | | |
| 4.0 ACH | 1.34% | $188.16 | 1.48% |
| 3.0 ACH | 4.83% | $220.55 | 5.32% |
| 2.0 ACH | 8.09% | $251.12 | 8.91% |
| Mechanical Upgrades | | | |
| HRV | | | |
| HRV 75% Efficiency | 0.26% | $166.55 | 0.39% |
| HRV/ERV 81% Efficiency (w/ ECM) | 0.69% | $190.21 | 0.68% |
| HRV/ERV 84% Efficiency (w/ ECM) | 0.80% | $190.33 | 0.81% |
| Domestic Hot Water | | | |
| Instantaneous Condensing @ 0.96 EF | 7.35% | $240.04 | 8.15% |
| Instantaneous Condensing @ 0.99 EF | 7.55% | $241.76 | 8.36% |
| Condensing Tank @ 90% TE | 7.31% | $240.46 | 8.09% |
| Condensing Tank @ 94% TE | 7.28% | $239.94 | 8.06% |
| Space Heating | | | |
| Condensing Furnace @ 96% AFUE | 19.25% | $371.03 | 21.08% |
| Condensing Furnace @ 98% AFUE | 20.21% | $379.45 | 22.14% |
| Cooling | | | |
| Air Conditioner @ 14 SEER | 0.21% | $220.61 | -0.16% |
| Air Conditioner @ 16 SEER | 0.47% | $201.99 | 0.31% |
| Air Conditioner @ 21 SEER | 0.67% | $213.30 | 0.45% |
| Heat Pump @ 8 HSPF and 14 SEER | 26.65% | -$19.71 | 33.43% |
| Drain Water Heat Recovery | | | |
| DWHR @ 42% (2 Showers) | 1.61% | $189.96 | 1.79% |
| DWHR @ 50% (2 Showers) | 1.87% | $192.22 | 2.07% |
| DWHR @ 54% (2 Showers) | 2.02% | $193.54 | 2.23% |
| Solar Photovoltaics | | | |
| 1 kW Photovoltaic (PV) system | 3.23% | $356.52 | 2.18% |
| 4 kW Photovoltaic (PV) system | 12.86% | $895.82 | 8.68% |
| Electrical Upgrades | | | |
| 25 - 75% Energy Efficient Lighting | 0.30% | $231.15 | -0.15% |

| | | | |
|---|---|---|---|
| >75% Energy Efficient Lighting | 0.36% | $283.61 | -0.57% |
| All Off Switch (-0.3 kWh/d) | 0.10% | $192.43 | -0.03% |