City of Yellowknife Corporate and Community Energy and GHG Emissions Inventory and Forecast Report

Stantec

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Prepared by:
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Executive Summary

Stantec Consulting Ltd. (Stantec) was retained by the City of Yellowknife (the City) to complete the City's Climate Action Plan (CAP). As part of the CAP development process, Stantec has prepared the City's 2023 Corporate and Community greenhouse gas (GHG) emissions inventories and used this information to forecast GHG emissions to 2050 to provide an outlook of anticipated GHG emissions, trending with respect to the City's 2009 base year emissions levels, and to inform GHG emission reduction planning activities. This document presents the 2023 calendar year Corporate and Community emissions inventory and Corporate and Community Business-As-Usual (BAU) GHG emissions forecasts to 2050.

To monitor the impact on energy and GHG emissions, as well as track progress toward related targets, the City maintains and oversees two inventories: a Corporate GHG inventory and a Community GHG inventory. The Corporate GHG emission inventory focuses on emissions from assets managed by the City, while its Community GHG emission inventory encompasses emissions from all sources within the City's municipal boundaries. The City's 2023 Corporate inventory boundary includes GHG emissions from electricity and fuel use by City owned buildings, streetlighting and traffic signals, City owned transit and non-transit fleet vehicles and water and wastewater facilities, and fugitive GHG emissions from the Yellowknife Solid Waste facility and Fiddler's Lake wastewater treatment lagoon. The 2023 Community inventory boundary includes emissions sources captured within the Corporate inventory, as well as GHG emissions from electricity and fuel use by residential buildings, industrial, commercial and institutional (ICI) buildings, and on-road and off-road transportation vehicles. The total estimated 2023 Corporate GHG emissions from assets managed by the City amount to 26,472 tonnes of carbon dioxide equivalent (tCO_2e), which represents 10% of the total 2023 Community GHG emissions of 269,053 tCO_2e.

The City's 2023 emissions profile by sector for the Corporate and Community GHG inventory is presented in **Figure E1**. GHG emissions from solid waste and water and wastewater facilities represent the major contributors to the City's 2023 Corporate GHG emissions inventory, representing approximately 87% of total 2023 Corporate GHG emissions. The high contribution of solid waste to the City's Corporate GHG emissions inventory is a result of fugitive methane emissions from the buildup of waste at the City's landfill. For the City's 2023 Community inventory, GHG emissions are dominated by off-road transportation, on-road transportation and Industrial, Commercial and Institutional (ICI) buildings, which together represent approximately 84% of total 2023 Community GHG emissions. Within these major contributing sectors, aviation turbojet fuel represents 95% of estimated GHG emissions from off-road transportation, passenger light-duty gasoline and diesel vehicles represent 50% of estimated GHG emissions from on-road transportation and heating oil represents 66% of estimated GHG emissions from ICI buildings.

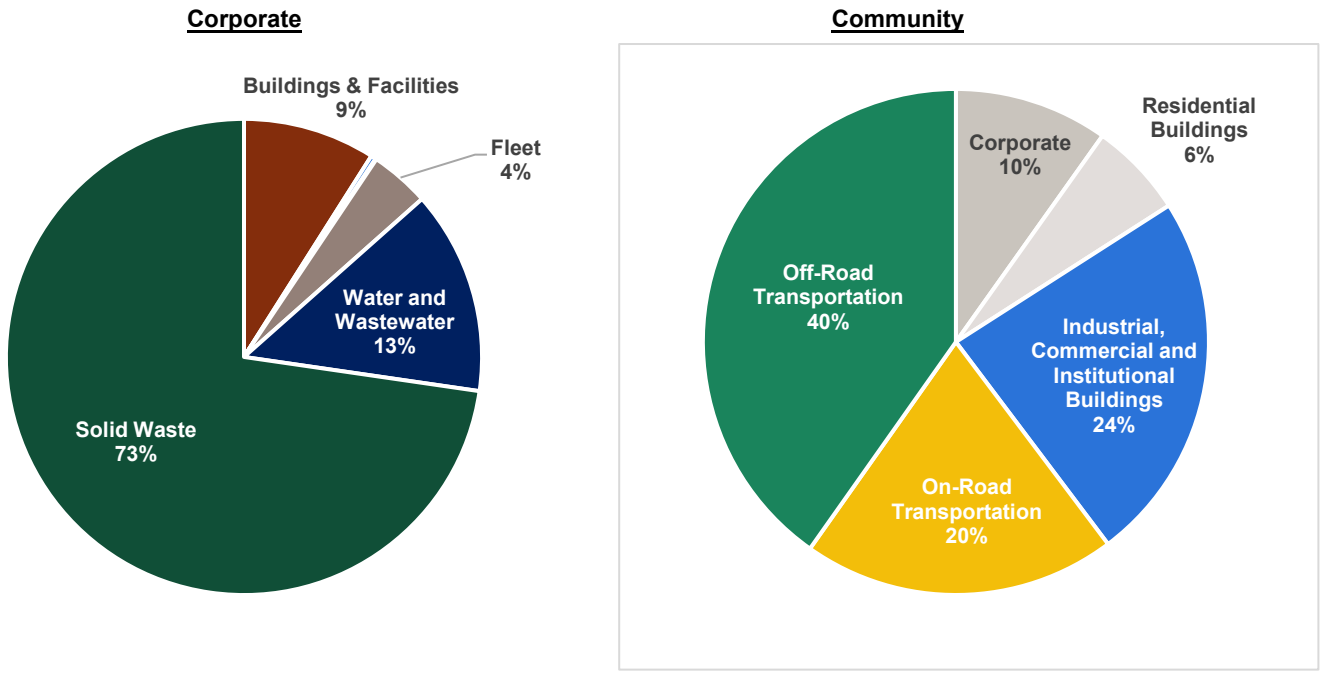

Figure E1: 2023 Corporate (Left) and Community (Right) GHG Emissions Profile[1][2]

Corporate and Community GHG emissions estimates from the last three years of quantification (2021 – 2023) indicate that total GHG emissions of both the Corporate and Community inventory increased from 2021 to 2023 with a total percent change of 3% and 16% for the Corporate and Community GHG inventories, respectively. The recent trend is likely a result of increased operations following the COVID-19 pandemic shutdowns, with Community inventory emissions activities such as on-road and off-road travel likely impacted more significantly by COVID-19 lockdowns, leading to a larger rebound in total Community GHG emissions post COVID-19 pandemic.

BAU forecasts were developed for the City's Corporate and Community GHG inventories. The forecast of the City's Corporate GHG emissions to 2050 is shown in **Figure E2**. Operations of City owned buildings and lighting infrastructure are assumed to remain stable under the BAU scenario, while operations and expected GHG emissions from Corporate and public transit fleet transportation, water and wastewater facilities and solid waste are expected to increase with the City of Yellowknife's projected population growth. Decarbonization of the Northwest Territories electricity grid represents the main source of Corporate emissions reductions under the BAU scenario. Solid waste represents the most significant contributor to the City's Corporate GHG emissions forecast. Fugitive methane emissions from the Yellowknife Solid Waste landfill are expected to contribute 80% of total Corporate emissions by 2050

[1] Sources that represent 1% or less of Corporate GHG emissions are excluded from Figure E1 (Left). This includes temporary electricity and streetlighting and traffic signals.

[2] GHG emissions in Figure E1 (Right) include all sectors captured within the Corporate energy and GHG inventory boundary. This includes Buildings and Facilities, Streetlighting and Traffic Signals, Temporary Power, Fleet Transportation, Water and Wastewater and Solid Waste.

under the BAU scenario, up 7% from its estimated 73% contribution to the City's total 2023 Corporate emissions.

