Appendix A – GHG Inventory Summary

1.0 INTRODUCTION

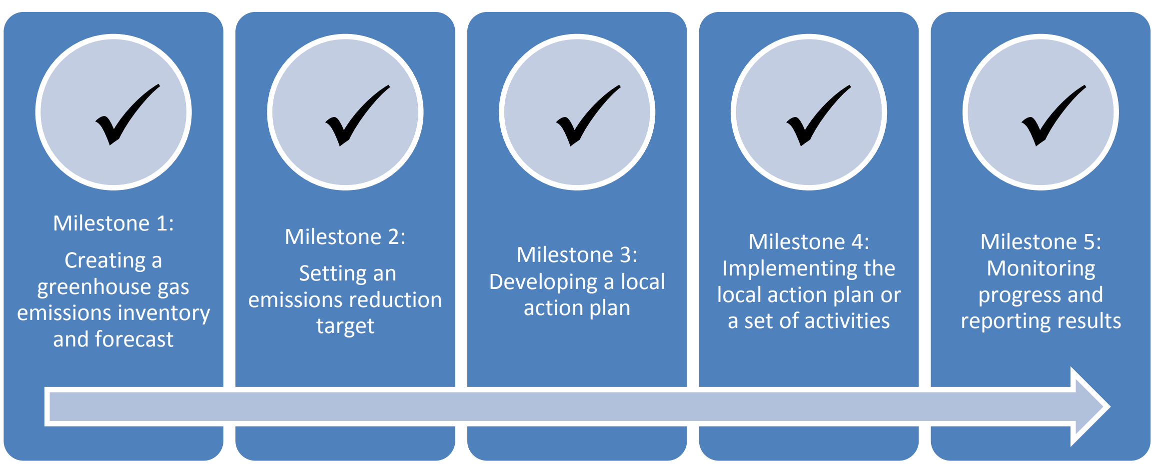
The purpose of this document is to present the 2012 community and corporate GHG inventory results; and to identify factors that led to changes since 2004 and 2008.

2.0 BACKGROUND

The City of Ottawa is a member of the *Partners for Climate Protection* (PCP) program of the Federation of Canadian Municipalities (FCM). The PCP is a network of Canadian municipalities committed to reducing GHG emissions and acting on climate change. The partnership currently has 240 municipal members, accounting for over 80% of the Canadian population.[1]

The PCP program comprises five “milestones” used to guide municipalities to reduce their GHG emissions. As illustrated in Figure 1, both Milestones 1 and 5 require municipalities to inventory and monitor GHG emissions. In 2012, the City reached Milestone 5 and became one of only 21 municipalities to have completed all five steps.

Figure 1: PCP Program Milestone Framework



3.0 VARIABLES AFFECTING GHG EMISSIONS

GHG emissions and air quality are directly related to how much energy we consume, which is a function of many variables including the following:

- Population – Everyone is a consumer of energy. As the population of a community grows, so does energy demand unless people reduce their individual usage.
- Weather – Summer and winter temperatures place pressure on heating and cooling systems. Years with high snow fall increase vehicle gas consumption and snow removal requirements. Hot humid summers place pressures on the electricity grid.
- Power generation methodologies – In 2014, Ontario Power Generation closed the last of the province's coal-fired electricity generating plants. More than any other action, the phase-out of coal power generation has reduced GHG emissions in Ontario, and by extension emission calculations for Ottawa.
- Regulatory changes – For example, changes in building codes and electrical standards can significantly reduce the demand for energy by requiring the construction of efficient buildings and installation of efficient fixtures; and, the requirement for waste recycling can reduce the volume going to landfill and consequent methane emissions.
- Technological changes – Regulatory change can drive technological improvements, and technological changes can drive the need for regulatory change. With the advent of the automobile came increased personal vehicle use, increased fuel consumption, and ultimately regulations governing vehicle emissions. Advancements in solar photovoltaic and other renewable energy supplies have the potential to further reduce GHG emissions per kWh consumed, and Ontario's new Energy Plan directs that these new technologies be used. In a similar vein, reduced demand for electricity to power inefficient vacuum tube technologies has been offset by the pervasive use of modern electronic devices by a growing population.
- Energy availability and price – How much energy we use is a function of how much we must buy to meet our basic needs, and how much we can afford to buy to meet our wants. In Ontario, electricity prices are regulated to ensure that people of limited financial means can afford their basic needs; but are also set to discourage peak usage. Vehicle fuels are subject to a gas tax that discourages waste, and that can be used to fund transit systems.
- Consumer behaviours – Individual energy use and GHG emissions are a function of how we drive and care for our vehicles; the model of appliances we purchase; the degree to which our homes are well insulated and sealed; and any number of other consumer behaviours and decisions.

Most of these variables are NOT considered by the GHG model, which necessarily simplifies these and other factors to a few key variables. Community GHG emissions, in particular, are general approximations that are used to provide order of magnitude results for gross trend analysis.

