City of Kingston

2017 COMMUNITY GREENHOUSE GAS INVENTORY

DECEMBER 2018

KINGSTON

Kingston Climate Action

PREPARED BY:

SSG SUSTAINABILITY SOLUTIONS GROUP

GIFTS
GIFTS

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Executive summary: Udo Shuklenk Introduction: Robin Dawes

NOTICE TO READER

Updated natural gas consumption data for 2011 and correction of 2017 GHG reduction estimates

Following the completion of this greenhouse gas emissions inventory report, the City of Kingston was made aware of a significant error in one of the third-party sources of natural gas consumption data. In previous year's inventories, including the 2011 baseline year, the data for natural gas usage erroneously included consumption from some customers outside the geographical boundary of the City of Kingston. The City has been provided with corrected natural gas usage data for 2011.

Due to this error, the estimate of 32% reduction in total community emission reductions between 2011 and 2017 that is provided within this report is incorrect. The corrected natural gas consumption data indicates that approximately 342,502 tonnes (CO2e) of GHG emissions were incorrectly added to the 2011 community inventory. The corrected data indicates the following conclusions with respect to 2011 and 2017 emission levels:

» Total community emissions in 2011 = 1,349,555 tonnes (CO2e)
» Estimated reduction in emissions between 2011 and 2017 = 14.9%

The City of Kingston apologizes for this error and will provide corrected data and restatements of previous year's results within future community GHG emission inventory reports.

Kingston 2017 Community GHG Inventory Update

EXECUTIVE SUMMARY

As a member of the Federation of Canadian Municipalities (FCM) Partners for Climate Protection (PCP) Program, the City of Kingston has committed to measuring its community and corporate energy and emissions, setting targets for their reduction, and to assembling and carrying out action plans to reduce emissions. This report includes updated GHG inventories for 2016 and 2017, a back-casted 1990 inventory and all past inventories, which were initiated in 2000, and carried out in 2003, 2006, 2009, 2011, 2014, and 2015. This inventory builds upon the work completed in previous years in order to identify significant emissions changes and their causes, and to better understand trends that are occurring in recent years.

The inventories were completed following the FCM Partners for Climate Protection protocol, using the geopolitical boundary of the Municipality of the City of Kingston. They document community emissions created by activities within the city boundary, as well as those emissions occurring outside the boundary that are resultant from in-boundary activities (e.g. using electricity from the electric grid). The energy and emissions sectors covered include: residential, ICI (industrial, commercial and institutional), transportation and waste. The emissions sources covered include: electricity, natural gas, fuel oil, propane, gasoline, diesel, waste, and wastewater.

Key updates since the 2015 GHG inventory include:

- Calculating a 1990 baseline;
- Including GHG emissions and carbon absorption from agriculture and forests;
- Including GHG emissions from aviation fuel;
- Updating emissions factors for electricity to align with the latest assumptions from Environment and Climate Change Canada; and
- Revising historical and current energy prices for electricity and natural gas.

As a result of the decline in natural gas consumption in the ICI sector, energy consumption dropped to 18.76 million GJ in 2017, a reduction of 28% over 2015 levels. Energy expenditures dropped from $528 million in 2015 to $426 million in 2016, and to $420 million in 2017. The reductions in 2016 were the result of a 40% drop in gasoline costs and in 2017 as a result of the Fair Hydro Plan, as well as reduced fuel purchases in the ICI sector. 2017 per capita energy expenditures declined more than $800 since 2015, totalling $2,752 in 2017.

To align with the Province of Ontario's GHG emissions targets, a baseline GHG inventory was calculated for 1990, with emissions totaling 1.4 $MtCO_2e$. GHG emissions in 2017 dropped 24% from 2015, from 1.5 $MtCO_2e$ to 1.15 $MtCO_2e$, primarily as a result of reductions in natural gas consumption in the ICI sector. On a per capita basis, GHG emissions were down from 12.8 tCO_2e/capita in 1990 to 7.5 tCO_2e in 2017, a drop of 41%, continuing an annual downward trajectory.

Kingston remains on track with meeting its emissions reduction goals. It's goal of 10% below 2000 levels by 2014 was met, achieving a 12% reduction in that year. An updated goal of a 15% reduction below 2011 levels by 2020 and 30% below 2011 levels by 2030 have been met as well, exceeding the 2030 target timeline: in 2017, emissions dropped to 32%[N] under 2011 levels. A large emissions reduction in 2017 was primarily the result of a significant reduction in natural gas consumption in the industrial sector.

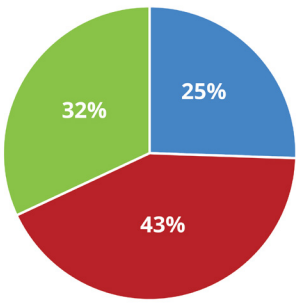
N - See Notice to Reader regarding correction to reduction estimates.

City of Kingston 2017 community inventory of community energy, emissions, and expenditures by sector

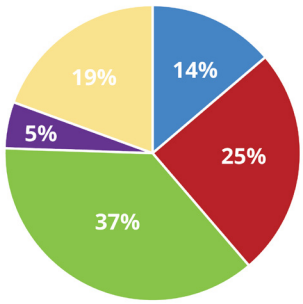
The following charts summarize Kingston's community energy use, GHG emissions and energy spending for 2017 with comparisons to restated estimates for 1990, 2000, 2011, and 2015.

	Sector	GJ (millions)	tCO_2e (thousands)	Expenditures ($ millions)
	Residential	4.77	158	87
	ICI	8.04	288	149
	Transportation	5.96	422	184
	Solid Waste	n/a	58	n/a
	Agriculture & Forests	n/a	221	n/a
	Total	**18.76**	**1,149**	**420**

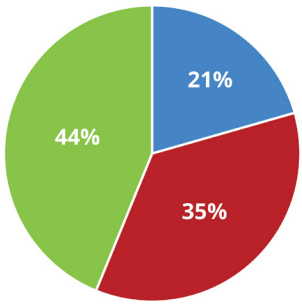
2017 Energy Consumption
18.76 million GJ

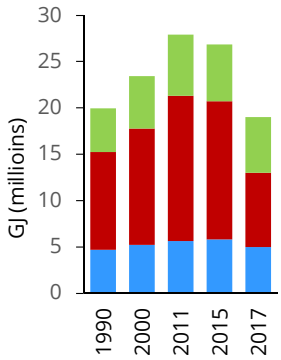


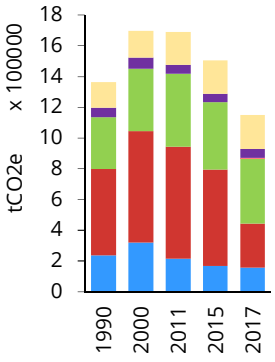
2017 Emissions
1.1 million tCO_2e

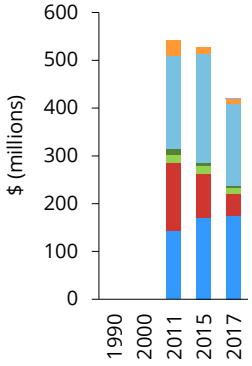


2017 Energy Expenditures
$420 million





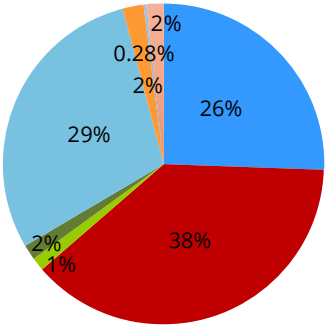




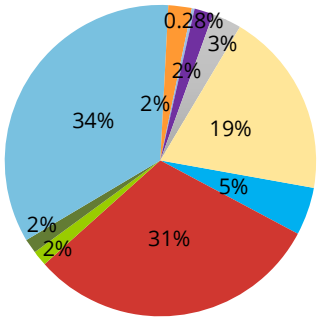
City of Kingston 2017 community inventory of community energy, emissions, and expenditures by source

Fuel Type	GJ (millions)	tCO_2e (thousands)	Expenditures ($ millions)
Electricity	4.80	57	174
Natural Gas	7.13	352	48
Fuel Oil	0.25	18	11
Propane	0.30	18	4
Gasoline	5.57	394	173
Diesel	0.39	28	11
Aviation Fuel	0.52	3.2	0.1
Wood	0.32	0	0
Solid Waste	n/a	22	n/a
Wastewater	n/a	36	n/a
Agriculture & Forests	n/a	221	n/a
Total	**18.76**	**1,149**	**420**

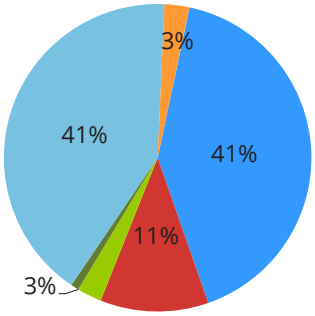
2017 Energy Consumption
18.76 million GJ

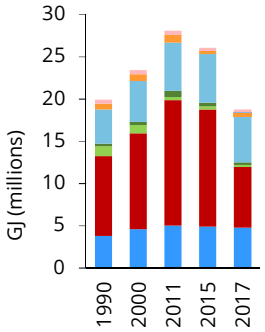


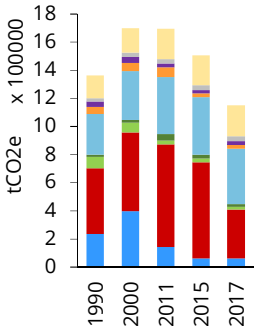
2017 Emissions
1.15 million tCO_2e

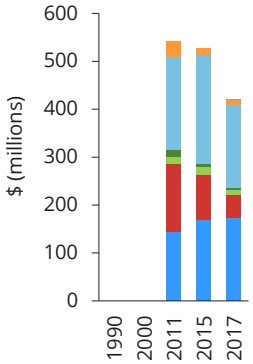


2017 Energy Expenditures
$420 million









INTRODUCTION

Global context

The global scientific consensus is that the activities required—and that we choose—to live our day-to-day lives are having direct consequences to our environment and climate.[1] To varying extents in different jurisdictions, all levels of governments all over the globe are making efforts to track and minimize their greenhouse gas emissions in attempts to mitigate and adapt to climate change.

National and international municipal organizations are rallying to the challenge of emissions reduction and climate change mitigation, recognizing that they have an important contribution to make to climate protection. According to the Federation of Canadian Municipalities (FCM), approximately 60% of Canada's greenhouse gas (GHG) emissions are under the direct or indirect control or influence of municipal governments, and cities can cut emissions from municipal operations and in the broader community.[2]

City of Kingston context

In 2004, the City of Kingston adopted an emissions reduction target of 10% below base year 2000 levels by 2014. This target was achieved, with the community's inventory showing a 12% reduction in the year 2014. In 2014, City Council updated its community emissions targets to a reduction of 15% below 2011 levels by 2020 and 30% below 2011 levels by 2030. Between 2014 and 2015, GHG emissions were more or less constant at 1.5MtCO_2e. In 2016, GHGs dropped significantly to 1.17 MtCO2e, and to 1.15MtCO_2e in 2017, a reduction of 32%[N] over 2011 levels, exceeding the City's 2030 GHG reduction target. The emissions reductions in 2016 and 2017 were primarily the result of a significant reduction in natural gas consumption in the industrial sector.

