FINAL REPORT - City of Hamilton: Air Pollutant and GHG Inventory Project

Final Report Prepared For:
City of Hamilton
55 York Blvd.
Hamilton, ON
L8N 4E4

File No. 1046818.

October 1, 2009

Executive Summary

Introduction to the Project

The purpose of this study is to provide the City of Hamilton (the City) and the Community of Hamilton (the Community) with a framework to assess and reduce air emissions. In particular, this study is broken down into 4 categories, labeled as objectives (as per RFP C2-03-08) including:

- Objective A: Completion of a City (municipal operations) and Community air pollutant and greenhouse gas (GHG) emissions inventory baseline and business as usual forecast.
- Objective B: Assessment of existing City and Community actions including a comparison of the baseline inventories to updated inventories for determining progress relative to emission reduction targets.
- Objective C: Policy Discussion and projections for City and Community emissions.
- Objective D: Carbon markets assessment.

The baseline years for this study are 2005 (City) and 2006 (Community). These were selected, in consultation with Hamilton, to correspond with internal City targets and availability of detailed data. The study includes the calculation of baseline and forecasted emission inventories for both GHG and Criteria Air Contaminant (CAC) emissions. However, ongoing trends in air quality are studied in detail by Clean Air Hamilton and therefore much of the discussion presented in this study is focused on GHG emissions.

City Emissions

The baseline emissions for the City of Hamilton, as determined from this study, are presented in Table E.1.

Table E.1 City Baseline Emissions (2005)

CO_2e (t)	CO (t)	SO_2 (t)	NO_X (t)	VOC (t)	TPM (t)	PM_{10} (t)	$PM_{2.5}$ (t)
135,038	1,450	979	17,717	4,021	256	224	178

In 2005, the City's baseline level of GHG emissions is estimated to be 135,058 metric tonnes of carbon dioxide equivalent (t CO_2e), which is a common measure of GHG emissions. The City has undertaken numerous initiatives (including but not limited to the Glanbrook Landfill Gas Collection System, the LightSavers project, installation of LED traffic lights, implementation of hybrid vehicles, energy efficiency projects and building renovations) to reduce emissions in

recent years. These programs have played a critical role in limiting the increase of GHG emissions in the City (3% increase from 2005 to 2007). It is anticipated that the growth of these programs will help to mitigate GHG emissions within the City and provide a considerable contribution towards reducing emission levels in Hamilton.

The City of Hamilton has set a corporate reduction target of 10% below 2005 emission levels by 2012. This study is an important step toward achieving this goal as it provides Hamilton with a solid foundation and the tools to move forward in quantifying their annual emissions. This will allow the City to track the progress of their reduction initiatives.

Based on the baseline GHG emissions presented in Table E.1, the City will need a reduction of 17,849 t CO_2e by 2012 to meet their 10% GHG reduction goal. Further, for the City to achieve a 20% reduction below 2005 levels by 2020 (in accordance with initial Kyoto goals), a reduction of 31,355 t CO_2e is required.

To meet the requirements of Milestone #1 under the Partners for Climate Protection (PCP) Program, a Business As Usual (BAU) forecast was completed for the City to estimate emission levels 10 years from the baseline. This forecast is conservative and assumes no substantive change to current City policy and emission reduction initiatives. The City BAU forecast presented in this study, estimates GHG emissions will decrease by approximately 20,000 t CO_2e by 2015 (115,011 t CO_2e). It is anticipated that, with the implementation of GHG reduction initiatives, the City may be able to meet their 2012 target.

Community Emissions

The baseline emissions for the Community of Hamilton, as determined from this study, are presented in Table E.2.

Table E.2 Community Baseline Emissions (2006)

CO_2e (t)	CO (t)	SO_2 (t)	NO_X (t)	VOC (t)	TPM (t)	PM_{10} (t)	$PM_{2.5}$ (t)
12,758,652	57,132	74,818	14,164	3,412	22,402	6,913	3,189

In 2006, the Community's baseline level of GHG emissions is calculated to be 12,758,652 t CO_2e. Following the City's lead, the Community has implemented several initiatives to reduce emissions in recent years including, but not limited to, Green Carts, the Blackout Challenge, the establishment of Clean Air Hamilton, the PowerSavings Blitz, a Bus Rapid Transit Program, the Hamilton Commuter Challenge and Anti-Idling Bylaws. These programs have played an important role in limiting the increase of GHG emissions in the City (3% increase from 2006 to 2008). The growth in popularity of these programs and community support will help to mitigate GHG emissions within the Community and provide a considerable contribution towards reducing emission levels in Hamilton.

The City of Hamilton is considering a community reduction target of 10% below 2005 emission levels by 2012. Based on the baseline GHG emissions presented in Table E.2, the Community will need a reduction of 1,648,310 t CO_2e by 2012 to meet their 10% GHG reduction goal. Further, for the City to achieve a 20% reduction below 2005 levels by 2020 (in accordance with initial Kyoto goals), a reduction of 2,924,175 t CO_2e is required.

To meet the requirements of Milestone #1 under the Partners for Climate Protection (PCP) Program, a Business As Usual (BAU) forecast was completed for the Community to estimate emission levels 10 years from the baseline. Like the City forecast, this forecast is conservative and assumes no substantive change to City or Community policies and emission reduction initiatives. In addition, the forecast presumes substantial growth in the population as predicted by studies commissioned by the City of Hamilton. The Community BAU forecast presented in this study, estimates GHG emissions will increase by approximately 3,279,380 t CO_2e by 2015 (16,038,032 t CO_2e). Based on this assessment, considerable reduction initiatives will be required for the Community to achieve any proposed reduction goals.

Federal and Provincial Policy Impacts

This report also examined the potential for Provincial and Federal policy and regulatory initiatives to influence GHG emissions in the City and Community. At the time of writing, both the Government of Canada (Turning the Corner: Taking Action to Fight Climate Change) and the Government of Ontario (Ontario's Climate Change Action Plan) have published roadmaps for GHG emission reductions. Although these plans are broad and consider a variety of sectors that may not be directly applicable to Hamilton, they have been used to assess the potential impact that non-municipal actions on Hamilton emission levels.

In particular, it is speculated that Hamilton could see GHG emission reductions associated with new regulation and policy in the electricity generation, industrial (particularly the Steel industry), and transportation sectors.

Carbon Market Assessment

A carbon markets assessment was completed as part of this study. This assessment recommends that the City of Hamilton wait for clarity in forthcoming provincial regulations before committing to any anticipated development of offset credits with the intent to sell in the near future. In particular, the City may wish to explore the opportunity of developing a landfill gas-to-electricity facility as a potential source of carbon credit generation.

Summary and Recommendations

Finally, a large number of recommendations from this study are presented in section 7. These recommendations include that the City:

- Address data gaps associated with City and Community emissions categories.

- Continue to investigate energy efficiency, renewable energy, and other GHG mitigation options to reduce emissions.
- Refine emissions estimation tools.
- Consider other options to minimize environmental effects (*i.e.* sustainable procurement, investments in ongoing tree programming).
- Examine emissions reporting methods.

This study highlights Hamilton's commitment to sustainable development and their contribution towards reducing regional GHG and CAC emissions. The emission inventories and forecasts presented in this study were developed using detailed information provided by Hamilton and represent robust technical documents that can be used to assess the success of emission reduction initiatives with City and surrounding Community. The completion of this study is a milestone for the City's commitment to the Partners for Climate Protection Program and puts them amongst the leading Canadian municipalities working to find solutions to climate change.

Glossary

Terms of use and Acronyms	Definition
ALGP	Aboriginal Loan Guarantee program
CAC	Criteria Air Contaminant
CANSIM	Statistics Canada's Key Socioeconomic Database
CCP	Cities for Climate Protection
CEPA	*Canadian Environmental Protection Act, 1999*
CEUD	Comprehensive Energy Use Database
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide equivalent
CSA	Canadian Standards Association
DARTS	Disabled & Aged Regional Transportation System
FCM	Federation of Canadian Municipalities
GHG	Greenhouse Gases
GJ	Gigajoule
GMF	Green Municipal Fund
GTHA	Greater Toronto and Hamilton Area
GRIDS	Growth Related Integrated Development Strategy
HAMN	Hamilton-Wentworth Air Monitoring Network
HAQI	Hamilton Air Quality Initiative
HECFI	Hamilton Entertainment and Convention Facilities
ICI	Industrial, Commercial and Institutional
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
kWh	Kilowatt hour; i.e. one thousand watts supplied for a period of one hour. A measure of electric power consumption.

Terms of use and Acronyms	Definition
LED	Light Emitting Diode
LEED	Leadership in Energy and Environmental Design
MOU	Memorandum of Understanding
MWh	Megawatt hour; i.e. one million watts supplied for a period of one hour. A measure of electric power consumption.
MRTC	Mountain Regional Transit Center
NIR	National Inventory Report
NPRI	National Pollutant Release Inventory
NRCAN	Natural Resources Canada
PCP	Partners for Climate Protection
REA	Renewable Energy Approval
REFO	Renewable Energy Facilitation Office
StatsCan	Statistics Canada
t CO_2e	Metric tonnes of carbon dioxide equivalent
UNFCCC	United Nations Framework Convention on Climate Change
USEPA	United States Environmental Protection Agency
WRI	World Resources Institute
WWTP	Waste Water Treatment Plant

Table of Contents

Table of Contents

Table of Contents

Table of Contents

LIST OF FIGURES

Table of Contents

LIST OF TABLES

Table of Contents

1.0 Introduction

Climate change is a serious challenge facing local governments. Greenhouse gases (GHGs) emitted as a result of human development are widely recognized as one of the main causes of climate change. The effects already being measured include: warming temperatures, changes to precipitation patterns and intensities, increased frequency and magnitude of severe weather occurrences, invasion of pests, and rising sea levels.

As a direct response to this, and to accompany a variety of ongoing initiatives to address air quality and climate change issues, the City of Hamilton (the City) commissioned this study with the following objectives:

- Objective A: Completion of an air pollutant and GHG emissions inventory and forecast.
- Objective B: Assessment of existing City and Community actions to determine progress relative to emission reduction targets.
- Objective C: Policy discussion and projection for City and Community emissions.
- Objective D: A Carbon markets assessment.

The approach and methodology used to achieve these objectives have been designed by drawing from all relevant and applicable standards and methodologies. In addition to this report, a City emission quantification toolkit (a spreadsheet and user guide) for continued emission quantification will be provided as a separate deliverable.

1.1 CONTEXT

The City has a history of addressing environmental issues through concerted action. In 1992, Hamilton adopted the Vision 2020 Strategy, a municipal strategy to ensure the long term sustainability and viability of the Hamilton-Wentworth region. One year later, the City established an aggressive goal as part of the Vision 2020 process “to ensure the City (Region) has the best air quality of any major urban center in Ontario.”

The city subsequently become a signatory to the Canadian Declaration on Climate Change and the Urban Environment in 1995, and joined as a member of the Federation of Canadian Municipalities (FCM) 20% Club in 1996, which has since become the Partners for Climate Protection (PCP) program in 1999. The program is a joint partnership between the FCM and the International Council on Local Environmental Initiatives (ICLEI) Local Governments for Sustainability and the program’s framework is based on the ICLEI Local Governments for Sustainability international campaign, Cities for Climate Protection (CCP) Protocol.

Originally, this initiative committed the City to conducting an air quality study of the region to identify strategic air quality priorities and to make recommendations related to potential initiatives that could be undertaken to improve air quality. It also committed the Hamilton-

Wentworth region to reducing CO_2 emissions by 20%, an initiative led by the Hamilton Wentworth Air Quality Initiative (HAQI) formed in 1997 (which became Clean Air Hamilton in 1998). The City both supports and is a member of Clean Air Hamilton.

The region had also developed a Climate Change Action Plan in 1997 and a complementary GHG Reduction Program (1999), called the Climate Protection Action Plan for Regional Operations, which included programs and activities in waste management, transportation, energy and land use.

In 1999, partial inventories to determine GHG emissions from municipal operations and activities were completed, and a tentative baseline year of 1994 was set while recognizing that improvements to the inventory were required. To support inventory improvement and other clean air objectives, the City helped establish the Hamilton Air Monitoring Network (HAMN) in partnership with the Ministry of Environment in 2001 and in 2002, and endorsed the Model Resolution by Municipal Governments to ratify the Kyoto Protocol in 2002.

The Vision 2020 strategy was renewed in 2003 and climate change considerations were incorporated, setting the foundation from which this current project could garner support.

As members of a continually evolving PCP program, the City has a new commitment to reduce GHG emissions in municipal operations in the short term and over the long term. Their corporate (City) emission reduction target is 10% below 2005 levels by 2012, and 20% below 2005 levels by 2020. This commitment extends to include reducing emissions within the community, with a proposed short term target of 10% below 2006 levels by 2012 and 20% below 2005 levels by 2020.

This report is designed to be submitted to the FCM and is intended to enable the City to receive recognition for completing Milestones 1 and 2 of the PCP program.

1.2 COMMUNITY GROWTH

Growth within the City[1] and Community[2] will be the most influential factor that will come to bear on the City and the Community's ability to achieve their emission reduction targets. The Growth Related Integrated Development Strategy (GRIDS Growth Options 2005) notes that the City should plan for a projected increase in population of 150,000 people, the addition of 80,000 additional households, and an increase of 90,000 jobs by 2031.

Although the evolving strategy aims to integrate social, economic, and environmental considerations to manage growth responsibly, this intense growth will raise emissions levels unless plans are implemented to reduce emissions per capita.

[1] The City encompasses City of Hamilton operations including buildings and infrastructure, vehicles, small engines, streetlights, waste on land, and wastewater.
[2] The Community encompasses all groups within City limits other than City of Hamilton operations, including the residential, commercial, industrial, steel industry, community transportation, waste, and agriculture sectors.

City operations will likely see an associated increase in demand for services and thus key factors that determine emissions like energy use may rise unless the City takes significant steps above current actions to reduce emissions intensity. Community emissions are also likely to rise as the City continues to increase population density and grow employment opportunities. Significant energy efficiency and demand reduction measures will be necessary to avoid increases in emissions due to population growth.

There are, however, a variety of innovative initiatives that will be encouraged by the strategy (*i.e.,* the use of a triple bottom line evaluation framework to determine preferred growth options) and they could maximize efficiencies and reduce emissions intensities (*i.e.,* emissions spread over a unit of population or residences).

1.3 METHODOLOGY

The following guidance and standards documentation were considered when developing the GHG emission inventory:

- *Developing Inventories for Greenhouse Gas Emissions and Energy Consumption* (PCP 2009);
- Canadian Standards Association (CSA) ISO 14064 Standards (CSA 2008);
- *The Climate Registry General Reporting Protocol (Version 1.0)* (The Climate Registry 2008);
- World Resources Institute (WRI) Guidance;
- World Business Council for Sustainable Development (WBCSD) Guidance;
- *The Greenhouse Gas Protocol Initiative: A Corporate Accounting and Reporting Standard (Revised Edition)* (WRI 2009);
- *Environment Canada Technical Guidance on Reporting Greenhouse Gas Emissions* (Government of Canada 2005);
- *Local Government Operations Protocol: For the Quantification and Reporting of Greenhouse Gas Emissions Inventories* (California Climate Action Registry 2008);
- *International Local Government GHG Emissions Analysis Protocol* (ICLEI, Version 1.0, 2008); and
- *The US Environmental Protection Agency (USEPA) AP-42 Volume 1, Fifth Edition* (USEPA 2009)

End use energy consumption and activity data were used as the preferred input for GHG emission estimates. Where these data sets were not available, activity data from authoritative, defensible sources were used to estimate the inputs required for GHG emission estimates.

A data set is considered “real consumption data” (RC data) when a vendor can provide accounting records that adhere to rigorous, third party scrutiny in accord with standard accounting principles.

A data set is considered "activity data" (AD) when indicators, averages, survey results, or national, provincial, or regional data is employed in a estimate. Data sources are classified and indicated in conjunction with all GHG estimates presented in this report.

A summary of the data types used in this study to complete the estimates is presented in table 1.1. In some cases, combinations of RC data were used with AD to complete the GHG quantifications. Further detail on data quality is provided in subsequent sections in this report.

Table 1.1 Data Used for GHG Quantifications

Operational Category or Sector Category	Type of Data Source				
	Electricity	Natural Gas	Gasoline/Diesel	Other Considerations (Other Fuels and Emissions)	Waste
CITY INVENTORY					
City Buildings	RC	RC	-	-	-
City Housing	AD	AD	-	-	-
Water and Sewage	RC	RC	-	-	-
Vehicle Fleet	-	RC	RC	-	-
Contracted Waste Fleet	-	-	AD	-	-
Expensed Kilometres	-	-	RC + AD	-	-
Employee Commuting	-	-	AD	-	-
Small Engines	-	-	RC + AD	-	-
Streetlights	RC	RC	-	-	-
Waste on Land	-	-	-	RC	-
Wastewater	-	RC	-	RC + AD	-
COMMUNITY INVENTORY					
Residential	RC	RC	AD	AD	-
Commercial	RC	RC	AD	AD	-
Industrial	RC	RC	AD	AD	-
Transportation	AD	RC + AD	AD	AD	-
Solid Waste	-	-	-	-	RC
Agriculture	-	-	-	AD	-

Notes:

AD – Activity Data

RC – Real Consumption Data

1.3.1 City and Community Toolkits

Emissions toolkits (i.e., spreadsheets were developed by Stantec and used to estimate the City and Community GHG and Criteria Air Contaminant (CAC) emissions. Actual consumption data were entered into the Toolkits and combined with emission factors and in some cases, Provincial and Federal statistics were used to quantify GHG and CAC emissions for each emission category. Emission factors used in estimates to quantify GHG emissions are referenced both in the toolkits and in text within this report. No normalization of GHG emissions has taken place, given the City's absolute GHG emission reduction targets.

In addition to emission estimates, emission forecasts were conducted to determine the potential cost savings associated with reducing emissions within emission categories. A description of the methodology and approach used to complete these project objectives is located within their respective sections.

1.3.2 ICLEI International Local Government GHG Protocol

The International Local Government GHG Protocol (LG Protocol, ICLEI 2008), is a set of guidelines that provides communities with a standardized approach to quantifying their GHG emissions. This approach facilitates the comparison across time and between different communities in a policy-relevant fashion. With the intent of helping local governments achieve tangible reductions in their GHG emissions, the LG Protocol enables measurement of progress towards climate-related goals. Its approach is complementary to existing or foreseeable regulatory requirements and potential emissions reduction certification.

This report and the approach for this project were completed in accordance with the ICLEI LG Protocol where relevant.

1.4 EMISSIONS ASSOCIATED WITH THE GENERATION OF ELECTRICITY

In Canada, Ontario consumes more electricity than any other province. The Province has some of the most advanced and innovative programs in Canada to support the efficient use of electricity generation from renewable sources. Additionally, Ontario has one of the most diverse electricity portfolios in Canada (see Figure 1.1):

Figure 1.1 Ontario's Electricity Portfolio 2005 (Environment Canada 2009)

From 2005 to 2007, Ontario showed a slight shift away from oil and natural gas fired electricity generation. The Province's electricity portfolio for 2007 is shown in Figure 1.2.

Figure 1.2 Ontario's Electricity Portfolio 2007 (Environment Canada 2009).

Within the next 20 years, nearly 80% of the province's existing generating capacity must be replaced as generators reach the end of productive life. There are commitments by the Province to shut down all of the coal-fired generation plants. Some will be replaced by nuclear power generation and others rendered obsolete through energy conservation. Additionally, renewable energy generation is slated to grow considerably in future years.

On February 23, 2009, the Government of Ontario proposed Bill 150 (Green Energy and Green Economy Act) and in May 2009 the Bill received Royal Assent. The Green Energy Act builds on the government's earlier initiatives, including plans to eliminate coal from the power supply, and aims to boost renewable energy, attract new investment, create new green economy jobs and

increase conservation. Plans include establishing the right to connect to the electricity grid for renewable energy projects that meet requirements outlined by the government, and guaranteeing specific rates for energy generated from renewable resources. The province is to commence a consultation process to help develop the regulations (Ontario Ministry of the Environment 2009).

The Government of Canada has also released a number of frameworks and plans to address GHG emissions in the coming years. These include:

- *Climate Change Plan for Canada* (Government of Canada 2002);
- *Moving Forward on Climate Change: A Plan for Honouring our Kyoto Commitment* (Environment Canada 2005);
- *Regulatory Framework for Air Emissions* (Environment Canada 2007);
- *Canadian Environmental Protection Act, 1999* (CEPA) Notice under Section 71 (Environment Canada December 2007); and
- *Turning the Corner: An Action Plan to Reduce Greenhouse Gas Emissions and Air Pollutants* (Environment Canada March 2008)

The Regulatory Framework for Air Emissions, CEPA Section 71, and the Federal "Turning the Corner" initiative identify emerging potential regulatory frameworks to address GHG emissions, specifically in the industrial sector.

As recently as July 11, 2009, Environment Canada published a notice under Section 46 of the Canadian Environmental Protection Act, 1999, with notification to at potential GHG reporters that the GHG emissions reporting threshold previously requiring emitters of 100,000 t CO_2e to report on their GHG emissions, was lowered from 100,000 t CO_2e to 50,000 t CO_2e.

If the Province is successful in meeting emission intensity reduction targets proposed as part of draft documents for emerging regulation, the City and Community of Hamilton could measurably reduce their GHG emissions well beyond their baseline year. Similarly, if emissions associated with the generation of electricity increase, the City's emissions could increase. From 2005 to 2006, the average emission factor associated with the generation of electricity in the Province decreased from 0.00021 to 0.00018 t CO_2e/kWh. From 2006 to 2007, this emission factor increased from 0.00018 to 0.00022 t CO_2e/kWh. On the whole, the increase in the GHG emission intensity from 2005 to 2007 is small and likely attributed to an increase in coal-fired generation (a 2% increase from 2005 to 2007). However, on an annual basis, these emission factors can change substantially. Therefore, these changes must be considered when interpreting the changes in emissions from year to year for sources consuming electricity. Small changes in emission factors can translate into dramatically altered emission profiles in municipalities, like Hamilton, that are major consumers of electricity at both the Corporate and Community level.

2.0 Objective A (Part 1): City Air Pollutant and GHG Inventory

In this section the air pollutant and GHG inventories are presented for the operation of the City (the corporate entity). The Community inventory is presented in Section 3.0. The City baseline emissions for 2005 are presented. The Community baseline emissions for 2006 are presented (as chosen by the City). Discussion on GHG and CAC emissions trends from 2005 to 2007 for the City and for the years 2006 to 2008 for the Community is included.

All data provided to Stantec in order to prepare the inventory is presented in this section were provided by City staff for full calendar years (January 1 – December 31) of operation unless otherwise stated. References for specific data sets can be found within the toolkits provided to the City.

Gaps in data and a business-as-usual (BAU) emission forecast are provided to enable the City to achieve milestones within the PCP program, and to improve data tracking systems in upcoming years.

The City's emissions can be subdivided into the following categories:

- Buildings and Infrastructure;
- Corporate Buildings;
- City Housing;
- Water and Sewage;
- Vehicles;
- Vehicle Fleet;
- Contracted Fleets;
- Expensed Kilometres;
- Employee Commuting;
- Small Engines;
- Streetlights;
- Waste on Land; and
- Wastewater Emissions.

Each of the following sub-sections contains a textual summary and table noting the data used to complete the quantifications, the data type/sources, the relevant methods of manipulation/analysis, the relevant emission factors, and the results of the quantification.

Emissions are provided for the City's 2005 baseline year. In addition, changes from the baseline to 2007 are quantified and trends are presented. It is noted that due to data availability, not all emission categories are available for this analysis. These areas are clearly identified in the analysis presented below.

The substantial sources of CACs for each emissions category have been identified, and a CAC summary with a breakdown for each category of emissions is provided in the '*Summary'* section of this chapter. A more detailed summary of CAC emissions for each category of emissions can be located in the City Toolkit (available from the City).

Billing, energy consumption, and other City records provided accurate data on City operations and energy consumption. The activity and energy data is converted into a GHG emissions inventory using a toolkit developed by Stantec, customized to meet the City's needs.

In addition to direct data on consumption patterns in each class, estimates were derived to estimate fuel consumption.

A more detailed summary of CAC emissions for each category of emissions can be located in the City Toolkit.

2.1.1 Summary

The GHG and CAC emissions by City emission category, scope and energy source are presented in this section. Gaps in baseline data are also provided for improvement of future inventories.

2.1.1.1 GHG Summary

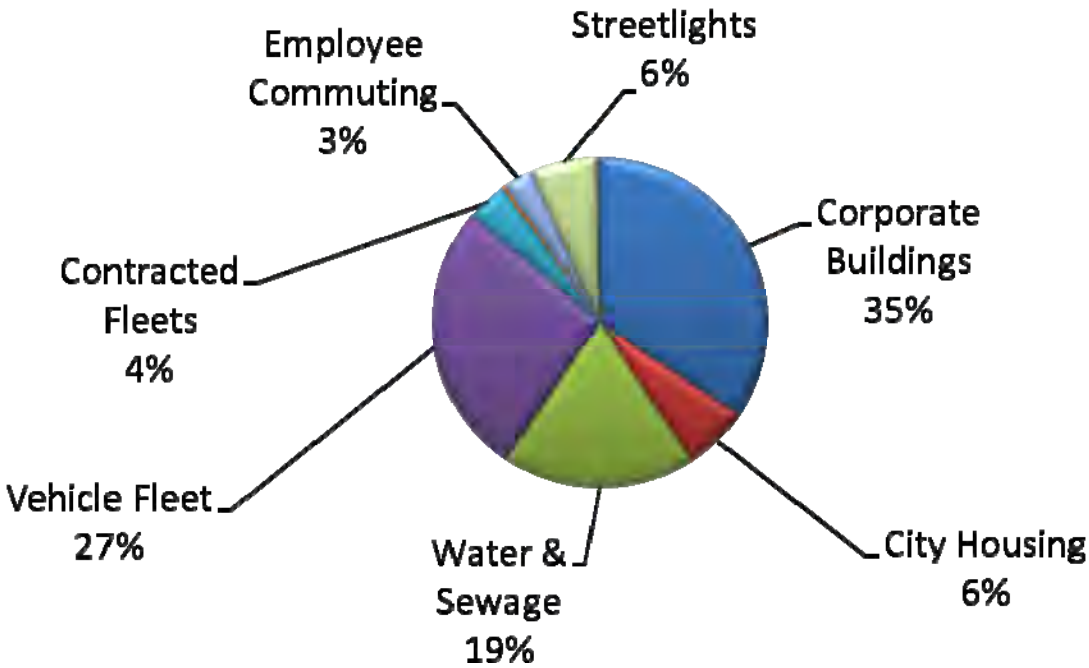
The total 2005 City GHG emissions are summarized in table 2.1.

Table 2.1 Total City GHG Emissions (2005)

Emission Category	Total Emissions (t CO_2e)
Corporate Buildings	46,599
City Housing	8,491
Water & Sewage	25,155
Vehicle Fleet	36,163
Contracted Fleets	5,336
Expensed Kilometres	493
Employee Commuting	3,835
Small Engines	33
Streetlights	8,428
Wastewater Emissions	525
TOTAL	135,058

The City GHG emissions by source as a percent of the total are shown in Figure 2.1. Based on this information, the major contributors to GHG emissions result from energy consumption at Corporate Buildings and Water and Sewage treatment facilities, as well as energy consumption associated with the vehicle fleet.

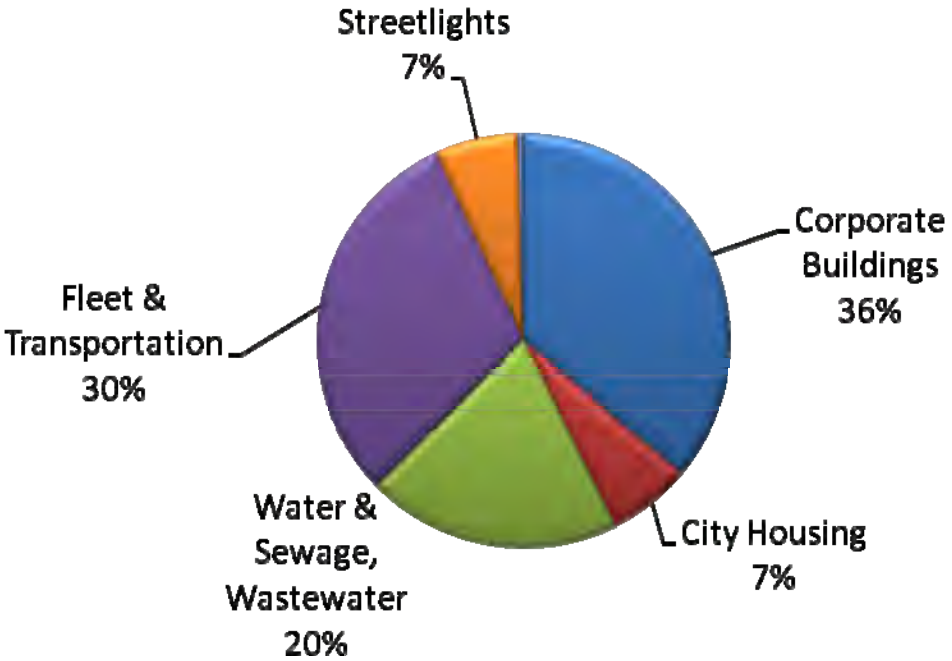
Figure 2.1 2005 GHG Emissions by Category



For the purposes of comparison, emissions for 2007 were also calculated. These are summarized and discussed in further detail in the Quantification of Emission Reduction Measures section of this report (Section 3.1.1.1).

A simplified view of the City's emissions by source is presented in Figure 2.2.

Figure 2.2 Simplified GHG Emissions by Sector



Another way to analyze the GHG emissions is to use Scope 1, Scope 2, and Scope 3 emissions delineations. These can be defined as follows:

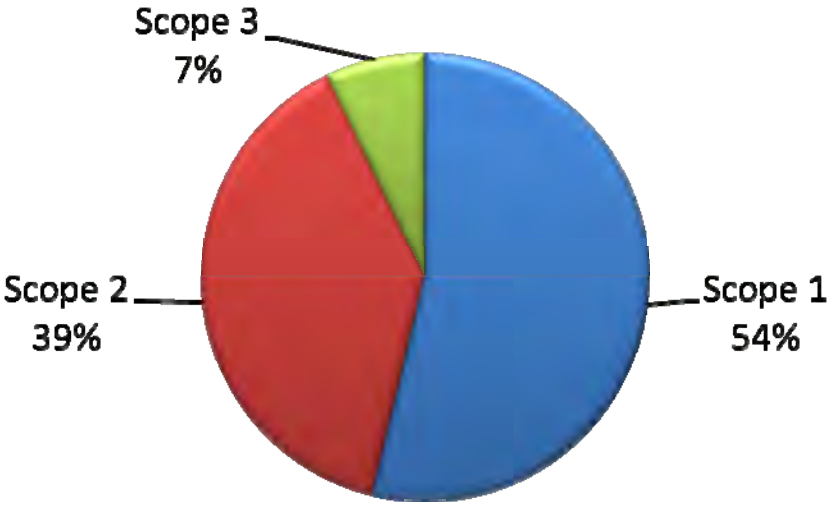
- Scope 1 Emissions: Direct emission sources owned or operated by the City;
- Scope 2 Emissions: Indirect emission sources limited to electricity, district heating, steam and cooling consumption; and
- Scope 3: All other indirect and embodies emissions over which the local government exerts significant control or influence (i.e. contracted fleets, expensed kilometres, employee commuting).

Essentially, the City's Scope 2 and Scope 3 emissions may be "owned" and controlled by another party.

Delineating the baseline into GHG emissions from Scope 1, Scope 2, and Scope 3 sources can inform the emission reduction planning process, and assist in communicating the extent to which you have 'control' over certain emission sources. Ultimately, local governments' ability to implement efficiency measures and reduce GHG emissions will depend on the degree of operational control a government can exert as a City over the factors that influence emissions in a given category.

The 2005 GHG emissions from corporate activities are broken down by scope and summarized in figure 2.3.

Figure 2.3 City GHG Emission Summary by Scope (2005)



2.1.1.2 CAC Summary

Table 2.2 summarizes the City CAC emissions by source for 2005.

Table 2.2 CAC Emissions by Source (2005)

Emission Category	CO (t)	SO_2(t)	NO_X(t)	VOC (t)	TPM (t)	PM_{10} (t)	$PM_{2.5}$ (t)
Corporate Buildings	48	234	126	2	24	11	5
City Housing	5	0	6	0	0	0	0
Water & Sewage	34	260	118	2	25	12	5
Vehicle Fleet	1,135	385	17,373	4,002	195	195	166
Contracted Fleets	9	1	41	2	1	1	1
Expensed Kilometres	23	0	1	1	0	0	0
Employee Commuting	181	0	9	11	0	0	0
Small Engines	3	0	0	0	0	0	0
Streetlights	12	98	43	1	9	5	2
Total	1,450	979	17,717	4,021	256	224	178

Based on the emissions presented in Table 2.2, NO_x emissions represent the largest contribution to the City's CAC inventory. This is largely due to fuel combustion in City owned/managed public transit system. In particular, the MRTC and Transit buses fueled by compressed natural gas (CNG) are responsible for large amounts of NO_x emissions. In addition, the City's CNG buses contribute large amounts of VOCs to the City's CAC emission inventory, due to the substantial use of natural gas to operate the public transit buses. Although CAC emissions associated with CNG buses appear to dominate the CAC inventory, it is important to note that these buses are responsible for transporting a large number of people within the City. The corresponding CAC emissions associated with individual automotive transportation of these people would likely far surpass the CACs emitted by the CNG bus fleet.

The other notable contributor to the City's CAC emissions inventory corresponds to emissions from owned/managed buildings. SO_2 and NO_x represent the largest emissions in this category due largely to the combustion of fossil fuels and natural gas to generate electricity in the Province and facility heating/cooling requirements respectively.

A detailed breakdown of data and calculation methodologies is presented in the following sections.

2.1.2 Buildings and Infrastructure

This section is divided into two parts, identified as Corporate Buildings and City Housing. These represent facilities and infrastructure that are owned and under the operational control of the City.

2.1.2.1 Corporate Buildings

Corporate Buildings' electricity consumption data was retrieved from a report provided by City Staff. All monthly kWh consumption was compiled and converted into metric tonnes of carbon dioxide equivalents (t CO_2e) by multiplying end use electricity consumption by an emission factor (t CO_2e/kWh) from the National Inventory Report (Environment Canada 2009). Natural Gas consumption data for facilities is derived from the same report provided by the City, and multiplied by GHG emission factors supplied by Environment Canada (Environment Canada 2008).

Table 2.3 Energy Consumption and GHG Emissions in Corporate Buildings (2005)

Building Category	Electricity (kWh)	Natural Gas (GJ)	Total Emissions (t CO_2e)
Arenas	20,372,731	77,720	8,160
Corporate Facilities	11,021,936	79,179	6,270
HECFI	16,534,073	28,815	4,911
Community Services	4,947,715	72,883	4,680
Rec Centres and Pools	3,937,359	73,950	4,521

Table 2.3 Energy Consumption and GHG Emissions in Corporate Buildings (2005)

Building Category	Electricity (kWh)	Natural Gas (GJ)	Total Emissions (t CO_2e)
Yards	6,074,673	48,037	3,675
Police	5,679,503	32,565	2,819
City/Town Halls	4,987,513	32,193	2,655
Fire/EMS	3,627,639	25,281	2,025
Libraries	7,363,852	8,018	1,947
Recreation, Parks, Stadiums, Golf	3,976,102	16,072	1,638
Museums & Historical	2,108,594	7,293	807
Forestry	406,889	13,751	772
Parks	2,908,239	1,814	701
Community Centers	1,125,250	8,662	669
O&M Operations	664,615	2,866	283
Cemeteries	184,249	130	45
Leased /Rented/ Demo Sites	60,258	0	13
Waste	39,809	0	8
Total	96,020,999	529,230	46,599

In total, the GHG emissions associated with operating this section of the City's buildings was 46,599 t CO_2e in 2005.

In 2007, the electricity consumption in this category increased by 5.5 %, and natural gas consumption decreased by 11.5%. This corresponded to a 1.9% decrease in emissions associated with operating the City's corporate buildings (905 t CO_2e).

The substantial sources of emissions within this emission category during the baseline year of 2005 were arenas (8,160 t CO_2e), and corporate facilities (6,270 t CO_2e). Their emissions are specified below, as well as the substantial source contributions to these emissions:

- Arenas: 8,160 t CO_2e. The consumption of electricity contributes about 52.4% of this total; and
- Corporate facilities: 6,270 t CO_2e. The combustion of natural gas contributes substantially to these overall emissions, representing 63.7% of this total.

The substantial sources of emissions within the Corporate Buildings category during the year 2007 were arenas (8,235 t CO_2e) and corporate facilities (5,991 t CO_2e). Their emissions are specified below, as well as the substantial source contributions to these emissions:

- Arenas: 8,235 t CO_2e. The consumption of electricity contributes substantially to these overall emissions, representing 55.9% of this total; and

- Corporate facilities: 5,991 t CO_2e. The combustion of natural gas contributes substantially to these overall emissions, representing 52.5% of this total

The substantial levels of CACs within this emission category during the baseline year of 2005 were from Arenas (50 t SO_2) and HECFI (40 t SO_2). Their emissions are specified below, as well as the substantial source contributions to these emissions:

- Arenas: 50 t SO_2. The consumption of electricity contributes substantially to these overall emissions, representing 100% of this total; and

- HECFI: 40 t SO_2. The consumption of electricity contributes substantially to these overall emissions, representing 100% of this total

The substantial levels of CACs within this emission category during the baseline year of 2007 were from Arenas (51 t SO_2) and HECFI (43 t SO_2). Their emissions are specified below, as well as the substantial source contributions to these emissions:

- Arenas: 51 t SO_2. The consumption of electricity contributes substantially to these overall emissions, representing 100% of this total; and

- HECFI: 40 t SO_2. The consumption of electricity contributes substantially to these overall emissions, representing 100% of this total.

2.1.2.2 City Housing

End use energy consumption data were not available for City housing units; however, it was determined by the City that these emissions may contribute significantly to the overall emissions associated with the operation of City owned facilities and infrastructure. Stantec modeled energy consumption in dwellings by classifying City housing units into facilities that were constructed before 1941, from 1941 – 1960, from 1961 – 1977, and after 1977.

Using statistical energy consumption averages of single dwellings in Ontario, derived from Natural Resources Canada's (NRCAN) Survey of Household Energy Use Database (NRCAN 2000), and EnerGUIDE data, as well as the Comprehensive Energy Use Database (CEUD) (NRCAN 2007), maintained by NRCAN, it was determined that natural gas is primarily used as space heating fuel and for domestic hot water. Electricity is used for most appliances, lighting, and cooling in residences.

Table 2.4 Energy Modeling Results for Each Dwelling Vintage Category and Emissions for a Sample Semi-Detached Dwelling (2005)

Dwelling Vintage	Number of Dwellings	Electricity (kWh)	Natural Gas (GJ)	Total Emissions (t CO_2e)
Before 1941	8	64,976	1,436	85
1941 – 1960	256	2,273,835	34,215	2,187
1961 – 1977	287	2,586,061	40,487	2,565
After 1977	21	209,853	2,301	159
Age Unknown[3]	391	3,523,171	55,158	3,495
Estimated Total	961	8,657,896	133,596	8,491

In total, the estimated GHG emissions associated with operating the City housing units were 8,491 t CO_2e in 2005.

The substantial sources of emissions within the emission category during the baseline year of 2005 were age unknown (3,495 t CO_2e), and 1961-1977 (2,565 t CO_2e). The substantial emission categories are specified below, along with the substantial source contributors to these emissions:

- Age unknown: 3,495 t CO_2e. The combustion of natural gas contributes substantially to these emissions, representing 78.8% of this total; and
- 1961-1977: 2,565 t CO_2e. The combustion of natural gas contributes substantially to these emissions, representing 78.8% of the total.

