Sample Fuel Conversion and Energy Conservation Report

(Air Source Heat Pump Version)

for Mr. and Mrs. Client

Any Street, Ottawa, ON.

Prepared for:
Mr. and Mrs. Client,
Any Street,
Ottawa, ON, H0H OHO

Prepared by:
The Building Science Trust Inc.
104-1380 Prince of Wales Dr.
Ottawa, ON, K2C 3N5
Telephone: 613.981.2612
www.buildingsciencetrust.com

November 6, 2021
Sample Report

1. Executive Summary

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

Measure Description	Recommendation and Rational
Introduction	Careful analysis of design and construction of this house and fuel selection show this house can be converted to non-GHG emitting renewable fuel (solar) with an economic benefit.
Solar Panel to Offset Electric Load	The conversion of the electricity to solar (Net Metered) has a good annual savings and makes a good annual and lifetime reduction in GHG for this house.
Air Sealing	Installation of better air sealing has a lifetime cost (i.e. very small annual savings and high upfront costs). Although not financially strategic to proceed with this recommendation, it has a measurable decrease in GHG and as the available roof area for solar panels is limited every saved kWh assists in reaching the net zero goal. We note that $2,500 was allocated for a contractor to seal the house but the home owner can do much of this sealing on their own for minimal costs (less than $200). This makes this measure much more attractive than indicated by the financial presentation and BST recommends the home owner perform the sealing as per the NRCan documents.
Insulating Blinds	Insulating Blinds can improve comfort and reduce energy requirements and GHG emissions. This is the case for the older blinds in this house. BST recommends that insulating blinds are not located in direct sunlight (as the heat generated may damage the window seals) and not in high humidity areas like the kitchen bathrooms with showers or poorly ventilated laundry rooms and the blinds be used at night and during unoccupied times of the day.
DHW HP	The energy conversion of the DHW from Natural gas to Solar/HP has a small annual cost above natural gas cost. However, the reduction in GHGs for this conversion is significant and as such is a recommended ECM. We note that the combination of switching the DHW heating from NG to HP and adding solar to offset the additional electricity cost is more competitive and recommend doing both simultaneously.
Solar for DHW	Adding solar power to offset the addition electric power when switching the NG DHW to Heat Pump powered heating, has a reasonable payback. We note that the combination of DHW HP and solar is more attractive than DHW HP alone.

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

Measure Description Continued	Recommendation and Rational
Space Heating ASHP	The energy conversion of the space heating from Natural gas to Solar/HP has a similar annual cost as natural gas cost. However, the reduction in GHGs for this conversion is significant and as such is a recommended ECM.
Improved AC	The existing older AC unit has a suspected lower energy efficiency than the proposed replacement unit. The increased energy efficiency results in a minor cost and GHG emissions reduction.
Solar Panel to Offset Space Heating	Adding solar power to offset the addition electric power when switching the NG furnace to Heat Pump powered heating, has a reasonable payback. We note that the combination of DHW HP and solar is more attractive than DHW HP alone.
End Statement	All ECMs combined result in a net positive annual and life savings.

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

Measure Description	Fossil Fuel Component Cost	Renewable Energy Component Cost	Incremental Cost	Annual Savings	Payback Years	Component Life	Lifetime Net Savings
Solar Panel to Offset Electric Load 2021	$0	$23,522	$18,520	$1,360	13.6	30	$22,280
Air Sealing 2021	$0	$2,500	$2,500	$33	74.8	75	$7
Insulating Blinds 2021	$2,000	$2,910	$910	$85	10.7	15	$364
DHW HP 2021	$1,700	$5,150	$3,450	$181	19.0	15	-$731
Solar for DHW 2021	$0	$5,600	$5,600	$290	19.3	30	$3,100
Space Heating ASHP 2030	$13,985	$15,245	$1,260	$203	6.2	20	$2,798
Improved AC 2030	$0	$0	$0	$90	0.0	20	$1,800
Solar Panel to Offset Space Heating 2030	$0	$15,446	$15,450	$810	19.1	30	$8,850
Totals	$17,685	$70,373	$47,690	$3,053	15.6		

Note this financial summary includes the recently announced increases in carbon Taxes to $170/ton to 2030.

The GHG emissions reduction summary is listed below;

Measure Description	Energy Savings [GJ]	Fuel Type	Incremental Cost	Annual Emissions Reductions [kg eCO2]	Annual Emissions Reductions [Tons eCO2]	House Remaining Lifetime Emissions Reductions [Tons eCO2]
Solar Panel to Offset Electric Load 2021	40	Electricity	$ 18,520	110	0.1	9
Air Sealing 2021	2	NG	$ 2,500	120	0.1	10
Insulating Blinds 2021	5	NG	$ 910	300	0.3	25
DHW HP 2021	19	NG	$ 3,450	1,680	1.9	139
Solar for DHW 2021	10	Electricity	$ 5,600	30	0.0	2
Space Heating ASHP 2030	38	NG	$ 1,260	3,960	4.4	327
Improved AC 2030	3	Electricity	$ -	10	0.0	1
Solar Panel to Offset Space Heating 2030	26	Electricity	$ 15,450	70	0.1	6
Totals	144		$ 47,690	6,280	6.9	519

The size of the heat pump is listed in the NRCan upgrade report; a separate report can be commissioned to determine the size of the DHW heat pump. See the following report for further details.

Note – A $5,000 Greener Homes Grant is applied against the cost of the initial solar panel installation.

The remaining life of the house is assumed to be 75 years.

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.

