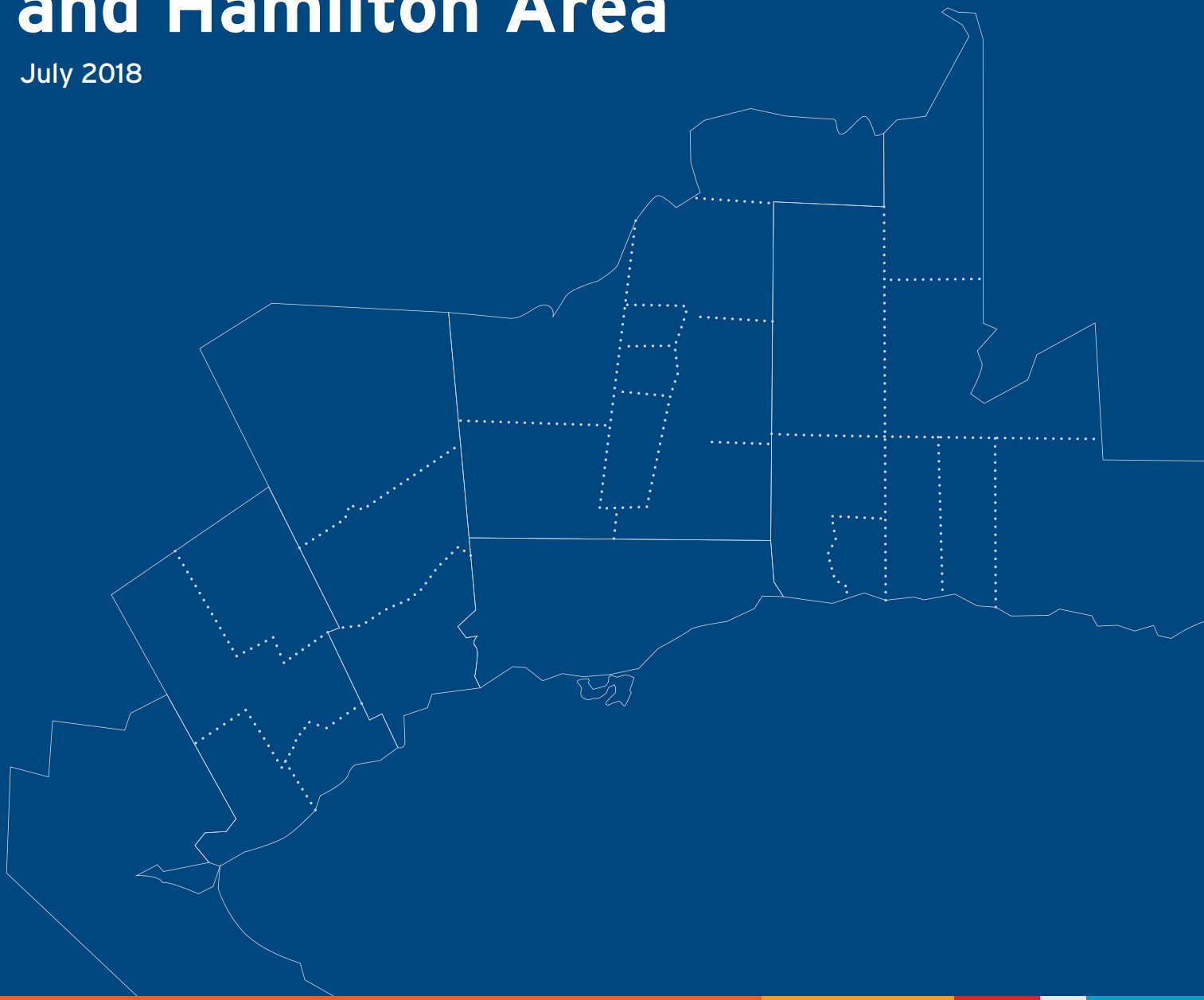
TAF The Atmospheric Fund

KEEPING TRACK:

2015 Carbon Emissions in the Greater Toronto and Hamilton Area

July 2018



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About The Atmospheric Fund (TAF)

Founded in 1991, The Atmospheric Fund (TAF) invests in urban climate solutions in the Greater Toronto and Hamilton Area to reduce carbon emissions and air pollution. TAF is supported by dedicated endowment funds provided by the City of Toronto (1991) and the Province of Ontario (2016) and has invested more than $50 million to date.

For more information about TAF, please visit **www.taf.ca** or message us at **info@taf.ca**