The substantial levels of CACs within this emission category during the baseline year of 2005 were from Age Unknown (9 t SO_2 and 6 t NO_x). These emissions are specified below, as well as the substantial source contributions to these emissions:

- Age Unknown: 9 t SO_2. The consumption of electricity contributes substantially to these overall emissions, representing 100% of this total; and
- Age Unknown: 6 t NO_X. The consumption of electricity contributes substantially to these overall emissions, representing 62% of this total.

The number of City housing units present during the baseline year was determined through a GIS study conducted by the City. However, this data was limited in that the number of dwellings per unit and the actual energy consumption values for each unit were not available. The City may wish to consider a more detailed inventory of City housing units including a compilation of some or all units in order to quantify emissions associated with City housing more accurately in

[3] The Age Uknown category includes all City Housing units for which data specifying the vintage and size were unavailable. Average statistics for single dwellings in Ontario have been used to estimate energy consumption for these dwellings.

the future. Due to limited data in this category, no increases or decreases in electricity or natural gas can be calculated from this estimated baseline.

2.1.3 Water and Sewage

Electricity consumption from Water and Sewage facilities and infrastructure was retrieved from a report provided by City staff. All monthly kWh consumption was compiled and converted into t CO_2e by multiplying end use electricity consumption by an emission factor derived from the National Inventory Report (Environment Canada 2009). Natural gas consumption data for facilities was derived from the same report provided by City staff, and multiplied by an emission factor supplied by Environment Canada (Environment Canada 2008). Table 2.5 presents energy consumption and resulting emissions from the buildings and infrastructure associated with the City's Water and Sewage Operations.

Table 2.5 Energy Consumption and GHG Emissions for Water and Sewage Operations (2005)

Water & Sewage Operations	Electricity (kWh)	Natural Gas (GJ)	Total Emissions (t CO_2e)
Total	106,669,584	55,136	25,155

In total, the baseline level of GHG emissions associated with operating the City's Water and Waste Water Systems were 25,155 t CO_2e in 2005. Please note that 2005 natural gas consumption was not consistent with usual consumption levels for these operations, and may be updated if the baseline is refined in the future.

In 2007, the electricity consumption decreased by 6.8 %, and natural gas consumption increased by 71.7%. This resulted in an overall increase in emissions associated with operating the City's facilities and infrastructure from water and sewage of 5.7% (1,442 t CO_2e).

The substantial source of emissions within this emission category during the baseline year of 2005 was the 900 Woodward Ave. water and wastewater treatment center, and it is also the most substantial source during the year 2007. Its emissions are specified below, as well as the substantial contributions to these emissions:

- 900 Woodward Ave in 2005: 16,602 t CO_2e. The consumption of electricity contributes substantially to these overall emissions, representing 85.3% of this total.
- 900 Woodward Ave in 2007: 17,761 t CO_2e. The consumption of electricity contributes substantially to these overall emissions, representing 74.6% of the total.

The substantial levels of CACs within this emission category during the baseline year of 2005 and 2007 were also from the 900 Woodward Ave. water and wastewater treatment center (165 t SO_2 and 75 t NO_x). These emissions are specified below, as well as the substantial source contributions to these emissions:

- 900 Woodward Ave in 2005: 165 t SO_2. The consumption of electricity contributes substantially to these overall emissions, representing 100% of this total; and
- 900 Woodward Ave in 2005: 75 t NO_X. The consumption of electricity contributes substantially to these overall emissions, representing 97% of this total.
- 900 Woodward Ave in 2007: 147 t SO_2. The consumption of electricity contributes substantially to these overall emissions, representing 100% of this total; and
- 900 Woodward Ave in 2007: 69 t NO_X. The consumption of electricity contributes substantially to these overall emissions, representing 94% of this total.

2.1.4 Vehicles

This section on vehicle emissions is divided into sub-sections on the contribution of emissions from the City vehicle fleet, contracted fleets, expensed kilometres, and employee commuting. At the request of the City, these categories are included as part of the City's baseline level of emissions.

2.1.4.1 Vehicle Fleet

Vehicle fleet fuel consumption data were derived from a report provided by City staff. This report identified consumption of regular gasoline, diesel, and natural gas used in different City departments, and within specific divisions of these departments. The fuel amounts were multiplied by an emission factor to convert the data into GHG emissions. In table 2.6, the results are summarized by department.

Table 2.6 Fuel Consumption and GHG Emissions in Vehicle Fleet (2005)

Department	Division	Regular Gasoline (L)	Diesel Fuel (L)	Natural Gas (kg)	Total Emissions (t CO_2e)
Public Works	Capital Planning & Implementation	24,016	-	-	57
	DARTS	69,193	670,623	-	2,003
	Fleets & Facilities	165,008	32,058	-	479
	Operations & Maintenance	993,791	1,463,216	-	6,367
	Redhill Project	1,958	-	-	5
	Transit	272,673	2,849,070	4,691,292	13,073
	MRTC Buses	-	-	6,577,165	6,468
	Waste Management	29,673	412,976	-	1,203
	Water and Wastewater	333,485	116,294	12,665	1,121
TOTAL		1,889,797	5,544,237	11,281,122	30,775
Police	Police	1,307,070	-	-	3,095
TOTAL		0	0	0	3,095
Emergency Services-Fire & Ambulance	Emergency Medical Services	72,005	167,779	-	631
	Fire	89,538	182,345	-	712
TOTAL		161,543	350,124	0	1,343
Planning & Economic Development	Building Services	78,633	-	-	186
	Development Engineering	21,321	-	-	50
	Parking & By-Law Services	143,613	585	-	342
TOTAL		243,567	585	0	578

Table 2.6 Fuel Consumption and GHG Emissions in Vehicle Fleet (2005)

Department	Division	Regular Gasoline (L)	Diesel Fuel (L)	Natural Gas (kg)	Total Emissions (t CO_2e)
Public Health & Community Service	Community Health Bus	-	4,222	-	12
	Finance & Admin –PH	2,388	-	-	6
	Health Protection	10,828	-	-	26
	Recreation	83,041	23,719	329	262
TOTAL		96,257	27,941	329	305
Library	Library	7,335	7,166	-	37
TOTAL		7,335	7,166	0	37
Corporate Services	City Clerk	6,858	-	-	16
	Communication - Postage	3,288	-	-	8
	Information Technologies	779	-	-	2
TOTAL		10,925	0	0	26
HECFI[4]	HECFI	844	-	-	2
TOTAL		844	0	0	2
Corporate Governance	Mayor's Office	523	-	-	1
TOTAL		523	0	0	1
GRAND TOTAL		3,717,861	5,930,053	11,281,451	36,163

[4] Hamilton Entertainment and Convention Facilities. HECFI operates Copp's Coliseum, Hamilton Place, and the Hamilton Convention Center.

In total, the baseline GHG emissions associated with operating the City's vehicle fleet were 36,163 t CO_2e in 2005.

In 2007, the total litres of gasoline increased by 5.4% and diesel increased by 43.3% respectively. The total kilograms of natural gas consumed decreased by 32.5%. On the whole, this corresponds to an increase in emissions associated with operating the City's vehicle fleet of 10.8% from 2005 levels (3,899 t CO_2e), to 40,062 t CO_2e.

The substantial source of emissions within this emission category during the baseline year of 2005 was Public Works (30,755 t CO_2e). Within that department, transit is the largest emission contributor (13,073 t CO_2e). These emissions are specified below, as well as the substantial source contributions to these emissions:

- Public Works: 30,775 t CO_2e. The combustion of diesel contributes substantially to these overall emissions, representing 49.4% of this total; and
- Transit: 13,073 t CO_2e. The combustion of diesel contributes substantially to these overall emissions, representing 59.8% of this total.

Subsequently, the substantial sources of emissions within this emission category during the year 2007 was Public Works (29,782 t CO_2e), with transit being the largest emissions contributor within that department (16,856 t CO_2e). Their emissions are specified below, as well as the substantial source contributions to these emissions:

- Public Works: 29,782 t CO_2e. The combustion of diesel contributes substantially to these overall emissions, representing 73.6% of this total; and
- Transit: 16,856 t CO_2e. The combustion of diesel contributes substantially to these overall emissions, representing 77.6% of this total.

The substantial levels of CACs within this emission category during the year 2005 were from Public Works (17,362 t NO_X). The substantial levels of CACs within that category were from Mountain Regional Transit Centre (10,105 t NO_X). These emissions are specified below, as well as the substantial source contributions to these emissions:

- Public Works: 17,362 t NO_X. The consumption of natural gas contributes substantially to these overall emissions, representing 99.8% of this total; and
- MRTC Bus: 10,105 t NO_X. The consumption of natural gas contributes substantially to these overall emissions, representing 100% of this total.

The substantial levels of CACs within this emission category during the baseline year of 2007 were from Public Works (11,734 t NO_X). The substantial levels of CACs with that category were from MRTC Bus (6,970 t NO_X). These emissions are specified below, as well as the substantial source contributions to these emissions:

- Public Works: 11,734t NO_X. The consumption of natural gas contributes substantially to these overall emissions, representing 99.7% of this total; and
- MRTC Bus: 6,970 t NO_X. The consumption of natural gas contributes substantially to these overall emissions, representing 100% of this total

2.1.4.2 Contracted Fleets

Contracted fleets include all vehicles run by organizations contracted by the City to provide services in certain City departments. At the time of this study, only data for the City's contracted waste fleet were available for quantification.

2.1.4.2.1 Contracted Waste Fleet

The contracted waste fleet includes vehicles run by the organizations that are contracted to assist in the fulfillment of the duties of the Waste Management Division in the Public Works Department at the City. All data used to estimate energy consumption and emissions in this sector were derived from the Waste Management Division. Trucks were categorized by method of garbage, organics, or recycling pickup, and the number of trucks within each category was provided. Additionally, the operating weeks / year for each category of truck were provided, as well as a percentage of the total distance travelled on Hamilton roads. The total number of road kilometres in the City was estimated the "Arc GIS" computer program. The roads data came from the *Geography Division at Statistics Canada*, from a file called the *2005 Road Network File 92-500-XWE/XWF* (Statistics Canada 2005).

Table 2.7 Fuel Consumption and Emissions from Contracted Fleets (2005)

Category	Total Distance (km) / Year	Diesel (L)	Total Emissions (t CO_2e)
Garbage and Organics (Curbside and Roadside Collection)	944,571	317,376	870
Garbage and Organics (Multi-unit bin collection)	82,137	27,598	76
Recycling Trucks	4,435,376	1,490,286	4,087
Multi-Unit Recycling Trucks	328,546	110,392	303
Total	5,790,630	1,945,652	5,336

In total, the baseline GHG emissions associated with the City's contracted fleets were 5,336 t CO_2e in 2005.

In 2007, the total litres of diesel decreased by 2.1%. Because the total number of waste collection units in operation also decreased, this corresponded to a decrease in emissions associated with operating the City's contracted fleets of 15.5% from 2005 levels (827 t CO_2e).

The substantial source of emissions during the baseline year of 2005 was recycling trucks (4,087 t CO_2e), where all emissions resulted from the combustion of diesel. Emissions from recycling trucks represent 76.2% of the total emissions for this emission category.

The substantial source of emissions within this emission category during the year 2007 was also recycling trucks (3,529 t CO_2e), where all emissions resulted from the combustion of diesel, representing 78.3%of the total emissions for this emission category.

The substantial levels of CACs within this emission category during the baseline year of 2005 were NO_x levels (41 t NO_x), where recycling trucks were the substantial source of emissions, contributing 76% of this total (31 t NO_x). All emissions resulted from the combustion of diesel.

The substantial levels of CACs within this emission category during the year 2007 were NO_x levels (39 t NO_X), where recycling trucks were the substantial source of emissions, contributing 79% of this total (31 t NO_x). All emissions resulted from the combustion of diesel.

2.1.4.2.2 Other Contracted Fleets

Due to unpredictable travel patterns and lack of available data, emissions associated with other vehicle fleets contracted by the City (including Operations & Maintenance for Public Works), were not quantified. This data gap is identified as an area that requires improvement in subsequent years. The City may wish to request information concerning fuel consumption, vehicle type, vehicle fuel efficiency, number of vehicles and travel patterns or annual distance travelled for the remainder of its contracted fleets.

2.1.4.3 Expensed Kilometres

The City tracks the extent to which employees use their own vehicles for City purposes through 'mileage claims'. The City reimbursed City staff $960,193 at a rate 0.45 cents / km in 2005. The estimated associated distance travelled and fuel use, calculated by assuming an average fuel efficiency based on NRCAN (NRCAN 2009), is provided in table 2.8.

Table 2.8 Emissions from Expensed Kilometres

Claim Year	Distance Travelled	Regular Gasoline (L)	Total Emissions (t CO_2e)
2005	2,133,763	208,042	493

In total, the baseline GHG emissions associated with employees travelling in their own vehicles for City purposes are 493 t CO_2e in 2005.

In 2007, the distance travelled by employees using their own vehicles for City purposes decreased by 10.3% to 1, 914, 084 kilometres, and the estimated fuel consumption also decreased by 10.3%, with a corresponding decrease in emissions of 51 t CO_2e.

2.1.4.4 Employee Commuting

Activity data associated with employee commuting was provided by City staff, following a GIS exercise to match postal codes of employees in City departments with work postal codes. The employee commuting data set identified in this exercise represents the commuting habits of employees in 2008, however, it is assumed to provide a reasonable estimation of 2005 employee commuting habits. Round trip distances were estimated by Stantec using origin and destination data, and an average fuel efficiency figure and number of commuting days was assumed to calculate the potential fuel consumption associated with commuting to work. Fuel consumption data was multiplied by emission factors (Environment Canada 2008), NRCAN (NRCAN 2009), and the US Environmental Protection Agency (USEPA 2000), to calculate emissions.

It was assumed that all fuel use was regular gasoline. The commuting data does not include employees at libraries, service centers, or emergency services, and assumes that all employees travel by single occupancy vehicle and that the data provided on employees reflects 2005 employment figures.

Table 2.9 Baseline Fuel Use and Emissions from Employee Commuting

Department	Regular Gasoline (L)	Emission Factor (t CO_2e / L)	Total Emissions (t CO_2e)
TOTAL	1,619,346	0.00237	3,835

In total, the baseline GHG emissions associated with employee commuting were 3,835 t CO_2e.

The substantial source of emissions within this emission category during the baseline year of 2005 was the commuting of employees in the Transit division of the Public Works department (465 t CO_2e), where all emissions resulted from the combustion of regular gasoline. The Transit division of Public Works represents 12.1% of the total emissions for this emission category.

The substantial levels of CACs within this emission category during the baseline year of 2005 were from employees in the Transit division of the Public Works department (22 t CO), and Community Services Recreation West (13 t CO), where all emissions resulted from the consumption of regular gasoline. The Transit division of Public Works represents 12.2% of the total CO emissions for this emission category, while Community Services Recreation West represents 7.2% of the total CO emissions.

Due to the limited nature of this data set, no increases or decreases in fuel consumption can be calculated from this estimated baseline.

In 2007, research was conducted to identify City employees' mode of transportation to and from work. Figure 2.4 summarizes this modal split using information derived from a survey of 607 City employees. The City has expressed interest in refining this survey in the future, and may wish to study the modal split retroactively to 2005, and recalculate their baseline using this data so that changes can be tracked from this estimated baseline using the new modal split method.

Figure 2.4 Mode of Transportation for Commuting in 2007

2.1.4.5 Small Engines

GHG and CAC emissions (including CO, SO_2, NO_x, TPM, PM_{10} and $PM_{2.5}$) were calculated for the inventory of small engines used by the City for landscaping and maintenance purposes. This inventory includes a number of gasoline powered 2 and 4-stroke engines, with the average age of the equipment provided by the City. Emissions from these engines were estimated with emission factors and formulas from the U.S. EPA's Nonroad Engine Model (U.S. EPA, 2005). As these factors are based on engine size and no engine size data was provided, it was necessary to estimate typical size ranges that could be present in a mix of engines. The model provided this estimation in the form of a sales mix survey of different engine types and sizes. The following table summarizes the emissions from the small engine equipment inventory.

Table 2.10 Baseline Fuel Use and Emissions from Small Engines

Equipment Category	Engine Type	Average Consumption (L)	Total Emissions (t CO_2e)
Lawn and Garden Care	2 stroke 0-1hp	129	0.28
	2 stroke 1-3hp	3,166	6.95
	2 stroke 3-6hp	382	0.76
	4 stroke 3-6hp	1,088	2.56
	4 stroke 6-25hp	574	1.36

Table 2.10 Baseline Fuel Use and Emissions from Small Engines

Equipment Category	Engine Type	Average Consumption (L)	Total Emissions (t CO_2e)
Portable Equipment	4 stroke 3-6hp	72	0.17
	4 stroke 6-25hp	185	0.44
Total Regular Gasoline Consumption		5,596	13
Total Diesel Consumption (no equipment counts available)		7,409	20
TOTAL		-	33

In total, the baseline GHG emissions associated with small engines were 33 t of CO_2e in 2005.

The substantial sources of emissions within this emission category during the baseline year of 2005 were diesel equipment (20 t CO_2e), and 2 stroke 1-3 hp gasoline engines used for lawn and garden care (6.95 t CO_2e). Their emissions are specified below:

- Diesel Equipment: 20 t CO_2e. Emissions from diesel equipment represent 60.6% of the total emissions for this emission category; and
- 2 Stroke 1-3 hp Gasoline Engines: 6.95 t CO_2e. Emissions from 2 stroke 1-3hp gasoline engines represent 21.1% of the total emissions for this emission category.

The substantial levels of CACs within this emission category during the baseline year of 2005 were from 2 stroke 1-3hp gasoline engines (1.82 t CO), and 4 stroke 3-6hp gasoline engines (0.74 t CO). Their emissions are specified below:

- 2 Stroke 1-3 hp Gasoline Engine: 1.82 t CO. Emissions from 2 stroke 1-3 hp gasoline engines represent 52.1% of the total CO emissions for this emission category; and
- 4 Stroke 3-6 hp Gasoline Engine: 0.74 t CO. Emissions from 4 stroke 3-6 hp gasoline engines represent 21.2% of the total CO emissions for this category.

No increases or decreases can be calculated from this estimated baseline without current data on specific pieces of small engine equipment.

2.1.5 Streetlights

Electricity consumption data from street and area lighting was retrieved from a report provided by City staff. All monthly kWh consumption data was compiled and converted into t CO_2e by multiplying end use electricity consumption by a coefficient derived from the National Inventory Report (Environment Canada 2009). The City divides their streetlights into lighting and parking lot lighting categories. The address of each lighting unit or names the type of lighting, and all associated energy consumption and the resulting emissions is presented below.

Table 2.11 Energy Consumption and GHG Emissions from Street and Area Lights

Streetlight Address	Electricity (kWh)	Total Emissions (t CO_2e)
Street Lighting	33,580,851	7,052
Traffic Lights	5,643,120	1,185
1562 Upper Shermane	11,049	2
1 James St South	0	0
100 Reno Avenue	0	0
100 Main Street East	0	0
109 Arbour Road	0	0
192 Wentworth St N	0	0
2 Fourth Avenue	0	0
40 Hess Village Lights	0	0
4640 Highway 6 Lights	0	0
801 Upper Paradise	0	0
Park- Conc 3 Lot 48	60.949	13
Park-23 Conc Lot 53	25,054	5
Park-Conc 4 Lot 4 B13	9.065	2
Park-Conc 8 Lot 3	8,700	2
Park- Conc 3 Lot 52	1,133	0
Park-13 Clarence St	0	0
LIGHTING SUB-TOTAL	39,339,921	8,261
York Parking	631,766	133
John & Rebecca Parking	40,640	9
King & Bay Parking	24,681	5
Barton & Caroline Parking	18,977	4
King William & Mary Parking	17,647	4
Bay & Cannon Parking	17,102	4
Barton Parking	10,032	2
Catherine & Hunter Parking	8,936	2
Main & Ferguson Parking	11,058	2
Dundas Parking Lot 5 – Golden Vall	2,479	1
Ferguson Parking	5,888	1
Dundas Parking Lot 7 – Hatt St	749	0
Dundas Parking Lot 4 –Royal Bank	122	0
Dundas Parking Lot 6 – C House	2,051	0
PARKING LOT LIGHTING SUB-TOTAL	792,128	166
GRAND TOTAL	40,132,049	8,428

In total, the baseline GHG emissions associated with streetlights were 8,428 t CO_2e in 2005.

In 2007, the estimated electricity consumption decreased by 0.2%.The corresponding increase in emissions associated with street and area lighting owned by the City was 4.5% (380 t CO_2e), due to a rise in GHG emissions associated with electricity generation in the Province in 2007.

The substantial sources of emissions within this emission category during the baseline year of 2005 were street lighting (7,052 t CO_2e), and traffic lights (1,185 t CO_2e), where all emissions result from the consumption of electricity. Their emissions are specified below:

- Street Lighting: 7,052 t CO_2e. Emissions from electricity consumption associated with street lighting represent 83.7% of the total emissions for this emission category; and
- Traffic Lights: 1,185 t CO_2e. Emissions from electricity consumption associated with traffic lights represent 14.1% of the total emissions for this emission category.

The substantial sources of emissions within this emission category during the year 2007 remained street lighting (7,482 t CO_2e) and traffic lights (1,099 t CO_2e). Their emissions are specified below:

- Street Lighting: 7,482 t CO_2e. Emissions from electricity consumption associated with street lighting represent 84.3% of the total emissions from this emission category; and
- Traffic Lights: 1,099t CO_2e. Emissions from electricity consumption associated with traffic lighting represent 12.6% of the total emissions from this emission category.

The substantial levels of CACs within this emission category during the baseline year of 2005 were from street lighting (82 t SO_2 and 36 t NO_x), which all resulted from the consumption of electricity. These emissions are specified below:

- Street Lighting: 82 t SO_2. Emissions from electricity consumption associated with street lighting represent 83.7% of the total SO_2 emissions within that emission category; and
- Street Lighting: 36 t NO_X. Emissions from electricity consumption associated with street lighting represent 83.7% of the total NO_x emissions within this emission category.

The substantial levels of CACs within this emission category during the year 2007 were once again from street lighting (83 t SO_2, and 37 t NO_X), which all resulted from the consumption of electricity. Their emissions are specified below:

- Street Lighting: 83 t SO_2. Emissions from electricity consumption associated with street lighting represent 84.7% of the total SO_2 emissions within that emission category; and
- Street Lighting: 37 t NO_X. Emissions from electricity consumption associated with street lighting represent 86.0% of the total NO_X emissions within this emission category.

2.1.6 Waste on Land

Due to lack of available data, waste quantities associated with the City's operations could not be disaggregated from the total Community. Please see the Community waste section (Section 3.1.7) for more information on waste and associated emissions.

2.1.7 Wastewater

Emissions from wastewater treatment processes, (excluding end use energy consumption associated with wastewater facilities and infrastructure (addressed in Section 2.1.3) are a new consideration under the ICLEI LG Protocol and PCP program.

Using Volume 5, Chapter 6 of the *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (*Wastewater Treatment and Discharge*) (IPCC 2006), substantial sources of emissions from the City's wastewater treatment systems were determined and quantified.

Domestic sewage is collected, treated, and is carried to a wastewater treatment plant through sewers. Aerobic treatment takes place at the plant, and all sludge associated with this process goes to an anaerobic digester. The methane (CH_4) produced from the anaerobic digester was flared in 2005, and sent to a co-generation plant to produce energy in 2007.

Aerobic treatment systems produce little or no CH_4 however they are small sources of N_2O where the system employs advanced treatment techniques to remove nutrients from the sludge. An average per person, per year emission factor (IPCC 2006) was used to calculate these emissions as reflected in the table in this section.

In 2005, wastewater CH_4 was combusted after being directed to two gas flares. This method prevented the emission of a substantial amount of this gas into the atmosphere (although trace amounts of CH_4 and N_20 are still present, and default IPCC values are used to calculate the emissions), but biogas is not used as an energy source.

In 2007, the biogas cogeneration project at the Woodward Avenue Wastewater Treatment Plant used the biogas to covert CH_4 steam into electricity and it recovered heat from this process that is used in the plant for space heating and to warm digesters.

At the Woodward Avenue Wastewater Treatment Plant, sludge is collected and treated by anaerobic digestion, with the biogas being used for energy generation in a 1.6 MW Caterpillar cogeneration turbine. The CO_2 emissions from biogas are considered zero (or carbon neutral) given their biogenic nature[5]. GHG emissions from the use of clarifiers are assumed to be negligible in accordance with their treatment by the IPCC. The total quantity of biogas combusted (m^3) annually was multiplied by an emission factor (IPCC 2006) to yield N_2O and CH_4 emissions.

In table 2.12, the emission categories, activity data used as inputs to calculate emissions, emission factors, and the resulting emissions are provided. Conversion factors were used to convert cubic metres to the energy equivalent in terajoules.

[5] It is common practice to assume that any GHGs associated with the decomposition of biogenic substances are balanced by the natural creation of organic matter in the carbon cycle. Accordingly, GHGs from biogenic substances need not be quantified.

Table 2.12 Emissions from Wastewater Treatment (2005)

Emission Type	Population (number of people) or Biogas Amount Produced (m^3)	Emission Factor	Units	Total Emissions (t CO_2e)
N_2O from advanced treatment of waste using nutrient removal	504,559 people	0.0032	kg N_2O/ person /year	481
CH_4 from biogas combusted	7,574,149 m^3	3	kg/TJ	18
N_2O from biogas combusted	7,574,149 m^3	0.3	kg/TJ	26
Total	-	-	-	525

In total, the baseline GHG emissions associated with wastewater treatment were 525 t CO_2e in 2005.

By 2007 the population of the City is estimated to have increased by 3% from the baseline period (see Section 2.1.9.4), and the biogas used for energy generation decreased by 7.5%. The corresponding increase in emissions associated with wastewater treatment from 2005 to 2007 was 1.3 % (7 t CO_2e).

2.1.8 Data Gaps

The data gaps that existed when the City GHG emissions were quantified for 2005 are presented in this section. Data gaps can skew the results of baseline emission levels, and can also compromise the quality of estimates to determine emission reductions from that baseline

Identifying data gaps assists in determining what new data is needed, the effort required to collect it, and provide an indication of the level of quality associated with the existing estimates. When data does become available to address gaps, some quantification methodologies may change and the City may consider a ‘rolling baseline’, where baseline years change as better data becomes available. Additionally, the City could update to their 2005 baseline and make a subsequent re-estimate of progress from that baseline.

Table 2.13 Data Gaps by Emission Category

Emission Category	Sub category	Data Gap (required data)	Data Used	Notes
Buildings and Infrastructure	City Housing	Number of dwellings per City owned housing unit and energy consumption in City owned housing units	Energy modeling results to estimate the potential electricity and natural gas consumption for different vintages of houses	Actual consumption data is currently being collected

Table 2.13 Data Gaps by Emission Category

Emission Category	Sub category	Data Gap (required data)	Data Used	Notes
Vehicles	Contracted Waste Fleet	Fuel consumption by type of fuel combusted in the City's contracted waste fleet	Distance travelled estimates for truck types and average fuel efficiency factors to estimate potential fuel consumption	n/a
	Other Contracted Fleets	Fuel consumption by type of fuel combusted in all of the City's contracted vehicles, including Public Works Operations & Maintenance	No data available and quantification did not occur	n/a
	Expensed Kilometres	Fuel consumption by type of fuel combusted from expensed mileage	Dollar amount claimed annually and a conversion factor to determine rate paid out per kilometre, and an average fuel efficiency factor to determine potential fuel consumption	n/a
	Employee Commuting	Fuel consumption by type of fuel Combusted and actual number of vehicles used in commutes	Estimated round trip commuting distances and an assumed single vehicle occupancy trip for each employee combined with an average fuel efficiency factor to determine fuel consumption	City exploring the possibility of applying modal split information to commuting data in the future, and possibility of refining/repeating mode of transportation survey
Small Engines		Fuel consumption, age of equipment and engine size broken down by small engine type	Average age of the equipment and engine size assumed and emissions estimated using the U.S. EPA's Nonroad Engine Model (U.S. EPA, 2005).	'Small Engines Module' spreadsheet in existence will continue to be modified and used to collect data. City's Operations & Maintenance Equipment Coordinator has been identified as a contact for information on the City's small equipment inventory

Table 2.13 Data Gaps by Emission Category

Emission Category	Sub category	Data Gap (required data)	Data Used	Notes
Waste on Land		Metrics tonnes of solid waste to landfill from City operations	No data available and quantification did not occur	n/a
Employee Air Travel		Total distance travelled by City employees in air planes	No data available and quantification did not occur	City exploring the possibility of including this in future emission inventories

2.1.8.1 Business as Usual Forecast (2015)

The business as usual (BAU) forecast is presented in this section, with the summary presented prior to the methodology and a detailed explanation of the emissions estimates. The BAU forecast is an estimate emission levels for the City's corporate entity by 2015, ten years from their baseline year of 2005. A ten year forecast is a requirement of the PCP program, and this forecast is limited to a prediction of GHG emissions only. Some emission categories were not forecast due to data limitations associated with initial baseline quantification exercises (*i.e.* the baseline is an estimate and the City cannot track changes from the baseline) or limitations in data that would allow the project team to predict future emission levels. Forecast estimates are completed using growth or decline multipliers. An extension of the City forecast to 2020 is provided in Section 5.1 of this report to help assess reductions required to meet the City's 2020 GHG target.

Summary

Figure 2.5 is a summary of the emission forecast to 2015. These totals and estimates presume no significant change in City service levels, no change in the emission factor associated with electricity generation, and the successful implementation of emission reduction measures noted in table 2.14.

Figure 2.5 Comparison of 2005 and 2015 City Emissions

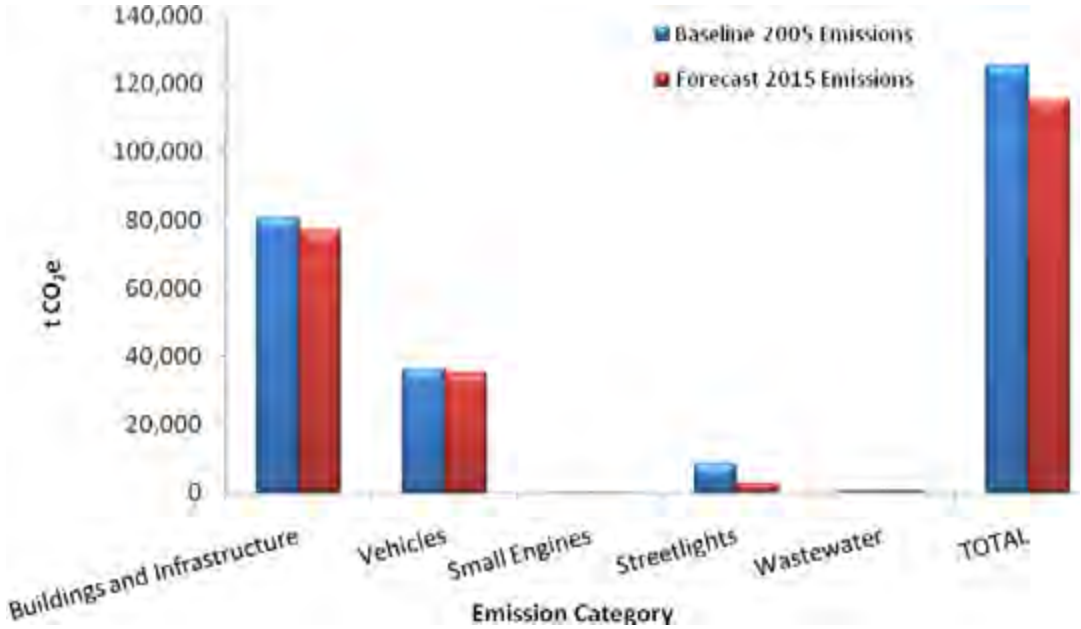


Table 2.14 is a summary of the emission forecast to 2015.

Table 2.14 Summary of Emission Forecast (2015)

Emission Category	Baseline Emissions (2005)	Total Emissions (2015)	% Change
Buildings and Infrastructure (Corporate Buildings, City Housing, Water and Sewage)	80,425	76,791	-4.30%
Vehicles	36,163	35,086	-2.98%
Small Engines	33	30	-8.28%
Streetlights	8,428	2,528	-70.00%
Wastewater	525	576	+9.71%
TOTAL	125,394	115,011	-8.28%

The complexity of this analysis was determined by the data the City has available on growth and decline trends and planning for each emission category. Where possible, intensity metrics are used to calculate average GHG emissions spread over units of the population or operation, as well as percentages found in planning documents.

The City forecast assumes that the City will continue to operate as they are currently. The City is uniquely positioned in that *'business as usual'* includes incorporating innovative measures and actions that result in emission reductions, and other forward thinking planning initiatives and policies that will impact emissions levels over time.

Table 2.15 notes the City emission category, and initiatives or trends considered in the estimates. Following the table, a discussion focused on each category notes the growth and decline multipliers, and the predicted level of emissions by 2015. Unlike the results and analysis presented as part of Objective A, this forecast combines corporate buildings, city housing, and water and sewage facilities and infrastructure into one category, for ease of application of policy and emission reduction measures to predict emissions levels.

When the forecast uses units of the population to predict emissions, it draws from the GRIDS Growth Management Strategy for the City to predict the population by 2015. This strategy notes that by 2021, the population of the City will reach 590,000 people, up from 2005 levels by approximately 14%, or 85,441 people. This number has been pro-rated over 16 years (2005 to 2021), to determine the average population growth each year (5340 people each year). This is a simplified assumption as the population and the associated emissions are likely to grow exponentially rather than in a linear fashion. Thus, the distribution of emissions reductions or increases may vary from the projections. By 2015, it can be reasonably estimated that the population of the City will have increased by 53,400 people, making the total population 557,959. Table 2.15 highlights some of the initiatives undertaken by the City that were considered when completing this forecast.

Table 2.15 Forecast Considerations

Emission Category	Initiatives and Trends Considered
Buildings and Infrastructure (Corporate Buildings, City Housing, Water and Sewage)	Energy Retrofit Pilot Program Corporate Energy Report Corporate Energy Policy
Vehicles	Fleet Strategic Plan Green Fleet Implementation Plan
Small Engines	-
Streetlights	Lightsavers Project, LEDs Replacement Traffic Signals
Wastewater	Annual Amount of Wastewater Treated GRIDS Growth Management Strategy

Building and Infrastructure (2015)

To forecast emissions from buildings and infrastructure, (which includes all commercial, institutional and other facilities and infrastructure owned and operated by the City such city housing units and water and sewage facilities), it is assumed that Corporate Energy Policy will be successful in encouraging emission reduction measures in all City owned facilities.

The Policy (Office of Energy Initiatives (OEI), 2007) calls for targeted reductions in the energy intensity including electricity and natural gas, of City-owned facilities and operations of 7.5% by 2012 and 20% by 2020, compared to a base year of 2008. As calculated by the City, these targets are expected to equal an estimated 1.5 per cent reduction in energy consumption annually.

Additionally, it was assumed that the City's building portfolio will grow linearly with population, at the rate of growth in population estimated by the GRIDS study (1.1% per year). It is also assumed that the emission factor associated with electricity generation will remain at the same as the reported 2007 level for the Province, which is 0.22 kg CO_2e / kWh of electricity. It was assumed that the percentage breakdown of electricity and natural gas consumption in City owned facilities will remain consistent into 2015.

In 2005, the energy consumed in this emission category was equivalent to 1,478,817 GJ, which is comprised of 760,855 GJ of electricity (or 211,348,479 kWh) representing 51.5% of the total, and 717,963 GJ of natural gas, representing 48.5% of the total. The estimated emissions associated with the City's buildings and infrastructure in 2005 are 80,245 t CO_2e. The anticipated decrease in energy consumption is 15% (1.5 % each year, until 2015).

The forecasted 2015 emissions associated with the City's buildings and infrastructure are 76,791 t CO_2e.

The City is currently planning to launch several energy efficiency and demand reduction programs which, if implemented successfully, could potentially cause emission reductions beyond the level predicted in this forecast by 2015. However, as these programs had yet to be launched at the time of this report, they were not included in this Business as Usual forecast.

Vehicles (2015)

To forecast emissions from the vehicle fleet in 2015, which include 9 categories of vehicles classified by the department or division that uses them, the *Fleet Strategic Plan and the Green Fleet Implementation Plan* Phase 1 and Phase 2 were assumed successful in encouraging the incorporation of emission reduction measures into the vehicle fleet.

Follow up reports on the success of the measures implemented as part of Phase 1 of the implementation plan (Fleet Advisory Committee, 2009) claim a 546 tCO_2e reduction in emissions, compared to a base year of 2005. As calculated by the City, other initiatives are planned for implementation from 2009 to 2011 such as adding 21 more hybrid vehicles to their substantial hybrid fleet, as well as increasing the use of biodiesel by 5%, which will result in an additional emission reduction of 504 t CO_2e. It is assumed that these emission reductions are calculated with respect to a specific emission category baseline, and do not consider end use consumption values from the entire vehicle fleet portfolio. The following analysis is provided as an example of this end use analysis.

When the vehicle fleet's 2007 regular gasoline, diesel, and natural gas consumption is compared to 2005 consumption levels, the following increases and decreases in consumption and emissions are shown. This analysis does not include the 2008 calendar year:

- Regular Gasoline Consumption and Emissions (2005): 3,717,861 L, 8,804 t CO2e.

  Regular Gasoline Consumption and Emissions (2007): 3,918,562 L, 9,280 t CO_2e.

  Percent Change in Consumption and Emissions: + 5.4 %, + 5.4 %;
- Diesel Consumption and Emissions (2005): 5,930,053 L, 16,264 t CO2e.

  Diesel Consumption and Emissions (2007): 8,494,381 L, 23,297 t CO2e.

  Percent Change in Consumption and Emissions: + 43.3%, +43.3 %; and
- Natural Gas Consumption and Emissions (2005): 11,281,451 kg, 11,094 t CO_2e.

  Natural Gas Consumption and Emissions (2007): 7,611,469 kg, 7,485 t CO_2e.

  Percent Change in Consumption and Emissions: -32.5 %, -32.5 %

The vehicle fleet total emissions in 2005 were 36,136 t CO_2e. The total emissions in 2007 were 40 062 t CO_2e. The total emission increase is 3,899 t CO_2e.

The forecasted 2015 emissions associated with the City's Vehicle Fleet are 35,086 t CO_2e (2005 baseline year emissions less 1050 t CO_2e of potential reductions from Green Fleet Implementation Plan Phase 1 and 2).

Small Engines (2015)

It is challenging to accurately predict emissions levels associated with this equipment in 2015, given the variety of assumptions for emissions associated with small engines.

The City's parks department implemented an equipment trial in May 2009 to test the benefits of electric powered rechargeable mowers in its 2009 Turf Management Program, but no indication has been provided for the continued uptake of such electric powered small engines, nor on the phase out of 2-stroke engine equipment for more fuel efficient and low emission equipment.

For the purposes of completing this estimate, emissions are assumed to decrease by the average percent decrease of all other emission categories.

The forecasted 2015 emissions associated with the City's small engines inventory are 30 t CO_2e.

Streetlights (2015)

To forecast emissions from City owned street and area lighting in 2015, the Lightsavers Pilot Project, which the City began participating in 2008, was assumed successful in reducing energy consumption associated with lighting by 70% (OCETA, 2009). This reduction is predicted to be achieved through increased use of LED lamps and intelligent lighting system controls.

It is also assumed that the City's lighting portfolio will remain consistent in size, and that the emission factor associated with electricity generation will remain at the same as the reported 2007 level for the Province, which is 0.22 kg CO_2e / kWh of electricity.

In 2005, the energy consumed in this emission category was equivalent to 144,475 GJ, which is comprised of 144,475GJ of electricity (or 40,132,049 kWh).The estimated emissions associated with street and area lighting in 2005 were 8,428 t CO_2e.

The forecasted 2015 emissions associated with City lighting are 2,528 t CO_2e.

