City of Whitehorse
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Corporate Greenhouse Gas Emissions Inventory

City of Whitehorse

2019

Updated June 8th 2020

Abstract:

This document provides a quantitative assessment of the City of Whitehorse's corporate greenhouse gas emissions. The assessment focuses on emissions from burning fossil fuels, while also providing estimates of methane emissions from anaerobic decomposition at the Whitehorse landfill and sewage lagoons.

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Executive Summary

Taking an inventory of the City's corporate greenhouse gas (GHG) emissions is a critical initial step to fighting climate change effectively. The emissions inventory provides the quantitative information necessary to help decision-makers and staff focus on actionable, impactful actions to reduce the City's greenhouse gas emissions. A corporate emissions inventory is also an important milestone in the Federation of Canadian Municipalities' (FCM's) Corporate Emissions Mitigation Maturity Scale.

This inventory analyzed three related but distinct indicators:

- Annual GHG emissions
- Annual energy consumption
- Annual energy costs

The inventory found that the City's total annual energy consumption has been staying relatively constant since 2015. Unfortunately, the City's fossil fuel based GHG emissions have risen by 40% since 2015, reaching a peak of 7023 tonnes CO2e in 2019. The City's Sustainability Plan targeted a 10% decrease in CO2 emissions from 2014 levels by 2020, so that target appears to be missed. The Sustainability Plan used 2014 as the reference year, but due to data gaps in 2014 this inventory uses 2015 as the baseline. Based on our analysis, the 2015 data provides an excellent proxy for 2014 emissions.

The emissions increase is driven largely by a lack of secondary electricity sales for the Canada Games Centre's (CGC's) electric boiler. Without secondary sales, the CGC has been heated primarily with oil, resulting in a substantial increase in GHG emissions. The GHG intensity of Yukon's electricity grid has also risen since 2015, resulting in an increase in electrical GHGs despite the City reducing corporate electricity consumption over this time period.

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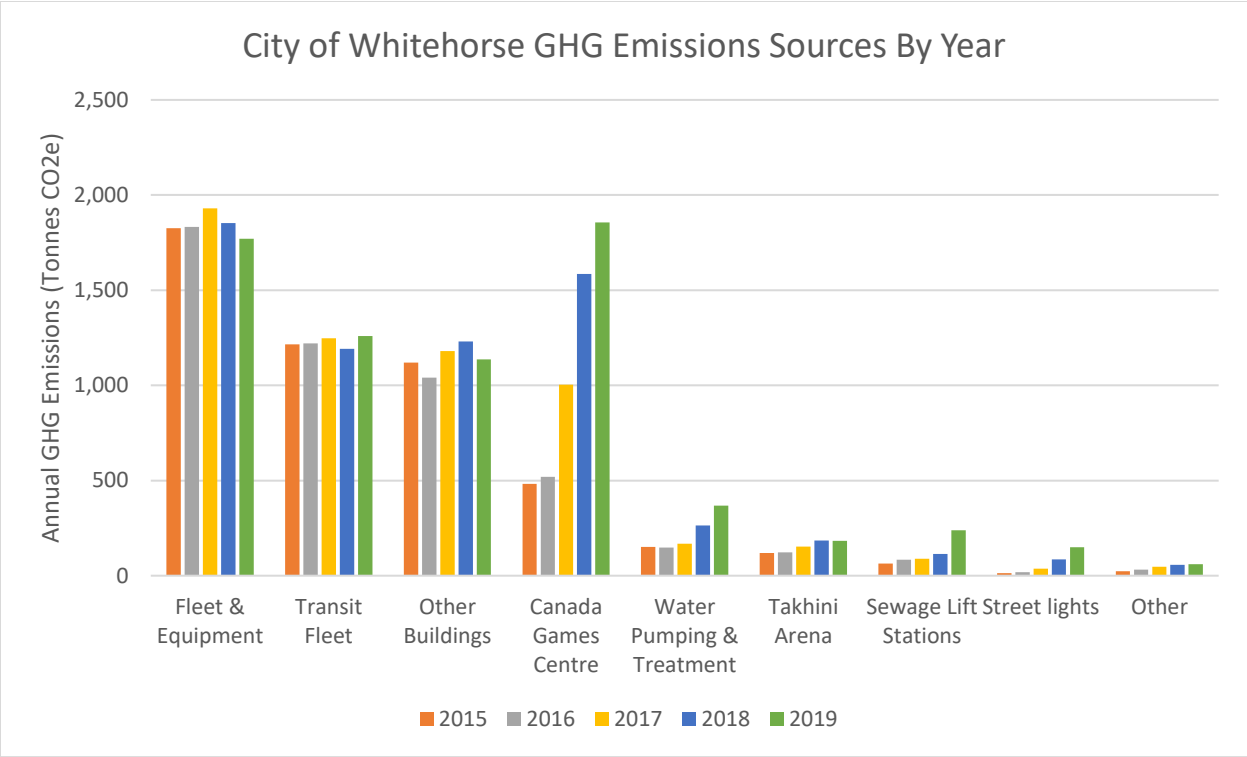

Landfill and wastewater emission are considered separately due to the high degree of uncertainty associated with the calculations, and the fact that landfill emissions (methane) are released slowly over many years as the waste decomposes. The City's composting program already reduces future landfill emissions by approximately 10% and the ongoing expansion into multi-residential and commercial organics will achieve further emissions reductions. **It must be noted that the City's landfill emissions are estimated to be significantly greater than all of the City's corporate fossil fuel emissions combined.**

The wastewater emissions estimates indicate that methane and nitrous oxide emissions from the sewage lagoons are also more GHG intensive than the City's corporate fossil fuel emissions. Wastewater emissions are expected to rise proportionately with the City's population growth.

None of the City's major fossil fuel emissions sources have achieved significant emissions reductions since 2015. This is not to say that the City hasn't taken positive steps towards reducing emissions; what it shows is that the current staffing levels, prioritization, and project funding approach have not been sufficient to make measurable progress on GHG emissions reductions consistent with the Whitehorse Sustainability Plan emissions reduction targets. A renewed focus is required to get the City back on track as a leader in sustainability and climate action.

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Table of Contents

City of Whitehorse
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Table of Figures

City of Whitehorse
2121 - 2nd Avenue, Whitehorse, Yukon Y1A 1C2 Bus: (867) 667-6401 Fax: (867) 668-8398

1.0 Introduction:

In 2008, the City of Whitehorse adopted its Strategic Sustainability Plan. In 2012 the City commissioned an Energy Management Plan, produced by ICF Marbek. A number of the recommendations have been implemented since then, while others have not. Later, in 2014, the City of Whitehorse set greenhouse gas emissions reduction targets as part of the 2015 Sustainability Plan. More recently, in September of 2019, Whitehorse City Council declared a climate change emergency and requested a response from staff including "options for enhancing our adaptation and mitigation efforts…" (Council motion 2019-17-7).

In 2019, the City of Whitehorse created an Energy Management position through the funding from the Federation of Canadian Municipalities (FCM). The goal of this position is to implement initiatives to produce a lasting improvement in municipal GHG emissions reductions. A key initial step is to establish a baseline GHG emissions inventory, providing the City of Whitehorse with a baseline to gauge the impacts of emissions reduction initiatives against.

City of Whitehorse buildings and fleets generate greenhouse gas emissions primarily through the consumption of electricity, heating oil, propane, gasoline, and diesel fuel. Fossil fuel based GHG emissions reductions can be achieved in two ways:

1. Reducing energy consumption.
2. Switching to a lower carbon or zero-carbon energy source.

From a financial perspective, reducing energy consumption results in long-lasting operational cost savings and thus is ideally implemented before switching to lower carbon energy sources. That said, switching energy sources can create large and immediate reductions in fossil fuel consumption, and as such is a valuable tool to reduce emissions.

This document also assesses GHG emissions from solid waste management at the landfill and wastewater treatment at the sewage lagoons. Due to the unique nature and high level of uncertainty associated with landfill and wastewater emissions, these are assessed separately from the fossil fuel-based emissions inventory, which comprises the bulk of this report.

2.0 Community and Corporate Emissions

Actions to reduce energy consumption and greenhouse gas emissions are frequently divided into the realm of corporate and community emissions.

- **Corporate emissions** – those that the local government creates through its activities (and which it has control over) such as local government building operations, recreation centres, vehicle fleets, and utility services; and

- **Community emissions** – those that the residents and businesses in the community create through their activities. The local government cannot directly control these emissions, but can influence them through city planning, infrastructure investments, and program activities.

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This document provides an inventory of the City's corporate emissions. Community emissions are not addressed in this document.

3.0 What is a Greenhouse Gas Emissions Inventory

A greenhouse gas emissions inventory is a compilation of the following over the course of a year:

- Total energy consumed
- Money spent on energy
- Greenhouse gases emitted

The data is further broken down by end use to help the City identify our largest emissions sources, notable trends, and activities of high energy intensity. This inventory covers the years 2015 to 2019 so as to include all years since the City implemented GHG emissions reduction targets. Unfortunately, the City is missing some critical data from 2014, so 2014 is not included in this inventory.

4.0 Unknown Emissions

There are a number of emissions sources for which the City does not have data. It is also of note that these emissions sources are not calculated as standard practice in the PCP Protocol for municipal corporate emissions inventories. These sources include:

- **Refrigerants:** refrigerants that leak out of equipment into the atmosphere have a significant Global Warming Potential (GWP).[2]
- **Air Travel:** The City of Whitehorse does not have a process to track air travel expenses or distances travels so currently there is no data upon which to base an emissions estimate. The addition of object/activity codes specific for air travel would be a valuable step toward quantifying the City's air travel emissions.
- **Employee Personal Vehicles:** Employees can submit their vehicle mileage but the fuel consumption is unknown.
- **Embedded Emissions:** Embedded emissions are those emissions generated in the creation of a product that the City purchases. Calculating embedded emissions is a complex field requiring a massive amount of data which the City does not have.

For the purposes of this inventory report, the above emissions sources are not included.

5.0 Data Sources

The City of Whitehorse utilizes an Energy Tracker software database, maintained by MakeIT, a local software development company. The City receives fuel/energy usage data periodically from suppliers, which is then uploaded into the Energy Tracker. The data is stored and can be viewed in the Energy Tracker. It can also be extracted for further analysis, as was done for the creation of this report. The City

[2] Global Warming Potential is a multiplier that quantifies the potency of greenhouse gases. CO2 has a GWP of 1. Some refrigerants have GWPs over 1000, making them over 1000 times more powerful greenhouse gases than CO2.

