A Better Heating Energy Source;

Solar Electric Powered Heat Pump vs. Natural Gas

Ottawa Ontario

Prepared for:
Linkedin Friends and Associates

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1 Document Purpose

I posted these graphs on linkedin;

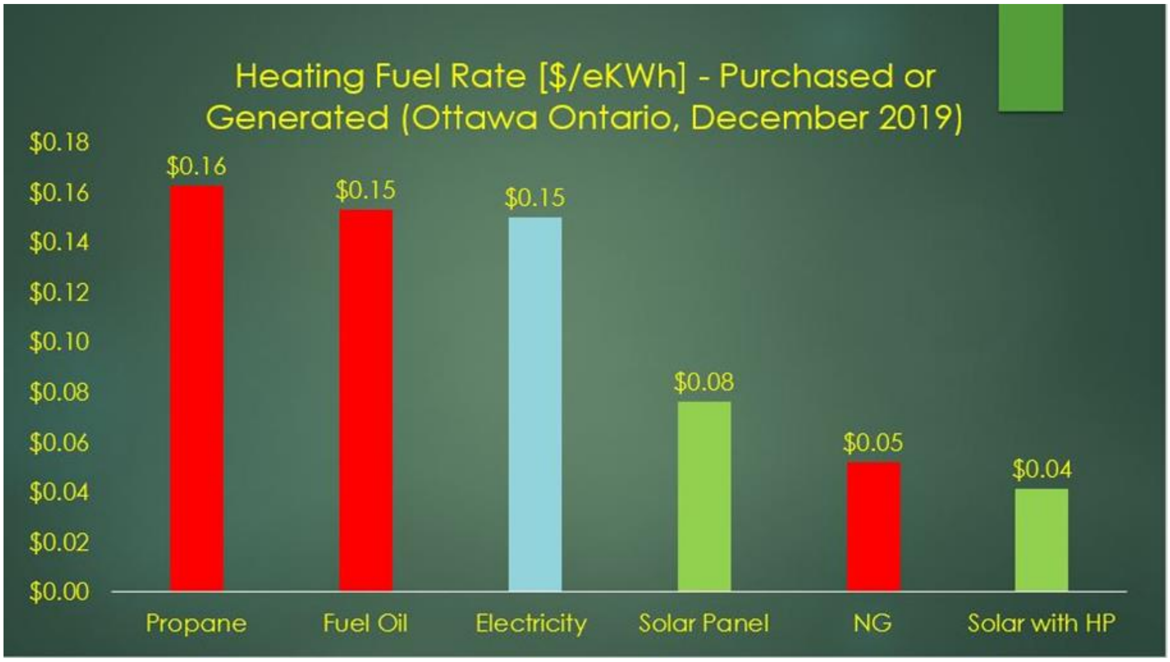


Figure 1- Heating Fuel Rates Purchased or Generated

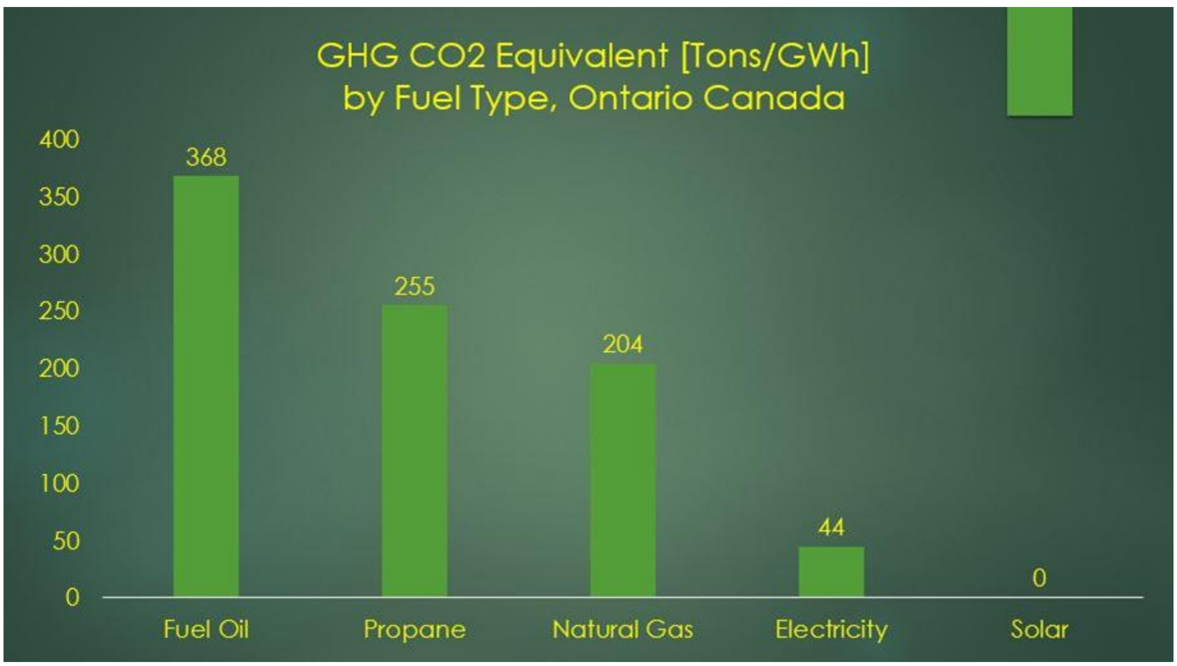


Figure 2- GHG CO2 Equivalent

The implications of these graphs are very significant, especially in this time of concern over climate change. The graphs clearly show that heat created by solar power combined with heat pump produced heat about the same cost or less expensive then heat created from natural gas and is orders of magnitudes less polluting then natural gas produced heat. As approximately 40% of energy consumed in the first world economies is consumed in buildings and a significant portion of that as heat, these implications are truly significant.

