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Development Of A Template To Benchmark Municipal Climate Change Action

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DEVELOPMENT OF A TEMPLATE TO BENCHMARK MUNICIPAL CLIMATE CHANGE ACTION

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ABSTRACT

The goal of this thesis is to produce a benchmarking template that can be applied by municipalities across Canada to reduce greenhouse gas emissions from their operations. This template will provide a common set of indicators for benchmarking municipal emissions. It will attempt to link the academic literature to existing conditions and practices within municipalities. It also provides original insight through interviews with municipal officials and municipal policy experts.

Research has shown that municipalities can mitigate climate change. Municipalities have authority to enact policies which reduce greenhouse gas emissions. While many municipalities have taken action, benchmarking initiatives still do not exist to allow for direct comparison of municipalities. Following a review of academic literature interviews were held with a panel of nine municipal policy experts to assess existing programs and a proposed benchmarking template. An indicator set with nine categories and 18 individual indicators measuring corporate and community GHG emissions was developed through consultations with the panel. A questionnaire was sent to 32 municipalities with a response rate of 25%.

Based on the results participating municipalities were compared against one another to determine best practices and areas for improvement. Indicators for residential densities, municipal building heating, solid waste, and municipal buildings and operations had the highest tCO_2e emissions for the equally-weighted results. Categories for land use and urban planning, municipal buildings and operations, solid waste, and transportation contributed the highest tCO_2e emissions for the weighted results. Many municipalities are taking encouraging steps to reduce emissions in absence of provincial and federal leadership. The questionnaire participants have taken actions to address climate change, which generally depended on the corporate culture and existing knowledge.

An examination of indicator set development, improved methods for modelling community emissions, assessment of the benefits of climate action and municipal networking for small municipalities would build upon this research.

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DEDICATION

I would like to dedicate this thesis to my supervisor and friend Dr. Bernard Fleet and to Jessica Piskorowski for her support and patience during the writing of this thesis.

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1. Introduction

Municipalities in Ontario have an important role to play in public policy. Approximately 80% of the national population is urban and urbanization rates are steadily increasing (Norman, MacLean, Kennedy 2006; Robinson 2000). Municipal governments determine building codes, zoning and official plans, by-laws and regulations, and the design of public transportation systems, in addition to operating public utilities, district heating systems and infrastructure, and waste management facilities.

The threat of disruptive anthropogenic climate change is a significant challenge that municipalities have been attempting to address since the late 1980s. While they contribute substantial levels of greenhouse gas (GHG) emissions themselves, municipalities present many opportunities for GHG emission reductions that directly influence citizens where they live and work through educational outreach programs, subsidies, and disincentives. In order to take action and reduce GHG emissions, municipalities and policymakers must know how to overcome barriers and educate themselves as to which best practices are being utilized elsewhere. There are many existing initiatives which help in this task. However, a benchmarking of municipal performance is necessary to help municipalities compare amongst one another to disseminate best practices, find value and cost savings, and to do better through continuous improvement. In this context benchmarking is defined as comparing a municipality against the municipality with the lowest GHG emissions, while best practices are defined as those which are recognized as being the most effective based on available knowledge. Best practices are often used when benchmarking. As of yet no such mechanism exists; climate change efforts are typically placed under broad sustainability initiatives. Municipalities often have to reinvent the wheel or learn about best practices through informal networks. A review of existing initiatives and networks is needed to assess their effectiveness, and a new approach to reducing municipal GHG emissions is required, possibly by fostering co-operation.

2. Objectives

The goals of the study are to produce a benchmarking template that can be applied by municipalities across Canada to reduce greenhouse gas emissions from their operations. This template will provide a common set of indicators for benchmarking municipal emissions. It attempts to link the academic literature to existing conditions and practices within municipalities. It also provides original insight through interviews with municipal officials and municipal policy experts.

The key benefits of the study are to:

- Provide a common reporting platform to assist all Canadian municipalities, whose activities make a substantial contribution to the country's GHG emissions, to develop a more focused effort to reduce their emissions.
- Enable any municipality, large or small, to evaluate its emission reductions on a performance scale against other communities on a standardized basis.
- Provide indicators to policymakers at multiple levels of government to improve decision making.

3. Literature Review

Prior to 1987, academic research on municipalities and climate change was negligible. Research often examined local environmental problems which were not yet linked in any significant way to greenhouse gas emissions and anthropogenic climate change. Much of the literature on municipalities examined urban design, material flows, transportation, local and regional air pollution, energy consumption, waste management, and changes in land use. Wolman (1965) wrote one of the earliest publications and was influential for creating the term 'urban metabolism' to describe cities' inflows and outflows of water, water pollution, and air emissions. In another example Land (1976) examined environmental components in Ontario's municipal official plans in the context of ecological land classification. Newman (1989) explored domestic energy use in seven Australian cities in 1976, noting a need for energy planning and urban development. By the late 1980s sustainability and the greenhouse effect began to appear in the literature.

3.1 Policy Development

The role of municipalities in promoting sustainable development and mitigating climate change was first recognized in 1987 by the World Commission on Environment and Development (WCED), also known as the Brundtland Commission. The landmark report Our Common Future specifically detailed municipalities' role in Chapter 9, The Urban Challenge (Our Common Future 1987, Betsill and Bulkeley 2005). In response to Our Common Future the Canadian federal government organised the World Conference on the Changing Atmosphere in Toronto, ON, in June 1988. It brought together 500 scientists, policymakers, and journalists from 46 countries in a dialogue on atmospheric change and economic impacts. The conference helped foster discussions amongst experts that often worked within academic silos without collaboration, thus providing an interdisciplinary analysis (Robinson and Gore 2005, Solem 1988). The 1988 World Conference produced a list of recommendations such as reducing $C0_2$ emissions by 20% (from 1988 levels) by 2005, increased funding for renewable energy research, the establishment of a World Atmospheric Fund, and a Global Action Plan for agreements to protect the atmosphere. Toronto city councillors including Jack Layton attended the World Conference on the Changing Atmosphere and encouraged action after returning to municipal council. Their efforts led to the establishment of the Special Advisory Committee on the Environment (SACE), comprised of many scientists and policymakers from the Changing Atmosphere conference. SACE eventually implemented many of the conference's goals including: adoption of an official CO_2 reduction target in 1990 (20% from 1988 levels by 2005), the establishment of the Energy Efficiency Office in 1991, and the establishment of the Toronto Atmospheric Fund in 1992 (Lambright, Changnon, and Harvey 1996, Harvey 1993). Together these actions made Toronto, in the words of Lambright *et al.,* "one of the first, if not the first, city in the world to have a local climate change policy".

In late 1990 the World Conference of Local Governments for a Sustainable Future was held at the United Nations. This conference led to the creation of ICLEI (International Council for Local Environmental Initiative) to implement UN programs and goals at the municipal level (Roseland 1992). In 1991 130 world mayors gathered in Toronto and signed the Toronto Declaration on World Cities and Their Environment which describes opportunities cities can provide in solving environmental challenges. The Declaration also cautioned that cities have limited resources and often require higher levels of government to provide financial assistance and increase policy-making authority to municipalities to achieve sustainable development goals (Roseland 1992).

International efforts culminated in the 1992 UN Rio Earth Summit in Brazil. This conference was the first global environmental summit in history. Canada's actions and commitments at the 1992 Rio Earth Summit are documented by Meakin (1992). Agenda 21: the UN Programme of Action from Rio was one of the Summit's key outcomes and describes areas for action including desertification, persistent organic pollutants (POPs), biodiversity, and climate change. Although it is not legally binding, Agenda 21 is an important international document to support fulfillment of the goals of the Rio Earth Summit (UN 2009). Section I, Chapter 7, of Agenda 21 titled "Promoting Sustainable Human Settlement Development" details action areas and measures for municipal governments.

The World Conference on the Changing Atmosphere, the 1992 Rio Earth Summit, and Our Common Future had a profound impact on climate change policy. Since the early 1990s municipalities have taken steps to mitigate their GHG emissions. Academic research has kept pace with policy developments and provides analysis of municipal efforts.

3.2 Academic Research

Following developments at the international, national, and municipal level, academic scholars began publishing extensively. Dr. Peter Newman (Curtin University, Australia) and Dr. Jeffery Kenworthy

(Curtin University, Australia) were early leaders and were influential in their examination of fuel efficiency, transportation in cities, urban structure and air pollution, and automobile dependence in cities. According to a Scopus journal database search on March 20 2012, Newman and Kenworthy published 13 peer-reviewed articles between 1986 and 1996. In their landmark paper *"Gasoline Consumption and Cities: a Comparison of US Cities with a Global Survey"* (1989) Newman and Kenworthy surveyed European, Asian, and North American cities and correlated population density with gasoline consumption from automobile use, concluding that "the policies of reurbanization and reorientation of transportation priorities outlined here should reduce gasoline use, and may also provide economic, social, and environmental benefits." *"Gasoline Consumption and Cities"* was complimented by *"Urban Structure and Air Pollution"* (Newman, Kenworthy, and Lyons 1989) which examined automobile emissions of CO, NO_x, and hydrocarbons in relation to driving patterns and population density in Perth, Australia. It concluded that enhanced public transportation systems would be the best option for reducing emissions.

Newman and Kenworthy have individually published a large body of work. In 1991 Newman published *Greenhouse, Oil, and Cities* which brought together the concepts of the greenhouse effect (climate change), peak oil, urban land use and transportation. Newman wrote:

> "the oil problem and the greenhouse effect raise serious questions about the direction of urban society...they are not like the kinds of pollution problems that industrialized societies have addressed so well over the past decades…they are not environmental impacts that are subject to normal assessment procedures" (pg. 336).

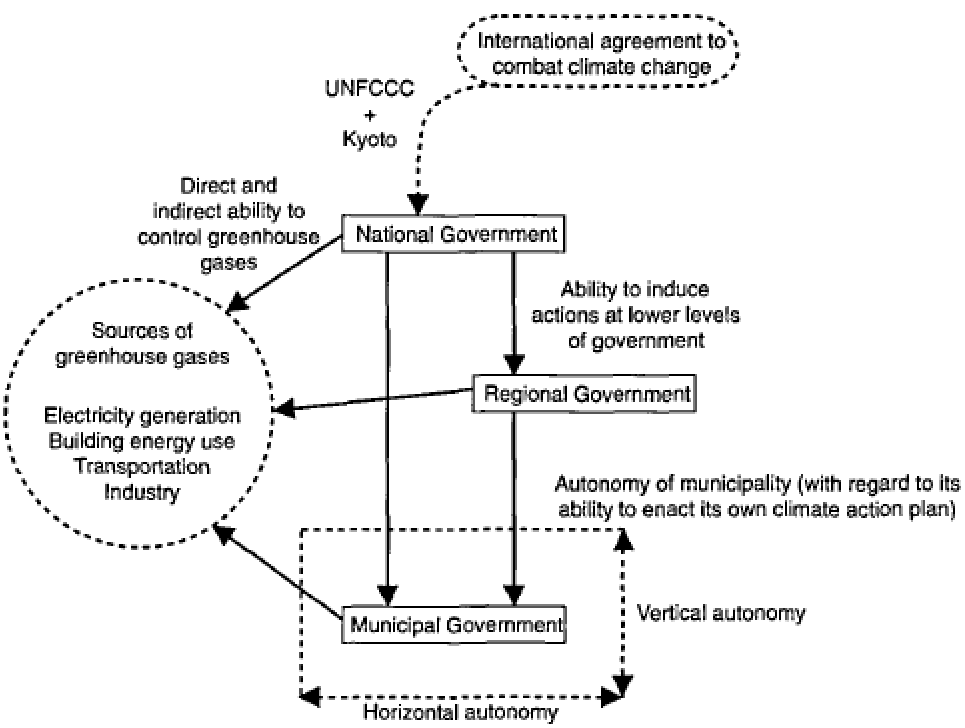
Newman also stated that "it is now a political necessity to draw up strategies for reducing greenhouse gases by 20% or 30% sometime over the next 10-15 years."

Dr. Harriet Bulkeley (Durham University, UK) and Dr. Michelle Betsill (University of Colorado-Boulder) have also had an important influence in the field of municipalities and GHG emissions. Betsill and Bulkeley have explored efforts to create sustainable cities in the US, UK, and Germany (Betsill 2001, Bulkeley and Kern 2006). Betsill and Bulkeley (2005) provide a history of sustainable cities in the United Kingdom and argue that, while useful, the prevailing analysis of urban sustainability is simplistic and divorced from multi-level scales. They propose further examination and consideration of scales, authority, stakeholders, and networks when assessing multi-level urban governance. Work published by Betsill and Bulkeley (2004) and Bulkeley and Kern (2006) examined multi-level governance structures.

Bulkeley described the development of municipalities as actors in mitigating climate change. Bulkeley examined case studies from global cities, policy measures, multi-level governance across jurisdictions, and the role of networks. For example, amongst nations there are important differences in relationships between local and federal governments. Bulkeley and Kern compared modes of governing local climate change, specifically *governing by authority*, *governing through enabling*, *governing by provision*, and, the most common, *self-governing*. The authors found four key sectors for climate change action: energy, transportation, urban planning, and waste management. Their results are found in Appendix 1. Bulkeley and Kern concluded that most GHG emission reductions "are concentrated in the energy sphere, and particularly within the local authority as forms of self-governing for climate protection are pursued."

In 1993 Dr. Danny Harvey (University of Toronto) wrote "*Tackling Urban CO_2 Emissions in Toronto"* which disseminated Toronto's progressive actions following the 1988 *Changing Atmosphere* conference. Deangelo and Harvey (1998) examined cities in Canada, the US, and Germany to assess how municipal actions related to national reduction goals. They explored whether the municipal-national relationship is a top-down command and control approach or a bottom-up influence (this work was later continued by Bulkeley and Kern in 2006). Citing examples of increased autonomy and important action in Toronto, Portland, and Wuppertal, Germany, Deangelo and Harvey suggested there are stronger proponents for action at the local level and less opposition from political parties or lobbyists. The authors proposed a conceptual framework for how municipal climate action exists within the broader national context (see Figure 1).

Figure 1 Conceptual Framework for Municipal Climate Action. Source: Deangelo and Harvey 1998.



The 1998 paper followed Lambright, Changnon, and Harvey (1996) which compared climate change action and reactions to Toronto and Chicago. The authors suggested a policy framework for municipal climate action based on the two case studies:

- Awareness of problem
- Trigger
- Planning
- Adoption
- Implementation

Dr. Christopher Gore (Ryerson University) has published two important papers on the topic of Canadian municipalities and climate change action. Gore (2010) examined the impact of municipal networks, such as the Federation of Canadian Municipalities' *Partners for Community Protection* network, on national climate policy. Together with Dr. Pamela Robinson (Ryerson University) they published an examination of barriers municipalities face when attempting to take action on climate change (Robinson and Gore 2005). In order to better understand relationships and interactions amongst municipalities Gore and Robinson are currently conducting a national survey of all Canadian municipalities with populations > 5,000 (Gore and Robinson 2010, Gore and Robinson 2011). This survey will provide an updated inventory of municipal response to climate change at the national and international level, perhaps eventually leading to "forming the basis for comparisons with other countries."

Dr. Christopher Kennedy (University of Toronto) has also influenced municipal climate action through his examination of urban emissions, building efficiency, and methods for inventorying urban GHG emissions. In 2010 Kennedy published "Getting to Carbon Neutral: A Guide for Canadian Municipalities" for the Toronto and Region Conservation Authority. He found that several sectors offer the most potential for mitigating climate change: buildings, land use and urban planning, transportation, energy, and efficiency and demand management. The report provides methods for inventorying emissions, potential actions, cost benefits, and overcoming barriers. In "*Greenhouse Gas Emissions from Global Cities"* (Kennedy *et al.* 2009) he examined ten global cities by using life-cycle analysis. He assessed geophysical and technical factors to quantify the volume of GHG emissions attributable to cities and suggested two scopes: the physical boundaries of the city and direct end-use emissions. According to Kennedy Barcelona, Spain, had the lowest per capita emissions at 4.6 tCO_2e per capita[1] due to its relatively high population density, low heating requirements, and relatively clean electricity supply

[1] tCO_2e refers to tonnes of carbon dioxide equivalents

mix. This study was followed by Kennedy *et al.* (2010) which developed a methodology for inventorying greenhouse gas emissions from global cities.

Kennedy has contributed a body of work on inventorying residential GHG emissions relative to population density (VandeWeghe and Kennedy 2007; Norman, MacLean, and Kennedy 2006). Norman, McLean, and Kennedy provide a comparative analysis of high and low residential densities and associated GHG emissions for two case studies in Toronto, concluding that low density suburban development is more energy and GHG intensive by a factor of 2.0–2.5. Fung and Kennedy (2005) developed a macroeconomic model to assess urban sustainability in Toronto by plotting emission trajectories from municipal solid waste, transportation, and residences. VandeWeghe and Kennedy (2007) examined the relationship between transportation and residential GHG emissions in Toronto. They found that transport emissions from cars often surpassed emissions from building operations, with the most emissions occurring from auto use in the suburbs.

The first paper on urban metabolism by Wolman (1965) has been expanded into an important body of work; for example Kennedy *et al.* (2007) and Sahely, Dudding, and Kennedy (2003). The papers discuss fluxes of energy, water, materials, and wastes into and out of urban regions by taking a life-cycle approach. Both papers note that CO_2 emissions have been steadily increasing. Fung and Kennedy (2005) state GHG emissions from the Toronto region are increasing by about 30% per decade. Some, such as Burström and Korhonen (2000), have applied industrial ecology to municipal environmental management. The authors advocate the development of a regional industrial ecosystem (IE) to address efforts conducted by others outside of municipal borders to facilitate cooperation between multiple stakeholders for joint management of physical material and energy flows.

Dodman (2009) provides a rebuttal to the argument that cities are inherently unsustainable and deserve blame for GHG emissions. Dodman argues that cities provide many opportunities for GHG reductions due to their spatial scale. Densification reduces overall environmental impacts and makes options such as enhanced public transportation systems or utilization of district heating and cooling feasible. This supports the work by Newman and Kenworthy on energy consumption and urban densities.

Dhakal (2010) reviewed the literature on urban carbon emissions to discover what is known about GHG emissions from urbanization worldwide, urban system boundaries (inputs and outputs), and what potential mitigation opportunities exist. Dhakal stated that “the GHG emissions of urban areas differ widely for the accounting methods, scope of GHGs, emission sources, and urban definition, thus, making place-based comparisons difficult.” He suggests that research on emissions sources and sinks is needed to understand urban development pathways and GHG consequences for various urban typologies. Dhakal's review touches upon the urban metabolism field of Wolman and would benefit from an examination of the work by Kennedy *et al.* (2010).

3.3 Municipal Governance and Climate Change

Under Section 92(8) of the Constitution Act (1867) Canadian municipalities are governed as creatures of the province. As such they only have legal authority as granted under provincial statutes; in Ontario those are the Municipal Act (2001) and, in the case of Toronto, the City of Toronto Act (2006). The question of municipal jurisdiction and efforts to mitigate change has been explored in detail (Roman 2009, Gore 2010, Kennedy *et al.* 2009, Newman 1991, UN 2009, Harvey 1993, Kousky and Schneider 2003, Betsill and Bulkeley 2005, Bulkeley 2010, Betsill 2001).

Important sectors under municipal jurisdiction include building codes and standards, infrastructure, municipal operations and facilities, land use planning, public transportation, waste, and energy consumption (Gore and Robinson 2009, Kousky and Schneider 2003). Municipalities operate public transportation systems, often own power and natural gas utilities and district heating systems, play a central role in waste management, and can influence the market through their own purchasing decisions (DeAngelo and Harvey 1998). Municipalities have some control over land use through zoning regulations and official plans, at minimum approving building permits and development proposals. Municipalities can also sponsor initiatives such as community-based building retrofit programmes (DeAngelo and Harvey 1998). Knuth (2010) provided a case study of reducing suburban emissions in a Philadelphia, PA neighbourhood. Knuth identified measures for climate action by sector (see Table 1) and important stakeholders in each sector. Knuth applied climate change mitigation options to the neighbourhood and provided an account of responses from municipal officials and the public.

Table 1 Climate Change Mitigation Measures Adapted from Knuth (2010)

Sector	Measures
Buildings and Energy Use	Enforce building codes, promote renewable energy purchases, enforce building codes, retrofit existing facilities, promote combined heat and power systems (large facilities)
Transportation	Reduce vehicle miles traveled (VMT), promote car alternatives, reduce traffic congestion, promote alternative fuels, reduce freight emissions, reduce off-road emissions
Waste	Reduce solid waste, target landfill methane, target incineration, target wastewater, reduce overall waste transportation, encourage multi-municipal cooperation, encourage local waste and recycling alternatives

Some municipalities question whether it is their responsibility to take action, while others argue to what degree. Case studies examining the jurisdictional framework for municipalities taking action have been explored by Bulkeley (2010) and Deangelo and Harvey (1998). Deangelo and Harvey stated "municipal governments, because they are more directly involved in local activities and more aware of local conditions and opportunities, are therefore well positioned to be able to capitalise on emission reduction opportunities within their own jurisdiction." Yarnal, O'Conner, and Shudak (2003) surveyed residents of several counties in central Pennsylvania to determine their willingness to voluntary reduce GHG emissions relative to national willingness to take action. Local residents were found to be generally less willing than national respondents to take action, likely because mitigation costs are borne locally and there are few obvious local benefits. These findings resonate with Betsill (2001) who stated the need to localise global climate change impacts to build support for emission reductions. Betsill also commented that many sources of emissions are outside the jurisdiction of municipal governments, citing regional transportation as an example. Wilbanks and Kates (1999) stated that, while emissions within the local boundaries can be easily traced, Scope 3 emissions (local consumption of electricity generated elsewhere) are much more difficult. Many local emissions are the result of forces and decisions made in other areas, for example highway emissions or emissions from local branches of businesses headquartered elsewhere.

While international negotiations in the early 1990s confirmed a role for municipalities in mitigating climate change, many jurisdictional challenges remained between municipalities and upper levels of government, about which there has been considerable research. Roseland (1992) proposed that municipalities may play a trickle-up role in influencing national policy on climate change. Deangelo and Harvey (1998) concluded that municipal action and reductions can serve to compliment national objectives and increase the confidence of national governments to take stronger action. Morlot, Cochran, and Teasdale (2008) suggest that national policymakers should empower cities to take climate action in order to "take advantage of the opportunities to learn from city-scale experimentation with a range of different climate response policies." They listed advantages such as the ability to work with local stakeholders, to incorporate climate change action into existing policies, and the ability to experiment with potential responses. Gore (2010) has suggested that the federal government should empower municipalities to take action. The federal government could then "concentrate on regulating large emitters and interprovincial emissions, leaving the more complex, vexing, and politically sensitive task of limiting or altering GHG-intensive social behavior to municipal governments."

Wilbanks and Kates (1999) examined research on land use changes, finding that the bulk of the research at that time had been top-down, "concentrating on methods of impact analysis that use as a starting point climate change scenarios derived from global models, even though these have little regional or local specificity." Wilbanks and Kates advocated the development of a bottom-up approach to meet the top-down approach midway, "putting localized observations into a conceptual structure that has a degree of coherence comparable to the current body of global change research."

Scott Pasternack, Supervisor of Policy Development with the City of Toronto's Environment Office, suggests that municipalities can use a multi-level government approach and implement local mandates, such as regulations, by-laws and standards, to pursue emission reduction objectives. Legal impediments do exist, for example paramountcy between federal and provincial laws (municipalities being creatures of the province). Laws and regulations can also result in costly litigation and risks; however the Croplife vs. Toronto pesticide case resulted in a beneficial provincial law (see Pralle 2006) and set an important precedent for upholding municipal legal power. David Miller, during his time as mayor of Toronto, led efforts to reduce Toronto's GHG emissions. For example, as mayor he allocated $4 billion to the climate change budget, developed a comprehensive LRT plan, a green roof by-law, and funding for projects such as tower renewal and Live Green Toronto. Mr. Miller also brought Toronto to discussions with other world cities through the C40 Cities and the Clinton Climate Initiative networks. Mr. Miller suggested that municipalities will lead the way on climate change due to the power of lobbyists to delay action at the federal level. He believes that municipalities will lead from the bottom up and will work to convince higher levels of governments to fund climate change projects.

3.4 Barriers to Action

Robinson and Gore (2005) and Kousky and Schneider (2003) have proposed several barriers that municipalities face when attempting climate change action. These include a lack of understanding about the issue of climate change (and the role of municipalities), lack of information, resistance to change, and perceived or real costs. Burstöm and Korhonen (2001) suggested the major barriers are political and institutional resistance to change and a lack of resources in municipalities, stating that "a lack of resources may simply force municipal authorities to sacrifice forward looking strategies to short term crisis management." Betsill (2001) reached similar conclusions and noted that GHG emission reductions, reported by municipalities in ICLEI's Communities for Climate Protection program, are often the result of policies and programmes that already existed, suggesting "cities are merely repackaging existing efforts as 'climate' initiatives and are not going beyond business-as-usual." Betsill also suggested that municipalities may be reducing emissions but failing to quantify GHG savings from measures, for example traffic signal LED lighting conversion. Fung and Kennedy (2005) found that GHG emissions from the Toronto region are increasing by about 30% per decade. The rise in municipal GHG emissions has continued despite climate action, suggesting more needs to be done. Kennedy *et al.* (2010) identified four primary barriers based on a review of existing case studies: technical (capacity constraints, engineering challenges, risks and uncertainty), social (working with stakeholders, understanding behavioural change), organisational (public vs. private sector issues, coordination and integration across departments), and legal (encouraging changes to provincial and federal laws). He also provided methods for overcoming those barriers based on the case studies.

Bulkeley (2010) discussed the limitations of existing policies, such as the “level of vertical autonomy between municipalities and other levels of government,” the lack of coincident boundaries between the scale of issues to be addressed (e.g. commuting) and municipal authority, knowledge capacity, and resources. Internal dynamics within municipalities also plays a significant role; expertise is often concentrated in environmental departments and/or marginalized.

Robinson and Gore (2005) discovered that smaller municipalities (those with populations <100,000) were less likely to have emission reduction plans than their larger counterparts. Morlot, Cochran, and Teasdale (2008) found climate policy at city-scale remains fragmented and that tools for decision making are lacking. Implementing climate policies can be a considerable challenge due to the complexity and number of stakeholders involved. Roseland (1992) reported institutional barriers at Vancouver city council when attempting to implement environmental policies. Wheeler (2008) reviewed climate change policies for select municipalities and found that there were many problems with the ‘first generation’ of municipal responses, specifically that proposed measures were inadequate, implementation was poor, and public understanding and/or involvement was minimal. While municipal action on climate change has occurred since the 1990s efforts have been hampered by a “lack of widely-accepted or standardized method[s] for calculating and compiling [municipal GHG inventories]… affecting the comparability and consistency of these efforts and creat[ing] a challenge for decision makers who wish to plan energy or emission reduction efforts” (NRCAN 2009). The City of London commented in its’ 2008 Greenhouse Gas Inventory Report:

> “Data on community energy use inventories and greenhouse gas emissions are not readily available for other Ontario municipalities. Unlike a number of municipal programs and services (e.g., waste management, road maintenance, etc.) that have data reported to the Ontario Municipal Benchmarking Initiative (OMBI) or the Municipal Performance Measurement Program (MPMP), municipal and community energy consumption is not reported” (Skimming, Russel and Stanford 2009 pg. 18).

3.4.1 Overcoming Barriers to Action

Equating GHG emission reductions with local co-benefits is widely accepted in the literature as a method of overcoming barriers. Gore, Robinson, and Stern (2009) suggested co-benefits could help overcome barriers, stating “actions to reduce GHG emissions are also deeply connected to other goals and co-benefits such as human health improvements through improved air quality, cost savings, adaptability to real or potential vulnerabilities due to climate change, and overall improvements in short, medium and long-term urban sustainability." Betsill (2001) stated "many local activities that produce GHG emissions produce other pollutants that have more direct effects on local air quality, including tropospheric ozone, nitrous oxides and sulphur oxides…thus, efforts to reduce GHG emissions also lower emissions of these substances, thereby improving local air quality." Dhakal (2010) affirmed the need to optimize GHG mitigation with local co-benefits. Maas (2009) reported on GHG emissions from municipal water and wastewater services, also recommending measures to reduce consumption and achieve co-benefits.

Betsill (2001) found that GHG emission reduction policies and measures "are motivated by the recognition that these activities contribute to other objectives, such as saving money, reducing local air pollution, enhancing alternative transportation and increasing the 'liveability ' of their communities." Improved public and alternative transportation systems reduce urban air pollution and alleviate traffic congestion, a benefit argued by Newman and Kenworthy. Kousky and Schneider interviewed 23 municipalities and found that a large majority of municipalities were motivated to action by cost savings and "the perceived existence of other local benefits stemming from many mitigation projects." Kousky and Schneider (2003) noted the following perceived municipal co-benefits from GHG emissions:

- Reductions in traffic that save people time on congested roadways and reduce accident-related injuries.
- Reductions in on-going maintenance and future operating costs derived from the use of energy efficient technologies.
- Reductions in air pollution, and the resulting health and ecological improvements.
- Decreases in municipal solid waste.
- Creating new market opportunities and enhancing the local economy.
- Creating a city environment that draws people and business.
- Creating partnerships across government departments that might not have worked together before the climate policy was enacted.
- Avoided costs (as in complying by default with other regulations or avoiding damages).

Lindseth (2004) also published similar comments on co-benefits.

While the barriers to action are substantial, there has been some examination of potential solutions. Bulkeley (2010) suggested opportunities to demonstrate leadership (both political and municipal) have provided a means of countering arguments against taking action, stating "these opportunities have arisen through the development of transnational municipal networks, which offer "soft" rewards for pioneering actions and trigger events, such as the hosting of global conferences or sporting events." Findings by Yarnal, O'Conner, Shudak (2003) and Betsill (2001) suggest localising global climate change is important to contextualize the issue and build political support for reducing emissions.

Burch (2010) provided three case studies of municipalities in the Lower Mainland of British Columbia overcoming institutional barriers. Burch suggested municipalities should rework structures and cultures that have led to unsuccessful policy development in the past and embedded long-range sustainability goals in strategic planning. Continuous evaluation of municipal successes and failures are needed to evaluate opportunities to action and changes.