Wastewater (2015)

A forecast of emissions from wastewater treatment (excluding the energy required to operate these facilities because these emissions are estimated in the Buildings and Infrastructure section) is challenging without direct knowledge of the potential biogas that will be produced and used for energy generation. For the purposes of this forecast, population increases in the City are used to predict emissions of N_2O from the advanced treatment of waste with nutrient removal, and the biogas produced has been assumed to reflect the same level of emissions, and thus the same N_2O and CH_4 emissions.

In 2005, the emissions in this category were equivalent to a total of 525 t CO_2e, which is comprised of

- 428 t CO_2e from waste treatment and nutrient removal; and
- 44 t CO_2e from biogas used for energy generation.

In 2015, the emissions in this category are predicted to increase with the expected increase in population.

The forecasted 2015 emissions associated with wastewater treatment in the City are therefore 576 t CO_2e.

In 2007, the City's Woodward Wastewater Treatment plant (WWTP) implemented a 1.6 MW co-generation facility fueled entirely by methane sourced from the anaerobic digestion of sewage sludge treated at the plant. The City notes that methane is currently produced at a rate of approximately 10,400 m^3/day. The Water and Wastewater Division plans to further enhance the sludge treatment process by adding further digestion capacity and sludge preconditioning facilities, and doubling the cogeneration capacity to 3.2 MW as sludge volumes grow over the next 20 years. The preconditioning facilities and additional digestion capacity may allow the WWTP to produce more methane from the existing sludge stream, and sludge increases could further enhance generation potential.

Emission reductions associated with creating and using electricity at the co-generation facility can only be claimed by the City if the electricity is being used to displace consumption of electricity that the City would otherwise purchase from the grid. If the electricity from the facility is being sold, emission reductions are not counted.

Although there are preliminary plans to increase generation potential and potentially displace the consumption of conventional electricity or other energy at the City, these initiatives are not factored into this business as usual forecast at this time.

3.0 Objective A (Part 2): Community Air Pollutant and GHG Inventory

The air pollutant and GHG inventory for the Hamilton Community is presented in this section, including the Community baseline emissions for 2006, and a discussion on GHG and CAC emissions trends for the years 2006 to 2008. Data presented in these sections was provided by City staff and other community stakeholders. Gaps in data and a business as usual emission forecasts are provided to enable the City to achieve milestones within the PCP program, and to improve data tracking systems in upcoming years.

The scope of the Community GHG emission inventory for the baseline calendar year of 2006 includes the following sectors:

- Residential;
- Commercial and Institutional;
- Industrial;
- Transportation;
- Agriculture; and
- Waste.

In addition to direct data on consumption patterns in each sector, estimates were made for energy consumption and activity data.

Actual energy consumption inputs used in emission estimates, explanations of estimation methods and data sources, and the resulting amount of CO_2e released as a result of energy consumption in each sector are presented.

Each section also includes information on increases or decreases in consumption and GHG emissions from 2006 to 2008 where sufficient data have been provided, as well as an indication of CAC releases in 2006, 2007, and 2008. The methods for calculating or deriving energy inputs and emissions releases for 2007 and 2008 are the same as the methods stated for 2006.

3.1.1 Summary

Data summarizing GHG emissions by sector, scope and energy source, CACs by sector, and gaps in baseline data are presented in this section.

3.1.1.1 GHG Summary

The total 2006 Community GHG emissions estimates are summarized in table 3.1.

Table 3.1 Community GHG Emissions by Sector (2006)

Emission Category	Total Emissions (t CO_2e)
Residential	793,635
Commercial	1,134,666
Industrial	1,960,442
Steel Industry	7,757,526
Transportation	964,590
Waste	105,798
Agriculture	41,995
TOTAL	12,758,652

The Community GHG emissions by source are summarized in figure 3.1.

Figure 3.1 Community GHG Emissions Summary (2006)

Steel industry emissions make up a large portion of the Community emissions, as demonstrated in the figure 3.1. If emissions from the steel industry and industrial sector are disregarded, the breakdown of Community GHG emissions by source changes. The Community GHG emissions by source without including the steel industry or industrial sector are summarized in the figure 3.2.

Figure 3.2 Community GHG Emissions Summary Excluding Industrial and Steel Industry

3.1.1.2 CAC Summary – Community

The Community CAC emissions by source for 2006 are summarized in table 3.2.

Table 3.2 CAC Emissions by Source (2006)

Emission Category	CO	SO_2	NO_X	VOC	TPM	PM_{10}	$PM_{2.5}$
Residential	3,666	4,360	2,310	611	863	607	484
Commercial	1,064	6,791	3,439	55	667	314	125
Industrial	983	55,366	6,927	316	17,795	4,199	1,132
Steel Industry	29,562	8,272	-	951	2,981	1,699	1,379
Transportation	21,690	28	1,448	1,479	96	95	69
Total	57,123	74,818	14,164	3,412	22,402	6,913	3,189

The Community CAC emissions in Hamilton are dominated by the presence of a large industrial sector. For the purposes of this study we have separated emissions from the steel industry which is the most significant emission source in the region. As described in upcoming sections, the CAC emissions by energy source were calculated using industrial fuel consumption statistics for the following categories:

- Electricity;
- Natural Gas;
- Diesel Fuel Oil, Light Fuel Oil, Kerosene;
- Heavy Fuel Oil;
- LPG and Gas Plant NGL;
- Coal;
- Coke and Coke Oven Gas; and
- Other (Petroleum Coke).

Based on the Provincial energy consumption statistics, the majority of CAC emissions arise from the industrial, steel, and transportation sectors within the Community. The majority of CO emissions arise from the steel and transportation sectors. These emissions are the result of coke oven gas, coal and gasoline combustion respectively. In addition, substantial SO_2 and total particulate matter (TPM) emissions arise from the transportation sector due to the combustion of fossil fuels.

A detailed breakdown of data and calculation methodologies is presented in the following sections.

3.1.2 Residential

Residential fuel consumption estimates were made using the “Comprehensive Energy Use Database” (NRCAN, 2007), which suggests that the energy demands of residences in Ontario would be met by electricity (30.3%), natural gas (60.5%), wood and other solid fuels (3.8%), oil (3.9%), and propane (1.5%).

Horizon Utilities billing data for the residential rate category denotes that residential electricity consumption during the calendar year in 2006 equaled 1,725,777,417 kWh, the equivalent of 6,212,798 GJ (Lord 2009). Billing data provided by Union Gas for the M1 rate category, which includes only residential natural gas use, denotes that residential natural gas consumption for 2006 equaled 222,359,878 m^3, or 8,449,675 GJ (Cummings 2009). Assuming the NRCAN estimates apply, and electricity and natural gas equate to 90.8% of the Community energy consumption or 14,662,473 GJ, the remaining 9.2% of energy consumption in the Community can be reasonably estimated to be comprised of wood and other solid fuels at 613,628 GJ (3.8%) oil consumption at 629,776 GJ (3.9%), which is equal to 16,437,150 litres of oil, and propane consumption at 242,221 GJ (1.5%), which is equal to 11,010,068 litres of propane.

Emissions from the wood and other solid fuels consumed are assumed to be climate neutral[6]. The consumption of oil, propane, and electricity in GJ, are converted into litres and kWh based on energy conversion factors. This data is summarized in table 3.3.

Table 3.3 Baseline Residential Sector Energy Consumption Estimations (2006)

Energy Type	Percentage	GJ	Consumption	Units
Electricity	30.3%	6,212,798	1,725,777,417	kWh
Natural Gas	60.5%	8,449,675	8,449,675	GJ
Wood and Solid Fuels	3.8%	613,628	33,169	Metric Tonnes
Oil	3.9%	629,776	16,437,150	Litres
Propane	1.5%	242,221	11,010,068	Litres
Total	100.0%	16,148,098	-	-

These energy consumption totals are multiplied by the associated carbon dioxide equivalency (CO_2e), which is a factor that considers the global warming potentials of CO_2, N_2O, and CH_4, and represents those as a common factor to determine emissions levels. This value is taken from the 2006 Community Carbon Toolkit Coefficients worksheet in order to determine the resulting GHG emissions. A summary of the residential sector GHG emissions by each energy type is provided in table 3.4.

Table 3.4 Baseline Residential Sector GHG Emissions by Energy Type (2006)

Energy Type	Use	Units	CO_2e Emission Factors (t CO_2e / unit of use)	Total CO_2e (t)
Electricity	1,725,777,417	kWh	0.00018	310,640
Natural Gas	8,449,675	GJ	0.04995	422,061
Wood and Solid Fuels	33,169	GJ	-	-
Oil	16,437,150	L	0.00282	46,413
Propane	11,010,068	L	0.00132	14,521
Total	-	-	-	793,635

In total, the GHG emissions attributable to the residential sector in 2006 are estimated to be 793,635 t CO_2e.

[6] It is common practice to assume that any GHGs associated with the decomposition of biogenic substances are balanced by the natural creation of organic matter in the carbon cycle. Accordingly, GHGs from biogenic substances need not be quantified.

From 2006 to 2008, Horizon Utilities billing records indicate that end use electricity consumption decreased 0.8%, from 1,725,777,417 kWh of electricity to 1,712,094,190 kWh of electricity (Lord 2009). The result was an increase in CO_2e of 21.3%, up from 310,640 t CO_2e to 376,661 t CO_2e (largely due to the increase in emissions associated with electricity generation). Union Gas records indicate that natural gas consumption increased 5.9% between these periods, from 222,359,878 m^3 of natural gas to 235,530,319 m^3 of natural gas (Cummings 2009). The result was an increase in CO_2e of 1.1%, up from 442,061 t CO_2e to 447,060 tCO_2e. An adjustment in these actual inputs resulted in a new emissions profile for this sector in 2008. The energy inputs and resulting emissions are specified in table 3.5.

Table 3.5 Predicted Residential Sector GHG Emissions by Energy Type (2007 and 2008)

Energy Type	Units	Use	CO_2e Emission Factors (t CO_2e / unit of use)	Total CO_2e (t)
2007				
Electricity	kWh	1,735,986,979	0.00022	381,917
Natural Gas	GJ	8,828,920	0.04995	441,005
Wood and Solid Fuels	Metric Tonnes	34,110	-	-
Oil	L	16,903,500	0.00282	47,729
Propane	L	11,322,422	0.00132	14,933
Total	-	-	-	885,584
2008				
Electricity	kWh	1,712,094,190	0.00022	376,661
Natural Gas	GJ	8,950,152	0.04995	447,060
Wood and Solid Fuels	Metric Tonnes	34,190	-	-
Oil	L	16,942,980	0.00282	47,841
Propane	L	11,348,887	0.00132	14,968
Total	-	-	-	886,530

In total, the GHG emissions attributable to the residential sector in 2008 are estimated to be 886,530 t CO_2e.

In addition to total CO_2e, CAC emissions were quantified using the same energy inputs. The results for 2006, 2007, and 2008 are provided in table 3.6.

Table 3.6 Baseline and Predicted Residential Sector CAC Releases for Each Energy Type in 2006, 2007, and 2008

Energy Type	Units	Use	Total CO (t)	Total SO_2 (t)	Total NO_x (t)	Total VOC (t)	Total TPM (t)	Total PM_{10} (t)	Total $PM_{2.5}$ (t)
2006 Residential Inventory (Baseline)									
Electricity	kWh	1,725,777,417	526	4,211	1,868	33	405	194	74
Natural Gas	GJ	8,449,675	299	2	356	-	27	7	7
Wood and Solid Fuels	GJ	33,169	2,830	7	46	578	427	404	403
Oil	L	16,437,150	10	140	39	0	4	2	0
Propane	L	11,010,068	10	0	17	1	1	1	1
Total	-	-	3,675	4,360	2,310	611	863	607	484
2007 Residential Inventory									
Electricity	kWh	1,735,986,979	530	4,236	1,879	33	407	195	74
Natural Gas	GJ	8,828,920	312	2	372	-	28	7	7
Wood and Solid Fuels	GJ	34,110	2,911	7	48	594	439	415	415
Oil	L	16,903,500	10	144	41	0	4	2	1
Propane	L	11,322,422	10	0	18	1	1	1	1
Total	-	-	3773	4,389	2,339	628	879	620	496
2008 Residential Inventory									
Electricity	kWh	1,712,094,190	522	4,178	1,853	33	402	193	73
Natural Gas	GJ	8,950,152	317	2	377	-	29	7	7
Wood and Solid Fuels	GJ	34,190	2,918	7	48	596	440	416	416
Oil	L	16,942,980	10	144	41	0	4	2	1
Propane	L	11,348,887	10	0	18	1	1	1	1
Total	-	-	3777	4,332	2,318	629	874	618	496

3.1.3 Commercial Sector

Commercial and institutional sector typically includes light manufacturing, retail, warehousing, and institutional buildings, and related activities.

The energy consumption estimates for the sector were made using the CEUD statistics (NRCAN 2007), which provides the end use energy consumption of the commercial sector in Ontario, not including fuel used for transport. Actual billing information was provided for electricity from Horizon Utilities (General Services < 50 kW and > 50 kW rate categories) (Lord 2009) and natural gas from Union Gas (M2, M4, and M5/7 rate categories) (Cummings June 2009), and this data was used in the estimates. The data indicates that commercial users of energy in the Community meet a large portion of their energy needs with electricity and natural gas (91% combined). It is anticipated that some energy needs are also met by the consumption of heating oil and other middle distillates, heavy fuel oil, and propane.

In the absence of additional, more detailed local information on energy statistics, it is assumed that in this sector 91% of the end use energy requirements are met by electricity and natural gas combined, 4.6% from heating oil and other middle distillates, 1.8% from heavy fuel oil, and 2.6% from propane (NRCAN, 2007). Propane is noted in the statistics as 'other' fuel combusted within this sector.

Horizon Utilities billing data denotes that commercial electricity consumption during the calendar year in 2006 equaled 2,656,900,786 kWh, the equivalent of 9,564,843 GJ (Stuart 2009). Union Gas billing data denotes that commercial natural gas consumption during the calendar year in 2006 equaled 273,164,695 m^3, the equivalent of 10,380,358 GJ (Cummings June 2009). When NRCAN estimates are applied, it is assumed that electricity consumption is representative of 44% and natural gas is representative of 47%. A heating oil value of 1,008,214 GJ, a heavy fuel oil value of 394,518 GJ, and a propane value of 569,860 GJ have been assumed. These are converted into litres using energy conversion factors to total 61,685,556 L.

Table 3.7 Baseline Commercial Sector Energy Consumption by Energy Type (2006)

Energy Type	Percentage	GJ	Use
Electricity	44%	9,564,843	2,656,900,786 kWh
Natural Gas	47%	10,380,358	273,164,695 m^3
Heating Oil and other Middle Distillates	4.6%	1,008,214	26,314,383 L
Heavy Fuel Oil	1.8%	394,518	9,468,444 L
Propane	2.6%	569,860	25,902,729 L
Total	100.0%	21,917,793	-

The commercial sector GHG emissions by each energy type are summarized in table 3.8.

Table 3.8 Baseline Commercial Sector GHG Emissions by Energy Type (2006)

Energy Type	Use	Units	CO_2e emission factors (t CO_2e / unit of use)	Total CO_2e (t)
Electricity	2,656,900,786	kWh	0.00018	478,242
Natural Gas	273,164,695	m^3	0.04995	518,494
Heating Oil and other Middle Distillates	26,314,383	L	0.00283	74,302
Heavy Fuel Oil	9,468,444	L	0.00311	29,464
Propane	25,902,729	L	0.00132	34,163
Total	-	-	-	1,134,666

In total, the GHG emissions attributable to the commercial sector in 2006 were 1,134,666 t CO_2e.

From 2006 to 2008, Horizon Utilities billing records indicate that electricity consumption increased 0.09%, to 2,659,161,613 kWh. The result was an increase in CO_2e of 22.3%, up from 478,242 t CO_2e to 585,016 t CO_2e (largely due to an increase in emissions associated with electricity generation). Union Gas records indicate that natural gas consumption increased 9.8% between these periods, to 299,850,173 m^3 of natural gas. The result was a 9.8% increase in CO_2e, up from 518,494 t CO_2e to 569,146 t CO_2e. Using electricity and natural gas consumption values for the year 2008 resulted in a different emissions profile for this sector in 2008. The energy inputs and resulting emissions are specified in table 3.9.

Table 3.9 Commercial Sector GHG Emissions by Energy Type (2007 and 2008)

Energy Type	Use	Units	CO_2e emission factors	Total CO_2e (t)
2007				
Electricity	2,718,335,971	kWh	0.00022	598,034
Natural Gas	10,977,748	GJ	0.04995	548,339
Heating Oil and other Middle Distillates	27,394,470	L	0.00283	77,352
Heavy Fuel Oil	9,857,081	L	0.00311	30,674
Propane	26,965,919	L	0.00132	35,565

Table 3.9 Commercial Sector GHG Emissions by Energy Type (2007 and 2008)

Energy Type	Use	Units	CO_2e emission factors	Total CO_2e (t)
Total	-	-	-	1,289,964
2008				
Electricity	2,659,161,613	kWh	0.00022	585,016
Natural Gas	11,394,307	GJ	0.04995	569,146
Heating Oil and other Middle Distillates	20,964,416	L	0.00283	78,110
Heavy Fuel Oil	7,543,418	L	0.00311	30,974
Propane	20,636,455	L	0.00132	35,914
Total	-	-	-	1,299,160

In total, the GHG emissions attributable to the commercial sector in 2008 were 1,299,160 t CO_2e.

In addition to total CO_2e emissions, CAC emissions were quantified using the same energy inputs. The results for 2006, 2007, and 2008 are provided in table 3.10.

Table 3.10 Commercial Sector CAC Releases for Each Energy Type in 2006, 2007, and 2008

Energy Type	Use	Units	Total CO (t)	Total SO_2 (t)	Total NO_x (t)	Total VOC (t)	Total TPM (t)	Total PM_{10} (t)	Total $PM_{2.5}$ (t)
2006 Baseline Commercial Inventory									
Electricity	2,656,900,786	kWh	810	6,484	2,876	51	623	299	113
Natural Gas	10,380,258	GJ	367	3	437	-	33	8	8
Heating Oil and other Middle Distillates	26,314,383	L	16	224	63	1	6	3	1
Heavy Fuel Oil	9,468,444	L	6	81	23	0	2	1	0
Propane	25,902,729	L	23	0	40	3	2	2	2
Total	-		1,222	6,791	3,439	55	667	314	125
2007 Commercial Inventory									
Electricity	2,718,335,971	kWh	829	6,634	2,942	52	638	306	116
Natural Gas	10,977,748	GJ	388	3	462	-	35	9	9
Heating Oil and other Middle Distillates	21,113,263	L	16	233	66	1	7	3	1
Heavy Fuel Oil	7,596,976	L	6	84	24	0	2	1	0
Propane	20,782,974	L	24	0	42	3	2	2	2
Total	-	-	1,264	6,954	3,536	56	684	321	128
2008 Commercial Inventory									
Electricity	2,659,161,613	kWh	811	6,489	2,878	51	624	299	144
Natural Gas	11,394,307	GJ	403	3	480	-	36	9	9
Heating Oil and other Middle Distillates	20,964,416	L	17	236	66	1	7	3	1
Heavy Fuel Oil	7,543,418	L	6	85	24	0	2	1	0
Propane	20,636,455	L	24	0	42	3	2	2	2
Total	-		1,261	6,813	3,491	55	672	315	126

3.1.4 Industrial

Actual billing information on end use consumption was provided for natural gas from Union Gas (T-1 rate category for users above 5,000,000 m^3 per year) (Cummings June 2009), and this data was used in the estimates after the consumption associated with the steel industry was subtracted from it. CEUD statistics indicate that industrial users of energy in the Community would meet 36.5% of their energy needs from natural gas. It is anticipated that some energy needs are also met by the consumption of diesel fuel oil, light fuel oil, and kerosene, heavy fuel oil, liquefied petroleum gas and gas plant NGL, coal, coke and coke oven gas, and 'other' unspecified fuels, that are assumed to be largely petroleum coke as noted in CEUD statistics.

In the absence of additional, more detailed local information on energy statistics, it is assumed that in this sector:

- 16.8% of the end use energy requirements are met by electricity;
- 36.5% from natural gas;
- 3.8% from diesel, light fuel oil, and kerosene;
- 3.4% from heavy fuel oil;
- 1% from liquefied petroleum gas and gas plant NGL;
- 1.5% from coal, 14.6% from coke and coke oven gas; and
- 22.2% from petroleum coke (NRCAN, 2007).

Petroleum coke is noted in the statistics as 'other' fuel combusted within this sector.

The steel industry in Hamilton represents a large portion of the Community's industrial emissions. For this reason, the emissions from the steel industry have been obtained from NPRI (Environment Canada National Pollutant Release Inventory 2007) and Environment Canada's GHG Reporting (Environment Canada September 2008), and are presented as a separate category. Steel Industry natural gas consumption has been subtracted from the overall industrial natural gas consumption number provided by Union Gas to give the energy consumption estimations below.

Table 3.11 Baseline Industrial Sector Energy Consumption Estimations (2006)

Energy Type	Percentage	GJ	Consumption	Units
Electricity	16.8%	5,131,774	1,425,492,805	kWh
Natural Gas	36.5%	11,149,390*	11,149,390	GJ

Table 3.11 Baseline Industrial Sector Energy Consumption Estimations (2006)

Energy Type	Percentage	GJ	Consumption	Units
Diesel Fuel oil, Light Fuel oil and Kerosene	3.8%	1,160,758	30,295,795	L
Heavy Fuel Oil	3.4%	1,038,573	24,295,760	L
LPG and Gas Plant NGL	1%	305,463	13,844,670	L
Coal	1.5%	458,194	18,328	Metric Tonnes
Coke and Coke Oven Gas	14.6%	4,459,756	4,459,756	GJ
Petroleum Coke	22,2%	6,781,273	6,781,273	GJ
Total	100.0%	30,485,181	-	-

**This does not include the steel sector.*

The commercial sector GHG emissions by each energy type are summarized in table 3.12.

Table 3.12 Baseline Industrial Sector GHG Emissions by Energy Type (2006)

Energy Type	Use	Units	Total CO_2e (t)
2006			
Electricity	1,425,492,805	kWh	256,589
Natural Gas	11,149,390	GJ	556,689
Heavy Fuel Oil	24,925,760	L	77,544
Diesel, Light Fuel Oil, Kerosene	20,295,795	L	77,374
LPG and Gas Plant NGL	13,844,670	L	18,312
Coal	18,328	tonnes	39,171
Coke and Coke Oven Gas	4,459,756	GJ	375,511
Other (Petroleum Coke)	6,781,273	GJ	559,252
Total	-	-	1,960,442

In total, the GHG emissions attributable to the industrial sector in 2006 were 1,960,442 t CO_2e.

Estimates of industrial natural gas usage were made for 2007 using the same method outlined above for the 2006 estimate. The emissions profile for 2008 could not be calculated because GHG and air pollutant emissions data for the year 2008 had not been released by Environment Canada at the time of this report. From 2006 to 2007, natural gas consumption decreased 15.3%, to 248,514,712 m^3 of natural gas. The result was a 15.3% decrease in CO_2e to 1,660,499 t CO_2e. Actual 2007 natural gas consumption inputs resulted in a different emissions profile for this sector in 2007. The energy inputs and resulting emissions are specified in table 3.13

Table 3.13 Industrial Sector GHG Emissions by Energy Type (2007)

Energy Type	Use	Units	Total CO_2e (t)
2007			
Electricity	1,207,395,678	kWh	217,331
Natural Gas	9,443,559*	GJ	471,517
Heavy Fuel Oil	21,122,176	L	65,680
Diesel, Light Fuel Oil, Kerosene	25,660,608	L	65,536
LPG and Gas Plant NGL	11,760,348	L	15,511
Coal	15,524	Tonnes	33,178
Coke and Coke Oven Gas	3,777,424	GJ	318,059
Other (Petroleum Coke)	5,743,754	GJ	473,687
Total	-	-	1,660,499

**This does not include the steel sector.*

In addition to total CO_2e emissions, CAC emissions were quantified using the same energy inputs. The results for 2006 and 2007 are provided in table 3.14.

Table 3.14 Industrial Sector CAC Releases for Each Energy Type in 2006, 2007

Energy Type	Use	Units	Total CO (t)	Total SO_2 (t)	Total NO_x (t)	Total VOC (t)	Total TPM (t)	Total PM_{10} (t)	Total $PM_{2.5}$ (t)
2006 Baseline Industrial Inventory									
Electricity	1,425,492,805	kWh	435	3,479	1,543	27	334	160	61
Natural Gas	11,149,390	GJ	394	3	469	-	36	9	9
Diesel Fuel Oil, Light Fuel Oil, Kerosene	24,925,760	L	18	258	73	1	7	4	1
Heavy Fuel Oil	20,295,795	L	15	1,174	165	3	30	26	17
LPG and Gas Plant NGL	8.038,493,260	L	12	0	22	2	1	1	1
Coal	18,328	tonnes	5	1,741	284	12	733	169	44
Coke and Coke Oven Gas	4,459,756	GJ	41	19,326	1,734	107	6.607	1,520	396
Other (Petroleum Coke)	6,781,273	GJ	63	29,386	2,637	163	10,046	2,311	603
Total	-	-	983	55,366	6,927	316	17,795	4,199	1,132

Table 3.14 Industrial Sector CAC Releases for Each Energy Type in 2006, 2007

Energy Type	Use	Units	Total CO (t)	Total SO_2 (t)	Total NO_x (t)	Total VOC (t)	Total TPM (t)	Total PM_{10} (t)	Total $PM_{2.5}$ (t)
2007 Industrial Inventory									
Electricity	1,207,395,678	kWh	368	2,946	1,307	23	283	136	52
Natural Gas	9,443,559	GJ	334	2	398	-	30	8	8
Diesel Fuel Oil, Light Fuel Oil, Kerosene	21,122,176	L	15	219	62	1	6	3	1
Heavy Fuel Oil	25,660,608	L	13	994	139	3	25	22	14
LPG and Gas Plant NGL	6.808,622,247	L	11	0	18	1	1	1	1
Coal	15,524	tonnes	4	1,475	241	10	621	143	37
Coke and Coke Oven Gas	3,777,424	GJ	35	16,369	1,469	91	5,596	1,287	336
Other (Petroleum Coke)	5,743,754	GJ	53	24,890	2,234	138	8,509	1,957	511
Total	-	-	833	46,895	5,867	267	15,072	3,556	959

3.1.5 Steel Industry

The City's steel industry represents a large portion of its industrial energy consumption and emissions, and thus has been separated from the rest of the City's industry. In particular, a small number of individual facilities that make large contributions to the Community's total emissions have been identified by the City. Annual natural gas use for these facilities has been estimated using the NPRI emissions and statistics detailing the average breakdown of fuel consumption in steel plants. Quantification of steel industry emissions focused on these facilities.

The GHG emissions for the individual facilities were obtained from Environment Canada's Facility GHG Reporting (Environment Canada September 2008), and air pollutant emissions were obtained from Environment Canada's National Pollutant Release Inventory (Environment Canada National Pollutant Release Inventory 2007), represented in tonnes / year.

Table 3.15 Baseline Steel Industry GHG and CAC Emissions (2007)

Facility Name	NPRI ID	Total CO_2e	Total CO	Total SO_2	VOCs	TPM	PM_{10}	$PM_{2.5}$
ArcelorMittal-Dofasco Inc.	3713	4,514,174	6,300	5,250	496	1,590	743	533
Hamilton Specialty Bar (2007)Inc.	2161	49,730	478	18	-	49	28	20
Mittal Canada Hamilton Inc.	4045	-	-	-	-	14	1	1
MULTISERV CANADA-Dofasco-Hamilton	1391	-	-	-	-	-	5	1
Multiserv Canada	1388	-	-	-	-	-	4	1
Nelson Steel (Division of Samuel Manu-Tech Inc.)	5768	-	-	-	-	-	-	-
Triple M Metal LP	11325	-	-	-	-	-	3	-

Table 3.15 Baseline Steel Industry GHG and CAC Emissions (2007)

Facility Name	NPRI ID	Total CO_2e	Total CO	Total SO_2	VOCs	TPM	PM_{10}	$PM_{2.5}$
Triple M Metal LP-Parkdale East	11615	-	-	-	-		-	-
Triple M Metal LP-Parkdale West	5645	-	-	-	-		-	-
Triple M Metal LP-Strathearne	11574	-	-	-	-		-	-
U.S. Steel Canada	2984	3,166,622	22,784	3,004	455	1,328	925	823
Total	-	7,757,526	29,562	8,272	951	2,981	1,699	1,369

"-" Dashes note that no data was available from NPRI

In total, the GHG emissions attributable to the steel industry for the baseline year 2006 were 7,757,526 t CO_2e.

From 2006 to 2007, GHG emissions increased 5.2% from 7,757,526 t CO_2e to 8,162,818 t CO_2e.

3.1.6 Community Transportation

Estimating community transportation emissions is challenging, given gaps in data. As noted in the ICLEI Local Government Protocol (ICLEI 2009), "in most cases it (tailpipe emissions from on-road vehicles) will be estimated based on regional distance traveled data."

Emissions associated with the Community's transportation sector were estimated by converting an annual distance travelled estimate provided by City staff to fuel consumption for regular gasoline and diesel vehicles. This value did not include distance travelled on highways.

To estimate the number of litres of regular gasoline and diesel fuel consumed, the total distance travelled (in km) by vehicles in the Community is pro-rated using percentages derived from Statistics Canada data on the total gasoline and diesel fuel purchases for road motor vehicles in Ontario (Statistics Canada 2008). An average fuel efficiency of 10.7 L/100km, calculated by averaging fuel efficiencies for different vehicle classes provided by NRCAN (NRCAN 2009), was then used to estimate annual consumption for the City.

The results are not presented in this report however, commuting emissions are estimated in a spreadsheet provided to the City and presented as a disaggregated value from these total values. Commuting origins and destinations for common commuting routes were identified using the Statistics Canada Common Commuting Flows report (Statistics Canada June 2008). This data show commuting flows in Hamilton by noting Hamilton commuters' place of residence, work destination, and the number of people who travel these routes. Round trip distances for these common routes for commuting were estimated.

The Community's estimated GHG emissions and air pollutant emissions from vehicle travel are all estimated by the Toolkit by multiplying energy inputs by the appropriate emission coefficient for regular gasoline or diesel fuel. CACs are calculated by multiplying energy inputs by emission factors for distance travelled by certain classes of vehicles.

Table 3.16 Emissions from Transportation Within the Community

Fuel Type	Use	Units	CO_2e Emission Factors	Total CO_2e (t)
Regular Gasoline	209,777,887	L	0.00237	496,775
Diesel	170,569,724	L	0.00274	476,815
Total	-	-	-	964,590

In total, the GHG emissions attributable to the Community transportation sector in 2006 were 964,590 t CO_2e.

In addition to total CO_2e emissions, CAC emissions were quantified using the same energy inputs. The results for the 2005 base year are provided in table 3.17.

Table 3.17 CAC Emissions from Transportation within the Community

Fuel Type	Units	Annual Amount	Total CO(t)	Total SO_2(t)	Total NO_X(t)	Total VOC(t)	Total TPM (t)	Total PM_{10} (t)	Total $PM_{2.5}$ (t)
Regular Gasoline	KM	1,954,452,366	21,304	7	1,093	1,294	31	30	14
Diesel	KM	691,966,428	386	22	396	185	65	65	55
Total	-	-	21,690	28	1,488	1,479	96	95	69

This area is identified as one where considerable improvement could occur in the future.

The McMaster Centre for Spatial analysis, with which the City has a partnership, has developed an innovative way to track emissions levels associated with transportation with the City for Environment Canada. Their model results include emissions assertions from mobile sources for four times of the day: morning peak, day, afternoon peak, night, and estimates of emissions on a per hour basis for the whole year.

The model is expected to be completed near the end of summer of 2009, and the results made available to the City.

3.1.7 Waste in the Community

Emissions associated with the management of mixed municipal solid waste after diversion in the City's landfills was provided directly by the Glanbrook Landfill Waste Management Facility. This facility conducts measurement based testing each year and reports methane levels associated waste management to the Ministry of Environment in a report titled *"Annual Monitoring Report, Glanbrook Landfill Site"*, submitted each year by the City's Public Works Department, Waste Management Division.

This value was converted into a CO_2e figure by multiplying the methane amount by its global warming potential.

In 2006, the total GHG emissions attributable to waste management in the Community were 105,798 t CO_2e.

A large number of private landfills exist within City boundaries. The City commissioned a report during their last fiscal year which resulted in an inventory of these landfills, however, no data associated with waste management techniques or emissions releases for these landfills were included within the scope of this study, and the quantification of these emissions has been identified as a data gap and area for improvement within the community inventory.

In 2007, GHG emissions attributable to waste management in the Community were 86,965 t CO_2e. This is a decrease of 17.8%, from 105,798 t CO_2e in 2006.

Although the emissions quantification was limited to the Glanbrook Landfill, it should be noted that the City increased their waste diversion rate by 25% over 8 years (from 2000 to 2007), up from 17% to 42%. By 2011, the City aims to increase this diversion to 65%.

Annual collection statistics from the City's Public Works department (City of Hamilton Public Works 2008 (2)) is provided in the table 3.18, and shows a decline in waste to landfill in recent years.

Table 3.18 Annual Collection Statistics from the City of Hamilton, Public Works

Year	Material								Total	Diversion
	Recycling		Organic		HHW	White Goods	Landfill	EFW*		
	Curbside	CRC	L & Y	GC						
2007	43,284	3,788	10,576	28,479	1,386	721	150,605	0	238,838	42%
2006	45,144	*4,736	13,262	**25,144	1,286	741	162,797	0	253,110	40%
2005	41,632	568	19,206	975	960	507	176,897	0	240,745	30%
2004	38,409	0	18,201	859	930	592	178,854	0	237,845	28%
2003	31,990	0	17,615	502	833	739	177,645	0	229,324	24%
2002	30,976	0	14,728	109	1,045	873	104,708	120,629	273,068	20%
2001	30,796	0	10,455	0	798	583	96,289	129,536	268,457	18%
2000	32,127	0	6,082	0	648	481	102,107	132,990	274,435	17%

Legend:
CRC = Community Recycling Centre
L & Y = Leaf and Yard
GC = Green Cart
HHW = Household Hazardous Waste
EFW = Energy From Waste
*SWARU closed permanently on December 6th, 2002.
**City wide Green Cart Organics Program rolled out to all City of Hamilton residents in April 2006.

3.1.8 Agriculture

The Community's agriculture profile was derived from the Statistics Canada's 2006 Agriculture Survey (Statistics Canada 2009). This survey contains detailed information on the quantity of agricultural livestock found in the Community in 2006. This information, together with emission factors found in Environment Canada's National Inventory Report 1990-2006 (Environment Canada 2008), was used to calculate the methane emissions from livestock. Methane emissions are the primary source of GHGs from the agricultural sector, and most of the emissions from this sector can be divided into two categories:

- Enteric Fermentation which is the digestive process by which microorganisms break down carbohydrates into simple molecules, producing CH_4 as a by-product; and,
- Manure Management which is the combination of systems typically used for manure handling and storing during which methane is emitted into the atmosphere.

The various types of livestock found in the Community were matched with the pertinent emission factor. However the lack of information in a few cases required that the following assumptions or simplifications be made:

- Canada's Privacy of Information Act required that the quantity of Turkeys and Other Poultry as well as all types of Pigs except Boars in the City be suppressed. The emissions from these animals were not quantified;

- No emission factors were available for Llamas and Alpacas, of which there is a small quantity in the Community. Therefore, the emissions from these animals were not quantified; and

- No Enteric Fermentation emission factors were available for Hens and Chickens. Only Manure Management emissions were quantified for these animals.

It is noted that the emissions associated with the operation of energy consuming equipment in this sector could not be calculated, due to lack of data. Where the agricultural census does provide information on equipment that specifies the number of units used within categories defined by horsepower, no information could be obtained on equipment usage.

The City may wish to explore the quantification of other agricultural sources of emissions in the future as the requirements for doing so under the PCP program evolve, and as more local data becomes available. This could include, but may not be limited to the following:

- Direct N_20 emissions from synthetic nitrogen fertilizers, crop residue decomposition, summer fallow, tillage practices, irrigation, and cultivation or organics soils/ and
- Indirect N_20 emissions from volatilizations and leaching of fertilizer, manure and crop residue nitrogen.

Agricultural emissions from enteric fermentation and manure management in 2006 are presented in table 3.19.

Table 3.19 Agricultural Emissions from Enteric Fermentation and Manure Management (2006)

Type of Livestock	Number of Livestock in 2006	Emissions from Enteric Fermentation (t CO_2e)	Emissions from Manure Management (t CO2e)	Total CO_2e (t)
Cattle	12,167	20,387	2,336	22,723
Pigs	17,485	554	2,273	2,828
Sheep and Lambs	3,159	5,373	17	5,391
Poultry	1,754,519	N/A	1,020	1,020
Other livestock	3,362	9,913	120	10,034
Total	-	36,228	5,767	41,995

In total, the GHG emissions attributable to the agricultural sector in 2006 were 41,995 t CO_2e.

3.1.8.1 Data Gaps

The data gaps that existed when the Community GHG emissions were quantified for 2006 are presented in this section. Data gaps can skew the results of baseline emission levels, and can also compromise the quality of estimates to determine emission reductions from that baseline When data does become available to address gaps, some quantification methodologies may change and the City may consider a 'rolling baseline', where baseline years change as better data becomes available. Additionally, the City could update their 2006 baseline and make a subsequent re-estimate of progress from that baseline.