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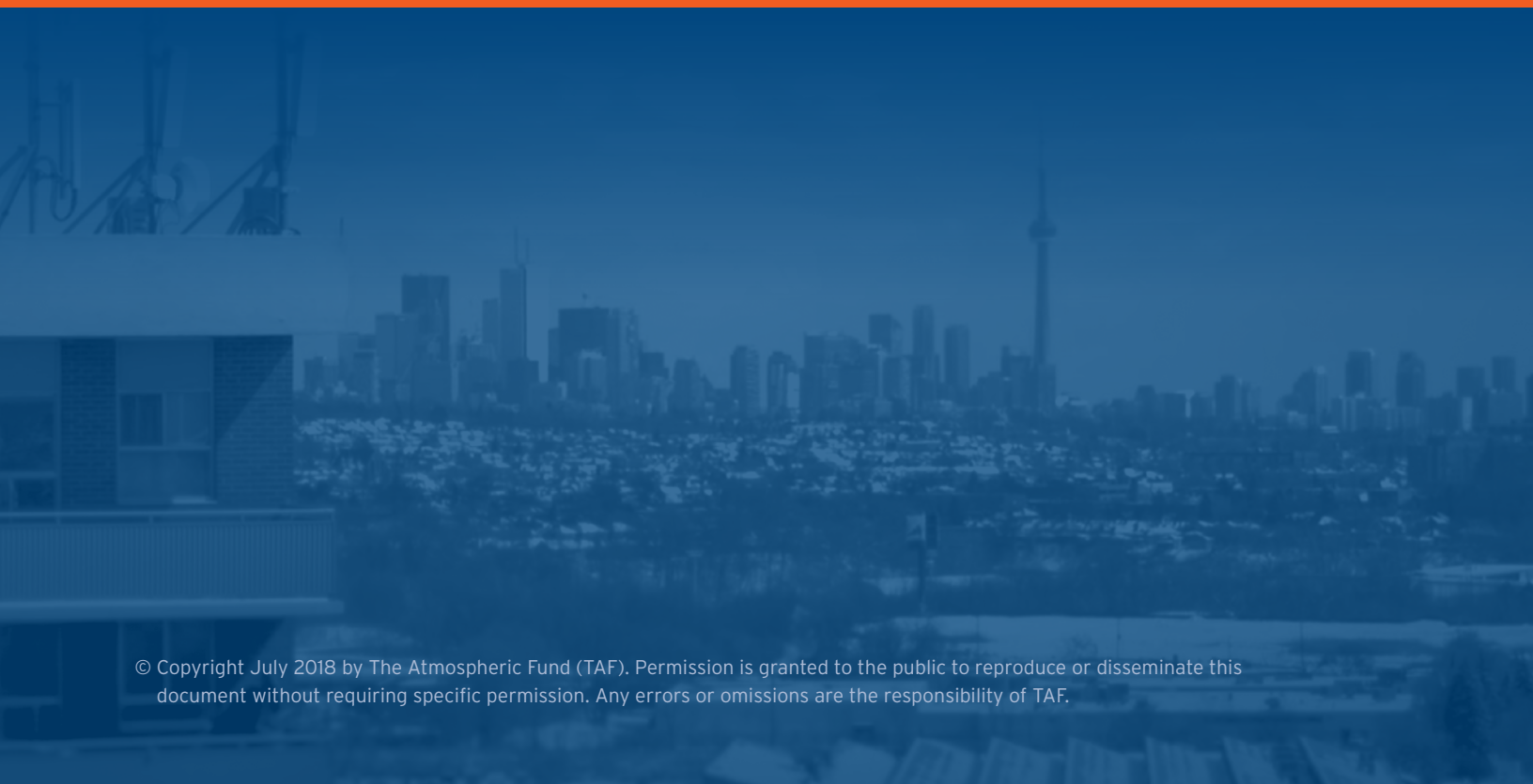

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The views expressed here are those of The Atmospheric Fund and do not necessarily reflect the views the City of Toronto or the Province of Ontario.

Executive Summary

The Greater Toronto and Hamilton Area (GTHA) is Canada's economic engine as an interconnected metropolis with seven million residents. It's also home to more than half of Ontario's population and one in five Canadians. As a result of the region's economic activity and population size, the GTHA is also a major source of greenhouse gases or carbon emissions.

Unfortunately, no reporting structure exists to catalogue the region's emissions. As a climate agency serving the GTHA, The Atmospheric Fund (TAF) set out to create the first regional carbon emissions inventory. Drawing on the most recent available data and using a consistent methodology, TAF compiled a regional inventory for the GTHA's 2015 carbon emissions:

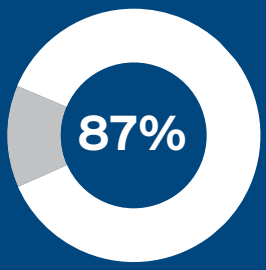
48 million

In 2015, the GTHA emitted around 48 million tonnes of carbon dioxide equivalent (or $MtCO_2eq$, for short)

This represents

29%

of Ontario's total carbon emissions and 7% of Canada's total emissions



In the buildings sector, 87% of emissions come from natural gas use for water and space heating.

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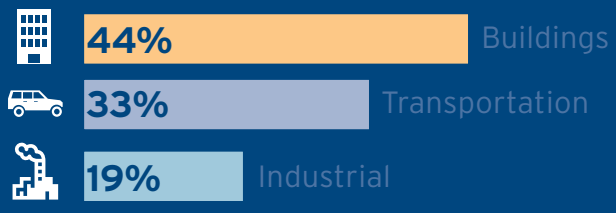
The City of Toronto and Peel Region (Mississauga, Brampton, and Caledon) together account for **more than half emissions** in the region



Buildings, transportation and industrial sectors account for over three quarters of total GTHA emissions.

Our research makes it clear that transportation sector emissions and natural gas use in buildings are key areas to reduce emissions in the GTHA.

This unprecedented research provides a clear understanding of the region's emissions and enables comparisons among municipalities and sectors. In addition, the findings help identify opportunities for deeper examination. Most importantly, the first regional emissions inventory will assist in the effective design of regional and municipal emission reduction efforts in the GTHA.

