BURNSIDE

Community Energy Plan

Volume 1
Comprehensive Report

Township of Mulmur

June 2020

BURNSIDE

Community Energy Plan
CEP Volume 1: Comprehensive Report

Township of Mulmur
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Glossary

Term	Description
BEV	Battery Electric Vehicle.
CHAdeMO	CHArge de Mode.
CEP	Community Energy Plan.
CO2	Carbon Dioxide.
CO2e & CO2eq	Carbon dioxide equivalent is a measure to compare the emissions from various greenhouse gases based on their global warming potential. E.g.: this means that emissions of 1 million metric tons of methane is equivalent to emissions of 21 million metric tons of carbon dioxide.
CCS	Combined Charging Stations.
DC quick chargers	Direct current quick charging.
EV	Electric Vehicles.
GHG	Greenhouse Gases.
GJ	Gigajoule (unit of measurement for power).
GJ/M^2	Gigajoules per meter squared.
GMC	General Motors Company.
HDD	The number of degrees of temperature difference between a base temperature (usually 18°C) and the mean daytime outside temperature on any given day.1
HPS Bulbs	High Pressure Sodium Bulbs.
IEAP	International Emissions Analysis Protocol.
kW	Kilowatt (unit of measurement for power)
kWh	Kilowatt / hour (unit of measurement for power)
LED	Light Emitting Diode
MEP	Municipal Energy Plan
MPAC	Municipal Property Assessment Corporation
NRCan	Natural Resources Canada
ROI	Return on Investment
°C	Degrees Celsius (unit of measurement for temperature)

1 Building Codes and Standards. (2015). Retrieved from NAIMA Canada: http://www.naimacanada.ca/for professionals/buildinginsulation/codes-standards/

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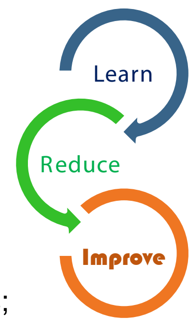
1.0 Introduction

1.1 Purpose of the Community Energy Plan (CEP)

The purpose of the Community Energy Plan is to develop a set of guidelines and goals that will help the Mulmur community and its municipal government:

- Improve energy efficiency;
- Reduce energy consumption and greenhouse gas emissions;
- Study the impact of future growth on energy needs; and
- Foster renewable energy production and economic development.



The CEP process evaluates a community's existing energy use and it's associated greenhouse gas (GHG) emissions in order to:

- Determine community-wide energy consumption and GHG emissions; and
- Identify and implement solutions to improve energy efficiency and conservation.

R.J. Burnside & Associates Limited (Burnside) in partnership with the Township of Mulmur (Mulmur) have created this CEP. The plan will be used as a reference tool to track and compare Mulmur's energy consumption and emissions in future years and set goals for reduction of GHG emissions. This plan will also serve as a tool for educational purposes and the report will provide a place to obtain additional information for the public. Mulmur and Burnside wishes to acknowledge funding provided by the Federation of Canadian Municipalities and the Ontario Ministry of Energy without which this important work would not have been possible.

1.2 Background

Mulmur is a unique rural community within Dufferin County. Mulmur is a hub for ecological activity, located on the Ontario Greenbelt with both the Niagara Escarpment and the Nottawasaga watershed. Flourishing farmlands surrounded by forested corridors cover the Township. It is a destination for weekend tourists, country cottagers, and city commuters. This agriculture-based Township has built a thriving economy.

The Township of Mulmur comprises a number of villages and hamlets. The largest by population are Honeywood and Mansfield.

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1.1

1.3 Demographics

Table 1-1: The Township of Mulmur's Historical Demographics[2]

Township of Mulmur	2016	2011	2006
Population	3,478	3,391	3,318
Land Area	286.77 km^2	286.73 km^2	286.73 km^2
Population Density	12.1/km^2	11.8/km^2	11.6/km^2
Median Age	47.9	45.2	42.3
Total Private Dwellings:	1,678	1,643	1,479
Median Household Income	$97,344.00	n/a	n/a

Table 1-2: Mulmur's Historical Population Demographics

Year	Population	Population Growth Rate
1991	2,591	-
1666	2,903	12.00%
2001	3,099	6.80%
2006	3,318	7.10%
2011	3,391	2.20%
2016	3,478	2.60%

Table 1-3: Mulmur's Gender Demographics

Gender (2016)	
Males	1,795
Females	1,680

Table 1-4: Mulmur's Age Groups

Age Groups (2016)	
0-17 years	635
18-64 years	2,220
65+	625

2 Mulmur's Demographic data was supplied by Statistics Canada and MPAC.

1.4 Objective

1.4.1 Community Energy Plan Vision (CEP)

This CEP captures Mulmur's energy use and provides a strategic plan on how to move towards a more sustainable energy system while reducing climate changing greenhouse gas (GHG) emissions. The CEP will make recommendations and outline actions to bring financial, social, and environmental benefits to the community. This study identified energy consumption and the associated GHG emissions by the community. It documents the sectors which are consuming the most and the least energy. It provides information on the GHG emissions associated with this energy consumption. The CEP's purpose is to guide the community on actions that can be taken to achieve both energy and GHG reduction goals. Goals and targets for reduction have been recommended in this report will need to be approved by Council following public review of the CEP reports.

The CEP will act as a baseline for monitoring if the goals and targets to reduce energy use and GHG emissions are being met. With increased energy cost, and global temperatures rising it is critically important for each community member to be informed of your individual roll to help mitigate our impact on the environment.

1.4.2 Mulmur 2040 Vision Statement

> *"By no later than 31/12/2040 the Municipality of Mulmur will have achieved Net Zero GHG Emissions from the engagement/participation of 95 % residents including Business Owners. The Municipality of Mulmur will be recognized among the top 10 [or better] in the Province for energy related GHG emission reduction."*

1.5 Study Limitations

This report follows the guidelines of the International Emissions Analysis Protocol (Canadian Supplement). However, because this report is focused on energy consumption and the associated GHG emissions other emission sources not directly associated with energy consumption have not been recorded. Examples of GHG emissions not captured in this study include the following sources:

- Waste and waste management;
- Livestock, enteric emission and manure management;
- Biomass burning;
- Harvesting wood products;
- Soil management, fertilization, liming, pesticides *except for emission released indirectly from machinery;
- GHG sinks such as forested areas;
- Emissions from leaks or spills; and
- Industrial processing and product use.

1.6 Greenhouse Gas

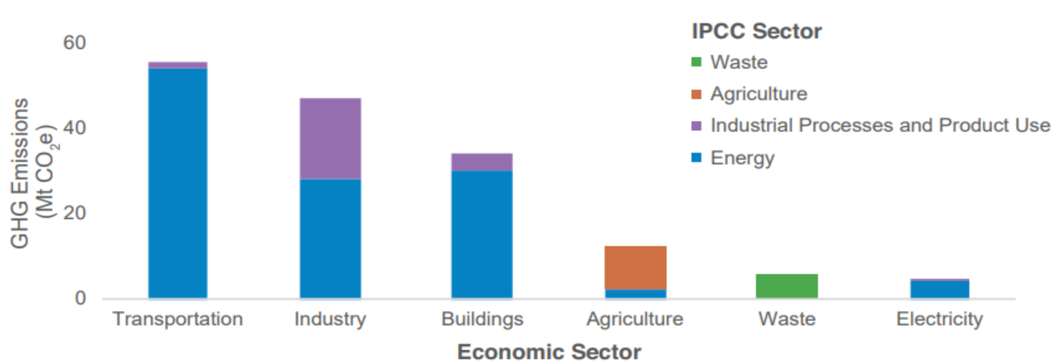
1.6.1 Why Track Greenhouse Gases?

A global climate crisis is occurring. The Canadian House of Commons passed a motion to declare a national climate emergency[3]. Immediate action is required to combat the effects of anthropogenic (originating from human activity) climate change. According to Lawrence National Centre for Policy and Management,[4]

> *"Canada's greenhouse gas (GHG) emissions currently represent about 1.6 % of the global total. Canada is among the top 10 global emitters and one of the largest developed world per capita emitter of GHGs (Canada stands firmly in the top 3 for emissions per capita). Canadian federal governments have committed to reduce annual GHG emissions from the current level of 726 mega tonnes (Mt) to 622 Mt in 2020 and 525 Mt in 2030. Within Canada, GHG emissions vary widely across provinces ranging from 267 Mt in Alberta to 1.8 Mt in PEI in 2013. In per capita terms, Saskatchewan and Alberta are among the developed world's largest emitters at 68 and 67 tonnes respectively. Per capita emissions in BC, Ontario, and Quebec are in the 10 to 14 tonne range, comparable to best performers in Western Europe."*

Figure 1-2 shows GHG emissions released in Canada by economic sector. Mulmur's CEP studies focus on the emission released from energy (blue bars below). Noted GHG emissions from energy encompasses about 78% of all global emissions (Natural Resources Canada, 2019).

Figure 1-2: (Environment and Climate Change Canada)



3 House of Commons, Motion Government Business No. 29 (National climate emergency).

4 "By the Numbers Canadian GHG Emissions", Paul Boothe and Félix-A. Boudreault Lawrence National Centre for Policy and Management, Ivey Business School at Western University, 2016.

Global goals have been set to reduce our emissions, the Paris Agreement being the most notable, which aims to keep global climate below 2° based on 1950's preindustrial levels. In Canada almost all territories and provinces agreed to the Pan-Canadian Framework on Clean Growth and Climate Change. Each community must do its part to reduce GHG levels.

This report follows the guidelines of the Canadian Supplement to the International Emissions Analysis.

Figure 1-3: History of Global CO2 Levels[5]

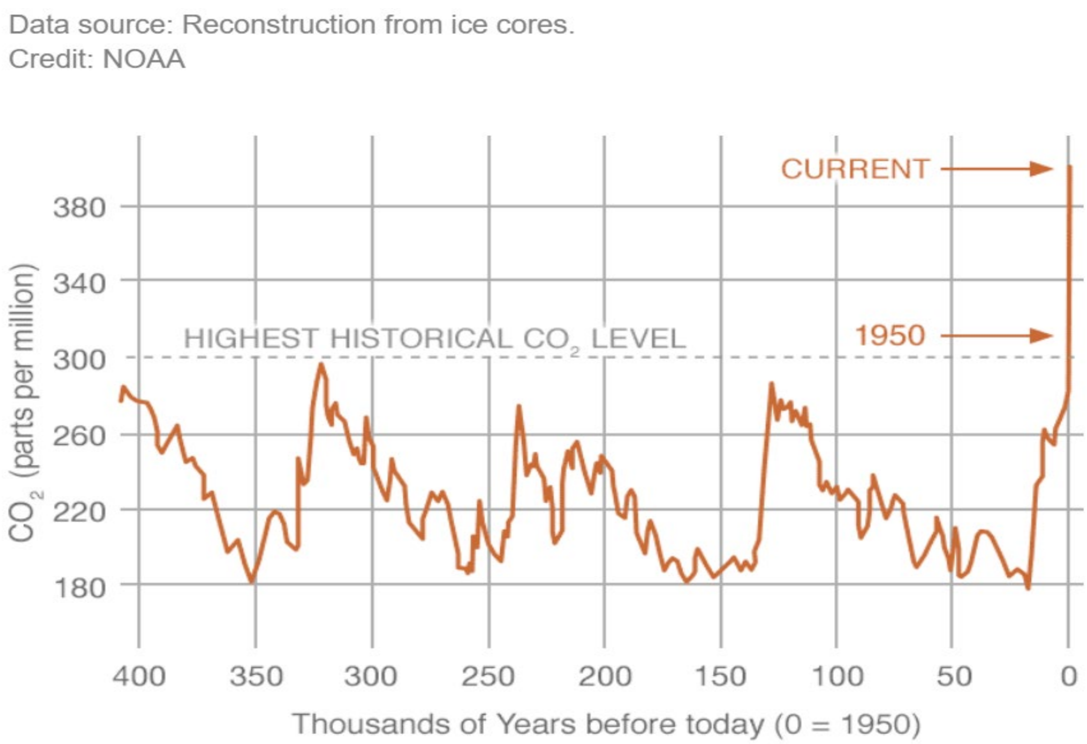


Figure 1-3 displays the levels of carbon dioxide through history bring attention to the spike in CO2 levels from 1950 to present. Global temperature increases and decreases for thousands of years have mirrored these CO2 levels.

5 NASA. (2019, May 17). Carbon Dioxide. Retrieved from Global Climate Change Vital Signs of the Planet: https://climate.nasa.gov/vital-signs/carbon-dioxide/

Study Protocols

The International Local Government Greenhouse Gas Emissions Analysis Protocol (IEAP) is resource for local governments to use when tracking GHG emissions and creating a standard for GHG recording. Though this report is energy focused, the IEAP structure was a suitable guide to follow, due to the correlation between energy use and greenhouse gas emissions. Because of this correlation, Mulmur's CEP has the added benefit of providing an inventory for greenhouse gases released from energy consumption.

1.6.2 The Climate Emergency

Readers may have noted the recent action by 11,000 of scientists from all over the world to issue a call to all of us and in particular governments worldwide to take immediate and decisive action to stop climate change. They state in their opening paragraph,

> *"**Scientists have a moral obligation** to clearly warn humanity of any catastrophic threat and to "tell it like it is." On the basis of this obligation and the graphical indicators presented below, we declare, with more than 11,000 scientist signatories from around the world, clearly and unequivocally that planet Earth is facing a climate emergency.*[6]

It is an important document and we urge readers to read it.

Many municipalities in Canada (recently Collingwood) along with our Federal Government and the European Union have made similar declarations. Mulmur may wish to consider a similar declaration. Burnside presents some very positive actions in our recommendations that may be taken locally to help achieve the objectives noted earlier in this study to reduce energy consumption s and prevent climate change.

Based on the most recent Canadian Government Report we must act quickly to prevent any further increases in GHG production and dramatically reduce levels in the atmosphere as quickly as possible. Although this report is focused on energy consumption one of the principle drivers for the CEP and programs is climate change. Burnside thought it was important to provide the following headline statements quoted from the most recent report released by the Canadian government. Please note the reference sections in the quote below refer to the Canadian report not this CEP. We encourage readers to read the full report for details. To view the full report, visit: www.ChangingClimate.ca/CCCR2019.

"CANADA'S CHANGING CLIMATE REPORT – HEADLINE STATEMENTS[7]

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6 William J Ripple, Christopher Wolf, Thomas M Newsome, Phoebe Barnard, William R Moomaw, World Scientists' Warning of a Climate Emergency, BioScience, biz088, https://doi.org/10.1093/biosci/biz088

7 Canada's Changing Climate Report, CCCR 2019 - See www.ChangingClimate.ca/CCCR2019.

*These headline statements tell a concise story about Canada's changing climate based on the findings of this report. The statements are cross-referenced to specific sections in chapters of the main report, where supporting evidence is found. There is **high confidence or more** associated with these statements, which are consistent with, and draw on, the Chapter Key Messages.*

Canada's climate has warmed and will warm further in the future, driven by human influence. *Global emissions of carbon dioxide from human activity will largely determine how much warming Canada and the world will experience in the future, and this warming is effectively irreversible. {2.3, 3.3, 3.4, 4.2}*

Both past and future warming in Canada is, on average, about double the magnitude of global warming. *Northern Canada has warmed and will continue to warm at more than double the global rate. {2.2, 3.3, 4.2}*

Oceans surrounding Canada have warmed, become more acidic, and less oxygenated, consistent with observed global ocean changes over the past century*. Ocean warming and loss of oxygen will intensify with further emissions of all greenhouse gases, whereas ocean acidification will increase in response to additional carbon dioxide emissions. These changes threaten the health of marine ecosystems. {2.2, 7.2, 7.6}*

The effects of widespread warming are evident in many parts of Canada and are projected to intensify in the future. *In Canada, these effects include more extreme heat, less extreme cold, longer growing seasons, shorter snow and ice cover seasons, earlier spring peak streamflow, thinning glaciers, thawing permafrost, and rising sea level. Because some further warming is unavoidable, these trends will continue. {4.2, 5.2, 5.3, 5.4, 5.5, 5.6, 6.2, 7.5}*

Precipitation is projected to increase for most of Canada, on average, although summer rainfall may decrease in some areas. *Precipitation has increased in many parts of Canada, and there has been a shift toward less snowfall and more rainfall. Annual and winter precipitation is projected to increase everywhere in Canada over the 21st century. However, reductions in summer rainfall are projected for parts of southern Canada under a high emission scenario toward the late century. {4.3}*

The seasonal availability of freshwater is changing, with an increased risk of water supply shortages in summer*. Warmer winters and earlier snowmelt will combine to produce higher winter streamflows, while smaller snowpacks and loss of glacier ice during this century will combine to produce lower summer streamflows. Warmer summers will increase evaporation of surface water and contribute to reduced summer water availability in the future despite more precipitation in some places. {4.2, 4.3, 5.2, 5.4, 6.2, 6.3, 6.4}*

A warmer climate will intensify some weather extremes in the future*. Extreme hot temperatures will become more frequent and more intense. This will increase the severity of heatwaves and contribute to increased drought and wildfire risks. While inland flooding results from multiple factors, more intense rainfalls will increase urban flood risks. It is uncertain how warmer temperatures and smaller snowpacks will combine to affect the frequency and magnitude of snowmelt-related flooding. {4.2, 4.3, 4.4, 5.2, 6.2}*

Canadian areas of the Arctic and Atlantic Oceans have experienced longer and more widespread sea-ice-free conditions. *Canadian Arctic marine areas, including the Beaufort Sea and Baffin Bay, are projected to have extensive ice-free periods during summer by mid-century. The last area in the entire Arctic with summer sea ice is projected to be north of the Canadian Arctic Archipelago. This area will be an important refuge for ice-dependent species and an ongoing source of potentially hazardous ice, which will drift into Canadian waters. {5.3}*

Coastal flooding is expected to increase in many areas of Canada due to local sea level rise*. Changes in local sea-level are a combination of global sea level rise and local land subsidence or uplift. Local sea level is projected to rise, and increase flooding, along most of the Atlantic and Pacific coasts of Canada and the Beaufort coast in the Arctic where the land is subsiding or slowly uplifting. The loss of sea ice in Arctic and Atlantic Canada further increases the risk of damage to coastal infrastructure and ecosystem as a result of larger storm surges and waves. {7.5}*

The rate and magnitude of climate change under high versus low emission scenarios project two very different futures for Canada. *Scenarios with large and rapid warming illustrate the profound effects on Canadian climate of continued growth in greenhouse gas emissions. Scenarios with limited warming will only occur if Canada and the rest of the world reduce carbon emissions to near zero early in the second half of the century and reduce emissions of other greenhouse gases substantially. Projections based on a range of emission scenarios are needed to inform impact assessment, climate risk management, and policy development. {all chapters}"*

"The cost of doing nothing to fight climate change far outweighs the cost of solving the problem." – Ontario Minister of the Environment and Climate Change[8]

2.0 Energy and Land Cover Maps of the Community of Mulmur

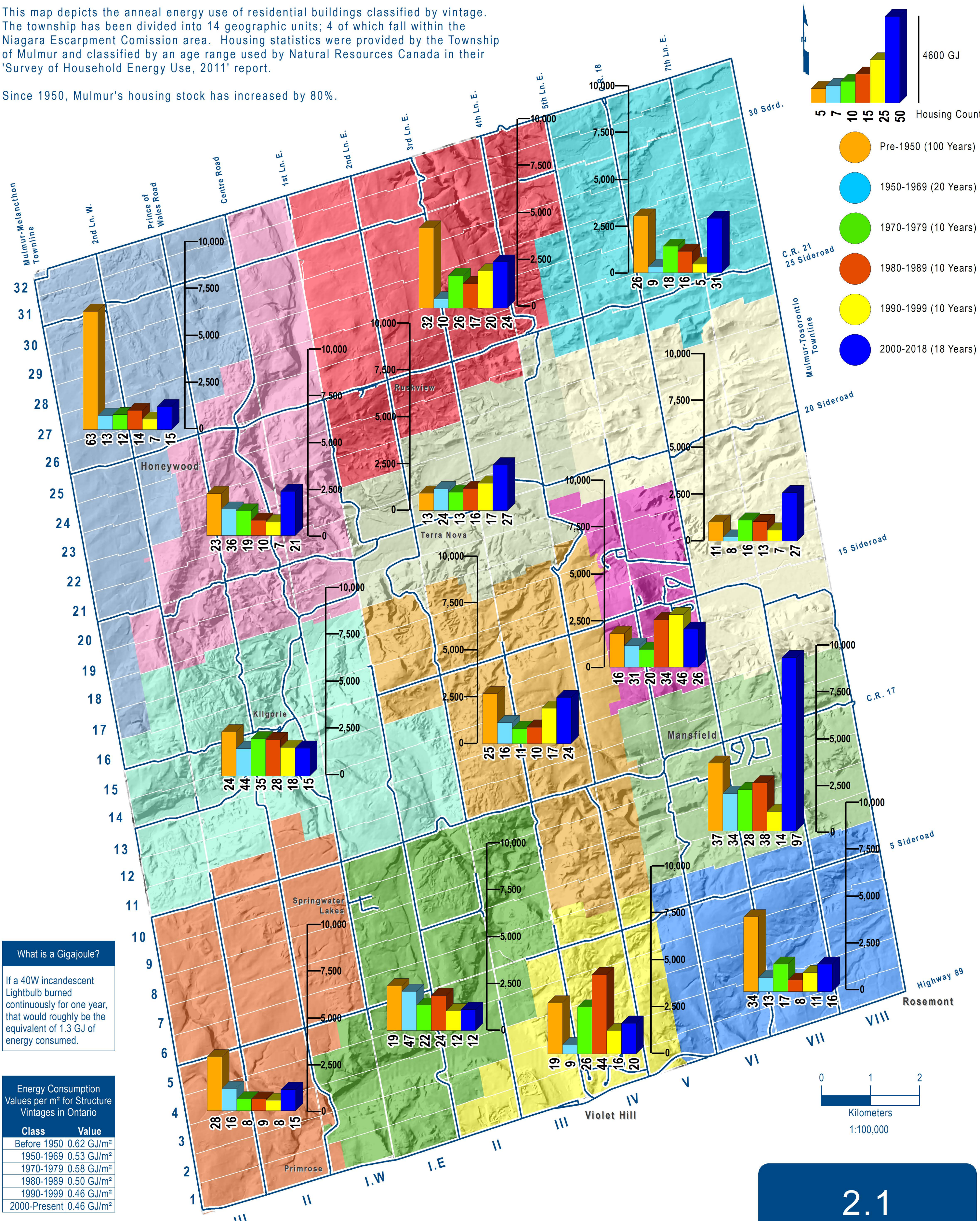
Figure 2-1 provides an overview of energy consumption for different areas throughout Mulmur broken out by building.

8 Glen Murray, Minister of the Environment and Climate Change, November 24, 2015. See full report at: https://www.ontario.ca/page/climate-change-strategy

ANNUAL RESIDENTIAL ENERGY USE IN GIGAJOULS (GJ) BASED ON HOUSING STOCK AGE BY STUDY STATISTICS AREA

This map depicts the anneal energy use of residential buildings classified by vintage. The township has been divided into 14 geographic units; 4 of which fall within the Niagara Escarpment Comission area. Housing statistics were provided by the Township of Mulmur and classified by an age range used by Natural Resources Canada in their 'Survey of Household Energy Use, 2011' report.

Since 1950, Mulmur's housing stock has increased by 80%.



What is a Gigajoule?

If a 40W incandescent Lightbulb burned continuously for one year, that would roughly be the equivalent of 1.3 GJ of energy consumed.

Energy Consumption Values per m² for Structure Vintages in Ontario

Class	Value
Before 1950	0.62 GJ/m²
1950-1969	0.53 GJ/m²
1970-1979	0.58 GJ/m²
1980-1989	0.50 GJ/m²
1990-1999	0.46 GJ/m²
2000-Present	0.46 GJ/m²

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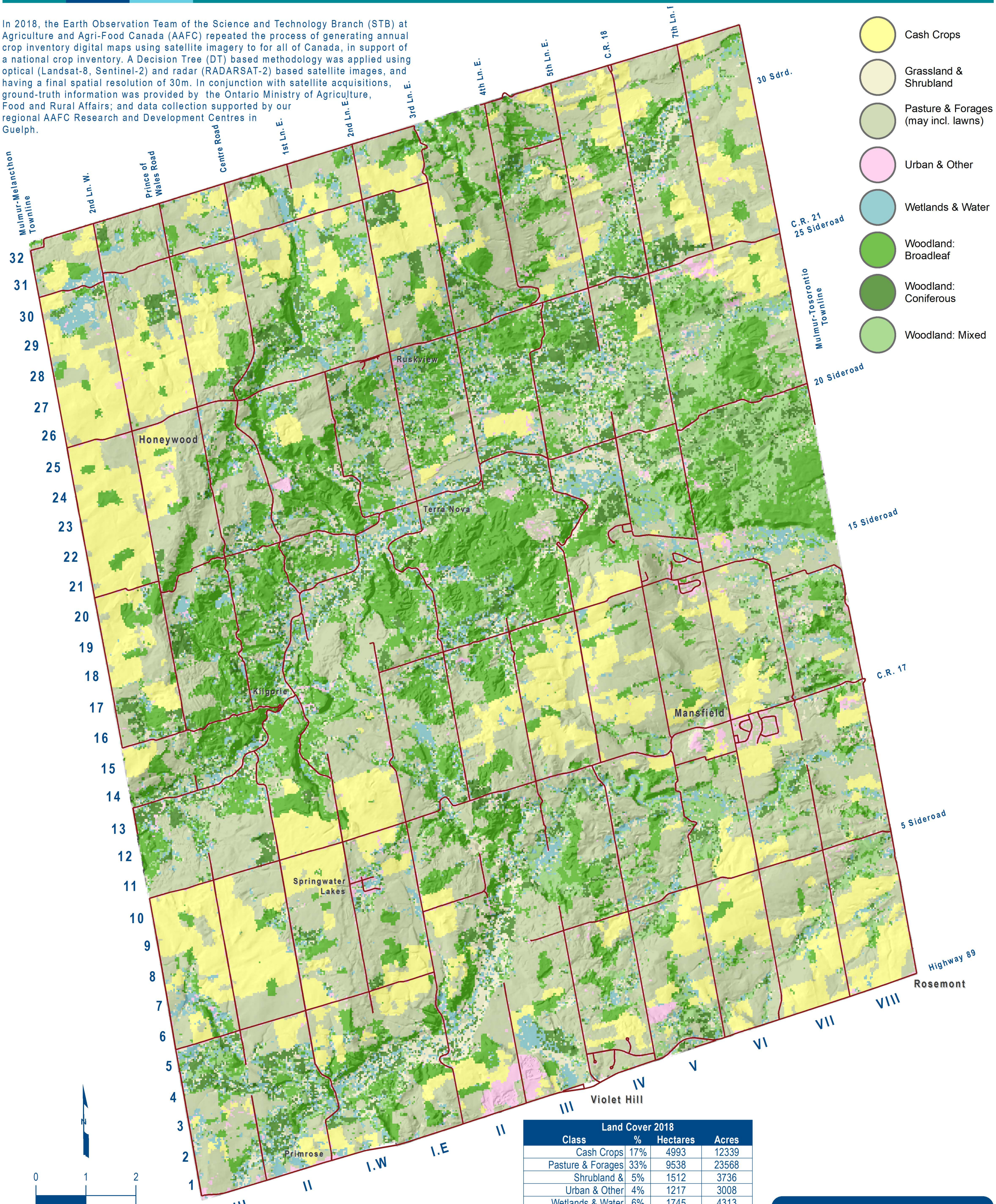
MULMUR LAND COVER BREAKDOWN 2018

In 2018, the Earth Observation Team of the Science and Technology Branch (STB) at Agriculture and Agri-Food Canada (AAFC) repeated the process of generating annual crop inventory digital maps using satellite imagery to for all of Canada, in support of a national crop inventory. A Decision Tree (DT) based methodology was applied using optical (Landsat-8, Sentinel-2) and radar (RADARSAT-2) based satellite images, and having a final spatial resolution of 30m. In conjunction with satellite acquisitions, ground-truth information was provided by the Ontario Ministry of Agriculture, Food and Rural Affairs; and data collection supported by our regional AAFC Research and Development Centres in Guelph.



