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Municipal Energy Plan

Bonfield Township Municipal Energy Plan

The Township wishes to acknowledge that this Plan was prepared with project funding support provided by the Government of Ontario.

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1.0 Executive Summary

Bonfield is taking action towards understanding its energy use and greenhouse gas emissions, identifying the available opportunities for energy efficiency and emissions reduction in the community, and setting a plan to achieve a clean energy future. Bonfield is aware of the need to reduce dependence on fossil fuels, thereby reducing GHG emissions and helping to prevent climate change. Bonfield Township has not yet set specific goals or a timetable to reduce GHG emissions; a key reason for this Municipal Energy Plan (MEP) is to determine what is possible in a small, rural township.

Bonfield is a rural community with approximately 2,000 inhabitants, approximately 1,100 homes and 35 commercial buildings (including 5 buildings owned and operated by the Township). With limited industrial and commercial activity, the primary energy consumers of energy are heating buildings (including hot water supply) and vehicles. The majority of the buildings in Bonfield are heated with propane or fuel oil, with a smaller number heated with electricity. It is assumed that wood is also used as a heating fuel, but no evidence was found that this was a significant contributor to the heating fuel mix. Both the population level and number of homes have been relatively stable for at least the past two decades and are expected to remain relatively unchanged for the foreseeable future.

Electricity consumption in buildings for general uses (i.e., other than heating such as: lights, electronics, electric motors, air conditioning) also consumes substantial amounts of energy, but contributes only a small amount to GHG emissions because grid electricity in Ontario is clean, with a low carbon content. Table 1 lists the estimated energy consumption from various activities in Bonfield, during the year 2019.

Table 1: Bonfield Aggregate Annual Energy Consumption for 2019 (MWh)

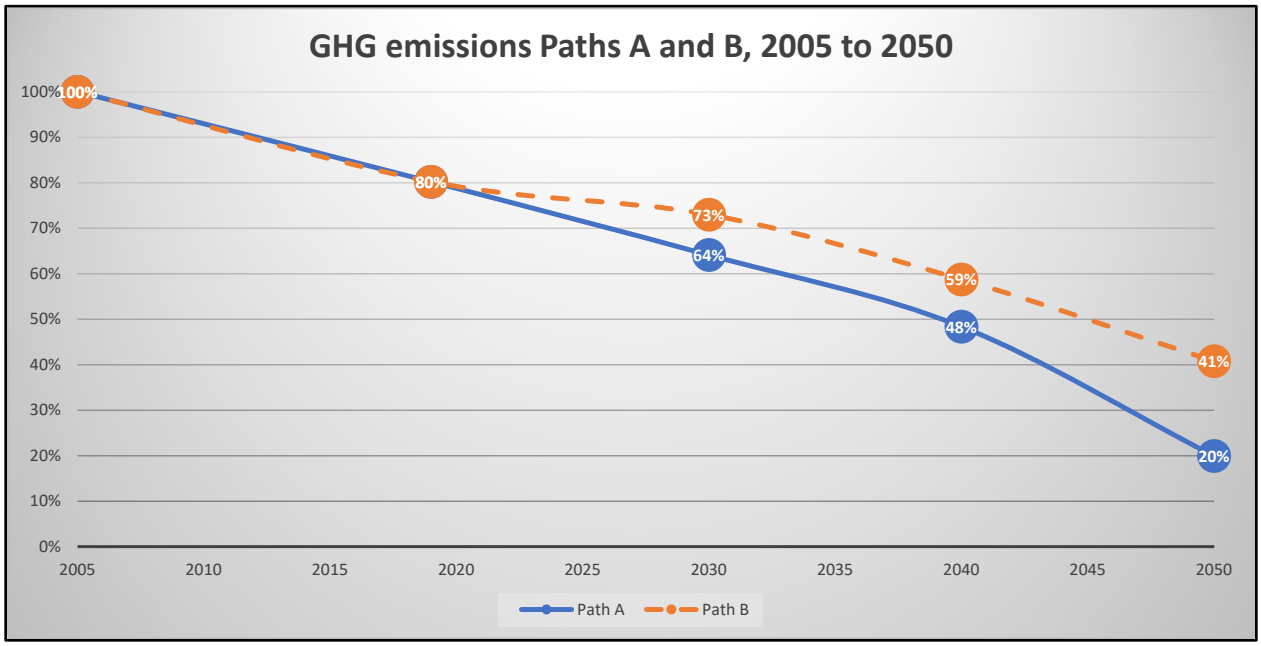
Energy Use Category	Annual (MWh)	Percentage
Energy for building heating, residential buildings	23,000	25.6%
Energy for building heating, commercial buildings	2,000	2.2%
General electricity consumption, all buildings	12,000	13.4%
Energy consumption of private vehicles	50,000	55.7%
Energy consumption of school buses	2,000	2.2%
Energy consumption of municipal vehicle fleet	800	0.9%
Total Township energy consumption	**89,800**	**100.0%**

As can be readily seen from the table, the largest energy consumers in Bonfield are privately-owned vehicles and homes; thus, these are the two areas that must be most strongly addressed within this Plan. This Plan acknowledges that the most reliable path to reducing greenhouse gas emissions is to electricity both building heating and vehicles. With Ontario grid electricity already relatively clean, with firm plans to further lower its carbon content, electrification offers a path to a clean energy future for Bonfield.

The intent of the MEP is to identify a pathway for the reduction of energy consumption and GHG emissions in the community. This report proposes two pathways for energy and GHG reduction in Bonfield, shown in Figure 1. Pathway A aligns with the Paris Accord and the federal

government's commitment to reduce GHG emissions by 80% from 2005 through 2050. Pathway B is less aggressive but still substantial, achieving a 59% reduction over the same period. Bonfield must choose which pathway they wish to adopt.

Figure 1 - Bonfield GHG Emission Pathways A & B



The reductions in GHG emissions presented in Figure 1, are estimated based on the measures and assumptions discussed in this study.

Minimizing the dependence on fossil fuel in heating the buildings in the Township would be the biggest emission reducing measure that can be implemented on the buildings. This is done by replacing the fossil fuel furnaces with air source heat pumps which can reduce the buildings emissions by more than 60%. The energy retrofit of the building envelope for the community can reduce in the energy required for heating by almost 10%. The municipality can accelerate and encourage the uptake of energy retrofit by home and building owners by maximizing the potential benefits and reducing financial burden on the owners. This can be performed through two important strategies: supporting the community's workforce and builders with training and awareness of the emission reduction measures and offers of low-interest financing or programs that can reduce the cost and complications of financing energy retrofit for homeowners.

The other sector that consumes the big portion of energy is the transportation, With the technological advancements and market growth in electric vehicles, it is expected that viability (cost, range, etc.) of electric vehicles will results in increasing uptake. The municipality, in alignment with the national plan of switch to electric vehicles in the near future, could also support the community residents in educational initiatives, low-interest loans or other incentives for switching to electric vehicles.

Bonfield's municipal energy plan evaluates the pathway to significantly reduce GHG emissions by 2050, using 2005 as the base year. This is discussed along with the measures that need to be

performed; many of these measure need to be planned for and initiated presently, so that they can build up the necessary momentum to reach the anticipated target.

The target of this MEP is achievable with the collaboration and education of the community of the methods to reduce the GHG emissions. The municipality can have a great role in the education and in the policy actions that can be set to accelerate the uptake of the energy retrofits in buildings and in electrifying the vehicles in the community.

This report presents two specific pathways to achieve GHG reductions, each pathway with its own specific set of changes and results. It should be noted that there are a myriad of possible pathways to reduce GHG emissions. If the Township is less successful in one area than shown in this report, this can be balanced by being more aggressive in other areas. For example, if fewer homes are converted to heat pumps, this shortfall could be made up by a higher rate of conversion to electric vehicles. Thus, while the two Pathways in this report were carefully selected as plausible, economical and successful, it can be expected that the final achievement of GHG reductions by 2050 will vary somewhat from the precise paths described in this report.

2.0 Background of the Municipal Energy Plan (MEP)

Climate change is a global crisis that had become a growing threat to our earth in recent years. Canada is collaborating with international efforts to support clean energy pathways, setting climate action plan targets, and investing in research and technology development and policies to improve national carbon reduction strategies. Since the Paris agreement in 2016, Canada has committed to GHG emission reduction targets of 30% by 2030, from 2005 levels, and 80% by 2050. Ontario has set similar, but slightly more aggressive reduction targets of 37% by 2030 and 80% by 2050. These targets are aggressive, and will require coordinated, persistent action by all levels of government, and indeed by all Canadians. Details of the national commitments can be found in the Pan-Canadian Framework on Clean Growth and Climate Change, which lays out a pathway to fight climate change and improve economic growth.[2]

Bonfield is working to establish a pathway for the community to transition to a lower carbon future that meets the federal climate change goals. Understanding the energy consumption and the greenhouse emissions in the Township is the cornerstone to identifying strategies to meet those targets. This report analyses the strategies and methodologies that will support reaching the target of energy and GHG emissions reductions for 2050 relative to 2005. The Municipal Energy Plan will consider two pathways: A and B. Pathway A has the target of reducing GHG emissions of the Township by 80% from the emission levels of 2005 by the year 2050. Pathway B has a less aggressive, and thus more readily achievable, target. These two pathways are intended as guidance for the Township, as clear illustrations of what is required to help Canada achieve our overall goal. Either target will require planning and early investment to be met.

The municipal government and the residents of Bonfield are cognizant of the importance of seeking a more sustainable future with regard to energy use and greenhouse gas (GHG) emissions. Transitioning the community into a lower carbon future involves increasing energy efficiency, reducing the use of fossil fuels in favour of electricity, and producing electricity from clean renewable energy resources.

This MEP's value lies in helping the community better understand opportunities available to reduce energy consumption and GHG emissions. By identifying strategies that are most appropriate for the Bonfield community, this plan can focus both the people and the government of the Township into efforts that will bear fruit in the effort the end to threat of climate change. The MEP fills an indispensable role in defining essential pathways to a low carbon economy and green energy investment. The MEP encompasses both short-term and long-term investment programs, policies, and regulations that culminate in the transition to a low carbon future. The MEP provides guidance on the methodologies to increase clean energy production, reduce GHG emissions, and improve environmental quality in the Township. This report describes how the Bonfield community can do its part toward meeting federal and international climate change targets.

2.1 Exclusions

This report addresses the greenhouse gas (GHG) emissions related to energy consumption in the Township. This report excludes emissions related to non-residents' vehicles driving to or through the Township; however, it does include all mileage of residents' vehicles, whether that driving occurs inside or beyond the Township borders.

This report does not consider emissions from non-energy-related sources such as landfills, or from livestock or agricultural activities (or wastes); such emissions result from chemical processes that depend on operational factors and material inputs/outputs other than energy production or consumption, and tabulation thereof is beyond the scope of this report. Nor does this report address the topic of the carbon that is embodied in materials or structures.

2.2 Bonfield 2019 Energy Consumption and GHG Emissions

Energy consumption in Bonfield Township is dominated by two categories: buildings (heating and electricity) and transportation (vehicle fuel). The energy consumption and GHG emissions for the Township were estimated for the baseline year of 2019 – the most recent year not affected by the temporary changes in energy consumption patterns caused by the pandemic. The building sector includes energy consumed both from fossil fuel combustion and electricity in commercial and residential buildings; the summary is presented in Table 2. Note that there are no significant industrial buildings in Bonfield. The vehicle sector includes personal vehicles, school buses the vehicles owned or leased by the Township. Note that for the included vehicles, all fuel consumption is included, whether or not the vehicle was within the Township or not. Conversely, vehicles that are not based in Bonfield are excluded, including the many vehicles that pass through Bonfield Township on Highway 17.

Table 2: Annual Energy Consumption and GHG emissions (2019)

Sector	Annual Energy Consumption (MWh)	Annual GHG Emissions (tCO2e)	Annual GHG Emissions (%)
General Electricity, all buildings (excl. heat)	12,000	300	1.6%
Heating Fuel, residential buildings	23,000	4,800	26.4%
Heating Fuel, commercial buildings	2,000	400	2.2%
Heating Fuel, municipal buildings	300	60	0.3%
Subtotal: Building Energy	**37,000**	**5,500**	**30.2%**

Fuel, personal vehicles	50,000	11,800	64.9%
Fuel, school buses	2,000	700	3.8%
Fuel, municipal fleet vehicles	800	200	1.1%
Subtotal: Transportation Fuel	**52,800**	**12,700**	**69.8%**
Bonfield Grand Total (2019)	***89,800***	***18,200***	***100%***

The buildings of Bonfield consume 41% of the aggregate energy consumption while transportation consumes 59%. When it comes to GHG emissions, the share from buildings decreases to 30.2%, while that from vehicles increases to 69.8%. This shift is primarily due to the fact that a substantial portion of energy consumed in buildings in 2019 was from low-GHG electricity, whereas electric vehicles had a negligible presence in 2019. The electricity consumption in Bonfield is imported from the Ontario grid. There is no current electricity production in the Township.

2.3 Bonfield 2005 ("Baseline") Energy Consumption and GHG Emissions

The baseline energy consumption and GHG emissions for the Township were estimated for the year 2019, a pre-COVID year. However, GHG emissions reduction targets are almost universally referenced to 2005, to align with the Paris Agreement and Canada's National Determined Contribution. The Paris Agreement is a legally binding international treaty on climate change; it was adopted by 196 Parties – including Canada – at the 21st Conference of Parties in Paris, on December 12, 2015, and entered into force on November 4, 2016.

As Bonfield did not have estimates of 2005 GHG emissions, the 2019 data was used to "back cast" estimates of energy consumption and GHG emissions. To do this, the following modifications were made to the 2019 data.

- In 2019 the distribution of building heating systems in houses and commercial buildings was 70% propane, 20% fuel oil and 10% electric resistance. In 2005 the assumed distribution was 20% propane, 70% fuel oil and 10% electric resistance. (That is, during the 14-year period it was assumed that half of the homes and commercial buildings in the Township had converted from fuel oil to propane as a heating fuel).
- In 2019 the distribution of building heating systems in the municipal buildings was 0% propane, 90% fuel oil and 10% electric resistance. In 2005 the distribution was 70% propane, 20% fuel oil and 10% electric resistance.
- Furnace efficiencies were assumed to have improved between 2005 and 2019. For propane furnaces, the average efficiency improved from 80% to 95%.
- Because of recent (~2018) envelope upgrades to some of the municipal buildings, these buildings were assumed to consume more energy in 2005 than in 2018.
- The GHG content of Ontario grid electricity decreased dramatically from 0.230 kg CO_2e/kWh in 2005 to 0.024 kg CO_2e/kWh in 2019.

In addition to the above changes, we note that a number of things were assumed to remain unchanged between 2005 and 2019.

- The population (~2,000) and number of houses (1,122) were assumed to be unchanged between 2005 and 2019.
- The number of vehicles, and kilometers driven, in the three groups (personal, school buses and Township) were assumed to be unchanged between 2005 and 2019.

- The fuel mix of all vehicles remained unchanged from 2005 to 2019. That is all vehicles were assumed to use gasoline or diesel, with negligible contribution from electric vehicles.

Based on these assumptions, there has already been a 20% decrease in Bonfield's GHG emissions from energy use between 2005 and 2019, substantial progress toward the general Canadian (and international) goal of achieving a 40% reduction from 2005 levels by 2030, an interim goal that is essential to keeping Canada in compliance with The Paris Agreement.

Table 3: Annual Energy Consumption and GHG emissions (2005)

Sector	Annual Energy Consumption (MWh)	Annual GHG Emissions (tCO2e)	Annual GHG Emissions (%)
General Electricity, all buildings (excl. heat)	12,257	2,819	12.4%
Heating Fuel, residential buildings	26,036	6,468	28.4%
Heating Fuel, commercial buildings	1,866	464	2.0%
Heating Fuel, municipal buildings	928	240	1.1%
Subtotal: Building Energy	**41,087**	**9,991**	**43.9%**
Fuel, personal vehicles	49,896	12,004	52.9%
Fuel, school buses	2,124	533	2.3%
Fuel, municipal fleet vehicles	2,946	205	0.9%
Subtotal: Transportation Fuel	**54,966**	**12,742**	**56.1%**
Bonfield Grand Total (2005)	***96,053***	***22,733***	***100%***

Because both the population and number of houses have been stable for more than 20 years, future GHG reduction targets assume no changes to population, no changes to their driving habits, nor any changes to the number of houses or other buildings through 2050.

2.4 Coordination with Other Plans

This MEP has been prepared in the context of other existing plans and documents. Key among these are:

- **Township of Bonfield Official Plan** (April 2013, and currently under review): The Official Plan provides guidance for the physical development within the Township. Specifically, it provides guidance on land use and development. During the round of review and updating that is currently underway, the Plan will be reviewed to ensure that it encourages the development of renewable energy facilities, small or large, by ensuring that they are permitted, and that there are no undue restrictions placed on them.

- **Township of Bonfield Zoning By-Law 2012-29** (May 2013, and currently under review): The Zoning By-Law is an essential companion to the Official Plan, with the Zoning By-Law including the detailed regulation of land use. While the MEP does not introduce any whole new types of land use, it does encourage the more widespread use of some newer facilities, such as ground-source heat pumps, ground-mount solar power systems, wind turbines, and electric vehicle chargers. As the Zoning By-Law is currently under review,

one step in the review is to ensure that these types of facilities are permitted in as many Zones as possible.

- **Township Asset Management Plan** (2017): The primary purpose of this document is to maximize benefits, control risks, and provide a basis to assist in ensuring a provision of a satisfactory level of service to the community ***in a sustainable manner***. The MEP contains specific goals for Township-owned buildings and vehicles which are in accord with the Asset Management Plan, and indeed provide additional detail on how and when these assets are to be converted to lower GHG emission energy technology in a fiscally responsible manner. It is the intention of the Township to incorporate the targets for the gradual conversion to low-GHG technologies directly into the Asset Management Plan, during its next revision.

- **Growth Plan for Northern Ontario** (June 2019): This Ontario Government plan is a 25-year plan for northern Ontario that sets priorities for economic growth and infrastructure investment in Northern Ontario. The most pertinent sections of this document include sections 5.3 (Transportation) and 5.6 (Energy). This MEP is in accord with the Growth Plan for Northern Ontario (GPNO) in several significant respects:

    - Section 5.1 of the GPNO calls for the promotion of renewable energy; the MEP sets specific targets for renewable electricity generation in Bonfield (presumably solar) and for the use of electric heat pumps.
    - Section 5.2.5 (f) of the GPNO calls for the reduction of emissions from transportation; the MEP encourages early conversion to electric vehicles (or other zero-emission vehicles) and identifies specific vehicles as more viable for early conversion.
    - Section 5.6 of the GPNO calls for the need for energy reductions; the MEP sets specific targets for reduced energy consumption, primarily in buildings.
    - Section 5.6.2 of the GPNO calls for the operators of the northern Ontario electric grid to accommodate renewable energy generation; the MEP sets specific targets for solar (or wind) electricity generation in Bonfield.
    - Section 6.6.3 of the GPNO calls for local distribution companies to seek opportunities to increase the efficiency of electricity consumption; the MEP lists specific objectives for reducing electricity use in buildings and identifies specific technologies that can lead to these increases in efficiency.

2.5 Stakeholder Engagement in Developing the MEP

The Township of Bonfield developed a Climate Change Adaptation Plan in 2021. The process of development of the Climate Change Adaptation Plan was initialized with a survey to the residence of Bonfield to determine the maturity level of Climate Change knowledge and to identify the priorities that the Township would engage in. The Climate Change Adaptation Plan was the initiating factor to produce a Municipal Energy Plan to further understand how the municipality can provide GHG reduction targets, by first understanding the status of GHG emissions, and to provide benchmark key point indicators to ensure that through the processes of education, energy efficient planning across the organization, gain buy in from the residents of Bonfield.

