Building Science Trust
Net Zero Retrofit Planning

Path to Net Zero Report

(Air Source Heat Pump Version)

For Mr. and Ms. Client

123 Any Street, Ottawa, ON, A1B 2C3

Prepared for:
Mr. and Ms. Client
123 Any Street,
Ottawa , ON,
A1B 2C3

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November 22, 2022
Draft Report

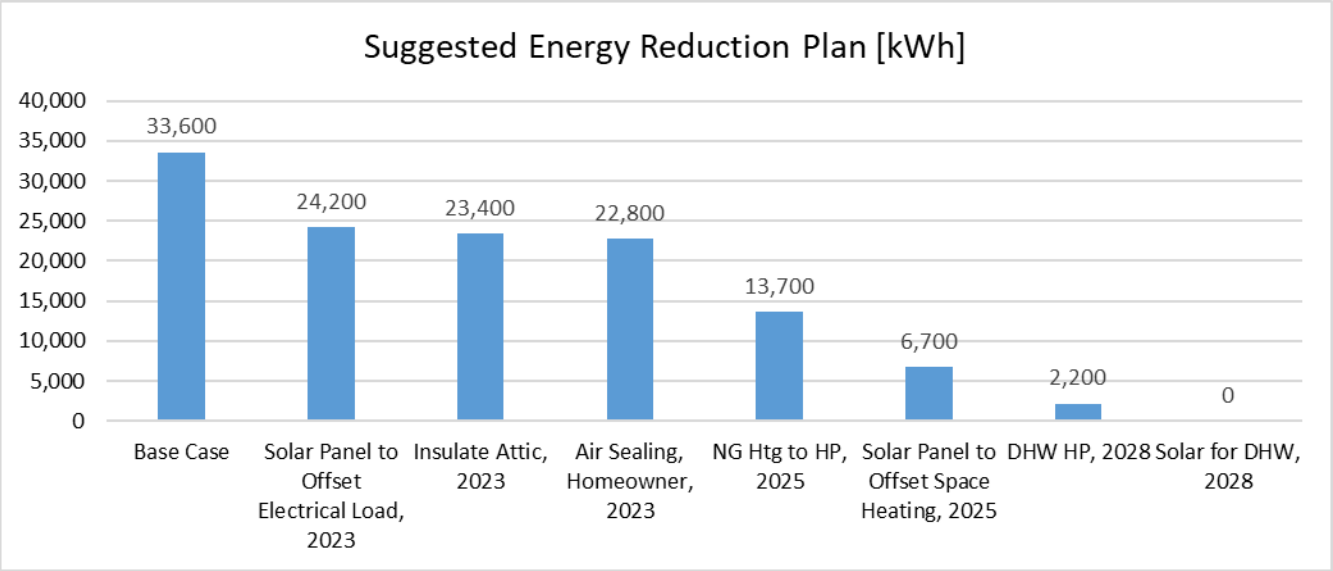
1. Executive Summary

BST recommends the house at 123 Any Street, A1B 2C3, ON be converted to Net Zero economically by following the following Energy Conservation Measures (ECMs) and appliance replacements in the recommended year[1]. As follows:

ECM, Year	Energy Conservation Measure (ECM)
Solar Panel to Offset Electrical Load, 2023	Add Photo Electric (PV) solar panels to offset the current electric load. The cost of solar electricity is significantly lower than grid supplied electricity and is GHG and nuclear waste free. We suggest the home owner get a solar contractor to quote the actual solar production and installation costs.
Insulate Attic, 2023	Add additional loose laid insulation to the attic as per the NRCan Upgrade Report.
Air Sealing, Homeowner, 2023	It is recommended that the home owner seal the significant air infiltration leaks as identified by the NRCan energy auditor and published documents. Review the website https://www.nrcan.gc.ca/energy-efficiency/homes/make-your-home-more-energy-efficient/keeping-the-heat/section-4-comprehensive-air-leakage-control-your-home/15635 for additional information.
NG Htg to HP, 2025	The majority of a Canadian house energy load is consumed in space heating. Presently this house is heated with natural gas. An economic fuel transition to heat pump heating is recommended to dramatically reduce the GHG emissions. When the electric power to the heat pump is supplied by net metered solar power the combination is competative with NG.
Solar Panel to Offset Space Heating, 2025	Once the space heating has been switched to heat pump then install enough solar power to offset this load.
DHW HP, 2028	Domestic Hot Water Heat Pump (DHW HP). A significant energy load is consumed in the DHW heater. Although initially more expensive, the operational costs are lower, when coupled with net metered solar power to supply the electricity.
Solar for DHW, 2028	Once the DHW has been switched to DHW HP supplied hot water then install enough solar power to offset this load.

[1] Appliance replacement dates are based on the expected remaining useful life of the appliance.

The existing annual energy requirement and subsequent requirements after each measure are listed below;



Note the energy requirements for EVs are not included in this plan to Net Zero for the house.

The financial summary of each of the recommended ECMs are listed below:

Measure Description	Existing Technology Component Cost	Renewable Energy Component Cost	Incentive	Incremental Cost	Annual Savings	Payback Years	Component Life	Lifetime Net Savings
Solar Panel to Offset Electrical Load, 2023	$0	$23,530	$5,000	$18,530	$1,130	16.4	25.0	$9,720
Insulate Attic, 2023	$0	$1,860	$750	$1,110	$50	22.2	101.0	$3,940
Air Sealing, Homeowner, 2023	$0	$440	$100	$340	$30	11.3	101.0	$2,690
NG Htg to HP, 2025	$15,340	$21,270	$0	$5,930	$120	49.4	20.0	-$3,530
Solar Panel to Offset Space Heating, 2025	$0	$17,490	$0	$17,490	$840	20.8	25.0	$3,510
DHW HP, 2028	$2,000	$5,150	$0	$3,150	$130	24.2	20.0	-$550
Solar for DHW, 2028	$0	$5,600	$0	$5,600	$270	20.7	25.0	$1,150
Total	$17,340	$75,340	$5,850	$52,150	$2,570			

Notes:

- This financial summary includes the recently announced increases in carbon Taxes to $170/ton to 2030.
- The addition of the heat pump for space and DHW heating (NG Htg to HP, DHW HP) shows negative values but when combined with solar power (next line) the combination has a lifetime positive or neutral (dollar savings) value. Different solar panel installation years can be combined into a single installation as appropriate.