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utilizes emissions factors for the various fuel types that are compiled by The Climate Registry. Electrical emissions factors were provided directly from Yukon Energy staff.

Landfill emissions were calculated by City staff using methodology provided by the Partners for Climate Protection (PCP) in the PCP Protocol document.[3] The PCP Protocol is a supplement to the International Emissions Analysis Protocol (IEAP), designed specifically for Canadian municipalities. As such, using the PCP Protocol methodology ensures that the City of Whitehorse's emissions inventory follows globally recognized standards. Additional information was extracted from the IPCC's GHG Inventory Guidelines.[4]

Wastewater treatment emission were calculated by City staff using methodology provided in the GHG Protocol's Global Protocol for Community-Scale Greenhouse Gas Emission Inventories[5] and the IPCC's GHG Inventory Guidelines.[6]

For further information on the emissions factors refer to Appendix A of this report.

6.0 Greenhouse Gas Emissions Reduction Commitments

Commitments to reduce greenhouse gas (GHG) emissions have been made in recent years by all levels of government. The reason for greenhouse gas emissions reduction efforts is stated simply by the Government of Canada as follows:[7]

> Climate change is one of the most important environmental issues of our time. Climate change is caused by the increase in concentrations of greenhouse gases (GHGs) in the atmosphere. These increases are primarily due to human activities such as the use of fossil fuels or agriculture.

Under the 2015 Paris Agreements, the Government of Canada has committed to reducing Canada's greenhouse gas (GHG) emissions by 30% below 2005 levels by 2030.[8]

In the fall of 2019, Yukon government released its draft climate change strategy titled "Our Clean Future". In this draft strategy, the territorial government targets a GHG emissions reduction of 30% below 2010 levels by 2030.[9]

The City of Whitehorse has also made commitments to reducing GHG emissions, however they are less ambitious than either Yukon government's or the Government of Canada's. The City's 2030 corporate

[3] https://fcm.ca/sites/default/files/documents/resources/report/protocol-canadian-supplement-pcp.pdf
[4] https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html
[5] https://ghgprotocol.org/sites/default/files/standards/GHGP_GPC_0.pdf
[6] https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html
[7] https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html
[8] https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/progress-towards-canada-greenhouse-gas-emissions-reduction-target.html
[9] https://yukon.ca/sites/yukon.ca/files/env/env-our-clean-future-draft.pdf

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reduction target is for 25% below 2014 levels.[10] Unfortunately, there are some gaps in the City's 2014 emissions data, so 2015 data is used as a proxy for 2014 emissions.

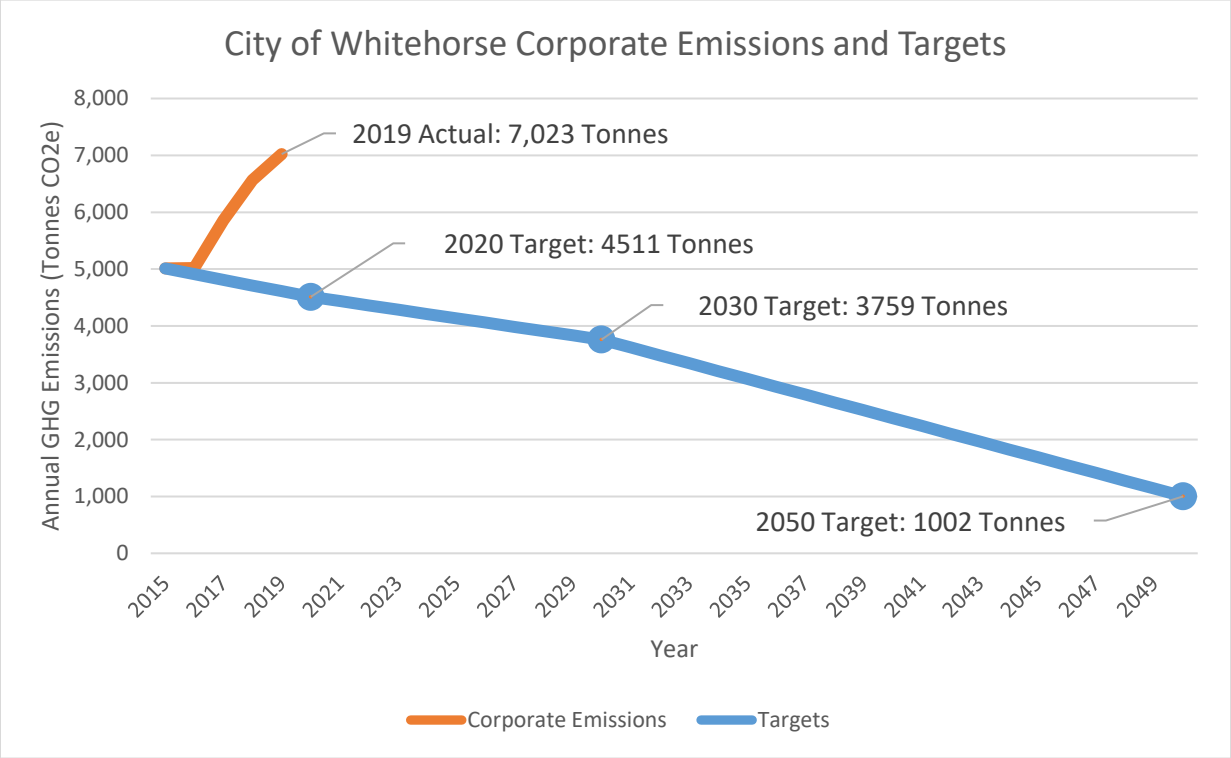

Figure 1: City of Whitehorse Corporate Emissions and Targets

The City's 2015 Sustainability Plan also targeted a 10% GHG emissions reduction by 2020 from 2014 levels. **Despite the City's sustainability efforts, our 2019 corporate GHG emissions have risen by 40% compared to 2015.** This rise is primarily due to a lack of secondary electricity sales which drove a gradual switch from electricity to oil for the primary heat source at the Canada Games Centre (CGC). The details of this change are expanded upon in Section 12.0. Increasing GHG intensity of Yukon's electricity grid has also contributed to the City's rising GHG emissions.

7.0 City of Whitehorse Annual Corporate Greenhouse Gas Emissions

Since 2015, the City of Whitehorse municipal government has generated between 5011 and 7023 tonnes of CO2e per year. The chart below shows the City's annual emissions since 2015. In 2019, the City's corporate emissions reached a new high of 7023 tonnes of CO2e, a rise of 40% compared to 2015 levels.

[10] https://www.whitehorse.ca/home/showdocument?id=5313

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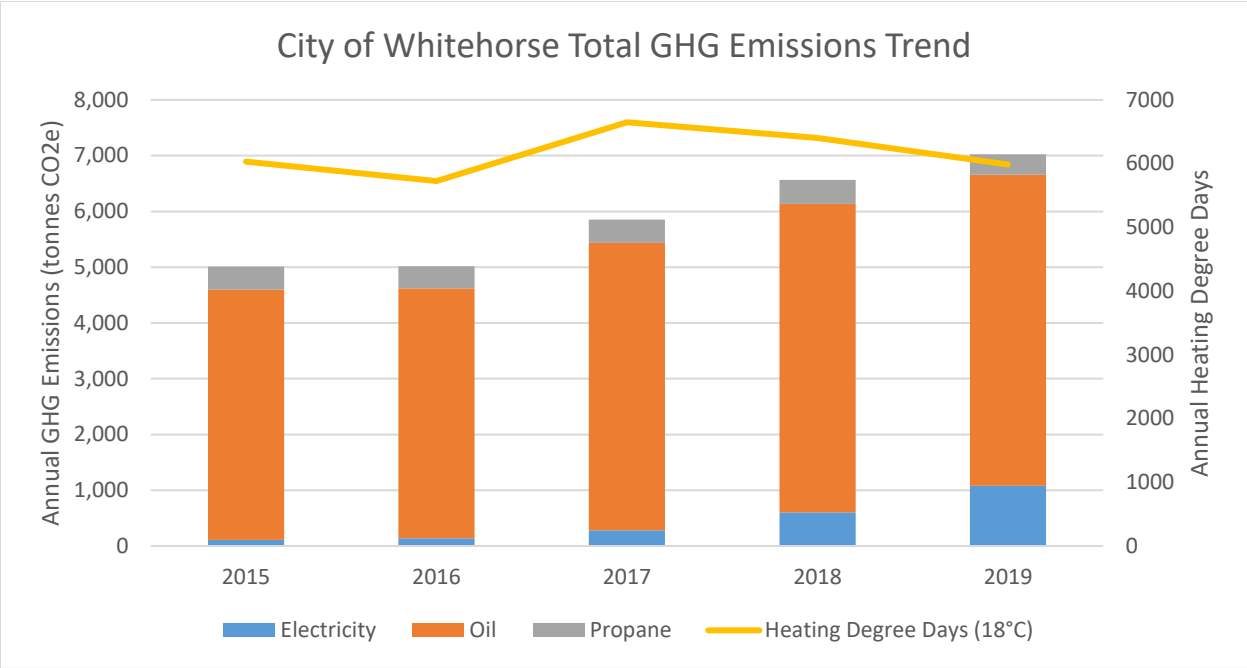

Figure 2: City of Whitehorse Corporate GHG Emissions Trend

The chart also shows the number of heating-degree-days each year. Fuel for heating buildings is a major energy use and source of GHG emissions for the City. The amount of fuel (or electricity) required to heat a building through the winter correlates linearly with the number of heating-degree-days in that year. Heating-degree-days allow us to normalize annual energy usage/ghg emissions and compare usage in a warm winter to that during a cold winter.[12]

The increase in GHG emissions due to electricity consumption in recent years is the result of Yukon Energy burning more liquefied natural gas (LNG) and diesel fuel to supply the Yukon's growing electrical load. As shown in Figure 4, the City has actually reduced our electricity consumption since 2015, however the emissions from electricity have increased over the same period. It must be noted that from a territorial GHG accounting perspective, the GHG emissions due to electricity will be accounted for by Yukon Energy, and thus depending on the context the City of Whitehorse should remove these emissions from our emissions accounting for some analyses. For the purposes of this report, the electrical emissions have been included.