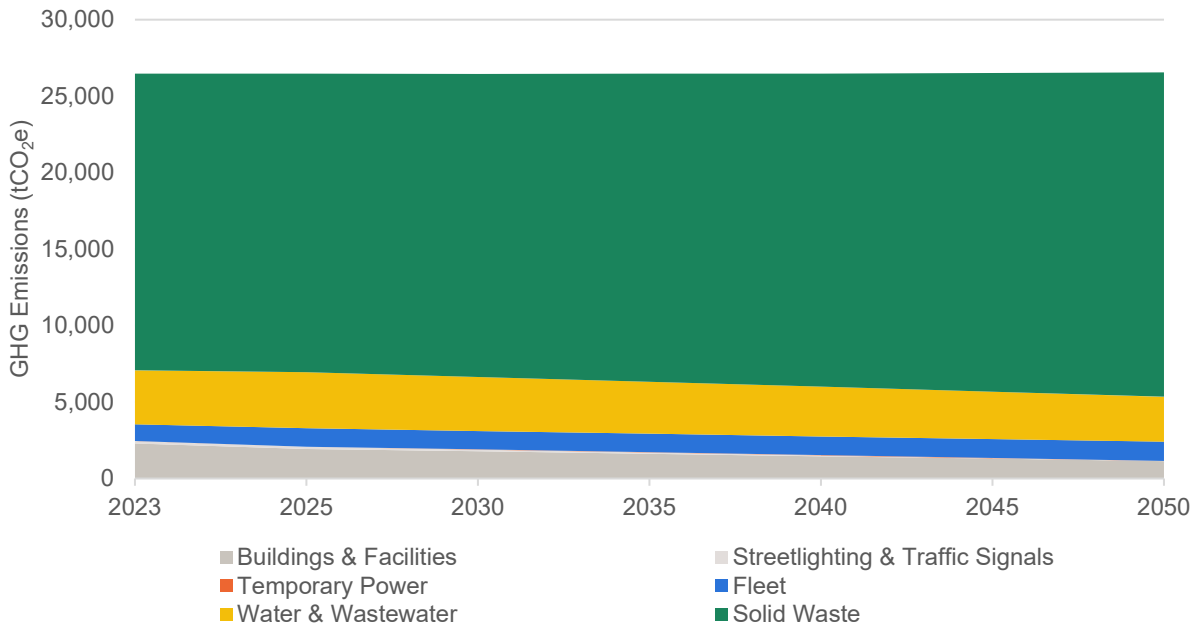

Figure E2: City of Yellowknife Business-As-Usual Corporate GHG Emissions

The forecast of the City's Community GHG emissions to 2050 is shown in **Figure E3.** The City's Community GHG forecast assumes increases in energy demand and emissions trend proportionally with population growth, while GHG reductions result from natural aging out of fossil fuel powered building heating systems and mobile vehicles, reduced GHG intensity of the Northwest Territories electricity grid and regulatory driven increases in vehicle efficiencies and battery-electric vehicle purchases. In the year 2050, under the BAU scenario, it is estimated that total Community GHG emissions will be around 195,302 tCO_2e, representing a reduction of approximately 27% from the estimated 2023 GHG emissions of 269,053 tCO_2e. Major contributing sources to the City's Community GHG emissions include gasoline from passenger vehicles, heating oil for ICI buildings and turbojet fuel for community air travel. Under the Community BAU scenario gasoline emissions from on-road passenger vehicles (not within Corporate control) are expected to decrease by approximately 56% from 2023 to 2050, with regulations driving increases in vehicle fuel efficiency and passenger vehicle fleet conversion to battery electric vehicles over fossil fuel vehicles. Heating oil emissions from residential and ICI buildings (not within Corporate control) are expected to decrease 34% from 2030 to 2050 under the BAU scenario, as heating oil systems age out and are replaced by lower carbon alternatives (e.g., electrification, biomass). No decreases in GHG emissions from jet fuel combustion for community air travel are expected under the current Community BAU scenario.

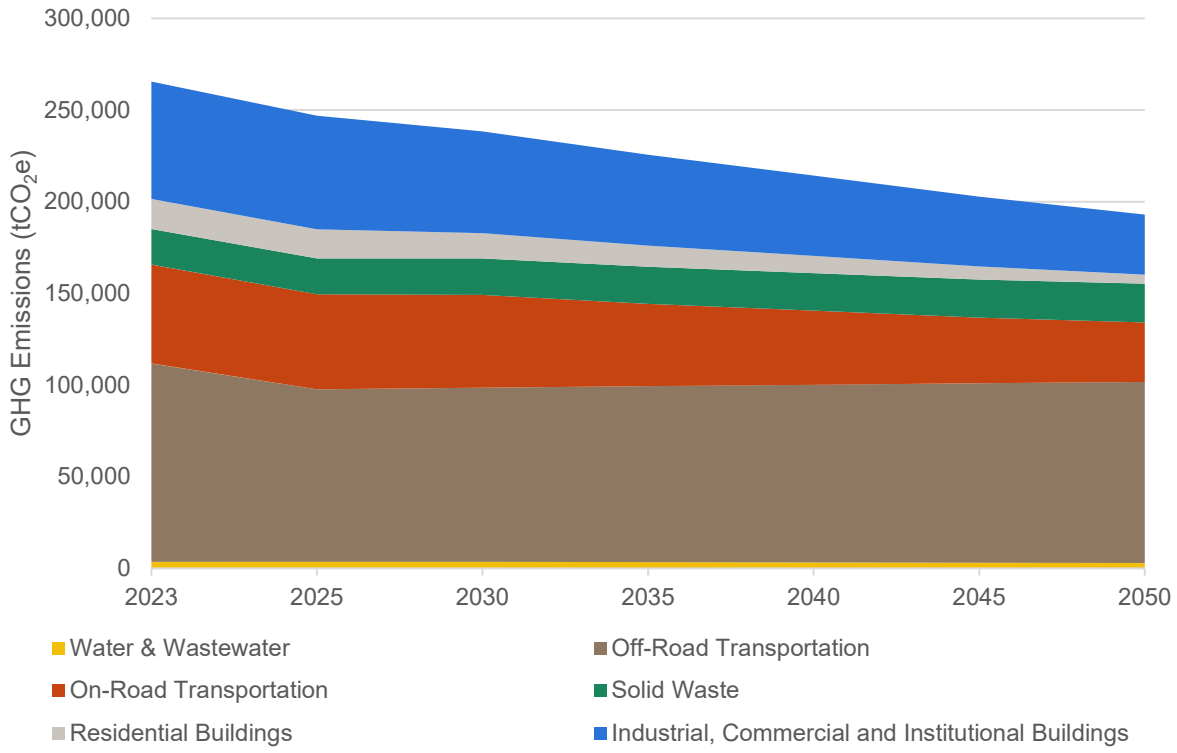

Figure E3: City of Yellowknife Business-As-Usual Community GHG Emissions[3]

The 2023 Corporate and Community GHG inventory and BAU GHG forecast results indicate that the City's most significant GHG emission sources include fugitive GHG emissions from the City's Solid Waste landfill, jet fuel combustion emissions from Community air travel, fuel combustion emissions from on-road passenger vehicle travel and heating oil combustion emissions from ICI buildings. Now that the City has developed a forecast of its expected BAU GHG emissions, the next step required for the City to achieve meaningful GHG emission reductions in line with Canada's GHG reduction targets will be to identify and evaluate relevant GHG mitigation actions. This will include reviewing best practices, policies, projects, programs and technologies being implemented by similar cities and evaluating the GHG reduction potential and technical and economic criteria required for implementation within the City of Yellowknife.

[3] Sectors that contribute less than 1% of total Community GHG emissions are excluded from Figure E3. This includes GHG emissions from the following Corporate owned assets: City owned buildings, streetlighting and traffic signals, temporary electricity and fleet transportation.

1 Introduction

Stantec Consulting Ltd. (Stantec) was retained by the City of Yellowknife (the City) to develop a Climate Action Plan (CAP). As part of the CAP development Stantec reviewed and updated the City's current combined Corporate and Community greenhouse gas (GHG) emissions inventory tool based on recommendations provided by Stantec to the City to best align with the reporting requirements and guidance of the GHG Corporate Protocol[4] (the GHG Protocol) and the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (The GPC Protocol)[5]. Stantec used the updated GHG inventory tool to quantify 2021, 2022 and 2023 reporting year emissions using Corporate and Community activity data provided by the City and developed business-as-usual (BAU) forecasts to provide an outlook for the City's Corporate and Community energy and GHG emissions. This report provides a breakdown of the City's 2023 Corporate and Community GHG Inventories, the City's Corporate and Community GHG emission trends over the last 3 reporting years (2021 – 2023) and relative to the City's 2009 base year GHG emissions levels, and forecasted BAU Corporate and Community energy and GHG emissions by energy source and sector. All methodologies and assumptions used for quantification of the GHG inventory and BAU forecast estimates are provided.

2 Energy and GHG Emissions Boundary & Methodology

To monitor energy consumption and GHG emissions and track progress towards energy and GHG reduction targets, the City maintains a Corporate and Community energy and GHG inventory. As per the criteria of the GHG Protocol, the boundary of a municipalities Corporate GHG inventory includes energy consumption and GHG emissions from operations, buildings and services for which the municipality owns and has direct operational control over. The boundary of a Community GHG inventory however, as per the criteria of the GPC Protocol, is extended to include all energy consumption and GHG emissions occurring from activities that take place within the municipal geographic boundary. These include emissions from the residential, commercial and institutional, industrial, transportation, water and wastewater and solid waste sectors, as well as energy consumption and GHG emissions from activities captured within the Corporate inventory that occur within the City's municipal boundary.

An example of a typical Community GHG inventory boundary for a municipality is provided in **Figure *1***. Energy use and GHG emissions under the direct control of the municipality are captured within the municipalities Corporate inventory, while the Community inventory is extended to include energy use and

[4] The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard (The GHG Protocol)

[5] The Global Protocol for Community Scale Greenhouse Gas Inventories (The GPC Protocol)

GHG emissions over which the municipality has indirect or no control over but occur from activities within the municipal boundary.

