REDUCING PROVINCIAL GHG EMISSIONS THROUGH REDUCTIONS IN ENERGY USE AND DEMAND: THE CASE OF THE RESTAURANT INDUSTRY IN TORONTO

By

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Abstract

In the absence of a national greenhouse gas reduction strategy, the provinces and territories of Canada have adopted legislated or policy-based reduction targets largely related to energy source, the adoption of carbon pricing models and by working with municipal governments. Municipalities have acknowledged their responsibility in emissions reduction by implementing a range of GHG reduction programs but they are limited by their area of influence and by financial constraints. The major focus of this thesis is a study to assess the contribution of the Toronto-based independent restaurant industry to municipal energy use based on an original survey; it was found that the restaurant industry contributes approximately 2.4% of Toronto's GHG emissions and 0.3% nationally. While GHG emissions related to electricity use has decreased as greater energy efficiency is achieved, similar trends are not seen in GHG emissions related to natural gas use demonstrating the need for further research in this area.

IMMENSE GRATITUDE

Humility and gratitude are often praised but seldom practiced desirable personality traits as no one does it all themselves, no matter what story you weave around your success. This five-year adventure into a part-time master's thesis has beaten me down, built me up and taught me great humility.

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DEDICATION

To my loving grandmother

Anita Coceancic (née Lavoie)
August 11, 1940 – July 22, 2013

Tu m'as donné ton amour inconditionnel et
je ne peux qu'espérer que je t'ai donné la même.
De tout mon cœur, Je t’aime.

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List of Acronyms

CO_2	Carbon Dioxide
CO_2E	Carbon Dioxide Equivalents
COP	Conference of the Parties
GHG	Greenhouse Gas
GWP	Greenhouse Gas Warming Potential
Kg	Kilograms
kWh	Kilowatt-hour
M^3	Cubic metres
NEG-ECP	New England Governors and Eastern Canadian Premiers
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change
UNEP	United Nations Environment Programme

1. Introduction

1.1 Overview

Day in and day out, office towers and commercial complexes energetically hum with activity as office workers and shoppers move continuously through the well lit and climate controlled corridors, piling into escalators and elevators, streetcars, buses, taxis and subway lines. As the day becomes night, the office towers continue to illuminate the cityscape as the City's more than 160,000 streetlights click on to keep the streets bright enough to guide the City's Great Daily Exchange (Toronto Hydro, 2015). Twice a day, tens of thousands of cars and trucks drive bumper-to-bumper along the Gardiner Expressway, the Don Valley Parkway and the 400 series highways between Toronto proper and its neighbouring cities, each trip lasting an average of 32.8 minutes barring accidents, construction or weather events.

Once home, nightlife sparks up as friends and loved ones meet up at some of Toronto's equally well lit, climate controlled 16,442 licensed restaurants and cafés (Toronto Public Health, 2014). Parents busily drive their children to after school practices and Maple Leafs and Blue Jay fans fill the bleachers of the Rogers' and Air Canada Centres. Theatre and concert goers fill multi-storied parkades they begin lining up at the doors of the Royal Alexandria, Roy Thompson Hall, Massey Hall, the Winter Garden theatres or one of the many other venues the city has to offer. All of this activity requires energy and our current energy systems contribute greenhouse gases to the atmosphere.

Since the 1950s, climate scientists have observed the atmosphere and oceans warming, ocean acidification (as the oceans attempt to absorb the greater quantities of carbon dioxide produced), sea level rise, and the amount of snow and ice diminishing (IPCC, 2014). Within Canada and across the globe, the largest contributor to Greenhouse Gas (GHG) emissions is energy generation from fossil fuel combustion. Climate Change, as exacerbated by greenhouse gas emissions, is one of the greatest threats humanity has faced to date. As the crisis of climate change continues to evolve, it is important to reduce greenhouse gases in the areas and industries in which they are produced.

While the national picture shows that electricity generation is the largest producer of greenhouse gas emissions, this situation varies by province. In the absence of a national GHG reduction policy, work is being done sub-nationally across every jurisdiction with some provinces becoming leaders, notably British Columbia, Québec and Ontario. In terms of carbon policy, British Columbia has implemented a carbon tax and dividend structure and Québec has joined the Western Climate Initiative's cap-and-trade program. Ontario is currently in a consultation and policy analysis phase to determine what next steps to take in climate action (Government of Ontario, 2015).

Ontario has already made a great step forward in carbon reduction by closing down all of their coal-fired power plants; the energy grid is now comprised of just hydroelectric, nuclear, biomass, natural gas and renewable energy under the province's Feed-in-Tariff program. Greenhouse gas emissions associated with electricity generation now comprises just 9% of Ontario's overall emissions (Government of Ontario, 2015). This is fourth, behind transportation (34%), industrial (30%) and buildings (17%) in Ontario's GHG profile. Continued dependency on natural gas and non-coal fossil fuels still generates GHG emissions associated with Ontario's electrical grid.

Fifty percent or more of the GHG generation in Canada happens within municipalities, related to energy use, transportation, industrial processes, a concentration of buildings and waste generation. The City of Toronto has reduced its GHG emissions by 15% of 1990 levels through retrofitting corporate and residential buildings, energy efficiency measures, the downtown deep water cooling system and other measures (City of Toronto, 2014); however, there remain areas of energy reduction efficiencies that would further contribute to Toronto and Canada's goals but also improve the ways in which the city functions. Furthermore, Toronto has acted as a template and role model for other cities.

Even though energy generation contributes to just 9% of Ontario's GHG emissions, this still equates to 14 megatonnes of GHG annually and can be further reduced with additional mitigation measures (Government of Ontario, 2015). However, energy generation is just a part of the municipal energy picture; natural gas has been and continues to be the largest contributor of GHG within Toronto.

This thesis begins by looking at the GHG reduction measures within Canada nationally and sub-nationally and what strategies the City of Toronto already employs to reduce its emissions. It then looks at how these municipal GHG reduction strategies translate to restaurants as a specific industry. Finally, it looks at additional GHG reduction measures used by other municipalities domestically and internationally.

A literature review was completed to determine what research was conducted or information was available on this subject. Additionally, communication with government officials was completed to assess how the provinces and territories of Canada are attempting to reduce the GHG emissions within their respective provinces and within the City of Toronto. A greenhouse gas assessment was completed for the energy use aspects of Toronto-based restaurants to better understand how this aspect of the commercial sector contributes to the overall GHG profile of Ontario.

1.2 Problem statement

Climate Change is the greatest threat humanity has faced to date; however, Canada's national government has not yet developed a national greenhouse gas reduction plan. In its absence, provinces and territories and many of their respective municipalities have stepped up to develop their own reduction strategies but it is not immediately clear what level of coordination exists between all three levels of government.

Furthermore, as the challenge of climate change continues to evolve, it is this the opinion of this thesis that every industrial, commercial and institutional operation should be analyzed to understand how they are contributing to greenhouse gas (GHG) production in order to identify areas where GHG can be reduced and to develop tools to aid in the reduction of GHG emissions.

Internationally, governments track and report on their GHG emissions by sectors as prescribed by the Intergovernmental Panel on Climate Change, but the data are for overarching sectors and not broken down by industry. This method leaves data gaps when attempting to develop programs or policy for GHG reduction by industry. While electricity comprises just 9% of the province's GHG output, electricity is not the sole GHG contributor in the restaurant industry; restaurant emissions are also a function of the energy sources and products they use, and waste they generate. This gap in analysis is one area that this thesis will attempt to fill.

1.3 Purpose and research objectives

The purpose of this research is to understand what greenhouse gas reduction strategies exist in Canada and how the Toronto-based restaurant industry contributes to Ontario's overall greenhouse gas emissions.

The objectives of this thesis are to:

1) Understand how provincial and territorial governments are addressing greenhouse gas reduction by compiling a comprehensive list of legislation and policies and to understand to what extent provinces and territories are coordinating sub-nationally.

2) Understand what strategies Canadian municipalities are currently employing to address GHG reduction and what barriers exist to the City of Toronto to implement novel strategies or expand existing strategies.

3) Using sub-national GHG reduction measures as the frame, determine greenhouse gas emissions attributed to the Toronto-based restaurant industry as a percentage of Toronto and Canada's overall emissions and in what areas improvement is needed.

1.4 Scope

The scope of this thesis is restricted to published greenhouse gas reduction measures, in the form of legislation, policies, programs and plans as well as information provided from interviews with public officials in the case of the City of Toronto and provinces and territories.

Since there is currently no national strategy to GHG reductions, many of the provinces and territories have developed their own legislation and policies to achieve GHG reduction. A similar approach has been adopted by mostly larger municipalities, including the City of Toronto, in the form of corporate policy around land use and zoning, building permits and development approvals, parking, roads and public transit, parks and recreation. These location actions can also include reductions through waste management and energy use.

The restaurant industry was chosen because there is very little information as to the GHG emissions generated within this industry. They are also a ubiquitous aspect of any municipality and tend to increase in number as cities grow. Restaurants also use provincial energy systems but may represent a large component of Toronto's energy consumption.

1.5 Organization of thesis

This thesis is organized into five chapters plus the references and four appendices. Chapter One introduces the thesis topic and establishes the problem and reason for the research. Chapter Two contains a literature review of existing research and published materials required for this study as well as understanding concepts presented in the thesis. Chapter Three contains an explanation of the methodology of the research project and what limitations were encountered. Chapter Four presents the results of the research and discussion of results. Chapter Five presents the conclusions to this research and future research areas. Following this, there is a reference section that presents literature and research used in the writing of the thesis along with five appendices contain additional source information that was summarized within the thesis.

2. Literature Review

The literature review presents background information required to frame the research, understand concepts and purpose of the research. Specifically, this literature review begins by discussing greenhouse gases, energy, energy efficiency and reduction measures. It then proceeds by discussing greenhouse gas policy and strategy in a global, national and sub-national context, sub-national regulatory and policy framework for greenhouse gas reduction, and the Toronto restaurant industry. The science of climate change includes several components; the effect of GHGs in the stratosphere, reflectivity from the Earth's surface (the Albedo effect), ozone depletion, and deforestation. However, the most important factor and the subject of this thesis are GHG emissions.

2.1 Climate Change

The last three decades have been successively warmer than any preceding decade with the warmest period being between 1983 and 2012. Globally, land and ocean temperature has increased between 0.65 ^{o}C and 1.06^{o}C from 1880 to 2012. The warming of the atmosphere causes changes in the weather systems causing more extreme weather events, like droughts leading to crop failure and storms leading to flooding. It has also seen the diminishing of the Greenland and Antarctic ice sheets from 1992 to 2011, and from 1979 to 2012 the annual mean Arctic sea-ice has decreased at a rate of 3.5% to 4.1% per decade. This melting snow and ice has lead to sea level rise of between 0.17m to 0.21m from 1901 to 2010 which has caused mass flooding and evacuation of low-lying nations, such as India (IPCC, 2014).

Climate change means a change or destabilization of the Earth’s climate system in that some areas of the planet will become warmer and some may become cooler with all areas having the potential to experience severe weather events. It is the added energy, from greenhouse gases, in the atmosphere that drives climate change. The greenhouse effect is a natural occurrence that regulates the temperature of the planet (Bergon et al., 2005). The sun radiates energy at short wavelengths as visible or near visible (ultraviolet) part of the light spectrum with approximately one-third of the energy is reflected back into space while the remaining two-thirds are absorbed by the Earth's surface and atmosphere. The Earth then emits this energy back into space as longer wavelength infrared radiation. Much of this thermal radiation emitted by the land and ocean is absorbed by greenhouse gases and water vapour in the atmosphere and reradiated back to Earth causing a greenhouse effect (IPCC, 2010). It is anthropogenic greenhouse gases that are subject of this thesis.

2.1.1 Greenhouse Gases and Global Warming Potential

While greenhouse gases do exist naturally, like all ecosystems, they exist in cycles that tend to stay in equilibrium. This is true for water and nutrient cycling and it is true for greenhouse gases. Carbon, in the form of carbon dioxide, has been removed from the carbon cycle long ago, sequestered beneath layers of earth as hydrocarbon deposits (oil, gas and tar sands) leaving the planetary ecosystem time to establish a new equilibrium. However, the constant withdrawal and subsequent combustion of hydrocarbons since the beginning of the industrial age produces carbon dioxide, which is released to the atmosphere (Bergon et al., 2005).

The key indicator as to how much a specific GHG contributes to global warming is its radiative force (watts per square metre) and different GHGs have different radiative forces. GHGs comprise a range of natural and manmade gases with carbon dioxide (CO_2) contributing approximately sixty percent of the total radiative force globally, methane (CH_4) around twenty percent, nitrous oxide (NO_2) around six percent and the halocarbon family around fourteen percent (Houghton el al., 2001).

In order to relate the potency of each GHG, climate scientists have calculated the Global Warming Potential (GWP) of each gas of concern as a relative measure of how much heat a greenhouse gas traps in the atmosphere. In addition to radiative force, GWP for a given GHG is calculated using the atmospheric lifespan (the amount of time a given gas will remain in the atmosphere), and the spectral location of its absorbing wavelengths. Therefore, a GHG that has a high GWP would have a large infrared absorption and a long atmospheric lifespan (IPCC, 2013).

Table 2-1 Greenhouse Gases and Global Warming Potentials (GWP) IPCC (2006)

Gas	Chemical Formula	Global Warming Potential (100 years)
Carbon Dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Hydrofluorocarbons (HFCs)		
HFC-23	CHF_3	11,700
HFC-32	CH_2F_3	650
HFC-41	CH_3F	150
HFC-43-10mee	$C_5H_2F_{10}$	1,300
HFC-125	C_2HF_5	2,800
HFC-134	$C_2H_2F_4$ (CHF_2CHF_2)	1,000
HFC-134a	$C_2H_2F_4$ (CH_2FCF_3)	1,300
HFC-143	$C_2H_3F_3$ (CHF_2CH_2F)	300
HFC-143a	$C_2H_3F_3$ (CF_3CH_3)	3,800
HFC-152a	$C_2H_4F_2$ (CH_3CHF_2)	140
HFC-227ea	C_3HF_7	2,900
HFC-236fa	$C_3H_2F_6$	6,300
HFC-245ca	$C_3H_3F_5$	560
Hydrofluoroethers (HFEs)		
HFE-7100	$C_4F_9OCH_3$	500
HFE-7200	$C_4F_9OC_2H_5$	100
Perfluorocarbons (PFCs)		
Perfluoromethane (tetrafluoromethane)	CF_4	6,500
Perfluoroethane (hexafluoroethane)	C_2F_6	9,200
Perfluoropropane	C_3F_8	7,000
Perfluorobutane	C_4F_{10}	7,000
Perfluorocyclobutane	c-C_4F_8	8,700
Perfluoropentane	C_5F_{12}	7,500
Perfluorohaxane	C_6F_{14}	7,400
Sulfur hexafluoride	SF_6	23,900

The GWP of a given GHG is calculated over a specific time interval, for this the IPCC commonly uses 20, 100 or 500 year intervals. In the case of methane (CH4), although it has a 12.4 year atmospheric lifespan, it does have a continued feedback effect over a 20, 100 or 500 year time frame (IPCC, 2013). Table 2-1 shows the global warming potentials of greenhouse gases. Using the global warming effect of CO_2 as a baseline (or a value of 1), each greenhouse gas is then compared to CO_2 expressed as the number of times more potent than CO_2 it is over the gas' atmospheric lifespan (IPCC, 2006). The GWP potential of GHGs are then used to calculate carbon dioxide equivalents (CO_2e). CO_2e is then used by industry and nations when reporting their GHG output.

Methane is a combustible gas produced biologically through decomposition of organic matter, such as what is found in sewage, swamps, bogs and permafrost as well as part of the digestive process, most notably cows and other domestic livestock and agricultural processes, as well as other sources (Hamilton et al., 2003). One molecule of methane will stay in the atmosphere for approximately 12.4 years but will cause a feedback warming effect that is 86 times that of CO_2 over a 20-year time span or 21 times that of CO_2 over a 100 year period (IPCC, 2013). It is also the primary component of natural gas which becomes CO_2 once combusted. Furthermore, CH_4 breaks down to CO_2 in the atmosphere.

Nitrous oxide (N_2O) is a non-flammable gas. It is produced in laboratories but also biologically in agricultural soils via microbial processes and through vehicular internal combustion. It is estimated that agricultural soils produce 3.5 billion kilograms of nitrous oxide annually (IPCC, 2006). N_2O also has the ability to destroy ozone and can stay in the atmosphere between 114 and 121 years and have a heating effect of 268 and 298 times that of CO_2 over a 20- and 100-year horizon, respectively.

The most potent of all GHGs is sulphur hexafluoride (SF_6). It is a completely manmade, non-combustible gas that is used as an electrical insulator as well as in diagnostic medicine. It consists of one sulphur atom with six fluorine atoms. It has an estimated atmospheric lifespan of 3,200 years and a heating effect of 16,300 and 22,800 times that of CO_2 over a 20- and 100-year horizon (IPCC, 2006).

Hydrofluorocarbons consist of hydrogen, fluorine and carbon atoms and are completely manmade. They escape to the environment through the manufacturing, leakage and end-of-life disposal of refrigerators and air conditioners. There are two of specific concern: fluoroform and 1,1,1,2-tetrafluoroethane. Fluoroform (CHF_3) has a 270-year atmospheric lifespan and a global warming potential of 12,000- and 14,800-times that of CO_2 over a 20- and 100- year timeframe. Tetrafluoroethane ($C_2H_2F_4$) has an atmospheric lifespan of 14 years and a global warming potential of 3,830- and 1,430- times that of CO_2 over a 20- and 100- year timeframe (IPCC, 2006).

Perfluorocarbons are another completely manmade gaseous by-product of industrial processes. Similar to the hydrofluorocarbons except that they consist entirely of just carbon and fluorine atoms. In the example of carbon tetrafluoride (CF_4), it can persist in the atmosphere for up to 50,000 years and have a global warming potential of 4950- and 7350- times that of CO_2 over 20- and 100- year period (IPCC, 2006).

2.1.2 Carbon Sinks

Carbon sinks are an important part of the planetary carbon cycle. They work to sequester atmospheric carbon dioxide thus reducing the atmospheric concentration. The natural carbon sinks are the world's oceans and terrestrial plant life. The world's forests presently cover 31% of the land area on the planet and have been estimated to absorb between 2.5 petagrams[1] and 2.7 petagrams annually, but are being reduced at a rate between 119 km^2 to 150 km^2 annually by deforestation in turn (Canadell et al., 2007; Pan et al., 2011).

The oceans cover approximately 71% of the planet surface and are estimated to be absorbing one third of the world's carbon dioxide emissions, but cannot expected and should not continue to do so as there is only so much the ocean can absorb and because ocean acidification has increased by 30 percent since first measured 150 years ago (IPCC, 2014). Increased acidity of the world oceans will impact the coral reef systems and any organism that needs to form a skeleton (as bones and coral are made of calcium carbonate which can be dissolved by even mild

[1] 1 petagram equals 1 trillion kilograms or 1 billion metric tonnes.

acid). The warming of the ocean also causes anoxic environments where no life can live and can affect marine life who cannot tolerate warmer temperatures.

2.2 Energy Systems

In a municipal context, the primary sources of energy are the provincial electrical grid, which is used to power appliances, lighting, air-conditioning, etc., and natural gas, which is used in heating, cooking, hot water heating, and natural gas powered appliances. Other sources of energy include propane, and gasoline and diesel generators as well as photovoltaic and other renewable energy sources; however, these are infrequently used in a municipal setting.

Therefore, in the context of this thesis, the terms energy use and energy systems refer to energy received and spent through the electrical grid and natural gas use. Our current electrical system is extremely inefficient. It involves the extraction of fossil fuels from domestic and foreign sources and its shipment via ships, railway and pipelines to large storage facilities prior to being transported to power generating facilities located in fixed areas. From here, electricity generated is then distributed to individual buildings for use. This system does allow for flexibility of demand (Mathiesen et al., 2015).

GHG emissions are associated with the production of electricity, especially energy created using fossil fuels. However, end-use demand also dictates how much electricity must be generated and therefore improvements in energy efficiency decreases energy demand, which decreases GHG production in turn. To this end, when looking at reduction measures meant to address GHG associated with energy, it is necessary to look at both production and use separately.

For the purpose of this thesis, the base units for electricity will be kilowatt-hours (kWh), cubic metres (M^3) for natural gas and kilograms (kg) for greenhouse gas. The GHG emissions associated with both energy sources can be calculated by multiplying the quantity of kWh of electricity or m3 of natural gas used by the Ontario provincial coefficients of 1 kWh of electricity produces 0.105 kg of GHG and 1 m^3 of natural gas generates 1.891 kg GHG (Toronto, 2012). These values will be later referred to as the provincial GHG coefficients.

2.2.1 Electricity Production

Energy source efficiency is equal to the useful energy output over the energy input and the efficiency changes dependent on the energy course and method of energy extraction (Eurelectric, 2003). Electricity has been traditionally generated using fossil fuel energy sources, such as coal. In a traditional coal-fired power plant, coal must be mined, purified and transported to storage areas awaiting shipment via railway, ship or other. Once delivered to the power plant it is then combusted to produce heat to boil water. The steam from the boiling water then turns turbines, generating electricity which is immediately transmitted via large, high voltage cables to substations that reduce the voltage to be transmitted to smaller wires. These smaller wires feed into transformers that lower the voltage again to make the electricity usable by our appliances and devices. This makes the entire energy generation process inefficient.

In addition to the energy requirements for the extraction and transport phase of fossil fuels, energy loss occurs when the coal is combusted to boil the water and more energy is lost as the steam turns the turbines. Once generated, the energy is then lost due to electrical resistance of the cables as it is transmitted to end-users (Mathiesen et al., 2015).

Different energy sources have different efficiencies and produce different quantities of GHG emissions (Table 2-2). For instance, the efficiency of coal-fired systems ranges between 39% and 47% efficient and releases between 0.960 to 1.050 KG GHG/kWh energy produced. This is similar for natural gas systems that are less than or equal to 39% efficient and release an average of 0.433 kg of GHG/kWh. On the highest end of the scale, large and small hydroelectric systems are the most efficient with both reaching up to 95% and 90% efficient, respectively. Biomass, biogas and nuclear facilities are between 30% and 40% efficient. Wind power is on the lower end of the scale with up to 35% efficiency while solar (photovoltaic) power is the least efficient at 15% (Eurelectric, 2003) but more recent data for new photosensitive substrates has been reported to exceed 20%. This is presented in Table 2-2.

From the perspective of lifecycle GHG emissions, from lowest to highest GHG emissions, the energy sources are as follows: wind turbine, large and small hydroelectric, biomass (dedicated, not coal co-generation), photovoltaic (solar), nuclear power, natural gas and coal-fired (Sovacool, 2008). Note that despite the values for the GHG emissions appearing low, they are expressed as kilogram of GHG per kilowatt-hour.

Table 2-2 Energy Source Efficiency and GHG production

Energy Source	Efficiency*	KG GHG / kWh!
Coal-fired power plant	39% to 47%	0.960 to 1.050
Natural gas turbine	≤ 39%	0.443
Biomass Dedicated	30% to 40%	0.014 to 0.030
Nuclear Power	33% to 36%	0.066
Photovoltaic (Utility Scale)	≤ 15%	0.032
Photovoltaic (Roof top Scale)	≤ 15%	0.032
Wind Turbine	≤35%	0.009 to 0.011
Large Hydroelectric	≤ 95%	0.010
Small Hydroelectric (≤5 MW)	≤ 90%	0.013

*Eurelectric (2003). ! Sovacool (2008).

Ontario's Energy Grid is presently comprised of nuclear (65.7%), hydroelectric (23.1%), natural gas (7.5%), wind (2.8%) and biofuel (0.9%) after completely phasing out coal-fired power plants in 2014 and lowering the province's GHG output (Ontario, 2015; Ontario Energy Report, 2015).

Natural gas is used directly by furnaces and natural gas powered appliances and indirectly as part of energy generation for the electrical grid. As discussed, natural gas is a hydrocarbon comprised primarily of methane gas (CH_4) that is colourless and ordourless. However, it can also contain other hydrocarbons, such as ethane, propane and butane, as well water, oil, sulphur, carbon dioxide, and nitrogen, among others. The removal of these impurities creates a "cleaner burn" during combustion; the motivation for a clean burn is to remove the potential for the formation of carbon monoxide, which can be lethal and cause irreparable damage.

When natural gas (methane) is combusted, it forms carbon dioxide (CO_2), heat and water:

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + Energy\ (Heat)$$

As discussed, the electrical grid is comprised of many energy sources, including natural gas. It is the composition of energy sources that dictate the quantity of GHG produced per kilowatt-hour. Thus, GHG per kilowatt-hour changes depending on the energy source composition. Natural gas has a 1:1 ratio where one molecule of methane produces one molecule of carbon dioxide (GHG).

From and end-use perspective, since the chemical reaction cannot be made more efficient, any energy efficiencies have been found for natural gas has been made by removing the impurities (Alberta, 2015). The next section will discuss energy efficiency in end-use.

2.2.2 Energy Efficiency

Since the majority of GHG emissions are produced by energy generation, which is produced to meet demand, the best way to reduce GHG emissions globally is to reduce energy demand. One possible way to do this is by improving energy efficiency, which then benefits all energy users.

The goal of Energy Efficiency, and as it is defined in this thesis, is to design a product or process in a way that uses less energy to do the same thing or more. The term Energy Efficiency is largely applied to end-user products such as appliances, lighting and other electrical devices, also natural gas-powered devices such as furnaces and hot water heaters and gasoline-powered vehicles.

Efficiency is largely achieved by innovation, with the most prominent example being the LED light bulb which saw the movement from an incandescent light bulb to a compact fluorescent light bulb (CFL) and finally to light emitting diodes (LED). Advances in efficiency has improved energy use by 24% since 1990 to the point that Canada has saved over 433 billion kilowatt-hours[2] and associated 81.1 megatonnes of greenhouse gas (NRCan, 2012).

The restaurant industry has directly benefitted from better building design, improvements to the heating and cooling systems and better energy use in industrial appliances. The history of energy efficiency goes back to the 1970s and is discussed in the next section.

2.2.3 History of Energy Efficiency

In 1956 M. King Hubbert (Barlett, 1999) predicted that several major oil reserves were in danger of being depleted and that, for a given oilfield, no matter how many new wells were put in place the overall output could not be sustained leading to a drop in production. In his paper, Hubbert predicted two scenarios: the first was that the maximum quantity of conventional U.S. crude oil was equal to 150 Giga-barrels and would peak in 1965 and the second was that the maximum amount of conventional U.S. crude oil was 200 Giga-barrels and this would peak in 1970. Both calculations were based on the current rate of consumption. This became known as the “Hubbert Peak” or “Hubbert Peak Theory” and was confirmed when U.S. oil production began to fall by the end of the 1960s.

In 1950, the United States provided 52% of the world’s oil supplies but by the end of the 1960 and early 1970s oil production peaked and extraction levels began falling in the United States, Germany and Venezuela causing a greater dependence on Middle Eastern oil. In response to the United States providing support to the Israeli military in October 1973, the Organization of Arab Petroleum Exporting Countries issued a trade embargo halting oil shipment to the United State and creating the “Oil Crisis” which lasted until March 1974 (USDE, 2002).

The effect was that the United States was exposed to vulnerability related to an unstable energy supply causing high rates of inflation increasing the cost of energy and other goods. During the same period, the environmental impacts of oil extraction, processing, transport and use were highlighted by environmental groups, which led to laws and the establishments of the Environmental Protection

[2] Reported as 1,560.4 petajoules.

Agency. The combination of events brought about the need for a national energy strategy, which included the need for energy efficiency standards (USDE, 2002).

Great efforts towards Energy Efficiency began in the 1970s and has come a long way, shaped largely by the United States in response to unstable oil supply. In 1975, the *Energy Policy and Conservation Act* was passed authorizing the Federal Energy Administration to develop energy efficiency standards for major household appliances along with vehicle fuel economy standards. In 1976 the *Energy Conservation and Production Act* provided incentives for conservation and renewable energy as well as retrofitting buildings. The Department of Energy was established in 1977 which consolidated the Federal Energy Administration, Energy Research and Development Administration and the Federal Power Commission into one department whose mandate was to develop a framework or a comprehensive national energy plan (USDE, 2002).