Further, Yukon government's 2019 draft Climate Change, Energy, and Green Economy Strategy proposes to ensure that 93%[13] of Yukon's electricity comes from renewable sources, so in the future it may be more practical for the City of Whitehorse to use a consistent long-term GHG intensity for electrical loads, rather than trying to account for the exact energy mix each year.

[12] More information on heating-degree-days can be found at: https://www.weather.gov/key/climate_heat_cool
[13] https://yukon.ca/sites/yukon.ca/files/env/env-our-clean-future-draft.pdf

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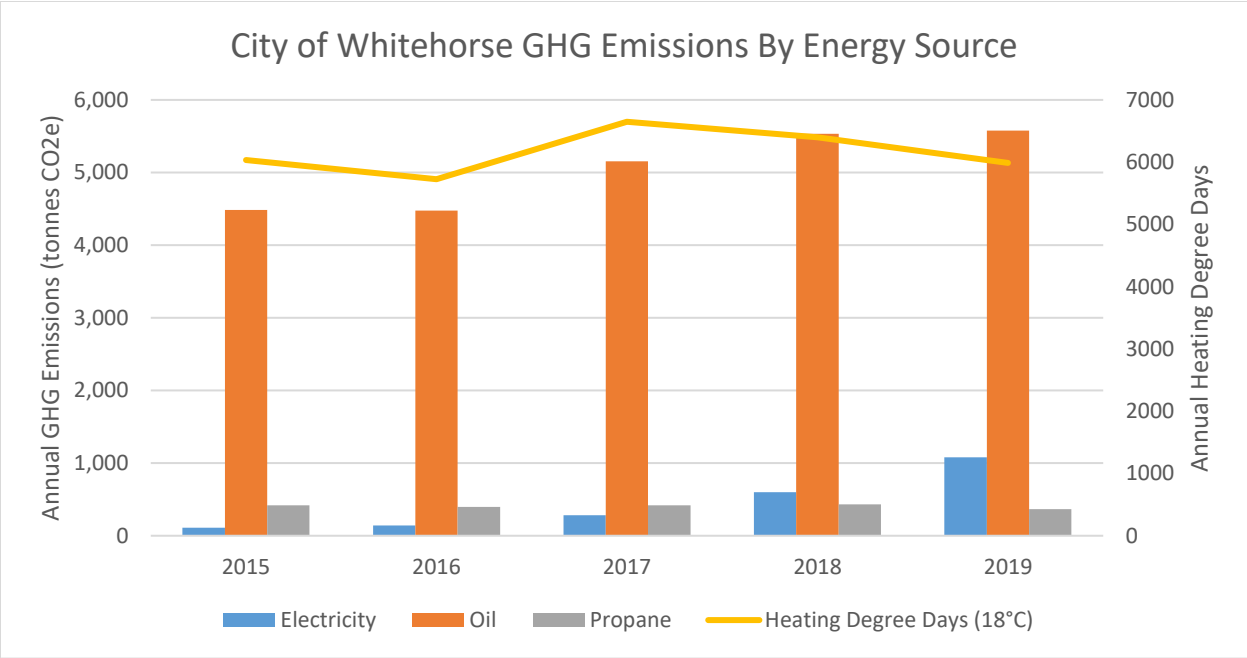

Figure 3: City of Whitehorse GHG emissions by energy source

The City of Whitehorse's emissions from oil/gas/diesel increased significantly from 2016 to 2018. This increase is largely driven by the CGC, which has burned much more oil for heat in recent years. In the past, the City benefited from Yukon Energy's secondary sales program which allowed the CGC to access discounted electricity rates to run an electric boiler when Yukon Energy had excess hydroelectric capacity. Unfortunately, Yukon Energy doesn't currently have excess clean energy, so the CGC has switched back to oil.

Emissions from propane have stayed relatively constant since 2014.

8.0 Energy Usage Trend

The City's total energy usage has remained relatively stable since 2015. Energy usage for both electricity and fuel is shown in kwh below. The increase observed in 2017 correlates well with the 2017 increase in heating degree days. In plain speech, the City used more energy in 2017 because the weather was colder.

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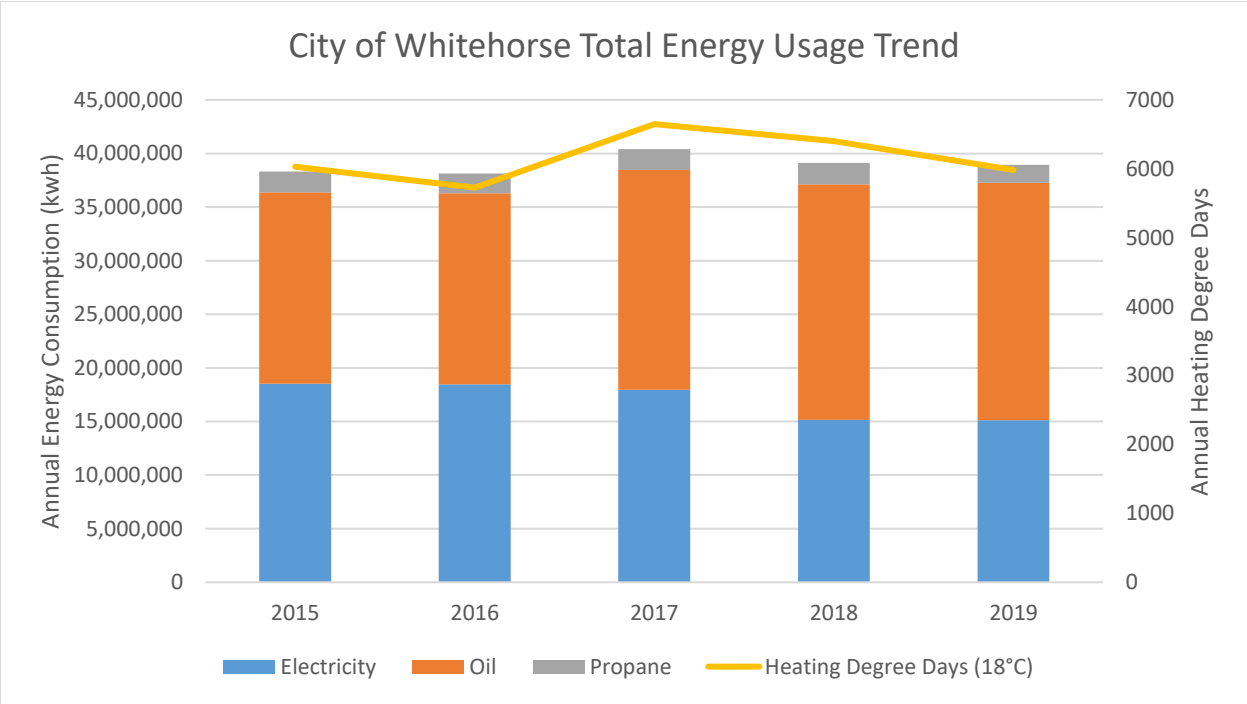

Figure 4: City of Whitehorse Total Energy Usage Trend

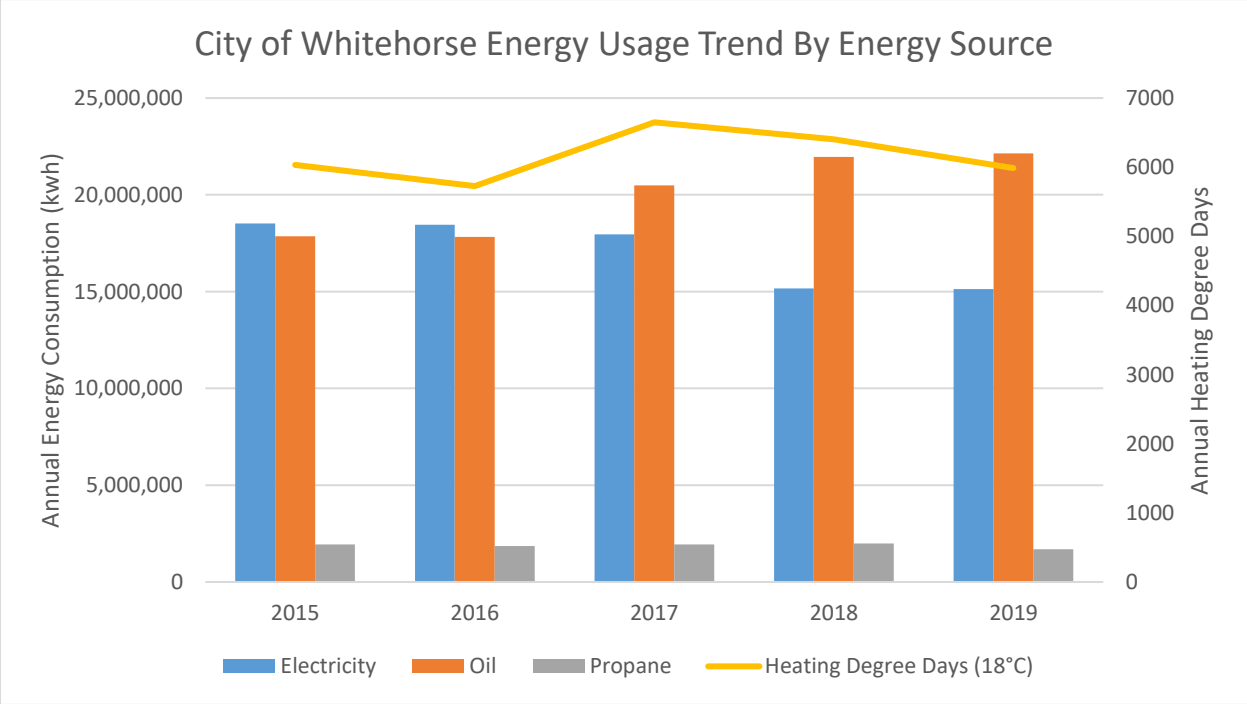

Figure 5: City of Whitehorse Energy Usage Trend by Energy Source

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Figure 4 above more clearly illustrates the energy usage trend for each energy source. Some key observations include:

- Propane energy usage has been quite stable. This is expected to increase with the addition of the new operations building.
- Electricity usage has decreased since 2017. This reduction is primarily due to the secondary electricity sales program being unavailable to heat the CGC. LED lighting upgrades have also contributed to this decrease.
- Oil usage has increased notably in 2017 and 2018, largely due to increased use of oil to heat the CGC (rather than secondary sales electricity).