3.1 Population Growth

Between 2004 and 2012, Ottawa's population increased by roughly 86,000 people or 10%.

3.2 Weather

Figure 2 and 3 illustrate differences in temperature and snow fall between 2004, 2008, and 2012. Of note:

- The year 2008 saw significantly higher than average snowfall in February and March, which experienced 92.4 cm and 97.4 cm, respectively (compared to an average of 34.7 cm and 29.1 cm, respectively.)
- The average daily High temperature during July and August 2012 was 4°C above those experienced in 2004 and 2008; and the average daily Low temperatures in January 2004 was 6 and 8 degrees colder than in 2012 and 2008, respectively.
- Following a mild winter and low rainfall in 2012, level one and two droughts were declared for the Rideau River watershed whereby residents were asked to voluntarily cut their water consumption by 20%.[2] The lower rainfall also had an impact on the local agricultural section including livestock operations.[3]

Figure 2: Minimum (Nov-April) and Max Day (May-October) Avg. Temperatures (°C)

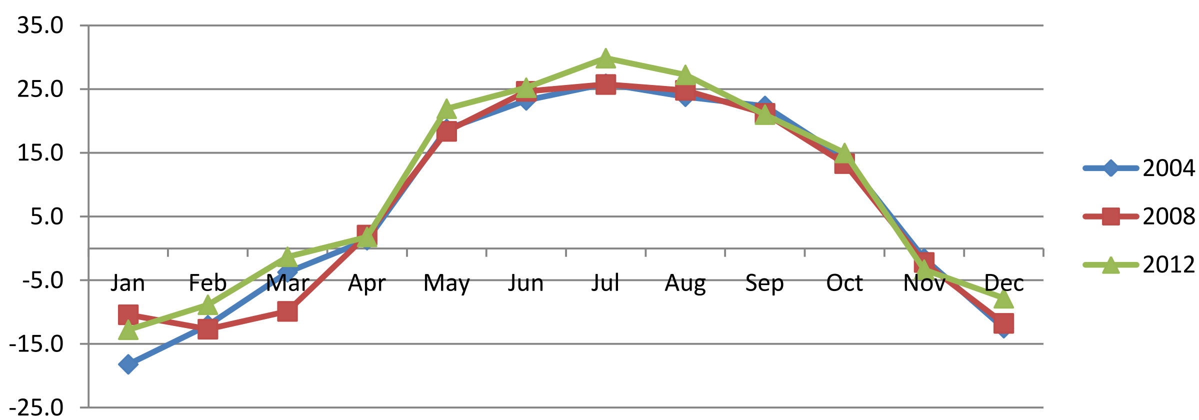
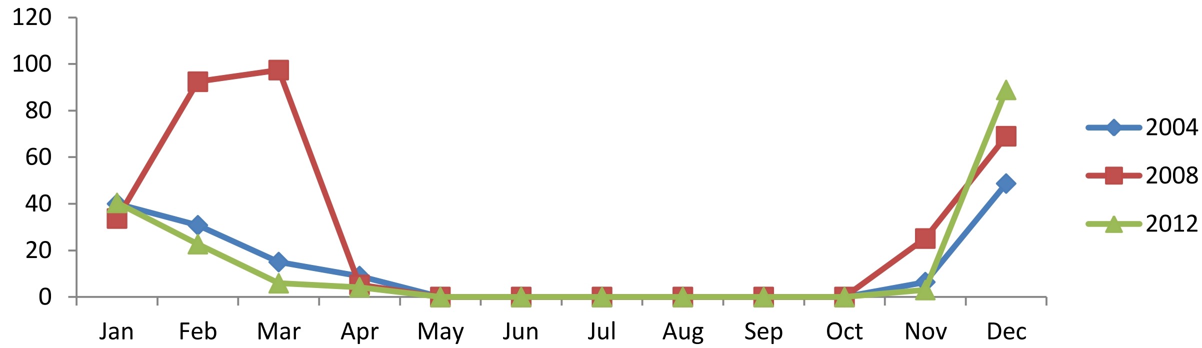


Figure 3: Total Snowfall (cm)



4.0 METHODOLOGY

GHG inventories carried out under the PCP program use the methodology established by ICLEI (www.iclei.org) and the protocols recommended by the Intergovernmental Panel on Climate Change and the World Resource Institute. The Canadian Standards Association (CSA) was contracted by the City to complete the 2012 inventory, and updated the 2004 and 2008 solid waste results based upon more current data and changes made to the reporting methodology. (Inventories are undertaken using the best available information at the time and may be revised subsequently if better data becomes available or improvements are made to GHG emissions modeling and analysis.)