The GHG emissions reduction summary are listed below:

Measure Description	Energy Savings [kWh]	Fuel Type	Incremental Cost	Annual Emissions Reductions [kg eCO2]	House Remaining Lifetime Emissions Reductions [Tons eCO2]	Additional Annual Solar Require-ment [kWh]	Accumulated Annual Solar Require-ment [kWh]
Solar Panel to Offset Electrical Load, 2023	9,410	Electricity	$18,530	190	21	9,410	9,410
Insulate Attic, 2023	830	NG	$1,110	150	17	0	9,410
Air Sealing, Homeowner, 2023	560	NG	$340	100	11	0	9,410
NG Htg to HP, 2025	9,090	NG	$5,930	2,790	311	0	9,410
Solar Panel to Offset Space Heating, 2025	7,000	Electricity	$17,490	140	16	7,000	16,410
DHW HP, 2028	4,480	NG	$3,150	1,180	131	0	16,410
Solar for DHW, 2028	2,240	Electricity	$5,600	40	4	2,240	18,650
Total	33,610		$52,150	4,590	511	0	18,650

Notes;

- For purposes of this report, the remaining life of the house is assumed to be 101 years.

Report Main Body

2. Background

In the industrialized countries, approximately 40% of energy is consumed in transportation, 40% in buildings and the rest is mainly consumed in industrial operations. Most of this energy is produced with fossil fuels which cause Green House Gases (GHGs) when consumed. GHGs are the most significant contribution to climate change. This report is developed to assist a homeowner to change their fuel consumption from fossil fuels to renewable energy in an economical way. It allows a homeowner to reduce their personal contribution to climate change: Their contribution to the 40% associated with buildings.

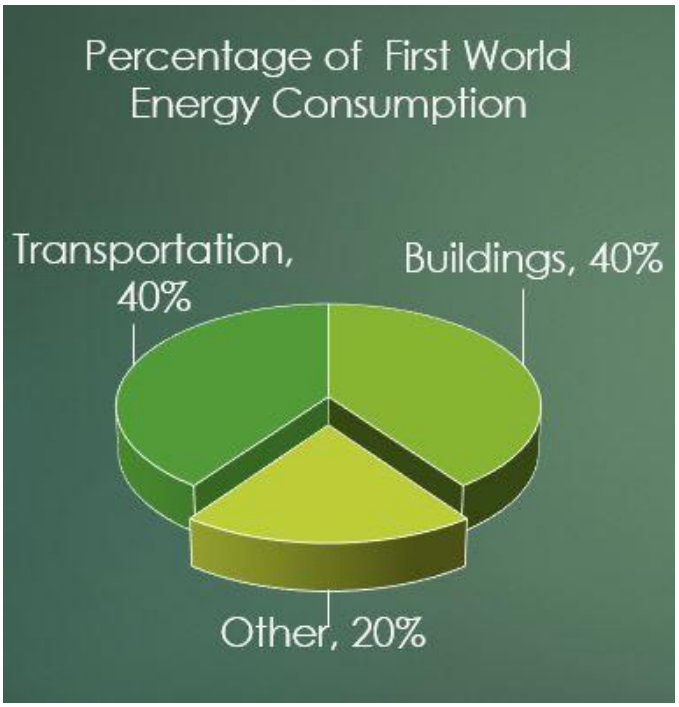


Figure 1 - Approximate energy mix for first world countries.

3. Introduction

This report shows how to implement Energy Conservation Measures (ECMs) to move the house's annual energy consumption to nearly carbon-free energy and save money at the same time, this is accomplished by moving the heating systems to low Green House Gas (GHG) emitting operation (also known as low carbon) in an economical and timely manner. Low carbon means the energy sources for the house are changed from higher carbon emitting energy source (natural gas, fuel oil or propane) to low carbon grid-supplied electricity. In addition, the grid-supplied electricity is changed to less expensive net metered solar power. Additional economic ECMs are also included where applicable. Some measures that are common and may have been recommended by the NRCan energy audit but are not economical have been rejected. Homeowners may have alternative reasons to want these measures (like comfort or improved air quality). This report concentrates on the economies.

Report Procedure

The report is developed as follows.

- An energy advisor visits the subject house to determine the house's construction and size and remaining life of each of the components.
- They analyze the house's base energy load by using the Natural Resources Canada (NRCan) Hot2000 building energy modelling software.
- They report that information in the NRCan Energy Advisor's reporting software. This step produces the base load energy report.
- Then the energy advisor applies familiar ECMs in an organized approach to the base building energy consumption to minimize the building's energy consumption and records these energy improvements.
- Next the advisor estimates the size of the PV panels required to move the house to an annual Net Zero load.
- They prepare an upgrade report that identifies measures in a "proposed" report.
- Finally, a "costing and lifecycle" engineer or technician then estimates the costs for the ECMs, using RS Means, local industry data, experience or other means.
- They also identify the age of the proposed replacement component, its Estimated Useful Life (EUL) and Remaining Useful Life (RUL) and finally the RUL of the house (a house has a typical 125 yr. EUL)
- These costs are combined with energy advisor's savings and the RUL estimates (in a preprogrammed excel spreadsheet) to calculate important metrics like implementation year for the ECM, paybacks, Return On Investments (ROI) and lifetime reduced GHGs. It is organized in a report that shows the homeowner how to move the house to Net Zero!

The following pages outline a plan to move the subject house to Net Zero, the strategy behind that plan and the reasoning for the plan.

4. Planning Strategy

Strategy 1 – Conservation First

In this study a Conservation First approach is applied and is explained as follows.

Below is a graph that show the lifecycle costs (on a rate basis) of various traditional fuels, renewable fuels and some ECMs based on previous studies' findings (based on Hydro Ontario rates, a similar version exists for other jurisdictions).