The following year, in 1978, Congress passed the *National Energy Act*, the *National Energy Conservation Policy Act*, the *Public Utility Regulatory Policies Act*, and the *Power Plant and Industrial Fuel Use Act*. The new regulatory powers focused on establishing energy efficiency standards on household appliances and products, primary fuel sources for power plant electricity generation, and the development of renewable energy facilities (USDE, 2002).

A second energy crisis happened in 1979 during the Iranian Revolution that saw just a 4% decrease in oil supply and sparked panic in the United States causing the price of oil to increase as it had in 1973-1974. It was further exacerbated in 1980 by the Iran-Iraq war that saw oil export from Iran nearly stop and production significantly fall in Iraq triggering a recession in the United States (USDE, 2002).

The next progress seen in energy efficiency was in 1988 when congress passed the *National Appliance Energy Conservation Act* that improved efficiency requirements for household appliances (NAPECA, 1988). The *Energy Policy Act* was passed in 1992 that contained significant energy efficiency provisions in the areas of building codes, equipment energy efficiency, Energy Star appliance labeling, as well as funding for efficiency research and development, and gas and electricity utility reforms (U.S. Energy Policy Act, 1992). The Energy Star program is now used in the

United States, Canada, Australia, Japan, New Zealand, Taiwan and the European Union.

The *Energy Policy Act* was revised in 2005 with further improved efficiency standards and tax incentives (U.S. Energy Policy Act, 2005). Two years later, in 2007, the *Energy Independence and Security Act* raised fuel economy standards and improved standards for appliance and lighting (EISA, 2007). Finally, in 2010, the *American Recovery and Reinvestment Act* was passed that allocated $25 billion dollars to energy efficiency programs, such as an appliance rebate program, state energy programs, weatherization assistance program, federal high performance green buildings, and tax incentives, and Smart Grid grants (ARRA, 2010).

The experience that Canada had with the 1970s energy crisis was different than what the U.S. experienced and may not have resulted in as many, if any, improvements to energy efficiency in Canada.

Within Canada, as of 1870, Canada's oil industry was extracting and refining oil for transport to Europe but because Canada's oil wells were small and shallow as compared to the U.S. wells, oil production began to decline around 1900 causing Canada to begin importing oil from the United States. This changed in 1947 when oil was discovered in Alberta and a 3,100 km pipeline was completed in 1956 to transport oil from Alberta to Sarnia, Ontario where all of the oil refineries were located. In 1953, the federal government approved the construction of a second 1,200 km pipeline from Edmonton, Alberta to Vancouver, British Columbia that eventually extended into the United States (Doern and Toner, 1984).

In 1959, the federal government created the National Energy Board (NEB) to regulate the pipelines and monitor and report on matters relating to energy, including the import and export of oil and utility rates. A national oil policy was introduced in 1961 whose purpose was to establish a domestic oil market within western Canada while eastern provinces still imported crude oil. The effect was that most of Ontario and all of western Canada relied on only domestic oil whose price was controlled by the NEB while Québec and the Maritime Provinces depended on imported oil and therefore world market prices (McDougall, 1982; Doern and Toner, 1984).

Canadian crude oil export to the United States increased in the fall of 1973 when the energy crisis began and threatened domestic supply. In response, the federal government took control of oil export and froze the domestic price of oil for 6 months while putting an export tax on oil to help subsidize eastern provinces still dependent on importing oil from overseas. This move angered western Canadians. In December 1973, the federal government announced the creation of Petro Canada as a crown corporation whose mandate was to boost oil and gas exploration in Canada's north, the tar sands and offshore as well as to secure reliable oil supplies for import. Petro Canada was formally established in 1975 and by the 1980s it was one of Canada's largest petroleum countries with gas stations all around the country. It ceased to be a crown corporation when Suncor Energy purchased it in 2009 (McDougall, 1982; Doern and Toner, 1984).

From 1973 to 1978, the price of domestic crude oil did increase but was still low compared to the rest of the world. However, by mid-1978 the price gap between domestic and international was nearly at parity. However, when the second energy crisis began in 1979, while world crude oil increased 150%, the Canadian domestic price remained low causing animosity between Alberta and the federal government. The greatest impact that the second energy crisis had on Canada was a large transfer of wealth between consumers and suppliers, inter-provincially and between Canada and the United States, who owned a significant portion of the Canadian oil and gas industry. It also made it difficult for the federal government to manage its finances in that it aggravated the rate of inflation and put stress on the equalization payment system (McDougall, 1982; Doern and Toner, 1984).

In 1980 the federal government introduced the National Energy Program whose goal it was to increase Canadian ownership of the oil and gas industry, achieve energy self-sufficiency, which included the government encouraging consumers to conserve energy and find other energy efficiencies. The National Energy Program also presented the controversial plan for the federal government to retain a greater portion of the profits, which created even more animosity between

Alberta and the federal government because it meant that Alberta would receive less revenue (McDougall, 1982; Doern and Toner, 1984).

Two years of negotiation between Alberta and the federal government were unsuccessful and Alberta responded by reducing their oil production and withholding approval of additional projects and they launched a legal challenge of the proposed export taxes on gasoline. The eventual agreement between Ottawa and Alberta involved substantial changes to the pricing and taxation provisions that brought domestic oil and gas prices in line with international prices. All remaining federal crown shares of oil and gas profit were eventually eliminated following the 1984 election of a new, conservative government (McDougall, 1982; Doern and Toner, 1984).

In the end, the United States was responsible in bringing in the concept of as well as implementation of energy efficiency. They have been the leader in moving the rest of the world forward with energy efficiency.

In 1992, Canada passed the *Energy Efficiency Act*, which established similar efficiency standards for household appliances, water heaters, heating and air-conditioning equipment, lighting products, electronics, vending machines, electric motors and other energy using devices (EEA, 1992). The act was last revised in 2009.

2.2.4 Smart Grid Technology

Current developments in energy efficiency have expanded beyond that of greater efficiencies in appliances. It has moved to making the entire energy grid smarter and more efficient.

Currently, power plants must always attempt to match the electricity supply instantly with demand, or brownouts will occur. Under this system, fossil fuel-based back-up power plants are required to be on standby so that they may provide additional power at a moment’s notice. However, these back-up systems are not cost effective and waste fossil fuels (Sioshansi, 2012). A smart grid has the potential to alleviate the need for standby generators.

Sioshansi (2012) defines a smart grid as an electrical grid that uses "any combination of enabling technologies, hardware, software or practices that collectively make the delivery infrastructure or the grid more reliable, more versatile, more secure, more accommodating, more resilient, and ultimately more useful to consumers." A smart grid is also one that could integrate a number of alternative energy sources, such as wind or photovoltaic power.

Another example of a smart grid could be in remote installations such as communities, mine sites, islands which are remote from the electrical grid can adopt a mix of wind or solar or both with battery storage along with diesel generation as a backup. A smart grid controller is used to balance the load demand with the inputs from the various sources.

With current smart grid technology, it is possible to reduce non-transportation energy use by greater than 20% by 2020 (Siohansi, 2012). A study conducted led by J.A. Latner with the American Council for an Energy Efficient Economy (2009) found that smart technology already saved 775 billion kWh in 2006 alone.

In Canada, the provinces of Ontario, Nova Scotia, Alberta and New Brunswick have begun developing a smart grid approach. In the case of Ontario, this has included a partial rollout of installing smart meters at residential, institutional, commercial and industrial properties. Nova Scotia set a target of 25% of its smart grid system to be powered by renewable energy sources by the end of 2015, and increasing this to 40% by 2020 (Hiscock and Beauvais, 2013).

Jiang and Fei (2015) suggest that a smart grid that is integrated with a distributed renewable source and combined with improved smart feedback technology would serve to achieve a high degree of energy efficiency. This would also translate to less GHG emissions related to fossil fuel dependent energy sources.

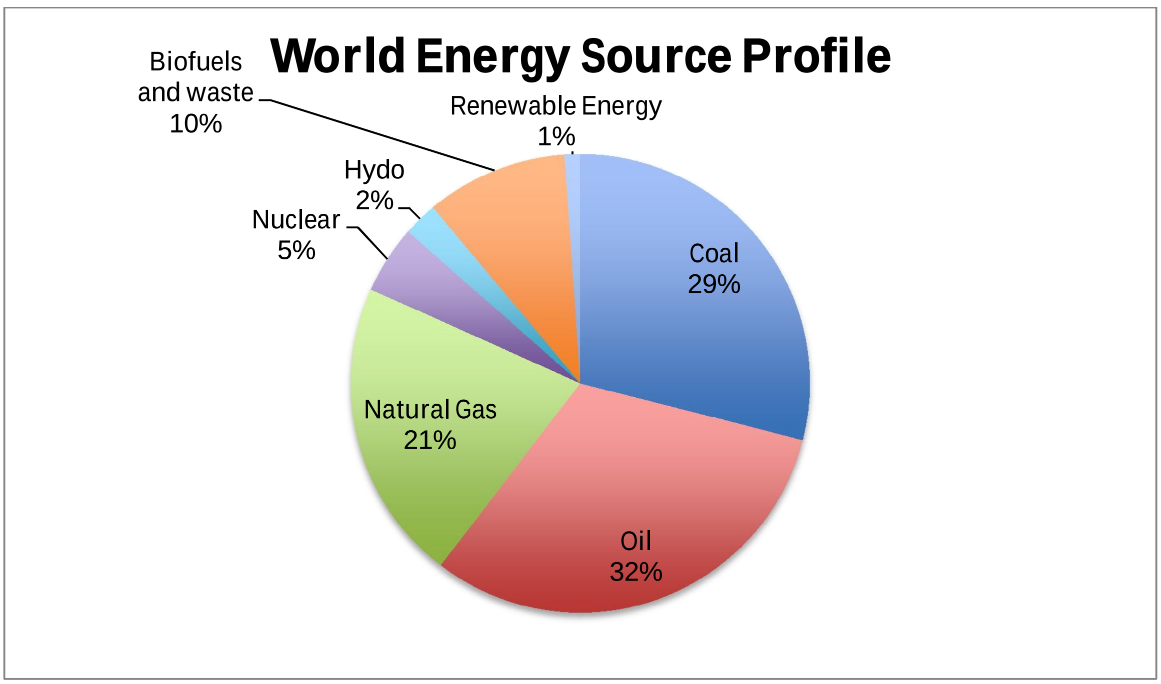
It is possible to install local renewable energy systems within a municipal context. One of the biggest hurdles to potential small-scale renewable energy projects is the upfront capital cost to the property owner. Renewable energy sources have existed for decades, but the limiting factor has always been lack of infrastructure, variability and intermittency (Mukhopadhyay and Chawla, 2014).

However, this technology offers promising ability to deal with the global energy situation.

2.3 The Global Energy Picture

Globally, energy use is one of the greatest contributors to greenhouse gas emissions. The problem is the not the quantity of energy used but the quality of the energy source used. As of 2011, the world energy source profile consisted of 29.0% coal, 31.4% oil, 21.3% natural gas, 4.8% nuclear, 2.4% hydroelectric, 10.0% biofuels and waste and 1.1% renewable energy (Figure 2-1). Aside from nuclear power losing one percentage to renewable energy, this has remained unchanged since 1993 (IEA, 2014).

Figure 2-1 International Energy Agency 2012 data (IEA, 2014)



Population growth and economic and social development are key drivers of energy demand. In their most recent study, the World Energy Council (2013) compiled information from 1993 and 2011 related to world population, total primary energy supply, electricity production, and GHG emissions. They also extrapolated this trend to the year 2020. This is summarized in Table 2-3.

As the world population increases, there is a need to meet the energy demand. Given the current quantity of GHG being produced and its current effect on our global climate system, it is also necessary to either curtail the world's dependency on fossil fuel energy sources or find some massive carbon sink technology or both.

The world's governments have recognized this, starting in the late 1980s with the establishment of the Intergovernmental Panel on Climate Change and formal international discussion began at the 1992 "Rio Earth Summit", which was the United Nations Conference on Environment and Development (UNCED) that introduced non-binding, voluntary carbon reduction measures as part of the Agenda 21.

Table 2-3 Energy Source, Production, GHG Emissions and Population (World Energy Council, 2013)

	1993	2011	2020
(A) Population (billions)	**5.5**	**7.0**	**8.1**
(B) Total Primary Energy Supply	**9,532**	**14,092**	**17,208**
Coal (Mt)	4,474	7,520	10,108
Oil (Mt)	3,179	3,973	4,594
Natural Gas (bcm)	2,176	3,518	4,049
Nuclear (TWh)	2,106	2,386	3,761
Hydroelectric (TWh)	2,286	2,767	3,826
Biomass (Mtoe[3])	1,036	1,277	1,323
Other renewables (TWh)	44	515	1,999
(C) Electricity Production (TWh)	**12,607**	**22,202**	**23,000**
(D) GHG Emissions (Gt)	**21**	**30**	**42**

In June 1992, the United Nations Conference on Environment and Development, also known as the "Earth Summit", was held in Rio de Janeiro and saw the participation of 172 governments, with 108 heads of state, and lead to the

[3] Mtoe stands for Megatons, oil equivalents.

establishment of the United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC is a non-legally-binding international treaty with the objective of stabilizing greenhouse gas concentrations that would lead to Global Warming. The first goal of the UNFCCC was to establish national inventories of greenhouse gas emissions and sinks which were used to set the 1990 baseline levels, a level against which all greenhouse gas emissions would be measured.

The Conference of the Parties (COP) met in 1995 with the intention to begin negotiation towards a legally-binding climate change mitigation framework and the goal to meet annually to assess progress made. The third COP met in Kyoto, Japan in 1997 with the intent of negotiating an international treaty with the goal of achieving the “stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system” (UNFCCC, 1997).

This treaty was the Kyoto Protocol and it came into force on February 16, 2005 to which most of the developed countries committed to the reduction greenhouse gases by 6 to 8 percent while other nations were allowed to increase their emissions by set amounts. The protocol also outlined the concept of GHG emissions trading (discussed below), the clean development mechanism and joint implementation. Canada initially ratified the agreement but the decision was reversed in 2006.

2.4 Carbon Pricing

Part of this thesis involves understanding what strategies Canada’s provinces and territories have undertaken to reduce their GHG emissions. Since four of the provinces have already adopted a carbon pricing model and since Ontario is currently considering the most appropriate carbon pricing approach for its needs, the concept of carbon pricing will be presented here.

Traditionally, impacts to the environment, including greenhouse gas emissions, have not been factored well into business models and are generally known as “externalities”. Rosen and Gayer (2008) define externalities as “an activity of one entity that affects the welfare of another entity in a way that is outside the market mechanism"; therefore, one way to remove the externality of carbon dioxide, as well as other greenhouse gases, is to bring the costs from outside of the market mechanism into the market mechanism.

One of the mechanisms proposed in the Kyoto Protocol was an international emissions trading system, which would be a market mechanism that would encourage efficiencies and potential for profit as a result. By putting a price on carbon, it would internalizes the cost, which is likely essential to achieve progress in the reduction of carbon dioxide and all greenhouse gases.

There are two standard methods of carbon pricing and these are carbon fees and emissions trading. To be clear, the industry terminology is carbon pricing, but it can apply to any of the greenhouse gases. Within Canada, these two methods, or a hybrid of the two, are employed by the provinces to encourage GHG reduction. These requirements are presently focused on larger GHG producing industries but could also be used to spur energy efficiency innovation in all industries.

2.4.1 Emissions Trading

Emissions trading is the technical term for what is commonly known as "Cap and Trade". It is called Cap and Trade because it places a maximum quantity of greenhouse gas emissions allotted to industry (the cap) and assigns carbon credits to represent this value. These carbon credits are what can be "traded" for a price. Individual businesses buy credits for the exact quantity of GHG emissions they wish to emit and will be fined if they exceed their emission cap. Should individual businesses achieve GHG reduction through changes or efficiencies in their operations, they may sell their surplus credits to another business that requires additional credits. The program can be applied as broadly across as many industries as needed or narrowed to target the largest emitters (Compston and Bailey, 2015).

In theory, government regulators can slowly reduce the number of credits issued annually which encourages companies to continue to find greater efficiencies. The benefit to businesses is that it works like the stock market with supply and demand setting the price and companies interacting with the system as they would the stock market.

Within North America, the Western Climate Initiative is the largest potential trading system. Since no national government in Canada or the United States has adopted any policy on greenhouse gas reduction, discussions about permit trading has been led sub-nationally at the state level in the United States and by the province of Québec in Canada, which is discussed later.

There has been criticism of this method. Of greatest note is in the European Union system that began by initially issuing too many credits which allowed for both greater amounts of GHG emissions than produced and it served to make the price of carbon credits extremely cheap, which did not create an incentive to reduce[4] or innovate operations. It also requires that industry report its own emissions (Plummer, 2013).

2.4.2 Carbon Fee

The second mechanism is placing a carbon fee on fossil fuel emission where emitters would have to pay per tonne of greenhouse gas emitted (e.g. $25/tonne of GHG). In some models, industry is allowed to have a threshold above which the fee system would apply (e.g. a company is allowed 1,000,000 tonnes annually, anything above that they must pay $25/tonne). In this sense, it perhaps behaves more as a hybrid of cap and trade and carbon fee.

Like the cap and trade program, a carbon fee can be applied to all fossil fuel emitters or applied narrowly to target the greatest emitters (Compston and Bailey, 2015). However, as above, the greatest effect in reduction and innovation would be better achieved through widespread application with higher fees leading to greater innovation.

While discussed later in more detail, the Province of British Columbia is best noted for implementing a Carbon Fee and Dividend program in 2008, which applies

[4] The article clarifies that carbon emissions have been lowered in Europe, but this is due to the global recession and not efficiencies in industry.

a fee to industrial operations for their emissions but passes this money to its consumers by way of savings on income and corporate tax rates .

Anecdotally, the major criticisms for this method are that the fee per tonne is too low and not encouraging reduction and innovation and that business sees this as another tax.

2.5 Greenhouse Gases in Canada

The United Nations Framework Convention on Climate Change (UNFCCC) was established in 1992 at the UNCED conference with the goal of working collaboratively, internationally to stabilize the atmospheric greenhouse gas levels and prevent "dangerous interference with the climate system" (Environment Canada, 2014). Following the withdrawal from the 1997 Kyoto Protocol, Canada did agree to the 2009 Copenhagen Accord which Canada agreed to voluntary GHG emissions reduction to 17% below the 2005 levels by 2020 (Environment Canada, 2014).

To achieve this, all signatory states develop, periodically update and publish the national GHG inventories by sources and including any offsets by carbon sinks. The details of this reporting is set out in the *UNFCCC Guidelines for the preparation of national communication by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines for national inventories* which serves as template for Canada's reporting (UNFCCC, 2000).

The Intergovernmental Panel on Climate Change is the world's leading authority on climate change. It was established in 1988 by the partnership of the United Nationals Environment Programme (UNEP) and the World Meteorological Organization (WMO) to provide a clear and scientifically defensible assessment of the state of the climate change and its potential impacts to environmental and socio-economic impacts (IPCCa, 2014).

The IPCC has established reporting guidelines for the purposes of standardized greenhouse gas monitoring under major categories of energy, industrial processes, solvent and other Product use, agriculture, waste and land-use. The last includes changes to land use and forestry activities that can be used as a carbon sink. From this, it produces periodic reports on the state of Earth's climate using the information collected.

2.5.1 National Inventory

In the global context, Canada's GHG emissions represent approximately 2% of the global GHG output but Canada is also one of the highest emitters globally on a per capita basis (Environment Canada, 2014). Canada is a federation comprised of ten provinces and three territories of sub-national jurisdiction. As such, federal and provincial or territorial laws and policies must be considered when looking at Canada's GHG reduction strategy as a whole. That said, Canada is represented federally on the world stage by the Department of Environment (also known as Environment Canada) and reductions achieved sub-nationally reflect on Canada as a whole regardless of a federal strategy.

As part of the treaty, Canada, as Environment Canada, is responsible for compiling data on Canada's greenhouse gas emissions and sinks and reporting to the UNFCCC. In addition to themselves, they work with various branches of the Canadian government, specifically Statistics Canada, Natural Resources Canada, Agriculture and Agri-Food Canada and Transport Canada, their provincial counterparts, consulting firms, industry and academia (Environment Canada, 2014).

In 2014, a comprehensive report titled the *National Inventory Report: Greenhouse Gas Sources and Sinks in Canada* (hereafter referred to as simply The National Inventory Report) was prepared with data spanning twenty-two years, from 1990 to 2012 (Environment Canada, 2014). Starting in 1990, when the total GHG emissions were 591 megatons to 2012 when it is 699 megatons. Table 2-4 is a reproduction of Canada's greenhouse gas emissions by IPCC sector form 1990 to 2012.

The report points out that while GHG emissions have increased by 18% since 1990, it has not matched the Country's Gross Domestic Product and in fact the emissions intensity[5], as GHG per GDP, has dropped by 29%; this is mostly in the manufacturing sector. This decrease is more likely due to the decline and

[5] Emission intensity is energy per unit of production.

outsourcing of the Canadian manufacturing sector and perhaps energy efficiency innovations than direct energy reduction policy (Environment Canada, 2014).

Table 2-4 Canada's GHG Emissions from 1990 to 2012 by IPCC Sector (Environment Canada, 2014).

GHG Contributor	1990	2000	2005	2008	2009	2010	2011	2012
Energy	469	591	595	592	560	570	573	566
Industrial Processes	56	54	60	59	52	54	55	56
Solvent & Other Product Use	0.2	0.4	0.4	0.3	0.3	0.2	0.2	0.3
Agriculture	47	56	58	58	56	55	53	56
Waste	19	21	22	22	22	20	20	21
Land use, change and forestry	-71	-52	53	-17	-27	76	77	41
Net	591	721	736	731	689	699	701	699

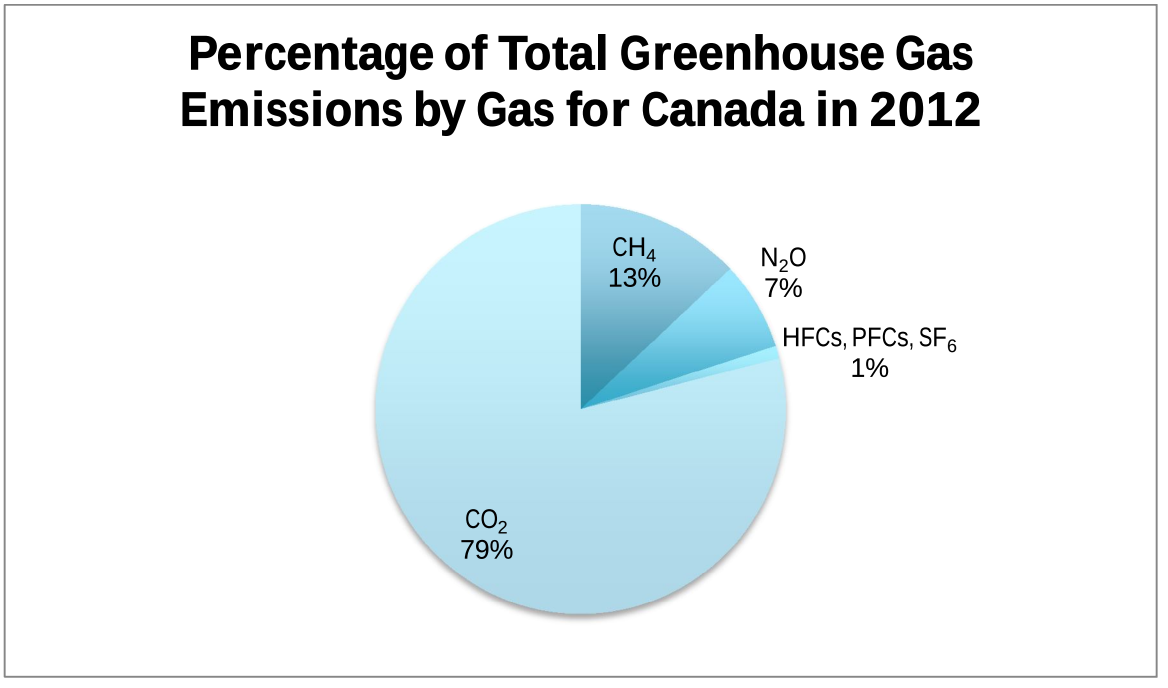
A study from 2004 to 2009 found that nearly 555,900 manufacturing jobs were lost in Canada (Statistics Canada, 2010). Pilat et al. (2006) has reported similar trends from 1990 to 2003 with a decline in manufacturing jobs in the United Kingdom by 29%, 24% in Japan, 20% in Belgium and Sweden and 14% in France. At the same time there has been an increase in manufacturing overseas, especially China, India and Bangladesh. So it may just be the movement of GHG emissions associated with Canada's manufacturing sector overseas to another state.

The National Inventory Report breaks down Canada's GHG profile for 2012 as follows: CO_2 was 551 Megatonnes (Mt) or 79%, CH_4 was 91 Mt or 13%, N_2O was 48 Mt or 7% and HFCs, PFCs, SF_6 were grouped together with a collective 10 Mt or 1% (Table 2-2). All values are reflected as CO_2e.

Both Canada and the United States provide information related to the types and quantities of GHG produced annually as published in a Greenhouse Gas inventory report on sources and sinks. In 2012, Canada released an estimated 740 million tonnes of GHG and the United States released 6,526 Mt of GHG in the same year; this equates to approximately 9 times the emissions of Canada.

Table 2-5 breaks down the types and quantities of GHG emissions released in Canada and the United States. In Canada, CO_2 accounts for 79% (551 million tonnes) of Canada's overall GHG contribution, followed by CH_4 at 13% (91 million tonnes), N_2O at 7% (48 million tonnes) and SF_6 at 1% (10 million tonnes). All values are reflected as CO_2e.

Figure 2-2 Greenhouse Gas Emissions by Gas (Environment Canada, 2014).



The quantity of GHG produced is obviously higher in the United States, given the larger population and economic activity, but the ratios are relatively similar. CO_2 accounts for 82% (5351.32 million tonnes) of the U.S. overall GHG contribution, followed by CH_4 at 9% (587.34 million tonnes), N_2O at 6% (391.56 million tonnes) and SF_6 at 3% (195.78 million tonnes). All values are reflected as CO_2e.

Canadian and United States data indicate that the majority of GHG emissions come from the energy generation sector. In 2012, Canada produced 740 million tonnes of GHG with 566 million tonnes (76.5%) coming from the energy sector (Environment Canada, 2014). The number is greater in the U.S. where the energy sector produced 2,154 million tonnes of GHG, which was only 41.4% of the total (USEPA, 2010).

Table 2-5 GHG produced in Canada and the United States in 2012 (represented by $C0_2e$)

Greenhouse Gas	Canada MT (million tonnes)	United States MT (million tonnes)
Carbon Dioxide (CO_2)	551 (79%)	5351.32 (82%)
Methane (CH_4)	91 (13%)	587.34 (9%)
Nitrous Oxide (NO_2)	48 (7%)	391.56 (6%)
Hydrofluorocarbons (HFCs), Perflurocarbons (PFCs) and Sulphur hexafluoride (SF_6)	10 (1%)	195.78 (3%)

Table 2-6 is an abbreviated version of the table published in Environment the National Inventory Report (Environment Canada, 2014). The table provides an overview of all of the GHG emission sources in Canada listed by sectors.

Table 2-6 GHG Production in Canada by Sector (Abbreviated Table) (Environment Canada, 2014).

SECTOR	TG CO_2E (Million Tonnes)	Percent
ENERGY PRODUCTION AND USE	**566**	76.5
➢ **Stationary Combustion Sources**	309 (of 566)	44.2 (of overall)
➢ **Transportation**	195 (of 566)	27.9 (of overall)
➢ **Fugitive Emissions**	61 (of 566)	8.7 (of overall)
INDUSTRIAL PROCESSES	**56**	7.6
SOLVENT AND OTHER PRODUCT USE	**0.3**	0.04
AGRICULTURE	**56**	7.6
WASTE	**21**	2.8
LAND USE, LAND USE CHANGE AND FORESTRY	**41**	5.5

The energy production and use sector accounted for 76.5% of Canada's overall GHG emissions in 2012 and includes GHG emissions produced through the combustion of fossil fuel for electrical generation for the power grid, transportation, and fossil fuels used in the residential, commercial and institutional sectors for heating, cooling, cooking, etc. Table 2-7 presents similar data produced by the United States Environmental Protection Agency and summarizes GHG emissions in the United States for 2012. The U.S. released was 6,526 million tonnes of GHG in 2012 with approximately 60% of its emissions associated with energy production and use.