TAF based its methodology on the Greenhouse Gas Protocol for Community-Scale Greenhouse Gas Emissions Inventories, an internationally accepted standard developed by GHG Protocol, a collaboration of the World Resources Institute (WRI) and the World Business Council for Sustainable Development (World Resources Institute). The data in this report includes direct emissions (such as burning gasoline in a vehicle) and indirect emissions from the generation of energy (such as burning natural gas to generate electricity) – also referred to as Scope 1 and Scope 2 emissions. We incorporated a wide range of data, including electricity and gas consumption from regional utilities; gasoline and diesel sales; and municipal, provincial, and federal government data on emissions.

While there are many commonalities in the emissions profile across the region, there are also notable differences. Compared to GTHA per capita averages, municipal per capita calculations reveal a number of patterns:

- **Hamilton:** lower natural gas emissions, but higher industrial, waste, and electricity emissions
- **Toronto:** lower transportation emissions, but higher natural gas emissions
- **York and Durham Regions:** lower waste emissions, which is due to a waste-to-energy plant that reduces landfill emissions
- **Durham Region:** highest agricultural emissions per capita

Overall, the GTHA compares favourably against other major Canadian cities on a per capita emissions basis. For example, Montreal and the GTHA both have annual per capita emissions of around seven tonnes of carbon emissions.

TAF's research makes it clear that transportation sector emissions and natural gas use in buildings are key areas to target for emissions reduction strategies in the GTHA. The necessary transition away from natural gas in buildings offers vast potential for collaboration among municipalities and other stakeholders such as public housing agencies in the region. The transportation sector is another area that requires collaboration, given that transportation emissions cut across municipal boundaries. Industrial emissions, particularly in the City of Hamilton, are also a potential opportunity for significant reductions.

By using the most recent complete set of data and a consistent methodology, the 2015 emissions inventory for the GTHA provides stakeholders across the region the opportunity to build new understanding about sources, relative emissions, and potential reduction priorities. This trailblazing snapshot of regional emissions is only the first step. In line with its new regional mandate, TAF will publish an annual GTHA emissions inventory going forward, allowing even deeper analysis. Ultimately, the 2015 regional emissions inventory and future annual editions will help strengthen municipal, regional, and provincial climate action in Canada's most populous urban area.

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GLOSSARY

C40 – C40 Cities Climate Leadership Group, a network of large cities committed to addressing climate change.

CO_2eq – Carbon dioxide equivalent, a common unit of greenhouse gas or carbon emissions that accounts for the different global warming potentials. The acronym is typically preceded by t for tonnes and Mt for megatonnes (million tonnes) (i.e. tCO_2eq and $MtCO_2eq$).

EV – electric vehicle, either fully electric (battery-powered electric vehicle) or plug-in hybrid.

GDP – Gross Domestic Product.

Carbon – typically referring to carbon dioxide equivalent is synonymous with Greenhouse Gas (GHG), a gas that absorbs and emits radiant energy. GHGs or carbon emissions are typically expressed in tons carbon dioxide equivalents or tCO_2eq.

GTHA – Greater Toronto and Hamilton Area, a metropolitan area comprised of the City of Hamilton, the City of Toronto, and the regional municipalities of York, Durham, Peel, and Halton. The GTHA is the mandated service area for The Atmospheric Fund.

ICLEI – Local Governments for Sustainability (originally International Council for Local Environmental Initiatives), a network of municipalities and regions committed to building a sustainable future.

LDC – Local Distribution Company, a company responsible for distributing power from transmissions lines to homes and local businesses in Ontario.

National Inventory Report – A set of documents that describe Canada's sources and sinks of carbon emissions as required by the United Nations Framework Convention on Climate Change.

RRR – Reporting and Record Keeping Requirements, a set of requirements that entities licensed by the Ontario Energy Board need to fulfill.

WRI – World Resources Institute, a non-profit organization that promotes sustainability, socio-economic opportunity, human health, and well-being.

Introduction

The Greater Toronto and Hamilton Area (GTHA) is an interconnected metropolis with seven million residents. Home to more than half of Ontario's population and one in five Canadians, the GTHA is also a region of significant economic activity, accounting for 57 per cent of Ontario's GDP and 21 per cent of Canada's GDP *(Statistics Canada, 2013).*

As a result of the region's economic activity and population size, the GTHA is also a major source of greenhouse gases or carbon emissions. Unfortunately, no reporting structure exists to catalogue the region's emissions. While individual cities and regional municipalities in the GTHA have created emissions inventories in the past, most of them are not regularly updated. Additionally, as individual inventories use differing methodologies and timeframes, it is difficult to get a complete picture of the emissions footprint of the GTHA at one point in time.

As a climate agency serving the GTHA, The Atmospheric Fund (TAF) set out to create the first regional carbon emissions inventory. Drawing on the most recent available data and using a consistent methodology, TAF compiled a regional inventory for the GTHA's 2015 carbon emissions.

In 2015, the GTHA emitted 48 million tonnes of carbon emissions, representing 29% of Ontario's total emissions.

Our ground-breaking research provides a clear understanding of the region's emissions and enables comparisons among municipalities and sectors. In addition, the findings help identify opportunities for deeper examination. Most importantly, the first regional emissions inventory will assist in the effective design of regional and municipal emission reduction efforts in the GTHA. In 2015, the GTHA emitted 47.8 million tonnes of carbon dioxide equivalent ($MtCO_2eq$); this represents around 29 per cent of Ontario's total carbon emissions and 6.6 per cent of Canada's total emissions. Major sources across the region include buildings, transportation, industry, and waste management, to varying degrees of importance in different municipalities within the GTHA.