Not surprisingly I was challenged to produce the proof. The following document shows the calculations I used to produce the graph.

Good luck reading this, although important this isn't the most riveting document to read. If someone has the perseverance to read and confirm these calculations, I (and perhaps others too) would be happy to have you confirm them or add your improvements in the comments. Even better, if someone has experimental data that can confirm these results (i.e. you have a house heated by heat pumps and collects enough solar power to power these heat pumps). Please contact me at buildingsciencetrust@gmail.com;

I provide studies using this technique and others to move houses and larger buildings to Net Zero. I call it Net Zero Retrofit (NZR) planning. If interested in this service for your house or building, please visit my website at https://www.buildingsciencetrust.com/.

Daniel E. Vivian, P.Eng.

2 Introduction

2.1 Purpose

This document identifies the unit costs ($/kWh) and unit greenhouse gas emissions (g/kWh) of various common fuels used for heating in the Ottawa area to provide guidance for the selection of heating methods. Heating is the most significant energy requirement of buildings in Ottawa. Typically, it consumes about 75% energy consumed in conventionally constructed buildings.

The fuel cost rates ($/kWh) is dependent on the heating system used for the house being studied. For instance distributed room by room heating is possible but not popular and very expensive for fossil fuels (i.e. it is possible to have a fossil fuel heater (gas or oil supply and combustion gas exhaust) in each significant room like electric resistance baseboard heaters or heat pump heads in each significant room but this type of heating system are not financially feasible. In addition, perhaps the most common heating system for detached houses is forced air duct distributed heating. Consequently, this study assumes forced air duct distributed heating for the study house. The house size used for this study is approximately 2,000 ft2 and the house is a detached 2 story house with a basement in Ottawa Ontario. It is a very common suburban house. Here is a photo of the house studied.

Photo 1- Subject House

3 Limitations

3.1 Applicability to Other Buildings

The technique and results may be applicable for larger buildings. This study is for a 2,000 sqft detached house with a forced air furnace and an approximately 4-ton heat pump unit. Likely these results are applicable in larger houses or buildings (maybe even up to 10 tons). However, I would be careful in extrapolating these results with heat pumps significantly larger than 10 tons without confirming the calculations for larger heating loads.

3.2 Unit Costs

Unit costs vary by region because suppliers' costs vary across regions depending on local markets and difficulty to transport fuels to the local market, generation methods (in the case of electricity), taxes, etc. For instance, in Ottawa electricity typically is provided at about $.17/kWh while just across the river electricity rates in Gatineau is approximately $.09/kWh as the generation source in Quebec (hydro power) is much cheaper than Ontario's major generation source (nuclear power). The relative cost for solar power also varies across regions depending on the annual solar energy supply for a region (i.e. Western North America (but not coastal) typically has more sunny and clear days then the Eastern North America). The Ottawa region's annual solar energy is typical of many regions in Eastern North America.

3.3 GHG Emissions

The GHG unit emissions for the fossil fuels remains independent of location used but the GHG unit emission for electricity are very dependent on the generation methods of the local utility. For instance, Hydro Quebec generates electricity using 98% hydro power which dramatically lowers GHG emissions. Ontario Power Generation delivers power to Ottawa with about 15% fossil fuel supply.

4 Study Considerations

4.1 Unit Conversions

This document is necessary because fuel suppliers provide fuel costs in dissimilar units (fuel oil in litres and natural gas in cubic meters). The energy content of these fuel also varies by volume (fuel oil is approximately 139000 BTU/USGal and natural gas contains approximately 37 GJ/m3). A third factor, initial energy fuel conversion efficiency for the fossil fuel appliance is included. For instance, natural gas appliance efficiency can reach approximately 92% while a fuel oil appliance more commonly works at about 78% efficiency. Consequently, comparison of the energy unit rates isn't possible without unit and efficiency conversions.

4.2 Capital Costs

Capital costs of the fuel conversion appliance (furnace, solar panel, heat pump, electric element, etc.) is considered in this study. With fossil fuel appliances the cost of appliance over the delivered energy during the life of the appliance is relatively small in comparison to the delivered energy costs. In contrast with solar panels there is no energy cost (solar power is free) however the capital cost of the appliance (solar panels, voltage converter, wiring, installation labour, etc.) is much higher than the cost of fossil fuel appliances. Consequently, the cost of solar panels ($) divided the energy delivered over the life of the solar panels (kWh) is significant.

4.3 Life Considerations

Life of appliances are considered in this study. As mentioned, solar energy is free, however the capital cost of the solar power equipment is relatively high. In order to compare the solar power unit rate to a fossil fuel rate, the capital cost of a solar panel system ($) is divided by the energy produced by the solar power system over the life of the system kWh) to produce a solar panel energy unit rate. As you can imagine if the life of the appliance (solar panel for instance) is longer, the solar panel will deliver more energy (kWh) for every additional year it is in operation. The longer the life the lower the unit rate associated with the initial capital investment. Also, the relatively low cost of the fossil fuel appliance ($) divided by the energy delivered over the life of the appliance (kWh) is added to the delivered energy unit rate ($/kWh) to produce a total fossil fuel energy unit rate. The life of these appliances is estimated from the capital planning industry techniques.

