City of Kingston
Information Report to Council
Report Number 24-009

To:	**Mayor and Members of Council**
From:	**Paige Agnew, Commissioner, Growth & Development Services**
Resource Staff:	**Julie Salter-Keane, Manager, Climate Leadership**
Date of Meeting:	**December 5, 2023**
Subject:	**2022 Community Greenhouse Gas Emission Inventory and Update on Community Focused Climate Initiatives**

Council Strategic Plan Alignment:

Theme: 2. Lead Environmental Stewardship and Climate Action

Goal: 2.2 Support climate action and sustainability for residents, businesses and partners.

Executive Summary:

This report provides a summary of the 2022 Community Greenhouse Gas (GHG) Emissions Inventory as well as an update on the progress of the Climate Leadership Division initiatives outlined in the Kingston Strategic Plan, 2023-2026, focused on the broader community.

The Climate Leadership Plan included a commitment to monitor community and corporate GHG emissions on an annual basis. The Plan defined a target to reduce 2018 GHG emissions by 15% by 2022 and report annually on the community GHG reduction progress. In February 2023, staff reported on the 2020 and 2021 Community GHG Emissions Inventory (Report Number 23-041). Pending the City's access to data, reporting for the 2023 Community GHG Emission Inventory is expected in Q3 of 2024.

An inventory of estimated community GHG emissions for 2022 (Exhibit A) has been completed for the City of Kingston by a specialist consulting firm with graphs that illustrate the aggregated sources of emissions, energy consumption and expenditures by sector, and types of energy and fuel. Information on the methods used for reporting and future methodological recommendations are contained in the supplemental information report for 2022 (Exhibit B). The inventory report and supplemental report will be posted on the City's website.

The 2022 Community GHG Inventory includes several notable improvements, including the use of an updated emissions factor for food-related emissions, based on Ontario's food consumption data, as well as enhanced livestock data, including a broader range of livestock than previous years. Comprehensive information on methodologies and improvements can be found in the supplemental report (Exhibit B).

The 2022 Community GHG Inventory shows an annual increase of 42,033 tonnes CO2e (4%) from 2021 to 2022, while community emissions remain 3.5% lower than pre- COVID-19 pandemic levels (2019) and total a reduction of 40,364 tonnes CO2e (3.6%) from the 2018 base year to 2022. These increases must be viewed as relative to the city's return to regular operations following the pandemic, as they were likely significantly impacted by resumed operations of the ICI sectors, as well as altered behaviour patterns of the public, including more people driving in 2022 than in 2021 and the increase in population.

This report also provides a progress update on the Climate Leadership Division Initiatives from the Corporate Strategic Plan. These initiatives target reductions in community emissions.

Recommendation:

This report is for information only.

Authorizing Signatures:

ORIGINAL SIGNED BY COMMISSIONER

**Paige Agnew, Commissioner,
Growth & Development Services**

ORIGINAL SIGNED BY CHIEF ADMINISTRATIVE OFFICER

**Lanie Hurdle, Chief
Administrative Officer**

Consultation with the following Members of the Corporate Management Team:

Jennifer Campbell, Commissioner, Community Services	Not required
Neil Carbone, Commissioner, Corporate Services	☑
David Fell, President & CEO, Utilities Kingston	☑
Peter Huigenbos, Commissioner, Major Projects & Strategic Initiatives	Not required
Brad Joyce, Commissioner, Infrastructure, Transportation and Emergency Services	☑
Desirée Kennedy, Chief Financial Officer & City Treasurer	☑

Options/Discussion:

GHG Reduction Targets

The Climate Leadership Plan includes a commitment to monitor community and corporate GHG emissions on an annual basis. The Plan defined a target to reduce corporate 2018 GHG emissions by 15% by 2022 and report annually on the community GHG progress. The City's corporate emissions represent less than two per cent of Kingston's overall community emissions, highlighting the importance of collaboration with residents, businesses, and industry. Through the Climate Leadership Plan 2021 (Climate Leadership Plan), the City of Kingston aspires to extend its goal of carbon neutrality across the community by 2040.

This report provides updated GHG emissions inventory for the community-wide scope of the City of Kingston for the year 2022. The scope of the report includes residential and ICI energy use, transportation fuel use, wastewater emissions, solid waste, and agriculture and forests. Energy and emissions are measured in the report as total energy consumption (GJ), total GHG emissions (tCO2e) and energy expenditures ($).

2022 Community GHG Emissions Inventory Takeaways

The 2022 Community GHG Inventory Report, completed for the City of Kingston by a specialist consulting firm, includes a number of enhancements being made compared to the 2020 and 2021 Community GHG Inventory Report (Report Number 23-041). These improvements include updated emissions factors for food related emissions, based off Ontario food consumption data, and an expanded range of livestock data, including additional species beyond cattle, further enhancing data accuracy.

The report provides the following key conclusions:

- Overall, community annual GHG emissions increased by 4% from 2021. There were 42,033 more tonnes of CO2e emitted in 2022 than in 2021. However, 2022 emissions remained 3.5% lower than pre-pandemic (2019) levels.
- The largest increase in emissions was from the transportation sector (6.6%), likely a result of more individuals resuming work commutes compared to 2021.
- Emissions from natural gas remained the largest source of GHG emissions among energy sectors (48.6%) followed by emissions from gasoline (41.1%).
- Natural gas and gasoline together account for nearly 90% of all of community emissions in the energy sector.
  - Emissions from natural gas usage climbed nearly 5% from the previous year, paralleled by an 8% rise in Heating Degree Days (HDD) since 2021. Conversely, electricity emissions saw a decrease of about 4% from 2021, while Cooling Degree Days (CDD) also fell by roughly 18%. This mismatch suggests a possible transition towards electricity-based heating and cooling solutions, which tend to be less emission-intensive. However, confirming this as a definitive trend will require observing changes over the forthcoming years.

- Programs that assist homeowners with the expenses of enhancing home energy efficiency and transitioning away from natural gas are critical. Home heating represents over 48% of the community's energy sector emissions, making it a priority in the pursuit of emission reductions. The continuation of Better Home Kingston, in combination with other funding programs currently offered, will provide this essential support.
- While the adoption of electric vehicles (EVs) is paramount for long-term emission cuts, promoting a shift to hybrid vehicles in the near term could yield substantial benefits. Hybrid vehicles can achieve fuel consumption reductions of more than 65% across various models, offering a significant opportunity for impact within the community. Considering gasoline's contribution to over 41% of energy sector emissions, such fuel efficiency improvements could lead to considerable community-level emission reductions.

Staff acknowledge the long-term goal of reducing community reliance on natural gas. Achieving this goal involves enhancing electric grid readiness, though local control over regional grid investments is limited. Presently, natural gas is vital for residential, commercial, and industrial purposes. Transitioning to alternative energy sources like renewable natural gas, solar, wind, and geothermal is currently unfeasible for the broader community and require significant provincial policy and infrastructure changes as there are long term challenges with electrical energy supply. Nevertheless, programs like Better Homes Kingston and the Green Standard Community Improvement Plan continue to support property owners in improving building and home performance. With new government programs focused on fuel-oil switching, and offering increased incentives for home energy-retrofits, there are many opportunities for homeowners to take action and reduce their home energy usage, with both loan and grant funding available from multiple sources.

Table 1: Current Community GHG Emissions (T CO2e) with Actual Estimated Emissions, and Percentage of Annual Emissions Reductions from 2018 Base Year

	2018 Base Year	2019	2020	2021	2022
Actual Estimated Emissions (T CO2e)	1,120,281	1,118,792	1,012,031	1,037,884	1,079,917
Percentage of Annual Emissions Reductions from 2018 Base Year	Base Year	.2%	9.7%	7.3%	3.6%

Annual total GHG emissions at the Community Scale from 2018 to 2022.

Figure 1 below, taken from the Community GHG emissions inventory report, shows the annual emissions trends at the community scale, including all sectors. A significant drop is observed

during 2020, when the COVID-19 Pandemic was at its height, with emissions slowly rising year over year, while remaining lower than the 2018 base in 2022 year by some 40,364 tonnes (CO2e).