Land Cover 2018			
Class	%	Hectares	Acres
Cash Crops	17%	4993	12339
Pasture & Forages	33%	9538	23568
Shrubland &	5%	1512	3736
Urban & Other	4%	1217	3008
Wetlands & Water	6%	1745	4313
Woodland: Broadleaf	18%	5170	12775
Woodland: Coniferous	5%	1539	3803
Woodland: Mixed	11%	3040	7511

Figure 2-2 shows a breakdown of land cover for Mulmur as of 2018. Cash crops make up 17%. Pasture & forages are 33%, and a mix of different woodland types make up 34% of the land cover. Other types of land cover include, shrubland, urban, and wetlands and water. The map is provided for general information on the extent of agricultural lands, woodlands and other land covers in the Township. If may be helpful for future GHG assessments if the Township wishes to consider other GHG emissions in addition to those related to energy use.

3.0 The Community of Mulmur

The CEP report distinguishes energy consumption and emissions created by the whole community and those specifically created by Mulmur's municipal government. As one might expect, the municipal government energy use and emissions are very small (about 2%) in comparison to the community as a whole.

To properly track energy use in Mulmur a base year is determined to show either future progress or regression in relation to any goals that may be set. As mentioned, for this study the base year chosen was 2018. Ideally the base year is as recent as possible to ensure the most up to date data. Not all data from 2018 was available. In the case of missing data alternative methods were used to calculate either energy consumption or CO2e emissions. Please see Appendices A to F for the methodologies supporting the data shown.

Readers are likely aware that not all forms of energy consumption produce the same amount of GHG emissions. If the energy is produced from renewable sources the emissions will be very small, if any. If the energy is produced from hydrocarbon sources the emissions are likely to be high. But a reduction in energy use no matter the source can save operating costs.

This section provides a detailed description of the energy consumption and production in Mulmur along with the emissions released due to energy consumption and/or production.

Figure 3-1: Mulmur's Estimated Energy Consumption

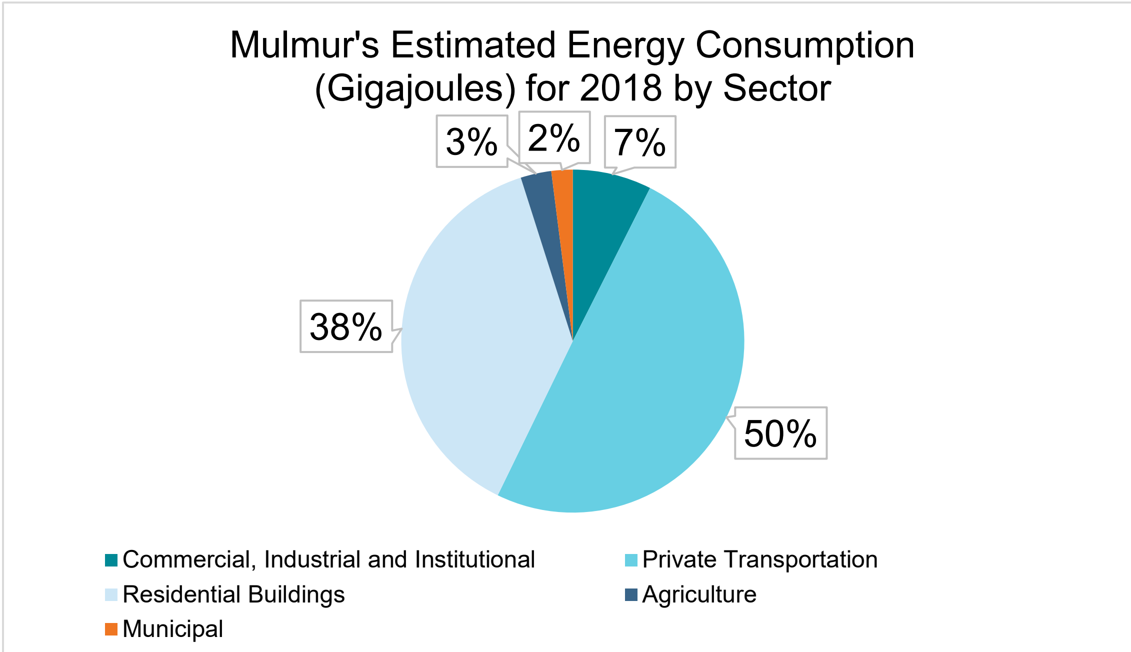
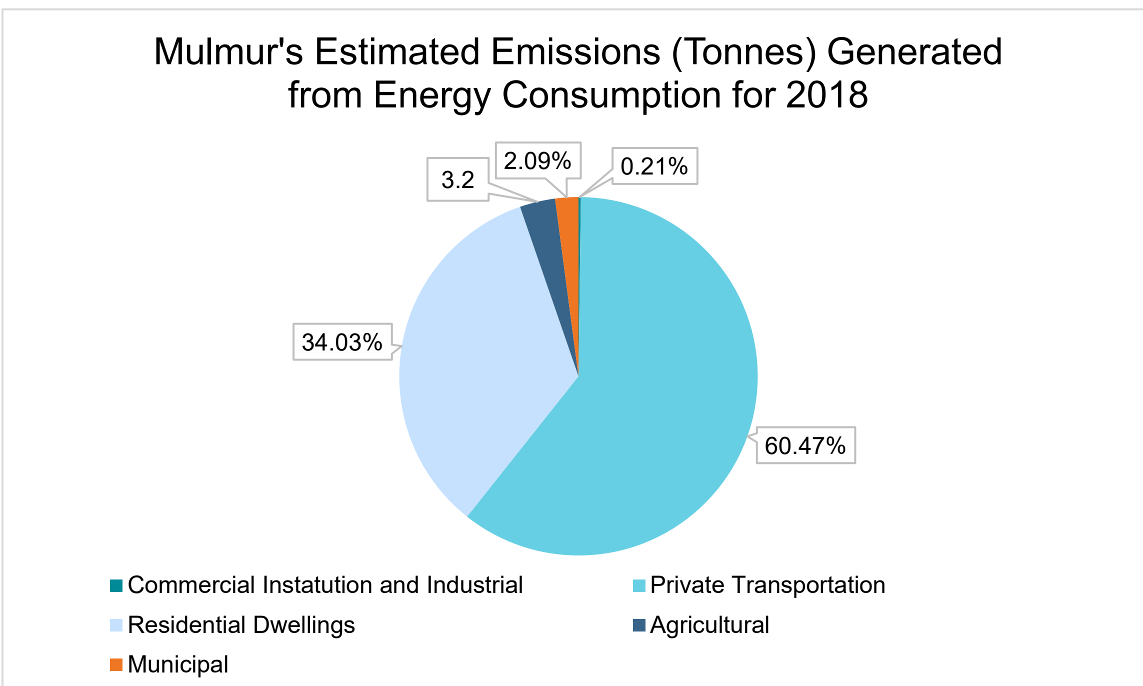


Figure 3-2: Mulmur's Generated GHG Emissions



3.1 Community Transportation Energy Consumption and GHG Emissions

Community transportation covers the estimated energy consumed in the form of combustion fuels within Mulmur's boundaries. Energy for this sector will be expressed in gigajoules to provide a consistency in units though out this report. Emissions directly released from combustion fuels and if applicable indirect emissions from grid sourced energy will be recorded into Mulmur's generated emissions from transportation, expressed in tonnes of CO2 equivalent.

The Canadian Supplement to the International Emissions Analysis Protocol provided three approaches to calculate and report emissions. With the information and resources available approach two was used to calculate Mulmur's energy consumed and emissions released with-in Mulmur boundaries. Approach two uses a method that combines total vehicle kilometers traveled (VTK) with assumptions on the characteristics and fuel efficiencies of the vehicles (Canadian Supplement to the International Emissions Analysis Protocol, page 38).

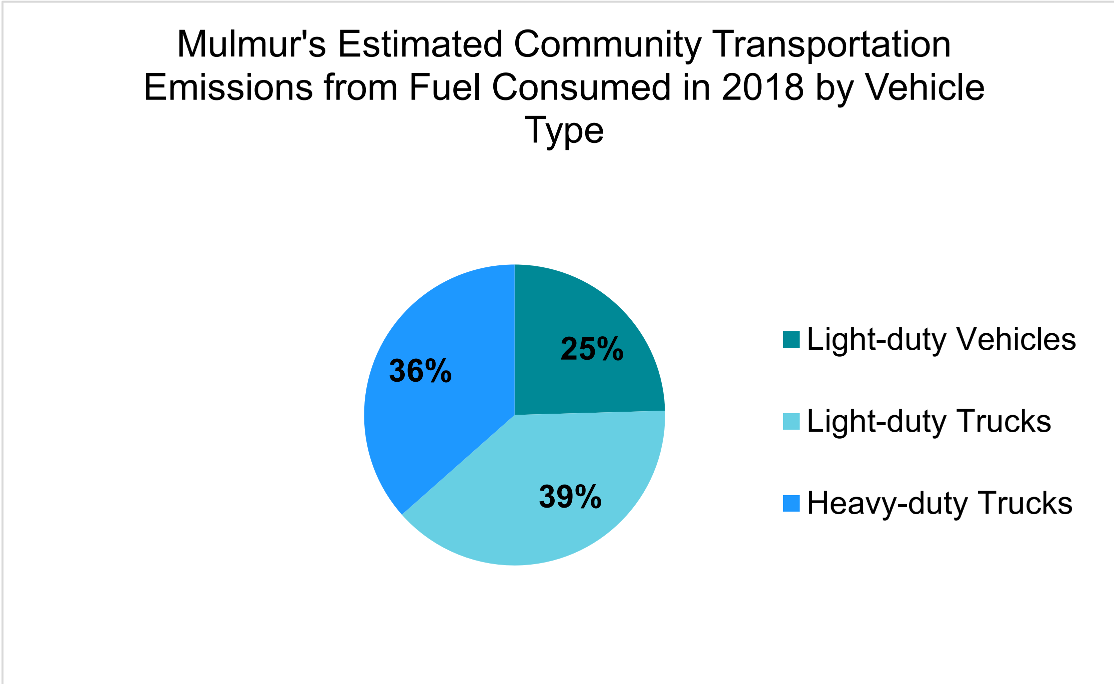
An alternate method to approach two was provided by the PCP protocol in lieu of specific traffic data for Mulmur. This approach is explained in detail in Appendix A. For Mulmur's CEP this alternate method was used to predict the total vehicle kilometers traveled (VKT) in Mulmur.

Below are some statistics used to project Mulmur's community transportation energy use and emissions released:

- Average VTK (km) – 16,024 (Canadian Supplement to the International Emissions Analysis Protocol, page 44);
- The average amount of fuel used per household is 2,903.2 L (rounded) per year for 2018; and
- The average amount of emissions released from transportation per household in Mulmur is 7.231 t of CO2e.

Mulmur's Energy consumption and CO2e emissions is categorized into 3 vehicle types as allocated in the Canadian Supplement to the International Emissions Analysis Protocol. Figure 3-3 below shows the comparison between vehicle type and total emissions released in Mulmur in 2018.

Figure 3-3: Mulmur's Estimated Community Transportation Emission from Fuel Consumed in 2018 (See Appendix A for Source Material)



Light-duty trucks contribute an estimated 39% of emissions released from community transportation in Mulmur. Note that *"light-duty trucks include pickups, minivans, SUVs and other similar sized vehicles"* (Canadian Supplement to the International emissions Analysis protocol, page 41).

According to Statistics Canada's 2016 census data just over 70% of the labour force commuting from within and to workplaces outside Mulmur travel less than one-hour round trip to work. At posted speed limits this would represent approximately 80 km. Obviously, residents travel for other personal reasons as well, but this provides a guide when considering the travel distances associated with the potential transition to EV use.

Mulmur's community transportation contributes half of the total energy consumed in Mulmur as shown in Figure 3-3, but it contributes a much higher percentage of GHG emissions (60.5%) as shown in Figure 3-2.

Figure 3-4: Private Transportation Energy Consumption

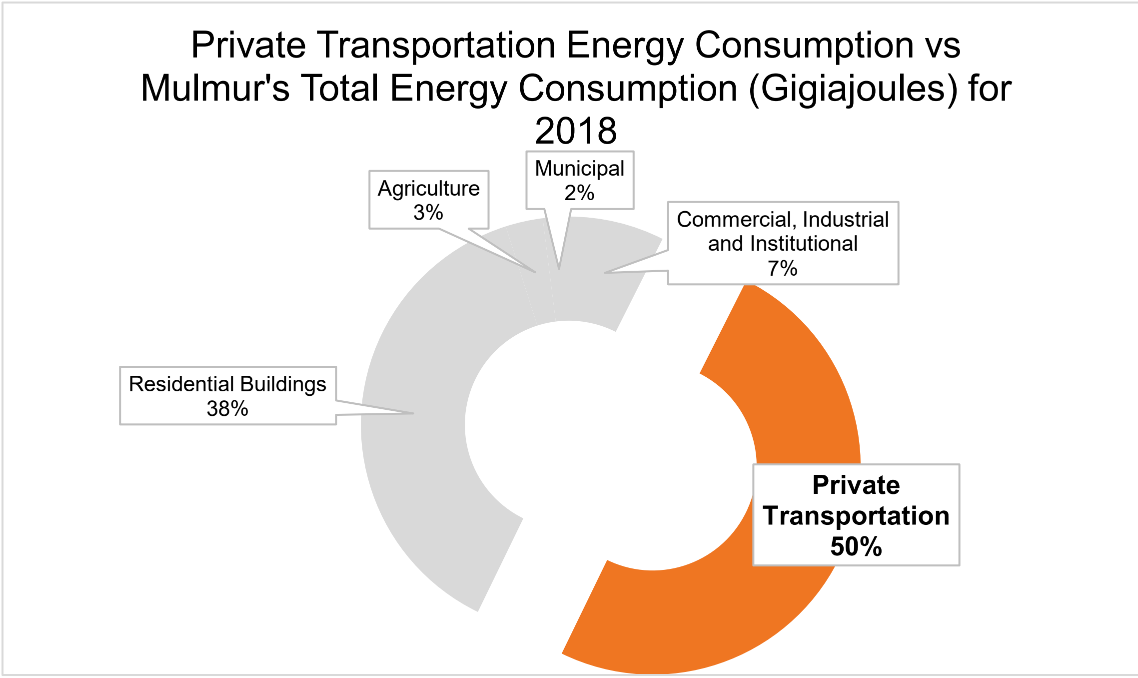


Figure 3-4 does not include any emissions from non-resident commuters travelling through Mulmur to other destinations.

3.2 Community Residential Energy Consumption and GHG Emissions

The residential sector refers to household building energy consumption and excludes personal transportation. Energy consumption for the Township of Mulmur residential sector is obtained from NRCan's CEUD[9] and MPAC taxation data. Residential emissions, strictly relating to energy consumption, were calculated using the PCP Protocol: Canadian Supplement to the International Emissions Analysis Protocol.

9 Natural Resources Canada. (n.d.). Comprehensive Database. Retrieved from Natural Resources Canada: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=com&juris=on&rn=22&page=0

Figure 3-5: Residential Energy Consumed

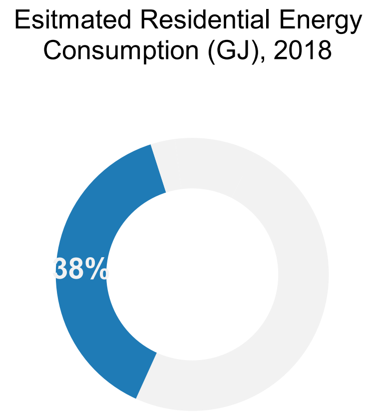
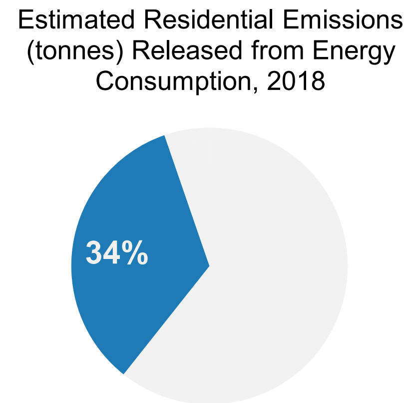


Figure 3-6: Residential Emissions



3.2.1 Residential Building Profiles

To interpret residential energy consumption a profile of the building structures was conducted. The profile examined building age and total gross floor area in relation to energy use. This information provides an idea of building structural factors that play a part in energy consumption/efficiency.

3.2.2 Residential Fuel Sources

Residential energy/fuel consumption considered includes the following fuel types: fuel oil, electricity, propane, wood and natural gas. Natural gas is available only in the immediate vicinity of Hwy 10 starting at Primrose through to Shelburne. It is not available anywhere else in Mulmur.

Emissions released from wood burning is not recorded, as recommended by the PCP Protocol: Canadian Supplement to the International Emissions Analysis Protocol.

3.2.3 Residential Building Age

Figure 3-8 below displays the percentage of houses by construction date correlating with Ontario's building code. 23% of houses in Mulmur were built before 1941 and since Ontario's building code wasn't developed till 1975, insulation standards, if any, were mandated by Mulmur. Due to the lack of high-quality insulation these older homes consume more energy for space heating and cooling. Renovations that improve insulation would change this assessment. However, renovation data available in the municipal records was not sufficiently detailed to allow an assessment of any benefits that may have accrued as a result.

Figure 3-7: Sum of Residential Floor Space by Year Built

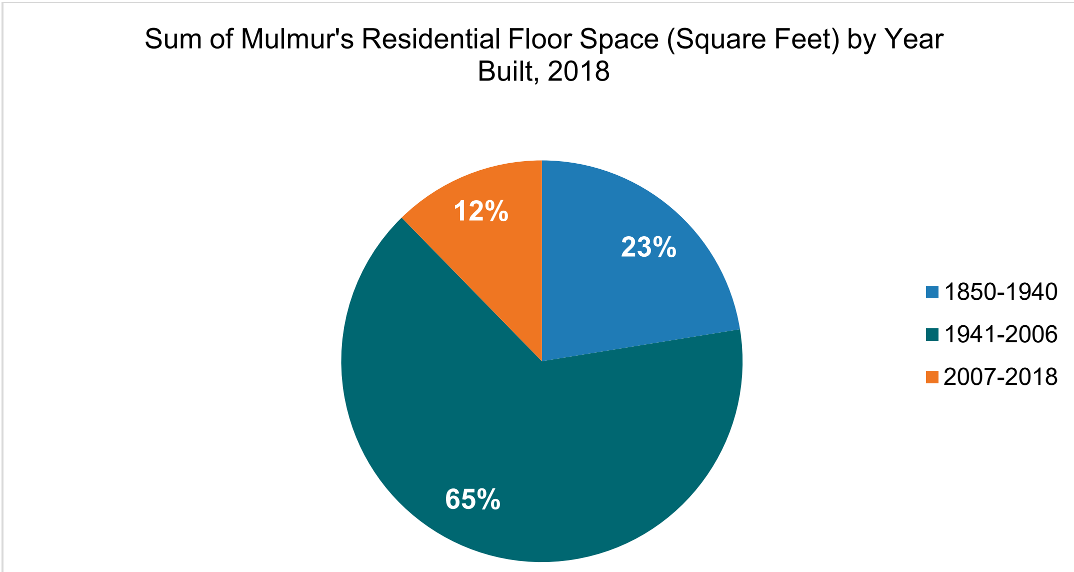
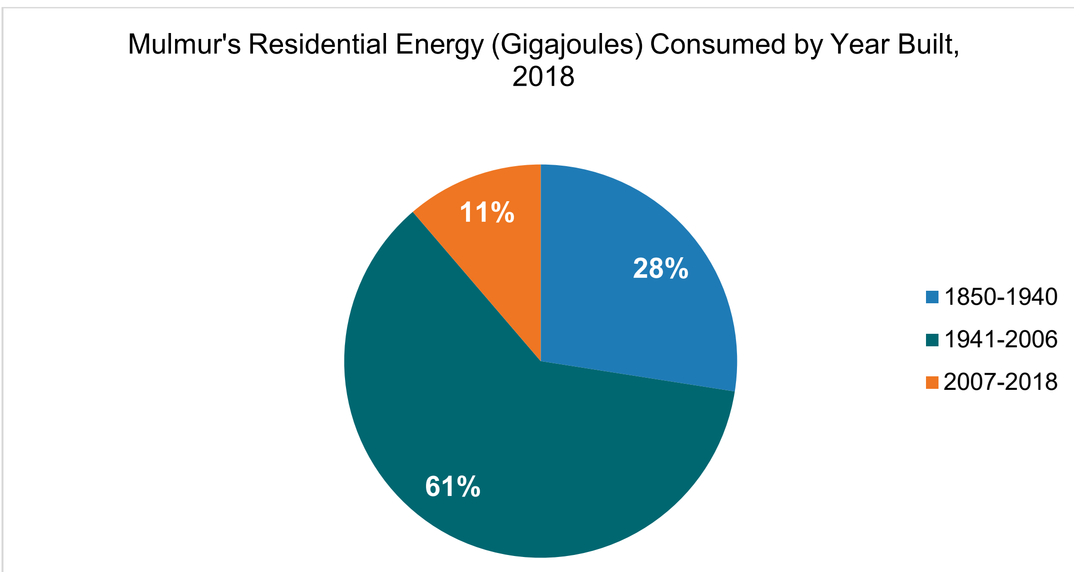


Figure 3-8: Residential Energy Consumed by Year Built



*"**Energy Intensity** is measured by the quantity of energy required per unit output or activity, so that using less energy to produce a product reduces the intensity."*[10]

10Energy Efficiency & Renewable Energy. (n.d.). Energy Intensity Indicators: Efficiency vs. Intensity. Retrieved from energy.gov: https://www.energy.gov/eere/analysis/energy-intensity-indicators-efficiency-vs-intensity

In this report Section 2.0 an energy map of the community is provided to show the different energy consumption by residential housing age in different areas of Mulmur. Settlement patterns are reflected in the house ages shown.

In Table 3-1 Mulmur's residential houses are grouped by construction date in relation to Ontario's building code development. The table also shows the average energy intensity in relation to houses built after 2007. Although houses built between 1850 to1940 only take up 23% of the total square footage of floor space, they are using 28% of Mulmur's residential energy (shown in Figure 3-7 and Figure 3-8). This highlights the inefficiency of houses built before 1941.

Table 3-1: Energy Intensity by Year Built[11]

Year Built	Average Energy Intensity	Energy Efficiency
1850-1940	.621 GJ/M^2	29.7% less efficient then houses built after 2007.
1941-2006	.513 GJ/M^2	19% less efficient then houses built after 2007.
2007-2018	.460 GJ/M^2	-

In Table 3-1 the average energy intensity shows that on average houses built between 1850 to1940 are using 29.7% more energy per square foot than houses built after 2007.

3.2.4 Residential Building Size

Mulmur's residential houses have been gradually growing in total floor space since 1950s. The Township of Mulmur's average total floor space per house is 1854 sq. ft as of 2018. This is 19% larger than Ontario's average for a typical single detached house.[12]

Private households in Mulmur are growing, but the number of people residing in these residences remained at 2.6 persons per household in 2016[13].

11 Natural Resources Canada. (n.d.). Comprehensive Database. Retrieved from Natural Resources Canada: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=com&juris=on&rn=22&page=0

12 Statistics Canada. (2019, May 03). Canadian Housing Statistics Program. Retrieved August 08, 2019, from 150 Statistics Canada: https://www150.statcan.gc.ca/n1/daily-quotidien/190503/dq190503b-eng.htm

13 Statistics Canada. (2017, November 29). Mulmur, TP [Census subdivision], Ontario and Ontario [Province] (table). Census Profile. 2016 Census. Retrieved from Statistics Canada Catalogue no. 98-316-X2016001: https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CSD&Code1=3522016&Geo2=PR&Code2=35&SearchText=Mulmur&SearchType=Begins&SearchPR=01&B1=All&GeoLevel=PR&GeoCode=3522016&TABID=1&type=0

Figure 3-9: Mulmur's Average Residential Floor Space by Year Built[14]

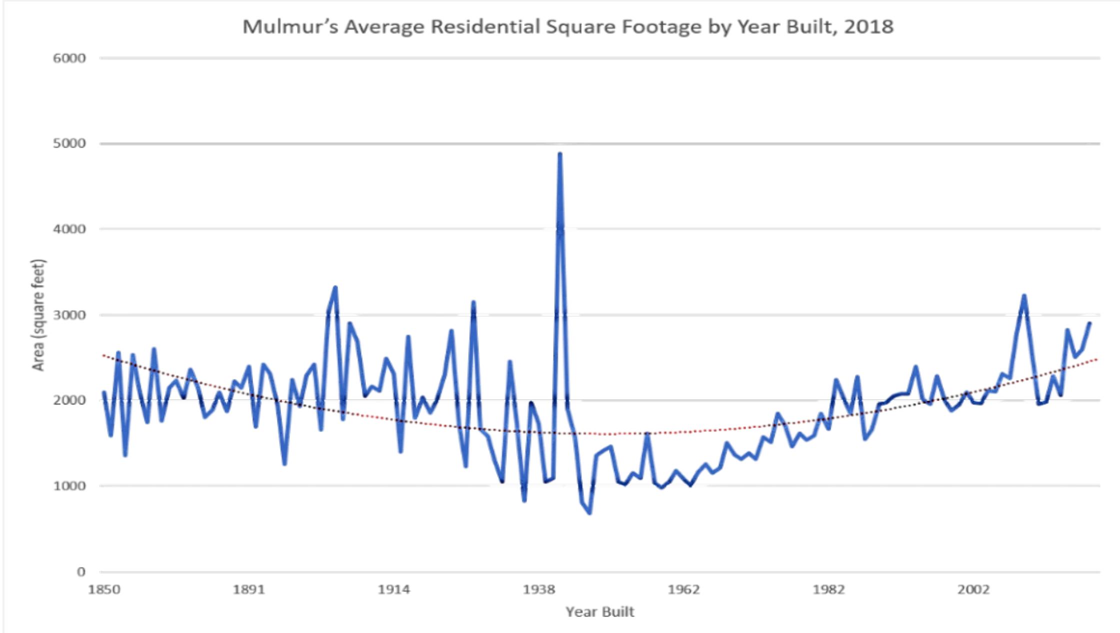


Figure 3-10: Average Residential Energy Consumption vs Square Footage

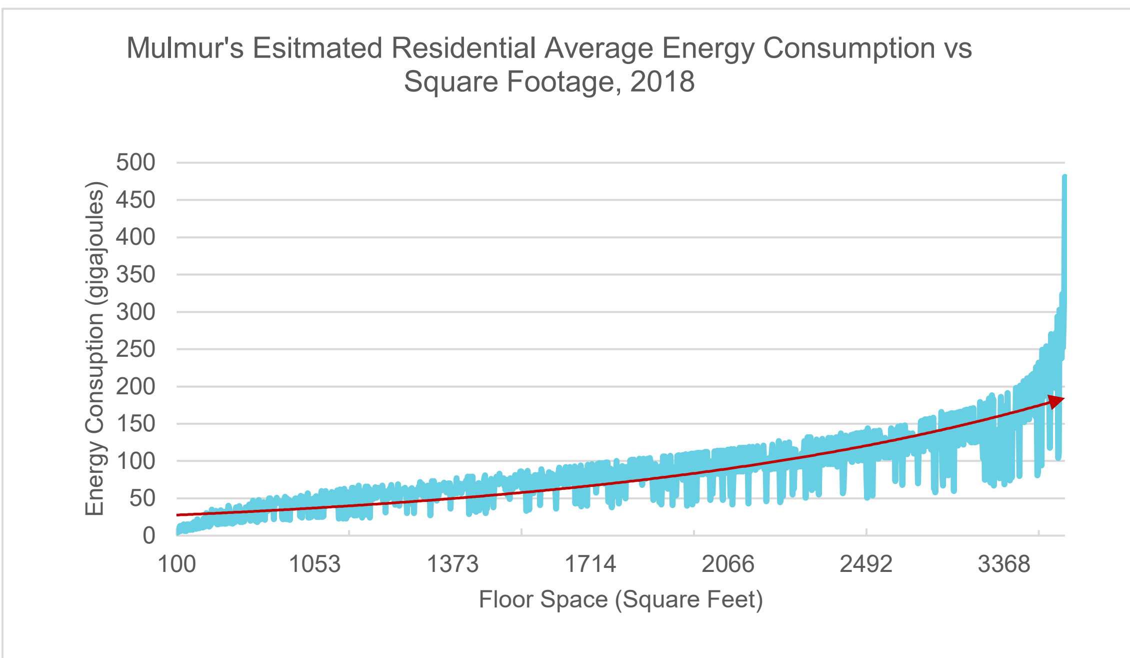


Figure 3-9 shows the gradual incease in house size from 1940 to 2018 and Figure Figure 3-10 shows Mulmur's energy consumption by floor space. There is a correlation between floor space and energy used. This means that to reduce Mulmur's energy consumption, efficiency improvements will not alone make a difference.