3.5 Existing Methods of Emissions Scoping

As noted by Dhakal (2010) there are significant variations in methodologies used to calculate municipal GHG inventories, making it difficult to directly compare and benchmark. There are standardized technical documents for conducting emissions inventories, such as ICELI's *International Local Government GHG Emissions Analysis Protocol* (IEAP) and the FCM's *Partners for Climate Protection* (PCP) program. The International Organisation for Standardization (ISO), ISO 14064: Quantification and Reporting of GHG Emissions for Organizations is supported by ISO 14069: Guidance for the Application of ISO 14064. However the experience with ISO 14001 is that requirements are broad and not specific to any one group, so while the standard may be useful as a reference it will likely not solve all methodological problems. Consulting companies often play an important role, for example inventory software created by TorrieSmith Associates Inc. has been used by over 300 municipalities. Other standards, such as the UK's Carbon Trust standard, have seen limited adoption. Boston (2009) discussed best practices for community inventories and explored the ICLEI and FCM models, the ISO 14064 protocol, computer software (such as TorrieSmith Associates Inc.) and others.

Municipal GHG emissions are generally placed into two broad categories, corporate (municipal governance) and those from the community. Corporate emissions pertain to municipal buildings and operations, vehicle fleet, public transportation, and the provision of public services, *i.e.* water and sewage treatment, and streetlights and traffic signals. By definition emissions from local government operations are a subset of the community emissions. Corporate emissions are a small percentage of total emissions compared to the community.

It is important to note that there are three levels of municipal government in Ontario: single, lower and upper tier. Upper tier are often referred to as regions, county, or districts, and provide services for their respective lower tier municipalities. For example, the Region of Waterloo (upper tier) has jurisdiction over solid waste, water treatment, police services, emergency medical services (EMS), museums, and public transit, whereas lower tier municipalities Kitchener, Cambridge, and Waterloo have jurisdiction over public recreation facilities, parks, public works, fire services, libraries, and individual city hall and municipal office buildings, among others. There are also single-tier municipalities, for example Toronto, Guelph, Hamilton, and Sudbury, which are responsible for all municipal services.

GHG inventory work can be complex and some municipal officials are not trained to properly assess municipal emissions. The variety of competing methodologies can add to the confusion. Without standardization there are significant differences in the allocation of corporate versus community emissions, and in Scope 1, Scope 2, and Scope 3 emissions. Table 2 (below) illustrates the *IEAP* standard for scoping and boundaries, which is one of the most commonly-used definitions. Since there is no agreed-upon methodology for emissions inventories there can be discrepancies about how emissions are reported.

Table 2 ICLEI IEAP Scopes for Emissions.

Scope Differentiations	**IEAP Definitions**	
	Government - Operational	**Community - Geopolitical**
Scope-1	Direct emission sources owned or operated by the local government.	All direct emission sources located within the geopolitical boundary of the local government
Scope-2	Indirect emission sources limited to electricity, district heating, steam and cooling consumption.	Indirect emissions that result as a consequence of activity within the jurisdiction's geopolitical boundary limited to electricity, district heating, steam and cooling consumption.
Scope-3	All other indirect and embodied emissions over which the local government exerts significant control or influence.	All other indirect and embodied emissions that occur as a result of activity within the geopolitical boundary.

NRCAN (2009) analyzed and reviewed 62 municipal energy and GHG inventory methodologies. Methodologies were assigned scores based on meeting criteria such as transparency, relevance, alignment with international standards, consistency, and accuracy. It criticized the FCM methodology, stating that it “seems to suffer from a lack of transparency, completeness and consistency.” The ICLEI *IEAP* scored highest amongst community GHG inventory methodologies.

An important formula for discussing GHG emissions in relation to a population is the Kaya identity (IPCC N.D). It closely resembles the IPAT identity in which the Impact (I) = Population (P) x Affluence (A) x Technology (T). The Kaya identity is as follows:

CO_2 Emissions = Population x (GDP/Population) x (Energy/GDP) x (CO_2/Energy)

The Kaya identity suggests that, all other factors remaining equal, a reduction in emission intensity would reduce total CO_2 emissions. This formula helps focus the scope of GHG reduction measures to energy intensive municipal processes such as fleet vehicles, water pumping and treatment, lighting, and heating. Increased efficiency also helps drive down costs, an important co-benefit.

3.6 Indicators

Indicators, if properly developed, can be a useful policy tool. This section will explore definitions of indicators, as well as their limitations.

3.6.1 Definition and Description of Indicators

There are many definitions of indicators. The Organisation for Economic Cooperation and Development (OECD) defines an indicator as "a quantitative or a qualitative measure derived from a series of observed facts that can reveal relative positions (*e.g*. of a municipality) in a given area…when evaluated at regular intervals, an indicator can point out the direction of change across different units and through time" (OECD 2008). The World Bank (2006) describes indicators as "models that simplify complex subjects to numbers which can be easily grasped and understood by policymakers and the public. They are simple numbers, comparable over time and space that have a clear link with policy implications."

Other definitions of an indicator include:

- "a variable which supplies information on other variables which are difficult to access…and can be used as benchmarker to take a decision" (Gras *et al.* 1989)
- an "alternative measure...which enables us to gain an understanding of a complex system…so that effective management decisions can be taken that lead towards initial objectives"(Mitchell *et al*. 1995).

This study utilizes the definition from Mitchell *et al*. (1995).

Bockstaller and Girardin (2003) suggest that indicators have two functions: an informative function, i.e. to supply simplified information about a complex system or an un-measurable criterion, and a decision aid function to help to achieve the initial objectives. Other uses for indicators include:

- the comparison of complex environmental conditions across time and space (Ebert and Welsch 2003)
- revealing conditions or trends that a community is moving toward, to help identify and address areas for GHG reduction (BC Ministry of Environment 2008)
- providing warning signals or identifying the cause of environmental problems (Dale and Beyeler 2001)

- providing an instrument to aid policymakers and improve governance (if properly designed) (Hezri and Dovers 2006)

Composite indicators are an amalgamation of individual indicators into an index with an underlying model. Composite indicators are used to capture multi-dimensional issues that cannot be measured with a single indicator, for example sustainability (OECD 2008). Table 3 below lists the pros and cons of composite indicators. The OECD notes that "composite indicators which compare country performance are increasingly recognized as a useful tool in policy analysis and public communications." Saisana and Tarantola (2002) state that composite indicators are useful for providing policymakers with:

- the direction of developments
- comparison across places, situations and countries
- assessment of state and trend in relation to goals and targets
- early warning
- identification of areas for action
- anticipation of future conditions and trends
- communication channel for general public and decision-makers

Table 3 Pros and Cons of Composite Indicators. Source: Adapted from Saisana and Tarantola (2002).

Pros	Cons
- Composite indicators can be used to summarise complex or multi-dimensional issues to help guide policymakers	- Composite indicators may send misleading policy messages if they are poorly constructed or misinterpreted. Sensitivity analysis can be used to test composite indicators for robustness
- Composite indicators provide the big picture. They can be easier to interpret than trying to find a trend in many separate indicators. They facilitate the task of ranking countries (municipalities in this study) on complex issues	- The simple results which composite indicators show may invite politicians to draw simplistic policy conclusions. Composite indicators should be used in combination with the sub-indicators to draw sophisticated policy conclusions
- Composite indicators can help attracting public interest by providing a summary figure with which to compare the performance across countries (municipalities) and their progress over time	- The construction of composite indicators involves stages where judgement has to be made: the selection of sub-indicators, choice of model, weighting indicators and treatment of missing values etc. These judgements should be transparent and based on sound statistical principles
- Composite indicators could help to reduce the size of a list of indicators or to include more information within the existing size limit	- There could be more scope for Member States (municipalities) about composite indicators than on individual indicators. The selection of sub-indicators and weights could be the target of political challenge
	- Composite indicators increase the quantity of data needed because data are required for all the sub-indicators and for a statistically significant analysis

From these definitions it is evident that indicators, when carefully and transparently developed, can be effective tools for reporting on complex policy issues, such as municipal greenhouse gas emissions. There is also the potential for incorrectly measuring actual emissions or misinterpreting them that would have negative consequences for policymakers.

3.6.2 Limitations of Indicators

As with any other statistical analysis understanding the context and data source is crucial. Indicators are only as useful as they are relevant and accurate. Saltelli *et al.* (2004) stated "composite indicators can send misleading or non-robust policy messages if they are poorly constructed or misinterpreted."

There are challenges to developing indicator sets, for example a "lack of robust procedures for selecting indicators makes it difficult to validate the information provided by those indicators" (Dale and Beyeler, 2001). Niemeijer and Groot (2008) studied and summarized the literature on indicators and concluded that most indicators are poorly developed and it is often impossible to determine the indicator selection process. Bockstaller and Girardin (2003) suggest the development of indicators should use scientific standards and a procedure of validation is required. Their review of literature found that few indicator developers undergo or consider such a procedure.

3.6.3 Indicator Development

Considerable work has been done regarding the development of viable, useful indicators, including Bossel (2001), Bockstaller and Girardin (2003), Hezri and Dovers (2006), and Niemeijer and Groot (2008). Dale and Beyeler (2001) provided criteria for selecting ecological indicators, such as that the indicator be straightforward and easy to measure. "The metric needs to be easy to understand, simple to apply, and provide information to managers and policymakers that is relevant, scientifically sound, easily documented, and cost-effective." Existing literature on commonly used criteria for indicator selection is summarized by Niemeijer and Groot (2008). The results of their analysis are shown in Table 4 below which shows a total of 34 selection criteria and a count of their occurrence in the literature.

Table 4 Indicator Selection Criterion Review by Niemeijer and Groot (2008)

Criterion	Count	Description/explanation
Scientific dimension		
Analytically soundness	4	Strong scientific and conceptual basis
Credible	1	Scientifically credible
Integrative	1	The full suit of indicators should cover key aspects/components/gradients
General importance	1	Bear on a fundamental process or widespread change
Historic dimension		
Historical record	2	Existing historical record of comparative data
Reliability	2	Proven track record
Systemic dimension		
Anticipatory	1	Signify an impending change in key characteristics of the system
Predictable	1	Respond in a predictable manner to changes and stresses
Robustness	1	Be relatively insensitive to expected source of interference
Sensitive to stresses	1	Sensitive to stresses on the system
Space-bound	1	Sensitive to changes in space
Time-bound	4	Sensitive to changes within policy time frames
Uncertainty about level	1	High uncertainty about the level of the indicator means we can really gain something from studying it
Intrinsic dimension		
Measurability	4	Measurable in qualitative or quantitative terms
Portability	1	Be repeatable and reproducible in different contexts
Specificity	1	Clearly and unambiguously defined
Statistical properties	3	Have excellent statistical properties that allow unambiguous interpretation
Universality	1	Applicable to many areas, situations, and scales
Financial and practical dimensions		
Costs, benefits and cost-effectiveness	1	Benefits of the information provided by the indicator should outweigh the costs of usage
Data requirements and availability	3	Manageable data requirements (collection) or good availability of existing data
Necessary skills	1	Not require excessive data collection skills
Operationally simplicity	2	Simple to measure, manage and analyse
Resource demand	5	Achievable in terms of the available resources
Time demand	1	Achievable in the available time
Policy and management dimensions		
Comprehensible	2	Simply and easily understood by target audience
International compatibility	2	Be compatible with indicators developed and used in other regions
Linkable to societal dimension	1	Linkable to socio-economic developments and societal indicators
Links with management	3	Well established links with specific management practise or interventions
Progress towards targets	1	Links to quantitative or qualitative targets set in policy documents
Quantified	1	Information should be quantified in such a way that it significance is apparent
Relevance	4	Relevance for the issue and target audience at hand
Spatial and temporal scales of applicability	2	Provide information at the right spatial and temporal scales
Thresholds	1	Thresholds that can be used to determine when to take action
User-driven	1	User-driven to be relevant to target-audience

Niemeijer and Groot (2008) note difficulties encountered when attempting to discern the indicator selection process, noting that indicators could vary significantly even for similar topics. They state:

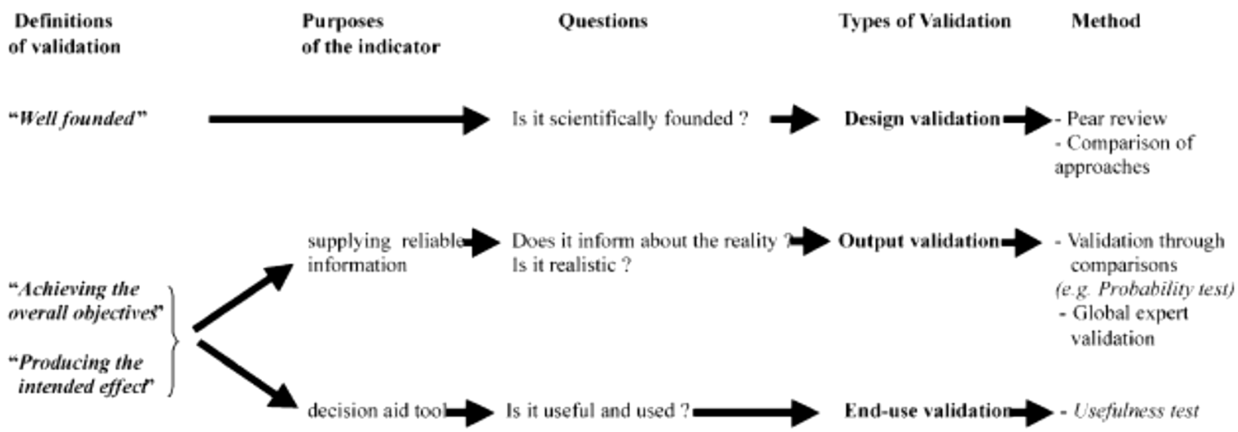
> "which indicators are considered highly influences conclusions as to whether environmental problems are serious or not, whether conditions are improving or degrading, and in which direction causes and solutions need to be sought. It is therefore very important to have a well-defined and transparent procedure leading from problem definition to indicator set to interpretation of the indicator values" (pg. 19)

It is important to note that, while literature may advocate certain indicators, factors within municipalities may change their viability. A lack of data or difficulty quantifying an indicator is more of a limiting factor to indicator development than the theory of what constitutes a good indicator (World Bank 2006).

3.6.4 Indicator Validation

The indicator set required validation in order to be used in the study. Bockstaller and Girardin (2002) suggested methods for validating indicator selection, such as the Delphi Technique, validation through comparison, statistical validation, or end-use validation. Bockstaller and Girardin's process for indicator development is illustrated in Figure 2.

Figure 2 Indicator Validation Methods Described by Bockstaller and Girardin (2002).



Bockstaller and Girardin suggest that while other validation techniques might not always be achievable, "validation based on expert judgement and expert consensus concerning the quality of the indicator design as well the quality of indicator outputs is always possible." Benarie (1988) noted that many environmental standards use Delphi-like methodologies. For example, Dee *et al.* (1973) developed the Battelle Environmental Evaluation System which applies the Delphi Technique by selecting a group of experts to rank and weight indicators, then apply average curves.

Linstone and Turoff (2002) define the Delphi Technique as "a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem." According to Benarie (1988) Delphi originated in the 1950s as a procedure "to obtain the most reliable consensus of opinion of a group of experts." The Delphi Technique is now applied in many fields and recognized as a process for validation. Niemeijer and Groot (2008) suggest that the Delphi Technique, wherein experts are brought together to select optimal indicators regarding a specific issue, is the best practice as observed in their analysis of existing literature. Benarie (1988) noted that Delphi has some inherent flaws that should be avoided, such as estimations of numerical values for environmental effects, vague questions, and lack of meaningful metrics. The selection of experts based on their qualifications can be arbitrary.

3.7 Best practices

While the term 'best practices' is ambiguous, it can be helpful for municipalities to examine successful initiatives in other jurisdictions to determine if it is feasible to attempt them domestically. As previously defined best practices are those which are recognized as being the most effective based on available knowledge.

Many NGOs publish examples of best practices in the fields of municipal climate change action, adaptation, and sustainability. The Ontario Municipal Knowledge Network (OMKN)[2], operated by the Association of Municipalities of Ontario, provides a forum for municipalities to share best practices on roads, public transit, waste management, energy management, water, and wastewater services. The Clean Air Partnership provides information on greening cities and also operates the North South Climate Exchange Network[3]. Both the FCM and ICLEI publish annual reports highlighting examples of municipal actions and successes. There are many other examples. Kousky and Schneider (2003) interviewed 23 municipal managers in the US and provided examples of paybacks and best practices for building and lighting retrofits, LED replacement in traffic signals, methane recovery projects, and fleet conversion.

3.8 Existing Initiatives

There are several voluntary initiatives established by non-governmental organisations which encourage municipal action. Some are limited to certain regions or within Canada, while others such as ICLEI and the C40 foster municipal networking worldwide, operating apart from national governments.

Several municipal ranking systems currently exist but include greenhouse gas emissions under the broad umbrella of sustainability (with the exception of the Green City report and Living City Report Card, which have more detailed information relative to the other reports). These include the "Green Cities" series sponsored by Siemens, the "Living City Report Card" by the Toronto and Region Conservation Authority, and Corporate Knights annual "Sustainable Cities Rankings". Each initiative differs significantly in methodology, use of indicators, and approach. For a breakdown of the reports and their methodologies see Table 5 below.

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[2] http://www.omkn.ca/AM/Template.cfm?Section=Best_Practices Accessed 23 March 2012.
[3] http://www.cleanairpartnership.org/north_south_climate_change Accessed 23 March 2012.

Table 5 Description of other Municipal Ranking Reports

Report/Scorecard Name	Author (s)	Description	Methodology Used
The Living City Report Card 2011 – An Assessment of the Environmental Health of the Greater Toronto Area	Toronto and Region Conservation Authority, Greening Greater Toronto	Measures carbon, air quality, water, waste, land use, biodiversity using 20 indicators. Letter grade (A-F) assigned relative to criteria for each of the 6 measures. Criteria relative to short and long term objectives.	Kennedy, C., J. Steinberger, B. Gasson, T. Hillman, M. Havránek, Y. Hansen, D. Pataki, A. Phdungsilp, A. Ramaswami, G. Villalba Mendez. "Methodology for Inventorying Greenhouse Gas Emissions from Global Cities" Energy Policy 37(9), 2010.
2011 Most Sustainable Cities in Canada	Corporate Knights	Number value in a 10 high, 0 low system. Ranked 17 cities in Canada with population >10,000.	5 categories (Ecological Integrity, Economic Security, Governance & Empowerment, Infrastructure & Built Environment, Social Well-being) and 28 indicators. Data for each normalized to a 0 – 10 value (10 high, 0 low). No penalty if indicator data not available.
US and Canada Green City Index (2011)	Economist Intelligence Unit, Siemens	Index of 27 major cities in Canada and US assessing environmental performance. Ranking out of 100 points.	Methodology developed by panel of 7 experts in urban environmental sustainability. Nine categories (CO_2, energy, land use, buildings, transport, water, waste, air quality, environmental governance) using 31 indicators (16 qualitative, 15 quantitative). Missing data filled in using estimates.
Scorecard on Prosperity (2011)	Toronto Board of Trade	Benchmark comparison of City of Toronto to 20 global cities and 22 municipalities in Toronto CMA. Report card grade (A-D).	25 indicators selected based on data availability and grouped into two domains: Economy and Labour Attractiveness. Composite index developed using common normalization techniques. Overall score developed using both domains.

3.8.1 ICLEI and FCM

The International Council for Local Environmental Initiatives (ICLEI), founded in 1990, is part of the UN and operates worldwide charged with helping to implement the goals of Agenda 21. It has produced one of the most utilized municipal GHG inventory standards, the *Local Government GHG Emissions Analysis Protocol* (IEAP).

ICLEI Canada has partnered with the Federation of Canadian Municipalities (FCM) to develop the Partners for Climate Protection Program (PCP). The FCM is the largest municipal association in Canada with 1900 members. It represents municipalities on policy matters that fall within federal jurisdiction. The PCP is the Canadian counterpart of ICLEI's Cities for Climate Protection (CCP) network, which involves more than 900 communities worldwide (FCM and ICLEI, 2010). The PCP program currently has over 200 members representing over 80% of Canada's population (FCM, 2009). The program uses a performance-based model in which members work towards completing five milestones: creation of a GHG emissions inventory, setting reduction targets, developing a local action plan; implementing the plan, monitoring progress and reporting results.

Gore (2010) found that only a small number of municipalities have reached three of five milestones, with the majority of municipalities having accomplished two or less. While the PCP program is encouraging, membership only encompasses 0.05% of 4,000 municipalities in Canada. Many large urban centres are members, capturing a large portion of Canada's population. Membership amongst small municipalities is an ongoing issue. Betsill and Bulkeley (2004) provide analysis of municipal motivations and experiences from joining the CCP program in the US, while Gore and Robinson (2009) and Robinson and Gore (2005) explored municipal motivations in joining the PCP program and critiqued their shortcomings. Lindseth (2004) argues that the CCP program needs to better link global and local concerns for climate protection, concluding that the current format makes it difficult to establish climate change as a concern for local governments.

ICLEI USA is developing the STAR Community Index to be launched in late 2012. It is a planning and performance management system for sustainability featuring a rating system which will "drive continuous improvement and foster competition" amongst municipalities[4].

In 2011 the C40 and ICLEI signed an MOU to announce that they would partner to develop a Global Standard on Cities Greenhouse Gas Emissions[5]. Citing the number of standards available and competing methodologies as an issue, the new common standard will incorporate policy and comparability amongst municipalities with similar characteristics. It is currently still in development.

3.8.2 C40 Cities

The C40 Cities Climate Leadership Group (C40) is a partnership of 40 global cities which works to share best practices and reduce GHG emissions through initiatives and programs. Toronto is currently the only Canadian member (C40 2010). Roman (2009) provides an assessment of the C40s successes to date. He notes that it has quickly become an important international framework and commended the C40s' unique style of 'governance from the middle' as both compelling and practical. Roman concluded

[4]ICLEI USA Accessed 13 Feb 2012 from http://www.icleiusa.org/sustainability/star-community-index/overview-of-the-star-community-index
[5]ICLEI Accessed 13 Feb 2012 from http://www.iclei.org/index.php?id=1487&tx_ttnews%5Btt_news%5D=4643&tx_ttnews%5BbackPid%5D=983&cHash=712a8184bb

by noting the importance of public/private partnerships and how they can be supported and expanded under transnational city networks.

3.8.3 Sustainable Waterloo Region's Regional Carbon Initiative

Sustainable Waterloo Region (SWR) has achieved success with the Regional Carbon Initiative, through which members in both the private and public sectors voluntarily agree to reduce greenhouse gas emissions[6]. The SWR facilitates reductions by providing information and toolkits. Recently SWR partnered with the Region of Waterloo to create the *Climate Collaborative*, which will assist the Region in developing a community-wide greenhouse gas inventory and reduction plan. Similar organisations have been created in Hamilton, ON, and in Niagara Region based on the SWR model.

3.9 Government Regulations

Ontario Regulation 397/11, made under the *Green Energy Act*, was passed into law in 2011. It requires municipalities to submit an annual report on energy consumption and to calculate greenhouse gas emissions for all facilities under their responsibility by July 2013 for 2012 energy consumption. The regulation includes all municipal buildings as well as hospitals and post-secondary institutions. Some municipalities have already begun establishing inventories in preparation for the new regulation.

4. Research Questions

The groundwork for municipal climate change action is well developed from Our Common Future, the 1988 World Conference on Changing Atmosphere, the 1992 Rio Earth Summit, and Agenda 21. Since the 1990s municipalities have begun taking action to reduce their GHG emissions. Research has examined barriers to action and how they can be overcome, motivations for taking action, and identification of best practices worldwide. Work by Gore, Robinson, Harvey, and Kennedy have provided a Canadian perspective. Research has also identified issues with indicator development and usage, as well as indicator validation techniques.

The literature confirms the need for benchmarking and identification of best practices. Currently no such system exists for comparing municipal GHG emissions against one another. There is no optimal set of indicators, and those that exist are often poorly developed and lack transparency. Municipalities face difficulties when attempting to conduct GHG emission inventories due to competing methodologies. This often results in a lack of standardization which makes benchmarking difficult, if not impossible. While there are municipal benchmarking and ranking initiatives for environmental issues in

[6] http://www.sustainablewaterlooregion.ca/regional-carbon-initiative/

general, there are as of yet no municipal benchmarking initiatives which specifically measure GHG emissions. Experience from the TRCA's Town Hall Challenge and the Ontario Municipal Benchmarking Initiative suggest that municipalities are interested in being evaluated, ranked, or benchmarked against one another as a measure of performance. Municipalities have taken action and joined networks such as the FCM's PCP program. Research suggests these initiatives have seen successful but are losing momentum. Many municipalities fail to move beyond the initial milestones, and many of the programs are now focussing on adaptation instead of emission reductions. An examination of alternate methods for encouraging action and cooperation through dissemination of best practices and co-benefits is needed. This research will attempt to address these gaps.

The research objectives for the study are:

- To develop a transparent indicator set which, once validated, can be used to examine municipal GHG emissions
- To gather data on municipal GHG emissions and reduction activities through the use of a questionnaire
- Direct comparison of municipalities based on the data from the questionnaire and indicator set

5. Methodology

The study has three distinct components:

- Consultations with municipal policy experts
- Development and validation of the indicator set
- The release of a questionnaire to participating municipalities
- Comparison of municipalities based on the questionnaire results and a case study

The study methodology uses components of a methodology developed for constructing composite indicators (OECD 2008). The OECD methodology is summarized in Appendix 2.

Ryerson University's Research Ethics Board (REB) approval was required in order to conduct the consultations, questionnaire, and interviews with municipal representatives. In October 2011 (REB) approval was granted; a copy of the letter is found in Appendix 3.

5.1 Municipal Expert Consultation

A panel of municipal climate change policy experts was assembled in November 2011. These particular representatives were contacted for their unique range of experience and perspectives in the field of GHG emission inventories and municipal climate change policy. The experts confirmed the need and validity of the project. They also helped ensure that the indicators are realistic, useful, and that data will be readily available. The meetings also raised many important issues and limitations with indicators.

The panel was consulted to provide feedback and criticism of the draft list of indicators. The final indicator set was developed in January 2012. The panel of municipal experts were again consulted to provide feedback and to validate the indicator set in February and March 2012.

All in person, email, and phone communications were in accordance with the conditions of the Research Ethics Board approval. Participation in the panel was voluntary. Meetings were typically 30 minutes in length and loosely structured to discuss the draft indicator set, the study methodology, and the need for the study. Meetings were held in the offices of participants or in public locations such as coffee shops. Participants were provided with summaries of the interviews prior to release in order to make changes and gain approval.

5.2 Indicator Selection

There is no set procedure for selecting the optimal set of indicators. Therefore when selecting indicators it is important that the indicator set is selected in a logical way, that the indicators are correctly measuring emissions, and that the indicators will generate data that is useful to policymakers. The indicators must have a clear rational and the selection process must be transparent.

The OECD (2008) has developed a list of criteria for effective indicators such as:

- Relevance
- Accuracy
- Timeliness
- Accessibility
- Interpretability
- Coherence

A review of the literature identified seven important sectors under municipal control including building codes and standards, infrastructure, municipal operations and facilities, land use planning, public transportation, waste, and energy consumption (Gore and Robinson 2009, Kousky and Schneider 2003). Kennedy (2010) recommended several areas for strategic action such as:

- Buildings
  - Retrofits of existing buildings for greater efficiency
  - Stricter regulation for resource consumption in new buildings
- Land use and urban planning
  - Increased density
  - Increased urban green spaces (parkland, urban tree canopy, green roofs)
- Transportation
  - Improved coverage of public transit infrastructure

        - Encourage adoption of electric or low-emission vehicles
- Energy Supply
    - Harvest energy from municipal waste stream
    - Increased renewable energy supply
- Efficiency and demand management
    - Increased efficiency of municipal services and buildings

Many Canadian municipalities adhere to the *IEAP* when conducting their GHG inventories. With respect to indicator categories, ICLEI's *IEAP* suggests municipalities classify their emissions based on eight categories:

- Buildings and Facilities
- Electricity or district heating/cooling generation
- Vehicle Fleet
- Streetlighting and Traffic Signals
- Water and Wastewater Treatment, Collection and Distribution
- Waste
- Employee Commute
- Other

Each of the municipal ranking/benchmarking initiatives discussed in the literature review were studied for their use of indicators. Municipal GHG inventories were compiled and studied to determine the indicators municipalities are using and what data would be easily accessible.

The development of the indicator set for the study followed several key principles outlined below. These principles were confirmed during consultation with municipal experts. The indicators must:

- Be selected in a logical, transparent process (Niemeijer and Groot 2008)
- Be relatively simple, easy to measure and useful to municipalities and policymakers (Dale and Beyeler 2001, expert meetings)
- Take into account the geo-socio-political context of each municipality, *ie.* population, economy, responsibilities, electricity mix emission factors (expert meetings)
- Benchmarking must allow for comparison between apples and oranges (expert meetings)

As discussed in the literature review there are methods to validate the indicator set, such as the Delphi Technique or other Delphi-like approaches. This study utilized an approach loosely based on the Delphi Technique in which a panel of experts were contacted and asked to provide input on the development of the indicator set. Expert consensus on which indicators were important and useful helped to draft the indicator set. The experts were then asked to validate the indicators.

A draft list of indicators was prepared in November 2011 and the indicator set was finalized in March 2012. There are two sets of indicators to be used throughout the study, primary and secondary indicators. The indicator set used 17 indicators. The indicators are only a measure of GHG emissions under the jurisdictional control of the municipality.

5.2.1 Primary Indicators

Primary, or outcome indicators, are those which directly measure greenhouse gas emissions (BC MOE 2008). These numbers are used to calculate emission totals and form the basis of comparison amongst municipalities. There are nine primary indicators. Their scope is limited to annual use and not the full life cycle of emissions. Therefore the indicators do not take into account manufacturing, construction or maintenance of equipment and facilities. A full life cycle assessment of municipal GHG emissions is beyond the scope of this study.

5.2.2 Secondary Indicators

The secondary indicators help measure municipal actions and support the primary indicators by providing context. They often have an influence on primary indicators in that they represent actions that can contribute to reduced GHG emissions. There are eight secondary indicators.