The community's ambitious target of reducing emissions by 30% from baseline levels by 2030 necessitates an additional reduction of 607,793 tonnes of CO2. To achieve this, a focus on the two most significant contributors to emissions—natural gas and gasoline, which together account for almost 90% of all energy-related emissions—will be essential.
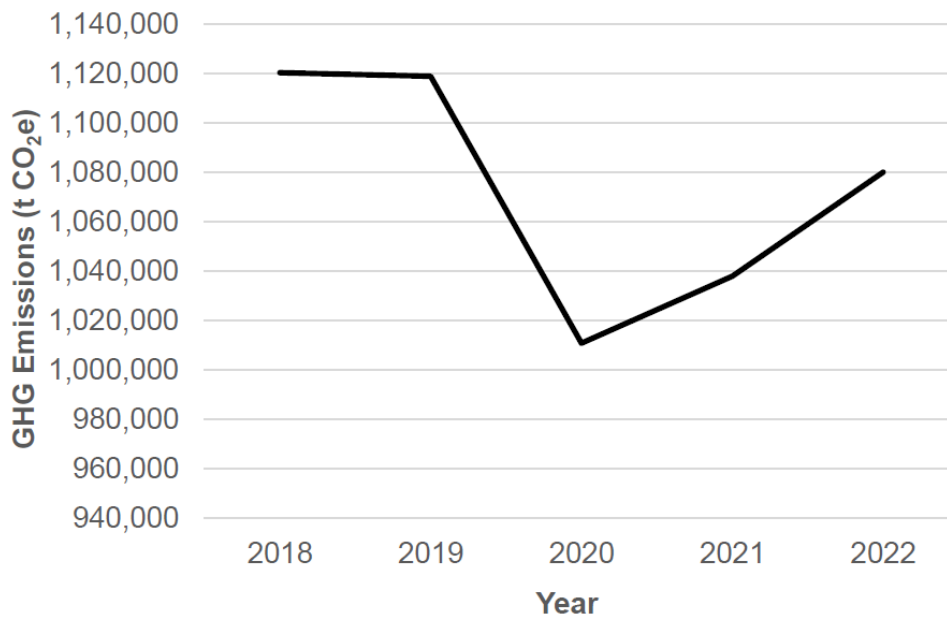

Figure 1. Annual total GHG emissions at the community scale from 2018 to 2022.

Ontario Electrical Grid Impacts

Earlier this year, the IESO reported progress towards the largest energy storage procurement ever in Canada, supporting long-term decarbonization goals, while relying on increased natural gas generation as a transitional energy source, to maintain reliability of peak electricity supply while nuclear refurbishments take place, and storage technologies develop. Given Ontario's escalating electricity demand, driven by the potential for across-the-board electrification and supply-side dynamics, the province faces an important need for substantial new capacity by the early 2030s. This urgency is particularly pronounced east of the Flow East Toward Toronto (FETT) interface, where the Independent Electricity System Operator's (IESO) 2022 Annual Acquisition Report (AAR) identified a looming capacity gap of over 4,100 MW by 2032.

This increase in emissions from electricity generation will be a significant challenge for reaching carbon neutrality across the corporation and community by 2040 and must be considered as the

city and community move forward with the implementation of the climate action objectives in the Climate Leadership Plan (CLP).

Staff continues to collaborate with the Independent Electricity System Operator (IESO) on their Regional Planning to try to inform grid readiness and proper planning. City staff's feedback included the need to consider the electrical demand for Council's priorities on climate leadership regarding the electrification of corporate fleet, the City's investment in public electric vehicle charging stations, new land use intensification policies, the Green Standard Community Improvement Plan for new development, the targeting of new advanced manufacturing development, and the City's overall commitment to reducing GHG emissions within its corporate operations and across the city with community partners.

Methodological Recommendations

The 2022 Community Supplemental Information Report (Exhibit B) provides details on several updates to the 2022 methods used, as well as future methodological recommendations aimed at improving accuracy and consistency from year to year for community GHG inventories.

Related to ICI sectors, it is recommended that efforts are made to work with these sectors to understand fuel sales. This would improve accuracy of emissions associated with gasoline and diesel fuel sales from card lock systems, commonly used in commercial installations.

For food emissions, improvements were made, with the use of an updated emissions factor for food-related emissions, based on Ontario's food consumption data, as well as enhanced livestock data, including a broader range of livestock than previous years.

Community Focused Climate Initiatives

The following table provides a progress update on Climate Leadership Division initiatives from the Corporate Strategic Plan and motions of Council. These initiatives target reductions in community emissions.

Table 2: Climate Leadership Division initiatives from the Corporate Strategic Plan and motions of Council

Initiative	Progress Update	Deliverables
Climate Leadership Plan	Passed by Council on December 21, 2021: The plan creates a roadmap to Carbon Neutrality for the City of Kingston and the community	Nine objectives and 54 actions planned for short-term (1-5 years) and long-term (6-20 years). Individual projects and initiatives stemming from the Climate

Initiative	Progress Update	Deliverables
	by 2040.	Leadership Plan are included below with additional information.
Better Homes Kingston	Launched in April 2022, Better Homes Kingston has provided local improvement charge (LIC) financing and incentives to encourage homeowners to undertake deep-energy retrofits. This program has a waitlist in place and is intaking applicants based on available funding on an ongoing basis, to ensure the maximum number of projects can be completed within the pilot period. At the November and December 2023, Council meetings, 75+ completed projects are being placed on the Council agenda, with individual Special Charge-By-Laws for each project being passed, to recollect the loan financing provided through the program. Of the 117 projects now completed, the average carbon-reduction is greater than 63%, more than double the program goal!	This program is designed to retrofit 25 to 50 percent of Kingston's pre-1991 single-family homes by 2040, achieving an average carbon-reduction impact of 30 percent per home. A Report will be presented to EITP Committee on December 12th, 2023, that will evaluate the potential to extend the Better Homes Kingston program beyond the initial four years, including programmatic changes, financing, and other considerations related to program equity.

Initiative	Progress Update	Deliverables
[Neighbourhood Climate Action Champions](#)	The Neighbourhood Climate Action Champions (NCAC) will inspire, motivate, and encourage other residents to undertake community-focused actions to support the City's Climate Leadership Plan and reach the City's target of carbon neutral by 2040, through the implementation of measurable, funded projects, to be completed within one year. The application period for the second year of the program was open from October 17th to November 16th, 2023. These neighbourhood leaders will be trained on climate science and evidence-based community engagement tools, to then engage with residents on local environmental issues and inspire climate action. The NCAC will be eligible to receive up to $2,000 to support projects that reduce greenhouse gas emissions and advance climate action.	A diverse range of ideas were shared and put into action by the Neighbourhood Climate Action Champions in 2022-2023, ranging from the creation of an edible community garden, to exploring the air-purification and carbon sequestration potential of moss, to information campaigns to raise awareness of ways to enhance residential energy efficiency, and planting pollinator gardens, among other innovative projects. For more information about the [2023 NCAC](#) cohort.
[Green Standard Community Improvement Plan](#)	The Green Standard CIP was approved by Council in Q4 2021. The Green Standard is designed to encourage the construction of new buildings in ways that achieve measurable improvement to energy and water performance	The Climate Leadership Division is undertaking a comprehensive program development initiative, creating a user-friendly guide for proponents, covering both program requirements and compliance pathways, while also

Initiative	Progress Update	Deliverables
	so that community GHG emissions are reduced or mitigated. The program and incentives are available, following budget approval in 2022.	addressing frequently posed questions. An embedded case study will offer practical insights, facilitating a smoother application process for proponents. A new program webpage will be developed with enhanced content, making it user-friendly and enabling proponents to easily navigate the program's intricacies and assess their suitability. A series of training courses are being developed, both for proponents, and various City staff, to enhance and streamline the program process. These courses are also designed to fulfill Council's strategic priority 2.2.1E Deliver an educational program that informs commercial building owners of the costs and benefits of fuel switching, deep carbon retrofits, building commissioning and available incentives and financing options. Training will begin starting in Q1 2024, through Q3 2024.
[Kingston Community Climate Action Fund](#)	The Kingston Community Climate Action Fund (KCCAF) launched in 2020 to support local charities and non-profit organizations, and their initiatives to become part of City-wide solutions to reduce GHG emissions. These organizations apply to	The following project is looking for support in this year's campaign that was launched on December 1, 2023, and will receive public donations until March 31, 2024. **All Our Relations Land Trust:** Installation of ground-mounted solar powered rainwater / well irrigation

Initiative	Progress Update	Deliverables
	participate in the fund, and when approved, fundraise to complete individual community projects. The City provides up to $15,000 annually to match the community donations raised each year.	system for community garden. Through the completion of this solar system installation, the garden will discontinue the use of fossil fuels for irrigation (gas generator currently being used to power a water pump) and will start the transition away from fossil fuel powered maintenance equipment in the future.
Climate Leadership Working Group	The Climate Leadership Working Group brings together 20+ major organizations and institutions to create an opportunity for input and peer-review from community leaders on the Climate Leadership plan actions, ensure ongoing two-way information sharing between the City and external partners, and mobilize all sectors of the community towards the shared goal of a carbon neutral, healthy, equitable, prosperous and resilient Kingston. The group has met on several occasions over the last year. Four issue tables have been created, based on the four primary sectors of the Climate Leadership Plan (Adaptation and Resilience, Buildings & Energy Production, Transportation, and Food & Forestry), which have all held by-monthly meetings in order	The Climate Leadership Working Group mandate extends to 2030. A summary of current progress and direction of each Issue Table is provided below: Buildings & Energy Production: • In final stages of developing a survey to engage with ICI sector, to gather information on current plans and progress of net-zero / mitigation plans, with the ultimate goal of supporting ICI sector to advance emissions reduction objectives. Adaptation and resilience: • Developing an infographic focused on climate change adaptation and resilience education, resources, and suggested actions for organizations, business, and households / individuals. • Contributing directly to initial

Initiative	Progress Update	Deliverables
	to plan and implement individual actions from their relevant sections of the Climate Leadership Plan.