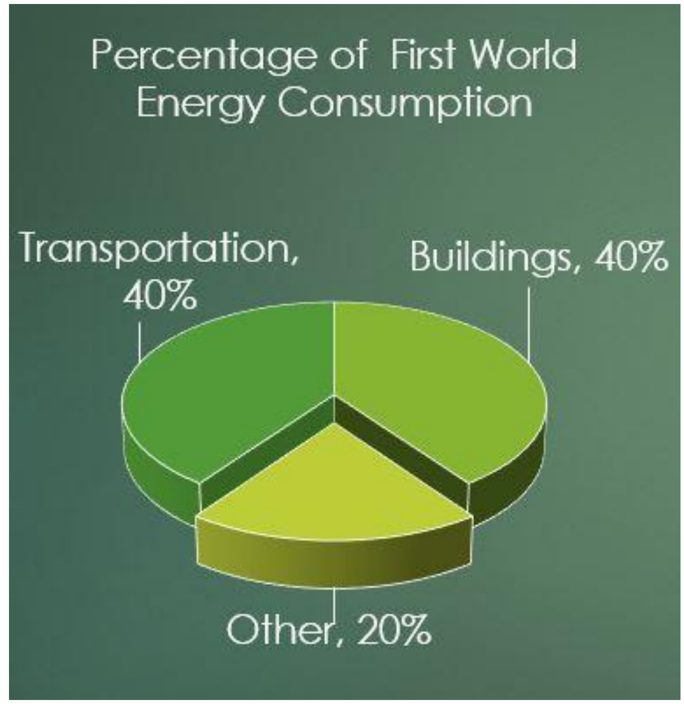


Figure 1 - Approximate energy mix for first world countries.

3. Introduction

This report provides a plan to move Any Street Ottawa Ontario to Net Zero in an economical and timely manner. Net Zero means the site will generate as much energy as it uses on an annual basis. This report shows how to implement Energy Conservation Measures (ECMs) and install renewable generation (Photo Voltaic (PV) solar panels) to move the equivalent annual energy consumption to carbon free energy. Carbon free means the energy sources for the house are changed from higher carbon emitting energy source (natural gas) to grid supplied electricity and the grid supplied energy is offset with onsite PV solar power. As electricity is approximately 4 times more expensive than natural gas several high value Energy Conservation Measures (ECMs) are proposed to minimize the impact on the annual energy costs. The most significant is to use heat pumps to generate space and domestic hot water heat. An Air Source Heat Pump (ASHP) used for space heating generates approximately 2.5 kW of heat for every 1 kW of electricity it consumes and similarly a Domestic Hot Water (DHW) heat pump has a 3:1 advantage. Site generated solar power is used because it is approximately ½ the cost of grid supplied energy and has no fossil fuel component that causes GHGs. When these two measures are applied together the resulting energy cost is very competitive or even better than the cost of other traditional fossil fuels including natural gas.

4. 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 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 reports 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, it’s 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.

5. Planning Strategy

We note that home heating with fossil fuels creates significant GHGs and operating with solar panels do not create any. For reference consider the following graph that shows GHG emissions by fuel type.

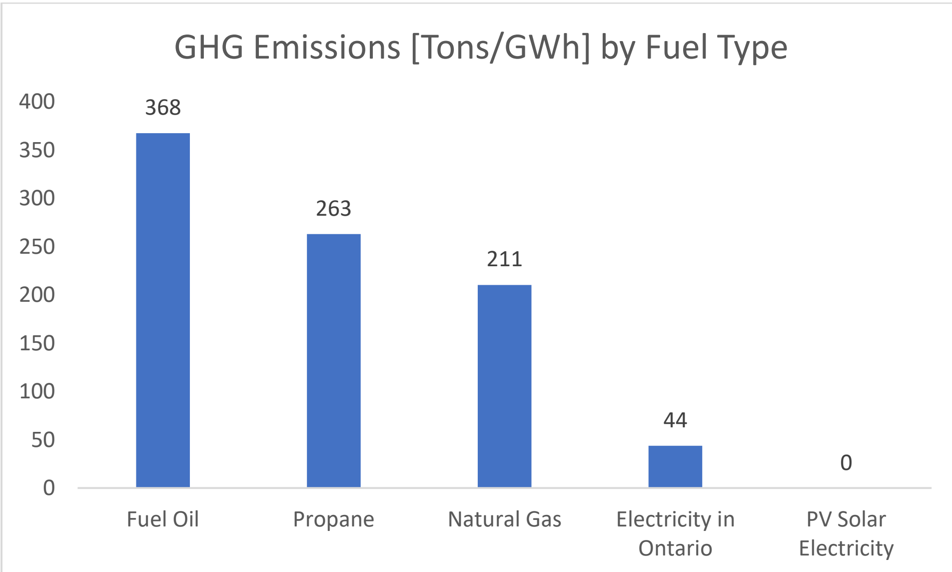


Figure 2- GHG Emissions by Fuel Type

Note that figure 2 shows that GHG emissions from solar power are non-existent and low for electrically produced power. 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.