5.3 Questionnaire

Prior to release of the questionnaire a list of municipalities for inclusion in the study was drafted in January and February 2012. In March 2012 the municipal contacts were sent an email inquiry which outlined the purpose of the study and asked if the municipality was interested in participating in the questionnaire. A questionnaire was created containing 20 questions regarding municipal climate change activities. The questions asked municipalities to voluntarily provide data pertaining to the indicators and provided opportunities to elaborate on GHG reduction activities. A copy of the survey questions is found in Appendix 4. It was approved by the Ryerson Research Ethics Board. If the municipality expressed interest in participating, a follow-up email was sent containing the ethics and confidentiality agreement.

The questionnaire was accessed online using FreeOnlineSurveys.com A hyperlink to the online survey was sent by email to all participating municipalities on April 10 2012. Reminder emails were sent on April 17 and April 24. After a period of four weeks the survey was closed on May 1 2012, although late submissions were received. Following the successful completion of the surveys the data was entered into the indicator set. This data was complemented by data from the most recent municipal GHG inventories, as well as information from the literature review; for example, such as Kennedy *et al.* (2010).

5.4 Case Study

To demonstrate how the municipal benchmarking template functions the Town of Newmarket was examined as a case study. Newmarket was selected because it is a PCP participants, is a typical medium-sized municipality, and data was easily accessible. A 2006 baseline was used in the case study, as opposed to the 2010 baseline used in the study.

The case study was useful for addressing some of the potential issues with comparing municipalities. Specifically, the case study provides transparency to the indicator set and calculations, as well as emission factors used, rounding, imputation of missing data, normalization techniques, robustness and sensitivity analysis, and uncertainty analysis.

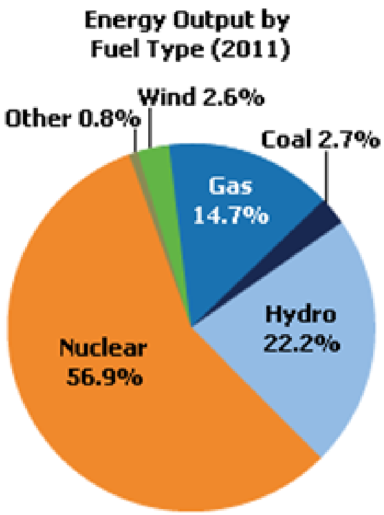
5.4.1 Emission Factors

A common problem when comparing municipal GHG inventories lies with the emission factors (EFs) used. EFs are controversial and can change depending on new research, economic conditions, electricity imports, and long-term changes to the provincial energy supply. For example Environment Canada uses an electricity EF of 150 gCO_2e/kWh for 2010 but Natural Resources Canada's GHG Genius tool uses 220 gCO_2e/kWh. Vehicle EFs depend on assumptions regarding fuel efficiencies for vehicle types and classes. Solid waste EFs rely on complex modeling techniques for decay of organic matter and release of methane over time based on factors like precipitation and climate (NRCAN 2011).

To avoid problems with EFs the benchmarking methodology utilized EFs developed by Environment Canada for the 2012 National Inventory Report submission to the UNFCC (see Appendix 5). Common EFs will increase equality and accuracy while also improving transparency. It is important to note that EFs have varying degrees of uncertainty and are subject to change based on improved methods and new knowledge. Environment Canada reports EFs for CO_2, CH_4, and N_2O; the latter two can be converted into CO_2 using their global warming potentials 21 and 310, respectively (Environment Canada 2012).

Electricity EFs change annually based on Ontario's energy supply mix. Ontario has been divesting itself from coal generation with the goal of completely phasing out coal by 2014. Ontario now relies on a mix of hydro, nuclear, natural gas, and renewable energy (see Figure 3). Cleaner sources of electrical generation have lowered emission factors, from a peak of 300 gCO_2e/kWh in 2003 to 150 gCO_2e/kWh in 2010, the most recent year that data are available (see Appendix 5).

Figure 3 Ontario Electricity Mix 2011. Source: IESO 2011



The EFs for vehicles are located in Table 5 below. To find the total tCO_2e, the amount of fuel consumed is multiplied by the EF, adjusted for global warming potential (GWP), summed, then converted into tonnes CO_2e (1 gram = $1*10^{-6}$ tonnes). All other emission factors used in calculations are found in Appendices 4 through 6. Information from the Ontario Power Authority suggests that net electricity imports have been negative since 2005 (refer to Appendix 6). Therefore the EF calculations are not adjusted for imports.

According to Environment Canada (2012) the EF for marketable natural gas in Ontario is 1,879 gCO_2/m^3. Some geothermal heating systems offset the need for natural gas heating. The heating from geothermal is often measured in GJ. To convert GJ into kWh the figure is multiplied by 277.78, converted into tCO_2e/kWh, and deducted from the total natural gas consumed.

Table 6 Emission Factors for Fleet Vehicle Fuel Consumption. Source: EC 2012 (p.199)

Fuel (Litres)	Emission Factors (g/L)		
	CO_2	CH_4 (GWP 21)	N_2O (GWP 310)
Light-Duty Gasoline Vehicles (Tier 0)	2,289	0.32	0.66
Heavy Duty Gasoline Vehicles (Uncontrolled)	2,289	0.49	0.084
Light Duty Diesel Vehicles (Uncontrolled)	2,663	0.10	0.16
Heavy Duty Diesel Vehicles (Uncontrolled)	2,663	0.15	0.075
Natural Gas Vehicles	1.89	0.009	0.00006
Propane Vehicles	1,510	0.64	0.028
BioDiesel	2,449	0.24	0.108

GHG emissions from residential land densities are calculated using data from Norman, MacLean, and Kennedy (2006). The study found low density dwellings contribute 0.3980 tCO2e annually/dwelling, while high density dwellings contribute 0.3474 tCO2e annually/dwelling. The 2006 Census by Statistics

Canada provides data on the number of dwellings by type, which are then multiplied by the density EFs and summed to produce the total. This indicator is explained further in section 6.2.3.6.

To establish tCO_2e for municipal solid waste, the emission factor from the 2012 National Inventory Report (EC 2012) was used. For Ontario, the average L_0 value (kg CH_4 per tonne of waste) is 78.34 (or 0.07834 g CH_4/tonne waste) for the period 1990-Present (refer to Appendix 7). This figure is then multiplied by CH_4's GWP, 21, to produce gCO_2e/tonne waste and converted into tonnes (1 gram = $1*10^{-6}$ tonnes). If methane from the landfill is captured and flared, the annual GHG reductions (in tCO_2e) are deducted from the total.

It is important to note that indicators for water and wastewater and sewage rely on the concept of an urban serviced population, that is, the population which has access to municipal services. A portion of the population will be rural and rely solely on groundwater wells and backyard septic systems. Statistics Canada (2009)[7] estimates that 89% of Ontarians receive municipal water, while 79% use municipal wastewater and sewage[8]. It is acknowledged that the Ontario averages used in calculations may in reality differ significantly amongst municipalities. Data for each individual municipality are not available.

5.4.2 Rounding

All calculations, including the summing of emission totals, were made using unrounded data. All data is shown to 10^{-4} decimal places and are expressed in tCO_2e.

5.4.3 Imputation of Missing Data

All attempts were made to gather data for each indicator. If the survey results were inconclusive the municipality was consulted directly. The municipal GHG inventory was examined for additional data. Nonetheless, some municipalities did not have records or data for some of the indicators.

If a municipality needed to be omitted from a particular indicator where data were unavailable or not under their responsibility, the municipality was not penalized. A note is made under each indicator explaining the issue.

5.4.4 Normalization of Data

A common problem in comparing data is different units of measurement. The municipal benchmarking template must be an apples-to-apples comparison, a point emphasised during the meetings with municipal experts. Ebert and Welsch (2003) state:

[7] http://www.statcan.gc.ca/pub/11-526-x/2011001/t001-eng.pdf Accessed May 14 2012
[8] http://www.statcan.gc.ca/pub/16-002-x/2008004/tbl/water-eau/tbl001-water-eau-eng.htm Accessed May 14 2012

> In constructing environmental indices from non-comparable variables, one often encounters the problem of incommensurability, *i.e.* there are no rules for weighting and aggregating the data on the basis of underlying scientific relationships. A common procedure pursued in these circumstances is to convert the data from their original units to 'normalized' units and then to aggregate the results (pg. 11)

The OECD indicator handbook suggests nine alternative methods for normalizing data (OECD 2008). The assignment of differential weights can reduce the impact of extreme scores on the overall score. Normalization using standardized z-scores was considered unnecessary for the study.

5.4.5 Weighting and Aggregation of Data

There are many ways to assign weights and aggregate data. Dee *et al.* (1973) developed the Environmental Evaluation System (EES) for estimating environmental impacts, which incorporates a mathematical method for weighting and uses the Delphi Technique to minimize judgement. Goyal and Deshpande (2001) examined the use of an importance scale matrix (ISM) which assigns weights to parameters based on their relative importance.

For the study weights were assigned by each indicator category out of a possible 100%. The weighting parameters were the indicators' relative importance, whether the indicator is a corporate or community emissions measure, and the amount of control that municipal governments have over them. Categories such as buildings and operations, transportation, and solid waste can be strongly influenced by the municipality, whereas the land use category is complex and dependant on provincial regulations. The indicator weights attempt to reflect these realities. The municipal experts were asked to provide input into the indicator weights during the consultations. The indicator weights and category weights are illustrated in Table 6 below.

Table 7 Proposed Indicator Weights

Indicator	Category	Weighting	Category Weight
Total GHG produced annually from electricity consumption by municipal buildings per m^2 of space	**Municipal Buildings and Operations**	**0.45**	**0.20**
Total GHG produced annually from heating in municipal buildings from natural gas per m^2 of space	**Municipal Buildings and Operations**	**0.35**	
Total GHG produced annually electricity consumption by streelighting/traffic signals per capita	**Municipal Buildings and Operations**	**0.20**	
GHG emissions from total annual fuel consumption in fleet operations (excluding public transit system) per capita	**Transportation**	**0.50**	**0.20**
GHG emissions from total annual fuel consumption in public transport fleet operations per capita	**Transportation**	**0.50**	
GHG emissions from residential densities per capita	**Land Use and Urban Planning**	**1.00**	**0.10**
GHG emissions from water pumping, treatment, and consumption, per capita urban serviced population	**Water Treatment and Use**	**1.00**	**0.15**
GHG emissions from the treatment of wastewater and sewage per capita urban serviced population	**Wastewater and Sewage Treatment**	**1.00**	**0.15**
GHG emissions from disposal of municipal solid waste per capita	**Solid Waste**	**1.00**	**0.20**

It is important to note the arbitrary and subjective nature of assigning weights. There is no set process or method, instead it is variable and could differ significantly depending on who was reviewing the indicators. This municipal GHG benchmarking template is flexible in regard to weighting. Therefore, depending on the municipality and its interests, the weights could be altered at will. The Newmarket case study (section 6.3) demonstrates how alternate weights could be realistically applied. For this reason the study places more emphasis on equally weighted results.

5.4.6 Robustness and Sensitivity Analysis

As described throughout the methodology, there are assumptions and decisions that influence the final results. This includes the selection of the primary and secondary indicators and the assignment of weights. Furthermore it is important to consider what the indicators are intended to capture. It is a measure of GHG emissions from operations, not total life-cycle emissions. They do not measure emissions from commercial and industrial sectors, while only some residential emissions are measured. Private automobile use, emissions from major roads and highways, passenger and freight rail, shipping, and airports are not included. Agriculture and land use changes are also not included. A comprehensive review of all emissions within the municipal boundary is beyond the scope of this research. The Climate Collaborative initiative by the Region of Waterloo and Sustainable Waterloo Region will provide a glimpse of total community GHG emissions when it is released later in 2012. The methodology and findings could be incorporated into future benchmarking efforts.

As previously stated, transparency is a key factor in this research. Robustness and sensitivity analysis provides an opportunity to scrutinize the results and explore possible sources of error and bias. The OECD (2008) states that "good modelling practice requires that the modeller provide an evaluation of the confidence in the model, assessing the uncertainties associated with the modelling process and the subjective choices taken... A combination of uncertainty and sensitivity analysis can help to gauge the robustness of the composite indicator ranking, to increase its transparency, to identify which [municipalities] are favoured or weakened under certain assumptions and to help frame a debate around the index." Uncertainty analysis can be performed on the weighted results. Many of the limitations surrounding the indicators have been made clear throughout the methodology.

5.4.7 Uncertainty Analysis

The OECD suggests seven potential methods for assessing uncertainty. This study employs two of the methods which are marked in bold.

- **Inclusion and exclusion of individual indicators**
- **Using different plausible values for the weights**
- Modelling data error based on the available information on variance estimation
  - *Not selected, not applicable.*
- Using alternative editing schemes, e.g. single or multiple imputation
  - *Not included since indicators were selected based on anticipated availability of data. If results warrant data imputation this may be revisited.*
- Using alternative data normalisation schemes, such as Min-Max, standardisation, use of rankings
  - *Not applicable; methodology does not use normalization.*
- Using different weighting schemes, e.g. methods from the participatory family (budget allocation, analytic hierarchy process) and endogenous weighting (benefit of the doubt)
  - *Alternate plausible weighting values will be used*
- Using different aggregation systems, e.g. linear, geometric mean of un-scaled variables, and multi-criteria ordering
  - *The data are aggregated by summing the weighted values. It is not anticipated that there is uncertainty related to this process.*

Once the benchmarking is completed, uncertainty analysis can be performed on the weighted results.

5.5 Interviews with Municipal Representatives

Phone interviews were held with most of the municipal contacts in order to discuss the study and the questionnaire results. Participants were provided with summaries of the interviews prior to release in order to make changes and gain approval. Draft results were finalized and sent back to municipalities for review and to receive consent for publication on May 9 2012. A final results report was prepared on May 18 2012 and released to all participants on May 25 2012. No in-person meetings were held. All email and phone communications were in accordance with the conditions of the Research

Ethics Board approval. Participation in the questionnaire was voluntary and participants could remain anonymous if they wished. The phone interviews were typically 30 minutes in length and loosely structured around the questionnaire and the respective municipalities' climate change mitigation strategies.

All Ontario municipalities were initially considered for inclusion in the study. However, due to the scope of the research and the available resources, the number of participants was narrowed down using several criteria. Municipalities were selected to represent a broad, diverse set with varying socio-economic, geographic, and population characteristics. Specifically, attempts were made to include small municipalities and those located in northern Ontario.

FCM PCP participation was one of the criteria used to select municipalities. The first PCP milestone, completing a greenhouse gas inventory, suggests that the municipality is aware of its GHG emission sources and would be a good candidate for inclusion in the study. Some municipalities were selected based on their participation in the Town Hall Challenge, an initiative by Toronto and Region Conservation Authority to rank Canadian municipalities on energy efficiency in their town halls and civic buildings[9].

During discussions in November 2011 with Peter Love, distinguished research fellow at Ryerson's Centre for Urban Energy, Mr. Love noted the Ontario Power Authority's Municipal Energy Conservation Officer (MECO) program (Mr. Love was the former Chief Energy Conservation Officer at the OPA from 2004-2009). MECOs are charged with helping create a culture of conservation in their respective municipalities. In November 2009, the last update to the list, 24 municipalities had MECOs[10]. The majority of the 24 municipalities were ultimately included in the study since it was assumed that participation in the MECO program signalled willingness on behalf of the municipality to take action.

Distance from Ryerson University was a consideration so that in-person meetings could be arranged as necessary, although this was not a deciding factor.

5.6 Methodology Overview

The study was conducted using four distinctive steps. These were consultations with a panel of municipal exerts, selection of the indicator set, an online questionnaire which was released to a group of municipal managers, and a case study which demonstrated how the municipal comparison would be achieved.

[9] http://www.trca.on.ca/the-living-city/programs-of-the-living-city/mayors-megawatt-challenge/the-town-hall-challenge.dot

[10] http://www.powerauthority.on.ca/meco/municipal-energy-conservation-officers

6. Results

This section discusses the results of the April 2012 questionnaire which was sent to municipal managers.

6.1 Municipal Expert Consultation

The following sections summarize meetings held with the expert panel from November 2011 to March 2012. This is illustrated in Table 7 below.

Table 8 Municipal Experts Consulted during Nov 2011-March 2012

Name	Position	Organisation	Meeting Dates	Issues Raised
Christopher Morgan	Program Manager, Air Quality	City of Toronto	November 17 2011, January 18 2012, March 8 2012	Determination of corporate vs community emissions and grouping, municipal responsibilities, boundaries, limitations of indicators, comments on FCM and ICLEI approaches, relate indicators to population.
Dave Roewade	Sustainability Planner	Region of Waterloo	December 7 2011	Municipal governance through single, upper/lower tier municipalities, the importance of intensity indicators to account for increases in population.
Sarah Brown, representing Mike Morrice	Project Manager, The Climate Collaborative	Sustainable Waterloo Region	December 7 2011, March 12 2012	Importance of community partnerships e.g. Climate Collaborative and RCI. Municipalities are interested in being ranked. Difficulties with land-use indicator development.
Mary Pickering	Vice President	Toronto Atmospheric Fund	December 16 2011, March 8 2012	Issues with using electricity consumption indicators relative to changing electricity mix, role for natural gas consumption and building retrofit/building code indicators.
Jon Yazer, representing Craig Applegath	Neighbourhood Engagement Coordinator	Project Neutral, Resilient Cities, DIALOG	December 16 2011, March 9 2012	Importance of land-use indicators. Perhaps use two surveys for large and small municipalities, try to account for large differences in responsibilities and priorities.
Ken Thompson	Manager, Water & Wastewater Expert Panel	Ontario Municipal Benchmarking Initiative	March 12 2012	If measuring emissions per capita, must use urban serviced population. OMBI working to develop GHG performance indicators. Wastewater effluent regulated by province, lack of municipal control.
Ralph Torrie	Manager Director	Trottier Energy Futures Project, Torrie Smith Associates Inc.	March 15 2012	Discussion of the indicators and potential end-uses. History of the development of municipal GHG inventories, issues with municipalities not taking measures to reduce emissions. Advice on narrowing the focus of the thesis to corporate emissions only, with end result being a business product or an academic exercise. Dangers of attempting to quantify community emissions, quickly becomes modelling and should be left to experts.
Muni Ahlawat	Program Officer, PCP National Programs	FCM	January 15 2012	

6.1.1 Christopher Morgan, City of Toronto

Christopher Morgan is Program Manager of Air Quality at the City of Toronto. He was involved in preparing Toronto's 2007 GHG inventory report. Mr. Morgan has extensive experience with gathering data for municipal GHG inventories with the City of Toronto, and as such has considerable knowledge about indicator development and municipal operations.

During the November 17th 2011 meeting Mr. Morgan provided extensive input on all of the draft indicators, as well as recommendations for the project methodology. He stressed keeping things simple, as it can be easy to delve into too much detail and encounter difficulties. Mr. Morgan discussed differences in corporate (government) emissions and community emissions, corporate being a subset of the broader community emissions. He also stressed the importance of comparing 'apples to apples.' He agreed that a significant problem is that municipal GHG inventories have no standardized methodologies; therefore a municipality can choose a methodology best suited to them.

Mr. Morgan provided input on each of the draft indicators. He raised concerns about measuring emissions from municipal buildings, stating that Toronto owns between 1,000-2,000 buildings; therefore measuring total emissions from all buildings could be challenging. He suggested that plug loads from electrical devices and office equipment were a significant factor in electricity consumption. Mr. Morgan questioned the overall impact of district energy systems on municipal emissions based on experience with local district energy provider Enwave in Toronto. He suggested measuring natural gas consumption by m^3 building volume rather than m^2 of floor space. Mr. Morgan proposed merging the Energy and Building Codes/Standards categories with a new Buildings and Operations category**.** He debated the need to include municipal streetlighting and traffic signals as an indicator since they are a relatively small percentage of corporate GHG emissions. For fleet transportation emissions Mr. Morgan advised measuring litres of fuel consumed and mileage due to the availability of data. Land use planning indicators could face issues when attempting to define urban boundaries. Overall Mr. Morgan estimated that corporate GHG emissions are small (~4%) when compared to the broader community (about 96%).

During meetings in January and March 2012 Mr. Morgan provided additional comments on the final indicators. He noted the importance of discussing the limitations with indicators, such as instances where indicators can provide a false signal and drive policy forward erroneously. He also noted their relation to the stated thesis objectives and provided clarification on municipal responsibilities. Mr. Morgan commented that indicators either describe what currently exists within the municipality, or suggest a possible deficiency or course of action. Most of the indicators should be on a per-capita basis to allow for comparison amongst municipalities regardless of population. Mr. Morgan agreed that the indicators need to reflect population growth and economic growth; therefore intensity-based measurements may be more appropriate. Mr. Morgan confirmed that TTC public transportation emissions are included as corporate emissions, a point that had been raised by Mr. Roewade.

Regarding limitations of the solid waste indicator Mr. Morgan commented that private waste collection can often surpass municipal collection, suggesting a ratio of about 2:1 (to be verified by the literature). Mr. Morgan commented on the public transportation indicator that a measure of kilometres driven often leads to abandonment of longer periphery routes and does nothing to measure GHGs. Mr. Morgan highlighted a public transit ‘myth’ that increased surface or underground transit reduces emissions from private vehicles. Instead, he suggested that the number of traffic lanes must be reduced, otherwise the excess capacity is soon filled and auto emissions actually increase as a result.

6.1.2 Dave Roewade, Region of Waterloo

Dave Roewade was selected for involvement due to his work at the Region of Waterloo. He helped author the Region of Waterloo’s Corporate Greenhouse Gas Inventory and Action Plan (2011)[11], and is responsible for reporting thr Region’s emissions to the FCM PCP program. He is the person of contact for partnership with Sustainable Waterloo Region to develop the Climate Collaborative, an initiative to oversee that the Region meets its community GHG reduction targets.

During a meeting with Mr. Roewade on December 6th 2011 he made several significant points and commented on the draft indicators. He stressed the need for context when comparing municipalities. For example, Waterloo Region is expected to grow considerably in the coming decades and therefore GHG intensity targets are more realistic than absolute emission reductions. He suggested that indicators must be relevant to the geo-political/socio-economic situation within the municipality. He also stressed scoping between upper and lower tier municipalities; their responsibilities differ and therefore emissions will be unevenly distributed. An apples-to-apples comparison is needed.

Mr. Roewade suggested beginning with what is currently being measured by municipalities, for example data regarding corporate (government) employee fleets. Indicators should be constructed by considering the availability of data and if they can be measured on an annual basis. They must also be useful to municipalities for benchmarking purposes, helping to improve decision making and initiate political action. Mr. Roewade suggested that the indicators be S.M.A.R.T: specific, measurable, achievable, relevant and time-bound.

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[11] http://www.regionofwaterloo.ca/en/aboutTheEnvironment/resources/CR-FM-11-011.pdf

A point was made to examine GHG reductions in relation to capital cost and spending. Mr. Roewade cited an example of Grand River Transit busses where trade-offs arose: the Region could either invest in *x* hybrid or natural gas transit vehicles versus *y* conventional diesels. While GHG emissions per vehicle would decrease with the former, the Region's limited funds would purchase many more conventional buses, thus helping improve transit ridership and reducing car use, important Regional objectives for meeting their established GHG reduction targets. He listed other initiatives such as right-sizing corporate fleet vehicles and banning certain materials from landfill, such as e-waste or organics, that had large payoffs with relatively little effort.

In regard to the indicators Mr. Roewade suggested the following:

- **GHG emissions from energy consumption** should be incorporated into buildings and municipal operations
- **Streetlighting** should be part of municipal operations, included in the corporate inventory.
- **Public transit** is now included under corporate emissions. He suggested looking into transit demand management and the Region's Travelwise program, which provides an assortment of tools and services aimed at reducing the number of people driving alone to work[12].
- **Land Use** indicators could be difficult to quantify or find data for. Mr. Rowade believed land use to be a small portion of overall GHGs, and questioned whether indicators such as density had a relation to GHG emissions.
- **Water** consumption intensity in Waterloo has been reduced with introduction of new regulations and conservation efforts such as rain barrels and toilet replacement. Electricity consumption (and GHGs) have increased with the switch to UV treatment instead of conventional chlorine.
- **Waste** emphasis on diversion programs and relation to reduced GHG emissions. Green bin diversion has helped avoid large amounts of methane.

6.1.3 Sarah Brown, Sustainable Waterloo Region

Ms. Brown is Project Manager of the Climate Collaborative, a partnership between REEP Green Solutions, Sustainable Waterloo Region, and the Region of Waterloo (represented by Mr. Roewade) to develop a community GHG emissions inventory, reduction target and action plan for Waterloo Region. Ms. Brown was selected to represent Mike Morrice, Executive Director and co-founder of Sustainable Waterloo Region (SWR). Her role is unique in facilitating partnerships among organisations, the public,

[12] http://www.regionofwaterloo.ca/en/gettingAround/travelwise.asp

and managing external communication. Ms. Brown was selected for involvement due to her experience with community GHG inventories through the Climate Collaborative project. The Climate Collaborative is currently using the ICLEI *IEAP* reporting tool to develop a community GHG emissions inventory for Waterloo Region. Some municipalities in Waterloo Region are also using the support of SWR's Regional Carbon Initiative program to quantity and report their corporate emissions (City of Kitchener, City of Waterloo, and the Region of Waterloo). SWR provides RCI members with a locally-developed tool to set out a reporting framework, reporting procedures and accounting methodology that draws on a number of external tools as well as guidance from local experts.

During the December 6th 2011 meeting Ms. Brown suggested the potential for negative publicity if the proposed rankings are used to unfairly compare municipalities within any given region based on her experience seeking to create positive working relationships between municipalities. Ms. Brown suggested that the template for benchmarking municipal emissions must be easy to use and able to fit within existing initiatives such as the RCI. Ms. Brown supported earlier comments by Mr. Roewade to differentiate between upper and lower tier municipalities. She also suggested some secondary indicators, for example measuring a municipalities' position within the PCP program or if an environmental management system (such as ISO 14001) has been implemented.

A second meeting was held by phone on March 12 2012. Ms. Brown supported the final list of indicators and methodology. Based on her recent experience with municipalities through the Climate Collaborative Ms. Brown remarked that municipal interest on being benchmarked is high.

Ms. Brown was asked to comment on the approach used to the land use indicator. She discussed SWR's experience with land-use indicators; ultimately land use GHG emissions were not included in the Climate Collaborative inventory due to several factors. Land use emissions are inherently complex to quantify and can be difficult to influence; land use is a flux indicator. There are no defendable methodologies yet constructed to incorporate land use emissions (this thesis has proposed a methodology for calculating residential emissions in relation to population density).

Ms. Brown also commented on agriculture which remains an important sector in Waterloo Region. She noted that Caledon and Hamilton have prepared methodologies for calculating GHG emissions from agriculture. Methane emissions (which have a high global warming potential) from livestock can be substantial.

6.1.4 Mary Pickering, Toronto Atmospheric Fund

Ms. Mary Pickering was selected for involvement due to her prominent role at the Toronto Atmospheric Fund (TAF). This unique government agency is tasked with supporting the reduction of

Toronto-wide greenhouse gas and air pollution emissions[13]. Mary Pickering has considerable experience with municipal GHG inventories and working with municipal government.

During the December 16th 2011 meeting Ms. Pickering emphasised the need for a common reporting tool, such as the FCM PCP framework or the ICLEI *IEAP*. Ms. Pickering drew attention to two important factors in municipal GHGs. First, that methane collection from landfills can drastically curb emissions. Second, that a reduction in municipal GHGs in the past decade is generally related to changes in Ontario's electricity mix and the provincial governments' pledge to phase out coal generation by 2014. She also suggested that electricity consumption as an indicator is overvalued in Ontario and believes that natural gas consumption deserves more attention for its role in municipal emissions. Ms. Pickering noted that consideration must be given to who has responsibility for reductions measured against the indictors; for example, are the emissions solely the responsibility of the municipality or are there other actors involved?

Ms. Pickering pointed out that land use and building codes are often components of provincial policies and legislation (Places to Grow, Provincial Policy Statement, Greenbelt Act, Planning Act), with the exception of Toronto (City of Toronto Act). She suggested building codes should be included as a land use indicator with emphasis on energy efficiency. Ms. Pickering also thought that a system for labelling energy efficient buildings and allowing for benchmarking would be beneficial. Better monitoring and additional funds for tower renewal programs are needed. The development of the *Toronto Green Standard* is a positive development; new development applications must adhere to a series of performance measures for sustainable site and building design[14]. She suggested that this standard could be dialled-up to improve provincial legislation similar to precedent set by the *Pesticide Act*. It should be noted that Natural Resources Canada has begun a trial program to develop a rating system and labels for commercial and industrial buildings[15]. Once the trial is completed the labels will allow for benchmarking and comparison of buildings by type. It is scheduled to be launched in 2012/2013.

In regard to the draft list of indicators Ms. Pickering made the following comments:

- **Public transit** should be included for its obvious importance, but must be placed appropriately in the indicator set to avoid being an 'orange.' Public transit is a somewhat difficult element since funding often comes from provincial and federal governments and municipalities may not have complete control over spending

[13] http://www.toronto.ca/taf/
[14] http://www.toronto.ca/planning/environment/greendevelopment.htm Accessed 13 February 2012.
[15] http://oee.nrcan.gc.ca/commercial/14117 Accessed 09 March 2012.

- **Water consumption** indicators may be moving away from the objective of municipal GHGs; water indicators are tied to electricity consumption, the shortcomings of which were already discussed
- **Street-lighting:** Pickering questioned the need for this indicator; it is simply another measure of electricity consumption
- **Waste** indicators are significant in regard to green waste, which produces methane. Ralph Torrie prepared Appendix A: *Greenhouse Gas Emissions from Waste Management: A Briefing Note* in Toronto's 2006 inventory report. The Appendix discusses quantification of GHGs from municipal recycling for Toronto[16]

Ms. Pickering provided comments on the final indicators and methodology during a meeting on March 08 2012. Her review of the indicator selection process and its justification was positive and no significant issues were raised. She reiterated the need to understand the reasons for municipal action on climate change and the reality that municipalities could be doing much more. Ms. Pickering was interested to know how this template will be used to encourage action, possibly in combination with other existing tools and frameworks.

6.1.5 Jon Yazer, Project Neutral, Resilient Cities

Jon Yazer was selected due to his ongoing involvement with several NGOs working to improve climate change adaptation in cities. These include Project Neutral, Resilient Cities, and DIALOG. Mr. Yazer represented Craig Applegath who is a Principal at DIALOG, an organisation which specializes in urban design. Mr. Applegath has also founded Resilient City, a non-profit network of professionals who work to improve the ability of cities to respond to climate change. Mr. Applegath was a speaker at the 2011 EnSciMan Symposium "Canada in 2035: Critical Issues of Canada's Environmental Near-Future" held on March 24 2011.