Table 2-7 GHG production by sector in the United States.

Sector	Tg CO_2 (Million Tonnes)	Percent CO_2
Energy Generation	2088.32	32%
Transportation	1827.28	28%
Industrial	1305.2	20%
Commercial and Residential	652.6	10%
Agriculture	652.6	10%

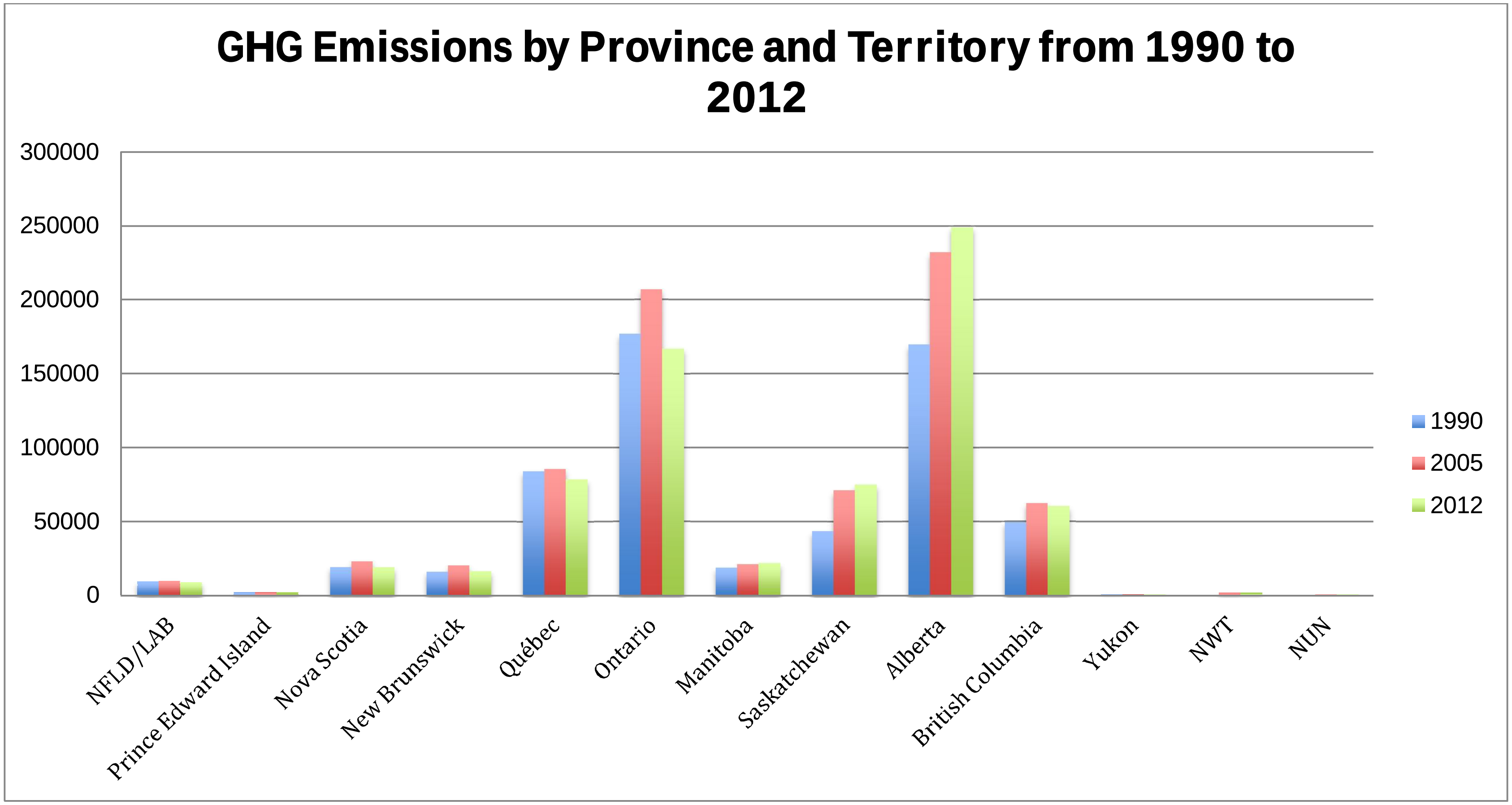
As previously stated, the agriculture sector is part of an international economic structure. While a country produces food through agricultural processes, it doesn't necessarily consume that food within that country.

2.5.2 Provincial Picture

Sub-nationally, the provincial and territorial greenhouse gas emissions have been reflected in Canada's National Inventory Report. Historically, the greatest contributors to GHG emissions have been provinces of Québec, Ontario, Saskatchewan, Alberta and British Columbia with GHG emissions of 40 megatons or higher (Figure 2-3).

In 2012, the greatest contributors to Canada's national GHG emissions were Alberta with 267.2 million tonnes and Ontario with 170.8 million tonnes. This is followed by Québec (82.6 million tonnes), Saskatchewan (74.8 million tonnes), British Colombia (62.8 million tonnes), Manitoba (21.4 million tonnes), Nova Scotia (18.3 million tonnes), New Brunswick (15.7 million tonnes), Newfoundland and Labrador (8.6 million tonnes), Prince Edward Island (1.8 million tonnes), the Northwest and Nunavut territories (1.7 million tonnes) and the Yukon Territory

Figure 2-3 GHG Emissions by Province and Territory from 1990 to 2012 (Environment Canada, 2014a)



(0.4 million tonnes) (Figure 2-3) (Environment Canada, 2014a). It should be noted that the on April 1, 1999, the eastern portion of the Northwest Territories was split into the Territory of Nunavut.

Despite a national strategy, Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick, Québec, Ontario and the Yukon have reduced their emissions collectively by seven percent from 1990 levels while the remaining jurisdictions increased their emissions (Table 2-8).

Table 2-8 Provincial and Territorial GHG Emissions and Percent Change from 1990 to 2012 (Environment Canada, 2014a)

Province or Territory	1990 (million tonnes)	2012 (million tonnes)	Percent Increase or Decrease
British Columbia	51.9	62.8	+21.0
Alberta	174.6	267.2	+53.0
Saskatchewan	45.0	74.8	+66.1
Manitoba	18.7	21.4	+14.4
Ontario	182.0	170.8	-6.2
Québec	89.8	82.6	-8.0
New Brunswick	16.5	15.7	-4.8
Nova Scotia	20.2	18.3	-9.4
Prince Edward Island	2.0	1.8	-10.0
Newfoundland and Labrador	9.8	8.6	-12.2
Yukon Territory	0.5	0.4	-20.0
Northwest Territories and Nunavut[6]	1.6	1.7	+6.2

[6] The Nunavut Territory separated from the Northwest Territories on April 1, 1999 therefore emissions are reported collectively for 1990 levels and carried through to present date for comparison purposes.

Within an Ontario context, the province achieved a 6.2 percent reduction between 1990 and 2012; this is most likely related to the partial closure of coal-fired power plants which continued until 2013 when the last coal plant was closed. To be clear, coal is still used to meet peak energy demand. In the Ontario Climate Change Discussion Paper 2015 (Ontario, 2015), the province reports that electricity generation has moved from the primary GHG emission source to the fourth. Specifically, the list is as follows: transportation (57 Mt, 34%), industrial processes (50 Mt, 30%), buildings (29 Mt, 17%), electricity generation (14 Mt, 9%), agriculture (9 Mt, 6%) and waste (7 Mt, 4%).

Ontario may also regulate GHG emissions for any sector operating within the province; in Ontario this is regulated under the *Environmental Protection Act* (OEPA). The OEPA and *Ontario Regulation 452/09* require companies to report GHG emissions if they released greater than 25,000 tonnes per year and if your emissions are related to specific sources (OEPA, 2009).

Following the *Green Energy Act* in 2009, the Ontario government began the process of phasing out coal-fired power plants throughout the province. This phase-out was completed after the last GHG inventory; therefore Ontario's contribution will appear even more reduced following the next national inventory. The coal-fired power plants were replaced with nuclear power and other clean or cleaner energy sources, such as wind, solar and hydroelectric, but also natural gas plants.

Outside of determining what statutory frameworks and policies exist within individual provinces and territories, there is also a question about what inter-governmental dialogue exists at all three levels of government.

2.5.3 Municipalities

This thesis is interested in how Canadian municipalities are also working to reduce GHG emissions at a corporate (municipal operations) level and at the community-wide level (entire municipality). Municipalities have a surprisingly high capacity to influence GHG emissions. Robinson and Gore (2005) found that municipalities have direct control, indirect control or influence over 52% of national emissions through land use and zoning, building permits and development approvals, parking, roads and public transit, parks and recreation and can be involved in water, power and gas utilities. At the same time, municipalities face many barriers when attempting to mitigate GHG emissions.

The first is recognition by the municipal administration of climate change being an important issue that will impact the city and for which the city has at least partial responsibility. This perception has most likely changed in the last ten years and was adopted early by the City of Toronto and most of the larger Canadian municipalities have undertaken some level of GHG mitigation programming (Robinson and Gore, 2005).

The next barrier is political and whether municipalities should be responsible for emission reductions. The role of municipalities in emission reductions remains a divisive issue. This has certainly been seen within the City of Toronto with the most recent example being the “end of the war on car” under Mayor Rob Ford (2010 to 2014) which saw the introduction and repeal of the vehicle registration taxes and the installation and removal of city bike lanes, among other changes to city program funding.

Capacity was also a barrier described by Robinson and Gore (2005). This barrier refers to cities having a lack of staff with technical understandings of climate change and the factors that influence it, not having an organizational structure to respond, budgetary constraints, and jurisdictional authority. Within the last ten years, the City of Toronto has established an effective and capable staff under their Environment and Energy Division. However, there still remains budgetary constraints that can affect the ability to develop environmental programs and poor organizational structure can lead to silos that limit cooperative approaches, knowledge and the ability to maximize existing budgets.

Outside of a municipality’s jurisdiction are efficiency standards, such as appliances, building code, vehicular emissions, and furnace and hot water tank efficiency. In some instances, a municipality can specify elements of building design, but have no hand in setting efficiency standard themselves. It is also not possible for the city to dictate how much and when energy systems can be used. The province attempts to influence how much and when people use electricity by the use of Smart Metres and Time-of-Use prices.

An additional limitation of municipalities is the energy grid. In Canada, it is the province's responsibility to regulate the energy grid, including the energy source composition, and most energy grids are comprised of a combination of energy sources that include coal, natural gas, hydroelectric, biomass, nuclear, and renewable sources (Mathiesen et al., 2015). Figure 2-4 shows how GHG emissions have changed for the two main sources of energy used in Canadian municipalities, electricity and natural gas, and how they have changed from 1990 to 2012.

Electricity is used primarily for lighting, appliances, cooling and heating, industrial processes, among other uses. Natural gas is used largely for heating, cooling, and cooking as well as industrial processes. The values presented are calculated by the province and used by the City of Toronto in their GHG calculations.

As the Ontario electrical grid removed more polluting energy sources, GHG emissions fell by more than half, from 0.220 kg GHG/kWh in 1990 to 0.105 kg GHG/kWh in 2012. While the electrical grid GHG output can vary over time as energy sources change, natural gas becomes cleaner only by improving its purity and it has not improved since 2008 (City of Toronto, 2014).

A final barrier to municipalities in the GHG reduction efforts is that they have only partial control over their land use planning. There have been instances where the province's Ontario Municipal Board has overruled city planning decisions in favour of developers and against city planning efforts (OMB, 2015).

Despite these barriers, for decades municipalities have been working together and with non-government organizations to reduce emissions. Starting in 2005, a group of 18 international municipalities convened to discuss reducing greenhouse gas emissions. The group has produced policies and guidance documents that encourage the uptake of technology that would reduce GHG emissions. The group has since expanded to 75 cities internationally and is now formally known as the C40 Cities Climate Leadership Group (C40, 2015).

The Cities of Toronto, Ontario and Vancouver, British Columbia have achieved measureable GHG reduction through landfill gas capture, carbon sequestration from their many urban forests and parks, residential tower retrofitting and other conservation retrofits and transit plans (City of Vancouver, 2014; Toronto, 2012).

As of 2007, approximately 21 million Canadians lived in a municipality that had committed to reduction GHG emissions through the Federation of Canadian Municipalities (FCM) Partners for Climate Protection program (Gore, 2010). As of 2014, over 240 Canadian municipalities from all provinces and territories are members of the Cities for Climate Protection program convened by the Federation of Canadian Municipalities. This represents 80% of the Canadian population.

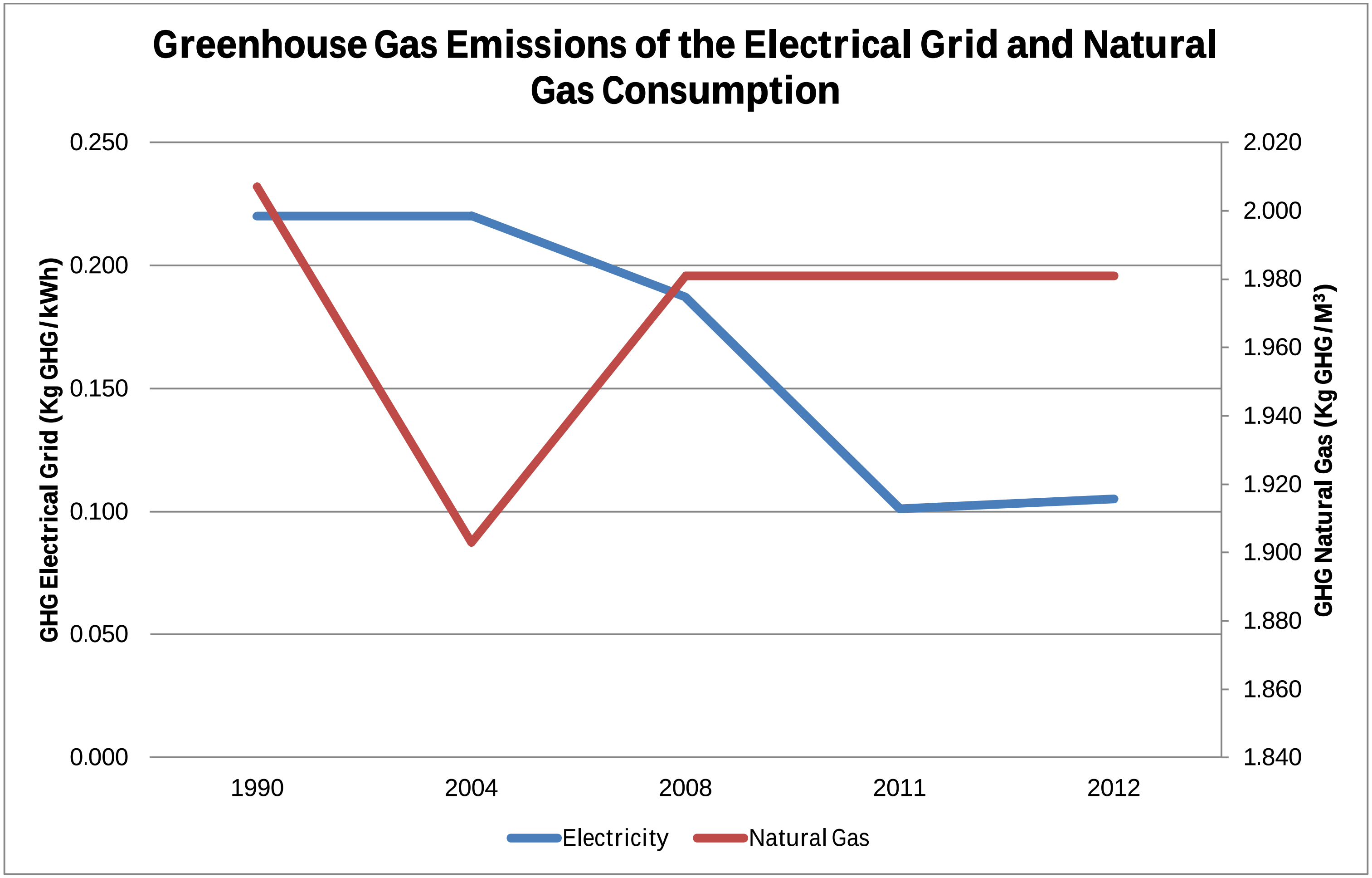
To date, there has been very little attention paid by the federal government to the role of municipalities in GHG reduction despite the fact that the majority of GHG generating activities take place in municipalities. The federal government has also not adequately explored how municipal climate change action and plans contribute to national GHG reduction (Gore, 2010). Gore (2010) does point out that the 2005 Liberal government budget committed to divert $5 billion of the federal gas tax to municipalities over a five year period to assist in infrastructure projects related to environmental and energy services and that the subsequent Conservative government made this arrangement permanent.

Therefore, the federal government may be slowly recognizing that municipalities need greater support but perhaps the link between municipalities and their influence over GHG emissions has not been fully made.

2.5.4 The City of Toronto

While climate change impacts have been seen worldwide, Torontonians may have had their first tastes in 2013. On July 8, 2013, Toronto experienced an “epic” rainstorm event that deposited 126 mm of rain in 7 hours, with 90 mm of rain in the first 2 hours (Toronto Star, 2013a).

Figure 2-4 GHG Emissions of Ontario Power Grid and Natural Gas System



The rainstorm drowned the subway system, submerged the Don Valley Parkway and the GO Transit train system, and flooded basements and roadways throughout the city causing more than $850 million dollars in damage across the region (Toronto Star, 2013b). The rainstorm exceeded previous records set in 1954 by Hurricane Hazel.

On December 20, 2013, Toronto experienced an extreme ice storm that coated the city in a significant amount of ice throughout the city. On December 22, 2013 a second and more significant ice storm hit the city breaking trees and pulling down hydro wires by sheer weight of the ice and leaving more than 300,000 households without electricity or heat. Toronto Hydro spent weeks restoring power aided by work crews from the provincial crown corporation, Hydro One, and the cities of Ottawa (ON), Windsor (ON), Winnipeg (MB), Michigan (U.S.) and New York (U.S.) (Toronto Star, 2013c). Damage was estimated to cost $106 million.

In the ten years that the City of Toronto has been recording Environment Canada Extreme Weather Alerts, the winter of 2013/2014 saw 36 extreme cold alert days and winter 2014/2015 has already had 35 to date[7] (City of Toronto, 2015b). Figure 2-5 shows extreme cold weather events during the winter season over the last ten years in Toronto. Extreme weather is considered to be one of the effects of climate change.

In October 1988, the leaders and policy experts of 46 countries attended the Toronto Conference on the Changing Atmosphere where discussion began of monitoring greenhouse gas emissions and a “Toronto Target” of 20% of 1988 GHG levels was set but never realized (Robinson and Gore, 2005).

In 1990, the City of Toronto established a baseline of community-wide GHG and concluded that the city produced 27,051,617 tonnes of GHG emissions at the time; however, the data collection method is no longer considered relevant in part due to how the data was collected and in part because the City of Toronto amalgamated with the surrounding cities of North York, East York, Scarborough and Etobicoke in 1998, which increased the area of the new city by approximately 509

[7] At the time of the writing of this thesis, there have been 35 extreme cold alerts for the City of Toronto with more than a month left of the winter season.

km^2 and added 1,585,153 people, according to the Statistics Canada 1996 census (Christopher Morgan, Personal Communication, Feb 5, 2015; Statistics Canada, 2015).

In 1998, the City established the Environmental Task Force charged with creating a framework for the protection and enhancement of the natural environment (Christopher Morgan, Personal Communication, Feb 5, 2015).

The City adopted the Task Force's Environmental Plan entitled "Clean, Green and Healthy: A Plan for an Environmentally Sustainable Toronto" that consisted of 66 recommendations and over 300 activities in the areas of transportation, energy use, economic development and education and awareness. The last update report was published in 2004.

Despite municipalities being unable to develop GHG regulations, they do have a role in mitigating GHG emissions. At the 2009 United Nations Climate Change Conference held in Copenhagen, Denmark, the mayors from 80 municipalities around the world met (Jones, 2011). Their goal was to push for a greater role of cities in climate change policy. Cities not only affect the national and global economies, they also approve activities such as construction, land use planning, and transportation. More importantly, perhaps, is that they have to deal with the impacts of climate change.

The city committed to reducing its greenhouse gas emissions according to the aggressive 1997 Kyoto Protocol with a target of 6% below the 1990 emissions by 2012, 30% by 2020 and 80% by 2050. This is set out in the City's *Climate Change, Clean Air and Sustainable Energy Action Plan: Moving from Framework to Action Phase 1* report (Toronto, 2007b).

As of 2012, Toronto had surpassed its goal by reducing their emissions by 49% for City Government and 25% lower for the entire city as compared to the 1990 levels (Toronto, 2012). To achieve this reduction, the city has retrofitted city-owned buildings to improve energy efficiency, installed solar photovoltaic systems on city property, captures methane gas produced by city-own landfill sites, installed and operates the Deep Water Cooling System that provides air conditioning to buildings in the downtown core, and the city has planted thousands of trees throughout the city (Toronto, 2015).

Figure 2-6 presents the available GHG emission data for the combined corporate and community-wide emissions for City of Toronto. The data shows that the City has reduced their GHG emissions from the next, reliable data point of 2004 by 19.02% (Toronto, 2012). Figure 2-7 breaks down Toronto's GHG emissions into electricity and natural gas. From this figure, it is possible to see how GHG emissions related to both electricity and natural gas have been reduced since 1990 and 2004. As of 2012, the City of Toronto contributed 20.313 megatonnes (20,313,000,000 kilograms) of GHG to Canada's overall emissions.

From 1990, a decrease of 52.53% was seen in GHG related to electricity use and an 18.92%reduction in natural gas use was achieved. From 2004, a decrease of 51.19%was seen in GHG related to electricity and 13.83% in natural gas use.

The other interesting information presented in Figure 2-7 is the disparity between GHG emissions associated with electricity use and natural gas use, which has been increasing over time which is potentially related to electrical energy efficiency. In 2011 the disparity was 200% difference between the two energy sources and this was reduced to 163% in 2012.

2.5.5 Toronto GHG Reduction Measures

The City of Toronto has a complex environment program with many subprograms. This thesis has identified seven subprograms under 5 programs that are aimed at reducing GHG emissions in the City of Toronto.

2.5.5.1 Live Green Toronto

The Live Green Toronto program is comprised of nine subprograms, two of which are designed to reduce GHG emissions by providing low-interest loans to homeowners to retrofit their homes and providing grants and incentives to groups for community improvements (City of Toronto, 2015a).

Figure 2-5 Toronto City Extreme Cold Weather Alerts from 2004 to 2015 (City of Toronto, 2015c)

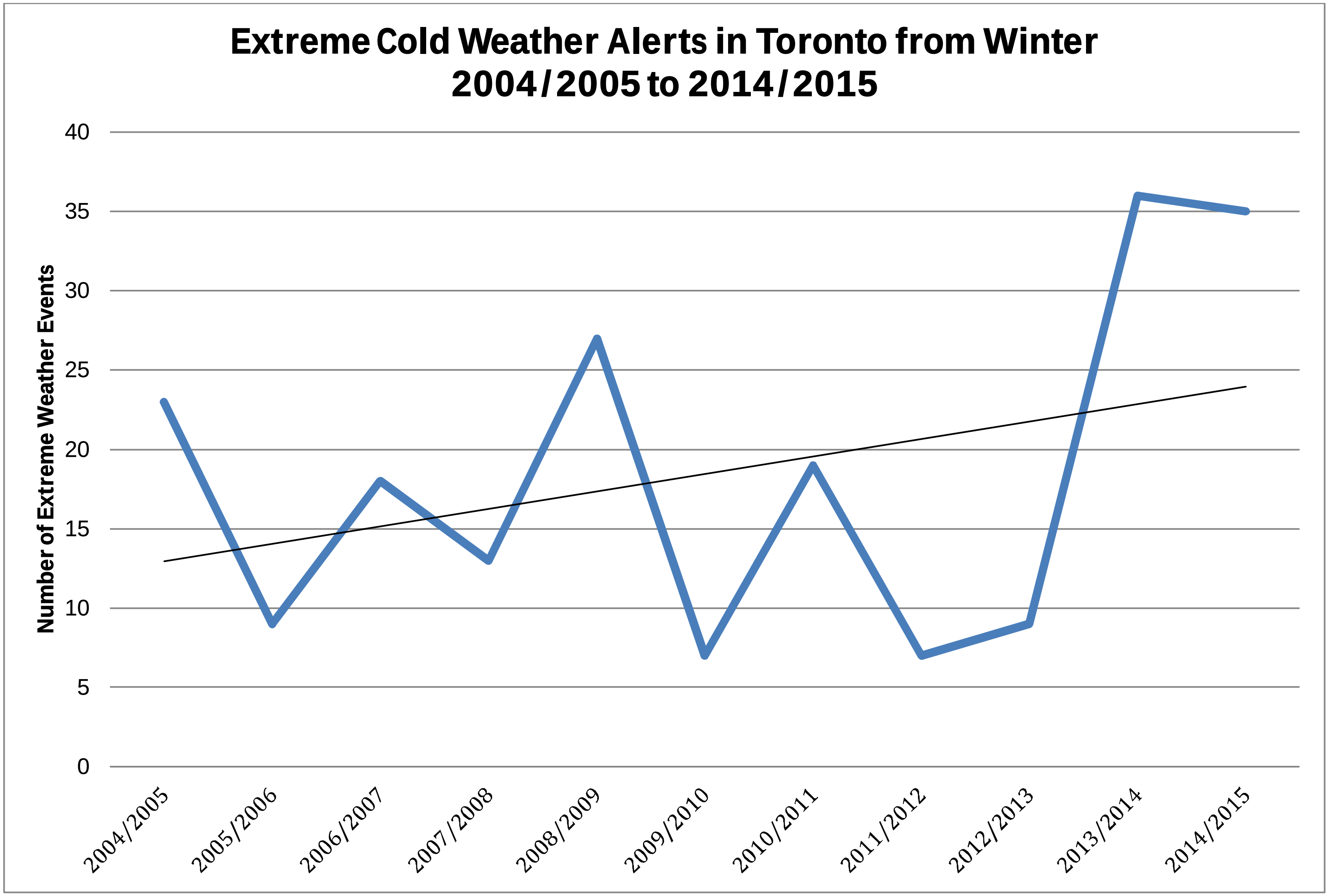


Figure 2-6 Toronto Greenhouse Gas Emissions from 1990 to 2012 (Toronto, 2012).