The City of Kingston is also a member of the Federation of Canadian Municipalities Partners for Climate Protection Program and has committed to measuring its community and corporate energy and emissions, setting targets for their reduction, and to assembling and carrying out action plans to reduce these emissions.[3]

1 More details on the relationship between climate change and greenhouse gases at: www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter01_FINAL.pdf

2 SSG analysis of the National Inventory Report.

3 For more information on GHGs and the PCP inventories, please see www.fcm.ca/Documents/reports/PCP/Developing_Inventories_for_Greenhouse_Gas_Emissions_and_Energy_Consumption_EN.pdf

N See Notice to Reader regarding correction to reduction estimates.

INVENTORY PROTOCOL, BOUNDARY, AND SCOPE

The protocol, boundary and scope of the past inventories have been applied to the 2016 and 2017 inventory update. Any upgrades to the methodology used for the 2016 and 2017 inventory have been applied retroactively to prior years' data, so that a consistent approach is reported for all years, as summarized in Table 1.

Table 1. Summary of protocol, boundary, and scope used in the 2017 and past inventories.

	2017 Inventory	Same as prior years?	Details
Protocol	ICLEI Protocol for community reporting (a.k.a PCP Protocol)	Yes	Sectors to be reported on include: residential, industrial, commercial, industrial, transportation and waste. As per prior years, the industrial and commercial data were unparsable; these sectors were combined into one industrial, commercial, and institutional (ICI) sector.
Boundary	Geopolitical	Yes	All emissions associated with activities occurring within the geopolitical boundary of the Municipality of the City of Kingston were included.
Scope	S1: Direct Emissions & S2: Indirect Emissions	Yes	Stationary »S1: Decentralized fuel consumption »S2: Decentralized electricity/heat/steam consumption Transport »S1: Tailpipe from on-road vehicles »S3: Aviation fuel associated with flights from Kingston Airport Solid Waste »S1: Direct Emissions from landfill, compost and incineration facilities within the community »S3: Landfill, incineration and compost emissions in the present year from waste produced in the community Waste water treatment and discharge »S1:Direct Emissions from facilities located within the community »S1:Emissions from agriculture and change in forest cover

Inventory Scopes Details

An inventory's scope outlines which emissions activities it covers. A Scope1 inventory covers the emissions from activities taking place and being released within the city's geopolitical boundary, while an inventory that includes Scopes1 through 3 will cover all emissions from activities within the boundary, including from energy or materials used in the city but produced elsewhere. This inventory covers Scopes 1 and 2, however does not include fugitive emissions or process emissions, consistent with prior inventories. The 2016-2017 inventory will cover Scope 3 emissions from aviation as the City is the operator of the Kingston Airport. GHG emissions from agriculture and forestry have been included for all inventory years to ensure consistency.

SCOPE 1: DIRECT EMISSIONS

These come from sources or activities taking place within the City's geopolitical boundary.

1. Stationary Combustion: Combustion that produces electricity, steam heat or power using equipment in a fixed location (i.e. power plants).
2. Mobile Combustion: Combustion of fuels for transportation. (i.e. cars, public transit).

SCOPE 2: INDIRECT EMISSIONS

Emissions associated with the consumption of purchased or acquired electricity,steam, heating or cooling. These emissions that take place within the geopolitical boundary but the release of the emissions (i.e. electricity power plant) may take place outside of the political boundary.

SCOPE 3: OTHER INDIRECT EMISSIONS

All other indirect emissions not included in Scope 2. These can be emissions resulting from extraction and production of purchased materials and fuels.

METHODOLOGY

Summary

DATA COLLECTION

Energy and emissions quantities and expenditures were collected from the City and utilities for the years 2016 and 2017 and compiled into a database. Assumptions were applied from prior years or the next most relevant data sources in cases where actual amounts for 2016 and 2017 could not be collected. Details on the energy and emissions data collected, their sources and their level of quality are indicated in the following Data sources and quality section. All assumptions applied are reported in Appendix 1 and the data itself is reported in Appendix 2.

INVENTORY ASSEMBLY

Energy usage, emissions, and yearly expenditures were calculated for the years 2016 and 2017 and reported by sector (residential, industrial/commercial/institutional, transportation, waste, agriculture and forestry) as well as by emissions source (electricity, natural gas, propane, heating oil, gasoline, diesel, waste, wastewater, agriculture and forestry). Complete inventories can be found in Appendix 3.

Energy quantities were converted to Gigajoules (GJ) for all sources. A Gigajoule is a metric measure of energy usage, equal to one billion joules, or the amount of energy used in a typical Canadian home over 3 days. Emissions quantities were measured in tonnes of carbon dioxide equivalents (tCO_2e). A weight of CO_2e is the measure of the amount of a gas that is released into the atmosphere alongside the relative radiative impact of that gas on it, also known as its Global Warming Potential. For energy and emissions factors used, please see Appendix 1.

COMPARISONS WITH PRIOR YEARS' DATA

The totals from the 2016 and 2017 inventories were compiled alongside information from the most recent (2014 and 2015) inventory and previous years (2000, 2006, and 2009). To ensure consistency and to allow for meaningful year-to-year comparison, modifications in methodologies and emissions factors were applied to the historical data sets as needed; previous year's estimates were restated. Any changes made to prior years' inventories are stated in the modification from past inventories section. While inventories for both the years 2016 and 2017 were completed, comparisons were reported from the base year (1990) to the most recent year (2017). The exception to this is expenditure data, for which there was no data available for the base year. The updated database for the years 1990-2017 is included in Appendix 4.

Data sources and quality

Table 2. Summary of inventory data sources and data quality for the 2016 and 2017 inventories.

Emissions source	Service provider	Quality of data	Data attribute	Comments
Electricity	HydroOne	high	consumption	Observed kwh usage was provided by sector from the utility.
		medium	cost	Cost/kwh was calculated by dividing power and distribution revenue by total kWh delivered from the IESO reports for Utilities Kingston. The resulting $/kWh was applied to electricity supplied by HydroOne.
	Utilities Kingston	high	consumption	Actual kwh usage was provided by sector from the utility.
		medium	cost	Cost/kwh was calculated by dividing power and distribution revenue by total kWh delivered from the IESO reports for Utilities Kingston.
Natural Gas	Union Gas	high	consumption	Actual m3 usage was provided by sector.
		medium	cost	Ontario Energy Board effective prices were used ($/m3) for Union Gas (South).
	Utilities Kingston	medium	consumption	Actual m3 usage was provided, but only distinguished between residential and commercial. The commercial sector was therefore treated as ICI.
		medium	cost	Ontario Energy Board effective prices were used ($/m3) for Union Gas (South).
Fuel Oil	modelled data	low	consumption	Modelled using base data from 2006 and projected residential and ICI growth to 2017. Primary source was NRCan's Comprehensive Energy Use Database Table for Ontario.
		medium	cost	NRCan 2016 and 2017 average retail price for furnace oil Kingston was used.
Propane	modelled data	low	consumption	Modelled using base data from 2006 and projected residential and ICI growth to 2017. Primary source was NRCan's Comprehensive Energy Use Database Table for Ontario.
		medium	cost	NRCan average retail price for propane in Kingston was used for 2016 and 2017.
Gasoline	Kent Marketing Services	high	consumption	Observed L of gasoline sold in Kingston.
		medium	cost	NRCan 2016 and 2017 average retail price for regular gasoline in Kingston was used.
Diesel	Kent Marketing Services	high	consumption	Observed L of diesel sold in Kingston.
		medium	cost	NRCan 2016 and 2017 average retail price for diesel in Kingston was used.
Waste	City of Kingston	low	tonnage	Resource Productivity & Recovery Authority Data call was used to identify waste managed and percent diverted for residential waste. ICI waste was excluded due to lack of data collection.
Wastewater	City of Kingston	high	flow	City reports of flows from Wastewater treatment plants in m3. Actual measured CODmg/L and BODmg/L were provided for 2 plants for 2016 and 2017and an average of these was used for the third plant to derive an emissions factor.

Legend for data quality:

- High: Actual usage data covering the period of the inventory year, from a credible data collector/provider.
- Medium: Actual usage data provided, with some assumptions from within or around the geographic boundary, inventory year,or otherwise to fill in data gaps.
- Low: Based mainly on assumptions.

Assumptions

Table 3. Emissions factor assumptions and their sources used in 2016 and 2017 inventory calculations.

Energy type/ source	Emission factor	Unit	Source	Additional comments
Electricity	0.043	$kgCO_2e$/ kwh	Environment Canada National Inventory Report 1990-2015 Greenhouse Gas Sources and Sinks in Canada, Part 3, Table A13-7	2015valueused,as 2016 and 2017data not yet available
Natural Gas	1.912	$kgCO_2e$/ m3	Environment Canada National Inventory Report 1990-2015 Greenhouse Gas Sources and Sinks in Canada, Table A6-1&2	Adjusted to incorporate Methane (CH4) and Nitrous Oxide (N2O)
Fuel Oil	2.755	$kgCO_2e$/L	Environment Canada National Inventory Report 1990-2015 Greenhouse Gas Sources and Sinks in Canada, Table A6-4 Light residential	
Propane	1.538	$kgCO_2e$/L	Environment Canada National Inventory Report 1990-2015 Greenhouse Gas Sources and Sinks in Canada, Table A6-3	
Gasoline	2.500	$kgCO_2e$/L	Environment Canada National Inventory Report 1990-2015 Greenhouse Gas Sources and Sinks in Canada, Table A6-12	Adjusted to incorporate Methane (CH4) and Nitrous Oxide (N2O)
Diesel	2.750	$kgCO_2e$/L	Environment Canada National Inventory Report 1990-2015 Greenhouse Gas Sources and Sinks in Canada, Table A6-12	Adjusted to incorporate Methane (CH4) and Nitrous Oxide (N2O)
Aviation fuel	2.370	$kgCO_2e$/L	Environment Canada National Inventory Report 1990-2015 Greenhouse Gas Sources and Sinks in Canada, Table A6-12	Adjusted to incorporate Methane (CH4) and Nitrous Oxide (N2O)
Waste water	0.25 0.6	$kgCH_4$/L COD $kgCH_4$/L BOD	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 6 Wastewater Treatment and Discharge	Wastewater emissions factors were calculated from yearly flow volumes and organic content measurements from the City's wastewater treatment plants. The treatment plants report on Biological and Chemical Oxidized Demand (BOD & COD) which are used to calculate methane amounts in wastewater; under normal conditions, higher COD/ BOD levels result in greater amounts of methane.
Waste	530	$kgCO_2e$/t	Applied the methane commitment method to derive the ratio	

Modifications from Past Inventories

ELECTRICITY EMISSIONS FACTOR

While the emissions factor for other fuel sources remained unchanged since the 1990 baseline inventory, the emissions factor for electricity changes year to year, depending on the electricity energy mix in the province. This emissions factor is reported by Environment Canada every year in its National Inventory Report (NIR). In addition, these reports include upgrades to historical emissions factors as the methodologies for emissions factor estimations are improved. The emissions factors used in the 2015/2016 inventory were updated as per the table below. Note that at the time of reporting, the most recent NIR report released was for 2017, for which the most recent emissions factor year was 2015. The emissions factor for electricity was held constant between 2015 and 2017 for electricity.