Mr. Yazer is a globally focused, locally active writer, researcher, and analyst specializing in urban sustainability and international governance issues. Mr. Yazer has also helped in the development of an index comparing cities' capacity for resilience, and co-authored a paper with Mr. Applegath for the City of Edmonton titled "Resilient Edmonton: When and How?" The paper informed the development of a new long-term municipal sustainability strategy and was approved by Edmonton City Council in July 2011.

During the meeting held December 16 2011 Mr. Yazer questioned how to best resolve the issue of large versus small municipalities. It was suggested two alternate methodologies be used, one for large

[16] http://www.toronto.ca/taf/pdf/ghginventory_jun07.pdf

urban areas and one for smaller towns. He also stressed the need for land-use indicators, since land-use is the basis for the NGOs he has been involved with. Feedback on the draft list of indicators was generally positive. Mr. Yazer was very supportive and reinforced the validity and importance of the present study. During a meeting on March 09 2012 Mr. Yazer reviewed the final indicators and methodology, finding no significant issues with the process. Mr. Yazer expressed his continued interest in the study and approved all action to date.

6.1.6 Ken Thompson, Ontario Municipal Benchmarking Initiative

Ken Thompson is Water and Wastewater Expert Panel Manager for the Ontario Municipal Benchmarking Initiative[17]. OMBI measures and compares performance data and operational practices, collecting data for more than 850 measures across thirty-seven municipal service areas. Sectors of interest include wastewater, solid waste, transit, water, fleet, and facilities, among others. OMBI acts as a source of credible information to assist municipal staff, policymakers, and citizens to understand how their municipality is performing over time and in relation to others. The initiative is led by Chief Administrative Officers and City Managers representing thirteen municipalities. As one of the OMBI's GHG emission subcommittees, the water and wastewater expert panel is tasked to develop indicators for the treatment plant level, varying by type of treatment system.

A meeting with Mr. Thompson was held by phone on March 12 2012. In his role as Manager of the water and wastewater panel he spoke to those indicators specifically. He cautioned using per-capita statistics; instead the number of serviced residents, or 'urban-serviced population,' must be used. Mr. Thompson discussed the Ontario Municipal Knowledge Network (OMKN), which is an initiative to share best practices on roads, public transit, waste management, water and wastewater services amongst municipalities. This unique initiative is operated by the Association of Municipalities of Ontario. Mr. Thompson raised an important point regarding wastewater treatment indicators; wastewater effluent is regulated at the provincial level and is often outside municipal control. Stricter regulations may require additional treatment methods which result in increased electricity consumption and GHG emissions, although it is recognized that there are additional environmental benefits. He commented that about 90% of emissions for water and wastewater are a result of electricity consumption.

6.1.7 Ralph Torrie, Trottier Energy Futures Project

Ralph Torrie is a renowned expert on municipal greenhouse gas inventories. With over 30 years of experience in the field he has had a strong influence on the development of municipal climate action

[17] http://www.ombi.ca/

policy. He is currently the Managing Director of the Trottier Energy Futures Project[18]. Trottier's objectives are to design and build a low-carbon, sustainable energy future for Canada by publishing and advocating policy actions including an 80% reduction in GHG emissions by 2050 and developing a low-carbon energy budget for Canada. Mr. Torrie is also President of Torrie Smith Associates Inc., which has developed unique GHG emissions software. Torrie Smith Associates Inc. has helped over 300 municipalities around the world analyze energy and greenhouse gas emissions with the software, as well as to plan technical and policy measures for emission reductions in municipalities. Mr. Torrie also sits on the Board of the Sierra Club of Canada Foundation, the Greater Toronto Area Clean Air Partnership, and Beyond the Blue Box. He is on the Load Forecasting Advisory Committee for the Ontario Power Authority and he is a Fellow at Queen's University's Institute for Energy and Environmental Policy. An in-person meeting was held with Mr. Torrie on March 15 2012.

Mr. Torrie stressed the need for a clearer focus. The thesis should be developed according to the audience; will it be used for business interests or will it remain academic in nature? Mr. Torrie suggested a business tool for municipal corporate GHG emissions would be a useful product.

Mr. Torrie provided feedback for the indicators, emphasising the need for a clear focus on corporate emissions. Indicators allowing for comparability amongst municipalities on the basis of energy use per m^2 were something he saw to be very useful. For example, he stated that an indicator capturing energy use per m^2 of gross floor space by building type (*ie.* library, indoor arena) would be an excellent indicator. He discussed public transit indicators and instances where increased public transit does not provide a positive net benefit. Conventional diesel busses have poor fuel efficiency (60L/100km in some instances) and periphery low-density bus routes with low ridership produce significantly more emissions than if the passengers drove fuel-efficient cars. For land use indicators he recommended examining the Holtzclaw Curve which measures the correlation between reductions in automobile usage and personal transportation costs, based on residential density and transit accessibility (Holtzclaw 1994). Mr. Torrie has experience with comparing fuel efficiency with vehicle ridership and GHG emissions since he has co-authored reports through his consulting firm Torrie Smith Associates Inc.

Mr. Torrie commented on the inclusion of streetlighting and traffic signal emissions. During international negotiations in the early 1990s the Helsinki Criteria were developed. The criteria stated indicators should be included even if they don't have a large impact based on political considerations, exchange of expertise, or leadership by example to demonstrate a best practice. Further review of the

[18] http://www.trottierenergyfutures.ca/

Helsinki Criteria can be found in the literature review. These criteria could be used to justify including certain indicators even if their impact is relatively minimal.

When referring to water measures Mr. Torrie said it is important to keep in mind that water conservation is essentially energy conservation. He identified some of the issues with municipal solid waste: that not every municipality owns a landfill, while those that do are penalized for emissions generated by waste from up to 30 years ago. The issue of ownership is an important factor since the only agent that can influence change is the owner. It is also important to consider that if a landfill were a facility, even if waste input were reduced to zero, there would still be emissions from the decaying landfilled waste. However there are now regulations for collecting fugitive methane, for example all new landfills have methane collection systems.

Mr. Torrie urged caution when weighting indicators; weighting is very subjective and the relative importance of weights can vary significantly depending on the author.

Mr. Torrie suggested that the indicators specifically target municipal corporate emissions. There are several reasons for doing so. There are significant differences in data availability and quantification between corporate and community emissions. Many corporate activities are tracked by the municipality, for example m^2 of gross floor space or number of vehicles by class. Therefore data are readily available and easy to use; it is often a simple process of multiplying by emission factors to arrive at a total. Corporate emissions can also be easily influenced by the municipality, it need only set a budget and responsibilities to effect change. Community emissions are a different proposition and, instead of relying on data it becomes a model for best estimates of emissions. For example to arrive at an estimate one would typically find average per-capita data for the province and then multiply by the population of the municipality. Very quickly this method for modeling community emissions faces problems. Municipal councils only have indirect influence over community emissions and can attempt to effect change through incentives, penalties, or educational programs with mixed results. Community emissions are complex, difficult to model, and pose significant challenges for policymakers. Mr. Torrie suggested consulting the body of work from Newman and Kenworth, who influenced urban planning and community GHGs in their 1991 book *Cities and Automobile Dependence: An International Sourcebook*. Lastly, Mr. Torrie believed that an indicator set with a tighter focus on corporate GHG emissions would enhance the final template considerably, both for policymakers and as a marketable product. There is an industry for municipal corporate GHGs and there is strong demand for useful meaningful indicators for benchmarking municipal buildings.

Mr. Torrie advised that the indicators should be developed and selected based on their applicability to municipal managers. He cautioned that there could still be resistance from the municipality even at the micro level, for example, emissions at a library branch. To avoid pushback and generate interest in the indicators, they must provide co-benefits that are made clear to the municipality. Mr. Torrie commented on the idea that municipal climate action has stalled which had been suggested by Gore (2010). Mr. Torrie suggested that if action has stalled that a relevancy test is not being passed my municipal managers. If municipal action has stalled then it is important to understand why and find new methods and motivations to continue advancing action. For the indicators to be accepted, people must be motivated about them; by discussing win-wins and synergies, this can be achieved. For example green buildings with LEED certification not only reduce energy consumption but increase worker productivity and are generally seen as being healthier, progressive places to work. Another co-benefit of reducing GHGs is improved urban air quality. Mr. Torrie referred to the Kaya Identity for modelling how GHG reductions may be achieved. All other things being equal (population, GDP per-capita) emissions will go down if energy efficiency is improved. Therefore, improvements at water and sewage treatment plants and in vehicle fuel efficiencies would reduce GHG emissions. He emphasized the need for useful, practical indicators which will motivate municipal managers to take action.

Mr. Torrie discussed some of the issues with municipal GHG inventories. There are significant challenges to be addressed in improving municipal inventories. Some inventories are poorly done if municipal managers are not properly trained. Completing an inventory can be an overwhelming task and managers can face significant difficulties navigating the various frameworks and protocols. Further to what was discussed in the previous paragraph, there is a significant difference between bookkeeping and taking action. Mr. Torrie expressed some frustration with current initiatives and their emphasis on conducting proper inventories rather than taking action. While inventories are obviously valuable for benchmarking and setting reduction targets, at some point measures must be taken to reduce emissions even if total emissions are not verified. Community sources of emissions can never be properly verified. For example, ICLEI's *IEAP* details the inventory process but only has a few paragraphs referring to measures and taking action. He suggests it is important to decouple measures from the inventories and begin acting, even without knowing the total GHGs emitted from municipal operations. For example, a manager could change indoor lighting to energy-efficient bulbs very easily and quantify the reduction in emissions without having a complete inventory. Likewise, measures to improve recycling rates lead to a quantifiable reduction in both landfilled waste emissions and upstream emissions from recycling as opposed to manufacturing using virgin materials.

During the meeting Mr. Torrie provided an extensive analysis of the research work to date. He affirmed the need for and validity of the indicators, and urged a refined scope and increased emphasis on end-use applications for municipal managers.

6.1.8 Muni Ahlawat, Federation of Canadian Municipalities

Mr. Ahlawat is Program Officer of the PCP program with the Federation of Canadian Municipalities. A conference call was held with Muni Ahlawat on January 16 2012. Also included in the call was Mr. Jonathan Connor of ICLEI and Ms. Kelly Hazlett, Research Associate for FCM.

Mr. Ahlawat discussed some of the issues with corporate and community GHG emission inventories. Similar to comments made by Mr. Roewade, airports are generally left out of emission inventories since they have little policy relevance for municipalities and can be difficult to measure. FCM is developing new software for conducting GHG inventories and an updated methodology is anticipated by fall 2012.

Mr. Ahlawat confirmed that research into municipal benchmarking is necessary and should be pursued. Municipalities need information on relative performance to gauge effectiveness, and for developing strategic plans. In the last 10 years the development of such tools in the industry has grown quickly. He noted that the TRCA Town Hall Challenge is a good model for comparison and that municipalities were very interested in being included in that initiative, even if they were to fare poorly relative to others. Comparisons between municipalities can also encourage activity and contribute to political dialogue. Mr. Ahlawat envisions the template as a tool to help examine the impact of measures, combining cost savings with GHG emission reductions. He noted that “nothing motivates change like knowing what your neighbours are doing!”

Mr. Ahlawat noted some of the challenges facing the research such as how to best incorporate smaller municipalities, how to compare apples to oranges, how to engage different jurisdictions to report their emissions, and how the results are to be presented. Mr. Ahlawat said that the benchmarks must have a municipal context, incorporating growth rates or changes to the electricity mix, but it must also be consistent and transparent.

6.1.9 Discussion

The panel of municipal experts helped develop and validate the final indicator set. Mr. Morgan made several important contributions to the indicators, personally reviewing each one and providing critical analysis. He recommended that the indicator set needed to have a strong purpose, to either help municipal managers understand their GHG emissions and to take action or to move academia forward. As a leader in quantifying municipal GHG emissions Mr. Ralph Torrie strongly supported the need for the study and the indicators. Mr. Yazer validated the indicators and expressed his approval for the study.

Section 6.2 describes the indicator development process in further detail. It includes comments from each of the panel experts. Each of the panel experts agreed with the indicators and their scope. Some of the experts had slight disagreements regarding the relative importance of certain indicators or the exclusion of others.

6.2 Indicator Development

The following sections discuss the development of the indicator set.

6.2.1 Draft Indicator Development

The indicator selection process began in October 2011. Six indicator categories were developed based on the academic literature review and an examination of existing initiatives:

- Municipal Buildings and Operations
- Transportation
- Land Use and Urban Planning
- Water Treatment and Use
- Wastewater and Sewage Treatment
- Solid Waste

These categories were considered to be comprehensive, covering all significant sources of GHG emissions under municipal control. By November 2011 the draft list of indicators had been created (refer to Appendix 8).

6.2.2 Final Indicator Selection

The final indicator set was finalized in March 2012 after consultation with the expert panel. There are 17 indicators in total, presented in Table 9 below.

Table 9 Final Indicator Set Used in the Study

Indicator	Category	Definition	Indicator Type	Measurement	Weighting	Category Weighting	Scale	Data Source
Total GHG produced annually from electricity consumption by municipal buildings per m^2 of gross floor space*	**Municipal Buildings and Operations**	The total GHG emissions due to electricity consumption in municipal buildings in relation to total square-metre of building space.	Primary	tCO_2e/year	0.45	0.20	Community - Corporate	Municipality, LDC
Total GHG produced annually from heating in municipal buildings from natural gas per m^2 of gross floor space*	**Municipal Buildings and Operations**	The total GHG emissions due to natural gas consumption in municipal buildings in relation to total cubic-metres of heated building space.	Primary	tCO2e/year	0.35	0.20	Community - Corporate	Municipality, local energy utility
Total GHG produced annually electricity consumption by streelighting/traffic signals	**Municipal Buildings and Operations**	The total GHG emissions due to electricity consumption for streetlighting and traffic signals in the municipal boundary.	Primary	tCO2e/year	0.20	0.20	Community – Corporate	Municipality, LDC
Strength of GHG reduction target	**Municipal Buildings and Operations**	A value judgement of the ambitiousness of the municipalities' GHG reduction target relative to Kyoto and Copenhagen Accord national reduction targets	Secondary	Scale of 0-10	N/A	N/A	Community - Corporate	Municipality
Internal programs and champions developed to make action plan, meet reduction target	**Municipal Buildings and Operations**	A measure of the development of internal support mechanisms to support the GHG reduction target	Secondary	Scale of 0-10	N/A	N/A	Community - Corporate	Municipality
LEED certified buildings	**Municipal Buildings and Operations**	Whether or not the municipality has achieved LEED certification for a new or existing building	Secondary	Scale of 0-10	N/A	N/A	Community - Corporate	Municipality
GHG emissions from total annual fuel consumption in fleet operations (excluding public transit system) per capita	**Transportation**	The total GHG emissions from all municipal corporate fleet vehicles in relation to municipal responsibilities (Upper, Lower, Single Tier).	Primary	tCO2e/year	0.50	0.20	Community – Corporate	Municipality

Table 9 (Continued from previous page)

GHG emissions from total annual fuel consumption in public transport fleet operations per km of route service	**Transportation**	The total GHG emissions from the provision of public transportation by the municipality. Attribution to kilometres of route service brings context to extent of transit services. If transit services are electrified coefficients are used to estimate GHG emissions.	Primary	tCO2e/year	0.50	0.20	Community – Corporate	Municipality
Program to 'right-size' municipal fleet vehicles or purchase/lease green vehicles	**Transportation**	Effort from the municipality to reduce fuel consumption by using green vehicles or using smaller vehicles whenever possible	Secondary	Scale of 0-10	N/A	N/A	Community - Corporate	Municipality
Anti-idling by-law in effect	**Transportation**	Whether the municipality has enacted an anti-idling by-law or not	Secondary	Scale of 0-5	N/A	N/A	Community	Municipality
GHG emissions from residential densities per capita	**Land Use and Urban Planning**	The total GHG emissions resulting from the average population density of the municipality, judged by total number of dwelling type. Residential dwelling type is multiplied by annual GHG emissions from building operations. A higher average population density would theoretically generate less GHG emissions and better protect natural areas by preventing urban sprawl.	Primary	tCO2e/year	1.00	0.10	Community	2006 Census Statistics Canada, NRCAN 2009 Residential Sector GHG Emissions.
Plans to accommodate population growth within existing urbanized area	**Land Use and Urban Planning**	Strength of zoning and by-law policies to encourage infill, redevelop brownfields, convert existing buildings into residential within the municipality to increase densities.	Secondary	Scale of 0-10	N/A	N/A	Community	Municipality
GHG emissions from water pumping, treatment, and consumption per capita urban serviced population*	**Water Treatment and Use**	The total GHG emissions resulting from the electricity needed to supply L^3 water to the municipality. Per capita to illustrate consumption trends.	Primary	tCO2e/year	1.00	0.15	Community	Municipality

Table 9 (Continued from previous page)

By-laws and programs to encourage reduced water consumption	**Water Treatment and Use**	Measure of the strength of municipal programs and by-laws to reduce water use, thereby reducing GHG emissions from water treatment.	Secondary	Scale of 0-10	N/A	N/A	Community	Municipality
GHG emissions from the treatment of wastewater and sewage per capita urban serviced population*	**Wastewater and Sewage Treatment**	The total GHG emissions resulting from operations at municipal water treatment plants. Electricity consumption converted using electricity emission intensities. Methane emissions converted to CO_2e.	Primary	tCO2e/year	1.00	0.15	Community	Municipality
GHG emissions from municipal solid waste per capita*	**Solid Waste**	The total GHG emissions from the disposal of municipal organic and solid wastes. Includes total fugitive CH_4, N_20 emissions. Methane, nitrous oxide emissions converted to CO_2e.	Primary	tCO2e/year	1.00	0.20	Community	Municipality
Strength of waste diversion programs	**Solid Waste**	Measure of the strength of municipal programs and by-laws to reduce waste generation and increase the diversion rate.	Secondary	Scale of 0-10	N/A	N/A	Community	Municipality

*If the municipality generates renewable energy through solar photovoltaic, wind, total annual CO_2 savings are subtracted from building and operations total. Renewable energy generation from methane capture is to be subtracted from wastewater/sewage treatment and solid waste.

The following sections describe the rationale for the selection and inclusion of these specific indicators in the thesis.

6.2.3 Primary Indicator Selection

The nine primary indicators were selected to cover the entire range of municipal responsibilities and operations. Two categories, Municipal Buildings and Operations and Transportation, received more indicators due to their importance in municipal GHG emissions relative to the other categories. A more detailed analysis and explanation of each indicator is provided below.

6.2.3.1 Total GHG Emissions Produced Annually from Electricity Consumption by Municipal Buildings per m^2 of Gross Floor Space

This indicator measures annual electricity consumption for all municipal buildings per m^2 of gross floor space. An intensity-based measurement of consumption provides a normalized basis for comparison across municipalities. Only corporate emissions are included since municipal governments have the most influence over their own electricity consumption; consumption trends for the general population are made more complex by the makeup of the local economy, provincial initiatives or the local electricity provider.

This indicator includes aspects such as electricity used for air conditioning and space heating but not outdoor streetlighting and traffic signals, which have a separate indicator. Emissions from natural gas water heaters are not included. District heating and cooling systems, wind, and solar generation help to avoid energy consumption and are incorporated in this indicator; the total annual energy savings (in kWh) is deducted from the energy consumption total. Municipalities currently gather data on electricity consumption through utility bills (many local distribution companies, or LDCs, are publically owned utilities).

6.2.3.2 Total GHG Emissions Produced Annually from Heating Municipal Buildings from Natural Gas per m^2 of Gross Floor Space

This indicator measures GHG emissions from the consumption of natural gas in municipal buildings for heating. Natural gas (CH_4) is a greenhouse gas, 21 times more potent than CO_2, so tracking consumption is a valuable indicator. It is normalized per m^2 of gross floor space to allow for comparison across municipalities. If district heating is used, the total annual energy saved is deducted from the gas consumption total since it is assumed the district heating would offset gas use. Municipalities have access to consumption data through utility bills. Hot water heaters were not included in this indicator but may be a significant source of emissions (see Rejected Indicators).

During discussions with municipal policy experts, concerns were raised about relying on electricity consumption as the principal energy indicator. Mary Pickering expressed interest in capturing natural gas consumption since consumption has been steadily increasing. Chris Morgan had suggested using building volume (per m^3) to measure emissions; however, after consideration this was rejected in favour of floor space m^2) due to complexities in collecting data on the volume of municipal buildings.

6.2.3.3 Total GHG Emissions Produced Annually from Electricity Consumption by Streelighting/Traffic Signals per Capita

This indicator measures electricity consumption for streetlighting and traffic signals. The decision whether to include streetlights as an indicator separate from electricity consumption was controversial. During meetings the municipal policy experts noted that emissions from energy use in outdoor lighting and signals are a relatively small percentage of overall municipal emissions. For example, Mr. Morgan noted that in the City of Toronto streetlighting was 2% of total municipal emissions.

This indicator was included based on several considerations. A 'low-hanging fruit' opportunity for municipalities exists by converting conventional streetlight bulbs to LEDs. Data from the C40 Cities initiative have shown substantial GHG emission reductions and cost savings from streetlight replacement programs: Los Angeles estimates that it will save USD 10 million and 40,500 tCO_2e annually from its replacement program[19]. From a policy viewpoint a municipality willing to convert to LED streetlighting may indicate a willingness by its council to take further action to mitigate GHG emissions. Many municipal GHG inventories consider streetlighting emissions as a separate category. Based on these factors it made sense to grant streetlighting its own indicator.

6.2.3.4 GHG Emissions from Total Annual Fuel Consumption in Fleet Operations (excluding Public Transportation System)

This indicator measures GHG emissions from the municipal vehicle fleet. It is a measure of corporate activities inducing (if applicable) EMS, police and fire, snowplows and road works vehicles, parks maintenance, and solid waste collection and disposal vehicles. This indicator excludes public transportation which received its own indicator based on consultation feedback. Community transportation emissions from roads, passenger rail, and ships are not included due to their complexity and lack of municipal control. This indicator does not take into account municipally-owned airport facilities; Mr. Roewade noted that airport emissions would provide little value to policymakers. Data are available from fuel billing and fleet records. To generate the annual emissions from fleet operations, the total fuel consumed is multiplied by the vehicle EF (see section 5.4.1). Adjustments are made based on type of fuel used.

[19] http://live.c40cities.org/blog/2011/8/11/new-data-strengthens-business-case-for-led-lighting-retrofit.html

6.2.3.5 GHG Emissions from Public Transportation Fleet per Capita

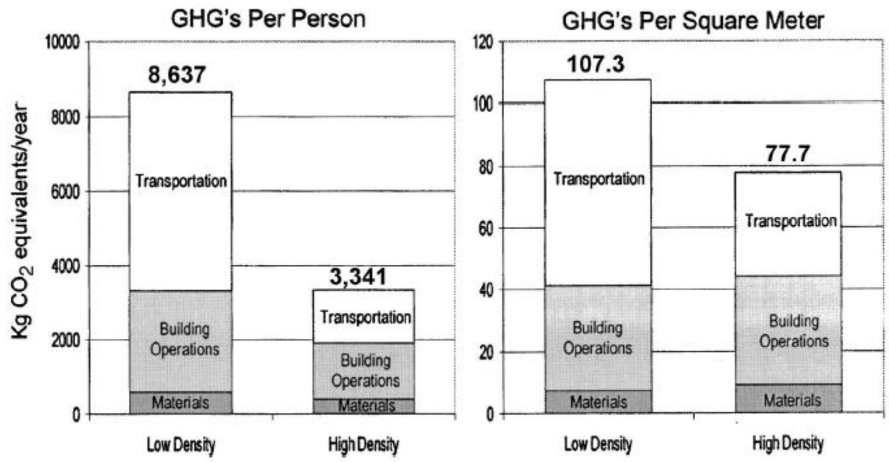
This indicator measures GHG emissions from the operation of public transportation vehicles. It is intended to measure the extent of a municipalities' public transportation infrastructure relative to its population. This indicator uses a per-capita measurement for comparison with other jurisdictions. The use of annual ridership statistics would be inaccurate (it counts riders multiple times), and a measure of commuter usage would capture only a percentage of the total number of riders. An indicator which related GHGs to kilometres of route served would unfairly penalize low-density municipalities in which vehicles must travel further to serve the population.

This indicator has significant limitations that are important to note. It can be difficult to measure transit emissions and establish clear boundaries if the service is operated by the upper tier 'regional' government. As mentioned by Mr. Morgan during consultations, improved public transit only reduces emissions from private auto use if traffic lanes are removed, otherwise excess capacity from people taking transit soon leads to increased auto use. This indicator does not take into account the many social and sustainability goals that transit affords such as increased densities, improved quality of life, and accessibility. Ms. Pickering noted that public transit funding often comes from provincial and federal governments, therefore the municipality may not have complete control over transit spending.

6.2.3.6 GHG Emissions from Residential Densities per Capita

This indicator models GHG emissions related to residential population densities. Municipal governments have some control over land use policy through official plans and zoning. During meetings Mr. Yazer reiterated the need for strong land use policies that encourage densification where needed and the avoidance of urban sprawl. Some of the experts asked if there was academic literature which linked density and GHG emissions; as previously discussed much of the work in this field has been done by Newman and Kenworthy. Norman, MacLean, and Kennedy (2006) provide a comparison of energy consumption and GHG emissions from high-density downtown residences and low-density suburban dwellings in the GTA. This study provides relevant, useful data that can be used for this research. In Norman, MacLean, and Kennedy (2006) high density is defined as being a 15 storey building representing 150 dwellings/hectare, and low density representing 19 dwellings/hectare. The authors used a life-cycle approach to explore construction materials, building operations, and transportation. The study found that low densities had roughly 2.5x the annual per capita GHG emissions compared to high densities, and when compared per unit of living area (m^2) the factor was 1.0-1.5x (see Figure 4 below).

Figure 4 Life-Cycle GHG Emissions per Person Relative to Population Density (Norman, MacLean, and Kennedy 2006).



The authors state “the overall trend between densities has not been fully reversed by changing the functional unit, which suggests a high level of overall energy and GHG emissions intensiveness for low density development.” They later note “it is quite probable that these findings are indicative of a more general relationship between urban density, GHG emissions, and energy use in many other North American cities” and that climate change-oriented urban planning should give priority to, among others, shifting land use to higher density development closer to a city’s core employment areas. Based on the results of this research it appears that an indicator measuring GHGs from residential densities would be valid.

For the purposes of the indicator some assumptions were made. Only values related to building operations were used since the study did not include life-cycle emissions (with the exception of public transportation emissions which are corporate and included in the indicator measuring public transit). This indicator only included community residential GHG emissions. Attempts to compare commercial and industrial densities amongst municipalities would be extremely difficult and no comparisons were found in the academic literature. This indicator does not consider the age of the building, which can be an important factor for energy efficiency. However Statistics Canada publishes census information on dwelling construction dates (number of dwellings constructed prior to 1986 and after 1986). Mobile homes or those listed as ‘other’ were not included.

NRCAN's Office of Energy Efficiency publishes annual reports on GHG emissions from Canada's residential sector. The most recent report contains 2009 data for housing stock totals by type[20] and GHG emissions[21] (in $MtCO_2e$) by building type. This information has been organised in Table 10 below.

Table 10 GHG Emissions (in tCO_2e) by Dwelling Type in 2009. Source: NRCAN 2011.

Dwellings by type	Total # of Dwellings Nationally (thousands)	Total National GHG Emissions (in $MtCO_2e$) by Dwelling Type	Individual Dwelling GHG Emissions by Type (tCO_2e)
Single Detached	7,825	47.31	0.1654
Single Attached	1,549	6.66	0.2326
Apartments	4,294	12.37	0.3471

It is important to consider that the NRCAN emission totals are national in scope, whereas Norman, MacLean, and Kennedy (2006) examined housing stock only in the GTA. However, the results of the study (low density emissions 2.5x greater than high density) were confirmed in the case of the Newmarket case study (section 6.3).

To complete this indicator, data from the 2006 census was used; 2011 census data were not released until November 2012. Census data provided percentages for single-detached and semi-detached homes, row homes, and types of apartment buildings. Low density structures included single-detached and semi-detached homes since they are similar to the count of 19 dwellings/ha used in Norman, MacLean, and Kennedy (2006). Similarly, row homes and apartments were considered high density at 150 dwellings/ha.

For this indicator single detached and attached dwelling emissions can be considered low density and aggregated to produce a total of 0.3980 tCO_2e annually. Apartments will be considered high density at 0.3474 tCO_2e annually.

To assess the total GHGs related to density for a municipality, 2006 census data was used to ascertain the percentage of low and high density dwellings for a given municipality. These percentages were then multiplied by the appropriate emission factors (see section 5.4.1) and aggregated to produce a total for community residential GHG emissions.

6.2.3.7 GHG Emissions from Water Pumping, Treatment, and Consumption per Capita (Serviced Population)

This indicator measures GHG emissions from water treatment and distribution in the municipality. Maas (2009) provides important context and emission factors for municipal water services.

[20] http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tablestrends2/res_ca_21_e_3.cfm?attr=0 Accessed 12 March 2012
[21] http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tablesanalysis2/aaa_00_2_e_4.cfm Accessed 12 March 2012

It is important to note that some residents within the municipal boundaries rely on groundwater wells. During consultations Mr. Thompson discussed the need to consider urban serviced population when developing the indicator set. Urban serviced population refers to the number of residents that are provides service, in this case treated water, by the municipality. This is different from the total population, since some rural residents may not be serviced and instead rely upon groundwater wells for drinking water. Municipalities have access to consumption data through water utility bills; municipalities already gather data on water processing operations.

There are several limitations to this indicator. Water treatment is often the responsibility of the upper-tier municipality, while lower-tier municipalities are only responsible for pumping. Some municipalities do not report water and sewage separately in their GHG emission reports, complicating the data collection process. Water pumping and treatment requires energy. Changes to the provincial energy mix can increase or decrease emissions without any action by the municipality.

During consultations Mr. Morgan noted that water systems are sometimes integrated amongst municipalities, for example the City of Toronto has integrated water systems at its northern boundary. This can make data collection difficult. It is also important to consider the water source. For example, Toronto receives water from Lake Ontario which is more than capable of meeting city needs, while Waterloo Region relies exclusively on groundwater; therefore much more stringent water control measures are needed in that municipality.