Table 3.20 Data Gaps for Community

Sector	Sub category	Data Gap (required data)	Data Used	Notes
Residential		Local end use energy consumption of wood & solid fuels, heating oil, and propane required	Provincial statistics on end use energy consumption for fuels used to estimate emissions	Actual end use electricity and natural gas values provided and used in estimates
Commercial		Local end use energy consumption of heating oil & other middle distallates, heavy fuel oil, and propane required	Provincial statistics on end use energy consumption for fuels used to estimate emissions	Actual end use electricity and natural gas values provided and used in estimates
Industrial		Local end use energy consumption of electricity, diesel fuel oil, light fuel oil, & kersone, heavy fuel oil, LPG and gas plant NGL, coal, coke & coke oven gas, and petroleum coke required	Provincial statistics on end use energy consumption for fuels used to estimate emissions as well as NPRI data	Actual end use electricity and natural gas values provided and used in estimates, as well as actual NPRI data from large energy users in the steel industry Hamilton
Community Transportation		Per hour emissions assertions from mobile sources at the link level for morning peak, afternoon peak, night and	Distance travelled by road motor vehicles in Hamilton, provincial statistics on end use fuel consumption, and local statistics on commuting flows	The McMaster Centre for Spatial analysis, with which the City has a partnership, will be providing local modeling to fill this data gap in the upcoming months
Waste		Information on type and amount of waste disposed of in private	n/a	n/a

Table 3.20 Data Gaps for Community

Sector	Sub category	Data Gap (required data)	Data Used	Notes
		landfills, as well as waste management techniques and any measurement based quantifications of emissions		
Agriculture		Information on emissions associated with data specified in agricultural section and methodology to quantify these emissions	Statistics Canada 2006 Agricultural Survey	Sufficient detail to determine quantification protocols that will be accepted as part of the PCP program has not be released
Forestry		Measurement of the carbon sequestration potential of trees in Hamilton	n/a	The City is continuing to compile an inventory of trees and may employ modeling software in the future to determine the carbon sequestration potential of trees in Hamilton

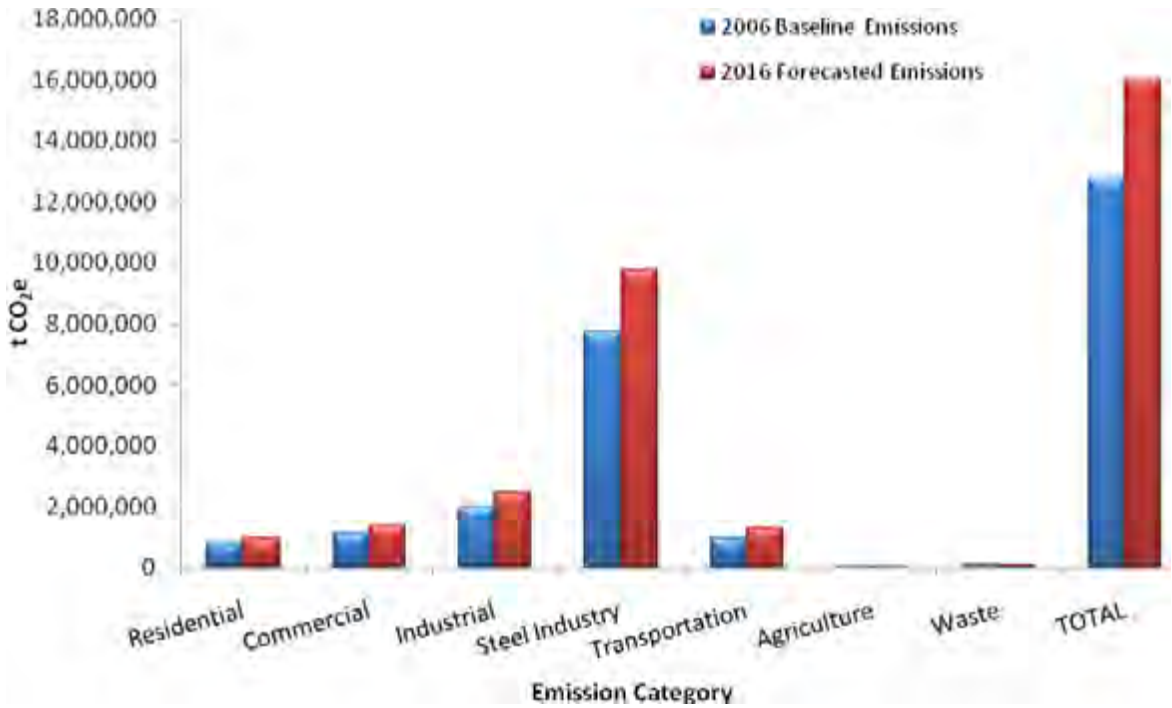
3.1.8.2 Business as Usual Forecast (2016)

The business as usual (BAU) forecast summary is presented in this section, with a detailed explanation of the GHG estimations to follow. This section is an estimate of emission levels for the Community by 2016, ten years from their baseline year of 2006. A ten year forecast is a requirement of the PCP program, and is limited to a prediction of GHG emissions only.

Summary

Figure 3.3 below is a summary of the emission forecast to 2016. These totals and estimates presume significant growth within the Community, and no change in the emission factor associated with electricity generation.

Figure 3.3 Comparison Between 2006 and 2016 GHG Emissions



In Table 3.21, a summary of the emission forecast to 2016 is provided.

Table 3.21 Summary of Emission Forecast (2016)

Emission Category	2006 Baseline Emissions (t CO_2e)	2016 Total Emissions (t CO_2e)	% Change
Residential	793,635	966,816	21.8%
Commercial	1,134,666	1,402,264	23.6%
Industrial	1,960,442	2,464,276	25.7%
Steel Industry	7,757,526	9,751,210	25.7%
Transportation	964,590	1,318,595	36.7%
Agriculture	41,995	41,995	0%
Waste	105,798	92,876	-12.2%
TOTAL	12,758,652	16,038,032	25.7%

These estimates are completed using growth or decline multipliers based on information provided by the City and research findings. An extended forecast to 2020 is provided in Section 5.2 of this report in order to assess reductions required to meet the Community's 2020 GHG reduction target. The forecast is limited to a prediction of GHG emissions only.

The complexity of this analysis was determined by the data available on growth and decline trends and planning for each community sector. Where possible, intensity metrics, as well as percentages found in planning documents are used to calculate emissions.

Like the City forecast, when the forecast uses population to predict emissions, it draws from the GRIDS Growth Management Strategy for the City to predict the population by 2015. This strategy notes that by 2021, the population of the City will reach 590,000 people, up approximately 14% from 2005 levels. This number has been pro-rated over 16 years (2005 to 2021), to determine the average population growth each year (5340 people each year). By 2016, it can be reasonably estimated that the population of the City will have increased by 58,740 people, making the total population 558,859. The GRIDS Strategy also predicts that employment in the City will reach 300,000 by 2031, up by approximately 43% from 2001 levels. The total predicted 30 year increase in employment is 90,000, or an average of 3,000 jobs a year. This translates to a 13% increase in employment from 2006 levels by 2016. For the purpose of this report, we have assumed that the number of commercial establishments will grow linearly with employment levels.

Additionally, it was assumed that the end use energy consumption statistics within the Community will remain consistent from year to year, and that the emission factor associated with electricity generation will remain at the same as the reported 2007 level for the Province of Ontario, which is 0.22 kg CO_2e / kWh of electricity.

Following is a discussion focused on each sector noting multipliers used in the estimates, and the predicted level of emissions by 2016. In cases where emissions were challenging to forecast, the constraints are noted.

Residential (2016)

The residential sector includes all dwellings classified as residential by Horizon Utilities, as well as dwellings classified within a residential Union Gas rate category. The total emissions in 2006 were estimated to be 793,635 t CO_2e, and during this year there were an estimated 204,922 residential units (Hamilton Economic Development 2007).

A simple estimate using the emissions intensity for residences in Hamilton multiplied by the number of expected residences in Hamilton in 2016 to predict emission levels is challenging. The mixed use of dwellings as well as the best-practice method used to quantify baseline emissions in this sector compounds the challenge (using end use energy consumption data from billing records that indicate total energy consumption in the sector). Using an energy model to predict the average energy consumption of a dwelling in Hamilton would also increase the potential error, given that housing vintages and energy consumption types and levels would

have to be assumed, and that this would be a break from the method used to calculate baseline emission levels.

For the purposes of forecasting emissions in a conservative manner, the increase in emissions is expected to grow incrementally with the increase in residences. Housing growth was estimated by drawing from the Places to Grow forecasts for Hamilton portion of the City's planning process. The baseline energy consumption levels for electricity and natural gas were then multiplied by this percentage increase, and the emission factor for electricity was changed to reflect the 2007 emission factor released from Environment Canada. Electricity and natural gas are the only energy sources multiplied to calculate the increase in emissions because they are the only actual billing data use in this quantification exercise. All other data are weighted relative to these values.

In 2006, the emissions from residences in this sector were 793,635 t CO_2e / year. Housing growth is predicted to reach 230,953 residences by 2016, an increase of 12.7%, up from 204,992 residences in 2006. When this percentage is applied to the baseline level of emissions, and the aforementioned assumptions apply, the following consumption patterns are found.

Predicted billing data for the residential rate category suggests that residential electricity consumption during the calendar year in 2016 could equal 1,934,130,524 kWh, the equivalent of 6,962,870 GJ. Predicted billing data for the M1 rate category denotes that residential natural gas consumption may equal 249,205,286 m^3, or 9,469,805 GJ. Assuming the NRCAN energy statistics apply, and electricity and natural gas equate to 90.8% of the residential energy consumption or 16,432,675 GJ, the remaining 9.2% of energy consumption in the residential sector can be reasonably estimated to be comprised of wood and other solid fuels at 687,711 GJ (3.8%), heating oil consumption at 705,309 GJ (3.9%), which is equal to 18,421,607 litres of oil, and propane consumption at 271,465 GJ (1.5%), which is equal to 12,339,313 litres of propane. Emissions from the wood and other solid fuels consumed are assumed to be climate neutral. The consumption of heating oil, propane, and electricity in GJ, are converted into litres and kWh based on energy conversion factors. Table 3.22 shows a summary of the data.

Table 3.22 Predicted Residential Sector GHG Emissions by Energy Type (2016)

Energy Type	Use	Units	CO_2e Emission Factors (t CO_2e / unit of use)	Total CO_2e (t)
Electricity	1,934,130,524	kWh	0.00022	425,509
Natural Gas	9,469,805	GJ	0.04995	473,017
Wood and Solid Fuels	37,174	Metric Tonnes	-	-
Heating Oil	18,421,607	L	0.00282	52,016

Table 3.22 Predicted Residential Sector GHG Emissions by Energy Type (2016)

Energy Type	Use	Units	CO_2e Emission Factors (t CO_2e / unit of use)	Total CO_2e (t)
Propane	12,339,313	L	0.00132	16,274
Total	-	-	-	966,816

The emissions forecast for 2016 associated with the Residential Sector are 966,816 t CO_2e.

Commercial (2016)

The commercial sector includes all commercial and institutional units classified as such by Horizon Utilities, and by Union Gas. The total emissions in 2006 were estimated to be 1,134,666 t CO_2e, and during this year there were an estimated 28,111 (Monaco 2009) commercial units.

A simple estimate using the emissions intensity for commercial units in Hamilton multiplied by the number of expected units in Hamilton in 2016 to predict emission levels is challenging for the same reasons that were explained for predicting emissions in the residential sector (see Residential section above).

For the purposes of forecasting emissions in a conservative manner, the increase in emissions is expected to grow incrementally with the increase in commercial units. Commercial growth was estimated by drawing from the City's GRIDS Growth Management Strategy. The GRIDS study provides forecasts for the growth in employment in the City, and for the purposes of this study, the number of commercial units has been assumed to grow linearly with the number of jobs. The baseline energy consumption levels for electricity and natural gas were then multiplied by the percentage increase in commercial units, and the emission factor for electricity was changed to reflect the most recent factor released from Environment Canada. Electricity and natural gas are the only energy sources multiplied to calculate the increase in emissions because they are the only actual billing data use in this quantification exercise. All other data is weighted relative to these values.

The predicted billing data suggests that commercial electricity consumption during the calendar year in 2016 may equal 3,002,297,888 kWh, the equivalent of 10,808,272 GJ. Predicted natural gas billing data denotes that commercial natural gas consumption during the Calendar year in 2016 may equal 308,676,105 m^3, the equivalent of 11,729,692 GJ. When NRCAN estimates are applied and it is assumed that electricity consumption is representative of 44% of energy consumption in the Community and natural gas is representative of 47%, the total remaining commercial energy consumption to calculate using provincial averages is equal to 2,229,030 GJ. Based on the assumption that the consumption of electricity and natural gas add up to 91% of total energy consumption in the commercial sector, the remaining percentage for the heating

oil and other middle distillates, heavy fuel oil, and propane energy sources noted in the CEUD are weighted to this percentage. The result is a heating oil value of 1,139,282 GJ, a heavy fuel oil value of 445,806 GJ, and a propane value of 643,942 GJ. These are converted into litres using energy conversion factors to total 41,078,536 L. This data is summarized in table 3.23.

Table 3.23 Predicted Commercial Sector Energy Consumption by Energy Type (2016)

Energy Type	Percentage	GJ	Consumption	Units	CO_2e Emission Factors (t CO_2e / unit of use)	Total CO_2e (t)
Electricity	44%	10,808,272	3,002,297,888	kWh	0.00022	660,506
Natural Gas	47%	11,729,692	11,729,692	GJ	0.04995	585,898
Heating Oil and other Middle Distillates	4.6%	1,139,282	29,735,253	L	0.00282	83,962
Heavy Fuel Oil	1.8%	445,806	10,699,381	L	0.00311	33,295
Propane	2.6%	643,942	20,270,084	L	0.00132	38,604
Total	100.0%	24,766,994	-	-	-	1,402,264

The forecasted 2016 emissions associated with the Commercial Sector are 1,402,264 t CO_2e.

Industrial (2016)

It is challenging to accurately predict emissions levels in the Industrial sector over the long term. Where consumption of some resources in this sector (*ie* natural gas) has decreased since 2006 in the short term as a result of a recessed economy in Ontario, this is not expected to continue in the long term. Compounding the difficulty in estimating these emissions are emerging cross border, as well as Federal and potential Provincial regulation of industrial GHG emitters.

For the purposes of completing estimates in a conservative manner, emission levels are assumed to increase on average by 25.7 %, which is the average increase associated with emissions levels in sectors that could be reasonably estimated.

The forecasted 2016 emissions associated with the Industrial sector are 2,474,276 t CO_2e.

Steel Industry (2016)

For the same reasons stated in the Industrial section above, it is challenging to accurately predict emission levels for the City's steel industry over the long term.

For the purpose of completing estimates in a conservative manner, emission levels are assumed to increase on average by 25.7%, which is the average increase associated with emission levels that could be reasonably estimated. It is also assumed that in 2016, the individual facilities that the City has identified as significant contributors to emissions within the Community will continue to be the substantial contributors, and that no significant contributors are added or closed.

The Forecasted 2016 emissions associated with the Steel Industry are 9,751,210 t CO_2e.

Transportation (2016)

To forecast emissions associated with the Community's transportation Ministry of Transportation in Ontario prediction of a 55% increase in vehicle travel in the Greater Toronto Area by 2021 (Smart Commute Initiative 2003) was used. Stantec has assumed that emissions will grow at the same rate as the vehicle travel.

This 55% growth multiplier is pro-rated to give an average increase in vehicle travel of 3.67% per year. This average percent increase was multiplied by ten years and applied to diesel and regular gasoline consumption in this sector in 2006. The resulting Community GHG emissions were calculated by the Toolkit by multiplying energy inputs by the appropriate emission coefficient for regular gasoline or diesel fuel.

In total, the GHG emissions attributable to the Community transportation sector in 2016 were 1,318,595 t CO_2e.

The McMaster Centre for Spatial analysis will be providing the City with transportation emissions modeling results in the future, which could improve the quality of any subsequent estimates and forecasts.

Emissions associated with transportation could be either markedly reduced, or remain at similar levels as compared to 2015 in future years. The City is an integral stakeholder as part of the Metrolinx initiative, which is a Provincial initiative intended to improve transportation from York and Durham areas, through to Toronto, Peel, Halton and into Hamilton. This initiative could result in an improved and interconnected bus rapid transit (BRT) and light rail transit (LRT) system, to serve existing and new residents within the City. Increases in population density, combined with Provincial and City support of the initiative, could result in a high uptake however, implementation of this system is expected to begin beyond the years considered as part of this forecast.

Agriculture (2016)

Baseline agriculture emissions are calculated using Agricultural Census data from Stats Can. This data is not available for the forecast year of 2016. Predicted residential and commercial growth in the Community will likely impact agricultural emissions levels, as land use changes occur within Hamilton's geopolitical boundaries to accommodate growth. This may have an impact on land available for agricultural uses and could result in a decrease in emissions, however, this cannot be known.

Using the current method to predict emission levels in this sector requires a reestimate of emissions when the next census is released and as such, no growth or decline multiplier can be applied at this time.

For the purposes of completing estimates in a conservative manner (and accounting for the possibility that emissions will decrease in the sector), emission levels are assumed to remain the same.

The forecasted 2016 emissions associated with the Agricultural sector are 41,995 t CO_2e.

Waste (2016)

To forecast the emissions generated at the Glanbrook Landfill, current and historical emission levels determined using measurement based methods were considered, as was population growth, and the solid waste management master plan approved in December of 2001, which called for a 65% waste diversion rate through an expansion of recycling and composting, up from 16% waste diversion. This commitment was renewed by the City, and the target year is 2011.

Baseline 2006 emission levels are 105,798 t CO_2e. In 2007, emissions were 86,965 t CO_2e, a 17.8 % decrease that was achieved through flaring methane. To be conservative, an average is calculated using 2006 and 2007 values, and this number is used to derive an emission intensity (the number of tonnes of CO_2e divided by the Community population in 2006). This emission intensity is then multiplied by the population growth up to 2016, as noted by the City's GRIDS Growth Management Strategy (See section 2.1.9.4). The average annual emissions are 96,382 t CO_2e, which are approximately 0.19 t CO_2e / person annually in 2006.

Reductions in emissions of landfill gas could result in the event of increased diversion of recyclable and compostable materials from the landfill. This is factored into the estimates.

In 2006, the waste diversion rate was 40%, and in 2007 and 2008 it was 42% and 44% respectively. This forecast assumes that the City will be successful in meeting its 65% diversion rate goal by 2011, and that this is achieved by 2011 through improvements of 3.67% each year from 2008 to 2011 (up 11 % from 2008 levels to reach 65%).

This percentage improvement is used as a factor to calculate potential emission decline up to 2011. It is assumed that the total emissions at the landfill could be reduced incrementally and simultaneously with the diversion rate, which will affect the emissions intensity in 2016, used to predict an operating level of emissions.

The total forecasted t CO_2e in 2016, considering population growth and improved diversion up to 2011, are 92,876 t CO_2e.

It is important to note that the BAU forecasts presented in this section have been completed to satisfy the requirements of the PCP program for Milestone #1. As such, the forecast extends 10 years from the baseline (2006) based on the conditions present during that fiscal year. Therefore, the emission reductions currently being achieved at the Glanbrook Landfill due to their newly implemented landfill gas collection system are not included in this forecast.

To date, emission reductions associated with the landfill gas collection system are estimated by the City as:

- 2006 – 1 candlestick flare operated for 6 months, 16% emission reduction compared to 2006 levels.
- 2007 – 1 candlestick flare operated for 12 months, 2nd candlestick flare operated for 6 months, 48% emission reduction.
- 2008 – 2 candlestick flares operated for 11 months, 2 Cat 3520 generators operated for 1 month, 51% emission reduction (44% for the flares, 7% for the generators).
- 2009 – projected to be 80% emission reduction.

Although these reductions are not considered in the forecast component in this study, it should be noted that substantive GHG emission reductions are being realized at the Glanbrook Landfill facility. These emission reductions will be quantified in subsequent GHG emission inventories completed by the City.

4.0 Objective B: Assess Existing Actions Against Emission Targets

Progress made towards achieving emission reduction targets in City operations and in the Community is presented in this section. Information is presented on quantitative and qualitative emission reduction measures, and emissions comparisons per annum are used as the measure of progress.

Quantitative measures are those measures that can be calculated as an emission reduction and represented as avoided t CO_2e. Qualitative measures are those measures that may have reduced emissions, but could not be quantified due to lack of available data, or due to other constraints, such as community engagement initiatives to reduce electricity consumption.

Descriptions of emission reduction initiatives are provided in the following sections. However, not all measures have been used in the estimates completed to measure the progress relative to targets. The reason for this is that in some cases, emissions have increased. To calculate the actual emission reductions, baseline emissions are compared to 2007 emissions for the City (two calendar years out from the base year) and 2008 emissions for the Community. This determines the actual change in emissions relative to the base year.

Quantifying emission reductions on a measure by measure basis is a valuable exercise to undertake to fulfill reporting and communication requirements, but does not necessarily account for changes in emissions as a result of either operational or activity changes from year to year. At the end of each year, an updated inventory should be completed to measure actual emission reductions (*i.e.* when data becomes available in 2009, the 2008 City inventory can be completed, which would capture three full years of emission reduction initiatives at the City from a baseline level of 2005).

The City's emissions baseline is 135,058 t CO_2e. The emission reduction targets are:

- 10% below 2005 levels by 2012 and 20% below 2005 levels by 2020.

The Community's emissions baseline is 23,342,209 t CO_2e. The proposed emission reduction targets are:

- 10% below 2006 levels by 2012 and 20% below 2006 levels by 2020.

4.1 CITY

This section draws on information provided by the City, as referenced in the text and the References section in this report. A quantification of actual emission reductions when comparing end use values from 2005 to 2007 follows this section.

4.1.1 Quantitative Emission Reduction Measures

4.1.1.1 Green Fleet Strategic Plan

In 2005, the City completed a *Green Fleet Implementation Plan* (City of Hamilton Public Works 2005) as a follow up to the Green Transition Plan portion of their Central Fleet Strategic Plan. The Implementation Plan applies to vehicles used by the City of Hamilton's Public Works Department, Planning and Development Department, and several other agencies. While it does not include vehicle acquisition for Police, Fire, and EMS, it does affect fuel for these organizations, and for Hamilton-based Go Transit buses. The goal of the plan is to reduce CO_2 output by 4,000 to 6,000 t CO_2e by 2008. The Plan intends to achieve this goal through greater use of biodiesel and hybrid-electric vehicles, and a corporate anti-idling policy. Specifically, the Plan states that the City will replace 46 of its vehicles with hybrid-electric vehicles by the end of 2007, and replace 10% of the 7,000,000 L of annual forecasted diesel fuel use with biodiesel. The corporate idling policy states that City employees in the City shall not leave a vehicle to idle for more than 10 seconds.

GHG emission reductions associated with the actions outlined in the *Green Fleet Implementation Plan* were released in April 2009. The City reduced GHG emissions by 546 t CO_2e over the 3 year timeframe of Phase I, a reduction of 5%, through the increased use of hybrid vehicles and biodiesel. The use of hybrid vehicles increased more than planned, and this initiative contributed a greater proportion of the total GHG reductions than had been anticipated. However, the actual use of biodiesel was lower than originally planned, primarily as a result of market constraints.

4.1.1.2 Green Fleet Implementation Plan, Phase 2

In April 2009, the City released Phase II of their Green Fleet Implementation Plan (City of Hamilton - Central Fleet Advisory Committee 2009), to build on Phase I. Phase II of the Plan covers the years 2009-2011, and examines a much larger number of technologies and best practices that can improve the corporate fleet's fuel efficiency and reduce exhaust emissions. The City's Green Fleet currently includes 135 hybrid vehicles, as well as 94 natural gas buses. Further reductions are planned for 2011, and involve a 5% increase in the use of biodiesel and the addition of 21 more hybrid vehicles for a reduction in GHG emissions of 504 t CO_2e and 454 t CO_2e respectively.

4.1.1.3 Corporate Energy Policy and Public Works Retrofit Program

In October 2007, the City released a Corporate Energy Policy for City Facilities and Operations (Office of Energy Initiatives, Fleets and Facilities, Public Works-City of Hamilton 2007). The policy is designed to:

- Address reporting requirements;
- Achieve city-wide energy reduction targets; and

- Define specific policies regarding capital investment related to energy, and specific policies regarding energy procurement.

The Energy Policy calls for targeted energy reductions in energy intensity of City owned facilities and operations of 3.0% by 2009 and 20% by 2020 compared to a base year of 2005.

In addition, the City of Hamilton's Public Works Office of Energy Initiatives launched a comprehensive Energy Pilot Retrofit Program in 2007, covering 20 of the City's buildings. Retrofit measures were implemented such as lighting, heating, ventilating and air conditioning, building envelope, and water conservation in order to demonstrate to internal stakeholders the environmental benefits that can be achieved through installation of energy efficient measures. The initiative was projected to save the City $280,000 and reduce CO_2 emissions by 1,000 t CO_2e annually.

4.1.1.4 Traffic Lights Conversion

The City started a retrofit program in 2007 aimed at converting all remaining incandescent traffic signals to LED traffic signals, which use 70% less energy than the incandescent bulbs. Since 2004, all newly installed traffic signals have been LED signals. In total, 13,000 individual signal stations at 441 intersections have been converted.

4.1.1.5 Cogeneration Facility

Hamilton Renewable Power Incorporated, which is owned by the City, constructed a 1.6 MW Biogas Cogeneration Facility at the Woodward Avenue Wastewater Treatment Plant (Environment Canada 2008). The facility became operational in 2006, and is anticipated to produce 13.6 million kWh of electricity, while the heat harvested from the engine is used to heat wastewater facilities and saves in excess of $500,000 in natural gas costs. The total energy requirements of the wastewater facilities have declined by 15% since the biogas plant was put into operation.

4.1.1.6 Glanbrook Landfill Gas Collection System

The Glanbrook Landfill Gas to Energy Facility, owned by the City, became operational in 2008. This facility collects landfill gas, primarily methane, which would otherwise be released into the atmosphere. This gas is a reliable, renewable energy source that is produced naturally as organic matter decomposes in landfills. When collected, it can be used directly as a gas (medium heat content) for industrial facilities or sold to gas-to-energy plants to fuel engine or turbine-driven generators that produce electricity.

The facility includes a landfill gas collection system and a Power Plant, which is connected to the Provincial electricity grid. The landfill gas collected is used to generate electricity, and any excess landfill gas will be flared. The power plant can generate 26 million kWh per year (City of Hamilton- Public Works 2009). It is estimated that methane emissions at the landfill may be reduced up to 80% in 2009. The potential reductions to GHG emissions associated with the Glanbrook Landfill gas collection system are presented in upcoming sections.

4.1.1.7 LEED Silver Woodward Avenue Environmental Laboratory

The City's Woodward Avenue Environmental Laboratory became the first Canadian building to achieve LEED (Leadership in Energy Efficient Design) silver certification by the Canada Green Building Council in December 2008 (City of Hamilton-Public Works 2008). The building includes many environmental innovations, and its energy performance was determined to be 32.4% better than the Model National Energy Code Building (MNECB) Energy cost savings of 30.6% are predicted at the Laboratory.

4.1.1.8 Light Savers

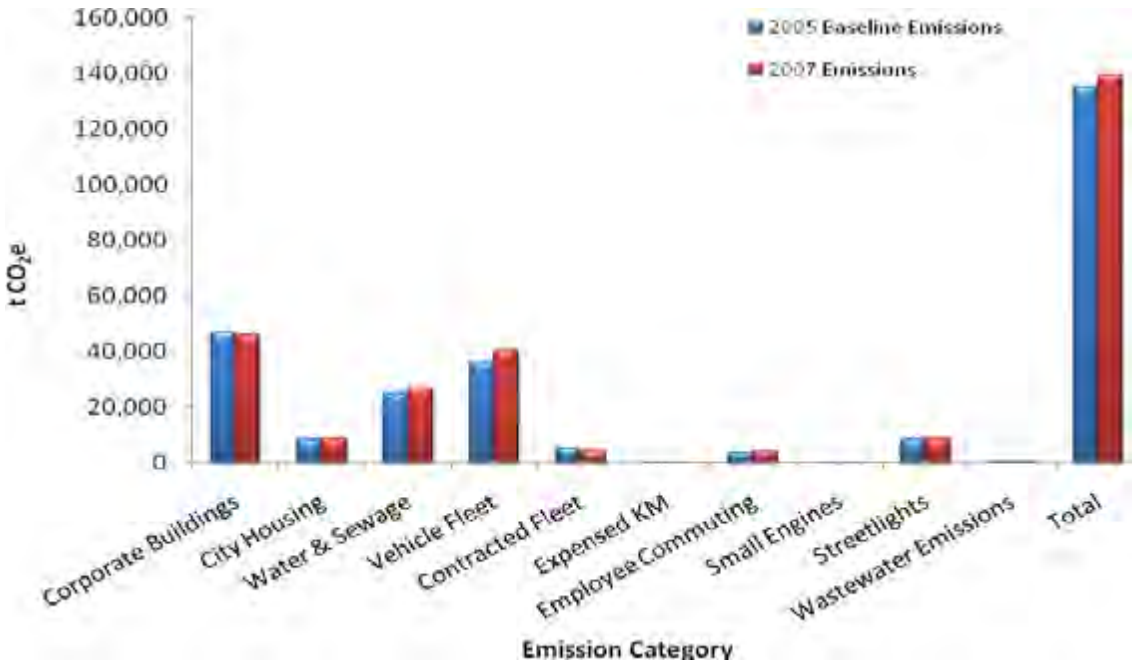
In 2008, the City participated in the LightSavers Pilot Project. The LightSavers program combines grants, new procurement standards, innovative financing and market research to build market awareness and advance the use of LED lamps and intelligent lighting system controls. It is estimated that the deployment of these new technologies could reduce the emissions associated with street, park, and parking area lighting by up to 70% (OCETA 2009).

4.1.2 Quantification of Emission Reduction Measures

Emission reduction measures are presented in this through a comparison of baseline emissions with 2007 emissions.

The 2005 baseline emission levels for the City are compared with these with emission levels in 2007 in the figure below. In cases where emissions within a certain category could not be quantified for the update year, the average change in emissions associated with categories of emissions that could be estimated have been applied to conservatively estimate emissions increases.

Figure 4.1 Comparison Between 2005 and 2007 GHG Emissions



The 2005 baseline emission levels for the City are compared with emission levels in 2007 in table 4.1 below, and the percent increase or decrease in emissions are shown.

Table 4.1 Summary of Change in City GHG Emissions

Emission Category	2005 Baseline Emissions (t CO_2e)	2007 Emissions (t CO_2e)	% Change
Corporate Buildings	46,599	45,694	-1.94%
City Housing	8,491	8,764	+3.22%
Water & Sewage	25,155	26,597	+5.7%
Vehicle Fleet	36,163	40,062	+10.8%
Contracted Fleet	5,336	4,509	-15.5%
Expensed KM	493	442	-10.3%
Employee Commuting	3,835	3,958	+3.22%

Table 4.1 Summary of Change in City GHG Emissions

Emission Category	2005 Baseline Emissions (t CO_2e)	2007 Emissions (t CO_2e)	% Change
Small Engines	33	34	+3.22%
Streetlights	8,428	8,808	-4.5%
Wastewater Emissions	525	532	+1.3%
Total	135,058	139,401	+3.22%

The City has increased their total emissions by 4,343 t CO_2e. This is a 3.22 % increase in emissions above 2005 levels.

A reduction of 17,849 t CO_2e is required by 2012 for the City to meet their goal of reducing GHG emissions 10% below 2005 levels by 2012.

Further, a reduction of 31,355 t CO_2e is required to meet 20% reduction below 2005 levels by 2020.

4.1.2.1 Reported and Estimated Cost Savings

Estimated cost savings associated with the purchases of energy by the City are shown in this section. City departments have budgeting processes and robust reporting systems which provide them with the ability to report on cost savings on a measure by measure basis. The information used to complete this section was drawn from the City's Corporate Energy Report (City of Hamilton – Public Works July 2009), which summarizes energy and cost savings results, compares performance against a base year of 2005, and tracks key performance indicators for City departments.

The report notes that the average price of electricity purchased by the City was $0.088 in 2005, $0.093 in 2006 and $0.085 in 2007. The average price of natural gas purchased by the City was $0.426 in 2005, $0.489 in 2006 and $0.427 in 2007 according to the Corporate Energy Report (City of Hamilton – Public Works July 2009). The City used these figures to calculate cost savings associated with reducing energy consumption.

The City has calculated its total annual electricity consumption for 2005 to be 239,307,767 kWh, at a cost of $20,939,573. In 2007, they reported an increase in total annual electricity consumption from 2005 levels to 241,708,307 kWh, but consumption was reduced to 229,698,311 kWh in 2008 (City of Hamilton – Public Works July 2009).

The City reported total natural gas consumption for 2005 to be 14,279,068 m^3, at a cost of $6,088,265. In 2007, the City reported an increase in natural gas consumption from 2005 levels to 14,644,552 m^3, however consumption was reduced to 13,956,020 m^3 in 2008 (City of Hamilton – Public Works July 2009).

The City reports energy cost savings and avoided costs in the areas of levy benefits (benefits or reductions reflected in the tax base), and rate benefits (benefits or reductions to the water rate base). Levy benefits and rate benefits combine to give the total corporate savings. The City reports both direct savings and avoided costs in these areas.

Direct savings refer to savings that directly benefit the City's bottom line through levy or rate savings, while avoided costs represent capital or an expense that the City would have had to pay had a project not proceeded. From May 2006 to December 31, 2008 the City has reported their Corporate Total cumulative savings and avoided costs associated with energy consumption and water and sewage treatment to be $10,037,971 (City of Hamilton – Public Works July 2009). A breakdown of these savings is shown in the table 4.2.

Table 4.2 Cumulative Savings and Avoided Costs May 2006 to December 31, 2008

Savings ($)/Avoided Costs	Levy Benefits (Tax Base)	Rate Benefits (Water Rates)	Corporate Totals
Avoided Costs	$4,713,481	$2,404,013	$7,117,493
Direct Savings	$2,685,103	$235,375	$2,920,478
Total Cost Reductions & Savings	$7,398,584	$2,639,388	$10,037,971

4.1.3 Qualitative Emission Reduction Measures

This information in this section contains information provided by both the City and the Community, as referenced in the text and the References section in this report.

4.1.3.1 Corporate Computer Shutdown

Phase I of the City's Air Quality and Climate Change Corporate Strategic Plan (August 2006), states that the City has Corporate Computer Shutdown Guidelines for the daily routine for shutting down corporate computer systems and related devices such as printers. The goal of the guidelines is to implement best practices that potentially will result in the reduction of energy consumption for the Corporation, reduce wear and time loss on systems, reduce security risks, and administrative updates (such as virus protection updates) to be loaded automatically at system start up.

4.1.3.2 Green Fleet Expo

On May 21, 2009 the City hosted the 4th annual Green Fleet Expo in partnership with the City of Toronto (City of Hamilton-Public Works 2009). The event, which took place this year at the Royal Botanical Gardens in Burlington, is an opportunity for the public and other municipalities to learn about the latest fuel-efficient fleet vehicle technology. This year's expo focused on advances in the field of electric vehicles.

4.1.3.3 Low Emission Turf Mowing Equipment Trials

The City's Parks and Recreation implemented an equipment trial in May 2009 to test the benefits of electric powered rechargeable mowers in its 2009 turf management program. Two electric mowers will be utilized in regular operations at Woodland and Mountview Garden Cemeteries to test their performance against the existing fleet of gas powered mowers. Electric powered rechargeable mowers are expected to benefit the City in by reducing operating costs and producing no direct emissions. They may also provide the City with the option of continuing grass maintenance even when Smog Alerts have been issued in designated areas.

4.2 COMMUNITY

4.2.1 Quantitative Emission Reduction Measures

The emission reduction measures are estimated in this section by comparing baseline emissions with 2008 emissions.

The 2006 baseline emission levels for the Community and a comparison of these with emission levels in 2008 are presented in this section. In cases where emissions could not be quantified for the update year, the average emissions increase calculated using the emission increases that have actually occurred has been applied to conservatively estimate increases in emissions in these categories.

In Figure 4.2, 2006 and 2008 community GHG emissions are compared.

Figure 4.2 Comparison of Community 2006 and 2008 GHG Emissions

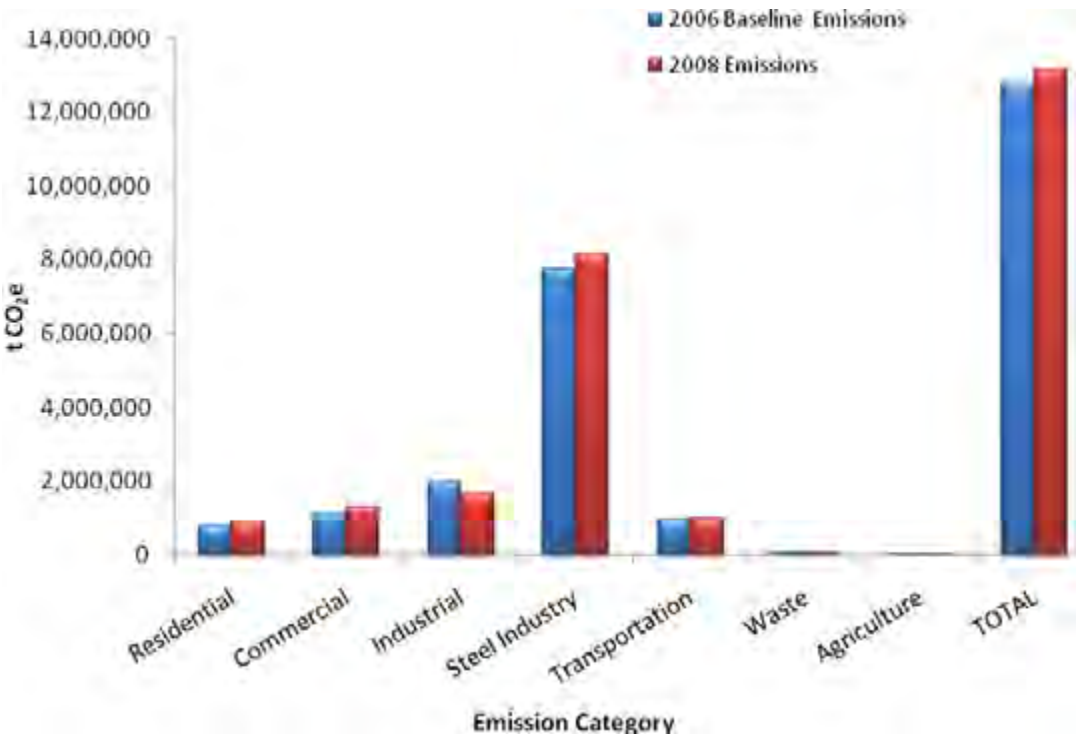


Table 4.3 shows 2006 baseline emission levels for the Community, compares these with emission levels in 2008, and shows the percent increase or decrease in emissions. In cases where emissions could not be quantified for the update year, the average emissions increase calculated using the emission increases that have actually occurred has been applied to conservatively estimate increases in emissions in these categories.

Table 4.3 Summary of Community GHG Emissions City Actions

Emission Category	2006 Baseline Emissions (t CO_2e)	2008 Emissions (t CO_2e)	% Change
Residential	793,635	886,530	+11.7%
Commercial	1,134,666	1,298,469	+14.4%
Industrial	1,960,442	1,660,499[7]	-15.3%
Steel Industry	7,757,526	8,162,818[8]	+5.2%

[7] Emissions data for 2008 had not yet been released by Environment Canada at the time of this report, value provided is 2007 data

Table 4.3 Summary of Community GHG Emissions City Actions

Emission Category	2006 Baseline Emissions (t CO_2e)	2008 Emissions (t CO_2e)	% Change
Transportation	964,590	992,563[9]	+2.9%
Waste	105,798	86,965	-17.8%
Agriculture	41,995	43,213[10]	+2.9%
TOTAL	12,758,652	13,131,097	+2.9%

The Community has increased their total emissions by 372,405 t CO_2e. This is a 2.9% increase in emissions from 2006 levels. A reduction of 1,648,310 t CO_2e is required by 2012 for the City to meet their goal of reducing GHG emissions 10% below 2006 levels by 2012.

Further, a reduction of 2,924,175 t CO_2e is required to meet 20% reduction below 2006 levels by 2020.

4.2.1.1 Green Carts

In 2006 the City implemented the Green Cart recycling program with the goal of diverting organic waste. By adding this program to the Blue Box recycling program already in place, the City has set an aggressive target of diverting 65% of waste from the landfill by 2011 (City of Hamilton Public Works 2007). Each dwelling receives a large, green, rigid plastic cart with wheels to collect organic waste. The waste is collected at the curb along with regular garbage and Blue Box recyclables each week. The City has special 'split-body' trucks designed to collect both garbage and organic waste and keep them separated so that the organic waste can be taken to the City's central composting facility. The emission reductions associated with the Green Cart program can be quantified by comparing tonnes of waste deposited in the landfill in 2005 and 2008.

4.2.1.2 Central Composting Facility

The City's central composting facility was completed in 2006 and results in the diversion of about 60,000 tonnes of household waste from the landfill annually. The Facility, which is located on a former brownfield site, features an in-vessel aerobic composting system that transforms household organic wastes into compost (City of Hamilton Public Works 2006). By quantifying the amount of waste diverted to the central composting facility, it is possible to calculate the GHG emission reductions associated with the completion of this project.

[8] Emissions data for 2008 had not yet been released by Environment Canada at the time of this report, value provided is 2007 data
[9] Average emissions increase applied
[10] Average emissions increase applied

4.2.1.3 Blackout Challenge

In 2007, Hamilton participated in the Blackout Challenge, an initiative urging Ontario municipalities to reduce energy consumption by 4% between the hours of 12 pm and 8 pm on August 14th, the anniversary of the 2003 blackout in Ontario. In 2007, Hamilton as a community reduced energy consumption by 2.2% and trimmed daily peak demand by about 3.2% between 12 pm and 8 pm. In 2008, Hamilton reduced consumption by 2.9% and peak demand by 5.2% between 12 pm and 8pm (City of Hamilton Public Works September 2008). The City has confirmed their participation in the Blackout Challenge for 2009.