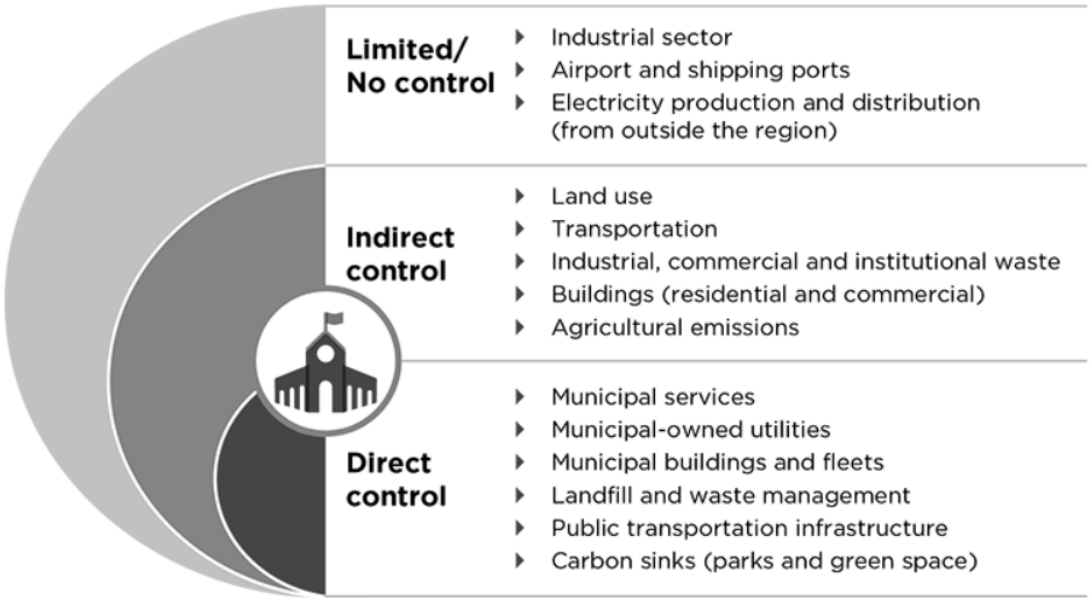

Figure 1: Example Community GHG Emissions Boundary[6]

The City's Corporate and Community GHG inventory was developed according to the described boundary criteria for municipalities from the GHG Protocol and the GPC Protocol. The following sections outline the sources captured within the City's Corporate and Community GHG inventory and the methodologies used to quantify energy use and/or GHG emissions.

2.1 Corporate & Community Inventory Breakdown

A summary of the City's Corporate and Community GHG inventories by included sectors and GHG emission sources is included in **Table *1***. The City's Corporate inventory includes GHG emissions from all assets managed by the City, while the Community GHG emission inventory encompasses emissions from all sources within the City's municipal boundaries.

Table 1: Corporate and Community GHG Inventory Breakdown

Corporate	Community
The Corporate inventory tracks energy and GHG emissions from major assets owned, leased, and operated by the City. The municipal inventory includes	The Community inventory tracks energy and GHG emissions from activities taking place within the geographic boundaries of the City of Yellowknife. The Community inventory includes the following energy and GHG emission sources:

[6] Green Municipal Fund: Factsheet: Municipal Governance for Deep Decarbonization

Corporate	Community
the following sectors and energy and GHG emission sources: • Buildings and Facilities: City owned facilities consume diesel, heating oil, biomass and electricity for heating, ventilation and air conditioning (HVAC), lighting and other building processes. • Streetlighting, Traffic Signals and Temporary Electricity: Streetlighting and Traffic signals within the City are powered exclusively by electricity. • Fleet Transportation: The City operates non-transit fleet vehicles for corporate use and transit fleet vehicles for resident transportation services. GHG emissions from this sector result from combustion of diesel, gasoline and propane in mobile vehicles. • Water and Wastewater: GHG emissions are released from diesel, heating oil, biomass and electricity consumed for operation of water and wastewater facilities and water conveyance systems. Fugitive methane and nitrous oxide emissions result from wastewater treatment. • Solid Waste: Waste does not directly consume energy, but when deposited into landfills or composted it decomposes and releases methane gas which is a potent GHG emissions source.	• Corporate: GHG emissions from Corporate Operations and the services delivered to the City of Yellowknife. Includes all sources included in the City of Yellowknife's Corporate inventory, including a**ll** community level fugitive emissions from the City owned wastewater treatment facility and landfill. • Residential Buildings: GHG emissions related to the operation of all residential buildings within City of Yellowknife. • Industrial, Commercial and Institutional Buildings: GHG emissions related to the operation of industrial, commercial and institutional buildings within City of Yellowknife. Institutional buildings includes First Nations, Federal, and Territorial government activities. • Transportation: GHG emissions related to the use of on-road, off-road (ATVs, ride on lawn mowers etc.) and aviation vehicles within the City of Yellowknife. • Waste: GHG emissions related to solid waste disposal at the landfill, composting, and wastewater treatment.

2.2 GHG Emissions Considered

A GHG can be any atmospheric gas that absorbs and re-emits infrared radiation, thereby acting as a thermal blanket for the planet and warming the lower levels of the atmosphere. Based on currently available data, the City currently includes the three most prevalent global GHGs: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), in the Corporate and Community GHG inventory. To compare CH_4 and N_2O on an equivalent global warming basis as CO_2, the 100-year global warming potentials from the Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report (AR5)[7] listed below were used to convert CH_4 and N_2O emissions values into tonnes of carbon dioxide equivalent (tCO_2e).

- Carbon dioxide (CO_2) = 1
- Methane (CH_4) = 28
- Nitrous oxide (N_2O) = 265

[7] Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5)

3 Corporate Energy and GHG Emissions Inventory

3.1 Corporate GHG Inventory Boundary & Methodology

The sectors and associated energy use and GHG emission sources captured within the City's Corporate GHG inventory are provided in **Table 2**. These include energy use and GHG emissions from assets owned and under the direct control of the City. Using the Corporate boundary summarized in **Table 2**, Stantec quantified the City's 2021, 2022 and 2023 Corporate GHG inventory and used the energy use and GHG results to generate BAU GHG emission projections for years 2024 through 2050.

Table 2: Corporate GHG Quantification Boundary

Sector	GHG Emissions Source
City Owned Buildings	Diesel, Heating Oil, Biomass and Electricity
Streetlighting, Traffic Signals and Temporary Electricity	Electricity
City Corporate Fleet and Public Transit	Diesel, Gasoline, Propane
Water and Wastewater Facilities	Diesel, Heating Oil, Biomass, Electricity and Wastewater Fugitives
Solid Waste Facilities	Landfill Fugitives

A summary of the main quantification methodologies used to generate the 2021, 2022 and 2023 energy use and GHG emissions for Corporate sectors owned and directly controlled by the City is provided below. To translate activity data from the various Corporate sources into GHG emissions, emission factors from Canada's 2024 National Inventory Report (NIR)[8] were used.

3.1.1 Fuel and Electricity GHG Emissions from City Owned Assets

Fuel and electricity emissions for Corporate owned assets were quantified using fuel and electricity consumption data tracked directly by the City. Appropriate emission factors from Canada's NIR were used to translate annual fuel and energy consumption values into annual GHG emissions. As shown in **Table 2**, emissions from Corporate owned assets include electricity and fuel consumption by City owned buildings, electricity consumption by streetlighting, traffic signals and temporary electricity equipment, fuel consumption by City owned fleet vehicles and public transit vehicles, and fuel and electricity consumption from the City's water and wastewater and solid waste facilities.

[8] National Inventory Report: Greenhouse Gas Sources and Sinks in Canada

3.1.2 Fugitive GHG Emissions from Wastewater Treatment

Fugitive emissions from wastewater are calculated using the total annual volume of wastewater discharged to Fiddler's Lagoon from the City's annual water license reports as the main source of activity data. Using the latest methodologies from Canada's 2024 NIR, Part 2, Section A3.6.4, for quantification of CH_4 and N_2O emissions from wastewater treatment and discharge, and the annual volume discharged to Fiddler's lagoon, the 5-day Biological Oxygen Demand (BOD_5) and nitrogen concentration of the influent and effluent wastewater to the facultative lagoon, and subsequent GHG emissions are estimated. For wastewater treatment fugitives, CH_4 emissions were calculated using default emission factors from Canada's NIR, for facultative wastewater lagoons. As per default methodologies in Canada's 2024 NIR, N_2O emissions from facultative lagoon wastewater treatment are assumed negligible. For fugitive CH_4 and N_2O emissions from discharge of treated wastewater effluent to Great Slave Lake, default emission factors and methodologies from the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories[9] for discharge to lakes are used.

3.1.3 Fugitive GHG Emissions from Solid Waste

Fugitive CH_4 emissions from decaying organic matter in the City's landfill are estimated using the Scholl Canyon model which is based on the first-order decay equation. This differs from the Waste-in-Place model (previously used in the City's GHG emissions methodology) as it accounts for both new waste deposits and ongoing decomposition, whereas the latter estimates GHG emissions based on total accumulated waste mass which tends to overlook past and current conditions of the landfill. The Scholl Canyon model considers key factors including the total tonnage of mixed solid waste landfilled annually, annual waste composition (i.e., food, garden, paper/cardboard, wood, textiles and inert), annual precipitation volumes and uses this information to estimate CH_4 generation potential. This represents a more accurate approach to quantifying total annual fugitive GHG emissions from the landfill.