6.2.3.8 GHG Emissions from the Treatment of Wastewater and Sewage per Capita (Serviced Population)

This indicator measures the GHG emissions from wastewater and sewage treatment in the municipality. It is recognized that municipalities have varying levels of treatment (primary, secondary, tertiary). This indicator uses the urban serviced population that are connected to the municipal sewer system. Some residents within the municipal boundary may not have any treatment, instead relying exclusively on backyard septic systems. A per-capita measurement helps to account for population growth.

The primary sources of emissions are electricity consumption from the treatment process and methane from decomposition. If the treatment plant captured methane and generates electricity, the total annual renewable electricity produced and subtracted from the consumption total. Municipalities already gather data on water processing operations and data availability was not a significant issue.

There are limitations to this indicator. As with water treatment, sewage is often the responsibility of the upper-tier municipality. Some municipalities do not report water and sewage separately in their GHG emission reports, which can make data collection more difficult. Sewage systems are also integrated amongst municipalities and separating the source may be difficult.

Provincial regulations on wastewater treatment (via the *Ontario Water Resources Act*) are an important factor outside of municipal control. In an effort to improve water quality and protect drinking water, government regulations on water content such as biological oxygen demand (BOD), phosphorus, and ammonia (among others) have been strengthened. Tougher regulations require advanced treatment which increases retention times and electricity consumption. An unfortunate consequence of improved effluent treatment is a related increase in wastewater GHG emissions.

6.2.3.9 GHG Emissions from Municipal Solid Waste per Capita

This indicator measures GHG emissions from solid waste disposal in the municipality. Waste collection and transport was included in the corporate fleet vehicle indicator. Emissions from composting and incineration are included. If the landfill captures methane and generates electricity, the total annual renewable electricity produced was subtracted from the total GHGs produced as an offset.

There are several limitations that must be considered with this indicator. Upper tier regional governments are responsible for waste collection and disposal from lower tier municipalities; landfill and incinerator facilities are typically owned by the upper-tier municipality.

This indicator may not capture all municipal solid waste. Private companies may transport waste across municipal boundaries for disposal. Commercial properties typically contract out waste collection to private firms such as Wasteco. It is estimated that the amount of solid waste collected privately is significant. Mr. Morgan estimated that in Toronto the ratio could be as high as 2:1 for private waste collection versus municipal, although this could not be verified in the literature. On its corporate website, Wasteco states "all material is brought to ministry approved transfer sites where it is sent to waste to energy facilities or landfill[22]." During a phone call Rob Hanna, Waste Auditor and Recycling Coordinator at Wasteco, confirmed that drivers typically take waste to the closest landfill or transfer station. Therefore it is possible that a significant percentage of municipal solid waste may migrate outside of the municipal boundaries by private waste collectors and contribute to emissions in other jurisdictions, and vice-versa.

6.2.4 Secondary Indicator Selection

The eight secondary indicators are presented in Table 9. Municipalities were scored on a scale of 0-10, with the exception of the anti-idling by-law indicator (0-5), for a total of 75 points. These indicators

[22] http://www.wastecogroup.com/services_waste_collection.php Accessed March 12 2012

address actions taken by the municipality, bringing additional context to the primary indicators and the questionnaire results. A detailed explanation of the indicators is included below.

6.2.4.1 Strength of GHG Reduction Target

This indicator measured the perceived strength of the municipality's GHG emission reduction target on a scale of 0-10. The ambitiousness of the target is judged relative to several factors: whether emissions will stabilize, how the target integrates estimates population growth, and how the target relates to Canadian international obligations under the Kyoto Protocol and Copenhagen Accord.

0: No defined reduction target, no plans for creating target
1: Municipality has agreed in principal to set reduction target in future
2: Municipality to begin work on setting reduction target this year
3: Preliminary work undertaken toward developing target
4: Work well underway on developing target
5: Target set, no rationale given. No chance of meeting target.
6: Target set, little rationale given
7: Reduction target well defined, some rationale given, but unlikely to achieve target
8: Reduction target well defined, rationale given, somewhat likely to achieve target
9: Well-defined, ambitious target set, likely to achieve target
10: Well-defined, ambitious target set, considered very like to achieve target

6.2.4.2 Internal Programs and Champions Developed to Make Action Plan, Meet Reduction Target

This indicator gauged the effectiveness of internal support mechanisms developed to help the municipality achieve its GHG reduction targets as identified in the first indicator. While many municipalities have made reduction commitments, few are on target to meeting them. Meeting reduction targets takes a determined effort with internal monitoring, review, and feedback to assess municipal efforts and made adjustments where necessary. Climate change programs also need a champion who organises and ensures activities are progressing. Factors for this evaluation include the development of a group to oversee activities, development of programs and annual goals, and awareness amongst municipal staff of the reduction targets.

A municipality with a strong plan and review process would score a maximum of 10. A score of 5 would suggest that a plan for meeting the reduction target had been developed but individual responsibilities were not defined and no monitoring process was established. Those municipalities which had already completed a GHG inventory (Milestone 1 of the PCP program) automatically received a score of 1. A score of 0 meant that no plans existed to meet the target and no inventory had been completed.

0: No plan to meet target, no GHG inventory completed

1: Municipality has committed to developing plan to reach target, has yet to do so. Basic GHG inventory completed.

2: Municipality to begin work on developing plan to meet reduction target in near future.

3: Preliminary work undertaken toward developing plan for meeting target.

4: Work well underway on developing plan for meeting target.

5: Plan to meet reduction target developed. GHG emission inventory completed

6: Plan developed, minimal annual reporting of GHG emissions, some monitoring mechanisms in place, responsibilities poorly defined, very unlikely to achieve target

7: Plan developed, some objectives developed, important emissions sources reported annually, on considerable monitoring mechanisms in place, individual responsibilities somewhat defined, somewhat likely to achieve target

8: Reduction target well defined, goals for meeting target in place, most important emissions sources reported annually, good internal monitoring process, likely to achieve target

9: Reduction target well defined, realistic goals for meeting target in place, comprehensive annual emission reporting, very good internal monitoring process, climate change champion, likely to achieve target

10: Steps to meet target well developed and realistic, comprehensive annual emission reporting, strong internal review mechanisms, influential climate change champion, considered very like to achieve target

6.2.4.3 LEED Certified Buildings

This indicator assessed whether the municipality had achieved LEED certification in any of its municipally-owned buildings. LEED certification of new or existing buildings helps reduce energy use which thereby reduces annual GHG emissions. No distinction was made from certification of a new building as opposed to an existing building, since modifying existing structures avoids GHG emissions from demolition, landfilling, and new construction materials.

A score of 0 indicated that no buildings have achieved certification and that there were no plans to do so. Certification would score a 2, Silver status a 4, Gold a 6, and Platinum status an 8. A perfect score of 10 was granted if multiple buildings are certified platinum.

0: no municipal buildings have achieved certification, no plans to do so
1: work undertaken to achieve certification in near future
2: one building certified
3: more than one building certified
4: one building achieved silver certification
5: silver certification achieved for multiple buildings
6: gold certification achieved for one building
7: gold certification achieved for multiple buildings
8: multiple buildings have achieved certified, silver, and gold status
9: platinum certification achieved for one building
10: platinum certification achieved for multiple buildings

6.2.4.4 Program to 'Right-size' Municipal Fleet Vehicles or Purchase/Lease Green Vehicles

This indicator assessed municipal programs to green the municipal vehicle fleet. Programs with the objective of leasing green vehicles (electric, hybrid, natural gas, biodiesel), enacting a fuel-efficient vehicle purchasing strategy (right-sizing the fleet), or participating in car-sharing initiatives would receive a high score on a scale of 0-10. The e3 vehicle certification program is included as a component of the rating scale[23]. E3 is similar to LEED and ranks municipal fleet performance through third-party audits. The scale is as follows:

0: no plan to reduce GHG emissions from fleet
1: has agreed take steps to reduce fleet impacts near future
2: work begun to explore ways to reduce GHG emissions from fleet
3: work completed on ways to reduce GHGs from fleet
4: scheduled to implement fleet GHG reduction plans in near future
5: initiatives in place to reduce fleet emissions
6: initiatives in place, initial actions taken to reduce fleet emissions, considerable room for improvement
7: initiatives in place and actions taken to reduce fleet emissions, room for improvement, bronze e3 certification achieved
8: several initiatives in place and actions taken to reduce fleet emissions, good progress made, silver e3 certification achieved
9: initiatives implemented including right-sizing vehicle fleet, involvement with car sharing initiative, program to lease green vehicles in place, biofuel purchasing strategy in place, considerable progress made to reducing fleet GHGs, gold e3 certification achieved
10: exceptional progress made to reducing fleet GHGs, platinum e3 certification achieved

6.2.4.5 Anti-Idling By-law in Effect

This indicator evaluated whether the municipality had by-laws prohibiting vehicle idling. The by-law incurs little cost to the municipality and is helpful in reducing unnecessary GHG emissions. A score of 5 was awarded if a by-law was in place.

Anti-idling by-law in place:

Yes – 5 points
No – 0 points

6.2.4.6 Plans to Accommodate Population Growth within Existing Urbanized Area

This indicator examined municipal plans to protect natural areas and agricultural land while encouraging new development within the existing urban area. Provincial policy has protected natural areas from development in the *Places to Grow Act*, among others, but many municipalities are still permitted to develop agricultural lands inside their borders. As previously noted, low-density suburban development increases GHG emissions (see the primary indicator for land use). Therefore this indicator

[23] http://www.e3fleet.com/

is an evaluation of policies which encourage redevelopment of vacant industrial lands, brownfields, and infilling of urban areas. Of particular interest is the percentage of population growth to be accommodated in the existing built-up area.

A municipality with plans to receive its growing population within the existing built-up area in order to increase densities received a high score of 10.

0: no plans to increase densities in existing developed areas, plan to develop new areas exclusively for future population growth
1: initial exploratory studies on increasing densities approved
2: exploratory studies on increasing densities completed
3: recommendation made to increase densities in urbanized areas, some restrictions on new development
4: recommendation approved to increase densities in urbanized areas, some restrictions on new development
5: municipal commitment to increasing urban densities found within official plan
6: some policies to increase densities, <20% of new development within existing urbanized area, some definition to urban/rural boundary
7: some Smart Growth policies enacted to increase densities, ~25% of new residents within existing urbanized area, brownfield clean-up and redevelopment incentives, fixed border separating urbanized and rural areas
8: Smart Growth policies enacted to increase densities, 25-35% of new residents within existing urbanized area, policies to increase densities such as mixed-use zoning and reliable public transportation, brownfield clean-up and redevelopment incentives, fixed border separating urbanized and rural areas
9: Smart Growth policies form planning focus, emphasis on urban redevelopment, most population increase (~40%) to be accommodated within existing urban area in official plans, policies to increase densities such as mixed-use zoning and reliable public transportation, brownfield clean-up and redevelopment incentives, fixed border separating urbanized and rural areas
10: very strong emphasis on urban redevelopment, bulk of population increase (>50%) to be accommodated within existing urban area in official plans, policies to increase densities such as mixed-use zoning and reliable public transportation in key areas, brownfield clean-up and redevelopment incentives, fixed border separating urbanized and rural areas

6.2.4.7 By-laws and Programs to Encourage Reduced Water Consumption

This indicator examined municipal by-laws and policies which promote water conservation. Research by the federal government has shown that many municipalities are undertaking water conservation initiatives[24]. Initiates promoting low-flow toilet and shower faucets, energy efficient washing machines and dishwashers, rain barrel promotions, and public education programs. Reduced water conservation is environmentally beneficial for multiple reasons, including reduced GHG emissions from water treatment related to energy consumption. The scale is as follows:

[24] http://www.cmhc-schl.gc.ca/publications/en/rh-pr/tech/01-121-E.htm

0: no by-law or plans in place
1: preliminary efforts to study water conservation measures
2: approval to study potential water conservation measures
3: by-laws and initiatives recommended
4: by-laws to be enacted in near future
5: by-laws in place
6: by-laws enacted, consideration for future incentives and community education programs
7: by-laws enacted, some incentives and education programs in place
8: good water conservation, several incentives and community education programs
9: high level of water conservation, numerous incentives and community education programs
10: exceptional water conservation, numerous incentives and community education programs

6.2.4.8 Strength of Waste Diversion Programs

This indicator measured municipal actions to reduce the volume of waste, which ultimately reduces GHGs by decreasing organic methane emissions. Examples of target programs include 'green bin' organic collection, the relative strength of municipal recycling (percentage, types of materials permitted to receive), and programs to eliminate e-waste, tires, wood, and construction materials, and corrugated cardboard from landfill. The landfill diversion rate is an important influence on this indicator. The scale is as follows:

0: no waste diversion target
1: preliminary work on waste diversion targets
2: waste diversion target set
3: preliminary work on objectives for reaching waste diversion target
4: work on objectives completed pending approval, waste diversion program in near future
5: achievable waste diversion program with objectives
6: achievable waste diversion program, <25% waste diverted from landfill. Some landfill ban policies in place
7: strong waste diversion program, >30% waste diverted from landfill. Several landfill waste bans in place
8: ambitious waste diversion program, >50% waste diverted from landfill. Tires, corrugated cardboard, recyclables, organics, e-waste, hazardous waste, wood banned from landfill
9: diversion rate ~70%, Tires, corrugated cardboard, recyclables, organics, e-waste, hazardous waste, and wood banned from landfill
10: exceptional diversion rate of >70%, very high waste separation

6.2.5 Rejected Indicators

As can be seen from the draft list of indicators (see Appendix 8) there were many that were ultimately not selected for the final list. Some were considered redundant or relatively insignificant. Attempts were made to avoid reliance on electricity consumption and include information on natural gas consumption based on feedback with municipal experts. Some potential indicators, such as renewable energy generation and district energy, are merged into the municipal building and operations indicators and can provide a credit for municipalities if present.

During the meetings with municipal experts the importance of improved building codes and standards was discussed. Better building codes would greatly reduce energy consumption. However there are many challenges to and interests involved in changing building codes. With the exception of Toronto, all municipal building codes are governed by the province under the *Building Code Act* and the Ministry of Municipal Affairs and Housing, making it difficult to enact changes. Toronto has developed the Green Building Standard, a template that could be exported to other municipalities. Nonetheless building codes and standards are a potential candidate for a future indicator.

Emissions from natural gas water heaters should also be included. They were not included in this indicator set due to the complexity in gathering data; it may be difficult to separate natural gas consumption for water heating from building heating.

Employee commuting habits and corporate travel were not included as transportation indicators since they are not likely significant for dictating climate change policy. Broader community transportation emissions from highways and rail are considered Scope 3 emissions and as such are harder to measure. As previously discussed, Scope 3 refers to indirect emissions from a municipalities' activities (see Table 2). Municipal airport facilities were not included since they are considered relatively insignificant based on discussion with municipal experts.

A land-use indicator which measured population density by urban boundaries was not included. This is a common indicator in other sustainability-themed reports. However as a result of amalgamation in the late 1990s some municipalities have very large boundaries (for example Sudbury and Ottawa) which include natural areas far beyond the urbanized area. For this reason, such an indicator would be unreliable.

Green space and urban forestry were not included as indicators for land use since their impact on GHG emissions is considered relatively insignificant. Canada's 2012 National Inventory Report to the UNFCCC states "in settlements… urban trees contribute very little to the national GHG budget. Estimates for 2010 indicate modest removals of less than 0.2 Mt CO_2" (EC 2012). Green space and urban forestry are not applicable issues for small and medium sized municipalities and are better suited for large urban centres.

An agriculture indicator was not included since it is not considered to be a major source of municipal emissions or have significant influence on climate change policy; although it is recognized that local food production reduces GHG emissions from importing food. GHG emissions related to livestock manure can be relatively high based on methane production. The City of Hamilton and the Town of Caledon have included agriculture as part of their community GHG inventories. They have developed a useful methodology for quantifying agriculture emissions by using data from Statistics Canada's 2006 Agriculture Survey. Agriculture was a small percentage of overall community emissions; in Caledon agriculture generated 10% (34, 400 tCO_2e in 2006) of community emissions, in Hamilton agriculture activities were less than 1% of the total. Future initiatives could examine the potential benefits of including agriculture emissions and adopting the aforementioned quantification methodology.

Indicators measuring municipal budgets for funding climate change action and awareness were not included, although it may be an interesting candidate for future endeavours. Small and medium-sized municipalities would be at an obvious disadvantage; therefore a measure of spending per capita would be needed. An indicator measuring the average carbon footprint of residents per municipality was not included since it would be complex and not enough data is available.

Secondary indicators for wastewater treatment were not included. This category is difficult when evaluating urban and rural municipalities since some smaller municipalities do not have wastewater treatment facilities and rely instead on septic tanks, putting them at a relative disadvantage.

6.3 Case Study

The following section demonstrates how the indicators are used in practice to develop a weighted result. For this example, the Town of Newmarket was benchmarked with 2006 baseline data from Newmarket's GHG inventory.

6.3.1 Data Input

The primary indicators are listed below and then weighted to generate the final score. Secondary indicators are not included in this example. This example assumes that no renewable electricity is generated and district energy is not used. All results are rounded up to 10^{-4} decimal places.

6.3.1.1 Total GHG Emissions Produced Annually from Electricity Consumption by Municipal Buildings per m² of Gross Floor Space

About 8,615,337 kWh was consumed. Newmarket is assumed to have 100,000m^2 of gross floor space; Guelph has a similar population with approximately 102,193m^2 gross floor space[25]. The EF for Ontario electricity in 2006 was 200g CO_2e/kWh (EC 2012).

GHG Emissions = Electricity consumption * electricity EF

8,615,337 kWh * 200g CO_2e/kWh = 1,723,067,400 gCO_2e or 1,723.0674 tCO_2e

1,723 tCO_2e / 100,000m^2 gross floor space = **0.0172 tCO_2e/m^2 floor space**

[25] http://guelph.ca/uploads/Finance/Budgets/2012/Operating/08_CommunitySocialServices.pdf pg 121 note: 1.1 million ft^2 gross floor area converted to metric is approximately 102 193 m^2

6.3.1.2 Total GHG Emissions Produced Annually from Heating Municipal Buildings from Natural Gas per m^2 of Gross Floor Space

In 2006 968,962m^3 of natural gas was consumed.

Natural Gas EF= 1,879gCO_2/m^3 natural gas (Environment Canada 2012)

968,962m^3 x 1,879gCO_2/m^3 = 18,206,795,598 gCO_2e or 1,820.6795 tCO_2e

1,820 tCO_2e / 100,000m^2 gross floor space = **<u>0.0182 tCO_2e/m^2 floor space</u>**

6.3.1.3 Total GHG Emissions Produced Annually from Electricity Consumption by Streelighting/Traffic Signals per Capita

5,181,025kWh consumed in 2006. 2006 population was 74,295.

5,181,025kWh * 200g CO_2e/kWh = 1,036,205,000 gCO_2e or 1,036.2050 tCO_2e

1,036.2050 tCO_2e / 74,295 people = **<u>0.0139 tCO_2e per capita</u>**

6.3.1.4 GHG Emissions from Total Annual Fuel Consumption in Fleet Operations (excluding Public Transportation System)

Newmarket reported 583 tCO_2e from vehicle fleet emissions (excluding fire services).

583 tCO_2e / 74,295 = **<u>0.0078 tCO_2e per capita</u>**

6.3.1.5 GHG Emissions from Public Transportation Fleet per Capita

Public transit is provided by the upper-tier municipality, York Region. For this example an estimate is used.

In 2001 YRT reported GHG emissions of 11,697 tCO_2e. Using 2006 population data (Newmarket 74,295 divided by York Region 892,712) Newmarket is 8.32% of the total population. Assuming the level of transit service is proportional to the population (excluding density) Newmarket would be responsible for about 970 tCO_2e.

583 O_2e / 74,295 people = **<u>0.0130 tCO_2e per capita</u>**

6.3.1.6 GHG Emissions from Residential Densities per Capita

According to Newmarket's 2006 census results there were 25,090 private dwellings. Low-density dwellings (single detached, semi-detached) constituted 66.4% of dwellings, while high density (row houses, apartments) was 33.4%. Therefore this translates into roughly 16,660 low density dwellings and about 8,380 high density dwellings.

16,660 low density dwellings * 0.3980 tCO2e annually/dwelling = 6,630.6800 tCO2e annually

8,380 high density dwellings * 0.3474 tCO2e annually/dwelling = 2,911.2100 tCO2e annually

9,541.8900 tCO2e annually / 74,295 = **<u>0.1284 tCO_2e per capita</u>**

6.3.1.7 GHG Emissions from Water Pumping, Treatment, and Consumption, per Capita (Serviced Population)

According to Statistics Canada the average Ontario serviced population for water is 89% of households. Newmarket reported 25 tCO_2e from water and sewage. Assuming half of that total is attributed to pumping clean water and half is pumping wastewater and sewage, 25 tCO_2e / 2 = 12.5 tCO_2e

74,295 *0.89 = approximately 66,122 serviced population

12.5 tCO_2e / 66,122 people = about **0.0002 tCO_2e per capita**

6.3.1.8 GHG Emissions from the Treatment of Wastewater and Sewage per Capita (Serviced Population)

According to Statistics Canada the average Ontario serviced population for sewage is 79%

12.5 tCO_2e / 58,693 people = about **0.0002 tCO_2e per capita**

6.3.1.9 GHG Emissions from Municipal Solid Waste per Capita

Emissions for Newmarket are unavailable unless contacted directly; comparable emissions from the City of Barrie were 17,392 tCO_2e in 2000. Assuming 17,000 tCO_2e / 74,295 = about **0.2288 tCO_2e per capita**

6.3.2 Benchmarking

The data provided by the indicators are multiplied by their respective category weights. For categories with multiple indicators the values are added and multiplied by the category weight. The category values are then added to generate the weighted result for the municipality. In Figure 5 the indicators are all equally weighted. In Figure 6 the weights presented in Table 9 are used.

6.3.3 Uncertainty Analysis

Uncertainty analysis was used to assess the overall influence of individual indicators and their respective weights on the results.

6.3.4 Inclusion and Exclusion of Individual Indicators

The indicators which scored the highest were GHG emissions from Residential Densities per Capita (0.1284 tCO_2e per capita) and Solid Waste (0.2288 tCO_2e per capita). The final weighted scores of the two indicators combined are about 90% of the total. If these indicators are removed, the next greatest sources of emissions are Municipal Buildings and Operations and Transportation. Water and wastewater treatment remain low, likely because Newmarket relies on York Region to supply its water and treat its wastewater.

Table 11 Indicator Scores for Newmarket Case Study (Newmarket 2006 data)

Indicator	Category	Score	Weighting	Scores	Category Weight	Final Scores
Total GHG produced annually from electricity consumption by municipal buildings per m^2 of space	**Municipal Buildings and Operations**	0.0172 tCO_2e/m^2 floor space	**0.45**	0.0077	0.20	0.0034
Total GHG produced annually from heating in municipal buildings from natural gas per m^2 of space	**Municipal Buildings and Operations**	0.0182 tCO_2e/m^2 floor space	**0.35**	0.0064		
Total GHG produced annually electricity consumption by streelighting/traffic signals	**Municipal Buildings and Operations**	0.0139 tCO_2e per capita	**0.20**	0.0028		
GHG emissions from total annual fuel consumption in fleet operations (excluding public transit system) per capita	**Transportation**	0.0078 tCO_2e per capita	**0.50**	0.0039	0.20	0.0021
GHG emissions from total annual fuel consumption in public transport fleet operations per capita	**Transportation**	0.0130 tCO_2e per capita	**0.50**	0.0065		
GHG emissions from residential densities per capita	**Land Use and Urban Planning**	0.1284 tCO_2e per capita	**1.00**		0.10	0.0128
GHG emissions from water pumping, treatment, and consumption per capita	**Water Treatment and Use**	0.0002 tCO_2e per capita	**1.00**	0.0002	0.15	0.0000
GHG emissions from the treatment of wastewater and sewage per capita	**Wastewater and Sewage Treatment**	0.0002 tCO_2e per capita	**1.00**	0.0002	0.15	0.0000
GHG emissions from municipal solid waste per capita	**Solid Waste**	0.2288 tCO_2e per capita	**1.00**	0.2288	0.20	0.0458
					TOTAL	**0.0641**

Figure 5 Chart of Newmarket's 2006 GHG Emission Sources, Equally Weighted

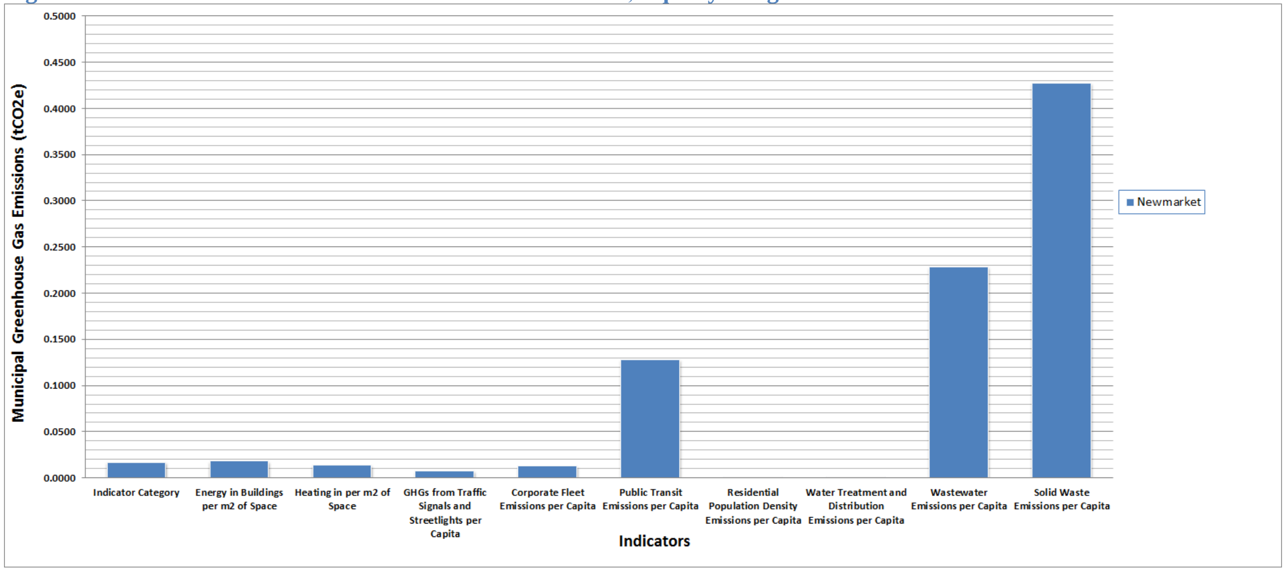
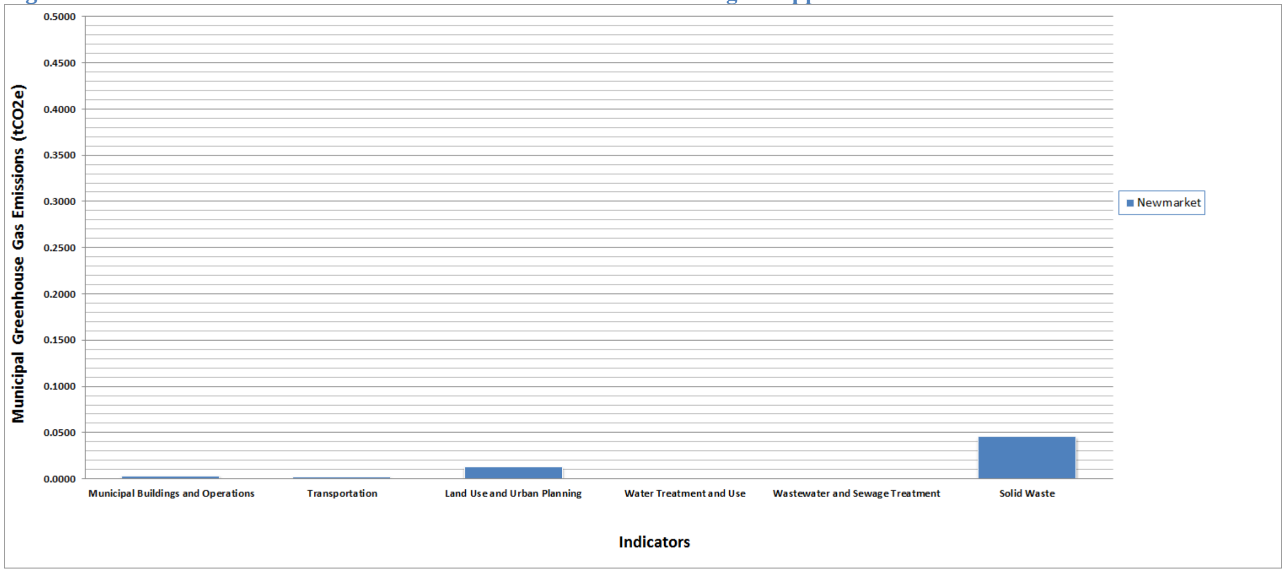


Figure 6 Chart of Newmarket's 2006 GHG Emission Sources with Weights Applied



6.3.5 Assigning Alternate Values for Weights

The weights could be adjusted to reflect an emphasis on corporate emissions over those from the community. As previously discussed, municipal governments have more direct control over corporate emissions. Community emissions are difficult to model and influence, therefore climate change programs may place an emphasis on corporate emissions first. This section will demonstrate how alternate weights could be applied. The assignment of weights is inherently arbitrary. Ideally an expert panel would review the weights and arrive at a consensus on the optimal weighting.