4.2.2 Qualitative Emission Reduction Measures

4.2.2.1 Clean Air Hamilton

Founded in 1998, *Clean Air Hamilton* is a multi-stakeholder group dedicated to improving air quality. The group's activities include: initiating research on air quality, providing policy advice to all levels of government, encouraging emission reductions amongst companies operating in Hamilton, and promoting behavioral changes amongst individuals living and working in Hamilton.

4.2.2.2 Hamilton Climate Change Champions

In 2009 the *Hamilton Climate Change Champions Project* was initiated. The project involves preparing custom made plans to help 24 organizations (including businesses, schools, faith groups, and community groups) cut their energy use, thereby reducing both energy costs and GHG emissions. The project aims to have the champions cut their energy use and GHG emissions by 10% for 2012 and cut their emissions by 20% by 2020. Additionally, *Climate Change Champions* aims to sign up 500 Hamilton residents to make their own pledges (Clean Air Hamilton 2009).

4.2.2.3 Earth Hour

Earth Hour began in Sydney, Australia in 2007 as an initiative to combat global warming by having citizens switch off their lights for one hour. Hamilton joined the Earth Hour initiative in 2008, with the objective of reducing energy use by 5%. The City surpassed this goal, reducing their energy consumption by 17.1% between 8:30 and 9:30 (City of Hamilton-Office of Energy Initiatives 2007).

4.2.2.4 Peaksaver Program

The Peaksavers Program is a program designed by Horizon Utilities, to reduce electricity demand in Ontario Communities. Since 2006, owners of single-family homes or small businesses can have a programmable Peaksaver thermostat installed free of charge. During a Peaksaver event, when central air conditioners' electricity use is near its peak, the thermostat will allow Horizon Utilities and the Ontario Power Authority to send a wireless signal to

temporarily alter the central air conditioners compressor cycle to reduce strain on the electricity system (Horizon Utilities 2009).

4.2.2.5 Powersavings Blitz

Powersavings Blitz (Horizon Utilities and the Ontario Power Authority) offers small businesses up to $1000 in energy and money-saving retrofits. Typical retrofits include replacing older inefficient lighting systems with energy efficient lighting and installing insulating blankets on electric water heaters (Horizon Utilities 2009 (3)).

4.2.2.6 Electricity Retrofit Incentive Program

Horizon Utilities and the Ontario Power Authority provide incentives for commercial, industrial, institutional and agricultural customers to complete projects that result in measurable reductions in electrical peak demand. Measures and initiatives eligible for receiving incentives include: lighting improvements, motors, cooling, and agribusiness (Ontario Power Authority 2009 (2)).

4.2.2.7 Cool Savings Rebate Program

The *Cool Savings Rebate Program* was implemented to encourage residents to replace old central air conditioning or heating systems with ENERGY STAR qualified systems. Residents could qualify for up to $550 in rebates by making the decision to have a participating contractor replace their heating or cooling system with a more efficient model. This program helps residents reduce electricity consumption affordably, which helps to reduce the emissions associated with producing electricity (Ontario Power Authority 2009).

4.2.2.8 Great Refrigerator Roundup

Starting in 2007, the *Great Refrigerator Roundup,* helps residents recycle old, inefficient appliances in an environmentally friendly manner. Horizon Utilities offers to collect these appliances for free, including removing them from a resident's basement if necessary and recycling and reclaiming most material from the devices (Horizon Utilities 2007).

4.2.2.9 Generation Conservation

Generation Conservation, launched by Horizon Utilities in 2007, features a 10 lesson curriculum on conservation of energy and resources. Approximately 7,500 Grade 5 students in 200 schools participated in the program (Horizon Utilities 2009 (2)).

4.2.2.10 Urban Official Plan

The City's new Urban Official Plan, set for release in 2009, includes air quality and climate change policies (City of Hamilton Planning and Economic Development 2009). The targets specified in this document are aligned with the targets used in this report.

4.2.2.11 Transportation Master Plan

The City's Transportation Master Plan was developed through GRIDS in 2007 to develop policies and strategies for its transportation network over the next 30 years. Key objectives include reducing dependence on single-occupant vehicles and promoting improved options for walking, cycling, and transit, while maintaining and improving the efficiency of trips related to the movement of good and servicing of employment areas (City of Hamilton 2007(4)).

4.2.2.12 Bus Rapid Transit Plan/Rapid Transit Initiative

In November 2008, Metrolinx released its final transportation strategy, which identified four rapid transit routes in Hamilton to be implemented consecutively over the next 25 years and beyond. The Big Move: Transforming Transportation in the Greater Toronto and Hamilton Area maps out $50 billion in new transportation projects over 25 years with additional routes identified for beyond the 25 year plan (City of Hamilton 2009). These improvements to Hamilton's transit system may help to reduce single occupancy vehicle trips, thereby reducing emissions and managing traffic despite significant anticipated growth in the area (City of Hamilton 2009).

4.2.2.13 Hamilton Commuter Challenge

Since 2000, the City has participated in the Commuter Challenge, which is a week-long friendly competition between cities organized by Smart Commute Hamilton. The objective of the Commuter Challenge is to reduce air pollution by using active and sustainable modes of transportation. In 2006, over 1700 individuals and 27 organizations from Hamilton participated in the Challenge. Collectively they travelled 207,575 km by sustainable modes of transportation, resulting in an estimated reduction in NO_x emissions of 224.61 kg (Clean Air Hamilton 2007).

4.2.2.14 Smart Commute

The City is a contributing partner in Metrolinx's Smart Commute initiative, which is a GTA-wide program involving Transportation Demand Management (TDM) initiatives, and the creation of Transportation Management Associations (TMAs). The initiative proposes to establish GTA-wide carpooling, vanpooling and carsharing programs as part of the solution to reduce single occupant vehicle use, and therefore reduce the burden transportation systems. When fully implemented, the Smart Commute Initiative could reduce single occupancy vehicle trips by up to 15% (Metrolinx 2009).

4.2.2.15 Traffic Signal Retiming

In 2008, the City followed up the LED Traffic Lights Conversion Project with a Traffic Signal Optimization Program to further reduce fuel consumption, GHG emissions, and travel delay. This revision of traffic signals is important to address changes in individual intersections traffic volumes, directional and time of day flows. *The National Traffic Signal Report Card* predicts that signal timing and maintenance could reduce travel delay by up to 15-20%, reduce fuel consumption by up to 10%, and reduce emissions by up to 22% (National Transportation Operations Coalition 2005).

4.2.2.16 Totally Transit

Totally Transit is a program created by Green Venture in partnership with Hamilton Street Railway to introduce elementary school students to Hamilton's public transit system. It promotes public transit's advantages in the areas of climate change, air quality, energy conservation, and health (Green Venture 2007(2)).

4.2.2.17 Passport to Hamilton

Passport to Hamilton is a project undertaken by Environment Hamilton in 2007 with the goal of ridership on the City's public transit system. The City has made bus passes available for groups of 6 people for only 8$ that provide them with access to the bus system for 24 hours. In addition, Environment Canada has partnered with over 60 destinations within the City who have agreed to provide exciting discounts for groups that present a valid day pass. Public transportation reduces dependence on single occupant vehicles, reducing local air pollution and GHG emissions (Environment Hamilton 2009 (2)).

4.2.2.18 Drive Clean

The City participates in the Ontario Ministry of the Environment's *Drive Clean* Program, which is a mandatory vehicle emissions testing program designed to reduce smog and its harmful effects. Vehicles in areas with smog problems must pass a clean air test. If they do not pass the test, they must be repaired then retested. Passenger cars and light duty trucks are required to be tested every two years before the stick on the license plate can be renewed (Ontario Ministry of the Environment 2007).

4.2.2.19 EcoDriver

Green Venture, in partnership with the Ontario Ministry of Environment, Green Communities Canada, and Clean Air Hamilton, implemented the EcoDriver Program in 2007. EcoDriver presentations, public outreach, workshops and materials present entertaining tips from drivers to help drivers increase the distance they can travel on a tank of gas. The program also encourages people to leave the car at home and opt for active and sustainable transportation on a regular basis.

4.2.2.20 Anti-idling Bylaw

The City passed The Idling Control By-Law in May 2007 stating that "No person shall cause or permit a motor vehicle to idle for more than three (3) consecutive minutes in a sixty minute period. Starting June 1, 2008, violations of the by-law became punishable with a fine of up to $ 5000 (City of Hamilton 2007).

4.2.2.21 Idling Stinks

Idling Stinks is a public education campaign delivered by Green Venture for the City in 2008. The campaign is designed to inform drivers about the benefits of turning off their vehicles to reduce unnecessary idling. On June 3, 4, and 5, 2008, Air Ambassadors from Green Venture stationed themselves outside a different elementary school each day to inform drivers that vehicle idling: wastes fuel and money, negatively impacts respiratory and cardiac health, contributes to local smog and poor air quality, emits CO_2, and violates Hamilton's *Idling Control By-Law* (Green Venture 2007).

4.2.2.22 Integrated Water and Wastewater Master Plan for the Lake Based Systems

Through its long-range strategic planning initiative called GRIDS (Growth Related Integrated Development Strategy), the City created a master plan in 2007 outlining policies and strategies for its water and wastewater servicing over the next 30 years. The master plan addresses existing service commitment and water quality issues in the Hamilton Harbour, and is designed to support growth for the next 30 years. This plan is meant to be integrated with the City's transportation master plan and stormwater master plan in support of the City's new Official Plan (City of Hamilton Public Works 2007(2)).

4.2.2.23 Biosolids Master Plan

In 2007, the City completed the *Biosolids Master Plan Class Environmental Assessment* process. The preferred alternative identified was thermal reduction with digestion for energy recovery. The plan recommends the establishment of a new technology for the thermal reduction process at the existing site while continuing the use of digestion for energy production through cogeneration.

4.2.2.24 Wise Water Use

The Wise Water Use program (October 2000), was designed to educate residents on ways they can preserve water. The program presents water usage facts and conservation tips for both indoors and outdoors. Reducing water consumption can reduce the amount of electricity used in water treatment, thereby reducing emissions (Green Venture 2000).

4.2.2.25 Hamilton Eat Local

Hamilton Eat Local was formed in 2005 by Environment Hamilton and other community partners to support programs that encourage residents to buy food grown by local farmers and harvest food from urban gardens and other settings that would otherwise go to waste. Consuming local food reduces the demand for food to be imported food and consequently reduces emissions associated with transporting food (Environment Hamilton 2009).

4.2.2.26 Urban Forest Health Program

The City's Urban Forest Health Program began in 2004 to monitor, detect, and assess diseases and pests, providing remediation recommendations, and educating the community on tree health issues and stewardship "best practices (City of Hamilton Public Works 2005)."

4.2.2.27 Tree By Law

The City has several by-laws ensuring the protection of trees the *Reforestation Policy - Municipally Owned Lands* provides that where trees are removed, injured or damaged, or otherwise lost, that, there will be funds available for their removal, repair and/or replacement. The City's By Law 06-151 prohibits against injury or destruction of public trees, outlines protective measures for trees during construction, and prohibits planting of certain species of trees on public property.

4.2.2.28 Street Tree-Planting Program

The *Street Tree Planting Program,* beginning in 2004, involves planting trees at commercial, residential, and city owned properties. Residents can request a tree planting at their home or work place. Over 4,000 trees per year are planted as a result of this program. Benefits associated include: improved air quality, emission reductions, reduction of the 'urban heat island' effect, smog reduction, storm water control, absorption of breathable particulates, noise abatement, improved health of citizens, and aesthetically enhanced landscapes (City of Hamilton 2004).

5.0 Objective C: Potential Impacts of Non-Municipal Policy on GHG Emissions

Information on the estimated impact that potential Provincial and Federal policy and regulation on GHG emissions at the City and Community levels are presented in this section. Detailed emissions modeling and policy simulation were not used to develop this section and no analysis of CAC emissions is provided. Rather, high level information on potential Provincial and Federal initiatives that are expected to reduce GHG emissions have been identified and to the extent possible, were applied to City and Community emissions profiles in an effort to determine policy and regulatory interactions and their potential effects to mitigate increases in GHG emissions.

To complete this analysis, the City's business as usual forecast (see Section 2.1.8.1) was extended from 2015 to 2020 to match the Province's forecasting efforts by determining the average percent decrease in emissions per year from 2005 to 2015, and assuming that emissions will continue to decline by the same percentage annually to 2020. This decrease is assumed to be 0.828% per year.

The Community's business as usual forecast (see Section 3.1.8.2) was extended from 2016 to 2020 by determining the average percent increase in Community emissions per year from 2006 to 2016 and assuming that emissions will continue to increase by the same percentage annually to 2020. This increase is assumed to be 2.57% per year.

Following this, potential percentage decreases in emissions noted in the Province of Ontario's "Go Green: Ontario's Action Plan on Climate Change" (Ontario Ministry of the Environment, 2007) and the federal government's "Turning the Corner: Taking Action to Fight Climate Change" (Environment Canada, 2008) policy and regulatory documents were applied to estimate emission reductions.

The following sections address potential areas of GHG reduction that may arise due to non-municipal initiatives. These Provincial and Federal policies will help local governments and the broader communities reduce their GHG emission levels.

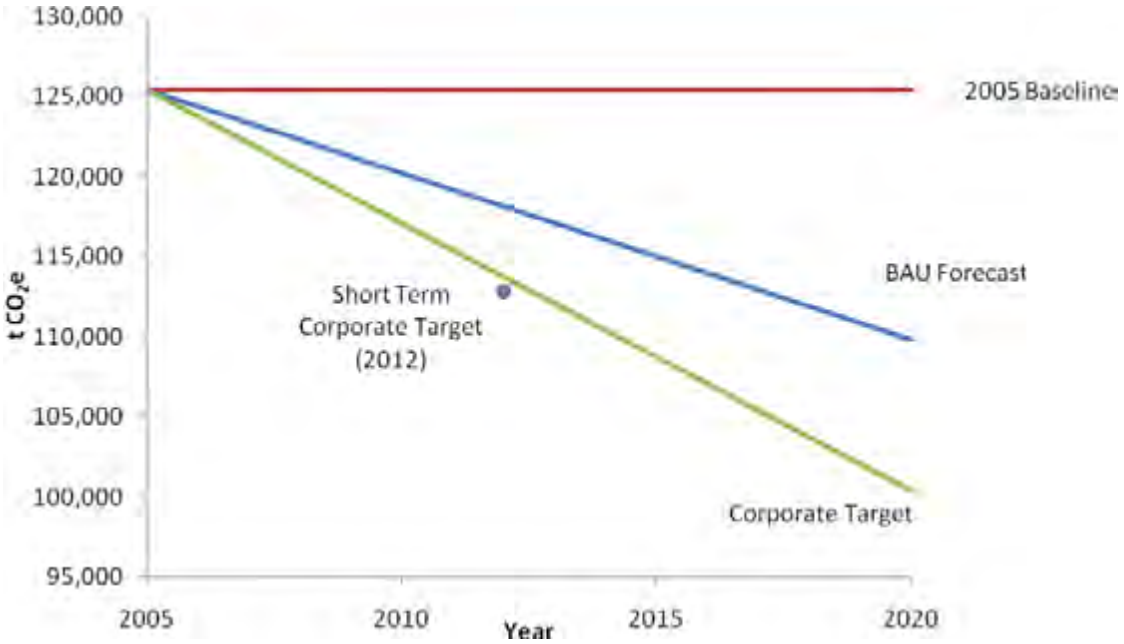
5.1 CITY – BUSINESS AS USUAL AND FORECASTED EMISSIONS

In 2005, the City's baseline emission levels were 135,058 t CO_2e and in 2007, they were calculated to be 139,401 t CO_2e. By 2020, these emissions are forecasted to be 109,820 t CO_2e. This corresponds to a 12.4 % decrease in GHG emissions when compared to the baseline emission levels.

The projected decrease in emissions is largely due to a combination of emission reducing actions that can be considered 'business as usual' actions for the City, and planned emission reducing actions over the long term (for further detail see Section 2.1.7.2).

Although emissions are predicted to decrease over time, by 2020 they are estimated to be 9,504 t CO_2e over the City's emission reduction target. In order to meet the 20% reduction target, the City will have to achieve a reduction of approximately 35,000 t CO_2e by 2020. The business as usual forecast, as compared to the short term and long term emission reduction targets, is presented in Figure 5.1.

Figure 5.1 BAU Forecast, and Short Term and Long Term Emission Reduction Targets



Therefore, to achieve the 20% reduction below 2005 emission levels, the City must rely upon its own internal initiatives and changes to Provincial and Federal policy. Local governments across Canada will need to rely on policy to support their reduction initiatives as many of the major emission sources are directly influenced by Provincial and Federal legislation. The following sections provide some context regarding the effect that new policies may have on the City's GHG emissions.

5.1.1 Impact of Provincial Policy on City Emissions

For the purposes of examining the potential for Provincial policy to enhance and contribute to the planned emission reductions at the City, information was used from the Province of Ontario's "Go Green: Ontario's Action Plan on Climate Change" (Ontario Ministry of the Environment, 2008), "Ontario's Climate Change Action Plan: Creating our Sustainable Future" (Ontario Ministry of the Environment, 2008) and "Ontario Greenhouse Gas Emission Targets: A Technical Brief" (Government of Ontario 2007).

In addition to other environmental initiatives, the Go Green Plan sets short, medium, and long-term targets for reducing GHG emissions in Ontario. The potential reductions include:

- Reduce GHG emissions 6% below 1990 levels by 2014 (61 Mt CO_2e reduction).
- Reduce GHG emissions 15% below 1990 levels by 2020 (99 Mt CO_2e reduction).
- Reduce GHG emissions 80% below 1990 levels by 2050.

To date, the Province of Ontario has implemented several current policies that have reduced emissions. These include:

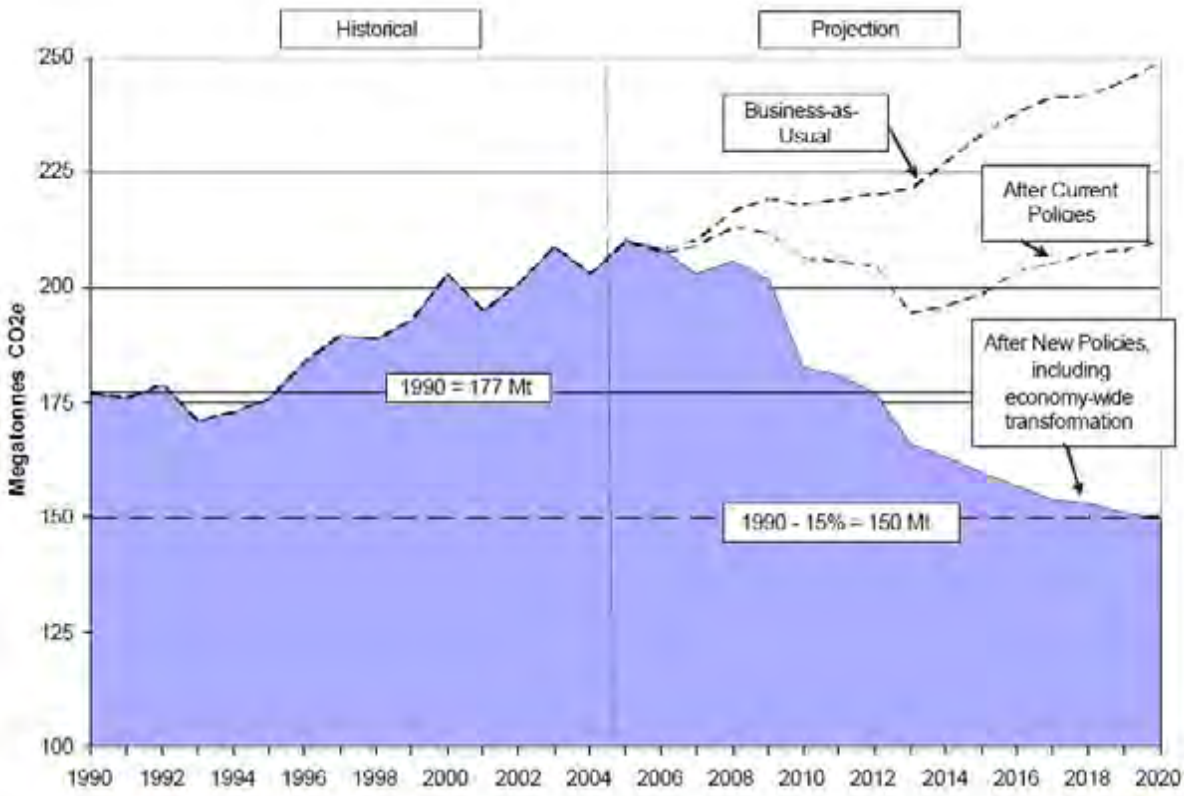
- Phase-out of Coal-fired Electricity Generation.
- Changes to the Energy Efficiency Act and the Ontario Building Code.
- Ethanol Blending of Gasoline.
- Investments in Public Transit.
- Implementation of the Places to Grow Act.
- Implementation of the Green Belt Act.

In addition, the Province plans to further reduce GHG emissions using a variety of mechanisms as part of the Go Green Plan including:

- Green Targets – includes new regulations, conservation, a phase-out of coal-fired power plants and much more renewable energy.
- MoveOntario 2020 - a $17.5 billion public transit plan that includes 52 rapid transit projects in the GTA and Hamilton.
- Creating Jobs by Going Green – a $650 million program aimed at securing the next generation of high-paying jobs to help support the development, use and sale of green technologies and businesses.
- Green Power – a $150 million investment to help homeowners conserve energy and adopt green technologies.
- Grow Green – in addition to the Greenbelt Act, which ensures there will always be nature and open spaces around highly populated areas, 50 million new trees will be planted in southern Ontario by 2020.

The projected trajectory of GHG emissions in Ontario, as published in the Ontario Greenhouse Gas Emission Targets: A Technical Brief, including reductions associated with current and new policy is presented in Figure 5.2.

Figure 5.2 Projected GHG Emissions in Ontario (1990 – 2020)



Currently, the population in Ontario is growing at approximately 1% per year, reaching almost 15 million by 2020. In addition, the provincial economy is anticipated to be 40% larger in 2020. This will inevitably increase the amount of fuel and electricity consumed, and in turn increased GHG emissions, in Ontario. As presented in Figure 5.2, it is estimated that the total GHG emissions in the Province could reach 249 Mt CO_2e by 2020 following a business as usual growth pattern.

For the purpose of this study, Provincial and Federal policies affecting electricity generation, transportation and the steel industry will be considered for potential areas of GHG reductions in addition to municipal initiatives.

5.1.1.1 Electricity Generation Impacts on the City

The Ontario Power Generation (OPG) has a mixture of electricity generation including:

- Coal
- Refined Petroleum Products
- Natural Gas
- Nuclear

- Hydro
- Biomass
- Wind

This broad mixture of generation yields a relatively low annual GHG emission intensity (t CO_2e/MWh) when compared to other Provinces in Canada. In particular, several of these generation categories are considered to be low GHG emitters or carbon neutral. A breakdown of GHG emissions by generation type from 2004 – 2006, as published in the National Inventory Report 1990 – 2006 (May 2008), is presented in Table 5.1.

Table 5.1 Breakdown of GHG Emissions by Generation Type in Ontario (2004 – 2006)

Generation Type	GHG Emissions (t CO_2e)		
	2004	2005	2006
Coal	24,460,000	27,290,000	24,000,000
Refined Petroleum Products	690,000	40,000	30,000
Natural Gas	4,810,000	5,660,000	4,430,000
Nuclear	NA	NA	NA
Hydro	NA	NA	NA
Biomass	NA	NA	NA
Other Renewables	NA	NA	NA
Other	0	0	0
Overall Total	29,950,000	32,980,000	28,460,000

NA – Indicates that GHG emissions are not applicable to this generation category.

Based on the information presented in Table 5.1, it is clear that GHG emissions associated with electricity generation in Ontario arise from the combustion of coal, refined petroleum products and natural gas. In particular, the majority of GHG emissions arise from coal-fired electricity generation. In 2006, 84% of all GHG emissions in the generation sector can be attributed to coal-fired electricity with the remaining 16% from refined petroleum products (0.1%) and natural gas combustion (16%). Although coal-fired generation accounts for 80 - 85% of electricity emissions, it only represents 16 – 20% of the Province's electricity supply.

To combat this trend, Ontario's government has committed to phasing out all coal generation in the province by 2014 (Ontario Regulation 496/07 under the EPA – Cessation of Coal Use). As part of this plan, power plant emissions in the Province would drop by 46 Mt CO_2e in 2003 to less than 7 Mt CO_2e by 2014 when the final coal plant is scheduled to be retired.

As a sign of its commitment to this plan, the Ontario government announced the closure of four coal fired generating stations in September 2009 to demonstrate a shift towards renewable energy and conservation. The OPG currently has 6,315 MW of coal-fired capacity provided by 15 units that operate at four plants across Ontario. These include the four coal units at Atikokan, Nanticoke, Thunder Bay and Lambton, with a combined capacity of 1,910 MW, will be permanently shut down in late 2010.

The shutdown of these facilities puts the Province on track to be one of the first jurisdictions in the world to eliminate coal-fired electricity generation. Since 2003, over 7,000 MW of new and refurbished generation have come online including over 3,700 MW of new natural gas fired plants and over 1,200 MW of renewable energy.

The phase-out of coal fired electricity and the implementation of new renewable generation technologies will help the City of Hamilton to further reduce GHG emissions. A presentation of baseline and projected GHG emissions is presented in Table 5.2.

Table 5.2 Potential Impacts of Coal Phase-Out on City GHG Emissions

Baseline (2005)		BAU Forecast (2020)		Phase-Out Forecast (2020)	
MWh Consumption*	Electricity GHG Emissions (t CO_2e)*	MWh Consumption	Electricity GHG Emissions (t CO_2e)*	MWh Consumption	Electricity GHG Emissions (t CO_2e)
251,481	52,811	356,700	74,097	356,700	62,045

* Denotes a value calculated in the emission inventory or forecast portion of this study.

The data presented in Table 5.2, is based on electricity consumption records and GHG emissions as calculated in this study for the City of Hamilton. The ratio of actual electricity consumption and GHG emissions for the baseline year (2005) were used with the BAU forecasted GHG emissions (as presented in Objective A) to determine an estimate of electricity consumption by the City in 2020 (BAU forecast). A potential GHG intensity factor was determined using the total provincial electricity generation (as presented in the National Inventory Report (NIR) for 2005) and NIR GHG emissions for all facilities excluding coal-fired plants. This emission intensity was then applied to the forecasted consumption to provide estimated GHG emissions for the coal phase-out forecast.

Assuming that the ratio of electricity consumption and GHG emissions remain constant for the baseline (as calculated in this study) and the BAU forecast, the City would see an increase of approximately 20,000 t CO_2e by 2020 based on current consumption. However, assuming that all coal-fired power plants are offline by 2020 and replaced entirely by renewable energy, the City could yield a reduction of approximately 13,000 t CO_2e below the 2020 BAU forecasted emissions due to changes in the Provincial electricity generation policy. Although it is more likely that low carbon generation facilities, as opposed to renewable technologies, will take over the bulk of the electricity needs in the Province, it is clear that a phase-out of coal power would have a substantive impact on the GHG emissions within the City of Hamilton.

Finally, on September 2009 the Government of Ontario released the Green Energy and Green Economy Act (Ontario Ministry of the Environment 2009) which includes the following commitments for the energy sector:

- The creation of an Aboriginal Energy Partnerships Program to build capacity and participation through support for community energy plans, funding for feasibility studies and the development of an Aboriginal Renewable Energy Network.
- An Aboriginal Loan Guarantee program (ALGP) to facilitate Aboriginal participation in energy projects by providing loan guarantees for up to 75% of an Aboriginal corporation's equity in an eligible project.
- Approval for Hydro One to begin work on 20 transmission projects that are expected to create about 20,000 jobs and spur green economic development across the province over the next three years.
- Creation of the Community Energy Partnerships Program to provide one-time support to community groups to assist with the developmental costs associated with new renewable energy projects.
- Launch of the Municipal Renewable Energy Program which provides support to municipalities for costs associated with new renewable energy projects.
- The establishment of the Renewable Energy Facilitation Office (REFO) to assist developers, communities and municipalities obtain information on developing renewable energy projects in Ontario.
- Legislation of the Renewable Energy Approval (REA) to ensure that renewable energy projects are developed in a way that is protective of human health, the environment, and Ontario's cultural and natural heritage.
- Implementation of domestic content requirements which would ensure at least 25% of wind projects and 50% of large solar projects be produced in Ontario. Requirements for solar will increase on Jan. 1, 2011 and requirements for wind will increase on Jan. 1, 2012.
- North America's first comprehensive feed-in tariff program that guarantees specific rates for energy generated from renewable sources.

Based on the information presented above, it is clear that new Provincial and Federal policies may have a substantive impact on the GHG emissions within the City of Hamilton.

5.2 COMMUNITY– BUSINESS AS USUAL AND FORECASTED EMISSIONS

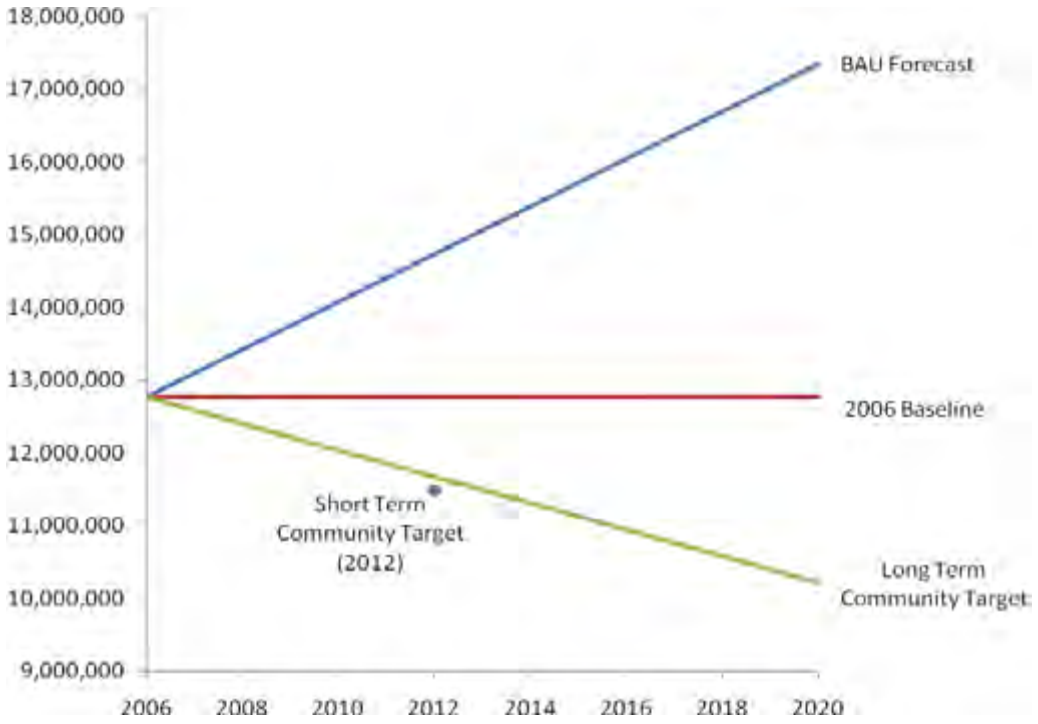
In 2006, the Community's baseline emission levels were 12,758,652 t CO_2e and in 2007, they were estimated to be 13,092,415 t CO_2e. By 2020, these emissions are forecasted to be 17,349,621 t CO_2e, 36% above baseline levels. This is 7,142,700 t CO_2e higher than the proposed 2020 Community emission reduction target of 10,206,922 t CO_2e.

The projected increase in emissions is largely due to increases in population, number of residences and number of commercial units predicted by the City's GRIDS Growth Management Strategy (City of Hamilton – Public Works 2007), as well as a 55% increase in vehicle travel predicted by the Ontario Ministry of Transportation (Metrolinx 2009). Figure 5.5 shows baseline levels of emissions for the City and Community, relative to short and long term emission reduction targets set by the City.

The emissions level that would meet the proposed Community target of 20% below 2006 levels by 2020 is 10,206,922 t CO_2e.

Figure 5.5 shows the business as usual forecast, as compared to the short term and long term emission reduction targets.

Figure 5.3 Comparison of Community Business as Usual Forecast to Short Term and Long Term Emission Reduction Targets



Therefore, to achieve the 20% reduction below 2006 emission levels, the Community must rely upon a combination of its own internal initiatives and changes to Provincial and Federal policy. Communities across Canada will need to rely on policy to support their reduction initiatives as many of the major emission sources are directly influenced by Provincial and Federal legislation. The following sections provide some context regarding the effect that new policies may have on the Community of Hamilton GHG emissions.

5.2.1 Impact of Federal and Provincial Policy on Community Emissions

For the purposes of examining the potential for Federal and Provincial policy to enhance and contribute to the planned emission reductions in the Community of Hamilton, information was used from the Province of Ontario's "Go Green: Ontario's Action Plan on Climate Change" (Ontario Ministry of the Environment 2008), "Ontario's Climate Change Action Plan: Creating our Sustainable Future" (Ontario Ministry of the Environment 2008), "Ontario Greenhouse Gas Emission Targets: A Technical Brief" (Ontario Ministry of the Environment 2007), "Green Energy

and Green Economy Act" (Ontario Ministry of the Environment 2009) and Environment Canada's "Turning the Corner: Taking Action to Fight Climate Change" (Environment Canada 2008).

The analysis provided in the following sections is focused primarily on areas that could yield substantive emission reductions to the Community. These include policies that affect the electricity generation, transportation, industry and steel sectors which contribute to Hamilton's Community emissions.

5.2.1.1 Electricity Generation Impacts on the Community

As discussed previously, the phase-out of coal-fired electricity generation could have significant impacts on the Community of Hamilton. A summary of these potential impacts is presented in Table 5.3.

Table 5.3 Potential Impacts of Coal Phase-Out on Community GHG Emissions

Baseline (2006)		BAU Forecast (2020)		Phase-Out Forecast (2020)	
GWh Consumption*	Electricity GHG Emissions (t CO_2e)*	GWh Consumption	Electricity GHG Emissions (t CO_2e)*	GWh Consumption	Electricity GHG Emissions (t CO_2e)
5,808,171	1,045,471	7,214,922	1,298,686	7,214,922	1,090,814

* Denotes a value calculated in the emission inventory or forecast portion of this study.

The data presented in Table 5.3, is based on electricity consumption records and GHG emissions as calculated in this study for the Community of Hamilton. The ratio of actual electricity consumption and GHG emissions for the baseline year (2006) were used with the BAU forecasted GHG emissions (as presented in Objective B) to determine an estimate of electricity consumption by the Community in 2020 (BAU forecast). A potential GHG intensity factor was determined using the total provincial electricity generation (as presented in NIR for 2006) and NIR GHG emissions for all facilities excluding coal-fired plants. This emission intensity was then applied to the forecasted consumption to provide estimated GHG emissions for the coal phase-out forecast.

Assuming that the ratio of electricity consumption and GHG emissions remain constant for the baseline (as calculated in this study) and the BAU forecast, the Community would see an increase of approximately 200,000 t CO_2e by 2020 based on current consumption. However, assuming that all coal-fired power plants are offline by 2020 and replaced entirely by renewable energy, the Community could yield a reduction of approximately 208,000 t CO_2e below the 2020 BAU forecasted emissions due to changes in the Provincial electricity generation policy. Although it is more likely that low carbon generation facilities, as opposed to renewable technologies, will take over the bulk of the electricity needs in the Province, it is clear that a phase-out of coal power would have a substantive impact on the GHG emissions within the Community of Hamilton.

As discussed in Section 5.1.1.1, the phase-out of coal-fired electricity generation and the recent publication of the Green Energy and Green Economy Act may have considerable impact on the reduction of GHG emissions for both the City and Community of Hamilton.

5.2.1.2 Transportation Policy Impacts on the Community

There are several Provincial transportation policies which may impact the Community of Hamilton's GHG emissions in the future.

The Government of Ontario has recently published the MoveOntario 2020 Rapid Transit Action Plan for the Greater Toronto and Hamilton Area (GTHA). This plan is a component of Ontario's Climate Change Action Plan as aims to reduce transportation emissions 10% by 2014. This plan includes several actions items such as:

- Mandating Metrolinx to develop and implement an integrated multi-modal transportation plan for the GTHA.
- Streamlining the Environmental Assessment process for public transit projects through a new provincial regulation (Ontario Regulation 231/08), introduced in June 2008, to limit the EA process to six months.
- Committing $744 million to Quick Win projects recommended by Metrolinx that will provide short term benefits and lay the foundation for the more expansive projects included in the MoveOntario 2020 initiative
- Providing $870 million in provincial support to Toronto and York Region, through the MoveOntario Trust, for an 8.6-km extension of the Toronto-York Spadina subway to York University and the City of Vaughan.

It is anticipated that these initiatives will help to cut GHG emissions by 5% in the GTHA. The impact this reduction might have to Hamilton's Community GHG emissions is presented in Table 5.4.

Table 5.4 Potential Impacts of MoveOntario 2020 on Community GHG Emissions

2006 Baseline Transportation GHG Emissions ($t\ CO_2e$) *	2016 Forecast Transportation GHG Emissions ($t\ CO_2e$) *	2016 MoveOntario Transportation Forecast GHG Emissions ($t\ CO_2e$)
964,590	1,318,595	1,186,736

* Denotes a value calculated in the emission inventory or forecast portion of this study.

Based on the information presented in Table 5.4, a 10% reduction in GHG emissions associated with the MoveOntario 2020 plan would correspond to an approximate reduction of 132,000 t CO_2e within the Community of Hamilton.

5.2.1.3 Federal Industrial Policy Impacts on the Community

In 2008, the "Turning the Corner: Taking Action to Fight Climate Change" was published (Government of Canada 2008). This regulatory framework aims to measurably reduce Canada's total GHG emissions by 20% below 2006 levels by 2020.

Regulated industrial sectors will be required to reduce their emissions intensity from 2006 levels by 18% by 2010, with 2% continuous improvement each year after that. The targets will be applied by government at the facility, sector, or corporate-specific level, depending on the industry sector.

Although the implementation of this regulatory framework is in question, it is anticipated that some form of cap-and-trade GHG system will be implemented in Canada. The enforcement of such a program would have substantive implications for both the City and the Community of Hamilton. All regulated facilities meeting a certain GHG emission threshold would be required to report and reduce their emissions on an annual basis. The proposed mechanisms for compliance could include:

- The Development of a Domestic Offset System (Cap-and-Trade).
- Clean Development Mechanism (CDM) under Kyoto.
- Credit for Early Action.
- Technology Fund.
- Emission Reductions.

The development of a cap-and-trade system would influence multiple areas of Hamilton's Community GHG emissions. However, it is anticipated that Hamilton's industrial and steel sectors would be the most impacted areas.

Following the Turning the Corner example, by 2016 regulated facilities would be required to have reduced emissions 30% below 2006 levels. The resulting decrease in Community GHG emissions for the industrial sector is presented in Tables 5.5.

Table 5.5 Potential Impacts of Turning the Corner on Industry Community GHG Emissions

2006 Industrial Baseline GHG Emissions (t CO_2e) *	2016 Industrial Forecast GHG Emissions (t CO_2e) *	2016 Turning the Corner Industrial Forecast GHG Emissions (t CO_2e)
1,960,442	2,464,276	1,724,993

* Denotes a value calculated in the emission inventory or forecast portion of this study.

Assuming that all of the Hamilton industrial sector falls under the reporting threshold the industrial sector of Hamilton would reduce its emissions by approximately 739,000 t CO_2e

should Turning the Corner become enforced. Although it is unlikely that all of the industrial sector, as presented in this study, would fall under the umbrella of the Turning the Corner legislation, it is clear that reductions in this sector could yield substantial reductions to Hamilton's Community emissions.