To estimate annual fugitive CH_4 emissions emitted from the landfill, the City provided historic data dating back to 2007. To estimate landfill GHG emissions from when the landfill opened in 1974, the 2007 waste data was prorated based on population figures. Because annual waste compositions vary greatly between each year, there is a high level of uncertainly around the estimate of historical tonnages before 2007 (+/-20%). To account for the slower decomposition rates in northern climate conditions as reported by City staff, and based on literature review, the CH_4 generation rate constant (k) in the model was reduced by a conservative 25%. This constant determines the speed at which organic waste breaks down and releases CH_4, influenced by factors such as waste composition, moisture levels, temperature, and landfill management practices.

[9] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

3.2 2023 Corporate GHG Emissions Inventory

A breakdown of the City's 2023 Corporate energy use and GHG emissions by Corporate inventory sector is provided in **Table 3**.

Table 3: City of Yellowknife 2023 Corporate Energy and GHG Emissions by Sector

Sector	2023 Energy Use (GJ)	% Energy Contribution	2023 GHG Emissions (tCO_2e)	% GHG Contribution
City Owned Buildings	46,839	47%	2,295	9%
Streetlighting and Traffic Signals	2,852	3%	151	0.6%
Temporary Electricity	335	0.3%	18	0.1%
Corporate Fleet and Public Transit	15,655	16%	1,084	4%
Water and Wastewater	34,118	34%	3,522	13%
Solid Waste	--	--	19,402	73%
Total	**99,800**	**100%**	**26,472**	**100%**

The City's total 2023 Corporate GHG emissions are estimated to be 26,472 tCO_2e. As is evident from **Figure 2** below, GHG emissions from Water and Wastewater facilities and Solid Waste dominate the 2023 emissions profile, representing approximately 13% and 73% of total 2023 Corporate GHG emissions respectively. The two most significant energy consuming Corporate sectors include City owned buildings and water and wastewater facilities, which represent 47% and 34% of total Corporate 2023 energy consumption respectively.

Energy Use (GJ) **GHG Emissions (tCO_2e)**

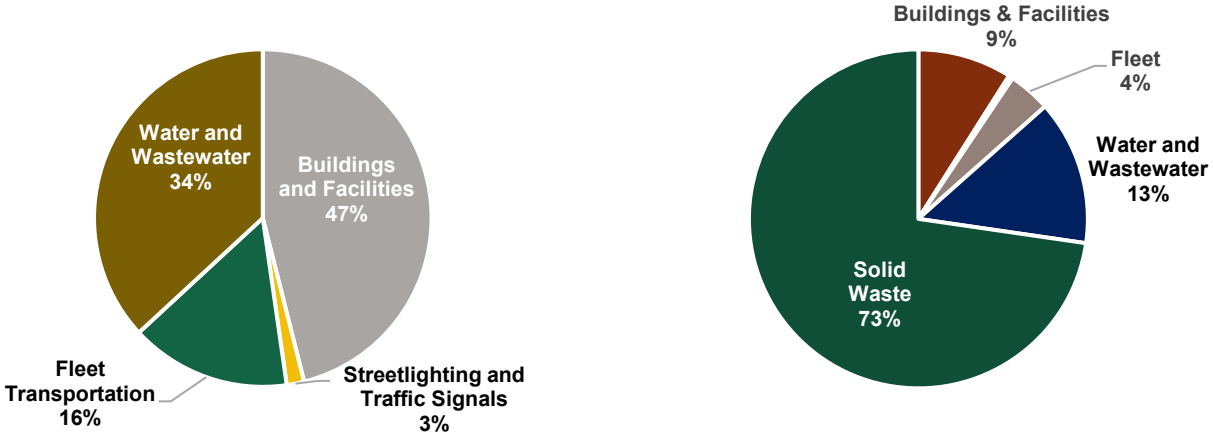

Figure 2: Breakdown of 2023 Corporate Energy Use (Left) and GHG Emissions (Right) by Sector[10]

Table 4 provides a breakdown of the City's 2023 Corporate energy and GHG emissions by source. As is evident from **Table 4**, electricity and heating oil represent the largest contributors to total 2023 Corporate energy use and GHG emissions by energy source, with both each representing 8% of total 2023 Corporate GHG emissions respectively. Outside of energy consumption, the City's fugitive emissions are highly material with landfill fugitive emissions and wastewater fugitive emissions representing approximately 73% and 6% of total 2023 Corporate GHG emissions respectively.

Table 4: City of Yellowknife 2023 Corporate Energy and GHG Emissions by Source

Source	2023 Energy Use (GJ)	% Energy Contribution	2023 GHG Emissions (tCO_2e)	% GHG Contribution
Biomass	16,262	16%	161	0.6%
Composting	--		49	0.2%
Diesel	10,762	11%	761	3%
Electricity	40,651	41%	2,145	8%
Gasoline	4,185	4%	280	1%
Heating Oil	27,229	27%	2,048	8%
Propane	711	0.7%	43	0.2%
Landfill Fugitives	--		19,353	73%

[10] Sources that represent 1% or less of Corporate energy use and GHG emissions are excluded from Figure 2. This includes temporary electricity for energy use and temporary electricity and streetlighting and traffic signals for GHG emissions.

Source	2023 Energy Use (GJ)	% Energy Contribution	2023 GHG Emissions (tCO_2e)	% GHG Contribution
Wastewater Fugitives	--	16%	1,631	6%
Total	**99,800**	**100%**	**26,472**	**100%**

3.3 Corporate GHG Emissions Trends

The City of Yellowknife Corporate GHG emissions trend from the years 2021 to 2023 is illustrated in **Figure 3**. Total Corporate GHG emissions are quantified to have increased from 25,720 tCO_2e to 26,610 tCO_2e (approximately 3%) from 2021 to 2022. The City's total Corporate GHG emission estimates between 2022 and 2023 are relatively constant with a difference of 139 tCO_2e or approximately 0.5%. The difference between 2021 and both 2022 and 2023 is likely attributable to increased operations following shutdowns associated with the COVID-19 pandemic.

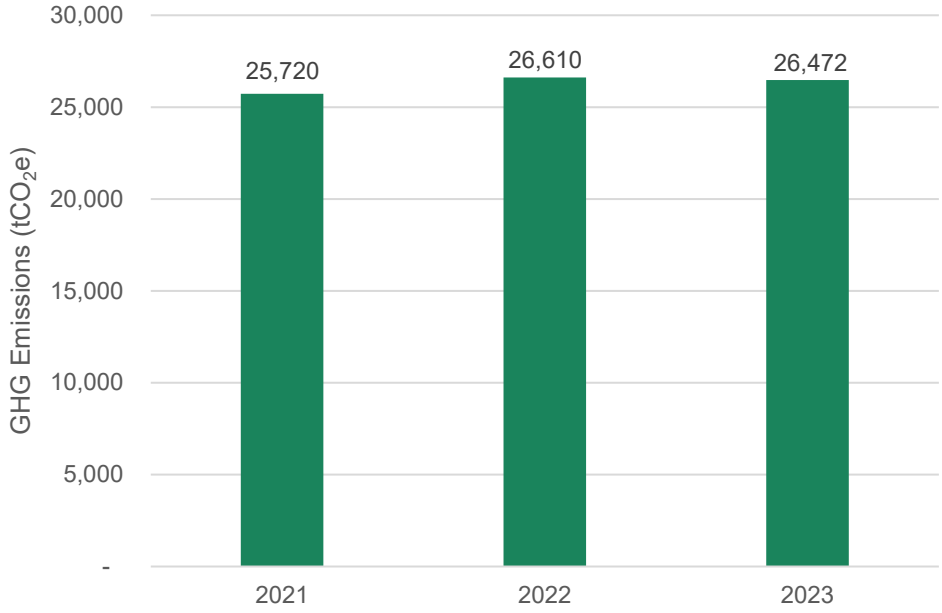

Figure 3: City of Yellowknife Corporate GHG Emissions Trend 2021 – 2023

Based on total estimated 2023 Corporate GHG emissions, the City's total Corporate GHG emissions as of 2023 represent a decline of 7% as compared to the City's 2009 base year emissions levels. For like-for-like comparison to 2009 base year emissions, the updated solid waste fugitive GHG emissions calculation methodology using the Scholl Canyon method was applied to 2009 base year emissions

3.4 Corporate GHG BAU Forecast

Figure 4 shows the City's estimated Corporate GHG emissions forecast to 2050 by energy source. For Corporate operations, consumption and GHG intensity of fuels is assumed to be relatively stable under the BAU scenario. Emissions associated with Corporate electricity use are expected to drop significantly with electricity grid decarbonization as per the Environment and Climate Change Canada (ECCC) electricity grid GHG intensity projections.