14 Data for Figure 3-9 was supplied by MPAC, (Appendix B)

The Figure 3-11 below shows the yearly energy intensity per household in the Township of Mulmur, by year built. Energy consumption per household for houses built before 1950 and houses built after 2000 consume the most energy on a yearly basis. It was determined that smaller less efficient houses (per household) use less energy than newer, more efficient households. This is illustrated in Table 3-2 where the darker colours are more energy use, blue is average, and white is below average.

Figure 3-11: Energy Intensity per House by Year Built, 2018

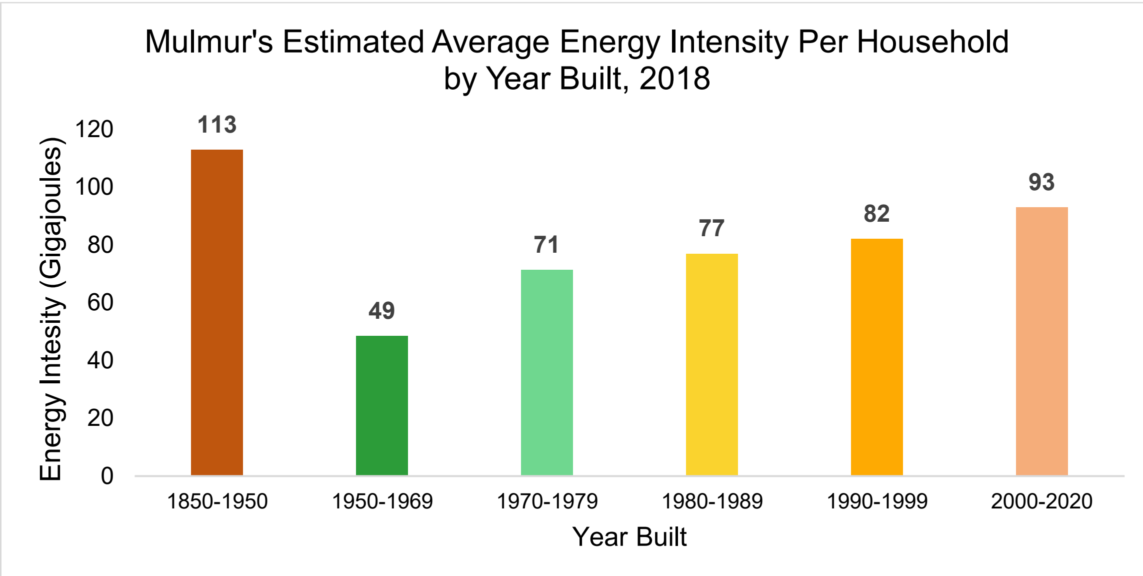


Table 3-2: Energy Per Household Versus Energy Per Square Meter

Year Built	**Estimated Average Energy Consumption (Gigajoules) Per Household**	**Estimated Average Energy Per Square Meter (Gigajoules)**
1850-1950	112.9	0.60
1950-1969	48.5	0.51
1970-1979	71.3	0.55
1980-1989	77.0	0.48
1990-1999	82.0	0.45
2000-2020	93.0	0.45

Understanding energy consumption through a structural lens allows for a better understanding on how buildings can reduce their energy use. This information helps to inform homeowners on how their home energy consumption compares to other homes and where some energy efficient tips might come in handy. Ontario's building code is constantly changing to help improve building standards, but it is also important to look at existing homes for energy efficient upgrades.

3.2.5 Energy Efficient Upgrades

> *"For every dollar spent on electricity conservation, there was a benefit of $2.54"*[15]

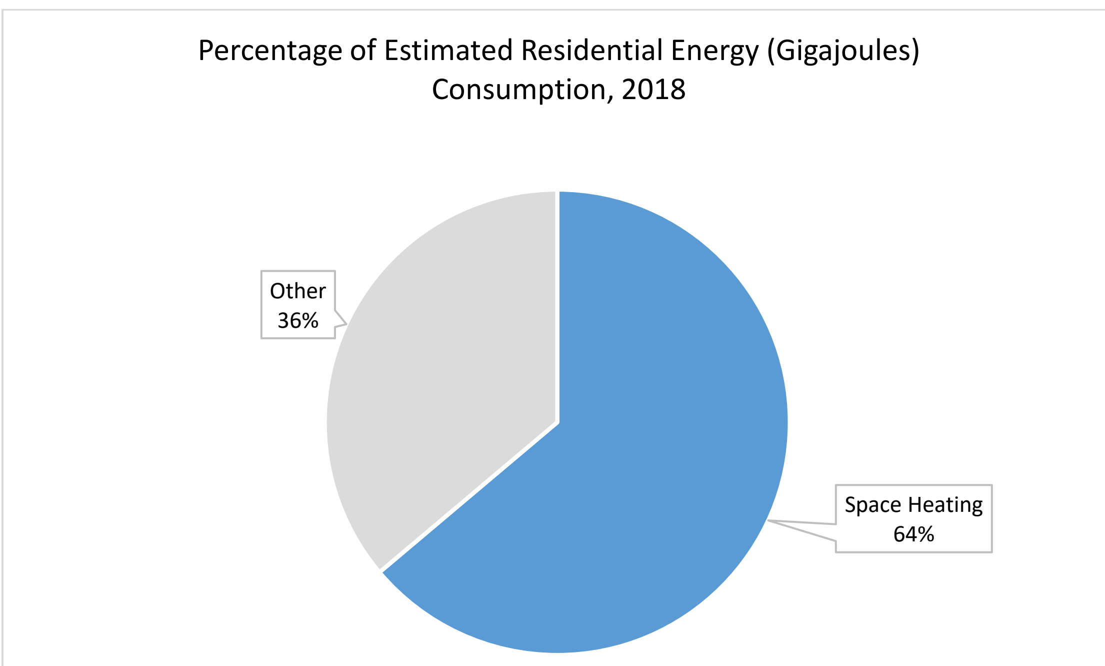
Since a total of 38% of Mulmur's energy and 34% of GHG emissions come from residential buildings this section is especially important. The flowing subsections will break down specific sources of energy consumption with tips for efficiency.

This subsection is meant to educate and provide some resources for funding and education. Funding and resources from various sources are constantly changing. The information provided is up to date as of December 2019. Many of the current Ontario funding programs consider income and only provide help those individuals and families who qualify. Other federal funding programs were expected during 2020 to 2021.

3.2.5.1 Energy Consumed for Heating in Mulmur

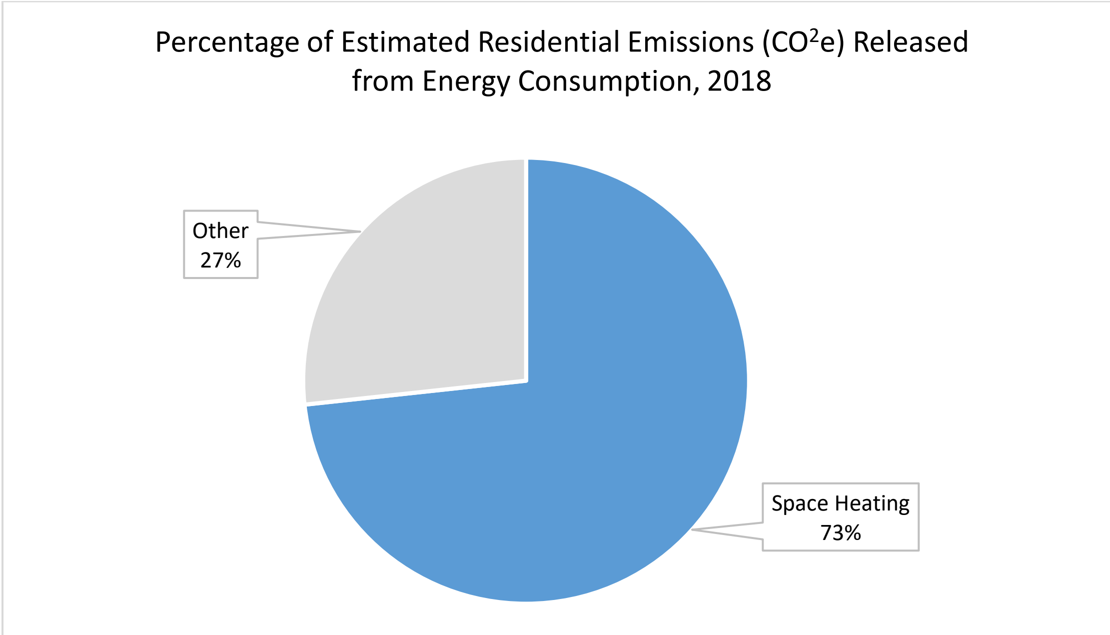
An improvement in insulation can help reduce energy used for space heating. Space heating makes up **64%** of Mulmur's residential energy use while producing **73%** of GHG emissions. Figure 3-12 and Figure 3-13 compares the percentage of energy consumption for space heating with Mulmur's total residential GHG emissions.

Figure 3-12: Percentage of Residential Energy Consumption, 2018



15 Saxe, D. (2019). Why we need more energy conservation, 2019 Energy Conservation Progress Report. Toronto: Environmental Commissioner of Ontario.

Figure 3-13: Percentage of Residential Emissions Released from Energy Consumption, 2018



Natural Resource Canada provides a page dedicated to insulation education, called Keeping the Heat In – Chapter 7: Insulating Walls. This chapter give an overview of the types of insulation and options residents can take to upgrade old insulation.

3.2.5.2 Insulation

Insulation plays a big roll in the houses of Mulmur, whether it is keeping the heating in during the winter or out during the summer. Mulmur's residents are no strangers to Ontario's climate but is your insulation up for the test? With 91% of houses in Mulmur being built pre 2006 (per energy efficient requirements to the building code) insulation standards across Mulmur need be addressed.

3.2.6 Building Code Development Overview

Below is a chart to help you understand why your home could use some energy efficiency upgrades due to your home's age.

Figure 3-14: Why Your Home Can Use Energy Efficiency Upgrades

<table>
<tr><th>Code Development</th><th>Typical Residential Construction</th><th>Suggested Conservation Measures</th></tr>
<tr><td>Prior to Ontario Building Code

Insulation requirements, if any, were mandated by the Municipal building code typically based on the National Building Code (1941 up to 1975).</td><td>Ceilings with Attic: Blown insulation (cellulose, vermiculite, fibreglass wool) or Batt insulation (fibreglass)

Exterior Walls: Wood frame with or without cavity insulation.

Windows: Wood frame (vinyl or metal frames nearer to 1975) and single pane glazing.</td><td rowspan="2">-Attic insulation: increase insulation thickness to current (or higher) standards.
-Wall insulation: if completing significant interior renovations, consider spray foam insulation for interior walls to increase R-value and reduce air leakage. If not considering significant interior renovations, consider blown insulation in uninsulated (empty) wall cavities.
-Windows: replace Windows with single pane glazing.
-Windows/Doors: install weather stripping to decrease air leakage, consider double or triple glazed replacement windows and insulated exterior doors. Choose replacement window styles that are the most energy efficient.
-Heating: if electric baseboard switch to alternate heating source, consider air source heat pumps.
-Water Heater Tank: Consider replacement with tankless Water Heater especially if electric heated.</td></tr>
<tr><td>Ontario Building Code (1975 up to 2006).

Prescriptive insulation requirements for housing were relatively unchanged during this period. Typical R-values for exterior walls were R30 and for ceilings with attics (R31 up to 1990, R40 after 1990).</td><td>Ceilings with Attic: Blown insulation (fibreglass wool and less commonly cellulose, vermiculite) or Batt insulation (fibreglass).

Exterior Walls: Wood frame with cavity insulation.

Windows: Vinyl or metal (metal with thermal breaks closer to 2006) and single- or double-pane glazing.</td></tr>
<tr><td>Ontario Building Code (2006 to 2012).

Energy efficiency requirements introduced in 2006 and strengthened in 2012. Attic R-values ranged between R40 to R50 in 2006, increased range of R50 to R60 in 2012. Exterior wall R-values ranged between R19 to R29 in 2006, increased range of R19/R22 + R7.5/R10 continuous insulation</td><td>Ceilings with Attic: Blown insulation (typically 18" required to achieve R50).

Exterior Walls: Wood frame with both cavity and continuous outboard insulation; spray foam cavity insulation.

Windows: Vinyl, thermally broken metal, or fibreglass frames are common. Double glazed with argon gas fill is common with krypton gas fill or triple glazing as less common upgrades.</td><td>-Attic insulation: confirm Attic insulation level meets current code requirements and increase if necessary.
-Windows/Doors: install weather-stripping to decrease air leakage.
-Water Heater Tank: consider replacement with tankless Water Heater especially if electric heated.</td></tr>
</table>

3.2.7 Understanding Energy Consumption by Use

Residential energy consumption was examined in five separate categories; appliances, water heating, cooling, lighting, and space heating. Understanding the use of residential energy consumption helps owners understand specific solutions for energy conservation. Space heating and cooling vary based on season and geographic location, whereas water heating, lighting and appliances remain relatively consistent.

Figure 3-15: Residential Energy Consumption by Use

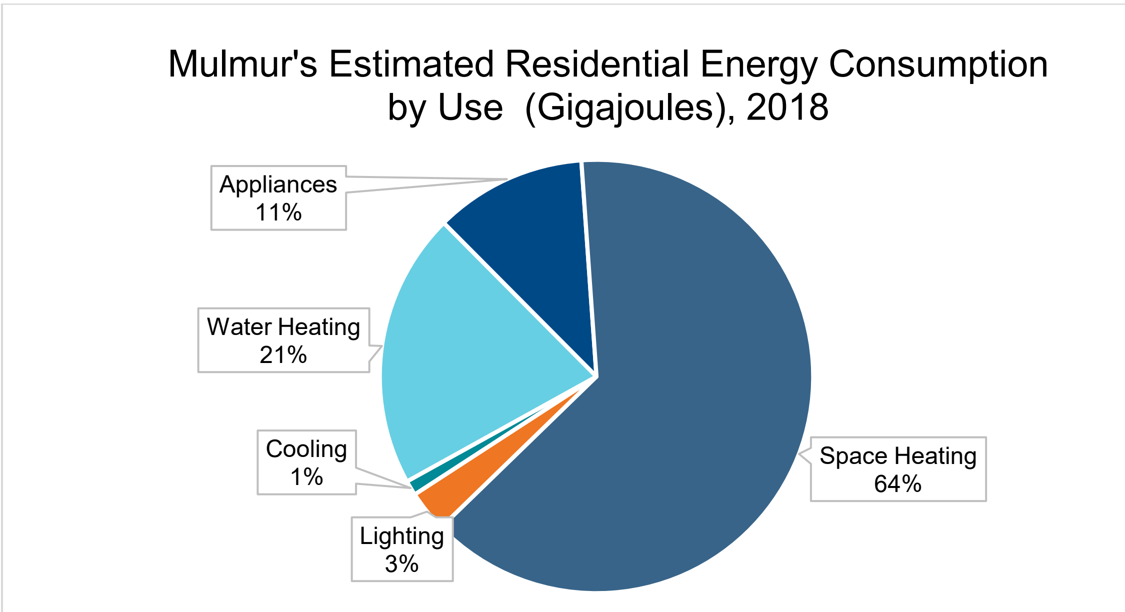


Figure 3-16: Residential Energy Emissions Released by Use

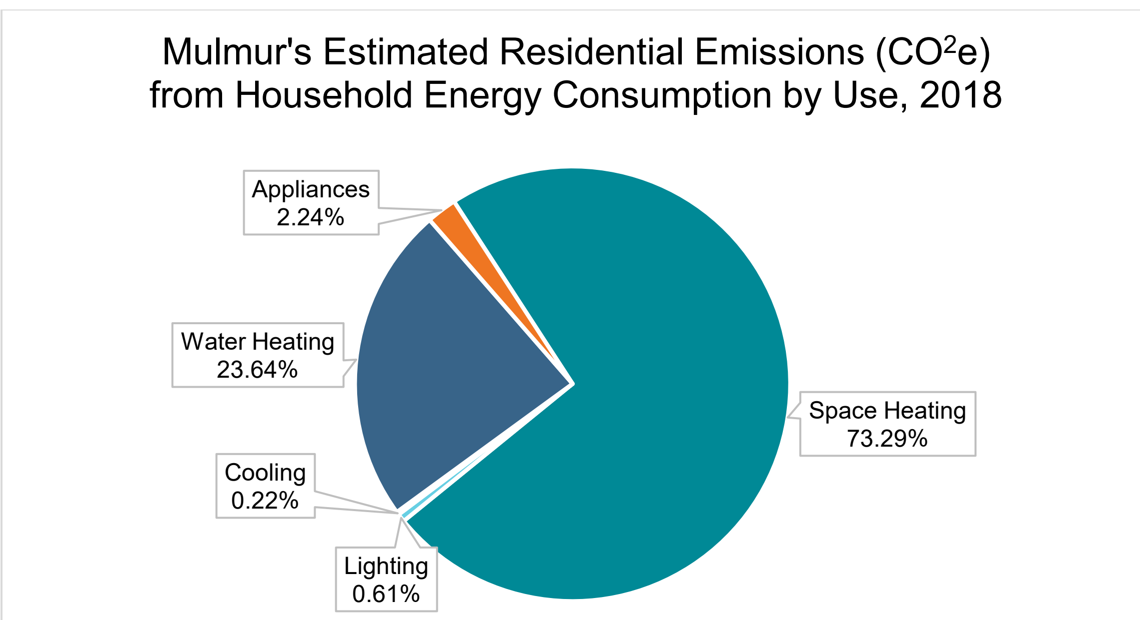


Table 3-3: Percentage of Energy Consumed and Emissions Released

	Percentage of Energy Consumption	Percentage of GHG Emissions	Average tonnes of GHG/Gigajoule
Space Heating	64%	73.3%	**.058**
Water Heating	21%	23.6%	**.058**
Appliances	11%	2.2%	.01
Lighting	3%	0.6%	.01
Cooling	1%	0.2%	.01

3.2.8 Energy Consumption by Fuel Source

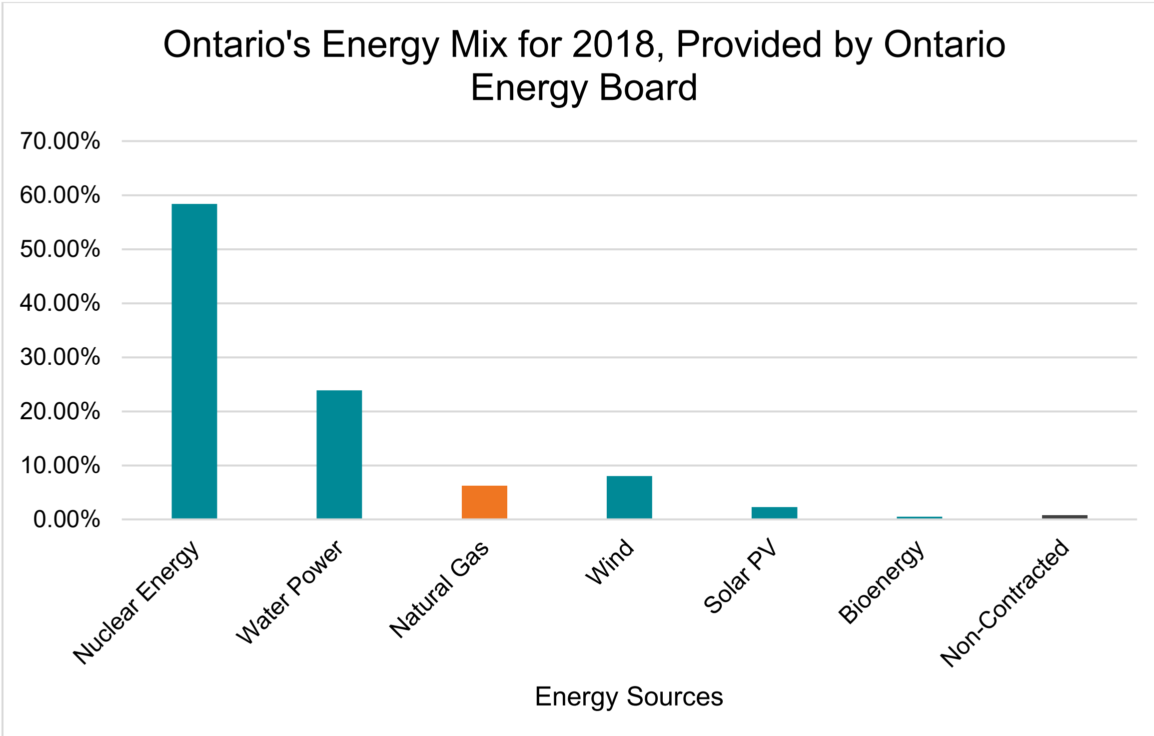
Energy is created by many difference sources and these sources all come with different energy out puts, GHG emissions rating, and costs. When looking at energy conservation it is important to consider the impact of the different energy conservation measures. Because this energy conservation study is also tracking GHG emissions it is important to look at the emissions each source of energy produces.

Figure 3-15 shows the percentage of energy used. By comparison Figure 3-16 shows the emissions released from energy consumed by each appliance type. Water heating and space heating produces more GHG per unit of energy consumed than lighting, appliances and cooling. This is because of the type of energy consumed for space heating and water heating. It is estimated that over 75% of energy for water heating and space heating is produced from fuel oil or propane. When you compare fuel oil for example to electricity (in Ontario), fuel oil pollutes (with GHG) almost 6 times more than energy from electricity as shown in Table 3-3: Percentage of Energy Consumed and Emissions Released, column 4. By contrast the results in Figure 3-16 show a decrease in emissions for cooling, lighting and appliances because energy for these sources predominantly comes from Ontario's electrical energy generation sources. Ontario's electrical mix is relatively clean except for its gas/oil power generation component which currently represents about 6.2% to 7% of the total.[16] Coal as a power source and major emitter of GHG emissions was eliminated by the Liberal government in 2014.

Figure 3-17 below shows the amount of energy generated by fuel type that is in commercial operation on Ontario's distribution systems, as of June 2019.

[16] Ontario's System-Wide Electricity Supply Mix for 2018, published by the Ontario Energy Board, June 28, 2019.

Figure 3-17: Ontario's Energy Mix for 2018



Source: Progress Report on Contracted Electricity Supply, Second Quarter 2019

3.3 Community Agricultural Sector Energy Consumption and GHG Emissions

This CEP report focuses on energy consumption and the GHG emissions released exclusively from agricultural energy consumption. Therefore, agriculture emissions shown in this report will not provide a total estimate of the emission's generated from that sector. For example, methane from enteric fermentation and manure management are not calculated or counted in Mulmur's emissions generation for agriculture.

It is also important to note that the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories groups emissions from building and vehicles on farms or other agriculture areas into stationary energy and transportation sources.

Mulmur's CEP report includes energy from agricultural buildings and vehicles used on farms in the agricultural sector. It provides estimates of tractor fuel used, and the emissions generated, it also reports electricity used from barn lighting and secondary emissions released from electricity generation.

Table 3-4: Data from Tractor Activity on Agricultural Land

Estimated Fuel Consumed by Tractors Used for Agricultural Purposes in Mulmur in 2018	
Fuel (Litres)	228,505.5
CO2e (tonnes)	687.1
Energy (Gigajoules)	8,834.0

Table 3-4: shows total estimated fuel used by tractor use on agricultural lands in Mulmur. This estimate was calculated using Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFA) fuel budgets reports and total acres “worked” in Mulmur during 2018.

Emissions were calculated using IPPC protocol, details are provided in Appendix C.

Table 3-5: Lighting Data for Agricultural Facilities

Estimated Energy from Facility Lighting in Mulmur’s Agricultural Sector in 2018	
Usage (kWh)	*729,111.2*
CO2e (tonnes)	*26.0*
Energy (Gigajoules)	*2,624.8*

Reliable data sources were not available for agricultural energy consumption of agricultural machinery (other than tractors), structure heating and product storage. These forms of energy consumption will not be accounted for in this report.

Data to track energy consumed from the agricultural sector and the associated emissions generated is needed. Agricultural activities represent a large portion of The Township of Mulmur and it would be beneficial to understand the true impact this sector has in regard to energy consumption and GHG emissions.

3.4 Community Commercial, Industrial and Institutional Sector Energy Consumption and GHG Emissions

Energy consumption and GHG emission from buildings and facilities for these three sectors were recorded and assessed. Appendix D explains the methodologies used to calculate both energy consumption and emission’s generated from these three sectors.

Data for this sector’s assessment was obtained from Natural Resource Canada’s (NRCan) comprehensive data base and GIS data analysis completed by Burnside.