TABLE 1: GTHA's Proportion of Population, GDP, and Emissions

	Population	GDP	Emissions
Ontario	51%	57%	29%
Canada	19%	21%	6.6%

We are convinced that a continual, collective understanding of the GTHA's emissions will accelerate the identification, prioritization and deployment of the solutions needed to meet our climate change goals.

This report describes the methodology, data sources, and findings of our regional inventory of the GTHA's 2015 carbon emissions. We will update this inventory on an annual basis, creating a dynamic picture of regional emissions over time.

Methodology

Scope 1 refers to direct emissions (such as burning gasoline in a vehicle), and scope 2 refers to indirect emissions from the generation of energy (such as burning natural gas to generate electricity). Scope 3 emissions are all other indirect emissions such as the mining and refining of fossil fuels or the emissions from producing imported goods.

The emissions inventory for the GTHA presented in this report uses the most recently available data from 2015. The inventory categorizes emissions into five sectors: buildings, transportation, waste, agriculture, and industrial, and six geographical areas; two single-tier municipalities (Toronto and Hamilton) and four regional municipalities (Peel, York, Durham, and Halton).

In general, we followed the guidelines in the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories and attempted to use as many primary sources of data as possible (ICLEI, WRI, C40, 2014). The inventory includes scope 1 and 2 emissions. While we recognize that scope 3 emissions are significant, we did not investigate scope 3 emissions in this inventory due to data constraints and methodological complexities. See Table 2 for more information on each sector and Appendix B for a detailed methodology on how we calculated emissions from each sector.

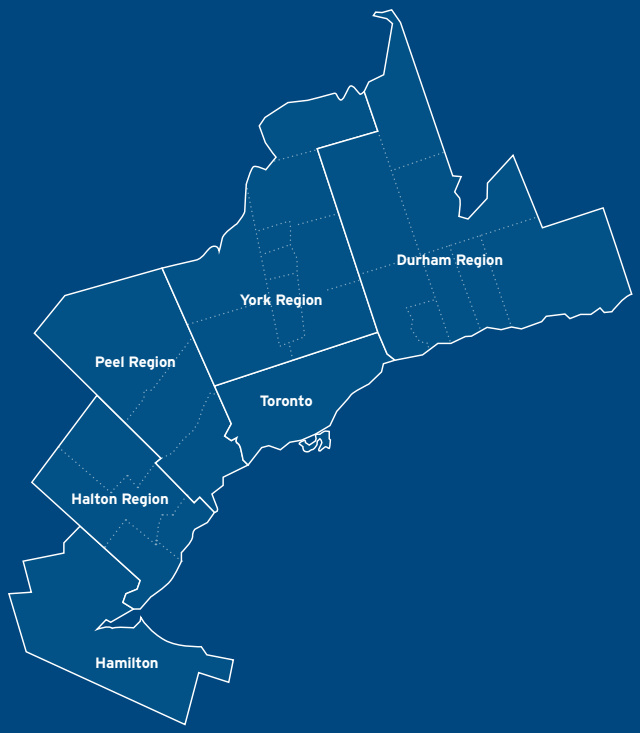
Municipalities that create their own inventories uses different methodologies and data sources. The results will ultimately differ between this inventory and other 2015 inventories, such as the inventories from the City of Toronto and Region of Durham's. Even without a standardized method, each inventory is still valid. However, it is important to acknowledge these differences when interpreting the results of the inventories.