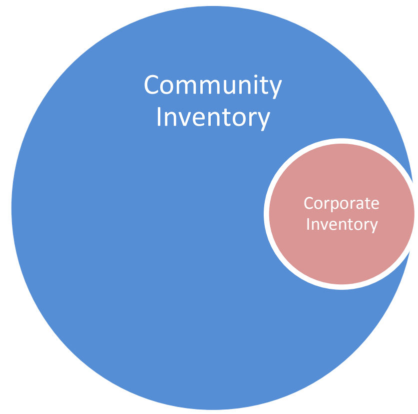
Generally speaking, the approach used to calculate GHG emissions is the following:

- Within each sector (e.g. buildings, transportation), identify the primary sources and quantity of energy consumed (e.g. kWh of electricity, litres of heating oil) or gases generated (e.g. m^3 of methane);
- Apply an emissions factor to each fuel type (different combustion processes yield different gases in varying quantities (i.e. tonnes of CH_4, CO_2, and N_2O));
- Apply a global warming factor that identifies the magnitude of impact of those emissions have on the atmosphere as measured in CO_2e[4]; and
- Sum the emission equivalents within each sector; and then across all sectors to yield the community or corporate results.

The inventory is divided into two categories for analysis: corporate and community emissions. **Corporate** emissions are defined as all emissions under the direct operational control of the City and include emissions from facilities, fleet (transit, municipal, and police), solid waste, and wastewater treatment. Most data used to calculate corporate emissions come from municipal sources.

Community emissions are attributed to Ottawa as a whole and include emissions from buildings, transportation, solid waste, wastewater, and agricultural sources. Data used to calculate community emissions come from a variety of sources including City departments, Statistics Canada, and Natural Resources Canada.

Figure 4 - Inventory



As shown in Figure 4, the community inventory includes the corporate emissions since it comprises all activities within the community. Therefore, the corporate and community inventories are NOT to be added.

At noted previously, while community emissions are dependent on the choices that Ottawa residents make and can be influenced by the policies and programs of the City, the model is not that robust, and uses limited locally generated data.

Community GHG emission results are largely derived by applying provincial and federal metrics on a pro-rated basis to Ottawa and do NOT reflect actual energy consumption and emissions in Ottawa. While these data sources are the best available at this time, they lack the accuracy and subtleties that could be captured by using local data. As importantly, the current methodology limits the ability of the City to assess the impact of local programs and actions on community emissions. For this reason, it is recommended that the methodology be revised for the next round of emission calculations. By comparison, **Corporate** emissions were calculated using actual energy consumption or site-specific derived approximations, and yield more accurate GHG emissions results. That said, none of the results are exact as the methodology is continuously changing and improving and as a result, the final figures are only accurate in terms of their order of magnitude.

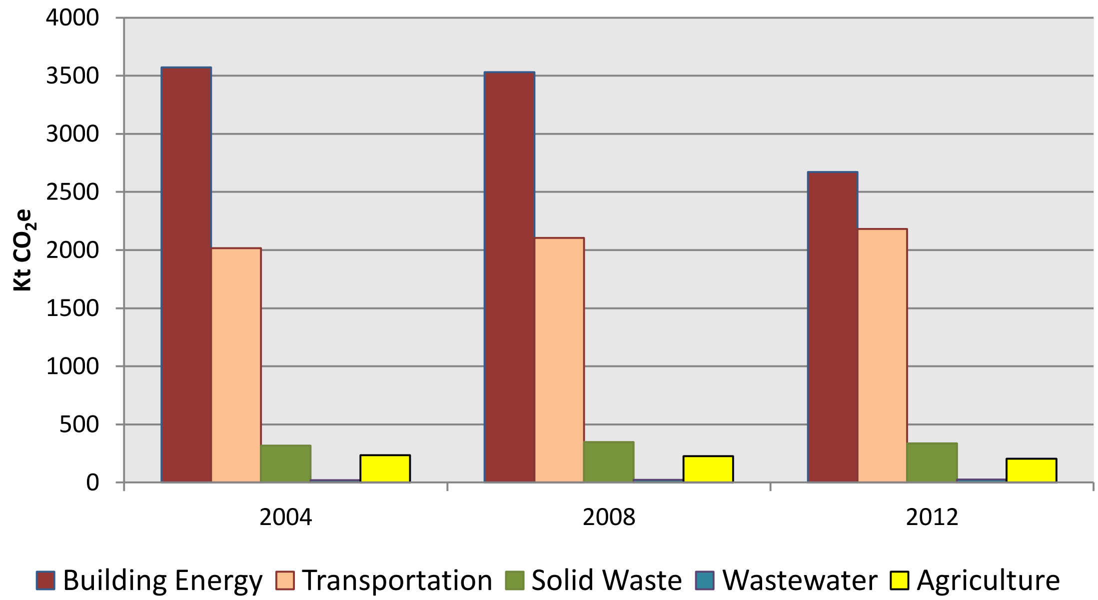
5.0 RESULTS

Due to the simplicity of the GHG emissions model, all Community results are rounded to the nearest kilotonne (kt.) Emissions are quoted in “CO_2e” or equivalent CO_2.