First, the individual indicator weights will be adjusted. In this scenario the weights would be:

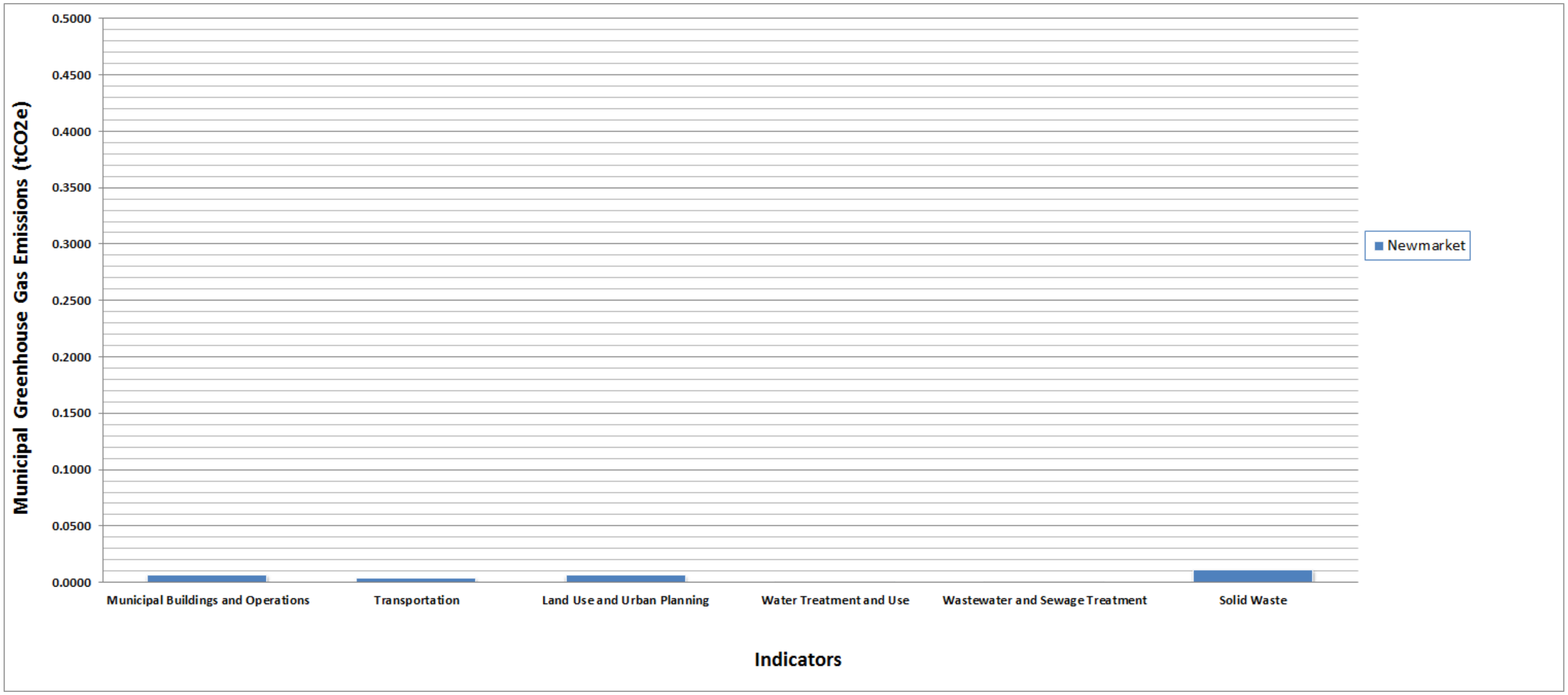
- Total GHG produced annually from electricity consumption by municipal buildings per m^2 of space **50%**
- Total GHG produced annually from heating in municipal buildings from natural gas per m^2 of space **40%**
- Total GHG produced annually electricity consumption by streelighting/traffic signals **10%**
- GHG emissions from total annual fuel consumption in fleet operations (excluding public transit system) per capita **60%**
- GHG emissions from total annual fuel consumption in public transport fleet operations per capita **40%**
- GHG emissions from residential densities per capita **100%**
- GHG emissions from water pumping, treatment, and consumption per capita **100%**
- GHG emissions from the treatment of wastewater and sewage per capita **100%**
- GHG emissions from municipal solid waste per capita **100%**

In this case the emissions from buildings rise to 5.39%, while transportation increases to 3.24%; a marginal increase. If category weights were adjusted to reflect emphasis on corporate emissions weights would be as follows:

- Municipal Buildings and Operations **40%**
- Transportation **40%**
- Land Use and Urban Planning **5%**
- Water Treatment and Use **5%**
- Wastewater and Sewage Treatment **5%**
- Solid Waste **5%**

The change in emissions is illustrated in Figure 7. Even at a reduced 5% weighting, land use and solid waste remain the dominant sources of emissions. Land use emissions are likely to be high relative to the other indicators since they reflect the total residential population.

Figure 7 Chart of Newmarket's 2006 GHG Emission Sources with Alternate Weights Applied



6.4 Questionnaire Results

Representatives from 32 municipalities were contacted in March 2012. Fourteen responses were received, with eight expressing interest and four declining to participate. Those that declined to participate cited a lack of available data and resources. One municipality reported that it was currently undergoing departmental restructuring and downsizing, therefore limited time and personnel were available to participate. Ultimately eight municipalities completed the online survey. This represents a response rate of 25%.

6.4.1 Interviews with Municipal Officials

Following the completion of the online survey the municipal officials were contacted for brief phone interviews to discuss the study results. Not all participating municipalities were available for comment.

Table 12 Municipalities Participating in the Study

Contact	Job Title	Municipality	Interview Date	Single, Upper, Lower Tier?	Municipal Responsibilities	2011 City Population (not CMA)	Land Area (km^2)	Location
Name Withheld	Environmental Coordinator	**Barrie**	May 1 2012	Single	Fire and EMS; police; public transit; parks; streetlights and traffic signals; roads; solid waste collection, disposal, and recycling; landfill site management, water pumping, treatment, distribution, libraries	135,711	77	Central Ontario
Name Withheld	Coordinator	**Burlington**	April 27 2012	Lower	Fire and EMS, parks and recreation facilities, roads, water, solid waste collection, public transit; streetlights and traffic signals	175,779	186	GTHA
Name Withheld	Climate Change Coordinator	**Hamilton**	April 20 2012	Single	Fire and EMS; police; public transit; parks and recreation facilities; streetlights and traffic signals; roads; solid waste collection, disposal, and recycling; landfill site management, water pumping, treatment, distribution, museums, libraries	519,949	1,117	GTHA

Table 12 (Continued from previous page)

Name Withheld	Environmental Manager	**North Bay**	No	Lower	Fire and EMS; police; public transit; parks; streetlights and traffic signals; roads; solid waste collection, disposal, and recycling; landfill site management, water pumping, treatment, distribution, libraries	53,651	319	Central Ontario
Name Withheld	Manager	**York Region**	May 3 2012	Upper	Fire and EMS; police; public transit; parks and recreation facilities; streetlights and traffic signals; public transit; roads; solid waste collection, disposal, and recycling; landfill site management, water pumping, treatment, distribution, museums, libraries	1,032,524	1,762	GTHA
Name Withheld	Manager	**Municipality X**	No	Lower	Fire and EMS; police; public transit; parks; streetlights and traffic signals; roads; solid waste collection, disposal, and recycling; landfill site management, water pumping, treatment, distribution, libraries	Under 100,000	164	Southwestern

Table 12 (Continued from previous page)

Name Withheld	Environmental Coordinator	**Municipality Y**	April 27 2012	Single	Fire and EMS; police; public transit; parks and recreation facilities; streetlights and traffic signals; roads; solid waste collection, disposal, and recycling; landfill site management, water pumping, treatment, distribution, museums, libraries,	210,000	146	Southwestern Ontario
Name Withheld	Associate Director	**Municipality Z**	No	Upper	Fire and EMS; police; public transit; parks and recreation facilities; streetlights and traffic signals; roads; solid waste collection, disposal, and recycling; landfill site management, water pumping, treatment, distribution, museums, libraries	430,000	1,854	Southwestern Ontario

6.4.1.1 Representative, City of Barrie

A phone call with an Environmental Officer at the City of Barrie was held on May 1 2012. During the conversation the representative noted some issues with collecting fleet information from various departments; for example Barrie's police services are a separate entity from corporate fleet. While Barrie does not have an official anti-idling by-law, it does have smog reduction plans during smog alert days where corporate fleet and outdoor work is reduced to avoid additional pollution. The representative also highlighted some of Barrie's waste management practices, such as the separation of cardboard and metal, and removal of organic yard waste.

6.4.1.2 Representative, City of Burlington

A phone conversation with an environmental coordinator at the City of Burlington was held on April 27 2012. The emission factors used in Burlington's inventory reports were discussed, highlighting the need for greater transparency and standardized EFs. The representative described Burlington's new Corporate Building Automation System (BAS), which will help Burlington meet its corporate emission reduction goals while avoiding $1.5million in energy consumption, HVAC equipment maintenance and operations related costs. The BAS provides monitoring and control over energy use, temperature, humidity, and CO_2 emissions, and automatically shuts down unoccupied equipment and room lighting across 27 major city facilities (arenas, city hall, administration facilities, and aquatic centres). The represenative also provided details regarding Burlington's land use development policies which promote urban intensification. A conversation with the Senior Sustainability Coordinator provided details of Burlington's Official Plan and growth strategies in relation to provincial legislation under the *Places to Grow Act* and the *GreenBelt Act*. As a coordinator in a lower-tier municipality the representatives highlighted the importance of local and regional responsibilities and how they relate to GHG emissions; for example Halton Region's responsibilities for water and waste.

6.4.1.3 Representative, City of Hamilton

A phone call with an environmental coordinator for the City of Hamilton's Public Health Services department was held on April 20 2012. The representative affirmed the value of indicators for gauging municipal performance, although there can be difficulties in quantification. For example, the provincial transit authority Metrolinx has an impact on Hamilton's public transportation plans and strategies and quantifying their emissions data can be difficult. Metrolinx plays a role in Hamilton's Transportation Demand Management programs through the Smart Commute Hamilton program. This program focuses on carpooling, ride sharing, and cycling. Although the numbers of participants and VKMT (vehicle km travelled) reduced by each participant is known, tracking the quantity of fuel saved and emissions reduced is neither clear nor tracked on an annual basis.

The representative also noted that many buildings are now being constructed to the LEED standard but are not being certified due to cost; thus only focusing on LEED could be misleading and a green building standard (such as the one in development by NRCAN) would be useful. The representative discussed Hamilton's plans for increasing density through its Official Plan and new public transportation LRT projects in relation to the Places to Grow Act. There are challenges to increasing density and he noted that projects can be held up for long periods of time at Ontario Municipal Board (OMB) hearings. Hamilton has begun work on the new provincial reporting requirements under Ontario Regulation 397/11 which come into effect in 2013. New regulations are proving useful for creating corporate emission reports; for example, Hamilton now produces annual energy reports to help reduce consumption and associated costs. The representative noted challenges from communicating across departments and the community, and a disconnect in how energy consumption is measured regarding absolute value and intensity values.

6.4.1.4 Representative, York Region

A phone call with an environmental manager at York Region was held on May 3 2012. The representative identified issues with emission factors and provided an example of York Region prepares its energy and GHG inventory reports. The representative confirmed the need for transparency with the methodology and suggested a possible alternative indicator for public transit; the current indicator measuring GHGs from transit on a per capita basis tends to negatively impact a municipality. An opportunity was identified using litres of fuel per passenger kilometres travelled, although this research would likely be too complex and costly to properly model. Citing recent experience with the Mayor's Megawatt Challenge, the representative explained the need for increased cooperation amongst municipalities. Instead of being obsessed with individual results they should work together, network, and identify opportunities to create value.

6.4.2 Benchmarking Results

The overall equally weighted benchmarking results by category are illustrated in Figure 8. Keep in mind municipal responsibilities between lower and upper tiers; not all indicators are relevant for every municipality. The data are presented in Table 11. Figure 9 below illustrates the equally weighted results for each individual municipality. The data are presented in Table 12.

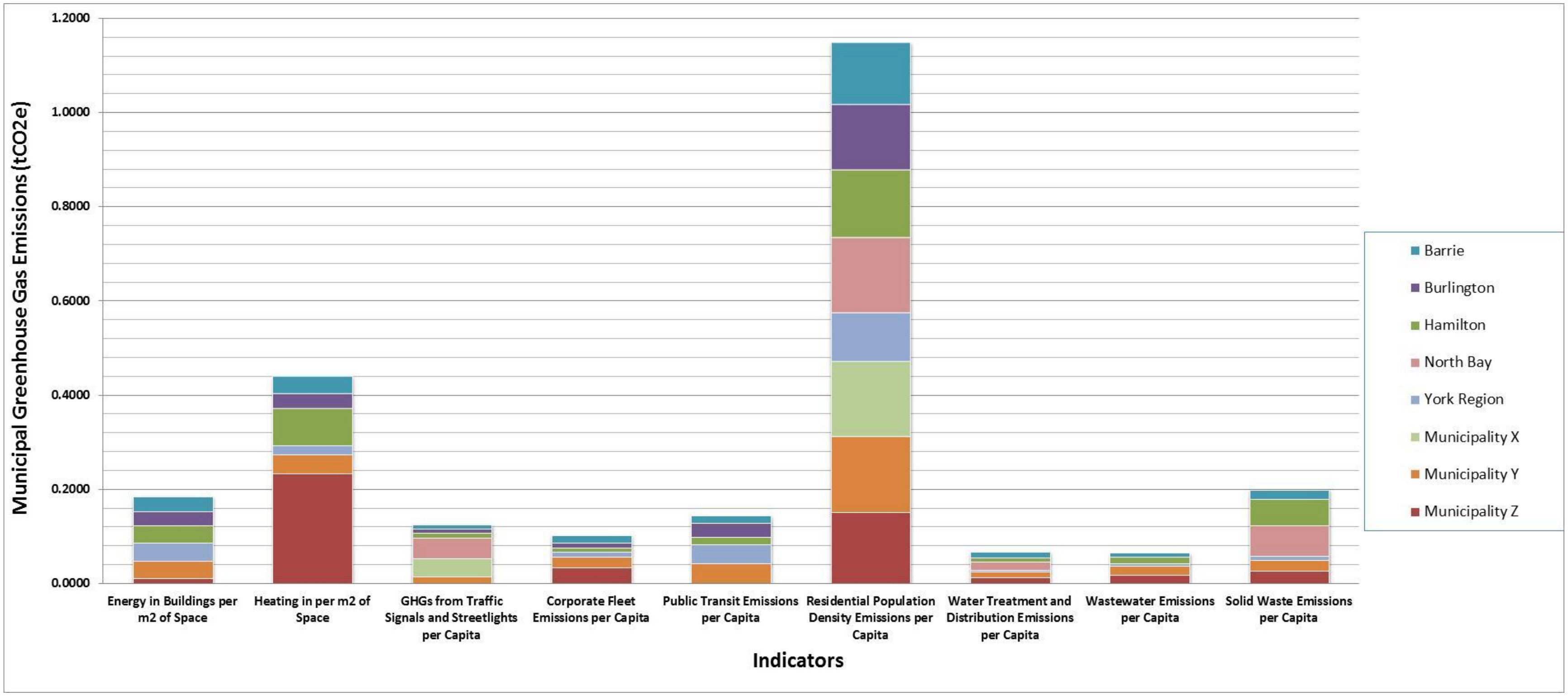


Figure 8 Equally Weighted Benchmarking Results (Overall) by Indicator

Table 13 Data for Figure 8

	Municipality							
Indicator Category	**Barrie**	**Burlington**	**Hamilton**	**North Bay**	**York Region**	**Municipality X**	**Municipality Y**	**Municipality Z**
Energy in Buildings per m2 of Space	0.0320	0.0302	0.0367	ND	0.0393	ND	0.0367	0.0104
Heating in per m2 of Space	0.0366	0.0312	0.0793	ND	0.0187	ND	0.0410	0.2334
GHGs from Traffic Signals and Streetlights per Capita	0.0092	0.0085	0.0113	0.0429	0.0011	0.0376	0.0142	0.0009
Corporate Fleet Emissions per Capita	0.0151	0.0103	0.0084	ND	0.0114	ND	0.0221	0.0345
Public Transit Emissions per Capita	0.0151	0.0298	0.0170	ND	0.0404	ND	0.0420	NA
Residential Population Density Emissions per Capita	0.1321	0.1388	0.1428	0.1597	0.1039	0.1600	0.1606	0.1513
Water Treatment and Distribution Emissions per Capita	0.0121	NA	0.0103	0.0169	0.0036	ND	0.0127	0.0124
Wastewater Emissions per Capita	0.0073	NA	0.0150	ND	0.0045	ND	0.0198	0.0181
Solid Waste Emissions per Capita	0.0208	NA	0.0557	0.0642	0.0095	ND	0.0223	0.0268
Total	**0.2804**	**0.2488**	**0.3765**	**0.2836**	**0.2323**	**0.1976**	**0.3714**	**0.4877**

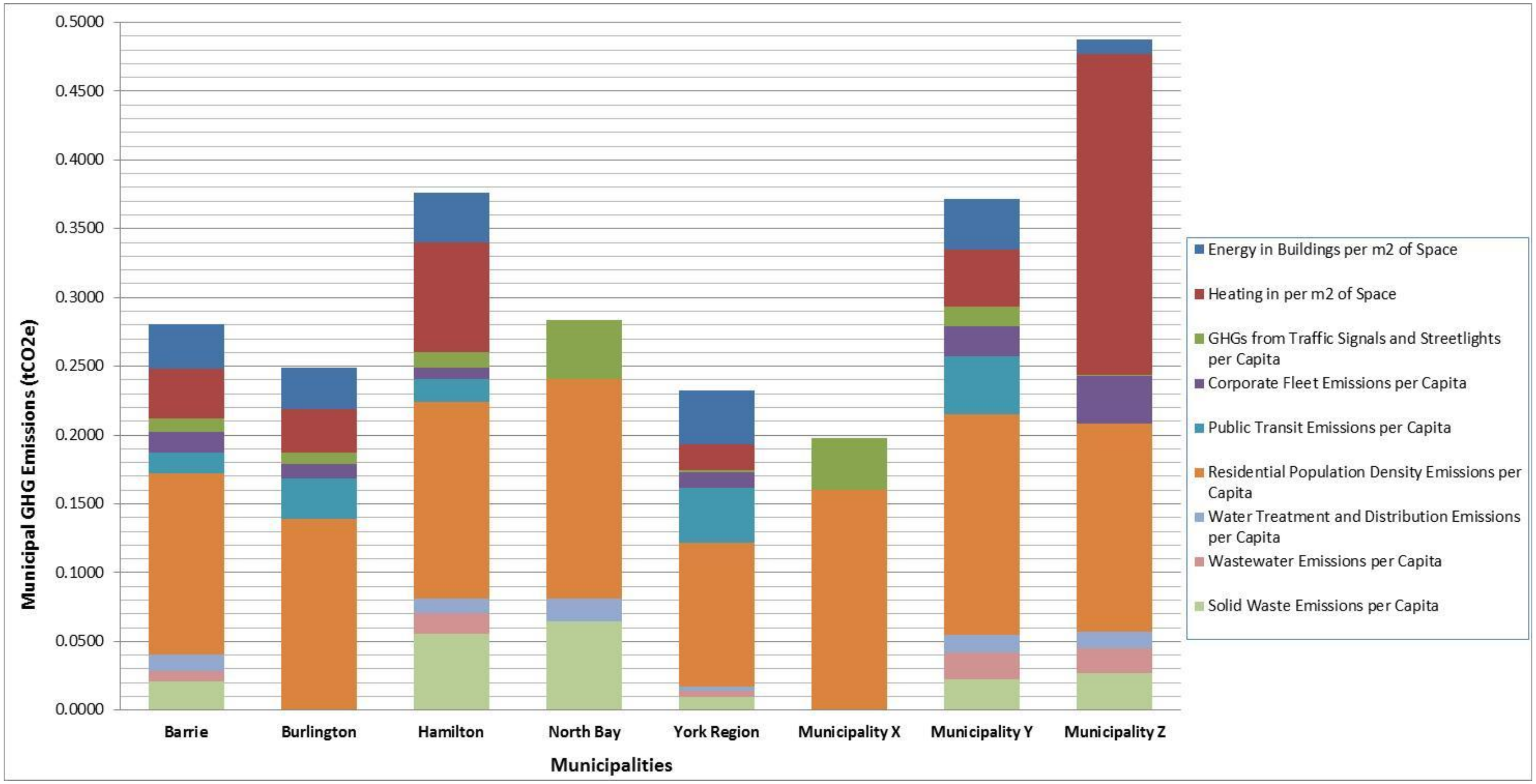


Figure 9 Equally Weighted Benchmarking Results (Overall) by Municipality

Table 14 Data for Figure 9

	Municipality							
Indicator Category	**Barrie**	**Burlington**	**Hamilton**	**North Bay**	**York Region**	**Municipality X**	**Municipality Y**	**Municipality Z**
Energy in Buildings per m2 of Space	0.0320	0.0302	0.0367	ND	0.0393	ND	0.0367	0.0104
Heating in per m2 of Space	0.0366	0.0312	0.0793	ND	0.0187	ND	0.0410	0.2334
GHGs from Traffic Signals and Streetlights per Capita	0.0092	0.0085	0.0113	0.0429	0.0011	0.0376	0.0142	0.0009
Corporate Fleet Emissions per Capita	0.0151	0.0103	0.0084	ND	0.0114	ND	0.0221	0.0345
Public Transit Emissions per Capita	0.0151	0.0298	0.0170	ND	0.0404	ND	0.0420	NA
Residential Population Density Emissions per Capita	0.1321	0.1388	0.1428	0.1597	0.1039	0.1600	0.1606	0.1513
Water Treatment and Distribution Emissions per Capita	0.0121	NA	0.0103	0.0169	0.0036	ND	0.0127	0.0124
Wastewater Emissions per Capita	0.0073	NA	0.0150	ND	0.0045	ND	0.0198	0.0181
Solid Waste Emissions per Capita	0.0208	NA	0.0557	0.0642	0.0095	ND	0.0223	0.0268
Total	**0.2804**	**0.2488**	**0.3765**	**0.2836**	**0.2323**	**0.1976**	**0.3714**	**0.4877**

The overall weighted benchmarking results are illustrated below in Figure 10. Keep in mind municipal responsibilities between lower and upper tiers; not all indicators are relevant for every municipality. The data are presented in Table 13.

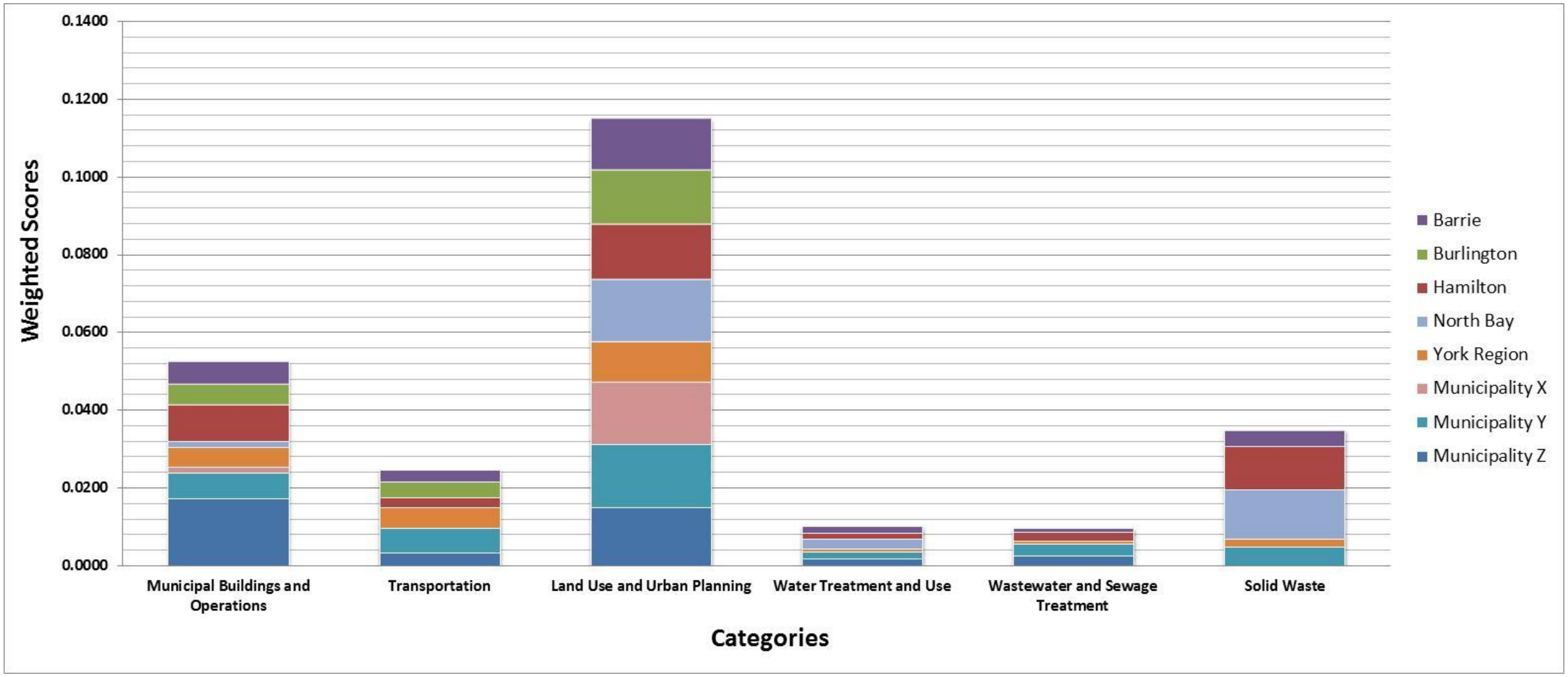


Figure 10 Weighted Benchmarking Results (Overall)

Table 15 Weighted Benchmarking Result Data for Figure 10

		Municipality						
Indicator Category	Barrie	Burlington	Hamilton	North Bay	York Region	Municipality X	Municipality Y	Municipality Z
Municipal Buildings and Operations	0.0058	0.0052	0.0093	0.0017	0.0049	0.0015	0.0067	0.0173
Transportation	0.0030	0.0040	0.0025	ND	0.0052	ND	0.0064	0.0034
Land Use and Urban Planning	0.0132	0.0139	0.0143	0.0160	0.0104	0.0160	0.0161	0.0151
Water Treatment and Use	0.0018	NA	0.0015	0.0025	0.0005	ND	0.0019	0.0019
Wastewater and Sewage Treatment	0.0011	NA	0.0023	ND	0.0007	ND	0.0030	0.0027
Solid Waste	0.0042	NA	0.0111	0.0128	0.0019	ND	0.0045	0.0005
Total	**0.0291**	**0.0231**	**0.0411**	**0.0331**	**0.0236**	**0.0175**	**0.0385**	**0.0409**

6.4.3 Benchmarking by Indicator

This section provides a breakdown of the indicator set by each municipality. The black bar represents the mean score; municipalities that did not have available data are not included. Below each graph are notes that discuss limitations in the data. Not all indicators are relevant for every municipality; please note differences in municipal responsibilities between lower and upper tier.

6.4.3.1 Total GHG Produced Annually from Electricity Consumption by Municipal Buildings per m² of Gross Floor Space

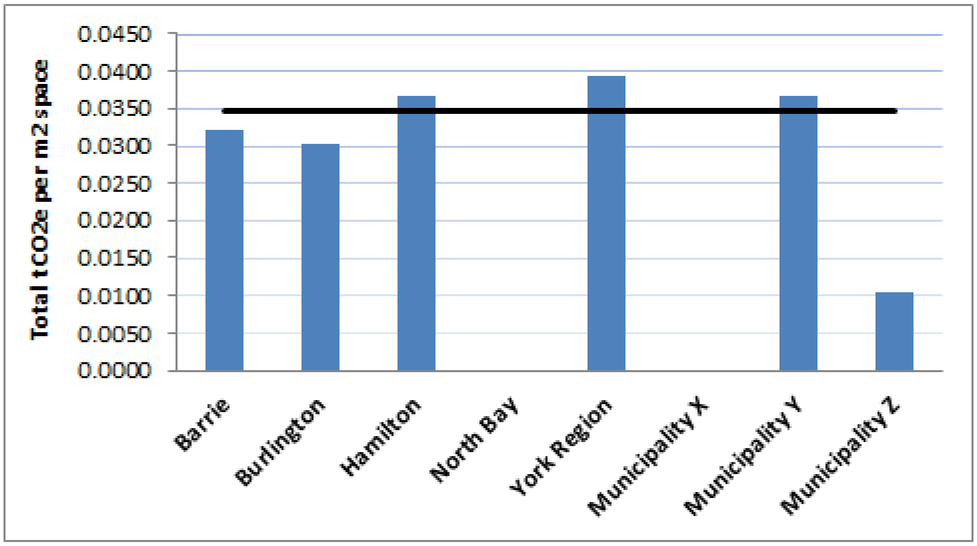


Figure 11 Equally Weighted Indicator Scores for Energy Consumption in Buildings

Table 16 Data used to create Figure 11. The mean score was 0.0309.

Barrie	0.0320
Burlington	0.0302
Hamilton	0.0367
North Bay	No Data
York Region	0.0393
Municipality X	No Data
Municipality Y	0.0367
Municipality Z	0.0104

Notes: Barrie will be installing 1.1 MW of solar power on five city facility roof tops in 2012; however, no 2010 data are available. Barrie already has 10.75 kW of installed solar but total renewable energy produced are not available. Burlington included some water and stormwater pumping in the total quantity of electricity consumed. Burlington installed a 10 kW solar PV system in 2011 and 2010 data is not available. North Bay is determining gross floor areas in preparation for *Green Energy Act* reporting but those values are not yet available; therefore this indicator could not be completed. Data for Municipality X is not available. Municipality Y reported 2005 data for this indicator and the information does not reflect building energy retrofits that have taken place since. Municipality Z has filed a FIT application for a wind project and plans for solar installations in 2013-2014. A solar thermal hot water heater and a solar collector are currently installed but 2010 data is not available.