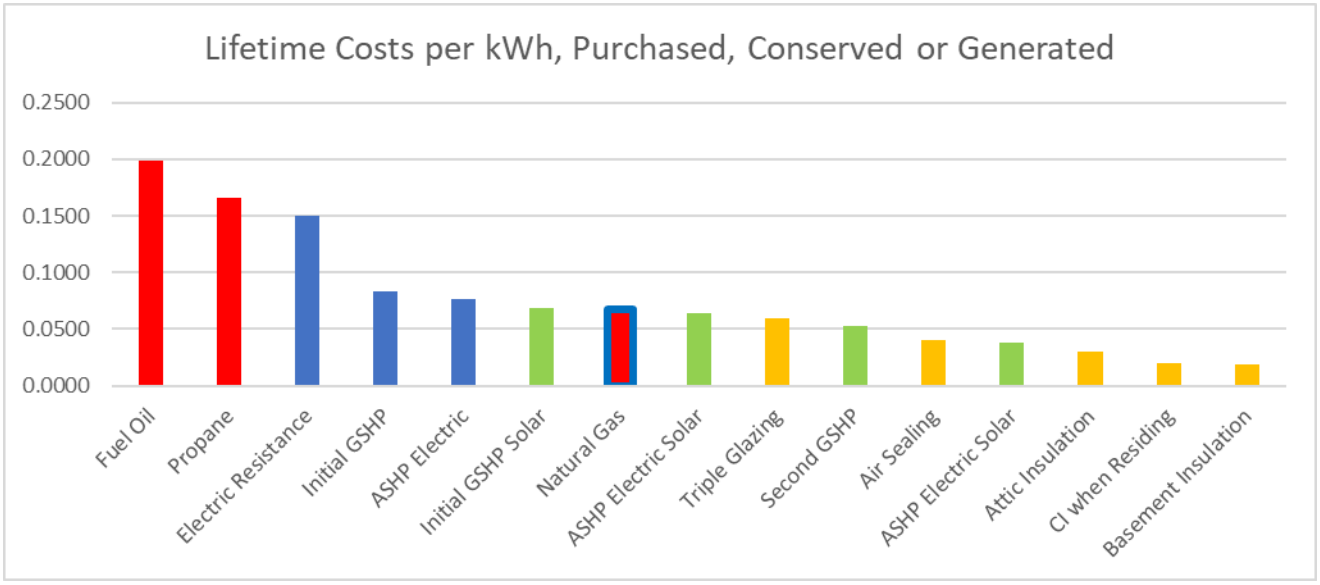


Figure 2- Fuel and ECM Rates

There are Energy Conservation Measures (ECMs) that can be more economical than the fuel conversion measures and these are applied to the energy conservation plan initially.

Graph Notes - The bars in red are the traditional fuels. The bars in green show renewable fuel (solar with no GHG emissions), the blue bars show electrically-supplied heat (with low GHGs) and the Orange bars are conservation measures. Natural gas is highlighted with a light blue outline to indicate this is the least expensive traditional fuel and renewable fuels or ECMs in areas with natural gas supplies must be less expensive (to the right of the natural gas bar) to be economically viable. A "rate" for renewable fuels is calculated by taking the total cost of the solar panel (and if applicable, the heat pump equipment) and dividing it by the total energy these devices will produce over their lifetime. Similarly, the "rate" for an ECM is calculated by taking the total cost of the ECM and dividing it by the total energy the ECM will save over its lifetime. A rate for conservation measures is calculated by taking the total cost of the measure in dollars and dividing it by the lifetime energy savings in kWh.

This list of ECMs is not all inclusive but shows the majority of typical ECMs. Each ECM is not a rigid value but depends on the particulars of each building, but these give a general indication of which measures are valuable and would likely be investigated in each of this type of study.

Strategy 2 – Fuel Conversion

We note that home heating with fossil fuels creates significant GHGs and operating with renewable power doesn't create any. For reference consider the following graph that shows GHG emissions by fuel type.

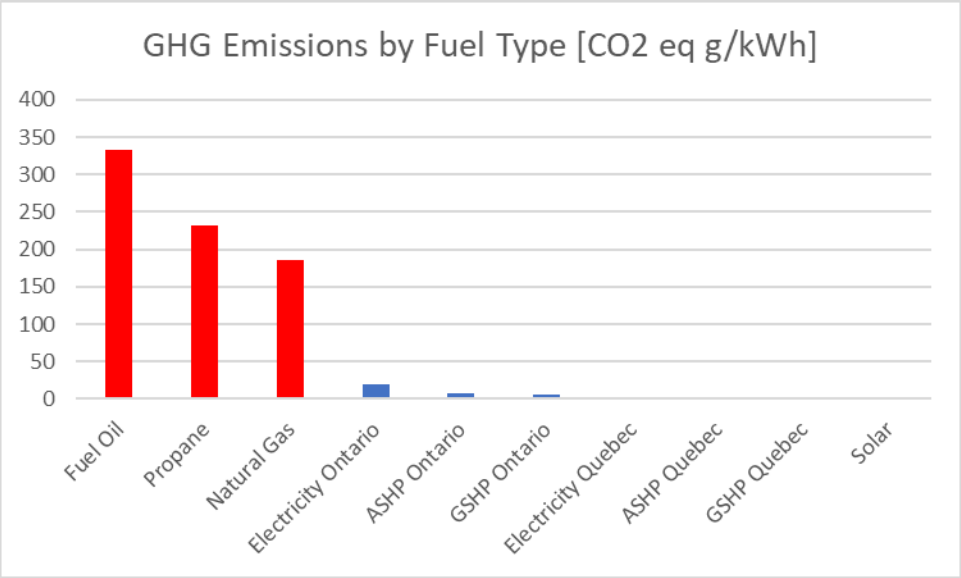


Figure 3- GHG Emissions by Fuel Type

Note that figure 3 shows that GHG emissions from renewable power (solar or electricity in Quebec) are essentially non-existent and can be low for electrical power in some jurisdictions. Note that Ontario-generated electricity has a significant nuclear power component and switching to solar also eliminates nuclear waste that is produced in Ontario-generated electrical power.

Typical costs of fuels are illustrated in the following graph.