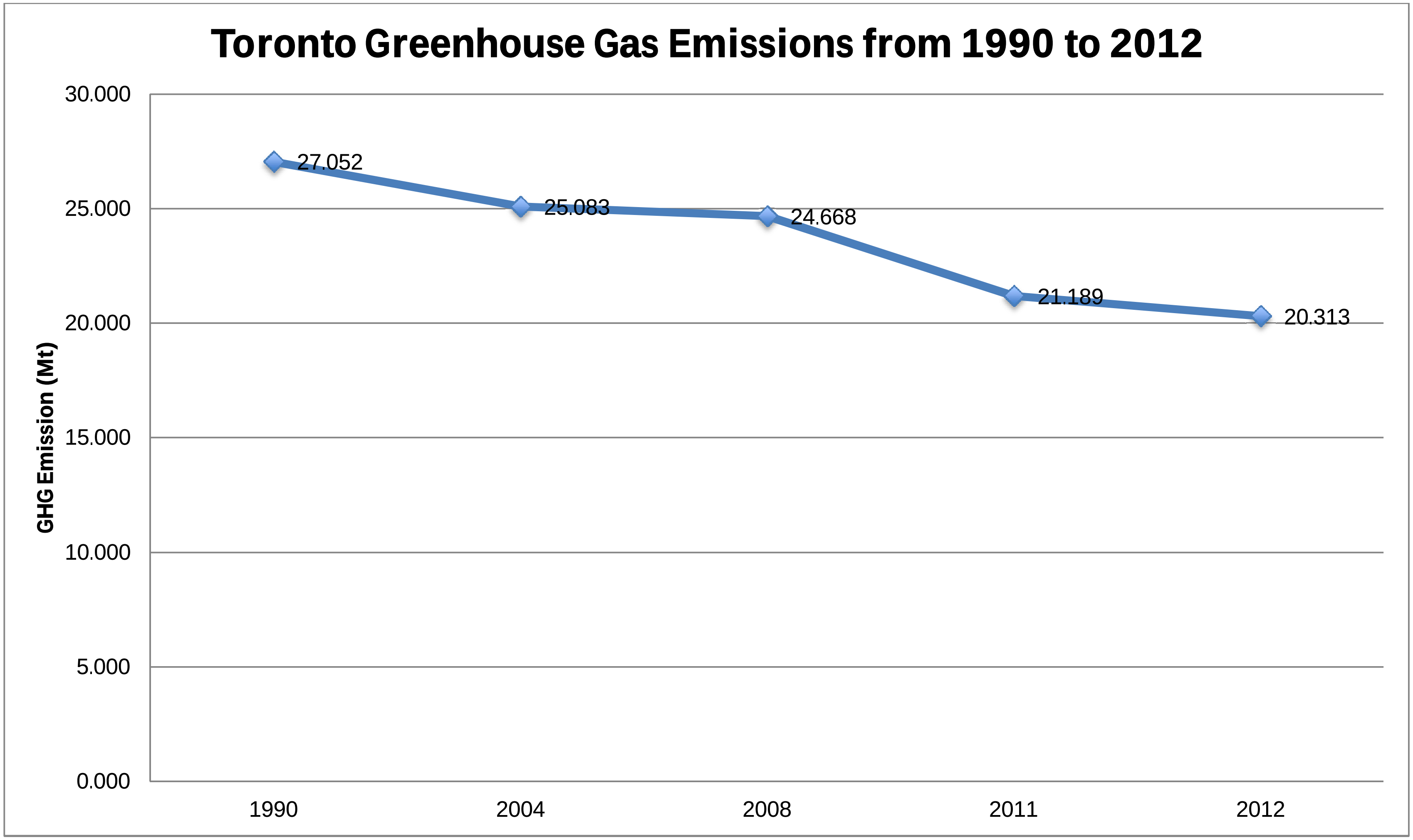
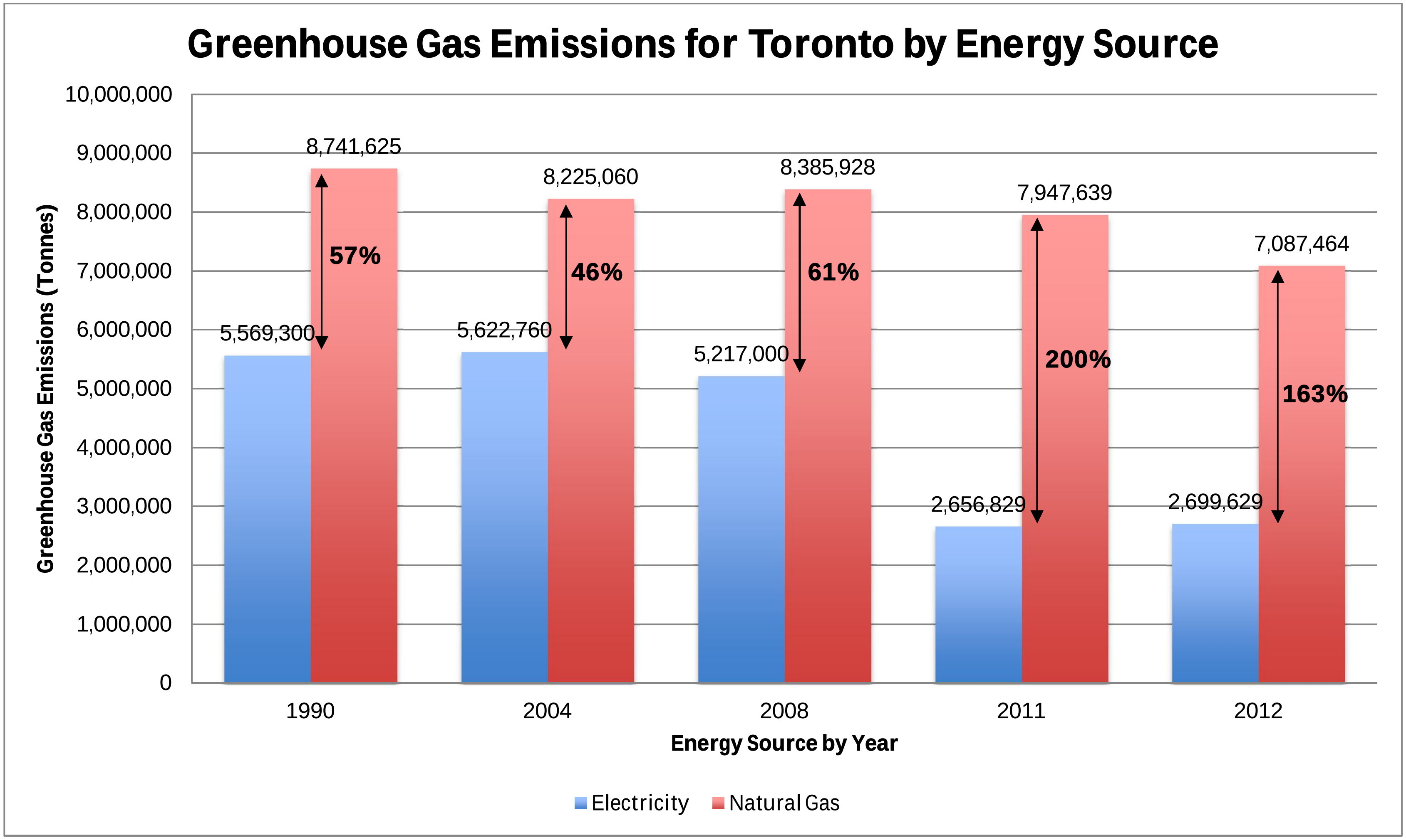


Figure 2-7 Greenhouse Gas Emissions by Source for Toronto and Disparity between GHG emissions by energy sources (Toronto, 2012).



2.5.5.2 Better Buildings Partnership

Under the Better Buildings Partnership, the City works with building owners, managers and builders to achieve higher energy efficiency in new and existing buildings. The City reports that it has completed over 2000 projects that have avoided the use of 3 million MWh and 500,000 tonnes of GHG emissions.

This has been achieved through the Municipal, Academic, Social and Healthcare Retrofit Program that works with building owners and managers to retrofit buildings. The New Construction Program supports conservation and demand management in new building and retrofits projects, such as the Toronto Tower Renewal project that is re-insulating and replacing windows in older buildings.

The City's Demand Response Program focuses adding city-owned assets to the Ontario Power Authority's Demand-Response program to optimize energy use. The city's Measurement and Verification program validates emissions reductions and identifies room for improvement, among other logistical aspects (City of Toronto, 2015b).

2.5.5.3 District Energy Systems

Like many other Canadian municipalities, Toronto is also involved in District Energy Systems. A District Energy System is a heating and cooling distribution system that is shared across multiple buildings removing the need for natural gas used in heating and electricity used in cooling. The City explains that District Energy Systems produce less GHG because they are more efficient than distantly located power plants. Since local renewable energy sources are used, a district system is more efficient than stand-alone systems and more resilient in coping with extreme weather events (City of Toronto, 2015b).

The next question is how do the City's efforts to reduce GHG emissions translate to specific industries within the city. For this, energy use and GHG emissions within the restaurant industry in Toronto will be studied.

2.6 The Restaurant Industry

One of the goals of this thesis is to understand how one large commercial sector in municipalities – restaurants – relates to municipal, provincial and national GHG emissions. They exist wherever there is a sufficient population to create a demand for and support of ongoing operations and are therefore a ubiquitous aspect of any municipality that tend to increase in number as cities grow.

A restaurant is defined as a business that specifically prepares and serves food and beverages to customers. This thesis will refer to fixed and mobile restaurants. A fixed restaurant is a standard, stationary building that prepares food to sit-down dining as well as take-out (e.g. McDonalds, Pizza Pizza); they generally operate year round. Mobile restaurants can be food carts, food trucks or large shipping containers that have been converted into restaurants; they generally operate seasonally. As of 2011, the Canadian market was comprised of 63% independent restaurants and 37% restaurant chains (Restaurant Canada, personal communication, 2014).

Canada has a national population around 34 million (as of 2012) living in more than 5,500 municipalities, including three major cities that have greater than 1 million people, with Toronto nearing 3 million (StatsCan, 2001; MAH, 2014). According to the Canadian Restaurant and Food Services Association (CRFA, 2014), there are more than 81,000 restaurants in Canada employing more than 1.1 million people and generating $68 billion for Canada's economy annually; this represents 6.4% of the Canadian workforce and 4% of the Canadian economy. Of the more than 81,000 restaurants nationally, approximately 16,442 operate and are inspected in the City of Toronto (Toronto Public Health, 2014; Restaurant Canada, personal communication, 2014).

The restaurant industry is also vulnerable to climate change. The Canadian Restaurant Association reports that food prices and bad weather come as the top two factors negatively affecting the restaurant industry and the ability of individual restaurants to survive (Canadian Restaurant Association, 2014). Climate change can be expected to negatively affect the restaurant industry since restaurants are dependent on food prices and weather events can affect the production and shipping of food which in turn affects food prices. Therefore, it would seem appropriate that the restaurant industry should take steps to reduce greenhouse gas emissions.

2.6.1 Ontario Restaurant Industry Regulatory Framework

Restaurants are also an industry whose aspects related to GHG emissions are regulated primarily by the municipality and they use the provincial electrical grid and natural gas as energy sources in their operations. For the independent restaurant industry operating within the City of Toronto, there are sixty-two permits that may be required under various federal, provincial/territorial and municipal regulations (Table 2-9) (Canada Business Network, 2015). These permits include business registration and administration, importing and exporting food and products, construction and renovation, water and sewer requirements, and those required to serve food and beverages, alcohol and gambling and zoning.

Of the possible sixty-two permits, only five permits that specifically affect the GHG emissions of individual restaurants and are bolded in Table 2-8. All five of these permits are required by the municipality; these are the preliminary project review that captures information on building design and plan, the building permit which includes municipal and provincial building code requirements, heating, ventilation and air-condition (HVAC) permit, the site plan control approval that reviews design and technical aspects of the restaurant and the permitted letter use that confirms appropriate zoning for any business venture (Canada Business Network, 2015).

The Ontario building code is a key element in building design and energy efficiency, compliance with the Ontario building code is undertaken by the municipality when reviewing design plans and issuing a building permit. Energy use is the only source of GHG emissions not being regulated.

s Required under Federal, Provincial and Municipal Regulation (Canada Business Network, 2015).

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Provincial or Territorial Permits

9. Commercial Sign Permit
10. ESA Certificate of Inspection
11. Elevating Device Licence
12. Encroachment Permit
13. Highway Building and Land Use Permit
14. Highway Entrance Permit
15. Licensing a Vehicle that is Registered in Another Jurisdiction
16. Liquor Sales Licence
17. Master Business Licence
18. Registration for a Partnership/Limited Partnership
19. Registration of a Business Name for a Corporation
20. Registration of a Sole Proprietorship/General Partnership
21. Registration of an Ontario Limited Liability Partnership
22. Sign Permit - St. Lawrence Parks Commission
23. Temporary Extension Application (Liquor Sales Licence)
24. Temporary Transfer under the Liquor Licence Act
25. Transfer of a Liquor Sales Licence

Municipal Permits

1. Boulevard Cafe Permit
2. **Building Permit**
3. Business Licence
4. Demolition Permit
5. Drain Site Services Permit
6. Food Handler Certification
7. **Heating, Ventilation and Air Conditioning (HVAC) Permit**
8. Municipal Information Form (Liquor Licence)
9. **Permitted Use Letter**
10. Plumbing Permit
11. Pre-Application Applicable Law (PAL) Review
12. **Preliminary Project Review (PPR)**
13. Private Sewage System Permit
14. Rental Housing Demolition and Conversion
15. Sign Permit
16. **Site Plan Control Approval**
17. Temporary Sign Permit

2.6.2 GHG in the Restaurant Industry

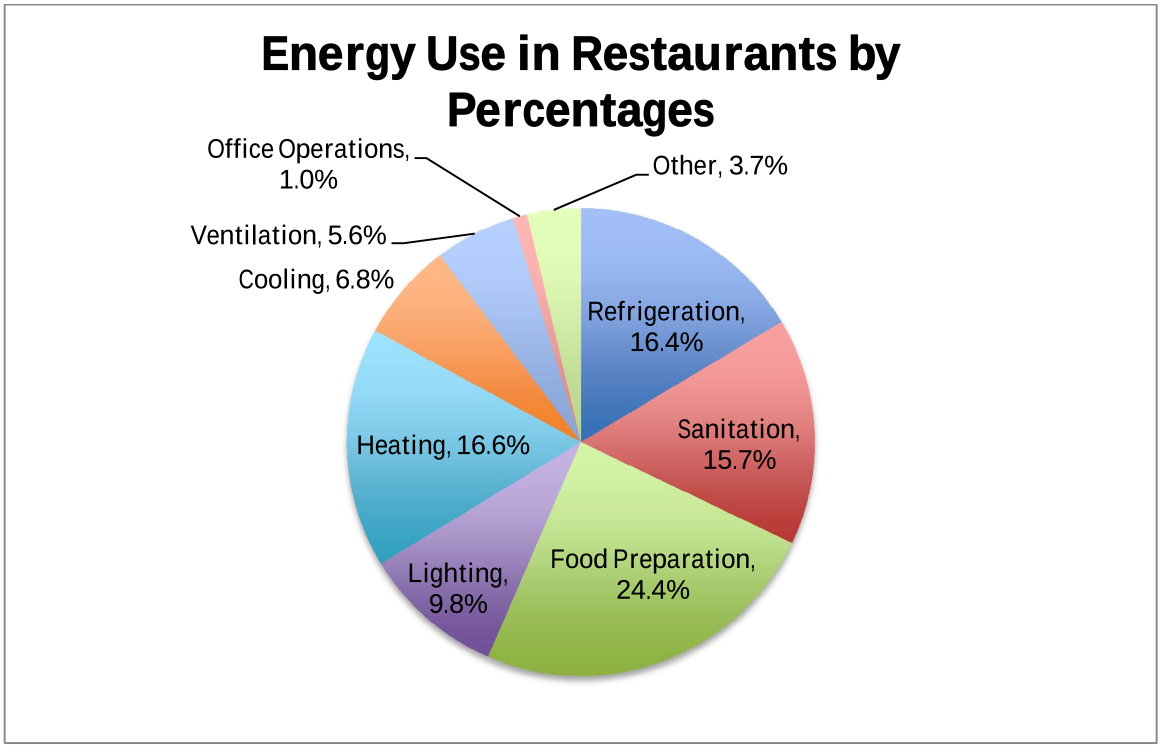
There has been little research GHG emissions within the restaurant industry and especially not within a Canadian and Ontario context. Furthermore, there is no clear guidance for the restaurant industry to reduce their environmental footprint, which includes GHG emissions, and the efforts that restaurants may currently be undertaking may not be the best approach (Baldwin et al., 2011).

A study in Macao found that the greatest contributors to the Chinese province's 3.70 million tonnes of GHG were the commerce industry followed by restaurants and hotels, transportation and households (Li and Chen, 2013). Majumdar et al. (2013) quantified the emissions from the restaurant industry in the Indian cities Nagpur and Raipur. They found that the restaurant industry within these two cities released between 19.3 billion and 21.2 billion kg of GHG annually; however, they also found that the energy sources used by these restaurants where all fossil fuel, namely liquefied petroleum gas, charcoal, wood, coal, diesel and candy coal which is vastly different from Ontario's energy sources.

In North America, Brondum and Palchick (2012) found that restaurants do use large quantities of energy in their operation but that systematically gathered information is not available; furthermore, they found that there was a gap between energy efficiency awareness and practice. Baldwin et al. (2011) used the Green Seal Standard for Food Services to undertake a lifecycle analysis of restaurants which included food procurement, storage, preparation and the operational requirements at the restaurant level. No actual restaurants were used in this assessment; it was strictly based on modeling and available information through various sources. Within the results, they found that the greatest direct contributors to climate change (as GHG emissions) were from food procurement and restaurant operations.

Research has been undertaken on elements of sustainable practices within the supply chain of and energy use within the restaurant industry. Figure 2-8 illustrates how energy is used, on average, in restaurants (Sustainable Food Services, 2014). Energy use in restaurants can include electricity from the standard electrical grid, but can also include natural gas, propane, gasoline and diesel fuel and each of these have specific GHG emissions associated with them. However, within an urban setting, the primary energy use is the provincial energy grid and the natural gas system.

Figure 2-8 Energy Use in Restaurants by Percentages (Sustainable Food Services, 2014)



Outside of the energy use within a restaurant, a lifecycle analysis was conducted by Baldwin et al. (2011) to understand the environmental impacts of the restaurant and food industry and they found that food procurement had the potential to have greatest environmental impact. Witoff et al. (2012) found that the average fruit and vegetable purchased within the United States has travelled over 1,500 miles (2,414 km) with half the energy being used during the production and the rest in the transportation (including refrigeration).

Table 2-10 Annual GHG Emissions from Food Manufacturing (Egilimez et al., 2014)

Food Manufacturing Sector	Annual Tonnes GHG	Food Manufacturing Sector	Annual Tonnes GHG
Dog and Cat Food	1.48×10^7	Ice Cream and frozen dessert	9.55×10^6
Other Animal Food	3.68×10^7	Animal (not poultry)	3.36×10^8
Flour Milling and Malt	2.02×10^7	Poultry	5.46×10^7
Wet Corn Milling	3.36×10^7	Seafood	9.96×10^6
Soybean and other oilseed	3.38×10^7	Bread and bakery	3.22×10^7
Fats and Oils	1.53×10^7	Cookie, Cracker, Pasta	1.63×10^7
Breakfast Cereals	8.16×10^6	Tortilla	1.68×10^6
Sugar cane mills and refining	9.52×10^6	Snack Food	1.70×10^7
Beet Sugar	5.92×10^6	Coffee and Tea	4.70×10^6
Chocolate and Confectionary (Raw Cacao)	4.04×10^6	Flavour Syrup	3.15×10^6
Confectionary from Chocolate	7.65×10^6	Seasoning and dressing (Salads)	1.13×10^7
Nonchocolate Confectionary	5.80×10^6	All other food	1.64×10^7
Frozen Food	2.87×10^7	Soft drink and ice	2.99×10^7
Fruit and Vegetable (canning, pickling, drying)	3.09×10^7	Breweries	1.83×10^7
Fluid Milk and Butter	5.51×10^7	Wineries	5.76×10^6
Cheese	5.29×10^7	Distilleries	2.85×10^6
Dairy (dry, condensed, evaporated)	1.93×10^7		

Egilmez et al. (2014) acknowledged that food manufacturing has a major impact on the environment when they looked at the direct and indirect environmental footprints of 33 food manufacturing centres in the United States. By way of Lifecycle Analysis, they looked at all aspects of the manufacturing process: energy, water, carbon, fishery, grazing, forestry and cropland to calculate the tonnes of GHG produced annually. From Table 2-10, the most GHG intensive food production is related to any livestock. Furthermore, current agricultural practices are energy intensive and as such food production accounts for 17% of all fossil fuel consumption in the United States (Witoff et al, 2012). This is largely due to manufactured fertilizers.

Kolokoftroni et al. (2015) found that the worldwide food system accounts for approximately 33% the worldwide GHG emissions and found that low energy ventilation strategies ranging from improved envelope, natural ventilation components, reduction of fan power, ventilative cooling, novel refrigeration systems using CO_2 combined with ventilation heat recovery, and storage with phase change materials would reduce GHG emission by 66% in restaurants, supermarkets and catering facilities.

Therefore, the research indicates that restaurants do contribute greatly to the worldwide GHG emissions and that the bulk of the emissions are associated with food procurement and restaurant operation. This will likely be different in a Canadian and especially an Ontario setting because the GHG emissions seen by Majumdar et al. (2013) were based entirely on fossil fuels whereas restaurants in Ontario use the Ontario electrical grid, which produces significantly less GHG emissions, and natural gas as energy sources. Despite using energy sources with lower GHG emissions, restaurant operations still comprise a significant portion of energy use and therefore associated GHG emissions associated, as found by Baldwin et al. (2011).

This thesis aimed to quantify the GHG emissions from Toronto-based independent restaurants to determine what percentage of the municipal and national GHG emissions can be associated with the restaurant industry. It also aimed to identify areas where further effort is required to reduce GHG emissions in the industry.

3. Methods

A mixed-methods approach was used for this research. An analysis of official government publications were completed to identify greenhouse gas reduction legislation, policies and plans that were developed by the provinces and territories and Canadian municipalities, including the City of Toronto. The content analysis was also supplemented with interviews.

A quantitative questionnaire was used to collect energy use data from Toronto-based restaurants. A content analysis was used to identify greenhouse gas reduction measures planned or implemented by other Canadian municipalities. These are further elaborated below.

3.1 Greenhouse Gas Reduction Legislation and Policies

An attempt was made to understand what GHG reduction policies exist within Canada's ten provinces and three territories through published material on the internet; however, the information was not clear or absent. Instead, interviews were held with public officials to identify greenhouse gas reduction legislation, policies and plans existed within all ten provinces and three territories. The interviews included three areas: regulatory or policy framework, national or sub-national coordination, and provincially/territorially supported municipal tools or policies. Each of these areas was comprised of sub-questions as seen below:

1. Regulatory or Policy Framework
    a. What renewable energy, green energy or greenhouse gas reduction legislation exists within the province?
    b. How has this legislation translated into policy, or what policy exists outside of statutory obligation to reduce GHG reduction?
    c. Under what time horizon do these polices fall?

2. National or Sub-National Coordination
    a. To what extent does federal (national) greenhouse gas policy or international commitments shape the province or territory's GHG reduction plan?

b. Does the province coordinate nationally and/or inter-provincially/inter-territorially to meet Canada's GHG reduction commitments?

3. Provincially Supported Municipal Tools or Policies
   a. Is the province or territory working with or giving tools to municipalities to assist them in greenhouse gas or energy reduction measures (e.g. allowing municipal gasoline taxes, etc)?
   b. Are there any examples of municipal provisions that stand out to curb GHG emissions or energy use?

The section on provincially supported municipal tools or policies was included because there has been discussion about the City of Toronto requesting the Province of Ontario to amend the City of Toronto Act to allow gasoline taxation and potential other revenue-generating tools that would serve as an energy disincentive.

To ensure completeness and accuracy, the content analysis was followed-up with interviews to review the data collected under the same structure. The Ryerson Research Ethics Board granted approval to conduct structured interviews, exactly as above, on October 17, 2013 (Appendix A).

Interviews were requested with public officials at the Ministries of Environment in each province and territory via their public inquiry email address during the last week of February 2015. A contact person was then identified and they had the option to be interviewed or to answer the interview questions as a questionnaire. Of the ten provinces, all but Québec responded. Alberta, Manitoba and Ontario requested a telephone interview while the remaining provinces requested to complete the questionnaire. Of the three territories, all but Nunavut responded. The Yukon Territory requested a telephone interview and the North West Territories requested to complete the questionnaire.

The purpose of the interviews was to verify the results from the content analysis and to discuss inter-governmental relationships at all three levels. From the content review and interviews, the information was sorted into the following components: a) actual legislation and associated regulation, b) policies and programs that establish reduction targets, and c) policies and programs that enable carbon pricing.

3.2 Municipal Greenhouse Gas Reduction Strategies

As described in Section 2.4.5, the City of Toronto already has a number of programs designed to assist in the GHG reduction measures, with the greatest reductions being achieved in the improvement of building codes and the renovation of older buildings. The city also captures and uses methane produced by city-owned landfill sites (City of Toronto, 2014). However, it is possible that other Canadian municipalities have other strategies in place that would allow the Toronto restaurant industry to reduce their GHG emissions.

Table 3-1 Canadian Municipalities Selected for Review

Canadian Municipalities		
Toronto (ON)	**London (ON)**	**Abbotsford (BC)**
Montreal (QC)	**Longueuil (QC)**	**St. Catherines (ON)**
Calgary (AB)	**Burnaby (BC)**	**Trois-Rivières (QC)**
Ottawa (ON)	**Saskatoon (SK)**	**Cambridge (ON)**
Edmonton (AB)	**Kitchener (ON)**	**Coquitlam (QC)**
Mississauga (ON)	**Windsor (ON)**	**Kingston (ON)**
Winnipeg (MB)	**Regina (SK)**	**Whitby (ON)**
Vancouver (BC)	**Richmond (BC)**	**Guelph (ON**
Brampton (ON)	**Richmond Hill (ON)**	**Kelowna (BC)**
Hamilton (ON)	**Oakville (ON)**	**Saanich (BC)**
Québec City (QC)	**Burlington (ON)**	**Ajax (ON)**
Markham (ON)	**Sudbury (ON)**	**Thunder Bay (ON)**
Vaughan (ON)	**Sherbrooke (QC)**	**Terrebonne (QC)**
Gatineau (QC)	**Oshawa (ON)**	**St. John's (NF)**
Surrey (BC)	**Saguenay (QC)**	**Langley (BC)**
Laval (QC)	**Lévis (QC)**	**Chatham-Kent (ON)**
Halifax (NS)	**Barrie (ON)**	

A content analysis of official municipal websites was also used to investigate general strategies used by other Canadian municipal governments to reduce greenhouse gas reduction emissions. A guiding question for this exercise was: What programs or policies exist within the municipality specifically to reduce GHG emissions related to (a) electricity use and (b) natural gas use?

To answer this question, the top 50 most populous municipalities in Canada were selected based on the 2006 Statistics Canada population census according to the Statistics Canada 2006 Census (Table 3-2). The first 50 also represented populations of 100,000 or more. This number was chosen to place a limit on the number of municipalities reviewed. Only instances of strategies not yet employed by the City of Toronto were recorded.

The analysis consisted of visiting the respective municipal websites using the following methodology:

1. Is there a listing of city departments?
2. Under which departments are programs related to GHG reduction measures?
3. What programs exist that intentionally reduce GHG emissions within the City, both corporate (city operations) and community-wide (entire city)?
4. Of the programs, which are not currently used in the City of Toronto or used at a greater extent than Toronto.

Following the content analysis, an interview was completed with Dr. Christopher Morgan, director of Energy and Environment program with the City of Toronto to explore the possibility of similar strategies being employed in the City of Toronto.

3.3 Toronto-Based Restaurant GHG Contribution

Outside of what sub-national government are doing to reduce GHG emissions there are actual industries functioning within the these respective jurisdictions. As discussed in section 2.6., restaurants are an industry that operates under various regulations at all three levels of government. In terms of energy efficiency of buildings, the municipality's building permits take into consideration provincial building code as well as any additional requirements of the municipality. In terms of GHG emissions related to energy use, restaurants rely on the provincial electrical grid to run appliances, lighting and cooling, and natural gas for heating, cooking and other gas powered appliances.

Restaurants are a ubiquitous industry found in every municipality regardless of size and tend to increase in number as the population of a municipality increases. There is presently no information for the GHG emissions related the restaurant industry in Canada. To understand how much of Toronto and Canada's GHG emissions can be attributed to the restaurant industry, the Toronto-based independent restaurant industry was chosen. As discussed, independent restaurants constitute 63% of the industry and were chosen over chain restaurants because corporately run businesses tend to produce annual reports that include environmental stewardship and other corporate social responsibility measures while independent restaurants do not.

To collect information on GHG emission from energy use within the Toronto-based restaurant industry, a questionnaire was designed and delivered to 120 independent restaurants. Respondents were requested to review their electricity and natural gas bills from the previous year (2012) and return this information by mail (Appendix B). All questionnaires were anonymous.

The use of questionnaires in this research required that the study methodology and questionnaires be submitted to the Ryerson University Ethics Review Board for review and approval. Approval was granted on October 17, 2013 for a one-year period (Appendix B).

On October 21, 2013, one hundred and twenty (120) questionnaires were delivered on foot to restaurants throughout Toronto with the physical boundaries of Islington Avenue to Woodbine Avenue (East to West) and from Sheppard Avenue to Front Street/Eastern Avenue (North to South). The restaurants selected were locally owned (i.e. not corporate, chain restaurants). These physical boundaries were arbitrarily chosen with the criteria that they had to be near public transit.