Figure 3-18: Commercial, Industrial, Institutional Energy Consumption

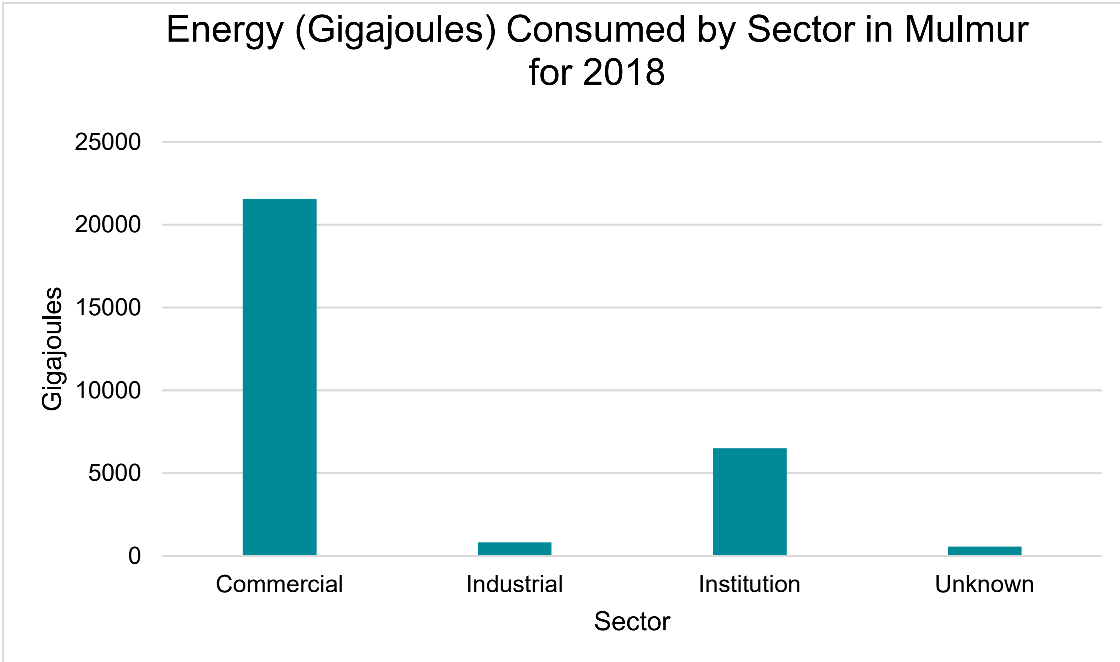


Figure 3-19: Commercial, Industrial, Institutional CO2e Emissions

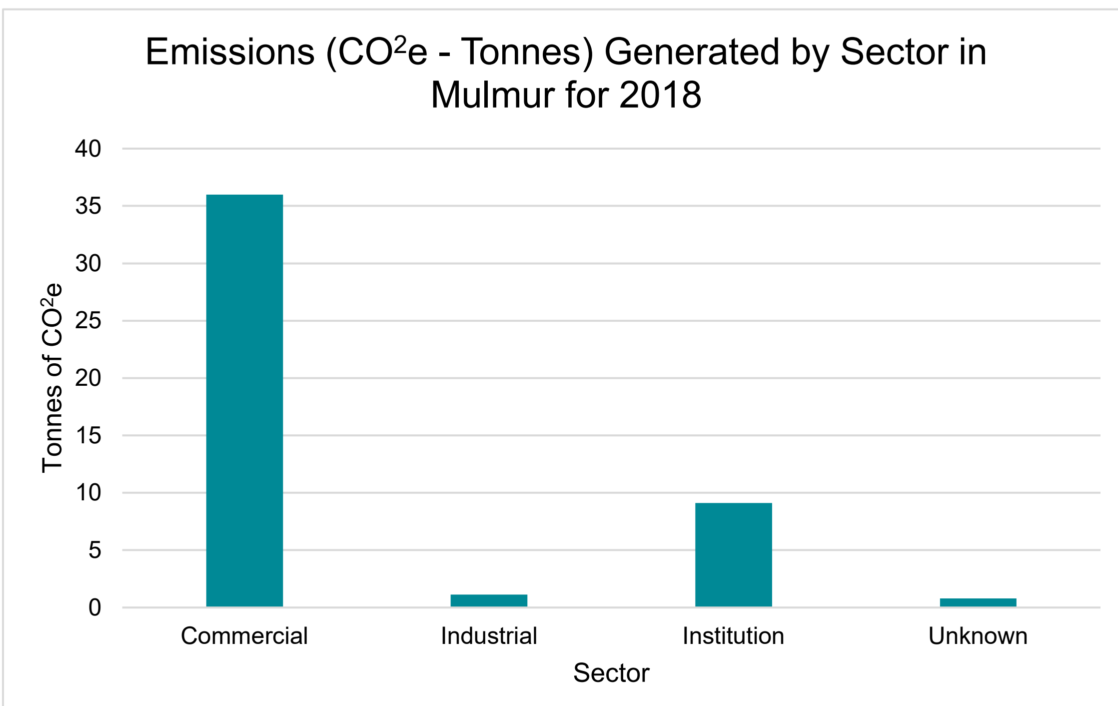


Figure 3-18 and Figure 3-19 show the energy consumption and GHG emissions released from each sector in Mulmur for 2018.

3.5 Linkage to Regional Energy Planning

4.0 The Municipality of Mulmur's Energy Consumption and GHG Emissions Profile in 2018

A detailed description of the energy consumption and production in each of Mulmur's municipal facilities has been assessed below. It includes the GHG emissions released due to energy consumption and/or production and is based for the most part on actual data provided by Mulmur.

Mulmur does not provide any sewage treatment facilities or solid waste management facilities. Although the Township used to provide landfill disposal services to its residents the County of Dufferin now provides all solid waste collection and disposal services. The Township does provide drinking water services to the hamlet of Mansfield.

Figure 4-1: Municipal Energy Consumption

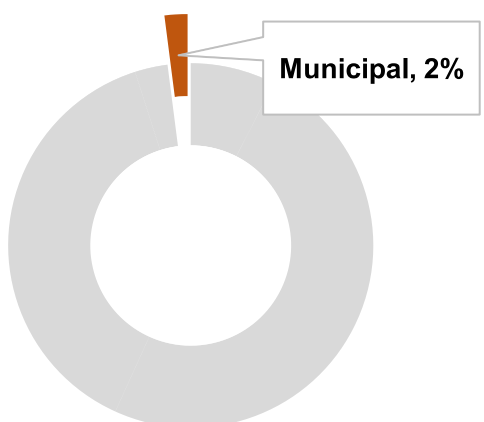
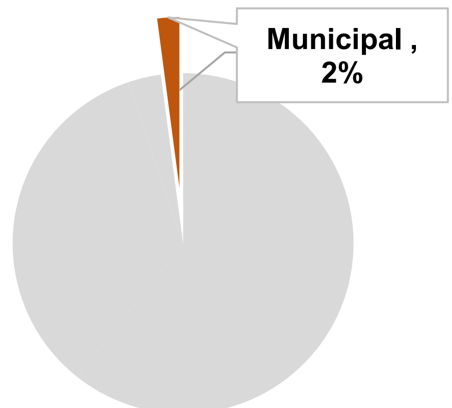


Figure 4-2: Municipal GHG Emission Released from Energy Consumption



Some limited data from 2018 was unavailable. If data was not available alternative methods were used to calculated either energy consumption or CO2e emissions. Please see Appendix F for the methodologies used in this assessment.

4.1 Municipal Fleet and Contracted Services, Energy Consumption and GHG Emissions

Municipal fleet energy consumption and GHG emissions is broken down into two categories, fleet vehicles, contracted vehicles, and equipment.

The inclusion protocol from the Canadian Supplement to the International Emissions Analysis Protocol states, in regard to Municipal fleet vehicles, to report all emission direct and indirectly generated by the use of motor fuels (including electricity)[17]

Figure 4-3: Contracted and Municipal Fleet Fuel Consumption

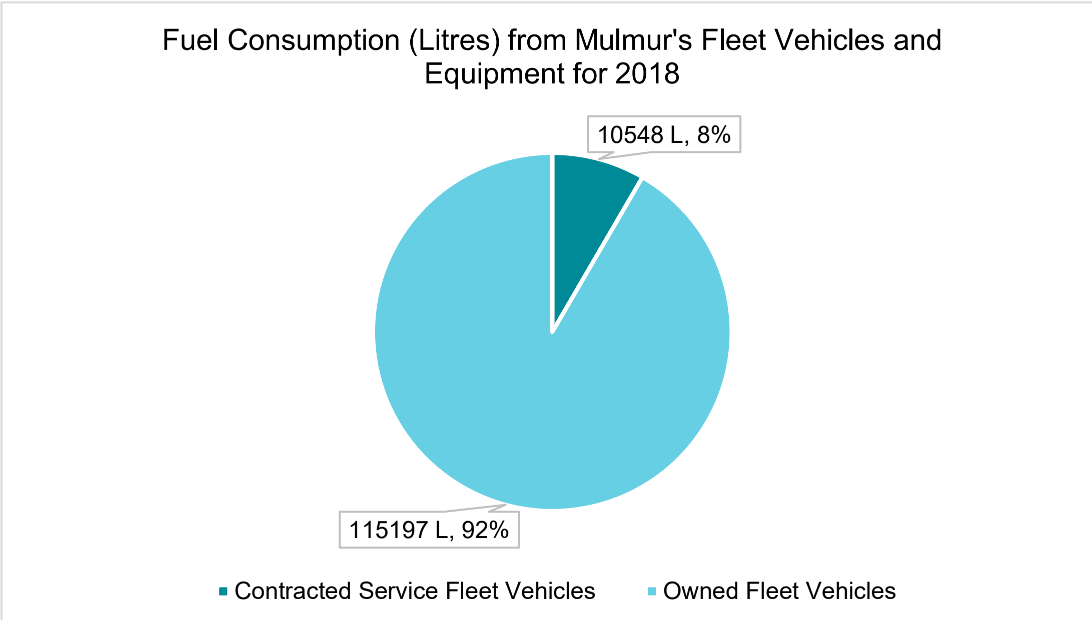
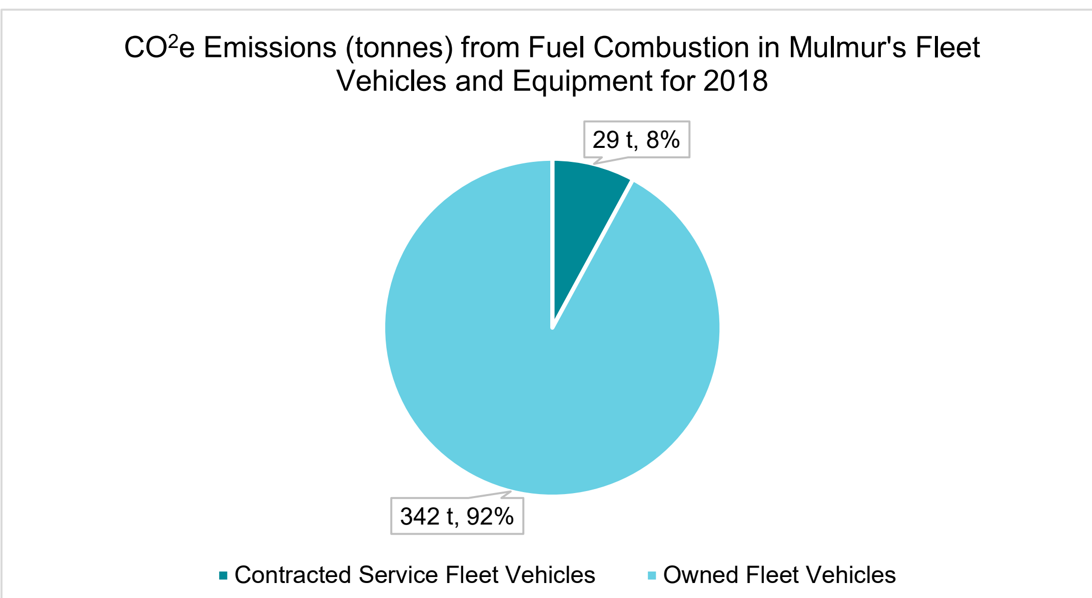


Figure 4-4: Contracted and Municipal Fleet Fuel Consumption



17 Federation of Canadian Municipalities. (n.d). Canadian Supplement to the International Emissions Analysis Protocol.

4.1.1 Municipal Owned Fleet Vehicles

In the case of Municipal owned fleet vehicles actual data was provided, by the Township of Mulmur from 2018. This data consisted of fuel cost; fuel consumption amounts for each fleet vehicle owned by Mulmur.

With actual fuel data, for Municipal owned fleet vehicles the recommended accounting guideline from The Canadian Supplement to the International Emissions Analysis Protocol was used. Please refer to Appendix E for the methodologies for data analysis.

Figure 4-5: Fuel Consumed from Municipally Owned Vehicles

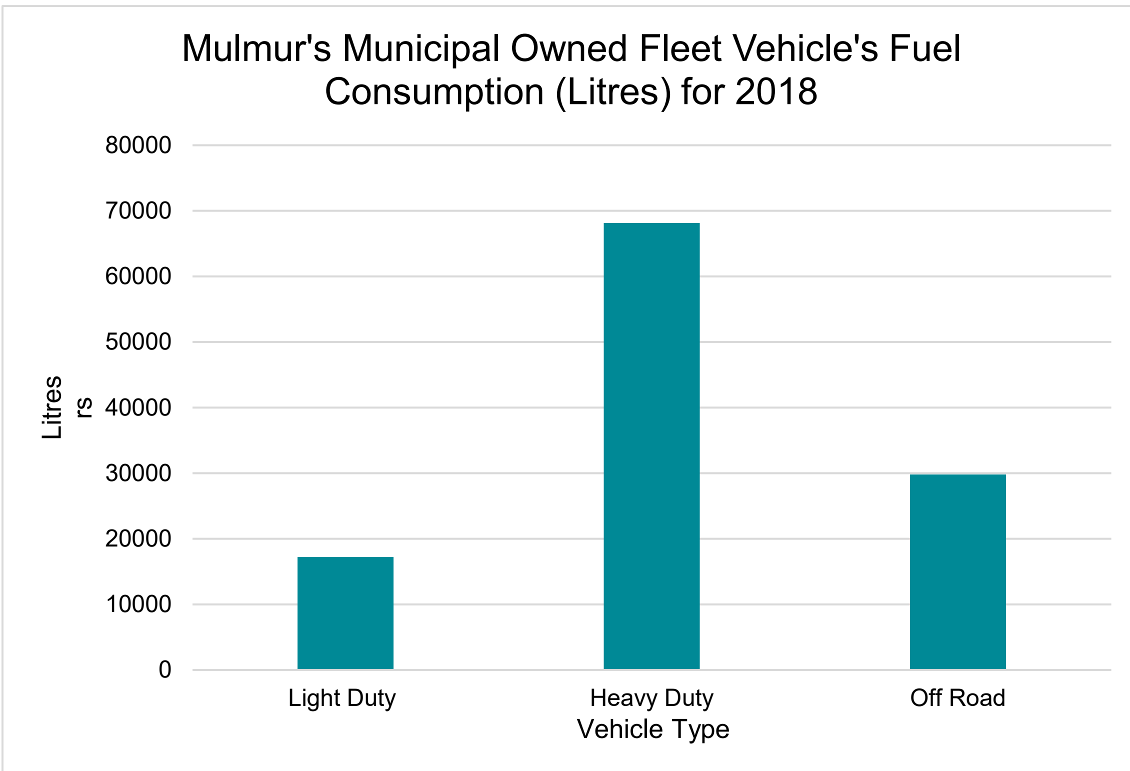
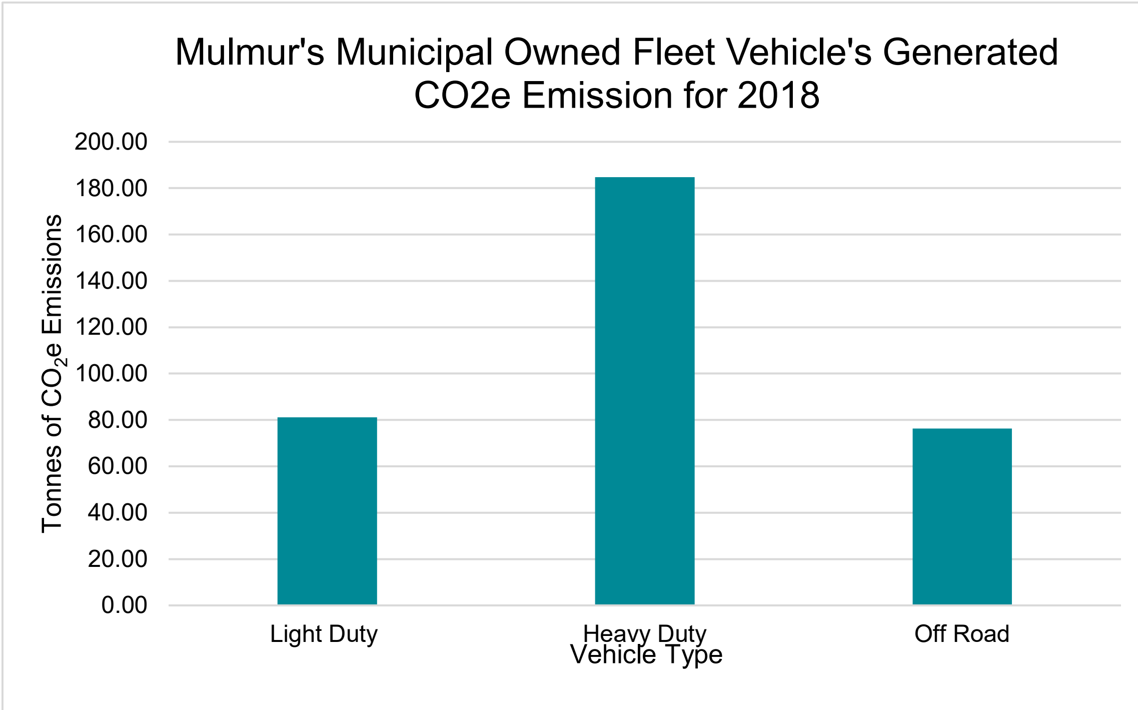


Figure 4-6: Emissions Released from Municipally Owned Vehicles



4.1.2 Contracted Services Fleet Vehicles and Equipment

Contracted services for 2018 in the Mulmur consisted of the following:

- Gravel & gabion stone haulage for road repairs;
- Roadside grass, brush cutting & ditching;
- Roadside tree cutting;
- Screening, hauling and mixing of water and sand; and
- Snow removal.

Actual fuel consumption data was provided from Mulmur for Roadside grass, brush cutting and ditching. All other contracted fuel consumption is calculated using the first alternate method provided by the Canadian Supplement to the International Emission Analysis Protocol, please see Appendix E for methodologies.

Table 4-1: Estimated Energy Consumption from Mulmur's Contracted Vehicle and Equipment for 2018

Service	Gravel & Gabion Stone Haulage for Road Repairs	Roadside Grass, brush Cutting & Ditching **Actual data*	Roadside Tree Cutting	Screening, Hauling and Mixing of Winter Sand	Snow Removal	Total
CO2e (Tonnes)	16.9 t	8 t	0.96 t	1.84 t	1.7 t	29.4t
Fuel (L)(Diesel)	6239 L	2,664 L	320 L	680 L	645 L	10548 L
Energy (Gigajoules)	241.2 GJ	102.9 GJ	12.4 GJ	26.3 GJ	24.9 GJ	407.8 GJ

Table 4-1: Estimated Energy Consumption from Mulmur's Contracted Vehicle and Equipment provides the calculated totals for contracted services energy consumption and emissions released from energy consumption.

4.2 Municipal Buildings

This section reviews municipal energy consumption from Township buildings, facilities. Energy production will also be recorded with emissions released from any energy associated activity. Energy consumed and produced from municipal buildings is shown in detail in the follow subsections. These subsections specifically show energy consumed and produced annually for 2018. Emissions released (from energy sources) are also presented.

4.2.1 Municipal Building Overview

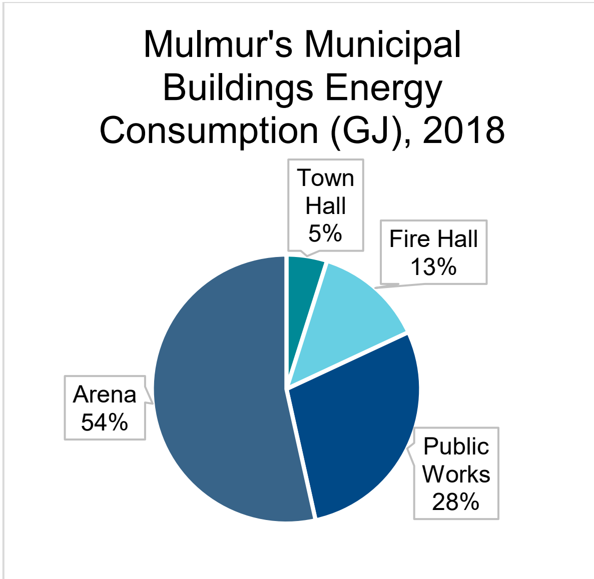
Table 4-2: Mulmur's Municipal Building Information

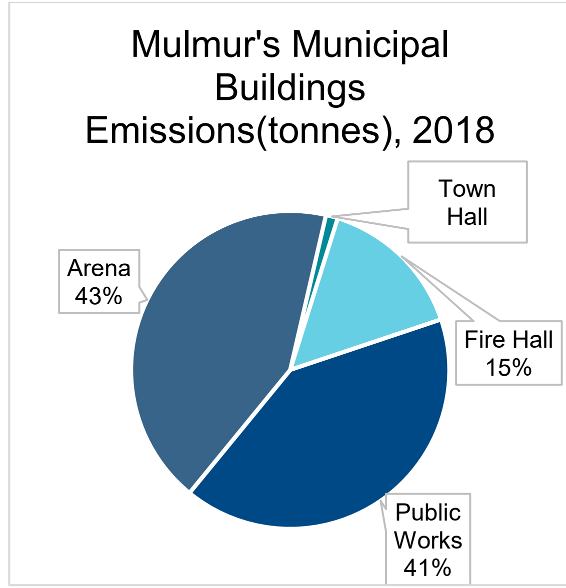
Building	Square Footage	Energy Costs	Energy Revenue*	GJs Consumed	Year Built
Town Hall	4,368	$7,686.97	$8,544.20	64.25	1990
Fire Hall	6,750	$10,860.14	$ 0.0	417.58	1990
Public Works	11,624	$25,521.45	$32,718.20	556.19	1965
Arena**	23,500	$68,497.15	$ 0.0	1,695.23	1982

Notes: * Energy revenue is from PV Solar installations.

** "Arena" refers to the North Dufferin Community Center in Honeywood.

Figure 4-7: Municipal Building Energy Consumption and GHG Emissions





4.2.2 Townhall Overview

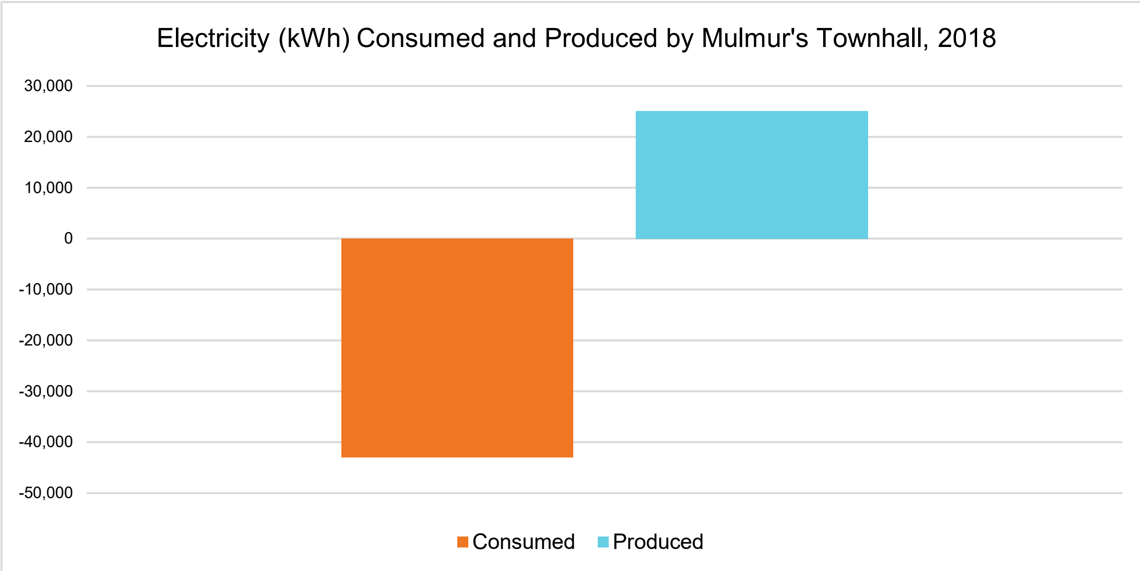
The Townhall is a municipally owned building that is operational all year round, with a total floor size of 4,368 ft^2. The Townhall has a solar photovoltaic system that has been operational since April 2016, under the Ontario FIT program. Solar panels No. 9 and No. 10 are situated on the building's south side. The heating system is geothermal, and electricity is used though-out the building for both heating and cooling.

4.2.2.1 Townhall Energy Consumption/ Production

In 2018 the Townhall consumed 42,976.01 kWh and produced 25,130.00 kWh of electricity[18].

[18] See Appendix F

Figure 4-8: Electricity Consumed and Produced by Mulmur's Townhall



4.2.2.2 Townhall Emission Released

Mulmur's Townhall produced 1.55 tonnes of CO2eq emissions in 2018. These are the associated emissions from the electricity consumed. Mulmur's Townhall did not release any emissions from the renewable energy they generated due to the fact the solar photovoltaic produces no emissions.

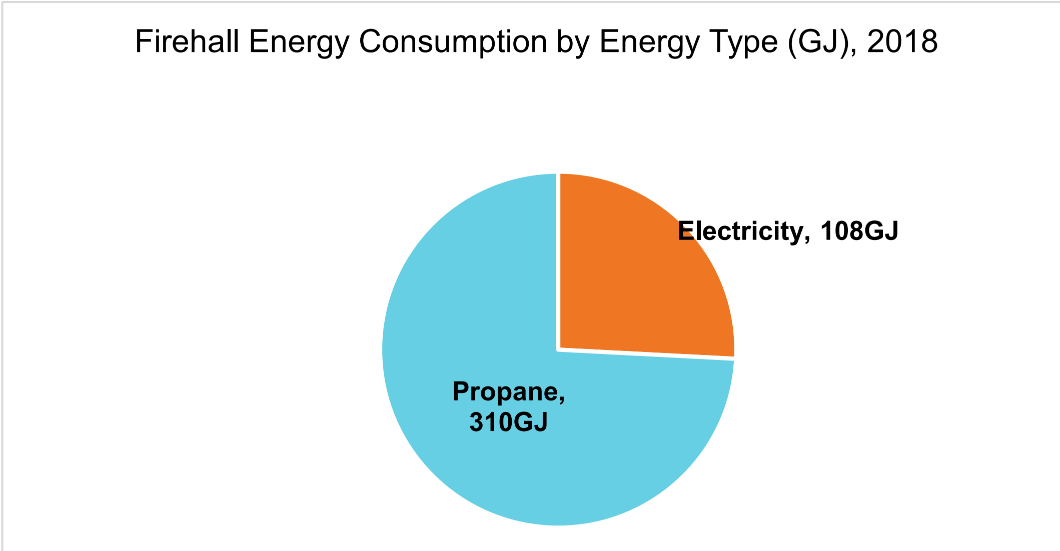
4.2.3 Firehall Overview

The Firehall is a municipal owned building that is operational year-round with a total floor size of 6750 ft^2. The Firehall uses radiant tube heating (propane). The propane for 2018 was supplied by Sparling Propane. The two graphs below clearly illustrate the difference in emissions between cleaner energy sources and those which use hydrocarbons (in this case propane).

4.2.3.1 Firehall's Energy Consumption

In 2018 the Firehall consumed 29,948.12 kWh of electricity, and 11,645.20 Litres of propane. Costs for energy in 2018 totaled $10,860.14.

Figure 4-9: Firehall Energy Consumption



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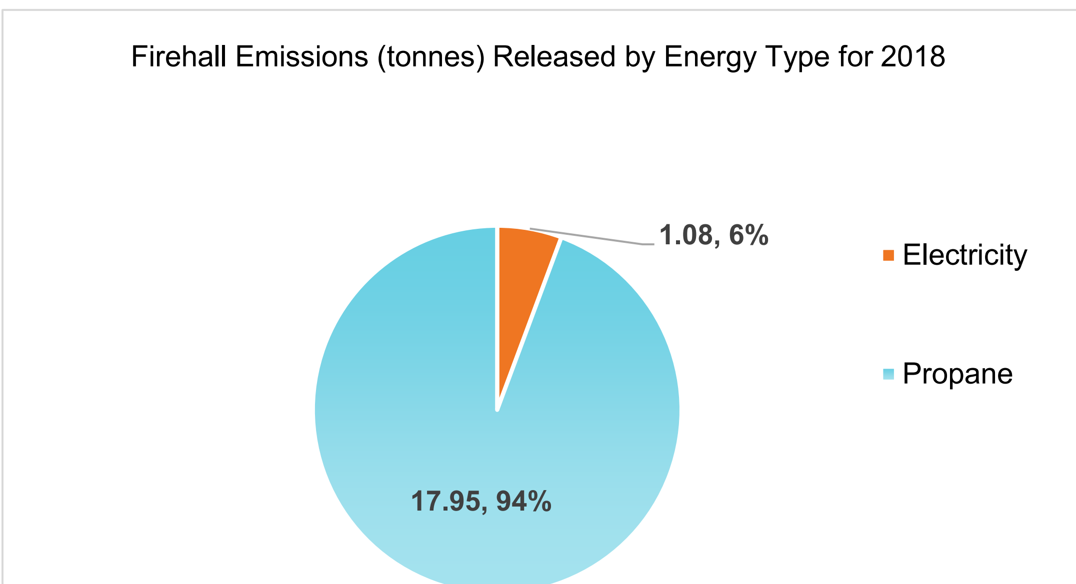
4.2.3.2 Firehall's GHG Emissions Released

Mulmur's Firehall produced a total of 19 tonnes of CO_2eq emissions in 2018. These emissions where based on the electricity and propane consumed.