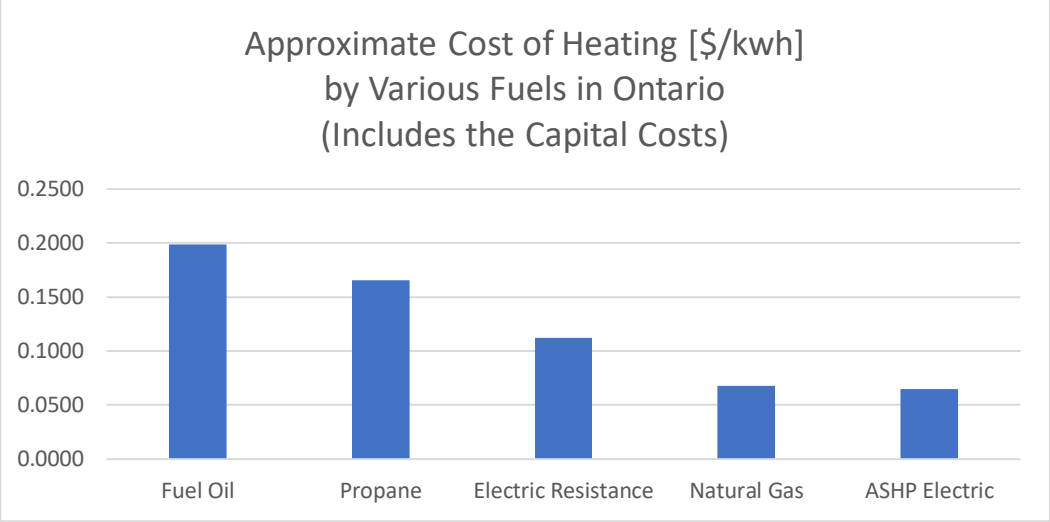


Figure 4 - Energy Costs by Fuel

Strategy – We note the GHG emissions of heat supplied by net metered solar power that drives heat pumps is negligible and the costs comparable to Natural Gas (NG) heating. Furthermore, carbon pricing will cause natural gas costs to rise. These observations are used to justify moving the space heating to ASHP supplied heat. Domestic Hot Water heating with electricity may be costlier than with natural gas but the reduction in GHG emissions is dramatic and if all NG appliances are removed the administration fees ($25/mn or $300/yr) can be eliminated. Net metered solar power is significantly less expensive than grid supplied, so we recommend moving to net metered solar power. Finally, we note some energy conservation measures not only save energy and money but reduce GHGs. Those that are found to be economical are used in this report.

Strategy 3 – Life Cycle Planning

The construction and delivery of building equipment (appliances) and building components (windows, doors, insulation, etc.) cause GHG's to be emitted as manufacturing and delivery use energy and energy is at least still partially produced by fossil fuels which emit GHGs. These manufacturing/delivery GHGs are commonly called embedded carbon as the released carbon is embedded in the manufacture of the equipment or component. Replacing appliances or building components early causes an unnecessary release of embedded carbon. Also, it is noted that retiring components too late may lead to a component breakdown in difficult circumstances (i.e. the furnace breaks down in the middle of a cold spell). In this circumstance the homeowner is often faced with a decision to replace with whatever is convenient (i.e. replace the furnace with an identical fossil fuel unit because no new design is required and supply is available) and misses the opportunity to upgrade to a low carbon version. So typically this report will recommend the replacement of appliances and components at about ¾ of the life of the appliance of component.

5. Suggested Plan to Move to Net Zero.

The executive summary lists the suggested ECMs, their date of implementation and describes the measure in more detail. It is omitted here to reduce redundancy.

We have prepared the following plan to move this building to renewable energy. This chart shows the reduction in required energy after each ECM is applied and the suggested year for the implementation (typically at the end of the component's estimated useful life).

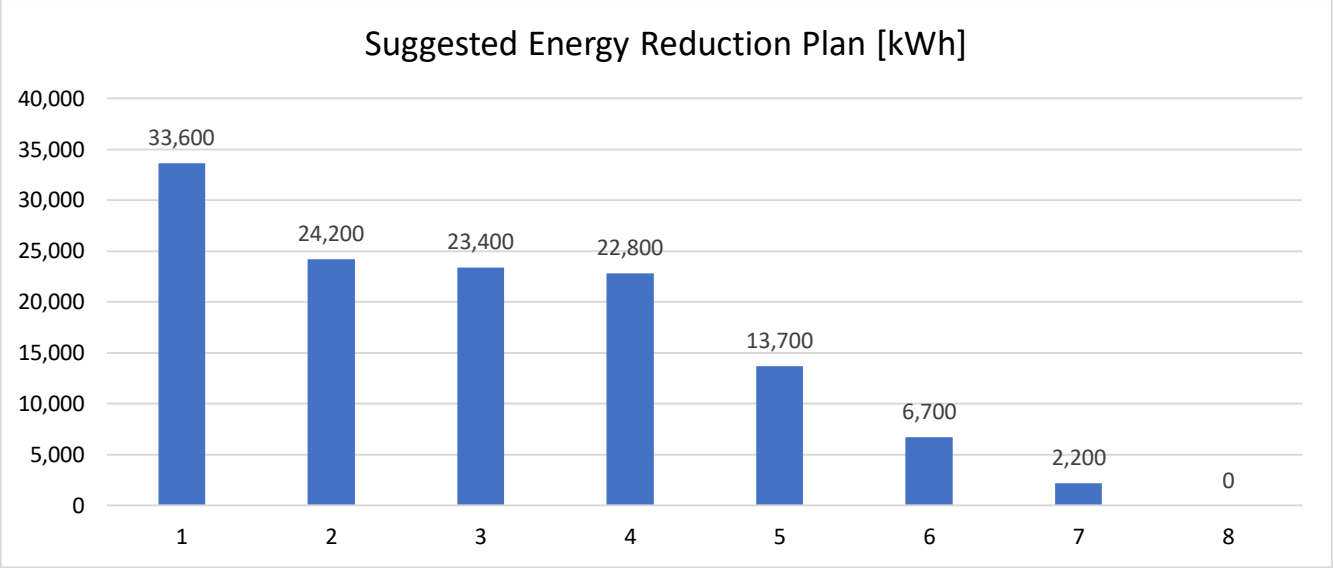


Figure 5- Plan to Move to Carbon Free

Note:

- The above estimates do not include the energy requirement for Electric Vehicles, outdoor pools, saunas or other similar electrical loads. The analysis is confined to the house and it's loads alone. Additional electric consumption for EVs is estimated (if present) in the executive summary.

6. Sustainability

The following graph shows the annual estimated GHG emissions in kilograms (kgs.). It is illustrated showing each ECM applied in recommended order, reducing the GHG emissions to nearly zero GHG emissions.