Forty questionnaires were delivered to large, 40 to medium and 40 small restaurants based on seating. Small restaurants had 10 seats or less, medium had between 11 and 20 seats and large restaurants has greater than 20 seats. Each questionnaire included a copy of the Ethics Review Board approval letter and a self-addressed, stamped envelope. The return by date was November 29, 2013; however, questionnaires continued to be received up until the end of January 2014. The general information collected included the type of restaurant (take-out, fast food, non-fast food), the size measured in square feet and type of mobile unit (cart, truck or shipping container).

Table 3-2 Outline of Restaurant Questionnaires

SECTION	CONTENT
SECTION 1:	GENERAL INFORMATION: the type of restaurant (take-out, fast food, non-fast food) and size which is measured in square feet or square metres for fixed restaurants, and type of mobile unit (cart, truck or shipping container).
SECTION 2:	TAKE-OUT CONTAINERS: the types and quantities sold.
SECTION 3:	TAKE-OUT BEVERAGE CONTAINERS, specifically the types and quantities sold.
SECTION 4:	ENERGY USE: the types and quantities of each energy source.
SECTION 5:	WATER USE: the quantity of water used (which is related to the amount of sewage produced).
SECTION 6:	OTHER INFORMATION: other potential energy sources were missed in this questionnaire.

The questionnaire was broken into sections that asked the restaurant owner or manager to complete as accurately as possible for the previous calendar year running from January to December. The sections are summarized in Table 3-1, these are: (1) the floor size of the restaurant and the type of food served, (2) the number and types of takeout food containers and utensils used, (3) the number and types of beverage containers used, (4) the quantity of energy used broken down as electricity, natural gas, propane, gasoline and diesel fuel, (5) the quantity of water used, and (6) any other sources of energy that was missed.

3.4 Limitations

As with most studies, there are limitations to information or ability to conduct research. For this thesis, the following were limitations:

1. Information that was included as part of the content review of greenhouse gas reduction measures undertaken by municipalities may not be complete or representative.

2. The Province of Québec and the Territory of Nunavut did not grant an interview to verify the completeness and accuracy of the content analysis of greenhouse gas reduction legislation, policy and strategic plans present within their jurisdiction. Additionally, Ontario did grant an interview but only the current policy message was delivered which did not answer any of the questions.

3. When calculating greenhouse gas emissions associated with individual restaurants, the energy use does not take into consideration the total volume of a restaurant (i.e. larger volume restaurants require greater effort to heat and cool). Instead, it only takes into consideration the area of the restaurant. This is because restaurant owners readily know the area of the space they rent, as rent is based on this and not volume.

The use of multiple data collection techniques allows for a greater breadth of research and enables the blending of science and social science. Therefore, as will be revealed in the following section, the data collection method employed by this thesis will show how society has responded to the need to reduce GHG emissions and how this response can be measured empirically.

4. Results and Discussion

This thesis set out to investigate greenhouse gas reduction efforts related to energy use in the national, sub-national and municipal Canadian context. Chapter 2 provided the national context. In this chapter, results from the review and analysis of the provinces and territories are presented, followed by the municipal assessment. This includes primary data from interviews and questionnaires provincially, and a survey of restaurants in Toronto.

4.1 Sub-National Greenhouse Gas Reduction Legislation and Policies

As set out in the introduction, in the absence of a national greenhouse gas reduction strategy, many of the provinces and territories have already taken measures to reduce their GHG output through official legislation and regulations, policies and strategic plans. This section will look specifically at the GHG reduction measures in each of the provinces and territories of Canada to understand the provincial context in which the restaurant industry operates.

Table 4-1 separates GHG reduction strategies as being either legislated and policy-based (non-legislated). Under both legislated and policy-pased, it records whether the jurisdiction has GHG reduction targets, directly prescribes clean energy sources, indirectly allows clean energy sources (i.e. through a feed-in-tariff program), and if there is legislation for carbon pricing.

A summary of statutes and policies for GHG reduction related to energy use are provided for each province and territory in Appendix D. In general, it was found that policies and strategic plans do exist with or without legislated mandate. The only two jurisdictions that have no GHG reduction strategies in place are Saskatchewan and the Territory of Nunavut.

Out of Canada's thirteen sub-national jurisdictions, six have legislation that establishes GHG reduction targets, six have legislation designed to shift to cleaner energy sources, one has legislation that allows for indirect cleaner energy, and four have legislation that establishes a carbon pricing model.

G Reduction Measures by Sub-National Jurisdiction

	Legislation				Policy-Based			
	GHG Reduction Targets	Direct Clean Energy	Indirect Clean Energy	Carbon Pricing Model	GHG Reduction Targets	Direct Clean Energy	Indirect Clean Energy	Carbon Pricing Model
	YES	YES	NO	YES	NO	NO	NO	NO
	YES	NO	NO	YES	NO	NO	NO	NO
	NO	NO	NO	NO	NO	NO	NO	NO
	YES	YES	NO	YES	NO	YES	NO	NO
	YES	YES	YES	NO	NO	NO	NO	NO[8]
	YES	NO	NO	YES	YES	NO	NO	NO
	NO	NO	NO	NO	YES	YES	NO	NO
	NO	YES	NO	NO	YES	NO	NO	NO
nd	NO	YES	NO	NO	YES	NO	NO	NO
	YES	YES	NO	NO	YES	NO	NO	NO
	NO	NO	NO	NO	YES	NO	NO	NO
y	NO	NO	NO	NO	YES	YES	NO	NO
	NO	NO	NO	NO	NO	NO	NO	NO

Using a non-legislated strategy, seven jurisdictions have reduction targets policy and three have policies directing energy suppliers to cleaner energy sources. the eastern provinces do have an agreement between themselves to reduce GHG emissions. The Yukon and Northwest Territories do not legislate reduction targets but have set targets as a policy or strategic plan.

With respect to putting a price on carbon, four provinces have already established some form of carbon pricing with Ontario promising to follow suit in late 2015 and Newfoundland and Labrador is also looking at adopting a carbon price system in the future. The two most discussed carbon-pricing schemes, as discussed in the literature review, are carbon cap-and-trade and carbon fee.

All of the existing legislation targets energy production and use. This reflects the National Inventory Report's conclusion that energy production and use is the greatest contributor of GHG emissions followed by transportation.

Each jurisdiction that was interviewed indicated that there was discussion between the federal and provincial governments, in terms of establishing a sector-by-sector emission reduction approach. For this, nothing is formalized but it may be part of Canada's overall GHG reduction strategy that it will need to present at the COP21 UNFCCC conference in Paris this fall (November 30 to December 11, 2015). While no details on the nature of discussion were provided, interviewees also indicated that inter-provincial/territorial discussions happen more frequently than federal-provincial/territorial discussions, but that no formal agreements have been signed.

The next sections present information specific to each jurisdiction.

4.1.1 British Columbia

The province of British Columbia has established the *Clean Energy Act (2010)* that specifies that at least 93% of electricity generation within the province must come from renewable or clean sources. Clean is defined as a fuel source that has zero greenhouse gas emissions. They also have the *Greenhouse Gas Reduction Targets Act (2007)* that specifies targets of 33% reduction below 2007 levels by 2020 and 80% below 2007 by 2050.

The province also has a revenue neutral (fee-and-dividend) carbon fee that came into effect on July 1, 2008. The province began charging polluters $10/tonne of GHG and it now $30 per tonne of GHG produced. The province then returns the tax dollars collected to its citizens, referred to as a dividend (B.C. Climate Action Secretariat, personal communication, February 19, 2015).

In terms of support being provided to its municipalities, the provincial government does have discussion with its municipalities in an attempt to coordinate GHG reduction and other environmental conservation strategies.

One hundred and eighty-two local governments across British Columbia have signed the BC Climate Action Charter. Charter signatories commit to carbon neutrality in their corporate operations, to measure and report on their community's greenhouse gas emissions profile and work to create compact, more energy efficient communities. All local governments who sign the Charter get 100% of their carbon tax payments reimbursed by the province through the Climate Action Revenue Incentive Program.

The provincial government, in partnership with energy utilities, maintains and updates the Community Energy and Emissions Inventory, which represents energy consumption and greenhouse gas emissions from community activities in on-road transportation, buildings and solid waste. The inventory helps local governments meet the Climate Action Charter commitment to measure and report on community GHG emissions profiles.

Additionally, all local governments are required to include greenhouse gas reduction targets in their Official Community Plans and Regional Growth Strategies. They must also include policies and actions which support the GHG reduction targets (B.C. Climate Action Secretariat, personal communication, February 19, 2015).

4.1.2 Alberta

The Province of Alberta has the *Specified Gas Emitters Regulation* under the *Climate Change and Emissions Management Act (2007)* that requires industries releasing greater than or equal to 100,000 metric tonnes of GHG annually to reduce their output by 12% by either improving their operations, purchased approved offset credits, contribute to the Climate Change and Emissions Management Fund or purchase or use Emission Performance Credits. If they chose the payment option, the cost is $15/tonne over 100,000 (Alberta Energy Office, personal communication, February 13, 2015).

The Climate Change and Emissions Management Fund (CCEMF) that assists companies in reducing emissions and invests in GHG reduction research (Alberta Climate Change Policy Section, personal communication, February 18, 2015). According to the CCEMF website, they have reduced emissions by between 3.74 and 11.06 megatonnes annually since 2007 with a total of 50.65 Mt over seven years (CCEMF, 2015).

The Government of Alberta does have discussion with its municipalities. It has established the Municipal Climate Change action centre that funds and issues rebates to municipalities that reduce GHG emissions. They also have a micro-generation (feed-in-tariff) program that allows for renewable energy projects within municipalities (Alberta Energy Office, personal communication, February 13, 2015).

4.1.3 Saskatchewan

The Management and Reduction of Greenhouse Gases Act was approved by the Saskatchewan cabinet in 2010 with an approved amendment in 2013 but has yet to be proclaimed. The Act is based on a sector-by-sector approach being discussed nationally that would allow the Saskatchewan government to regulate greenhouse gas emissions if it exceeds or meets the federal regulatory standards. The Government of Saskatchewan did not respond to the question about providing support to its municipalities on GHG reduction or climate change. (Saskatchewan Ministry of Environment, personal communication, February 19, 2015).

4.1.4 Manitoba

Manitoba's Greenhouse *Gas Reductions and Emissions Act* (2008) set provincial reduction targets of 6% below 1990 levels by 2012; however, there were no penalties in place for not achieving this target and the target was not achieved. What was achieved was a stabilization of GHG emissions to 2010 levels. The province is currently reviewing what should be done next. Manitoba did phase out its coal-fired power plants as part of the standard grid; it does retain one in stand-by as emergency power until 2019 when a new hydroelectric power plant comes online. The phase out of coal power has reduced Manitoba's emissions from 300,000 tonnes to between 40,000 to 50,000 tonnes annually.

Manitoba also has a carbon-pricing strategy targeted to just coal use specifically in their agricultural sector as the majority of their farms rely on large quantities of coal to provide heating and other farming operations. As of 2013, each farm was required to submit a plan to convert from coal to an alternative energy source, including natural gas and compressed hay. The plans must be implemented by 2017. To assist in this transition, the Province of Manitoba aids in the purchase of necessary equipment as well as invests in research and development (Manitoba Climate Change Branch, personal communication, February 18, 2015).

The Government of Manitoba does provide support to its municipalities to reduction GHG emissions by way of using gas tax to build infrastructure and it works with its municipalities on municipal bylaws and polices. It also monitors and shares best management practices being employed by its municipalities between municipalities, such as a citizen neighbourhood planning model that is used to incorporate green space, bicycle paths and roundabouts.

4.1.5 Ontario

An interview was granted for Ontario; however, the questions posed were not answered and instead the Ministry of the Environment and Climate Change Ontario's Climate Change Discussion Paper 2015 was presented for details. Unfortunately, the discussion paper did not verify or elaborate on any of information; therefore information provided here should be considered content analysis only.

The Province of Ontario has a combination of legislation and policies that are designed to reduce GHG emissions within the province. The significant pieces of legislation are the Green Energy and Green Economy Act (2009) which allowed for the establishment of the Province's Feed-in-Tariff (FIT) and micro-FIT programs. Under the FIT program, independent power developers could develop renewable energy projects of greater than 10MW that would feed into the existing energy grid. The developers would receive a higher rate per kilowatt-hour. This is the same concept for the micro-FIT program; however, micro-FIT was meant for 10 MW or less and generally installed on residential and institutional buildings.

The *Climate Change Action Plan (2007)* outlines reduction targets, a regional transit plan, a green jobs fund, renewable energy investments and limits to urban sprawl. In terms of GHG reduction, the province committed to a 6% below 1990 levels by 2014 (61 Mt), 15% below 1990 levels by 2020 (99 Mt) and 80% below 1990 levels by 2050 (Ontario, 2007).

On Monday, June 13, the Province of Ontario announced that they would join the Province of Québec and the State of California in the Western Climate Initiative's Cap-and-Trade program. While an agreement was signed between Ontario and Québec, no formal law has been past as of yet.

No information on to what degree the Government of Ontario provides support to its municipalities was provided.

4.1.6 Québec

The Provinces of Québec, Newfoundland and Labrador, Nova Scotia, New Brunswick and Prince Edward Island have all committed to GHG reduction targets as an agreement at the Conference of New England Governors and Eastern Canadian Premiers (NEG-ECP) to reduce their emissions by 10% of 1990 levels by 2020 and 75%-85% below 2001 level by 2050.

The Province of Québec did not grant an interview for this thesis, so all of the information presented is strictly content analysis. With respect to legislation designed to reduce greenhouse gas emissions, Québec has taken a different approach than the other provinces.

Under the *Loi sur la qualité de l'environnement* (*Environmental Quality Act*, 1978), two regulations were added in 2012: *Regulations concerning the delegation of* *the management of certain parts of the cap-and-trade gas emission rights for greenhouse*[8] and *Determination of annual gas emission units of greenhouse gases related to the cap-and-trade gas emission rights for greenhouse ceiling for 2013-2020*.[9] The first regulation is a short document that adopts the principles and regulations of the Western Climate Initiative for Carbon Cap-and-Trade. The second regulation establishes the annual allotted emissions from 2013 to 2020. Technically, this second regulation does establish reduction targets.

The provinces website does indicate that it works with its municipalities in GHG reduction strategies, but provided no specific examples.

4.1.7 Newfoundland and Labrador

The Province of Newfoundland and Labrador does not have any legislation to reduce greenhouse gas; however, 90% of the province's energy comes from renewable sources. This number will rise to 98% by the end of 2017 when the new hydroelectric development at Muskrat Falls is completed. In terms of establishing reduction targets set under the NEG-ECP commitments, the province nearly met its commitment to stabilize GHG emission by 2010 by 0.4% and is proceeding with its commitment of 10% below 1990 levels by 2020.

The province has also committed to developing a framework for reducing GHG emissions in their large industrial sector, which accounts for 50% of all provincial emissions. They are considering the carbon pricing tools employed by British Columbia, Alberta and Québec (Office of Climate Change and Energy Efficiency, personal communication, February 18, 2015).

The provincial government does work with its municipalities to address matters relating to both climate change mitigation and climate change adaptation, including the provision of resources, tools and information. Many resources can be found on government's "Turn Back the Tide" website that contains information and

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[8] Original title: *Règlement concernant la délégation de la gestion de certaines parties du système de plafonnement et d'échange de droits d'émission de gaz à effet de serre* (2012)

[9] Original title: *Détermination des plafonds annuels d'unités d'émission de gaz à effet de serre relatifs au système de plafonnement et d'échange de droits d'émission de gaz à effet de serre pour la période 2013-2020* (2012)

resources on climate change and energy efficiency. It has portals specifically for households, businesses and communities.

Some examples provided were the Climate Change Vulnerability Assessment Tool to help communities assess their vulnerability to climate change and the carbon calculator tool that allows municipal governments to estimate the GHG emissions from their municipal operations. It also provides tips and information on how to save energy, reduce GHG emissions and lower operating costs (Office of Climate Change and Energy Efficiency, personal communication, February 18, 2015).

4.1.8 Nova Scotia

There are two primary pieces of legislation intended to reduce greenhouse gas emissions in the Province of Nova Scotia. The first is the *Environment Act* (1994) where sections 28(6) and 112 outline greenhouse gas regulations that establish progressively lower cumulative caps on GHG emissions within the province. *Environmental Goals and Sustainable Prosperity Act* (2007) originally established the NEG-ECP target of 10% below 1990 levels with 18.5% of energy coming from renewable sources by 2020. This act was replaced by the Green Economy Act (2012) that sets out significant reductions targets in GHGs from the electricity sector, of at least 25% below 2007 levels by 2020 and 55% below 2007 levels by 2030, will be achieved as the electricity sector meets the GHG caps set under the Greenhouse Gas Emissions Regulations (Climate Change Nova Scotia, personal communication, February 27, 2015).

As of December 2013, Nova Scotia municipalities were required to prepare and submit to the province a Municipal Climate Change Action Plan that focuses on both climate change adaptation and mitigation and describe how municipalities plan to respond to climate change (Climate Change Nova Scotia, personal communication, February 27, 2015).

4.1.9 New Brunswick

The Province of New Brunswick does not have any legislation designed to specifically reduce or set GHG reduction targets. It does have a Climate Change Action Plan that mirrors the commitments of the NEG-ECP agreement. To achieve this goal, it added the Electricity from Renewable Energy Regulation under its *Electricity Act* that requires 40% of its power to come from renewable sources by 2020. Outside of the regulation, the province has a stricter energy policy that requires New Brunswick Power to acquire 75% of all its electrical supply from clean or renewable energy sources in the same timeframe.

In terms of providing municipalities with measures to reduce GHG measures, municipalities have been allowed to set electricity rates within their boundaries; however, there is no information on how this has aided municipalities in the reduction of their GHG emissions (Ministry of Environment and Local Government, personal communication, February 18, 2015).

4.1.10 Prince Edward Island

The province of Prince Edward Island passed the *Renewable Energy Act* in 2004 that provides legislative force to many components of the province's Renewable Energy Strategy. The Act allows small capacity renewable energy generators to add power to the energy grid. It also set the requirement that electrical utilities must acquire at least 15% of their energy from renewable sources by 2015, this was achieved by 2007 and a policy decision was put in place to increase this to the current 27%. They are currently considering repealing this requirement because it eliminates or significantly reduces the potential sale of renewable energy credits in a carbon market (Office of Energy Efficiency, personal communication, February 10, 2015).

With respect to the province supporting its municipalities on GHG reduction or climate change, Island municipalities are able to take advantage of the province's commercial grant program. Also, some municipalities have installed small-scale wind generators with provincial government funding (Climate Change Nova Scotia, personal communication, February 27, 2015).

4.1.11 Yukon Territory

Of all the sub-national jurisdictions in Canada, the territories have been experiencing the greatest impacts by climate change with priorities in infrastructure at risk due to permafrost melt, the changing hydrologic cycle and increased forest fires. They also have the greatest challenges in terms of energy generation, with Nunavut being completely dependent on fossil fuel energy generation.

The Yukon Territory does not currently have any legislation that specifically targets greenhouse gas reductions. They do; however, have a comprehensive Climate Change Action Plan that is addressing mitigation measures and adaptation issues concurrently. From a mitigation aspect, the Yukon has committed to cap GHG emissions related to government operations at 2010 levels and reduce this by 20% by 2015 and become carbon neutral by 2020. They have also identified a commitment to adopt the more stringent LEED buildings code for government and government funded commercial and institutional buildings (Yukon Climate Change Secretariat, personal communication, February 18, 2015).

4.1.12 Northwest Territories

Legislation for the reduction of GHG emissions in the Northwest Territory has not yet been developed. However, the Government of the Northwest Territories has developed a Greenhouse Gas Strategy to guide actions to control emissions under the Energy Action Plan, the Biomass Energy Strategy and the Solar Energy Strategy. The current target is to stabilize emissions in 2015 at 2005 levels; however, they anticipate there will be some growth in emissions through to 2020. The long-term goal is to further develop renewable energy supplies so that emissions return to the 2005 levels by 2030 (Department of Environment and Natural Resources, personal communication, March 2, 2015).The territory has established and funds the Arctic Energy Alliance that provides advice and assistance to communities to encourage better use of energy leading to emission reductions. It also provides funding for community based solar photovoltaic systems and biomass heating systems.

4.1.13 Nunavut Territory

The Government of Nunavut did not grant an interview as part of the development of this thesis therefore the information presented here is strictly content analysis. The government website is clear that 100% of its energy generation is fossil fuel which presents challenges to reduction strategies. That said, they are retrofitting buildings with LED lights, solar hot water heating systems and solar wall air preheating. No legislation was found pertaining to GHG reduction. There was no information related to support provided to its municipalities.

4.1.14 Summary of Findings

Greenhouse gas reduction targets have been established in eleven of the thirteen jurisdictions with and without legislative support, with only the province of Saskatchewan and the Nunavut Territory not having set targets. Reduction targets established by the remaining jurisdictions are largely focused on moving to cleaner energy sources with five jurisdictions also introducing a carbon pricing model to encourage GHG reduction.

All of the provinces and territories have confirmed that there is national and inter-sub-national discussion on GHG reduction but no coordination. The federal government is currently developing a sector-based approach for GHG reduction in preparation for the next COP meeting in Paris, France in December 2015. It will likely be a legislative approach and it was suggested that federal regulation may supersede any provincial requirements. However, until this federal government announces its approach, it is merely speculation.

The majority of the provinces and territories are working with their municipalities on matters of climate change mitigation measures and adaptation strategies. The support has included the development of tools and guides, establishment of feed-in-tariff programs and the establishment of a province-wide

GHG monitoring and reporting system. These measures should be considered best management practices and better shared between jurisdictions.

As discussed, municipalities also have a range of tools that can be used to directly and indirectly influence GHG emissions within its boundaries through land use and zoning, building permits and development approvals, parking, roads and public transit, parks and recreation and can be involved in water, power and gas utilities. At the same time, municipalities face many barriers when attempting to mitigate GHG emissions. The following section will look at other strategies that Canadian municipalities have employed to reduce their GHG emissions.

4.2 Municipal GHG Reduction Strategies for Energy Use

Section 4.1 looked at how GHG reduction was being addressed by the provinces and territories in Canada. This section will look at GHG reduction strategies within municipalities across Canada. Greenhouse gas reduction strategies were analyzed for the top fifty most populous Canadian municipalities, including Toronto. All fifty municipalities had populations of 100,000 people or more. It was found that exactly fifty percent of the studied municipalities had an official GHG reduction strategy.

Many municipalities did have an array of environmental programs including GHG reduction measures; however, this thesis was only concerned with strategies that other municipalities are using to reduce GHG emissions. Only actions related to electrical and natural gas use were recorded.

The majority of the cities had similar actions such as retrofitting buildings, gas recovery from landfill sites for use in energy generation, hybridized or electric public transit vehicles, anti-idling bylaws, expanded bicycle trails and some urban forestry measures. Of particular interest was the concept of neighbourhood heating and cooling systems, which Toronto has partially implemented. The next two subsections will discuss the measures identified in other Canadian cities.

4.2.1 Potential Reduction Strategies

A review of GHG reduction programs and policies of fifty of Canada's most populous cities was conducted to get a picture of strategies used to reduce GHG emissions. This review was conducted using municipal websites and the method presented in section 3.2. Ten strategies were identified and this section will discuss each program. Following the compilation of these programs, an interview with Dr. Chris Morgan, Director of Energy and Environment with the City of Toronto has conducted to explore the opportunities or barriers of these programs within the context of the City of Toronto.

Table 4-2 Municipal Programs to Reduce GHG and Opportunities and Barriers to Toronto

Measures	Reduction	Opportunity/Barrier
LED street lights and Traffic Lights	19% - 44% energy reduction	Owned by Toronto Hydro, public opposition to brightness of LED
Expanded Solar on Public Buildings	~ 6.28 tonnes GHG/m^2	Unknown # buildings/area and average daylight, program expansion underway.
Expand Peaksaver Program	2^{o}C to 4^{o}C reduction, unknown energy reduction	Unknown savings, not current focus of the City.
Solar Heating Program	~ 50% energy reduction	Incentive barrier, no influence at the moment.
Increase Urban Density	Unknown but potentially very high reduction	Opportunity is compound effect with districting heating/cooling, planning underway.
Free Home Energy Assessment	Unknown	Incentive barrier and savings unknown, pilot program discontinued
Green Insurance	Unknown	Incentive barrier and savings unknown, Toronto not interested.
Reducing heat island effect	4^{o}C to 6^{o}C reduction, unknown energy reduction	Barriers are provincial building code and developer lobbying, Toronto aware of issue.
Expand District Heating and Cooling	225 to 400 tonnes GHG/tower/year	Outside of city influence, need to expand and upgrade but lack of funding.
Smart Grid with Renewable Energy	Unknown	Incentive barrier, aged infrastructure, lack of funding.

Table 4-2 presents these programs and policies that serve to reduce GHG emissions in both electricity and natural gas, how much GHG could be reduced and what barriers exist to implementation. The programs and associated cities can be found in Appendix E.

Most municipalities have addressed energy use reduction through the capturing of landfill gases and replacing equipment with more energy efficient versions, or indirectly by measures such as retrofitting a building. Natural gas efficiency improvements have generally been achieved via purifying the energy source and in improving the efficiency of appliances, furnaces, etc.

However, novel approaches to energy reduction in general also exist, such as implementing neighbourhood heating and cooling, micro-energy grid, smart grids, etc. This section will review these novel approaches; however, no follow-up interview was granted by the City of Toronto to explore the feasibility of these options, therefore additional research in these areas are recommended.

4.2.1.1 LED Street and Traffic Lights

According to the International Energy Agency (2006), lighting uses 19% of the global electricity generated; this translates to approximately 6% of the total global greenhouse gas emissions. Standard street lights are based on high pressure sodium (HPS), low pressure sodium (LPS) and metal hydride (MH) and have a lifespan of up to 60,000 hours per bulb and use between 18 and 400 watts her hour (Juntunen et al., 2015). As mentioned in the first section, the City of Toronto has 160,000 streetlights.

Outside of the general energy use considerations of Toronto's street lamp system, another problem is that the time during which the light tends to be on is poorly executed because they are on a citywide timer that does a poor job at estimating when the lighting is needed. Several researchers have looked at the efficacy and energy savings found when switching to an LED-based lightening system both with and without smart technology (Juntunen et al., 2015; Zhang et al, 2014; Elejoste et al., 2013; Beckwith et al., 2011). Consensus was reached between the researchers that between 19% to 44% of the overall energy is saved without smart technology and between 40% and 60% using smart technology. Smart technology can mean a centralized system that can be easily controlled from a single office, either wired or wirelessly, or it means equipping the street lamps with light sensors that automatically turn the light on when it is dark enough and turn them off when it is bright enough.

The cities of Edmonton (AB), Calgary (AB), Ottawa (ON), Halifax (NS) and Coquitlam (QC) have replaced or are replacing street lights, traffic lights or both with LED lights that are estimated to save between 40% and 60% of electricity a compared to the standard High Pressure Sodium Lamps. In all of these cities, implementations are proceeding as a phased approach for old lighting and are standard installation in new subdivisions.

If implemented in Toronto, the replacement of over 160,000 street lights and over 2,100 traffic lights with LED lights these would assist in further reducing the City's GHG emissions associated with electricity use. However, this measure would not aid in the reduction of GHG related to natural gas consumption.

In conversation with Dr. Christopher Morgan, Director of Energy and Environment at the City of Toronto he explained that there was an effort approximately ten years ago to install energy efficient street lighting but it was before LED technology. Since then, the City transferred ownership of the hydro poles and associated lighting to Toronto Hydro. Although the City has majority ownership of Toronto Hydro, they have very little influence on Toronto Hydro operations. There is, however, an effort to replace traffic lights with LEDs throughout the city.

4.2.1.2 Expanded Solar Power on Public Buildings

Toronto, as well as other Canadian cities, such as Edmonton (AB), Kingston (ON), and Yellowknife (YK), have begun installing solar panels on municipally-owned buildings which feed into the energy grid. Within the C40 group of cities, San Francisco has installed solar panels covering 60,000 square feet that generates 826,000 kWh annually, equivalent to powering 184 average American homes for an entire year and reducing 35,000 tonnes of GHG annually (C40, 2011).