4.4 Fixed Costs included in Fuel Rate

The fixed costs per house for natural gas and electricity (those primarily related metering and customer service) are included in the unit rate. If a house or building size is significantly different than the subject house the fixed costs may have a significant influence on the fuel rate. In this case the fixed costs are in the order of 10 to 25% of the utility bill.

4.5 Drop in Fuel Efficiency Neglected

Fuel efficiency drops over the life of the appliance (furnace, boiler solar panel, etc.). Fossil fuel appliances drop somewhat over their life (10 to 20 % is likely) due to fouling of heat exchangers, incomplete combustion due to burner or nozzle wear or fouling, etc. as do solar panel systems (caused by soiling of the panels, decreases in photovoltaic efficiencies with time, etc.). This drop in efficiency is not easy to quantify and fossil fuel appliances and solar panels efficiency drop relatively similarly over the life the appliances. Consequently, the drops in efficiency of the appliances have not been considered in this study. An improvement in this study might be to study these efficiency drops in more detail across numerous appliances in the various appliances and add those effects to the study.

4.6 Interest Rates for Capital Investment not Included

Interest rates for an investment in solar panels and or other equipment (heat pumps, furnaces etc) are not included. In effect the investment (heat pump, solar panel or natural gas furnace, etc.) is assumed to be financed 100% in cash by the house or building owner. A useful variation on this study could include financing capital costs.

4.7 Fossil Fuel Unit Rate Conversion

$/kWh is the unit that is used for the common fuel rate for each of the fuels. This unit is used since most households use utility supplied energy and house owners have a familiarity with this unit. Natural gas and electricity fuel costs are provided by reviewing local utility bills (anonymized and attached to this document). Propane costs were provided by a verbal quote from a local liquid propane fuel supplier and the fuel oil price is provided from the Natural Resources Canada (NRCan) list of fuel costs for Ottawa. The conversion of natural gas, propane and fuel oil into $/kWh includes the typical efficiencies of the furnaces used to produce the heat. Natural gas and propane efficiencies are provided at two levels (high efficiency condensing furnace rates of 92% and conventional efficiencies of 80%). The fuel oil efficiency is assumed to be 78%. If the reader has a different efficiency or local fuel rate(s) that they would like to study a request can be sent to buildingsciencetrust@gmail.com to provide a local study for a fee. Most districts will have similar results except for electrical costs in districts blessed with significant hydro resources, electricity may be so inexpensive a grid supplied electricity powered heat pump may be more economical then solar panels with similar emission results.

5 The calculations;

5.1 Common Fuel Rates

The following fuel rate costs were used for the study;

Fuel	Rate	Unit	Source
Propane	$0.859	/ L	Propane Quote by W.O. Stinson, Dec 30th, 2019
Enbridge	$0.427	/m3	Enbridge Bill for a bungalow in Ottawa
Hydro Ottawa	$0.145	/kWh	Electricity Bill for a 3-bedroom townhouse in Ottawa
Fuel Oil	$1.348	/ L	NRCan Website

Figure 3- Common Fuel Rates

The energy values of the fuels are converted to kWh as follows;

Propane	91330	Btu		Gallon		kWh	=	7.072	kWh
		US Gallon	3.785	L	3412	BTU			L

Natural Gas	1000	BTU	35.314	ft3		kWh	=	10.350	kWh
		ft3		m3	3412	BTU			m3

Fuel Oil	139000	Btu		Gallon		kWh	=	10.763	kWh
		US Gallon	3.785	L	3412	BTU			L

Combining the two tables gives;

Propane	0.859	$		L	=	0.121	$
		L	7.07194	kWh			kWh

Natural Gas	0.4267	$		m3	=	0.041	$
		m3	10.34994	kWh			kWh

Fuel Oil	1.348	$		L	=	0.125	$
		L	10.76316	kWh			kWh

Applying the typical efficiency of each common fossil fuel type to the above unit rates provides the fuel rates ($/kWh) as follows;

Fuel	92%	80%	78%
Propane	$0.132	$0.152	N/A
Natural Gas	$0.045	$0.052	N/A
Fuel Oil	N/A	N/A	$0.161

Figure 4- Equivalent Fossil Fuel Rates

5.2 Equivalent "Capital Rates"

These calculations have provided the equivalent costs of each fuel but neglect the capital costs of the furnaces and fuel supply (tanks and lines) in the case of propane and fuel oil. In addition, solar power has no fuel cost (sun power is free) but the capital cost of the solar panel, converters, wiring, etc. has a cost. These also have a life (approximately 25 years) and a total amount of energy (kWh) produced over that life.

5.3 Solar Power "Rate"

A local "utility" Ottawa Renewable Energy Co-op (OREC) provides the cost of equipment that produces solar power energy produced as $1.90/kWh per year or over a 25-year life. This produces a solar power rate of $0.076/kWh. This figure was compared to values provided by a local solar panel supplier and are similar.

5.4 Combined Solar and Heat Pump "Rate"

Heat pumps in Ottawa produce a Seasonal Co-efficient of Performance (SCOP) of about 2.25 when expressed in unitless dimension (i.e. kWh heat produced for the house/kWh of electricity consumed, this is not the standard SCOP of the heat pump alone but one that includes the entire house demand). This SCOP if applied to a solar "fuel rate" would indicate a solar power combined with Heat pump rate of $0.034/kWh. However, this neglects the cost of the heat pump, electric resistance coils for the extreme cold back up heat and furnace to provide the heated air to the distribution ducting. So, these capital costs must be summed and distributed over the life of the energy (kWh) that would be required over the life of the heat pump.