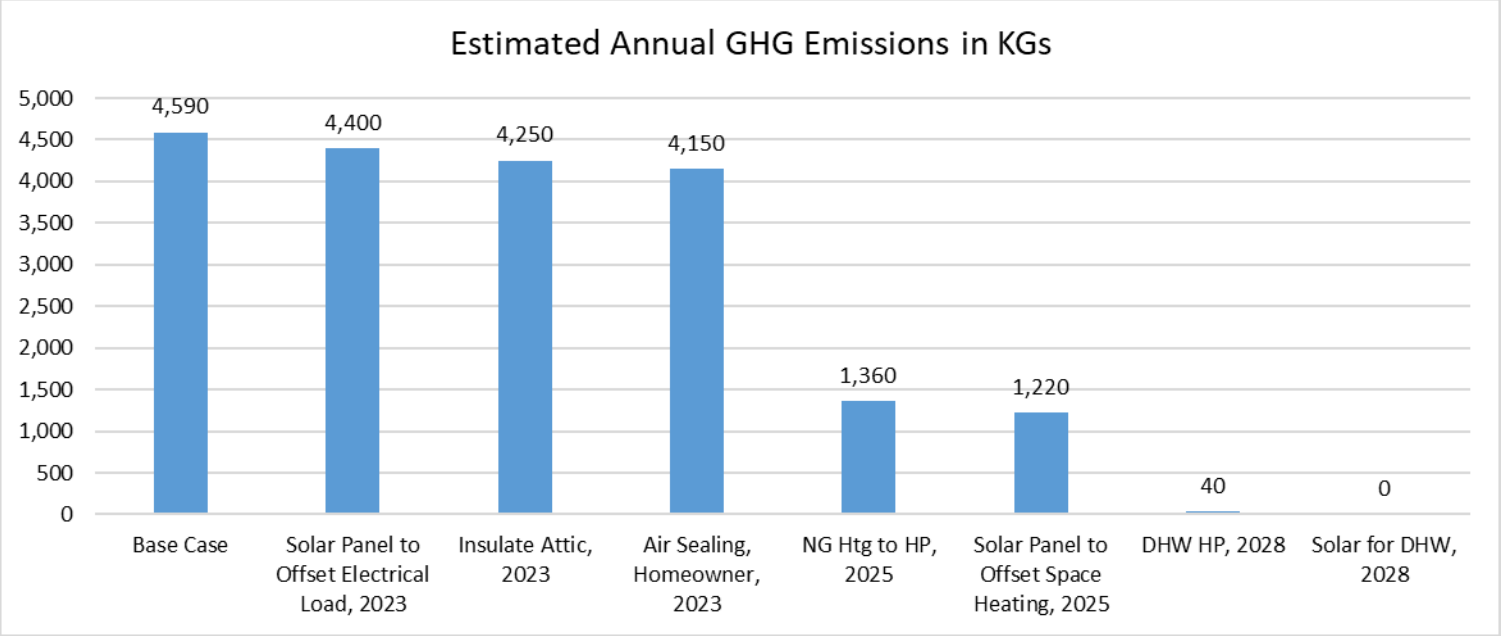
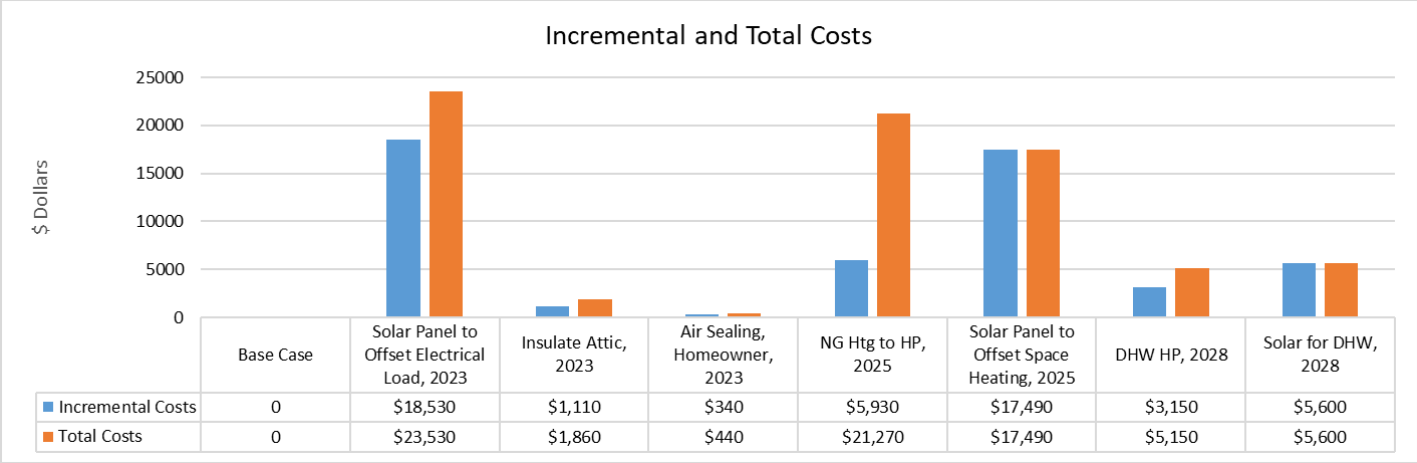


Figure 6 - Sustainability (lifetime GHG Reduction by ECM)

7. Incremental and Total Costs

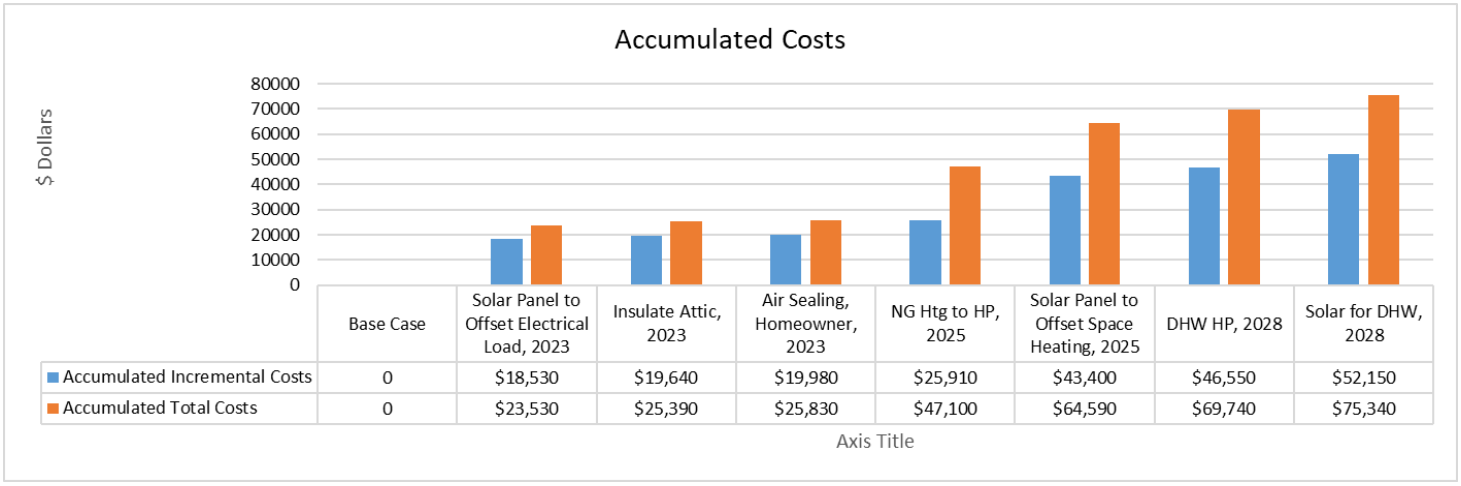
The following graph shows the costs for each measure and suggested investment year. The incremental cost assumes the appliance has to be replaced and the cost difference between the appliance and its replacement minus any rebate are shown.