The outcome of the survey helped to narrow the climate change adaptation plan to practical suggestions to produce a pragmatic series of actions. In this sense, this climate change

adaptation plan is more focused on feasible actions that can be accomplished within the timeline of producing this climate change adaptation plan rather than recommending actions to be taken in the future, including the Municipal Energy Plan.

During the development of the Municipal Energy Plan, another survey of residents was undertaken, to understand the energy use within the Township. This survey collected data regarding types of vehicles driven by residents, heating systems and fuels in homes, types of windows in homes and other parameters that helped to draw a more detailed picture of how energy is currently used in Bonfield.

In addition to the survey of residents, operators of several energy supply (home heating oil, propane) were interviewed. They supplied information on the number of clients they served in Bonfield and, in some cases, some aggregate sales volumes, to assist in developing the baseline energy consumption In Township homes.

A newsletter was issued at Christmas (2021) and sent to all the Community which discussed the MEP that it would analyze historical energy usage within the Township and then develop a practical and viable plan to reduce energy consumption, and related GHG emissions, of the Township and the community.

3.0 GHG Emissions Reduction Pathways A and B

To better explore how Bonfield can reduce GHG emissions and energy consumption, two pathways were identified with estimates of how GHG emissions are impacted between 2005 and 2050. Both pathways consist of a collection of similar measures (e.g. increased use of electric vehicles, increased use of heat pumps for heating), differing primarily in intensity. Pathway A is targets an 80% GHG emission reduction by 2050, the target set out in the Paris Agreement, and formally adopted by Canada. Pathway B is proposed as a less aggressive path, and therefore can be achieved more readily, but still results in a 59% reduction in GHG emissions by 2050.

3.1 Energy consumption categories

Energy consumption in Bonfield can be grouped into two major sectors: buildings and transportation. To discuss the measures proposed for each pathway, it is essential to break down energy consumption into more detailed categories. These categories can have independent measures implemented to reduce energy consumption and/or GHG emissions. We have defined eight categories, each of which is separately addressed in the following sections, along with forecasts of how they may change through 2050. Seven of the categories, related to energy consumption in buildings and vehicles, are included in the preceding table on energy characteristics in 2005 and 2019; the eighth category is renewable electricity generation, for which we consider solar generation (although wind would be equally applicable, if the same amount of clean electricity is generated annually).

3.1.1 General Electricity, all buildings

The general electricity category includes electricity use for non-heating purposes (e.g. lights, appliances, electronics, other plug loads) in all building types: residential, municipal, and commercial. In addition to electricity consumed in

buildings, this category includes a very small amount (less than 1%) for street lighting and other outdoor loads not associated with a specific building.

Changes in the amount of electricity consumed for this category could result from changes in the quantity of loads or changes in the efficiency of loads. GHG emissions can be affected by those factors, plus changes in the GHG content of electricity. Predictions of future electricity consumption for general purposes are uncertain. In recent history many electrical loads have become more efficient (e.g. computers, TVs, microwaves, refrigerators, lighting), but at the same time the number of electric loads has tended to increase (e.g. number of TVs, computers and other communications electronics), with some new types of loads being added into the mix (e.g. electronic air filtration units, WIFI equipment, an increasing range of small kitchen appliances). Because of these opposite trends and the lack of clarity in future trends, the amount of electricity consumed in this sector is assumed to remain unchanged from 2019 through 2050.

The GHG content of grid electricity in Ontario has been decreasing and is forecast to continue decreasing, achieving a reduction of 93.5% from 2005 to 2050. Calculations in this report rely on the forecast values from the federal department Environment and Climate Change Canada, which are summarized in Table 4.

Table 4: Historical and Forecast GHG Content of Ontario Electricity

Year	GHG Content (kg of CO_2e/kWh)
2005	0.2277
2019	0.0242
2030	0.0164
2040	0.0147
2050	0.0149

It is worth noting that in 2019 the GHG emissions attributed to the general electricity category in all buildings amounted to only 1.6% of Bonfield's total emissions associated with energy use.

3.1.2 Heating fuel and furnace efficiencies, residential buildings

The energy required to heat buildings is one of the largest contributors of the Township's GHG emissions, accounting for 26.4% of GHG emissions in 2019, with the vast majority of the energy consumed in residences.

The largest projected change for home heating in the Township is a shift among the energy source sources. In 2019 the percentage of the homes heated by propane, oil and electric resistance (baseboard) was found to be 70%, 20% and 10%, respectively. These proportional represent a gradual shift from oil to propane during the preceding years. In 2005 the percentage of the homes heated by propane, oil and electric resistance was assumed to be 20%, 70% and 10%, respectively. Thus, it was assumed that 50% of all homes in the Township switched from oil to propane heat between 2005 and 2019.

Also, between 2005 and 2019 it was assumed that the average efficiency of oil furnaces increased from 70% to 80%, and the average efficiency of propane furnaces increased from 80% to 95%.

Energy consumption is also affected by the quality of the building envelope (air tightness, insulation, thermal bridging) and presence or absence of energy recovery on ventilation air, as they affect the amount of heat required each year. It was assumed that there were no changes to these parameters between 2005 and 2019.

We do note that natural gas heating is rare in the Township, due to a lack of availability.

3.1.3 Heating Fuel, commercial buildings

There are relatively few commercial buildings in the Township, and they are small, with their heating accounting for only 2.2% of Bonfield's GHG emissions in 2019. It was assumed the past, current and future mix of heating equipment in the commercial buildings (fuel, type, efficiency) paralleled that in residential buildings, as described in the preceding section.

3.1.4 Heating Fuel, municipal buildings

At 1.1%, the 2019 share of the Township's GHG emissions from heating municipal buildings was even smaller than commercial buildings. This is partly due to the small number of buildings, but also partly due to the fact that, in 2019, 70% of their heat requirement was met by propane, due to an aggressive approach to switching from higher GHG fuel oil since 2017.

3.1.5 Fuel, personal vehicles

In 2019 it is estimated that fully 64.9% of the Township's energy related GHG emissions were from driving personal, light duty vehicles. In alignment with Canada's stated objective of moving virtually all light-duty vehicles to electric by 2050, it was assumed that the percentage of kilometers driven by electric vehicles will increase from virtually 0% in 2019 to 25%, 50% and 80% in 2030, 2040 and 2050, respectively. This will have the effect of reducing GHG emissions from these vehicles by 54% from 2005 levels by 2050.

Because emissions from personal vehicles are currently the single largest contributor to GHG emissions, this sector warrants particular attention. Even greater reductions are possible, if the switch to zero-emission, light-duty vehicles goes beyond the value of 80% assumed in this report. (For example, if 100% of personal vehicles are converted to electric by 2050, rather than the 80% assumed in Pathway A, this would reduce total Township emissions by an additional 5.5%, thus achieving an 85.5% reduction.)

Based on the past and predicted stable population of Bonfield, it was assumed that the number of kilometers driven by these vehicles would also remain stable from 2005 to 2050.

3.1.6 Fuel, school buses

The school buses are a dedicated fleet of vehicles that operate in consistent patterns; this type of operation is more conducive to electrification than the highly varied usage of private vehicles. Thus, while the GHG emissions from school buses in 2019 was a relatively small 3.8% of Township emissions, it is estimated that this will decrease more quickly than private vehicles, with the percentage of kilometers driven decreasing by 25%, 50% and 100% by 2030, 2040 and 2050, respectively. Currently the school buses are owned and operated by only two companies, which permits rapid change with the cooperation of relatively few parties.

It was assumed that there were no changes in GHG emissions from 2005 to 2019, and that the total kilometers driven by school buses would remain stable from 2005 through to 2050.

3.1.7 Fuel, municipal fleet vehicles

The municipal fleet of vehicles was assumed to follow the same pattern of electrification as the school buses (with no change in total distance driven), achieving full electrification by 2050.

3.1.8 Renewable electricity generation

As of 2019, there was no significant renewable electricity generation systems operating in Bonfield. It is anticipated that this will grow steadily until approximately 14 MW-DC of PV systems are installed by 2050. This is nominally divided into a total of 1.8 MW-DC of rooftop PV (equivalent to 20% of all homes, with an average of 8 kW each) and 12 MW-DC of utility scale PV, which is a common size for a solar farm in Ontario. It is also possible that a single utility-scale system of approximately 14 MW-DC (10 MW-AC) could meet this target on its own.

While solar is the more likely renewable energy to be developed within the Township, the same net effect on GHG emissions could be achieved by the development of approximately 10 MW-AC of wind turbines.

3.2 Pathway A & B common starting points

In both Pathways A and B, the GHG emissions between 2005 and 2019 are the same, using the 2019 GHG emissions data. Working from this data, the analysis in this section estimates, the energy consumption and GHG emissions for each category, for every ten years until 2050.

3.3 Pathway A: Assumptions

Pathway A estimates the GHG emissions for each category between 2005 and 2050, achieving an 80% reduction in total GHG emissions by 2050.

Table 5 shows the assumed changes to achieve Pathway A through to 2050. The assumptions are related to the energy efficiency measures suggested, renewable energy generation, equipment efficiency and heating fuel type.

Note that the coefficient of performance (COP) is a measure of how efficiently energy input into heating pumps is converted into heat energy, i.e. the higher the value, the more energy efficient the unit is. Air source heat pumps are able to achieve COPs of greater than 2.0, while ground source heat pumps can achieve COPs in excess of 4.0. For simplicity in the table, we have shown heat pump COP (the proper term) as an efficiency; that is a COP of 2.2 is shown as 220%. In comparison, fossil fuel equipment such as propane and fuel oil furnaces or boilers are limited to efficiencies below 100%, while electric resistance heating is 100% efficient because all input electricity is converted to heat.

Table 5: List of Assumptions for Pathway A

	Parameter Description (Pathway A)	2005	2019	2030	2040	2050
1	Average efficiency of propane furnace	80%	95%	95%	95%	95%
2	Average efficiency of fuel oil furnace	70%	80%	80%	80%	NA
3	Average efficiency of air source heat pumps	NA	NA	NA	220%	220%
4	Percentage of fuel oil space heating (residential & commercial)	70%	20%	10%	5%	0%
5	Percentage of propane heating (residential & commercial)	20%	70%	77%	79%	40%
6	Percentage of electric baseboard heating (residential & commercial)	10%	10%	10%	10%	5%
7	Percentage of air source heat pumps (residential & commercial)	0%	0%	0%	0%	45%
8	Percentage of wood furnaces (residential)	0%	0%	3%	6%	10%
9	Percentage of fuel oil space heating (municipal)	90%	20%	0%	0%	0%
10	Percentage of propane heating (municipal)	0%	70%	90%	90%	0%
11	Percentage of electric baseboard heating (municipal)	10%	10%	10%	10%	0%
12	Percentage of air source heat pumps (municipal)	0%	0%	0%	0%	100%
13	Percentage of energy reduction from envelope upgrade (res. & comm.)	0%	0%	2%	5%	10%
14	Percentage of energy optimization from envelope upgrade (municipal)	0%	0%	0%	0%	0%
15	Percentage of kilometers driven by electric vehicles (private)	0%	0%	25%	50%	80%
16	Percentage of kilometers driven by electric vehicles (municipal fleet)	0%	0%	25%	60%	100%
17	Percentage of kilometers driven by electric vehicles (school buses)	0%	0%	25%	60%	100%
18	Percentage of buildings with PV production	0%	0%	5%	10%	20%
19	Utility-scale PV system capacity	0 MW	0 MW	0 MW	0 MW	12 MW
20	Electricity GHG emissions factor (kg CO2e/kWh)	0.2300	0.0242	0.0164	0.0147	0.0143

Pathway B: Assumptions

Pathway B estimates the energy consumption and GHG emissions from each category from 2005 to 2050, achieving a total reduction of 59% in 2050. Key assumptions to reach that target are summarized in Table 6.

Note that, in Table 6, all of the values that are identical in both Pathway A and Pathway B are in light gray cells; thus the only items that differ between the two pathways are in white cells. Because the first two columns are historical (2005 and 2019) all parameters in these two columns are identical in both pathways, and thus are shown in gray.

Table 6: List of Assumptions for Pathway B

	Parameter Description (Pathway B)	2005	2019	2030	2040	2050
1	Average efficiency of propane furnace	80%	95%	95%	95%	95%
2	Average efficiency of fuel oil furnace	70%	80%	80%	80%	NA
3	Average efficiency of air source heat pumps	NA	NA	NA	220%	220%
4	Percentage of fuel oil space heating (residential & commercial)	70%	20%	20%	20%	5%
5	Percentage of propane heating (residential & commercial)	20%	70%	70%	70%	63%
6	Percentage of electric baseboard heating (residential & commercial)	10%	10%	10%	10%	10%
7	Percentage of air source heat pumps (residential & commercial)	0%	0%	0%	0%	20%
8	Percentage of wood furnaces (residential)	0%	0%	0%	0%	2%
9	Percentage of fuel oil space heating (municipal)	90%	20%	0%	0%	0%
10	Percentage of propane heating (municipal)	0%	70%	90%	90%	0%
11	Percentage of electric baseboard heating (municipal)	10%	10%	10%	10%	0%
12	Percentage of air source heat pumps (municipal)	0%	0%	0%	0%	100%
13	Percentage of energy optimization from envelope upgrade (res. & comm.)	0%	0%	2%	4%	5%
14	Percentage of energy optimization from envelope upgrade (municipal)	0%	0%	0%	0%	0%
15	Percentage of electric vehicles (private)	0%	0%	10%	35%	55%
16	Percentage of electric vehicles (municipal fleet)	0%	0%	25%	60%	100%
17	Percentage of electric vehicles (school buses)	0%	0%	25%	60%	100%
18	Percentage of buildings with PV production	0%	0%	2%	4%	6%
19	Utility-scale PV system capacity	0 MW	0 MW	0 MW	0 MW	0 MW
20	Electricity GHG emissions factor (kg CO2e/kWh)	0.2300	0.0242	0.0164	0.0147	0.0143

Lightly grayed cells indicate values that are the same in both Pathway A and Pathway B.

4.0 Carbon Reduction Measures

Climate change is a challenge in which our present actions impact the future. Improved awareness and understanding of climate change, targeted education on solutions, and action strategies will help Canada progress in the pathway to a clean energy future.

There are two approaches that Bonfield can undertake toward carbon reductions in the community – the first is through awareness and education, and the second is through policies and programs that are supportive of the energy efficiency measures that are presented in this section. These carbon reduction measures would reduce the energy consumption and the GHG emissions produced in the Township to reach the planned targets. The municipality has a great impact in encouraging the shift to a carbon neutral future, by supporting education and policies that can facilitate the achievement of each of the following planned measures in the community.

There are funds and programs funds available for climate change action, that most often fall to one of these forms:

1. Support for communities to create climate action plans.
2. Support for municipalities to plan and invest in more sustainable municipal assets.
3. Support for building sustainable new municipal buildings and affordable housing.
4. Educational programs and/or support for creating such programs.
5. Support for businesses and residents to undertake energy saving and climate reduction actions.

The Green Municipal Fund is a program that highlights the collaboration between the federal government and municipalities in Canada. It also emphasizes the strong and direct role that municipalities play in development of green economy in Canada. This Fund, established by the federal government and operated by the Federation of Canadian Municipalities, has a significant budget to cover most of the tasks listed above. This Fund invests in both studies and capital projects that would support energy conservation, GHG reduction, environmental goals, and economic benefits. It also has many resources for the education of municipal staff.

Bonfield needs to support the community to transition to a low carbon future. One aspect of this support would be for Bonfield to exhibit leadership in reducing the carbon footprint of its own assets. This might start with low carbon retrofit roadmap studies of municipal buildings.

Several governmental and nongovernmental organizations provide activities, webinars, and educational material to spread awareness and knowledge of climate change. Climate change is taught in primary and secondary curriculum in schools in Canada. The above-mentioned associations assist educators with provision of some resources to support in the teaching deliverables of the curriculum. However, to improve uptake in the community, the biggest need is for financial decision makers (i.e. homeowners, property managers, vehicle owners, etc.) to have information about the availability and viability of low carbon options for their buildings and their transportation needs.

It is also worth noting that planned increases in federal carbon pricing will make citizens and business owners aware how some of their actions may include high carbon consumption. But

the program is structured such that each homeowner will receive an annual rebate from the funds that are raised. People that reduce their carbon footprint will be able to avoid these price increases, and yet will still receive this rebate.

Some of the main powers that municipalities have at their disposal include: development planning, zoning, protected areas selection, property taxes, financing programs, exemptions and flexibility in some regulations and standards.

4.1 Energy and GHG Emissions Reduction in Buildings

This section of the report provides commentary around the projected changes in energy consumption within buildings listed in tables 5 (Pathway A) and 6 (Pathway B); these tables should be referred to for details of the actual projections.

Bonfield consumes 41% of its energy in buildings. The energy consumed in buildings includes electricity and fuel for space heating. As described in the baseline energy report, the buildings in Bonfield are 97% residential and 3% commercial. This section will evaluate the suggestions addressing reduction of energy in Bonfield's buildings.

4.1.1 Electrification of Space Heating

In 2005, Bonfield's buildings consumed one-third of their energy as electricity and two-thirds from fossil fuels, with the fossil fuels sued almost exclusively for space heating and water heating. One of the most effective methodologies used in reducing energy consumption and greenhouse gas emissions in buildings is to electrify heating systems. Using air source heat pumps (or ground source heat pumps) instead of fossil fuel furnaces can reduce both energy consumption and GHG emissions. As reported by the Township, the majority of the buildings (70% of houses at the date of this report) upgraded their furnaces to high performance propane models with efficiency rated as 95%. The lifetime of a furnace is approximately 20 years. The most economic approach to implement electrification of heating is to fuel switch when the propane furnaces reach their end of life. The average COP of air source heat pumps is currently greater than 2.0; for this report, an average COP of 2.2 (220% efficiency) has been assumed for all heat pumps installed in the future. This is subject to research and development, and is expected to improve in the future. Present day heat pumps will often need supplementary heating to provide the required heating load (as the efficiency of heat pumps decreases for low temperatures) in typical homes; buildings with high performance envelopes may avoid the need for supplementary heating. We do note that cold weather performance of ASHPs has been improving rapidly in recent years, to the point where several manufacturers now supply units that can operate well down to temperatures of -25°C. Further improvements are expected; when the need for a supplementary heating source is eliminated, attractiveness of ASHP systems is expected to improve dramatically.

In all scenarios, the efficiency of 220% of heat pumps means that heat pumps can produce the heating required for buildings with less than half the electricity consumption (kWh) relative to the energy consumption of fossil fuel heating (i.e. each kWh electricity consumption provides 2.2 equivalent kWh of heat).

In addition, for Ontario electricity grid, the GHG emissions produced are much lower than propane or fuel oil. Electricity as energy source is more costly than fossil fuel (propane or fuel oil), but the reduction in energy consumption to less than half would offset the increase in energy cost. Also, the projected increase in carbon tax from $50 per ton of carbon dioxide equivalent (in place at the time of writing this report) to $170 per ton of carbon dioxide equivalent in 2030 and $300 per ton of carbon dioxide equivalent in 2050 will incur additional operational costs that can be avoided by reducing energy and GHG emissions in buildings.

In alignment with the ambitious plan for fighting climate change, Bonfield is planning to reduce its GHG emissions by 80% or 60% by 2050 from 2005 level for pathway A and B respectively. This ambitious target requires some planning and improvement of the regular energy consumption of the Township. By converting most buildings to heat pump heating, this energy and GHG reduction measure would provide higher energy efficiency in Bonfield's buildings and removes dependence on fossil fuels in heating buildings. Development of educational and incentive programs that Bonfield could provide for the community would encourage investing in air source heat pumps for heating system in buildings.

Replacement of aging propane and fuel oil furnaces with heat pumps would result in reduction in energy consumption and GHG emissions. The table of assumptions for each pathway presents the percentage of replacement of propane or fuel oil furnaces with air source heat pumps (which can be happening after end life of furnaces by 2040). Table 5 & 6 have the assumptions related to the heating systems in the buildings along the years for pathway A and Pathway B.