Vaughan Metropolitan Centre, Vaughan, York Region

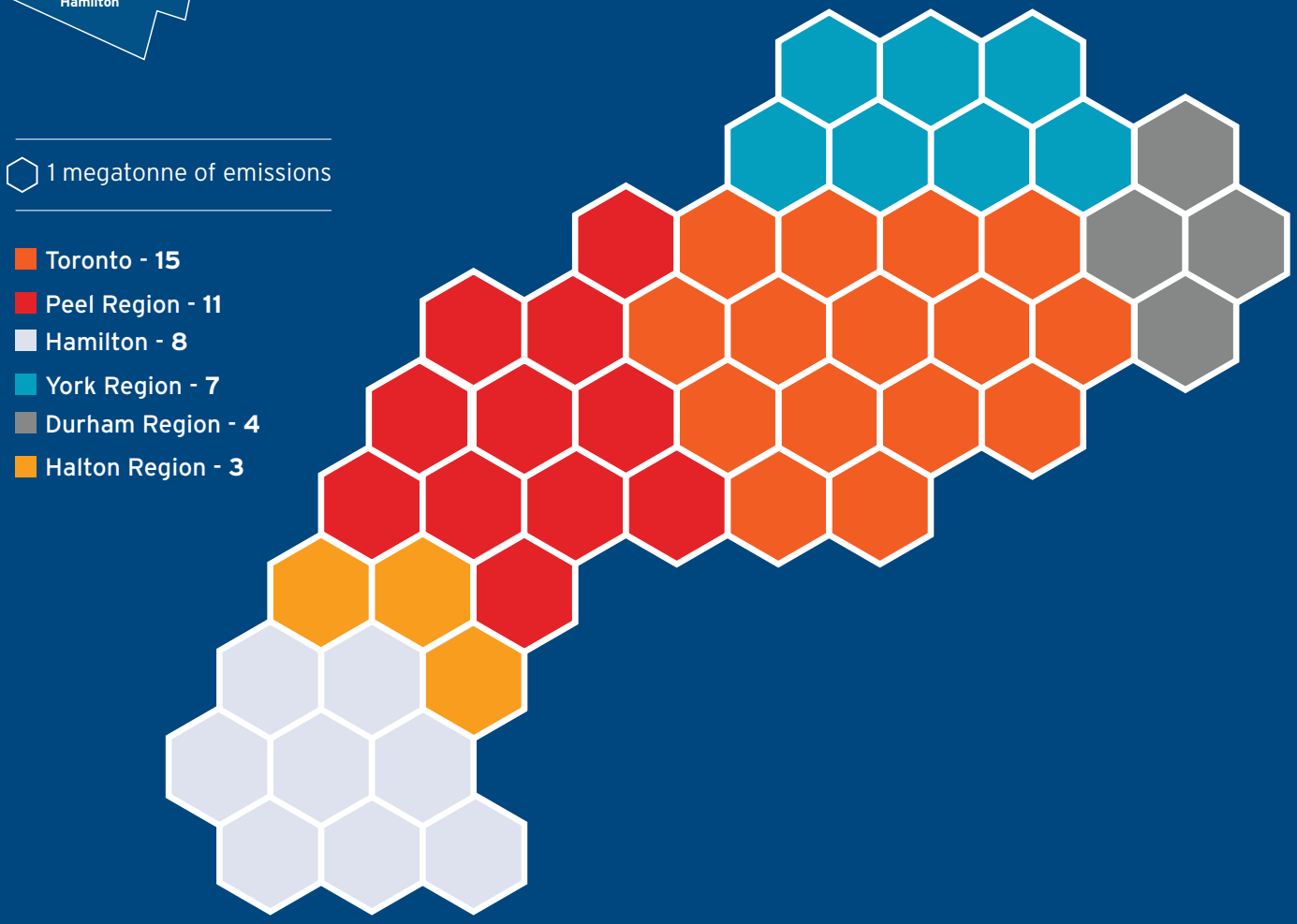
TABLE 2: Summary of Emissions Sectors

Sector	Description
Buildings	We calculated building emissions using electricity and natural gas consumption data. We excluded other fuels (such as fuel oil, and propane) due to data limitations and their minor share of emissions. Electricity consumption may include non-building related uses such as EV charging, transit operations, and street lighting. We did not disaggregate these sources for simplicity and because of their insignificant percentage of total emissions.
Transportation	To determine transportation-related emissions, we used diesel and gasoline sales data. Fuel sold in one jurisdiction was attributed to that municipality due to data availability, although we acknowledge that fuel purchased in one municipality may be consumed in another. Given current renewable fuel content regulations in Ontario, we assumed five per cent of gasoline and two per cent of diesel is from renewable sources. Due to data limitations, we did not account for some fuel sources, including private sales, railway, marine, aviation, and sales at unsupervised stations.
Waste	We assessed waste emissions using data on the tonnage of waste from residential sources sent to landfill, waste-to-energy emissions data, waste composition data, and the provincial ratio of non-residential to residential waste tonnage. We assumed there would be zero emissions from wastewater, as they are biogenic and combusted on site while sludge end-uses are unaccounted for.
Agriculture	We interpolated provincial agricultural emissions based on local agricultural activity data to determine the carbon footprint of farming in the GTHA. We excluded upstream emissions from fertilizer production as it is considered out of scope.
Industry	Industrial emissions are from Ontario's large emitters database. We excluded sources identified as district energy or electricity generating as their emissions are captured in the buildings category. However, some of these emissions may still be double counted. Additionally, the large emitters database only captures sources that emit over or near 25,000 tCO_2eq a year, so sources with fewer emissions than that are not captured.

Results



As a climate agency serving the GTHA, The Atmospheric Fund (TAF) set out to create the first regional carbon emissions inventory. Drawing on the most recent available data and using a consistent methodology, TAF compiled a regional inventory for the GTHA's 2015 carbon emissions. The findings reveal commonalities and differences that could help shape climate policies and collaboration across the region.



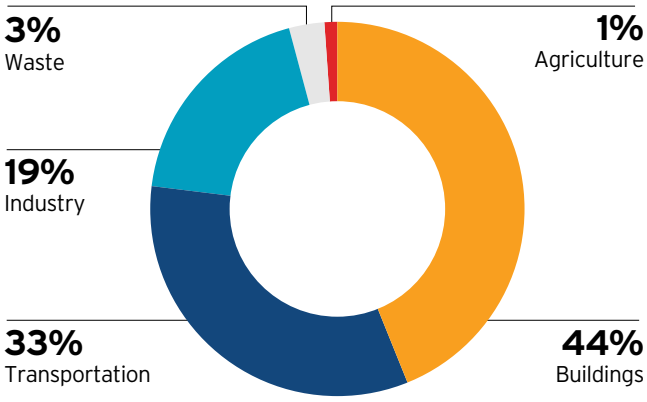
Hamilton. Copyright Queen's Printer for Ontario, photo source: Ontario Growth Secretariat, Ministry of Municipal Affairs

MUNICIPALITY AND SECTORAL COMPARISONS

Emissions by Sector

Overall, the GTHA's emissions come primarily from buildings (44 per cent) and transportation (33 per cent). Industrial operations are the third-largest emissions source at 19 per cent. Waste and agricultural emissions are relatively minor at three per cent and one per cent, respectively (figure 1). Emissions from the buildings and transportation sectors are significant across the GTHA, while industrial emissions vary greatly among GTHA municipalities.