	Base Case	Solar Panel to Offset Electrical Load, 2023	Insulate Attic, 2023	Air Sealing, Homeowner, 2023	NG Htg to HP, 2025	Solar Panel to Offset Space Heating, 2025	DHW HP, 2028	Solar for DHW, 2028
Incremental Costs	0	$18,530	$1,110	$340	$5,930	$17,490	$3,150	$5,600
Total Costs	0	$23,530	$1,860	$440	$21,270	$17,490	$5,150	$5,600

Figure 7 - Individual ECM Costs

The following graph shows the accumulated costs to move the house off GHG emitting fossil fuels.



	Base Case	Solar Panel to Offset Electrical Load, 2023	Insulate Attic, 2023	Air Sealing, Homeowner, 2023	NG Htg to HP, 2025	Solar Panel to Offset Space Heating, 2025	DHW HP, 2028	Solar for DHW, 2028
Accumulated Incremental Costs	0	$18,530	$19,640	$19,980	$25,910	$43,400	$46,550	$52,150
Accumulated Total Costs	0	$23,530	$25,390	$25,830	$47,100	$64,590	$69,740	$75,340

Figure 8- Accumulated Costs to Net Zero

8. Annual Fuel Costs

The following charts identify the estimated annual fuel costs and provides a rough estimate of the expected annual utility savings.

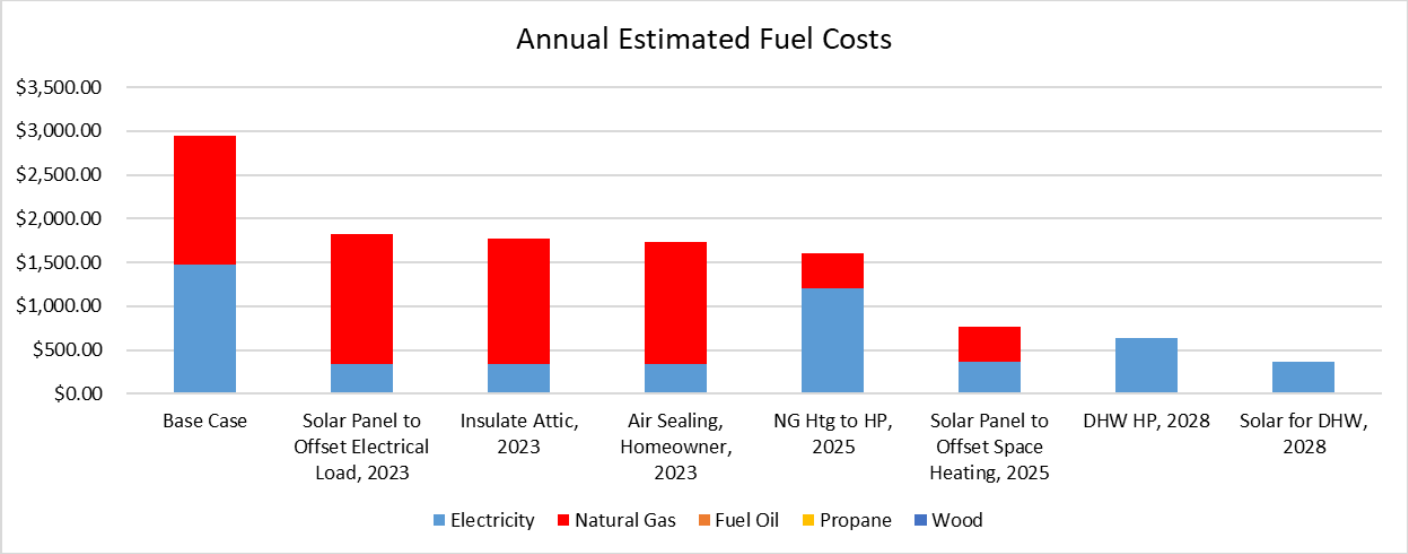


Figure 9- Annual Fuel Costs

Note – There is a small grid connection and delivery charge for electricity even when all energy is net metered solar power.

The following graph shows the tons of GHG emissions for the next 50 years of the house's remaining life for 3 fuel options (do nothing, convert all energy use to grid-supplied electricity and convert to solar-supplied electricity and heat pump heating).

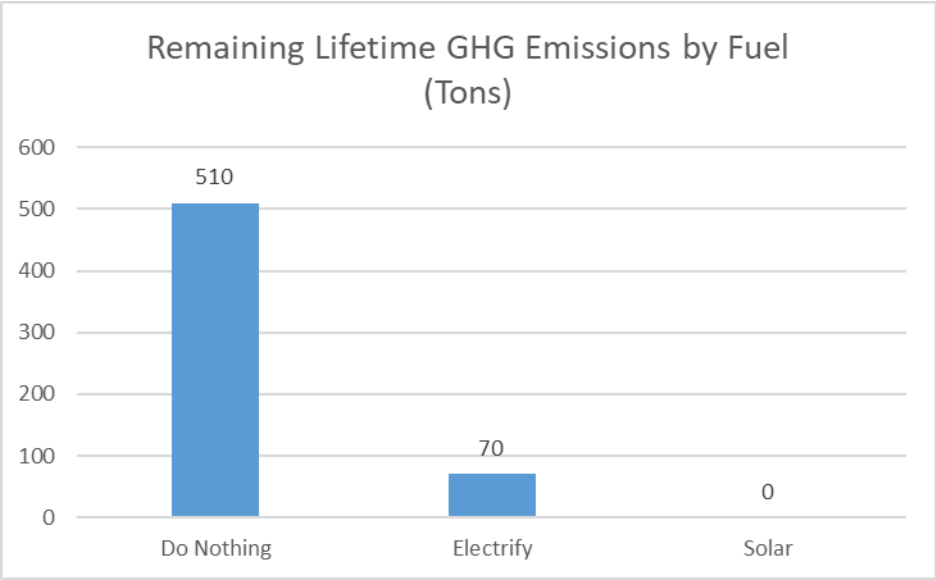


Figure 10 Lifetime GHG Production by Fuel

9. Financial Analysis, Sustainability Analysis and Summary

The following charts summarizes the costs, savings, paybacks, component life and GHG reductions for these measures.