9.0 2019 Energy Costs Breakdown

The City of Whitehorse spent over $5 million on energy in 2019. This includes electricity, heating oil, gasoline, diesel fuel, and propane. Electricity accounts for 62% of the cost, while heating oil, gasoline, and diesel combine for 36%.

It should be noted that the Energy Tracker data does not include the various taxes on fuels which include Carbon Tax, Federal Excise Tax, and Gas Tax. City staff are working with the software supplier to add this capability; in the meantime the reader can assume that true cost of oil (including all taxes) is 5 - 10% higher than the total in the figure below.

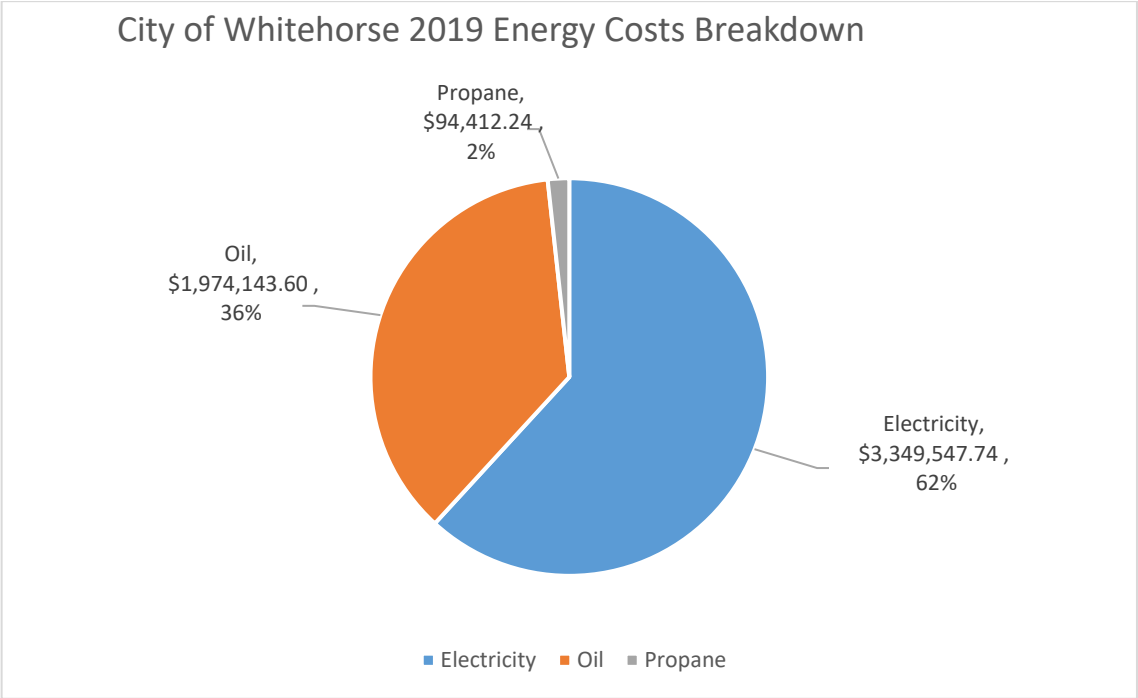

Figure 6: City of Whitehorse Energy Costs Breakdown

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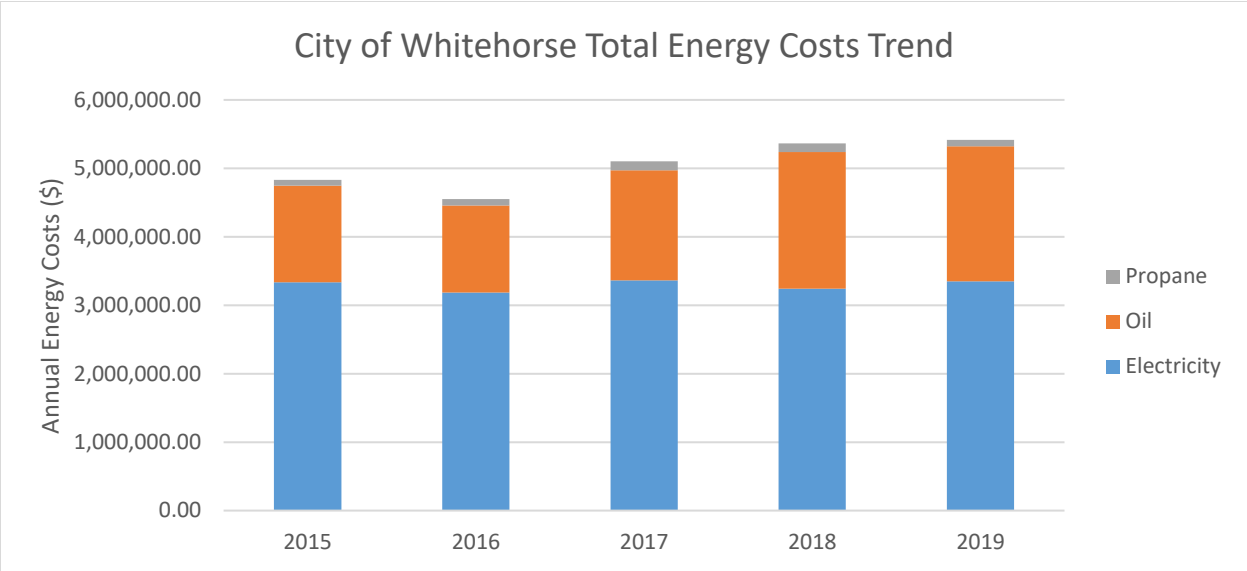

Figure 7: City of Whitehorse Total Energy Costs Trend

The chart above illustrates the trend in the City's energy costs since 2015. Energy costs have been rising largely due to rising costs per unit of fuel and electricity.

10.0 Energy Consumption By End Use

The chart below shows the City's past energy consumption by end use. The CGC stands out as the largest energy user, followed by the vehicle fleet, other buildings, and the transit fleet. Note that this data combines electricity, liquid fuels (oil, diesel, gasoline), and propane into a total energy consumption value.

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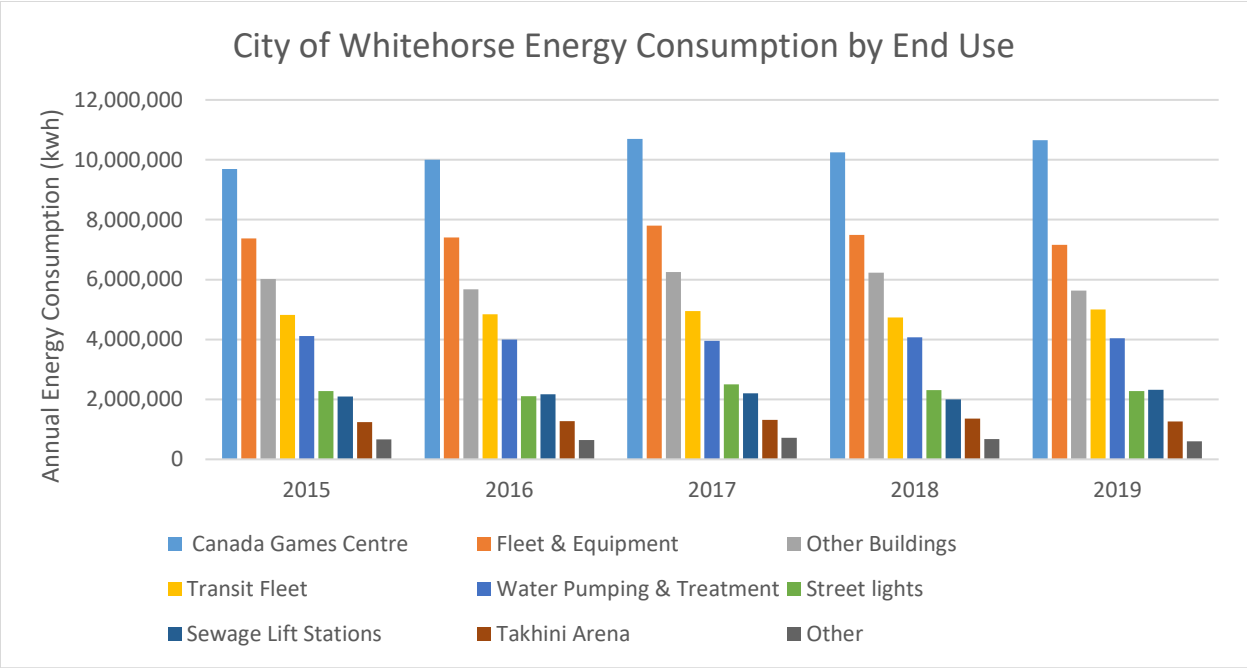

Figure 8: City of Whitehorse Total Energy Consumption by End Use

11.0 GHG Emissions by End Use

The City's fleet of vehicles (light vehicles and heavy equipment) has typically been the largest source of corporate GHG emissions. In 2019 however, the CGC has became the largest GHG emitter due to the switch from electric heat to heating oil and increasing use of fossil fuels on the electrical grid. The Transit Fleet also generates significant GHG emissions, as do Other Buildings, which includes all the City's buildings except for the CGC and Takhini Arena.