Figure 4-10: Firehall GHG Emissions Released



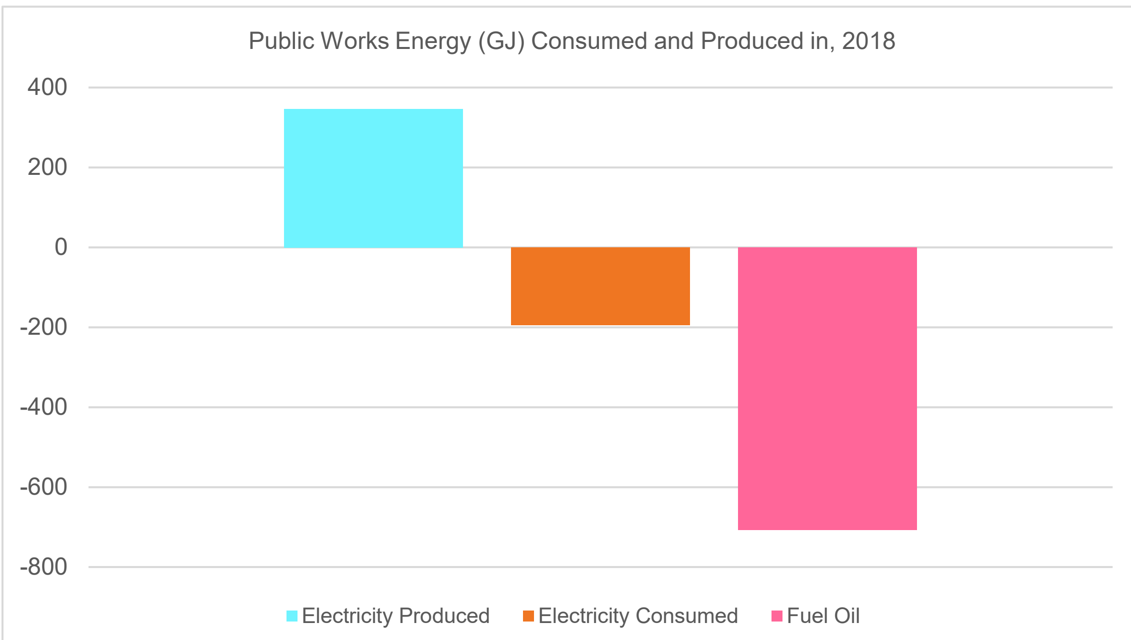
4.2.4 Public Works

The Public Works building is a municipal owned building that is operational all year round, with a total floor size of 11,624ft^2. The Public Works building has a solar photovoltaic system that has been operational since April 2016, approved under the Ontario FIT program. Solar panels No. 1 to 8 are situated on the building. The building heating system is radiant tubing powered by fuel oil.

4.2.4.1 Public Works Energy Consumption and Production

In 2018 the Public Works building consumed 54,106.42 kWh, produced 96,230.00 kWh of electricity[19] and consumed 18,290.31 L of fuel oil.

Figure 4-11: Public Works Buildings Energy Consumption and Production

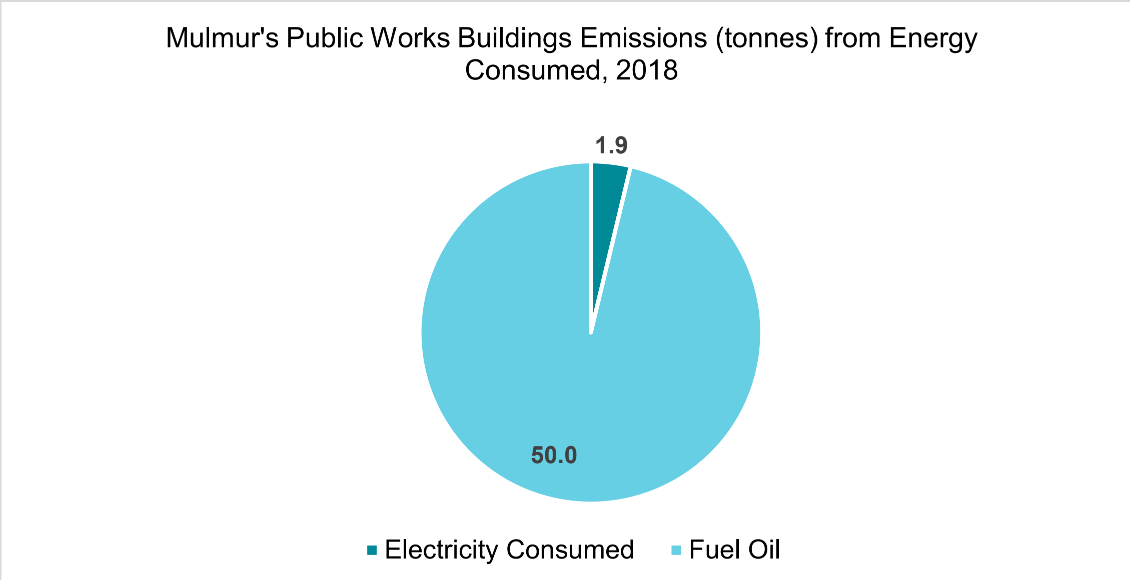


4.2.4.2 Public Works Building's GHG Emissions Released

Mulmur's Public Works produced 51.9 tonnes of CO2eq emissions in 2018. These emissions were from the electricity and fuel oil used. Mulmur's Public Works did not release any emission from the energy they produced due to the fact the solar photovoltaic emits zero emission therefore no emissions were recorded.

[19] See Appendix F

Figure 4-12: Public Works GHG Emissions from Energy Consumption



4.2.5 North Dufferin Community Center (Arena), Overview (Ice Plant included)

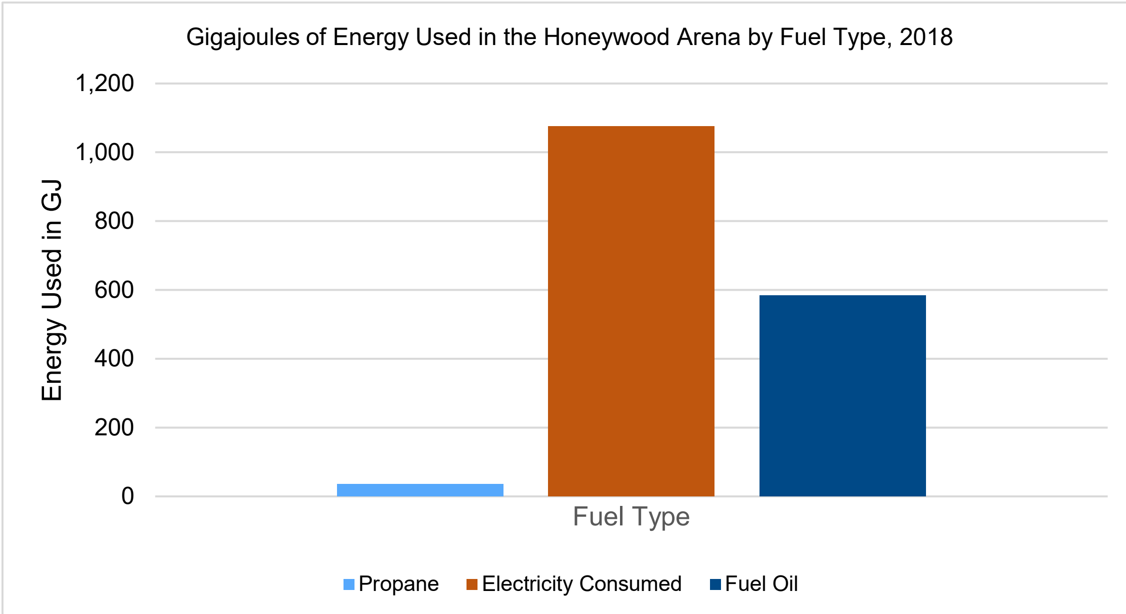
The Arena is a municipally owned building located in Honeywood that is operational year-round with a total floor size of 23,500 ft^2. The arena's rink area use is limited during the summer months, but the community hall is used for various functions throughout the year. The arena uses forced air (fuel oil and propane) for heating. The oil for 2018 was supplied by Wayne bird, the propane source is unknown. Detailed information has been provided on the Arena under separate cover.

As part of our demonstration projects review, Burnside conducted an energy audit of the arena to demonstrate the value of a building energy audit. The findings are reported in the CEP Report, Volume 3. The following summarizes the critical energy consumption and GHG emissions data associated with the arena.

4.2.5.1 Arena Energy Consumption

In 2018 the arena consumed 298,911.97 kWh of electricity, 15,069.31 Litres of fuel oil and 1,351.90 Litres of propane.

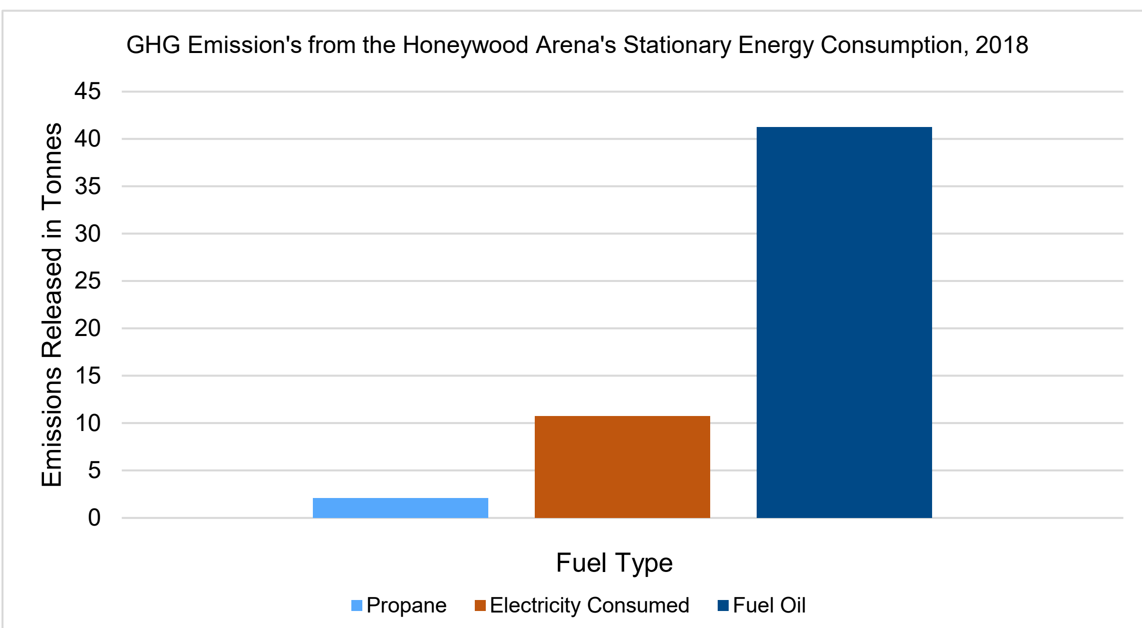
Figure 4-13: Energy Consumed by the Honeywood Arena



4.2.5.2 Honeywood Arena GHG Emissions Released

The Honeywood arena produced a total of 54 tonnes of CO2eq emissions in 2018. These emissions were based on electricity, fuel oil and propane consumed.

Figure 4-14: GHG Emissions Generated by the Honeywood Arena



4.2.6 Hamlet Drinking Water Supplies, Mansfield

Mulmur's Mansfield pump-house uses an average of 42,049 kWh of energy per year. The pump used 51,115 kWh in 2018. There are other wells serving Mansfield, but we understand that this well provides the principle source of drinking water.

There is a good opportunity for the pumphouse to benefit from a net-metered solar installation due to the energy consumed and amount of available municipal property in the vicinity.

Figure 4-15: Mansfield Pumphouse (source Google Maps)

4.3 Other Stationary Energy Consumption

4.3.1 Municipal Energy Consumption and Emissions Released

Other stationary energy refers to stationary energy used from sources other than buildings. Energy consumed is also for infrastructure owned by the Township.

4.4 Supply, Generation Constraints and Growth Pressures

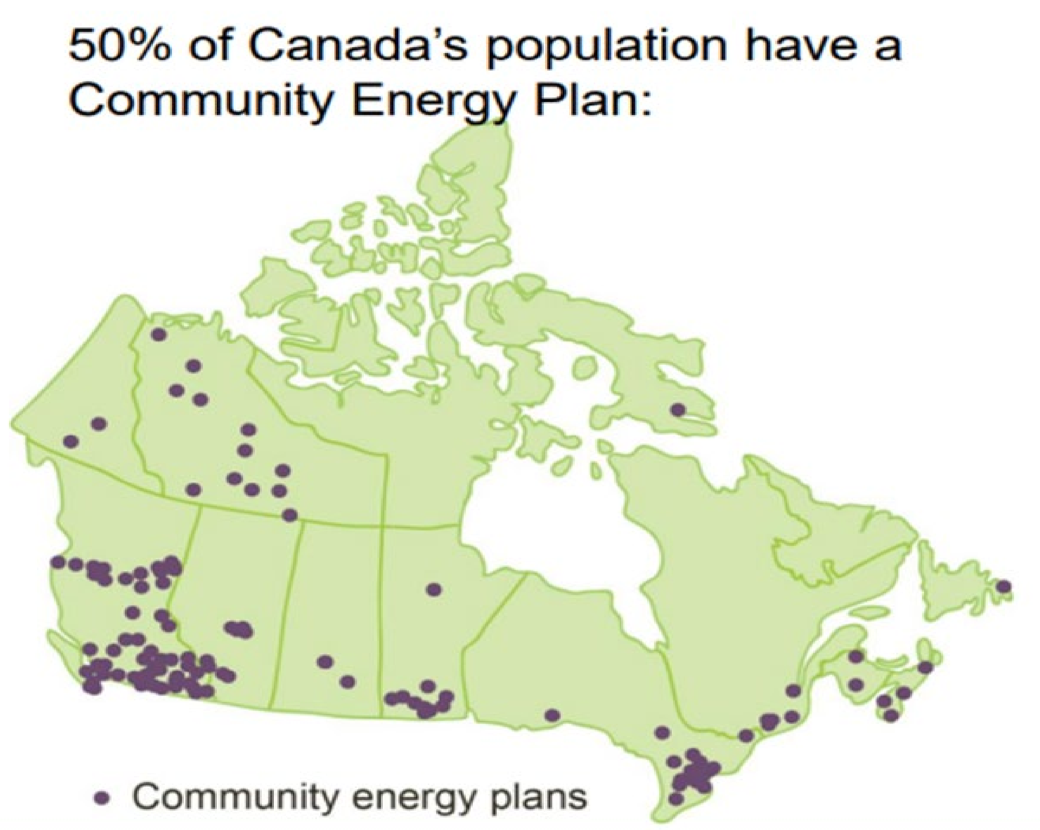
Table 4-3: Energy Consumption and Emissions Released from Other Stationary Sources

	Streetlights	Pump House	Scale House	Mansfield Park
Electricity Consumed (KWh)	71,399.90	72,401.10	360.00	1,160.24
CO2e (tonnes)	2.57	2.61	0.01	0.04
Energy Consumed (GJ)	257.04	260.64	1.30	4.18

5.0 Net Zero Road Map for Economic Development and Energy Security

In Canada over 50% of our population have set CEP goals that they plan to achieve.

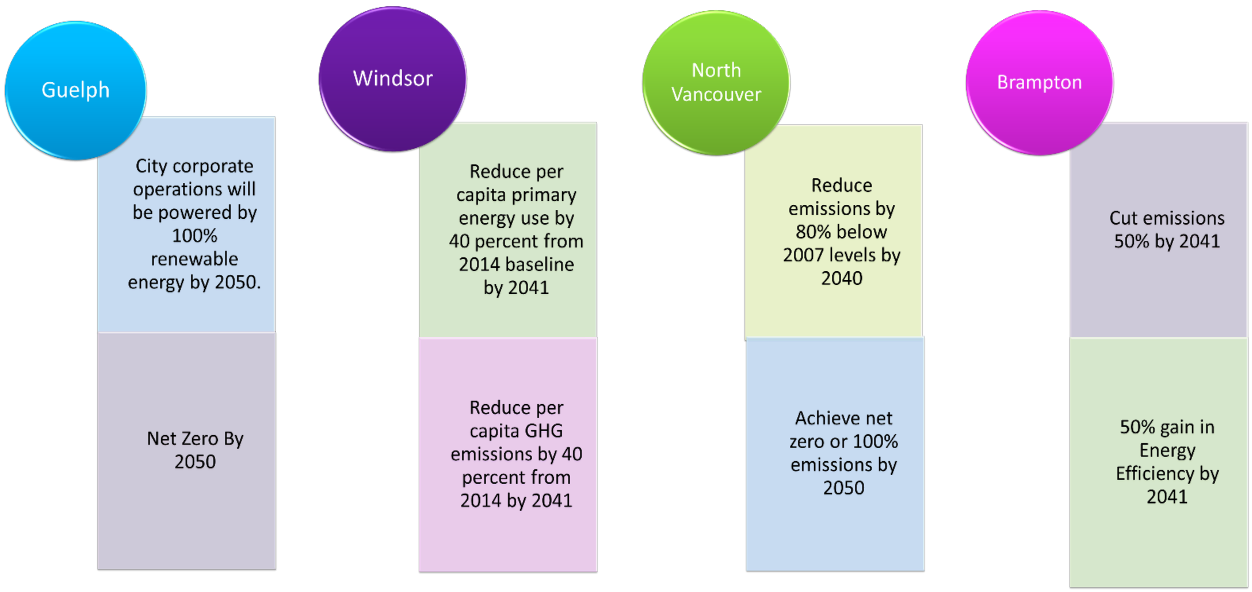
Figure 5-1: Map of Community Energy Plans in Canada



The map illustrates the location of a number the CEP's completed. The map is reproduced from Guelph's CEP report.

The chart below illustrates some examples of these CEP goals.

Figure 5-2: CEP Goals Set by Other Communities



The Lawrence National Centre for Policy and Management.[20] (page 13) cited in this report's introduction notes that: *"even if all provinces achieved their announced or proxy targets, Canada would still face a gap of about 45 Mt in 2020 and 55 Mt in 2030."*

Recent statements by 11,000 of the world's scientists paint a bleak picture of the future that will require ambitious goals to limit human impact on the environment. One of those goals is reduced energy consumption particularly from those sources that cause GHG emissions.

Based on public comments received to date, the goals discussed below are recommended for Mulmur as a starting point. Mulmur may determine that they wish to make the proposed GHG emission goals more ambitious or extend achievement of these goals over a longer period. We believe that the GHG emissions reductions which are associated with the energy conservation measures proposed are the critical goals to reach by the dates suggested.

20 "By the Numbers Canadian GHG Emissions", Paul Boothe and Félix-A. Boudreault Lawrence National Centre for Policy and Management, Ivey Business School at Western University, 2016

It is possible to in order to achieve these lower GHG emissions that electrical energy consumption (hopefully from renewable sources) may rise to provide the energy needed for electric cars, residential heating and cooling, etc. However, if any energy consumption increases can be met with renewable energy sources the GHG effects will be minimized. If GHG emissions can be reduced to meet the proposed goals, critical objectives will have been reached.

5.1 Proposed CEP Goals for Mulmur 2018 to 2040

Burnside proposes aggressive goals to achieve Net Zero GHG emissions by 2040. A five-year review and reporting schedule on progress achieved is proposed. Updates and modifications to the program every 5 years should be made to ensure progress and the goals are achieved. From the public comments received to date there appears to be strong support from the majority of those responding for the Council to act.

What does Net Zero emissions mean?

Net zero emissions means that all man-made greenhouse gas emissions must be removed from the atmosphere through reduction measures. "Net emissions" means gross emissions (including all sector activities associated with fossil fuel combustion) minus carbon sinks from forestry activities and agricultural soils. Although Mulmur can be expected to benefit from the consideration of carbon sinks due largely to its forested areas. We recommend that a more easily measured Net Zero emissions target focus on the buildings and transportation sectors which are the largest emitters of GHG.

As defined by the U.S. Department of Energy, a Net Zero energy building as a building with zero net energy consumption, meaning the total amount of energy used by the building on an annual basis is equal to the amount of renewable energy created on the site, or by renewable energy sources offsite.[21] Net Zero Emissions for Mulmur's transportation sector could be measured by the reduction of vehicle hydrocarbon fuel consumption and conversion to EV's. From public comments there is support for EV's and charging stations in Mulmur.

The following summarize the initial general goals set by Mulmur for the CEP:

- Cost Savings: Through education and energy conservation measures Mulmur plans to demonstrate the benefits of reducing energy use;
- Economic Growth: Mulmur's economic objective is to implement strategies that will keep more energy dollars in the community and thereby spur local economic activity;
- Energy Security: Aligning the built environment, energy and land use growth planning: To help identify the best possible energy options to create a complete community and enhanced mobility; and

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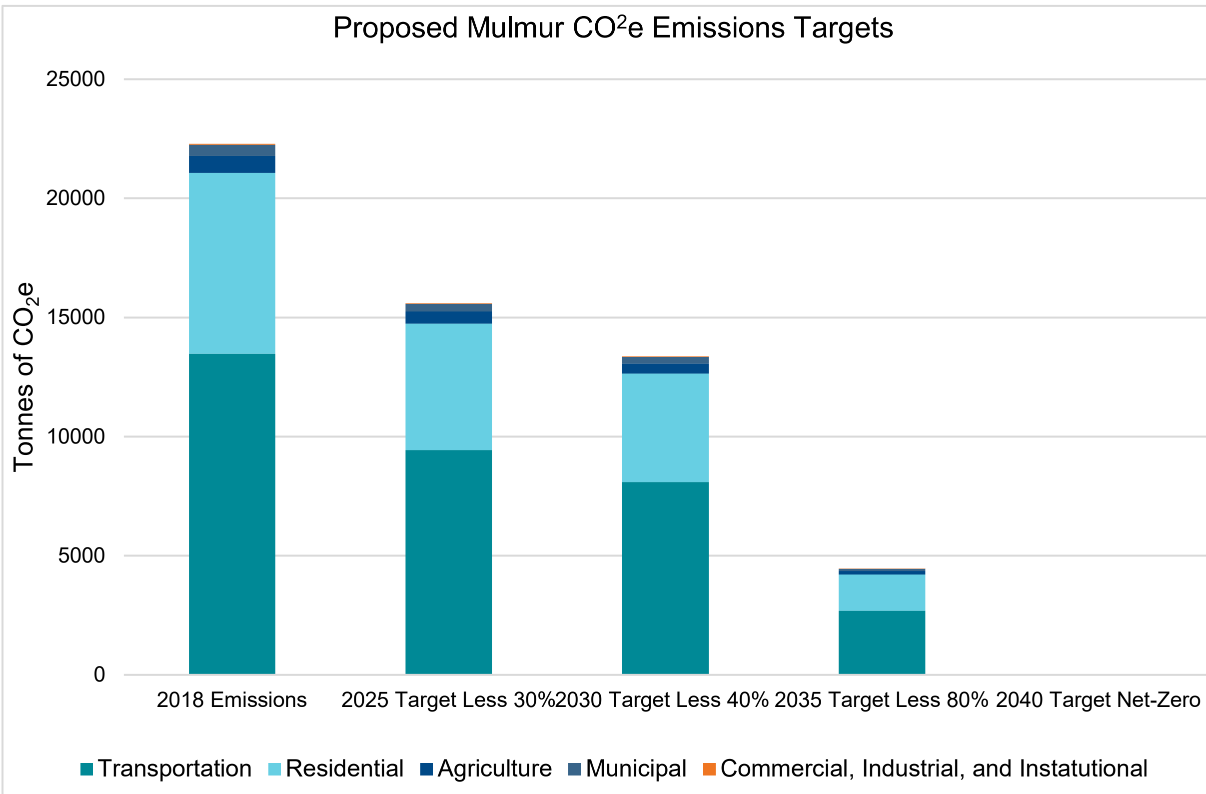
21 A Common Definition for Zero Energy Buildings, The National Institute of Building Sciences, September 2015,.U.S. Department of Energy

- Protecting the Environment: CEPs, and the associated energy conservation plans can consequently drive significant emissions reductions.

Although this study focuses on energy conservation, we recommend that the priority targets at this time for a Net Zero future (by 2040) relate GHG emissions. Moving from current energy consumption using carbon based fuels to clean energy consumption based on renewables will represent a giant step forward in achieving the goals set out earlier and as recommended in Figure 5-3: Proposed Mulmur GHG Emissions Targets. We believe that if the recommendations in this report are implemented and the Mulmur community proactively engage, achievement of both the general and target goals can be reached.

Figure 5-3: Proposed Mulmur GHG Emissions Targets calculated as CO2e



Although Figure 5-3 shows a proportionate decline in all sectors every 5 years it is possible that some sectors could move more quickly to reduce energy consumption and GHG emissions such as transportation and residential sectors.

5.2 Population Growth in Mulmur 2018 to 2050

The implications of population growth in Mulmur should be considered when establishing targets. However, this is difficult since population growth in rural municipalities including Mulmur has been typically ranged from a high of 12% in 1991 to 2.6% in 2016. The equivalent population increase in 2021 based on these percentages would be 417 to 90 people. Housing for this small number of people although beneficial to the tax base of the Township will not be a critical matter to consider (with respect to GHG emissions) as it would be for a larger urban municipality. Burnside expects energy consumption may rise to some extent with the increase in population growth, but the key to reducing impacts in relation to climate change (GHG emissions) rests with ensuring that any increase in energy consumption is derived from renewable and sustainable sources such as wind, solar, water, nuclear and other clean energy sources.

6.0 Demonstration Project Examples

Several demonstration projects examples were studied to prove that action by individual Mulmur residents is not only possible but will provide cost effective solutions. The demonstration projects show the estimated return on investment. In most cases the proposed investments in either energy conservation or renewable energy provide a positive return. The demonstration projects reviewed can be found in Volume 2 and 3 and include the following:

6.1 Energy Audit of the North Dufferin Community Centre, Honeywood

The purpose of this audit was to show the benefits of a formal professional energy audit and how it can save money for property owners. In this case several energy saving measures were recommended that with capital investments will save the Township of Mulmur a range from $17,000 to $21,000 (rounded) per year with a reasonable pay-back period depending on government programs and actual energy prices. If that savings estimate was constant over the next 10 years it would represent $170,000 to $210,000 in savings. Other potential measures that have a longer payback period were not recommended. Since this assessment was very detailed a separate report was produced.

6.2 Demonstration Solar Feasibility Assessment for a Typical Mulmur Community Residence

The Solar Photovoltatic (PV) Feasibility Assessment demonstrated that even under the current net-metering program by the Ontario Government a solar project can have a reasonable payback on the investment. The average residential house size in Mulmur is 1854 sq. ft. (see section 3.2.2). To replace existing energy sources consumption (electricity, oil, propane, wood) the average residence is estimated to require approximately 20 kW of electricity.

The payback period or Return on Investment (ROI) for a solar system that is paid for 100% without a loan is about 11.5 years. The solar system would be connected to the grid under the net-metering program and will provide all of the electrical energy needed for the house. Solar systems can be expected to produce energy for 25 to 30 years.

6.3 A Demonstration Heating Source Assessment for a Typical Mulmur Community Residence

A simplified lifecycle cost analysis comparing different heating sources; propane, oil, geoexchange (geothermal) heat pump (GSHP), and air source heat pumps (AHSP) was analyzed. For all cases analyzed ASHP and GSHP outperform the fossil fuel furnace options.

The high efficiency furnaces for both oil and propane were a lower Net Present Cost than the mid efficiency furnaces. GSHP and AHSP have a high initial capital cost but a low yearly operating cost. Based off these assumptions geoexchange systems and Air source heat pumps could offer financial benefits to Mulmur residents. More detailed lifecycle cost analysis for site specific considerations should be undertaken before any development decisions are made. For the base case scenario, the ASHP had a net present cost of $35,000 compared to $42,700 for a high efficiency propane furnace.

6.4 Electric Vehicle (EV) Infrastructure Assessment

The EV infrastructure assessment determined that there is currently limited publicly available electric charging stations in or close to Mulmur. Two locations were identified at the time of this report's production. One is located at the Mansfield Ski Resort on Airport Road and the other EV charging station just outside of Mulmur at Trillium Ford (located at Hwy 10 between Primrose and Shelburne).