The Climate Leadership Working Group is scheduled to meet on December 12th, 2023, where the issue table leads will present on progress to date, and engage in capacity building workshops, facilitated with the support of ICLEI Canada. | foundation Council Strategic Objective 2.2.1A Develop a Climate Adaptation and Resilience Strategy and implementation Plan.

Transportation:

• Developing an implementation plan for key actions promoting active transportation, and transit adoption across the City.

Food & Forestry:

• Developing a Survey to gather input from local farmers, food producers, distributors, retailers, meal programs to enhance local food production, and resilience. |
| Climate Lens Framework | An information report outlining the Climate Lens Framework Tool was presented to council on September 19th, 2023. The Tool is designed to provide a preliminary, qualitative assessment of whether a municipal decision will affect climate (Mitigation - through the reduction of greenhouse gases) or be affected by climate (Adaptation - through increased exposure to extreme weather impacts). | Phase 1: Q4 2023 – Q3 2024, staff will begin to incorporate the Climate Lens for new projects, programs, or policies with reporting requirements to Council and Committee.

The Tool is currently undergoing testing with several relevant departments, and will be rolled out through Q4 2023, starting with the Climate Leadership Division, to ensure successful launch and implementation. Staff training and resources are also under development, to implemented |

Initiative	Progress Update	Deliverables
		starting in Q1, 2024.

Existing Policy/By-Law:

None

Notice Provisions:

None

Accessibility Considerations:

None

Financial Considerations:

The creation of community GHG emission inventory reports for future years is expected to require approximately $7,000 per reporting year which has been reflected within the capital budget of the Climate Leadership Division.

Contacts:

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Other City of Kingston Staff Consulted:

Soren Christianson, Project Manager, Climate Leadership

Paul MacLatchy, Environment Director, Business, Real Estate & Environment

Ian Semple, Director, Transportation and Transit Services

Karen Santucci, Director, Public Works and Solid Waste Services

Brent Fowler, Director, Corporate Asset Management and Fleet

Hugh McLaren, Energy Analyst, Water/Wastewater, Utilities Kingston

Dan Korneluk, Manager, Energy & Asset Management, Facilities Management & Construction Services

Exhibits Attached:

Exhibit A   City of Kingston Community GHG Inventory Report - 2022

Exhibit B   City of Kingston Community GHG Inventory Report - 2022 – Supplemental Information

City of Kingston Community GHG Inventory Report – 2022

November 2, 2023

Prepared By:

Greenscale Inc.

Nathan C. Manion

Prepared For:

City of Kingston

Julie Salter-Keane, Manger, Climate Leadership

Executive Summary

This report presents the greenhouse gas (GHG) emissions inventory for the City of Kingston for the year 2022. The inventory covers various sectors, including residential and industrial, commercial, and institutional (ICI) energy consumption, transportation fuel usage, wastewater emissions, solid waste management, and the influence of agriculture and forests. The report quantifies emissions through key metrics: total energy consumption (measured in GJ), total GHG emissions (reported in tCO2e), and energy-related expenditures (expressed in $).
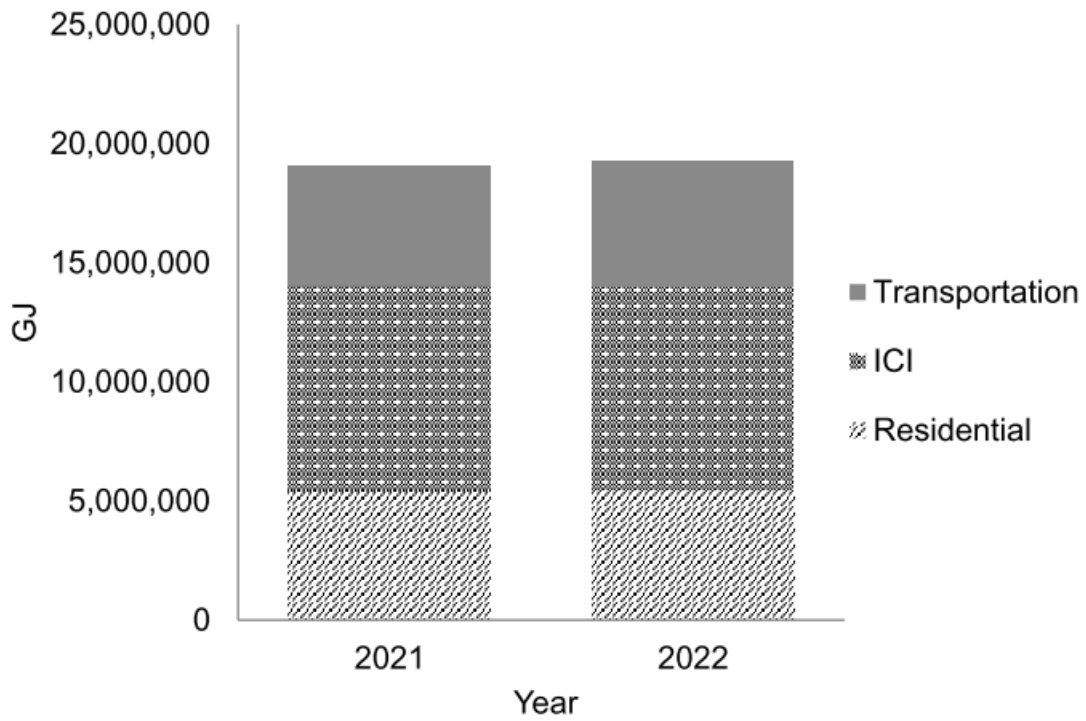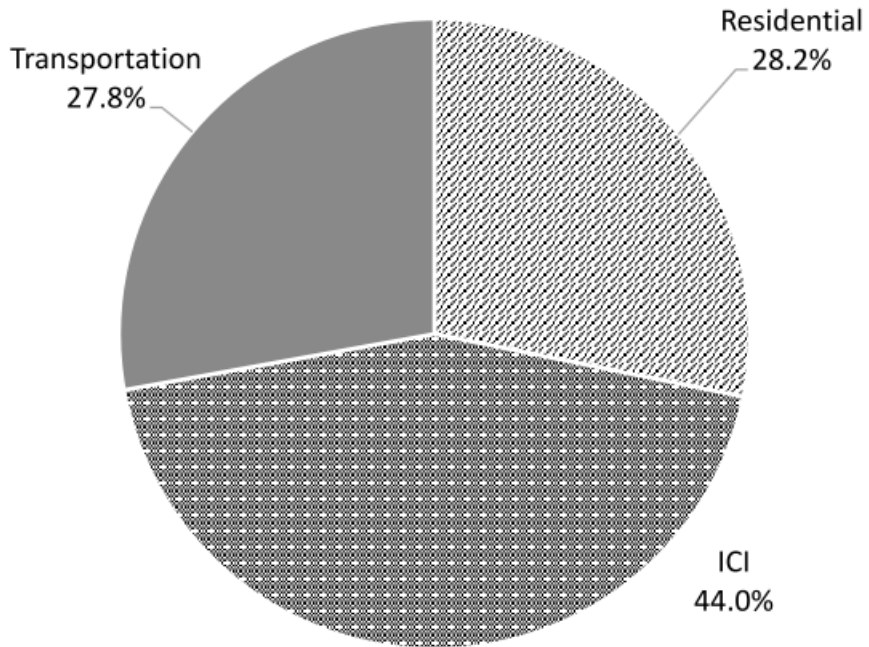
Emission calculations rely on data obtained from the City of Kingston, Utilities Kingston, Hydro One, Enbridge, and Kalibrate Technologies Ltd., and Statistics Canada. Emission factors used recently updated references from the National Inventory Report 1990-2021 (ECCC 2023). Energy conversion metrics referenced Canada Energy Regulator (2022), while electricity emission factors for 2022 are forecasted using information from the Independent Electricity System Operator (IESO, 2022).