As shown in Table 4, the emissions factor for electricity generation in the Province decreased by approximately 80% from 1990 to 2015, attributable to the phase out of coal as a fuel source for electricity. This was replaced with no-emission and lower-emission alternatives such as nuclear, hydroelectric, natural gas, biomass, and renewables such as wind and solar moving from 25% coal in the supply mix in 2003, to 0% in 2014.

NATURAL GAS EMISSIONS FACTOR

The emissions factor for natural gas was updated from 1.891 kg/CO_2e/m3 to a value of 1.912 kgCO_2e/m3, according to data from Environment Canada's National Inventory Report 1990-2015, Tables A6-1&2 for Ontario's emissions factor for natural gas (Table A6-1) plus the Methane (CH4) and Nitrous Oxide (N2O) emissions factors for electric utilities (Table A6-2), converted to CO_2e using factors of 28 and 210,respectively.

AVIATION FUEL

GHG emissions from aviation fuel were added to the 2016/2017; this included all fuel sales from Kingston Airport. The primary flights from Kingston Airport are to Toronto.

WASTE

Only residential landfill tonnage values were available for the City for 2016/2017, an approach consistent with the 2014 and 2015 inventories. Prior inventories have also been adjusted to be consistent with this approach. Should more accurate waste generation and landfill emissions results be collected in subsequent inventories, a similar approach could be taken to update past years' waste results and to incorporate waste generated from all sectors.

WASTEWATER

Emissions for wastewater were included in the 2016/2017 inventory, which had not been included in prior years' inventories.

AGRICULTURE AND FORESTS

GHG emissions from agricultural practices and forestry were added to the 2016/2017 inventory, and were back dated until 1990. The primary data source for agricultural activities was the Agricultural Census. The forest area was held constant at 12,067 hectares, which results in a net reduction of GHG emissions through absorption.

Table 4. Comparison of Ontario electricity emissions factors for 2000-2017 from Environment Canada's National Inventory Reports and used in Kingston's emissions inventories. The emissions factor dropped from 0.22 in 1990 to 0.043 in 2016/2017— approximately 80%.

	Electricity emissions factors (kg CO_2e/kWh)														
NIR year	1990	2000	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1990-2010		0.31		0.21	0.24	0.17	0.12	0.15	0.15						
1990-2012		0.32	0.24		0.24	0.17	0.12	0.15	0.11						
1990-2014		0.32	0.24					0.15	0.11	0.11	0.08	0.05			
1990-2015	0.22	0.31	0.23				0.15	0.14	0.10	0.10	0.08	0.04	0.043	0.043	0.043

Emissions factors which have changed in the 2016/2017 update over previous inventories

Emissions factors which were carried over from previous years due to a data gap

ENERGY EXPENDITURES

In the 2016-2017 inventory, total energy expenditures were calculated using the Ontario Energy Board Historical Data for electricity and natural gas. This data source has now retroactively been used for previous inventories as the previous rates were interpolated from previous inventories or current rates from Utilities Kingston. The updated rates are generally lower than previous inventories, resulting in lower total energy expenditures for the Residential and ICI sectors. The cost of electricity for the ICI sector was assumed to be a higher rate than residential, although bulk purchases can create variances. The costs for gasoline and expenditures related to transportation have remained constant and continue to be sourced from NRCan. Finally, in the 2016-2017 inventory, expenditures for aviation fuel were included at 0.05$/L Table 6 below details the difference in total expenditures using previous sources and the updated sources.

Table 5. Expenditure Rates and Associated Data Sources for Current Inventory and Previous.

Energy type/source	Unit	Source	2010	2011	2012	2013	2014	2015	2016	2017
Electricity	$/GJ	Ontario Energy Board, Yearbook of Electricity Distributors	26.55	28.55	30.39	33.64	34.23	34.81	39.43	36.20
Natural Gas	$/m3	Utilities Kingston Historical Data	0.30	0.37	0.28	0.26	0.25	0.26	0.28	0.26
		Data Used in Previous Inventories								
Electricity	$/GJ	Interpolated from 2011 Inventory	37	38	N/A	N/A	38	38	N/A	N/A
Natural Gas	$/m3	Interpolated from Utilities Kingston Current Data	0.33	0.38	N/A	N/A	0.33	0.33		

Table 6. Difference in total expenditures when new sources are applied.

	Previous Inventory ($Millions)	Current Inventory ($Millions)
2014	$548	$505
2015	$578	$528

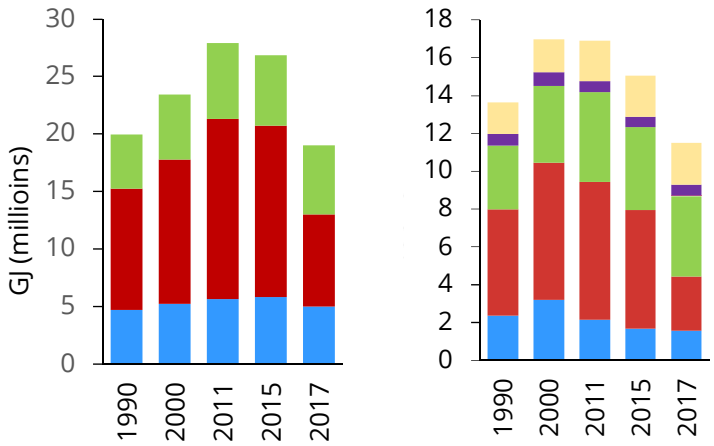
RESULTS

Emissions were 32%[N] lower in 2017 than 2011, achieving the City's Climate Action Plan 2030 target of a 30% reduction below 2011 levels, twelve years early.

Overall, the City's annual GHG emissions increased by 140,325 tCO_2e (10%) between 1990 and 2015 and decreased by 194,000 tCO_2e (14%) in 2016, and an additional 19,000 tCO_2e in 2017. Per capita energy consumption decreased to123 GJ/capita in 2017 from 176 GJ/capita in 2015, and 127 GJ/capita in 2016. Overall energy consumption was approximately 26 million GJ in both 2015 and 2016, before falling to 19 million GJ in 2017.

Emissions reductions since 1990 are largely attributable to the significant decrease in the electricity production emissions factor, due to improvements to the Ontario energy mix and the phasing out of coal-fired plants. The drop between 2016 and 2017 is explained by a major reduction in natural gas consumption in the ICI sector. The ICI sector was in flux in the period between 2016-2017,this may have occurred due to fuel switching, efficiencies, production schedules, or periods of vacancy.

Figure 1. Energy use and emissions, 1990-2017.

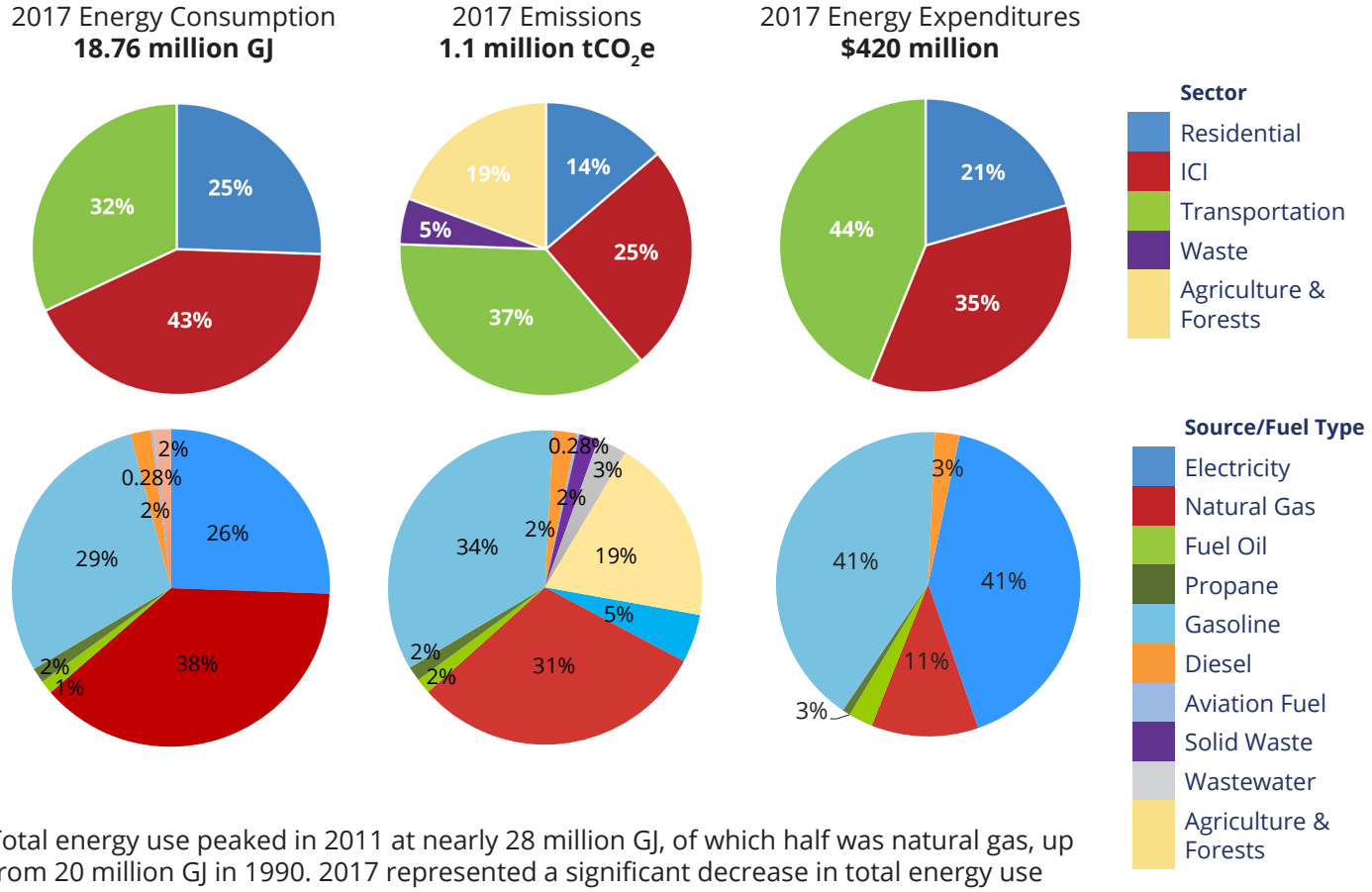


	Residential		Transportation
	ICI		Waste
	Agriculture and Forests		

In 2017, the ICI sector was the largest user of energy and contributor to emissions, while the transportation sector was responsible for the majority of energy expenditures. For energy sources, natural gas consisted of the most used energy by GJ amount and contributed the most emissions, while the greatest amount of expenditures were on gasoline.