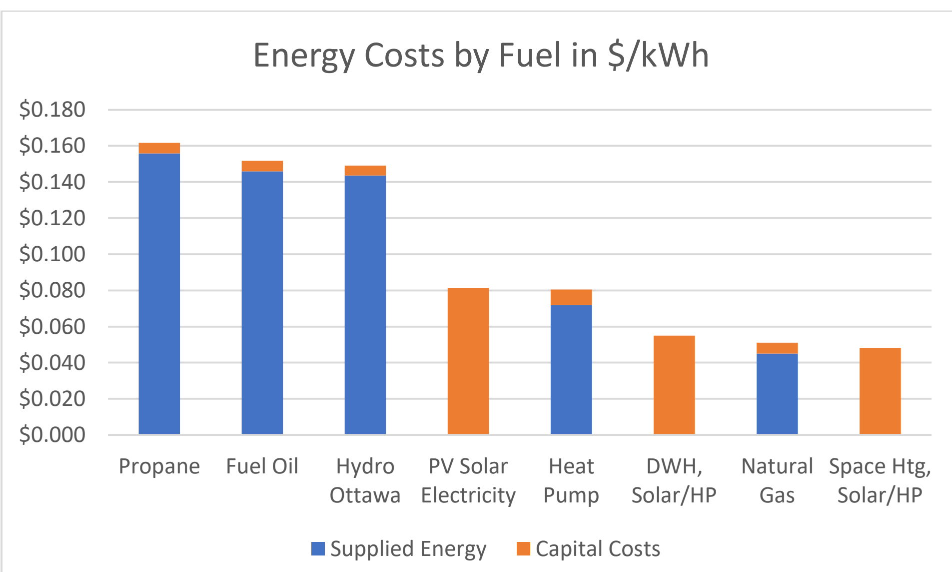


Figure 3 - Energy Costs by Fuel

Note that figure 4 shows that PV Solar Electricity ($.08/kWh) is cheaper than the utility supplied electricity ($.15/kWh) by nearly half the cost. Also note that Domestic Hot Water heating and space heating by Solar/HP are significantly cheaper than propane, fuel oil or electric resistance (Hydro Ottawa) supplied heat and about equivalent to natural gas supplied heat. These observations are used to develop the strategy to move this house off fossil fuels and onto renewable fuels (solar PV) in an economical way as follows.

1. **Move Grid Supplied Electricity to PV Solar Electricity**

   The first step (strategy) is to install enough solar power to move the electrical supplied power to PV solar supplied power. This recommendation happens in the first year to provide immediate savings and GHG reductions. Note that solar power requires the installation of solar panels which can be expensive but once installed there is no cost for the solar supplied power (i.e. no electrical power bill for supplied power just a meter cost which is approximately $25 per month).

2. **Move the natural gas heated Domestic Hot Water (DHW) to Solar/Heat Pump Supplied DHW**

   Next step is to move the DHW energy supply from natural gas ($.055/kWh) to an electric heat pump. This recommendation occurs when the DHW heater requires replacement.

   If the electrical power is supplied by electricity from the grid in a traditional electric resistance DHW heater, this conversion would cost the homeowner a significant increase in their annual DHW energy bill. However, this report recommends installing a heat pump supplied DHW heater. In Ottawa heat pumps for DHW heating supply on average 3.0 kW of heat energy for every kW of electrical energy consumed. This additional heat is not magic or violates the second law of thermodynamics but is environmental heat that is collected from the outside atmosphere. See this website for an explanation.

   https://home.howstuffworks.com/home-improvement/heating-and-cooling/heat-pump.htm

   As a simple conversion to a grid supplied heat pump DHW heater would also be significant annual energy bill increase for the homeowner, this report recommends a conversion of the annual electricity required for the heat pump DHW heater to less costly solar powered electricity. When both measures are pursued the annual emissions are completely reduced or offset and the annual equivalent energy bill is similar to a natural gas powered DHW heater.

   It is important to note that the combination of electric supplied heat pump energy and a solar powered electric supply is crucial in achieving both the desired savings and GHG emissions. Note that in this scenario the solar panels do not directly power the heat pump. They do however generate enough solar power in the year to offset the annual energy consumed by the heat pump. This in effect leaves the homeowner with no energy consumption bill for the DHW heating. This kind of electrical power supply by solar panels and the utility grid is called Net Metering.

3. Move the Space Heating from natural gas supply to Solar/Heat Pump Supplied Space Heating

Next space heating can be moved to solar/heat pump in two similar ways to the DHW heating as DHW heating.

1. Change the natural gas supplied space heat from the furnace to an electrically powered heat pump with electric back up heat and offset the additional expensive grid supplied electricity with solar supplied electricity. Note that this option effectively eliminates or offsets the fossil fuel consumption and nuclear waste production associated with this house's energy consumption. In addition, it eliminates all-natural gas bills and all but the meter bill for the electrical meter.
2. Change the natural gas supplied space heat from the furnace to an electrically powered heat pump with electric back up heat without offsetting the additional expensive grid supplied electricity with solar supplied electricity. Note that this option eliminates all-natural gas bills and the previous solar installations offset the GHGs associated with fossil fuel content of the grid supplied power. The annual energy bill will be somewhat higher than before the transition but not as much capital for solar power needs to be invested to move off fossil fuels. The house will continue to create nuclear waste in this option.

The second space heating fuel transition option is rejected because the resulting electrical bill would be very high and leave the homeowner frustrated with the perceived poor financial performance of this option.

Finally, note that there are Energy Conservation Measures (ECMs) that can be more economical than the fuel conversion measures. The following graph identifies the rates for traditional fuels, renewable fuels and some ECMs based on previous studies findings.