This year's report includes notable improvements, including an updated emission factor for food-related emissions based on Ontario food consumption data (Veeramani et al, 2017), enhancing the precision of our data. Additionally, our livestock data for 2022 now encompasses a broader range of livestock, extending beyond cattle, further enhancing data accuracy. For a comprehensive understanding of our methodologies, data sources, and employed emission factors, please consult the accompanying Supplemental Information Report. This resource ensures transparency and reflects our commitment to maintaining high standards of accuracy and accountability in our annual GHG inventory.
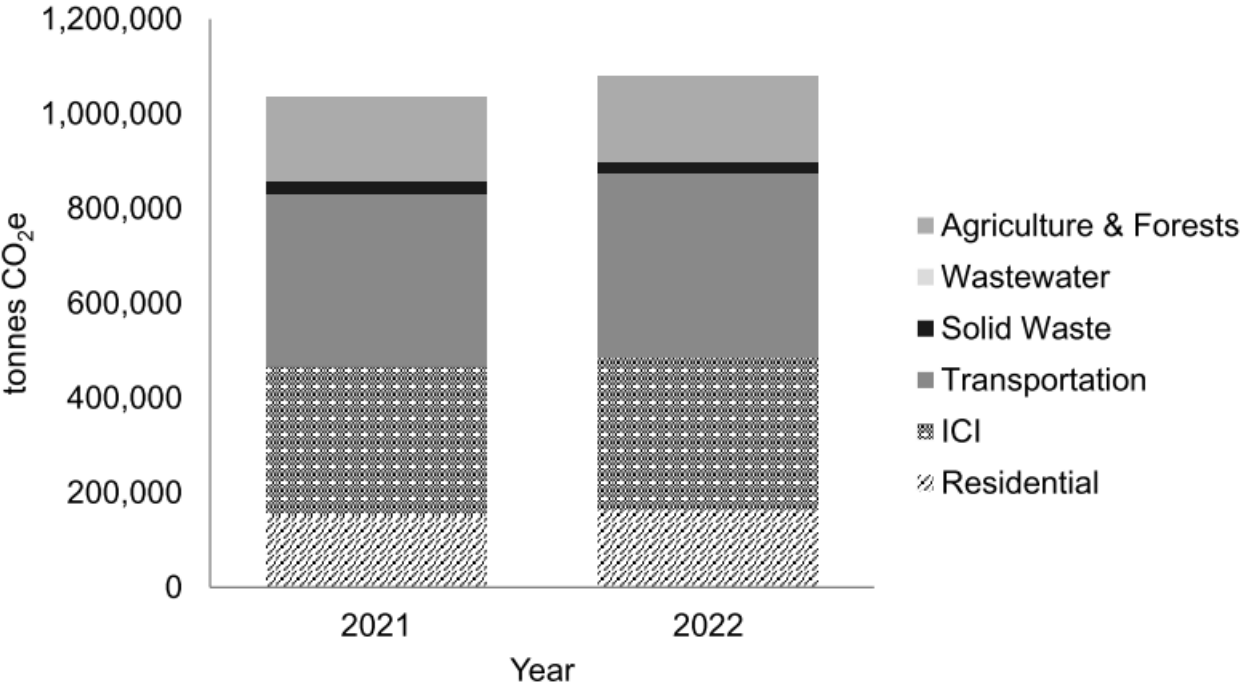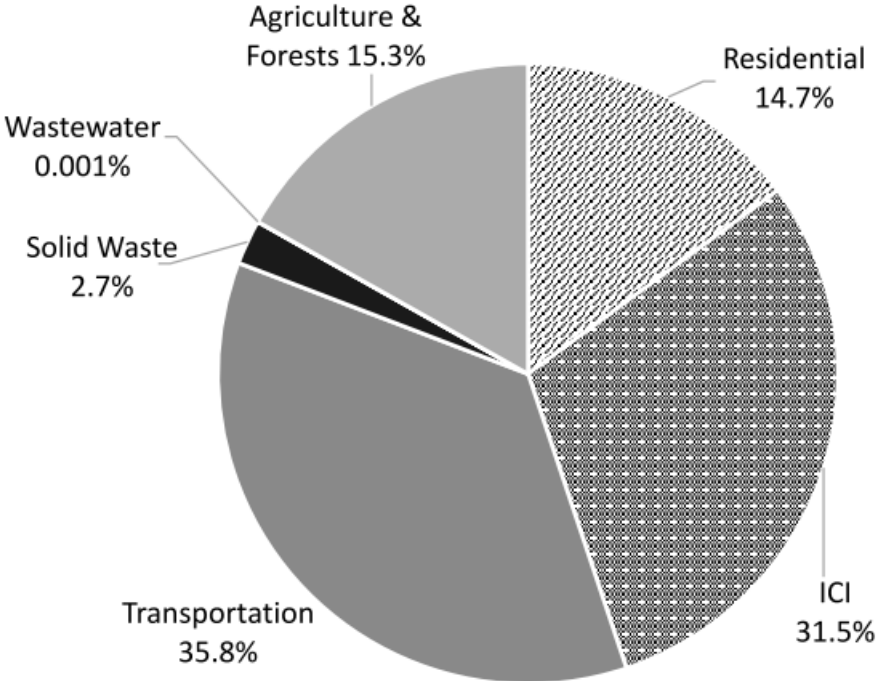

Summary of Results

1. Overall, community annual GHG emissions increased by 4% from 2021. There were 42,033 more tonnes of CO_2e emitted in 2022 than in 2021, however 2022 emissions remained 3.5% lower than pre-pandemic (2019) levels.

2. The largest increase in emissions was from the transportation sector (6.6%), likely a result of more individuals resuming work commutes compared to 2021.

3. Emissions from natural gas remained the largest source of GHG emissions among energy sectors (48.6%) followed by emissions from gasoline (41.1%). Natural gas and gasoline together account for nearly 90% of all of community emissions in the energy sector.

2022 Energy Consumption by sector (total: 19,316,600 GJ) and historical trend

2022 GHG Emissions by sector (total: 1,079,917 tonnes CO_2e) and historical trend

Agriculture & Forests 15.3%

Wastewater 0.001%

Solid Waste 2.7%

Residential 14.7%

ICI 31.5%

Transportation 35.8%

Legend:
- Agriculture & Forests
- Wastewater
- Solid Waste
- Transportation
- ICI
- Residential

Y-axis: tonnes CO_2e (0 to 1,200,000)
X-axis: Year (2021, 2022)