In addition, the steel industry in Hamilton is likely to fall under any potential cap-and-trade system. An estimate of the associated reductions in the steel sector is presented in Table 5.6.

Table 5.6 Potential Impacts of Turning the Corner on Steel GHG Emissions within the Community

2006 Steel Baseline GHG Emissions (t CO_2e) *	2016 Steel Forecast GHG Emissions (t CO_2e) *	2016 Turning the Corner Steel Forecast GHG Emissions (t CO_2e)
7,757,526	9,751,210	6,825,847

* Denotes a value calculated in the emission inventory or forecast portion of this study.

Arguably, the largest single area for potential GHG emission reduction associated with a cap-and-trade system corresponds to the steel sector.

As presented in Table 5.6, a 30% reduction in GHG emissions by 2016 would result in a reduction of approximately 3,000,000 t CO_2e within the Community of Hamilton. It is clear that potential Federal policy on GHG emissions is likely to have considerable effects on GHG emissions within the Community of Hamilton.

In 2005, Federal Government, the Government of Ontario and the Canadian Steel Producers Association signed a Memorandum of Understanding (MOU) to work together to address climate change. At the time, the agreement set short-term and long-term plans for government and industry to reduce GHG emissions. At time of this MOU, the steel industry committed to help reduce GHG emissions provided it did not undermine the competitiveness of the industry. Based on this MOU, the Government of Canada was to design emissions-reduction targets that reflect this commitment work with the industry to develop new low-emissions technologies by committing to an international research effort. Although the preliminary results of this MOU are unclear, it provides a foundation from which the Federal government and steel industry can use to reduce GHG emissions.

5.3 SUMMARY OF POTENTIAL POLICY IMPACTS ON CORPORATE AND COMMUNITY GHG EMISSIONS

A summary of the potential emission reduction areas associated with emerging Provincial and Federal Regulations discussed in these sections is presented in Table 5.7.

Table 5.7 Summary of Potential Policy Impacts on Corporate and Community GHG Emissions

Policy	Category	Baseline GHG Emissions (t CO_2e)	Forecast GHG Emissions (t CO_2e)	Policy Impacted Forecast GHG Emissions (t CO_2e)
Electricity Generation (Coal Phase-Out)	Corporate Electricity	52,811	74,097	62,045
	Community Electricity	1,045,471	1,298,686	1,090,814
Provincial Transportation	Community Transportation	964,590	1,318,595	1,186,736
Federal GHG Cap-and-Trade System	Community Industrial Sector	1,960,442	2,464,276	1,724,993
	Community Steel Sector	7,757,526	9,751,210	6,825,847
Total		11,780,840	14,906,864	10,890,435

Based on this information, substantial GHG emission reductions could be achieved in a variety of different sectors. They represent areas over which the municipality has no direct control, but which contribute considerably to City and Community GHG emissions. These policies are likely to assist local governments in reaching their reduction targets.

6.0 Objective D: Analysis of GHG Credit Options

6.1 AN OVERVIEW OF THE CANADIAN REGULATORY AND VOLUNTARY CARBON MARKETS

An overview of Canada's current and proposed regulatory and voluntary carbon markets and provides guidance on the future of carbon markets in Canada and North America is presented in this section. Within the private carbon market (sometimes called 'Over the Counter (OTC)' or bilateral markets), four (4) GHG credit standards are analyzed for potential use in the development of offset credits, as well as Renewable Energy Certificates (RECs), and a potential vehicle for municipal focused project development.

As with any rapidly developing market and industry, terminology often develops that is used interchangeably and can lead to confusion. Some helpful definitions are:

- **Regulated Carbon Market** – This is a market that has been created by a given jurisdiction to enforce reductions in GHGs. Regulated entities are given a 'cap' in GHGs which they can emit, and often must purchase or are given 'allowances' up to the cap that has been established. Carbon offsets are sometimes allowed into these systems to give regulated entities another option for meeting their 'cap' requirements. This system is sometimes called a 'cap and trade' system and is one of the most common regulatory approaches.
- **Carbon Offset Credits or GHG Reduction Projects** – These are efforts to reduce GHG emissions that are quantified and verified. Depending on variables such as type, dates the reductions occurred, and volume, certain projects may be monetized as a GHG Program (or more than one) and transacted between parties. After a project has successfully passed all the steps to monetize the project, they typically are certified as carbon credits.
- **Offset Registry** – A registry is a system where GHG reduction projects are registered after having been verified under a specific GHG program. They are integral to the offset market to ensure there is no double counting (offsets being applied to multiple programs or customers).
- **Offset Markets** – Much like stock or commodity markets, markets act as real time brokers to bring together buyers and sellers. Futures contracts are also available, and many markets support multiple GHG programs and standards.
- **GHG Programs & Standards** – A GHG program provides broad definitions under which a project proponent (i.e. project owner) will draft documentation in order to register their GHG reduction efforts. Typically, a GHG program will have specific protocols (*i.e.*, landfill methane, no-till agriculture.) that will detail how a GHG reduction project needs to be described and quantified in order to successfully be verified as carbon credit.

- **GHG Verification** – the process of 'auditing' statements about actual GHG information or actions (e.g. reports or credits) undertaken by an independent third party.
- **GHG Validation** – the process of 'auditing' a GHG project prior to the acceptance of a GHG project by a program or the issuing of crediting. This is a step analogous to 'licensing' a project to create credits.

6.1.1 Canada's Current and Proposed Regulated Carbon Markets

The Government of Canada has made both domestic and international commitments to address climate change. In 1992, Canada signed the United Nations Framework Convention on Climate Change (UNFCCC) along with more than 150 other countries. In 1997, the Kyoto Protocol was negotiated to provide implementation details for the Convention. The Protocol became legally binding for its ratifying members (including Canada) in 2005. Canada's Liberal government committed to reducing emissions to 6% below 1990 levels during the 2008-2012 commitment period.

In 2006, a Conservative minority government (having previously expressed opposition to Kyoto), replaced the Liberal government and announced that Canada would not be able to meet its Kyoto commitments, and further that environmental funding designed to meet Kyoto standards had been cut. To replace this commitment, in 2007, the federal government unveiled *"Turning the Corner: A Plan to Reduce Greenhouse Gases and Air Pollution"* that set a 2010 implementation date for emission-intensity reduction targets. Existing Canadian facilities had to achieve a 6% improvement each year from 2007 to 2010, to yield an 18% reduction under a base year of 2006, enforceable in 2010 (Environment Canada, 2008). Regulations limiting industrial GHG emissions are now scheduled for 2010, and will not take legal effect for up to six years, to match the newly proposed United States timetable. Emission cuts will be harmonized with U.S. rules to protect Canadian jobs and investments, which will likely take effect between 2012 and 2016.

Delays in the creation of a federal framework have opened the door for Provinces to move forward with other initiatives. Consequently, Canada is developing climate change regulation, but not cohesively. The following describes regional initiatives happening throughout Canada.

6.1.1.1 Western Climate Initiative[11]

The Western Climate Initiative (WCI) is a multijurisdictional collaboration that began in February 2007 which commits signatory states to developing regional targets for reducing GHG emissions. The agreement requires members to participate in a registry to track and manage GHG emissions and develop a market-based program to reach their targets (Western Climate Initiative 2009).

[11] http://www.westernclimateinitiative.org/index.php

The Premiers of British Columbia, Manitoba, Ontario, and Quebec have joined to address climate change at a regional level. Through the WCI, Partners plan to achieve an overall reduction of GHG emissions of 15% below 2005 levels by 2020 (WCI 2009).

The WCI jurisdictions are recommending a broad cap-and-trade program to reduce GHGs, encourage growth in new green technologies, help build a strong clean-energy economy, and reduce dependence on foreign oil. When fully implemented in 2015, it aims to work in conjunction with federal programs in Canada and the United States (Western Climate Initiative 2008).

The WCI cap-and-trade program will cover GHG emissions from the following sectors of the economy:

- Electricity generation, including imported electricity.
- Industrial and commercial fossil fuel combustion.
- Industrial process emissions.
- Gas and diesel consumption for transportation.
- Residential fuel use.

These entities and facilities (emitting annually more than 100,000 t CO_2e) will be required to surrender enough allowances to cover emissions that occur within each three-year "compliance period" (WCI 2008).

6.1.1.2 Ontario's Bill 185

Ontario has introduced legislation that will pave the way for a cap-and-trade system for GHG emissions designed to link to the WCI. If passed, Bill 185, *The Environmental Protection Amendment Act (Greenhouse Gas Emissions Trading), 2009* will help the province reduce greenhouse gas emissions by 6% below 1990 levels by 2014, 15% by 2020 and 80% by 2050.

Consultation on Ontario's cap-and-trade model will be conducted over the summer in 2009. The discussion paper, *Moving Forward: A Greenhouse Gas Cap-and-Trade System for Ontario,* outlines a reporting system beginning in 2011 for calendar year 2010 and emission reductions would be required for 2012. The WCI will include caps for facilities that emit more than 100,000 t CO_2e.

6.1.1.3 Alberta

Alberta's Climate Change and Emissions Management Amendment Act and its accompanying *Specified Gas Emitters Regulation* is the first (and only) regulation of its kind in North America. The Regulation requires companies to incrementally reduce the intensity of their GHG emissions by 12%. Alberta companies have three options: improve energy efficiency, buy carbon credits in the Alberta-based offset system, or pay $15 into the Climate Change and Emissions Management Fund for every t CO_2e emitted beyond their reduction target.

6.1.1.4 British Columbia

British Columbia will introduce a *Mandatory GHG Reporting Regulation* to back the *Greenhouse Gas Reduction (Cap and Trade) Act*, having received Royal Assent in 2008. The regulation will require facilities to report GHG emissions to the province. The information will serve as the basis for a regional cap and trade system. The regulation is expected to come into force in late 2009, and the framework for the system will likely be developed in concert with the Western Climate Initiative or WCI.

6.1.1.5 Canada's Voluntary Offset System for Greenhouse Gases

Environment Canada has proposed the launch of a *Voluntary Canadian Offset System* to be initiated in the fall of 2009. The system is designed to encourage cost-effective domestic GHG reductions or removals from activities or sectors not covered by planned federal GHG regulations (Environment Canada June 2009).

The *Voluntary Canadian Offset System* will be administered under the Canadian Environmental Protection Act (CEPA), 1999. Under the proposed program guidelines (which are currently open for consultation),

Projects eligible under Canada's Offset System, must have started on or after January 1, 2006 with reductions occurring on or after January 1, 2011. Offset projects will have no minimum threshold size, and in order to reach economies of scale, smaller projects can be aggregated and sold together (Environment Canada June 2009). Guidance on project types is yet to be specified beyond the objective to make the system as broad and inclusive as possible.

Project proponents must ensure that an accredited third-party verification body provides a verification statement to the Offset System to a degree of reasonable assurance. Verification bodies must be accredited by the Standards Council of Canada, and verifications must be completed in accordance with ISO 14064-3: *Specification with guidance on the validation and verification of greenhouse gas assertions* (Environment Canada June 2009).

Once a project has been accepted, the appropriate number of credits will be released into the Project Proponent's account in the tracking system, and the Offset System Regulatory Body will provide a Certification Report to the Project Proponent. The value of credits will be based on supply and demand (Environment Canada June 2009).

6.1.2 Other Voluntary Carbon Standards & Markets Outside of Canada

There are a wide range of voluntary transactions that make up a voluntary market not driven by an emissions cap. Because this market is not part of a cap-and-trade system where emissions allowances can be traded, almost all carbon credits purchased in this voluntary market originate from emissions reduction projects. For the most part, these transactions occur in the "Over-the-Counter" (OTC) market, and more and more registries and electronic markets are appearing to facilitate transactions as well. Credits sourced specifically for these markets are often generically referred to as Verified (or Voluntary) Emission Reductions (VERs), or simply as

carbon offsets, and are verified according to one of the GHG programs or standards described below.

The voluntary market is driven by *pure voluntary* or *pre-compliance* buyers. *Pure voluntary* buyers purchase credits to offset their own emissions and thus "retire" their credits immediately upon purchase. *Pre-compliance* buyers purchase VERs with one of two goals in mind: to receive early-action credit under a regulatory scheme for their voluntary offset purchase made at a cheaper price, or to sell them at a higher price to entities regulated under a future compliance cap-and-trade scheme. Companies with the first goal are entities likely to be regulated, and companies with the second goal are largely financial firms.

Suppliers in the offset market include online offset retailers, conservation organizations, developers of potential Clean Development Mechanism (CDM) or Joint Implementation (JI) projects with credits that (for a range of reasons) cannot currently be sold into the CDM or JI markets, project developers, and aggregators.

Joint Implementation is a Kyoto Protocol mechanism which allows developed countries, particularly those in transition to a market economy to host carbon-reducing projects funded by another developed country. The credits generated are transferred to the investor country while the emission allowances of the host country are reduced by the same amount.

The CDM is also an arrangement under the Kyoto Protocol that allows countries with a GHG reduction commitment to invest in or develop emission reduction projects in developing countries, earning credits which they can use to reach their own reduction targets.

Depending on their position in the supply chain, sellers can be categorized into four major groups:

- *Project Developers* develop GHG emissions reduction projects and may sell the credits to aggregators, retailers, or final customers;
- *Aggregators/Wholesalers* only sell offsets in bulk and often have ownership of a portfolio of credits;
- *Retailers* sell small amounts of credits to individuals or organizations, usually online, and have ownership of a portfolio of credits;
- *Brokers* do not own credits, but facilitate transactions between sellers and buyers.

This market has most recently been dominated by renewable energy projects, including both wind and hydroelectric projects. The price of credits is often determined by the type of projects, credibility of standard and various risks.

6.1.3 GHG Programs & Standards

Market prices fluctuate based on the standard used to review, approve and verify a project. Fundamental differences exist among standards. A project conducted without a clear and transparent standard exacerbates conflicts of interest, particularly where auditors are selected

and paid for by the project developer. This can degrade the credibility of the carbon credit and influences the market price.

There are roughly 17 readily identifiable GHG programs and standards worldwide. The most exercised third-party standards are the Voluntary Carbon Standard, followed by the Gold Standard, the Climate Action Reserve, and the American Carbon Registry Standard (Hamilton, Sjardin, Shaprio & Marcello 2009). In the past year, almost all credits on the OTC market were verified by independent third-party organizations, but there is little information on the quality of verification or the training of verifiers. The following provides details on some of the more commonly accepted standards.

6.1.3.1 The Chicago Climate Exchange[12]:

The Chicago Climate Exchange (CCX) defines itself as "the world's first and North America's only voluntary, legally binding, rules-based GHG emission reduction and trading system (Chicago Climate Exchange 2007)." Launched in 2003, it is driven by a membership-based cap-and-trade system. Members voluntarily join the CCX and sign up to its legally-binding reductions policy. The CCX trades six different types of GHG emissions converted into one common unit denominated in t CO_2e (CCX 2007).

There are three levels of membership in the CCX:

- *Full Members* are entities with significant direct GHG emissions who have committed to reducing their emissions 1% per year from a baseline determined by their average emissions from 1998 through 2001. The current goal (Phase II) is for members to reduce their total emissions to 6% below the baseline by 2010. As of April 2009, there were 92 Full Members of the CCX;
- *Associate Members* are entities with negligible direct GHG emissions. Associate Members commit to report and fully offset 100% of their indirect emissions associated with energy purchases and business travel from year of entry through 2010. As of April 2009, 52 companies were participating as Associate Members; and
- *Participant Members* are project developers, offset providers, offset aggregators, and liquidity providers, the last of which trade on the Exchange for purposes other than complying with the CCX emissions reduction schedule. As of April 2009, there were 33 offset providers, 92 offset aggregators, and 68 liquidity providers participating in the CCX (Chicago Climate Exchange 2007).

The unit of exchange on the CCX is the annual emission allowance, which is allocated in accordance with member's emissions baseline and the CCX Emission Reduction Schedule. Members who reduce beyond their targets have a surplus of allowances to sell or bank; those who do not meet their targets must comply by purchasing CCX Carbon Financial Instrument Contracts (CFI). The CFI Contracts are a blend of Exchange Allowances and Exchange Offsets (CCX 2007).

[12] Hamilton, Sjardin, Shaprio and Marcello: May 20, 2009: Fortifying the Foundation: State of the Voluntary Carbon Markets 2009

All offset projects must undergo third-party verification by an approved CCX verifier. Verification reports, however, are not released, nor available from the CCX. Current offset projects include: Agricultural Methane; Coal Mine Methane; Landfill Methane; Agricultural Soil Carbon; Rangeland Soil Carbon Management; Forestry; Renewable Energy; Ozone Depleting Substance Destruction. Other projects types, approved on a project-by-project basis include Energy Efficiency and Fuel-Switching as well as Clean Development Mechanism (CDM) projects (Chicago Climate Exchange 2007).

Credits verified on the CCX continue to remain at the bottom of the price spectrum at an average transaction price of less than $4/t CO2e (Hamilton, Sjardin, Shaprio, & Marcello 2009).

6.1.3.2 Climate Action Registry

The Climate Action Registry (CAR) evolved out of the California Climate Action Registry, a non-profit established in 2001 that focused on developing standards for reporting corporate GHG inventories. This effort evolved into the National Climate Registry, which is now embraced by most provinces in Canada and states in the US. With the Climate Registry established, CAR focused on developing standards for GHG reduction projects. According to CAR, "It does this by establishing regulatory-quality standards for the development, quantification and verification of GHG emissions reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRT) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system. Adherence to the Reserve's high standards ensures that emissions reductions associated with projects are real, permanent and additional, thereby instilling confidence in the environmental benefit, credibility and efficiency of the U.S. carbon market."[13]

To date, CAR has four protocols available (Forest, Livestock – US, Landfill – US, Urban Forestry) and has several more in development. Because of the active participation of Canadian provinces in the Climate Registry, there is a strong commitment to develop protocols specific to Canada in the near future.

6.1.3.3 Voluntary Carbon Standard (VCS)

Credits certified through the VCS are called voluntary carbon units (VCU). The goal of the VCS program is to provide integrity to the voluntary carbon market by establishing a basic quality threshold and providing assurance for buyers that the VCUs they purchase are real, measurable, permanent, additional, and independently verified. Additionally, the VCS program aims to ensure each VCU is unique and is associated with a single GHG emission reduction or removal activity (Voluntary Carbon Standard Association 2008).

The average cost of a VCU in 2008 was $5.50 U.S. dollars per tCO_2e and these VCUs are retireable. The VCS was the most used OTC standard in 2008 with approximately 48% of the market share (Hamilton, Sjardin, Shaprio, Marcello 2009).

[13] Climate Action Registry Website: About Us.

Although the VCS is well recognized, creating and reporting projects on the VCS is not possible in Canada. The reason is that Canada has international commitments to reduce GHGs and the VCS requires that the Federal government write a letter indicating that any project created and reported on the VCS would not be double counted in order to meet international commitments (Voluntary Carbon Standards Association 2006). To date we understand that the Government of Canada does not issue such letters as a point of policy.

6.1.3.4 Verified Emissions Reductions Standard (VER+)

The VER+ standard was developed and launched in mid 2007, by a designated operational entity (DOE) for the validation and verification of CDM projects. The criteria for VER+ are in line with the CDM and JI but VER+ projects are not registered with the UNFCCC and are often purchased by those who want to voluntarily reduce their emissions.

VER+ excludes credits from large hydroelectricity and nuclear energy projects. The average cost of a VER+ credit was $5.9 U.S. dollars per t CO_2e in 2008. In 2008, the VER+ standard accounted for approximately 2% of the OTC market share due to the small average size of a VER+ transaction (Hamilton, Sjardin, Shaprio, Marcello 2009).

6.1.4 Other Applicable Programs

6.1.4.1 Renewable Energy Certificates

Renewable Energy Credits (RECs), also known as Green Tags or Tradable Renewable Certificates, are certificates that represent megawatt hours of renewable electricity. REC markets have been in existence for much longer in North America than GHG based markets, with many US states having in place Renewable Portfolio Standards which mandate the use of renewable energy in their jurisdictions.

Renewable Energy Credits on the voluntary market may be certified by various programs such as EcoLogo and Green-e (Hamilton, Sjardin, Shaprio, Marcello 2009). Not all projects are necessarily verified by a third party, but it is possible to purchase RECs that are. The certificates can be retired, and there are multiple registries to do so.

It is important to note that many companies and organizations buy and retire RECs strictly for the potential carbon reductions associated with them. Many in the GHG community, especially those coming from a project based system like CDM/JI, openly question the viability of expressing a REC as GHG reductions (Gillenwater 2007). The price of RECs varies greatly, but the average price is about $20 per MWh.

6.1.4.2 GMC

FCM created the Green Municipal Corporation (GMC) to purchase, aggregate and sell carbon-offset credits earned by municipal governments. The Green Municipal Corporation offered the following services to FCM members:

- Regulatory assistance;

- Risk management;
- Purchase and sale of offset credits; and
- Technical and financial advice (Federation of Canadian Municipalities 2007).

However, the program has recently been suspended due to a lack of Federal financial support, and there are no expectations that it will start up again in the near future.

6.2 VOLUNTARY MARKET DECISION MATRIX

The matrix below is made up of a series of critical questions that have been created to guide Hamilton in a custom carbon market strategy. We considered market long-term growth and development. This custom-designed matrix examines four types of credits and standards for potential use in project development of carbon credits for the City of Hamilton, plus RECs as an additional option to monetize renewable electricity projects.

Table 6.1 Voluntary Carbon Market Decision Matrix

Criteria	Over the Counter	Chicago Climate Exchange	Climate Action Registry	Voluntary Carbon Standard	Voluntary Emissions Reductions + Standards	Renewable Energy Certificates
What Standard does the system follow?	Depends	None (CCX internal requirements)	CAR is based on ISO14064 and develops its own performance standards	VCS is based on ISO14064	Kyoto protocol	Various (eco-logo, green e)
Does the system require projects to be Validated to international standards?	Depends	No	Yes	Yes	Yes	Not necessarily
Does the system required third party Verification to international standards?	Depends	No	Yes	Yes	Yes	Not necessarily
Is there access to a Verification Report?	Depends	Not through the CCX – but sometimes the project proponent will disclose a copy.	Yes	Yes	Yes	Not necessarily
Is there a project Registry?	No	Yes	Yes	Yes	Yes	No
What are the types of projects?	Various	Various	Various	Various	Various	Renewable power generation projects
What is the average price per credit?	$7.34	Less than $4.00 USD	$7-$10 USD	$5.50 USD	$5.80 USD	$20.00 mWh

Table 6.1 Voluntary Carbon Market Decision Matrix

Criteria	Over the Counter	Chicago Climate Exchange	Climate Action Registry	Voluntary Carbon Standard	Voluntary Emissions Reductions + Standards	Renewable Energy Certificates
What is the public perception/credibility of the project?	Poor	Average	Good	Good	Good	Poor - Average
Are Canadian projects eligible?	Yes	Yes	Yes	Not currently due to Federal Government Policy	Yes	Yes
Recommendation	No	No	Yes	No	Yes	No

6.3 CARBON REDUCTION PROJECT AND CREDIT ASSESSMENT

Due to a lack of regulation in the voluntary market by governments and other entities, some projects, verifiers and offsets have been called into question. In addition, many voluntary carbon market players use RECs as carbon offsets, which are sometimes criticized because RECs were not developed to specifically address carbon reductions, but rather to express a broad set of environmental benefits. We recommend that Hamilton take a conservative approach to developing carbon credits, and be very clear if the environmental benefits associated with Hamilton's projects are intended to be monetized as carbon reductions or RECs.

Recently, offset buyers in this market are demanding projects that adhere to international standards such as ISO14064 and the VCS. The CCX and OTC do not require that carbon projects adhere to international standards, although it is possible to find credits on the CCX and OTC that do follow international standards. For this reason this approach is not recommended.

Although VCS does ensure credits adhere to ISO14064 standards, the use of this system is not recommended due to the issue of receiving approval from the Canadian Federal government.

The matrix above indicates that both CAR and VER+ credits could be a suitable possibility for Hamilton should they wish to develop offset credits in the future. Both CAR and the VER+ standard follows international protocols, requires validation, verification and provides access to these documents on the registry. However, due to the current uncertainty in the carbon market, it is recommended that the City of Hamilton wait for clarity in forthcoming provincial regulations before committing to any anticipated development of offset credits with the intent to sell in the near future. Rather, it is recommended that Hamilton have quantification documentation, legal ownership, and other project specific materials ready so that when the regulated Canadian landscape surrounding carbon credits becomes clear, the City of Hamilton will be ready to be an early mover in the market.

6.4 ECONOMIC FEASIBILITY OF CARBON REDUCTION PROJECT DEVELOPMENT

Companies and municipalities have started to review their liabilities and opportunities in a carbon-constrained economy. To successfully profit from environmental improvements, organizations must understand how they are priced in various markets, recognize that these markets will be volatile over the near/medium term, and have some knowledge of the costs associated with feasible project development.

In addition to the specific opportunities for Hamilton derived from the GHG inventory process, the following provides some basic information on market pricing and conditions.

6.4.1 Market Pricing Overview

As OTC markets have generated the most turnover and liquidity to date, the following analysis for pricing is focused on that particular segment. It cannot be stressed enough that these markets are still developing and are expected to exhibit much volatility. As such, the recommendations for follow-up should be considered in light of future market changes and the evolving regulatory and voluntary frameworks.

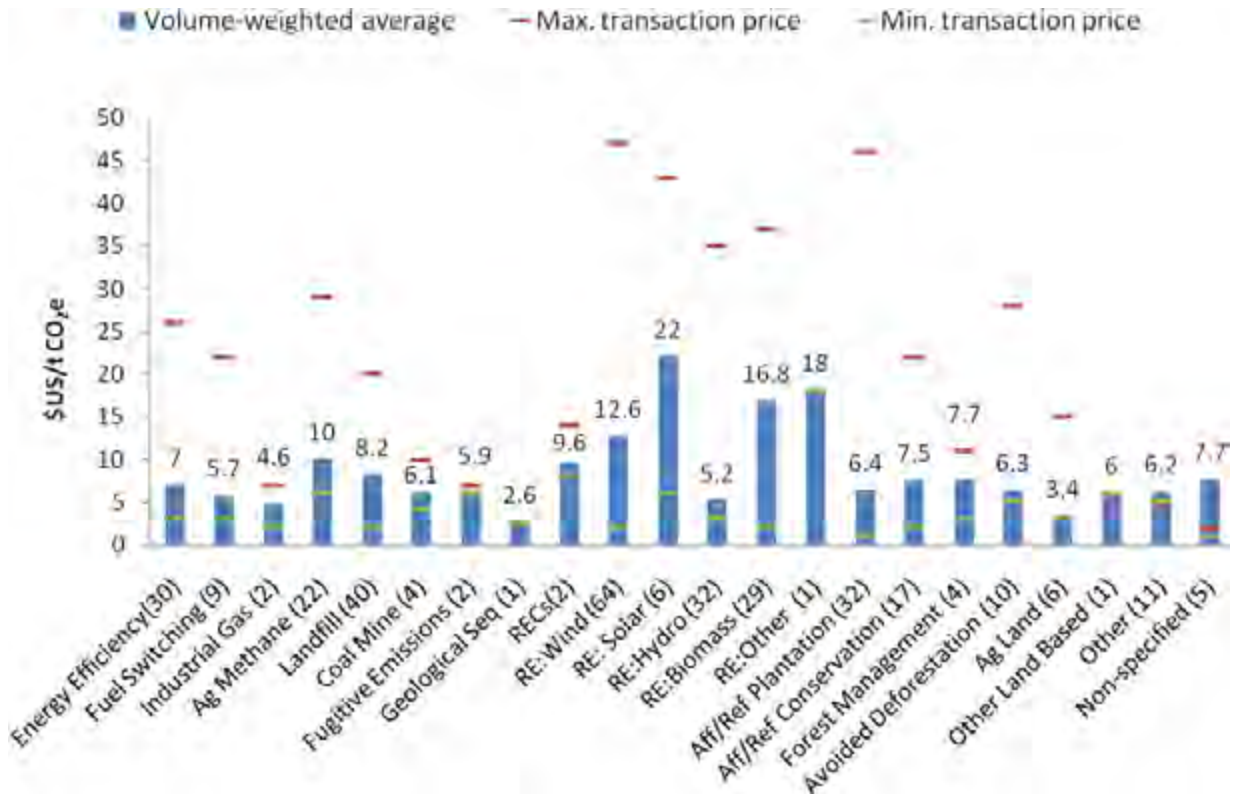
In addition, when trying to understand environmental benefits pricing, it is important to distinguish between voluntary and regulated markets as voluntary markets typically yield significantly lower pricing.

In order to provide a stronger price comparison in the following pricing analysis, GHG standards that feed into regulated systems are in **bold**, while voluntary standards are in *italics*.

6.4.2 Over the Counter (OTC) Market

In 2008, the price of carbon offset credits ranged from $1.20 - $46.90 per t CO_2e, down from 2007 which ranged from $1.80 - $300/t$CO_2$e. Renewable energy projects (distinct from RECs) attracted the top purchase price in 2008, of which solar ($21.09 per t CO_2e), geothermal ($18.00 per t CO_2e) and biomass ($16.84 per t CO_2e) were the highest. Low end projects were geothermal sequestration ($2.58 per t CO_2e), agricultural soil sequestration ($3.35 per t CO_2e) and industrial gas credits ($4.57 per t CO_2e) (Hamilton, Sjardin, Shaprio, Marcello 2009). An average price comparison for 2008 is shown in figure 6.1.

Figure 6.1 Credit Prices Ranges and Averages by Project Type (Hamilton, Sjardin, Shaprio, Marcello 2009)



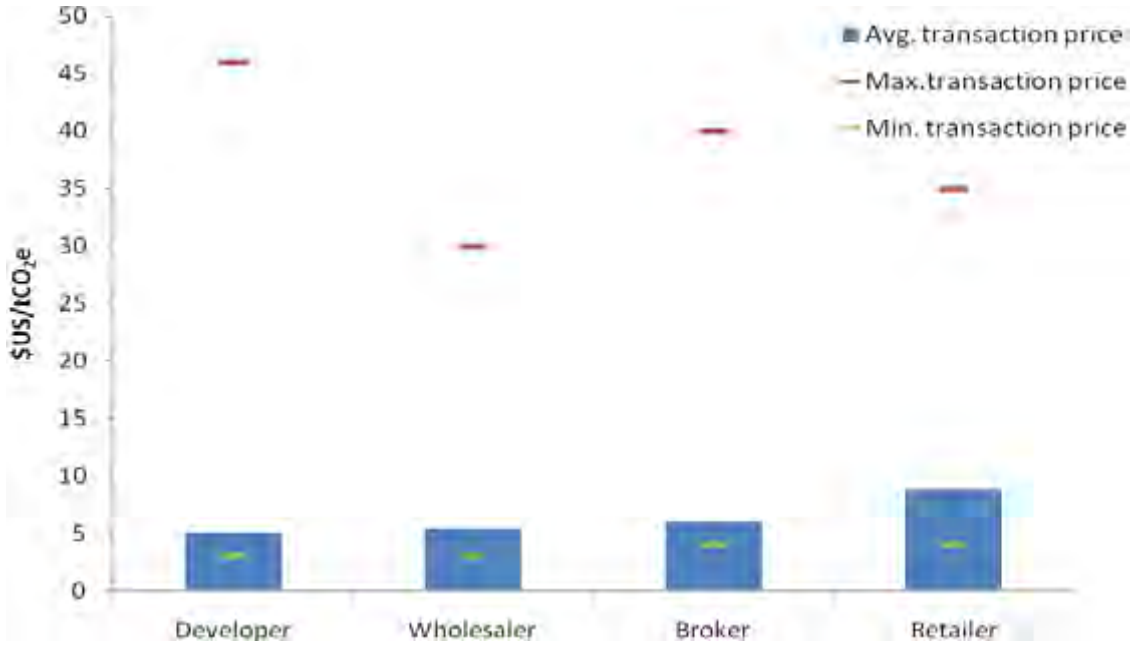
6.4.3 Pricing by Standard

Offset prices are determined by project type, verification standards, and whether the standard feeds into regulated or voluntary markets. CDM/JI projects maintained an above average selling price ($21.30 per t CO_2e) while other standard and program based credits such as the CarbonFix, Gold Standard, Green-e, GHG Friendly, Climate, Community and Biodiversity Project Design Standards, CAR, ISO standards, Social Carbon and even internally-created standards sold above average (>$7.34/t$CO_2$e). The CCX and ACR (American Carbon Registry) trailed at the bottom of the spectrum at an average price of less than $4 per t CO_2e (Hamilton, Sjardin, Shaprio, Marcello 2009).

6.4.4 Price by Supplier Business Activity

Prices of carbon offsets can also be examined across the supply chain. The least expensive credits can be purchased from project developers directly. The most expensive credits are sourced from retailers. Brokers and wholesalers facilitate transactions between developers and final buyers. The average, maximum, and minimum credit price and range by business category is presented in figure 6.2.

Figure 6.2 Credit Price Average and Range by Business Category (Hamilton, Sjardin, Shaprio, Marcello 2009)

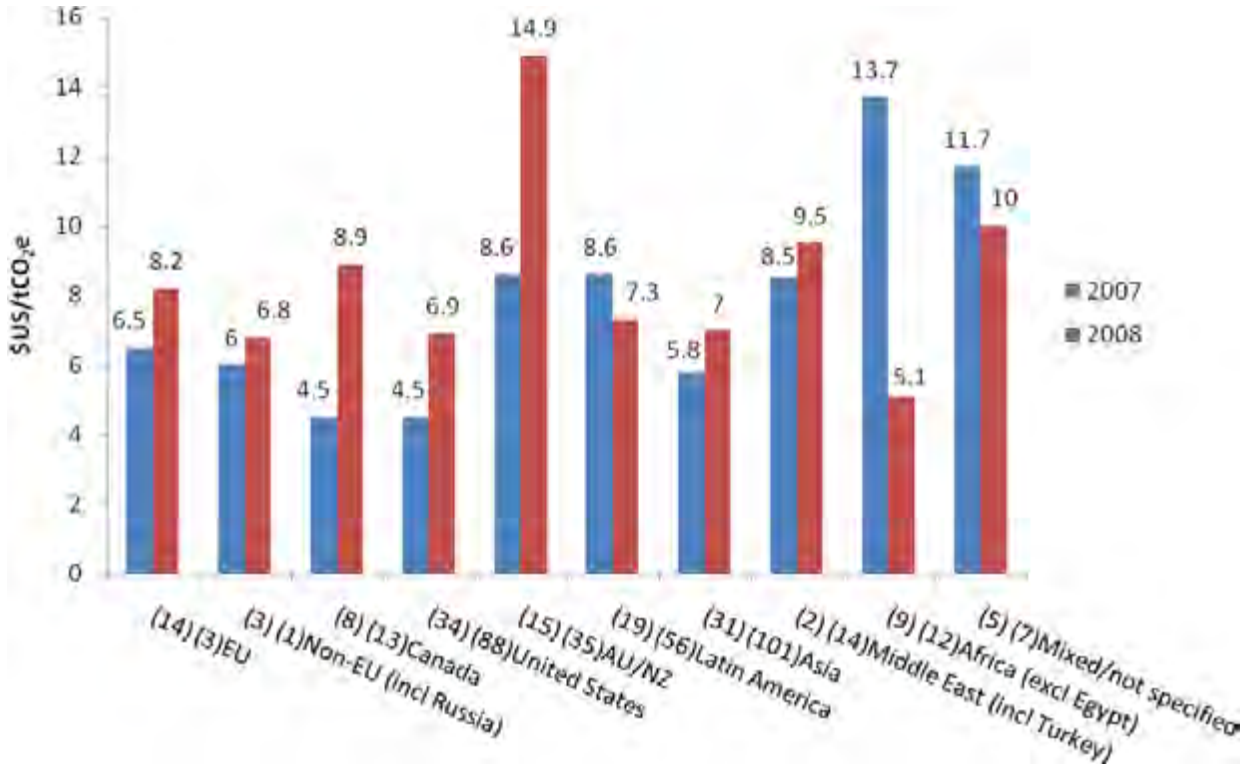


6.4.5 Price by Location

Canada, in addition to South Africa and Thailand, sourced VERs into the OTC market at consistently higher-than-average prices than other countries in 2008. However, there is still a weak correlation between a project's originating country and an average VER price. Data can be heavily skewed depending on the size of projects and their nature. For example, the lower than average price of Nicaraguan credits in 2008 ($2.8 t CO_2e) was a result of one low-end project consisting of 90% of their transaction volume for 2008 (Hamilton, Sjardin, Shaprio, Marcello 2009).

The average credit price and price ranges for 2007 and 2008 by location are presented in figure 6.3.

Figure 6.3 Average Credit Price and Price Ranges by Location (Hamilton, Sjardin, Shaprio, Marcello 2009)



6.5 FORECASTING MARKET CONDITIONS

The first few months of 2009 have been volatile in the carbon markets with the influx of new voluntary systems, protocols, standards and exchanges. At the same time, stakeholders, both in the regulated and voluntary markets, wait to see how the financial and regulatory market uncertainty will play out. It is anticipated that global carbon markets will continue to expand with some projections suggesting an increase to 257 Mt CO_2e in 2012, 347 Mt CO_2e in 2015 and 476 Mt CO_2e in 2020 (Hamilton, Sjardin, Shaprio, Marcello 2009).

Voluntary markets have declined in wake of the global economic situation which has limited investment, access to capital, and discretionary spending. Thus, the current market lacks liquidity. Although many historical stakeholders continue to purchase, the rate at which new buyers are entering the market has decreased. According to New Carbon Finance's Voluntary Carbon Index (VCI), roughly 7 Mt CO_2e were transacted in the first quarter of 2009, down roughly 50% since 2008. Prices have had a similar decrease averaging $4.90 per t CO_2e in the OTC and $1.20 per t CO_2e on the CCX (Hamilton, Sjardin, Shaprio, Marcello).

In the medium term, it is anticipated that global carbon markets will accelerate again as the global economy improves and new regulatory systems (notably the USA and Canada Federal and Provincial systems) come on-line (Hamilton, Sjardin, Shaprio, Marcello 2009).

6.6 QUANTIFICATION OF CARBON OFFSET CREDITS

Through the development of the GHG Emissions Inventory for the City of Hamilton, several initiatives and projects were identified with the potential for quantification to produce carbon offset projects. They are outlined in table 6.2.

Table 6.2 City Projects with Potential to Produce Carbon Offset Projects

Project	Description	Opportunity & Quantification
Green Fleet Implementation Plan Phase I	Goal of the plan was to reduce CO_2e output by included vehicles by 4000-6000 tCO_2e by 2008. Includes vehicles found within the City of Hamilton's Public Works Department, Planning and Development Department and several other agencies.	Approximately 546 tCO_2e
Green Fleet Implementation Plan Phase II	Building on the momentum of Phase I, Phase II looks to implement a wide range of new technologies and best practices for green fleet management. It covers the period of 2009- 2011.	Estimated to be 511 tCO_2e by 2011
Corporate Energy Policy	The policy is designed to address legislated reporting requirements, achieve city-wide energy reduction targets, define specific policies regarding capital investment related to energy, and specific policies regarding energy procurement.	Quantifiable by comparing energy fuel use between 2005 and 2008
Traffic Lights Conversion	In 2007, the City of Hamilton began converting all remaining incandescent traffic signals to LED traffic signals, which used 70% less energy than incandescent bulbs. Since 2004, all newly installed traffic signals have been LED signals.	Quantifiable by comparing electricity use between 2005 and 2008.
1.6MW Cogeneration Facility	Hamilton Renewable Power Incorporated, owned by the City of Hamilton, constructed a 1.6MW Biogas Cogeneration Facility at the Woodward Avenue Wastewater Treatment Plant. The facility became operational in 2006, and is expected to produce 13.6 million kWh of electricity.	Two opportunities exist; the first relates to methane releases avoided because of the Biogas facility, the second to renewable energy produced. The opportunities can be quantified by calculating avoided methane releases, and the decrease in the amount of electricity displaced from the grid expressed as kWh of renewable energy.