5.1 Overall Results

Figure 5 and Table 1 contain Community emissions by sector for the years 2004, 2008, and 2012 and show that, since 2004, community emissions have declined in the order of 12%. The greatest decrease occurred in emissions arising from the heating and cooling of buildings; and the greatest increase was in transportation emissions.

Figure 5: Community GHG Inventory Results



The drop in building emissions is largely due to the province's phase-out of coal powered electricity generation. Between 2008 and 2012, building emissions dropped by 30%. By comparison, emissions dropped by only 5% between 2004 and 2008.

Table 1: 2004, 2008, and 2012 Community Inventory Results

Emission Source	Emissions (kt CO_2e)			% Change between 2004 and 2012
	2004	2008	2012	
Building Energy	3,571	3,531	2,671	-25%
Transportation	2,016	2,105	2,181	8%
Solid Waste	319	347	338	6%
Wastewater	20	22	25	25%
Agriculture	234	227	205	-12%
Total	**6,160**	**6,232**	**5,420**	**-12%**

Emissions per Ottawa resident dropped approximately 21% between 2004 and 2012, from 7.3 to 5.8 t CO_2e per person as illustrated in Figure 6.

Figure 6: Population and Community GHG Emissions

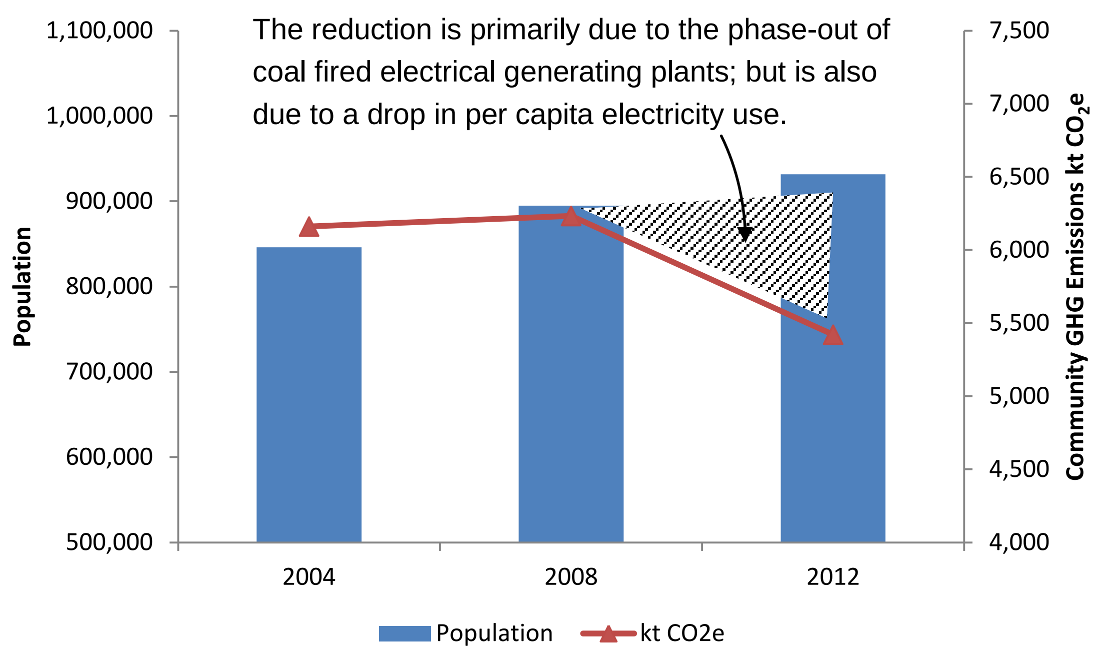


Figure 7 and Table 2 present **Corporate** inventory results for the years 2004, 2008, and 2012, and show that since 2004 emissions have decreased by 20.6 kt CO_2e, or 6%. Most of this reduction was achieved through implementation of an energy savings at municipal facilities; and due to the commissioning and operation of the landfill gas to energy co-gen plant at the City's Trail Waste Facility.