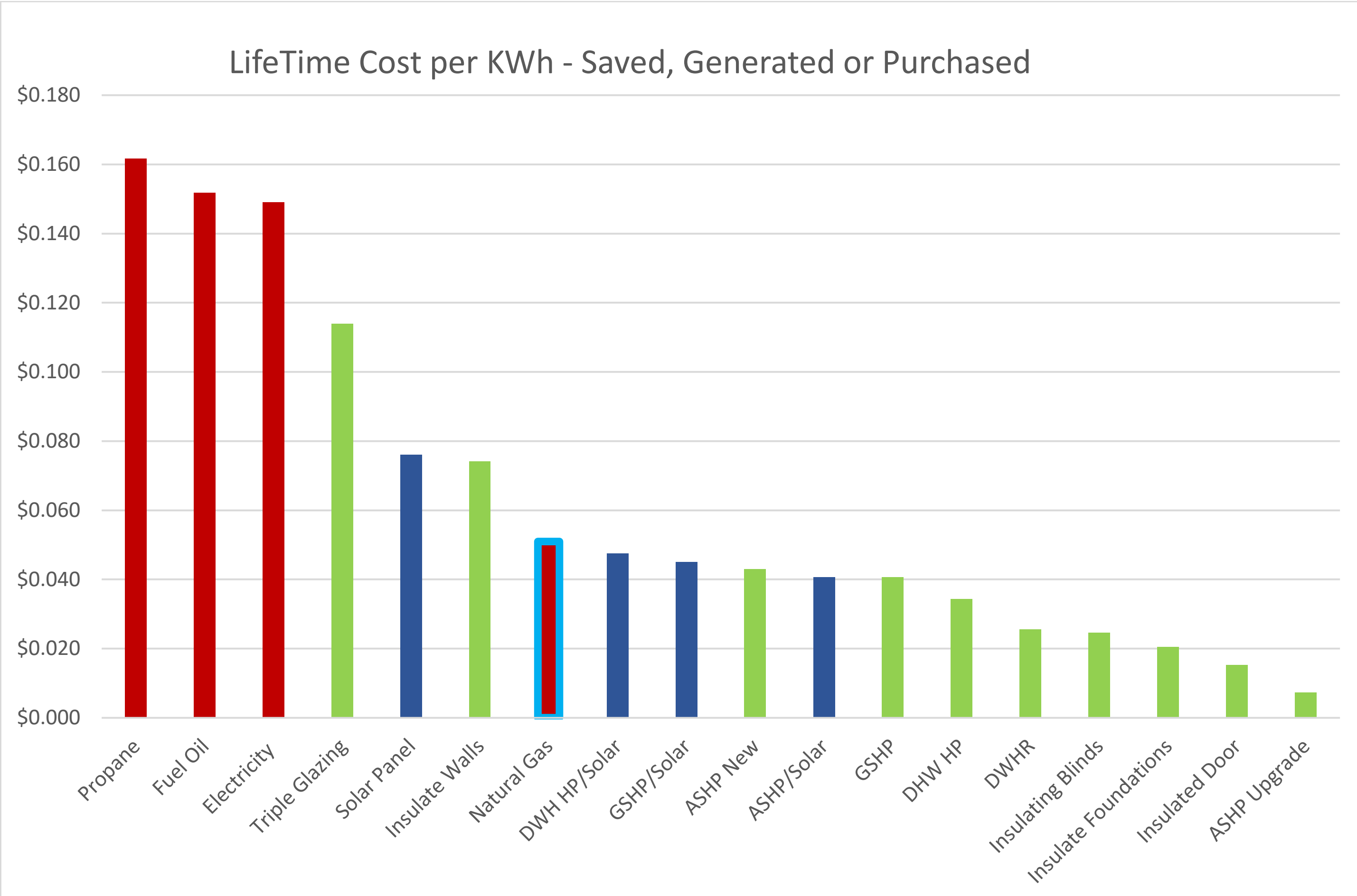


Figure 4- Fuel and ECM Rates

The bars in red are the traditional fuels. The bars in blue show renewable fuel (solar) and the green bars show the ECMs. 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 are 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.

This list of ECMs is not all inclusive but show 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.

NRCan verse BST Report Differences

Some typical measures are less effective and costlier than installing a slightly larger heat pump and/or more solar power.Consequently BST sometimes lists typical rejected measures.

In addition, NRCan now offers incentives for a number of measures that may not be the best economic option but the home owner 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. Such as;

Rejected ECMs	Rational
Insulate the Attic and Cathedral Ceilings.	These areas have adequate insulation, additional insulation causes higher cost per kWh than heat pump and solar, consequently it is rejected, and additional heat pump and solar power are recommended.
Ground Source Heat Pump (GSHP)	Initial costs for the well are expensive and the paybacks are long. ASHPs are recommended for this house.
Drain Water Heat Recovery (DWHR)	A Domestic Hot Water Heat Pump (HWHP) is recommended as opposed to multiple DWHR stacks. The payback and GHG reductions are better with (HWHPs).
Triple Glazed Windows	High initial value, low energy savings and relatively new windows preclude this measure.
HRV	Heat Recovery Ventilators have no or low net energy savings below 3 ACH (Air Changes an Hour). For economic reasons BST typically recommends sealing a house to 3 ACH but not lower without installing an HRV unless air quality or moisture issues are present.
Condensing Furnace	NG furnaces emit significant GHG emissions. These contribute to global warming. The reason for this report is to lower GHG emsisions.
Insulate Foundation	The foundation is already adequately insulated. Additional insulation was found to not be an economical measure. A slightly larger heat pump and additional solar panels are a better economic
Insulate Basement Floors	Very low energy conservation and significant costs produce long paybacks and poor economical value. A slightly larger heat pump and more solar panels are better value.

6. Suggested Plan to Move to Net Zero.

We have prepared the following plan to move this building to renewable energy and eventually to Net Zero. 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). Alternatively, it shows how much power would have to be produced by solar panels if the ECMs were not applied.