The assessment reviewed the critical issues to consider when selecting EV charging locations and charger needs depending on use expectations. For example, home use overnight charging versus commuter use.

The assessment also provided a review of EV's currently available on the market. It was determined that EV's that are both cost competitive and can achieve significant travel distances before needing to be recharged are now available. Mulmur residents are strongly encouraged to consider purchase or lease of an EV.

6.5 Agricultural Anaerobic Digestion (AD) Assessment

Our study considered a potential project opportunity for Mulmur agricultural operations to benefit from a renewable energy project. An anaerobic digester (AD) is considered a renewable energy technology.

The anaerobic digestion process occurs in an enclosed vessel where agricultural manure and/or plant waste materials are broken down by micro-organisms in the absence of oxygen. Methane gas is generated and is directed to an internal combustion engine powering an electrical generator (for electrical production). The heat produced from the facility can also be used.

According to a report by Robert C. Anderson, Don Hilborn, and Alfons Weersinka,[22]

> *"…Previous studies have generally found ADs to be a poor investment for private firms without public assistance. The mixed results on the financial feasibility of ADs could be due to the site of the analysis since results vary with size, geographic location or the type of AD system, which are not standardized but rather customized to the individual situation."*

Readers are encouraged to review the CEP, Volume 2 report which provides more detail on the subject. Projects could be viable under certain circumstances and with public sector grants.

7.0 Stakeholder Engagement and Consultations

The success of the program and achievement of any goals established by Council will be highly dependent on participation of the Mulmur community's residents and businesses. Our recommendations reflect this reality and if approved by Council will provide strong financial incentives for the Mulmur community to participate and act.

A number of opportunities for stakeholder engagement were provided during the study as documented in the Stakeholder Engagement and Consultation Report such as:

- Newsletter and newspaper information provided;
- A website which provided information and reports is established;
- Invitations to join a leadership team, appointment of a council member team leader and team formation;
- An opinion survey was undertaken;
- A public open house was held with preliminary findings of the study provided; and
- Formal presentations to Township Council, Staff Meetings and presentations.

Details of the public engagement and consultation activities can be found in Volume 4.

8.0 CEP Conclusions

Energy consumption and GHG emissions from energy related activities of the Mulmur community and its Municipal Government have been clearly established through this study. Although this study documents GHG emissions related to energy consumption Mulmur's emissions recorded in this report do not represent total emissions as noted in Section 1.5 GHG emissions from Agriculture are thought by many experts to be higher

22 An economic and functional tool for assessing the financial feasibility of farm-based anaerobic digesters
Robert C.Anderson, Don Hilborn, Alfons Weersinka https://www.sciencedirect.com/science/article/abs/pii/S0960148112005782

than the energy related emissions shown in this report. This is illustrated by the bar graph shown in Figure 1-2.

The principle driver for CEP studies in Canada is climate change, but in this study, we have shown that taking action to prevent climate change and reduce or change the type of energy consumed can be very beneficial to each property owner. The CEP includes recommendations and ideas that can bring financial, social, and environmental benefits to the community and its Municipal Government. The demonstration project examples show that there are benefits to be accrued by implementing the solutions recommended in this report. These benefits need to be acted on now to accrue the anticipated benefits. The urgency to act now should be obvious to those who have read this report.

Mulmur residents have so far been sheltered from the dramatic effects that are being felt around the world in varying degrees. This will not last! Canada is warming at twice the rate of some other areas of the world. This study shows that it is not only possible for Mulmur's residents to individually contribute, but also benefit from the recommended actions proposed.

Active engagement of Mulmur's Municipal Government and other sources by providing funding incentives and marketing the proposed solutions will encourage residents and businesses to act.

9.0 Recommendations and Actions Proposed to Achieve the CEP Goals

This report and the recommendations for action that follow, if approved by Council, are expected to encourage the Mulmur community to embrace the CEP and work to achieve the stated general and specific target goals.

Mulmur residents and businesses will need to help ensure that electrical energy cost and energy security benefits accrue directly by acting on the energy conservation measures proposed and by developing renewable energy projects on their property. Both hydrocarbon fuel and electrical energy costs are expected to increase in the future. Energy conservation and development of renewable energy projects will provide not only cost benefits but energy security to those who act now. Transition to renewable energy will ensure local GHG emissions are substantially reduced. This CEP study shows that energy conservation will reduce transportation, residential and business costs.

Most of the recommended actions that the Mulmur community and municipal government need to take will involve capital expenditures. This is capital that many may not be able to easily access. Therefore, our key recommendations focus on access to capital to help the Mulmur Community and its government undertake the energy conservation and renewable energy projects that will make a difference. These expenditures will not only be recovered but will provide cost savings once the return on investment (ROI) has been achieved. The ROI time frames will vary depending on the type of energy conservation and renewable energy investment involved. The demonstration project examples illustrate opportunities for various sectors. In most cases capital investments will provide a good ROI over time, but in some specific cases government incentives or subsidies are needed to assist project development.

There are incentive programs from the federal and provincial governments that can help reduce costs and these should be taken advantage of when available. Bank loans are possible for some property owners who might wish to develop a project. The current Canadian Liberal government promised to provide no interest loans up to $50,000.00 for energy efficient upgrades as part of its climate action plan in the recent election. Not all will want to take this course of action.

In 2012 the Ontario Government changed some critical regulations to allow Local Improvement Charges (LIC) by Municipalities to finance residential energy upgrades. Burnside recommends that this program be adapted by the Township of Mulmur. We believe it will provide a critical incentive among other recommendations to promote implementation of this CEP plan. Our recommended actions to implement the goals of the CEP follow.

9.1 Establish a Local Improvement Charges (LIC) Fund

Until recently, use of the LIC mechanism was confined to public, not private property. On October 24, 2012, the Ontario Ministry of Municipal Affairs and Housing authorized Ontario Regulation (O.Reg.) 322/12, amending O.Reg. 586/06 under the Municipal Act, 2001. While the original LIC can still be applied to the existing uses, the regulatory amendments expanded the examples of uses to specifically include energy efficiency, renewable energy and water conservation in alignment with municipal goals and policies. The following are excerpts from the Clean Air Partnership that describe the LIC program features.[23]

> *"The new LIC regulation describes a user-pay cost allocation method that covers all costs, which include the upgrades plus pro-rated administrative costs of delivering the program (such as marketing) as well as interest on borrowing. As with traditional LICs, this LIC would be repaid as a special temporary charge on the participating owner's property tax bill that would*

23 Using Local Improvement Charges to Finance, Residential Energy Upgrades, by Sonja Persram, BSc., MBA, LEED® AP, President, Sustainable Alternatives Consulting Inc. dated July 25,2013. http://www.cleanairpartnership.org/wp-content/uploads/2016/08/Primer.pdf

be removed once the cost is recovered by the municipality. Another unique LIC benefit is that financing stays with the property not the owner, on sale. As a result, if owners move before completing the repayments, the new owner continues LIC payments and receives the benefits. If property ownership changes before the full LIC debt is repaid, the municipality continues to collect the charge through the property tax charged on that property. In legal terms, the charge runs with the land. The property owner is able to make a one-time payment to the municipality to clear the outstanding balance before selling a property. Otherwise, the LIC automatically transfers to successive owners upon sale.

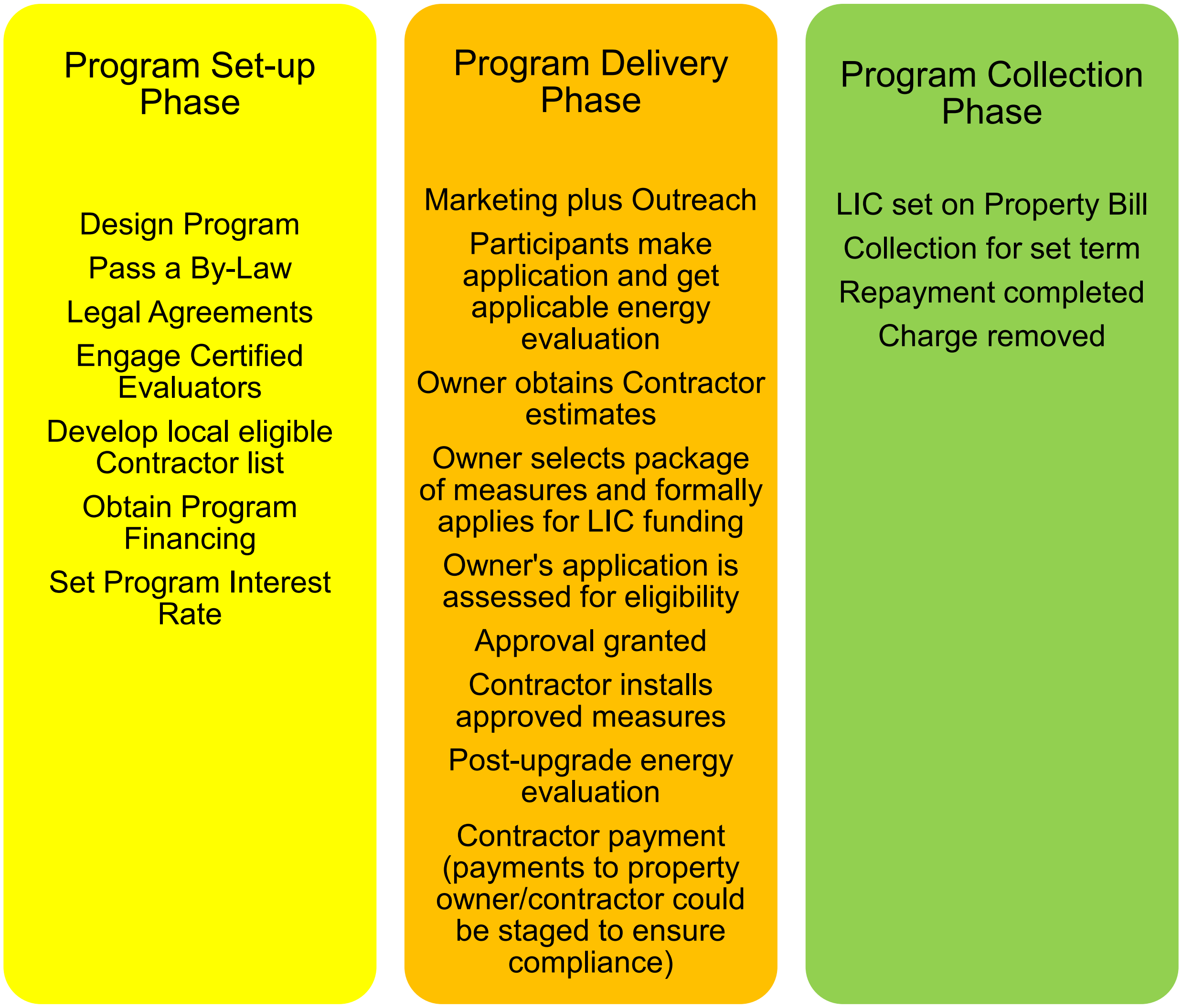
A municipality, with local Council approval, could offer a LIC financing program to local property owners to support energy efficiency upgrades and other work as defined by the municipal program.

How can municipalities finance an LIC program? Municipalities have a variety of options for financing LIC programs. For smaller programs they can draw on internal funds, such as operating surpluses or capital reserves. This type of program might also qualify for financing through external parties such as Infrastructure Ontario, which provides a low-cost and flexible source of capital. Alternatively, municipalities can raise financing by direct borrowing from the bond market. Participation in the program is completely voluntary. Upon entering into an agreement with the municipality, participants could access financing for extended terms up to 20 years at a competitive fixed rate that would include a provision for administrative costs. The opportunity to have long term financing at an attractive rate can help homeowners finance larger, higher-impact upgrades that could achieve deeper savings. The participants repay the financing as a user fee on their property tax bill for the duration of the term. The LIC does not increase the owner's property taxes. The participants in the program, not the general taxpayer, share the cost of program administration."

9.1.1 What might an LIC program look like?

The following charts (modified from the previous referenced report) review the phases and tasks that could be involved in the LIC program set-up and delivery.

Figure 9-1: An LIC Energy Upgrade Program Example



As previously stated, LIC program costs are supported by the participants, not the general taxpayer, so these types of programs pay for themselves and do not add any operational costs to the municipality. The regulatory amendment permits the municipality to recover pro-rated administrative, marketing and other costs associated with running the program directly from participants. Costs would need to be set at competitive rates to promote program use.

Availability of funding provided to participants under the LIC program will be critical to the CEP's success. As outlined above following the program set-up phase interested participants would make application to the municipality for an energy evaluation of their property.

The evaluator (see recommendation 9.1.5 below) would make formal recommendations and the property owner would select those energy saving opportunities (which would include energy conservation and renewable energy opportunities) they would like to proceed with. Likely the property owner would obtain competitive bids for the work from local contractors who would provide estimates for the selected energy saving opportunities along with estimates of the capital payback periods involved.

Legal advice will be required to set up the program and construct the appropriate agreements that the Mulmur will require. Much of the initial legal work has already been completed with a very thorough (23 page) legal opinion provided by John Mascarin, AIRD & BERLIS LLP, Barristers and Solicitors for the Clean Air Partnership on July 11, 2013.[24]

9.1.2 LIC Program Design

In this report we have not attempted to prepare a comprehensive program design, however the following provides some preliminary suggestions and a list of project types are recommend for inclusion in the LIC program.

There should be an expectation that all projects that receive any LIC funding will remain with the property. This condition should be part of any standard agreement between the property owner and the Township.

An energy evaluation will be the first step in the process in order to obtain LIC program funding. We recommend that energy evaluations be offered to property owners of residential, business (including agriculture) and institutional facilities in Mulmur as an incentive. A payment for the initial energy evaluation might be required as part of the application and would be reimbursed upon completion of the energy saving project. The energy evaluation could be offered at no charge with the provision that the property owner will proceed with at least some of the energy evaluators recommendations or else the property owner would not be reimbursed for the evaluation.

Cost recovery of the energy evaluation service would be through the program or other funding sources such as discussed in recommendations, 9.1.3 to 9.1.5 below. If funding is obtained for the Energy Manager from NRCan (see recommendation 9.1.5) the program costs could be adjusted accordingly.

Projects should only be eligible for funding if they are recommended through the energy evaluation by the energy manager/auditor and authorized under the terms of a By-Law. It is possible that some straight-forward measures such as tree planting (if included in the LIC) may not require energy manager evaluation.

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24 https://www.cleanairpartnership.org/wp-content/uploads/2018/03/Local-Improvements-on-Private-Property-by-Agreement-1.pdf

Projects to be funded should have some reasonable schedules for completion established. A follow up energy evaluation should follow the project work installed to confirm the estimated efficiency measures have been installed and have reasonably met the anticipated renewable energy and/or, energy efficiency estimated by the evaluation.

It is possible that some of the projects would require approvals in accord with the Mulmur's By-Laws such as By-Law 39-2019 and/or other local or provincial requirements.

9.1.3 Retain the Services of a Consultant to Design the LIC Program

Assistance of a consultant will be needed to help design and estimate the start-up cost of the full LIC program. The consultant will need to work with municipal staff and a legal advisor to develop the appropriate By-Law(s). It would appear that the Federation of Canadian Municipalities has a program that will provide at least 50% funding for pilot projects. We believe that this project would qualify. The remaining costs can be recovered through the proposed LIC program once established.

9.1.4 Retain Legal Services to Provide Advice and Prepare the LIC Legal Agreements

It is recommended that the services of a municipal lawyer be retained with background knowledge and experience with the LIC program. The lawyer can advise on the proposed program, work with the above referenced consultant and municipal staff to develop the appropriate by-law(s) wording and agreements that will be necessary to implement the program. Funding should be available as discussed in recommendation 9.1.2.

9.1.5 Retain the Services of an Energy Manager

Burnside has assisted Mulmur with an application to NRCan for 100% funding under their energy manager program. Unfortunately, this funding was not approved. Other programs may be available to assist with implementation of the CEP recommendations in the future.

9.2 CEP and LIC Program Development by Sector Recommendations

Among those stakeholders who responded, it is clear there is strong support for action by Council. Our recommendations are focused on the key sectors that are major consumers of energy and the associated emitters of GHG emissions in Mulmur. The recommendations assume that a LIC program will be established. Those sectors in order of importance are:

- Transportation;
- Residential, business, institutional buildings and properties;
- Agriculture; and
- Municipal infrastructure.

9.2.1 Recommendations for the Community Transportation Sector

Use of private vehicles for transportation in Mulmur is the largest energy consumer and contributor to GHG emissions. Transition of internal combustion vehicles to EV's can rapidly reduce hydrocarbon fuel consumption and the associated GHG emissions. We recognize that some of the larger internal combustion vehicles such as transport trucks are only beginning to be adapted to electric or other non-polluting source fuels, but the transition is expected to rapidly develop. EV (cars and SUV's) are now available, and half tonne electric trucks are expected in 2020 to 2021 at competitive costs.

It is proposed that electric charging stations for both residents in their homes and at local businesses be promoted and funded under the LIC program. This should help promote use of electric vehicles. Local businesses and rest areas could consider installation of Level II or Level III chargers for their employees and Level III chargers for commuters.

The program would not need to cover Level I chargers since these chargers are typically supplied with the vehicle. Program funding could also cover back-up batteries and renewable energy sources associated with vehicle charging. Both the cost of the equipment and electrical installation required could be covered.

9.2.2 Community Residential, Business, Institutional Buildings and Properties

Recommended projects for residential, business and institutional buildings and properties that should be included in the LIC Program are:

- Replacement of gas or oil furnaces including associated measures with heat pumps for heating and cooling;
- All renewable energy projects including solar, wind, biogas, and small run-of-the-river hydro power. We recommend that biomass incineration systems not be included since they will contribute to GHG production;
- Solar hot water and solar wall heating systems;
- All energy conservation related home renovations and retrofits such as added insulation; weather stripping; vapor barrier sealing; window and door replacement to more energy efficient models; energy saving blinds for windows;
- Replacement of existing appliances to new energy star energy efficient models;
- Tree planting (minimum number to be specified). LIC agreement should specify trees cannot be harvested for at least 40 years;
- Lighting retrofits to LED's;
- Smart thermostats;
- HRV Heat Recovery and Fresh Air System;
- Smart low water use faucets;
- Hot water tank insulation;
- Replacement of hot water tanks with on demand heaters; and
- Other energy conservation and renewable energy opportunities as might be determined by the energy evaluation.

9.2.3 Recommendations for the Agricultural Sector

- All renewable energy projects including solar, wind, biogas, and small run-of-the-river hydro power;
- If applicable, solar hot water and solar wall heating systems;
- Tree planting (minimum number to be specified). LIC agreement should specify trees cannot be harvested for at least 40 years;
- Lighting retrofits to LED's; and
- Other energy conservation and renewable energy opportunities as might be determined by the energy evaluation.

9.2.4 Other Non LIC Eligible Opportunities for Energy Conservation and Reducing GHG Emissions

- Use no till farming practices where possible;
- If purchasing new tractors or other equipment, consider fuel efficiency of the equipment; and
- If Provincial or Federal funding is provided, consider an Anaerobic Digestion (AD) project for farm waste materials. Some consideration could be given to LIC funding for AD if project feasibility is demonstrated.

9.3 Recommendations for Municipal Infrastructure

The Township is to be praised for its past and current efforts to adapt energy conservation and renewable energy measures at its facilities. Its solar installations at the town hall and public works building and installation of a geothermal system for the administrative building plus installation of LED lighting have provided several years of energy cost savings. These measures have also reduced GHG emissions from municipal infrastructure.

The LIC program proposed for the private sector and to be managed by the municipality would not apply to municipal infrastructure improvements, but other provincial or federal funding programs are expected to be available to help with further improvements that may be taken.

All of the above project suggestions for the private sector as may be applicable to municipal assets should be considered by the municipality. The following are some specific considerations for energy efficiency for municipal buildings and other assets.

9.3.1 Recommendations for Municipal Fleet Transportation

Almost 50 % of municipal energy use and 68 % of GHG emissions are from the municipal fleet transportation. This includes its graders, trucks, tractors and other equipment required for various operations. It is recommended that Mulmur reduce transportation related energy use and GHG emissions to the extent possible.

The electric vehicle infrastructure assessment included with the CEP in Volume 2 demonstrates the availability of both charging technology and EV's that could potentially be used for some aspects of municipal operations. It is recognized that at this time only smaller fleet vehicles such as cars, SUV's and half tonne trucks are available. Hybrids or other alternative fuel vehicles such as hydrogen might also be considered. Alternative energy fleet vehicles are rapidly evolving and are expected on the market in the next few years. The following are suggested:

- If electric vehicles will currently not meet performance needs, ensure that applicable municipal vehicle lease or purchase requirements include the lowest EPA fuel consumption standards available;
- Install EV charging stations at the Terra Nova municipal parking area. Most could be Level II chargers for overnight charging, but for municipal vehicles that require quick turn-around times Level III chargers should be considered for a one-hour or less turn-around charging time. If a sufficient number of chargers were available municipal staff could consider EV purchase for their commute to work; and
- Mulmur maintains records of its fuel usage. If not already the case, fuel records for each piece of equipment should be recorded by the operators. This will provide valuable information associated with vehicle use and future replacement purchases.

The Township could consider a tree planting program to off set its actual GHG emissions from its fleet vehicles.

9.3.2 Recommendations for Municipal Contractors

It is recommended that Council formally make the demonstration of energy efficiency and conservation part of its public works equipment and contractor purchasing policy. Municipal contractual obligations should include a requirement that contractors retained for services provide commitments to energy efficiency and conservation measures. Consideration could also be made for contractors to provide other compensation measures if they either cannot upon bidding or have not achieved contractual obligations. There are two examples offered for consideration:

- Purchase and planting of an appropriate number of trees (perhaps on municipal properties that would off-set GHG emissions of their contract work. GHG emission off-sets can be easily calculated; and
- A carbon off-set payment to the municipality for those contractors who cannot meet fuel efficiency standards.

9.3.3 North Dufferin Community Centre, Honeywood

Burnside completed an energy audit of the Honeywood arena and found several opportunities for energy efficiency improvements and renewable energy with relatively rapid return on investments that would be required. The annual savings from those investments is substantial. Those are mentioned in Section 6.0 with details provided in our CEP Volume 3.

9.3.4 Consider Installation of a PV Solar System on the Honeywood Firehall

The Honeywood firehall's GHG emissions primarily relate to the use of propane for heating. An audit of this building could be considered and along with possible replacement of propane with an air source heat pump. (See the CEP, Volume 2 for details about heat pumps.) Replacement of a heat pump for heating and cooling could potentially save costs. However, this should be carefully evaluated prior to proceeding.

If the evaluation showed that the propane heating system should be replaced by an air source heat pump additional savings could be achieved by installation of a PV solar system on the roof of the building. It is not recommended that a solar system be considered unless the evaluation suggested shows that the heating system will be converted to an air source heat pump which would increase electricity consumption.

9.3.5 Consider Installation of a PV Solar System at the Main Mansfield Well

Installation of a PV system at the Mansfield main water well could off-set electrical pumping costs of operations. There appears to be vacant municipally property available for a ground mount solar system at this location. The feasibility for a solar PV project at this location would need to be assessed.

9.3.6 Consider a Tree Planting Program

Consider a tree planting program on Township property or other properties. A tree can absorb as much as 48 pounds of carbon dioxide per year and can sequester 1 tonne of carbon dioxide by the time it reaches 40 years old. However, if the trees are cut and burned the sequestered carbon dioxide is released back into the atmosphere.

9.3.7 Discuss Local and County Authority to Require New Housing and Other Building Infrastructure to Meet Net Zero Building Standards or Approach the Province to Promote Building Code Improvements

Mulmur might wish to approach the County to consider if it has any authority under the Building Code Act, Property Standards provisions to encourage energy conservation and renewable energy measures.

9.3.8 Consider a Mulmur Promotional Program to Encourage Net Zero for Both the Building and Transportation Sector

Regardless of decisions on the LIC Mulmur could consider promotional energy conservation and renewable energy program information in tax notices, on its web site, local newspapers, etc. If a promotional program is established in conjunction with development of a LIC funding program, then any associated costs could be recovered through the program.

9.4 Update CEP with Comprehensive GHG data at Next Plan Update

Comments received by Mulmur Council and staff outlined the desire for a comprehensive GHG emissions baseline. Some of the data needed for this was unavailable at the time of the study, furthermore, the resulting calculation is out of the scope of the funding for this Community Energy Plan. However, it is recommended that a comprehensive GHG inventory study including sources and sinks from non-energy related items accompany an update to the CEP when funding becomes available.

The missing data could be collected through better data from Statistics Canada (StatsCan) as outlined in section 10.2. If data can not be obtained through StatsCan data could be collected from a qualified social research firm. This was an item applied for in the initial funding request for this report, however budget that would have allowed this work was denied. With the required data a qualified firm could calculate a comprehensive net GHG inventory from sources other than energy.

9.5 Establish Energy Conservation Stakeholder Committee

A Council member has been identified to lead this committee. It is intended that the committee be a recommending body who can potentially help with community outreach efforts to engage with fellow community members and local businesses and implement the CEP recommendations.

9.6 Apply for Energy Manager and Other Funding When Available

In cooperation with municipal staff Burnside previously assisted in an application for Energy Manager funding from NRCan. The Township applied for 100% funding for the professional assistance that will be required to undertake and report on energy assessments for municipal, residential, business and institutional facilities in Mulmur. This professional assistance integrates well with development of the proposed LIC funding program. Unfortunately, the funding application was not approved, however, when funding becomes available again, Mulmur should apply. Other funding programs should be considered to help implement the CEP recommendations. Council approval of a CEP report is currently a pre-requisite for some funding programs.

9.7 Implementation Strategy

9.7.1 Immediate Goals (1 to 2 Years)

- Apply for energy manager;
- Establish energy conservation stakeholder committee;
- Establish LIC Program; and
- Complete retrofits at North Dufferin Community Centre.

9.7.2 Short Term Goals (3 to 7 Years)

- Update CEP with comprehensive GHG data at next plan update;
- Consider PV Installations at Honeywood Firehall and Mansfield Well;
- Consider Tree Planting Program; and
- Consider changing building codes to promote net zero construction for new buildings.

9.7.3 Medium and Long Term Goals (8 to 20 years)

- Mulmur Promotional program to make transportation and buildings net zero
- *"By no later than 31/12/2040 the Municipality of Mulmur will have achieved Net Zero GHG Emissions from the engagement/participation of 95 % residents including Business Owners. The Municipality of Mulmur will be recognized among the top 10 [or better] in the Province for energy related GHG emission reduction."*

10.0 Measuring Net Zero Success

During development of our study Burnside had to rely heavily on data from various sources from outside the Township of Mulmur. Burnside did use extensive GIS and municipal data for our analysis and evaluation. The results present our best estimate of the current energy consumption and GHG emissions. This study establishes a baseline for comparison of future energy consumption and GHG emissions from all public and private sectors discussed in this report.

10.1 Report CEP Progress Against the Goals Set

A CEP report on progress should be produced every 5 years and made available for public review.

Municipal records maintained will be available to measure actual Energy Consumption and GHG reductions and determine if specific municipal government goals have been met. Based on this study, municipal energy consumption and GHG emission contributions are small in comparison to the private sectors in the community.

The challenge will be to determine if Mulmur's private sectors are engaged and meeting the goals in the future. This will not be possible unless there is a means established to measure actual private sector performance. We recommend the following as a means of measuring CEP success toward meeting the goals.

10.2 Recommend that Statistics Canada Ask Energy Consumption Questions in the Next Census

Burnside has provided a draft letter for Municipal Approval to forward to the appropriate federal authorities and Statistics Canada. The letter contains examples of the types of data that should be collected during the next census and explains why it is needed. Although Statistics Canada already collects valuable data that will be helpful, additional data is needed to document energy conservation and the associated GHG emissions of the private sector. The purpose of the data collection recommendation is to enable all municipal jurisdictions in Canada measure their community's success in the reduction of energy use and calculate the associated GHG emissions. The next Statistics Canada Census will be in 2021. If they agree to include questions about a year following the survey will be required before the data collected can be evaluated and published in 2022 to 2023. Mulmur's Net Zero five-year reporting periods could easily be adjusted to follow the census data release.