For Pathway A, it is assumed that there will be no buildings heated by fuel oil by 2050; for Pathway B, it is assumed that 5% of residences will still use fuel oil in 2050. For the minority of homes currently using baseboard electric heaters, no change is assumed in Pathway B, while half of them are assumed to switch to ASHPs in Pathway A. The biggest difference between the two paths is that in Pathway A, it is assumed that 45% of homes are equipped with ASHPs in 2050, whereas in Pathway B this value is 20%.

Note that we have not assumed that any buildings will be employ geothermal heat pump systems. In practice, it is likely that some buildings will use this technology, and to the extent that they do, they will perform similar to, but better than, ASHPs with respect to reducing GHG emissions.

4.1.1.1 Municipal Government's Role

Energy efficiency in buildings should be the subject of some educational events in the Township. Education, discussion and engagement of the community with low carbon solutions and practices that differ from business as usual and their positive environmental impact would influence the mindset and behaviour of Township residents. It is essential to engage the people and organizations of Bonfield in planning, goals and vision of low carbon and clean energy future. The community of Bonfield has been

engaged in some surveys and public consultations related to climate change.

There are some funded educational programs that Bonfield can use for spreading awareness in the community about clean energy generation and energy conservation which can be found in the Appendix A.

The government of Canada funded some fuel oil companies supporting some programs that encouraged people to switch from fuel oil to propane such as the rebate program offered by Superior Propane. It was reported that such programs were attractive to a majority of homeowners in Bonfield where about 70% of the people had switched their homes from fuel oil to high performance propane furnaces. In future, similar federal or provincial programs may encourage conversion from propane to ASHPs.

Bonfield has control on property taxes and building permits for residents. This is an area where energy efficient standard and lowering GHG emissions can be controlled. There is also the possibility of encouraging reductions of GHG emissions via property taxes or through implementation of a clean energy loan program that pins the load to the property, rather than the current owner. This can contribute to encouraging and enforcing the strategies required for green economy and low carbon buildings.

4.1.2 Wood as a Heating Fuel

Several studies have assessed the emissions produced by burning wood and wood products. Fossil fuel burning produces GHG emissions. On the other hand, wood can be is a renewable resource and can be considered as a zero-carbon fuel. This is since the tree absorbs carbon dioxide (CO2) during its lifetime and emits CO2 at the end of its life when it decomposes. It is estimated that burning wood could release an equivalent amount of CO2 as when it decomposes naturally. Some consider wood to be a zero-carbon fuel only if it is harvested from forests that have sustainable forestry practices.

In this report, wood burning for space heating is assumed to produce no GHG emissions. We also note that the use of wood is expected to remain a minor contributor to the mix of space heating technologies in use in Bonfield.

The projections in this report are based on the assumption that a manufactured wood fuel is used (e.g. wood pellets) not simple fire wood. Wood pellets can be manufactured from waste products from the forestry industry, or from purpose grown “crops”. Equally important, wood pellet furnaces can be fully automated, with pellets fed to the furnace as needed, typically using an auger system to move the pellets from a storage bin.

Pathway A projects a gradual increase in the use of wood as a heating fuel, until it provides 10% of all residential heating requirements in 2050. Pathway B projects

a minimal increase in the use of wood as a heating fuel, providing only 2% of all residential heating requirements in 2050.

4.1.2.1 Municipal Government's Role

The municipality can facilitate the delivery of wood or wood pellets to the residents of Bonfield. Education and awareness of pellet stoves and furnaces can be promoted at a community level. The municipality may have an opportunity to attract a wood pellet manufacturing facility within the Township, which would raise the local profile of the technology.

4.1.3 Building Envelope Retrofits

Building materials have been improving in thermal performance and cost. It is estimated by 2050 that the building envelopes – on average – will have improved thermal performance envelope with more insulation (walls, roofs, doors, and windows), improvement in air tightness, and reduced thermal bridging. There are many approaches to improving the thermal performance of building envelopes, from mandating higher standards in new buildings (as the Ontario Building Code has done), to replacing windows, adding attic insulation or completing a complete envelope upgrade by "wrapping" the entire building in new insulation and cladding.

For Pathway A, the average residence in Bonfield is expected to require 10% less heat than the 2019 baseline year, whereas for Pathway B the corresponding value is 5%. Clearly this would likely be achieved by very substantial improvements in new construction and some extensive renovations, while a substantial number of buildings are likely to remain unchanged.

4.1.3.1 Municipal government's role

Municipality of Bonfield can implement energy efficiency standards for existing buildings and new buildings. As for community homeowners, Bonfield can support them in seeking incentives or rebates that will improve energy efficiency investment in the community.

It is recommended that Bonfield collaborate with federal funding programs to provide incentives for buildings' envelope upgrades where homeowners can receive incentives coupled with low interest loans. The Township can also offer a property tax exemption if the property is able to achieve a predetermined reduction in energy use and GHG emissions.
Some examples of existing programs that provide grants, rebates or incentives that can encourage energy retrofits and a transition to low carbon buildings in Bonfield are included in Appendix A.

4.2 Energy and GHG Emissions Reduction in Transportation

4.2.1 Electrification of transportation

In order to evaluate the GHG implications of transitioning to electric vehicles in both the private and public sectors, it is first necessary to compare the efficiencies of a

gasoline fueled internal combustion engine (ICE) to a battery electric vehicle (BEV). In a typical ICE, between 12 – 30% of the fuel energy is used to propel the vehicle; the remaining 70 - 88% of fuel energy is lost (mostly as heat) to inefficiencies in the powertrain or used to power accessories. As BEVs have fewer moving parts, direct electromagnet motors with efficiencies of 80%, and generally have only a single speed transmission, the energy losses are significantly less than in ICEs. Total energy loss in a BEV is in the range of 30%, when losses in the battery charging/discharging process are included alongside the drive train losses. Unlike ICEs, BEVs use regenerative braking, which captures the waste energy from braking (which would otherwise be dissipated as heat) , generating electricity to replenish the battery; this recovery of energy is commonly reported as an increase in vehicle efficiency, and is strongest during city driving. Overall, BEVs have superior energy performance, with the net efficiency of current models (including the benefit of regenerative braking) ranging from 75% to above 90%, depending on the drive cycle.

4.2.2 Private sector

As efficiencies in both ICE and BEVs vary, this study will use the energy efficiency values published by the federal government for 2021 with modifications made to reflect the typical driving profile of Bonfield residents (i.e. private vehicles). Specifically, the common assumptions used in energy efficiency testing reflect 55 percent city and 45 percent highway driving, but as many Bonfield residents commute to North Bay for work, groceries and other necessities, thus a shift to 25 percent city and 75 percent highway drive cycle has been assumed. For comparison, the average ICE has a fuel efficiency of 8.9 liters per 100 kilometers, while BEVs typically get 2.4 liters (equivalent) per 100 kilometers.

It is important to understand that the high energy efficiency and relatively low operational energy costs (electricity) of BEVs mean that they have significantly lower operational costs. This operational cost advantage becomes more significant the further that people drive, thus the long commutes of Bonfield residents into North Bay increases the financial advantage of residents switching from ICEs to BEVs; for example, a typical BEV today can travel a kilometer for 2 to 3 cents, while an average gasoline ICE costs 10 to 12 cents. The increasing carbon tax will continue to widen this difference, as Ontario has a very clean electrical grid, thus limiting the impact of planned increases to the cost of carbon.

Furthermore, fossil fuel prices can vary significantly with market trends and international events, whereas electricity costs are controlled by provincial governments and are expected to have relatively smooth and modest cost escalations over time.

It is worth noting that Canada’s average vehicle has consistently ranked last in fuel efficiency of all countries included in the International Energy Agency’s study on energy efficiency in the transportation sector. In part, this is due to the increasing trend of consumer preference for pickup trucks and SUVs over sedans, and the relatively low price of fuel in Canada. Thus any initiatives that encourage purchase of smaller, more fuel efficient ICEs will have some positive impacts on carbon

footprint of transportation. However, these gains would be minimal compared to switching to electric vehicles.

In Pathway A, the percentage of total private sector vehicle mileage driven by electric vehicles increase to 80% by 2050; in Pathway B, the 2050 value is a more modest 55%.

4.2.2.1 Municipality's role

Due to the inherent challenges in providing adequate and affordable public transit in rural locations, the majority of Bonfield residents rely on private vehicles for transportation, especially commuting into North Bay. This is unlikely to change in the foreseeable future, so it is necessary to consider a strategy to reduce the GHGs emitted by private vehicles (which vehicles account for the largest portion of transportation related emissions).

Generally, owners of BEVs undertake around 80% of the charging at home, using Level 2 chargers installed at their homes. These need to be installed by a licensed electrician and, depending on the home electricity needs and service, it may require an electrical service upgrade. Once in place, charging at home on a daily/nightly basis becomes very convenient to most BEV owners; 8 hrs of overnight charging can deliver more than 200 km of range. The municipality can look for opportunities to support electricians and installation companies to install BEV chargers in residences, as well as publicizing any government or utility programs that support charger installations.

There is likely value in creating public BEV charging infrastructure at select municipal buildings or at popular locations in town. This provides public demonstration of an alternative supply to home charging, for those that cannot install a charger at home. These could be a combination of Level 2 and Level 3 (high capacity) chargers.

Additionally, there may be value in installing a Level 3 charging station at a location along Highway 17 where vehicles transiting through Bonfield can pay for charging. This provides visibility to Bonfield residents, and may also become a source of additional income, more from co-located business that can take advantage of travelers stopping for ~20 – 60 minutes, than from selling electricity.

The Township can also explore options for providing rebates or other incentives for public charging infrastructure to be installed.

While it is unlikely that the Township has the financial capacity to offer incentives on the purchase price of BEVs, another effective tool that the Township has at its disposal is the ability to host educational campaigns that showcase the provincial and federal incentives available, as well as the advantages of BEVs. These education campaigns can be as simple

as advertising the available incentives via the official Township website, social media posts, at townhall meetings, or through a day-long showcasing event with BEV retailers (new and used) and advocates. In particular, Plug'n Drive is a non-profit organization that hosts such events. This education campaign should also highlight the fact that it is substantially cheaper to operate and maintain a BEV versus an ICE.

Encouraging the community to consider hybrids as an introduction to BEVs can also be an effective strategy to encourage uptake, as many used plug-in hybrid electric vehicles (PHEVs) currently exist on the market. Switching to a PHEV can help familiarize residents with the technology while also providing the familiar security of an ICE. PHEVs also don't require any infrastructure upgrades, such as chargers, as the battery packs are much smaller than full BEVs and can be charged with a Level 1 charger, which simply plugs into a standard 15 amp wall outlet.

4.2.3 Municipal fleet

The Township currently has a mix of light to heavy duty vehicles that contribute to less than 2% of the transportation sector's GHG emissions in Bonfield. It is understood that none of the vehicles are BEVs as of the date of this report. In both Pathways A and B, it is projected that these will be converted to 100% BEVs by 2050. There are two primary reasons for this: one of the simplest ways for the Township to educate local residents of the advantages of BEVs is for the Township to adopt them early and, secondly, most vehicles in the municipal fleet follow a more regular pattern of use than do privately-owned vehicles, making it relatively easy to adjust to a new usage pattern where vehicles takes from 1 – 8 hours to "fill up" (depending on charger and vehicle), rather than 5 minutes to fill up with fuel.

4.2.3.1 Municipality's role

While the share of GHG emissions that the municipal fleet is responsible for is marginal, the impact of electrifying its fleet can be large. The Township has full control over its fleet and can take immediate actions toward the transition to an all-BEV fleet by both replacing aged ICE vehicles with equivalent hybrids or BEVs, and at some point making a policy decision to procure only BEVs. By procuring BEVs, the Township will be able to introduce and familiarize the community with the viability of battery electric vehicle technology, which is a key pillar in moving Bonfield toward a low carbon future. While there is still a gap in the market for certain heavy duty BEVs, this is expected to close rapidly over the next decade. The Government of Canada has developed a best-practices guide for greening government fleets, which will be useful for the Township to help guide the transition.

The municipality should also monitor for provincial or federal programs that fund that may become available for funding the transitioning of municipal fleets to BEVs. One possibility is the Zero Emission Vehicle Infrastructure Program (ZEVIP), a federal funding program that may continue to encourage BEV infrastructure deployment, which also

includes public fleets. Successful applicants will be able to recover up to 50% of total project costs for chargers (including electrical studies, installation and hardware). Note that the previous round of funding was highly sought after and fully subscribed in a matter of weeks.

4.2.4 School buses

The Township currently has agreements with two private sector companies (East Ferris Bus Lines and Belanger Brownway Bus Lines) to provide bus transportation for children in Bonfield to attend school in North Bay. The current fleets of buses owned by both companies are understood to be all diesels.

Because school buses follow a very regular usage pattern, they are among the easiest fleets to convert to electric vehicles. For this reason, both Pathways A and B have assumed 100% conversion to BEV's by 2050, following the same pattern as assumed for municipal fleet vehicles. Electric school buses are currently available – at least as pilots, if not yet full production vehicles – from major school bus suppliers in Canada including Bluebird, Thomas, Lion Electric and GreenPower Motor Company. Orders for well over one thousand BEV school buses have already been placed by Ontario bus operators, with hundreds expected to be on the road by 2025.

4.2.4.1 Municipality's role

The municipality should use their contracting position to encourage the two school bus providers to either pilot one or more battery electric buses, then fully transition. Funding currently exists through Infrastructure Canada's Zero Emission Transit Fund for private-sector school bus operators to move to battery electric buses. The municipality should act immediately to support its school bus providers in applying for this funding program, as funds are limited and timing is important (the program expires in 2025 and applications are accepted on a first come, first serve basis).

4.3 Renewable Energy Production

Electricity production in the Township via renewable resource can be done by installing rooftop photovoltaic panels on some buildings and construction of utility-scale ground mount solar farms Solar power systems are widely recognized around the world as the lowest cost-to-construct electricity generation plants, and continue to prove to be profitable investments, including in Canada.

For Pathway A, the forecast is that 20% of all homes in Bonfield will be equipped with rooftop solar systems by 2050; for Pathway B, this figure is 5%. In addition, Pathway A assumes construction of 12 MW of utility-scale solar, which could be a single solar farm occupying approximately 40 hectares of land (a common size in Ontario). Pathway B has no utility-scale solar.

Stated another way, Pathway A includes installation of 14 MW of solar by 2050, generating 18,000 MWh of clean electricity annually. Pathway B includes 0.5 MW of solar installed by 2050, generating 650 MWh.

While neither pathway A or B forecasts include any wind power or hydro power, these technologies could equally meet the challenge of generating zero-GHG electricity, as could newer, emerging technologies such as using biogas or hydrogen to generate electricity. The important fact is that 18,000 MWh (Pathway A) or 650 MWh (Pathway B) of zero-GHG electricity be generated from any mix of clean technologies by 2050. Solar is simply judged – at this time – to be the most readily deployable and most likely technology to fill this role.

4.3.1 Municipal government's role

Bonfield can educate the community of the PV systems that can be installed in personal properties. The municipality can coordinate public seminars or provide online material on its website on residential and commercial solar arrays. Some of the installation companies or industry associations may be willing to be presenters in educational events or provide supportive consultation to the public in the community. This will encourage people to invest in renewable energy such as PV. With the prices of solar systems decreasing, this is an encouraging opportunity to invest in solar energy.

Some programs can be initiated in the future to support the community with some incentives to encourage investment in renewable energy generation. This is an example of an ongoing program. Bonfield can collaborate with the federal government in initiating such programs. Bonfield staff can also inform operators of for-profit businesses located in Bonfield of the accelerated capital cost allowance (CCA or, commonly "depreciation") available as income tax deductions for businesses for solar or other clean technologies (see Classes 43.1 and 43.2 of Schedule II to the Tax Regulations).

4.4 Summary of energy efficiency measures

Table 7 summarize the projected effects of the measures discussed, in terms of annual energy consumption and GHG emissions. The first table shows the results from Pathway A; the second table for Pathway B.

Table 7: Projected Energy Consumption and GHG Emissions: Pathway A

Parameter	Energy Consumption (MWh/year)			GHG Emissions (tCO_2e/year)		
	2030	**2040**	**2050**	**2030**	**2040**	**2050**
Electricity, all buildings (excluding heat)	12,250	12,250	12,250	201	180	175
Municipal building heating	285	285	130	50	50	2
Residential building heating	21,758	20,440	13,484	4,393	4,067	1,875
Commercial building heating	1,608	1,559	1,114	325	312	167
Municipal vehicles	677	475	243	154	84	3
School buses	1,732	1,183	555	399	216	8
Private vehicles	40,866	31,836	21,001	9,060	6,103	2,558
Renewable energy generation	- 600	- 1,200	- 2,400	- 10	- 18	- 257
Totals	**78,576**	**66,826**	**46,375**	**14,572**	**10,995**	**4,351**

Table 8: Projected Energy Consumption and GHG Emissions: Pathway B

Parameter	Energy Consumption (MWh/year)			GHG Emissions (tCO_2e/year)		
	2030	2040	2050	2030	2040	2050
Electricity, all buildings (excluding heat)	12,250	12,250	12,250	201	180	175
Municipal building heating	285	285	130	50	50	2
Residential building heating	22,431	21,973	18,937	4,634	4,535	3,335
Commercial building heating	1,608	1,575	1,389	332	325	246
Municipal vehicles	677	475	243	154	84	3
School buses	1,732	1,183	555	399	216	8
Private vehicles	46,284	37,254	30,030	10,826	7,874	5,510
Renewable energy generation	-240	-480	-720	-4	-7	-10
Totals	**85,027**	**74,514**	**62,813**	**16,592**	**13,257**	**9,269**

Figures 2 and 3 on the following pages present the estimated GHG emissions from each category along both pathways A and B, respectively, showing projected GHG reductions through 2050.