Figure 7: Corporate Inventory Emissions Results

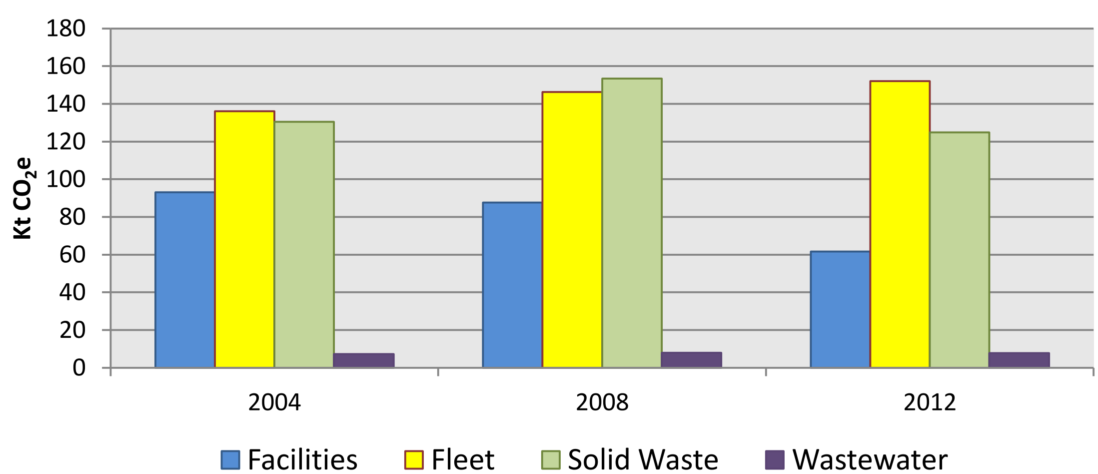


Table 2: 2004, 2008, and 2012 Corporate Inventory Emissions Results

Emission Source	Emissions (Kt CO_2e)			% Change between 2004 and 2012
	2004	2008	2012	
Facilities	93.1	87.7	61.7	-34%
Fleet	136.1	146.3	152.0	12%
Solid Waste	130.4	153.4	124.8	-4%
Wastewater treatment	7.2	7.9	7.7	7%
Total	**366.8**	**395.3**	**346.2**	**- 6%**

The following sections contain detailed results by sector. Explanations of results are largely confined to corporate emissions as, with few exceptions, community results cannot be tied to local actions and programs.

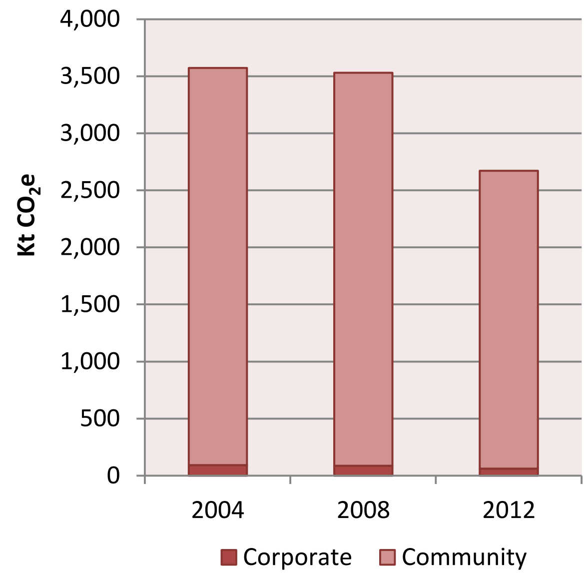
5.2 Facilities and Buildings Energy

Between 2008 and 2012, community emissions from buildings dropped 25%, the largest reduction amongst all sectors. As noted previously, this decline is largely due to the province's phase-out of coal fired electricity generating plants and move towards "cleaner" power generation sources, which reduced the provincial electricity intensity factor from 170 gCO_2/kWh to 97 gCO_2/kWh. Such a significant drop in this factor is unlikely to occur again as the last coal plant was closed in early 2014. Table 3 provides the steps followed to calculate emissions from all buildings in Ottawa; and, as a subset, how emissions were calculated for City facilities.

Table 3: Approach used to calculate Emissions from Buildings[5]

Residential Building Emissions	Commercial/Institutional Building Emissions	Corporate Facility Emissions
1. Residential energy use in Ontario (peta joules.) 2. Prorate to the population living in Ottawa. 3. Divide into fuel/energy types 4. Multiply by emissions factors 5. Multiply each gas by its global warming potential factor. 6. Sum resultant CO_2e across all fuel types.	1. Commercial/Institutional energy use in Ontario (PJ) 2. Prorate to the number of jobs in Ottawa. 3. Divide into fuel/energy types 7. Multiply by emissions factors 4. Multiply each gas by its global warming potential factor. 5. Sum resultant CO_2e across all fuel types.	1. Sum all energy consumption billed to the City in 2012 by fuel/energy type. 2. Multiply volume of each fuel type by its emissions factor. 3. Multiply gases emitted by their global warming potential factor. 4. Sum resultant CO_2e across all fuel types.

Figure 8: Building/Facility Emissions



As shown in Figure 8, between 2008 and 2012, municipal facilities increased in size by 670,000 sq.ft. Despite this, corporate building emissions declined by <u>30%</u> due to a combination of actions carried out under the City's *Energy Management and Investment Strategy,* and the effect of the above noted change in the energy emissions factor for electricity. Without the change in the emissions factor, facility emissions would have declined by only <u>3%</u> from 2008 levels[6]. However, the 3% decrease is fully attributable to significant work undertaken to improve energy efficiency at City facilities.[7]

Most City facilities are heated and cooled by natural gas and electricity, with some also using heating oil or propane. Since 2003, the City has been increasing the number of natural gas accounts, rising from 241 accounts to 335 accounts. While some of these accounts were for new facilities, a large number of accounts were because of conversions to from heating oil and other energy sources to natural gas and natural gas has a lower emissions factor than the former. Other example projects carried out under the City's energy strategy are the following[8]:

- Replacement of High Density Discharge lamps and fixture in arenas with T5HO fluorescent technology (43 ice pads completed) (2007-2010);
- Replacement of all the T12 fluorescent lighting technology in the City with T8 technology (2004-2012);
- Three solar photovoltaic systems were installed through the Ontario's microFIT program with a total installed capacity of 23 kW: one on the roof of City Hall; one at the Transit Services Integrated Control Centre; and one at the Huron Early Education Centre (2010-2011); and
- LED lighting was installed at three indoor parking garages (2012).