In most instances, the buildings cannot use the energy they generate but they do serve to add additional renewable energy to the Ontario power grid and aid in the reduction of associated GHG emissions. There are plans to expand renewable energy in general within Toronto, with a current focus on biomass but will also include installing solar panels on public buildings (Christopher Morgan, personal communication, March 13, 2015).

4.2.1.3 Expand and Require Peaksaver Program

Peaksaver is a partnership program with Toronto Hydro, HydroOttawa, HydroOne, the Ontario Power Authority and other utilities that allows electricity utilities to adjust individual home thermostats remotely during peak electricity demand times, specifically very hot days. The program involves the installation of a smart thermostat into people's homes that receive commands from electric utilities.

The program is currently designed to reduce only air-conditioning energy use by 2 to 4 degrees Celsius, but the technology could also be expanded to adjust winter-time heating. By expanding the program to include heating reduction, the Peaksaver program would aid in the reduction of both electricity and natural gas use.

Toronto does have access to the program and it is also used in Ottawa (ON). The program could be even more useful if electricity utilities or municipalities required every home to have a smart thermostat and be subscribed to the Peaksaver program. However, no data were available on how much energy is saved or has been saved by the program to date.

The City of Toronto does have interest in following New York City's example of mandatory "Statements of Consumption" of electricity and natural gas use for residential and office towers. This would allow the city to direct energy reduction efforts, such as prioritizing building retrofitting or other programs like passive solar heating, etc. There is a report currently been prepared on the matter that will be presented late 2015 (Christopher Morgan, personal communication, March 13, 2015).

4.3.1.4 Solar Hot Water Heating

In Canada, GHG related to residential energy use is 41 million tonnes and 38 million tonnes in the commercial sector. Water heating accounts for approximately 17% of residential energy use in Canada and solar water heating systems have been shown to reduce this energy use by 50% or 20.5 million tonnes of GHG (Natural Resources Canada, 2015; U.S. Department of Energy, 2015). There is no information on the reduction of energy use in the commercial sector (which includes the restaurant industry) when installing a solar water heating system but this is an area of future research.

In passing discussion with restaurant owners as part of this thesis, it was mentioned that there was a trend of restaurants replacing their large water heating tanks with tankless water heaters. If this is true, this would also serve to reduce energy use, largely from natural gas, and have some measure of GHG reduction. More research is required in this area.

Halifax (NS) and Saanich (BC) have piloted a solar heating and solar hot water heating projects that either use solar energy to heat public buildings and apartment complexes or preheat water, both measures aid in the reduction of natural gas use and associated GHG emissions.

Pilots of this program already exist in Toronto and it is slowly expanding.

4.3.1.5 Increase Urban Density

As population increases it can either spread outwards or it can be concentrated in the existing city. The cities of Montreal (QC) and Surrey (BC) include policies to increase urban density to improve energy efficiency in the cities. Part of the plan includes the establishment of neighbourhood heating and cooling systems, but could also include smart energy grids and building-mounted renewable energy. Therefore, this approach would work to reduce both electricity and natural gas energy use.

The City of Toronto is currently working on development plans for the city; the goal is to have “Stable Neighbourhood” and “Growth Nodes” plans that will control density around the city. (Christopher Morgan, personal communication, March 13, 2015).

4.3.1.6 Free Home Energy Assessments

The City of Gatineau (QC) provides free home energy audits and the City of Oakville (ON) lends out energy meters to test the energy efficiency of household appliances. Both types of assessment allow homeowners to know and understand their home efficiency in order to make improvements. This approach would work to reduce both electricity and natural gas energy use.

The City of Toronto ran a pilot program in the early 2000s in Wards 30 and 32 to provide home energy assessments. The program was well received by residents and aided homeowners in directing their energy reduction efforts, from changing light bulbs to retrofits. It was cancelled after approximately 8 years and there has been no discussion on revisiting the program (Christopher Morgan, personal communication, March 13, 2015).

4.3.1.7 Green Home Insurance

While Green Home Insurance is not a program offered by the City of Gatineau (QC), it does promote working with the insurance companies to receive a “Green Home Rate”. Insurance companies have recognized climate change as being a risk to their business operation and may be willing to aid in GHG mitigation by offering better rates. This approach would work to reduce both electricity and natural gas energy use. There is no interest in this at the moment from the City of Toronto (Christopher Morgan, personal communication, March 13, 2015).

4.3.1.8 Reducing with Heat Island Effect

The Urban Heat Island (UHI) effect is a phenomenon where the temperature within an urban setting (i.e. city) is warmer than the ambient rural temperature surrounding the urban area (Hu and Brunsell, 2015). In Toronto, the Urban Heat Island Effect increases the average temperature of Toronto streets between 4^{o}C and

6°C depending on land use (Rinner and Hussain, 2011). The City of Windsor (ON) is addressing their UHI effect that artificially creates microclimates of increased heat in order to better land use plan.

UHI is largely related to areas of the city with a lot of dark surfaces, such as parking lots, streets and roof shingles. Reducing the heat island effect would allow for lower temperatures during the summer months and therefore reduce energy required for air conditioning. This measure could reduce both electricity and natural gas use (for those with natural gas-powered air conditioners).

This problem is being partially addressed as part of Toronto's air quality improvement program where they are ventilating streets with poor quality air. The greatest problem that Toronto is having is the albedo effect of all the glass buildings within the high-density areas. The glass is reflecting infrared heat down towards the streets increasing the temperature (Christopher Morgan, personal communication, March 13, 2015). In this sense, the newer glass buildings may have better window technology to keep the additional heat out. More research in this area is needed.

4.3.1.9 Expand District Heat and Cool Program

Toronto currently has a district deep-water cooling program that is operated by EnWave. It operates by using the cool waters of Lake Ontario to generate air conditioning to 100 office buildings in the downtown core, covering 3 million square metres. EnWave estimates that it prevents approximately 40,000 tonnes of GHG annually as compared to traditional air conditioning. The Cities of Vancouver (BC), Surrey (BC) and Richmond (BC) have also implemented a district heating and cooling systems.

The City of Vancouver based this project on the EnWave project that has been operating in the City of Seattle, Washington since 1893. Seattle's EnWave uses biomass to supply heating and cooling to 200 high rise buildings in the Seattle downtown core and eliminating approximately 45,000 tonnes of GHG annually, it also serves to low the utility costs to residents.

Perhaps the most significant aspect of this technology is eliminating the demand for natural gas heating, as discussed above, as methane is a greenhouse gas that is 86 times as potent as carbon dioxide over a 20-year period.

Therefore, the expansion of Toronto's current cooling system would serve to reduce more GHG related to air conditioning, which is generally electrical energy. However, the creation of a heating system like the Cities of Vancouver and Seattle would likely remove a significant quantity of GHG associated with natural gas heating.

The City of Toronto used to own EnWave when it was the Toronto District Heating Centre. It did formerly offer district heating via steam and turbine but this is no longer efficient or employed. The City still partially owns EnWave but has little influence on its direction. Although it is welcomed by the City, EnWave has no plans to expand operations or establish satellite systems elsewhere in the city (Christopher Morgan, personal communication, March 13, 2015).

4.3.1.10 Smart Grids and Local Grids

At present, fossil fuel based stand-by power plants are used to accommodate periods of higher energy demand. The purpose of smart grid technology is to provide real-time feedback to power plants so that they may increase their cleaner energy production and negate or reduce the need for stand-by fossil fuel energy.

While the City of Toronto may not have control over the energy sources chosen by the province, it does have the ability to work with the provincial government to expand the smart meters on all electricity recipients in the city and to work with the Province, perhaps through Ontario's micro-fit program, to begin incorporating renewable energy sources throughout the city.

Since the Ontario power grid still uses natural gas as part of its electrical grid energy source, it may also be possible to incorporate Feed-In Tariff renewable energy sources (10 kilowatts or less) to the local energy grids to further reduce the need for fossil fuel derived energy. There is currently no data available on the exact quantity of GHG attributed to stand-by power plants; however, since fossil fuels contribute directly to GHG emissions, the elimination of stand-by power plants would reduce GHG emissions associated with the electrical grid.

Presently, the province's Smart Metres are not functioning as designed in that the utility cannot currently read the electrical demand in real-time. The city has discussed the idea of smart girds with renewable energy interspersed throughout the City; however, Toronto Hydro engineers have stated that the age and type of the transmission lines prevent this at present. Furthermore, the cost of replacing the existing transmission lines and expanding a smart grid is too costly at the moment and would likely require a rate increase (Christopher Morgan, personal communication, March 13, 2015).

However, smart energy grids, with or without renewable energy, requires long-term planning, organizational commitment and despite long-term savings, are accompanied by high initial costs.

4.2.2 Summary of Findings

When reviewing the GHG reduction programs within Canada's top fifty most populous cities, it was found that fifty percent of the cities had developed a various programs aimed to reduce GHG emissions. The most basic of the programs was support for urban forestry and parks to be used as carbon sinks and the most advanced programs involved old building retrofit programs, low interest loans, public involvement in neighbourhood design (for bicycle lanes and roundabouts), landfill methane capture and heating and district heating and cooling programs.

Several additional greenhouse gas reduction measures employed by other Canadian municipalities have been identified for potential adoption in Toronto. However, many of these other measures are being done as part of new standard operations (and therefore not advertised as in the case with other cities), or they have been tried as pilot projects and discontinued regardless of success rates, or are outside of the influence of the City. Other measures, such as a district heating and cooling system, are outside of the influence of the City to undertake.

Finally, the top fifty most populous cities in Canada represented communities with a population of 100,000 people or greater.

The overall conclusion here is that the city needs to work with the province to facilitate greater opportunities to promote and implement local energy efficiency and energy reduction strategies at the municipal level, including for restaurants.

As discussed, municipalities also have a range of tools that can be used to directly and indirectly influence GHG emissions within its boundaries. With respect to the restaurant industry, outside of energy sources, municipalities regulate matters of zoning, issuing building permits, reviewing building plans and enforcing provincial and municipal building codes. The next section will see how sub-national GHG reduction measures translate to action, energy use and associated emissions of independent Toronto-based restaurants were examined as part of this thesis.

4.3 Energy Use and GHG in the Restaurant Industry

As set out at the beginning of this thesis, the restaurant industry was chosen because there is very little information as to the GHG emissions generated within this industry. As discussed, they are also a ubiquitous aspect of any municipality and tend to increase in number as cities grow. Restaurants also use provincial energy systems but are a large component of Toronto's energy consumption. Therefore, if restaurants can improve energy consumption they may have a direct impact on municipal and provincial energy use.

Energy use in the restaurant industry includes both electricity and natural gas. Figure 2-8 presented how energy is used, on average, in the restaurant industry. From greatest to least: food preparation (24.4%), heating (16.6%), refrigeration (16.4%), sanitation (15.7%), lighting (9.8%), cooling (6.8%), ventilation (5.6%), office operations and other (4.7%) (Sustainable Food Services, 2014).

In most cases, electricity is used for lighting, appliances and air conditioning while natural gas is used for cooking and heating. Because of this, energy use is expected to fluctuate throughout the year in response to temperature changes and customer flow.

As part of this study, 120 restaurants were invited to participate in a questionnaire that asked them general information as to the size and nature of their restaurant (i.e. take-out, sit-down, both), the types and quantities food and beverage containers used, and energy and water use. A total of 34 restaurants responded representing a 28% participation rate. The raw data is presented in Appendix C.

The questionnaires asked respondents to review and report on their electricity and natural gas bills, reported as kilowatt-hours (kWh) and cubic metres (m^3), respectively. They were also asked to report on the size of their entire space, or area, as square metres (m^2). The size of the restaurants spanned from 41.81 m^2 to 195.09 m^2.

Collectively, these 34 restaurants consumed 277,641.65 kWh of electricity and 433,205.87 m^3 of natural gas. Using the Provincial coefficients of 0.105 kg GHG/kWh and 1.891 GHG/m^3, these 34 restaurants generated approximately 29,152.37 GHG from the electric grid and 819,192.30 kg GHG from natural gas for a combined total of approximately 848,344.67 kg of GHG over the course of one year. This would equate to an average of 24,951.31 kg per restaurant.

As of 2012, Canada has more than 81,000 restaurants with Toronto having approximately 16,442 restaurants, by using an average of 24,951 kg GHG per restaurant, this would mean 2,021,056,110 kg of GHG nationally and 410,244,342 kg GHG within Toronto.

Since Canada released approximately 740 million tonnes of GHG in 2012, the restaurant industry would comprise 0.27% of the natural GHG emissions. Within the context of the City of Toronto, it released 20.31 million tonnes in 2012 from this, the restaurant industry accounted for approximately 2.02% of Toronto's overall GHG emissions. Therefore, the GHG emissions related to the restaurant industry can be considered to be nominal.

4.3.1 Restaurant Size and GHG Emissions

Using the provincial energy coefficients, as above, the kg of GHG emissions for each restaurant was calculated using the data on electrical and natural gas use. Figure 4-1 shows that there are three groups of restaurants based on their size, which will be called small, medium and large restaurants.

It is expected that GHG emissions would increase as the size of a restaurant increases, to confirm this Figure 4-1 presents a linear regression of restaurant respondent sizes (m^2) against the associated GHG emissions (kg). Linear regression is used to model the relationship between two variables by fitting a linear equation to the observed data. Unfortunately, the line does not fit well between the data points suggesting that there is no reliable relationship between the size of a restaurant and the GHG emissions produced.

However, the linear regression of the GHG intensity of restaurants, as GHG emissions per unit size of the restaurant (kg GHG/m^2), does reliably show that as restaurants increases in size, the intensity of their emissions decrease (Figure 4-2). This suggests that energy is being used less efficiently in smaller restaurants as compared to larger restaurants.

There are various physical and operational parameters that may be responsible for smaller restaurants being less energy efficient. Physically, restaurants were asked to report on the area of their restaurants and it is expected that restaurants with a larger area (m^2) to heat, cool and light will use more energy to do so; however, what was not reported was the total volume of a restaurant (m^3). Restaurants with larger volumes require more heating, cooling and potentially lighting. There may also be a difference in insulation efficiency of buildings.

Operationally, how food is prepared would affect the quantity of energy used, such as pizza ovens versus burger grills versus woks versus deep fryers. The nature of the business may also have an effect; restaurants that rely more on take-out may mean the door would be opened and closed more often.

Figure 4-1 Restaurant Size and GHG Intensity by Respondent

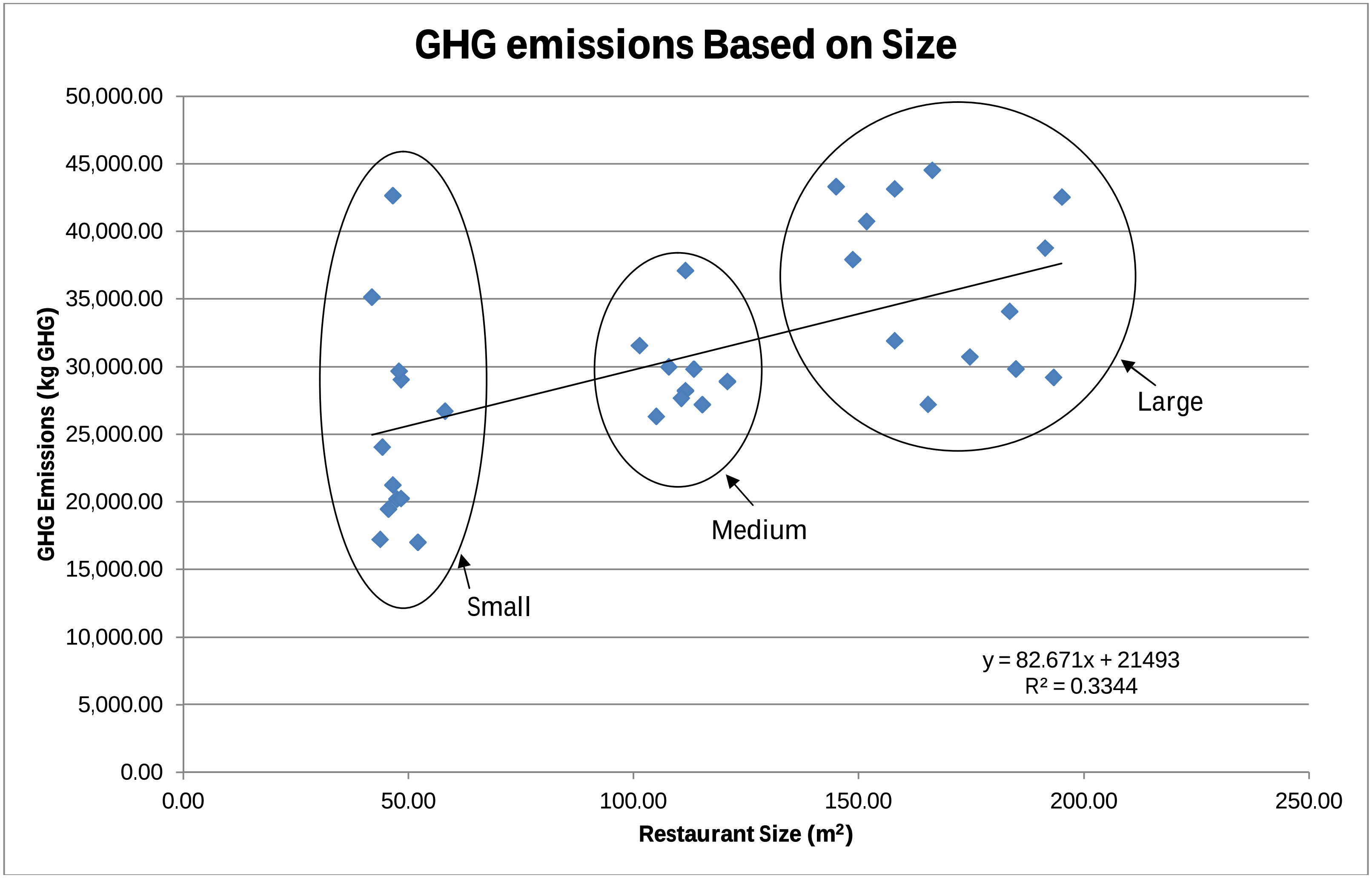
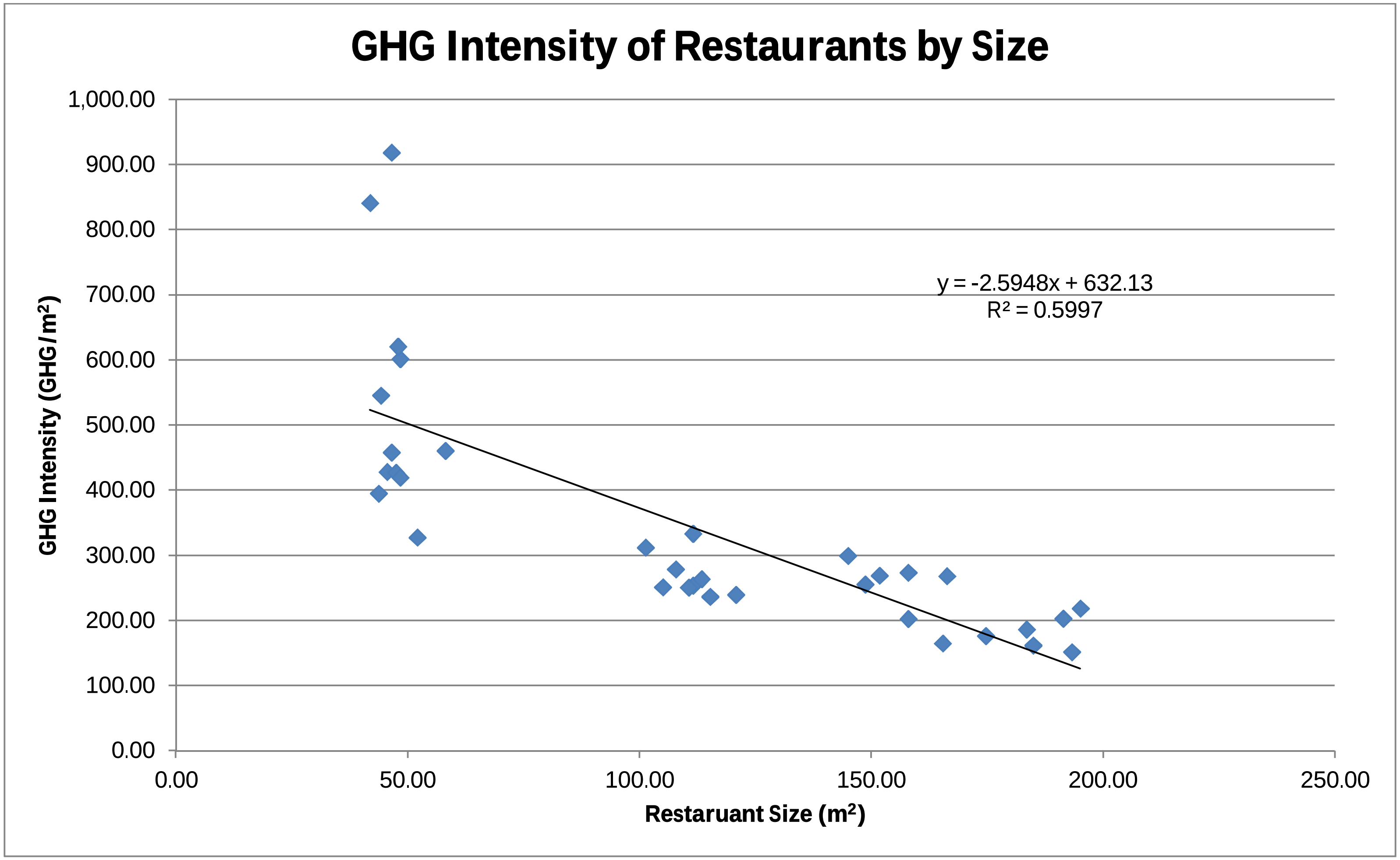


Figure 4-2 GHG Intensity of Restaurants by Size



Finally, the types of food prepared would dictate how food was prepared but also how it is stored; some restaurants may need larger or more refrigeration units and food may need to be cooked longer or at a higher temperature. Further research in this area is required.

To further investigate energy intensity and to understand why it appears that smaller restaurants have the highest energy intensity, the next three sections will look closer at individual restaurants.

4.3.2 Seasonal Variance

From Figure 4-1, the sizes of restaurants were sorted into small, medium and large restaurants based on size. Using the monthly data that was collected for electricity and natural gas, figures 4-3, 4-4 and 4-5 contrasts the GHG intensity of electricity use against GHG emissions of natural gas use for small, medium and large restaurants.

From these figures, seasonal variance in emissions can be seen in both energy sources and are most likely related to heating and cooling. It would be expected that, gas emissions increase in the winter months as heating need increases and electricity increases in the summer as air-conditioning use increases.

From figure 4-3, natural gas use does increase in what are considered to be winter months (January, February and March), with a decrease in use in March but it increases in April again. Electrical energy use does increase in the warmer months, which may be associated with air-conditioning. It may also represent an increase in patronage.

From figure 4-4, for medium-sized restaurants, the same increase in natural gas is seen in the same cold months and the same increase in electricity use is seen in the same warm months; however, there is greater use in natural gas as compared to the larger restaurants. This may be related to natural gas-powered air-conditioning and refrigeration or the types of food prepared.