6.4.3.1.1 Strength of GHG Reduction Target

Municipality	Score /10	Notes
Barrie	**8**	Reduction target of 20% from 2001 levels by 2012 for corporate emissions, 6% reduction from 2001levels for community emissions
Burlington	**8**	Corporate emissions reduced by 20% per capita from 1994 levels; target was based on Partners for Climate Protection (PCP) program guidelines which stipulated a per capita % reduction in GHG levels based on 1994 data. Measures taken on the policy side include anti idling, right sizing vehicles, Strategic Plan directions, and projects such as Tansley Woods Solar Thermal System, implementation of new Corporate Wide Building Automation System, LEED guidelines for new construction of facilities.
Hamilton	**9**	Corporate reduction target of 10% below 2005 levels by 2012, 20% of 2005 greenhouse gases levels by 2020. GHG inventory completed, annual energy reports, strong website content, Hamilton was recognized as one of the Top 10 Canadian Cities tackling Climate Change by the World Wildlife Fund in 2011.
North Bay	**3**	**Target set, initial plans developed to reduce fuel and energy consumption.**
York Region	**8**	2011 GHG inventory. No specific targets, but has a Regional Sustainability Strategy requiring increased energy efficiency and sustainability of York Region buildings through retrofits, procurement and conservation measures, and pursuing renewable energy. Will reduce greenhouse gas emissions in existing and future Regional facilities by tracking energy performance and costs across the Region on an annual basis, monitoring greenhouse gas emissions corporate-wide.
Municipality X	**0**	Current focus on adaptation plans; will be working on the reduction targets and mitigation plan soon.
Municipality Y	**3**	Current focus on adaptation plans; will be working on the reduction targets and mitigation plan after 2014.
Municipality Z	**4**	A bottom up target is currently being formulated based on expected achievements with energy reductions based on findings in 2006 Corporate GHG emission report.

6.4.3.1.2 Internal Programs and Champions Developed to Make Action Plan, Meet Reduction Target

Municipality	Score /10	Notes
Barrie	**7**	Completed 2nd ed. of Integrated Energy Mapping report to help establish a plan to meet targets. Community Energy Plan case study, FCM Green Municipal Fund reports. Hoping to use these reports to set appropriate targets and timelines based on costs and knowledge of what is required to achieve targets.
Burlington	**9**	Council voted in 2007 to develop a Corporate Action Plan to Reduce GHG Emissions. FCM Milestone 1 met, Council working to complete Milestones 2 and 3. Environmental Management Team, Sustainable Development Committee formed to create deliverables and targets. Many policies in place such as corporate green fleet transition strategy, corporate green procurement policy, corporate sustainable building policy, Energy Policy Burlington Our Future (2011-2014) strategic plan, and a corporate energy management plan is in development. Energy initiatives include **traffic** signal LED retrofits, facility lighting retrofits, new energy tracking tools, corporate building energy audit ongoing. Currently working to develop culture of conservation, prioritize and implement energy conservation projects
Hamilton	**8**	See previous indicator notes
North Bay	**3**	GHG inventory conducted in 2010, steps taken to reduce consumption of energy, natural gas and fuel.
York Region	**8**	See previous indicator notes
Municipality X	**N/A**	
Municipality Y	**5**	Extensive energy retrofits at most city facilities, renewable energy projects on swimming pools, LED streetlight pilot projects, replacement of LED traffic signals.
Municipality Z	**6**	Energy efficiency initiatives undertaken.

6.4.3.2 Total GHG Produced Annually from Heating in Municipal Buildings from Natural Gas per m² of Gross Floor Space

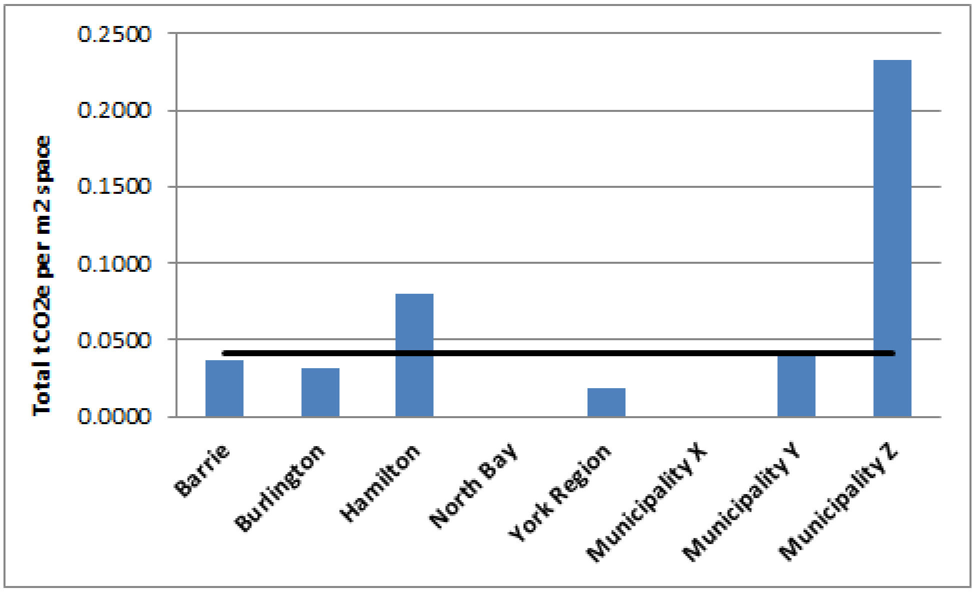


Figure 12 Equally Weighted Indicator Scores for Natural Gas Consumption in Buildings

Table 17 Data used to create Figure 12. The mean score was 0.0734

Barrie	0.0366
Burlington	0.0312
Hamilton	0.0793
North Bay	No Data
York Region	0.0187
Municipality X	No Data
Municipality Y	0.0410
Municipality Z	0.2334

Notes: The quantity of gas consumed for Barrie includes gas used in a sewage treatment plant and surface water treatment plant. Energy from wastewater treatment plant flaring is used to heat the treatment plant but the total emissions avoided are not known. York Region's figure includes natural gas consumed in leased housing and public housing (Housing York Inc.), and does not include gross leased and Region-owned / 3rd-party-operated housing. North Bay is determining gross floor areas in preparation for *Green Energy Act* reporting but the information is not yet available; therefore this indicator could not be completed. Data for Municipality X are not available. Municipality Y reported 2005 data for this indicator. Municipality Z did not report the volume of natural gas consumed; the tCO_2e is from their inventory report and the EF was not reported.

6.4.3.3 GHGs from Traffic Signals and Streetlights per Capita

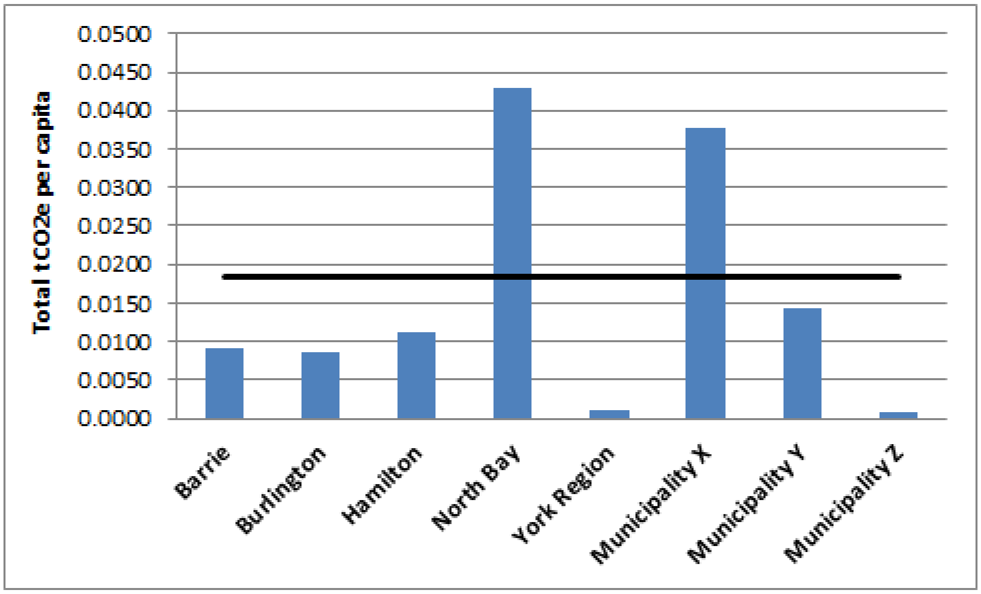


Figure 13 Equally Weighted Indicator Scores for Electricity Consumption in Streetlights per Capita

Table 18 Data used to create Figure 13. The mean score was 0.0157

Barrie	0.0092
Burlington	0.0085
Hamilton	0.0113
North Bay	0.0429
York Region	0.0011
Municipality X	0.0376
Municipality Y	0.0142
Municipality Z	0.0009

Notes: North Bay reported tCO_2e and may have used a different EF. The quantity of electricity consumed for Municipality X was taken from the 2010 Financial Information Return to the Ministry of Municipal Affairs and converted into tCO_2e. Municipality Y reported 2005 data for this indicator and does not reflect the results of an LED lighting conversion program. Municipality Z reported 2006 data for this indicator.

6.4.3.3.1 Municipal LEED-Certified Buildings

Municipality	Score /10	Notes
Barrie	**5**	Silver certification achieved for a fire station and a library
Burlington	**8**	Appleby Ice Centre Expansion, Burlington Transit Administration Centre Expansion, Burlington Performing Arts Centre, Fire Station 8 (LEED Silver) Corporate Sustainable Building Policy requiring a LEED Silver rating for new corporate facilities and major retrofits Corporate energy audits currently being conducted, Dec 2012 completion date Corporate-wide building automation system (BAS) in place which monitors and controls energy use, temperatures, humidity, CO_2, shuts down unoccupied equipment and room lighting.
Hamilton	**5**	One LEED bronze certified building, one LEED silver at Woodward Avenue Environmental Laboratory. One more LEED building under construction.
North Bay	**1**	Work undertaken to achieve certification in near future.
York Region	**8**	LEED standard for new construction and retrofits/additions to existing buildings. Currently have five certified gold and silver LEED facilities, five silver certified pending certification, six in the design phase.
Municipality X	**0**	No Data Available
Municipality Y	**5**	New facilities have built to LEED design; recently built 2 facilities to LEED silver design criteria, waiting for certification.
Municipality Z	**5**	LEED Silver for Headquarters Building (2006); LEED Silver for Long TermCare Home under construction. Affordable housing development to be built to LEED standards.

6.4.3.4 Corporate Fleet Emissions per Capita

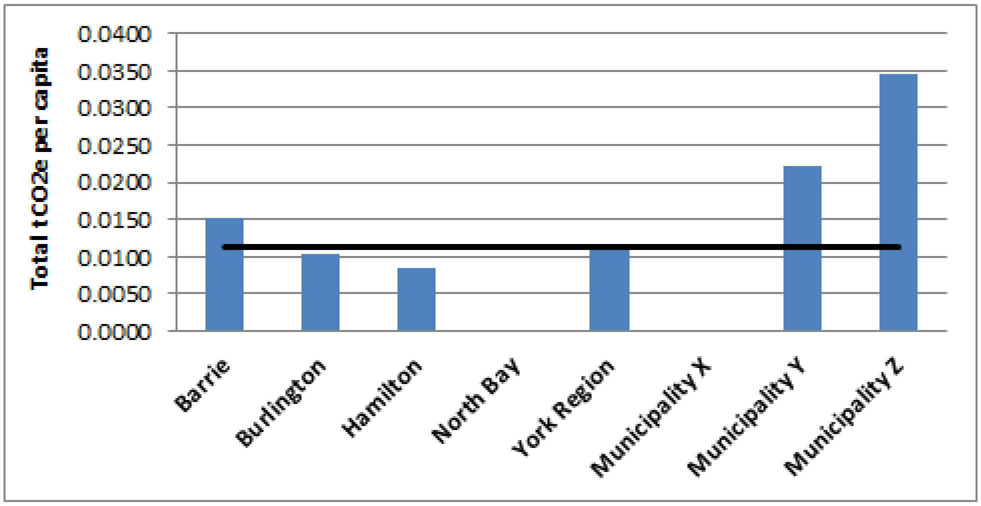


Figure 14 Equally Weighted Indicator Scores for Fleet Emissions per Capita

Table 19 Data used to create Figure 14. The mean score was 0.0170

Barrie	0.0151
Burlington	0.0103
Hamilton	0.0084
North Bay	No Data
York Region	0.0114
Municipality X	No Data
Municipality Y	0.0221
Municipality Z	0.0345

Notes: The tCO_2e for Barrie is based on a 2011 estimate from the 2006 corporate inventory report. Data for Municipality X are not available. Municipality Y reported 2005 data for this indicator.

6.4.3.4.1 GHG Emission Reductions in Corporate Vehicle Fleet

Municipality	Score /10	Notes
Barrie	**6**	Four hybrid vehicles in fleet. Considerable policy actions outlined in 2006 GHG inventory report; have yet to be implemented
Burlington	**9**	Corporate green fleet transition strategy in place. Ten focus areas including right sizing fleet vehicles, use of hybrid vehicles, alternate fuels and plug in vehicles, driver training, Smart Commute program for employees.
Hamilton	**8**	E3 silver certified. Green fleet exposition, low emission mowing equipment, green fleet strategic and implementation plans, right sizing initiative, driver training for employees.
North Bay	**6**	Fleet is being right-sized. Reduced fuel consumption in fleet vehicles. Public works has undertaken several initiatives when purchasing new equipment such as snow plows.
York Region	**7**	Region's Green Fleet's Plan, investigates use of alternative fuels, operating and maintenance procedure s in Regional vehicles Municipal green fleet and trip reduction programs demonstrate GHG reductions of 15% - 20%.
Municipality X	**1**	
Municipality Y	**6**	Draft green fleet plan , several report recommendations are being implemented - right-sizing of vehicles, enhanced maintenance, Fleet Challenge Ontario, increased driver's training
Municipality Z	**7**	Recently received a Green Fleet Award. Right sizing vehicles, hybrid vehicles (Ford Escape Hybrids), anti-idling devices installed where appropriate on corporate vehicles. Has promoted anti idling amongst its staff.

6.4.3.5 Public Transit Emissions per Capita

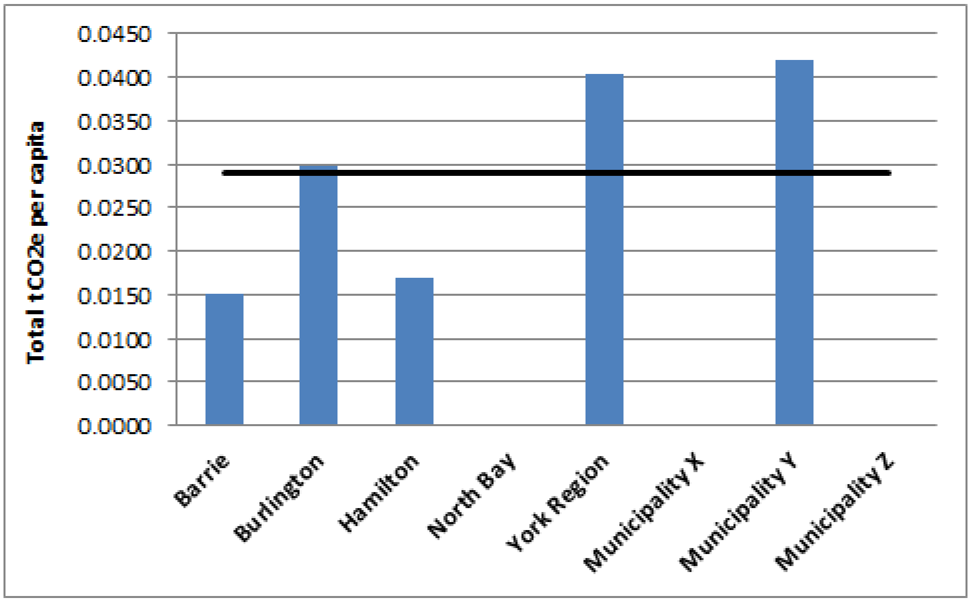


Figure 15 Equally Weighted Indicator Scores for Fleet Emissions per Capita

Table 20 Data used to create Figure 15. The mean score was 0.0289

Barrie	0.0151
Burlington	0.0298
Hamilton	0.0170
North Bay	No Data
York Region	0.0404
Municipality X	No Data
Municipality Y	0.0420
Municipality Z	Not applicable

Notes: Burlington purchases low-sulphur diesel for busses. The figure reported for York Region does not include a biodiesel credit; public transit department purchases B5 biodiesel in winter and B20 biodiesel in summer for part of its bus fleet, leading to a reduction in fossil-based diesel of approximately 600,000 litres. An EF for B5 and B20 could not be found so the standard biodiesel EF was applied which may result in differences. Data for Municipality X is not available. Municipality Y reported 2005 data for this indicator. Municipality Z launched a new regional public transportation service in 2011, 2010 data is not available.

6.4.3.5.1 Anti-Idling By-law in Effect

Municipality	Yes/No	Notes
Barrie	**No**	
Burlington	**Yes**	By-law applies to both corporate fleet and transit vehicles
Hamilton	**Yes**	
North Bay	**Yes**	
York Region	**N/A**	Not applicable in this case, lower-tier responsibility.
Municipality X	**Yes**	
Municipality Y	**Yes**	By-law applies to both corporate fleet and transit vehicles
Municipality Z	**No**	Not applicable in this case, lower-tier responsibility. Anti-idling actions undertaken for corporate fleet.

6.4.3.6 Residential Population Density Emissions per Capita

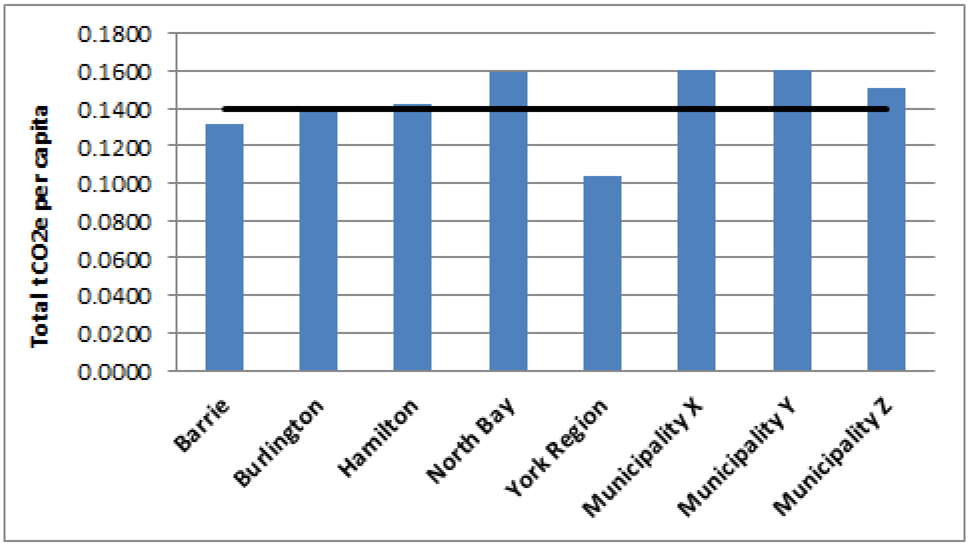


Figure 16 Equally Weighted Indicator Scores for Residential Emissions per Capita

Table 21 Data used to create Figure 16. The mean score was 0.1436

Barrie	0.1321
Burlington	0.1388
Hamilton	0.1428
North Bay	0.1597
York Region	0.1039
Municipality X	0.1600
Municipality Y	0.1606
Municipality Z	0.1513

Notes: All data is based on the 2006 Census. 2011 data will be released by Statistics Canada in November 2012.

6.4.3.6.1 Plans to Accommodate Population Growth within Existing Urbanized Area

Municipality	Score /10	Notes
Barrie	**3**	New design standards being developed to increase density. Also developing a brownfield plan; neither are in place
Burlington	**9**	Former Mayor MacIsaac worked with provincial government to establish Greenbelt, strengthening Burlington's protection of its rural area. Under *Places to Grow Act* Burlington designated a growth centre. Growth in urban area now focused on intensification projects either in downtown or along arterial corridors, with exception to a few remaining developments. No brownfield redevelopment strategy at this time. No history of contaminated industrial sites so hasn't been a priority.
Hamilton	**9**	Brownfield redevelopment strategy, natural spaces protection, , improved public transit plans (BRT/LRT), firm boundaries set for urban development, downtown renewal strategy, indicator for tracking number of hectares of agricultural land lost due to Official Plan amendments. Strategic planning such as Vision 2020 report, urban official plan. Growth Related Integrated Development Strategy (GRIDS) designed to be consistent with provincial policies on growth planning, which emphasize urban intensification, greater land-use diversity (mixing uses in one district) and redevelopment instead of conventional urban expansions.
North Bay	**5**	Brownfield development incentives.
York Region	**9**	Regional Official Plan outlines development policies such as: focusing on growth in Regional centres and corridors (minimum of 40% residential intensification within the built-up area), innovation in urban design and green building. New community areas designed to a higher standard: requirements for sustainable buildings, water and energy management, public spaces, mixed-use, compact development, and urban design. Urban development and infrastructure projects that contribute enhancements to the Regional Greenlands System: a natural heritage legacy based on a linked and enhanced Regional Greenlands System, protection of the rural and agricultural countryside.
Municipality X	**4**	Rezoning of vacant school properties to allow housing development
Municipality Y	**5**	Natural Area Protection by-law, brownfield development strategy, tax incentives.
Municipality Z	**9**	Municipality Z SmartGrowth plan. Features: Promote compact built form, produce walkable neighbourhoods and communities, preservation of farmland and natural resources, Direct development into existing communities, providing a variety of transportation choices (new inter-municipal transit system launched Fall 2011 to enable public transit between five population centers in Municipality Z), obstacles to implementing Smart Growth should be removed. FCM G.M.F case study, community improvement plan (brownfield redevelopment). Rehabilitation would curb urban sprawl, increase property tax revenue and improve neighbourhood stability and quality of life. Council strategy for evaluating and prioritizing redevelopment sites using Smart Redevelopment Framework.

6.4.3.7 Water Treatment and Distribution Emissions per Capita

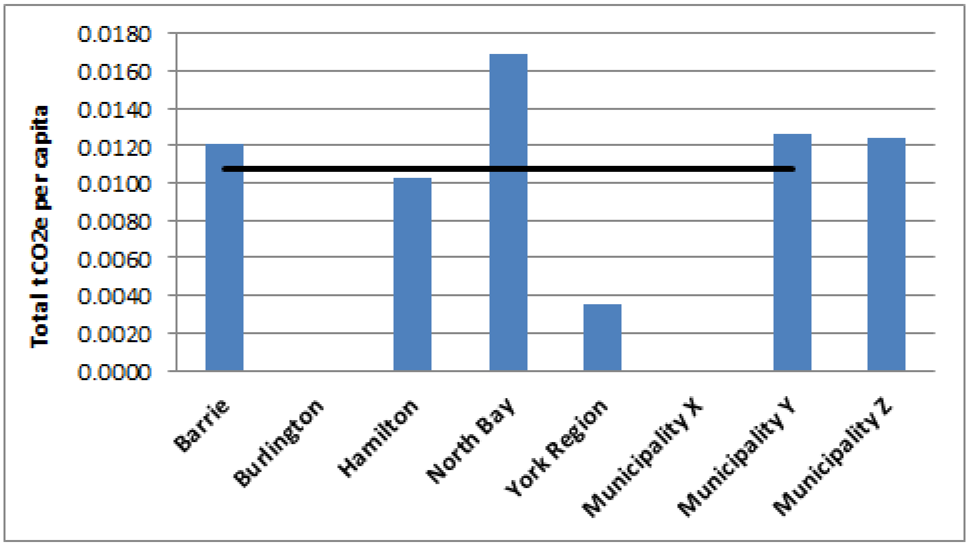


Figure 17 Equally Weighted Indicator Scores for Water Treatment Emissions per Capita

Table 22 Data used to create Figure 17. The mean score was 0.0113

Barrie	0.0121
Burlington	Not Applicable
Hamilton	0.0103
North Bay	0.0169
York Region	0.0036
Municipality X	No Data
Municipality Y	0.0127
Municipality Z	0.0124

Notes: Burlington is a lower-tier municipality and is not responsible for water. Hamilton reported 2005 values (in tCO_2e) from their inventory report and may have used a different EF. Data for Municipality X are not available. Municipality Y reported 2005 data for this indicator; it has a separate entity responsible for water. Municipality Z water and wastewater emissions are not tracked separately; therefore, emissions for each indicator is half of the total.

6.4.3.7.1 By-laws and Programs to Encourage Reduced Water Consumption

Municipality	Score /10	Notes
Barrie	**3**	Toilet rebate program, rain barrel sale day. An even /odd day and time of day restriction for lawn watering in effect. Aggressive escalating water rate structure.
Burlington	**N/A**	Water is a Regional responsibility.
Hamilton	**8**	Residential and youth educational programs, rain barrel giveaways, low flow toilet rebate program, strong water conservation website, waterwise outdoor management program, WiseWater Use Program.
North Bay	**5**	Summer water use by-law.
York Region	**9**	Water for Tomorrow Program. Summer Water Conservation by-law, All nine lower-tier municipalities have an Outdoor Water Use by-law in place. Toilet rebate program available for residential, multi-unit residential, industrial, commercial, and institutions. Free Education seminars e.g. Water Efficient Garden Design Seminars, Water Efficient Landscape Visit (residential), Water Efficiency At Home Guide. Children's Water Festival (Grade 4), Grade 7 Curriculum Package for water conservation education.
Municipality X	**5**	Lawn watering by-law
Municipality Y	**6**	Water conservation not a priority due to excess capacity. Summer rate levy, rain barrels and downspout disconnection, reduced watering.
Municipality Z	**6**	WaterSmart conservation program. Education and community outreach, rain barrels available.

6.4.3.8 Wastewater Emissions per Capita

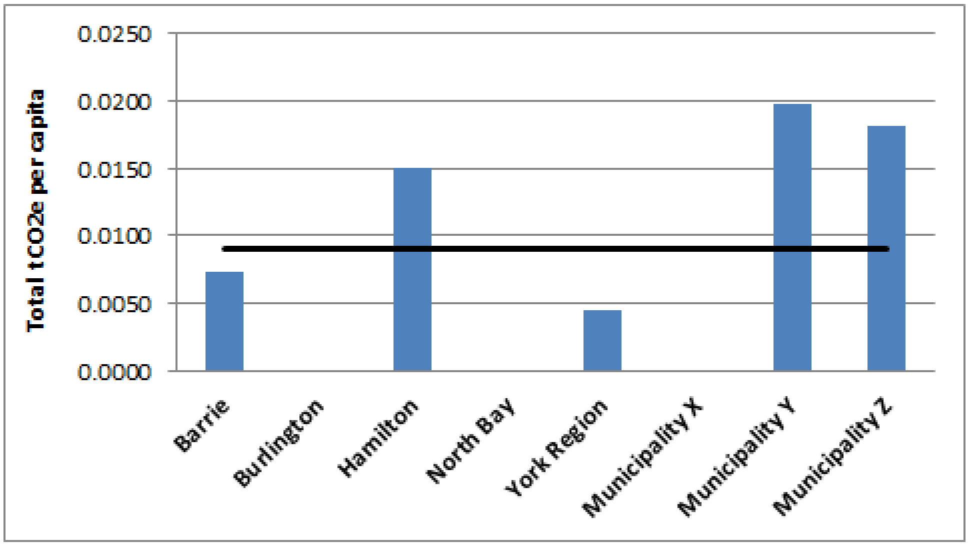


Figure 18 Equally Weighted Indicator Scores for Waste Water Treatment Emissions per Capita

Table 23 Data used to create Figure 18. The mean score was 0.0130

Barrie	0.0073
Burlington	Not Applicable
Hamilton	0.0150
North Bay	No Data
York Region	0.0045
Municipality X	No Data
Municipality Y	0.0198
Municipality Z	0.0181

Notes: Hamilton reported 2005 values (in tCO_2e) from their inventory report and may have used a different EF. Burlington is a lower-tier municipality and is not responsible for water. Burlington is a lower-tier municipality and is not responsible for wastewater treatment. North Bay did not have available data for this indicator. Data for Municipality X is not available. Municipality Y reported 2005 data for this indicator. Municipality Z water and wastewater emission are not tracked separately; therefore emissions for each indicator is reported to be half of the total. CH_4 from wastewater is flared but quantity of GHGs avoided is not reported.

6.4.3.9 Solid Waste Emissions per Capita

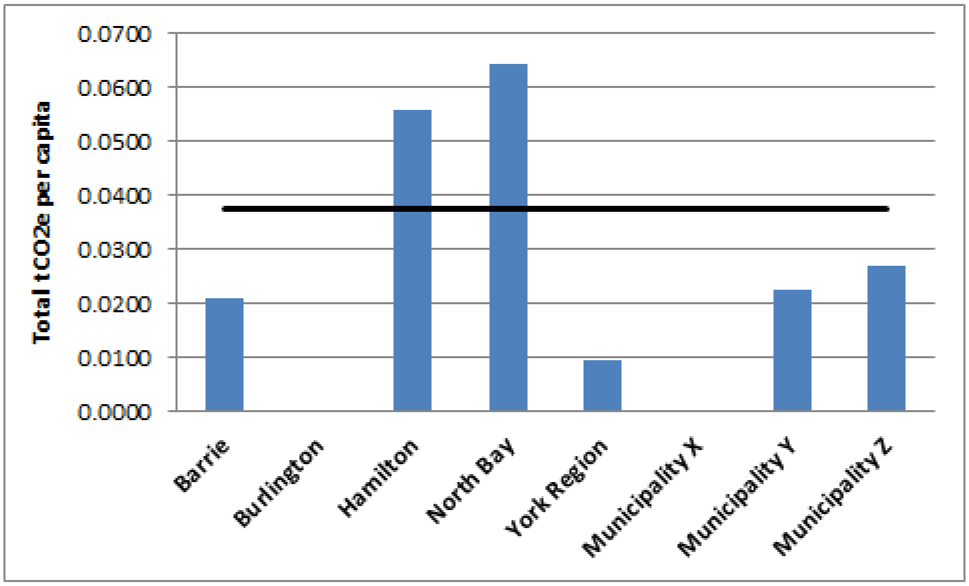


Figure 19 Equally Weighted Indicator Scores for Solid Waste Emissions per Capita

Table 24 Data used to create Figure 19. The mean score was 0.0332

Barrie	0.0208
Burlington	Not Applicable
Hamilton	0.0557
North Bay	0.0642
York Region	0.0095
Municipality X	No Data
Municipality Y	0.0223
Municipality Z	0.0268

Notes: Hamilton reported tCO_2e from their inventory report and may have used a different EF. Burlington is a lower-tier municipality and is not responsible for waste. Barrie reported 2006 data for this indicator. CH_4 is flared but quantity GHGs avoided is unknown. Data for Municipality X is not available. Municipality Y reported 2005 data for this indicator; municipal landfill operated by third party. Municipality Z reported 2006 data for this indicator. CH_4 is flared but quantity GHG emissions avoided is unknown.