Additionally, since 2005, all new corporate facilities over 500 m^2 are built to a minimum LEED Certified standard, and in some instances have achieved LEED Silver and Gold standards. The LEED policy has lowered the energy use per sq.ft. of new buildings.

5.3 Fleet and transportation

Table 4 provides the steps followed to calculate vehicle emissions. In summary, community transportation emissions were calculated by applying modelled results for one day over the entire year. Corporate GHG emissions were calculated using actual fuel consumed by the City's fleet which includes: the transit fleet (i.e. OC Transpo, Para Transpo, O-Train), the municipal fleet (e.g. snow plows, garbage trucks, backhoes), and the police fleet. City fleet emissions are influenced by the size of the fleet, age and type of vehicles, actual usage, and fuel type. Biogenic emissions are excluded.

Table 4: Approach used to Calculate Transportation/Fleet Emissions[9]

Community Transportation Emissions	Corporate Fleet Emissions
1. The City's TRANs model is used to estimate total CO_2 emissions from vehicle trips for one weekday in October. [10] 2. The one-day amount is applied over the entire year, with allowance for less traffic on weekends. 3. Vehicle counts during one hour of that one day are used to determine the ratio of vehicles on the road (80% light duty gasoline, 19% light duty diesel, 1% heavy duty diesel vehicles.) 4. CO_2 emissions are apportioned by vehicle/fuel type. 5. Emission factors are applied on a proportionate basis to each vehicle/fuel type to calculate tonnes of CH_4 and N_2O emitted. 6. Multiply tonnes of gas emitted by their global warming potential factor. 7. Sum resultant CO_2e across all fuel types.	1. Total fuel sales by type (gasoline, diesel, and propane.) 2. Multiply volume of each fuel type by its emissions factor. 3. Multiply tonnes of gases emitted by their global warming potential factor. 4. Sum resultant CO_2e across all fuel types.

In 2012, transit vehicles constituted approximately 75% of total corporate fleet emissions. Buses were the primary source, with less than 5% attributable to the O-Train and Para Transpo.

Between 2004 and 2012, transit fleet emissions increased by approximately 8% (almost 9 kt CO_2e); however, during that same timeframe, OC Transpo also increased its ridership by 12%, the number of kilometres travelled by 14%, and the number of buses increased by 300 to a total of 1,006. Over this same period, OC Transpo took the following actions that mitigated increases in emissions:

- Older buses were phased-out and new models purchased that included hybrids and double decker buses;

- A ‘SmartDriver’ training was introduced for bus drivers; and
- Network routing was optimized to better manage the kilometres travelled.

In 2012, **municipal** fleet (vehicles used by public works, ambulance, by-law etc.) constituted approximately 21% of corporate fleet emissions. Between 2004 and 2008, municipal fleet emissions increased by roughly 32%, but only increased by 3% between 2008 and 2012. Three key initiatives were used to mitigate increases in GHG emissions during this period:

- 40 hybrid vehicles were purchased;
- Fleet replacement was used to shift from diesel to gasoline powered vehicles;
- A higher ethanol-blend fuel was purchased.

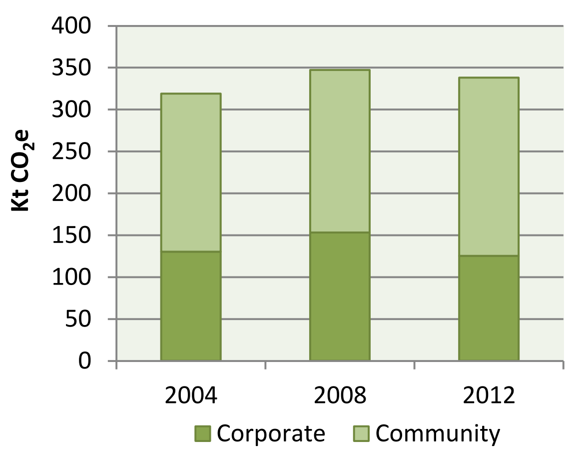
The **police** fleet makes up roughly 4% of the corporate fleet emissions. It experienced a similar trend as the municipal fleet, whereby the large shift from diesel to gasoline and the greater use of biofuels assisted in reducing emissions per vehicle.