A house in Ottawa was analysed to provide the energy required over the life of the heat pump. This house has 3 bedrooms, a semi-finished basement with poor insulation and is approximately 2,000 sqft.

It's annual heating energy requirement is 36,900 kWh (133 GJ). The house has an old central air conditioner that must be replaced. In this case only the incremental cost of the heat pump improvement over the central air conditioner is required to be accounted (an alternative where an AC unit is not available is shown with all other capital cost contributions later). The heat pump equipment requirements are as follows;

Furnace	$3,500
Electric Coil	$1,500
Heat Pump Coil	$2,000
AC Upgrade to Heat Pump	$2,500
	======
Total	$9,500

Figure 5- Capital Cost "Rate" for Various Systems.

A house heated by a heat pump (operating at a SCOP of 2.25) will reduce the annual energy consumption to 16,400 kWh. If powered by solar panel the solar panel cost would be $31,160 (16,400 kWh per year x $1.90/kWh per year). Summed together the solar panel and heat pump costs are $40,660 ($9,500+$31,160). This combination avoids the 36,900 kWh per year for 25 years (i.e. 922,500 kWh), that would have been required to be provided to the house. It results in an equivalent energy rate of $ $0.044/kWh (i.e. $40,660/922,500 kWh).

Similar calculations are available for all the fuel types as follows;

Capital Costs	Installed Furnace	Tank and Lines	Burner	Electrical Coil	Heat Pump Coil	Heat Pump Upgrade	Solar Panels	Total	Capital Cost [$/kWh]
Propane	$3,500	$5,000	$2,000					$10,500	$0.011
NG	$3,500		$2,000					$5,500	$0.006
Fuel Oil	$3,500	$5,000	$2,000					$10,500	$0.011
Electric Furnace	$3,500			$1,500				$5,000	$0.005
Heat Pump	$3,500			$1,500	$2,000	$2,500		$9,500	$0.010
Solar	$3,500			$1,500			$70,110	$75,110	$0.081
HP on Solar w A/C	$3,500			$1,500	$2,000	$2,500	$31,160	$40,660	$0.044
HP on Solar w/o A/C	$3,500			$1,500	$2,000	$5,000	$31,160	$43,160	$0.047

Figure 6- Heat Pump Upgrade Costs

And finally combining the equivalent fuel rate and capital costs provides the following chart and graph;

Fuel	CoP	Rate	Capital	Combined
Fuel Oil	78%	$0.161	$0.006	$0.167
Propane, Conv.	80%	$0.152	$0.011	$0.163
Electricity	100%	$0.145	$0.005	$0.150
Propane, H.E.	92%	$0.132	$0.011	$0.143
Elec & HP	225%	$0.072	$0.010	$0.083
Solar	N/A	$0.000	$0.081	$0.081
Natural Gas, Conv.	80%	$0.052	$0.006	$0.058
Natural Gas, H.E.	92%	$0.045	$0.006	$0.051
HP/Solar w/o A/C	N/A	$0.000	$0.047	$0.047
HP/Solar w A/C	N/A	$0.000	$0.044	$0.044

Figure 7- Combined Fuel and Capital Rate

And graphing these values results in;

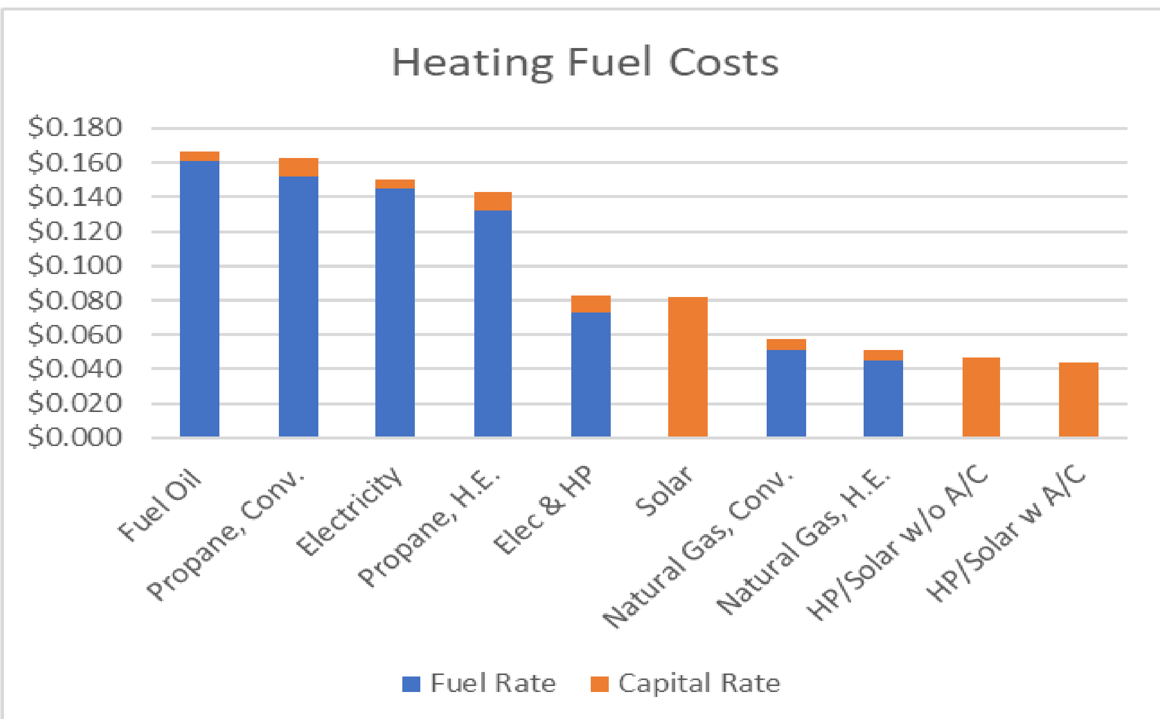


Figure 8- Heating Fuel Costs

These results are the same (with some additional efficiency options) as the fuels rates identified in figure 1. This forms the support calculations for the first graph identified in figure 1.