Table 6.2 City Projects with Potential to Produce Carbon Offset Projects

Project	Description	Opportunity & Quantification
Glanbrook Landfill Gas Collection System	The Glandbrook Landfill Gas Collection System, owned by the City of Hamilton, is currently under construction. It will include a landfill gas collection system and a power plant. The power plant will generate 26 million kWh/year.	The opportunities are the same as the CoGen facility, with approximately 100,000 tCO_2e available as a carbon reductions, and the renewable electricity may be expressed as kWh of renewable energy.
Wastewater Lab	The City of Hamilton's Woodward Avenue Environmental Laboratory became the first Canadian building to achieve LEED silver certification. The building's energy performance was determined to be 32.4% better than the Model National Energy Code Reference building. Energy cost savings of 30.6% are predicted at the laboratory.	A comparison of end use fuel and electricity consumption between 2005 and 2008 can be used to quantify emissions reductions.

6.7 CITY OF HAMILTON'S OFFSET POTENTIAL

Of the various options available to the City of Hamilton, there are two options available to pursue:

- Landfill Gas Electricity Generation as Renewable Energy Certificates; and
- CoGen facility Electricity Generation as Renewable Energy Certificates.

The other options stated above are either too small to pursue given the costs associated with them, or other impediments exist that make the projects infeasible at this time. Overall, it is recommended that the City of Hamilton monitor the substantive legislative movements happening in both Washington and Ottawa that will dramatically impact carbon and renewable energy markets, identifying trends or opportunities that may change in the future.

6.7.1 Viable Projects

6.7.1.1 Glanbrook Landfill Gas Collection System

Emissions from landfill gas projects are readily quantifiable with existing protocols. However, Ontario, under Regulation 347 of the Environmental Protection Act, requires the Glanbrook landfill to have either a flare or gas collection system in place. The requirement creates a barrier to developing a carbon reduction project under most GHG programs.

The landfill gas collection system was completed in 2008 and is currently in operation. However, Hamilton has entered into a power purchase agreement under the Standard Offer Program. Therefore, any potential carbon credits have been transferred to the Province of Ontario.

Finally, it is understood that the City of Hamilton considering the construction of a municipally-owned waste-to-energy facility. If this project proceeds, there may be a possibility that a carbon reduction project could be derived from the process. The City could quantify the environmental benefits of any renewable electricity generation as RECs and potentially generate carbon credits for internal requirements or sale to a regulated facility.

6.7.1.2 Cogeneration Facility

The first opportunity is to quantify the GHG reductions associated with using the CH_4 for the CoGen facility rather than letting it disperse into the atmosphere. However, given that the emissions are considered biogenic by the IPCC, and that the total volume is 525 t CO_2e based on the 2005 data (relatively small), the project barriers and size make it an unlikely option to pursue.

Like the Glanbrook landfill, there is also an opportunity for RECs associated with the electricity generation but these would likely be part of the negotiation of a power purchase agreement.

6.7.2 Non-Viable Projects

6.7.2.1 Fleet Management

Although fleet management is a popular carbon reduction instrument, a readily identifiable quantification protocol does not exist, nor is there a market (regulated or voluntary) that has accepted this initiative as a carbon offset project. A quantification protocol could potentially be created, but time, effort, and capital would need to be directed at such an initiative. The cost of development for the City of Hamilton would far surpass the potential profit from such an initiative (estimated at roughly $8,000 considering current average prices of $7.34 t CO_2e) unless external funding for the protocol development could be secured.

6.7.2.2 Corporate Energy Policy, Traffic Lights & WasteWater Lab

Between the City's *Corporate Energy Policy*, *Traffic Light Conversion* initiative and LEED Building, there does exist the potential to generate offset credits. The CCX currently analyzes energy efficiency projects on a project-by-project basis but given the credibility issues of the CCX, this is not viewed as a viable option.

Depending upon developments in the Canadian markets, other opportunities may arise. This process may also lend itself to the City of Hamilton working with a carbon offset aggregator. Aggregators accumulate many smaller projects and walk through validation and verification requirements which ultimately reduce the cost to any single project proponent. Although the profit gained on any single credit is decreased by the profit margin taken by an aggregator, it is still a beneficial process to minimize risk and exposure to entry-level carbon market stakeholders.

6.7.3 General Project Development Criteria

As the City of Hamilton continues the process of identifying the feasibility of revenue generating offset projects, there are several questions which project proponents should attempt to address:

1. Do quantification protocols currently exist for these types of projects?
2. What is the cost of bringing credits to market – i.e. validation & verification?
3. What are markets willing to pay for these types of projects?
4. What are market forecasts predicting for these types of projects?
5. As project proponents, are we likely to be regulated in the future? Are we better holding onto our credits for future compliance?

Desk validation and feasibility studies may cost between $5,000 and $10,000. With a successful validation and documentation of the project, a 3rd party verification is always required, and costs for a project proponent range $10,000 - $15,000 (depending on the size, type and protocol adhered to). As such, based on verification costs alone, it is generally expected that a project will generate roughly $100,000 in carbon credit profits before it becomes cost-effective to pursue offset sales. A guiding rule of thumb suggests that the verification should cost no more than 10%-15% of a projects projected profit. Using the 2008 OTC average price, that would entail producing roughly 14,000 tCO_2e from a project before advancing to the verification stage.

It is noted that both validation and verification processes require independent 3rd parties. This means, for example, that Stantec, because it has consulted with the City on GHG related issues, would not be eligible to perform validation or verification work on projects the City of Hamilton is an owner and project proponent. Likewise, another party that performed a validation of a City project, could not also verify that same project, but may be eligible to be a verifier on yet another project the City owns.

7.0 Summary of Recommendations

It is recommended that the City of Hamilton give consideration to the following:

- Update the City and Community inventories for 2008 when data becomes available for the full calendar year and continue to update the inventory on an annual basis;
- Prepare a staff report following the completion of the 2008 calendar year inventory to inform departments and council on performance relative to targets within each City emission category and continue to provide reports on an annual basis;
- Develop and implement improved mechanisms and tools to collect data to address data gaps and if possible, re-estimate elements of the estimated portion of the baseline using new data;
- Report on absolute emission reductions annually for each emission category by comparing baseline emission levels and future years' emissions levels;
- Bundle yearly reports of emission reductions for specific initiatives with reporting on other emission increases in the emission category;
- Continue to investigate building and infrastructure components that can be targeted to reduce energy demand in existing and new City buildings and infrastructure;
- Explore the potential for renewable supplies of energy to provide heat and electricity to City buildings and infrastructure;
- Assess the local energy assets of potential future developments and communities to determine the extent to which renewable energy can be incorporated into plans of these future projects;
- Consider the potential for future projects to generate carbon offsets;
- Invest in climate change adaptation planning, as well as continuing to invest in climate change mitigation programs; and
- Compile a complete inventory of trees in Hamilton and determine the carbon sequestration potential of these trees.

Additionally, the project team compiled a variety of other recommendations which may assist in reducing emissions, provided for City consideration:

- Identify off road emission sources within the Community and quantify emissions;
- Investigate the feasibility of incorporating electric vehicles in the vehicle fleet, including investigating the potential for these vehicles to reduce emissions;
- Improve the small engines module spreadsheet used by the City to collect data on small engines, and consider a project to review regulatory, policy, and standards as is relates to small engines, an evaluation of alternatives to using 2-stroke engines, and alternative landscape and maintenance practices to reduce the use of equipment that uses small engines;

- Assess the local energy assets of potential future developments and communities to determine the extent to which renewable energy can be incorporated into plans of these future projects;
- Continue to build on efforts to adjust signal lighting to allow traffic to flow during peak times;
- Address City Housing data gaps and investigate opportunities to reduce emissions associated with these units;
- Consider an energy asset mapping exercise to determine the extent to which local energy resources can be harnessed and used by the City and Community;
- When developing contracts or soliciting quotations for contracted fleet services, incorporate emission considerations into the appropriate documentation, and consider optimization of vehicle travel associated with contracted fleets;
- Consider developing green or sustainable procurement policies, in addition to the existing environmental purchasing considerations; and
- Servers and storage rooms associated with information technology can consume substantial energy which produces emissions. Consider disaggregating this energy use from total energy consumption, and investigate opportunities to reduce emissions.

8.0 Closure

Jacques Whitford Stantec Limited is pleased to present this final report to the City of Hamilton. This report has been prepared for the sole benefit of the City. Any use that a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. JWSL accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made, or actions taken, based on this report.

A portion of the information presented in this report was collected from existing documents and interviews with City staff, energy providers, and others. Although attempts were made to obtain confirmatory sources of information, JWSL was required to assume that certain data sets and information provided were accurate. In certain areas, best professional judgment was used to analyze and prepare emissions estimates based on the best readily available data available within the fiscal constraints of the contract. Where assumptions were made, they were recorded in the report and additional future analysis and data collection is encouraged.

JWSL gratefully acknowledges the substantive assistance of Brian Montgomery, Air Quality Coordinator with the City of Hamilton, City of Hamilton staff, Union Gas, and Horizon Utilities for their help in providing information essential to completion of this project.

This report was written by Joe Harriman, Brent MacDonald, Craig Coulter and Terry Ricketts. Other JWSL employees were engaged where appropriate. Technical review was provided by Dr. Joe Harriman, Ph.D., P.Chem, and Matthew Peachman, P.Eng. Senior review was provided by Lauren Jones B.Sc., MBT and Dr. Michael Murphy, Ph.D., P.Eng.

Yours truly,

JACQUES WHITFORD STANTEC LIMITED

Original Signed By

Dr. Joe Harriman, Ph.D., P. Chem
Project Manager, Technical Lead
Atmospheric Environment
Joe.Harriman@Stantec.com

Original Signed By

Lauren Jones, B.Sc., MBT
Director
GHG Services
Lauren.Jones@Stantec.com

BM/DJH/MCM/jef

9.0 References

California Climate Action Registry. 2008. Local Government Operations Protocol: For the quantification and reporting of greenhouse gas emissions inventories. Available online: http://www.arb.ca.gov/cc/protocols/localgov/pubs/final_lgo_protocol_2008_09-25.pdf

Canadian Mortgage Housing Council. 2009. Energy-Efficient Housing Made More Affordable with Mortgage Loan Insurance. Available online: http://www.cmhc-schl.gc.ca/en/co/moloin/moloin_008.cfm#buy

Canadian Standards Association. 2008. Measuring Your Organization's Carbon Footprint. *CSA-ISO 14064-1: Essentials – Greenhouse Gas Inventories for Organizations.* Mississauga, ON: CSA Education and Training.

Central Fleet Advisory Committee - City of Hamilton. 2009. Green Fleet Implementation Plan, Phase II. MyHamilton website . Available online: www.myhamilton.ca/myhamilton.

Chicago Climate Exchange. 2007. Chicago Climate Exchange website. Available online: http://www.chicagoclimatex.com/index.jsf

City of Hamilton. 2004. Street Tree Planting Program. MyHamilton website. Available online: http://www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PublicWorks/Parks/Forestry/StreetTreePlantingProgram/

City of Hamilton. 2007. By-Law No. 07-160: To Prohibit Unnecessary Idling of Vehicles within the City of Hamilton. Available online: http://www.cleanair.hamilton.ca/downloads/Anti-Idling%20By-law.pdf

City of Hamilton. September 2007. Notice of Completion: Biosolids Master Plan Class Environmental Assessment. MyHamilton website. Available online: http://www.myhamilton.ca/NR/rdonlyres/1C3F27BC-861B-44FA-B0D1-7F0F66B3AD0E/0/ays070914.pdf

City of Hamilton. 2008. Information Report:Metrolinx Regional Transportation Plan and Investment Strategy Implications for Hamilton (PW08043e). MyHamilton website. Available online: http://www.myhamilton.ca/NR/rdonlyres/86A334D5-1233-4B03-916C-B583434BD510/0/Jan19PW08043e.pdf

City of Hamilton-Office of Energy Initiatives. 2007. Hamilton Shines for Earth Hour! MyHamilton website. Available online: http://www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PublicWorks/Office+of+Energy+Initiatives/

City of Hamilton-Planning and Economic Development. 2009. Urban Official Plan (pending Council approval). MyHamilton website. Available online: http://www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PlanningEcDev/StrategicServicesSpecialProjects/Policy+Planning/HamiltonNewOfficialPlan/UrbanArea.htm

City of Hamilton-Public Works. 2005. Urban Forest Health Program Report (PW15115). MyHamilton website. Available online: http://www.myhamilton.ca/NR/rdonlyres/9A6D0B7F-D470-40D5-BF7C-EF66AE7672F2/0/Sep19PW05115.pdf

City of Hamilton-Public Works. May 2005. Urban Forest Gets a Boost from Trees Across Hamilton. MyHamilton website. Available online: http://www.myhamilton.ca/NR/exeres/B0AD5FD8-0CEA-412E-B64E-FB0807F737DE.htm

City of Hamilton-Public Works. 2006. Green facility opens in Brownfield. MyHamilton website. Available online: http://www.myhamilton.ca/myhamilton/CityandGovernment/NewsandPublications/NewsReleases/2006News/June/06-06-24ph.htm

City of Hamilton-Public Works. 2007.Why we need a Green Cart program now and how it works. MyHamilton website. Available online: http://www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PublicWorks/WasteManagement/ProgramsAndServices/GreenCartComposting/WhatIsIt.htm

City of Hamilton-Public Works. 2007(2). Water/Wastewater Master Plan. MyHamilton website. Available online: http://www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PublicWorks/CapitalPlanning/StrategicPlanning/StrategicEnvironmentalPlanningProjects/GRIDS/Water+Wastewater+Master+Plan.htm

City of Hamilton-Public Works. 2007(3). Stormwater Master Plan. My Hamilton website. Available online: http://www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PublicWorks/CapitalPlanning/StrategicPlanning/StrategicEnvironmentalPlanningProjects/GRIDS/Stormwater+Management+Master+Plan.htm

City of Hamilton-Public Works.2007(4). Transportation Master Plan. MyHamilton website. Available online: http://www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PublicWorks/CapitalPlanning/StrategicPlanning/StrategicEnvironmentalPlanningProjects/GRIDS/Transportation+Master+Plan.htm

City of Hamilton-Public Works. 2008. City of Hamilton Wins 2nd Award for Woodward Avenue Water and Wastewater Treatment Facility. MyHamilton website. Available online: www.myhamilton.ca/myhamilton.

City of Hamilton-Public Works. 2008 (2). Year-End Statistics (Tonnes). MyHamilton website. Available online: http://www.myhamilton.ca/myhamilton/CityandGovernment/CityDepartments/PublicWorks/WasteManagement/Statistics/

City of Hamilton-Public Works. September 2008. Media Release: Hamilton takes second place in Blackout Challenge. Horizon Utilities website. Available online: http://www.horizonutilities.com/pdf/BlackoutChallengeCity2008.pdf

City of Hamilton – Public Works. 2009. City of Hamilton initiative produces green energy from landfill gas. MyHamilton website. Available online: www.myhamilton.ca/myhamilton.

City of Hamilton - Public Works. 2009. Green Fleet Expo. MyHamilton website. Available online: www.myhamilton.ca/myhamilton City of Hamilton-Public Works.

City of Hamilton – Public Works. July 2009. Corporate Energy Report – Year End 2008 (PW09069) – (City Wide). Email correspondence.

Clean Air Hamilton. 2007. The Hamilton Commuter Challenge. Clean Air Hamilton website. Available online: http://www.cleanair.hamilton.ca/whatsnew/challenge.asp

Clean Air Hamilton. 2009. Clean Air Hamilton 2008 Progress Report. Clean Air Hamilton website. Available online: http://www.cleanair.hamilton.ca/downloads/CAHProgressReport2008.pdf

Cummings, Hugh. 2009. Excel/Hamilton consumption 06-08. Union Gas. Email correspondence.

Cummings, Hugh. June 2009. Microsoft Outlook email Community NG Inquiry. Email correspondence.

Davis, Gerry. 2006. City of Hamilton Information Update Re: Energy Retrofit Program. Email correspondence.

Davis, Gerry. 2009. City of Hamilton Information Update Re: Corporate Energy Report-January 2009. Email correspondence.

Ecoaction. 2009. Incentive Rate. Available online:

http://www.ecoaction.gc.ca/ECOENERGY-ECOENERGIE/heat-chauffage/v2008/incentiverate-tauxincitatif-eng.cfm

Ecoaction. 2009. Incentive Rate. Available online:

http://www.ecoaction.gc.ca/ECOENERGY-ECOENERGIE/heat-chauffage/v2008/incentiverate-tauxincitatif-eng.cfm

Ecoaction. 2009 (2). Commercial Deployment Incentives Terms and Conditions. Available online: http://www.ecoaction.gc.ca/ECOENERGY-ECOENERGIE/heat-chauffage/v2008/conditions-eng.cfm

Environment Canada. 2005. Moving Forward on Climate Change. *EnviroZine* 54, Available online: http://www.ec.gc.ca/EnviroZine/english/issues/54/feature1_e.cfm

Environment Canada. 2007. Regulatory Framework for Air Emissions. Environment Canada website. Available online: http://www.ec.gc.ca/doc/media/m_124/toc_eng.htm

Environment Canada. 2008. Hamilton Renewable Power Incorporated: 2008 Winner of the Canadian Council of Ministers of the Environment Pollution Prevention Award for Overall Reductions of Greenhouse Gases. Environment Canada website. Available online: http://www.ec.gc.ca/pp/EN/storyoutput.cfm

Environment Canada. December 2007. Canadian Environmental Protection Act, 1999. Environment Canada website. Available online: http://www.ec.gc.ca/cleanair-airpur/Turning_the_Corner/CEPA_1999,_Sec._71-WS074B0A75-1_En.htm

Environment Canada. March 2008. Turning the Corner: Canada's Energy and GHG Emissions Projections. Reference case:2006-2020. 22. Available online: http://www.ec.gc.ca/doc/virage-corner/2008-03/pdf/nat_eng.pdf

Environment Canada September 2008. GHG Reporting: Information on Greenhouse Gas Sources and Sinks. Environment Canada website. Available online: http://www.ec.gc.ca/pdb/ghg/onlineData/dataSearch_e.cfm

Environment Canada, 2009. National Inventory Report: Greenhouse Gas Sources and Sinks in Canada, 1990-2006. Annex 9: Electricity Intensity Tables. Table A9-7: Electricity Generation and GHG Emission Details for Ontario. Environment Canada website. Available online: http://www.ec.gc.ca/pdb/ghg/inventory_report/2006_report/ta9_7_eng.cfm.

Environment Canada. June 2009. Canada's Offset System for Greenhouse Gases: Overview Guide. Environment Canada website. Available online: http://www.ec.gc.ca/creditscompensatoires-offsets/default.asp?lang=En&n=92CA76F4-1

Environment Canada National Pollutant Release Inventory (NPRI). 2007. NPRI Data-Facility Reported Data. NPRI website Available online: http://www.ec.gc.ca/pdb/websol/querysite/query_e.cfm

Environment Hamilton. 2009. About Hamilton Eat Local. Environment Hamilton website. Available online: http://www.environmenthamilton.org/eatlocal/

Environment Hamilton. 2009(2). Passport to Hamilton: Your Guide to Family Discount Adventures. Environment Hamilton website. Available online: http://www.environmenthamilton.org/view/page/passport_to_hamilton

Federation of Canadian Municipalities. 2007. FCM opens carbon offset market to municipalities. Federation of Canadian Municipalities website. Available online: http://www.sustainablecommunities.fcm.ca/announcement/announcement10290701.asp

Government of Canada. 2002. Climate Change Plan for Canada. Available online: http://dsp-psd.pwgsc.gc.ca/Collection/En56-183-2002E.pdf

Government of Canada. 2005. Technical Guidance Document. Greenhouse Gas Reporting Site. Available online: http://www.ghgreporting.gc.ca/ghg-ges/page15.aspx

Government of Canada. 2008. *Turning the Corner: Taking Action to Fight Climate Change. Ottawa, ON.*

Government of Ontario. 2007. Go Green: Ontario's Action Plan on Climate Change. Available online: http://www.ene.gov.on.ca/publications/6445e.pdf

Government of Ontario. 2008. Ontario's Climate Change Action Plan: Creating Our Sustainable Future (Annual Report 2007/2008). Available online: http://www.ene.gov.on.ca/publications/6869e01.pdf

Green Venture. 2000. Wise Water Use. Available online: http://water.greenventure.ca/

Green Venture. 2007. Idling Stinks. Green Venture website. Available online: http://air.greenventure.ca/idling-stinks

Green Venture. 2007 (2). Totally Transit. Green Venture website. Available online: http://air.greenventure.ca/totally-transit

Green Venture. 2007 (3). EcoDriver. Green Venture website. Available online: http://www.greenventure.ca/current-projects

Hamilton Economic Development. 2007. Economic Development Review 2007. Hamilton Economic Development website. Available online: http://www.investinhamilton.ca/images/stories/publications/EcRev07.pdf

Hamilton, Sjardin, Shaprio, & Marcello. 2009. Fortifying the Foundation: State of the Voluntary Carbon Markets 2009 - A Report by Ecosystem Marketplace and New Carbon Finance. Available online: http://ecosystemmarketplace.com/documents/cms_documents/StateOfTheVoluntaryCarbonMarkets_2009.pdf

Hill, Chris. 2009. Excel/Price and Usage Analysis (2003-2008). Email correspondence.

Hill, Christopher. 2004. Central Fleet Strategic Plan 2004. MyHamilton website. Available online: www.myhamilton.ca/myhamilton.

Horizon Utilities. 2009. PeakSavers. Horizon Utilities website. Available online: http://www.horizonutilities.com/HHSC/html/conservation/con_OPApeaksaver.jsp.

Horizon Utilities. 2009(2). Generation Conservation. Horizon Utilities website. Available online: http://www.horizonutilities.com/pdf/GCBackgrounder.pdf

Horizon Utilities. 2009(3). Powersavings Blitz. Horizon Utilities website. Available online: http://www.horizonutilities.com/HHSC/html/conservation/con_PowerSavingsBlitz.jsp

Horizon Utilities. 2007. The Great Refrigerator Roundup is Here. Horizon Utilities website. Available online: http://www.horizonutilities.com/HHSC/html/conservation/con_OPA_Fridge.jsp.

ICLEI. 2008. International Local Government GHG Emissions Analysis Protocol Version 1.0. Available online: http://www.iclei.org/fileadmin/user_upload/documents/Global/Progams/GHG/LGGHGEmissionsProtocol.pdf

Intergovernmental Panel on Climate Change. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories titled, Wastewater Treatment and Discharge. Available online: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/5_Volume5/V5_6_Ch6_Wastewater.pdf

i-Tree Software Suite v2.0, Tools for Assessing and Managing Community Forests User Manual. 2008. Cooperative initiative between: USDA For. Ser., Davey, Arbour Day Foundation, Society of Municipal Arborists, ISA. Available online: http://www.itreetools.org/resource_learning_center/elements/i-Tree_v20_UsersManual.pdf

Jenkins, J.C., Chojnacky, D.C.,Heath, L.S., Birdsey, R.A. 2003. National-scale biomass estimation for United States tree species. Forest Science. 49(1): 12-35.

Lord, Stuart. 2009. Excel/ Book 1.xls. Horizon Utilities. Email correspondence.

McNeil, J. and C. Vava. 2006. Oakville's urban forest: Our solution to our pollution. Town of Oakville Report, Oakville, Ontario. 67 p. Available online: http://www.oakville.ca/Media_Files/forestry/UFORE.pdf

Metrolinx. 2009. Smart Commute: Choose Your Way! Available online: http://www.smartcommute.ca/

Monaco, Angela. 2009. Excel/606_CPBJune2008.xls. Email correspondence.

Montgomery, Brian. 2009. Excel/6091jl-EMME2 Model Statistics. Email correspondence.

Montgomery, Brian. April 20 2009. Excel/ Employee Commuting Distance-Postal Codes2.xls. Email correspondence.

Montgomery, Brian. June 25 2009. Hamilton Industrial Sheet with Updated Natural Gas Numbers. Email correspondence.

National Transportation Operations Coalition. 2005. National Traffic Signal Report Card 2005. Available online: http://www.ite.org/REPORTCARD/2005/default.asp

Natural Resources Canada. 2000. 1997 Survey of Household Energy Use – Summary Report. NRCAN website. Available online: http://oee.nrcan.gc.ca/infosource/pdfs/SHEU_e.pdf

Natural Resources Canada. 2007. Commercial/Institutional End Use Model. NRCAN website. Available online: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/index.cfm?fuseaction=Sources.display

Natural Resources Canada. 2009. Fuel Consumption Ratings. NRCAN website. Available online: http://oee.nrcan.gc.ca/transportation/tools/fuelratings/ratings-search.cfm

OCETA. 2009. Lightsavers program monitoring and evaluation approach. Available online: http://206.130.170.35/taf/pdf/ls-monitoring-evaluation.pdf.

Ontario Ministry of the Environment. 2007. Drive Clean. Ministry of the Environment website. Available online: http://www.ene.gov.on.ca/en/air/driveclean/

Ontario Ministry of the Environment, 2007. Ontario Greenhouse Gas Emissions Targets: A Technical Brief (June 18, 2007). Available online: http://www.ene.gov.on.ca/

Ontario Ministry of the Environment, 2008. Ontario's Climate Change Action Plan: Creating our Sustainable Future. Annual Report 2007-2008. Available online: http://www.ene.gov.on.ca/

Ontario Ministry of the Environment. 2009. Ontario's Green Energy Act. Ministry of the Environment website. Available online: www.mei.gov.on.ca.wds6.korax.net/english/energy/gea

Ontario Power Authority. 2009. Every Kilowatt Counts Website. Available online: http://everykilowattcounts.ca/residential/coolsavings.

Ontario Power Authority. 2009(2). Electricity Retrofit Incentive Program (ERIP) – About the Program. Horizon Utilities website. Available online: http://horizon.erip.ca/retrofit/

Partners for Climate Protection. 2009. Developing Inventories for Greenhouse Gas Emissions and Energy Consumption: A Guidance Document for Partners for Climate Protection in Canada. Available online: http://www.sustainablecommunities.fcm.ca/files/Capacity_Building_-_PCP/pcp-ismd-pub-en.pdf

Smart Commute Initiative. 2003. A Collaborative Proposal of the Greater Toronto Area and Hamilton to the Urban Transportation Showcase Program. Available online: http://www.tc.gc.ca/programs/environment/UTSP/docs/Smart%20Commute%20REV.pdf

Statistics Canada, Geography Division. 2005. 2005 Road Network File 92-500-XWE/XWF. Available online: http://roadmap.sourceforge.net/maps.html

Statistics Canada. 2006. 2006 Statistics Canada Census for the City of Hamilton. (emailed)

Statistics Canada. 2008. CANSIM Table 405-0002: Sales of fuel used for road motor vehicles, by province and territory. Available online: http://www40.statcan.ca/l01/cst01/trade37b-eng.htm

Statistics Canada. June 2008. Catalogue no. 97-561-XCB2006010: Commuting distance (km) (9), Age Groups (9), and Sex (3) for the Employed Labour Force 15 Year and Over Having a Usual Place of Work of Canada, Provinces, Territories, Census Metropolitan Areas and Census Agglomerations, 2006 Census-20% Sample Data. Available online: http://www12.statcan.ca/english/census06/data/topics/RetrieveProductTable.cfm

Statistics Canada. 2009. 2006 Census of Agriculture. Statistics Canada website. Available online: http://www26.statcan.ca:8080/AgrProfiles/cp06/Table1.action?prov=00&search=search&placename=hamilton&placestart=0&geog_id=350125005&geog_id_amal=350125005&loccode=22449&tab_id=1

The Climate Registry. 2008. General Reporting Protocol Version 1.0. Available online: http://www.theclimateregistry.org/downloads/GRP.pdf

U.S. EPA, Exhaust Emission Factors for Nonroad Engine Modeling: Spark Ignition, EPA420-R-05-019, NR-010e, December 2005.

TÜV SÜD Industrie Service GmbH. 2008. Criteria Catalogue: VER+ (version 2.0) – CMS Standard GHG 30. Available online: https://www.netinform.de/GW/files/pdf/VER+%20GHG%2030.pdf

US Environmental Protection Agency. 2009. Emission Factors & AP 42. USEPA website: Technology Transfer Network- Clearinghouse for Inventories & Emission Factors. Available online: http://www.epa.gov/ttnchie1/ap42/

US House of Representatives Committee on Energy and Commerce. 2009. Chairmen Waxman, Markey Release Discussion Draft of New Clean Energy Legislation. US House of Representatives Committee on Energy and Commerce website. Available online: http://energycommerce.house.gov/index.php?option=com_content&task=view&id=1560

Voluntary Carbon Standard Association. 2006. The Voluntary Carbon Standard: Verification Protocol and Criteria – Proposed Version 2. International Emissions Trading Association website. Available online: http://www.ieta.org/ieta/www/pages/getfile.php?docID=1918

Voluntary Carbon Standard Association. 2008. About the VCS. Voluntary Carbon Standard website. Available online: http://www.v-c-s.org/about.html

Watson, Adam. 2009. Excel/ACTUALS 2005.xls. Email correspondence.

Watson, Adam. March 26 2009. Waste Management Contracted Collection Fleet Information (MSN Outlook Email). Email correspondence.

Western Climate Initiative. 2008. Design Recommendations for the WCI Cap and Trade Program. Western Climate Initiative Website. Available online: http://www.westernclimateinitiative.org/the-wci-cap-and-trade-program/design-recommendations

Western Climate Initiative. 2009. About the WCI. Western Climate Initiatives Website. Available online: http://www.westernclimateinitiative.org/about-the-wci

World Resources Institute. 2007. The Greenhouse Gas Protocol: A Corporate Reporting and Accounting Standard – Revised Edition. Available online: http://www.ghgprotocol.org/files/ghg-protocol-revised.pdf

World Wildlife Fund Canada. 2008. Earth Hour. WWF website. Available online: http://wwf.ca/earthhour/

Coefficients

City and Community Inventories

NOTE: Emission and conversion factors associated with Small Engines calculations available upon request to the City of Hamilton.

Ontario kWh Coefficients / Year

Inventory Year	Coefficient (kg CO_2e / kWh)	Coefficient (t CO_2e / kWh)
1990	0.21	0.00021
1991	0.2	0.0002
1992	0.2	0.0002
1993	0.13	0.00013
1994	0.1	0.0001
1995	0.12	0.00012
1996	0.13	0.00013
1997	0.17	0.00017
1998	0.23	0.00023
1999	0.24	0.00024
2000	0.28	0.00028
2001	0.26	0.00026
2002	0.26	0.00026
2003	0.27	0.00027
2004	0.2	0.0002
2005	0.21	0.00021
2006	0.18	0.00018

Root Source: National Inventory Report 1990 - 2006
Includes:
a Report on Energy Supply-Demand in Canada, Catalogue No. 57-003-XIB, Statistics Canada
b Electric Power Generation, Transmission and Distribution, Catalogue No. 57-202-XIB, Statistics Canada
c Electricity data from CANSIM , tables v222128, v222129, v222130, v222131, v222132, v222133 - downloaded February 5, 2008
Notes:
1 Data presented includes emissions, generation and intensity for public utilities
2 Includes emissions from the use of light fuel oil, heavy fuel oil and diesel fuel oil
3 Emissions from the flooding of land for hydro dams are not included
4 Emissions related to the use of biomass for electric power generation are not included
5 Other Renewables - includes electricity generation by wind and tidal
6 Others - includes electricity generation by fuels not easily categorized (i.e. waste)
7 Wind generation data provided by Independent Electricity System Operator, news release dated January 10, 2008
NA - Not Available

Transportation Fuel Combustion Emission Factors and Statistics

Fuel Type	Energy Content (GJ/m^3)	Energy Content (GJ/L)	Energy Content (TJ/L)	Emission Factor (t CO_2e/TJ)	t CO_2e/unit	Unit
Natural Gas (Pipelines)	0.038	0.000038	0.000000038	50.16	0.05016	GJ
Natural Gas (other)	0.038	0.000038	0.000000038	49.95	0.04995	GJ
Motor Gasoline	35	0.035	0.000035	67.66	0.0023681	L
Aviation Gasoline	33.52	0.03352	0.00003352	69.86	0.002341707	L
Jet/Turbo Fuel	37.4	0.0374	0.0000374	68.4	0.00255816	L
Diesel Fuel	38.3	0.0383	0.0000383	71.61	0.002742663	L
LPGs	22	0.022	0.000022	60.47	0.00133034	L
Residual Fuel (HFO)	42.5	0.0425	0.0000425	73.34	0.00311695	L

Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and Emission Factors for transportation. GHG emissions provided as Carbon Dioxide Equivalents (CO_2e) which includes emission contributions from CO_2, N_2O and CH_4.

Vehicle - Criteria Air Contaminants (by vehicle class)

Vehicle Class	Critical Air Contaminants	Gasoline (g/km)	Diesel (g/km)	Propane (g/km)	Natural Gas (g/km)	E85 (g/km)	Hybird (g/km)
Light duty Passenger Vehicles - Automobile	CO	10.9	0.662	6.54	6.54	7.2	7.57
	NOx	0.559	0.507	0.504	0.504	0.512	0.389
	SO2	0.0035	0.0216	0.0035	0.0035	0.0035	0.0025
	VOC	0.662	0.166	0.331	0.146	0.605	0.459
	TPM	0.0158	0.0683	0.0039	0.0032	0.0077	0.011
	PM10	0.0155	0.0682	0.0039	0.0031	0.0076	0.0108
	PM2.5	0.0071	0.0556	0.0018	0.0014	0.0035	0.0049
Light Duty Passenger Vehicles - Truck	CO	12.8	0.558	7.67	7.67	8.44	8.88
	NOx	0.701	0.572	0.631	0.631	0.641	0.487
	SO2	0.0045	0.0313	0.0045	0.0045	0.0045	0.0031
	VOC	0.709	0.268	0.354	0.156	0.648	0.492
	TPM	0.016	0.0942	0.004	0.0032	0.0079	0.0111
	PM10	0.0158	0.094	0.0039	0.0032	0.0077	0.011
	PM2.5	0.0073	0.0794	0.0018	0.0015	0.0036	0.0051
Heavy Duty Commercial Vehicle	CO	14.4	1.49	0.172	0.173	0	0
	NOx	2.86	7.01	4.03	4.07	0	0
	SO2	0.0092	0.0902	0.0902	0.0902	0	0
	VOC	0.959	0.267	0.921	0.932	0	0
	TPM	0.0584	0.192	0.0154	0.0448	0	0
	PM10	0.0569	0.192	0.0154	0.0448	0	0
	PM2.5	0.0406	0.163	0.0131	0.0381	0	0

Source: Transport Canada. Urban Transportation Emissions Calculator. Data presented is based on 2006 calculations. Available at http://www.tc.gc.ca/programs/environment/UTEC/CacEmissionFactors.aspx

NRCAN Fuel Consumption Ratings for Regular Gasoline Vehicles - 2006 Model Year

Vehicle Class	Mid-Class Vehicle	Rank	City Fuel Efficiency (L / 100 km)	Highway Fuel Efficiency (L / 100 KM)	Average Fuel Efficiency (L / 100 KM)
Two Seater	Mercedes-BENZ SLK350	22 out of 45	12.3	9	10.65
Subcompact	AUDI TT Couple Quattro	55 out of 113	11.7	7.6	9.65
Compact	Chevrolet Optra	68 out of 136	11	7.1	9.05
Mid size	Buick Allure	55 out of 110	12.2	7.3	9.75
Full size	Ford Crown Victoria	29 out of 56	14	8.5	11.25
Station Wagon	Mazda 5 Wagon	42 out of 83	10.6	8	9.3
Pickup Truck	GMC K1500 Sierra Hybrid	72 out of 140	14.3	11.3	12.8
Special Purpose	Chevrolet Trailblazer	108 out of 215	14.8	9.8	12.3
Van	Ford Freestar Wagon	31 out of 57	14.1	9.6	11.85

Fuel Consumption Ratings, Natural Resources Canada. Available online at: http://oee.nrcan.gc.ca/transportation/tools/fuelratings/ratings-search.cfm. Please note that where possible, mid range vehicles have been selected. In some cases, the exact mid-range fuel consumption information was not available. In these cases, the next available fuel efficiency rating was selected.

Conversion Factors for Energy Types

Conversion Factors for Energy Types	
To convert from kWh to GJ, multiply 0.0036	0.0036
To convert from GJ to kWh, multiply 277.8	277.8
Natural Resources Canada, Office of Energy Efficiency http://oee.nrcan.gc.ca/Publications/infosource/Pub/hospitality_sector/english/section_02.cfm?PrintView=N&Text=N	
1 GJ = 26.1 litres Fuel Oil (Middle Distallates and Diesel)	26.1
1 GJ= 24.2 litres Bunker Blend (Bunker A/ #5 Oil)	24.1
1 GJ = 24 litres #6 Oil (Heavy Fuel Oil)	24
1GJ=50.792 kg Natural Gas	50.792
1 GJ = 39.2 litres Propane	39.2
Heritage Gas Conversion Factors: http://www.heritagegas.com/converting/Business/b_rates.asp	

Square Meters to Square Feet Conversion	
1 m2=10.763 sq ft	10.763

Population Statistics

Year	Population
2001	490,268
2006	504,559
2006 Community Profiles: Hamilton Ontario (statcan)	

Road Lengths

Hamilton Road Length		
Category	Distance	units
Total Length of Roads	3159.1	KM
ArcGIS 9.2 program used with a roads dataset from Geography Division, Statistics Canada, 2005 Road Network Fiel (RNF), 92-500-XWE/XWF and a Hamilton boundary dataset from ESRI, which was originally obtained from DMTI Spatial Inc., to determine KM of roads within Hamilton		

Quality Indicators

Quality Indicators	
Tier Classifications	Indicator
Tier 1 Activity Data	
Tier 1 activity data is defined as activity data which is sufficient to approximate the scale of emissions from a particular source, but which will not accurately respond to local changes in use or behavior. Tier 1 activity data shall be used only in cases where more accurate data is unavailable and where the source is secondary. Examples of Tier 1 data are:	Medium to Low
• national average fuel use per capita	
• national average solid waste generation per employee	
• methane recovery system effectiveness estimates based on the assumption that the system meets regulatory guidelines	
Tier 2 Activity Data	
Tier 2 activity data is defined as activity data which is sufficient to approximate the scale of emissions from a particular source and which will accurately respond to local changes in use or behavior. While Tier 2 data is often based on estimates or models, it is important that the sources of data adhere to a professional standard for conducting such estimates. It is also important that, wherever possible, estimation methods comply with methods used elsewhere in the local government's planning efforts. Examples of Tier 2 data are:	Medium
• engineering estimates of energy use based on system use and design	
• estimates of heating fuel use based on known historical use modified based on	
population changes and variations in annual temperatures (heating degree days)	
• fuel use estimated from distance traveled times average fuel efficiencies	
• methane recovery system effectiveness estimates based on system design	
• total community distance traveled estimates based on systematic traffic counts and road segment lengths	
• local population change forecasts by an approved census body	
• quantity of fuel used in a year based on known price paid times average fuel cost in that year	
Tier 3 Activity Data	
Tier 3 activity data is defined as activity data which is sufficient for regulatory or billing purposes and which will precisely respond to local changes in use or behavior. Examples of Tier 3 data are:	High
• metered energy use	
• metered methane recovery	
• quantity of solid waste as weighed at a transfer station	
Tier Classifications: International Local Government Greenhouse Gas (GHG) Protocol (Release Version 1.0), Available online - www.iclei.org	

City Inventory

IPCC 1997 Default Fuel Efficiency Values (Revised 1996 Guidelines for National GHG Inventories Reference Manual)

Emissions based on distance						
Vehicle/Travel Type	MPG	L/100km	kg CO2e/passenger mile	kg CO2e/vehicle mile	kg CO2e/passenger km	kg CO2e/vehicle (km)
hybrid auto	56	4.2	0.0895	0.161	0.0556	0.1001
small gas auto	29	8.1	0.1727	0.3109	0.1073	0.1932
medium gas auto	23	10.2	0.2178	0.392	0.1353	0.2436
large gas auto	19	12.4	0.2636	0.4746	0.1638	0.2949
diesel auto	24	9.8	0.2406	0.433	0.1495	0.2691
gas light truck	14	16.8	0.3578	0.664	0.2223	0.4002
gas heavy truck	6	39.2	0.8349	1.5028	0.5188	0.9338
diesel light truck	15	15.7	0.3849	0.6928	0.2392	0.4305
diesel heavy truck	7	33.6	0.8248	1.4847	0.5125	0.9226
light motorcycle	60	3.9	0.0835	0.1503	0.0519	0.0934
long distance bus			0.0781	N/A	0.0485	N/A
urban transit bus			0.2997	N/A	0.1862	N/A
urban CNG bus		137.25	0.14		0.23	
road freight			0.1033	*short ton miles	0.072	*metric tonne km

Miles per gallon for typical vehicles, EPA/USA. Other default factors are from IPCC 1997. Revised 1996 Guidelines for National Greenhouse Gas Inventories Reference Manual * Urban CNG bus MPG retrieved from http://www1.eere.energy.gov/vehiclesandfuels/avta/pdfs/heavy/nyct_interim_report_final.pdf

Energy Modeling Results for Semi-Detached Homes in Ontario by Dwelling Vintage

Dwelling Vintage	Energy Type	Consumption	Units
Before 1941	Electricity	8122	kWh
	Natural Gas	4723	m3
1941 to 1960	Electricity	8917	kWh
	Natural Gas	3531	m3
1961 to 1977	Electricity	9,011	kWh
	Natural Gas	3,712	m3
After 1977	Electricity	9993	kWh
	Natural Gas	2883	m3

According to published data, the statistical weighting factor of dwellings in these categories of vintage for ON primarily use Natural Gas as space heating fuel, and for domestic hot water. Electricity is primarily used for appliances, lighting and cooling. All of the energy consumption data presented in this chart are based on the statistical averages of single dwellings in Ontario, derived from the SHEU database and EnerGUIDE data. All simulation results are from ESP-r & SNNS and these results have been independently verified. To derive energy consumption statistics for the dwelling vintage 1961 to 1977, an average was taken from each category of vintage

Municipal Wastewater Treatment: N_20 Emission Factors Associated with Wastewater Treatment (N_20 from human sewage)

Table 8-4 (Environment Canada's National Inventory Report 1990-2006): N_2O Emission Factors		
Year	Annual per Capita Protein Consumption	N_2O Emission Factor
	(kg protein/person per year)	(kg N_2O/person per year)
1990	25.74	0.065
1991(1)	25	0.063
1992	26.01	0.065
1993	26.15	0.066
1994	26.29	0.066
1995	26.42	0.066
1996(1)	26	0.065
1997	26.68	0.067
1998	26.79	0.067
1999	26.89	0.068
2000	26.98	0.068
2001(1)	27.72	0.07
2002(1)	27.54	0.069
2003(1)	27.17	0.068
2004(1)	27.41	0.069
2005(1)	27.18	0.068
2006(2)	26.4	0.066

Source:
1. Statistics Canada (2006b). The data have been adjusted for retail, household, cooking, and plate loss.
2. Statistics Canada (2007c). The data have been adjusted for retail, household, cooking, and plate loss.