N - See Notice to Reader regarding correction to reduction estimates.

Figure 2. Summary of community energy consumption, emissions, and expenditures by sector and fuel type.



Total energy use peaked in 2011 at nearly 28 million GJ, of which half was natural gas, up from 20 million GJ in 1990. 2017 represented a significant decrease in total energy use from the peak, returning to the level of consumption in 1990 at 20 million GJ. Since 2010, electricity consumption has been relatively consistent at approximately 5 million GJ plus or minus 200,000 GJ each year. GHG emissions also peaked in 2010 at 1.7 $MtCO_2e$. At 1.2$MtCO_2e$, 2017 represented the lowest level of GHG emissions since1990 (1.4$MtCO_2e$).

Energy expenditures were not calculated for 1990 due to a lack of data. Electricity expenditures in 2017 were $174 million, slightly higher than 2014 and 2015 ($164 and $170, respectively), but lower than the 2016 peak at $195 million in 2016. Natural gas expenditures were $48 million in 2016 and, both were significantly lower than 2015 where $100 million was spent. On a per unit basis, natural gas costs remained consistent between from 2015 and 2017 at roughly 0.26$/m3.

Impact of Weather

One confounding factor influencing energy consumption and emissions is the weather, or, more specifically, the number of heating and cooling degree days (HDD and CDD, respectively). Relatively warmer years will result in greater electrical consumption for air conditioning while relatively cooler years will result in more consumption of natural gas and electricity for heating. A heating degree day is the number of degrees that a day's average temperature is below 18°C, indicative of the amount of energy needed to heat buildings to operating temperatures in that day. For example, a day with an average temperature of 4°C will have a Heating Degree Day of 14°C. Similarly, a cooling degree day provides a measure of energy needed to cool buildings, noted by the number of degrees that a day's average temperature is above 18°C.

Figure 3. Annual heating and cooling degree days for the City of Kingston.

YEAR	HDD	CDD	SUM
2000	4,372	132	4,504
2006	3,742	252	3,994
2007	4,062	281	4,343
2008	4,113	205	4,318
2009	4,192	159	4,351
2010	3,777	321	4,098
2011	3,870	237	4,107
2014	4,325	143	4,468
2015	4,186	180	4,366
2016	3,782	294	4,076
2017	3,375	160	3,895

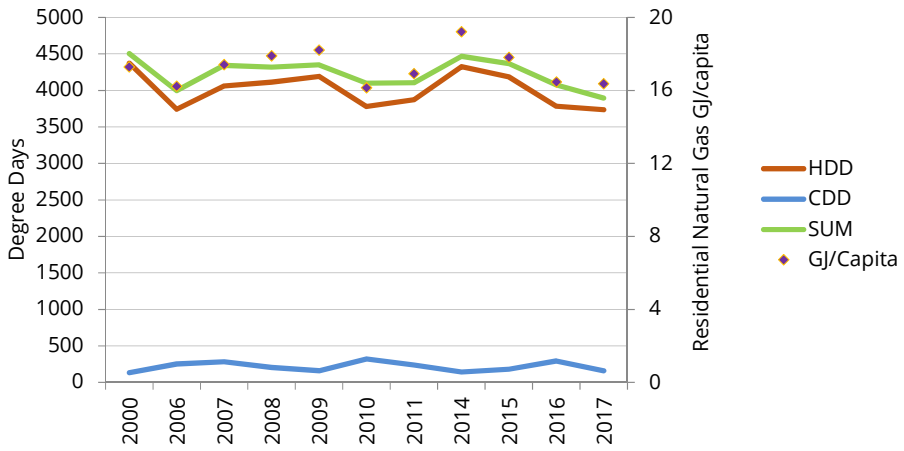


Figure 3 shows the relationship between the total heating and cooling degree days and yearly per capita residential natural gas usage. The number of HDD in 2016 and 2017 was low for the period between 2000 and 2017, with 2017 having the lowest overall number and reducing natural gas usage by 6% compared to 2015, the last inventory year. Of note in 2017, there were nearly half as many CDD than 2016 which resulted in a 3% electricity reduction for the residential sector.

However, as the earth continues to warm, there will be an increase in the number of cooling days (days requiring air conditioning) resulting in increased energy use and likely offsetting gains made from fewer heat degree days (days required heating).

Results by sector

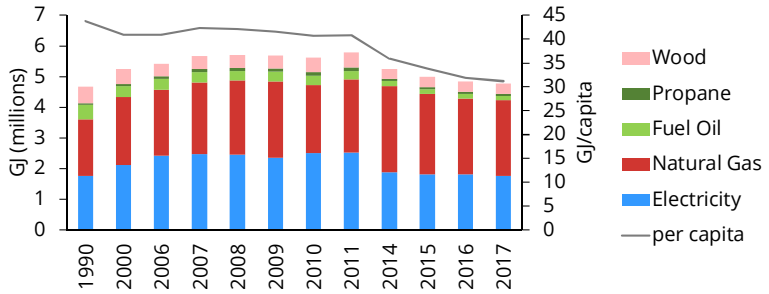
RESIDENTIAL

Residential emissions originate from fossil fuel energy used for heating, cooling, lighting, running appliances, etc. Energy use can occur on-site, as is the case with natural gas, fuel oil, and propane for heat provision, or off-site, as is the case for electricity produced by natural gas burning electric utilities.

From 1990 to 2017, the residential sector observed a 2% increase in energy consumption, but a 29% decrease in per capita energy consumption. This was accompanied by a 33% decrease in total emissions, translating to a 53% decrease in per capita emissions. The dramatic drop in emissions is largely attributable to the reduction in electricity's emissions factor (fewer fossil fuels used in electricity production).

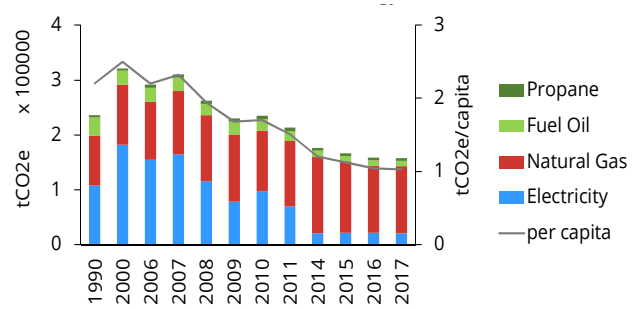
Figure 4. Annual energy consumption, emissions, and expenditures by fuel source for the residential sector. Per capita amounts include post-secondary student population, noted in Appendix 2, Table 20.

Annual Residential Energy Consumption



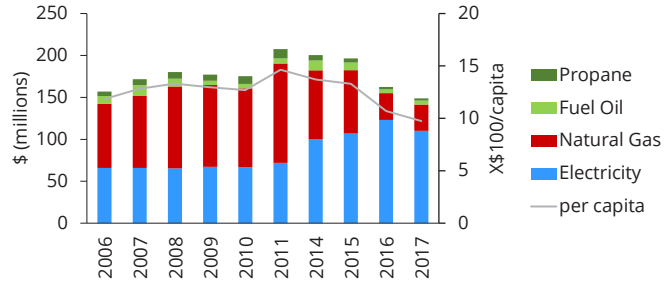
	Total Change	Change Per Capita
1990-2017	2%	-29%
2000-2017	-9%	-24%
2015-2017	-5%	-8%

Annual Residential Energy Emissions



	Total Change	Change Per Capita
1990-2017	-33%	-53%
2000-2017	-51%	-59%
2015-2017	-5%	-9%

Annual Residential Energy Expenditures



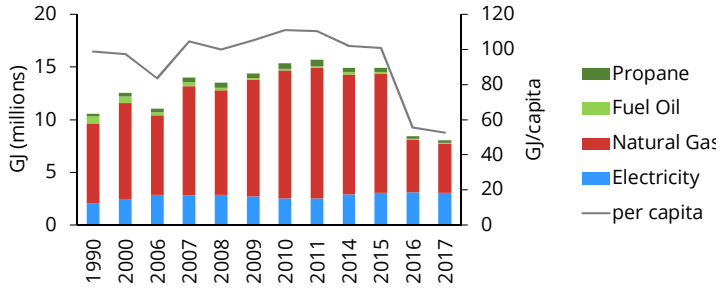
	Total Change	Change Per Capita
2006-2017	-4%	-16%
2015-2017	-2%	-5%

INDUSTRIAL/COMMERCIAL/INSTITUTIONAL

ICI emissions are generated in the operation of buildings, as well as by technologies used for commercial operations such as materials processing or manufacturing. Emissions can be produced from ICI processes themselves, however they are not covered in the scope of this inventory. The ICI sector accounted for 44% of total energy use in 2016 and 43% in 2017, dominated by natural gas (75% of energy usage for this sector in 2015). Natural gas consumption has been consistent in the low 11 million GJ range since 2014, but fell to 5 million GJ in 2016, and 4.6 million GJ in 2017. This drop translated into a reduction in GHG emissions from 630,045 tCO_2e in 2015 to 304,032 tCO_2e in 2016, and 287,683 tCO_2e in 2017. This reduction is one of the key factors for community wide reductions in 2016 and 2017.

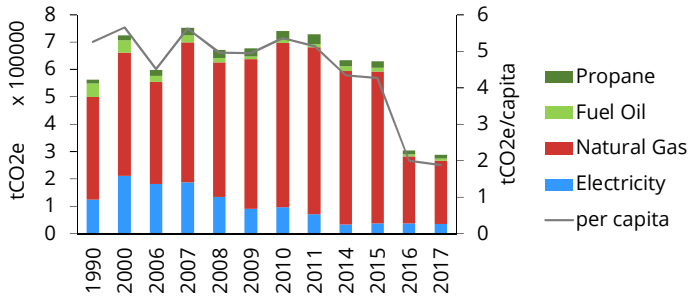
Figure 5. Annual energy consumption, emissions, and expenditures by fuel source for the ICI sector. Per capita amounts include post-secondary student population, noted in Appendix 2, Table 20.