Figure 2 - Summary of Pathway A

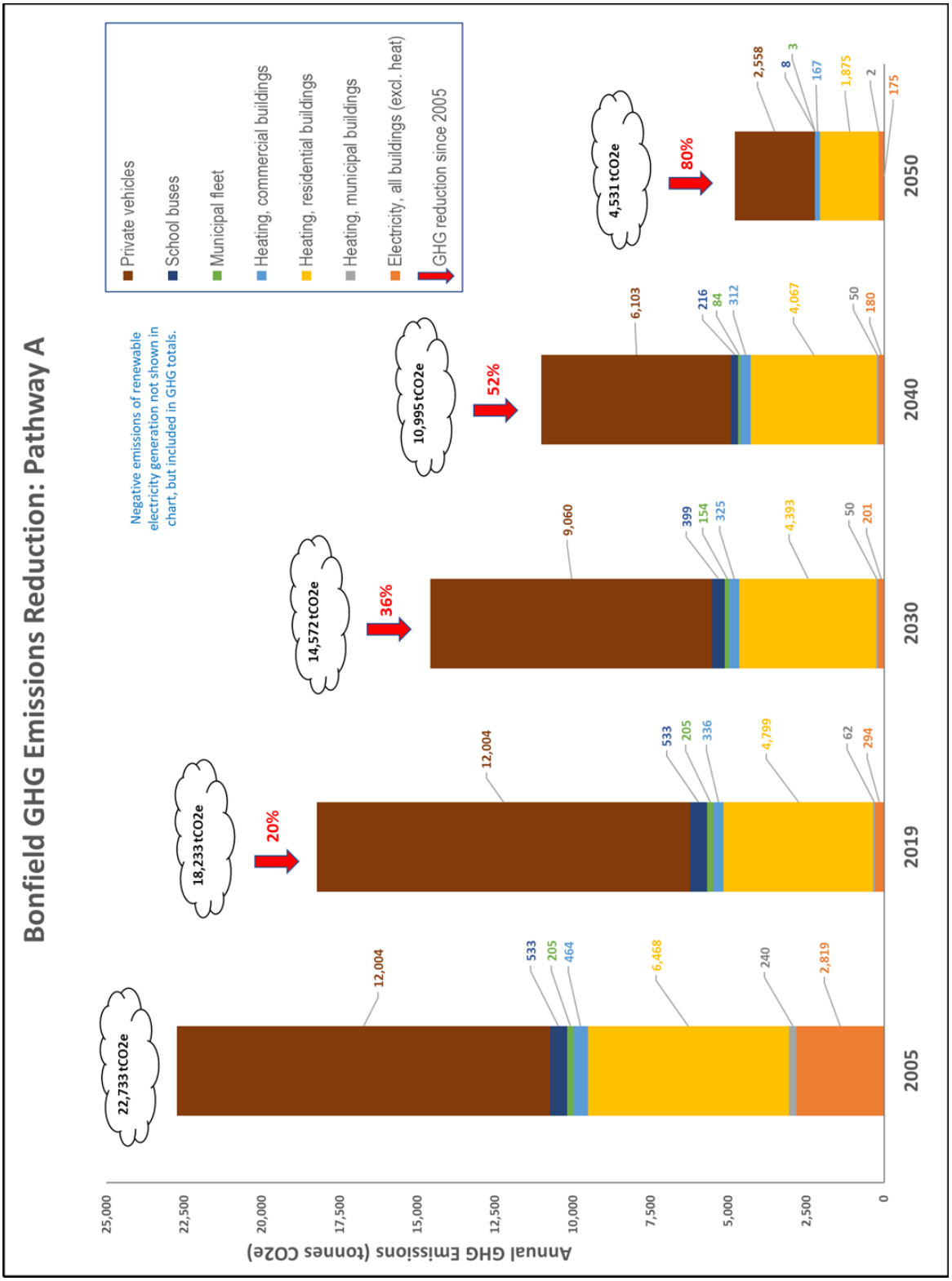
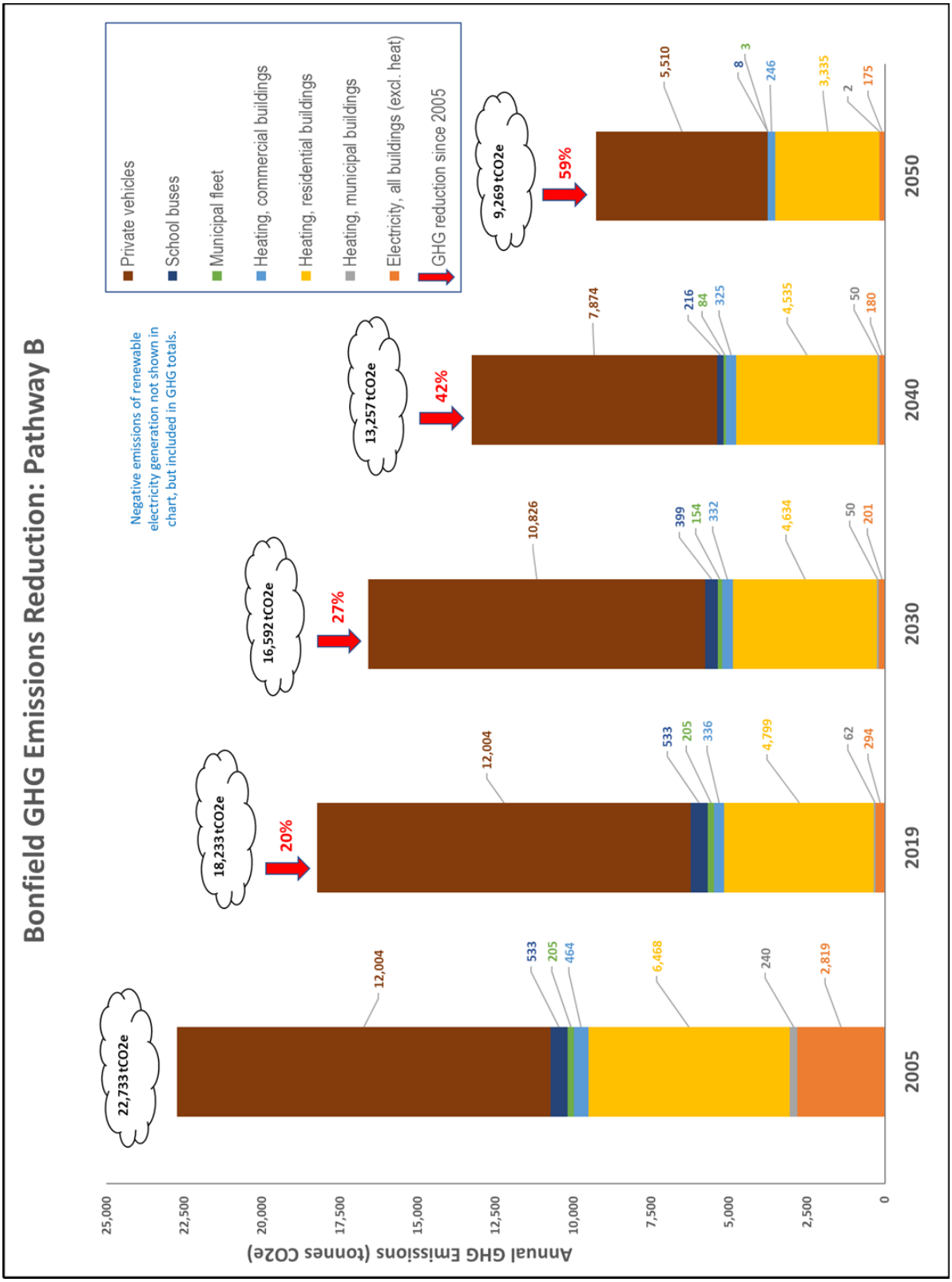


Figure 3 - Summary of Pathway B



5.0 Implementation

This section of the Report summarizes how this MEP will be implemented in the coming years. The first section is a list of specific goals that the Township has set to track and accomplish. Subsequent sections describe how the MEP will be communicated, future engagement with stakeholders, and how this MEP coordinates with other Township or regional documents (e.g. Bonfield's Official Plan).

5.1 Specific Goals

To ensure implementation of this Municipal Energy Plan, Bonfield Township has developed a set of thirty specific, measurable goals, divided into four topical categories (General, Buildings, Transportation and Renewable Energy) and then subdivided into three groups, those to be complete by the ends of 2025, 2030 and 2050. While the tracking of these goals rests with Township councilors and staff, accomplished of many of these goals requires the active cooperation of the residents of the Township.

5.1.1 General Goals

5.1.1.1 Short Term Goals (by the end of 2025)

1. Based on the 2022 Municipal Energy Plan report, choose and adopt either Path A or Path B as the Township's GHG reduction targets. This will set the formal GHG reduction goals of the Township for 2030, 2040 and 2050.
2. Define a set of GHG/energy metrics that can be tracked, and determine a method for tracking them, including assigning a council or staff member to lead the tracking effort.
3. Begin educating Township residents about the MEP.
4. Assign a council or staff member to keep abreast of climate action funding opportunities pertinent to Bonfield Township and its residents.
5. Update the Township's Asset Management Plan to include an emphasis on reducing GHG emissions from vehicles and buildings, when they are due for updating or replacement.

5.1.1.2 Medium Term Goals (by the end of 2030)

6. Issue a public report indicating progress toward GHG emission reduction targets, as of the end of the year 2030.
7. Cooperate with the local electric utility (Hydro One Networks Inc.) in sharing information on the potential changes of electricity loads and/or generation within the Township.

5.1.1.3 Long Term Goals (by the end of 2050)

8. Issue a public report indicating progress toward GHG emission reduction targets, as of the end of the years 2040 and 2050.

5.1.2 Buildings Goals

5.1.2.1 Short Term Goals (by the end of 2025)

9. Arrange an opportunity for Township residents to attend a seminar on cold weather heat pumps (possibly on-line).
10. Set targets for every five years (2030, 2035, 2040, 2045 & 2050) for the number of private residences within the Township to be heated without using fossil fuels.
11. Identify a municipally owned building to be the first to be converted to heat pump heating and cooling.
12. Begin educating residents about cold weather heat pumps for homes.

5.1.2.2 Medium Term Goals (by the end of 2030)

13. Assist in informing residents of the financials related to GHG emission reduction techniques (e.g. heat pumps, rooftop solar, biomass furnaces, electric vehicles).

5.1.2.3 Long Term Goals (by the end of 2050)

14. Convert at least one Township-owned building to 100% heating and cooling from electric heat pumps by 2035.
15. Eliminate fuel oil as a heating fuel for all buildings within the Township.
16. Eliminate propane as a heating fuel for all buildings within the Township.
17. Convert all Township-owned buildings to 100% heating and cooling from electric heat pumps (or other non-fossil fuel technology).
18. Reduce non-HVAC electricity consumption of all Township-owned buildings by 25% from the 2019 values (measured the basis of total floor space).

5.1.3 Transportation

5.1.3.1 Short Term Goals (by the end of 2025)

19. Arrange an opportunity for Township residents to attend a seminar on electric vehicles (possibly on-line).
20. Act, along with neighbouring municipalities, to establish a regional “working group” to develop ideas and programs for cooperatively reducing GHG emissions from transportation by promoting initiatives that reduce GHG emissions from transportation, possibly including such concepts as ride-sharing, enhanced regional connectivity of transport, a regional network of public EV charging stations or education programs.

5.1.3.2 Medium Term Goals (by the end of 2030)

21. Enable the installation of at least one publicly accessible EV charging station within the Township.
22. Acquire the first Township-owned zero emission vehicle (ZEV).
23. Develop a plan to replace all Township vehicles with ZEVs.
24. Work with local school bus operators to trial at least one electric school bus.

5.1.3.3 Long Term Goals (by the end of 2050)

25. Complete the conversion of all Township vehicles to ZEVs.
26. Work with school bus operators to convert all school buses to ZEVs.

5.1.4 Renewable Energy Production

5.1.4.1 Short Term Goals (by the end of 2025)

27. Arrange an opportunity for Township residents to attend a seminar on solar power systems (possibly on-line).
28. Review Township land use and zoning regulations with a view to ensuring that renewable energy developments (e.g. solar farms, wind farms, residential rooftop solar, ground source heat pumps) are permissible in appropriate areas within the Township.

5.1.4.2 Medium Term Goals (by the end of 2030)

29. Identify locations within the Township, of minimum 25 hectares, that may be suitable to host a utility-scale PV power system.

5.1.4.3 Long Term Goals (by the end of 2050)

30. Work with one or more private developers, at one or more locations, to encourage the establishment of at least 12 MW of solar farms within the Township. (Alternately, this could be 12 MW of wind farms.)

5.2 Communication

Several steps will be taken to communicate the content of this MEP to Township residents and other stakeholders, and to report progress on achieving the goals and GHG reductions within this plan:

- Formal adoption of this plan will be noted in the minutes of the Council meeting, when this occurs.
- Once adopted, a PDF file of this MEP will be posted on the Township website.
- Township staff will maintain a master list of the MEP goals (section 5.1), including reporting completion of goals at Council meetings, on an ongoing basis.
- The Township will prepare estimates on GHG emissions in 2030, 2040 and 2050, and publicly report on actual reductions vs. the planned reductions in this MEP.
- On an irregular basis, key elements of the MEP will be highlighted using existing communication channels (e.g. newsletters, council meetings, public meetings).

5.3 Stakeholder Engagement

In the coming years, implementation of this MEP will require ongoing engagement with stakeholders. The most obvious and most important stakeholders are the Township residents, especially those who own the homes and automobiles which are the source of so much of the GHG emissions. The Township's engagement with residents will consist primarily of two "tasks": education, whereby the Township will use existing communication channels to educate residents about the value of such things as zero emission vehicles, cold weather heat pumps and various

subsidies available to support specific GHG reduction steps; and listening to residents about what is working well, and what is not working as well. Such listening will be used to fine tune the MEP on an ongoing basis.

In addition to Township residents, there will be other stakeholders involved over the more than two decades it will require to fully implement this MEP. A partial list of such stakeholders would include:

- Neighbouring municipalities.
- Businesses that currently sell fuel oil and/or propane fuel (e.g. Moore Propane, McDougall Energy).
- Business that currently sell automotive fuel such as gasoline and diesel (e.g. MacEWEN Petroleum).
- Forestry businesses, as a source of biomass fuel.
- Hydro One, as the local electricity distributor.
- Local and regional HVAC businesses, as the suppliers/installers of heat pumps.
- Local and regional automobile sales businesses.
- Businesses that operate fleets of vehicles at least partly within the Township (.e.g. school buses, delivery vehicles).

A few specific stakeholders include:

- East Ferris Bus Lines and Stockfish Bus Lines, who operate school buses, and the school boards who contract their services.
- Caisse Populaire Bank, a local lender who can assist in financing GHG reduction projects (e.g. mortgages to pay for energy-related home improvements).
- All businesses that either consume substantial energy and/or have sufficient landholdings that may host larger renewable energy facilities, such as HoeNorth Aggregates, DeGagne Aggregates, Kwik Way, Gagne's Red and White, and Bell Canada.
- Community organizations such as the Bonfield Community Centre and the Senior Housing Board Corporation.

Of note, businesses and institutions that directly serve the public also have the potential to play a role in educating and informing the public about the MEP, or specific elements within it, in cooperation with the Township.

5.4 Coordination

A key element in successfully implementing this MEP is to ensure that it is linked to other Township documents. To that end, the Township is committed to ensuring that our Official Plan (2013) and our Zoning By-Law will be updated to reflect the priorities of the MEP. This may be accomplished by directly incorporating some elements of the MEP into the Official Plan or Zoning By-Law, or by referring to the MEP within these two documents.

The following is a list of some specific actions that the Township intends to undertake on an ongoing basis to ensure coordination between the MEP and other documents and tasks for which the Township is responsible:

- The Township will provide for lands to be identified for the purpose of energy generation and transmission infrastructure within the Official Plan as well as within the comprehensive zoning by-law.
- The land planning provisions within the Official Plan will be reviewed to ensure that they will enable the commercialization of green industries.
- We propose to update the wording of clause 2.2.2 of the Official Plan – "to minimize the negative impacts to air quality and climate change by encouraging energy efficient buildings and development" – to more explicitly support the objectives of the MEP.
- During a forthcoming review of the Zoning By-Law, the Township proposes to explicitly permit non-residential land uses for the purpose of providing lands for solar farms, power generators or other renewable energy sources.
- Bonfield's Climate Adaptation Plan (2021) will be reviewed with the intention of amending it to provide "actions" to minimize GHG emissions and track measurable targets, in accord with the MEP.
- The Township's Asset Management Plan will be reviewed and updated as needed to conform with the MEP. Specifically the eventual end-of-life replacement of the Township's fleet and building assets will prioritize a move toward hybrid and electric vehicles, and a switch to more energy efficient buildings with non-fossil fuel heating systems.

In addition to the specific tasks listed, the Township will, on an ongoing basis, work with residents and business owners to encourage and enable them to more quickly adopt low-GHG options within their homes, business and vehicles. Much of this work will be primarily educational, working to keep residents aware of the measures of the MEP, and of programs or requirements from more senior levels of government. However, when necessary the Township will more directly participate in decision making processes by ensuring that local policies encourage, rather than inhibit, adoption of low-GHG options.

6.0 Conclusion

This report presents a pathway for Bonfield Township to reduce GHG emissions associated with all forms of energy consumption by 80% over 2005 levels, by 2050, in line with national and international goals set to reduce the impact of climate change. This path will require aggressive measures both by the Township and by other bodies beyond the Township's control (automotive industry, Ontario electricity grid operator, etc.). The pathway to achieving this goal includes a 20% reduction in GHG emissions that has already occurred between 2005 and 2019 (the most recent pre-pandemic year).

Key measures required to achieve this 80% reduction in GHG emissions include:

- Increased electrification of transportation.
- Increased electrification of building heating, primarily via air-source heat pumps.
- Construction of new buildings with tighter, better insulated envelopes, and envelope renovations of some buildings.
- Installation of solar or other zero-carbon, renewable electricity generation within the Township.
- Replacement of many electric devices with more efficient units.

This report also presents a pathway that achieves a lesser reduction in GHG emissions by 2050 – 59% from 2005 levels. This less aggressive path is presented in recognition of the fact that for Canada (and the world as a whole) to achieve the target of 80% reduction by 2050, there will be some variation across sectors and communities. If the 80% national target is met, some communities will achieve better than an 80% reduction, and others will achieve somewhat less. This report makes no claim that Bonfield should be a community with a less aggressive goal; this less aggressive goal is presented merely as a comparison of what might be achieved, if similar steps are taken to reduce GHG emissions, but followed less rigorously.

The role of the Township's government and administration is not clearly defined within this report, but it can be reasonably assumed that at least these three tasks would be included:

1. Providing exemplary leadership by being among the first to adopt lower GHG technologies within its own operations (as it has already done in eliminating fuel oil as a building heating fuel.)
2. Educating residents of the need and benefits of adopting lower GHG technologies into their lives, and of the progress made as it occurs.
3. Seeking out funding opportunities that support the implementation of low-GHG practices and either participating directly or encouraging Township residents to participate.

Achieving a massive reduction in GHG emissions from energy consumption can appear to be an unwieldy task. This report attempts to provide perspective, revealing that smaller changes taking place gradually over time can result in achieving the desired targets. This report also discusses how measures taken by governments and industries beyond Bonfield will also have substantial impact on achieving GHG goals within Bonfield, such as the ongoing efforts to make Ontario's grid electricity cleaner and the joint industry/federal government goal to eliminate the sales of new light vehicles duelled by fossil fuels by 2035.

From the data in this report, it is clear that, as personal vehicles currently are the largest emitter of GHG's in Bonfield, this sector deserves special attention. Additional effort to better measure current emissions from this sector, to better track changes as electric vehicles become more common, to evaluate barriers to charging and then support charging needs, and to better educate the residents of Bonfield on the advantages of electric vehicles is likely to bear positive results.

It is clear that the second major effort must be made within Bonfield to reduce the use of fossil fuels in heating the buildings within the Township. This can be achieved both by making buildings more energy efficient, and by switching from fossil fuels (heating oil, propane) to electricity. Bonfield should regularly review how this can be encouraged, which may range from educating residents generally, helping to provide special training to those within the local construction industry and perhaps by undertaking example projects on one or more of their own buildings.

With steady, consistent, targeted effort – and with the assistance of more senior governments – it should be possible for Bonfield to reduce its GHG emissions from energy consumption to 80% less than 2005 emissions, by 2050.

6.1 Limitations

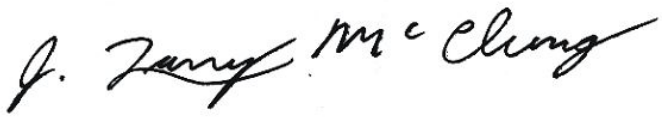
This report has been prepared by J.L. Richards & Associates Limited for The Township of Bonfield's exclusive use. Its discussions and conclusions are summary in nature and cannot

properly be used, interpreted or extended to other purposes without a detailed understanding and discussions with the client as to its mandated purpose, scope and limitations. This report is based on information, drawings, data, or reports provided by the named client, its agents, and certain other suppliers or third parties, as applicable, and relies upon the accuracy and completeness of such information. Any inaccuracy or omissions in information provided, or changes to applications, designs, or materials may have a significant impact on the accuracy, reliability, findings, or conclusions of this report.

This report was prepared for the sole benefit and use of the named client and may not be used or relied on by any other party without the express written consent of J.L. Richards & Associates Limited, and anyone intending to rely upon this report is advised to contact J.L. Richards & Associates Limited in order to obtain permission and to ensure that the report is suitable for their purpose.

J.L. RICHARDS & ASSOCIATES LIMITED

Prepared by:



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Associate, Innovative Energy Market Chief

REFERENCES

1. Canada's National Reports to the United Nations Framework Convention on Climate Change (2017) - Canada.ca

2. Greenhouse gas emissions projections - Canada.ca

3. Government of Canada supports climate action by Smart Prosperity Institute and the Institute of the Environment at the University of Ottawa - Canada.ca

4. Building Canada's Green Economy.pdf (smartprosperity.ca)

Appendix A: Potential Funding Programs

Listed below are some programs that may provide funding to help implement various elements of the plan outlined in this document.