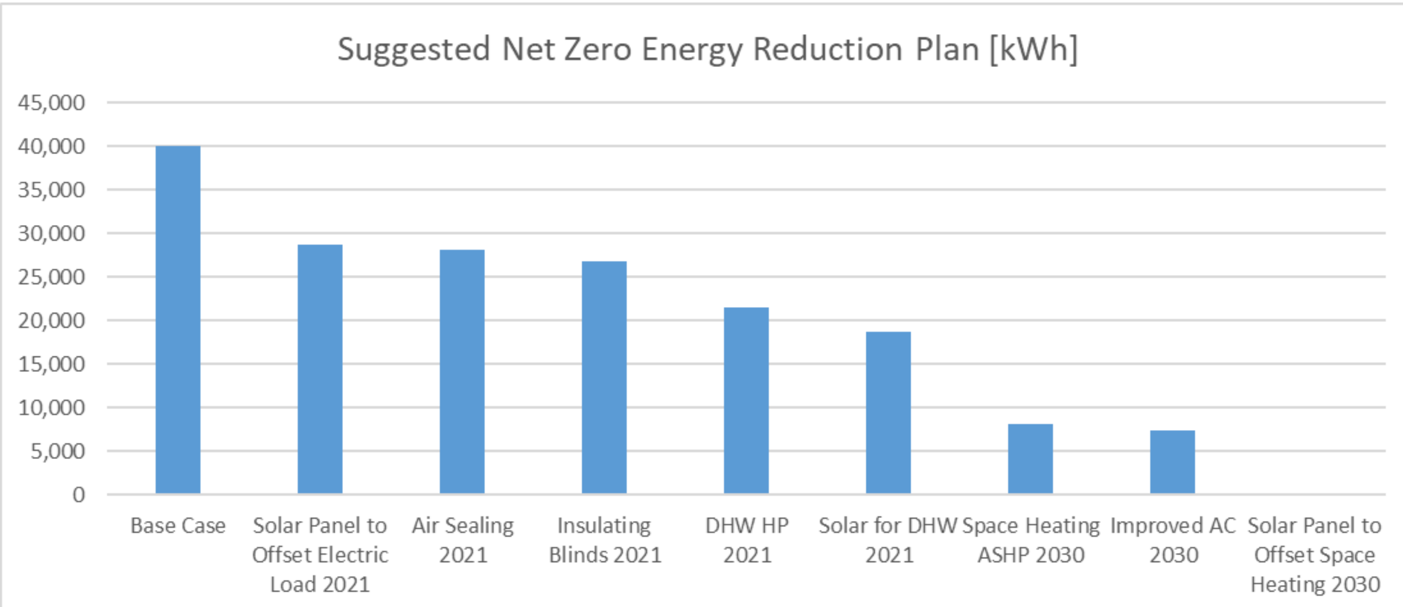


Figure 5- Plan to Move to Carbon Free

ECM Plan and Glossary

The executive summary lists the suggested ECMs and likely years of implementation to plan for the most economical way to move off fossil fuels.

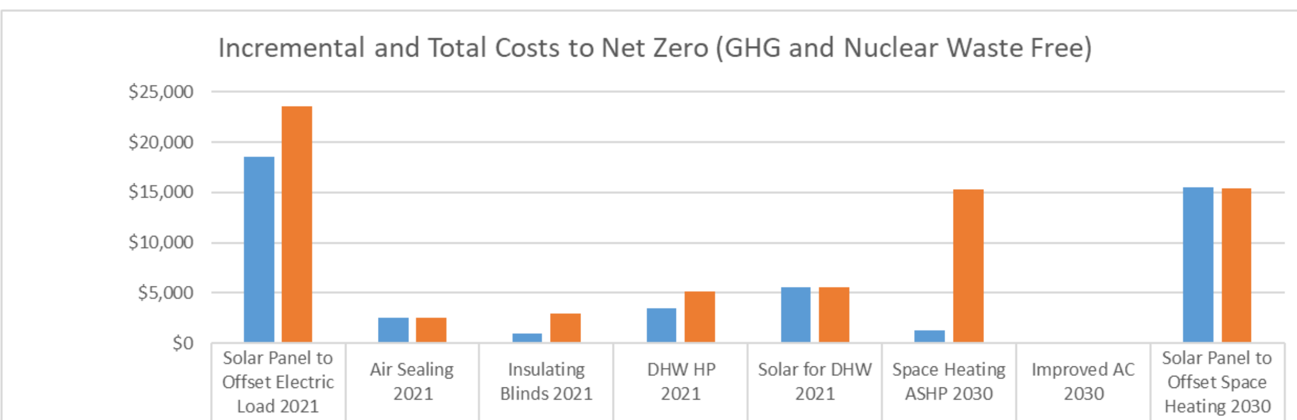
Notable Assumptions

- Additional structural studies or reinforcement are not included in any costs for roof mounted solar equipment.
- The local utility has adequate capacity to allow this house to generate net metered solar power. (BST has not checked with the local electric utility to determine if the utility will allow for additional solar production from the house).
- 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 local comfort issues.
- The report is based on the energy usages identified in the NRCan energy audit. A home owner'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 home owner confirm historical electricity usage when identifying It'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's or more history additional solar power be installed to ensure the home owner doesn't over-install the solar power capacity as the utility doesn't pay the home owner for an annual over production in Ontario.
- Duct upgrades are not required to provide increased airflows over the existing furnace airflows.