6.4.3.9.1 Strength of Waste Diversion Programs

Municipality	Score /10	Notes
Barrie	**6**	Sustainable Waste Management Strategy initiated in Jan 2011, development ongoing. A one bag waste limit and no free dumping at municipal landfill. No limit on recycling containers. Organic waste collected curbside; composters distributed at a subsidized cost.
Burlington	**6**	Waste is a Regional responsibility but actions being taken at corporate facilities including a water cooler pilot project, bottled water ban, organic waste composting at corporate buildings, battery recycling, e-waste management. Green procurement policy under development
Hamilton	**6**	Expanded blue and red bin programs, Green bin program and composting facility in place, outreach programs, one bag limit
North Bay	**3**	Some landfill material banned: Corrugated cardboard and tires.
York Region	**8**	Achieved over 50% diversion rate in 2010, target rate of 70% set. Annual waste diversion reports, educational campaigns, online tools, citizen communication and engagement. Two community environmental centres (CEC), waste management facilities where residents can drop off materials to increase diversion. Tire recycling, e-waste collection, hazardous waste recycling.
Municipality X	**3**	Waste by-laws in place which limit amount of solid waste and outlining materials to be recycled.
Municipality Y	**7**	Landfill operated by separate entity. Current diversion rate >30%. No specific by-laws; collectors can refuse to pick up garbage is recyclables are known to be in the bags, bag limits in place. Expanded recycling collection and new bins, green bin program plan in negotiation but potential for increased composters – subsidized composters and waste digesters. HHW depot, e-waste, tire recycling.
Municipality Z	**7**	Waste reduction, waste disposal site mitigation measures taken Information on Regional website for proper waste separation. Green bin organic program, advanced recycling program coupled with single bag per household garbage limit. Waste diversion rate was >50% in 2012.

7. Discussion

The study results have provided the data for benchmarking the participating municipalities. While other initiatives exist for sustainability and energy consumption, this study is a first in Ontario to benchmark municipalities exclusively on their GHG emissions. As suggested by a review of published academic research, Ontario municipalities have taken considerable action to mitigate their corporate GHG emissions.

Those municipalities which participated in the study have taken actions to mitigate emissions. All of the municipalities, with exception of one, have set GHG reduction targets and have developed plans to meet them. There is obviously some bias since municipalities that have taken climate action were more willing than others to participate in the study. However, the extent of climate action seems to depend significantly on the municipal corporate culture; for example, the attitudes of staff, level of knowledge, and political will. Some municipalities have a history of environmental action and have tackled the problem of climate change.

For the equally-weighted emissions, those from residential land use densities, municipal building heating, solid waste, and municipal buildings and operations were the highest (in tCO_2e), while streetlighting and traffic signals, transportation, water, and sewage treatment remained relatively low. Land use and urban planning, municipal buildings and operations, solid waste, and transportation were the biggest categories for the overall weighted results.

Interestingly, for this small sample of municipalities size does not appear to be as much of an issue as previously thought. Barrie and North Bay have considerably smaller populations and fewer resources than other municipalities, namely York Region, Hamilton, and Burlington. Yet they preform fairly well against them in most of the indicators. A larger sample size would help determine the extent of this relationship.

Most of the municipalities have taken steps to reduce building emissions; nearly all are pursuing green building strategies and LEED certification. Residential population density emissions are fairly uniform, which perhaps speaks to larger development trends in the west following World War 2. Many have plans to protect natural areas and promote intensification based on provincial legislation. Many are actively attempting to reduce corporate fleet emissions, possibly as a cost-cutting measure as fuel costs continue to rise. Public transportation improvements are being made in many of the southern Ontario municipalities in response to provincial legislation, economic stimulus funding, traffic congestion, and other issues. The majority of municipalities have an anti-idling by-law in place Most have water conservation initiatives and waste reduction strategies in place.

Most of the municipalities in this study are taking innovative and meaningful action to reduce their GHG emissions and prepare for climate change. It is encouraging to see the actions being taken in lieu of provincial and federal climate change leadership. The implications of this research are that municipalities can take action to reduce GHG emissions independent of other levels of government. Indeed, many municipalities are striving to reduce emissions. However frameworks and standardized reporting is needed to avoid a patchwork system. Action from provincial and federal levels of government would likely be the best approach, but without serious government commitment to emission reductions templates such as the one described in this study can help fill the void.

7.1 Areas for Future Study

This research has revealed many areas for future study. As noted by Gore (2009), larger municipalities in Canada, especially Toronto, dominate the existing literature and case studies. More research examining the challenges facing small and medium-sized municipalities is needed to help assist them meet climate change objectives. This was also evident from the survey results where larger municipalities had considerably more data available than those with populations of under 100,000.

It would be valuable to conduct this study over a period of several years to evaluate how the tCO_2e emitted changes over time, relative to changes in emission factors. This could help identify trends and areas where improvement is needed.

Burstom and Korhonen (2001) suggested using an industrial ecology approach to municipal environmental management. The merits of this approach and follow-up studies detailing successes from IE utilization would be very useful. Exploration into the use of environmental management systems (EMS) such as ISO 14001 to initiate municipal climate action and overcome barriers would also be beneficial.

Research into new methods for selecting optimal indicators would be interesting. For example, Niemeijer and DeGroot proposed adopting causal frameworks as opposed to the traditional use of the Delphi Technique. Gayol study, Delphi-like alternatives? More indicators are needed for measuring changes in land-use, perhaps one of the most important aspects and yet the least developed.

Feedback from meetings raised issue about the relatively broad guidelines in the FCM and ICLEI climate programs that often drive municipalities to develop their own approaches for GHG inventories. Research into the kinds of informal structures that have evolved outside of established programs, including how information is disseminated, and what successes have been achieved would be worthwhile. It may help improve the FCM and ICLEI initiatives to motivate municipalities to reach additional program milestones. Research should be conducted on the effectiveness of arms-length organisations such as the Toronto Atmospheric Fund in reducing GHG emissions. Sustainable Waterloo Region's work, specifically on the Climate Collaborative project, will set precedent for many more municipal-NGO relationships of this kind. A study of their effectiveness and successes would be useful.

As noted during interviews with municipal experts, community GHG emissions are very difficult to quantify due to scoping issues and issues with measurement. They are also more difficult to influence than corporate emissions. Current approaches to quantifying community emissions require expensive modeling. Research into new approaches and methods for accurately gauging community emissions are needed if significant reductions are to be attempted.

This benchmarking initiative could be conducted on an annual basis, utilizing much of the data sent to the province under Ontario Regulation 397/11. This new regulation presents an opportunity to assess annual performance without having to gather and assemble GHG emissions data separately. Future surveys will need an updated indicator set to better assess issues such as public transportation, sewage treatment, and land use. A greater effort is needed to evaluate community GHG emissions and assign responsibility for Scope 3 emissions, for example highways. Existing indicators will need to be modified to include concepts such as heating-degree days to better model differences in geography and climate amongst municipalities. Hopefully more municipalities would agree to participate in future surveys, thus generating a broader dataset. A discussion of cost savings and value created from undertaking municipal GHG reduction actions would be an excellent way of moving forward and encouraging others to take action.

8. Conclusion

This research has attempted to evaluate municipal action to mitigate climate change through reductions in corporate and community GHG emissions. To evaluate the municipal response to mitigating GHG emissions, this study developed an indicator set to measure municipal emissions, and then implemented an online survey to gather indicator data. Based on the success of the survey municipalities were ranked. The indicators provide a basis for comparison and benchmarking as trends became evident, a first in Ontario. Existing initiatives such as the FCM's PCP program currently do not allow for direct comparison, while the Ontario Municipal Benchmarking Initiative (OMBI) does not focus specifically on GHG emissions.

Municipal action is certainly supported by the literature and Canadian law, and many communities are making important strides to reduce their emissions and associated energy costs. Two drivers became evident during the research; a desire to avoid exposure to rising energy costs, and imminent provincial regulations requiring more environmental reporting from municipalities. Further investigation in this field is necessary to better understand municipalities, improve upon existing indicators and models, and to find way of encouraging additional action.

APPENDIX

Appendix 1 Modes of Governing and Local Climate Change Action. Source: Bulkeley and Kern (2006).

Self-governing	Governing by authority	Governing by provision	Governing through enabling
Energy			
Energy efficiency schemes within municipal buildings (such as schools) Use of CHP within municipal buildings Purchasing green energy Procurement of energy-efficient appliances Eco-house demonstration projects Renewable energy demonstration projects (Internal) contracting (Germany)	Strategic planning to enhance energy conservation Supplementary planning guidance on energy efficiency design Supplementary planning guidance on CHP installations or renewables Supplementary (private) contracts to guarantee connection to CHP or renewable energy installations (Germany)	Energy efficiency measures in council housing Energy Service Provider* (*Stadtwerke*) (Germany) Energy Service Companies (UK) Community energy projects (UK)	Campaigns for energy efficiency Provision of advice on energy efficiency to businesses and citizens Provision of grants for energy efficiency measures Promote the use of renewable energy Loan schemes for PV technology HECA report (UK)
Transport			
Green travel plans Mobility management for employees Green fleets	Reducing the need to travel through planning policies Pedestrianisation Provision of infrastructure for alternative forms of transport Workplace levies and road-user charging (UK)	Public Transport Service Provider (*Verkehrsbetriebe*) (Germany)[a]	Education campaigns on alternatives Green Travel Plans Safer Routes to School Walking Buses Quality partnerships with public transport providers
Planning			
High energy efficiency standards in new buildings Use of CHP and renewables in new council buildings Demonstration projects—house or neighbourhood scale.	Strategic planning to enhance energy conservation Supplementary planning guidance on energy efficiency design Supplementary planning guidance on CHP installations or renewables Supplementary (private) contracts to guarantee connection to CHP or renewable energy installations (Germany)		Guidance for architects and developers on energy efficiency Guidance for architects and developers on renewables
Waste			
Waste prevention, recycling and reuse within the local authority Procurement of recycled goods	Provision of sites for recycling, composting and 'waste to energy' facilities Enable methane combustion from landfill sites	Recycling, composting, reuse schemes Service provider (*Stadtwerke*) (Germany)	Campaigns for reducing, reusing, recycling waste Promote use of recycled products

Appendix 2 Methodology for Constructing Composite Indicators Source: OECD (2008).

Step	Why it is needed
1. Theoretical framework Provides the basis for the selection and combination of variables into a meaningful composite indicator under a fitness-for-purpose principle (involvement of experts and stakeholders is envisaged at this step).	• To get a clear understanding and definition of the multidimensional phenomenon to be measured. • To structure the various sub-groups of the phenomenon (if needed). • To compile a list of selection criteria for the underlying variables, *e.g.*, input, output, process.
2. Data selection Should be based on the analytical soundness, measurability, country coverage, and relevance of the indicators to the phenomenon being measured and relationship to each other. The use of proxy variables should be considered when data are scarce (involvement of experts and stakeholders is envisaged at this step).	• To check the quality of the available indicators. • To discuss the strengths and weaknesses of each selected indicator. • To create a summary table on data characteristics, *e.g.*, availability (across country, time), source, type (hard, soft or input, output, process).
3. Imputation of missing data Is needed in order to provide a complete dataset (*e.g.* by means of single or multiple imputation).	• To estimate missing values. • To provide a measure of the reliability of each imputed value, so as to assess the impact of the imputation on the composite indicator results. • To discuss the presence of outliers in the dataset.
4. Multivariate analysis Should be used to study the overall structure of the dataset, assess its suitability, and guide subsequent methodological choices (*e.g.*, weighting, aggregation).	• To check the underlying structure of the data along the two main dimensions, namely individual indicators and countries (by means of suitable multivariate methods, *e.g.*, principal components analysis, cluster analysis). • To identify groups of indicators or groups of countries that are statistically "similar" and provide an interpretation of the results. • To compare the statistically-determined structure of the data set to the theoretical framework and discuss possible differences.
5. Normalisation Should be carried out to render the variables comparable.	• To select suitable normalisation procedure(s) that respect both the theoretical framework and the data properties. • To discuss the presence of outliers in the dataset as they may become unintended benchmarks. • To make scale adjustments, if necessary. • To transform highly skewed indicators, if necessary.

Appendix 2 (Continued from previous page)

Step	Why it is needed
6. Weighting and aggregation Should be done along the lines of the underlying theoretical framework.	• To select appropriate weighting and aggregation procedure(s) that respect both the theoretical framework and the data properties. • To discuss whether correlation issues among indicators should be accounted for. • To discuss whether compensability among indicators should be allowed.
7. Uncertainty and sensitivity analysis Should be undertaken to assess the robustness of the composite indicator in terms of e.g., the mechanism for including or excluding an indicator, the normalisation scheme, the imputation of missing data, the choice of weights, the aggregation method.	• To consider a multi-modelling approach to build the composite indicator, and if available, alternative conceptual scenarios for the selection of the underlying indicators. • To identify all possible sources of uncertainty in the development of the composite indicator and accompany the composite scores and ranks with uncertainty bounds. • To conduct sensitivity analysis of the inference (assumptions) and determine what sources of uncertainty are more influential in the scores and/or ranks.
8. Back to the data Is needed to reveal the main drivers for an overall good or bad performance. Transparency is primordial to good analysis and policymaking.	• To profile country performance at the indicator level so as to reveal what is driving the composite indicator results. • To check for correlation and causality (if possible). • to identify if the composite indicator results are overly dominated by few indicators and to explain the relative importance of the sub-components of the composite indicator.
9. Links to other indicators Should be made to correlate the composite indicator (or its dimensions) with existing (simple or composite) indicators as well as to identify linkages through regressions.	• To correlate the composite indicator with other relevant measures, taking into consideration the results of sensitivity analysis. • To develop data-driven narratives based on the results.
10. Visualisation of the results Should receive proper attention, given that the visualisation can influence (or help to enhance) interpretability	• To identify a coherent set of presentational tools for the targeted audience. • To select the visualisation technique which communicates the most information. • To present the composite indicator results in a clear and accurate manner.

Appendix 3 Ryerson Research Ethics Board letter of Approval

RYERSON UNIVERSITY
RESEARCH ETHICS BOARD

To: Dan Beare
ENSCIMAN

Re: REB 2011-122: Development of a Template to Assist Canadian Municipalities Benchmark their Efforts to Address Climate Change

Date: October 11, 2011

Dear Dan Beare,

The review of your protocol REB File REB 2011-122 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 2011-122) on future correspondence.

Congratulations and best of luck in conducting your research.

Nancy Walton, Ph.D.
Chair, Research Ethics Board

Appendix 4 Online Survey Questions

Online survey questions

Thank you for agreeing to participate in this master's thesis research!

This survey will generate information to be used in measuring your municipalities' climate change mitigation efforts. The survey data will be combined with data from your most recent municipal greenhouse gas inventory report, publications, data from public utilities, and census data.

The data will be weighted with established indicators to produce a ranking of municipal performance which will then be shared with you prior to release.

All completed surveys will be considered confidential and will not be shared with anyone else without prior consent. This survey has been approved by Ryerson University's Research Ethics Board.

There are 20 open-ended questions. Please attempt to provide data from the year 2010, or use the next available year.

You are not obligated to answer questions or complete the survey. Participation is optional.

Questions

1. Have you prepared a greenhouse gas inventory? If so, what is the most recent year that an inventory was produced?

2. Does your municipality have a GHG reduction target? If so, how was your GHG reduction target set? What is included within its scope?

3. What kinds of measures and plans have been taken to meet the GHG reduction target?

4. What was the total electricity consumed in all municipally-owned buildings in 2010? Please state if your municipality subscribes to a green electricity provider such as Bullfrog Power.

5. Does your municipality produce any renewable electricity from solar or wind? If so please state the total electricity produced in 2010.

6. Does your municipality use any district heating or geothermal systems for municipal buildings? If so what were the estimated annual electricity savings in 2010?

7. What is the total square-metre (m^2) gross floor space for all municipally-owned buildings?

8. What was the total volume of natural gas (m^3) consumed in all municipally-owned buildings in 2010?

9. Has your municipality achieved L.E.E.D (Leadership in Energy and Environmental Design) certification for any new or existing buildings? If so, how many? What level of certification?

10. What was the total amount of fuel consumed (by fuel type) by your municipal vehicle fleet (excluding public transportation) in 2010? Provide the total GHG emissions (in tCO_2e) if available.

11. What was the total amount of fuel consumed (by fuel type) by your public transportation fleet in 2010? Provide the total GHG emissions (in tCO_2e) if available.

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12. Does your municipality have any programs to green the vehicle fleet? Examples include 'right-sizing' or green vehicle purchasing/leasing. Please briefly describe your initiatives.

13. Does your municipality currently have an anti-idling by-law in effect?

14. What specific by-laws and zoning policies have been passed by your municipality to increase densities and preserve natural areas? Examples include policies curbing urban sprawl, brownfield redevelopment, and urban infilling.

15. What were the total GHG emissions (tCO2e) from pumping, treating, and providing drinking water to your municipality in 2010? If emissions are not known, what was the total electricity consumed?

16. If your municipality operates a wastewater treatment plant, what were the total GHG emissions (tCO_2e) from operations at the plant in 2010?

17. Does your municipality flare methane from the municipal wastewater treatment plants or capture methane for renewable energy production? If renewable electricity is produced please state the total electricity produced in 2010.

18. Does your municipality have any by-laws or programs in place to reduce water consumption? Examples include lawn watering/car washing bans, low-flow toilet programs, and rain barrel giveaways.

19. What were the total GHG emissions (tCO2e) from the disposal of municipal solid wastes? If renewable electricity is produced from waste please state the total electricity produced in 2010.

20. What specific by-laws and zoning policies have been passed by your municipality to reduce solid waste generated by the municipality and increase the waste diversion rate?

21. Please provide us with any comments that you have regarding this survey or the municipal benchmarking study.

Thank you for completing the survey! Your participation is greatly appreciated.

Appendix 5 Ontario Electricity GHG Emission Factors. Source: Environment Canada National Inventory Report 2012

	1990	2000	2005	2006	2007	2008	2009	2010[2]
	Greenhouse Gas Emissions[3]							
	kt CO_2 eq							
Overall Total[4,5]	25 100	42 500	34 700	29 700	32 700	27 300	14 600	19 700
	Electricity Generation[6,7]							
	GWh							
Combustion								
Coal	26 100	44 400	28 800	24 800	28 900	24 600	11 100	13 700
Refined Petroleum Products[8]	1 320	290	720	120	220	80	120	30
Natural Gas	0	7 400	11 600	10 900	12 200	10 000	10 500	16 700
Biomass	0	220	420	450	410	530	460	450
Other Fuels[9]	0	10	0	0	0	0	0	0
Nuclear	59 400	59 800	78 000	83 500	79 800	85 800	81 400	82 000
Hydro	38 700	36 600	34 600	35 000	33 400	38 700	38 700	31 800
Other Renewables[10]	0	0	26	145	490	960	2 100	3 230
Other Generation[11]	0	0	0	0	0	0	0	0
Overall Total[12]	**125 500**	**148 700**	**154 000**	**154 900**	**155 400**	**160 700**	**144 400**	**147 900**
	Greenhouse Gas Intensity							
	g GHG / kWh electricity generated							
CO_2 intensity (g CO_2/ kWh)	200	280	220	190	210	170	100	130
CH_4 intensity (g CH_4/ kWh)	0.002	0.01	0.01	0.01	0.01	0.01	0.01	0.01
N_2O intensity (g N_2O/ kWh)	0.003	0.004	0.004	0.003	0.004	0.003	0.002	0.003
Generation Intensity (g CO_2 eq / kWh)	**200**	**290**	**230**	**190**	**210**	**170**	**100**	**130**
Unallocated Energy (GWh)[13,14]	8 300	12 400	13 600	15 500	17 500	1 600	22 600	16 300
SF_6 Transmission Emissions (kt CO_2 eq)[15]	80	79	53	73	109	65	63	60
Consumption Intensity (g CO_2 eq / kWh)[16]	**210**	**310**	**250**	**210**	**240**	**170**	**120**	**150**

Notes:
1. Data presented include emissions, generation and intensity for public utilities.
2. Preliminary data.
3. Data taken from the *Report on Energy Supply-Demand in Canada*, Catalogue No. 57-003-XIB, Statistics Canada.
4. Emissions from the flooding of land for hydro dams are not included.
5. Emissions related to the use of biomass for electric power generation are not included.
6. Adapted from data provided in CANSIM Table 127-0007 using CANSIM Tables 127-0004 and 127-0006 (for 2005-2010).
7. Adapted from data provided in *Electric Power Generation, Transmission and Distribution* (EPGTD), Catalogue No. 57-202-XIB, Statistics Canada (for 1990-2004).
8. Includes electricity generated by combustion of light fuel oil, heavy fuel oil and diesel fuel oil.
9. Others - includes electricity generation by fuels not easily categorized, including Petroleum Coke and Still Gas
10. Other Renewables - includes electricity generation by wind, tidal and solar.
11. NAICS Category 221119.
12. Electricity generation may not add up to overall total due to rounding.
13. Adapted from Statistics Canada CANSIM Table 127-0008 (2005-2010) or Cat. No. 57-202-XIB (1990-2004).
14. Includes transmission line losses, metering differences and other losses.
15. Emissions from electrical equipment from CRF Category 2.F.viii (Production and Consumption of Halocarbons and SF_6).
16. Consumption intensity values are rounded and incorporate unallocated energy and SF_6 transmission emissions.

Appendix 6 Ontario Annual Imports vs. Exports. Source: IESO 2012

Year	Imports (TWh)	Exports (TWh)	Net Imports (TWh)
2011	3.9	12.9	-9.0
2010	6.4	15.2	-8.8
2009	4.8	15.1	-10.3
2006	6.2	11.4	-5.2
2003	10.4	6.3	4.1
2000	5.1	5.5	-0.4

Appendix 7 Provincial and Territorial CH4 Generation Potential (L_0) Values. Source: Environment Canada Report 2012

Province/Territory	2002 Organic Waste Diversion[1] (%)	1941 to 1975		1976 to 1989		1990 to Present	
		DOC	L_0 (kg CH_4/t waste)	DOC	L_0 (kg CH_4/t waste)	DOC	L_0 (kg CH_4/t waste)
Newfoundland	N/A	0.30	121.01	0.18	71.60	0.18	71.50
Prince Edward Island	N/A	0.28	111.20	0.16	63.82	0.15	60.34
Nova Scotia	29.7	0.26	105.92	0.15	60.24	0.15	60.56
New Brunswick	19.8	0.24	97.53	0.16	63.23	0.15	59.98
Quebec	13.7	0.38	153.06	0.20	79.71	0.19	77.43
Ontario	16.4	0.37	147.61	0.20	79.19	0.20	78.34
Manitoba	4.9	0.34	137.60	0.19	74.28	0.18	73.41
Saskatchewan	4.3	0.37	149.93	0.21	82.63	0.21	82.33
Alberta	16.7	0.28	111.53	0.17	69.25	0.17	67.95
British Columbia	23.3	0.27	109.62	0.17	66.34	0.15	59.58
Territories (Yk., N.W.T. & Nvt.)	N/A	0.23	91.70	0.14	56.68	0.16	62.36

Notes:
Sources: Derived from data obtained from NRCan (2006), Statistics Canada (2007a) and CRC Press (1973).
1. Thompson et al. (2006).
N/A = Not available.

Appendix 8 Draft List of Indicators

Category	Definition	Scale	Primary Indicators	Secondary Indicators
Municipal Buildings and Operations	GHG generation from municipal office buildings, including but not limited to electricity consumption and heating/cooling. Includes municipal offices, public works, hydro utilities, recreation and community centres, libraries, museums, police, fire, and EMS stations, and public housing. Does not include water treatment, pumping, wastewater and sewage, solid waste.	**Corporate**	**Electricity Consumption** - Total energy consumption in municipal office buildings (kWh/year) - Energy consumption/m^2 of floor area (in Kt/Mt CO_2e /year) - Total GHG produced annually from electricity consumption (Mt CO_2e/year) - Total kWh produced, total Mt CO_2e/year saved from renewable or alternative energy sources (Wind, solar photovoltaic, solar heating systems, geothermal, biogas) - Fuel consumed (L^3) for generators, GHG produced **Heating/Cooling** - Total GHG produced annually from heating/cooling (Mt CO_2e/year) - Fugitive emissions (Kt CO_2e/year) from refrigerants in chillers and air conditioning units - Natural gas consumed/m^3 - GJ/year from district heating/cooling system - Total energy consumed (kWh) / per capita employees **Streelighting/Traffic Signals** - energy consumed annually (kWh/year) GHG released Kt/Mt CO_2e/year **Other** - # of employees per building - Building operating hours - m^2 floor area of building - public transit facilities - airport terminal facilities	**Bylaws** - Green roof/ eco roof initiatives? - Solar water heater initiative? - Renewable energy initiative? - Tower renewal/building retrofit initiative? - District energy? Eg. Deep lake water heating/cooling **Environmental Management** - Energy-saving audit conducted? Eg. REEP. - Energy efficient building initiatives eg. LEED certified? Environmental Management System in place? - CO_2 reduction strategy? Target set? - Research, pilot projects for renewable/alternative energy for corporate facilities? - Streetlight/traffic signal light replacement program in place? GHG reductions? **Environmental Commitment** - Sustainability representative or working group established? Program(s) developed encouraging employees to reduce energy consumption - Member of FCM PCP program? Milestone reached? - GHG Inventory and Reduction Plan completed? - Member of regional sustainability reporting initiative eg. Sustainable Hamilton, Sustainable Waterloo Region, Niagara Sustainability Initiative

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Transportation	GHG emissions from fleet, service vehicles, public transit, public works, staff commuting habits, and business travel.	**Corporate**	**Fleet** - Total km driven annually per vehicle - Fuel consumed annually (mega litres), GHG released Kt/Mt CO_2e/year - Fuel consumed/km - GHG released Kt/Mt CO_2e/year from contractors performing essential services - Fuel consumed annually (mega litres), GHG released Kt/Mt CO_2e/year Fire, Police, EMS, By-law enforcement vehicles - Fuel consumed annually (mega litres), GHG released Kt/Mt CO_2e/year from hydro vehicles - Fuel consumed annually (mega litres), GHG released Kt/Mt CO_2e/year from grass cutting and park maintenance - Fuel consumed annually (mega litres), GHG released Kt/Mt CO_2e/year from snowplows, sanders, sidewalk clearing - Fuel consumed annually (mega litres), GHG released Kt/Mt CO_2e/year from garbage and recycling collection, heavy equipment operations at landfill **Employee Commuting Habits** - % transit, bicycle, carpool, car, in Kt/Mt CO_2e/year **Corporate Travel** - # business trips/year, mode of transport, in Kt/Mt CO_2e	**Fleet** - Composition of municipal vehicle fleet, Class 1-8 categories of vehicles - Types of fuels used? - Vehicle right-sizing - Shift to diesel vehicles - Shift to biodiesel fuel - Driver training program - Anti-idling bylaw? - Transit ridership (trips made annually) **Employees** - Travel Demand Management, eg. TravelWise, results from employees reporting

Appendix 8 (Continued from previous page)

Land Use and Urban Planning	Zoning and densification strategies for managing growth, reducing sprawl, protecting land, enhancing green space, reduce GHGs.	**Community**	- % of city as built, agriculture, green space - Overall relative density (persons/km^2), relation to GHG production - Density of public green areas (m^2 per capita. m^2 per 100 km^2)	- Protection of green spaces, ESAs? - Urban forestry initiatives, goals, tree planting? - Size of municipality (km^2)
Water Treatment and Use	Includes all GHG emissions associated with water pumping, treatment, and transport.	**Community**	- Water consumption (L^3) per capita, electricity consumed (kWh/capita), CO_2e/year - Annual GHGs (CO_2e/year) - Rain barrel, toilet replacement GHG savings (CO_2e/year) -	- Water conservation bylaws? Water bans? - Toilet replacement initiative? - Water Efficient Technology (W.E.T.) program in place? - Rain barrel initiative in place? - Nature-scaping initiatives? - UV or chlorine treatment option?
Wastewater and Sewage Treatment	Includes all GHG emissions associated with wastewater treatment and disposal.	**Community**	- Volume wastewater and biosolids handled (m^3/year)/capita - Wastewater and - GHG emissions from sewage/year (kt/Mt CO_2e/year) - KWh electricity consumed for water pumping, CO_2e/year) - Total kWh energy produced/year from methane, renewable generation - Total fugitive CH_4, N_20 emissions (CO_2e/year) - Total GHGs produced from biosolids landfilled (CO_2e/year)	- ISO 14001, EMS in place?
Solid Waste	Garbage, recycling, green bin initiatives, solid waste.	**Community**	- Kt/Mt waste produced /capita - Size of landfill area (m^2) - Total fugitive CH_4, N_20 emissions per year (CO_2e/year) - Total kWh energy produced/year from methane capture and electricity generation - Fugitive landfill gas CO_2e/year - GHG produced from incineration (kt/Mt CO_2e/year) - Biological treatment of solid waste	- % of city's solid waste that is recycled? - Green bin program? - Tires, corrugated cardboard, wooden pallet, electronic waste bans? - ISO 14001, EMS in place?

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GLOSSARY OF TERMS

C40: Cities Climate Leadership Group

CCP: Cities for Climate Protection

CH4: methane

CO2 carbon dioxide

CO_2e: carbon dioxide equivalent

Community emissions: greenhouse gas emissions from the broader community

Corporate emission: GHG emissions from the governance of the municipality; is a subset of the community emissions

EC Environment Canada

EF: emission factor

FCM: Federation of Canadian Municipalities

GHG: greenhouse gas

GHG inventory: An accounting of the amount of greenhouse gases emitted to or removed from the atmosphere over a specific period of time (for example, one year) (EC 2012).

GWP: Global Warming Potential

IE: industrial Ecology

IEIP: Local Government GHG Emissions Analysis Protocol

ICLEI: International Council for Local Environmental Initiatives, also known as ICLEI - Local Governments for Sustainability

IPCC: Intergovernmental Panel on Climate Change

ISO: International Organisation for Standardization

kWh: kilowatt hour

NGO: Non-government organisation

NIR: National Inventory Report

N_20: nitrogen oxides

OMKN: Ontario Municipal Knowledge Network

OECD: Organisation for Economic Co-operation and Development

PCP: Partners for Climate Protection program

RCI: Regional Carbon Initiative, a community GHG emission initiative managed by Sustainable Waterloo Region.

REB: Ryerson University's Research Ethics Board

SWR: Sustainable Waterloo Region