List of Programs for education and awareness of incentives for electrification in buildings

1) "Education and Capacity Building Program"
   http://www.ieso.ca/get-involved/funding-programs/education-and-capacity-building-program/overview
2) "Energy Management Training for employees in a business or in contracting Program"
   Energy Management Training and Support for Business | Save on Energy
3) "Educational Incentives for Enbridge Customers which is a collaborative incentive with IESO for training customers and employees for certain training courses".
   Energy Management Training and Support for Business | Save on Energy
4) "Quest Canada program for communities to prepare energy plans, educate the community and identify grant opportunities and support in its development".
   National Net-Zero Community Accelerator Expression of Interest (questcanada.org)
5) "Federation of Canadian Municipalities training for energy use in municipal buildings and communities".
   E-learning series: tackling energy use in your municipal and community buildings | Federation of Canadian Municipalities (fcm.ca)

List of Programs for education and awareness of incentives for envelope retrofit in buildings

1) "Energy Affordability Program that helps eligible homeowners in identifying and providing electricity reducing measures for their homes".
   https://www.saveonenergy.ca/Consumer/Programs/Home-Assistance-Program.aspx
2) "Enbridge Retrofit and Custom Projects program for energy efficient upgrades"
   Retrofits & Custom Projects | Enbridge Gas
3) "Enbridge Rebates and Energy Conservation program for energy efficient upgrades if eligible".
   Rebates & Energy Conservation | Enbridge Gas
4) "SaveOn Energy Program and Incentive for business and contracting "https://saveonenergy.ca/Business/Program-Overviews/Retrofit-for-Commercial.aspx
5) "Built Green Canada certification program that identifies energy efficient design and supports in rebates from Canada mortgage and housing corporation (CMHC)".

Appendix B: Bonfield Township Baseline Energy Report

JLR No.: 31182-000
Revision: 01

September 28, 2021

Prepared for:

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Energy Report

Bonfield Township Baseline Energy Report

J.L.Richards
ENGINEERS · ARCHITECTS · PLANNERS

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1.0 Introduction

This report is developed to provide an overview of all energy types that are utilized in Bonfield, and to estimate its quantities that were consumed as of the year of 2019. The report also assesses the greenhouse gas emissions (GHG) associated to the energy consumption of the year 2019. The baseline energy consumption for Bonfield is an important first step for a Municipal Energy Plan for the Township. The study of the baseline energy consumption will help guide the evaluation of energy reduction measures, renewable energy opportunities, and possible energy supply type changes towards achieving the Township's targets for energy and greenhouse gas emission reductions.

The energy types included in this report are energy consumed by the residents of Bonfield in their buildings and their vehicles – it excludes energy consumed by vehicles passing by or through the Township by non-residents of Bonfield, and excludes energy consumed by agricultural or delivery vehicles.

The energy supply in the Township depends on imported fuel that is distributed by fuel supplying companies and electricity supplied by Hydro One. It is assumed that there are some photovoltaic systems that produce energy for individual building's consumption. In addition, in previous years, there was an intention in investing in production of wood pellet supply to the market in Bonfield, which did not happen. In consultation with the Township, this study will consider that there is no local production of energy.

This report is part of the Bonfield Municipal Energy Plan. Bonfield is located in the District of Nipissing, in the Mattawa River watershed, 27 km east of the City of North Bay. It spreads over an area of 200 km^2, covering mostly rural areas, and contains the communities of Bonfield and Rutherglen. Bonfield is connected to Ontario Highway 17 by Ontario Highway 531, while Rutherglen is located directly on Highway 17, as shown in Figure 1.[1]

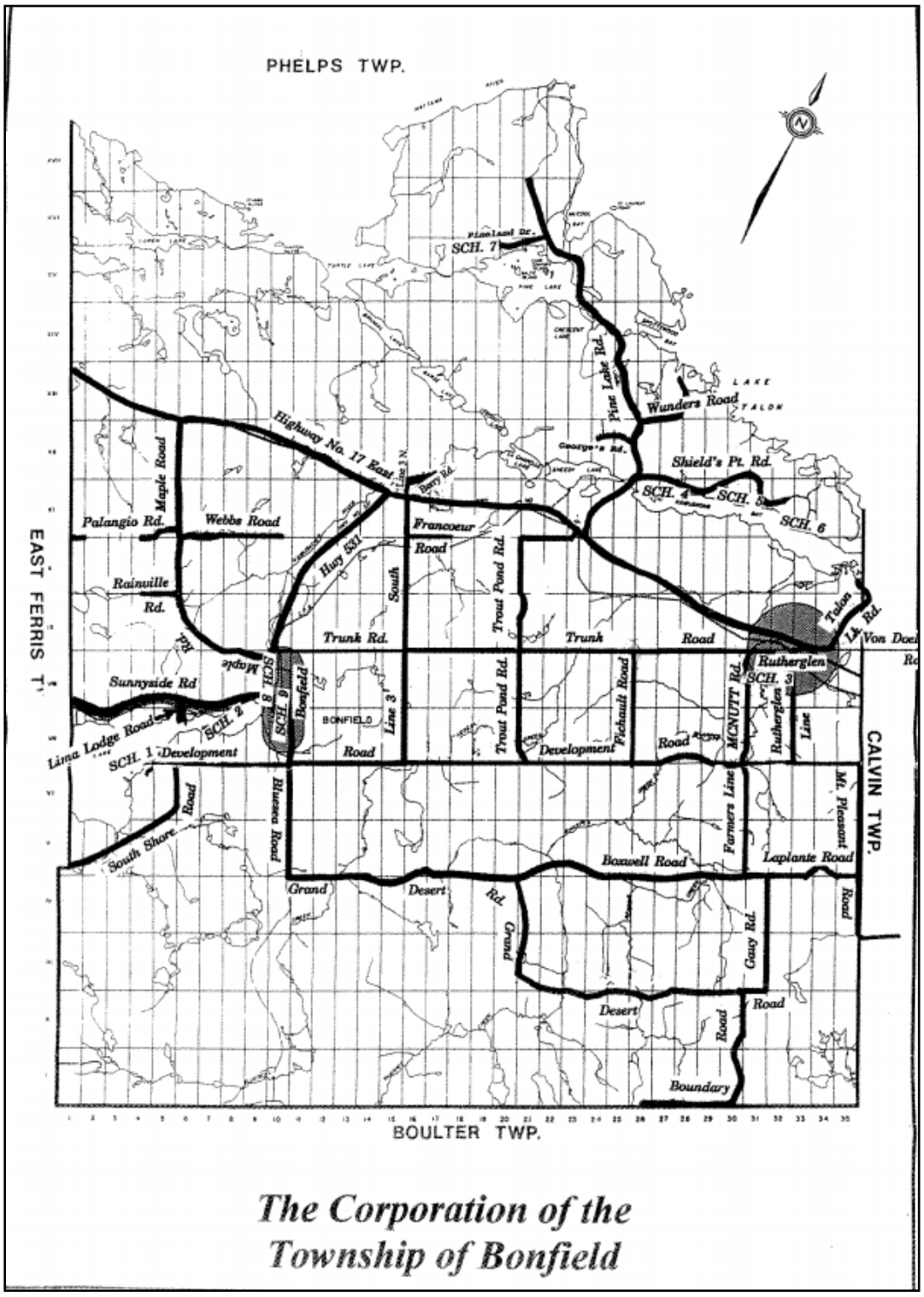


Figure 1: Bonfield Geographic Site Plan

Bonfield has a population of approximately 2,000 inhabitants, as per the 2016 Census. It is comprised of 97% residential buildings; the remaining 3% of the buildings are commercial, which includes municipal buildings (as reported by the Township). Most of the residential homes are single detached houses (91%); the rest are rowhouses and duplexes.[1]

There are reportedly 1,122 permanently inhabited houses, 153 seasonal cottages and 35 commercial buildings in Bonfield. All the houses in the community have private water supply and septic or holding tanks.

2.0 Township of Bonfield Energy Performance

2.1 Energy Consumption

Bonfield uses several sources of energy. These companies supply Bonfield by fuel and electricity as reported by the Township: electricity (Hydro One), propane (Moore Propane, Superior Propane, Grant Propane, and McDougall Energy), fuel oil (Jim Moore Petroleum, Bluewave Energy, Co-op Régionale, Grant Fuels, and McDougall Energy). Wood (firewood and pellets) is another source of energy in Bonfield. Because Bonfield consumes energy in buildings and transportation, the existing buildings and infrastructure in the community have the most impact on energy consumption. Information collected from Bonfield's administration personnel about the community's infrastructure has guided this report.

Most of the residential buildings in Bonfield are single detached houses, with a small percentage of attached or duplex homes. Electricity is used for lighting, electric equipment, ventilation, minor cooling, and most of the domestic hot water (90%) in this sector. Most of the space heating in these buildings is achieved through fuel oil and propane, with firewood typically used for supplementary heating. There has been a notable shift in recent years from fuel oil to propane for space heating, which represents a transition to a lower greenhouse gas emitting fuel. At the time of producing this report, the breakdown of energy consumption used for residential space heating by fuel type is: 70% propane, 21% fuel oil, and 9% electricity. It is estimated that almost 50% of the residential houses have wood stoves that are used occasionally for heating and as a backup source of heating with minor contribution to energy consumption.

The other remaining 3% of the buildings in the Township are commercial including the municipal buildings. The commercial buildings in the community are presented in Table 18 (refer to Appendix A). The five municipal buildings use electricity and propane. The other (approximately 30 buildings) commercial or institutional buildings use oil, propane and electricity.

Bonfield's transportation sector is another area that adds to the overall energy consumption. The proximity of Bonfield to North Bay, which is where many Bonfield residents commute for work and access educational and recreational facilities, increases the overall fuel consumption.

2.1.1 Electricity

Hydro One Limited (HOL) supplies electricity to the Township. Electricity generation from HOL is provided through the Ontario power grid, which has decarbonized significantly since the early 2000s with its move to remove coal from its supply mix. Biomass power plants, wind farms, solar farms and hydroelectric generation have also been increasing sources of clean power production. These

nuclear plants are aging and require refurbishment. As this is a costly undertaking, Ontario is considering investing in more sustainable energy production. It is also possible that the decreased nuclear production is supplemented with increased natural gas generation, which would increase the Ontario grid's GHG emissions.

The electricity consumption in the Township is shown in Figure 2: 90% of electricity consumption is attributed to the residential buildings, 9.4% of the electricity consumption is attributed to the commercial buildings (including the municipal buildings), and 0.44% of the electricity consumption is attributed to others (mostly street lighting).

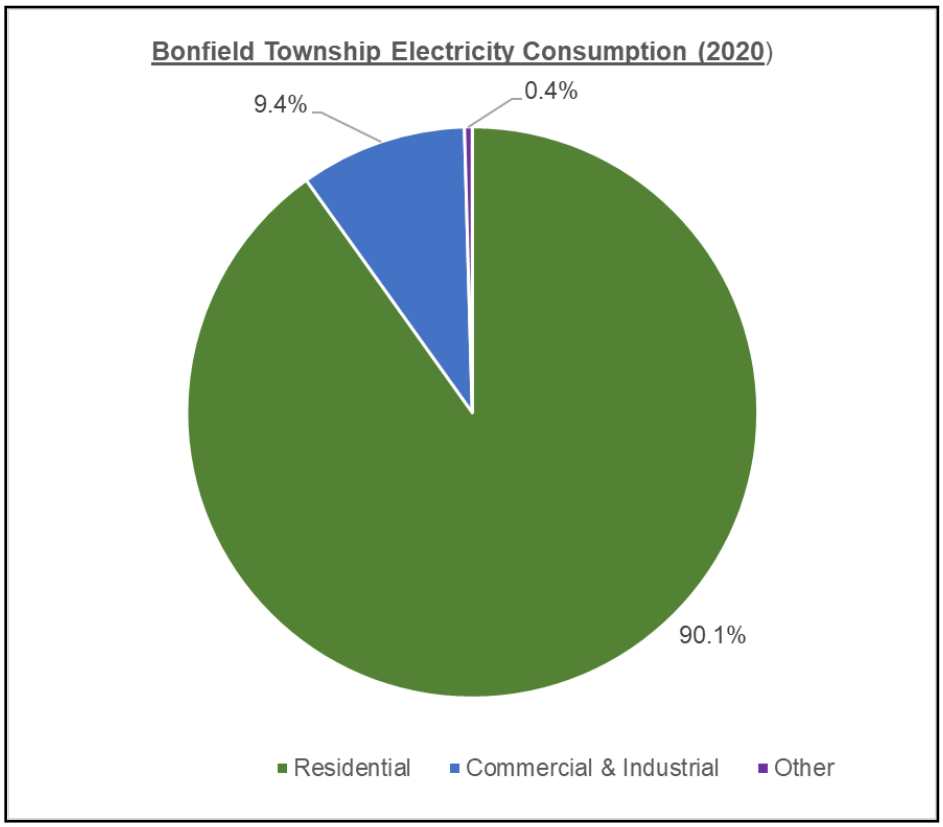


Figure 2: Electricity Consumption Distribution in Bonfield

The portion attributed to commercial buildings includes the municipal buildings; the HOL data of electricity consumption in Municipal buildings for 2019 indicates that municipal buildings only account for 1.25% of the Township's overall electricity consumption.

Also, the electricity consumption of the street lighting (2019) (collected data from HOL) accounts for 0.37% of the total electricity consumption of the Township (which is associated in Figure 2 with "other" portion in 2020 consumption).

As the largest electricity consuming sector in Bonfield is residential buildings, this will influence the measures that are suggested in the municipal energy plan to reduce energy consumption in the Township.

Electricity consumption in Bonfield was further analyzed and is presented in Figure 3 below. Note that the consumption drops in the summer and increases in the winter months. Monthly electricity consumption for residential buildings only is shown in

Figure 4.

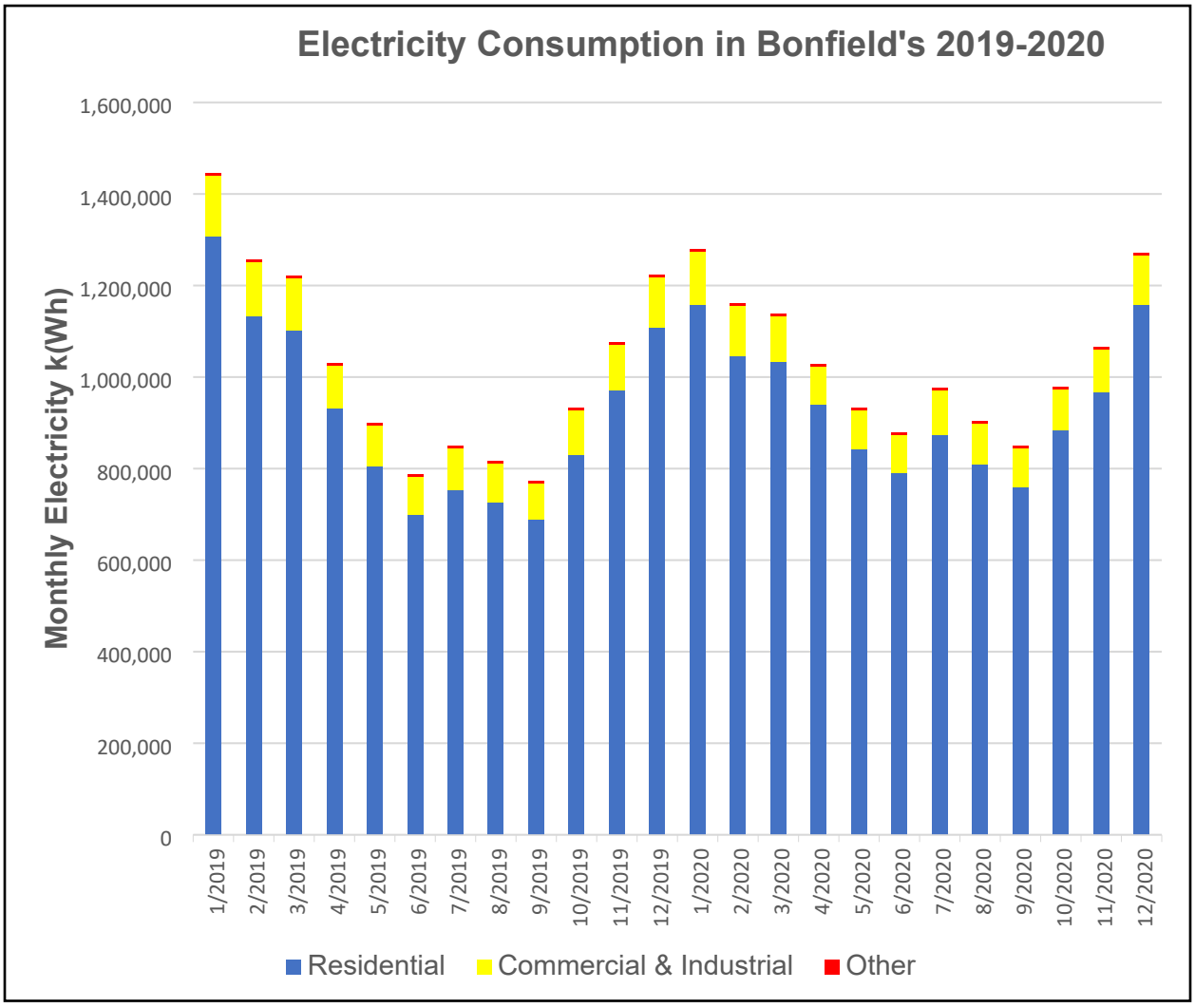


Figure 3: Bonfield Monthly Electricity Consumption for 2019-2020

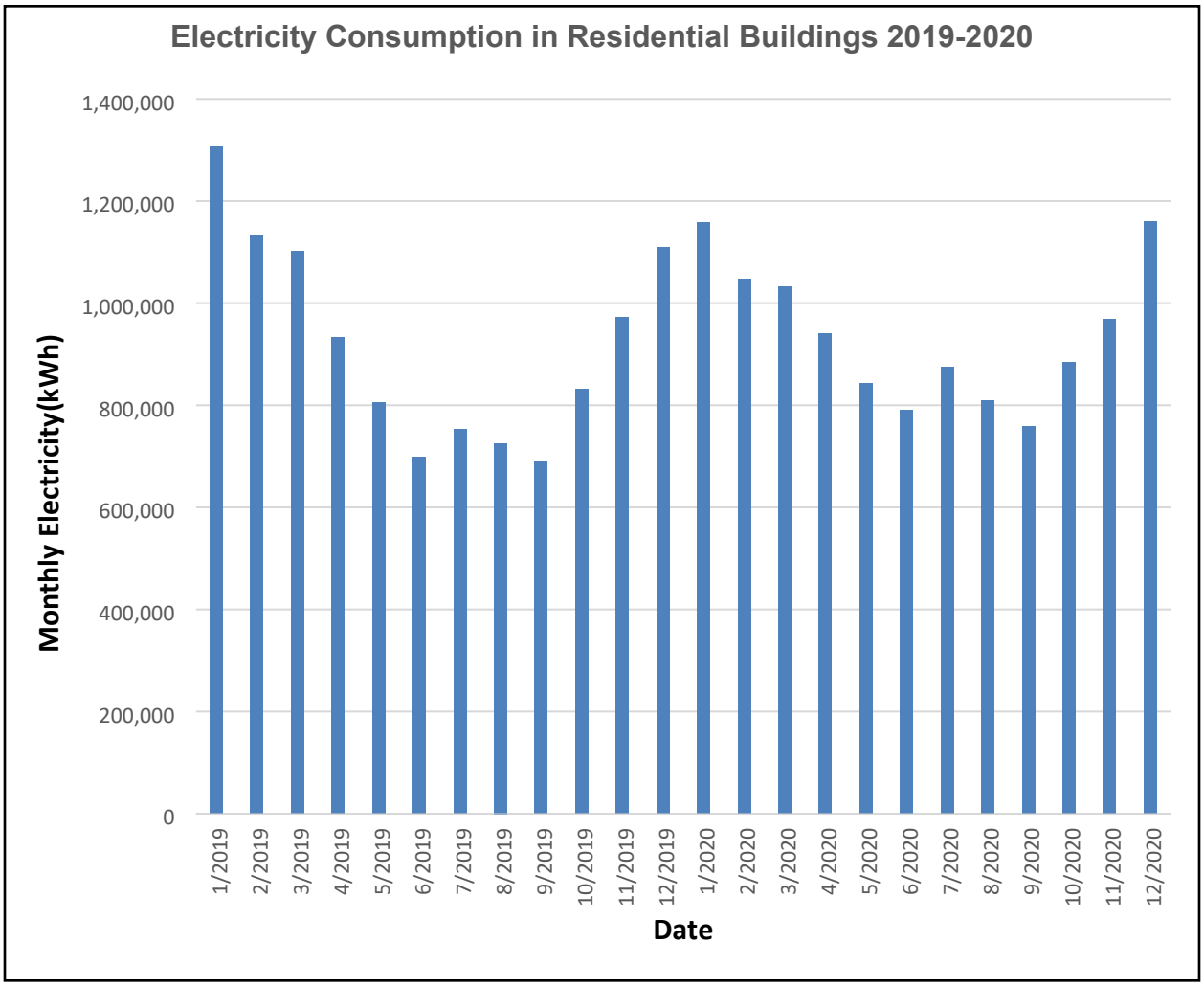


Figure 4: Monthly Electricity Consumption in Residential Buildings in Bonfield

Electricity consumption is higher in the winter than in spring and summer due to increased use of hot water, space heating and lighting. The summer data shows July electricity consumption to be higher than August. Although August is hotter than July and this usually triggers higher electricity consumption for cooling in August. This might show that the cooling is not a significant influence on the electricity consumption. This odd increase in electricity consumption in July relative to August is potentially attributed to higher use of the seasonal cottages in July. At the same time August electricity consumption is still slightly higher than in June, this might be linked to less frequent use of cottages in early summer.