10.3 Survey the Community by a Qualified Professional Social Research Firm

If Statistics Canada does not include critical questions concerning energy consumption in its census it will be necessary to measure and evaluate actions taken by its private sectors by other means. A qualified social research firm can develop a survey to determine actions that have been taken. We would not recommend informal surveys that are not statistically accurate. Unless a survey is properly designed and carried out it will not provide statistically valid data that can be used to assess and evaluate community success at achieving the stated goals.

10.4 Measure the LIC Program Uptake as a Measure of Success

Assuming that the LIC program is implemented its uptake by residents and businesses can be recorded and reported. This will not provide a complete picture of actions taken by the Mulmur private sectors who have acted to make changes but not utilized the LIC program. The reporting can, provide valuable supplementary data to evaluate program success.

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Appendix A

Community Transportation Methodologies

Community Energy Consumption and Emissions Generation from Energetic Sources Methodology

Boundary

Energy consumed by community transportation is defined as energy consumed from the on-road, off-road, marine, and aviation subsectors which are attributable to the Township of Mulmur. Within Mulmur's Township boundaries, marine and aviation are not applicable and are therefore not recorded. It can be assumed there is energy consumed from off-road transportation in Mulmur, however due to lack of accessible data off-road transportation will not be recorded.

The Canadian Supplement to the International Emissions Analysis Protocol

This methodology report explains the calculations used to report Mulmur's energy consumption from community transportation and emissions generated as a result of energy consumption. Methods for energy consumption and emissions generation calculation were provided by The Canadian Supplement to the International Emissions Analysis Protocol.

The Canadian Supplement to the International Emissions Analysis Protocol provided three approaches to calculated and report emission. With the information and resources available approach two was used to calculate Mulmur's energy consumed and emissions released with-in the Township's boundaries. Approach two used a method that combines total vehicle kilometers traveled (VTK) with-in the Township of Mulmur with assumptions on the characteristics and fuel efficiencies of the vehicles. (Canadian Supplement to the International Emissions Analysis Protocol, page 38).

Figure 1: VKT Description from The Canadian Supplement to the International Emissions Analysis Protocol[1]

> Approach 2: Vehicle Kilometres Travelled (VKT)
> The VKT approach combines data on the total kilometres travelled by vehicles within the community with assumptions about the characteristics and fuel efficiencies of vehicles in the community. VKT is a common measure of roadway use and can be calculated using a number of methods including traffic counts, household activity surveys, odometer reporting programs, and transportation models. Using the VKT approach can be advantageous for municipalities that have a traffic volume counting program.

An alternate method to approach two was provided in lieu of specific traffic data for the Township. For Mulmur's Community Energy Plan this alternate method was used to estimate the total vehicle kilometers traveled (VKT) in Mulmur. Figure 2 shows the methodology provided by The Canadian Supplement to the International Emissions analysis Protocol.

1 (Federation of Canadian Municipalities, n.d)

Figure 2: Alternate Approach to (VKT) Calculation [2]

VKT travelled by light-duty vehicles within the community can be estimated based on the number of households within the community, the number of vehicles per household, and the average annual distance traveled per vehicle. To estimate the total annual VKT for the community using this approach, follow the formula below and table 7 and 8 for 2000-2009 inventory years:

$VKT = H \bullet V \bullet F$

Description			Value
VKT	=	Total annual VKT for the community	Computed
H	=	Number of households in the community	User input
V	=	Number of light-duty vehicles per household	User input
D	=	Average annual distance traveled by light-duty vehicles	User input

Figure 3 provides the average fuel types used to calculate the fuel type used for light duty vehicles/trucks and heavy-duty trucks, the chart below is provided by the Canadian Supplement to the International Emissions Analysis Protocol. To calculate the fuel use for Light duty vehicles we ratioed the total fuel numbers to get a percentage for light vehicles, light duty trucks and heavy-duty trucks.

Figure 3: Fuel Percentage Chart [3]

Allocate the total VKT for the community in percentages to specific vehicle and fuel types. If a regional or provincial study is not available to extrapolate data from, use the general VKT percentages[27] below:

	Light-Duty Vehicle	Light-Duty Truck	Heavy-Duty Truck	Total
Gasoline	53.17%	32.67%	1.20%	**87.04%**
Diesel	0.15%	0.93%	10.59%	**11.68%**
Propane	1.28%	0%	0%	**1.28%**
Compressed Natural Gas	0%	0%	0%	**0%**
Ethanol Blend (10%)	0%	0%	0%	**0%**
Total	**0.546**	**0.336**	**0.1179**	**100%**

The propane fuel percentage for light duty vehicles to diesel the diesel fuel percentage, going from .15% to 1.34%The percentage weight was modified for light-duty vehicle and heavy-duty trucks.

2 (Federation of Canadian Municipalities, n.d)

3 (Federation of Canadian Municipalities, n.d)

Below are the adjusted numbers. This change was created to account for the amount of heavy-duty trucks on the roads of Mulmur:

- Light duty vehicles, gasoline 33.17%; and
- Heavy-duty trucks, gasoline 21.20%.

Calculations for Energy Consumption from Mulmur's Community Transportation Source

Figure 4: VKT Formula[4]

VKT travelled by light-duty vehicles within the community can be estimated based on the number of households within the community, the number of vehicles per household, and the average annual distance traveled per vehicle. To estimate the total annual VKT for the community using this approach, follow the formula below and table 7 and 8 for 2000-2009 inventory years:

$VKT = H \bullet V \bullet F$

Description			Value
VKT	=	Total annual VKT for the community	Computed
H	=	Number of households in the community	User input
V	=	Number of light-duty vehicles per household	User input
D	=	Average annual distance traveled by light-duty vehicles	User input

Number of Household in the Township of Mulmur **(H)** = 1864 *MPAC (2018)

Number of light-duty per household in the Township of Mulmur **(V)**=1.25 (Ontario 2009)

Average annual distance travels by light-duty vehicles in Mulmur **(D)** =16,024 (Ontario 2009)

VKT= H*V*F*

$$(1864) \times (1.25) \times (16{,}024) = 37{,}335{,}920$$

Calculations:

LIGHT-DUTY VEHICLES

VKT for Gasoline

[4] (Federation of Canadian Municipalities, n.d)

$H \times EFa \times D = 2330 \times .3317 \times 16024 = 12{,}384{,}324.6\, VTK\ for\ Gasoline$

VKT for Diesel

$H \times EFa \times D = 2330 \times .0143 \times 16024 = 5'339'03.6\, VTK\ for\ Diesel$

Light-Duty Trucks

VTK For Gasoline

$H \times EFa \times D = 2330 \times .3267 \times 16024 = 12'197'645\, VTK\ for\ Gasoline$

VKT for Diesel

$H \times EFa \times D = 2330 \times .0093 \times 16024 = 347224.056\, VTK\ for\ Diesel$

Heavy-Duty Trucks

VTK for Gasoline

$H \times EFa \times D = 2330 \times .2120 \times 16024 = 7915215.04\ VTK\ for\ Gasoline$

VTK for Diesel

$H \times EFa \times D = 2330 \times .1059 \times 16024 = 3953873.9\, VTK\ for\ Diesel$

Calculations for Emissions Generated from Energy Consumption by Mulmur's Community Transportation

Protocol for emissions calculations regarding community transportation are sources from the Canadian Supplement for Emission Analysis Protocol. Figure 5 provides the formula used to calculate emissions sourced by vehicle, varying for fuel type.

Figure 5: Emissions Calculation[5]

For each energy source consumed, multiply the vehicle and fuel specific VKT by its corresponding vehicle and fuel specific fuel efficiency. Add the resulting amount of fuel consumed from each vehicle type to obtain the total amount of each energy source consumed.

$x_a = \sum(VKT_{va} \bullet FE_{va})$

Description			*Value*
x_a	=	Total amount of energy source 'a' consumed in one year	Computed
VKT_{va}	=	Annual VKT for vehicle type 'v' and fuel type 'a'	User input

5 (Federation of Canadian Municipalities, n.d)

EFv_a	=	Fuel efficiency for vehicle type 'v' and fuel type 'a'	User input
a	=	Energy source (e.g. gasoline, diesel, ethanol, etc.)	
v	=	Vehicle type (e.g. light-duty vehicle, light duty truck, etc.)	

Calculations:

LIGHT-DUTY

Gasoline

$Xa = (12{,}384{,}324.6\, VTK)\,(9L/100Km) = 1{,}114{,}589.2L$

Diesel

$Xa = (\,5{,}339{,}03.6VTK)\,(7.7/100) = 41110.6L$

CO_2e Emissions (see Table 6: CO_2 Emissions Factors for Mobile Energy Combustion Sources, IEAP)

Gasoline

$(1{,}114{,}589.2)\,(0.002299) = 2{,}562.4\; tonnesCO2e$

Diesel

$(41{,}110.6L)\,(.002732) = 112.3\; tonnesCO2e$

LIGHT-DUTY TRUCKS

Gasoline

$Xa = (12{,}197{,}645.06VTK)\,(14.7/100) = 1{,}793{,}053.8L$

Diesel

$Xa = (347{,}224.056VTK)\,(12.5/100) = 43{,}403.0L$

CO_2e Emissions (see Table 6: CO_2 Emissions Factors for Mobile Energy Combustion Sources, IEAP)

Gasoline

$(1{,}793{,}053.8L)\,(0.002299) = 4{,}122.2\; tonnesCO2e$

Diesel

$(43{,}403.0L)\,(.002733) = 118.6\; tonnesCO2e$

HEAVY-DUTY TRUCKS

Gasoline

$Xa = (7{,}915{,}215.04\ VTK)\ (31.5L/100Km) = 2{,}493{,}292.7L$

Diesel

$Xa = (3{,}953{,}873.9VTK)\ (34.5/100) = 1{,}364{,}086.5L$

CO_2e Emissions (see Table 6: CO_2 Emissions Factors for Mobile Energy Combustion Sources, IEAP)

Gasoline

$(2{,}493{,}292.7L)\ (0.002299) = 5732.08\ tonnesCO2e$

Diesel

$(1{,}364{,}086.5L)\ (.002732) = 3728.04\ tonnesCO2e$

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Appendix B

Appendix B

Residential Methodologies for Energy Consumption and Emission Generation

Calculating Energy Consumption and Emissions Released for Mulmur's Residential Sector

Methodology for Calculating Energy Consumption

Mulmur's Community Energy Plan tracks and records all known energy consumption / production that is happening with in the geographical limits of Mulmur. Greenhouse Gas Emissions released as a result of energy consumed or produced in Mulmur is also recorded. The Township is broken down into sectors to better research and recorded energy / emission data. The section of the Appendix addresses residential energy consumption and emissions released from energy consumption / production.

PCP Protocol

Due to a lack of actual consumption data, provincial energy data was projected on the Township of Mulmur (Mulmur) to estimate the total yearly gigajoules used for residential stationary fuel combustion and purchased electricity.

The calculation of the energy intensity from residential buildings the PCP Protocol: Canadian Supplement to the International Emissions Analysis Protocol alternative method was as stated below.

> If actual consumption data are not available, local governments can estimate a facility's annual energy consumption based on the facility's total floor area and average energy intensity values. Energy intensity values estimate a facility's annual energy consumption per area of floor space (e.g. GJ/m^2). A list of energy intensity values for commercial/institutional facilities is provided in the *Comprehensive Energy Use Database* published by Natural Resources Canada's Office of Energy Efficiency.[3] [1]

Municipal Property Assessment Corporation (MPAC) tax information (2018) allowed for the data to incorporate house age and heating type as well as total floor area. Natural Resources Canada (NRCan's) comprehensive data base supplied energy intensities varying for certain house ages and floor space (2011).

Residential Energy Sources

The comprehensive data base gives a list of energy sources as follows: lighting, space heating, water heating, cooling and appliances. Each energy source uses a percentage of total yearly energy. These percentages were calculated from the total energy values presented in the comprehensive database. This allowed the energy totals from Mulmur's residential data to be categorized into energy sources. These percentages remained consistent from house age to house size.

1 Federation of Canadian Municipalities. (n.d). PCP Protocol: Canadian Supplement to the International Analysis Protocol

Yearly energy consumption allotted to lighting, cooling, and appliances were grouped under electrical energy use.

Yearly energy consumption from water heating and space heating was categized into heat type as listed in Table 1 below, along with the assigned energy source:

Table 1: Fuel Types Assigned to Heat Source Regarding Residential House Heating

Heat Source	Fuel Type
Forced Air	Fuel Oil
Electric Baseboard	Electric
No Central Heating	Wood
Other Central Heat Type	Unknown (Energy Remained in Gigajoules)
Hot Water	Propane
In Floor Radiant	Fuel Oil
Radiant Electric	Electric
Gravity Hot Air	Fuel Oil
Airtight Stove	Wood
Pipeless Hot Air	Natural Gas

Calculating Energy Intensity

Total Energy

The alternative approach states, to calculate annual energy consumption the total floor space of the total residential buildings must be multiplied by the energy intensity (GJ/m^2).

In calculating the energy intensity, a modified approach was taken to calculate more representative numbers. In the comprehensive data base energy intensity for Ontario houses varied from house type, age, family size, and house size. Since MPAC only provided data on age, type, and size those were the only energy intensity varying values used.

The area for each house in Mulmur was then multiplied by a specific energy intensity (GJ/m^2) varying on house age, size, and type. The energy was then totaled giving us a total energy consumption in gigajoules for Mulmur's residential houses.

Each house's energy consumption was divided into five sources, lighting, space heating, water heating, appliances, and cooling.

Electricity

Yearly energy allotted to cooling, lighting, appliances, radiant electric and electric base board were categorized as sourced from electric energy. The total energy was then converted into total yearly kilowatts/ hour (kWh) from (GJ's).

Conversion sourced from NRCan[2]:

$$\frac{GJ}{.0036} = kWh$$

Fuel Oil (Oil N°.2 light)

Yearly energy allotted to forced air, gravity hot air and in floor radiant, regarding to space heating and water heating were categorized as sourced from fuel oil. The energy was then converted into total yearly liters used (fuel oil).

Conversion sourced from NRCan[3]:

$$\frac{GJ}{.0387} = liters\ of\ fuel\ oil$$

Propane

Yearly energy allotted to hot water heating, regarding space heating and water heating was categorized as sourced from propane. The total energy was then converted into total yearly liters used (propane).

Conversion sourced from NRCan:

$$\frac{GJ}{.0266} = liters\ of\ propane$$

Natural Gas

Yearly energy allotted to pipeless hot air regarding space heating and water heating, was categorized as sourced from natural gas. The total energy was then converted into total yearly meters cubed used (natural gas).

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2 Natural Resources Canada. (2013, 11 16). Archived Step 1: Calculate Your Energy Costs and Consumption. Retrieved from Natural Resources Canada: https://www.nrcan.gc.ca/energy/publications/efficiency/buildings/6561

3 Natural Resources Canada. (2013, 11 16). Archived Step 1: Calculate Your Energy Costs and Consumption. Retrieved from Natural Resources Canada: https://www.nrcan.gc.ca/energy/publications/efficiency/buildings/6561

Conversion sourced from NRCan:

$$\frac{GJ}{.0372} = meters\ cubed\ of\ natural\ gas$$

Wood and Other

A calculation was not available to convert GJ's of wood into a cord of wood, therefore the energy allotted to wood, regarding heating and water heating remained in GJ's.

Houses with a heat sourced listed has other also kept their energy intensity regarding heating and hot water heating has GJ's.

Calculating CO_2e Emissions from Mulmur's Residential Energy Consumption

PCP Protocol

Greenhouse gas emissions vary from energy source and vary year to year. The PCP Protocol gives a detailed description on how to calculate emission for residential stationary energy sources.

Inclusion and Exclusion Protocol

All direct and indirect emissions generated using energy at residential dwellings will be including in the report. *"CO2e emissions associated with the combustion of biomass or biomass-based energy sources (e.g., wood, wood residuals, pellets) are considered to be biogenic origin and [are] excluded from the GHG inventory*" (Federation of Canadian Municipalities, n.d).

Calculation

The calculation of GHG emissions released from residential buildings the PCP Protocol: Canadian Supplement to the International Emissions Analysis method was as stated below.

> Use province/territorial or utility-specific emission factors for stationary fuel combustion and electricity consumption. Environment Canada's *National Inventory Report* provides emission factors for a variety of emissions-generating activities, including stationary combustion of fuels (Annex 8) and consumption of grid electricity (Annex 13).

Fuel Used

Wood

Emissions from energy produced by wood were not calculated or included in the emissions total for Mulmur, please see Section 3.2 for reference.

Other

Due to the fact there is no fuel source tied to the gigajoules used for heat sources classified under “other”, an alternative approach was used to calculate emission released from heat sources pertaining to “other”. To calculate the corresponding GHG emissions from gigajoules (GJ) of energy the total amount of emissions released from 2011 for the residential sector (Natural Resources Canada, 2013) was divided by the total energy used for Ontario. 393.7 peta joules (PJ), **excluding electricity.** This equaled 20.6 GHG emissions Mega tonnes (Mt) of carbon dioxide equivalent (CO_2e) (**excluding electricity**).

1. Convert PJ of energy into GJ:

$$393.7 \times 1{,}000{,}000 = 393{,}700{,}000 GJ$$

2. Convert Mt of CO_2e to tonnes of CO_2e:

$$20.6\ Mt \times 1{,}000{,}000 = 20{,}600{,}000\ Tonnes$$

3. Calculate the emissions released per GJ of energy:

$$20{,}600{,}000t \div 393{,}700{,}000GJ = .052t/GJ$$

4. To get Mulmur’s specific CO_2e emission the factor **.052t/GJ** was multiplied by the amount of GJ used per household’s with heat types, no central heating and other, provided by MPAC.

$$total\ yearly\ emissions\ from\ wood\ and\ other\ energy\ sources\ (tonnes) = .052 \times Gigajoules\ from\ 'wood'\ and\ 'other'$$

Electric

To calculate the CO_2e emissions from residential electrical energy consumption an emission factor of **36g CO2e /kwh**, Ontario specific from 2016[4] was multiplied by the total yearly kWh used.

This emissions unit is multiplied by the amount of electricity consumed by each residential house in Mulmur. Encompassing energy from lighting, appliances, radiant electric (space heating/ water heating), electric baseboards (space heating/water heating) and cooling.

4Environment and Climate Change Canada. (2018). National Inventory Report 1990–2016: Greenhouse Gas Sources and Sinks in Canada. Gatineau: Her Majesty the Queen in Right of Canada.

$$total\ yearly\ emissions\ from\ elecrical\ sources\ tonnes = \frac{(36gC02e\ \times total\ energy\ from\ electial\ sources\ kWh)}{1{,}000{,}000}$$

Fuel Oil

To calculate the emissions from residential fuel oil consumption an emissions factor from the PCP Protocol is multiped by the total yearly fuel use from Mulmur's residential houses.

This emissions unit is multiplied by the number of liters of fuel oil consumed by each residential house in Mulmur. Encompassing energy from space heating and water heating with forced air, in floor radiant, and gravity hot air.

Light Fuel Oil is given an emissions factor of (2735g CO_2e /L fuel oil)[5]

$$total\ yearly\ emission\ from\ fuel\ oil\ tonne = \frac{(2735g \times total\ liters\ of\ fuel\ oil)}{1{,}000{,}000}$$

Propane

To calculate the emissions from residential propane consumption an emissions factor from the PCP Protocol is multiped by the total yearly fuel use from Mulmur's residential houses.

This emissions unit is multiplied by the number of liters of fuel oil consumed by each residential house in Mulmur. Encompassing energy from space heating and water heating with a hot water heat source.

Propane is given an emissions factor of (1,541g CO2e /L propane)[6].

$$total\ yearly\ emissions\ from\ propane\ tonnes = \frac{(1541g \times total\ liters\ of\ propane)}{1{,}000{,}000}$$

Natural Gas

To calculate the emissions from residential yearly natural gas consumption an emissions factor from the PCP Protocol is multiped by the total yearly fuel use from Mulmur's residential houses.

This emissions unit is multiplied by the number of cubic meters of natural gas consumed by each residential house in Mulmur. Encompassing energy from space heating and water heating with pipeless hot air.

5Federation of Canadian Municipalities. (n.d). PCP Protocol: Canadian Supplement to the International Analysis Protocol.

6Federation of Canadian Municipalities. (n.d). PCP Protocol: Canadian Supplement to the International Analysis Protocol.

Natural Gas is given an emissions factor of (1,891g $CO2e$ /m^3 natural gas)[7].

$$total\ yearly\ emissions\ from\ natural\ gas\ tonnes = \frac{(1891g \times total\ cubic\ meters\ of\ natural\ gas)}{1{,}000{,}000}$$

7 Federation of Canadian Municipalities. (n.d). PCP Protocol: Canadian Supplement to the International Analysis Protocol.

References

Environment and Climate Change Canada. (2018). *National Inventory Report 1990–2016: Greenhouse Gas Sources and Sinks in Canada.* Gatineau: Her Majesty the Queen in Right of Canada.

Federation of Canadian Municipalities. (n.d). *PCP Protocol: Canadian Supplement to the International Analysis Protocol.*

Natural Resources Canada. (2013, 11 16). *Archived Step 1: Calculate Your Energy Costs and Consumption*. Retrieved from Natural Resources Canada: https://www.nrcan.gc.ca/energy/publications/efficiency/buildings/6561

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Appendix C

Agriculture Fuel Use and Emission Release Methodologies

Methodologies for Agricultural Sector Energy (Fuel) Consumption and Emissions Release

Limitations of the Agricultural Sector Inventory

Introduction

Mulmur's agricultural inventory includes, energy from fuel use for tractors in relation to planting, tilling, cultivation, fertilization and electrical use in relation to lighting from buildings listed under agricultural properties, excluding residential buildings.

Actual data was not available for this report therefore the numbers displayed here are projections. This document provides a detailed description on the methodology for agriculture energy use and GHG emissions released.

Energy Consumption

In this report Burnside was unable to record all energy consumed from Mulmur's agricultural sector. Due to a lack of actual data, certain agriculture activities could not be recorded or estimated. Below is a list of agricultural actives that consume energy that will not be assessed in Mulmur's Community Energy Plan.

Direct Energy used from:

- Equipment used for crop and produce processing;
- Crop and produce storage;
- Irrigation;
- Water pumps;
- Tractor fuel use from on road activity;
- Electricity from any heating, and cooling in barns;
- Heating hot water for sanitation; and
- Any milking systems or milk storage.

Indirect energy from:

- Food sourced off farm; and
- Produce transportation.

GHG Emissions

The GHG emissions calculated from the agricultural sector does not cover all emissions produced by this sector. Mulmur's CEP emissions recorded are from fuel use from tractors in relation to planting, tilling, cultivation, fertilization and electrical use in relation to lighting from buildings listed under agricultural properties, excluding residential buildings. Emissions generated from agricultural activity not accounted for in Mulmur's CEP are listed below.

Direct Emissions from:

- Application of fertilizer and pesticides;
- From crop cultivation and tilling;
- Manure and manure management;
- Urea application;
- Liming;
- On road tractor use;
- Equipment used for crop and produce processing;
- Crop and produce storage;
- Irrigation;
- Water pumps;
- Tractor fuel use from on road activity;
- Electricity from heating, and cooling in barns;
- Heating hot water for sanitation; and
- Any milking systems or milk storage.

In-Direct Emissions from:

- Produce and feed transportation.

Calculations

Fuel from mobile combustion engines.

Assumptions are stated below.

OMAFRA field crop budgets give a fuel use per acre for the crops listed below.

Table 1: Fuel Used per Acre by Crop

Crop Species	Fuel Use per Acre (liters)
Barely	14L
Spring Canola	17L
Winter Canola	13L
Colored Beans	29L
Grain Corn	20L
Silage Corn	13L
Flax	14L
Oats	14L
Soybeans	14L
Switchgrass	12L
Soft Red Winter Wheat	14L
Hard Red Winter Wheat	14L
Hard Red Spring Wheat	14L
White/Black Beans	21L[1]

An average fuel use from the crops provided by OMAFRA's budget report was calculated and projected on to the area of fields used for cash crop (seeds and feed) in Mulmur.

There wasn't a clear indication on percentage of farm fields used for each specific crop. Statistics Canada provided the acreage of crops grown in Mulmur, but there were gaps in the data due to confidentiality requirements of the Statistics Act. For this reason, Burnside decided to average the fuel use (using OMAFRA data) and project that onto the total crop acreage farmed in Mulmur from 2018. Total crop acreage was calculated from GIS data.

$$\text{Average fuel use } = \sum \text{Fuel use Per Acre (OMAFRA)} \div the\ number\ of\ crops\ (OMAFRA)\ (14)$$

$$= 15.92 L/acre$$

The total area of fields used for agriculture crop cultivation (from MPAC)

$$= 14353.36\ acres$$

$$\sum Fuel\ =\ Liters\ per\ Acre\ *\ total\ acreage\ farmed\ (2018)$$

∑ Fuel = 228'505.49(Liters)

GHG Emissions

All fuel used from tractors for crop cultivation was assumed to be diesel.

1 Crop numbers sourced from Ministry of Agriculture, Food, and Rural Affairs. (2019). 2019 Field Crop Budgets. Toronto: Ontario Ministry of Agriculture, Food and Rural Affairs.

To calculate greenhouse gases fuel type must be identified to an accurate representation of the emission being released (reference Global protocol for community- scale greenhouse gas emissions inventory, 7.7 page 82. paragraph 2). Off-road Vehicle and Equipment data will be used to project the emission from the fuel consumed from tractor use for field work only. (tractor use on roadways will not be captured due to deficiency of data).

$$CO2ea = (Xa * CO2eEFa)$$

$$Xa = 228'505.49L$$

$$CO2eEFa = .003007\ (diesel\ 2013)$$

$$CO2ea = 228'505.49 * .003007$$

$$\mathbf{CO2ea = 687.116\ (tonnes\ CO2e)}$$

Electricity Used

Actual, electrical data was unavailable for this study. There was also an insufficient amount of structural data available to create energy projections using NRCan's Comprehensive database. In leu of the lack of data, electrical energy consumption could only be estimated for lighting in agricultural structures.

The methodology used to project Mulmur's agricultural electrical consumption is described below. As a result of data limits the estimates provided represent a percentage of electrical use in the agriculture sector.

> *Energy not covered by the scope would be, heating, any equipment run off electricity in the buildings, and generators associated with farm properties. These will not be counted in Mulmur's CEP report because of a lack of information leading to a possible high margin of error.*

Methodology

There are 772 buildings allocated to barns (insulated and uninsulated), green houses, milking centers, and workshops in Mulmur* MPAC. These building were assigned an energy intensity from NRCan's residential sector.

Burnside chose to use the energy intensity regarding light from the residential sector because it would be more representative then the lighting factors from commercial/industrial. Since commercial/industrial energy intensity (for lighting) accounts for building offices and health care building which consume more energy allocated to lighting than agricultural structures. The structure count was also used has the multiplying factor rather than the square footage, because NRCan's data was presented in a per household number. It was also decided that lighting would not represent well using an energy intensity per square foot, because on average the light intensity for larger areas goes down rather then up. However, if the energy intensity for lighting was converted into an energy intensity per square foot, large barns would create high energy outputs that might not represent the actual conditions.

To calculate the energy intensity structures labeled barns (insulated and uninsulated), green houses, milking centers, and workshops MPAC data was used. That total was then multiplied by 3.4(GJ/ household, NRCan's lighting intensity.

$$\sum Electrical\ energy\ from\ lighting = 3.4GJ/household * Total\ Number\ of\ agricultural\ buildings$$

$$722\ (agricultural\ structures) * 3.4\ (energy\ intensity, GJ) = 2624.8\ GJ\ (total)$$

The total energy was converted into (kilowatts per hour) kWh

$$2624.8GJ * 277.7778 = 729111.2\ kWh$$

GHG Emissions from Electrical Use

The guidelines from the PCP Protocol: Canadian Supplement to the International Emissions Analysis Protocol were used to calculate the emissions released from electrical energy consumption.