Measure Description	Existing Technology Component Cost	Renewable Energy Component Cost	Incentive	Incremental Cost	Annual Savings	Payback Years	Component Life	Lifetime Net Savings
Solar Panel to Offset Electrical Load, 2023	$0	$23,530	$5,000	$18,530	$1,130	16.4	25.0	$9,720
Insulate Attic, 2023	$0	$1,860	$750	$1,110	$50	22.2	101.0	$3,940
Air Sealing, Homeowner, 2023	$0	$440	$100	$340	$30	11.3	101.0	$2,690
NG Htg to HP, 2025	$15,340	$21,270	$0	$5,930	$120	49.4	20.0	-$3,530
Solar Panel to Offset Space Heating, 2025	$0	$17,490	$0	$17,490	$840	20.8	25.0	$3,510
DHW HP, 2028	$2,000	$5,150	$0	$3,150	$130	24.2	20.0	-$550
Solar for DHW, 2028	$0	$5,600	$0	$5,600	$270	20.7	25.0	$1,150
Total	$17,340	$75,340	$5,850	$52,150	$2,570			

Figure 11 – Financial Summary by ECM

Use the cost estimates for this project as a guideline (i,e, get additional quotes if the contractor's estimate exceeds this estimate by much) and ensure the potential contractor provides all necessary paperwork to apply for the incentives. Consult with the NRCan energy auditor to determine the required paperwork.

Measure Description	Energy Savings [kWh]	Fuel Type	Incremental Cost	Annual Emissions Reductions [kg eCO2]	House Remaining Lifetime Emissions Reductions [Tons eCO2]	Additional Annual Solar Require-ment [kWh]	Accumulated Annual Solar Require-ment [kWh]
Solar Panel to Offset Electrical Load, 2023	9,410	Electricity	$18,530	190	21	9,410	9,410
Insulate Attic, 2023	830	NG	$1,110	150	17	0	9,410
Air Sealing, Homeowner, 2023	560	NG	$340	100	11	0	9,410
NG Htg to HP, 2025	9,090	NG	$5,930	2,790	311	0	9,410
Solar Panel to Offset Space Heating, 2025	7,000	Electricity	$17,490	140	16	7,000	16,410
DHW HP, 2028	4,480	NG	$3,150	1,180	131	0	16,410
Solar for DHW, 2028	2,240	Electricity	$5,600	40	4	2,240	18,650
Total	33,610		$52,150	4,590	511	0	18,650

Figure 12- Sustainability Summary by ECM

Note – The annual solar requirement is the amount of annual solar power required to move the respective electrical power to solar. Provide it to the solar contractor for their conversion to the required solar capacity as per the recommendations in the “Notable Assumptions Section”.

Measure Description	Fuel Affected	Approx. Fuel Cost [$/kWh]	Cost of Measure / Lifetime Kwh Saved or Conserved	Cost [$] per Annual kG of CO2 Saved
Solar Panel to Offset Electrical Load, 2023	Electricity	$ 0.12	$0.079	$97.53
Insulate Attic, 2023	NG	$ 0.06	$0.013	$7.40
Air Sealing, Homeowner, 2023	NG	$ 0.06	$0.006	$3.40
NG Htg to HP, 2025	NG	$ 0.06	$0.033	$2.13
Solar Panel to Offset Space Heating, 2025	Electricity	$ 0.12	$0.100	$124.93
DHW HP, 2028	NG	$ 0.06	$0.035	$2.67
Solar for DHW, 2028	Electricity	$ 0.12	$0.100	$140.00

Figure 13- Comparison to Fuel Costs and Investment Dollars per kG of CO2 Saved

Note – the approximate fuel cost includes the lifetime cost per kWh of the equipment providing the energy (furnace for instance) and the announced carbon taxes.

Analysis

Measure Description, Implementation Year	Recommendation and Rationale
Introduction	Careful analysis of design and construction of this house and fuel selection show this house can be converted to non-GHG emitting renewable fuels with an economic benefit.
Solar Panel to Offset Electrical Load, 2023	The conversion of the electricity to solar (Net Metered) has a good annual savings and makes a positive annual and lifetime reduction in GHG for this house.
Insulate Attic, 2023	Insulating the attic, has a positive effect on energy conservation and cost savings.
Air Sealing, Homeowner, 2023	Air sealing has a good return on investment (payback) it increases comfort and reduces GHGs. It is recommended that an experienced handyman (the home owner in this case) do the air sealing for this house and the results tested when a NRCan follow-up review is conducted.
NG Htg to HP, 2025	The energy conversion of the space heating from natural gas to Solar/HP has an small lifetime cost but a large reduction in GHGs. It is also a hedge against rising carbon taxes and has a much larger impact in future years from now. Note that it is necessary to switch the electricity supply to Net Metered solar power to have a neutral cost savings in comparison to natural gas.
Solar Panel to Offset Space Heating, 2025	The conversion of the electricity to solar (Net Metered) has a good annual savings and makes a positive annual and lifetime reduction in GHG for this house.
DHW HP, 2028	The energy conversion of the DHW from natural gas to Hot Water Heat Pump (HWHP) has a small annual cost above natural gas cost. However, when combined with net metered solar power the combined savings outweigh the costs and result in a overall lifetime savings.
Solar for DHW, 2028	The conversion of the electricity to solar (Net Metered) has a good annual savings and makes a positive annual and lifetime reduction in GHG for this house.
End Statement	The application of all measures eliminates any net consumption of utility energy and net environmental emissions of GHGs. We note that NRCan has made a $40,000 no interest loan through the Greener Homes Loan program. A low interest loan of up to $125,000 is available in the City of Ottawa through the Better Homes Loan program. Both of these loans are available for any measures that have been recommended in the NRCan upgrade report.