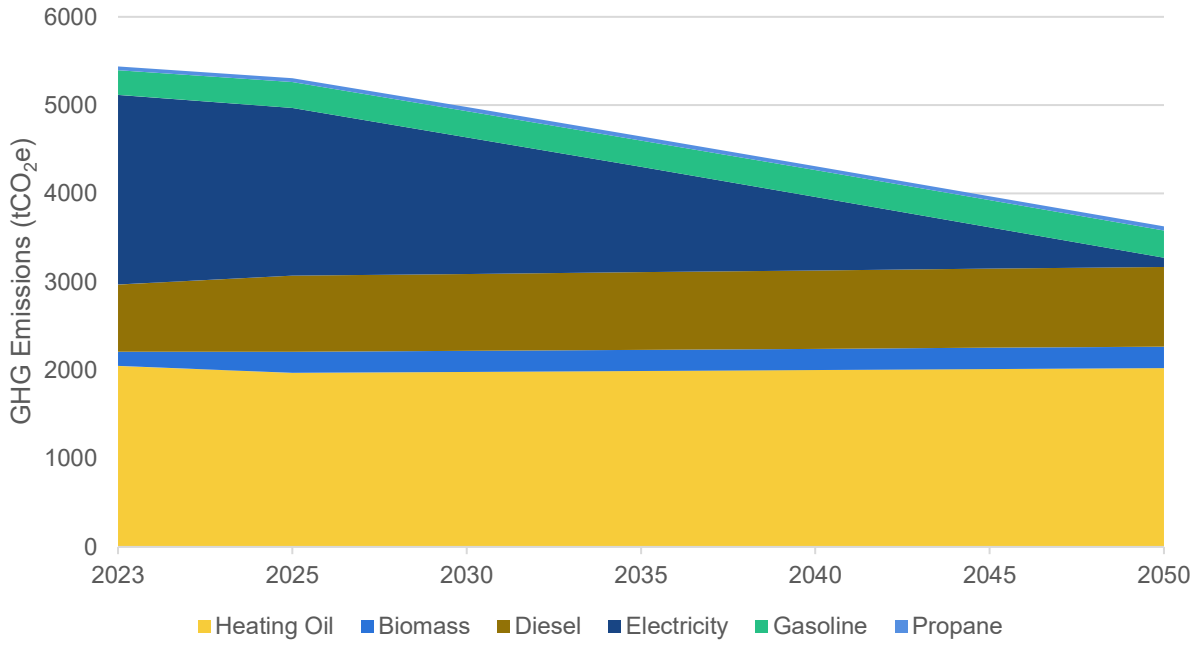

Figure 4: Business-As-Usual City of Yellowknife Corporate GHG Emissions by Source

A Corporate GHG emissions forecast by sector is provided in **Figure *5***. GHG emissions from most of the City's sectors are expected to stay relatively constant with increases in energy consumption with population growth countered by the projected reduction in the Northwest Territories (NWT)'s electricity grid GHG intensity. As is evident from **Figure 5,** the most significant contributor to Corporate emissions is Solid Waste. Fugitive methane emissions from the Yellowknife Solid Waste landfill are expected to contribute 80% of total Corporate emissions by 2050 under the BAU scenario, up 7% from its estimated 73% contribution to the City's total 2023 Corporate emissions.

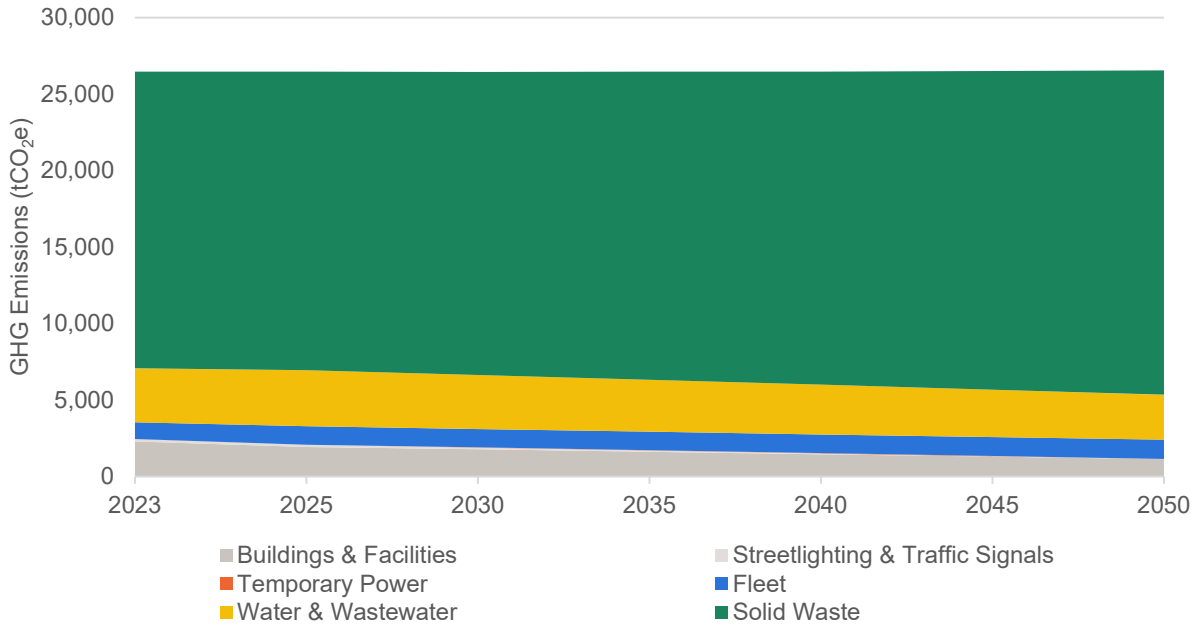

Figure 5: Business-As-Usual City of Yellowknife Corporate GHG Emissions by Sector

The Corporate BAU forecast assumes that under the BAU scenario Corporate operations and associated energy consumption and GHG emissions are relatively stable, with the exception of City owned fleet and public transit transportation, water and wastewater operations and solid waste management, where the City's projected population growth is expected to drive proportional increases in energy usage. It is assumed that reduced GHG intensity of the Northwest Territories electricity grid according to ECCC projections from the ECCC data catalogue[11], will drive GHG emission reductions associated with purchased electricity. A summary of the assumptions used to generate the Corporate BAU GHG emissions forecast is provided in **Table 5**.

Table 5: Corporate Business-As-Usual (BAU) Forecast Assumptions

Sector	Projection Assumptions
City Owned Buildings and Facilities	• Stationary energy use in city-owned buildings is assumed to remain constant.
Streetlighting, Traffic Signals and Temporary Power	• Stationary electricity use for streetlighting and traffic signals and temporary electricity uses is assumed to remain constant.
City Corporate Fleet and Public Transit	• An increase in demand for fleet vehicle and public transit services with a growing population is expected

[11] ECCC Data Catalogue

Sector	Projection Assumptions
	• Increased fuel demand is assumed to trend linearly with the Yellowknife population projections from the NWT Bureau of Statistics.[12]
Water and Wastewater Facilities	• An increase in water delivery and wastewater treatment services is expected to meet the capacity needs of a growing population. • Increased energy demand for water and wastewater services and increased fugitive emissions from wastewater treatment and discharge is assumed to trend linearly with the Yellowknife population projections from the NWT Bureau of Statistics.
Solid Waste Facilities	• Total annual municipal solid waste generation and disposal tonnages are expected to increase with a growing population. • Increased landfill fugitive emissions and composting emissions are assumed to trend linearly with the Yellowknife population projections from the NWT Bureau of Statistics.

[12] NWT Bureau of Statistics Population Projections (2023 – 2043)

4 Community Energy and GHG Emissions Inventory

4.1 Community GHG Inventory Boundary & Methodology

The sectors and associated energy use and GHG emission sources captured within the City's overall Community GHG inventory are provided in **Table *6***. GHG emissions sources from emissions generating activities occurring within the geographic boundary of the City are captured, including energy use and GHG emissions from Corporate owned assets captured within the Corporate inventory. Using the Community boundary summarized in **Table *6***, Stantec quantified the City's 2021, 2022 and 2023 Community GHG inventory and used the energy use and GHG results to generate BAU GHG emission projections for years 2024 through 2050.

Table 6: Community GHG Quantification Boundary

Sector	GHG Emissions Source	Boundary Details
City Owned Buildings	Diesel, Heating Oil, Biomass and Electricity	From Corporate Inventory
Streetlighting, Traffic Signals and Temporary Electricity	Electricity	From Corporate Inventory
City Corporate Fleet and Public Transit	Diesel, Gasoline, Propane	From Corporate Inventory
Water and Wastewater Facilities	Diesel, Heating Oil, Biomass, Electricity Wastewater Fugitives	From Corporate Inventory
Solid Waste Facilities	Landfill Fugitives	From Corporate Inventory
Residential Buildings	Heating Oil, Biomass, Propane, Electricity	Community Specific Scope
Industrial, Commercial and Institutional (ICI) Buildings	Heating oil, Biomass, Propane, Electricity	Community Specific Scope
Community Transportation	Aviation Gasoline, Jet Fuel, Diesel, Motor Gasoline, Propane Electricity	Community Specific Scope

A summary of the main quantification methodologies used to generate the 2021, 2022 and 2023 energy use and GHG emissions for sectors falling within the City's Community GHG inventory boundary is provided below. In alignment with the Corporate inventory quantification, emission factors from Canada's 2024 NIR[13] were used to translate activity data into resultant GHG emissions..