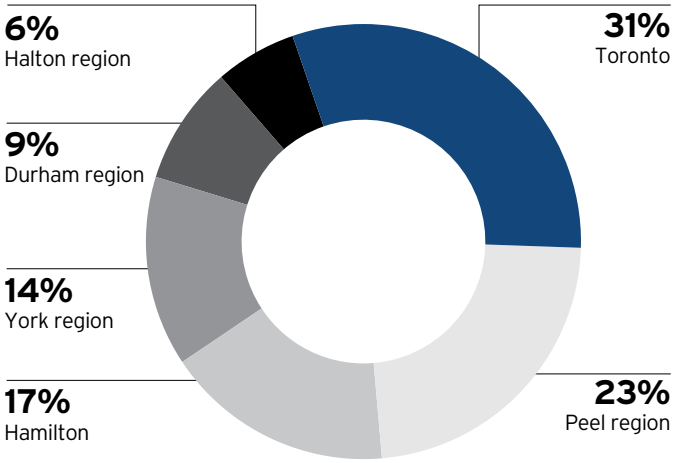
Figure 1: Proportion of GTHA Carbon Emissions by Sector



Emissions by Municipality

Home to 39 per cent of the region's population, Toronto contributes the largest portion of the GTHA's emissions at 31 per cent. Peel Region is the second-largest contributor to regional emissions at 23 per cent. Each municipality's emissions are generally similar to their population size, with the exception of Hamilton, which has the lowest population but the third-largest emissions due to its industrial operations. Figure 2 shows the regional emissions by municipality.

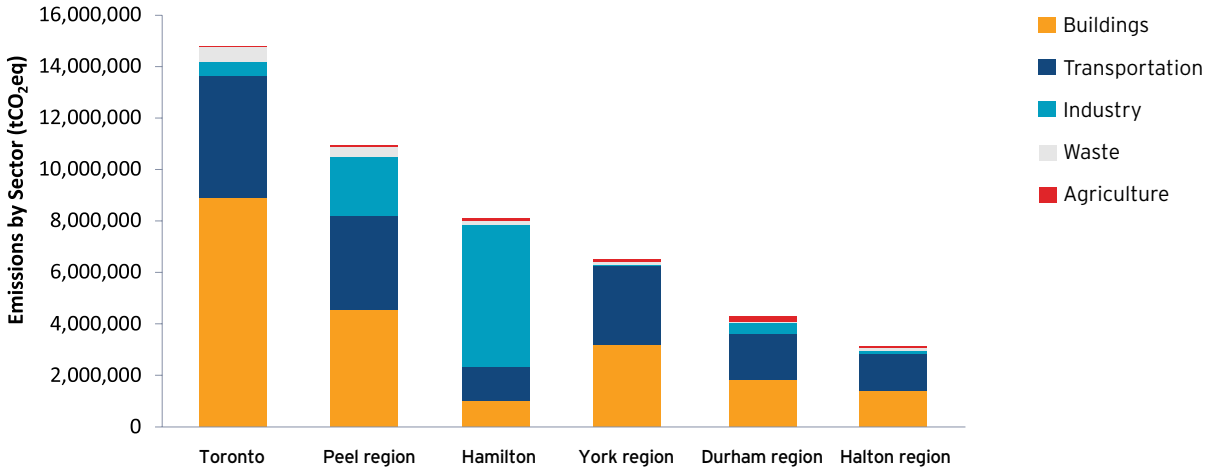
Figure 2: Proportion of GTHA Emissions by Municipality



Municipal Emissions by Sector

While the major sources of emissions are consistent across all of the city-regions, the relative importance of the sources varies considerably as seen in Figure 3. For example, Toronto's emissions are notably dominated by the buildings sector at 60 per cent, whereas Hamilton's emissions are dominated by industrial activity at 68 per cent. Peel Region has the second highest emissions from industrial activity after Hamilton. York Region and Halton Region have the highest proportion of their emissions from transportation at 47 per cent. Durham Region has a markedly higher share of agricultural emissions (five per cent) than the rest of the GTHA (one per cent).

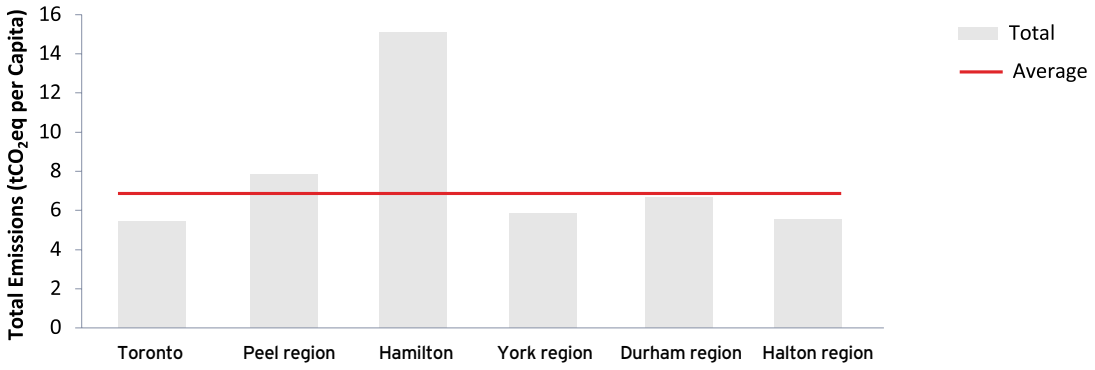
Figure 3: Carbon Emissions by Sector and Municipality