Annual ICI Energy Consumption



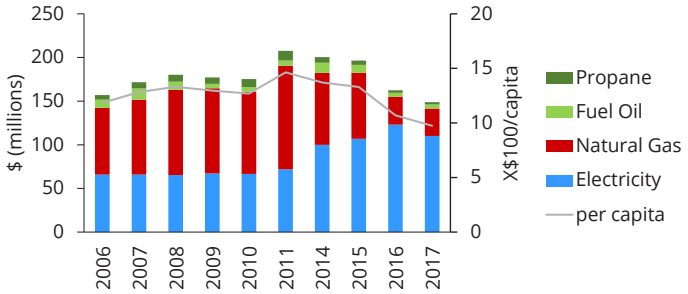
	Total Change	Change Per Capita
1990-2017	-24%	-47%
2000-2017	-36%	-46%
2015-2017	-46%	-48%

Annual ICI Emissions



	Total Change	Change Per Capita
1990-2017	-49%	-64%
2000-2017	-60%	-67%
2015-2017	-54%	-56%

Annual ICI Energy Expenditures



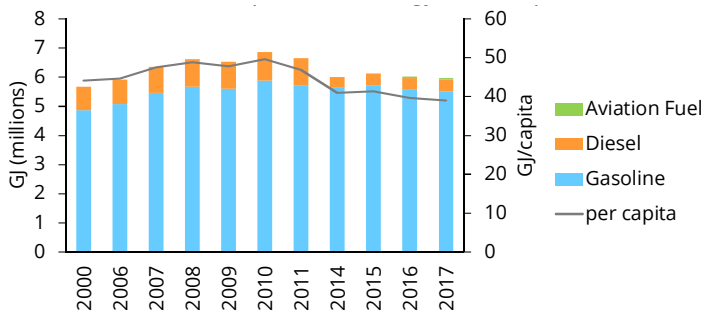
	Total Change	Change Per Capita
2006-2017	-5%	-18%
2015-2017	-24%	-27%

TRANSPORTATION

Transportation emissions are generated in the combustion of fossil fuels to power vehicles. In Kingston, nearly all vehicles use gasoline and diesel. The transportation sector accounted for 31% of energy, 36% of emissions, and 51% of energy expenditures for the City in 2016. Total energy consumption declined by 2% in 2016 over 2015 and again by 1% in 2017 over 2016, reflecting an ongoing downward trend that started in 2010. GHG emissions from transportation in 2017 were down to the lowest levels since 2010. Total expenditures on transportation totalled $169 and $184 million in 2016 and 2017 respectively.

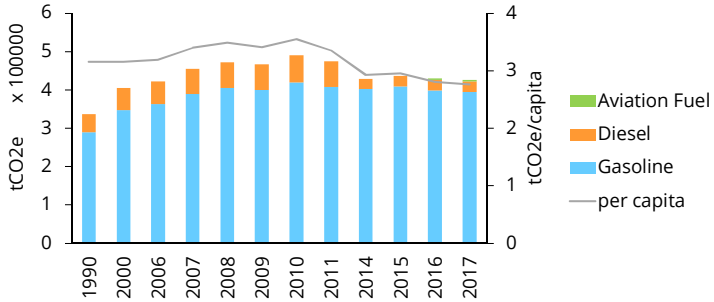
Figure 6. Annual energy consumption, emissions, and expenditures by fuel source for the transportation sector. Per capita amounts include post-secondary student population, noted in Appendix 2, Table 20.

Annual Transportation Energy Consumption



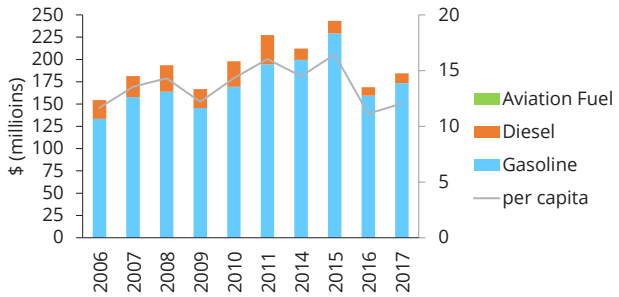
	Total Change	Change Per Capita
1990-2017	26%	-12%
2000-2017	5%	-12%
2015-2017	-3%	-6%

Annual Transportation Emissions



	Total Change	Change Per Capita
1990-2017	25%	-12%
2000-2017	4%	-12%
2015-2017	-3%	-7%

Annual Transportation Energy Expenditures



	Total Change	Change Per Capita
2006-2017	19%	4%
2015-2017	-24%	-27%

WASTE AND WASTEWATER

Solid waste generates emissions when it decomposes at landfills, is biologically treated, and/or incinerated. When landfilled, its organic components decompose with the help of bacteria, releasing CH_4 and CO_2 emissions. The extent of emissions associated with disposed solid waste will depend on the amount of solid waste disposed, the composition of the waste stream, the method through which it is treated, as well as whether the gases produced are recovered (known as 'landfill gas capture'). The City of Kingston's waste emissions calculation was based on 42,007 tonnes of residential waste in 2016, of which 60% is diverted from the landfill.

Wastewater emissions are generated from the decomposition of its organic content. Similar to solid waste, the extent of emissions will depend on the amount of waste produced, the amount of organic content within it, how the wastewater is treated, as well as the amount of gas capture and organic content removal that is undertaken in the treatment process. Wastewater emissions factors were calculated from flow volumes and organic content measurements from the City's wastewater treatment plants, noted in Appendix 2, Tables 11 and 15.

Due to lack of data availability and in order to apply a consistent approach, waste emissions for prior years were calculated based on the 2015 per capita value, and were updated for 2016 observed totals. In 2016, solid waste and wastewater accounted for 4% of the City's total GHG emissions. As previously noted, only residential waste was considered, and this amount would likely be higher if ICI waste were included.

AGRICULTURE AND FORESTS

Agriculture and forest represent a source of emissions and a sink to absorb emissions. Sources of emissions from this sector include deforestation, peatland drainage, livestock, and burning of biomass. Afforestation and crop management for soil sequestration absorb emissions.

Data used to calculate Agriculture, Forestry, and other Land Use (AFOLU) emissions was found in Statistics Canada Census of Agriculture CANSIM tables of livestock for the City of Kingston for 2016, with no major changes in farm activity assumed from 2016 to 2017.

Environment Canada's 2016 National Inventory Report was used to obtain emissions factors for livestock and croplands, and total area classified as woodland was obtained from the City of Kingston as shown in Schedule 8 of the Official Plan.

Carbon absorption from forests represented 7% in 2016-2017 as no major change was assumed during the years. The resulting net emissions from agriculture came to 229 tCO_2e in 2017, which represents 19% of total community emissions. Livestock emissions decreased by 17% from 2007 to 2017, from 12,820 tCO_2e to 9,784 tCO_2e, primarily owing to a decrease of 715 cattle.

Results by emissions source

The charts on the following pages show the changes in fuel and emissions sources for the City from 1990 to 2017. Natural gas usage accounted for the greatest amount of energy usage in 2016 and 2017. Because of the dramatic decrease in natural gas use in the ICI sector of Kingston in 2016- 2017, Gasoline became the most significant source of GHG emissions in both years.

Electricity and gasoline made up the larger majority of expenditures, accounting for 87% and 81% of the total in 2016 and 2017 respectively. Summaries of the total makeup for 2015, as well as changes from 2011 for each emission source are provided in the remainder of this section.

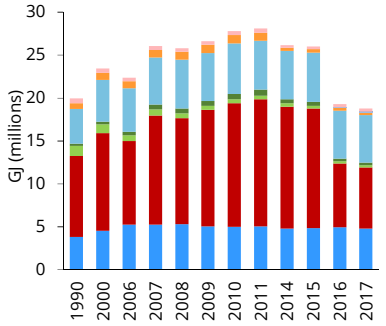
The decreasing emissions factor for electricity has played a major role in overall emissions reductions for the city. In 2017, total GHG emissions from electricity were 57,000 tCO_2e, while in 2000, GHG emissions from electricity were nearly 400,000 tCO_2e.

Kingston showed higher per capita emissions results from the other Ontario cities throughout the years 2000-2017. It is important to note that it is difficult, however, to draw meaningful comparisons between total reported emissions from one city to the next, due to the variability in contexts and scopes for their emissions and energy usages, and for the methodologies used to report them. Table 5 shows the different scopes covered by the different cities.

Population counts used for the 2017 inventory update were provided by the City of Kingston. Where no reported data was available, population totals were interpolated. City of Kingston estimated student population numbers were provided by the City's Planning, Building and Licensing Department, as noted in the 2011 inventory.

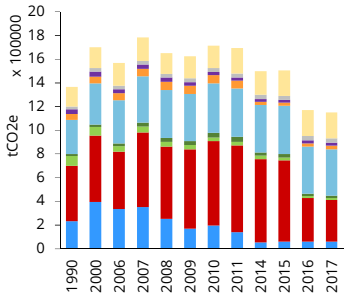
Figure 7. Aggregated and split apart annual energy consumption, emissions, and expenditures by emissions source. Aggregated emissions by source are highlighted, as an overall summary of the City's past and current emissions from 2000 to date.

Annual energy usage by emissions source (aggregated)

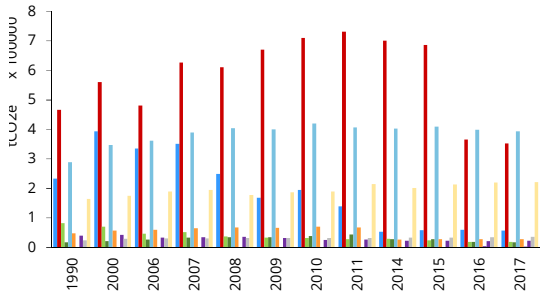


Annual energy usage by emissions source (individual)

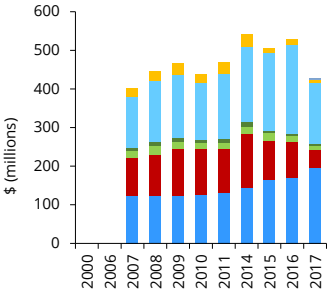
Annual emissions by source (aggregated)



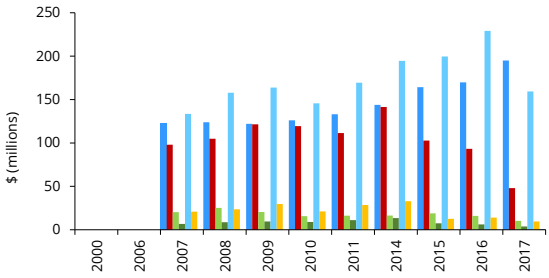
Annual emissions by source (individual)



Annual expenditures by source (aggregated)



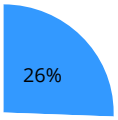
Annual expenditures by source (individual)



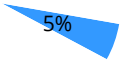
Electricity
Natural Gas
Fuel Oil
Propane
Gasoline
Diesel
Aviation Fuel
Wood

Electricity Portion of 2017 Total Energy Consumption

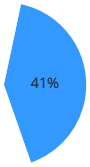
Energy Consumption
4.80 million GJ



Emissions
57,347 tCO_2e



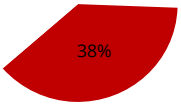
Expenditures
$174 million



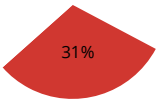
	Total Change	Per Capita	Total Change	Per Capita	Total Change	Per Capita
1990-2017	26%	-12%	-75%	-83%		
2000-2017	5%	-12%	-85%	-88%		
2015-2017	-2%	-5%	-2%	-5%	-13%	-26%