[13] National Inventory Report: Greenhouse Gas Sources and Sinks in Canada

4.1.1 GHG Emissions from City Owned Assets

2021, 2022 and 2023 GHG emissions from all City Owned Assets are included in the City's Community GHG inventory boundary. These emissions are equivalent to the emissions quantified for the City's Corporate inventory and include all GHG emissions from City owned buildings, streetlighting, traffic signals and temporary electricity usage, City owned fleet vehicles and public transit vehicles, water and wastewater facilities and solid waste facilities. Including the Corporate emissions sources into the Community inventory does not result in double counting as the Corporate and Community inventories represent two distinct inventories at two different reporting scales. This is similar to how Yellowknife's Community GHG inventory would be incorporated into the NWT's GHG inventory, despite being reported separately by the City of Yellowknife. For a summary of the methodologies used to quantify these emissions see Section 3.1.

4.1.2 GHG Emissions from Residential and ICI Buildings

Fuel consumption in residential and Industrial, Commercial and Institutional (ICI) buildings are estimated using GIS residential and commercial floor area data tracked by the City and energy use intensity per unit floor area data by building type and fuel type from Natural Resource Canada's Comprehensive Energy Use Database 2021[14].

Electricity emissions from residential and ICI buildings are estimated using electricity consumption data provided directly by Northland Utilities. Consumption data is converted into expected GHG emissions using Northwest Territories consumption-based electricity emission factors from Canada's 2024 NIR.

4.1.3 GHG Emissions from Community Transportation

Emissions from air travel are estimated using Statistics Canada 2024 Aircraft Movements data for Yellowknife Airport, Inuvik Airport, and Norman Wells Airport[15], and aviation gasoline and jet fuel consumption data from Government of Northwest Territories (GNWT) annual carbon tax reports[16]. The percentage of total Northwest Territories (NWT) flight counts representing counts from Yellowknife Airport was used to estimate the percentage of NWT aviation gasoline and jet fuel consumption attributable to Yellowknife Airport, assuming flight counts trend proportionally with fuel consumption. Calculated total fuel consumption was then multiplied by aviation fuel emission factors from Canada's 2024 NIR to generate GHG emissions values from air travel.

Emissions from on-road and off-road vehicle travel are estimated using vehicle registration by vehicle and fuel type data and the estimated total vehicle kilometers travelled within Yellowknife provided by the GNWT. The total vehicle kilometers travelled within Yellowknife is attributed to vehicle and fuel types

[14] Natural Resources Canada (NRCAN) Comprehensive Energy Use Database

[15] Statistics Canada Aircraft Movement and Civil Aviation Statistics (March 2024)

[16] Government of Northwest Territories Annual Carbon Tax Reports

based on the ratio of vehicle registrations by vehicle type to total NWT vehicle registrations, assuming total vehicle kilometers travelled trends proportionally to vehicle registrations. The average fuel consumption associated with each vehicle and fuel type pairing sourced from the publicly available Community Energy and Emissions Inventory (CEEI) data from the Government of British Columbia[17] is then used to convert estimated vehicle kilometers travelled to fuel and/or electricity consumption. The GHG inventory was updated to include emissions from battery-electric and hybrid-electric vehicles, in addition to diesel, gasoline and propane vehicles. To generate total GHG emissions, calculated total fuel consumption by fuel type was then multiplied by mobile combustion emission factors from Canada's 2024 NIR.

4.2 2023 Community GHG Emissions Inventory

A breakdown of the City's 2023 Community energy use and GHG emissions by inventory sector is provided in Table 7.

Table 7: City of Yellowknife 2023 Community GHG Emissions by Sector

Sector	2023 Energy Use (GJ)	% Contribution Energy	2023 GHG Emissions (tCO_2e)	% Contribution GHG
Buildings and Facilities	46,839	1%	2,295	1%
Streetlighting and Traffic Signals	2,852	0.1%	151	0.1%
Temporary Power	335	0.01%	18	0.01%
Fleet Transportation	15,655	0.4%	1,084	0.4%
Water and Wastewater	34,118	1%	3,522	1%
Solid Waste			19,402	7%
Residential Buildings	303,639	8%	16,396	6%
Industrial, Commercial and Institutional Buildings	986,433	27%	64,026	24%
On-Road Transportation	765,338	21%	53,965	20%
Off-Road Transportation	1,493,379	41%	108,195	40%
Total	**3,648,588**	**100%**	**269,053**	**100%**

The City's total 2023 Community GHG emissions are estimated to be 269,053 tCO_2e. As is illustrated in **Figure 6**, GHG emissions from off-road transportation, on-road transportation and ICI buildings represent

[17] BC Community Energy and Emissions Inventory Data (2007 – 2022)

the major contributing sectors to the City's 2023 Community energy and GHG emissions inventory, representing 40%, 20% and 24% of total 2023 Community GHG emission estimates respectively. Together these sources represent approximately 84% of the City's 2023 Community GHG emissions estimates and approximately 89% of the City's 2023 Community energy use. 2023 Community GHG emissions estimates indicate that emissions from the City's Corporate owned assets represent approximately 10% of total Community GHG emissions.

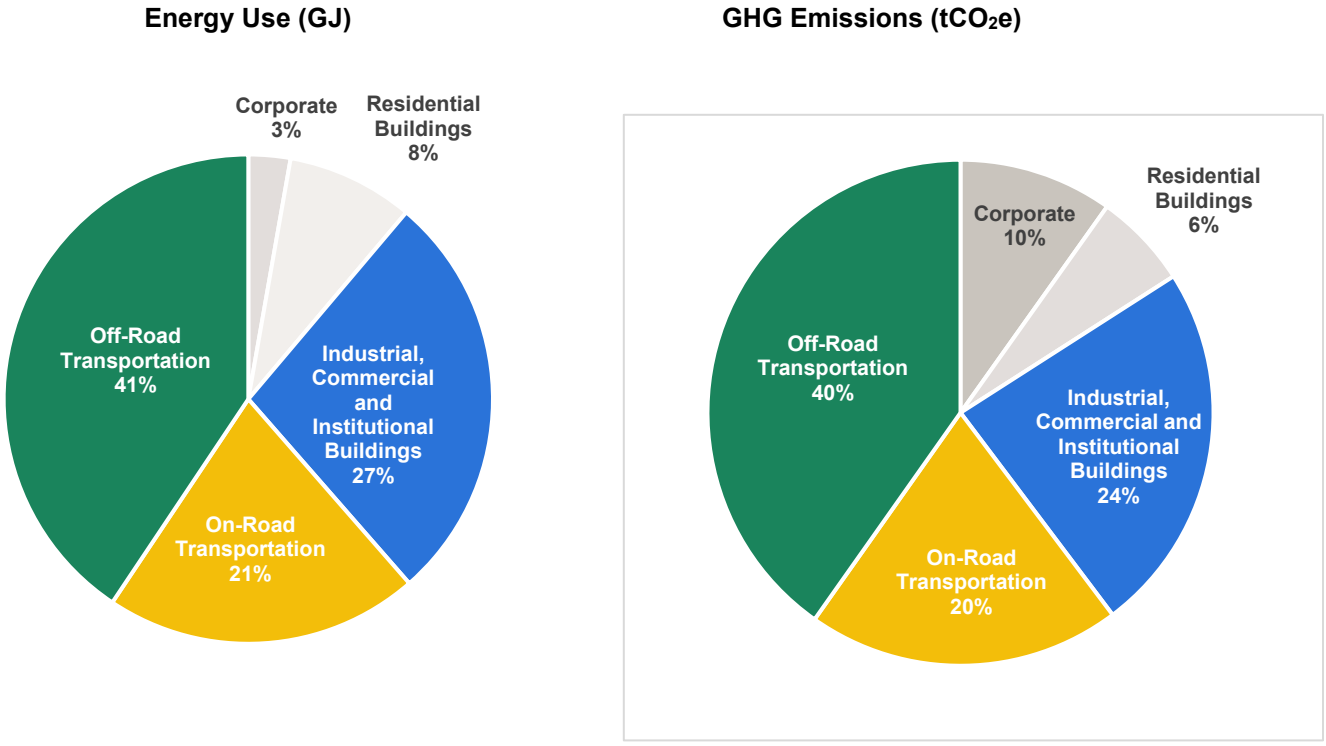

Figure 6: Breakdown of 2023 Corporate Energy Use (Left) and GHG Emissions (Right) by Sector[18]

4.3 Community GHG Emissions Trends

The City of Yellowknife Community GHG emissions trend from the years 2021 to 2023 is illustrated in **Figure 7.** Total Community GHG emissions are quantified to have increased from 231,814 tCO_2e to 254,711 tCO_2e (approximately 10%) from 2021 to 2022. The City's total Community GHG emission estimates increase again between 2022 and 2023 from 254,711 tCO_2e to 269,053 tCO_2e (approximately 6%). The increase in total Community emissions estimates between 2021 and 2023 is likely attributable

[18] Corporate energy use and GHG emissions in Figure 6 includes all sectors captured within the Corporate energy and GHG inventory boundary. This includes Buildings and Facilities, Streetlighting and Traffic Signals, Temporary Power, Fleet Transportation, Water and Wastewater and Solid Waste.

to increased operations following shutdowns associated with the COVID-19 pandemic.