No effort has been made to discuss error due to ranges of values. The above figures provided are finite, however note that small variations due to local price changes, efficiencies, etc. will cause these rates to vary within a small range.

Also note that there are essentially 3 ranges of fuel rates. Fuel oil, propane and electric resistance heating are essentially the same rates. Electricity on heat pumps and solar with electric resistance heating is in essential the same rate and finally the solar panel and heat pump combination rate is in the same range as the natural gas rate which is significantly lower than the first two groups. Implications are the solar/heat pump "fuel" is financially competitive with natural gas and in locations without natural gas supply (rural areas) the solar/heat pump "fuel" is significantly less than fuel oil, propane or electric resistance heating. Clearly rural customers who are supplied by fuel oil, electricity or propane should investigate a change in fuel.

Next the analysis of the carbon emissions by fuel should clearly identify the solar/heat pump "fuel" as an overall superior fuel choice and will also confirm the calculations shown in figure 2.

5.5 Equivalent CO2 Emissions by Fuel

Fossil fuels when combusted produce carbon dioxide (CO2), water (H2O) and other minor combustion products. CO2 is a Greenhouse Gas (GHG). The other minor combustion products can also create GHGs. The strength of GHG contribution for the other minor GHGs varies by mass depending on the chemistry of the GHG. The other minor GHGs can be expressed as a factor of CO2. These factors can be summed together to give one an equivalent CO2 GHG number (e CO2 number).

GHGs are known to cause climate change in the earth's atmosphere which are causing significant issues like;

- More violent and intense storms (extra energy);
- Mass extinctions (Sudden Climate Changes too quick for Wildlife);
- Melting of the polar ice caps;
- Global sea level rises, flooding of low-lying Pacific Islands and Coastal Cities (Venice Miami);
- Droughts (Central America, Syria, North Africa);
- Environmental Mass Emigrations and
- War (contributing factor to war in Syria)

Various fuels create various concentrations of e CO_2. These values are listed by Environment Canada in their common units of sale as follows;

Fuel	Natural Units	GHG emission factors g/unit			
		CO_2	CH_4	N20	CO_2 equivalent
Natural Gas	m3	1,891	0.037	0.035	1,903
Light Fuel Oil [1]	L	2,725	0.026	0.031	2,735
Heavy Fuel Oil [2]	L	3,124	0.057	0.064	3,145
Propane	L	1,510	0.024	0.108	1,544
Diesel [3]	L	2,663	0.133	0.4	2,790
Kerosene [4]	L	2,534	0.026	0.031	2,544
Jet Fuel [5]	L	2,534	0.026	0.031	2,544

Figure 9 - GHG Emission Factors

The common heating fuels used in Ottawa are natural gas, fuel oil (light fuel oil [1]) and propane.

Energy values vary for different fuels as described in previous sections. These are summarized below;

Propane	7.072	kWh
		L
Natural Gas	10.350	kWh
		m3
Fuel Oil	10.763	kWh
		L

Figure 10 - Common Fuel Energy

In addition, there are typical efficiencies for furnaces that combust natural gas, fuel oil and propane. For the gaseous fuels (natural gas and propane) there are two types of combustions that have two levels of associated efficiencies. The combustion types are high efficiency and conventional efficiency. The high efficiency type is commonly used in newer furnaces and are typically chosen for replacement furnaces purchased today. The following chart identifies the typical efficiencies used for this study.

CoP	
Natural Gas, H.E.	92%
Natural Gas, Conv.	80%
Fuel Oil	78%
Propane, H.E.	92%
Propane, Conv.	80%

Figure 11- Typical Furnace Efficiency Values

As with any machine efficiency the actual efficiency is dependent on the machine design, construction and level of wear. The efficiencies chosen for these fuels and combustion types are reasonable rates.

Combing these values provides an emission rate for a kWh of heat consumed in a house by fuel and furnace efficiency.

Natural Gas, H.E.	1903.000	g CO2		m3		=	199.9	g CO2
		m3	10.35	kWh	0.92			kWh
Natural Gas, Conv.	1903.000	g CO2		m3		=	229.8	g CO2
		m3	10.35	kWh	0.80			kWh
Fuel Oil	2790.000	g CO2		L		=	332.3	g CO2
		L	10.76	kWh	0.78			kWh
Propane, H.E.	1544.000	g CO2		L		=	237.3	g CO2
		L	7.07	kWh	0.92			kWh
Propane, Conv.	1544.000	g CO2		L		=	272.9	g CO2
		L	7.07	kWh	0.8			kWh

Converted to tons of e CO2 pollution per GWh gives the following;