Sectoral Emissions per Capita

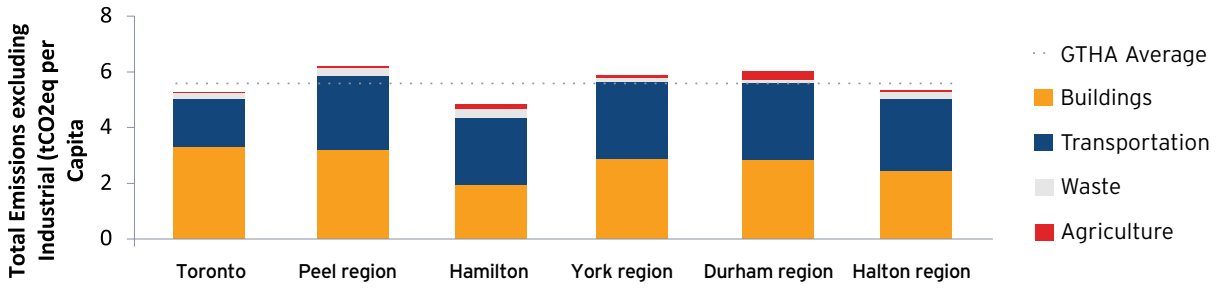
Hamilton has the highest per capita emissions in the GTHA due to significant industrial sector emissions, as seen in Figure 4. Toronto, Halton Region, and York Region have noticeably lower than average emissions per capita. No correlation was found between median income per capita and emissions per capita.

Figure 4: Municipal Emissions per Capita



When we exclude industrial emissions, Hamilton has the lowest emissions per capita; Toronto and Halton also have lower emissions per capita than the regional average. Figure 5 shows that the emissions per capita (excluding the industrial sector) range from 4.8 to 6.2 tonnes of carbon dioxide equivalent, a 29 per cent difference between the lowest and highest municipalities.

Figure 5: Carbon Emissions per Capita by Sector excluding Industrial Sector by Municipality



Natural gas usage makes a significant difference in average per capita emissions. Hamilton and Halton Region have lower than GTHA average per capita emissions from natural gas, which factors into their overall lower than average per capita emissions. As seen in Figure 6, Hamilton's natural gas emissions per capita are almost half of that of Toronto's.

Figure 6: Natural Gas Emissions per Capita by Municipality

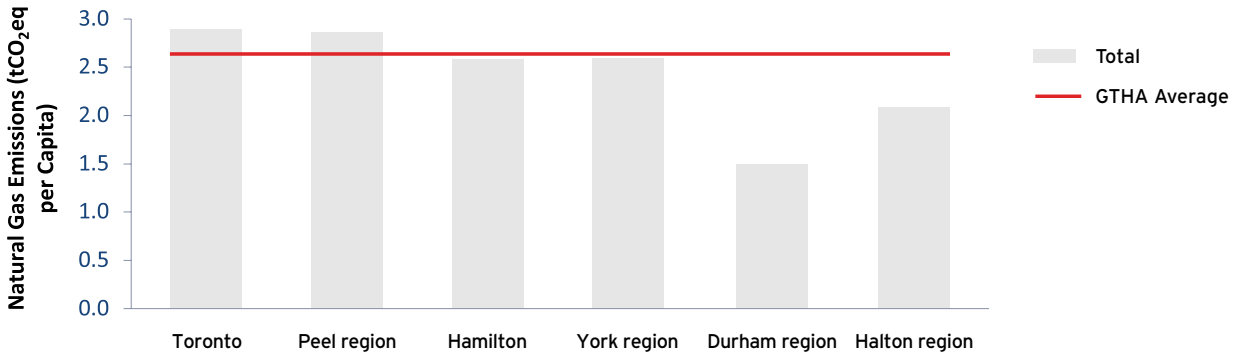
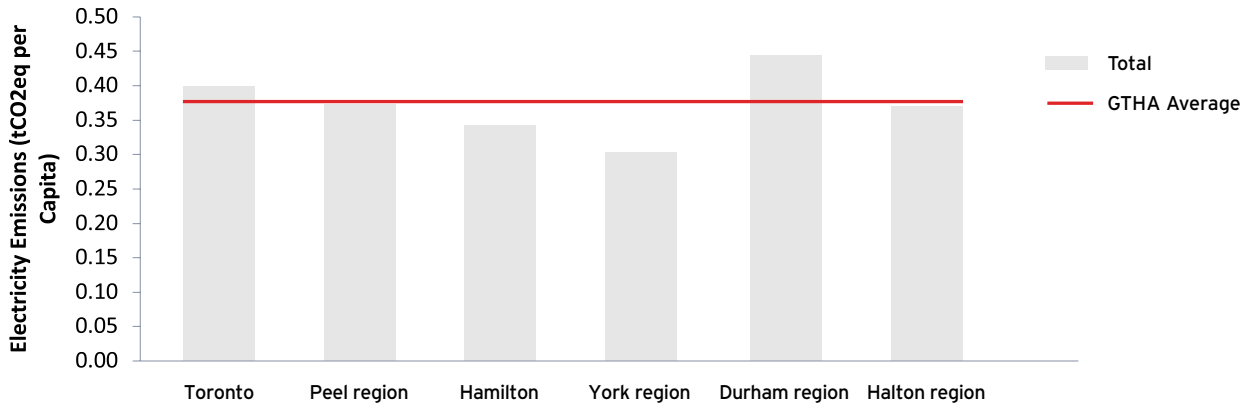