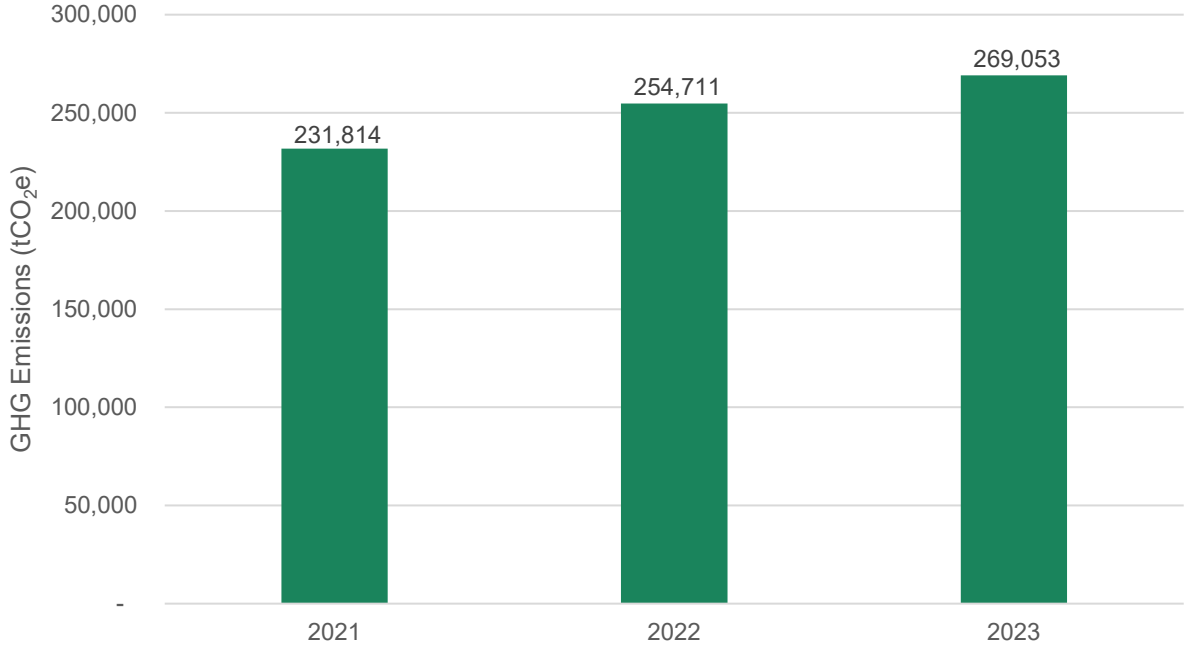

Figure 7: City of Yellowknife Community GHG Emissions Trend 2021 – 2023

Based on total estimated 2023 Community GHG emissions, the City's total Community GHG emissions as of 2023 have decreased approximately 20% as compared to the City's 2009 base year GHG emissions levels. As is evident from **Table 8**, the decrease in Community GHG emissions relative to the City's baseline year is driven largely by decreases in GHG emissions from transportation and residential buildings. The decrease in transportation emissions is largely a result of decreases in off-road air travel GHG emissions driven by decreased flight counts from the Yellowknife Airport in 2023 relative to the 2009 baseline year. For residential buildings the decrease in emissions from 2009 baseline year levels to 2023 results from fuel switching from heating oil to electricity for building heating as evident by the NRC Comprehensive Energy Use Database (2021).

Opposite to the overall Community trend, 2023 GHG emissions from ICI buildings are estimated to have increased by approximately 40% of 2009 baseline levels. The increase is a result of a 55% increase in ICI building floor area (according to updated City of Yellowknife building GIS data), driving up total energy consumption from ICI Buildings.

Table 8: City of Yellowknife Community 2023 GHG Emissions vs. Baseline (2009) GHG Emissions

Sector	Updated Baseline (2009) GHG Emissions (tCO_2e)	2023 GHG Emissions (tCO_2e)	% Change
Buildings and Facilities	2,055	2,295	12%
Streetlighting and Traffic Signals	527	151	-71%
Temporary Power	--	18	--
Fleet Transportation	860	1,084	26%
Water and Wastewater	2,745	3,522	28%
Solid Waste	14,842	19,402	31%
Residential	43,620	16,396	-62%
Industrial, Commercial and Institutional	45,576	64,026	40%
Transportation (On-Road and Off-Road)	226,645	162,160	-28%
Total	**336,870**	**269,053**	**-20%**

4.4 Community GHG BAU Forecast

Figure 8 shows the City's Community GHG emissions forecast to 2050 by energy source. The City's Community GHG forecast assumes increases in energy demand and emissions trend proportionally with population growth, while GHG reductions result from natural aging out of fossil fuel powered building heating systems and mobile vehicles, reduced GHG intensity of the Northwest Territories electricity grid and regulatory driven increases in vehicle efficiencies and battery-electric vehicle purchases

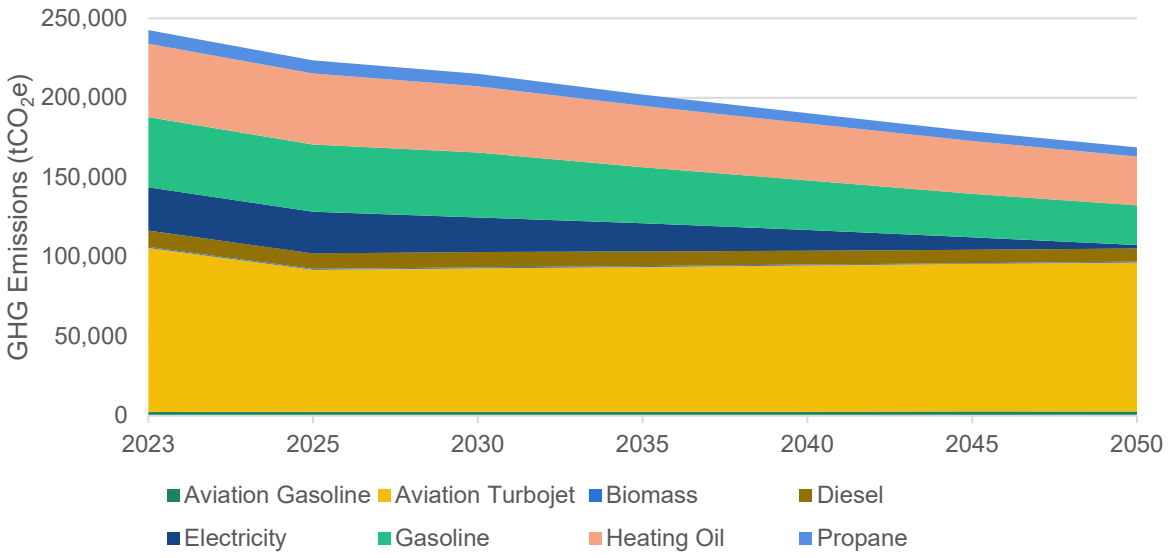

Figure 8: Business-As-Usual Community GHG Emissions by Energy Source.

The estimated Community GHG emissions outlook to 2050 by sector is shown in **Figure 9**. In the year 2050, under the BAU scenario, it is estimated that total Community GHG emissions will be around 195,302 tCO_2e, representing a reduction of approximately 27% from the estimated 2023 GHG emissions of 269,053 tCO_2e. Major contributing sources to the City's 2023 Community GHG emissions include gasoline from passenger vehicles, heating oil for ICI buildings and turbojet fuel for community air travel. Under the Community BAU scenario gasoline emissions from on-road passenger vehicles are expected to decrease by approximately 56% from 2023 to 2050, with regulations driving increases in vehicle fuel efficiency and passenger vehicle fleet conversion to battery electric vehicles over fossil fuel vehicles. Heating oil emissions from residential and ICI buildings are expected to decrease 34% from 2023 to 2050 under the BAU scenario, as heating oil systems age out and are replaced by lower carbon alternatives (e.g., electrification, biomass). No decreases in GHG emissions from jet fuel combustion for community air travel are expected under the current Community BAU scenario.