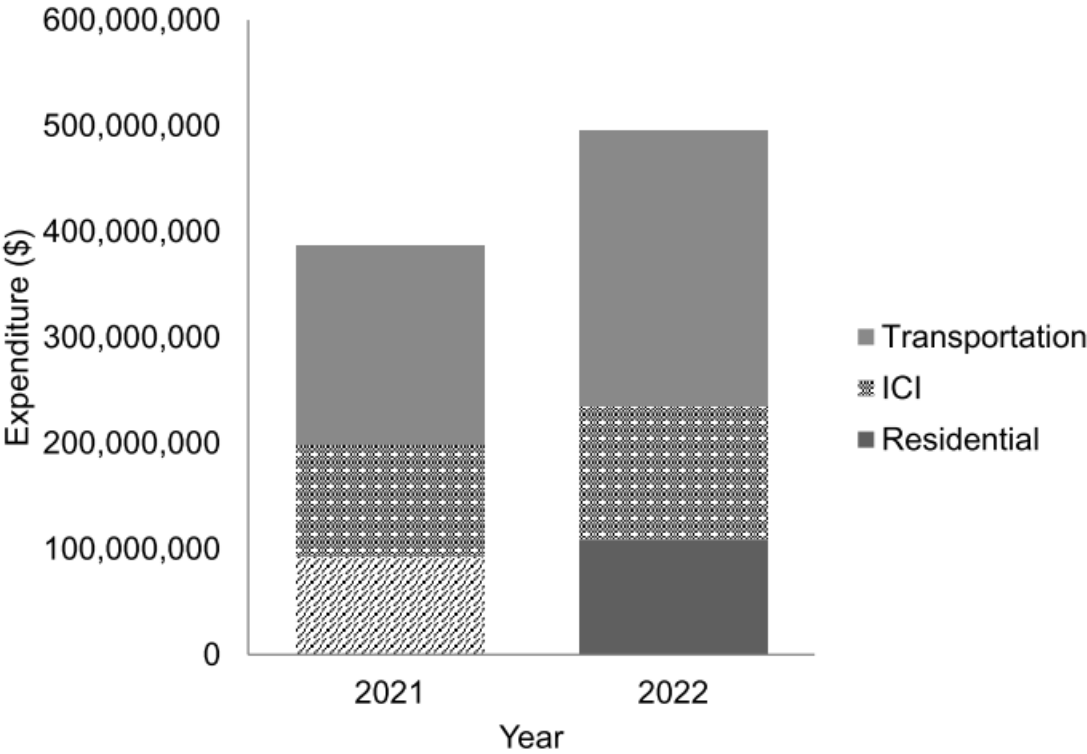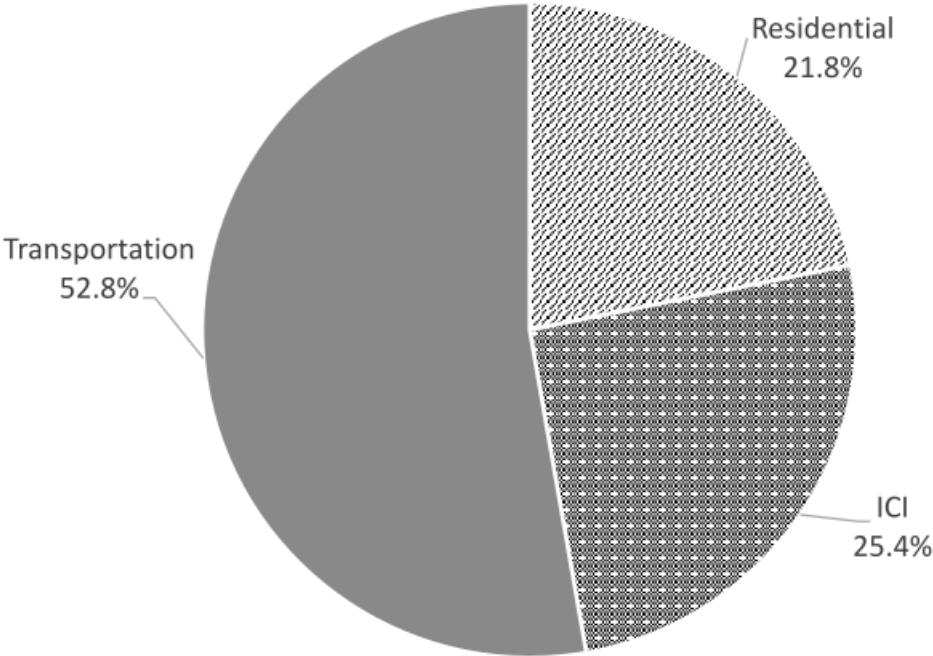## 2022 Expenditures by sector (total: $496,012,848) and historical trend

2022 Energy Consumption by source (total: 19,316,600 GJ) and historical trend
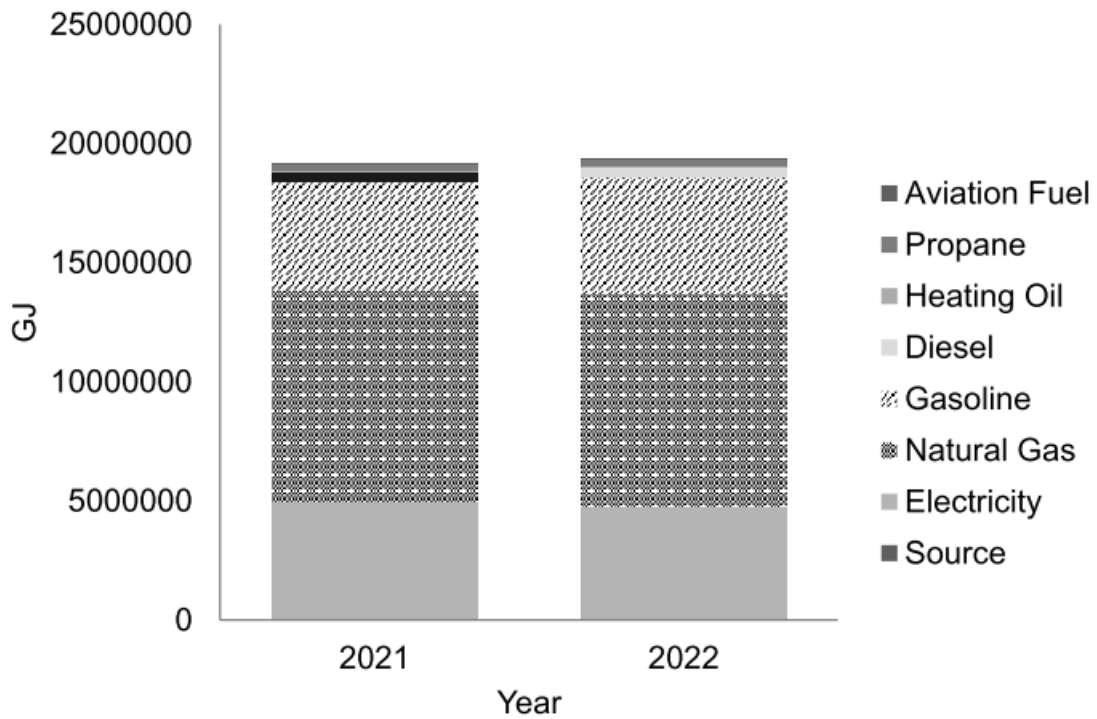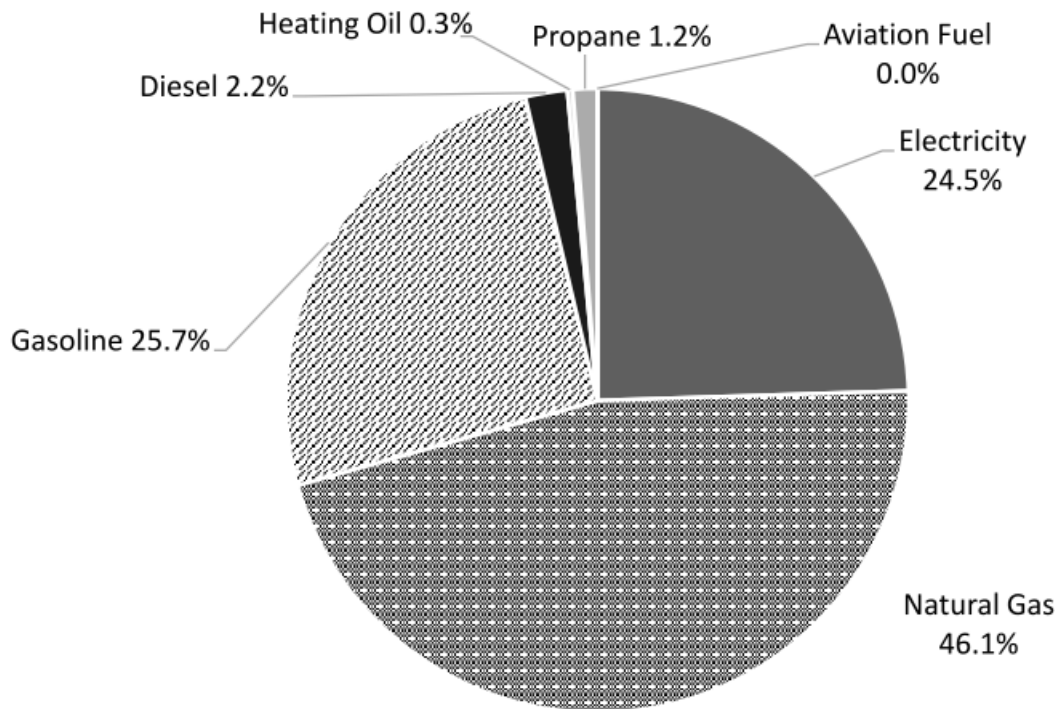
2022 GHG Emissions by source (total: 872,835 tonnes CO_2e) and historical trend
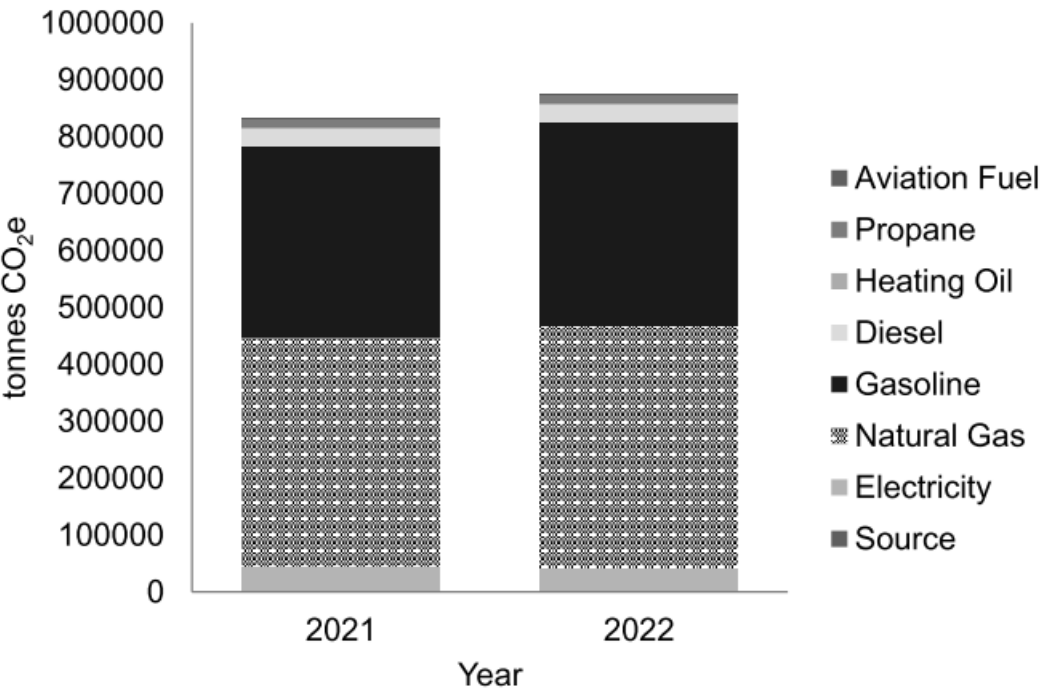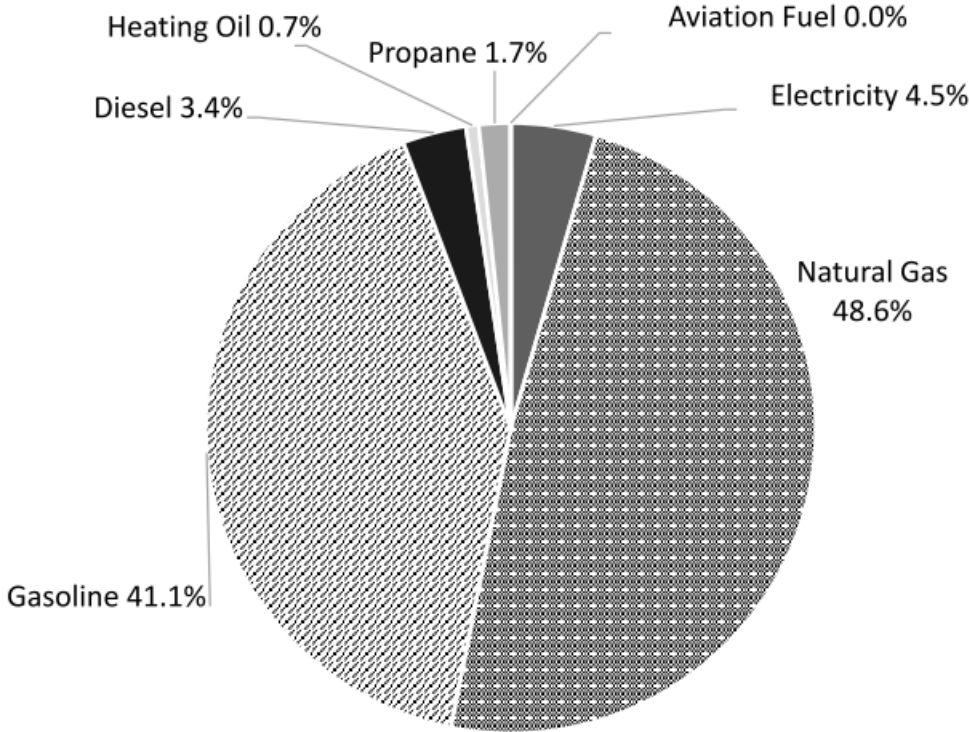
2022 Expenditures by source (total: $496,012,848) and historical trend