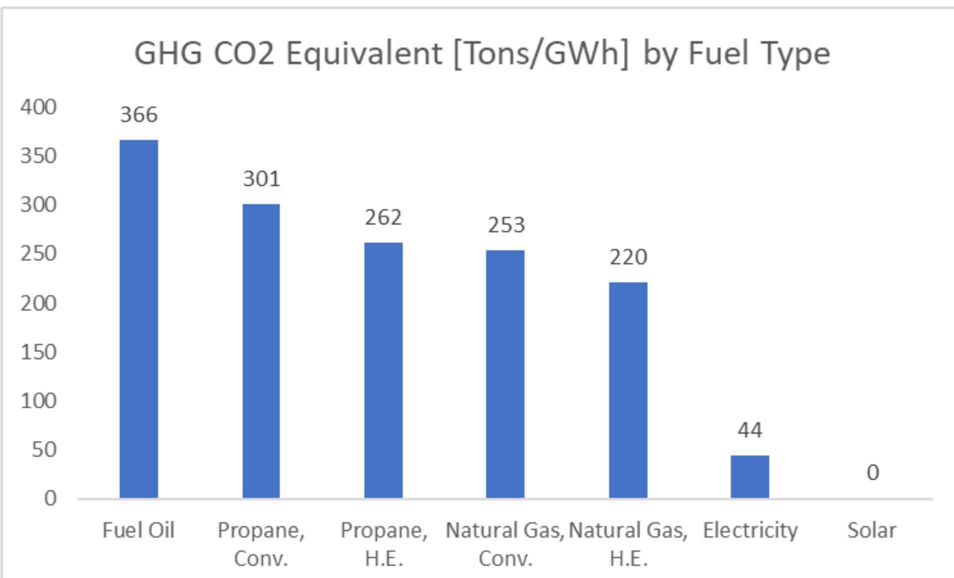


Figure 12- CO2 Equivalents by Fuel Type

Figure 12 is essentially the same figure as shown in Figure 2 with additional conventional propane and natural gas furnace emissions. This forms the support calculations for the first graph identified in figure 2.

Also, these figures shown in figure 12 can be shown in the more relatable data of tons of CO2 produced for the remaining life of the house. Consider that the house illustrated in this example is about 25 years old and it likely has at least 75 years of remaining life. The NRCan Hot2000 model prepared for this house predicts that it will use 36,900 kWh per year or in 75 years the house will consume about 2.768 GWh of heating energy.

The total emissions that would be produced by using various fuels over the next 75 years would be;

Fuel	Life Energy Req'd		Emission Rate		=	Total Pollution	
Fuel Oil	2.7675	GWh	366.3	Ton CO2 per	=	1014	Tons
Propane, Conv.	2.7675	GWh	300.8	Ton CO2 per	=	833	Tons
Propane, H.E.	2.7675	GWh	261.6	Ton CO2 per	=	724	Tons
Natural Gas, Conv.	2.7675	GWh	253.3	Ton CO2 per	=	701	Tons
Natural Gas, H.E.	2.7675	GWh	220.3	Ton CO2 per	=	610	Tons
Electricity	2.7675	GWh	44.09	Ton CO2 per	=	122	Tons
Heat Pump	2.7675	GWh	19.6	Ton CO2 per	=	54	Tons
Solar	2.7675	GWh	0	Ton CO2 per	=	0	Tons

Figure 13- Remaining Life Household Emissions

Plotting these creates the following graph;

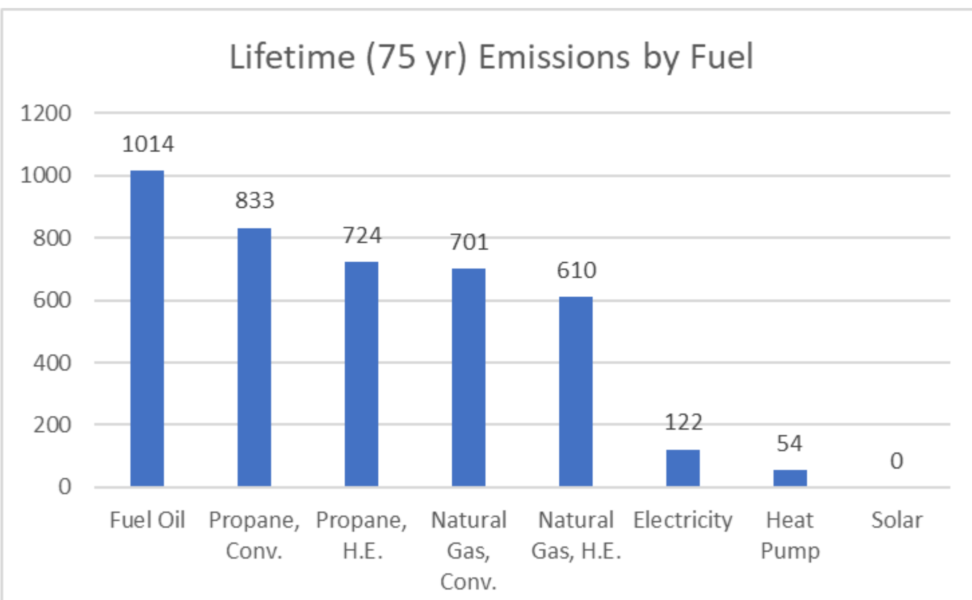


Figure 14 - 75 Year Emissions Summary by Fuel and Efficiency

These are surprisingly large numbers.

6 Conclusions

Solar Power and heat pump provided heating energy is essentially the same cost or less then natural gas but produces orders of magnitude less GHG pollution then fossil fuel provided heating for forced air heated houses.

Although not specifically studied similar results may be found for larger buildings.

7 Qualifications

7.1 Limiting Conditions

Building Science Trust and Daniel E. Vivian makes no representations regarding the sufficiency for the reader's purposes of the procedures described in this report. The reader must verify the calculations in this report for their own conditions. Engineer's Certification

Pretium certifies that the information contained in this report is accurate and complete in accordance to the terms of our engagement. All information contained herein is based on visual observations made during the on-site assessment and conclusions are based on our best engineering judgment and on our experience with similar buildings.