Between 2004 and 2012, **community** transportation emissions increased by 165 kt CO_2e or 8%. Over that period, per capita transportation emissions saw a marginal drop from 2.38 t CO_2e per person to 2.34 t CO_2e. This may correspond to increased transit use, walking and cycling instead of private vehicle use and is a trend that will be monitored going forward.

5.4 Solid Waste

As with other sector emission calculations, community emissions are based upon the pro-rating of provincial data to Ottawa’s population; and corporate emissions are based upon actual data or site-specific estimates for Trail Waste Facility (TWF.) Both the corporate and community emissions have been reduced by the amount of gas known to be collected and processed at the TWF, as shown in Table 5.

Figure 9: Solid Waste Emissions



Between 2004 and 2012, corporate solid waste emissions decreased by almost 6 kt CO_2e, or by 4%. In 2007, Powertrail Inc (a partnership between the City of Ottawa, Energy Ottawa, and Integrated Gas Services) introduced a landfill gas-to-energy plant at Trail Road that captures landfill gas and converts it into energy, minimizing the amount of gas that is flared and yielding an 18% drop in emissions between 2008 and 2012

Between 2004 and 2012, community solid emissions increased by 22 kt CO_2e (6%), but decreased between 2008 and 2012 by 9 kt CO_2e (3%) as a result of the commissioning of the TWF go-gen plant. While the privately owned Carp Road landfill also underwent significant improvements in its landfill gas collection system during this period, the data needed to show reduced GHG emissions was not obtained. It is recommended that the City work with other local landfill operators to allow for improved and more representative reporting during the next inventory.

Table 5: Approach used to Calculate Emissions from Solid Waste

Community Emissions	Corporate Emissions (Trail Waste Facility)
1. Amount of waste generated in Ontario. 2. Prorate to the population living in Ottawa. 3. Use Landgem model to estimate total GHG fugitive emissions (CH_4 and CO_2) generated from that tonnage of waste. 4. Subtract methane collected/processed at TWF (item 3 to right.) 5. Multiply net gases by their global warming potential factor. 6. Sum resultant CO_2e of both gas types.	1. Use reported emissions values sent to Environment Canada for Trail Waste Facility 2. Multiply <u>fugitive</u> landfill gases by their emissions factor. 3. Subtract CO_2 gas: a. recovered by the co-gen facility; b. recovered by the flare; 4. Multiply gases emitted from <u>co-gen</u> and <u>flare</u> by their global warming potential factor. 5. Multiply total tonnes of <u>leaf and yard</u> (L&Y) composted at Trail by their emissions factor 6. Multiply gases emitted from L&Y waste by their global warming potential factor. 7. Sum resultant CO_2e across all <u>sources</u>.

5.5 Wastewater Treatment

Wastewater emissions are generated from two primary sources: the City's central sewage treatment plant: the Robert O. Pickard Environmental Centre (ROPEC); and from individual private septic systems. The only difference between the corporate and community emissions is that corporate emissions <u>exclude</u> septic system emissions while community emissions <u>include</u> them. Emissions were calculated based on a three-step methodology prescribed in the Climate Registry's Local Operations Government Protocol. See Table 6 for a summary of how emissions are calculated.

As shown in Figure 10, community wastewater emissions have increased since 2004 with population growth and those living in the rural area on private septic systems. However, since 2008 there has been a modest reduction in emissions at ROPEC attributed to an approximately 7% decrease in N_2O emissions from effluent discharged. (Emissions from effluent discharge account for roughly 70% of total wastewater emissions.)

Comparing 2008 and 2012, there was very little change in the number of people using septic tanks; however the BOD_5 load coefficient (i.e. the biological oxygen demand) in 2008 was lower than what was used to calculate 2012, which accounts for the change between years.

Table 6: Approach used to Calculate Emissions from Wastewater Treatment

1. CH_4 Emissions from ROPEC digesters	2. N_2O emissions from ROPEC processes	3. N_2O emissions from ROPEC effluent w/o denitrification[11]
1. Volume of digester gas produced in a day, applied over a year. 2. Multiply by fraction that is CH_4. 3. Multiply by default CH_4 destruction efficiency of digesters. 4. Multiply by global warming potential factor for CH_4. **PLUS** 5. Sum gases released: a) by the co-gen plant; b) by the flare; c) by boilers; and d) due to emergency releases. 6. Multiply by fraction that is CH_4. 7. Multiply by global warming potential factor for CH_4.	1. Population served by ROPEC. 2. Multiply by default factor for industrial and commercial discharges. 3. Multiply by default emission factor of N_2O released per person per year. 4. Multiply by global warming potential for N_2O.	1. Actual average Nitrogen discharged per day, applied over a year. 2. Multiply by N_2O emission factor wastewater effluent 3. Multiply by global warming potential factor of N_2O. **PLUS** 4. Population served by ROPEC. 5. Multiply by default factor for industrial and commercial discharges. 6. Multiply by kg of N produced per person over a year; MINUS nitrogen uptake during aerobic and anaerobic processes; MULTIPLIED by kg of BOD_5 produced per person over a year. 7. Multiply by default N_2O emission factor for wastewater effluent. 8. Multiply by global warming potential for N_2O.
For Community Emissions, add CH_4 emissions from private septic systems		
1. Estimated population using septic systems. 2. Multiply by kg of BOD_5 produced per person over a year. 3. Multiply by default maximum CH_4 producing capacity of wastewater. 4. Multiply by efficiency factor of septic systems. 5. Multiply by global warming potential factor for CH_4.		