Pie chart: Heating Oil 0.9%, Propane 2.6%, Aviation Fuel 0.0%, Electricity 34.1%, Natural Gas 9.6%, Gasoline 48.6%, Diesel 4.2%

Bar chart: Expenditures ($) by Year (2021, 2022). Legend: Aviation Fuel, Propane, Heating Oil, Diesel, Gasoline, Natural Gas, Electricity, Source

Table 1. Summary of energy consumption (GJ), GHG emissions (t CO_2e), and expenditures ($) for 2021 - 2022 across all sectors.

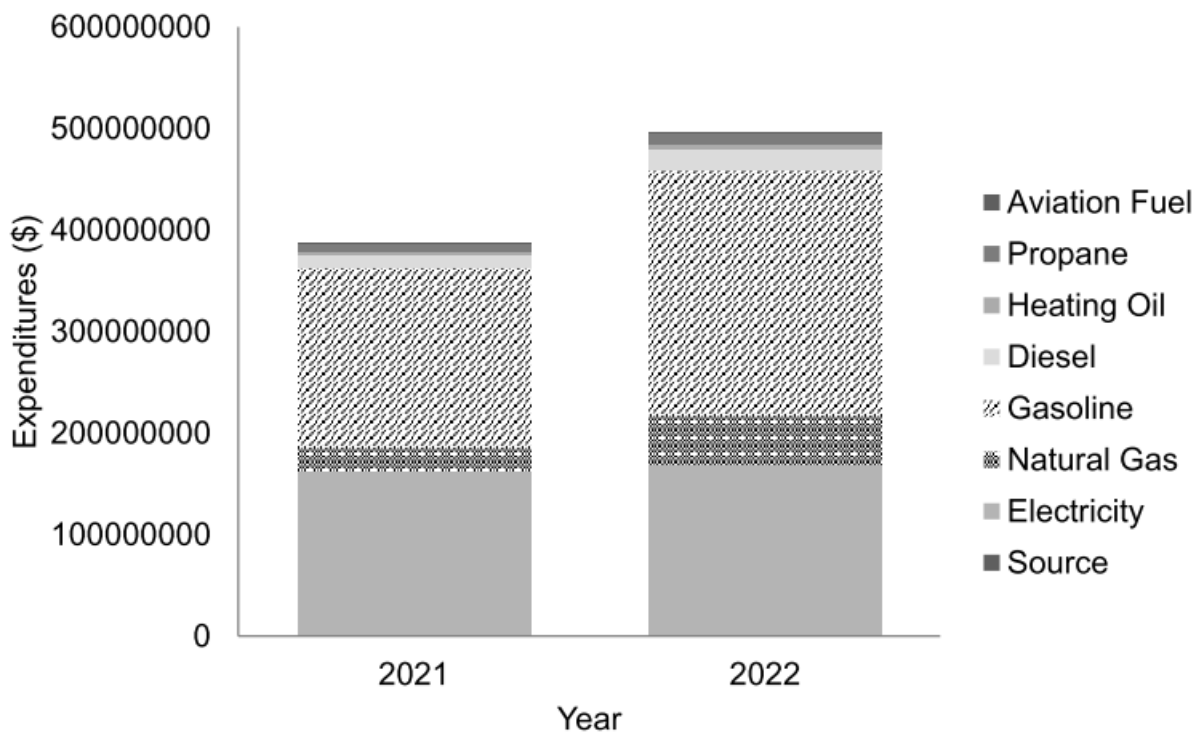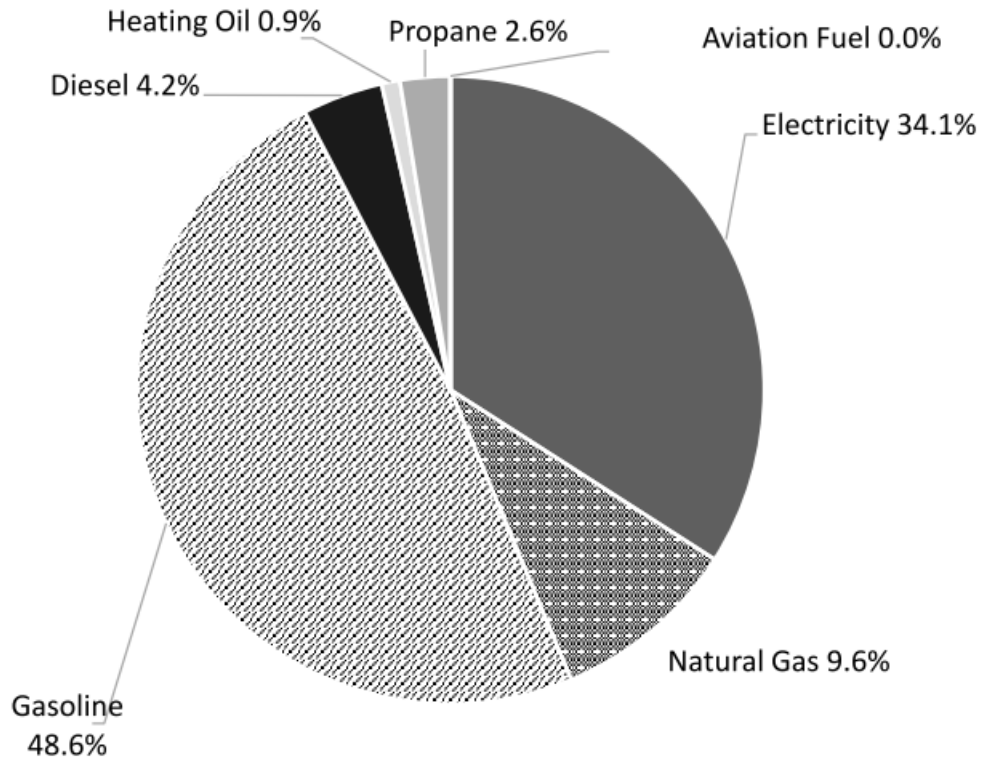| Sector	2021			2022			Energy Change (GJ)	GHG Emissions Change (tCO$_2$e)	Change ($)
	Energy Consumption (GJ)	GHG Emissions (t CO$_2$e)	Expenditure ($)	Energy Consumption (GJ)	GHG Emissions (t CO$_2$e)	Expenditure ($)			
Residential	5,420,848	149,306	92,130,344	5,445,934	161,168	108,251,597	25,087	11,862	16,121,254
ICI	8,651,855	316,898	105,843,258	8,492,130	323,282	126,034,413	-159,725	6,384	20,191,155
Transportation	5,045,450	364,266	188,823,953	5,378,536	388,385	261,726,838	333,085	24,119	72,902,885
Solid Waste	0	27,743	0	0	25,200	0	0	-2,543	0
Wastewater	0	11	0	0	32	0	0	22	0
Agriculture & Forests	0	179,659	0	0	181,849	0	0	2,190	0
TOTAL	19,118,153	1,037,884	386,797,554	19,316,600	1,079,917	496,012,848	198,447	42,033	109,215,294