Natural Gas Portion of 2017 Total Energy Consumption

Energy Consumption
7.13 million GJ



Emissions
352, 106 tCO_2e

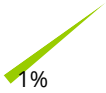


Expenditures
$48 million

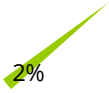
	Total Change	Per Capita	Total Change	Per Capita	Total Change	Per Capita
1990-2017	-25%	-47%	-25%	-47%		
2000-2017	-37%	-47%	-37%	-47%		
2015-2017	-49%	-50%	-49%	-50%	-49%	-50%

Fuel Oil Portion of 2017 Total Energy Consumption

Energy Consumption
0.51 million GJ



Emissions
36 ,000 tCO_2e

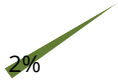


Expenditures
$11 million

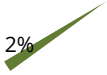
	Total Change	Per Capita	Total Change	Per Capita	Total Change	Per Capita
1990-2017	-78%	-85%	-78%	-85%		
2000-2017	-74%	-79%	-74%	-79%		
2015-2017	-26%	-29%	-26%	-29%	-32%	-34%

Propane Portion of 2017 Total Energy Consumption

Energy Consumption
0.31 million GJ



Emissions
19,034 tCO_2e

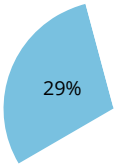


Expenditures
$4 million

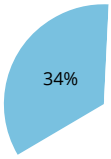
	Total Change	Per Capita	Total Change	Per Capita	Total Change	Per Capita
1990-2017	5%	-27%	5%	-27%		
2000-2017	-16%	-30%	-16%	-30%		
2015-2017	-37%	-39%	-37%	-39%	-42%	-44%

Gasoline Portion of 2017 Total Energy Consumption

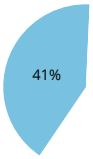
Energy Consumption
5.52 million GJ



Emissions
394,040 tCO_2e



Expenditures
$173 million



	Total Change	Per Capita	Total Change	Per Capita	Total Change	Per Capita
1990-2017	36%	-5%	36%	-5%		
2000-2017	13%	-5%	13%	-5%		
2015-2017	-4%	-7%	-4%	-7%	-24%	-27%

Diesel Portion of 2017 Total Energy Consumption

Energy Consumption
0.39 million GJ

Emissions
28,150 tCO_2e

Expenditures
$173 million

	Total Change	Per Capita	Total Change	Per Capita	Total Change	Per Capita
1990-2017	-41%	-59%	-41%	-59%		
2000-2017	-51%	-59%	-51%	-59%		
2015-2017	1%	-3%	1%	-3%	-22%	-25%

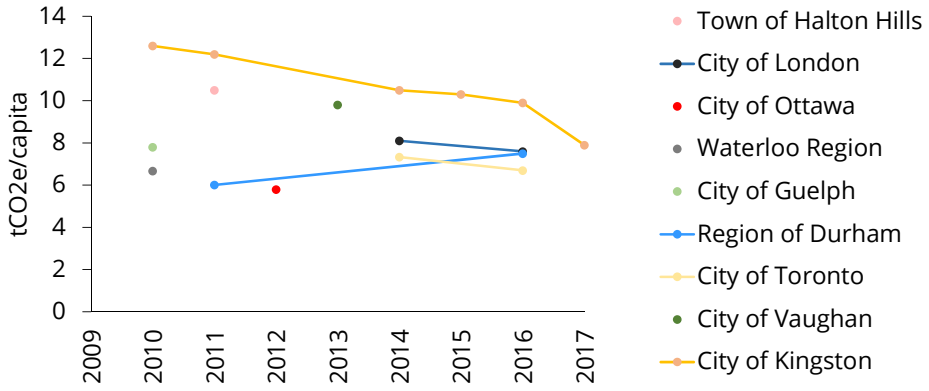
Other Components of 2017 Total Emissions Production

Wastewater	Residential Solid Waste	Aviation Fuel	Agriculture and Forests
Emissions 35,555 tCO_2e	**Emissions** 22,278 tCO_2e	**Emissions** 3,240	**Emissions** 220,902

	Total Change	Per Capita	Total Change	Per Capita	Total Change	Per Capita	Total Change	Per Capita
1990-2017	45%	1%	-44%	-59%	-	-	-	-
2000-2017	20%	1%	-47%	-59%	-	-	-	-
2015-2017	5%	1%	0%	-0.3%	-	-	-	-

Comparison with other cities

Figure 8. Total emissions per capita for nine cities in Ontario from 2010-2017.



Kingston has had higher per capita emissions results compared to other Ontario cities throughout the years 2000-2016. The 2017 emissions inventory data shows a steepening of a downward trend in per capita emissions. It is important to note that it is difficult, however, to draw meaningful comparisons between total reported emissions from one city to the next, due to the variability in contexts and scopes for their emissions and energy usages, and for the methodologies used to report them. Table 7 shows the different scopes covered by the different cities.

Table 7. Per capita emissions and scopes covered for nine Ontario cities' inventories.

Jurisdiction	tCO_2e/capita								Scope
	2010	2011	2012	2013	2014	2015	2016	2017	
City of Kingston	12.6	12.2			10.5	10.3	9.9	7.9	Buildings, industry, transportation, solid waste, wastewater
Town of Halton Hills		10.5							Buildings, industry, transportation, solid waste, wastewater, agriculture and forestry
City of London					8.1		7.6		Buildings, industry, transportation and solid waste
City of Ottawa			5.8						Buildings, transportation, solid waste, wastewater and agriculture
Waterloo Region	6.67								Buildings, industry, transportation, solid waste and agriculture
City of Guelph	7.8								Buildings, industry, transportation and solid waste
Region of Durham		6.01					7.5		Buildings, industry, transportation and solid waste
City of Toronto					7.33		6.7		Uncertain
City of Vaughan				9.8					Uncertain

APPENDIX 1: ASSUMPTIONS

Table 8. Energy conversion factors.

Energy type/ source	Amount	Unit	Source
Electricity	0.004	GJ/kWh	National Energy Board - https://www.neb-one.gc.ca/nrg/tl/cnvrsntbl/cnvrsntbl-eng.html#s1ss1
Natural Gas	0.039	GJ/m3	2014 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions, Table 1
Fuel Oil	0.039	GJ/L	2014 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions, Table 1
Propane	0.025	GJ/L	2014 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions, Table 1
Gasoline	0.035	GJ/L	2014 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions, Table 1
Diesel	0.038	GJ/L	2014 B.C. Best Practices Methodology for Quantifying Greenhouse Gas Emissions, Table 1

Table 9. Cost assumptions and their sources used in 2017 inventory calculations.

Energy type/ source	Cost	Unit	Source
Electricity	36.20	$/GJ	Ontario Energy Board, Electricity Yearbook
Natural Gas	0.26	$/m3	Utilities Kingston, Historical Natural Gas Rates
Fuel Oil	1.10	$/L	NRCan - Average retail price for furnace oil Kingston
Propane	0.49	$/L	NRCan - Average retail price for propane in Kingston, 2014 value was used, no 2017 reported amounts available at time of reporting
Gasoline	1.10	$/L	NRCan - Average retail price for regular gasoline Kingston
Diesel	1.07	$/L	NRCan - Average retail price for diesel Kingston

APPENDIX 2: INVENTORY INPUT DATA

2016

Table 10. 2016 Residential utility data.

Fuel Type	Usage	Units	Data sources
Electricity	505,954,000	kWh	HydroOne: (323,312,795) Utilities Kingston: (182,640,706)
Natural Gas	63,918,535	m3	Union Gas: (38,396,787) Utilities Kingston: (25,431,253)
Fuel Oil	146,000	L	Modelled data
Propane	70,000	L	Modelled data

Table 11. 2016 Industrial/Commercial/Institutional utility data.

Fuel Type	Usage	Units	Data sources
Electricity	867,667,000	kWh	HydroOne: 'Commercial' (155,404,162), 'Industrial' (180,882,084); Utilities Kingston: 'Commercial' (377,203,982), 'Industrial' (154,176,337)
Natural Gas	293,394,759	m3	'Union Gas & Utilities Kingston: 'Commercial' (19,714,346), 'Industrial' (219,610,228)
Fuel Oil	198,000	L	Modelled data
Propane	391,000	L	Modelled data

Table 12. 2016 Fuel usage data.

Fuel Type	Usage	Units	Data Source
Gasoline	159,388,533	L	Kent Group Ltd. fuel data
Diesel	9,996,016	L	Kent Group Ltd. fuel data

Table 13. 2016 Waste data.

Input	Amount	Units	Data Sources
Residential Waste	42,007	t	2011-2016 Resource Productivity and Resource Authority- Datacall
Wastewater	82,861	m3	Utilities Kingston, Cana: 90.6 m3/day
			Utilities Kingston, Cat Bay: 26,125 m3/day
			Utilities Kingston, Ravensview: 56,465 m3/day

Table 14. 2016 Agricultural Data

Input	Amount	Units	Data Source
Total agricultural land	9,462	ha	Census data
Percentage for local production	2%	%	Estimated
Mass of food consumed per year (per capita)	840	kg/yr	BC's food self reliance report, p2
Agricultural land-perennial cover (current yr)	4,512	ha	Census data
Agricultural land-till (current yr)	3,418	ha	Census data
Agricultural land-no till (current yr)	2,219	ha	Census data
Beef Cows	1,192	#	Census data
Dairy Cows	1,046	#	Census data
Forest: Absorption, Soil	12,067	ha	2006 Central Cataraqui Region Natural Heritage Study, EMP Annual report natural areas plus 35% of man-made green areas.

2017

Table 15. 2017 Residential utility data.

Fuel Type	Usage	Units	Data source(s)
Electricity	488,363,000	kWh	HydroOne: (309,816,227) Utilities Kingston: (178,546,332)
Natural Gas	63,963,149	m3	Union Gas (39,506,701) Utilities Kingston (24,367,337)
Fuel Oil	143,000	L	Modelled data
Propane	68,000	L	Modelled data

Table 16. 2017 Industrial/Commercial/Institutional utility data.

Fuel Type	Usage	Units	Data source(s)
Electricity	845,282,000	kWh	Utilities Kingston: 'Commercial' (361,859,676), 'Large User' (155,576,490) HydroOne: 'Commercial' (152,416,084), 'Industrial' (175,430,138)
Natural Gas	145,450,831	m3	Union Gas: 'Commercial' (20,554,403), 'Industrial' (65,946,420) Utilities Kingston: (45,177,253)
Fuel Oil	124,000	L	Modelled data
Propane	245,000	L	Modelled data

Table 17. 2017 Fuel usage data.

Fuel Type	Usage	Units	Data Source
Gasoline	157,616,173	L	Kent Group Ltd. fuel data
Diesel	10,236,464	L	Kent Group Ltd. fuel data

Table 18. 2017 Waste data.