7. Energy Conservation First Approach

The following graph shows the accumulated costs and suggested investment year of each ECM and solar panel installation required to move the building to Net Zero. Net Zero eliminates both GHG and nuclear waste. Both the toal cost of the measure and the incremental cost of the measure are shown. The incremental cost assumes the appliance has to be replaced and the cost difference between the appliance and it's replacement minus any rebate are shown.

The following graph shows the individual incremental costs of each recommended ECM in the order it is recommended to proceed.



	Solar Panel to Offset Electric Load 2021	Air Sealing 2021	Insulating Blinds 2021	DHW HP 2021	Solar for DHW 2021	Space Heating ASHP 2030	Improved AC 2030	Solar Panel to Offset Space Heating 2030
Incremental Costs	$18,520	$2,500	$910	$3,450	$5,600	$1,260	$0	$15,450
Total Costs	$23,522	$2,500	$2,910	$5,150	$5,600	$15,245	$0	$15,446

Figure 6 - Individual ECM Costs

Notes

- Improved AC is a function of the better efficiency of the proposed heat pump so no additional costs above the proposed ASHP are associated with this measure.

The following graph shows the accumulated costs to move the house to Net Zero.

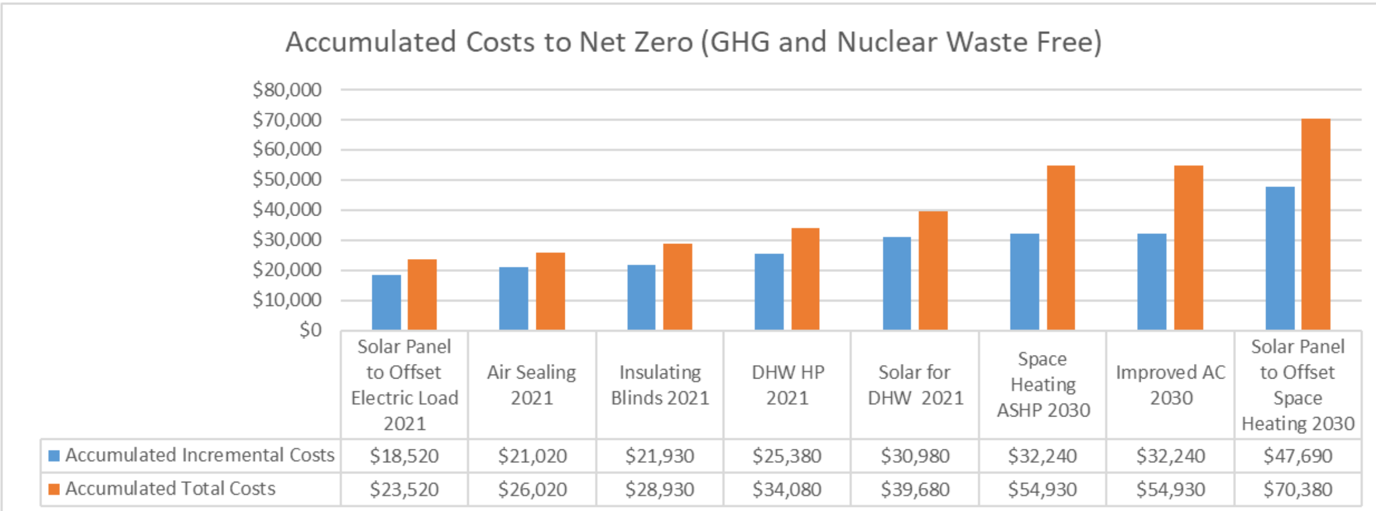


Figure 7- Accumulated Costs to Net Zero

Note BST has not confirmed that there is adequate roof area to generate the additional require energy to offset new electric demands from the recommended heat pumps. A request can be made a local solar power installer for confirmation.

8. Annual Utility Costs

The following charts identify the estimated annual fuel costs.