Figure 1: PCP Protocol Methodology[2]

> Use province/territorial or utility-specific emission factors for stationary fuel combustion and electricity consumption. Environment Canada's *National Inventory Report* provides emission factors for a variety of emissions-generating activities, including stationary combustion of fuels (Annex 8) and consumption of grid electricity (Annex 13).
>
> Note that emission factors for electricity consumption are updated annually based on the energy sources used to generate electricity in each province or territory. Emission factors for stationary combustion of fuels, such as natural gas or fuel oil, are influenced primarily by the carbon content of the fuel, and as such do not vary considerably between inventory years (see table 4 and 5 below).

The Canadian National Inventory Report 2016 electricity CO2e emissions factor for Ontario is 36g (CO2e/kwh). 2016 is the most recent data released and will be the data assigned to all electrical usage in Mulmur CEP study.

2 Federation of Canadian Municipalities. (n.d). PCP Protocol: Canadian Supplement to the International Emissions Analysis Protocol.

Table 2: Greenhouse Gas Intensity[3]

	Greenhouse Gas Intensity[14] g GHG / kWh electricity generated								
CO_2 intensity (g CO_2 / kWh)	200	300	230	95	95	65	39	40	35
CH_4 intensity (g CH_4 / kWh)	0.002	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.01
N_2O intensity (g N_2O / kWh)	0.003	0.005	0.004	0.002	0.002	0.002	0.001	0.001	0.001
Generation Intensity (g CO_2 eq / kWh)[7]	**200**	**300**	**230**	**96**	**96**	**66**	**39**	**40**	**36**
Unallocated Energy (GWh)[17,18]	10 000	12 000	12 000	16 000	15 000	22 000	9 000	9 000*	9 000*
SF_6 Emissions (kt CO_2 eq)[17]	76	75	50	38	56	64	43	56	56
Consumption Intensity (g CO_2 eq / kWh)[18]	**220**	**320**	**250**	**110**	**110**	**80**	**40**	**40**	**40**

Calculation

$$CO2e\ Emission\ from\ all\ recorded\ agriculture\ electrical\ consumption = Electrical\ consumption \times 36$$

$$729{,}111.2\ kWh * 36gC02e = 26{,}248{,}003.2g\ CO2\ eq$$

$$Tonnes\ of\ CO2 = \text{grams of CO2} \div 1{,}000{,}000$$

$$= 26\ tonnes$$

3 Environment and Climate Change Canada. (2018). National Inventory Report: 1990-2016 Greenhouse Gas Sources and Sinks in Canada. Gatineau: Her Majesty the Queen in Right of Canada, represented by the Minister of Environment and Climate Change, 2018.

References

Environment and Climate Change Canada. (2018). *National Inventory Report: 1990-2016 Greenhouse Gas Sources and Sinks in Canada.* Gatineau: Her Majesty the Queen in Right of Canada, represented by the Minister of Environment and Climate Change, 2018.

Federation of Canadian Municipalities. (n.d). *PCP Protocol: Canadian Supplement to the International Emissions Analysis Protocol.*

Ministry of Agriculture, Food, and Rural Affairs. (2019). *2019 Field Crop Budgets.* Toronto: Ontario Ministry of Agriculture, Food and Rural Affairs.

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Appendix D

Commercial, Industrial and Institutional Methodologies

Energy and Emissions Calculations for the Industrial, Commercial, and Institutional Sectors in Mulmur for 2018

Introduction

As part of the Mulmur's Community Energy Plan a total calculation of energy consumed or produced will be recorded. GHG emissions from any energy production and/or consumption would also be recorded.

Each sector in this report contains its own methodologies due to the variation in data collection and data interpretation.

The section below breaks down the methodologies used to calculate industrial, commercial and institutional energy consumption and or production and GHG emissions generation resulting from energic sources.

Data Collection Methods

Partners for Climate Protection (PCP)

The Canadian Supplement to the International Emissions Analysis Protocol provides three methods to calculate energy consumption and emissions generation from buildings and facilities. Because actual data was not available the second alternate method was used for each sector (industrial, commercial, and institutional).

Figure 2-1: PCP Alternative Method[1]

Alternative	If actual consumption data are not available, local governments can estimate a facility's annual energy consumption based on the facility's total floor area and average energy intensity values. Energy intensity values estimate a facility's annual energy consumption per area of floor space (e.g. GJ/m^2). A list of energy intensity values for commercial/institutional facilities is provided in the *Comprehensive Energy Use Database* published by Natural Resources Canada's Office of Energy Efficiency.[3]

Figure 2-1 provides a detailed description of the methodologies provided by the PCP protocol.

Industrial

Defining an industrial building.

1 Federation of Canadian Municipalities. (2006). Canadian Supplement to the International Emissions Analysis Protocol.

General-purpose industrial properties in Ontario have the following characteristics:

- *uses may include warehousing, light manufacturing or other general industrial uses*
- *they are multi-purpose buildings that typically include office space*
- *special purpose features are limited*
- *they can usually be converted to another use without extensive alterations*[2]

Once a property was categorized as industrial a total area of the building or buildings was calculated using 2018 Orthophotography by Burnside.

Natural Resource Canada (NRCan) comprehensive database provided average energy outputs (per meter squared) for Ontario industrial buildings. Energy outputs and emission generation varied from industry.

Seven percent (7%) of buildings in these three categories (industrial, commercial, and institutional) were classified as industrial. Due to the uncertainty of their industry status they were assigned an energy intensity and emission rating from Table 22: Other Services Secondary Energy Use and GHG Emissions by Energy Source" (Natural Resources Canada, n.d.)

Using NRCan's energy and emissions ratings a total energy consumption along with CO_2 (emissions) generation were calculated for each building. This was completed by taking the energy intensity in gigajoules/meter squared and multiplying it by the total floor area of each building.

Commercial

Defining a commercial building

Commercial properties have the following characteristics:

- Uses may include retail, food service, office or other general commercial uses;
- They are multi-purpose buildings that typically include interior finish;
- Special purpose features are limited; and
- They can usually be converted to another use without extensive alterations.[3]

Once a property was categorized as commercial a total area of the building was calculated using 2018 Orthophotography by Burnside.

2 Municipal Property Assessment Corporation. (2019). Industrial Properties. Retrieved from MPAC: https://www.mpac.ca/PropertyTypes/IndustrialProperties

3 Municipal Property Assessment Corporation. (2019). Industrial Properties. Retrieved from MPAC: https://www.mpac.ca/PropertyTypes/IndustrialProperties

The NRCan's comprehensive database provided average energy outputs (per meter squared) for Ontario commercial buildings. Energy outputs and emission generation varied from commercial building classification e.g. retail, arts and recreation etc.

Seventy six percent (76%) of buildings in these three categories (industrial, commercial, and institutional) were classified as commercial. From there they were divided into four groups, provided by NRCan's comprehensive data base.

Below are the four categories from which energy use and emissions generation were sourced.

- Table 6: Retail Trade Secondary Energy Use and GHG Emissions by Energy Source;
- Table 18: Arts, Entertainment and Recreation Secondary Energy Use and GHG Emissions by Energy Source;
- Table 20: Accommodation and Food Services Secondary Energy Use and GHG Emissions by Energy Source; and
- Table 22: Other Services Secondary Energy Use and GHG Emissions by Energy Source.

(Natural Resources Canada, n.d.)

Using NRCan's energy and emissions ratings a total energy consumption along with CO_2 (emissions) generated were calculated for each building. This was done by taking the energy intensity in gigajoules/meter squared and multiplying it by the total floor area of each building.

Institutional

Institutional buildings will be classified by MPAC's 600 series.

Once a property was categorized as commercial a total area of the building or buildings was calculated using 2018 Orthophotography by Burnside.

NRCan's comprehensive database provided average energy outputs (per meter squared) for Ontario institutional buildings. Energy outputs and emissions generation varied from institutional building classification e.g. hospitals, schools etc.

Fourteen percent (14%) of buildings in these three categories (industrial, commercial, and institutional) were classified as commercial. They were then divided into three groups, provided by NRCan's Comprehensive data base.

Below are the three categories from which energy use and emissions generation were sourced:

- Table 14: Educational Services Secondary Energy Use and GHG Emissions by Energy Source;
- Table 18: Arts, Entertainment and Recreation Secondary Energy Use and GHG Emissions by Energy Source; and

- Table 22: Other Services Secondary Energy Use and GHG Emissions by Energy Source.

(Natural Resources Canada, n.d.)

Using NRCan's energy and emissions ratings total energy consumption along with CO_2 (emissions) generation were calculated for each building. This was completed by taking the energy intensity in gigajoules/meter squared and multiplying it by the total floor area of each building.

Other

Buildings that were unknown in classification and could not be placed in either commercial, industrial or institutional sectors were given and energy intensity and emissions rating from "Table 22: Other Services Secondary Energy Use and GHG Emissions by Energy Source" (Natural Resources Canada, n.d.)

References

Federation of Canadian Municipalities. (2006). *Canadian Supplement to the International Emissions Analysis Protocol.*

Municipal Property Assessment Corporation. (2019). *Industrial Properties*. Retrieved from MPAC: https://www.mpac.ca/PropertyTypes/IndustrialProperties

Natural Resources Canada. (n.d.). *Comprehensive Database*. Retrieved from Natural Resources Canada: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/showTable.cfm?type=CP&sector=com&juris=on&rn=22&page=0

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Appendix E

Corporate Fuel Use in Municipal Fleet Vehicles

Appendix E

Mulmur's Municipal Transportation in 2018

Fuel Use in Municipal Fleet Vehicle

Fleet Vehicles/ Equipment

Corporate fleet account for energy and emission's generated from fuels such as gasoline, and diesel or indirect sources from grid electricity.

To calculate emissions IEAP guidelines were used as follows:

1. For each energy source determine the total amount of energy (fuel) consumed by corporate vehicles and equipment during the inventory year.
2. Identify corresponding emissions factors for CO_2 CH_2 and N_2O.
3. Multiply energy consumption data by the corresponding emission factor and their global warming potential (GWP) to determine total CO_2e.

Methodology

Fuel quantities were collected from Mulmur's *Transaction Report by Vehicle* from Jan 1/18 12:00AM to Dec 31/18 11:59PM. The report included vehicle description, type, value and quantity of fuel used.

From there Burnside broke the vehicles down by group light-duty trucks, heavy duty vehicles, and off road. Once the vehicle was in its respective category it was divided again by fuel type, gas and diesel. *Tractors, and miscellaneous fuel were grouped into off-road, while the rest of the vehicles followed the IEAP description, as shown below.*

Emissions Calculation

Figure 1-1 Vehicle Classification[1]

[1]Light duty vehicles are cars with a gross vehicle weight rating (GVWR) of less than or equal to 3,900 kg. Assumes average light-duty vehicle on the road in any given year is 7 years old. [2]Light-duty trucks are pickups, minivans, SUVs, etc. with a GVWR of less than or equal to 3,900 kg. Assumes average light-duty truck on the road in any given year is 7 years old. [3]Heavy-duty vehicles are vehicles with a GVWR above 3,900 kg. Assumes average heavy-duty truck on the road in any given year is 9 years old. [4]Emission factors for natural gas vehicles are measured in g/kg of fuel.

Equation 1 of the Vehicle Classification methodology shows the formula supplied by the PCP Protocol, this formula is used to convert Mulmur's Fleet vehicles fuel consumption into emissions released.

1 (Federation of Canadian Municipalities , n.d)

Equation 1 For CO_2e Emissions

For each energy source, multiply the amount of energy consumed by the corresponding emission factor for CO_2 equivalent.

$CO_2e_a = (x_a \bullet CO_2eEF_a)$

Description			Value
CO_2e_a	=	Total CO_2e emissions produced from vehicles consuming energy source 'a' in the inventory year	Computed
x_a	=	Amount of energy source 'a' consumed in one year	User input
CO_2eEF_a	=	The CO_2 equivalent emission factor for energy source 'a'	User input
a	=	Energy source (e.g. gasoline, diesel, ethanol, etc.)	

[2]

Mulmur's Fleet Vehicle data was converted into a spread sheet where totals for all the respected categories where formed. These totals where then used with the PCP protocol emissions equation.

Heavy Duty Vehicles

Diesel

$$CO2e = (Xa * CO2eFEa)$$
$$Xa - 68175.1L$$
$$CO2eFEa - .002712$$
$$CO2e = (68175.1L * .002712)$$
$$CO2e = 184.89\ tonnes$$

Light Duty Trucks

Gasoline

$$CO2e = (Xa * CO2eFEa)$$
$$Xa - 10329.1L$$
$$CO2eFEa - .002299$$
$$CO2e = (10329.1 * .002299)$$
$$CO2e = 23.74\ tonnes$$

Diesel

$$CO2e = (Xa * CO2eFEa)$$
$$Xa - 6871.7L$$

2 (Federation of Canadian Municipalities , n.d)

$$CO2eFEa - .002733$$
$$CO2e = (6871.7 * .002733)$$
$$CO2e = 18.78\ tonnes$$

Off Road

Gasoline

$$CO2e = (Xa * CO2eFEa)$$
$$Xa - 14203L$$
$$CO2eFEa - .002361$$
$$CO2e = (14203 * .002361)$$
$$CO2e = (33.53\ tonnes)$$

Diesel

$$CO2e = (Xa * CO2eFEa)$$
$$Xa - 11697.1L$$
$$CO2eFEa - .003007$$
$$CO2e = (11697.1 * .003007)$$
$$CO2e = (35.17\ tonnes)$$

The Tables below are taken directly from the PCP Protocol: Canadian Supplement to the International Emissions Analysis Protocol.

Table 3: CO_2e Emission Factors for Mobile Energy Combustion Sources[7]

Light-Duty Vehicles[1] (tonnes CO2e/unit fuel)									
	Fuel Type								
Inventory Year	Gasoline	Diesel	Propane	CNG [4]	E10	E85	B5	B10	B20
1990-1999	0.002500	0.002730	0.001513	0.003023	0.002271	0.000555	0.002597	0.002464	0.002197
2000	0.002500	0.002730	0.001513	0.003023	0.002271	0.000555	0.002597	0.002464	0.002197
2001	0.002500	0.002730	0.001513	0.003023	0.002271	0.000555	0.002597	0.002464	0.002197
2002	0.002440	0.002730	0.001513	0.003023	0.002211	0.000494	0.002597	0.002464	0.002197
2003	0.002440	0.002732	0.001513	0.003023	0.002211	0.000494	0.002599	0.002466	0.002199
2004	0.002440	0.002732	0.001513	0.003023	0.002211	0.000494	0.002599	0.002466	0.002199
2005	0.002440	0.002732	0.001513	0.003023	0.002211	0.000494	0.002599	0.002466	0.002199
2006	0.002440	0.002732	0.001513	0.003023	0.002211	0.000494	0.002599	0.002466	0.002199
2007	0.002440	0.002732	0.001513	0.003023	0.002211	0.000494	0.002599	0.002466	0.002199
2008	0.002440	0.002732	0.001513	0.003023	0.002211	0.000494	0.002599	0.002466	0.002199
2009	0.002440	0.002732	0.001513	0.003023	0.002211	0.000494	0.002599	0.002466	0.002199
2010	0.002440	0.002732	0.001513	0.003023	0.002211	0.000494	0.002599	0.002466	0.002199
2011	0.002299	0.002732	0.001513	0.003023	0.002070	0.000353	0.002599	0.002466	0.002199
2012	0.002299	0.002732	0.001513	0.003023	0.002070	0.000353	0.002599	0.002466	0.002199
2013	0.002299	0.002732	0.001513	0.003023	0.002070	0.000353	0.002599	0.002466	0.002199
Light-Duty Trucks[2] (tonnes CO2e/unit fuel)									
	Fuel Type								

Inventory Year	Gasoline	Diesel	Propane	CNG (kg) [4]	E10	E85	B5	B10	B20
1990-1999	0.002498	0.002730	0.001513	0.003023	0.002269	0.000552	0.002597	0.002464	0.002197
2000	0.002498	0.002730	0.001513	0.003023	0.002269	0.000552	0.002597	0.002464	0.002197
2001	0.002498	0.002730	0.001513	0.003023	0.002269	0.000552	0.002597	0.002464	0.002197
2002	0.002474	0.002730	0.001513	0.003023	0.002245	0.000528	0.002597	0.002464	0.002197
2003	0.002474	0.002733	0.001513	0.003023	0.002245	0.000528	0.002600	0.002467	0.002200
2004	0.002474	0.002733	0.001513	0.003023	0.002245	0.000528	0.002600	0.002467	0.002200
2005	0.002474	0.002733	0.001513	0.003023	0.002245	0.000528	0.002600	0.002467	0.002200
2006	0.002474	0.002733	0.001513	0.003023	0.002245	0.000528	0.002600	0.002467	0.002200
2007	0.002474	0.002733	0.001513	0.003023	0.002245	0.000528	0.002600	0.002467	0.002200
2008	0.002474	0.002733	0.001513	0.003023	0.002245	0.000528	0.002600	0.002467	0.002200
2009	0.002474	0.002733	0.001513	0.003023	0.002245	0.000528	0.002600	0.002467	0.002200
2010	0.002474	0.002733	0.001513	0.003023	0.002245	0.000528	0.002600	0.002467	0.002200
2011	0.002299	0.002733	0.001513	0.003023	0.002070	0.000353	0.002600	0.002467	0.002200
2012	0.002299	0.002733	0.001513	0.003023	0.002070	0.000353	0.002600	0.002467	0.002200
2013	0.002299	0.002733	0.001513	0.003023	0.002070	0.000353	0.002600	0.002467	0.002200

Heavy-Duty Vehicles[3] (tonnes CO2e/unit fuel)

	Fuel Type								
Inventory Year	Gasoline	Diesel	Propane	CNG [4]	E10	E85	B5	B10	B20
1990-1999	0.002310	0.002691	0.001513	0.003023	0.002081	0.000364	0.002558	0.002425	0.002158
2000	0.002310	0.002691	0.001513	0.003023	0.002081	0.000364	0.002558	0.002425	0.002158
2001	0.002310	0.002691	0.001513	0.003023	0.002081	0.000364	0.002558	0.002425	0.002158
2002	0.002310	0.002691	0.001513	0.003023	0.002081	0.000364	0.002558	0.002425	0.002158
2003	0.002310	0.002691	0.001513	0.003023	0.002081	0.000364	0.002558	0.002425	0.002158
2004	0.002310	0.002691	0.001513	0.003023	0.002081	0.000364	0.002558	0.002425	0.002158
2005	0.002352	0.002712	0.001513	0.003023	0.002123	0.000407	0.002579	0.002446	0.002179
2006	0.002352	0.002712	0.001513	0.003023	0.002123	0.000407	0.002579	0.002446	0.002179
2007	0.002352	0.002712	0.001513	0.003023	0.002123	0.000407	0.002579	0.002446	0.002179
2008	0.002352	0.002712	0.001513	0.003023	0.002123	0.000407	0.002579	0.002446	0.002179
2009	0.002352	0.002712	0.001513	0.003023	0.002123	0.000407	0.002579	0.002446	0.002179
2010	0.002352	0.002712	0.001513	0.003023	0.002123	0.000407	0.002579	0.002446	0.002179
2011	0.002352	0.002712	0.001513	0.003023	0.002123	0.000407	0.002579	0.002446	0.002179
2012	0.002352	0.002712	0.001513	0.003023	0.002123	0.000407	0.002579	0.002446	0.002179
2013	0.002352	0.002712	0.001513	0.003023	0.002123	0.000407	0.002579	0.002446	0.002179

Off-road Vehicles/Equipment* (tonnes CO2e/unit fuel)

	Fuel Type								
Inventory Year	Gasoline	Diesel	Propane	CNG [4]	E10	E85	B5	B10	B20
1990-1999	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2000	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2001	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2002	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474

2003	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2004	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2005	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2006	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2007	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2008	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2009	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2010	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2011	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2012	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474
2013	0.002361	0.003007	0.001513	0.003023	0.002132	0.000416	0.002874	0.002741	0.002474

References

Federation of Canadian Municipalities . (n.d). *PCP Protocol: Canadian Supplement to the International Emissions Analysis Protocol.*

Municipalities, F. o. (n.d). *Canadain Supplement to the Emissions Analysis Protocol.*

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Appendix F

Municipal Buildings Energy and Emissions

Appendix F

Stationary Energy Consumption for Mulmur's Municipal Buildings and Other in 2018

Energy Consumed

To calculate Mulmur's energy consumption actual data was provided by the Township of Mulmur for 2018. This data included energy bills, fuel records, total floor area and building age. All data in the Mulmur CEP pertaining to Municipal buildings and other stationary energy consumption is based on actual data.

Emissions Released

PCP Protocol

Emissions can be produced from stationary combustion fuels or indirectly from use of grid electricity.

To calculate emissions IEAP guidelines where used as follows:

1. For each energy source, determine the total amount of energy consumed by each corporate building and facility in the inventory year.
2. Identify corresponding emissions factors for CO_2 CH_2 and N_2O.
3. Multiply energy consumption activity data by the corresponding emissions factors and their global warming potential (GWP) to determine total CO_2e emissions.

The Municipal stationary energy is then converted into gigajoules to allow the energy output to be compared to the Township of Mulmur's total energy.

Electrical

The Township of Mulmur provided electrical data for their municipal accounts and with Canada's National Inventory (Annex 13, Table A13-7) a calculated number for GHG emissions was recorded.

Ontario's electrical emissions factor for 2016 is (36 gCO_2e/kWh).

Equation

$$CO2e\ emissions\ from\ grid\ \ supplied\ electicity\ in\ tonnes$$
$$= Total\ electrical\ energy\ kWh\ \times 36g/1{,}000{,}000$$

Converting into gigajoules.

Gigajoule conversion factor .0036[1].

Town Hall

Consumption 42,976.01 (kWh).

Emissions factor 36 g per (kWh).

$$\mathbf{42,976.01\ (kWh) * 36g\ /1,000,000}$$

$$= \mathbf{1.54 tonnes\ CO2}$$

Converting (kwh) into gigajoules.

Gigajoule conversion factor .0036[2].

$$\mathbf{42,976.01 \times .0036 = 154.71\ GJ}$$

Fire Hall

Consumption 29,948.12 (kWh).

Emissions factor 36 g per (kWh).

$$29{,}948.12(kwh) * 36g/\ 1{,}000{,}000$$
$$= \mathbf{1.07 tonnes\ CO2}$$

Converting (kwh) into gigajoules.

Gigajoule conversion factor .0036.

$$\mathbf{29,948.12 \times .0036 = 107.81\ GJ}$$

Public Works

Consumption 54,106.42 (kWh).

Emissions factor 36 g per (kWh).

$$54{,}106.42(kWh) * 36g/1{,}000{,}000$$
$$= \mathbf{1.94 tonnes\ CO2}$$

1 (Natural Resources Canada, 2013)

2 (Natural Resources Canada, 2013)

Converting (kwh) into gigajoules.

Gigajoule conversion factor .0036

$$\mathbf{54,106.42\ \times .0036 = 194.78\ GJ}$$

Arena (Ice Plant)

Consumption 266,100 (kWh).

Emissions factor 36 g per (kWh).

$$\boldsymbol{266,100(kWh) * 36g/1,000,000}$$

$$\boldsymbol{= 9.57 tonnes\ CO2}$$

Converting (kwh) into gigajoules.

Gigajoule conversion factor .0036

$$266{,}100\ \times .0036 = 957.96\ \mathbf{GJ}$$

Arena

32,811.97 (kWh).

Emissions factor 36 g per (kWh).

$$23,811.97\ (kWh) * 36g\ /1{,}000{,}000$$
$$= \boldsymbol{1.18 tonnes\ CO2}$$

Converting (kwh) into gigajoules.

NRCan conversion factor .0036

$$32{,}811.97\ \times .0036 = 118.12\ \mathbf{GJ}$$

Other Stationary Energy Consumption

Other stationary energy refers to stationary energy used from sources other than buildings. Energy consumed is also controlled by the municipality.

Streetlights

Consumption 71399.90 (kWh).

Emissions factor 36g per (kWh).

$$71399.90(kWh) * 36g/1,000,000$$

$$= 2.57 tonnes\ CO2$$

Pump House

Consumption 72401.10 (kWh).

Emissions factor 36 g per (kWh).

$$72401.10(kWh) * 36g/1,000,000$$

$$= 2.61 tonnes\ CO2$$

Scale House

Consumption 360.00 (kWh).

Emissions factor 36 g per (kWh).

$$360.00(kWh) * 36g/1,000,000$$

$$= 0.01 tonnes\ CO2$$

Mansfield Park

Consumption 1160.24 (kWh).

Emissions factor 36 g per (kWh).

$$1160.24(kWh) * 36g/1,000,000$$

$$= 0.04 tonnes\ CO2$$

Fuel Oil

Calculating the emissions released from fuel oil use in Mulmur's Municipal Buildings.

An emissions factor for fuel oil is used to calculate the amount CO_2e realised by energy sourced from fuel oil. This factor is retrieved from the PCP Protocol and a graph is provided - please find in references.

Emissions factor for light fuel oil (2,735 g CO_2e/L light fuel oil).

Equation

$$emission\ from\ fuel\ oil\ in\ tonnes = \frac{2735g\ \times total\ yeraly\ fuel\ oil\ consumed}{1{,}000{,}000}$$

Public Works Building

Fuel oil consumed 18,125.00L

$$\frac{2{,}735g\ \times 18{,}125L}{1{,}000{,}000} = \mathbf{49.5\ tonnes\ CO2e}$$

Converting fuel oil into gigajoules.

NRCan conversion factor .0387

$$18{,}125.00\ \times\ .0387 = 701.43\ \mathbf{GJ}$$

The Arena

Fuel oil consumed 14,121.70 L

$$\frac{(2{,}735\text{g} \times 14{,}121.70\text{L})}{1{,}000{,}000} = \mathbf{38.6\ tonnes\ CO2}$$

Converting fuel oil into gigajoules.

NRCan conversion factor .0387

$$14{,}121.70\ \times\ .0387 = 546.5\ \mathbf{GJ}$$

Propane

Fire Hall

Propane consumed 11,645.20 L

$$\frac{1{,}541 \times 11{,}645.2}{1{,}000{,}000} = \mathbf{17.9\ tonnes}$$

Converting propane into gigajoules.

NRCan conversion factor .0266

$$\mathbf{11,645.20 \times .0266 = 309.76\ GJ}$$

The Arena

Propane Consumed 1,351.9

$$\frac{1{,}541 \times 1{,}351.9}{1{,}000{,}000} = \mathbf{2.08}\ \boldsymbol{tonnes\ CO2}$$

Converting propane into gigajoules.

NRCan conversion factor .0266

$$1{,}351.9 \times .0266 = 35.96\ \mathbf{GJ}$$

References

Tables from The PCP Protocol: Canadian Supplement to the International Emissions Inventory.

Table 2: CO_2, CH_4 and N_20 Emission Factors for Other Stationary Fuels[5]

Fuel Type	Emission Factors (g/L)			
	CO2	CH4	N2O	CO_2e
Light fuel oil	2,725	0.026	0.031	2,735
Heavy fuel oil	3,124	0.057	0.064	3,145
Kerosene	2,534	0.026	0.031	2,544
Propane	1,507	0.024	0.108	1,541
Diesel	2,663	0.133	0.4	2,790

*CH_4 and N_2O emission factors are specific to the commercial and institutional sector.

For each energy source, multiply the amount of energy consumed by the corresponding emission factor for CO_2 equivalent.

$$CO_2e_a = (x_a \bullet CO_2eEF_a)$$

Description			Value
CO_2e_a	=	Total CO_2e emissions produced from a building consuming energy source 'a' in the inventory year	Computed
x_a	=	Amount of energy source 'a' consumed in one year	User input
CO_2eEFa	=	The CO_2 equivalent emission factor for energy source 'a'	User input
a	=	Energy source (e.g. electricity, natural gas, fuel oil, etc.)	

[3]

3 (Federation of Canadian Municipalities, n.d)

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