Input	Amount	Units	Data Source
Residential Waste	42,283	t	2011-2016 Resource Productivity and Resource Authority- Datacall
Wastewater	116,477	m3	Utilities Kingston, Cana: 136.1 m3/day
			Utilities Kingston , Cat Bay: 30,041 m3/day
			Utilities Kingston , Ravensview: 86,300 m3/day

Table 19. 2017 Agricultural Data (Agricultural data for 2017 held constant from 2016 due to lack of data availability)

Input	Amount	Units	Data Source
Total agricultural land	9,462	ha	Census data
Percentage for local production	2%	%	Estimated
Mass of food consumed per year (per capita)	840	kg/yr	BC's food self reliance report, p2
Agricultural land-perennial cover (current yr)	4,512	ha	Census data
Agricultural land-till (current yr)	3,418	ha	Census data
Agricultural land-no till (current yr)	2,219	ha	Census data
Beef Cows	1,192	#	Census data
Dairy Cows	1,046	#	Census data
Forest: Absorption, Soil	12,067	ha	2006 Central Cataraqui Region Natural Heritage Study, EMP Annual report natural areas plus 35% of man-made green areas.

Table 20. Population counts and sources used for the 2017 inventory update. Where no reported data was available, population totals were interpolated. City of Kingston estimated student population numbers were provided by the City's Planning Department, as noted in the 2011 inventory.

Year	Census population	Interpolated population	City of Kingston population report	City of Kingston estimated student population	Interpolated student population	Total
1990		106,889				
2000		113,590		14,785		128,375
2001	114,195			14,864		129,059
2002		118,437				
2003		119,682				
2004		120,939				
2005		122,210				
2006	117,206			15,256		132,462
2007		118,437		15,416		133,853
2008		119,682		15,578		135,260
2009		120,939		15,742		136,681
2010		122,210		15,907		138,117
2011	123,363			18,460		141,823
2012		124,670			18,656	143,326
2013		125,978			18,851	144,829
2014			127,286		19,047	146,333
2015			128,578		19,240	147,818
2016	123,798			28,918		151,804
2017		123,885		28,918		152,803

APPENDIX 3: INVENTORY RESULTS

2016 Inventory

BY SECTOR

RESIDENTIAL

Fuel Type	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Electricity	1.821	21.756	71.82
Natural Gas	2.473	122.039	15.96
Fuel Oil	0.146	10.342	5.65
Propane	0.070	4.225	0.90
Wood	0.330		
TOTAL	**4.839**	**158.363**	**94.33**

INSTITUTIONAL/COMMERCIAL/INDUSTRIAL

Fuel Type	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Electricity	3.124	37.31	123.17
Natural Gas	4.952	244.391	31.95
Fuel Oil	0.117	8.309	4.54
Propane	0.231	14.023	2.86
TOTAL	**8.423**	**304.032**	**162.53**

TRANSPORTATION

Fuel Type	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Gasoline	5.579	398.471	159.39
Diesel	0.383	27.489	9.50
Aviation Fuel	0.060	3.725	0.08
TOTAL	**6.022**	**429.685**	**168.96**

AGRICULTURE/FORESTS

	kgCO2e (millions)
Food	227.717
Livestock	9.784
Forests	- 18.101
TOTAL	**219.400**

WASTE

	kgCO2e (millions)
Residential Waste	22.132
Wastewater	35.240
TOTAL	**57.372**

2016 TOTAL BY SECTOR

Sector	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Residential	4.839	158.363	94.33
ICI	8.423	304.032	162.53
Transportation	6.022	425.960	168.88
Aviation		3.725	
Waste		57.372	
Agriculture/Forests		219.400	
TOTAL	**19.284**	**1,168.853**	**426**

2016 PROPORTIONS BY SECTOR

Sector	GJ (millions)	kgCO2e (millions)	Expenditures ($)
Residential	25%	14%	22%
ICI	44%	26%	38%
Transportation	31%	36%	40%
Aviation	0%	0%	0%
Waste	0%	5%	0%
Ag & Forests	0%	19%	0%

BY FUEL TYPE

2016 TOTAL BY EMISSIONS SOURCE

Fuel Type	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Electricity	4.945	59.066	194.99
Natural Gas	7.424	366.430	47.91
Fuel Oil	.263	18.651	10.19
Propane	.300	18.248	3.76
Gasoline	5.579	398.471	159.39
Diesel	.383	27.489	9.50
Fuel for Aviation	.060	3.725	0.08
Wood	0.330	-	-
Solid Waste	-	22.132	-
Wastewater	-	35.240	-
Agriculture/Forests	-	219.400	-
Total	**19.284**	**1,168.853**	**426**

2016 PROPORTIONS BY EMISSIONS SOURCE

Fuel Type	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Electricity	26%	5%	46%
Natural Gas	39%	31%	11%
Fuel Oil	1%	2%	2%
Propane	2%	2%	1%
Gasoline	29%	34%	37%
Diesel	2%	2%	2%
Fuel for Aviation	0%	0%	0%
Wood	2%	0%	0%
Solid Waste	0%	2%	0%
Wastewater	0%	3%	0%
Agriculture/Forests	0%	19%	0%

2017 Inventory

BY SECTOR

RESIDENTIAL

Fuel Type	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Electricity	1.758	21.000	63.65
Natural Gas	2.474	122.128	16.61
Fuel Oil	0.143	10.124	6.09
Propane	0.068	4.136	0.84
Wood	0.323		
TOTAL	**4.766**	**157.387**	**87.18**

INSTITUTIONAL/COMMERCIAL/INDUSTRIAL

Fuel Type	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Electricity	3.043	36.347	110.16
Natural Gas	4.660	229.978	31.27
Fuel Oil	0.112	7.946	4.78
Propane	0.221	13.411	2.74
TOTAL	**8.035**	**287.683**	**148.95**

TRANSPORTATION

Fuel Type	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Gasoline	5.517	394.040	173.38
Diesel	0.392	28.150	10.95
Aviation Fuel	0.052	3.240	0.07
TOTAL	**5.961**	**425.431**	**184.40**

AGRICULTURE/FORESTS

	kgCO2e (millions)
Food	229.219
Livestock	9.784
Forests	- 18.101
TOTAL	**220.902**

WASTE

	kgCO2e (millions)
Residential Was te	22.278
Wastewater	35.555
TOTAL	**57.833**

2017 TOTAL BY SECTOR

Sector	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Residential	4.766	157.387	87.18
ICI	8.035	287.683	148.95
Transportation	5.961	422.191	184.33
Aviation		3.240	
Waste		57.833	
Ag & Forests		220.902	
TOTAL	**18.763**	**1,149.237**	**420**

2017 PROPORTIONS BY SECTOR

Sector	GJ (millions)	kgCO2e (millions)	Expenditures ($)
Residential	25%	14%	21%
ICI	43%	25%	35%
Transportation	32%	37%	44%
Aviation	0%	0%	0%
Waste	0%	5%	0%
Ag & Forests	0%	19%	0%

BY FUEL TYPE

2017 TOTAL BY EMISSIONS SOURCE

Fuel Type	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Electricity	4.801	57.347	173.81
Natural Gas	7.134	352.106	47.88
Fuel Oil	0.254	18.070	10.86
Propane	0.289	17.547	3.58
Gasoline	5.517	394.040	173.38
Diesel	0.392	28.150	10.95
Fuel for Aviation	0.052	3.240	0.07
Wood	0.323	-	-
Solid Waste	-	22.278	-
Wastewater	-	35.555	-
Agriculture/Forests	-	220.902	-
Total	**18.763**	**1,149.237**	**421**

2017 PROPORTIONS BY EMISSIONS SOURCE

Fuel Type	GJ (millions)	kgCO2e (millions)	Expenditures ($ millions)
Electricity	26%	5%	41%
Natural Gas	38%	31%	11%
Fuel Oil	1%	2%	3%
Propane	2%	2%	1%
Gasoline	29%	34%	41%
Diesel	2%	2%	3%
Fuel for Aviation	0%	0%	0%
Wood	2%	0%	0%
Solid Waste	0%	2%	0%
Wastewater	0%	3%	0%
Agriculture/Forests	0%	19%	0%

APPENDIX 4: UPDATED 1990-2017 DATABASE

BY SECTOR												
Fuel Type	**1990**	**2000**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2014**	**2015**	**2016**	**2017**
RESIDENTIAL GJ (millions)												
Electricity	1.765	2.120	2.420	2.470	2.460	2.350	2.500	2.520	1.878	1.808	1.821	1.758
Natural Gas	1.848	2.220	2.150	2.330	2.420	2.490	2.230	2.400	2.811	2.634	2.473	2.478
Fuel Oil	0.465	0.356	0.354	0.350	0.292	0.318	0.307	0.254	0.169	0.149	0.146	0.143
Propane	0.058	0.052	0.090	0.103	0.106	0.098	0.102	0.122	0.075	0.0071	0.070	0.068
TOTAL	4.679	5.246	5.425	5.670	5.697	5.681	5.613	5.792	5.250	4.998	4.843	4.770
RESIDENTIAL $kgCO_2e$ (millions)												
Electricity	107.872	182.556	154.611	164.667	116.167	78.333	97.222	70.000	20.868	21.594	21.756	21.000
Natural Gas	91.230	109.568	106.113	114.997	119.439	122.894	110.061	118.452	138.748	129.985	122.039	122.128
Fuel Oil	33.002	25.258	25.147	24.845	20.720	22.599	21.834	18.030	11.988	10.554	10.342	10.124
Propane	3.531	3.177	5.473	6.267	6.462	5.968	6.211	7.437	4.529	4.312	4.225	4.136
TOTAL	235.635	320.559	291.344	310.776	262.787	229.794	235.329	213.919	176.133	166.445	158.363	157.387
RESIDENTIAL Expenditures (millions $)												
Electricity	-	-	56	58	57	59	66	72	64	63	72	64
Natural Gas	-	-	22	19	24	22	17	23	20.32	17.68	15.96	16.61
Fuel Oil	-	-	11	12	11	11	11	10	7	7	6	6
Propane	-	-	1	2	2	2	2	2	1	1	1	1
TOTAL	-	-	90	91	93	93	96	108	93	89	94	87
INSTITUTIONAL/COMMERCIAL/INDUSTRIAL GJ (millions)												
Electricity	2.040	2.450	2.830	2.810	2.830	2.690	2.510	2.520	2.921	3.069	3.124	3.043
Natural Gas	7.610	9.140	7.590	10.370	9.970	11.110	12.160	12.410	11.398	11.264	4.952	4.660
Fuel Oil	0.686	0.639	0.302	0.373	0.240	0.147	0.147	0.145	0.235	0.196	0.117	0.112
Propane	0.218	0.293	0.338	0.455	0.469	0.462	0.526	0.597	0.381	0.387	0.231	0.221
TOTAL	10.554	12.522	11.060	14.008	13.509	14.409	15.342	15.671	14.935	14.916	8.423	8.035
INSTITUTIONAL/COMMERCIAL/INDUSTRIAL $kgCO_2e$ (millions)												
Electricity	124,663	210,972	180,806	187,333	133,639	89,667	97,611	70,000	32,457	36,660	37,310	36,347
Natural Gas	375,603	451,104	374,604	511,811	492,069	548,333	600,156	612,495	562,528	555,931	244,391	229,978
Fuel Oil	48,704	45,385	21,440	26,462	17,075	10,452	10,425	10,264	16,708	13,935	8,309	7,946
Propane	13,249	17,802	20,518	27,654	28,489	28,091	31,951	36,279	23,180	23,519	14,023	13,411
TOTAL	562,220	725,264	597,368	753,260	671,271	676,542	740,143	729,037	634,873	630,045	304,032	287,683
INSTITUTIONAL/COMMERCIAL/INDUSTRIAL Expenditures ($ millions)												
Electricity	-	-	66	66	65	67	67	72	100	107	123	110
Natural Gas	-	-	76	86	98	98	94	119	82	76	32	31
Fuel Oil	-	-	9	13	9	5	5	6	12	9	5	5
Propane	-	-	5	7	8	7	9	11	6	5	3	3
TOTAL	-	-	157	172	180	177	175	208	201	197	163	149