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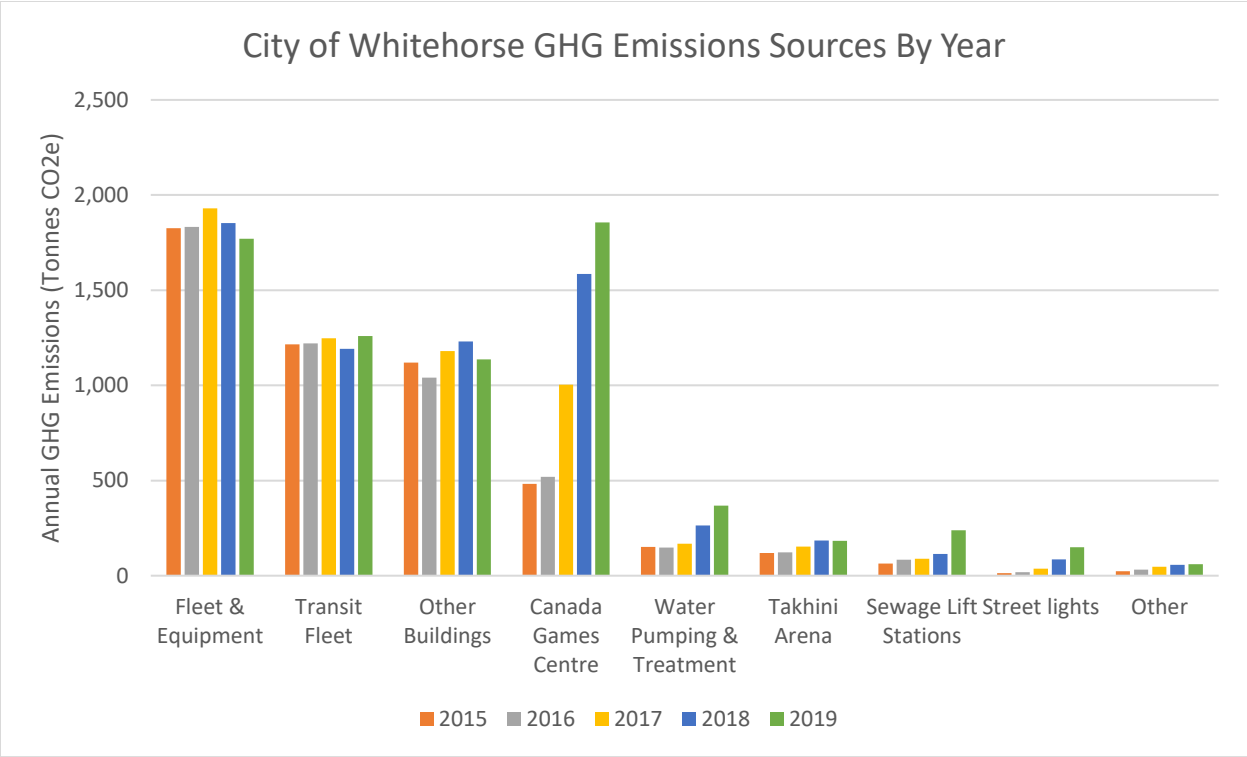

Figure 9: City of Whitehorse GHG Emissions Sources by Year

12.0 Oil Consumption by End Use

To better understand why the City's GHG emissions have been increasing, it is helpful to dig deeper into our oil consumption. 'Oil' includes heating fuel, diesel, and gasoline.

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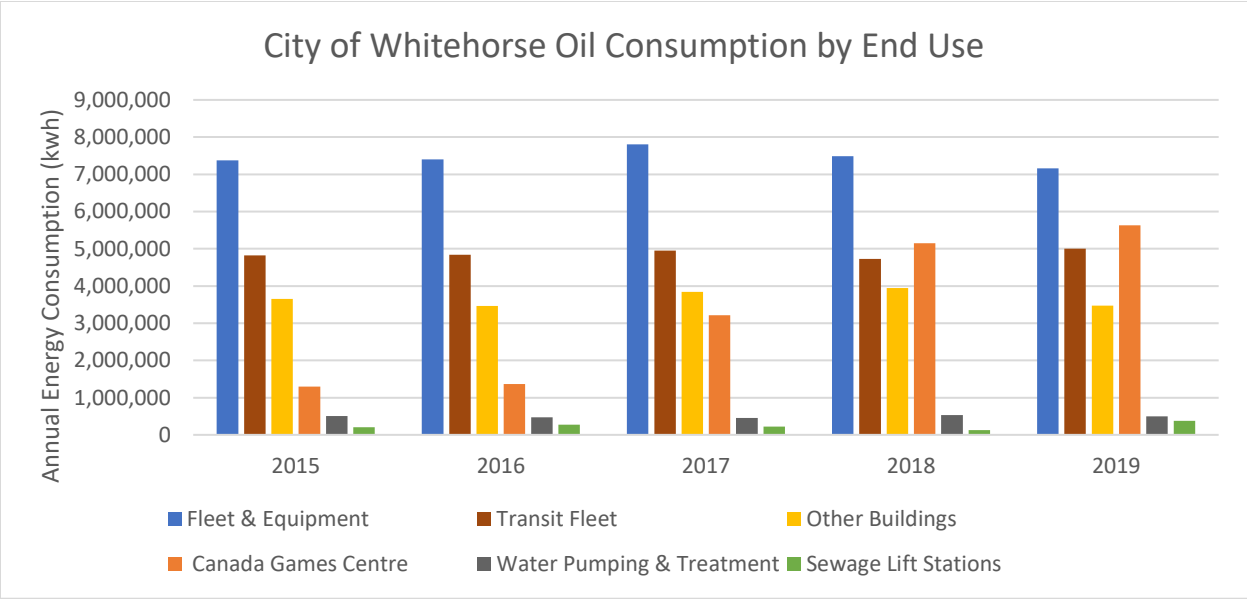

Figure 10: City of Whitehorse Oil Consumption by End Use

The City's vehicle fleet and equipment (blue) stands out as the largest consumer of fossil fuels, and as such will be an important piece of an emissions reduction strategy.

By far the largest observed change is that oil usage at the CGC (orange) increased by 4,334,424 kwh from 2015 through 2019. Over the same period, the City's total oil usage increased by 4,275,966 kwh so effectively the entire increase can be attributed to the CGC.

As discussed previously, the increased oil usage at the CGC is the result of heating the building primarily with the oil boilers as secondary electricity sales became less available for the electric boiler.

13.0 Electricity Consumption by End Use

Examining electricity consumption by end use tells a similar story. Most end uses stay relatively constant while the CGC's electricity consumption drops off after 2016, corresponding with the increase in oil consumption.

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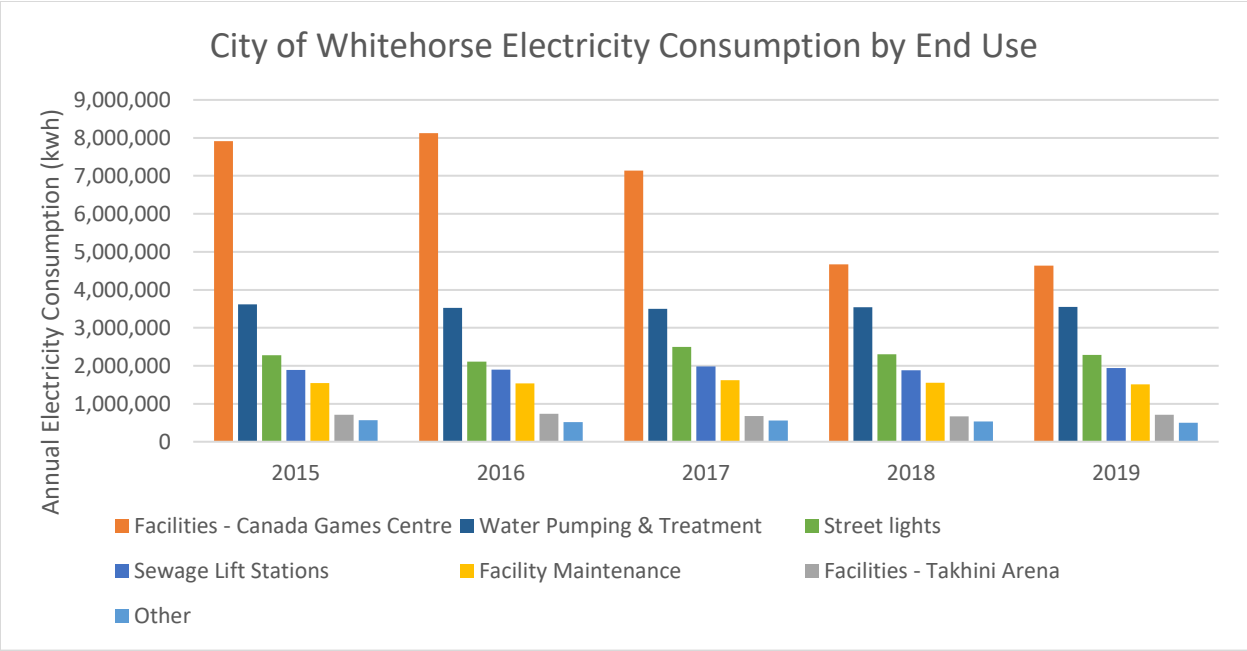

Figure 11: City of Whitehorse Electricity Consumption by End Use

Recent LED lighting upgrades at the CGC (starting in 2016) have also contributed to the reduction in electricity usage at the facility, with an estimated reduction on the order of 200,000 kwh/year, compared to a total observed reduction of over 3,000,000 kwh/year.

14.0 Propane Consumption by End Use

Takhini arena, the Public Safety Building (PSB), and the CGC are the City's largest propane users. The PSB is heated entirely with propane. At Takhini arena propane is also used for building heat, and at the CGC propane is used for a dehumidification system in the arenas.

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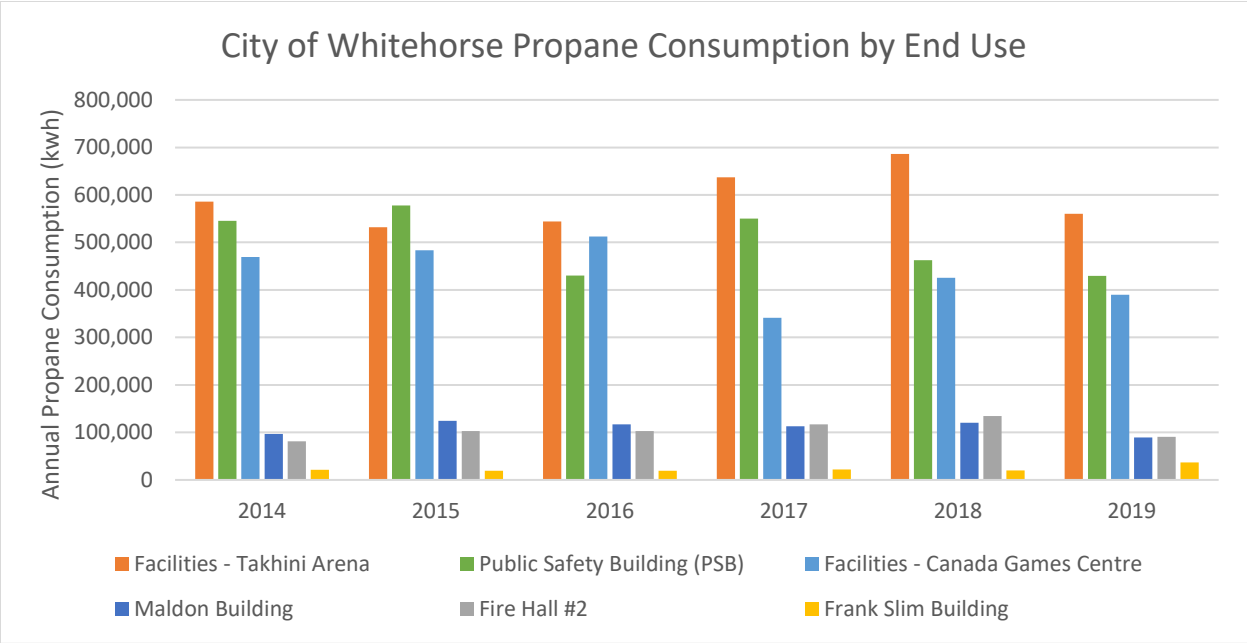

Figure 12: City of Whitehorse Propane Consumption by End Use

15.0 Looking Ahead to 2020

The City of Whitehorse has made a major investment into a new Operations Building as a key part of a building consolidation project. A key goal of the project is to retire old, inefficient buildings to reduce operating costs and GHG emissions. The new building has been designed with an energy performance target of 80% better than the national building code (NECB 2011). Although this building is extremely energy efficient, its floor space (11,567m^2) is second only to the CGC, as shown in Figure 13 below. Due to its size, the new Operations Building will be one of the City's major energy consumers, with higher energy consumption than either Mt Mac or Takhini Arena.[14] It is notable that the new operations building is expected to use about the same amount of energy as the Municipal Services Building, despite being more than twice the size.