Table 2. Summary of energy consumption (GJ), GHG emissions (t CO_2e), and expenditures ($) for 2021 - 2022 for energy sources.

Energy Source	2021			2022			Energy Change (GJ)	GHG Emissions Change (tCO$_2$e)	Change ($)
	Energy Consumption (GJ)	GHG Emissions (t CO$_2$e)	Expenditure ($)	Energy Consumption (GJ)	GHG Emissions (t CO$_2$e)	Expenditure ($)			
Electricity	4,932,418	41,103	162,001,154	4,732,765	39,440	169,060,303	-199,653	-1,664	7,059,149
Natural Gas	8,846,885	404,779	24,167,139	8,909,421	424,517	47,782,336			

Report Takeaways

- Community-wide GHG emissions have risen by 4% since 2021, reaching a total of 42,033 tonnes. Despite this increase, emissions remain 3.5% below the levels recorded in 2019.

- Transportation-related GHG emissions surged by 6.6%, adding over 24,000 tonnes of CO_2 compared to 2021. The reduction in transportation emissions in 2020 and 2021, attributed to widespread remote work, was reversed in 2022 as more individuals resumed commuting. This shift is likely a key driver of the increased transportation emissions.
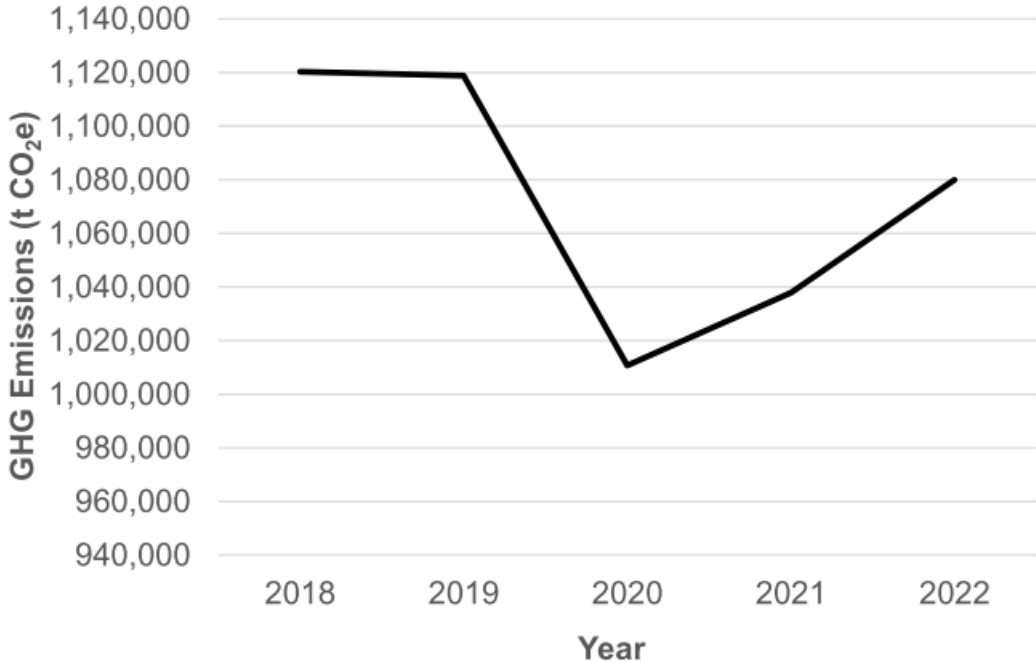
Figure 1. Annual total GHG emissions at the community scale from 2018 to 2022.

- Emissions from natural gas usage climbed nearly 5% from the previous year, paralleled by an 8% rise in Heating Degree Days (HDD) since 2021. Conversely, electricity emissions saw a decrease of about 4% from 2021, while Cooling Degree Days (CDD) also fell by roughly 18%. This mismatch suggests a possible transition towards electricity-based heating and cooling solutions, which tend to be less emission-intensive. However, confirming

this as a definitive trend will require observing changes over the forthcoming years.

- The community's ambitious target of slashing emissions by 30% from baseline levels by 2030 necessitates an additional reduction of 607,793 tonnes of CO_2. To achieve this, a focus on the two most significant contributors to emissions—natural gas and gasoline, which together account for almost 90% of all energy-related emissions—will be essential.

- Interventions that assist homeowners with the expenses of enhancing home energy efficiency and transitioning away from natural gas are critical. Home heating represents over 48% of the community's energy sector emissions, making it a priority in the pursuit of emission reductions.

- While the adoption of electric vehicles (EVs) is paramount for long-term emission cuts, promoting a shift to hybrid vehicles in the near term could yield substantial benefits. Hybrid vehicles can achieve fuel consumption reductions of more than 65% across various models, offering a significant opportunity for impact within the community. Considering gasoline's contribution to over 41% of energy sector emissions, such fuel efficiency improvements could lead to considerable community-level emission reductions.

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City of Kingston Community GHG Inventory Report – 2022 – Supplemental Information

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1. Residential and ICI Sector Methods

Consumption data for electricity and natural gas for both the Residential and ICI (Industrial, Commercial, and Institutional) sectors from 2021 to 2022 was obtained by the City of Kingston from Utilities Kingston, Hydro One, and Enbridge. Estimates for light fuel oil and propane consumption were based on the total per capita use within Ontario for 2021, as informed by Statistics Canada's Report on Energy Supply and Demand (2021; 2022).

This consumption data was translated into energy use (GJ) according to the energy conversion standards set by the Canada Energy Regulator (CER 2022), and greenhouse gas emissions (tCO$_2$e) were calculated using emission factors from the latest National Inventory Report (ECCC 2023). Emission factors used for the years 2021 and 2022 are listed in the emission factor table in Appendix 1 for electricity and natural gas.

Expenditures for electricity in 2021 and 2022 were summarized from Hydro One invoices, and an average price per kilowatt-hour ($/kWh) was calculated. This average cost was then utilized to estimate expenditures for the remaining electricity consumption data. Additionally, natural gas price data obtained from the Ontario Energy Board were applied to consumption figures from Utilities Kingston and Enbridge to calculate natural gas expenditures.

2. Transportation Sector Methods

Total retail fuel sales for diesel and gasoline consumption data for the Kingston region for 2021 and 2022 were provided by Kalibrate Technologies Ltd. Private card lock fuel consumption data from the ICI sector remains an exclusion from the community GHG inventory. Consumption data was converted to energy use (GJ) based on energy conversions set out by the Canada Energy Regulator (CER 2022), and GHG emissions (tCO$_2$e) were calculated using emission factors from the 2020 and 2021 National Inventory Reports (ECCC 2022; ECCC 2023). Expenditures were estimated using NRCAN average retail prices (NRCAN, 2022,2023). Emission factors used for the years 2021 and 2022 are listed in the emission factor table in Appendix 1.