Electricity consumption for all buildings in Bonfield, as provided by Hydro One for a typical year (2019), is presented in Table 1; note that Table 19 (refer to Appendix A) contains the detailed monthly consumption of electricity in Bonfield collected from Hydro One).

Table 1: Annual Electricity Consumption Breakdown for Bonfield (2019)

	Electricity Consumption in Residential Buildings	Electricity Consumption in Commercial Buildings	Electricity Consumption in Others (representing street lighting)	Total Electricity Consumption
kWh/year	11,057,262	1,197,262	54,635	12,309,159
Percentage	90%	10%	0.4%	100%

2.1.2 Fuel Oil and Propane

Many buildings in Bonfield Township consumed fuel oil for heating. Most of the buildings in the Township had fuel oil furnaces, but in recent years, due to the awareness of greenhouse gas emissions, and financial incentives, many homeowners have been shifting their furnaces from oil to propane. Although fuel oil has higher thermal efficiency compared to propane, the efficiency of the fuel oil furnaces is lower than the propane furnaces. At the same time, propane produces less carbon dioxide than fuel oil per litre (1.5 $kgCO_2$/litre of propane vs. 2.7 $kgCO_2$/litre fuel oil). In addition, propane furnaces are cheaper than oil furnaces and cost less to install and maintain. With all this said, since 2018 there has been an increase in the consumption of propane as a heating fuel and a proportional decrease in fuel oil use in Bonfield.

As of the date of this study, 70% of the residential buildings, all municipal buildings (the five buildings mentioned in the previous section) and most of the other commercial buildings consume propane for space heating. Fuel oil is still consumed by 21% of the residential buildings and some of the commercial buildings other than the municipal buildings. Nine percent of the residential buildings and a small percentage of the commercial buildings consume electricity for space heating.

The companies that supply the Township with fuel oil and propane are presented in Table 2.

Table 2: Fuel Companies Supplying Bonfield Township

Oil Companies	Propane Companies
Jim Moore Petroleum	Moore Propane
Blue Wave Energy	Superior Propane
Co-op Régionale	n/a
Grant Fuels	Grant Fuels
McDougall Energy	McDougall Energy

Aggregate data of fuel consumption for the Township was not made available for this study, only municipal buildings' fuel consumption was available. Fuel use for residential buildings was determined through benchmarking.

Using the municipal buildings' fuel consumption data, the shift from fuel oil solely to a mixed use of propane and fuel oil was notable in 2018 and 2019. In 2021, the five municipal buildings had completely shifted to propane for space heating (data for 2020 and 2021 fuel consumption was not available at the date of producing this report). Once the new data of consumption of fuel for the Municipal buildings of 2020 is available, the total propane shift in the buildings would present the actual current comparison.

Figure 5 shows the breakdown of annual fuel consumption and fuel and its energy from 2017 to 2019.

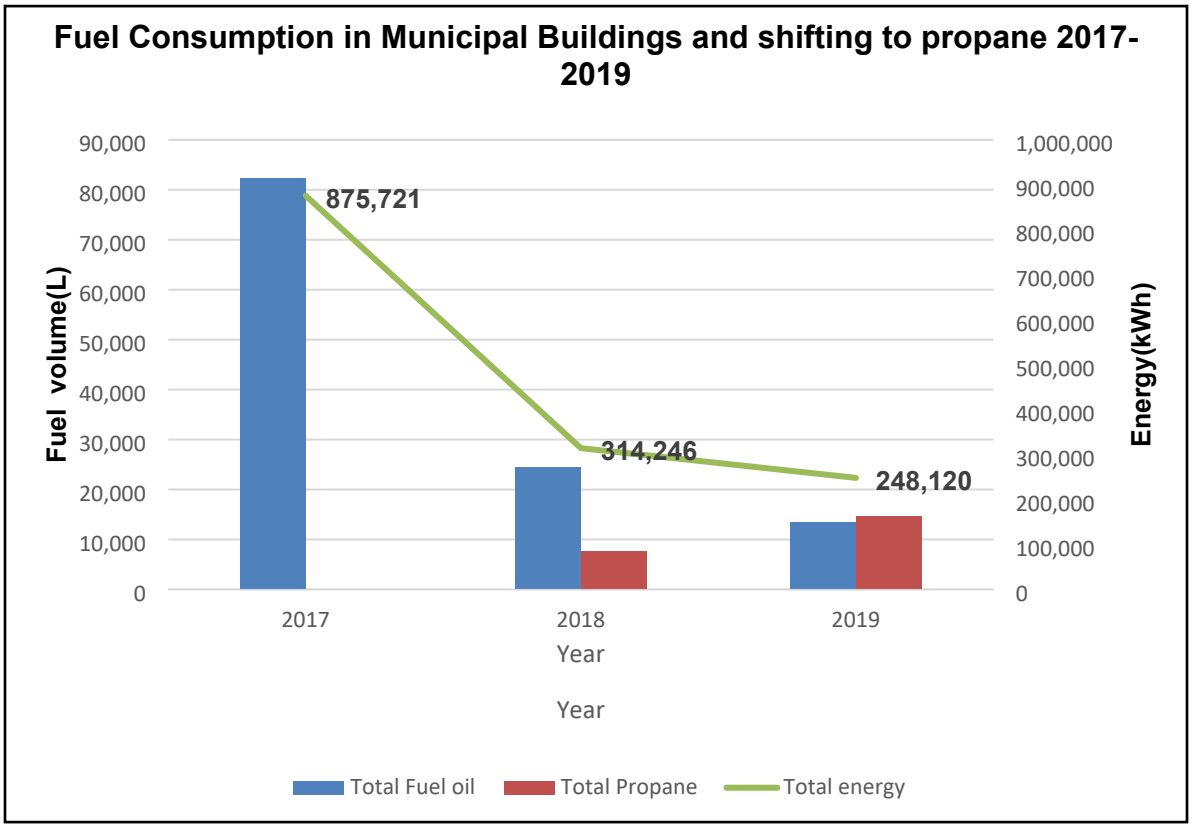


Figure 5: Breakdown of Fuel Consumption in Municipal Buildings between 2017-2019

The figure above shows the annual consumption of fuel oil and propane (for space heating) and the equivalent energy for the municipal buildings from 2017-2019.

The energy consumption for these municipal buildings will be studied in a separate energy audit.

With a lack of aggregate annual fuel consumption data for the Township, building on JLR's experience in energy consumption in existing residential and commercial buildings, the estimate of the aggregate energy use of the buildings of Bonfield was produced. Aggregate electricity consumption for most buildings in Bonfield was

provided by Hydro One. This section will estimate the energy consumption for space heating in all buildings of Bonfield (commercial and residential). Then the energy consumption from the two categories (electricity and fuel) will be added to get the aggregate energy consumption in the Bonfield Buildings. Note that, due to the lack of fuel data, there will be some variabilities from the actual aggregate consumption and its associated greenhouse gas emissions.

2.1.2.1 Summary of Residential Buildings' Energy Consumption

Electricity consumption in residential buildings was available from HOL. Since the fuel consumption in residential buildings is not available, an estimate of energy consumption in residential buildings is produced. An average house of the age of houses in Bonfield is estimated to have the breakdown of energy consumption presented below. It is worthy to mention that these values are estimates with a level of deviation from the actual fuel consumption depending on the actual conditions of the houses. In the following estimation, all houses considered in the study, (1122 houses), are considered of same conditions and an average area of 120m^2. This area was estimated in consultation with the Township and this value was in general agreement with our observations during the study.

EUI (energy use intensity) = 235 kWh/m^2 year (electric and fuel)
Electricity Consumption = 65 kWh/m^2 year
Fuel Consumption = 170 kWh/m^2 year

- Wood stove energy consumption was considered negligible as it was used only as a backup source of heating and minor use.

Table 3: Aggregate Fuel Consumption in Bonfield's Residential Buildings

Average Fuel Consumption in Residential Buildings kWh/m^2year	Bonfield Aggregate Fuel Consumption for all Residential Buildings kWh/year
170	22,888,800

2.1.2.2 Summary of Commercial Buildings' Energy Consumption

EUI = 375 kWh/m^2 year (electric and fuel)
Electricity Consumption = 115 kWh/m^2 year
Fuel Consumption = 260 kWh/m^2 year

The ratio of fuel to electricity consumption from the municipal buildings was estimated to also be representative of energy use in all commercial type buildings; this ratio was 30% electricity and 70% fuel. This ratio is combined with the known value for electricity consumption in commercial buildings to estimate the aggregate energy consumption of fuel in

commercial buildings. Estimation is based on the following values: 375 kWh/m^2 year is the EUI for commercial buildings, which includes 115 kWh/m^2 year for electricity and 260 kWh/m^2 year for fuel (heating).

All the buildings available in the Township are presented in Table 18 (refer to Appendix A) along with their areas (collected from Google Earth). Using the above EUI, the annual energy consumption for space heating in commercial buildings based on consumption per area multiplied by the area of each building. The fuel consumption that was available for the 5 municipal buildings (available from the Township) was added to the commercial buildings' energy consumption and produced the aggregate fuel energy consumption in all commercial and municipal buildings in Bonfield. The results of the aggregate fuel consumption for commercial buildings is presented in Table 4 below (Table 18 in Appendix A has the list of commercial buildings of Bonfield).

Table 4: Aggregate Fuel Consumption in all Bonfield Commercial Buildings

Average Fuel Consumption in Commercial Buildings kWh/m^{2}year	Aggregate Fuel Consumption for all Commercial Buildings kWh/year
260	1,888,979

Adding the Residential and the Commercial energy consumption for space heating resulted in the aggregate energy consumption of all buildings in Bonfield from fuel (space heating). Then adding Bonfield aggregate energy consumption for space heating (fuel), and the aggregate energy consumption for electricity, produced Bonfield Aggregate energy consumption from Buildings. These results are presented in Table 5.

Table 5: Aggregate Energy Consumption in Bonfield Buildings

Aggregate Electric Consumption for all Buildings kWh/year	Aggregate Fuel Consumption for all Residential Buildings kWh/year	Aggregate Fuel Consumption for all Commercial Buildings kWh/year	Aggregate Energy Consumption in all Buildings kWh/year
12,309,159	22,888,800	1,888,979	37,086,938

The aggregate energy consumption for the Township from all buildings was **37,087** MWh/year. The fuel consumption from transportation will be added it to this figure and reach the Aggregate Energy Consumption of the Township.

The figure below presents the breakdown of energy consumption in Bonfield buildings. Taking into consideration that 97% of the buildings in the Township are residential, Figure 6 shows that 62% of the aggregate energy consumed in buildings of Bonfield is for space heating and 30% for electricity consumption of residential buildings. This is an important detail in the energy saving measures that will be studied in the Municipal Energy Plan.

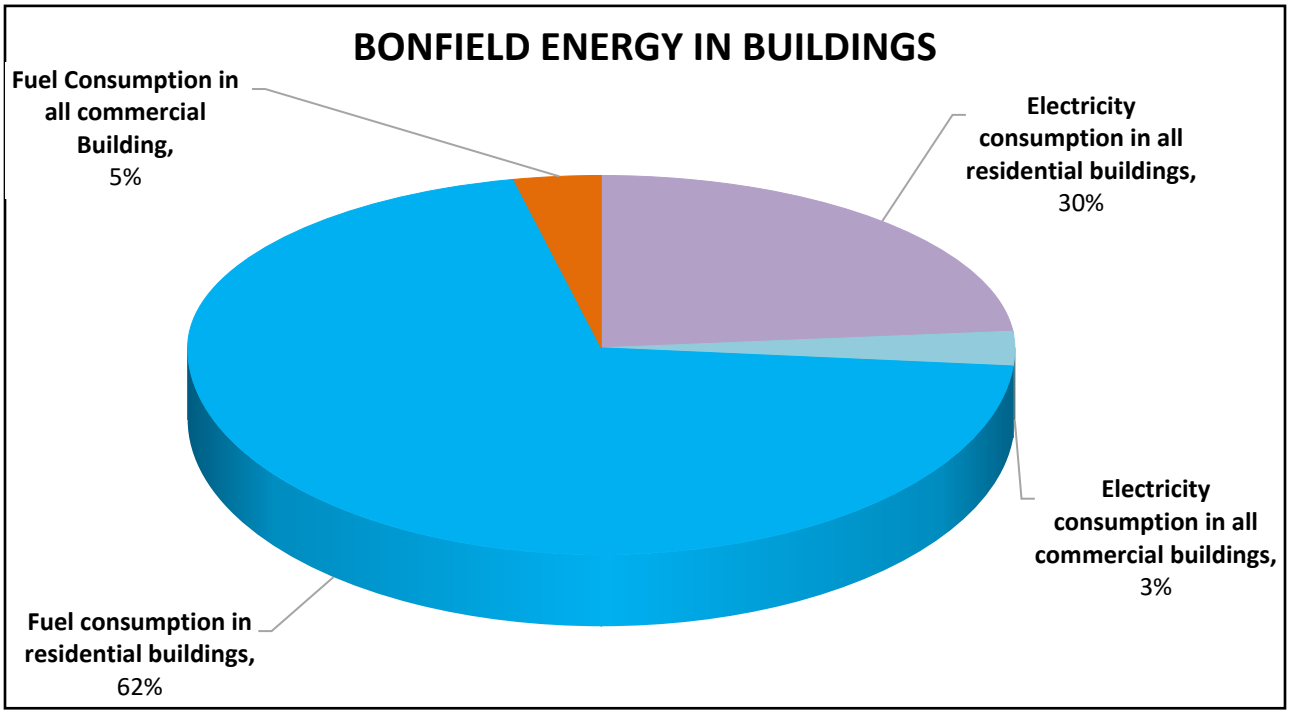


Figure 6: Breakdown of Energy Consumption in all Bonfield Buildings

2.1.3 Transportation

The Township consumes fuel in the transportation sector. The fuel consumed by vehicles in Bonfield are organized into three categories: private cars, municipal fleet cars, and other fleet cars that would be counted as the school buses. This is an estimation as the actual number of cars of Township residents was unavailable. The number of municipal fleet vehicles and school buses were reported by the Township. The following estimation excludes: vehicles passing through the Township, delivery vehicles based outside the Township and farming vehicles.

This study of the transportation energy consumption is not built on the actual liters of fuel consumed per year by all types of vehicles in the Township, as it was not available. It is an estimation and there would be some deviation from the actual situation.

2.1.3.1 Private automobiles

The number of private cars in the Township was estimated at 2,244 cars (i.e., an average of two cars per household), with the average mileage on private cars considered as 22,000 km/year. The mileage on private cars was estimated based on Bonfield being a rural area in Ontario and in consultation with the Township. It is estimated as per FWHA that a private car travels an average of 36 km/gallon. Using the energy contents in fuels that is available in Table 20 (refer to Appendix A) and considering the private cars consume gasoline, energy consumption in private cars is shown in Table 6 below.

Table 6: Annual Fuel and Energy Consumption in Private Cars in Bonfield

Gasoline litres per year for each Private Car	Total number of Private Cars	Gasoline total litres/year for all Private Cars	Total annual energy consumed by Private Cars kWh/year
2,316	2,244	5,196,632	**49,896,342**

2.1.3.2 Municipal fleet cars:

The annual consumption of diesel and gasoline by all the municipal fleet cars was provided by the Township for this study. Adding the annual consumption of fuel and getting the energy content in the total volume of different types of fuel (gasoline and diesel), as per Table 20 (refer to Appendix A), resulted in the total volume of fuel and the total energy consumption per the municipal fleet cars shown in Table 7.

Table 7: Annual Fuel and Energy Consumption in Municipal Fleet Vehicles for Bonfield

Type of Fuel	Annual Volume of fuel consumed by Municipal Fleet Vehicles litres/year	Total energy consumption for Municipal Fleet Vehicles kWh/year
Diesel	65,976	711,050
Gasoline	11,646	111,969
Total		**823,019**

2.1.3.3 School buses:

It was estimated by the Township that there is an average of 15 buses traveling on school days around Bonfield. The average kilometers of a school bus per year in Ontario is estimated to be 50,000 km/year/bus. The average fuel efficiency of a school bus is almost 14 km/gallon diesel, using Ontario averages.

From this and typical energy content in fuels (refer to Appendix A Table 20), we estimated the aggregate annual energy consumption by school buses in Bonfield to be as shown in Table 9 below.

Table 8: Annual Fuel and Energy consumption in school buses in Bonfield

Average distance traveled (km/year/bus)	Number of buses	Total distance by buses (km/year)	Average fuel for a bus (km/litres of diesel)	Annual volume of diesel fuel by buses (litres/year)	Annual energy by buses (kWh/year)
50,000.0	15.0	750,000.0	3.8	197,368.4	2,124,308.4

Adding the energy consumption by all the three categories of transportation vehicles in Bonfield, we established the aggregate fuel energy consumed annually in the transportation sector that is presented in Table 10 below.

Table 9: Aggregate Annual Energy Consumption from fuel in Transportation sector in Bonfield

Annual energy consumption by Private Cars (MWh/year/Township)	**49,896**
Annual energy consumption by Municipal fleet vehicles (MWh/year/Township)	823
Annual energy consumption by buses (MWh/year/Township)	2,124
Aggregate annual energy consumption in transportation (MWh/year)	**52,844**

The total energy consumption in Transportation in Bonfield is **52,844 MWh/year.** The numbers that are presented in Table 9 were used to generate the proportion of transportation consumption by the three categories shown in Figure 7. The figure emphasizes the bigger proportion of energy consumption of fuel in the private cars in the Township. These details will also be considered in the Municipal Energy Plan that will be produced based on this Baseline Energy Report.