Figure 4-3 GHG Intensity by Energy Source for Large Restaurants

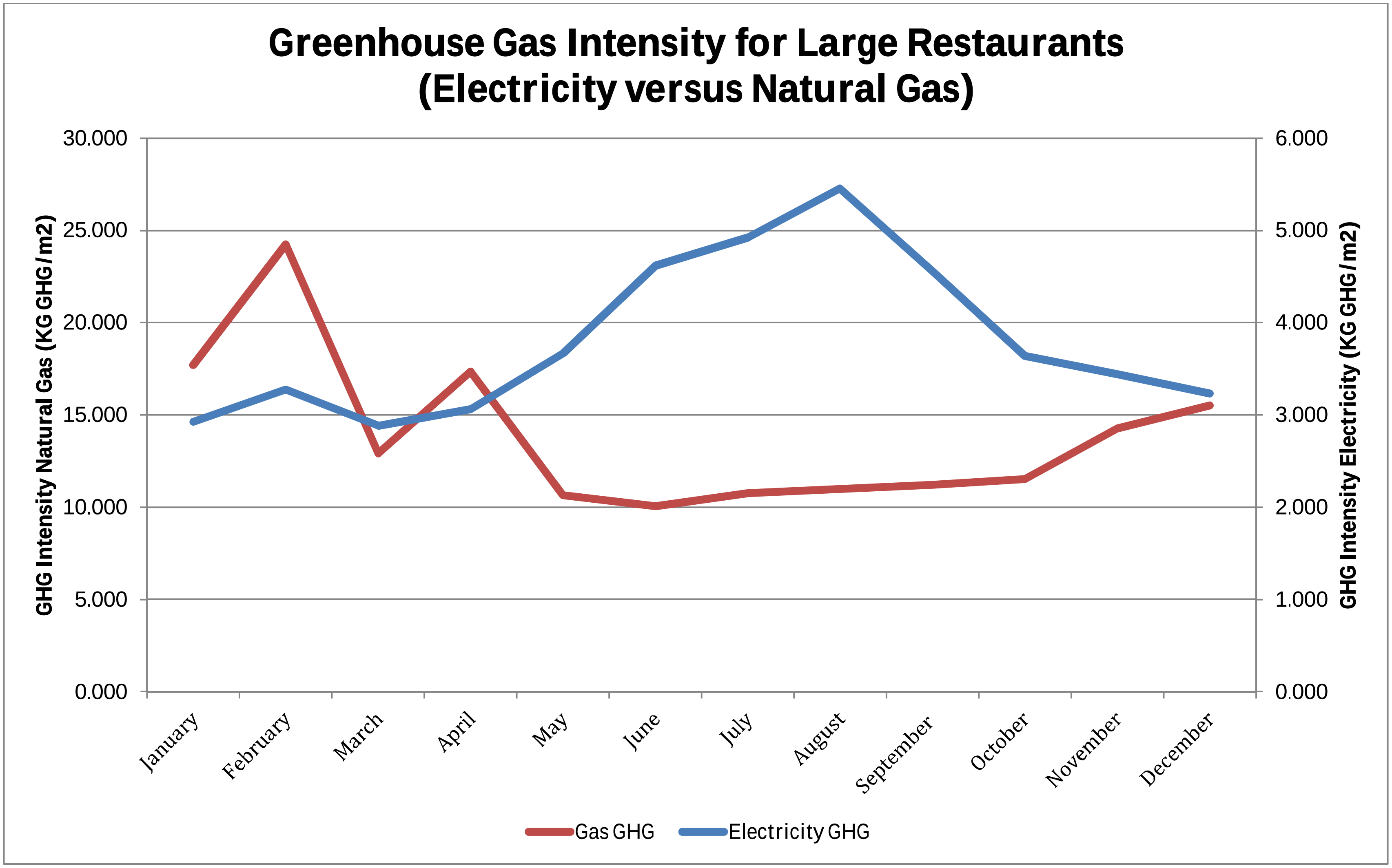


Figure 4-4 Intensity by Energy Source for Medium Restaurants

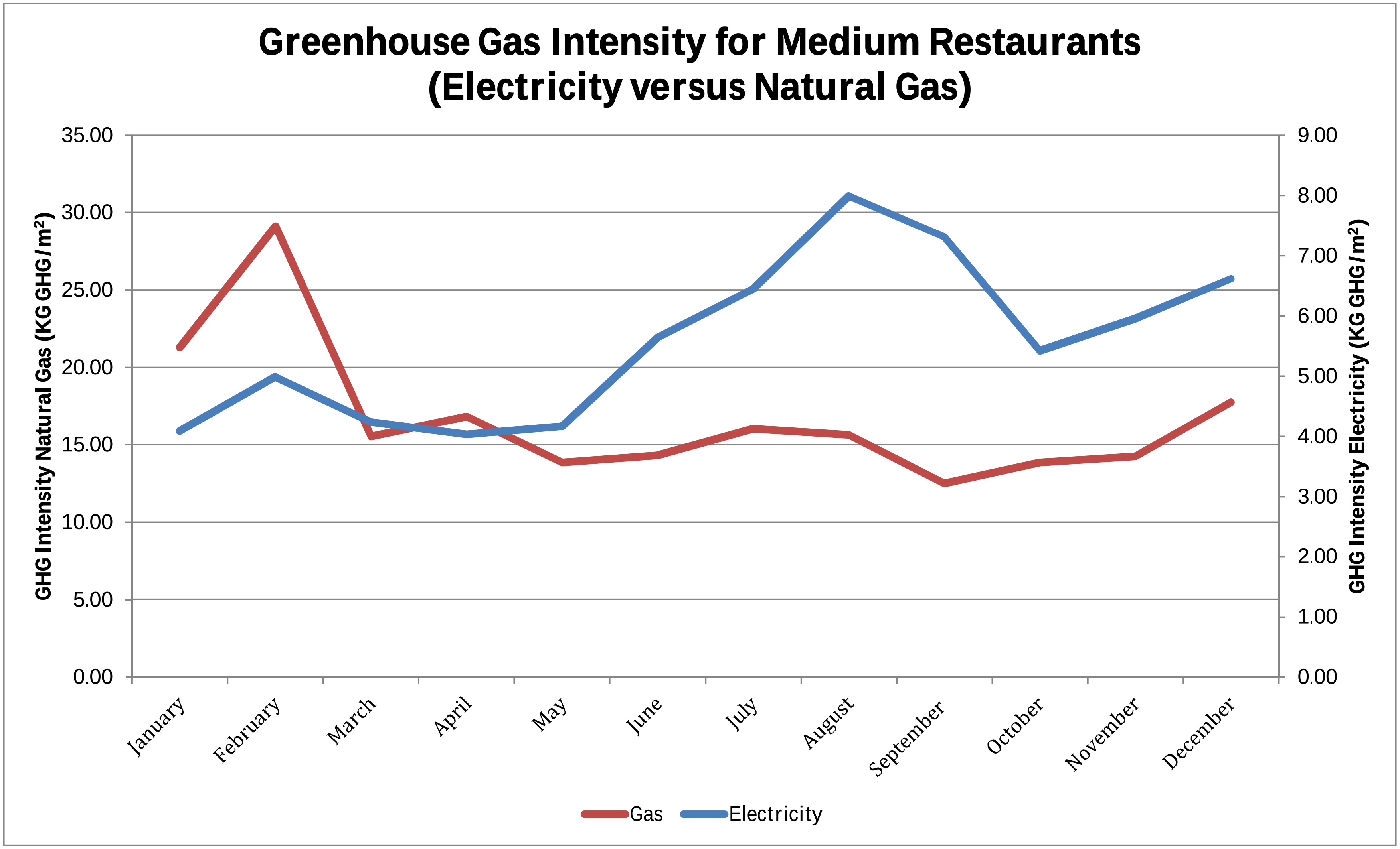


Figure 4-5 Intensity by Energy Source for Small Restaurants

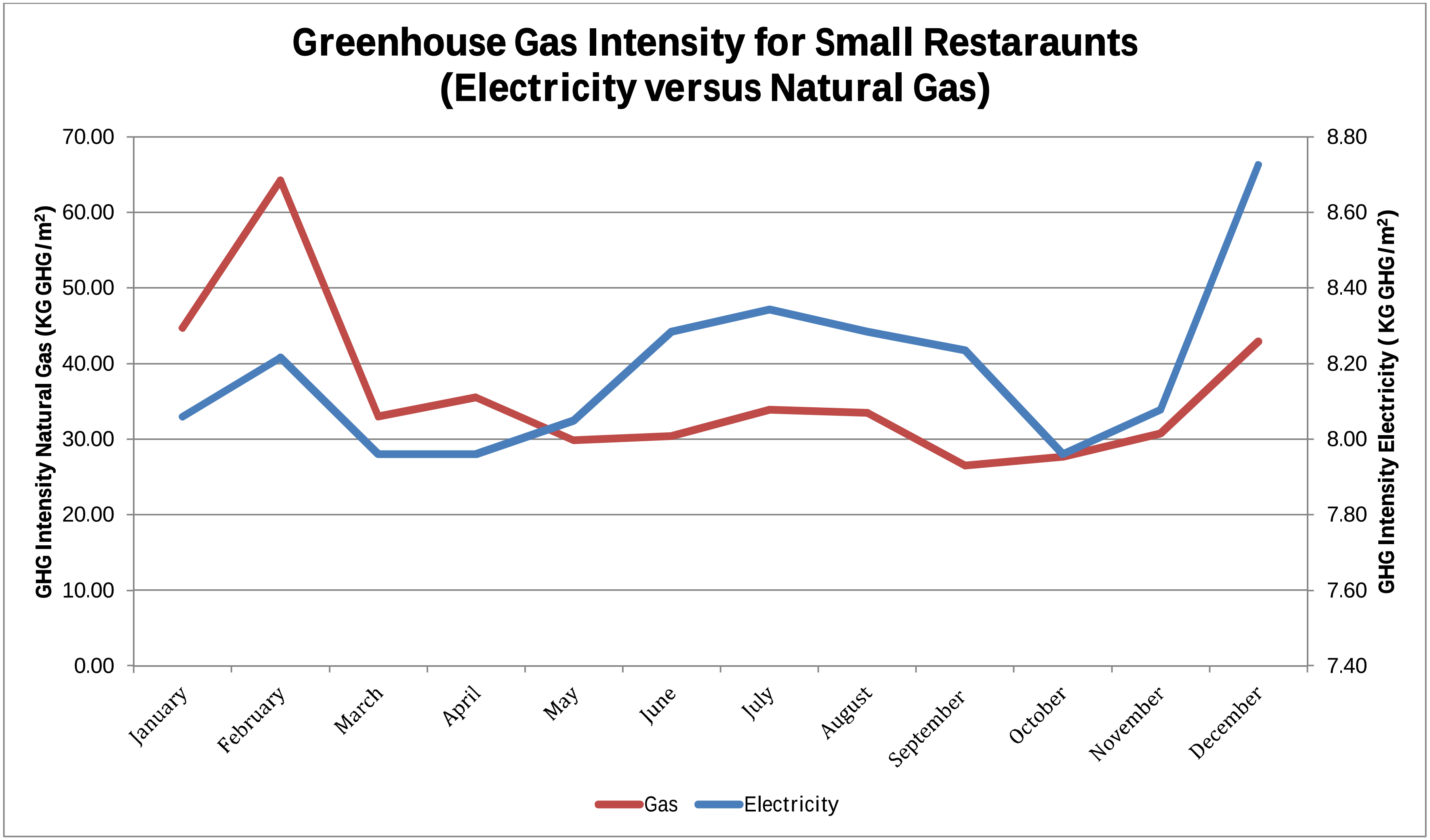
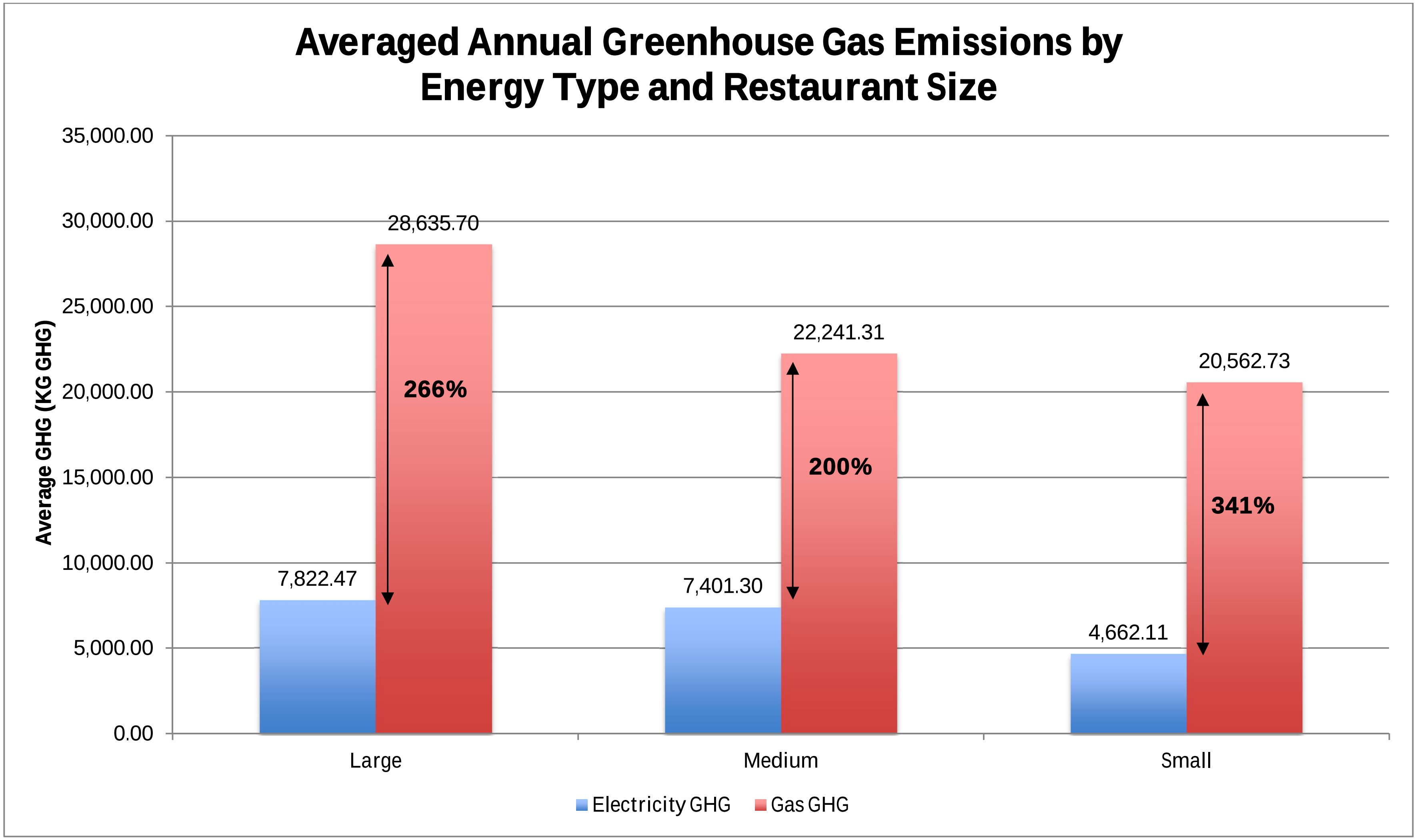


Figure 4-6 Averaged Annual GHG Emissions by Energy Type and Restaurant Size



For small restaurants (Figure 4-5), the same natural gas and electricity increase is seen in the colder and warmer months again; however, electricity use in smaller restaurants is markedly reduced as compared to medium and large restaurants which may mean less air-conditioning is being used. Again, natural gas use increased in the warmer months which, like medium-sized restaurants, may be related to natural gas-powered air-conditioning and refrigeration or the types of food prepared.

4.3.4 Energy-Natural Gas GHG Disparity

As seen in Table 2-7 in the literature review for GHG emissions related to electricity and natural gas use in the City of Toronto, there is a large disparity between GHG emissions produced by electricity and those produced by natural gas. In 2004, there was a 46% difference between the GHG emissions of both energy sources and this increased to 162.5% difference seen in 2012.

Figure 4-6 shows the average annual GHG emissions by energy source for small, medium and large restaurants, from this figure the disparity between energy sources is seen with a difference of 266%, 200% and 341% for large, medium and small restaurants respectively. The significance of this does indicate the need for greater efficiency measures in natural gas use. The energy profile for all respondents is available in Appendix F.

The next section will look at greenhouse gas reduction measures adopted by other domestic cities as well as some international cities.

4.3.5 Summary of Findings

Collectively, the 34 restaurants studied as part of this thesis consumed 277,641.65 kWh of electricity and 433,205.87 m^3 of natural gas, which represents an approximate release of 1,043,437 kg of GHG over the course of one year. This means approximately 30,689 kg of GHG per restaurant (when averaged).

Canada released approximately 740 million tonnes of GHG in 2012 with the restaurant industry contributing 0.3% of the natural GHG emissions. Within the context of the City of Toronto, it released 20.31 million tonnes in 2012 from this, the restaurant industry accounted for approximately 2.02% of Toronto's overall GHG emissions. Therefore, the GHG emissions related to the restaurant industry can be considered to be nominal.

When looking at GHG emissions associated with Toronto's restaurant industry, it was found that there is no reliable relationship between the size of a restaurant and its GHG emissions. It was found that smaller restaurants have greater GHG intensity than large and medium-sized restaurants. When looking at trends in energy use, the greatest variation is seen in the summer and winter months and evidence suggests that this may be related to heating and cooling measures.

Finally, it appears that natural gas use in the Toronto restaurant industry contributes two to three times the GHG emissions than electricity use. This is consistent with the energy profile seen in the entire city. This finding means that greater effort is needed to reduce natural gas use or achieve greater levels of efficiency.

5. Conclusions

This thesis that three objectives, these were to understand how provincial and territorial governments are addressing greenhouse gas reduction by compiling a comprehensive list of legislation and policies and to understand to what extent provinces and territories are coordinating sub-nationally, to understand what strategies Canadian municipalities are currently employing to address GHG reduction and what barriers exist to the City of Toronto to implement novel strategies or expand existing strategies, and using sub-national GHG reduction measures as the frame, determine greenhouse gas emissions attributed to the Toronto-based restaurant industry as a percentage of Toronto and Canada's overall emissions and in what areas improvement is needed.

Despite the lack of federal government policy, Canadian provinces and territories are working towards greenhouse gas reduction measures themselves by developing legislation, policy and strategic plans. From this, it was found that eleven of Canada's thirteen provincial and territorial jurisdictions have legislation or policies for GHG reduction in place. The six provinces of British Columbia, Alberta, Manitoba, Ontario, Québec and Nova Scotia have legislated reduction targets, while the provinces of Newfoundland and Labrador, New Brunswick, Prince Edward Island and the Yukon and Northwest Territories have a GHG reduction policy in place.

Reduction strategies of these jurisdictions are largely focused on shifting to cleaner energy sources and carbon pricing models. Within Canada, there currently exist five carbon pricing models based on carbon fee-and-dividend, cap-and-trade and a highbred of the two, with Ontario signing an agreement to join Québec and California in the cap-and-trade program under Western Climate Initiative.

All of the provinces and territories have confirmed that there is national and inter-sub-national discussion on GHG reduction but no coordination. The federal government is currently developing a sector-based approach for GHG reduction in preparation for the next COP meeting in Paris, France in December 2015.

The majority of the provinces and territories are working with their municipalities on matters of climate change mitigation measures and adaptation strategies. The support has included the development of tools and guides, establishment of feed-in-tariff programs and the establishment of a province-wide GHG monitoring and reporting system.

Given that the majority of greenhouse gas emissions are generated within municipalities, municipalities have also developed programs and policies intended to reduce greenhouse gas emissions. It was found that fifty percent of the fifty largest Canadian municipalities reviewed had measures in place to reduce GHG emissions. This indicates an acknowledgement of responsibility from municipal government in reducing GHG emissions. Municipalities have achieved measureable GHG reduction through landfill gas capture, carbon sequestration from urban forests and parks, residential tower retrofitting, solar installations on public buildings and transit plans.

However, barriers exist for municipalities to achieve greater reduction most notably financial resources, but in the case of Toronto, it is also lack of influence in strategies such as district heating and cooling systems and Toronto Hydro projects and decisions. Given that only fifty percent of Canada's top fifty most populous municipalities had a GHG reduction strategy in place, more municipalities could be doing more but that municipalities are becoming increasingly involved in GHG reduction and climate change mitigation. Further, greater coordination between provinces and municipalities could generate valuable energy and GHG emission reductions.

While GHG emissions related to electricity use has decreased as greater efficiency is achieved, similar trends are not seen in GHG emissions related to natural gas use. This phenomenon is seen at the city level and within the restaurant industry as seen in this research. Therefore, additional effort is required to reduce natural gas consumption within the city. Since natural gas is largely related to heating systems, the most promising mitigative measure would be to expand the district cooling system to cover more of the City of Toronto and convert it into a heating and cooling system.

Several additional greenhouse gas reduction measures employed by other Canadian municipalities have been identified for potential use in Toronto. However, many of the proposed ideas are being done as part of new standard operations (and therefore not advertised as other cities have done), or they have been tried as pilot projects and discontinued regardless of success rates, or are outside of the influence of the City.

At present, the restaurant industry is adding an insignificant amount of GHG to Toronto and Canada's national emissions at 2.0% and 0.3% respectively. From looking at where GHG emissions are generated by the restaurant industry, what is more obvious is that additional effort is required to reduce the emissions associated with natural gas use. Since the energy source cannot be made more efficient, energy efficiencies will have to come from the end-use appliances and from a general effort to reduce consumption.

5.1 Future Research

There are some areas where future research is required that were encountered while writing this thesis. The first area could be what energy efficiency improvements can be achieved for the use of natural gas, from extraction to end-use. A second area of research could focus on how a smart energy grid using renewable energy sources could be implemented and how this model could potentially be replicated in other cities. A third area of future research could involve conducting a complete GHG life-cycle analysis on the restaurant system, not just energy use but all inputs and outputs. This thesis originally set out to attempt to capture the GHG footprint of Toronto restaurants, however, various barriers such as unknown water use, no information on the quantity and quality of waste produced, and GHG emissions generated by patrons and employees were encountered. For a complete picture, a smaller sample size with full cooperation with the owners and managers over a number of years would be most useful.

A fourth area of future research could look at how to establish regional heating and cooling systems in the densest areas of the city. A fifth area of research could be investigating the trend where energy intensity increases as the size of restaurants decrease and what this means to home food preparation.

Finally, a sixth area of research could follow-up on the expected report to the City of Toronto on requiring “Statements of Consumption” of energy use in residential and office towers. If implemented, there would be data on energy use that would identify areas where improvement on energy efficiency is required and there will need to be an assessment of options and an implementation plan.

Appendices

Appendix A: Research Ethics Board Approval and Recruitment Script

RYERSON UNIVERSITY
RESEARCH ETHICS BOARD

To: Daniel Johnson
Environmental Applied Science and Management

Re: REB 2013-277: DETERMINING THE CARBON FOOTPRINT OF TORONTO'S RESTAURANT INDUSTRY AND THEIR ROLE IN THE CITY OF TORONTO'S ENVIRONMENTAL PLAN

Date: October 17, 2013

Dear Daniel Johnson,

The review of your protocol REB File REB 2013-277 is now complete. The project has been approved for a one year period. Please note that before proceeding with your project, compliance with other required University approvals/certifications, institutional requirements, or governmental authorizations may be required.

This approval may be extended after one year upon request. Please be advised that if the project is not renewed, approval will expire and no more research involving humans may take place. If this is a funded project, access to research funds may also be affected.

Please note that REB approval policies require that you adhere strictly to the protocol as last reviewed by the REB and that any modifications must be approved by the Board before they can be implemented. Adverse or unexpected events must be reported to the REB as soon as possible with an indication from the Principal Investigator as to how, in the view of the Principal Investigator, these events affect the continuation of the protocol.

Finally, if research subjects are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and approvals of those facilities or institutions are obtained and filed with the REB prior to the initiation of any research.

Please quote your REB file number (REB 2013-277) on future correspondence.

Congratulations and best of luck in conducting your research.

Lynn Lavallée, Ph.D.
Chair, Research Ethics Board

MASTER'S THESIS STUDY RECRUITMENT SCRIPT
<u>FOR RESTAURANTS/COUNCILLORS</u>

DETERMINING THE CARBON FOOTPRINT OF TORONTO'S RESTAURANT INDUSTRY AND THEIR ROLE IN THE CITY OF TORONTO'S ENVIRONMENTAL PLAN

- Hello, my name is Daniel Johnson. I am a master's student at Ryerson University in the Environmental Applied Science and Management Program.

- For my thesis, I am attempting to calculate the carbon footprints of traditional and mobile restaurants so that I can determine whether they have similar footprints or if one is greater than the other.

- Since part of this study is designed to discuss areas for better environmental practice or policy related to the restaurant industry, results of this study may have an economic impact on your operations.

- This study with be conducted using a questionnaire and your participation is completely voluntary.

- If you do choose to participate, please complete the entire questionnaire as accurately as possible.

- This questionnaire is completely anonymous as no name, contact information or other identifying feature will be collected or recorded.

- Would you like to participate in this study?

If YES

- Thank you. Here is the survey. I have included a self-address, stamped envelope that I ask you use to return your questionnaire by **DATE**.

- Alternatively, you complete an online version of this questionnaire at **URL**.

If NO

- Thank you for your time.

MASTER'S THESIS STUDY <u>EMAIL</u> RECRUITMENT SCRIPT
<u>FOR CITY OFFICIALS</u>

DETERMINING THE CARBON FOOTPRINT OF TORONTO'S RESTAURANT INDUSTRY AND THEIR ROLE IN THE CITY OF TORONTO'S ENVIRONMENTAL PLAN

Dear _______________,
Hello, my name is Daniel Johnson. I am a master's student at Ryerson University in the Environmental Applied Science and Management Program.
For my thesis, I am attempting to calculate the carbon footprints of traditional and mobile restaurants so that I can determine whether they have similar footprints or if one is greater than the other.

Since part of this study is designed to discuss areas for better environmental practice or policy related to the restaurant industry and environmental matters are often politicized, the results of this study may have an economic or political impact to you.
This study with be conducted using the attached questionnaire and your participation is completely voluntary. If you do choose to participate, please complete the entire questionnaire as accurately as possible.
I really appreciate your time and feedback.

Sincerely,
Daniel Johnson

CONSENT TO PARTICIPATE IN RESEARCH

DETERMINING THE CARBON FOOTPRINT OF TORONTO'S RESTAURANT INDUSTRY AND THEIR ROLE IN THE CITY OF TORONTO'S ENVIRONMENTAL PLAN

Dear Sir or Madame:

You are being invited to participate in a research study. Please read this Consent Form so that you understand what your participation will involve. Before you consent to participate, please ask any questions necessary to be sure you understand what your participation will involve.

INVESTIGATORS

This research study is being conducted by DANIEL JOHNSON, a graduate student in Ryerson University's Environmental Applied Science and Management program. He is being supervised by Drs. Bernard Fleet and Christopher Gore. The results of this study will contribute *to* a Master's thesis. If you have any questions or concerns about the research, please feel free to contact the supervisors:

Dr. Bernard Fleet fleetec@gmail.com	Dr. Christopher Gore chris.gore@politics.ryerson.ca

PURPOSE OF THE STUDY

It is the goal of this study to determine the carbon footprint of fixed and mobile restaurants for comparison purposes and to identify areas in which the city could enhance its environmental performance.

DESCRIPTION OF THE STUDY AND YOUR PARTICIPATION

If you volunteer to participate in this study, you will be asked to do the following things:

- Complete an online questionnaire or telephone interview on (1) the city's environmental plan, (2) the role of restaurants in the city's environmental plan, and (3) the role the province plays in the city's environmental initiatives.

- The questionnaires or interviews will take approximately 20 minutes.
- No follow-up questions are expected; however, should it be necessary it would be by way of email.

POTENTIAL RISKS AND DISCOMFORTS

The nature of this study involves the collection of information from city ward councillors on city environmental policies, issues within wards and opinions of city councillors. The personal risk factor is considered to be very low.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

The data produced from this study will help (1) set a baseline carbon footprint for various restaurants by way of size, type of cuisine and type of restaurant (mobile versus fixed); (2) contribute to future research; and (3) aid in incorporating restaurant policy in the city's environmental plan.

I cannot guarantee, however, that you will receive any benefits from participating in this study.

PAYMENT FOR PARTICIPATION

You will not be paid to participate in this study.

CONFIDENTIALITY

The questionnaire is seeking information related to official city policies and issues within your ward. Your name will be used as part of the references.

VOLUNTARY PARTICIPATION AND WITHDRAWAL

Participation in this study is voluntary. You can choose whether to be in this study or not. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. If you choose to withdraw from this study you may also choose to withdraw your data from the study. You may also choose not to answer any question(s) and still remain in the study. Your choice of whether or not to participate will not influence your future relations with Ryerson University.

QUESTIONS ABOUT THE STUDY

If you have any questions about the research now, please ask. If you have questions later about the research, you may contact:

Daniel Johnson
daniel.johnson@ryerson.ca

This study has been reviewed by the Ryerson University Research Ethics Board. If you have questions regarding your rights as a research participant in this study, please contact:

Toni Fletcher, Research Ethics Coordinator
Research Ethics Board
Office of the Vice President, Research and Innovation
Ryerson University
350 Victoria Street
Toronto, Ontario M5B 2K3
416-979-5042 or toni.fletcher@ryerson.ca

SIGNATURE OF RESEARCH PARTICIPANT / LEGAL REPRESENTATIVE

Your signature below indicates that you have read the information in this agreement and have had a chance to ask any questions you have about the study "*Establishing a Baseline Carbon Footprint for Traditional and Mobile Restaurants based on size and cuisine for comparison and policy development*" as described herein. Your questions have been answered to your satisfaction, and you agree to participate in this study. You have been given a copy of this form.

____
Name of Participant (please print)

______________________________ ____________________
Signature of Participant Date

Appendix B: Restaurant Questionnaire

FIXED RESTAURANT QUESTIONAIRE

STUDY: DETERMINING THE CARBON FOOTPRINT OF TORONTO'S RESTAURANT INDUSTRY AND THEIR ROLE IN THE CITY OF TORONTO'S ENVIRONMENTAL PLAN

Objective of the Study: This study is a NEUTRAL ASSESSMENT of the carbon footprints within Toronto's diverse food industry and is not intended to support or oppose one type of restaurant over another. It is simply meant to be a research tool that the City of Toronto may choose to include when planning emission reduction measures.

It is the goal of this study to determine whether fixed and mobile restaurants have similar carbon footprints or if one is greater than the other. The study may also provide recommendations for better environmental practice or policy related to the restaurant industry.

INFORMED CONSENT

This research study is being conducted by DANIEL JOHNSON, a graduate student in Ryerson University's Environmental Applied Science and Management program. He is being supervised by Drs. Bernard Fleet and Christopher Gore. The results of this study will contribute *to* a Master's thesis.

If you have any questions or concerns about the research, please feel free to contact the supervisors:

Dr. Bernard Fleet fleetec@gmail.com	Dr. Christopher Gore chris.gore@politics.ryerson.ca

The questionnaire will take approximately 30-45 MINUTES.

The data produced from this study will help (1) set a baseline carbon footprint for various restaurants by way of size, type of cuisine and type of restaurant (mobile versus fixed); (2) contribute to future research; and (3) aid in incorporating restaurant policy in the city's environmental plan.

You will not be paid to participate in this study.

Participation in this study is voluntary. If you volunteer to be in this study, you may withdraw at any time without consequences of any kind. If you choose to withdraw from this study you may also choose to withdraw your data from the study. You may also choose not to answer any question(s) and still remain in the study.
Your choice of whether or not to participate will not influence your future relations with Ryerson University.

If you have any questions about the research now, please ask. If you have questions later about the research, you may contact Daniel Johnson at daniel.johnson@ryerson.ca .

This study has been reviewed by the Ryerson University Research Ethics Board. If you have questions regarding your rights as a research participant in this study, please contact:

Toni Fletcher

Research Ethics Coordinator, Research Ethics Board
Office of the Vice President, Research and Innovation
Ryerson University
350 Victoria Street, Toronto, Ontario M5B 2K3
416-979-5042 or toni.fletcher@ryerson.ca

THANK YOU!

I understand the amount of work that is required to complete this survey and your participation in this study is greatly appreciated.

SECTION 1: GENERAL INFORMATION

1. WHAT IS THE NATURE OF YOUR RESTAURANT?

- ☐ Take-Out or Take-Out Mostly
- ☐ Fast Food Restaurant
- ☐ Non-Fast Food Restaurant

2. WHAT TYPES OF FOOD DO YOU SERVE

____

____

____

____

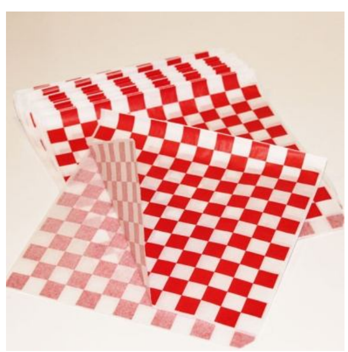
3. WHAT IS THE SIZE OF YOUR RESTAURANT IN SQUARE FEET?