3. Waste Sector Methods

Data on waste collection was supplied by the City, detailing the mass of various types of waste including garbage, organics, and leaf and yard waste, measured in tonnes. Emission factors for waste were determined using the methane commitment method outlined in the Partners for Climate Protection (PCP) protocol, with an assumed methane capture rate of 80% (fraction of methane managed is 0.8), while all other

variables were retained at their default values. This yielded an emission factor of 1.5 tCO_2e per tonne of waste for 2021 and 1.43 tCO_2e per tonne for 2022. These factors were then applied to the aggregate mass of municipal waste directed to landfills in the respective years, with data being provided by the City.

4. Wastewater Methods

Wastewater treatment data, including annual flow rates for the Ravensview, CANA, and Cataraqui Bay facilities, are available online. Average annual $CBOD_5$ values were obtained from the Utilities Kingston annual wastewater reports (2022a,b,c; 2023a,b,c). Facility-specific emission factors, which account for the technology used at each wastewater treatment facility, were determined using the updated Canadian value (0.36 kg CH_4/kg BOD) for maximum methane potential (ECCC 2023). The conversion from $CBOD_5$ to BOD_5, necessary for the emission calculations, was based on a ratio of 1.16, as indicated by the literature (DEQ, 2021; Washington State Department of Ecology, 1998). The annual flow and average $CBOD_5$ values are utilized to estimate CH_4 and CO_2 emissions, detailed in Table 1.

Table 1. Data and emissions calculated from treated water at wastewater facilities

	Annual Flow (m^3)	Average Annual $CBOD_5$ Flow (mg/L)	BOD_5 Flow (mg/L)	TOW (kgBOD / yr)	Treatment Plant Specific Emission Factors (kgCH_4/ kgBOD)	kgCH_4/ yr	t CO_2e/yr
Ravensivew	25004203	2.41	2.8	69,902	0.0036	251.65	6.29
CANA	22801	2.97	3.4	79	0.0180	1.41	0.04
Cat Bay	10724065	8.4	9.7	104,495	0.0036	376.18	9.40

In 2022, there were bypass events that resulted in additional emissions, which were quantified and added to the wastewater emissions inventory. Information on these bypass events, including flow rates and BOD5 estimates, is documented in Table 2.

Table 2. Data and emissions calculated from overflow events.

Bypass Events	Event Flow (m³)	Average Event $CBOD_5$ Flow (mg/L)	BOD_5 Flow estimate (mg/L)	TOW (kgBOD/ yr)	Treatment Plant Specific Emission Factors ($kgCH_4$/kgBOD)	$kgCH_4$/yr	t CO_2e/ yr
Cat 1	44.75	7.3	8.468	0	0.0036	0.00	0.000034
Cat 2	98.3	7.3	8.468	1	0.0180	0.01	0.000375
Cat 3	37.8	2.99	3.468	0	0.0036	0.00	0.000012
Cat 4	159.3	5.8	6.728	1	0.0036	0.00	0.000096
Rav 1	11961	5.8475	6.783	81	1.0036	81.42	2.04
Rav 2	25455.73	5.8475	6.783	173	2.0036	345.96	8.65
Collingwood	11,885.63	5.8475	6.783	81	3.0036	242.15	6.05

5. Agriculture & Forest Sector Methods

Agricultural emissions primarily originate from enteric fermentation and manure management associated with livestock. Emission factors for these processes were sourced from the National Inventory Report (ECCC 2023). The total livestock count for the region was derived from the Census of Agriculture (2021). Detailed enteric fermentation and manure management emission factors, along with livestock numbers from the City of Kingston, are presented in Appendix 2.

Emissions from crops and other agricultural activities often require data on land-use changes, such as forest to cropland conversion, cropland to pasture transformation, or the repurposing of agricultural land. Due to a lack of data on these land-use changes within agricultural crops, these factors were not included in the agricultural sector emissions calculations.

Online GIS data for Kingston, available for the year 2021, indicated a tree group area of 15,983 hectares and a count of 300,506 individual trees. Pasher et al. (2014) reported net sequestration rates for this region of Ontario at 1.29 tons of carbon per hectare per year. This study was utilized in the current report to determine forest group sequestration rates, as it offers a more conservative estimate that is geographically specific, particularly relevant to Kingston's mix of hardwood and softwoods. For

individual trees, a conservative average sequestration rate of 0.036 from Table 8-2 in Chapter 8 of the IPCC (2006) Guidelines for Settlements was adopted. This rate is in alignment with findings by Ritchie (2017) for the University of Windsor and Dalhousie University.

Regarding food emissions, the emission factor was adopted from a peer-reviewed study by Veeramani et al. (2017), which assessed the emissions footprint of actual consumption diets in Ontario. The study estimated an average production of 1.62 tons CO_2e per person per year for the average Ontarian. This emission factor was then applied to the population of Kingston for the years 2021 and 2022.

6. Reporting Methods

This document references results displayed in Table 1 and Table 2 of the Community GHG Inventory Report. Table 1 categorizes emissions by sector, highlighting the sectors responsible for the most significant emissions. Table 2 provides a breakdown of emissions within each sector according to the energy source. It should be noted that the greenhouse gas emissions totals in Table 1 from the Community GHG Inventory Report are slightly higher than those reported in Table 2. This discrepancy arises as Table 1 encompasses emissions from the Wastewater sector and the Agriculture and Forests sectors, which originate from biological and environmental processes and not solely from the consumption of energy resources like gas or electricity in Table 2.

7. Future Methodological Recommendations

- Understanding fuel sales from the ICI sector would greatly improve accuracy of emissions associated with gasoline and diesel sales. Efforts should be made in the coming years to work with the ICI sector to try and understand fuel sales from card locks.

Appendix 1. GHG Emission Factors used and their sources.

Emission Source	Unit	2021	2022	Sources
Electricity	g CO_2e/kWh	30.00	30.00	ECCC 2023, IESO 2021
Natural Gas	g CO_2/m^3	1888	1921	ECCC 2023
	g CH_4/m^3	0.037	0.037	
	g N_2O/m^3	0.035	0.035	
	g CO_2e/m^3	1899	1932	
Light Fuel Oil	g CO_2/L	2753	2753	ECCC 2023
	g CH_4/L	0.026	0.026	
	g N_2O/L	0.031	0.006	
	g CO_2e/L	2763	2755	
Propane	g CO_2/L	1515	1515	ECCC 2023
	g CH_4/L	0.027	0.027	
	g N_2O/L	0.108	0.108	
	g CO_2e/L	1548	1548	
Gasoline	g CO_2/L	2307	2307	ECCC 2023
	g CH_4/L	0.210	0.210	
	g N_2O/L	0.660	0.660	
	g CO_2e/L	2509	2509	
Diesel	g CO_2/L	2681	2681	ECCC 2023
	g CH_4/L	0.140	0.140	
	g N_2O/L	0.082	0.082	
	g CO_2e/L	2708	2708	
Aviation Fuel	g CO_2/L	2365	2365	ECCC 2023
	g CH_4/L	2.200	2.200	
	g N_2O/L	0.230	0.230	
	g CO_2e/L	2489	2489	
	MCF (kg CH_4/kg BOD_5)	0.05	0.05	NIR Table A6.7-1 Methane Correction

		0.018	0.018	Factors (MCF) and
Wastewater - Sequencing Batch Reactor	EF (kg CH$_4$/kg BOD$_5$)	0.018	0.018	Emission Factors (EF) for CH4 from
Wastewater - Secondary	MCF (kg CH$_4$/kg BOD$_5$)	0.018	0.018	Wastewater Treatment
Biofiltration	EF (kg CH$_4$/kg BOD$_5$)	0.0036	0.0036	
Wastewater Canada Specific Bo value (Max CH4 producing capacity)	kg CH$_4$/kg BOD$_5$	0.36	0.36	IPCC (2006) Guideline Refinement

Appendix 2. Agriculture GHG Emission Factors used and livestock counts for 2022.

Livestock Type	# head in 2022	Enteric EF (kgCH$_4$/head/yr)	Manure Management EF (kgCH$_4$/head/yr)	N$_2$O lost during storage EF (kgN$_2$O/head/yr)
Beef Cows	1100	120	4.5	1.094
Dairy Cows	512	145.3	39	0.927
Bulls	70	127.6	4.9	1.634
Heifers, beef	184	90.9	3.2	0.837
lambs	1,546	8	0.22	0.043
sheep	3111	8	0.33	0.044
Deer	300	20	0.22	0.222
Calves (under 1 yr)	1040	43.9	2.9	0.383
Heifers, dairy	291	76.7	17	0.752

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