8 Signature

The figures and calculations shown in this report are true to the circumstances described in this report and every effort has been made to verify their accuracy.

Yours very truly,

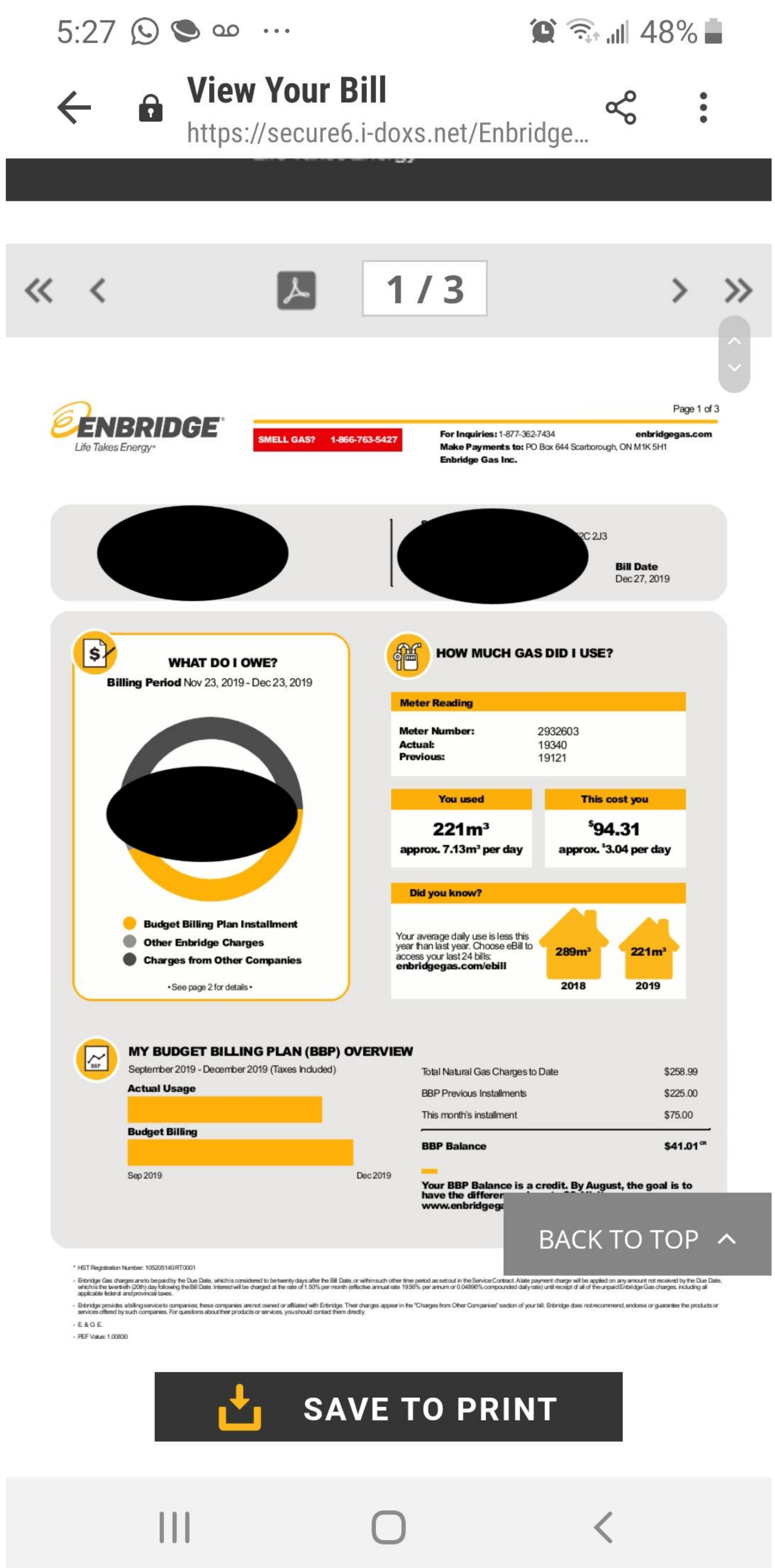
The Building Science Trust Inc.

Daniel E. Vivian

Principal

For more information or if you're interested in a study for your building
contact me at this email address buildingsciencetrust@gmail.com

Appendix A
Enbridge Sample Invoice



5:27 48%

View Your Bill
https://secure6.i-doxs.net/Enbridge...

1 / 3

ENBRIDGE
Life Takes Energy

SMELL GAS? 1-866-763-5427

Page 1 of 3

For Inquiries: 1-877-362-7434 **enbridgegas.com**
Make Payments to: PO Box 644 Scarborough, ON M1K 5H1
Enbridge Gas Inc.

[redacted]

[redacted] 2C 2J3

Bill Date
Dec 27, 2019

WHAT DO I OWE?
Billing Period Nov 23, 2019 - Dec 23, 2019

[redacted]

Budget Billing Plan Installment
Other Enbridge Charges
Charges from Other Companies

• See page 2 for details •

HOW MUCH GAS DID I USE?