____

____

SECTION 2: TAKE-OUT CONTAINERS AND DISPOSIBLE CUTLERY

4. **FOR TAKE-OUT, DELIVERY OR LEFTOVERS, WHAT DO YOU USE?** Select all that apply.

☐ Styrofoam	☐ Box Board	☐ Cardboard
	 	
☐ Aluminum	☐ Paper or Wax Paper	☐ Plastic
 		 

OTHER (Specify): ____

5. **HOW MANY TAKE-OUT CONTAINERS/MATERIAL DO YOU USE IN A MONTH?** Please provide numbers for each type of container if more than one is used.

You may use a specific number or number of sleeves, packages or boxes used as long as you specify what the unit is. (i.e. a box of 1000).

MATERIAL	QUANITY USED PER MONTH	MATERIAL	QUANITY USED PER MONTH
Styrofoam		Paper or Wax Paper	
Box Board		Plastic	
Card Board		Other	
Aluminum			

6. **HOW MUCH OF EACH DISPOSIBLE CUTERLY DO YOU USE IN A MONTH?** Please provide numbers for each type of utensil if more than one is used. (Number of boxes, quantity of utensil in a box, etc).

ITEM	QUANITY USED PER MONTH	ITEM	QUANITY USED PER MONTH
FORK		GLOVES	
SPOON		APRONS	
KNIFE		OTHER	
CHOPSTICKS			

SECTION 3: ENERGY USE

For this section, I am trying to determine the amount of energy directly used in your restaurant.

7. **WHAT ENERGY SOURCES ARE USED FOR HEATING, LIGHTING, COOKING, BAKING, REFRIGERATION OR ANY OTHER OPERATION?** Select all that apply.

- ➢ Please provide quantity used for each energy source as found on your bill.
- ➢ Please circle the units being used for nature gas or propane.

	Natural Gas	**UNIT**	Propane Gas	**UNIT**	Electric (kWh)
JANUARY		**ft^3 or m^3**		**ft^3 or m^3**	
FEBRUARY		**ft^3 or m^3**		**ft^3 or m^3**	
MARCH		**ft^3 or m^3**		**ft^3 or m^3**	
APRIL		**ft^3 or m^3**		**ft^3 or m^3**	
MAY		**ft^3 or m^3**		**ft^3 or m^3**	
JUNE		**ft^3 or m^3**		**ft^3 or m^3**	
JULY		**ft^3 or m^3**		**ft^3 or m^3**	
AUGUST		**ft^3 or m^3**		**ft^3 or m^3**	
SEPTEMBER		**ft^3 or m^3**		**ft^3 or m^3**	
OCTOBER		**ft^3 or m^3**		**ft^3 or m^3**	
NOVEMBER		**ft^3 or m^3**		**ft^3 or m^3**	
DECEMBER		**ft^3 or m^3**		**ft^3 or m^3**	

SECTION 4: WATER USE

8. ACCORDING TO YOUR UTILITY BILL, HOW MUCH WATER DO YOU USE (Cubic Meters (m^3))? If your utility bill is not monthly, place the value in the month that you received your bill.

JANUARY		**JULY**	
FEBRUARY		**AUGUST**	
MARCH		**SEPTEMBER**	
APRIL		**OCTOBER**	
MAY		**NOVEMBER**	
JUNE		**DECEMBER**	

SECTION 6: OTHER INFORMATION

9. **WHAT OTHER ENERGY SOURCES THAT YOU USE WAS MISSED? PLEASE STATE TYPE AND QUANTITY.**

____
____
____
____
____

10. **DO YOU HAVE ANY OTHER INFORMATION THAT YOU WOULD LIKE TO SHARE?**

____
____
____
____
____
____

11. **DO YOU WISH TO RECEIVE A COPY OF THE FINAL THESIS UPON COMPLETION?** Please select type and method of delivery. Please indicate physical or email address.

☐ Yes, I want to receive a copy of the final thesis.
☐ No, I DO NOT want to receive a copy of the final thesis.
IF you want to receive a copy of my thesis, please include your email or physical address:

____
____
____

Appendix C: Data Tables

Data Table for Restaurants: KG GHG produced by electricity use

			KG GHG Electricity											
Area	Electricity	Gas	Jan	Fed	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
184.87	8,568.00	21,266.19	548.14	614.15	540.39	574.29	687.59	866.07	923.94	1,023.43	856.01	682.65	645.18	606.15
191.37	8,412.81	30,361.90	538.21	603.03	530.60	563.89	675.14	850.38	907.21	1,004.89	840.51	670.29	633.50	595.17
157.93	7,070.07	36,074.61	452.31	506.78	445.91	473.89	567.38	714.66	762.41	844.50	706.36	563.31	532.39	500.18
148.64	8,298.57	29,626.30	530.90	594.84	523.39	556.23	665.97	838.83	894.89	991.25	829.09	661.19	624.90	587.09
144.92	6,972.32	36,345.02	446.06	499.78	439.75	467.34	559.53	704.77	751.87	832.83	696.59	555.52	525.03	493.26
195.09	8,328.71	34,210.08	532.83	597.00	525.29	558.25	668.39	841.88	898.14	994.85	832.11	663.59	627.16	589.22
151.71	8,613.26	32,133.76	551.03	617.40	543.24	577.33	691.22	870.64	928.82	1,028.83	860.53	686.26	648.59	609.35
183.48	9,084.81	25,004.69	581.20	651.20	572.98	608.93	729.06	918.31	979.67	1,085.16	907.65	723.83	684.10	642.71
193.23	8,410.50	20,801.00	538.06	602.86	530.45	563.74	674.95	850.15	906.96	1,004.62	840.28	670.10	633.32	595.01
166.29	6,510.00	38,016.66	416.48	466.64	410.59	436.35	522.43	658.04	702.01	777.61	650.40	518.68	490.21	460.55
174.65	6,991.95	23,732.05	447.31	501.18	440.98	468.65	561.11	706.76	753.99	835.17	698.55	557.08	526.51	494.65
157.93	8,169.95	23,747.18	522.67	585.62	515.28	547.61	655.65	825.83	881.02	975.88	816.24	650.94	615.21	577.99
165.36	6,261.15	20,944.72	400.56	448.80	394.89	419.67	502.46	632.89	675.18	747.88	625.54	498.86	471.47	442.95
120.77	7,686.00	21,217.02	469.61	572.61	486.52	463.47	478.84	648.70	740.93	917.71	840.08	623.33	684.05	760.15
115.20	7,250.88	19,950.05	443.03	540.19	458.98	437.23	451.73	611.97	698.98	865.76	792.52	588.05	645.33	717.11
104.98	7,401.45	18,919.46	452.23	551.41	468.51	446.31	461.11	624.68	713.50	883.73	808.98	600.26	658.73	732.00
111.48	6,191.85	22,030.15	378.32	461.29	391.94	373.37	385.75	522.59	596.89	739.31	676.77	502.16	551.07	612.37
101.26	7,827.75	23,732.05	478.28	583.17	495.50	472.01	487.67	660.66	754.60	934.63	855.57	634.83	696.67	774.16
107.76	7,232.40	22,748.73	441.90	538.81	457.81	436.11	450.58	610.41	697.20	863.55	790.50	586.55	643.68	715.28
111.48	7,989.45	29,121.40	488.16	595.21	505.73	481.76	497.74	674.31	770.18	953.94	873.25	647.94	711.06	790.16
113.34	8,091.93	21,727.59	494.42	602.85	512.22	487.94	504.13	682.96	780.06	966.18	884.45	656.26	720.18	800.29
110.55	6,939.98	20,725.36	424.03	517.03	439.30	418.48	432.36	585.73	669.01	828.63	758.54	562.83	617.66	686.36
44.13	3,255.00	20,801.00	267.24	272.44	263.98	264.31	266.58	274.72	276.68	274.72	273.09	263.98	267.89	289.37
45.52	4,252.50	15,222.55	349.13	355.93	344.88	345.30	348.28	358.91	361.46	358.91	356.78	344.88	349.98	378.05
41.81	4,887.12	30,256.00	401.23	409.05	396.35	396.83	400.26	412.47	415.41	412.47	410.03	396.35	402.21	434.46
46.45	5,106.47	37,536.35	419.24	427.41	414.13	414.64	418.22	430.99	434.05	430.99	428.43	414.13	420.26	453.96
43.66	4,777.50	12,452.24	392.23	399.88	387.46	387.93	391.28	403.22	406.09	403.22	400.83	387.46	393.19	424.72
47.38	3,785.25	16,429.01	310.77	316.83	306.98	307.36	310.01	319.48	321.75	319.48	317.58	306.98	311.53	336.51
48.31	5,276.78	23,760.42	433.22	441.67	427.95	428.47	432.17	445.36	448.53	445.36	442.72	427.95	434.28	469.11
46.45	5,140.28	16,111.32	422.02	430.24	416.88	417.39	420.99	433.84	436.92	433.84	431.27	416.88	423.04	456.97
58.06	4,814.78	21,897.78	395.29	403.00	390.48	390.96	394.33	406.37	409.26	406.37	403.96	390.48	396.26	428.03
47.84	5,934.60	23,732.05	487.23	496.73	481.30	481.89	486.04	500.88	504.44	500.88	497.91	481.30	488.42	527.59
48.31	3,990.00	16,262.60	327.58	333.96	323.59	323.99	326.78	336.76	339.15	336.76	334.76	323.59	328.38	354.71
52.02	4,725.00	12,291.50	387.92	395.48	383.20	383.67	386.98	398.79	401.63	398.79	396.43	383.20	388.87	420.05

Data Table for Restaurants: KG GHG produced by natural gas use

			KG GHG Natural Gas											
Area	Electricity	Gas	Jan	Fed	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
184.87	8,568.00	21,266.19	2,252.09	3,081.47	1,643.88	2,205.30	1,354.66	1,280.22	1,369.54	1,397.19	1,426.96	1,465.24	1,816.13	1973.502
191.37	8,412.81	30,361.90	3,215.32	4,399.44	2,346.97	3,148.53	1,934.05	1,827.79	1,955.31	1,994.78	2,037.28	2,091.93	2,592.91	2817.584
157.93	7,070.07	36,074.61	3,820.30	5,227.21	2,788.57	3,740.94	2,297.95	2,171.69	2,323.20	2,370.10	2,420.61	2,485.54	3,080.77	3347.724
148.64	8,298.57	29,626.30	3,137.42	4,292.85	2,290.11	3,072.25	1,887.20	1,783.50	1,907.93	1,946.45	1,987.92	2,041.25	2,530.09	2749.32
144.92	6,972.32	36,345.02	3,848.94	5,266.39	2,809.47	3,768.98	2,315.18	2,187.97	2,340.62	2,387.87	2,438.75	2,504.17	3,103.86	3372.818
195.09	8,328.71	34,210.08	3,622.85	4,957.04	2,644.44	3,547.59	2,179.18	2,059.45	2,203.13	2,247.60	2,295.50	2,357.07	2,921.54	3174.696
151.71	8,613.26	32,133.76	3,402.97	4,656.18	2,483.94	3,332.27	2,046.92	1,934.45	2,069.41	2,111.19	2,156.18	2,214.02	2,744.22	2982.013
183.48	9,084.81	25,004.69	2,648.00	3,623.18	1,932.86	2,592.99	1,592.80	1,505.28	1,610.30	1,642.81	1,677.81	1,722.82	2,135.40	2320.436
193.23	8,410.50	20,801.00	2,202.83	3,014.06	1,607.92	2,157.06	1,325.02	1,252.22	1,339.58	1,366.63	1,395.75	1,433.19	1,776.41	1930.333
166.29	6,510.00	38,016.66	4,025.96	5,508.61	2,938.69	3,942.33	2,421.66	2,288.60	2,448.27	2,497.69	2,550.92	2,619.35	3,246.62	3527.946
174.65	6,991.95	23,732.05	2,513.22	3,438.77	1,834.49	2,461.01	1,511.73	1,428.67	1,528.34	1,559.20	1,592.42	1,635.14	2,026.72	2202.334
157.93	8,169.95	23,747.18	2,514.83	3,440.97	1,835.66	2,462.58	1,512.70	1,429.58	1,529.32	1,560.19	1,593.44	1,636.18	2,028.01	2203.738
165.36	6,261.15	20,944.72	2,218.05	3,034.89	1,619.03	2,171.97	1,334.18	1,260.87	1,348.84	1,376.07	1,405.39	1,443.09	1,788.68	1943.67
120.77	7,686.00	21,217.02	2,244.76	3,076.47	1,640.08	1,775.86	1,461.85	1,512.77	1,693.12	1,650.68	1,319.70	1,461.85	1,506.41	1873.463
115.20	7,250.88	19,950.05	2,110.72	2,892.76	1,542.14	1,669.82	1,374.56	1,422.44	1,592.01	1,552.11	1,240.89	1,374.56	1,416.45	1761.589
104.98	7,401.45	18,919.46	2,001.68	2,743.32	1,462.47	1,583.56	1,303.55	1,348.96	1,509.77	1,471.93	1,176.79	1,303.55	1,343.28	1670.588
111.48	6,191.85	22,030.15	2,330.79	3,194.37	1,702.93	1,843.92	1,517.88	1,570.75	1,758.01	1,713.95	1,370.28	1,517.88	1,564.14	1945.262
101.26	7,827.75	23,732.05	2,510.85	3,441.15	1,834.49	1,986.37	1,635.14	1,692.10	1,893.82	1,846.35	1,476.13	1,635.14	1,684.98	2095.54
107.76	7,232.40	22,748.73	2,406.82	3,298.57	1,758.48	1,904.07	1,567.39	1,621.98	1,815.35	1,769.85	1,414.97	1,567.39	1,615.16	2008.713
111.48	7,989.45	29,121.40	3,081.04	4,222.60	2,251.08	2,437.46	2,006.46	2,076.36	2,323.89	2,265.64	1,811.35	2,006.46	2,067.62	2571.42
113.34	8,091.93	21,727.59	2,298.78	3,150.50	1,679.54	1,818.60	1,497.03	1,549.18	1,733.86	1,690.41	1,351.46	1,497.03	1,542.66	1918.546
110.55	6,939.98	20,725.36	2,192.74	3,005.18	1,602.07	1,734.71	1,427.98	1,477.72	1,653.88	1,612.43	1,289.12	1,427.98	1,471.50	1830.049
44.13	3,255.00	20,801.00	2,148.74	3,084.79	1,587.12	1,707.76	1,433.19	1,462.31	1,628.72	1,607.92	1,273.02	1,329.18	1,476.87	2061.379
45.52	4,252.50	15,222.55	1,572.49	2,257.50	1,161.48	1,249.77	1,048.83	1,070.15	1,191.93	1,176.70	931.62	972.72	1,080.80	1508.555
41.81	4,887.12	30,256.00	3,125.44	4,486.96	2,308.53	2,484.02	2,084.64	2,127.00	2,369.04	2,338.79	1,851.67	1,933.36	2,148.18	2998.37
46.45	5,106.47	37,536.35	3,877.50	5,566.64	2,864.02	3,081.73	2,586.25	2,638.81	2,939.10	2,901.56	2,297.22	2,398.57	2,665.08	3719.852
43.66	4,777.50	12,452.24	1,286.32	1,846.67	950.11	1,022.33	857.96	875.39	975.01	962.56	762.08	795.70	884.11	1234.016
47.38	3,785.25	16,429.01	1,697.12	2,436.42	1,253.53	1,348.82	1,131.96	1,154.96	1,286.39	1,269.96	1,005.46	1,049.81	1,166.46	1628.115
48.31	5,276.78	23,760.42	2,454.45	3,523.67	1,812.92	1,950.73	1,637.09	1,670.36	1,860.44	1,836.68	1,454.14	1,518.29	1,686.99	2354.657
46.45	5,140.28	16,111.32	1,664.30	2,389.31	1,229.29	1,322.74	1,110.07	1,132.63	1,261.52	1,245.41	986.01	1,029.51	1,143.90	1596.632
58.06	4,814.78	21,897.78	2,262.04	3,247.44	1,670.80	1,797.81	1,508.76	1,539.41	1,714.60	1,692.70	1,340.14	1,399.27	1,554.74	2170.07
47.84	5,934.60	23,732.05	2,451.52	3,519.46	1,810.76	1,948.40	1,635.14	1,668.36	1,858.22	1,834.49	1,452.40	1,516.48	1,684.98	2351.846
48.31	3,990.00	16,262.60	1,679.93	2,411.74	1,240.84	1,335.16	1,120.49	1,143.26	1,273.36	1,257.10	995.27	1,039.18	1,154.64	1611.624
52.02	4,725.00	12,291.50	1,269.71	1,822.83	937.84	1,009.13	846.88	864.09	962.42	950.13	752.24	785.43	872.70	1218.088

Appendix D: Summary of Legislation and Policies

Province	Legislation	Policies and Programs
British Columbia	*Clean Energy Act (2010)* *Greenhouse Gas Reduction Targets Act (2007)*	• At least 93% of electricity must come from clean or renewable sources (CEA) as part of the Clean or Renewable Resources Regulation. • 33% GHG reduction below 2007 levels by 2020, 80% reduction by 2050. 6% below 2007 by 2012, 18% below 2012 levels by 2016. • Revenue neutral carbon tax as of July 1, 2008 with $10/tonne increased $5 annually until current $30/tonne as of July 2012. Money given back as tax refund.
Alberta	*Climate Change and Emissions Management Act (CCEMA, 2007)*	• Specified Gas Emitters Regulations under CCEMA. • Emissions >100,000 tonnes annually must reduce by 12% annually • Alberta offset credits in wind, solar, bioenergy • $15/tonne carbon levy on emissions above 100,000 tonnes • Climate Change and Emissions Management Fund • 50-megatonne reductions by 2020, 200 Mt by 2050.
Saskatchewan	*The Management and Reduction of Greenhouse Gases Act (proposed)*	• Currently in draft, designed to allow Saskatchewan to regulate its own GHG emissions if it meets and exceeds federal regulatory standards.
Manitoba	*Greenhouse Gas Reduction and Emissions Act (2008)*	• 6% reduction below 1990 levels by 2012 (not achieved, no penalty). • Did meet the 2010 target to stabilize emissions. • Carbon tax on coal as of 2013. • Agriculture still uses much coal, must have conversion plan by 2014 and implement by 2017.
Ontario	*Green Energy and Green Economy Act*	• Feed-in-Tariff (FIT) for large-scale renewable energy projects and Micro-FIT for smaller (≤10 MW) with premium rates

	(2009) *Climate Change Action Plan (2007)*	• Phase out coal-fired power plants • 6% below 1990 levels by 2014, 15% below 1990 levels by 2020, and • 80% below 1990 levels by 2050.
Québec	*Loi sur la qualité de l'environnement (1978)* *Règlement concernant la délégation de la gestion de certaines parties du système de plafonnement et d'échange de droits d'émission de gaz à effet de serre (2012)* *Détermination des plafonds annuels d'unités d'émission de gaz à effet de serre relatifs au système de plafonnement et d'échange de droits d'émission de gaz à effet de serre pour la période 2013-2020 (2012)* *Règlement sur les émissions de gaz à effet*	• English title: *Regulations concerning the delegation of the management of certain parts of the cap-and-trade gas emission rights for greenhouse* • Refers to the regulations under the Western Climate Initiative cap-and-trade program to which the province subscribes. • The Cap-and-Trade program only applies to large electricity generators, industrial, transportation and heating fuels. • English title: *Determination of annual gas emission units of greenhouse gases related to the cap-and-trade gas emission rights for greenhouse ceiling for 2013-2020* • Sets the GHG limits annually from 2013-2020 • English title: Regulation on vehicular Greenhouse Gas emissions • Prescribes greenhouse gas emissions for motorized vehicles sold, leased or marketed in Québec from 2009 onwards with capacities of 12 people or below. • 2006-2012 Action Plan on Climate Change and 2013-2020 Climate Change Action Plan • Invest $2.7 billion by 2020 in individual activities, developing partnerships, supporting innovative enterprises and adaptation measures. • 20% below 1990 levels by 2020; sitting at 2.5% by 2009.

	de serre des véhicules automobiles (2009)	
Newfoundland and Labrador	None.	• Committed to reducing GHG emissions by 10% of the 1990 levels by 2020. • Developing a framework for reducing GHG emissions in the large industrial sector by looking at the possibility of carbon pricing or cap and trade
Prince Edward Island	*Renewable Energy Act (2004)* *Energy Accord*	• "Net-metering" for small capacity renewable energy generators • 15% renewable energy by 2010, 100% by 2015 (will not be achieved) • Ability to designate areas for large-scale wind development and allows feed-in-tariff for medium community operated and large-scale renewable energy developments • Climate change strategy
New Brunswick	*Electricity Act (2013)*	• Climate Change Action Plan • Regulations under the Electricity Act require power to be 40% renewable by 2020 • Energy policy
Nova Scotia	*Environment Act (1994)* *Environmental Goals and Sustainable Prosperity Act (2007)* *Green Economy Act (2012), replaces the previous EGSPA*	• Greenhouse Gas Emissions Regulations made under subsection 28(6) and Section 112 of the Environment Act (2009) that set emission caps. • Under the EGSPA, economy-wide GHG reduction targets of 10% below 1990 levels and 18.5% of electricity sourced by renewable energy by 2013 • Under the GEA, total electricity needs to be 25% renewable by 2015, 40% by 2020 (5 mt), caps on GHG emissions from energy sector. • Nova Scotia Climate Change Action Plan

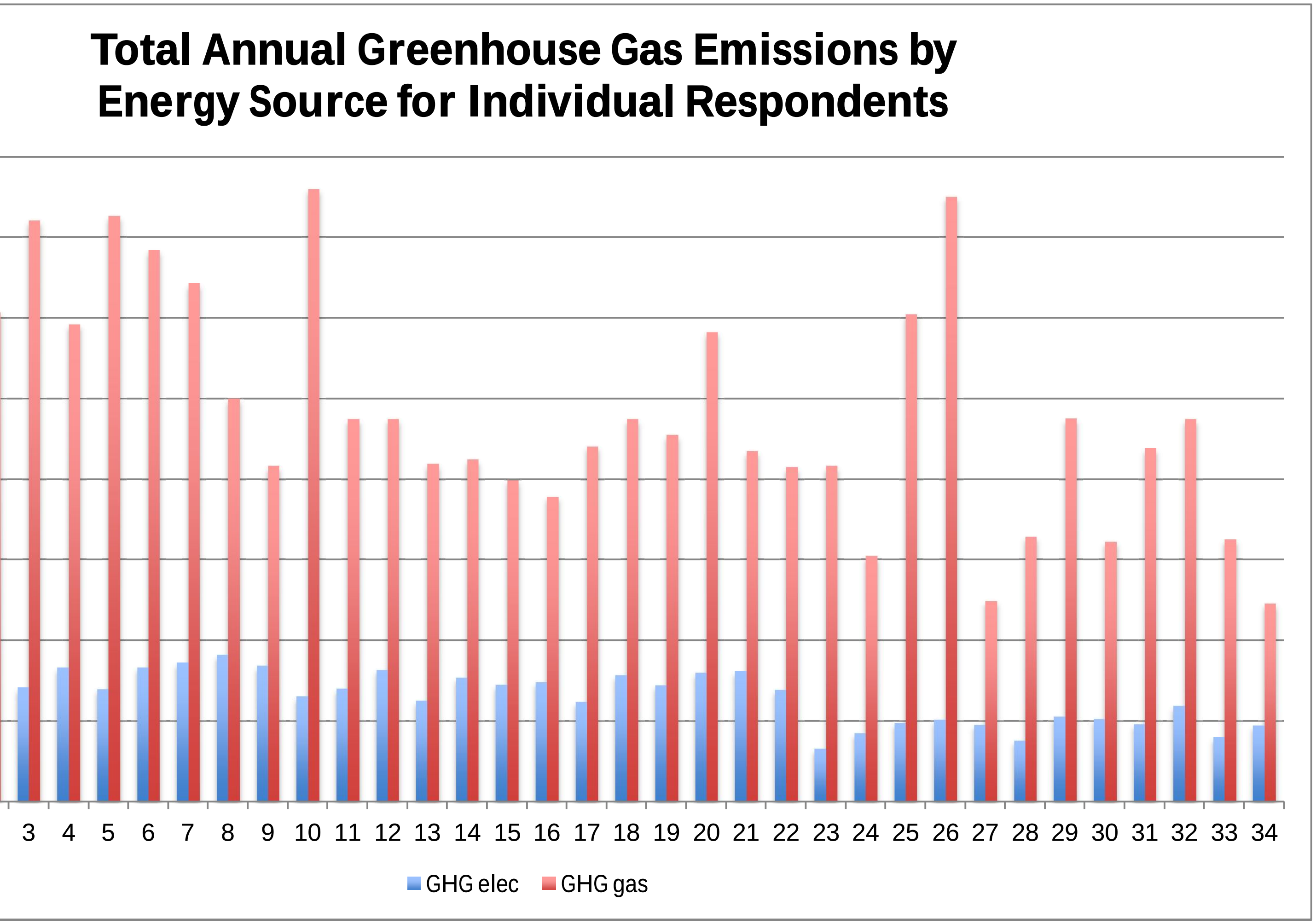
	Nova Scotia Climate Change Action Plan	
Yukon	None.	• Capping GHG emissions related to government operations at 2010 levels, reduce by 20% by 2020 and become carbon neutral by 2020. • Government and government funded commercial and institutional buildings are required to build to LEED standards. • Government fleet moving to greater energy efficiency. • Greater focus on adaptation because they have experienced great changes in climate. Priorities are infrastructure at risk due to permafrost melt, the changing hydrologic cycle and increased forest fires.
Northwest Territory	None.	• Greenhouse Gas reduction strategy from 2011-2015 • The Greenhouse Gas Strategy as part of the Energy Action Plan, the Biomass Energy Strategy and the Solar Energy Strategy. • Stabilize emissions at 2005 levels by 2015 • Limit emissions increase to 66% above 2005 level by 2020 • Return emissions to 2005 level by 2030 • District heating systems • EnerGuide 80 standards to new homes and 25 percent better • than Model National Energy Codes for new buildings
Nunavut	None.	• Since all Nunavut energy is from fossil fuel, they are retrofitting buildings with LED lights, solar hot water heating systems and solar wall air preheating

Appendix E: Municipal Programs

Top 50 most populous municipalities in Canada (2012 Data) and existence or absence of a GHG reduction strategy.

Municipality	Population	Policy/program	Municipality	Population	Policy/program
Toronto	2,615,060	YES	Richmond Hill	185,541	NO
Montreal	1,649,519	YES	Oakville	182,520	YES
Calgary	1,096,833	YES	Burlington	175,779	NO
Ottawa	883,391	YES	Sudbury	160,274	NO
Edmonton	812,201	YES	Sherbrooke	154,601	NO
Mississauga	713,443	YES	Oshawa	149,607	YES
Winnipeg	663,617	YES	Saguenay	144,746	NO
Vancouver	603,502	YES	Lévis	138,769	YES
Brampton	523,911	YES	Barrie	135,711	NO
Hamilton	519,949	NO	Abbotsford	133,497	YES
Quebec City	516,622	YES	St. Catherines	131,400	NO
Surrey	468,251	YES	Trois-Rivières	131,338	NO
Laval	401,553	NO	Cambridge	126,748	NO
Halifax	390,096	YES	Coquitlam	126,456	YES
London	366,151	YES	Kingston	123,363	YES
Markham	301,709	NO	Whitby	122,022	NO
Vaughan	288,301	NO	Guelph	121,688	NO
Gatineau	265,349	YES	Kelowna	117,312	NO
Longueuil	231,409	YES	Saanich	109,752	YES
Burnaby	223,218	NO	Ajax	109,600	NO
Saskatoon	222,189	YES	Thunder Bay	108,359	NO
Kitchener	219,153	NO	Terrebonne	106,322	NO
Windsor	210,891	YES	St Johns	106,172	NO
Regina	193,100	NO	Langley	104,177	NO
Richmond	190,473	YES	Chatham-Kent	103,671	NO

Appendix F: Energy Profile of All Restaurant Respondents



Total Annual Greenhouse Gas Emissions by Energy Source for Individual Respondents
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