Figure 10: Wastewater Emissions

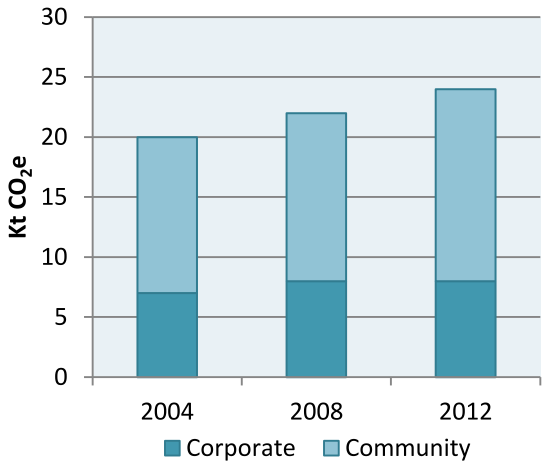
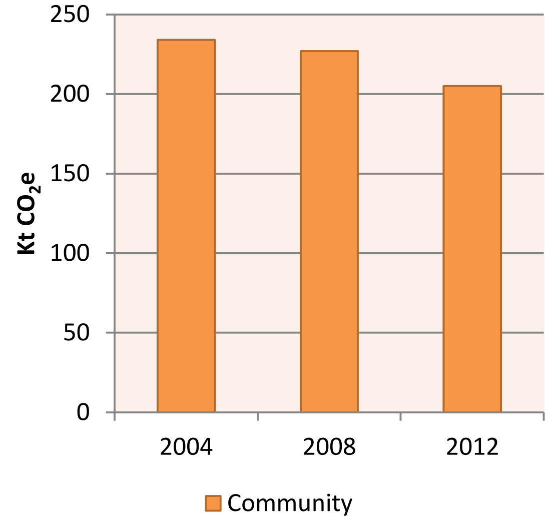


Figure 11: Agricultural Emissions



5.6 Agricultural Emissions

Agriculture is calculated within the community inventory only and includes agricultural land use and livestock operations. Emissions are calculated by prorating estimated provincial emissions from crop production and livestock operations to Ottawa based upon population. Emissions from soil vary according to whether it is in pasture, range or paddock use; and from livestock according to whether it is cattle or pig manure.

Between 2004 and 2012, emissions have been declining due to an apparent decline in the number of livestock farms and the number of animals. The calculations do not allow for the growing trend towards using biogen plants under the FIT program; or for the distribution and concentration of such farms across the province.

6.0 CONCLUSION AND RECOMMENDATION

While not a precise science, GHG emission calculations allow a community to see where and how they are generated, and to identify opportunities for improvement. The 2012 results, and year over year comparisons illustrate the impact of actions carried out by the corporation, particularly at the landfill and city facilities, but do not adequately show what is being done in the community. It is recommended that work be undertaken to improve the methodologies used for Ottawa in cooperation with ICLEI and community partners, to allow the 2018 inventory to be more robust and relevant to Ottawa.

1 Partners for Climate Protection http://www.fcm.ca/home/programs/partners-for-climate-protection.htm

2 http://www.cbc.ca/news/canada/ottawa/level-two-drought-conditions-announced-1.1273025

3 http://www.agr.gc.ca/cb/index_e.php?s1=n&s2=2012&page=n120827a

4 Equivalent CO_2 is a measure of the impact of radioactive gases such as methane and NOx on the net amount of energy absorbed and held by the earth's atmosphere.

5 Emissions were calculated based on provincial data from the National Energy Use Database and Statistics Canada, and emissions factors and intensity factors provided by Environment Canada.

6 Calculation uses the 2008 electricity consumption intensity rate

7 Data was provided by the City's Public Works Department based upon actual amounts purchased from electricity and fuel suppliers.

8 Energy Conservation and Demand Management Plan 2015. Tabled April 2014 at Environment Committee.

9 Data was provided by Transit Services, Public Works, and Environmental Services Departments, as well as Ottawa Police Services.

10 The model was run to analyze one day in October as it is thought to represent the most accurate depiction of traffic in Ottawa as tourism levels are low, schools are running at normal capacity, and business travel is assumed to be average. Only one day was modelled due the extensive amount of time required to model city traffic.

11 Plants with nitrification/denitrification treatment processes generate lower quantities of N_2O than those that lack those facilities, such as ROPEC. Accordingly, a different formula is used depending upon the treatment facilities in place.