10. NRCan versus Building Science Trust Report Recommendations

NRCan now offers incentives for a number of measures that may not be the best economic option but the homeowner may have other reasons to take advantage of the measure. For this reason, the service organization that prepared the NRCan report may have listed these measures as conservation opportunities. In addition, the NRCan service organization that performed the audit doesn't perform a cost study with their audits as per NRCan procedures. These differences sometimes result in differences between our reports.

For this house the following NRCan report recommendation(s) was(were) rejected.

Rejected ECMs	Rationale
New Air Conditioner	A heat pump which is recommended acts as an air conditioner with equivalent efficency. To clarify a separate replacement of the AC system is not required.

Note: Manufacture, distribution, marketing and related business functions used in the production, sales and distribution of building components consumes energy. Most of this energy is currently provided by fossil fuels which when consumed produce GHGs. These GHGs are called embedded carbon or embedded GHGs. Early retirement of building components (furnaces, DHW heaters, windows, AC units, etc.) causes extra production of embedded carbon. The suggested installation dates are selected to typically coincide with the end of the estimated useful life of each component to minimize the embedded carbon emissions and allow for replacement planning. Early retirement of components at dates preceding the suggested dates isn't required to minimize overall GHG production. Early retirement also unnecessarily reduces the ROI of associated ECMs.

Other: Notable Assumptions

- The roof has adequate support to carry the load of solar equipment. (i.e. no provision has been made for structural upgrades to the roof to support solar panels). That analysis is beyond the scope of this report. The homeowners have to investigate that contingency at their own expense.
- The local utility has adequate capacity to allow this house to generate net metered solar power if solar power has been recommended. (Building Science Trust has not checked with the local electric utility to determine if the utility will allow for additional solar production from the house).
- This report has not checked that adequate unshaded roof area is available to meet the entire annual electric requirements to move the house to Net Zero. The report identifies the requirement. It is up to the homeowner to contact a solar contractor to confirm adequate production capacity. Generally solar contractors provide this service free of charge (embedded in their installed costs).
- Adequate ventilation must be provided to a DHW HP (Domestic Hot Water Heat Pump) to ensure the cooling effect of the heat pump on its local space doesn't cause comfort issues.

- The report is based on the energy usages identified in the NRCan energy audit. A homeowner's lifestyle (very frugal or extravagant with the energy they use) may cause deviations from the report. Generally, these don't have a substantial influence on the values shown in this report with the exception of the anticipated solar production requirements. BST recommends that the homeowner confirm historical electricity usage when identifying the home's solar panel requirement and additional solar requirements for space or DHW heating be installed at 85% or less than the estimated load. Then after a year or more history, additional solar power can be installed to ensure the homeowner doesn't over-install the solar power capacity, as the utility doesn't pay the homeowner for an annual over production in Ontario.
- Minor fossil fuel appliances (dryers, fireplaces, stoves, etc.) aren't considered in this report. It is assumed that the homeowner will replace those appliances with electric versions to eliminate the monthly administration and metering fees for these remaining NG appliances after the space and DHW have been converted to net metered solar powered options. These fees are about $25/mn or $300/yr.
- The report does not investigate if the electrical service into the house can carry 200 or more Amps. This is generally required (unless otherwise indicated) for a heat pump installation and often for EV charging. To confirm consult one of the electricians recommended in the contractors list (for Ottawa Area only). Alternatively, most electricians will supply this information in their free electrical upgrade estimates.
- Building Science Trust is available to investigate and resolve any of the above assumptions (for an additional fee) if required.

Cautions

- When contracting projects that qualify for NRCan grants, ensure the contractor will provide any documentation that is required for NRCan validation. Ask the contractor or manufacturer to include a statement in the quote that the product you're buying qualifies for the NRCan grant. Also note that the Enbridge grants for conservation measures (windows, insulation, doors, etc.) have to be procured before the furnace is replaced with a heat pump (i.e. Enbridge incentives are only available while natural gas is supplied by Enbridge in other words install the heat pump first and the Enbridge grants are no longer available).
- Sometimes HVAC contractors choose a backup heater size to be a little lower than the minimal size listed in the NRCan base conditions report. Implications may be rare insufficient heating for a possible significant cost savings (especially in houses with smaller electrical panels and services). If the backup heater size in the contractor's quote is lower than the Design Heating Load in the NRCan report (located in the Mechanical Systems, Space Heating paragraph of the Homeowner Information report), discuss the implications with your contractor and be sure that when choosing competitive bids that all contractors are quoting identical systems for cost comparisons.
- Contractors may interpret your needs differently than this detailed report and analysis provide. This may lead to suboptimal estimates. For the best results give your contractors this report to ensure they know the intent of the design.

- The conversion of the electricity to solar (Net Metered) has a good annual savings and makes a small but positive annual and lifetime reduction in GHG for buildings. This report shows the energy requirement to move annual electrical energy load(s) after conservation measure to zero. It doesn't confirm that there is enough appropriate roof or alternative space to do so and the costs are based on an average number for Ottawa solar generation. The building owner should call a reputable solar contractor to confirm annual energy estimates will meet the load requirements and identify those costs precisely (solar contractors offer these estimates for free to potential clients as it's embedded in the final sales, consultants have to charge for it). If adequate solar panel space is not available this report outlines the annual energy requirements for an investment in offsetting renewable energy.

Summary

In summary this building can be converted to electrical power which is offset by PV solar power in a Net Metering application to significantly reduce the carbon footprint of the building and have a positive financial outcome overall.

11. Limitations

Energy savings are based on engineering calculations and are similar to the estimated savings for each ECM as generated by NRCan's HOT2000 modelling software. Actual savings may vary from these estimates depending on how closely the actual conditions match the assumed conditions. Also, yearly variation in weather conditions may cause variance from the estimated savings measured. Occupant behavior causes actual energy usage to vary significantly between various households. Deviations from the modelled estimates are expected.

Costs are based on RS Means estimates for construction components, construction experience of the estimator or costs as sourced from suppliers or contractors. Actual construction costs vary significantly based on local contractor and supplier availability and market conditions, and actual component and contractor quality and skill (for instance insulation may vary by as much as 25%).

12. Conclusion

In Conclusion we verify that this report is accurate within the expected and allowable errors associated with predicting energy consumption in future weather. We hope the building owner finds this information very valuable in assisting them to make their investment decisions in their property and more importantly, the environment.

Signature in the final report.

Daniel E. Vivian, P.Eng.