[14] Based on simulation model results.

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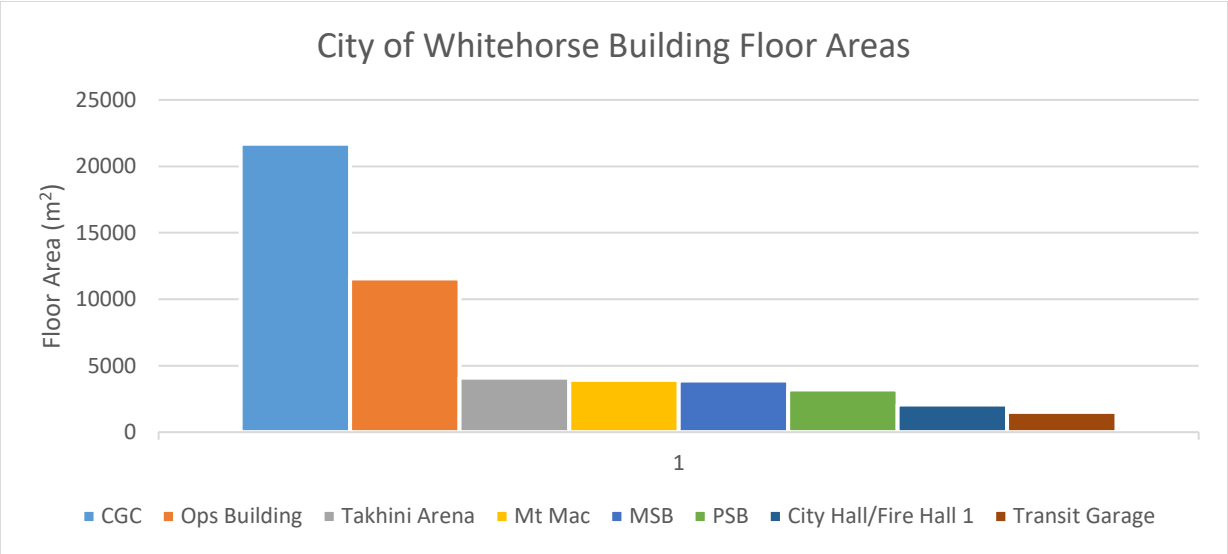

Figure 13: Floor areas of major City buildings

Despite its high efficiency, the Operations Building will increase the City's GHG emissions and energy costs in 2020. The table below outlines the impacts of the new building on various metrics.

Table 1: Energy Impacts of New Operations Building

Metric	2015 City Wide[15]	Operations Building	% Change
Annual GHG Emissions (tonnes CO2e)	5012	207	+4.1%
Annual Energy Costs ($)	$4,830,461	$161,226[16]	+3.3%
Annual Energy Usage (kwh)	33,540,443	1,415,367[17]	+4.2%

Retirement or demolition of the Municipal Services Building (MSB) will result in emissions and energy cost reductions that should overcome the increases associated with the Operations Building.

[15] 2015 Data is used as a proxy for incomplete 2014 data. 2014 is the baseline for the City's GHG reduction targets.
[16] From EnerSys Analytics Inc 2019 IFC Energy Performance Update
[17] From EnerSys Analytics Inc 2019 IFC Energy Performance Update

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Table 2: Impact of Retiring the Municipal Services Building

Metric	2014 City Wide[18]	Municipal Services Building	% Change when demolished
Annual GHG Emissions (tonnes CO2e)	5012	324	-6.5%
Annual Energy Costs ($)	$4,830,461	$160,335+ 5% = $168,351[19]	-3.5%
Annual Energy Usage (kwh)	33,540,443	1,484,310	-4.4%

16.0 Landfill Emissions

The City of Whitehorse Waste Management Facility includes a transfer station, landfill, and compost facility. Emissions from these facilities are calculated as per the PCP Protocol methodology, and thus are consistent with IEAP standards. The following excerpt from the PCP Protocol describes how landfill emissions are assessed:

> "The corporate solid waste sector tracks methane (CH_4) emissions that enter the air directly as waste decomposes at landfills as well as CH_4, nitrous oxide (N_2O) and non-biogenic carbon dioxide (CO_2) emissions associated with the combustion of solid waste at incineration facilities.
>
> When solid waste is landfilled, its organic components (e.g. paper, food and yard waste, etc.) decompose over time into simpler carbon compounds by bacteria in an anaerobic (oxygen poor) environment generating CH_4 and CO_2 emissions. The CO_2 emissions associated with the decomposition of the organic waste are considered to be of biogenic origin and are excluded from the GHG inventory. Landfill emissions are unique in that the disposed solid waste generates emissions over many years."[20]

For the purposes of this report, the City is using a Methane Commitment Model to evaluate changes in landfill emissions from one year to the next.

> "The methane commitment model (also known as 'total yield gas') estimates the total downstream methane (CH_4) emissions generated over the course of the waste's decomposition i.e. future CH_4 generation is attributed to the inventory year in which the solid waste was generated and disposed. This approach is typically the simplest for local governments in terms of data collection requirements and methodology. It is also the most comparable approach."[21]

[18] 2015 Data is used as a proxy for incomplete 2014 data. 2014 is used because it is the baseline for the City's GHG reduction targets.
[19] Increased cost by 10% to account for taxes that are not included in energy tracker data.
[20] https://fcm.ca/sites/default/files/documents/resources/report/protocol-canadian-supplement-pcp.pdf
[21] https://fcm.ca/sites/default/files/documents/resources/report/protocol-canadian-supplement-pcp.pdf

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The limitation of the Methane Commitment Method is that the calculated emissions are those that will be released in the future, rather than the emission that were released this year (due to the waste from previous years). The result is that the calculated emissions shouldn't be added or compared directly to the City's annual fossil fuel based emissions. That said, the Methane Commitment Method is useful because it helps us understand the long-term emissions reductions associated with changes in waste management such as organics separation.

The chart below shows the Methane Committed in each year due to the landfilled waste. The chart also shows the Avoided Methane Emissions due to the City's compost and clean wood separation programs. In 2019, the composting program reduced the committed methane by about 10%.[22] City staff are currently rolling out a significant expansion of the composting program into multi-residential and commercial compost. It is expected that this program expansion will result in an additional 3% reduction in committed methane for 2020.

The calculation spreadsheet is attached in Appendix B.

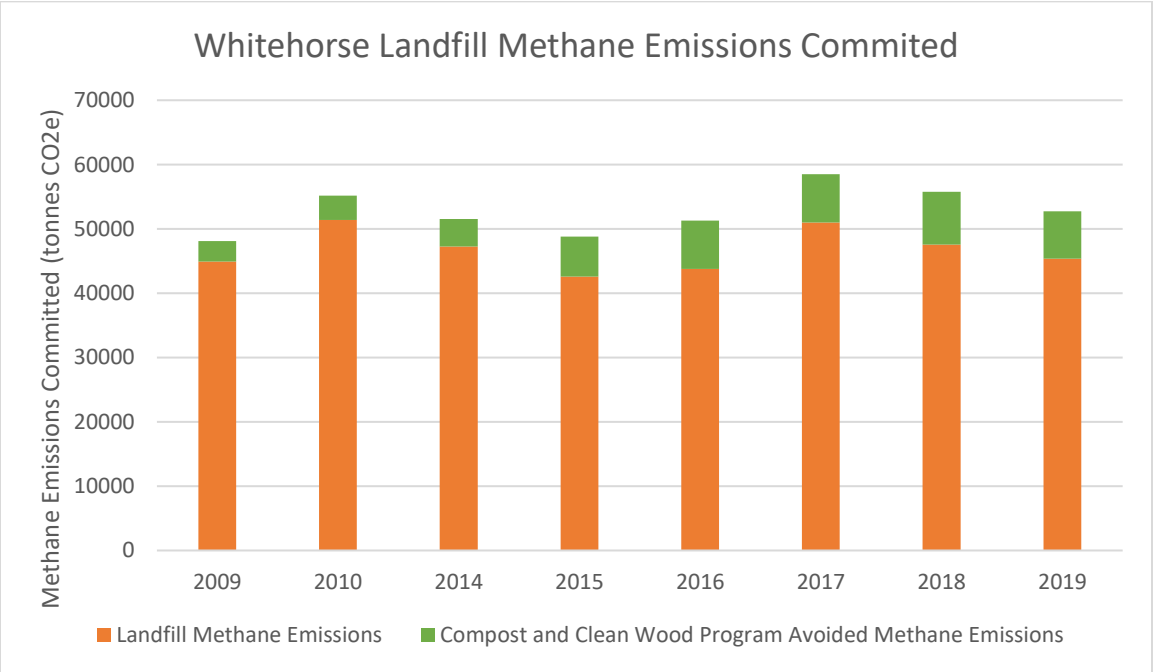

Figure 14: City of Whitehorse Landfill Emissions

17.0 Wastewater Emissions

Wastewater can be a source of methane emissions when treated anaerobically. It can also be a source of nitrous oxide (N2O) emissions. In accordance with IPCC emissions inventory guidelines, CO2 from

[22] Compared to a base case that assumes all the organics are landfilled.