BY SECTOR (continued)												
Fuel Type	**1990**	**2000**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2014**	**2015**	**2016**	**2017**
TRANSPORTATION GJ (millions)												
Gasoline	4,051	4,865	5,075	5,460	5,670	5,600	5,880	5,705	5,633	5,728	5,579	5,517
Diesel	670	805	839	902	940	925	977	945	368	390	383	392
Aviation Fuel	-	-	-	-	-	-	-	-	-	-	60	52
TOTAL	4,721	5,670	5,914	6,362	6,610	6,525	6,857	6,650	6,001	6,118	6,022	5,961
TRANSPORTATION $kgCO_2e$ (millions)												
Gasoline	289,339	347,500	362,500	390,000	405,000	400,000	420,000	407,500	402,377	409,176	398,471	394,040
Diesel	48,099	57,768	60,215	64,786	67,508	66,448	70,166	67,852	26,426	27,995	27,489	28,150
Aviation Fuel	-	-	-	-	-	-	-	-	-	-	3,725	3,240
TOTAL	337,438	405,268	422,715	454,786	472,508	466,448	490,166	475,352	428,803	437,172	425,960	422,191
TRANSPORTATION Expenditures ($ millions)												
Gasoline	-	-	133	158	164	146	169	195	200	229	159	173
Diesel	-	-	21	24	30	21	29	33	13	14	9	11
Aviation Fuel	-	-	-	-	-	-	-	-	-	-	.1	.1
TOTAL	-	-	154	181	194	167	198	227	212	243	169	184
WASTE $kgCO_2e$ (millions)												
Residential Waste	39,594	41,740	33,810	34,786	36,020	32,262	25,416	26,539	22,895	22,210	22,132	22,278
Wastewater	24,579	29,519	30,459	30,779	31,102	31,429	31,759	32,611	33,648	33,990	35,240	35,555
TOTAL	64,172	71,259	64,269	65,565	67,122	63,691	57,175	59,150	56,543	56,200	57,372	57,833
AGRICULTURE AND FORESTS $kgCO_2e$ (millions)												
Food	160,095	193,025	199,170	200,686	203,377	205,514	207,673	212,693	220,026	222,259	227,717	229,219
Livestock	9,315	-	-	12,820	-	-	-	11,871	-	-	9,784	9,784
Forests	-18,101	-18,101	-18,101	-18,101	-18,101	-18,101	-18,101	-18,101	-18,101	-18,101	-18,101	-18,101
TOTAL	164,032	174,924	188,868	195,406	177,477	187,413	189,572	214,602	201,926	213,960	219,400	220,902

SECTORAL TOTALS

Sector	1990	2000	2006	2007	2008	2009	2010	2011	2014	2015	2016	2017
TOTAL GJ (millions)												
Residential	4,679	5,246	5,425	5,670	5,697	5,681	5,613	5,792	5,250	4,998	4,839	4,766
ICI	10,554	12,522	11,060	14,008	13,509	14,409	15,342	15,671	14,935	14,916	8,423	8,035
Transportation	4,721	5,670	5,914	6,362	6,610	6,525	6,857	6,650	6,001	6,118	6,022	5,961
TOTAL	19,954	23,437	22,398	26,040	25,816	26,616	27,813	28,113	26,187	26,033	19,284	18,763
TOTAL $kgCO_2e$ (millions)												
Residential	235,635	320,559	291,344	310,776	262,787	229,794	235,329	213,919	176,133	166,445	158,363	157,387
ICI	562,220	725,264	597,368	753,260	671,271	676,542	740,143	729,037	634,873	630,045	304,032	287,683
Transportation	337,438	405,268	422,715	454,786	472,508	466,448	490,166	475,352	428,803	437,172	425,960	422,191
Aviation	-	-	-	-	-	-	-	-	-	-	3,725	3,240
Waste	64,172	71,259	64,269	65,565	67,122	63,691	57,175	59,150	56,543	56,200	57,372	57,833
Agriculture/ forests	164,032	174,924	188,868	195,406	177,477	187,413	189,572	214,602	201,926	213,960	219,400	220,902
TOTAL	1,363,497	1,697,273	1,564,564	1,779,793	1,651,166	1,623,890	1,712,386	1,692,062	1,498,278	1,503,822	1,168,853	1,149,237
TOTAL Expenditures ($ millions)												
Residential	-	-	90	91	93	93	96	108	93	89	94	87
ICI	-	-	157	172	180	177	175	208	201	197	163	149
Transportation	-	-	154	181	194	167	198	227	212	243	169	184
TOTAL	-	-	402	444	467	437	470	543	505	528	426	420

BY FUEL TYPE												
Fuel Type	1990	2000	2006	2007	2008	2009	2010	2011	2014	2015	2016	2017
1990-2017 Energy consumption by emissions source (million GJ)												
Electricity	3,805	4,570	5,250	5,280	5,290	5,040	5,010	5,040	4,799	4,877	4,945	4,801
Natural Gas	9,459	11,360	9,740	12,700	12,390	13,600	14,390	14,810	14,209	13,898	7,424	7,134
Fuel Oil	1,151	995	656	723	532	465	454	398	404	345	263	254
Propane	276	345	428	558	575	560	628	719	456	458	300	289
Gasoline	4,051	4,865	5,075	5,460	5,670	5,600	5,880	5,705	5,633	5,728	5,579	5,517
Diesel	670	805	839	902	940	925	977	945	368	390	383	392
Aviation Fuel	-	-	-	-	-	-	-	-	-	-	60	52
Wood	543	498	411	417	419	425	473	495	317	337	330	323
TOTAL	19,954	23,437	22,398	26,040	25,816	26,616	27,813	28,113	26,187	26,033	19,284	18,763
1990-2017 Emissions by emissions source (million kgCO2e)												
Electricity	232,536	393,528	335,417	352,000	249,806	168,000	194,833	140,000	53,325	58,254	59,066	57,347
Natural Gas	466,833	560,672	480,717	626,808	611,508	671,227	710,217	730,947	701,277	685,916	366,430	352,106
Fuel Oil	81,706	70,643	46,587	51,308	37,795	33,051	32,259	28,294	28,695	24,490	18,651	18,070
Propane	16,781	20,979	25,992	33,921	34,951	34,059	38,162	43,716	27,709	27,831	18,248	17,547
Gasoline	289,339	347,500	362,500	390,000	405,000	400,000	420,000	407,500	402,377	409,176	398,471	394,040
Diesel	48,099	57,768	60,215	64,786	67,508	66,448	70,166	67,852	26,426	27,995	27,489	28,150
Aviation Fuel	0	0	0	0	0	0	0	0	0	0	3,725	3,240
Residential Waste	39,594	41,740	33,810	34,786	36,020	32,262	25,416	26,539	22,895	22,210	22,132	22,278
Wastewater	24,579	29,519	30,459	30,779	31,102	31,429	31,759	32,611	33,648	33,990	35,240	35,555
Agriculture/ Forests	164,032	174,924	188,868	195,406	177,477	187,413	189,572	214,602	201,926	213,960	219,400	220,902
TOTAL	1,363,497	1,697,273	1,564,564	1,779,793	1,651,166	1,623,890	1,712,386	1,692,062	1,498,278	1,503,822	1,168,853	1,149,237

BY FUEL TYPE												
Fuel Type	1990	2000	2006	2007	2008	2009	2010	2011	2014	2015	2016	2017
1990-2017 Expenditures by emissions source ($ million)												
Electricity	-	-	122	124	122	126	133	144	164	170	195	174
Natural Gas	-	-	98	105	122	119	111	141	103	93	48	48
Fuel Oil	-	-	20	25	20	16	16	16	19	16	10	11
Propane	-	-	7	9	10	9	11	13	7	6	4	4
Gasoline	-	-	133	158	164	146	169	195	200	229	159	173
Diesel	-	-	21	24	30	21	29	33	13	14	9	11
Aviation Fuel	-	-	0	0	0	0	0	0	0	0.0	0.1	0.1
Total	-	-	402	444	467	437	470	543	505	528	426	420

ENERGY SOURCE COSTS

Energy type/ source	Unit	1990	2000	2006	2007	2008	2009	2010	2011	2014	2015	2016	2017
Electricity	$/GJ		23.30	23.30	23.47	23.07	25.01	26.55	28.55	34.23	34.81	39.43	36.20
Natural Gas	$/m3	-	-	0.39	0.32	0.38	0.34	0.30	0.37	0.28	0.26	0.25	0.26
Fuel Oil	$/L	-	-	0.80	0.90	0.99	0.87	0.92	1.06	1.28	1.19	1.00	1.10
Propane	$/L	-	-	0.62	0.62	0.66	0.63	0.70	0.74	0.67	0.67	0.51	0.49
Gasoline	$/L	-	-	0.92	1.01	1.01	0.91	1.01	1.19	1.24	1.40	1.00	1.10
Diesel	$/L	-	-	0.95	1.00	1.21	0.88	1.12	1.33	1.31	1.38	0.95	1.07
Aviation fuel	$/L	-	-									0.05	0.05

EMISSIONS FACTORS

Energy type/ source	Unit	1990	2000	2006	2007	2008	2009	2010	2011	2014	2015	2016	2017
Electricity	$kgCO_2e$/kwh	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60	3.60
Natural Gas	$kgCO_2e$/m3	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Fuel Oil	$kgCO_2e$/L	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Propane	$kgCO_2e$/L	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Gasoline	$kgCO_2e$/L	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Diesel	$kgCO_2e$/L	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Aviation fuel	$kgCO_2e$/L	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

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Kingston Climate Action

PREPARED BY:

SSG SUSTAINABILITY SOLUTIONS GROUP