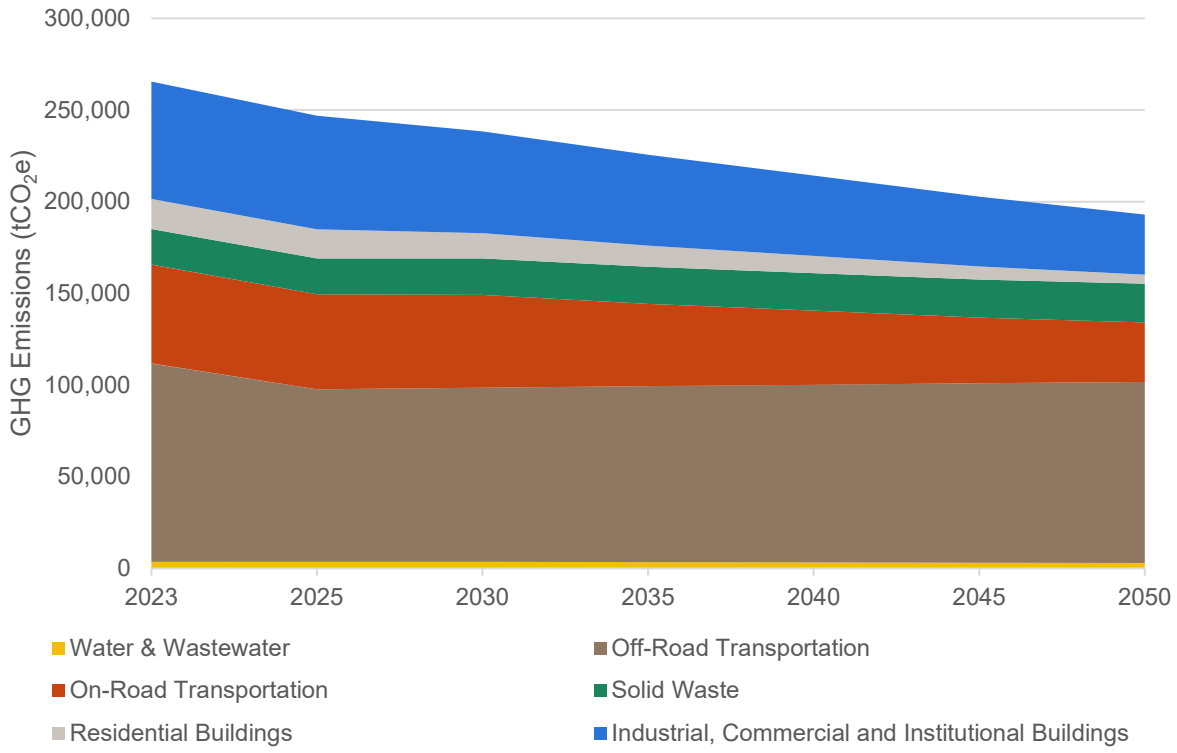

Figure 9: Business-As-Usual Total Community GHG Emissions by Sector[19]

The GHG emissions projected to remain in the year 2050 under the BAU scenario indicate the importance of implementing GHG reduction measures that extend beyond the current BAU scenario. To achieve significant near-term GHG emission reductions, decarbonization initiatives for sectors and sources contributing the most to total GHG emissions should be prioritized. In the case of the City's total estimated Community GHG emissions, recommended sources of focus include jet fuel consumption from Yellowknife Airport air travel, gasoline and diesel consumption for on-road vehicle travel, heating oil and propane use for City owned, residential and ICI buildings and landfill fugitive emissions from the Solid Waste facility.

A summary of the assumptions used to generate the Corporate BAU GHG emissions forecast is provided in **Table 9**.

[19] Sectors that contribute less than 1% of total Community GHG emissions are excluded from Figure 9. This includes GHG emissions from the following Corporate owned assets: City owned buildings, streetlighting and traffic signals, temporary electricity and fleet transportation.

Table 9: Community Business-As-Usual (BAU) Forecast Assumptions

Sector	Projection Assumptions
City Owned Buildings	• Stationary energy use in city-owned buildings is assumed to remain constant.
Streetlighting, Traffic Signals and Temporary Power	• Stationary electricity use for streetlighting and traffic signals and temporary electricity uses is assumed to remain constant.
City Corporate Fleet and Public Transit	• An increase in demand for fleet vehicle and public transit services with a growing population is expected • Increased fuel demand is assumed to trend linearly with the Yellowknife population projections from the NWT Bureau of Statistics.[20]
Water and Wastewater Facilities	• An increase in water delivery and wastewater treatment services is expected to meet the capacity needs of a growing population. • Increased energy demand for water and wastewater services and increased fugitive emissions from wastewater treatment and discharge is assumed to trend linearly with the Yellowknife population projections from the NWT Bureau of Statistics.
Solid Waste Facilities	• Total annual municipal solid waste generation and disposal tonnages are expected to increase with a growing population. • Increased landfill fugitive emissions and composting emissions are assumed to trend linearly with the Yellowknife population projections from the NWT Bureau of Statistics.
Residential Buildings	• The total gross floor area of residential buildings is expected to increase with population growth and increase total energy consumed by residential buildings within the City. • The per capita residential floor area was used to scale the total residential floor area with population growth, assuming a linear trend with the Yellowknife population projections from the NWT Bureau of Statistics. • Using the average EUI estimated for residential buildings for electricity and biomass heating, the assumed increase in residential floor area with population was used to estimate projected energy use. The higher carbon intensive energy sources of heating oil and propane are assumed to not increase with population growth due to phase out for lower carbon alternatives. • The GHG intensive stationary energy sources used by residential building systems within the City (i.e., heating oil, propane) are assumed to naturally decline in use as the systems age out and are replaced by lower GHG intensive biomass heating. • The natural phasing out of heating oil and propane heating with biomass alternatives is assumed to occur at a rate of 2.5% per year, with a reduction of 1 kg of heating oil assumed to result in the added consumption of 2.1 kg biomass and the reduction of 1 kg of propane assumed to result in the added consumption of 1.5 kg biomass.

[20] NWT Bureau of Statistics Population Projections (2023 – 2043)

Sector	Projection Assumptions
Industrial, Commercial and Institutional (ICI) Buildings	• Energy demand from ICI buildings is expected to remain stable with population growth, assuming no significant expansion in operations under the BAU scenario • The GHG intensive stationary energy sources used by ICI building systems within the City (i.e., heating oil, propane) are assumed to naturally decline in use as the systems age out and are replaced by lower GHG intensive biomass heating. • The natural phasing out of heating oil and propane heating with biomass alternatives is assumed to occur at a rate of 2.5% per year, with a reduction of 1 kg of heating oil assumed to result in the added consumption of 2.1 kg biomass and the reduction of 1 kg of propane assumed to result in the added consumption of 1.5 kg biomass.
Community Transportation	• Yellowknife airport flight counts are expected to increase with population growth. It is assumed that flight counts and aviation gasoline and jet fuel consumption increase linearly with population growth projections from the NWT Bureau of Statistics (NWT Bureau of statistics, 2023). • Mobile energy consumption from all on-road and off-road vehicle types (with the exception of government vehicles) is expected to increase linearly with population growth projections from the NWT Bureau of Statistics. Government vehicle energy consumption is assumed stable under the BAU scenario. • Reductions in energy consumption and GHG emissions from commercial vehicles, construction vehicles, off-road vehicles, trailers and motorhomes are assumed to occur as a result of both updated vehicle fuel efficiency standards (a 1.3% increase in vehicle fuel efficiency from 2027 to 2037) and a regulatory driven shift in the new vehicle population from fossil fuel vehicles to battery electric vehicles (starting in 2045 and linearly reaching 100% conversion over a 12-year span). The shift to battery electric vehicles is assumed to occur later than in passenger vehicles. • Reductions in energy consumption and GHG emissions from passenger vehicles (including motorcycles) are assumed to occur as a result of updated vehicle fuel efficiency standards (a 1.3% increase in vehicle fuel efficiency from 2027 to 2037), operational turnover of existing fossil fuel vehicles to battery electric vehicles (1% per year) and a regulatory driven shift in the new vehicle population from fossil fuel vehicles to battery electric vehicles (starting in 2024 and linearly reaching 100% conversion by 2035). • As government vehicle energy consumption is assumed to trend independently from population under the BAU scenario, reductions in fuel consumption and GHG emissions are assumed to result from operational turnover (1% per year starting in 2030) and a regulatory driven shift to battery electric vehicles (starting in 2030 and linearly reaching 100% conversion by 2045). The conversion of school buses to battery electric vehicles is assumed to occur equivalently to government vehicles, however total energy consumption by school buses is expected to trend linearly with population growth, similar to the assumption made for City owned transit vehicles.

5 Conclusions and Next Steps

As of 2023 the City's Community GHG emissions profile is dominated by Community sources not owned and under the direct control of the City of Yellowknife, which make up approximately 90% of total Yellowknife 2023 Community GHG emissions. Under the BAU scenario, this trend is expected to remain up to 2050, with Community transportation emissions from on-road and off-road travel estimated to represent approximately 67% of total 2050 Community GHG emissions under the BAU scenario. Of GHG emissions from Corporate owned assets, emissions from the Solid Waste facility are most significant, estimated to represent 7% of total 2023 Community GHG emissions and 73% of total 2023 Corporate GHG emissions. Although it is anticipated that the NWT's electricity grid will decarbonize and governmental regulations will lower the GHG intensity of community on-road vehicles, BAU projections illustrate that additional GHG reduction initiatives will need to be implemented for the City to completely decarbonize in line with the Canadian and Paris Agreement target of net zero GHG emissions by 2050.

Now that the City has developed a forecast of its expected BAU GHG emissions, the next step required for the City to achieve meaningful GHG emission reductions in line with Canada's GHG reduction targets will be to identify and evaluate relevant GHG mitigation actions. This will include reviewing best practices, policies, projects, programs and technologies being implemented by similar cities and evaluating the GHG reduction potential and technical and economic criteria required for implementation within the City of Yellowknife.