Meter Reading

Meter Number:	2932603
Actual:	19340
Previous:	19121

You used	This cost you
221m³ approx. 7.13m³ per day	**$94.31** approx. $3.04 per day

Did you know?
Your average daily use is less this year than last year. Choose eBill to access your last 24 bills: **enbridgegas.com/ebill**

289m³ 2018
221m³ 2019

MY BUDGET BILLING PLAN (BBP) OVERVIEW
September 2019 - December 2019 (Taxes Included)

Actual Usage
Budget Billing
Sep 2019 Dec 2019

Total Natural Gas Charges to Date	$258.99
BBP Previous Installments	$225.00
This month's installment	$75.00
BBP Balance	**$41.01 CR**

Your BBP Balance is a credit. By August, the goal is to have the differen
www.enbridgega

BACK TO TOP

* HST Registration Number: 105205140RT0001
- Enbridge Gas charges are to be paid by the Due Date, which is considered to be twenty days after the Bill Date, or within such other time period as set out in the Service Contract. A late payment charge will be applied on any amount not received by the Due Date, which is the twentieth (20th) day following the Bill Date. Interest will be charged at the rate of 1.50% per month (effective annual rate 19.56% per annum or 0.04896% compounded daily rate) until receipt of all of the unpaid Enbridge Gas charges, including all applicable federal and provincial taxes.
- Enbridge provides a billing service to companies; these companies are not owned or affiliated with Enbridge. Their charges appear in the "Charges from Other Companies" section of your bill. Enbridge does not recommend, endorse or guarantee the products or services offered by such companies. For questions about their products or services, you should contact them directly.
- E. & O. E.
- PEF Value: 1.00830

SAVE TO PRINT

Appendix B

Hydro Ottawa Sample Invoice

HydroOttawa
hydroottawa.com
Questions/Questions : 613-738-6400
Power Outage/Panne d'électricité : 613-738-0188

Service For • Service pour	
Account Number • Numéro de compte	
Meter Number • Numéro de compteur	
Meter Reading (current) Relevé de compteur (actuel)	69211.30
Meter Reading (previous) Relevé de compteur (précédent)	68486.38
kWh Consumption Consommation en kWh	724.93

Account Summary • Sommaire de compte

Page 1 of/de 2

Previous Balance/Solde précédent		$374.70	CR
Payment/Paiement	2019-11-15	$150.00	CR
Electricity Charge TOU/Frais d'électricité FHC			
From/Du 2019-10-15 To/Au 2019-10-31 (16 Days/Jours)			
Off-peak/Période creuse 227.861376 kWh @ $0.065000/kWh		$14.81	
Mid-peak/Période médiane 47.026139 kWh @ $0.094000/kWh		$4.42	
On-peak/Période de pointe 17.216814 kWh @ $0.134000/kWh		$2.31	
Electricity Charge TOU/Frais d'électricité FHC			
From/Du 2019-10-31 To/Au 2019-11-14 (14 Days/Jours)			
Off-peak/Période creuse 322.635831 kWh @ $0.101000/kWh		$32.59	
Mid-peak/Période médiane 46.516423 kWh @ $0.144000/kWh		$6.70	
On-peak/Période de pointe 63.671416 kWh @ $0.208000/kWh		$13.24	
From/Du 2019-10-15 To/Au 2019-10-31 (16 Days/Jours)			
Delivery/Frais de livraison		$18.93	
Regulatory Charges/Frais réglementés		$1.31	
From/Du 2019-10-31 To/Au 2019-11-14 (14 Days/Jours)			
Delivery/Frais de livraison		$20.73	
Regulatory Charges/Frais réglementés		$1.86	
HST No. 863391363 RT0001/No. TVH 863391363 RT0001		$15.20	
8% Provincial Rebate/Rabais provincial de 8 %		$3.34	CR
Ontario Electricity Rebate/ Remise de l'Ontario pour l'électricité		$23.88	CR

Bill Date Date de la facture	2019-11-28	Due Date Date d'échéance	2019-12-17	Credit Balance Solde créditeur	**$419.82 CR**

For your information • Autres renseignements

On November 1, 2019, electricity rates changed for Regulated Price Plan (RPP) customers. Most residential customers are on the RPP. The winter rate period is now in effect. Details about rates and other charges are available at hydroottawa.com/rates.

La grille tarifaire réglementée, à laquelle sont assujettis la plupart des clients résidentiels, a changé le 1er novembre 2019. Les tarifs d'hiver sont maintenant en vigueur. Renseignements sur les tarifs et autres frais à hydroottawa.com/tarifs.

SAVE TREES. HELP CHEO. Online billing is good for the planet and for our community. Register before Dec. 31 and we'll donate $5 to help purchase medical equipment for CHEO. hydroottawa.com/gopaperless

SAUVEZ DES ARBRES. AIDEZ LE CHEO. La facture en ligne, c'est bon pour la Terre et la collectivité. Inscrivez-vous d'ici le 31 déc. et nous verserons 5 $ pour aider le CHEO à acheter de l'équipement médical. hydroottawa.com/adieupapier

Additional information on reverse. Please retain this portion. • Information supplémentaire au verso. Prière de conserver cette partie. E & OE

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hydroottawa.com

Service For • Service pour	
Account Number • Numéro de compte	
Due Date Date d'échéance	2019-12-17
Credit Balance Solde créditeur	**$419.82 CR**

Late payments will be charged 1.50% interest per month.
Les paiements en retard portent d'intérêt au taux mensuel de 1,50 %.

Appendix C
NRCan Fuel Oil Quote

Weekly Average Retail Prices for Furnace Oil in 2019

(Cents per litre)

NOTE: Prices include taxes

	Week Ending	Price
2019-12-24		134.8

NOTE: Monthly prices for gasoline, diesel and furnace oil are calculated by averaging price data available by fı
However, monthly prices for propane and natural gas are calculated by averaging weekly price data (Tuesday
As a result, for propane and natural gas, this calculation is an imperfect representation of monthly prices and