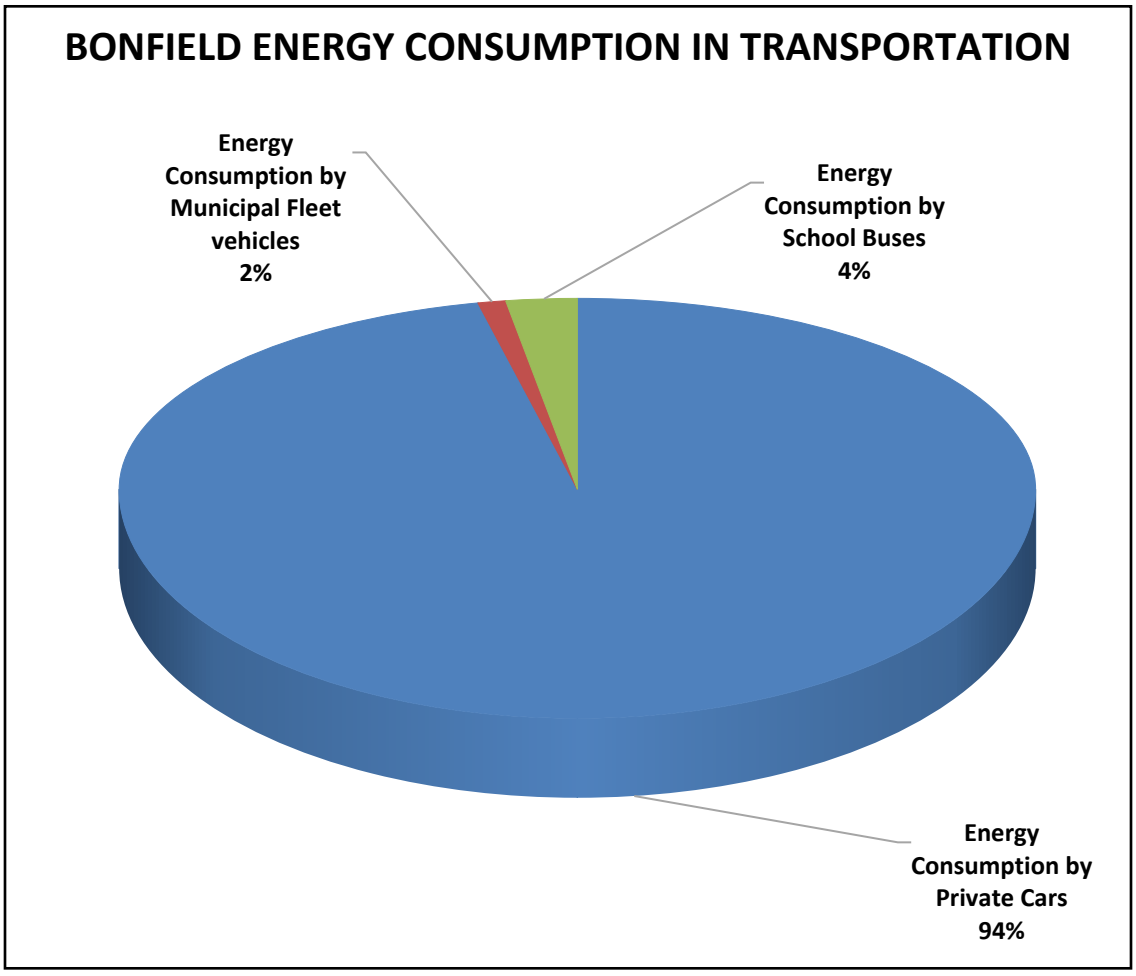


Figure 7: Breakdown of Energy Consumption from fuel in all vehicles in Bonfield

2.1.4 Aggregate Bonfield Baseline Energy Consumption

Bonfield Township consumes energy in the form of electricity and fuel for buildings and transportation.

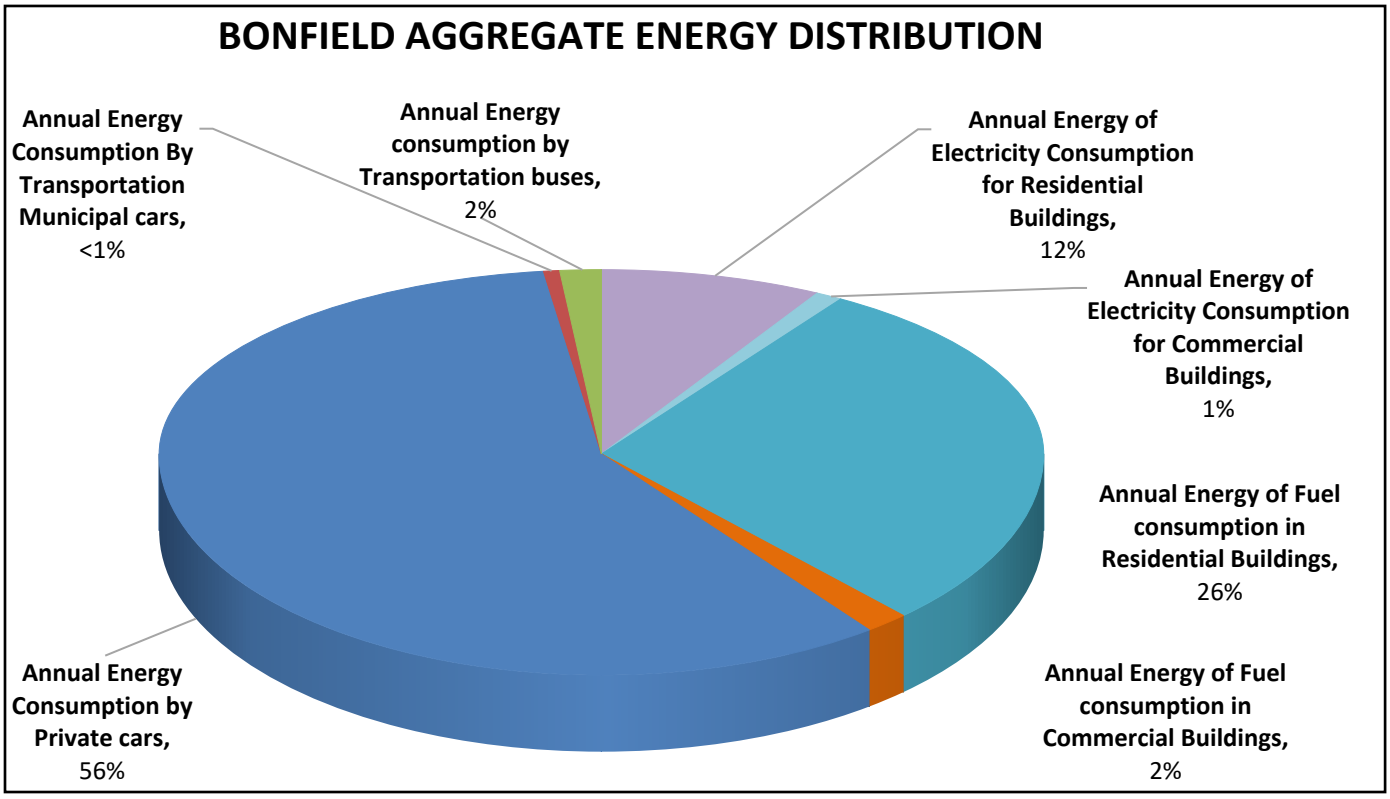
Adding the energy consumption in the buildings to the energy consumption in the transportation sector will get us to the Aggregate Annual Energy Consumption in Bonfield. This is presented in Table 11.

Table 10: Bonfield Aggregate Annual Energy Consumption

Bonfield Aggregate Annual Energy Consumption in Buildings (MWh/year)	Bonfield Aggregate Annual Energy Consumption by Fuel in Transportation (MWh/year)	Bonfield Aggregate Annual Energy Consumption Bonfield Baseline Energy Consumption (MWh/year)
37,087	52,844	89,931

The aggregate energy consumption in Bonfield is estimated at 89,900 MWh/year. 59% of energy consumption is in the transportation sector and 41% in the building sector. A more detailed breakdown is shown in Figure 8.

Figure 8: Aggregate Annual Energy Consumption Breakdown in Bonfield Township



2.2 Greenhouse Gas Emissions

Total greenhouse gas (GHG) emissions are determined from the fuel consumption of the previous section. Using the emission factors from the Canadian National Inventory Report and considering all the greenhouse gas emissions (methane, nitrogen oxides, etc.) converted to equivalent of tons of CO2, it's all summed up in a single unit of tCO2.

Bonfield has three categories producing GHG emissions:

1) Fuel and electricity consumption in buildings for space heating (propane, fuel oil and electricity).
2) Electricity consumption from the Ontario grid for use in all buildings (all other uses than space heating).
3) Fuel consumption in the transportation sector (diesel and gasoline).

1) Emissions from Fuel Consumption in buildings for space heating (propane and fuel oil)

Aggregate energy consumption from fuel for space heating in residential and commercial buildings was estimated in section 2.1.2 and was presented in Table 5. As noted, space heating for residential and commercial buildings is estimated to be 70% propane, 21% fuel oil, and 9% electricity.

Using Table 20 (refer to Appendix A), which provides the energy contents in each unit volume of fuel (refer to Enbridge energy contents in fuel [3]), we estimated the average volume of each fuel (propane and oil fuel). Carbon dioxide emissions by each fuel and energy source were estimated using Tables 21, 22, 23, and 24 in Appendix A (Energy Star portfolio management report[4]). The results were produced in Tables 11 and 12 shown below.

Table 11: Aggregate Volumes of Fuels Consumed in Space Heating and GHG Emissions for Residential Buildings

Heating Method	Percentage of Total	Annual Energy Consumption (kWh)	Fuel Volume (litres)	GHG Emissions (tCO2e)
Propane	70	16,022,160	2,261,133	3,500
Fuel Oil	21	4,806,648	452,178	1,249
Electric	9	2,059,992	n/a	41
Total tCO2e from space heating in Residential buildings				**4,790**

Table 12: Aggregate Volume of Different Fuels Consumed in Space Heating of Bonfield's Commercial Buildings and its GHG Emissions

Heating Method	Percentage of total	Annual Energy Consumption (kWh)	Fuel Volume (litres)	GHG Emissions (tCO2e)
Propane	70	1,322,285	186,608	289
Fuel Oil	21	39,668,559	3,731,755	10,311
Electric	9	17,000,811		340
Total				**10,940**

Table 13: Aggregate GHG emissions from space heating in Building sector

Heating Methods in Buildings	Aggregate GHG Emissions (tCO_2e)	Percentage of total
Propane	3,789	24%
Fuel Oil	11,560	74%
Electric	381	2%
Total	**15,731**	100%

The aggregate carbon emissions from the space heating by different energy sources in buildings of Bonfield (electricity, propane, and fuel oil) is shown in Figure 9.

Figure 9: Breakdown of carbon emissions from space heating by different energy sources of Bonfield Buildings

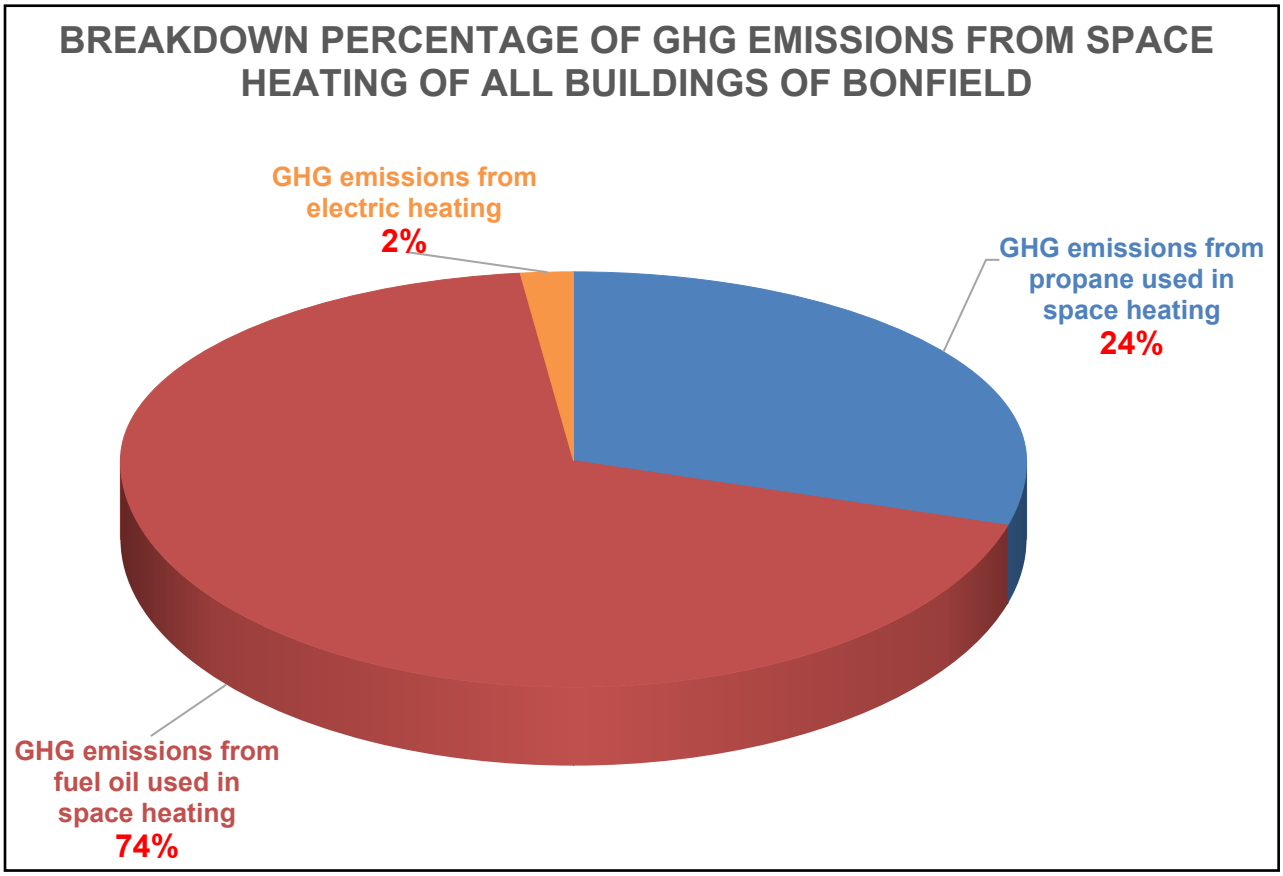


Figure 9 shows the highest proportion of carbon emissions in building space heating to be related to fuel oil (74%), which is particularly notable because only 21% of the buildings use fuel oil. This is due to the lower thermal contents in fuel oil compared to propane per unit volume (10.63 kWh/litre of fuel oil, 7.08 kWh/litre propane) and the higher carbon emissions from fuel oil than propane per unit volume (2.76 $kgCO_2$/litre fuel oil, 1.548 $kgCO_2$/litre propane). A further 24% of carbon emissions derive from propane.

2) Electricity Consumption from the Ontario grid for all buildings and street lighting

Bonfield consumes electricity from the grid in commercial and residential buildings for usage in all demand other than space heating (except a minor use of electricity in heating), and in some street lighting (as shown in Table 1). Table 21 (refer to Appendix A) is used for estimating the carbon emissions from the electricity grid in Ontario. It is estimated to be 20 gCO_{2e}/kWh.

With the aggregate electricity consumption of the Township presented in Table 1, and the carbon emission per kWh, we estimated the total emission from electricity consumption of Bonfield as shown in Table 14.

Table 14: Aggregate GHG emissions from Electricity Consumption in Bonfield Building sector

Aggregate Electricity Consumption in building sector kWh/year	GHG emissions from Electricity consumption in buildings (tCO2e)
12,309,159	246

3) Fuel Consumption in the transportation sector (diesel and gasoline)

Transportation in Bonfield is the third factor in carbon emissions for the Township. Adding the total volumes of diesel and gasoline, we can estimate the carbon emissions based on Table 22 (refer to Appendix A) that presents 2.7 $kgCO_2$/litre of diesel and 2.31 $kgCO_2$/litre of gasoline. The results are presented in Table 15.

Table 15: Aggregate GHG emissions from Transportation in Bonfield

Fuel Consumption in Transportation	Volume (litres/year)	Breakdown of GHG emissions in Transportation (tCO2e)
Gasoline use by private cars (litres/year)	5,196,632	**12,004**
Diesel use by Municipal fleet (litres/year)	65,976	**178**
Gasoline use by Municipal fleet (litres/year)	11,646	**27**
Diesel use by buses (litres/year)	197,368	**533**
Total	5,471,622	**12,742**

Adding all the carbon emissions from the above three categories, the aggregate figure of GHG emissions in tons of CO_2 annually produced in Bonfield is shown in Table 16.

Table 16: Annual Aggregate GHG emissions by total energy consumption in Bonfield

GHG emissions for space heating of Buildings (tCO2e)	**15,731**
GHG emissions for Electricity consumption in Buildings (tCO2e)	246
GHG emissions for Transportation (tCO2e)	12,742
Total Annual GHG emissions by energy consumption (tCO2e)	28,719
GHG emissions per Capita (tCO2e/capita)	14.4

The above figures in Table 16 are presented in the following pie chart. Figure 10 below presents the percentage of carbon emissions by building sector versus the carbon emission by the transportation sector.

The percentages show 45% of the Bonfield carbon emissions are due to transportation **(12,742 tCO_{2e})**; and 55% of the carbon emissions are due to buildings energy consumption **(15,977 tCO_{2e})**. This demonstrates slightly higher contribution of CO_{2e} emissions from the Buildings in Bonfield than the Transportation of Bonfield population.

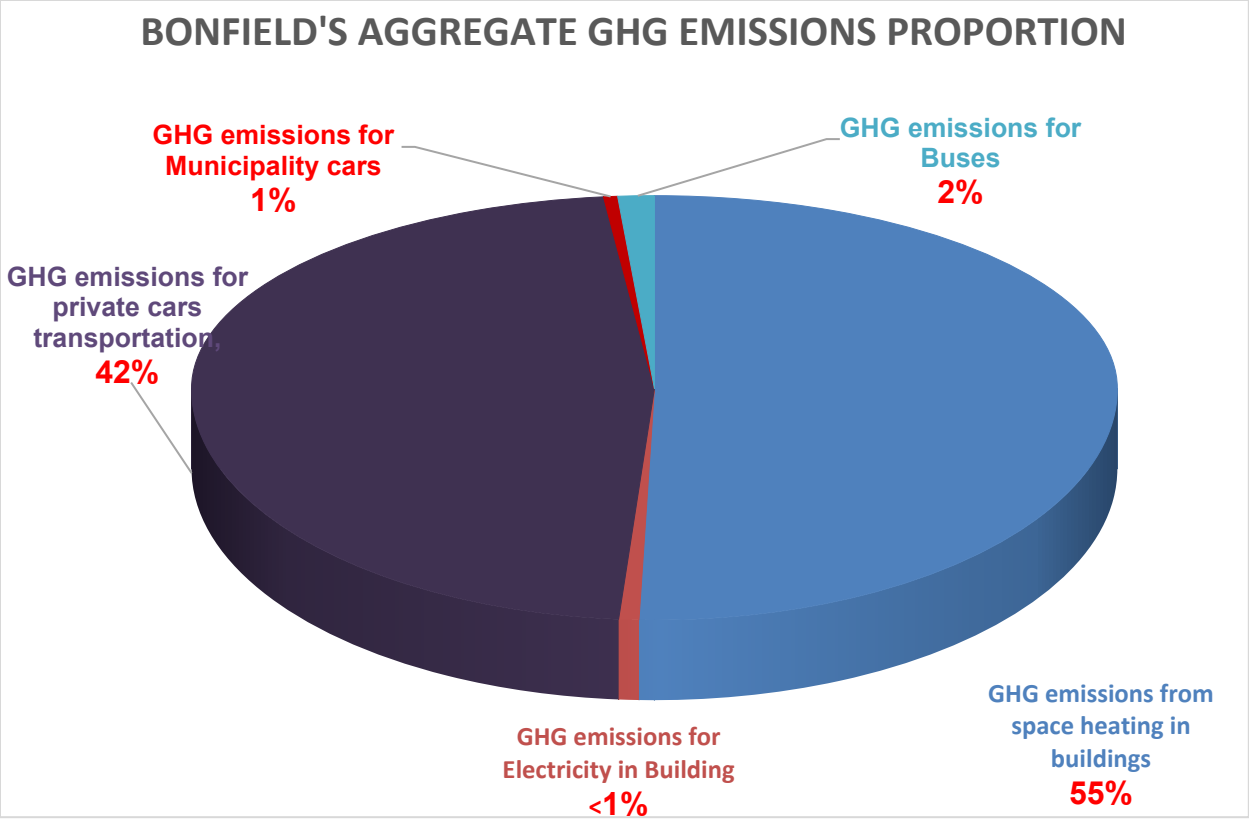


Figure 10: Percentage of GHG emissions Transportation by the aggregate energy consumption of Buildings and of Bonfield

It is worth mentioning that the Aggregate energy consumption in Bonfield's buildings was estimated to be 41% of the total Township's energy while the Aggregate energy consumption in transportation was estimated to be 59% of the total Township's energy. On the other hand, the emissions associated with that energy was estimated to be 56% emissions from Bonfields' buildings and 45% emissions from Bonfield's transportation out of the total Township's emissions.