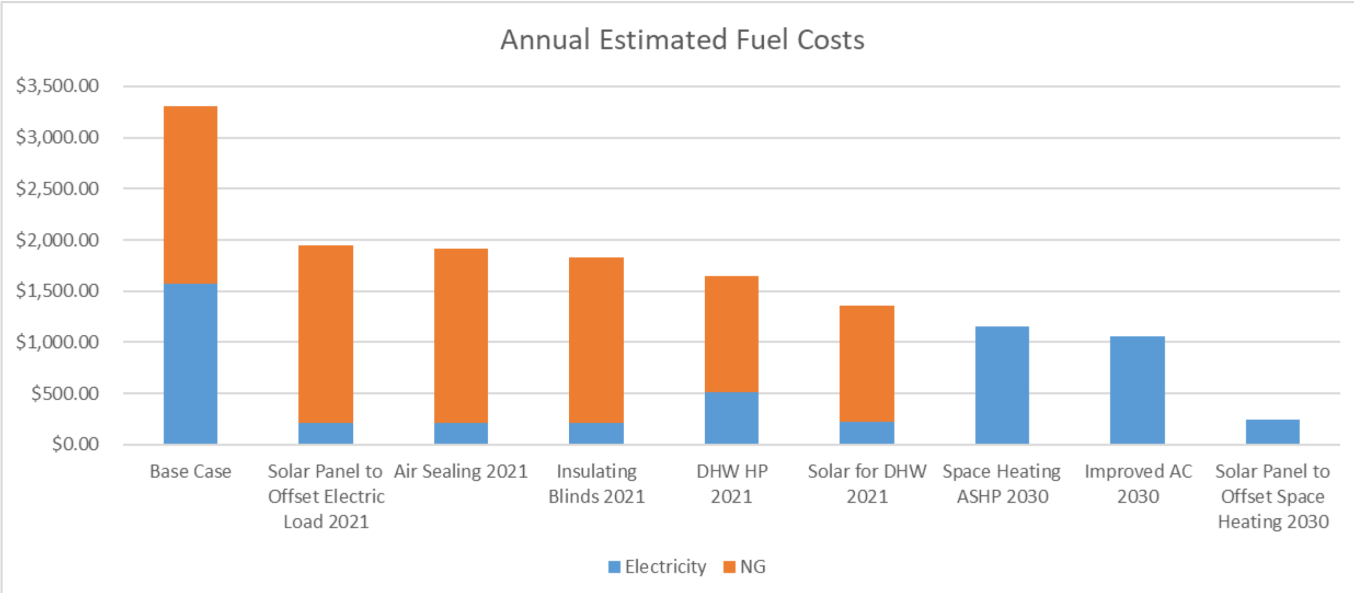


Figure 8- Annual Utility Costs

Note – Installation of the heat pumps (DHW and Space) may cause higher utility costs unless the additional electric loads are offset with net metered solar power. Not present in this house however the best value is to combine heat pumps with net metered solar power.

9. 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 eventual zero GHG emissions.

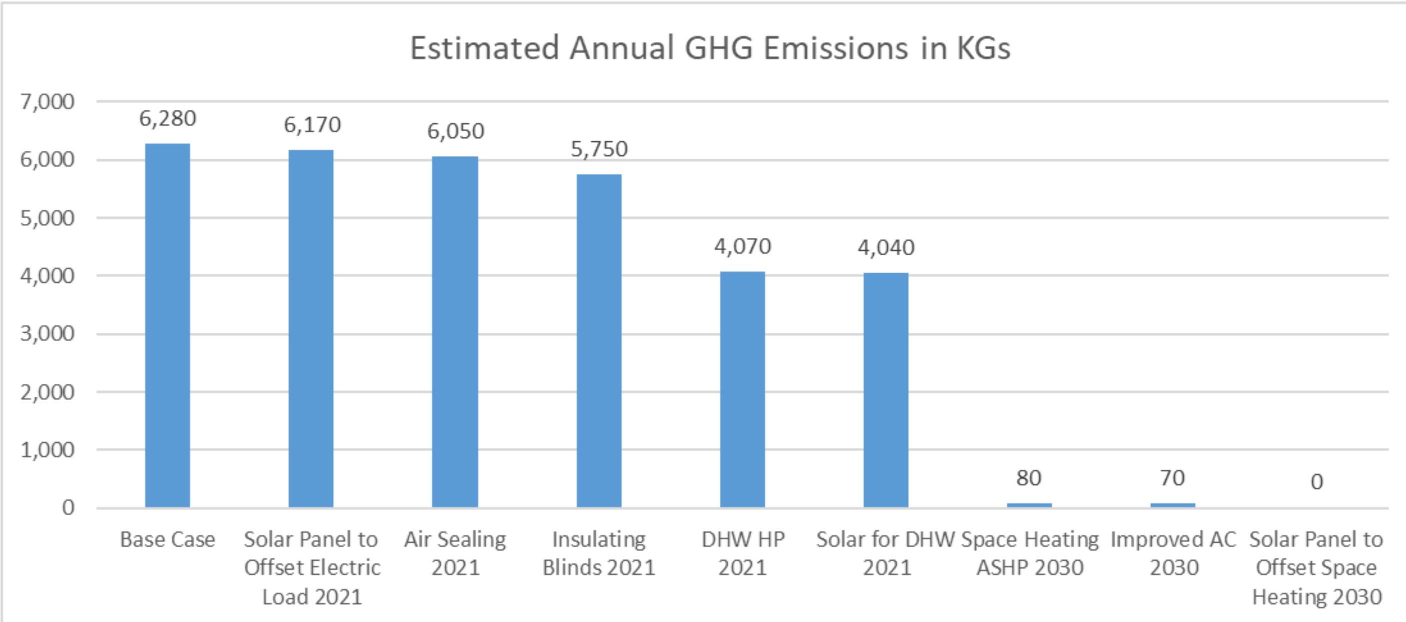


Figure 9 - Sustainability (lifetime GHG Reduction by ECM)

Note – The reductions in GHG emissions shown reflect only the reductions associated with the use of energy onsite. Higher reduction values may even occur as more GHG emissions are noted in the leakage of methane from natural gas in the delivery from the wells to the house or power plants.

The following graph shows the tons of GHG emissions for the next 75 years of the house's remaining life for 3 fuel options (natural gas, electricity and complete retrofit to solar produced energy).