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wastewater treatment is not included in the inventory because it is of biogenic origin. This is consistent with how CO2 emissions are dealt with for landfills.

The City of Whitehorse operates sewage lagoons to treat wastewater. Treating wastewater in a lagoon typically results in anaerobic conditions and the generation of methane.[23] The City of Whitehorse's Wastewater emissions were estimated using the methodology presented by the GHG Protocol for Cities[24]. It must be noted that these calculations are estimates based on standard parameters and correction factors. Population is the only factor that changes from one year to the next, so the calculated emissions rise as Whitehorse's population increases. There is a high degree of uncertainty in these numbers, but they are still a useful tool to guide and identify opportunities for the City's GHG emissions reduction efforts.

The calculation spreadsheet is attached in Appendix C.

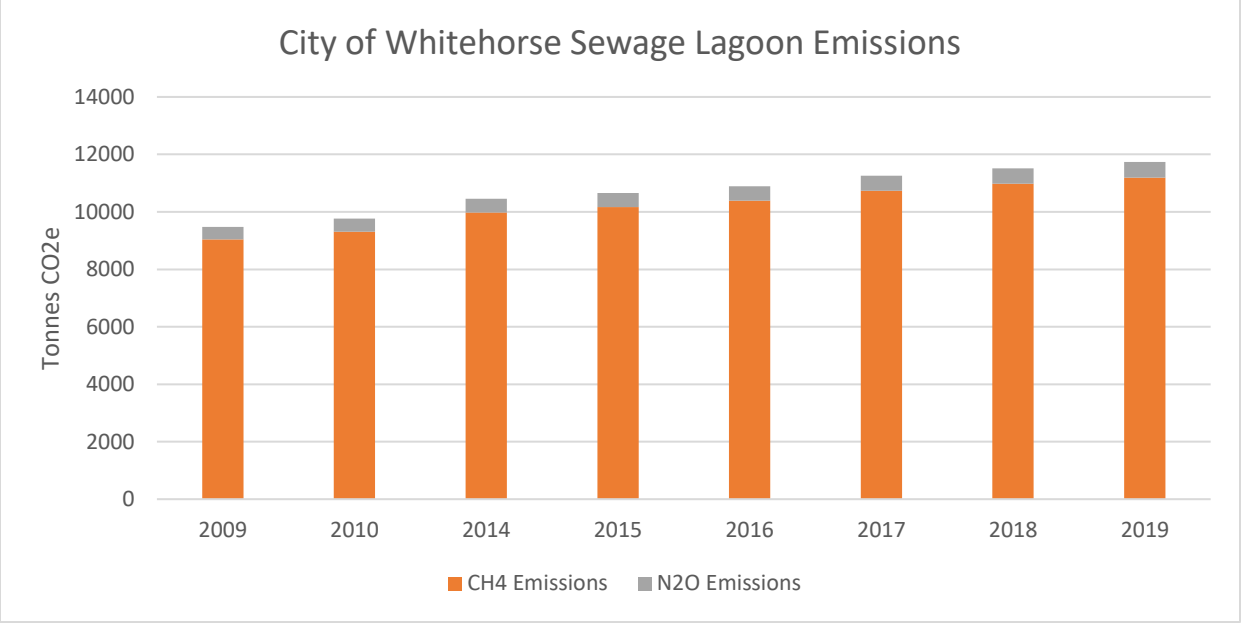

Figure 15: City of Whitehorse Sewage Lagoon Emissions

[23] IPCC Guidelines for National Greenhouse Gas Inventories, Vol 5, Section 6.1 https://www.ipcc-nggip.iges.or.jp/public/2006gl/

[24] Section 8.6, pg 99-103, https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

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18.0 Conclusion

The City of Whitehorse's corporate emissions have been rising in recent years, primarily driven by the transition from electric heat to oil heat at the CGC. Smaller increases in fuel usage by the transit fleet and vehicle fleet have also contributed, as well as the increasing GHG intensity of Yukon's electric grid. The new Operations building will also increase corporate emissions (and energy costs) until the MSB and other buildings are retired.

In 2014 the City set a target to reduce corporate emissions by 10% by 2020. That deadline has come and gone and our emissions have unfortunately risen by 40%. This result highlights that the current staffing levels, prioritization, and project funding approach have not been sufficient to make progress on GHG emissions reductions. To get the City back on track as a leader in sustainability and climate action, a renewed focus is required.

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Appendix A: Emissions Factors

The City of Whitehorse uses emissions factors provided by The Climate Registry (TCR). TCR produces an annually updated report (2019 Default Emissions Factors) with emissions factors for a wide range of fuel types. The annual report also includes Global Warming Potential (GWP) factors for various greenhouse gases including CO2, CH4, and N2O. The GWP factors are original produced by the Intergovernmental Panel on Climate Change (IPCC), via their Assessment Reports. The City of Whitehorse has used the latest GWP factors, which originate in the IPCC's Fifth Assessment Report (AR5).

https://www.theclimateregistry.org/

A summary of the Emissions Factors used in the City's Energy Tracker can be found on the next page.

Public Buildings Energy Tracker Emissions Factors Update

Prepared By: Cody Reaume

December 5th 2019

Verifying the emission factors and formulas was identified as part of my workplan for the 2019-2021 Climate Change Staff Grant from FCM. This document summarizes the steps I took and changes made to the emissions factors in the City of Whitehorse's Energy Tracker software.

Emissions from Burning Fossil Fuels Directly

To ensure that our GHG emissions inventory is comparable to other jurisdictions, it is important to use standard calculation methods and emission factors. The Yukon government was selected as the reference organization to which the City's emissions factors should match.

I reached out to the Yukon Government's Energy Manager and subsequently the Climate Change Secretariat to request the source for their emissions factors. Staff at the Climate Change Secretariat sent me an emissions factors document produced annually by The Climate Registry (TCR), a non-profit organization from California.[1] The document has been saved at:

R:\Development_Services\Environmental_Sustainability\Internal\Energy\Energy Tracker Data\Information on Emissions Factors

The Climate Change Secretariat uses this annually updated document to calculate the GHG emissions associated with burning diesel fuel, gasoline, liquefied natural gas (LNG), propane, and home heating fuel, as well as other fossil fuels.

The previous and new (from TCR) emissions factors are summarized in the table below. These updated factors have been input into the Energy Tracker database and thus any data extracted from the Energy Tracker after December 5th 2019 will have these updated emission factors attached.

Fuel Type	Unit	Previous Energy Density (MJ/unit)	Previous Emissions Factor (tonnes CO2e/unit)	TCR 2019 Energy Density (MJ/unit)	TCR 2019 Emissions Factor (tonnes CO2e/unit)
Propane	Litres	25.31	0.001548	25.31	0.001515
Heating Oil	Litres	38.40	0.0027306	38.80	0.002753
Diesel Fuel	Litres	38.40	0.0027306	38.30	0.002681
Gasoline	Litres	38.40	0.00236189	35.00	0.002307

Emissions From Electricity

The Energy Tracker calculates emissions associated with electricity used by the City of Whitehorse. These emissions are dependent on the mix of fossil fuels and renewables that Yukon Energy Corporation (YEC) used to generate that electricity. YEC's monthly average mix of fossil fuels and renewables is used to estimate the emissions associated with that month's electricity usage. Individual emissions factors are

[1] https://www.theclimateregistry.org/tools-resources/reporting-protocols/general-reporting-protocol/

then applied to electricity produced by diesel generators and to electricity produced by LNG generators. The old and updated factors are presented below. The updated emissions factors were supplied by Travis Ritchie, Manager of Environment, Assessment, & Licensing at Yukon Energy. It is of note that the emissions factors supplied by Travis are less precise than the old emissions factors. According to Travis, the reason for the reduced precision is that "Individual units will vary around these numbers depending on a variety of unit condition and operating factors…".

Electricity Generated From:	Unit	Previous Emissions Factor (tonnes CO2e/unit)	New Emissions Factors from YEC (tonnes CO2e/unit)
Diesel Generators	kWh	0.00050954	0.000700
LNG Generators	kWh	0.00043585	0.000450

It is of note that Yukon government uses a single emissions factor for all electricity in a given year. This value is pulled from Table 3.2 in The Climate Registry's Default Emissions Factors Document. For 2019, the factor is 41g CO2/ kWh. This works out to an assumption of roughly 7% fossil fuel generation, with the rest coming from zero emissions sources (hydroelectricity).[2] Using this standard figure provides a simpler calculation that will be consistent with Yukon government's calculation and easy to compare from one year to the next, but may sacrifice precision compared to the City's current methodology.

[2] This was calculated assuming a 50/50 split of diesel and LNG generation, resulting in a combined emissions factor of 575gCO2/kWh for fossil fuel electricity. The Yukon value of 41gCO2/kWh results in 41/575 = 7.1%. So 7.1% comes from fossil fuels, and the other 92.9% comes from hydroelectricity with an emissions intensity of zero.

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Appendix B: Landfill Emissions Calculations

City of Whitehorse 2019 GHG Emissions Inventory - Landfill Emissions Calculation
Prepared By: Cody Reaume and Sarah Preiksaitis
January 28th 2020
Updated: Feb 17th 2020

This spreadsheet calculates an estimate of the City's landfill emissions using the Methane Commitment model described in the Partners for Climate Protection (PCP) PCP Protocol document.
R:\Development_Services\Environmental_Sustainability\Internal\Climate Change and Adaptation\GHG inventory\2019 Emissions Inventory\References\protocol-canadian-supplement-pcp

Additional details and information can be found here: R:\Development_Services\Environmental_Sustainability\Internal\Climate Change and Adaptation\GHG inventory\2019 Emissions Inventory\References\GHG Protocol

The City of Whitehorse's landfill does not currently have a landfill gas (LFG) collection system.

From the PCP Protocol, the calculation steps are:
Determine quantity of solid waste landfilled during the inventory year.
Determine the composition of the waste stream.
Calculate the degradable organic carbon content from the waste stream.
Calculate the methane generation potential of the landfilled waste.
Calculate the emissions of CO2e.