Municipal Wastewater Treatment: CH_4 Emission Factor Associated with Wastewater Treatment (CH_4 from anaerobic wastewater)

CH4 Emission Factor for Anaerobically Treated Wastewater (Environment Canada's National Inventory Report 1990-2006)		
CH4 Emission Factor for Anaerobically Treated Wastewater	4.015	kg CH_4 / person
	0.004015	t CH_4 / person

Global Warming Potentials

GWPs of Common Greenhouse Gases and Refrigerants		
Gas or Blend	**GWP**	**Source**
CO2	1	IPCC Fourth Assessment Report (2007)
CH4	21	IPCC Third Assessment Report (2007)
CH4	25	IPCC Fourth Assessment Report (2007)
N2O	298	IPCC Fourth Assessment Report (2007)
HFC-23	14800	IPCC Fourth Assessment Report (2007)
HFC-32	675	IPCC Fourth Assessment Report (2007)
HFC-125	3500	IPCC Fourth Assessment Report (2007)
HFC-134a	1430	IPCC Fourth Assessment Report (2007)
HFC-143a	4470	IPCC Fourth Assessment Report (2007)
HFC-152a	124	IPCC Fourth Assessment Report (2007)
HFC-236fa	9810	IPCC Fourth Assessment Report (2007)
SF6	22800	IPCC Fourth Assessment Report (2007)
R-401A	16.12	ASHRAE Standard 34
R-401B	13.64	ASHRAE Standard 34
R-401C	21	ASHRAE Standard 34
R-402A	2100	ASHRAE Standard 34
R-402B	1330	ASHRAE Standard 34
R-403A	1400	ASHRAE Standard 34
R-403B	2730	ASHRAE Standard 34
R-404A	3921.6	ASHRAE Standard 34
R-406A	0	ASHRAE Standard 34
R-407A	2107	ASHRAE Standard 34
R-407B	2803.5	ASHRAE Standard 34
R-407C	1773.85	ASHRAE Standard 34
R-407D	1428	ASHRAE Standard 34
R-407E	1363	ASHRAE Standard 34
R-408A	1944	ASHRAE Standard 34
R-409A	0	ASHRAE Standard 34
R-409B	0	ASHRAE Standard 34
R-410A	2087.5	ASHRAE Standard 34
R-410B	2228.75	ASHRAE Standard 34
R-411A	15.4	ASHRAE Standard 34
R-411B	4.2	ASHRAE Standard 34
R-412A	350	ASHRAE Standard 34
R-413A	1774	ASHRAE Standard 34
R-414A	0	ASHRAE Standard 34
R-414B	0	ASHRAE Standard 34
R-415A	25	ASHRAE Standard 34
R-415B	105	ASHRAE Standard 34
R-416A	767	ASHRAE Standard 34
R-417A	1954.8	ASHRAE Standard 34
R-418A	3.5	ASHRAE Standard 34
R-419A	2403	ASHRAE Standard 34
R-420A	1144	ASHRAE Standard 34
R-500	36.68	ASHRAE Standard 34
R-501	0	ASHRAE Standard 34
R-502	0	ASHRAE Standard 34
R-503	4691.7	ASHRAE Standard 34
R-504	313.3	ASHRAE Standard 34
R-505	0	ASHRAE Standard 34
R-506	0	ASHRAE Standard 34
R-507 or R-507A	3985	ASHRAE Standard 34
R-508A	11384	ASHRAE Standard 34
R-508B	11776	ASHRAE Standard 34
R-509 or R-509A	3920	ASHRAE Standard 34
PFC-218 (C3F8)	7000	UNEP OzonAction Programme Chemical Database
PFC-116 (C2F6)	9200	IPCC Second Assessment Report (1995)
PFC-14 (CF4)	6500	IPCC Second Assessment Report (1995)
Taken from the Greenhouse Gas Protocol Initiative's Sector Specific Calculation tool: "HFC and PFC emissions from the manufacturing, installation, operation and disposal of refrigeration and air-conditioning equipment." Found at http://www.ghgprotocol.org/calculation-tools/all-tools		

Total Natural Gas Intensity (GJ/m2) by type of dwelling

Total natural gas intensity (GJ/m^2)								
	Single detached		**Double/row house**		**Apartment**		**Mobile home**	
Region								
Atlantic		U		U		U		U
Quebec		U		U		U		U
Ontario	0.76	A	0.75	A		U		U
Prairies	1.1	A	1.02	M		U		U
British Columbia	0.64	A	0.64	M		U		
SOURCE: Survey of Household Energy Use: http://oee.nrcan-rncan.gc.ca/corporate/statistics/neud/dpa/data_e/sheu03/publication_en_048_2.cfm?attr=0								

Community

Residential Sector Fuel Consumption Emission Factors and Statistics

Residential Sector							
	1990	2001	2002	2003	2004	2005	2006
Total Energy Use (PJ)	489.6	514.4	529.8	568.8	548.3	559	521.7
Energy Use by Energy Source (PJ)							
Electricity	163	159.9	158.8	160.5	163	164.3	158.3
Natural Gas	252.3	302.3	316.5	349.2	335.6	342.5	315.4
Heating Oil	51.2	29.1	30.1	32	23	23.5	20.4
Other[2]	6.4	4.7	4.5	5.2	5.4	6.8	7.7
Wood	16.8	18.4	19.8	21.9	21.4	21.9	19.9
Shares (%)							
Electricity	33.3	31.1	30	28.2	29.7	29.4	30.3
Natural Gas	51.5	58.8	59.7	61.4	61.2	61.3	60.5
Heating Oil	10.5	5.7	5.7	5.6	4.2	4.2	3.9
Other2	1.3	0.9	0.9	0.9	1	1.2	1.5
Wood	3.4	3.6	3.7	3.8	3.9	3.9	3.8
Total Floor Space (million m^2)	483	599	609	619	624	638	649
Total Households (thousands)	3632	4413	4487	4560	4591	4674	4737
Energy Intensity							
Energy Intensity (GJ/m^2)	1.01	0.86	0.87	0.92	0.88	0.88	0.8
Energy Intensity (GJ/household)	134.8	116.6	118.1	124.7	119.4	119.6	110.1

Comprehensive Energy Use Database Tables, NRCAN. Available online at http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tablestrends2/res_on_1_e_3.cfm?attr=0 FOOTNOTE2: "Other" includes coal and propane.

Commercial Sector Fuel Combustion Emission Factors and Statistics

Fuel Type	Energy Content (GJ/m^3)	Energy Content (GJ/L)	Energy Content (TJ/L)	Emission Factor (t CO_2e/TJ)	CO_2e/unit	Unit
Natural Gas	0.038	0.000038	0.000000038	49.95	0.04995	GJ
Light Fuel Oil	38.68	0.03868	0.00003868	73	0.00282364	L
Kerosene	37.68	0.03768	0.00003768	67.74	0.002552443	L
LPGs	22	0.022	0.000022	59.95	0.0013189	L
Residual Fuel (HFO)	42.5	0.0425	0.0000425	73.22	0.00311185	L

Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and Emission Factors for transportation. GHG emissions provided as Carbon Dioxide Equivalents (CO_2e) which includes

Commercial and Institutional Sector Fuel Consumption Estimations

Commercial and Institutional Sector Fuel Consumption (ONTARIO)			
2001		*2006*	
Energy Type	**Percent of Total**	**Energy Type**	**Percent of Total**
Electricity	38.90%	Electricity	44.00%
Natural Gas	53.30%	Natural Gas	47.00%
Steam	0.00%	Steam	0.00%
Heating Oil and other middle distallates	4.00%	Heating Oil and other mi	4.60%
Propane	0.00%	Propane	0.00%
Heavy Fuel Oil	1.80%	Heavy Fuel Oil	1.80%
Diesel	0.00%	Diesel	0.00%
Other	2.00%	Other	2.60%
Total	100.00%	Total	100.00%

Natrual Resources Canada, Office of Energy Efficiency: Comprehensive Energy Use Database (The Comprehensive Energy Use Database provides an overview of sectoral energy markets in Canada and in each region of the country. These tables are intended to complement data published in the latest edition of the Energy Use Data Handbook, 1990 to 2006): http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/comprehensive_tables/index.cfm?attr=0

Energy Intensity Associated with Commercial and Institutional Establishments / Sector or Sub-sector

Number of Commercial and Institutional establishments, energy consumption, floor area and energy intensity						
Sector or subsector	**Number of Establishments**	**Quality**	**Energy consumption (GJ)**	**Floor area (m^2)**	**Energy intensity (GJ/m^2)**	**% of Consumption**
Wholesale and warehousing	**45,868**	A	**114,162,037 C**	**73,462,291 A**	**1.55 B**	**10%**
Retail trade	**97,265**	A	**146,861,780 A**	**84,568,645 A**	**1.74 A**	**22%**
-Non-food retail	*80,383*	*A*	*110,542,345 B*	*71,506,001 B*	*1.55 A*	*18%*
-Food retail	*16,881*	*A*	*36,319,436 A*	*13,062,643 A*	*2.78 A*	*4%*
Information and cultural industries	**8,429**	A	**25,589,044 B**	**16,822,634 C**	**1.52 B**	**2%**
Offices (excluding public administration)	**86,531**	A	**139,826,874 C**	**98,417,673 B**	**1.42 A**	**20%**
Public administration	**6,329**	A	**35,305,615 A**	**28,927,539 A**	**1.22 A**	**1%**
Education[1]	**16,512**	A	**212,807,311 A**	**158,044,023 B**	**1.35 A**	**4%**
-Elementary and secondary schools	*14,587*	*A*	*114,789,224 B*	*113,207,778 B*	*1.01 A*	*3%*
-Community colleges and CEGEPs	*1,686*	*A*	*21,945,276 B*	*15,488,872 A*	*1.42 A*	*0%*
-Universities	*239*	*A*	*76,072,812 A*	*29,347,374 A*	*2.59 A*	*0%*
Health care[1]	**47,001**	A	**101,035,185 A**	**57,596,579 A**	**1.75 A**	**11%**
-Ambulatory health care services	*31,238*	*A*	*24,815,948 B*	*16,925,082 A*	*1.47 A*	*7%*
-Hospitals	*703*	*A*	*51,035,328 A*	*18,061,710 A*	*2.83 A*	*0%*
-Nursing and residential care facilities	*4,649*	*A*	*17,976,487 A*	*13,894,201 A*	*1.29 A*	*1%*
-Social assistance	*10,410*	*A*	*7,207,421 A*	*8,715,586 A*	*0.83 A*	*2%*
Accommodation services	**5,887**	A	**45,843,413 B**	**24,391,987 A**	**1.88 A**	**1%**
Food services and drinking places	**37,932**	A	**42,222,892 A**	**13,777,378 A**	**3.06 A**	**9%**
Religious organizations[2]	**24,451**	A	**50,605,742 B**	**46,687,141 A**	**1.08 A**	**6%**
Other[3]	**64,658**	A	**122,518,056 B**	**68,982,813 B**	**1.78 A**	**15%**
TOTAL	**440,863**	A	**1,036,777,949 A**	**671,678,701 A**	**1.54 A**	**100%**

The letter to the right of each estimate indicates its quality, as follows: *A* – Very good, *B* – Acceptable, *C* – Use with caution, *F* – Too unreliable to be published or eliminated for reasons of confidentiality.
[1] The scopes of certain subsectors within the Education and Health Care sectors were modified from the preceding survey. Refer to the summary report at Appendix B for further details on the methodology.
[2] Care must be exercised in interpreting data concerning Religious Organizations. See Appendix B for further details on this subject.
[3] The residual category Other includes the categories Arts, Entertainment and Recreation (NAICS 71) and Other services excluding public administration (religious organizations not included) (NAICS 81, except 813110).
Due to rounding, the numbers may not add up to the total shown, and some numbers may differ slightly from one table to the next.

http://oee.nrcan.gc.ca/Publications/statistics/cices06/chapter1.cfm?attr=0

Energy Intensity Associated with Commercial and Institutional Establishments / province

Number of Commercial and Institutional establishments, energy consumption, floor area and energy intensity, by region									
Region	Number of Establishments	Quality	Energy consumption (GJ)	Quality	Floor Area (m^2)	Quality	Energy intensity (GJ/m^2)	Quality	Energy Intensity (GJ / establishment)
Atlantic	32,987	A	55,019,228	A	48,159,323	A	1.14 A	A	1668
Quebec	95,947	A	223,099,154	A	176,422,988	A	1.26 A	A	2325
Ontario	168,143	A	442,096,442	A	259,213,367	A	1.71 A	A	2629
Prairies	85,435	A	225,716,405	A	129,792,376	A	1.74 A	A	2642
British Columbia	58,351	A	90,846,720	A	58,090,647	A	1.56 A	A	1557
Canada	440,863	A	1,036,777,949	A	671,678,701	A	1.54 A	A	2352
The letter to the right of each estimate indicates its quality, as follows:*A* – Very good, *B* – Acceptable, *C* – Use with caution, *F* – Too unreliable to be published or eliminated for reasons of confidentiality.									
Due to rounding, the numbers may not add up to the total shown, and some numbers may differ slightly from one table to the next. http://oee.nrcan.gc.ca/Publications/statistics/cices06/chapter2.cfm?attr=0									

Industrial Sector Fuel Combustion Emission Factors

Fuel Type	Energy Content (GJ/m^3)	Energy Content (GJ/L)	Energy Content (TJ/L)	Emission Factor (t CO_2e/TJ)	t CO_2e/unit	Unit
Natural Gas	0.038	0.000038	0.000000038	49.93	0.04993	GJ
Motor Gasoline	35	0.035	0.000035	67.72	0.0023702	L
Kerosene	37.68	0.03768	0.00003768	67.78	0.00255395	L
Distillate	38.68	0.03868	0.00003868	72.22	0.00279347	L
Residual Fuel (HFO)	42.5	0.0425	0.0000425	73.2	0.003111	L
LPGs	22	0.022	0.000022	60.03	0.00132066	L
Coal Metalurgical	29	0.029	0.000029	82.12	0.00238148	
Coke Oven Gas	18.6	0.0186	0.0000186	84.2	0.00156612	
Pet Coke (Refineries)	46.35	0.04635	0.00004635	82.47	0.003822485	
Pet Coke (Aluminum)	46.35	0.04635	0.00004635	82.47	0.003822485	
Still Gas (Refineries)	36.08	0.03608	0.00003608	50.46	0.001820597	
Energy content provided by Environment Canada in Turning the Corner						

U.S. Department of Energy's (DOE's) Bioenergy Feedstock Development		
Assumptions	Average Energy Content (GJ / tonne)	Tonnes of Wood (Residential Sector, Hamilton)
1.0 metric tonne wood = 1.4 cubic meters (solid wood, not stacked)	18.5	
Energy content of wood fuel (HHV, bone dry) = 18-22 GJ/t (7,600-9,600 Btu/lb)		
Energy content of wood fuel (air dry, 20% moisture) = about 15 GJ/t (6,400 Btu/lb)		
http://bioenergy.ornl.gov/papers/misc/energy_conv.html		

Non-Energy Related Fuel Combustion (i.e. Feedstock)

Fuel Type	Energy Content (GJ/m^3)	Energy Content (GJ/L)	Energy Content (TJ/L)	Emission Factor (t CO_2e/TJ)	t CO_2e/unit	Unit
LPGs	22	0.022	0.000022	12.1	0.0002662	GJ
Petrochemical	35.17	0.03517	0.00003517	14.18	0.000498711	L
Lubes & Greases	39.16	0.03916	0.00003916	35.58	0.001393313	L
Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and Emission Factors for transportation. GHG emissions provided as Carbon Dioxide Equivalents (CO_2e) which						

Coal

Conversions	Energy Content	Units	Source
Coal	25	GJ/t	Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and GHG emissions provided as Carbon Dioxide Equivalents (CO2e) which includes emission contributions from CO2, N2O and CH4. Based on heat content in coal used for Ontario power generation.

Component	From	To	Action	Divide By
still gas	GJ	L	Divide by 0.000036 -- 36.08 MJ/m3.	0.000036
petroleum coke	GJ	L	Divide by 0.04238 -- 42.38 GJ/m3.	0.04238
LPG	GJ	L	Divide by 0.022 -- 22.00 GJ/m3.	0.022
Gas Plant NGL	GJ	L	Divide by 0.000038 -- 38.00 MJ/m3.	0.000038
Coal	GJ	t	Divide by 25 -- 25 GJ/t.	25
Coke Oven Gas.	GJ	L	Divide by 0.0186 -- 18.60 GJ/m3.	0.0186

Notes

1. Emission Factors and Type of Livestock obtained from Environment Canada National Inventory Report, Greenhouse Gas Souces and Sinks, 1990-2006, May 2008
2. No emission factor available

CAC Emission Factors

Fuel	Units	CO	NOx	SOx	VOC	TSP	PM10	PM2.5	Units	Source
LPG	kg/L	8.98E-04	1.56E-03	2.00E-06	1.20E-04	8.38E-05	8.38E-05	8.38E-05	kg/L	Emission factors are from AP-42 (Chapter 1.5). See US EPA AP-42 for EF rating definitions. Assumes a sulfur content of 0.18 gr/100 ft3.
NG	kg/L	1.57E-06	4.48E-06	9.60E-09	8.80E-08	1.22E-07	9.12E-08	3.04E-08	kg/L	Emission factors are from AP-42 (Chapter 1.4, worst case factor for each contaminant). See US EPA AP-42 for EF rating definitions.
Coal	kg/tonne	2.50E-01	1.55E+01	9.50E+01	6.50E-01	4.00E+01	9.20E+00	2.40E+00	kg/tonne	Emission factors are from AP-42 (Chapter 1.1). See US EPA AP-42 for EF rating definitions. Assumes an ash content of 8%. Bituminous Coal, 5% sulphur, worst case combustion emission factor
Wood Waste (not for residential woodstoves)	kg/mmbtu	2.73E-01	2.23E-01	1.14E-02	7.73E-03	2.55E-01	2.27E-01	1.95E-01	kg/mmbtu	Emission factors are from AP-42 Ch 1.6. Assumes worst case combustion
Still gas										I don't think this will apply to Hamilton, assume negligible unless advised otherwise.
Petroleum coke	kg/tonne	2.50E-01	1.05E+01	1.17E+02	6.50E-01	4.00E+01	9.20E+00	2.40E+00	kg/tonne	SO2, NOX Emission factors are from EIA website for electricity emissions- http://www.eia.doe.gov/cneaf/electricity/epav2/html_tables/epav2ta3p1.html. Sulphur 6%, all other emisisons assumed same as coal
Coke and Coke Oven Gas	kg/tonne	2.50E-01	1.05E+01	1.17E+02	6.50E-01	4.00E+01	9.20E+00	2.40E+00	kg/tonne	Emissions conservatively assumed the same as petroleum coke/coal. Couldn't find any factors. Ch.12 of USEPA refers to Coke production from coal, emissions in terms of tonnes of coal input.
Heavy Fuel Oil	kg/L	6.00E-04	6.60E-03	4.71E-02	1.36E-04	1.20E-03	1.03E-03	6.72E-04	kg/L	Emission factors are from AP-42 (Chapter 1.3,). See US EPA AP-42 for EF rating definitions. Assumes Boiler is < 100 Million Btu/hr, assumes 2.5% sulphur, VOC=TNMOC, 86% of PM=PM10, 56%=PM2.5
Kerosene	kg/L	6.00E-04	2.40E-03	8.52E-03	2.40E-05	2.40E-04	1.20E-04	3.00E-05	kg/L	Emissions conservatively assumed the same as No. 2 (light) oil
No. 2 Fuel oil	kg/L	6.00E-04	2.40E-03	8.52E-03	2.40E-05	2.40E-04	1.20E-04	3.00E-05	kg/L	Emission factors are from AP-42 (Chapter 1.3). See US EPA AP-42 for EF rating definitions. Assumes Boiler is > 100 Million Btu/hr, sulphur % in fuel is 0.5%

Heat content of Coke (27 GJ/tonne) as published by IOR Energy available at http://www.ior.com.au/ecflist.html.
All emission factors assume no emission controls
No pulp and paper in the area

GHG Emission Factors-Industrial

Fuel	Emission Factor	Units	Source
LPG	0.0013189	t CO2e/L	Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and GHG emissions provided as Carbon Dioxide Equivalents (CO2e) which includes emission contributions from CO2, N2O and CH4.
Gas Plant NGL	1.8981E-06	t CO2e/L	Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and GHG emissions provided as Carbon Dioxide Equivalents (CO2e) which includes emission contributions from CO2, N2O and CH4.
Coal	2.13725	t CO2e/t Coal	Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and GHG emissions provided as Carbon Dioxide Equivalents (CO2e) which includes emission contributions from CO2, N2O and CH4. As calculated using energy content and t CO2e/TJ for coal used in Ontario's power generation sector.
Wood Waste and Pulping Liquor	0.028304	t CO2e/t Wood	2006 IPCC Guidelines for Greenhouse Gas Inventories. The IPCC values were orginally on an NCV (LHV) basis and were converted to a GCV (HHV) basis using rule of thumb. NCV=GCV x 0.95 for solids/liquid fuels and NCV=GCV x 0.90 for gaseous fuels
Still gas	0.00218189	t CO2e/L	Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and GHG emissions provided as Carbon Dioxide Equivalents (CO2e) which includes emission contributions from CO2, N2O and CH4.
Petroleum coke	0.004117641	t CO2e/L	Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and GHG emissions provided as Carbon Dioxide Equivalents (CO2e) which includes emission contributions from CO2, N2O and CH4.
Coke and Coke Oven Gas	0.00156612	t CO2e/L	Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and GHG emissions provided as Carbon Dioxide Equivalents (CO2e) which includes emission contributions from CO2, N2O and CH4.
Heavy Fuel Oil	0.003111	t CO2e/L	Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and GHG emissions provided as Carbon Dioxide Equivalents (CO2e) which includes emission contributions from CO2, N2O and CH4.
Kerosene	0.00255395	t CO2e/L	Energy content provided by Environment Canada in Turning the Corner Canada's Energy and GHG Emissions Projections (March 2008) in the Conversions and GHG emissions provided as Carbon Dioxide Equivalents (CO2e) which includes emission contributions from CO2, N2O and CH4.

Industrial Sector Energy Share Percentages

Industrial Sector – Aggregated Industries (ONTARIO)		
Table 1: Secondary Energy Use and GHG Emissions by Energy Source		
Energy Source	2001	2006
	% Share	% Share
Electricity	20.1	16.8
Natural Gas	34.2	36.5
Diesel Fuel Oil, Light Fuel Oil and Kerosene	3.3	3.8
Heavy Fuel Oil	4.1	3.4
Still Gas and Petroleum Coke	10.4	10.9
LPG and Gas Plant NGL	0.4	1
Coal	2.2	1.5
Coke and Coke Oven Gas	14.8	14.6
Wood Waste and Pulping Liquor	8.8	9.6
Other	1.7	1.7
TOTAL	100	99.8
Natrual Resources Canada, Office of Energy Efficiency: Comprehensive Energy Use Database (The Comprehensive Energy Use Database provides an overview of sectoral		

Wood Burning Appliance Emission Factors

Table 4: Wood Burning Appliance Emission Factors (Kg/tonne)							
Appliance	**CO**	**NOx**	**SOx**	**VOC**	**Part**	**PM10**	**PM2.5**
Fireplace; Advanced Technology	70.4	1.4	0.2	7	5.1	4.8	4.8
Fireplace; Conventional Without Glass Doors	77.7	1.4	0.2	6.5	19.3	18.5	18.4
Fireplace; Conventional With Glass Doors	98.6	1.4	0.2	21	13.5	13	12.9
Central Furnace/Boiler (inside)	68.5	1.4	0.2	21.3	14.1	13.3	13.3
Central Furnace/Boiler	68.5	1.4	0.2	21.3	14.1	13.3	13.3
Central Furnace/Boiler (outside)	68.5	1.4	0.2	21.3	14.1	13.3	13.3
Fireplace Insert; Advanced Technology	70.4	1.4	0.2	7	5.1	4.8	4.8
Fireplace Insert; Catalytic	70.4	1.4	0.2	7	5.1	4.8	4.8
Fireplace Insert; Conventional	115.4	1.4	0.2	21.3	14.4	13.6	13.6
Woodstove; Advanced Technology	70.4	1.4	0.2	7	5.1	4.8	4.8
Woodstove; Catalytic	70.4	1.4	0.2	7	5.1	4.8	4.8
Woodstove; Conventional	100	1.4	0.2	35.5	24.6	23.2	23.2
Woodstove; Conventional, Not Air-Tight	100	1.4	0.2	35.5	24.6	23.2	23.2
Woodstove; Conventional, Air-Tight	115.4	1.4	0.2	21.3	14.4	13.6	13.6
Other Equipment	115.4	1.4	0.2	21.3	14.4	13.6	13.6
AVERAGE EMISSION FACTORS / TONNE	**85**	**1.4**	**0.2**	**17**	**13**	**12**	**12**
April 1, 2004, Revised May 17, 2005 (British Columbia Ministry of Water, Land and Air Protection (WLAP) Service Plan							
Root Source: Residential Wood Combustion, Overview of Appliance Categories, John Gulland, June 2003, Updated September, 2003.							

Wood Waste Emission Factor

Fuel Type	kg CO_2e/GJ
Wood, wood waste	100.44
Default emissions factors are from IPCC 1999, Volume 2, Section 1	

Energy Content of Wood

Energy Content of Wood			
Assumptions		**Average Energy Content (GJ / tonne)**	**Tonnes of Wood (Residential Sector, Hamilton)**
1.0 metric tonne wood = 1.4 cubic meters (solid wood, not stacked) Energy content of wood fuel (HHV, bone dry) = 18-22 GJ/t (7,600-9,600 Btu/lb) Energy content of wood fuel (air dry, 20% moisture) = about 15 GJ/t (6,400 Btu/lb)		18.5	
U.S. Department of Energy's (DOE's) Bioenergy Feedstock Development Program (BFDP) at Oak Ridge National Laboratory: http://bioenergy.ornl.gov/papers/misc/energy_conv.html			

Agriculture Emissions - Livestock

Type of Livestock	Inventory on Census	Enteric Fermentation				Manure Management				Total Emissions
		Emission Factor[1]	Emission Factor Source[1]	Emissions		Emission Factor	Emission Factor Source[1]	Emissions		
		kg CH4/head per year		kg CH_4 per year	tonnes CO_2e per year	kg CH4/head per year		kg CH_4 per year	tonnes CO_2e per year	tonnes CO_2e per year
Cattle	12,167			**970,802**	**20,387**			**111,249**	**2,336**	**22,723**
Calves under 1 year	3,212	48.3	Calves	155,140	3,258	2.1	Calves	6,745	142	3,400
Steers 1 year and over	1,004	60.4	Steers	60,642	1,273	1.9	Steers	1,908	40	1,314
Heifers for slaughter or feeding	918	67	Heifers for Slaughter	61,506	1,292	2.1	eifers for Slaughte	1,928	40	1,332
Heifers for beef herd replacement	514	75.3	Beef Heifers	38,704	813	2.7	Beef Heifers	1,388	29	842
Heifers for dairy herd replacement	1,390	73	Dairy Heifers	101,470	2,131	15.4	Dairy Heifers	21,406	450	2,580
Beef cows	2,601	84.8	Beef Cows	220,565	4,632	3.3	Beef Cows	8,583	180	4,812
Dairy cows	2,315	135.2	Dairy Cows	312,988	6,573	29.6	Dairy Cows	68,524	1,439	8,012
Bulls 1 year and over	213	92.9	Bulls	19,788	416	3.6	Bulls	767	16	432
Pigs	17,485			**26,402**	**554**			**108,261**	**2,273**	**2,828**
Boars	46	1.51	Boars	69	1.5	6.4	Boars	294	6.2	7.6
Sows and gilts for breeding	1,077	1.51	Sows	1,626	34.2	6.3	Sows	6,785	142.5	177
Nursing and weaner pigs	4,603	1.51	Pigs < 20 kg	6,951	146.0	1.8	Pigs < 20 kg	8,285	174.0	320
Grower and finishing pigs	11,759	1.51	Pigs > 60 kg	17,756	372.9	7.9	Pigs > 60 kg	92,896	1,950.8	2,324
Sheep and Lambs	3,159			**255879**	**5,373**			**817**	**17**	**5,391**
Rams	96	81	Sheep	7,776	163	0.3	Sheep	29	1	164
Ewes	1,751	81	Sheep	141,831	2,978	0.3	Sheep	525	11	2,989
Lambs	1,312	81	Lambs	106,272	2,232	0.2	Lambs	262	6	2,237
Poultry	1,754,519			**0**	**0**			**48,552**	**1,020**	**1,020**
Hens and chickens	1,618,411	N/A[2]	Chickens	N/A	N/A	0.03	Chickens	48,552	1,020	1,020
Turkeys	131,455	N/A[2]	Turkeys	N/A	N/A	0.08	Turkeys	N/A	N/A	0
Other poultry	4,653	N/A[2]	Other poultry	N/A	N/A	N/A[2]	Other poultry	N/A	N/A	0
Other Livestock	3,362			**472,056**	**9,913**			**5,738**	**120**	**10,034**
Horses and ponies	2,397	181	Horses	433,857	9,111	2.3	Horses	5,513	116	9,227
Goats	749	51	Goats	38,199	802	0.3	Goats	225	5	807
Wild boars	0	1.51	Boars	0	0	6.4	Boars	0	0	0
Mink	0	N/A[2]	N/A[2]	N/A	N/A	N/A[2]	N/A[2]	N/A	N/A	0
Fox	0	N/A[2]	N/A[2]	N/A	N/A	N/A[2]	N/A[2]	N/A	N/A	0
Bison (buffalo)	0	551	Buffalo	0	0	2	Buffalo	0	0	0
Llamas and alpacas	77	N/A[2]	N/A[2]	N/A	N/A	N/A[2]	N/A[2]	N/A	N/A	0
Deer (excluding wild deer)	139	N/A[2]	N/A[2]	N/A	N/A	N/A[2]	N/A[2]	N/A	N/A	0
Elk	0	N/A[2]	N/A[2]	N/A	N/A	N/A[2]	N/A[2]	N/A	N/A	0
Total					**36,228**				**5,767**	**41,995**

National Inventory Report: Provincial and Territorial CH_4 Generation Potential (L_o) Values from Waste Decomposition

Table A3-42: Provincial and Territorial CH_4 Generation Potential (L_o) Values

Province / Territory	2002 Organic Waste Diversion (%) [a]	1941 to 1975		1976 to 1989		1990 to Present				IPCC Third Assessment Report
		DOC	L_o (kg CH_4 / t waste)	DOC	L_o (kg CH_4 / t waste)	DOC	L_o (kg CH_4 / t waste)	L_o (kg CO_2e / t waste)	L_o (t CO_2e / t waste)	GWP of Methane
British Columbia	23.3	0.28	111.86	0.17	69.89	0.16	63.71	1337.91	1.33791	
Alberta	16.7	0.39	157.63	0.26	104.46	0.18	71.87	1509.27	1.50927	
Saskatchewan	4.3	0.36	143.92	0.22	86.39	0.22	86.75	1821.75	1.82175	
Manitoba	4.9	0.33	131.37	0.19	76.82	0.19	76.59	1608.39	1.60839	
Ontario	16.4	0.36	143.74	0.21	82.75	0.21	83	1743	1.743	
Quebec	13.7	0.36	144.45	0.21	82.52	0.2	81.23	1705.83	1.70583	21
New Brunswick	19.8	0.23	91.91	0.16	65.91	0.16	63.22	1327.62	1.32762	
Nova Scotia	29.7	0.25	100.89	0.16	62.35	0.16	64.1	1346.1	1.3461	
Prince Edward Island	NA	0.27	108.74	0.17	67.19	0.16	64.63	1357.23	1.35723	
Newfoundland	NA	0.28	112.62	0.18	73.28	0.18	73.35	1540.35	1.54035	
Territories (YT, NT & NU)	NA	0.22	87.59	0.15	58.54	0.16	65.13	1367.73	1.36773	

Community Statistics

Mode of Transportation to Work in Hamilton and Ontario

Employed labour force by mode of transportation to work, by province and territory (2006 Census)			
(Canada, Nova Scotia)			
2006			
	Hamilton	Ontario	% of total
	number		
Total - modes of transportation	5,690,960	231,850	100%
Car, truck or van, as driver	4,038,035	172,520	74%
Car, truck or van, as passenger	470,410	20,975	9%
Public transit	736,060	21,665	9%
Walked or bicycled	389,105	14,700	6%
All Other Modes (Motorcycle, Taxi Cab, Other Method)	57,350	1,985	1%
Source: Statistics Canada, 2006 Census of Population,			
591/details/Page.cfm?Lang=E&Geo1=CSD&Code1=3525005&Geo2=PR&Code2=35&Data=Count&SearchText=Hamilton&SearchType=Begins&SearchPR=01&B1=All&Custom=			

Sales of Fuel Used for Road Motor Vehicles in Canada and Ontario

Sales of fuel used for road motor vehicles, by province and territory					
(Ontario)					
	2003	2004	2005	2006	2007
	thousand litres				
Canada					
Net sales of gasoline	38,421,608	38,911,752	38,484,324	38,653,955	39,640,225
Gross sales of gasoline	39,797,315	40,146,013	39,845,934	39,918,335	40,854,912
Net sales of diesel oil	14,720,634	15,671,144	16,216,420	16,611,819	17,196,304
Ontario					
Net sales of gasoline	15,381,530	15,505,570	15,338,069	15,268,667	15,707,150
Gross sales of gasoline	15,549,036	15,693,065	15,576,477	15,507,629	15,846,885
Net sales of diesel oil	5,029,839	5,303,501	5,430,385	5,384,342	5,443,318
GASOLINE PERCENTAGE OF TOTAL LITRES OF FUEL PURCHASED	75%	75%	74%	74%	74%
DIESEL PERCENTAGE OF TOTAL LITRES OF FUEL PURCHASED	25%	25%	26%	26%	26%
Notes:					
- Sales on which tax was paid at road-use rates.					
- Gross sales represents total sales of all road grades of gasoline for all uses, including off-road activities such as farming, forestry, construction or mining.					
- Net sales refer to the sale of gasoline, diesel, and liquefied petroleum gas on which taxes were remitted at road-use rates. These net figures represent, with minor exceptions, the amount of taxable fuel actually consumed on public roads in Canada.					
Source: Statistics Canada, CANSIM, table (for fee) 405-0002.					
Last modified: 2008-07-30.					

Motor Vehicle Registrations in Ontario and Representative Fuel Efficiency

Motor vehicle registrations, by province and territory[b]		
(Canada, Ontario)		
Category	2007	
	Canada	Ontario
	Number of Registrations	
Total vehicle registrations	27,577,524	9,990,267
Total road motor vehicle registrations	20,593,251	7,435,973
Vehicles weighing less than 4 500 kilograms[2]	19,198,960	7,038,695
Vehicles weighing 4 500 kilograms to 14 999 kilograms[2]	461,144	97,823
Vehicles weighing 15 000 kilograms or more[2]	328,128	118,556
Buses[3]	82,583	27,457
Motorcycles and mopeds[4]	522,433	153,441
Trailers5	5,231,114	1,992,156
Off-road, construction, farm vehicles[2]	1,753,158	562,138
Source: Statistics Canada, CANSIM, table (for fee) 405-0004. Last Modified: 2008-02-27.		

Commuting Distance of Workers in Hamilton

Table 10: Proportion of the median commuting distance and commuting distance of workers, census metropolitan areas, 2001 and 2006

Census metropolitan areas	2001					2006				
	Median commuting distance	Commuting distance				Median commuting distance	Commuting distance			
		Less than 5 km	5 to 14 km	15 to 24 km	25 km and over		Less than 5 km	5 to 14 km	15 to 24 km	25 km and over
	kilometres	percentage				kilometres	percentage			
Total	7.3	35.8	40.6	13.7	9.9	7.5	35.3	40.4	13.9	10.4
Hamilton (ON)	8.2	33	35.9	12.4	18.8	8.3	32.8	34.9	12.9	19.4
Sources: Statistics Canada, censuses of population, 2001 and 2006. http://www12.statcan.ca/english/census06/analysis/pow/19_oshawa.cfm										

Population in Ontario

Subtopic	Census year				
	2004	2005	2006	2007	2008
	Population				
Total population count	12,390,600	12,528,500	12,665,300	12,793,600	12,929,000
http://www40.statcan.gc.ca/l01/cst01/demo02a-eng.htm					

Population in Hamilton

Subtopic	Census year		
	2006	2001	1996
	Population		
Total population count	692,911	662,401	624,360
http://www12.statcan.ca/english/census06/data/trends/Table_1.cfm?TID=0&T=CMA&PRCODE=35&GEOCODE=537&geosubCSD=Submit&GEOLVL=CMA			