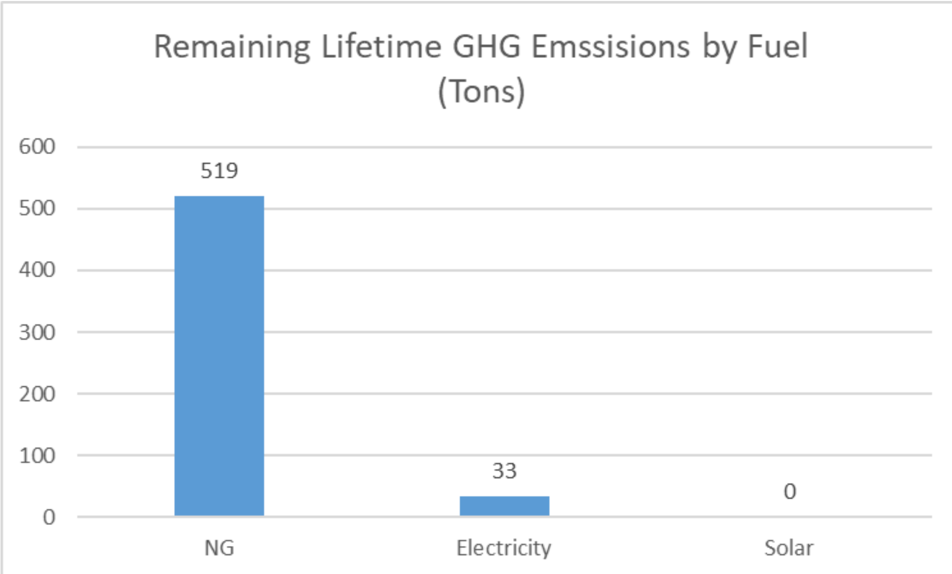


Figure 10 Lifetime GHG Production by Fuel

10. Financial Analysis, Sustainability Analysis and Summary

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

Measure Description	Fossil Fuel Component Cost	Renewable Energy Component Cost	Incremental Cost	Annual Savings	Payback Years	Component Life	Lifetime Net Savings
Solar Panel to Offset Electric Load 2021	$0	$23,522	$18,520	$1,360	13.6	30	$22,280
Air Sealing 2021	$0	$2,500	$2,500	$33	74.8	75	$7
Insulating Blinds 2021	$2,000	$2,910	$910	$85	10.7	15	$364
DHW HP 2021	$1,700	$5,150	$3,450	$181	19.0	15	-$731
Solar for DHW 2021	$0	$5,600	$5,600	$290	19.3	30	$3,100
Space Heating ASHP 2030	$13,985	$15,245	$1,260	$203	6.2	20	$2,798
Improved AC 2030	$0	$0	$0	$90	0.0	20	$1,800
Solar Panel to Offset Space Heating 2030	$0	$15,446	$15,450	$810	19.1	30	$8,850
Totals	$17,685	$70,373	$47,690	$3,053	15.6		

Figure 11 – Financial Summary by ECM

Measure Description	Energy Savings [GJ]	Fuel Type	Incremental Cost	Annual Emissions Reductions [kg eCO2]	Annual Emissions Reductions [Tons eCO2]	House Remaining Lifetime Emissions Reductions [Tons eCO2]
Solar Panel to Offset Electric Load 2021	40	Electricity	$ 18,520	110	0.1	9
Air Sealing 2021	2	NG	$ 2,500	120	0.1	10
Insulating Blinds 2021	5	NG	$ 910	300	0.3	25
DHW HP 2021	19	NG	$ 3,450	1,680	1.9	139
Solar for DHW 2021	10	Electricity	$ 5,600	30	0.0	2
Space Heating ASHP 2030	38	NG	$ 1,260	3,960	4.4	327
Improved AC 2030	3	Electricity	$ -	10	0.0	1
Solar Panel to Offset Space Heating 2030	26	Electricity	$ 15,450	70	0.1	6
Totals	144		$ 47,690	6,280	6.9	519

Figure 12- Sustainability Summary by ECM

Analysis

Measure Description	Recommendation and Rational
Introduction	Careful analysis of design and construction of this house and fuel selection show this house can be converted to non-GHG emitting renewable fuel (solar) with an economic benefit.
Solar Panel to Offset Electric Load	The conversion of the electricity to solar (Net Metered) has a good annual savings and makes a good annual and lifetime reduction in GHG for this house.
Air Sealing	Installation of better air sealing has a lifetime cost (i.e. very small annual savings and high upfront costs). Although not financially strategic to proceed with this recommendation, it has a measurable decrease in GHG and as the available roof area for solar panels is limited every saved kWh assists in reaching the net zero goal. We note that $2,500 was allocated for a contractor to seal the house but the home owner can do much of this sealing on their own for minimal costs (less than $200). This makes this measure much more attractive than indicated by the financial presentation and BST recommends the home owner perform the sealing as per the NRCan documents.
Insulating Blinds	Insulating Blinds can improve comfort and reduce energy requirements and GHG emissions. This is the case for the older blinds in this house. BST recommends that insulating blinds are not located in direct sunlight (as the heat generated may damage the window seals) and not in high humidity areas like the kitchen bathrooms with showers or poorly ventilated laundry rooms and the blinds be used at night and during unoccupied times of the day.
DHW HP	The energy conversion of the DHW from Natural gas to Solar/HP has a small annual cost above natural gas cost. However, the reduction in GHGs for this conversion is significant and as such is a recommended ECM. We note that the combination of switching the DHW heating from NG to HP and adding solar to offset the additional electricity cost is more competitive and recommend doing both simultaneously.
Solar for DHW	Adding solar power to offset the addition electric power when switching the NG DHW to Heat Pump powered heating, has a reasonable payback. We note that the combination of DHW HP and solar is more attractive than DHW HP alone.

Measure Description Continued	Recommendation and Rational
Space Heating ASHP	The energy conversion of the space heating from Natural gas to Solar/HP has a similar annual cost as natural gas cost. However, the reduction in GHGs for this conversion is significant and as such is a recommended ECM.
Improved AC	The existing older AC unit has a suspected lower energy efficiency than the proposed replacement unit. The increased energy efficiency results in a minor cost and GHG emissions reduction.
Solar Panel to Offset Space Heating	Adding solar power to offset the addition electric power when switching the NG furnace to Heat Pump powered heating, has a reasonable payback. We note that the combination of DHW HP and solar is more attractive than DHW HP alone.
End Statement	All ECMs combined result in a net positive annual and life savings.

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.

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 Here in Final Report

Daniel E. Vivian, P.Eng.