City of Whitehorse Landfill Emissions

Category	Carbon Fraction	North American Waste Fractions	2009	2010	2014	2015	2016	2017	2018	2019	Unit
Total Mass			19297	22089	20293	18299	18805	21910	20432	19492	tonnes waste
Food	0.15	34%	14%	14%	24%	24%	24%	24%	24%	24%	N/A
Garden	0.2	0%	5%	5%	0%	0%	0%	0%	0%	0%	N/A
Paper/Cardboard	0.4	23%	14%	14%	10%	10%	10%	10%	10%	10%	N/A
Wood Products	0.43	6%	15%	15%	19%	19%	19%	19%	19%	19%	N/A
Textiles	0.24	4%	3%	3%	2%	2%	2%	2%	2%	2%	N/A
Inert Materials (Glass, metal, plastic, etc.)	0.15	33%	50%	50%	44%	44%	44%	44%	44%	44%	N/A
Degradable Organic Carbon (DOC)		0.228	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	tonnes carbon/tonne waste
Estimate Methane Generation Potential (Lo)			0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.092	tonnes CH4 / tonne waste
Estimate of Methane Committed			1604	1836	1687	1522	1564	1822	1699	1621	tonnes CH4 committed
Estimate of CO2e			44904	51400	47246	42603	43781	51010	47569	45381	tonnes CO2e committed
Waste Data Reference			2009 -10 Waste Audit	2009 -10 Waste Audit	2017-18 Waste Audit	2017-18 Waste Audit	2017-18 Waste Audit	2017-18 Waste Audit	2017-18 Waste Audit	2017-18 Waste Audit	
Whitehorse Population			26078	26872	28794	29325	29991	30984	31687	32304	Data from: http://www.sewp.gov.yk.ca/data?regionId=YK.WH&subjectId=POPCOM&groupId=POPCOM.POP&dataId=YBS_HCRF_POP_AGE_SEX&tab=region
Waste Generation / Person (tonnes)			0.740	0.822	0.705	0.624	0.627	0.707	0.645	0.603	
GHG's / Person (tonnes CO2e)			1.722	1.913	1.641	1.453	1.460	1.646	1.501	1.405	

City of Whitehorse Organics Diversion Methane Emissions Reductions

Year	Carbon Fraction	N/A	2009	2010	2014	2015	2016	2017	2018	2019	Source / Notes
Organics Diverted from Landfill Annually (tonnes)	-	-	1828	2149	2222	2758	2517	2316	2739.01	2648	The City operates a compost pickup program for residents. The program currently expanding into multi-residential, and subsequently commercial.
Clean Wood Diverted from Landfill Annually	-	-	0	0	2	31	235	141	337	396	The diverted clean wood is chipped and added to the compost to improve the carbon ratio for composting.
Wood Chips Diverted from Landfill Annually	-	-	0	0	160	599	2066	2959	2189	1304	
Organics/Wood Ratio	-	-	N/A	N/A	13.7	4.4	1.1	0.7	1.1	1.6	
Estimated Carbon Fraction of Diverted Organics	0.175	-	-	-	-	-	-	-	-	-	The mass fractions of the compost stream are unknown, so we have assumed it to be 50% Food and 50% garden waste, resulting in a Carbon Fraction of 0.175.
Carbon Fraction of Diverted Clean Wood and Wood Chips	0.43	-	-	-	-	-	-	-	-	-	
DOC of Compost (organics + clean wood)	-	-	0.175	0.175	0.192	0.222	0.297	0.321	0.297	0.275	
Methane Generation Potential of Organics (Lo)	-	-	0.070	0.070	0.077	0.089	0.119	0.128	0.119	0.110	
CH4 Avoided from Organics and Clean Wood Diversion	-	-	115	135	154	221	269	268	293	262	Assumes that the compost is 100% aerobic and no methane is released from the compost piles.
CO2e Avoided from organics and clean wood diversion	-	-	3225	3791	4308	6183	7530	7493	8209	7332	Applying GWP for CH4 of 28 (from IPCC AR5).
% Emissions Reduction	-	-	6.7%	6.9%	8.4%	12.7%	14.7%	12.8%	14.7%	13.9%	

Commercial Compost 2020 Forecast

Add'l Mass Diverted (tonnes)	713	From Water and Waste Department's Program Forecasting
Carbon Fraction	0.175	
DOC	0.175	
Lo	0.070	
CH4 Avoided	45	
CO2e Avoided	1258	
% of 2019 Landfill Emissions	2.8%	

More Below - Continue Scrolling Down

Factors for estimating methane emissions.

The factors below and calculation formulas were extracted from the PCP Protocol document: R:\Development_Services\Environmental_Sustainability\Internal\Climate Change and Adaptation\GHG inventory\2019 Emissions Inventory\References\protocol-canadian-supplement-pcp

Additional information and details can be found here: R:\Development_Services\Environmental_Sustainability\Internal\Climate Change and Adaptation\GHG inventory\2019 Emissions Inventory\References\GHG Protocol

	Methane Correction Factor (MCF)
managed	1
Unmanaged (>5m deep)	0.8
unmanaged (<5m deep)	0.4
uncategorized	0.6

Fraction of DOC dissimilated	0.6	Default value is 0.6
Fraction of methane in landfill gas	0.5	Default value is 0.5
Stoichiometric ratio between methane and carbon	1.33	16/12
GWP of CH4	28	From IPCC Assessment Report 5
Fraction recoved by LFG system	0	No LFG system in place
Oxidation Factor	0.1	0.1 for well managed lanfills, ~0 for unmanaged landfills

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Appendix C: Wastewater Emissions Calculations

City of Whitehorse 2019 GHG Emissions Inventory - Sewage Lagoon Emissions Calculation

Prepared By: Cody Reaume and Arcadio Rodriguez

February 18th 2020

Updated: Feb 19th 2020

This spreadsheet calculates an estimate of the City's sewage lagoon emissions using the methodology presented in Section 8.6 of the Greenhouse Gas Protocol's Global Protocol for Community-Scale Greenhouse Gas Emission Inventories document. Document can be found here: R:\Development_Services\Environmental_Sustainability\Internal\Climate Change and Adaptation\GHG inventory\2019 Emissions Inventory\References\GHG Protocol

The City of Whitehorse's sewage lagoons are a passive wastewater treatment system, with no aeration, agitation, or other energy inputs.
This spreadsheet calculates a simple estimate of methane (CH4) emissions from the lagoons. N2O emissions are assumed to be insignificant and are not included.
CO2 emissions from the lagoon are of biogenic origin and are thus not included in the GHG emissions inventory, as per Section 8.6 of the GHG Protocol document.

From the GHG Protocol document, the calculation steps are:

Determine the TOW (Total Organics, kg BOD/year)
Determine the EF (Methane Emissions Factor, unitless)
Calculate CH4 emissions
Calculate CO2e emissions

Factor	Quantity	Unit	Source
BOD (Biochemical Oxygen Demand)	56.5	g/person/day	City of Whitehorse 2019 Annual Report, Water License #: MN18-059, yukonwaterboard.ca
I (Correction factor for industrial BOD)	1.25	-	Default value from Equation 8.10 in GHG Protocol Document
B (Maximum CH4 producing capacity)	0.6	kgCH4/kg BOD	Default value from Equation 8.10 in GHG Protocol Document
MCF (Methane Correction Factor)	0.8	-	Table 6.3 , page 6.13, https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf
U (Fraction of Pop. in Income Group)	1.0	-	Assumed a single income group for the entire City of Whitehorse.
T (Degree of utilization of treatment/discharge pathway or system	1.0	-	All of Whitehorse's sewage goes through the same lagoons. There are no alternative treatment pathways. See 2006 IPCC GHG Inventory Guidelines, https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf
GWP of Methane	28.0	-	From IPPC AR5

City of Whitehorse Sewage Lagoon CH4 Emissions Calculation

Category	2009	2010	2014	2015	2016	2017	2018	2019	Unit	Source
Whitehorse Population	26078	26872	28794	29325	29991	30984	31687	32304	people	Data from: http://www.sewp.gov.yk.ca/data?regionId=YK.WH&subjectId=POPCOM&groupId=POPCOM.POP&dataId=YBS_HCRF_POP_AGE_SEX&tab=region
TOW (Total Organics In Wastewater)	672	693	742	756	773	799	817	833	tonnes BOD	Calculated
EF (Methane Emissions Factor)	0.48	0.48	0.48	0.48	0.48	0.48	0.48	0.48	N/A	Calculated
S (Organics Removed as Sludge)	0	0	0	0	0	0	0	0	tonnes BOD	Sludge removal only applicable for aerobic treatment
R (Methane Recovered)	0	0	0	0	0	0	0	0	tonnes CH4	The sewage lagoons do not have methane recovery
Estimated CH4 Emissions	323	333	356	363	371	384	392	400	tonnes CH4	Calculated
Estimated CO2e	9038	9313	9979	10163	10394	10738	10982	11195	tonnes CO2e	Calculated
GHG's / Person	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	tonnes CO2e/capita	Calculated

City of Whitehorse Sewage Lagoon N20 Emissions Calculation

Category	2009	2010	2014	2015	2016	2017	2018	2019	Unit	Source
Whitehorse Population	26078	26872	28794	29325	29991	30984	31687	32304	people	
Annual per capita protein consumption	36.50	36.50	36.50	36.50	36.50	36.50	36.50	36.50	kg/person/year	~ 100 g/capita/day (developed conuntries) https://doi.org/10.3390/foods6070053
Estimate of N2O Emissions	1.65	1.70	1.82	1.85	1.89	1.95	2.00	2.04	tonnes N2O/year	Calculated
Estimated CO2e	436	449	481	490	501	518	530	540	tonnes CO2e/year	

Factors for N20 Emissions Calculation	Value	Unit	Source
Non-consumed protein factor	1.1	N/A	1.1 for locations without garburators - Waste grinding devices are banned in the City's Sewer and Storm Utility Bylaw 2013-56
Nitrogen Fraction in Protein	0.16	kg N/kg protein	Default value is 0.16kgN/kg protein - IPCC Guidelines
Industrial/Commercial protein discharge factor	1.25	-	Default value is 1.25 - IPCC Guidelines for GHG Inventories, Table 6.11
Nitrogen removed in sludge	0	kg N/year	No sludge removal
Emission factor for N2O in wastewater	0.005	-	Default Factor is 0.005 - IPCC Guidelines for GHG
Stoichiometric factor for N2O-N to N2O	1.57	kg N2O-N / kg N2O	IPCC Guidelines for GHG Inventories, pg 6.25
GWP of N2O (Nitrous Oxide)	265.00	-	From IPCC AR5