As shown in Table 16, the greenhouse gas emissions per capita in Bonfield is estimated to be 14.4 tons of carbon equivalent. Comparing the carbon emissions per capita of Bonfield to the carbon emissions per capita of Ontario and other Canadian provinces is done using Figure 11.

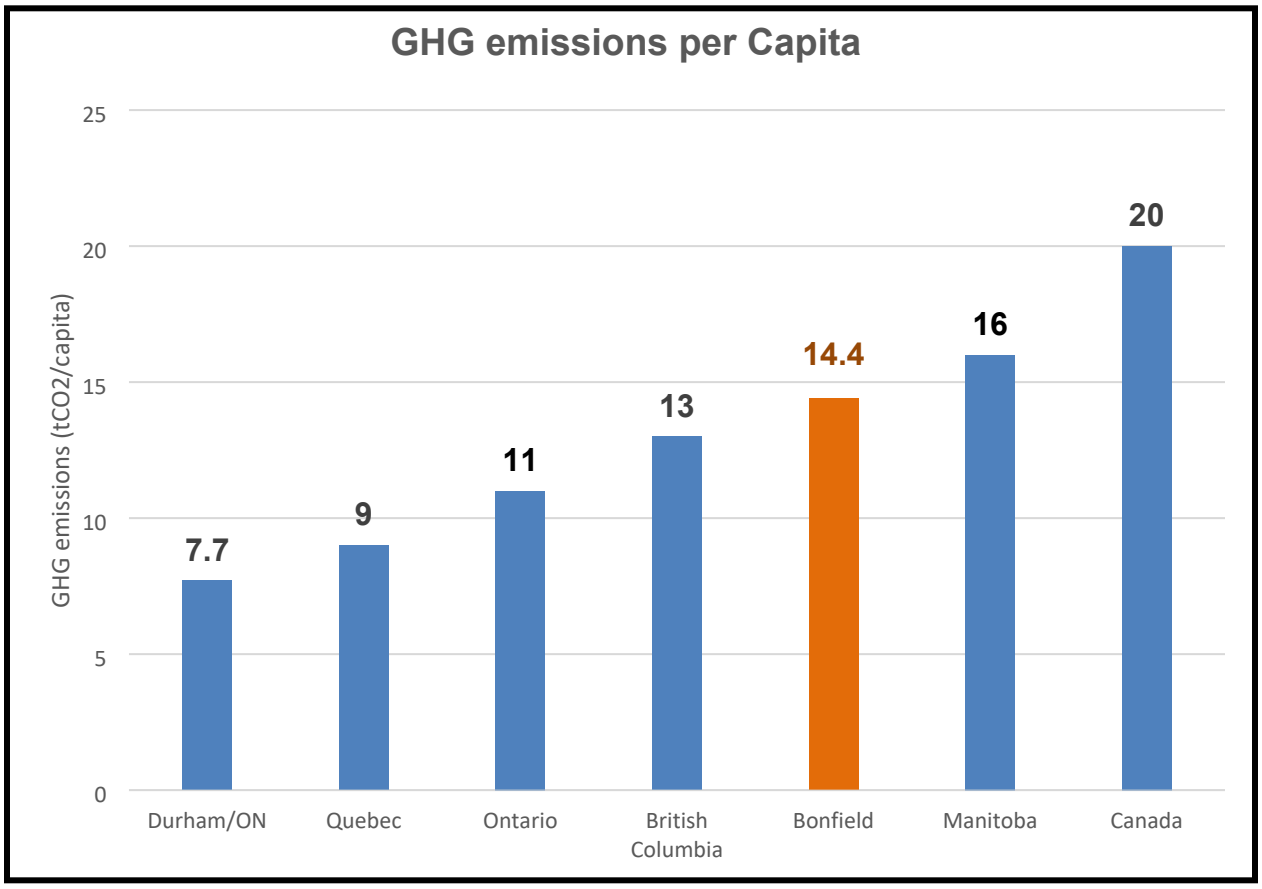


Figure 11: GHG Emissions per Capita of Bonfield relative to other Townships in Ontario, and other Canadian Provinces

The values of the carbon emissions per capita for other Townships in Ontario were collected from the Township's Municipal Plans (2016). Carbon emissions per capita in other provinces of Canada's, carbon emissions in other Townships, and the carbon emission in Canada were collected from a report [5] and Table 25 (refer to Appendix A) that were validated by National Inventory Report for greenhouse gas sources [6].

Figure 11 shows that the emissions per capita in Bonfield is 46% higher than other Townships in Ontario and 23% more than Ontario's emissions per capita. This might be associated with the old buildings condition and fuel oil and propane consumption in space heating compared to natural gas in the urban areas of Ontario. Another factor in the increase of emissions of Bonfield relative to Ontario is the fuel consumption in private cars since the Township is mostly residential buildings and minor commercial building use. This explains that more residents would be using cars in rural areas such as Bonfield. Comparing Bonfield emissions to other provinces' emissions can depend on the electricity production grid emissions by each province. Also, comparing Bonfield's greenhouse gas emissions per capita to Canada's emissions per capita shows close values. Another factor that could contribute to the difference of emissions per capita in the above values of Figure 11 may be associated to different sources and methodologies used in the estimation of emissions by different firms and reports.

3.0 Conclusion

This report developed the Baseline Energy Consumption of Bonfield for 2019. This is the basis that will build the Municipal Energy Plan and the measures that will be considered to reach the greenhouse gas emission reduction target.

- The annual energy consumption in Bonfield for 2019 was **89,931 MWh/year**, where the transportation sector consumes 59% of the total Township's annual energy and the buildings sector consumes 41% of the total Township's energy (largest contributor was residential buildings).
- The GHG emissions associated with the total energy consumed in 2019 was **28,719 tCO_{2e}** where 45% of the emissions were associated to transportation (largest contributor was private cars) and 55% of the emissions were associated with the buildings sector.
- The GHG emissions per capita for 2019 was estimated to be **14.4 tons of CO_{2e} per capita**.
- The Township is assumed to have no local energy production, and all its energy consumption is imported and supplied by providers (Hydro One and fuel companies).

This report was produced based on the data collected and engineering experience in building field to get the most realistic estimation. More accurate results would be expected if fuel consumption data were made available.

The survey results weren't considered in the analysis of this report as there were not enough contribution to build on related conclusions to support the study.

4.0 References

1. Township of Bonfield – Official Plan and Zoning By-law Review 2011-2012 Background Report.

2. http://www.ieso.ca/Learn/Ontario-Supply-Mix/Ontario-Energy-Capacity.

3. https://www.uniongas.com/business/save-money-and-energy/analyze-your-energy/energy-insights-information/conversion-factors.

4. Greenhouse Gas Inventory and Tracking in Portfolio Manager (energystar.gov).

5. Ontario's Plan to Reduce Greenhouse Gas Emissions (auditor.on.ca)

6. National Inventory Report 1990–2017: Greenhouse Gas Sources and Sinks in Canada: Executive Summary.

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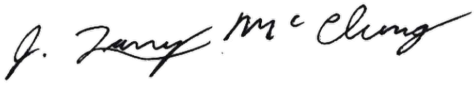

Larry McClung, P.Eng.
Chief Energy Systems Engineer

APPENDIX A

Additional - energy consumption
and greenhouse gas emissions

Table 18: List of Buildings in Bonfield

	Establishment Name	Establishment Type	Address	Community	Postal Code	Total Floor Area (m^2)
1	Municipal: Fire Station No. 1	Fire station and associated offices and facilities	107 Railway Street	Bonfield	P0H 1E0	774
2	Municipal: Post office (in the Fire Hall 1 building)	Post office	107 Railway Street	Bonfield	P0H 1E0	-
3	Municipal: Fire Station No. 2	Fire station and associated offices and facilities	440 Rutherglen Line	Rutherglen	P0H 2E0	178.5
4	Municipal: Medical Center/Office/Exam Rooms	Ambulance station and associated offices and facilities	105 Landon Street	Bonfield	P0H 1E0	104.5
5	Municipal: Public Library	Public library	365 ON-531	Bonfield	P0H 1E0	450
6	Municipal: Bonfield Twp. Garage - City government office	Garage	356 Line 3 S	Bonfield	P0H 1E0	420
7	St. Margaret's Anglican Church	Church	1376 Hwy 17, 1376 Hwy 17	Rutherglen	P0H 2E0	260
8	Paroisse Ste. Bernadette	Church	408 Gagnon St	Bonfield	P0H 1E0	668
9	Mount Pleasant United Church - United Church of Canada	Church	1050 Trunk Road	Rutherglen	P0H 2E0	110
10	Caisses: C P De Bonfield Ltee - Caisses Populaires	Financial company	230 Yonge St	Bonfield	P0H 1E0	272
11	Caisses: LCBO (same area as Caisses Populaires)	Liquor store	230 Yonge St	Bonfield	P0H 1E0	155
12	Caisses: Rollys Pitstop (same area as Caisses Populaires)	Restaurant	230 Yonge St	Bonfield	P0H 1E0	-
13	Flee Market	Flee Market belongs to Gagne	1381 Hwy 17	Bonfield	P0H 1E0	-
14	Gagne Home improvement (including post office, fast food, hardware store, gas station, convenience store)	Hardware & Convenience Store	1402 Hwy 17	Rutherglen	P0H 2E0	676
15	Country Style (it is part of Gagne store)	Fast food and coffee kiosk	1402 Hwy 17 E Gagne's Red and White	Rutherglen	P0H 2E0	-
16	Gagne: Gas station	Gas station	1402 Hwy 17	Rutherglen	P0H 2E0	-

	Establishment Name	Establishment Type	Address	Community	Postal Code	Total Floor Area (m^2)
17	Gagne: Tricker's Treats	Fast food diner	5 Gagne St	Rutherglen	P0H2E0	80
18	Lorraine Catholic School	School	245 Yonge St	Bonfield	P0H 1E0	1900
19	Dinner Bell Motel	Motel/ Restaurant	4 ON-531	Bonfield	P0H 1E0	700
20	Yogi Bar	Restaurant	309 Church St	Bonfield	P0H 1E0	150
21	Kwik-way close to yogi bar almost same building	Convenience store	309 Church St	Bonfield	P0H 1E0	150
22	Sampson Sales	Equipment store	104 Levesque St,	Bonfield	P0H 1E0	320
23	Ontario Dock Ltd. Workshop	Workshop	617 Hwy 17	Rutherglen	P0H 1E0	-
24	Toners Welding	Welding Shop / sanitation for septic tanks	79 Hwy 17	Bonfield	P0H 1E0	200
25	Northern Motorsports Neighborhood Event Park	Racetrack	357 Development Rd	Bonfield	P0H 1E0	-
26	Reptile Camp	Kids day camp	2101 S Shore Rd,	Bonfield	P0H 1E0	290
27	Hunting Gear	Hunting tools store	1442 Hwy 17	Bonfield	P0H 1E0	150
28	Sunny Side Resort	Resort and camping ground	128 Sunnyside Rd	Bonfield	P0H 1E0	-
29	Talon Lake Campground & Marina	Camp and swimming pool	185 Talon Lake Rd	Rutherglen	P0H 1E0	-
30	Lions Club	Service hall	350 Line 3S	Bonfield	P0H 1E0	230
31	Community Hall (Parish Hall belongs to the Paroisse Church)	Has a large kitchen	408 Gagnon St	Bonfield	P0H 1E0	-
32	Permanent Residential houses	**1122 houses**	-	Bonfield & Rutherglen	P0H 1E0& P0H2E0	-
33	Seasonal Residential houses	**153 houses**	-	Bonfield & Rutherglen	P0H 1E0& P0H2E0	-

Table 19: Monthly Electricity Consumption in Bonfield Buildings 2019

Hamlet	Postal Code	Sector	Monthly Energy (KWH) in 2019													Percentage of consumption of electricity by sector
		Sector	1/2019	2/2019	3/2019	4/2019	5/2019	6/2019	7/2019	8/2019	9/2019	10/2019	11/2019	12/2019		
Bonfield	P0H1E0	Residential	861,656	752,058	737,101	627,999	544,607	473,160	508,965	494,087	472,978	563,726	658,135	745,298		
		Commercial & Industrial	86,259	75,560	72,298	59,027	57,165	50,835	52,007	50,078	48,188	65,950	62,666	68,190		
		Other	4,233	3,779	4,388	4,076	4,052	4,206	4,193	4,065	4,105	4,226	4,017	3,982		
Rutherglen	P0H2E0	Residential	446,130	381,230	365,057	304,152	260,128	224,821	244,097	231,523	216,402	267,126	313,488	363,340		
		Commercial & Industrial	47,089	42,215	42,052	33,632	31,930	34,189	39,103	36,433	31,138	32,088	36,651	42,520		
		Other	463	442	498	463	459	444	437	421	438	463	404	382		
Monthly Total kWh			**1,445,829**	**1,255,284**	**1,221,395**	**1,029,348**	**898,340**	**787,655**	**848,801**	**816,606**	**773,249**	**933,579**	**1,075,361**	**1,223,712**		
Annual Residential Total kWh															11,057,262	89.83%
Annual Commercial Total															1,197,262	9.73%
Annual Other Total kWh															54,635	0.44%
Annual Aggregate Electricity Consumption kWh (2019)															12,309,159	

Table 20: Energy Contents in Different Fuel Types

Energy Source	Unit	Energy Content (*Btu*)
Electricity	1 Kilowatt-hour	3412
Butane	1 Cubic Foot (cu.ft.)	3200
Coal	1 Ton	28000000
Crude Oil	1 Barrel - 42 gallons	5800000
Fuel Oil no.1	1 Gallon	137400
Fuel Oil no.2	1 Gallon	139600
Fuel Oil no.3	1 Gallon	141800
Fuel Oil no.4	1 Gallon	145100
Fuel Oil no.5	1 Gallon	148800
Fuel Oil no.6	1 Gallon	152400
Diesel Fuel	1 Gallon	139000
Gasoline	1 Gallon	124000
Natural Gas	1 Cubic Foot (cu.ft.)	950 - 1150
Heating Oil	1 Gallon	139000
Kerosene	1 Gallon	135000
Pellets	1 Ton	16500000
Propane LPG (Liquid Petroleum Gas)	1 Gallon	91330
Propane gas 60°F	1 Cubic Foot (cu.ft.)	2550
Residual Fuel Oil [1)]	1 Barrel - 42 gallons	6287000
Wood - air dried	1 Cord	20000000
Wood - air dried	1 pound	8000

Table 21: Carbon Emissions by Electricity in Canadian Provinces

Indirect GHG Emissions Factors for Electricity in Canada

Province	CO_{2eq} Emissions (kg/MBtu)	CO_{2eq} Emissions (g/kWh)
Alberta	231.54	790.0
British-Columbia	2.99	10.2
Manitoba	0.56	1.9
New Brunswick	76.20	260.0
Newfoundland and Labrador	11.72	40.0
Northwest Territories	46.89	160.0
Nova Scotia	213.95	730.0
Nunavut	222.74	760.0
Ontario	5.86	20.0
Prince Edward Island	76.20	260.0
Quebec	0.41	1.4
Saskatchewan	211.02	720.0
Yukon	16.41	56.0
National Average	**41.03**	**140.0**

Table 22: Carbon Emissions by Different Fuel Types in Canada

Climate Change.[10]

Figure 1 – Direct GHG Emissions Factors for the U.S. and Canada

Fuel Type	CO_{2eq} Emissions			
	United States	Canada		
	(kg/MBtu)	(kg/MBtu)	(g/L)	(kg/tonne)
Natural Gas	53.11		*By Province*	
Propane	64.25	64.52	1,548	-
Fuel Oil (No. 1)	73.50	75.13	2,763	-
Fuel Oil (No. 2)	74.21	75.13	2,763	-
Fuel Oil (No. 4)	75.29	75.13	2,763	-
Fuel Oil (No. 5,6)	75.35	78.86	3,176	-
Diesel Oil	74.21	74.09	2690	-
Kerosene	77.69	71.96	2,570	-
Coal (anthracite)	104.44	94.76	-	2,488
Coal (bituminous)	94.03	100.36	-	2378
Coke	114.42	116.36	-	3,180

Table 23: Carbon Emissions by Natural Gas in Canadian Provinces

Direct GHG Emissions Factors for Natural Gas by Canadian Province

Province	CO_{2eq} Emissions (kg/MBtu)	CO_{2eq} Emissions (g/m^3)
Alberta	53.24	1,939
British-Columbia	53.19	1,937
Manitoba	52.09	1,897
New Brunswick	52.50	1,912
Newfoundland and Labrador	52.50	1,912
Northwest Territories	52.50	1,912
Nova Scotia	52.50	1,912
Nunavut	52.50	1,912
Ontario	52.14	1,899
Prince Edward Island	52.50	1,912
Quebec	52.12	1,898
Saskatchewan	50.53	1,840
Yukon	52.50	1,912

Table 24: Carbon Emissions by Different Fuel Types

Fuel type	Kg of CO2 per unit of consumption
Grid electricity	43 per kWh
Natural gas	3142 per tonne
Diesel fuel	2.68 per litre
Petrol	2.31 per litre
Coal	2419 per tonne
LPG	1.51 per litre

Table 25: Carbon Emissions in Canadian Provinces

	Population (000)	Emissions per Capita (t)	Total Emissions (Mt)
World	7,426,103	6	47,200
G20 Members			
China	1,378,665	9	12,700
United States	323,071	20	6,570
European Union	511,219	9	4,353
India	1,324,510	2	2,870
Russia	144,342	18	2,670
Japan	126,995	10	1,310
Brazil	206,163	5	1,050
Germany	82,349	11	918
South Korea	51,246	14	732
Mexico	123,333	6	718
Canada	**36,109**	**20**	**716**
Saudi Arabia	32,443	21	676
Indonesia	261,554	3	674
Australia	24,191	23	552
South Africa	56,204	9	531
Turkey	79,821	6	504
United Kingdom	65,596	8	494
France	66,860	7	468
Italy	60,627	7	433
Argentina	43,590	8	334
Canadian Provinces and Territories			
Alberta	4,244	64	273
Ontario	**14,071**	**11**	**159**
Quebec	8,298	9	78
Saskatchewan	1,151	68	78
British Columbia	4,922	13	62
Manitoba	1,335	16	22
Nova Scotia	951	16	16
New Brunswick	767	19	14
Newfoundland and Labrador	529	20	11
Prince Edward Island	151	12	2
Yukon	40	13	1
Nunavut	38	16	1
Northwest Territories	45	28	1

* Note: Per capita emissions are in tonnes per person. Data is from 2017 for Canadian jurisdictions, and from 2016 for G20 countries and the world.

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