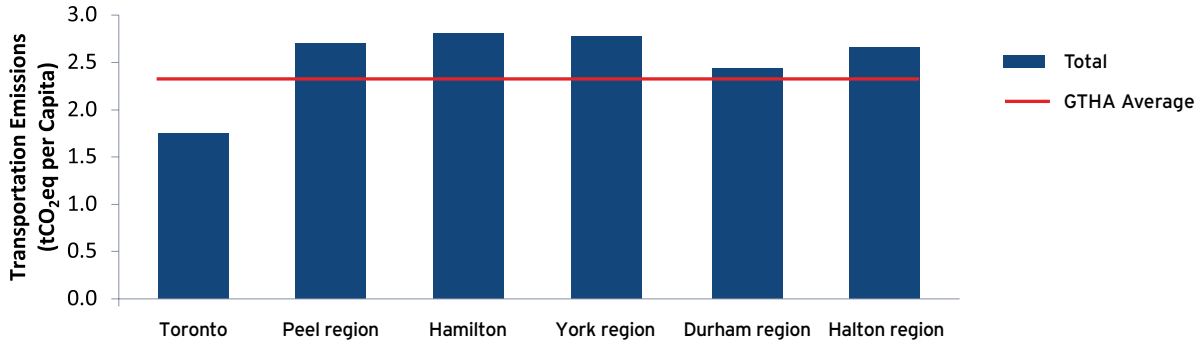
Figure 7 shows electricity emissions per capita by municipality. We found that Durham Region and York Region have noticeably lower electricity emissions per capita, while Hamilton has noticeably higher electricity emissions per capita. To investigate potential reasons for this, we analyzed the proportion of electrically-heated homes as a potential explanatory variable. A look at the Households and the Environment Survey shows Hamilton actually has a lower percentage of primarily electrically heated homes at 14 per cent than the rest of the GTHA at 24 per cent (Statistics Canada, 2017). We found no correlation between the percentage of households in apartments and building emissions per capita. Further research could explore reasons to explain this difference in electricity emissions per capita.

Figure 7: Electricity Emissions per Capita by Municipality



Toronto's per capita transportation emissions are 25 per cent lower than the GTHA average. In contrast, the regional municipalities have higher-than-average transportation emissions per capita. We calculated transportation emissions based on fuel sales in each municipality as there is no data to assess emissions based on actual travel patterns within or across municipalities.

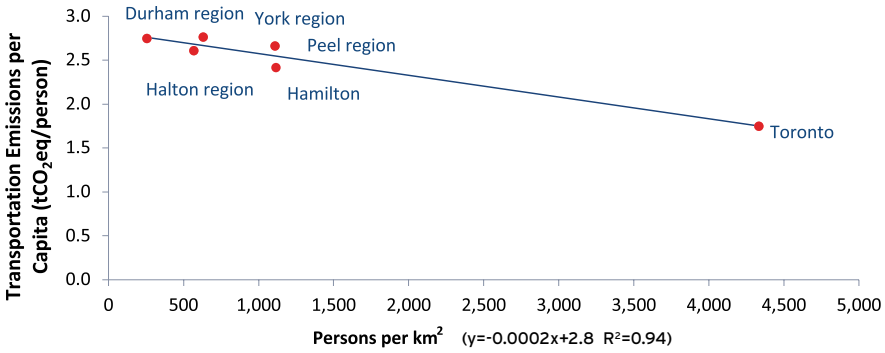
Figure 8: Transportation Emissions per Capita by Municipality



Transportation emissions per capita in the GTHA have a strong negative correlation with population density, i.e. the higher the density, the lower the emissions (Statistics Canada, 2016). Note that our analysis calculated transportation emissions from fuel sales. Since the City of Toronto has a low ratio of gas stations to population, this could impact the convenience of filling up in the city. It is also important to consider the role of factors such as urban form, transportation infrastructure, and local income levels that may also affect transportation emissions. However, given the current analysis, the previously established relationship between population density and transportation emissions per capita is quite clear.

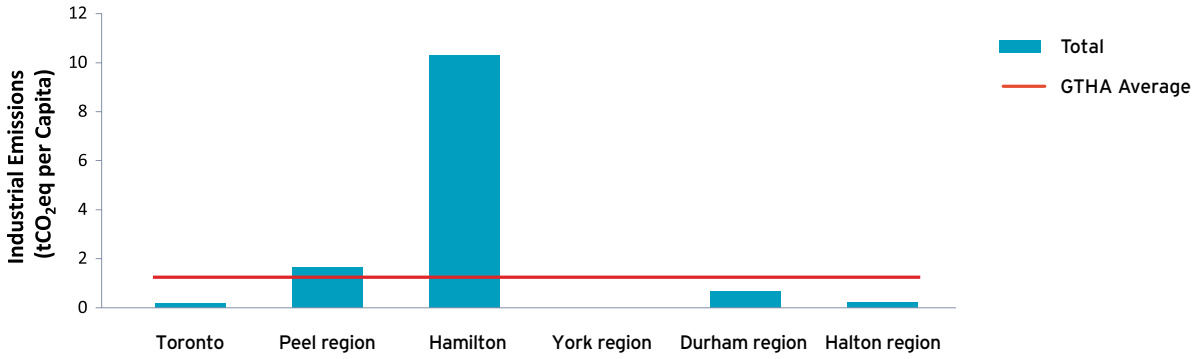
Our research makes it clear that transportation sector emissions and natural gas use in buildings are key areas to reduce emissions in the GTHA.

Figure 9: Population Density and Transportation Emissions per Capita



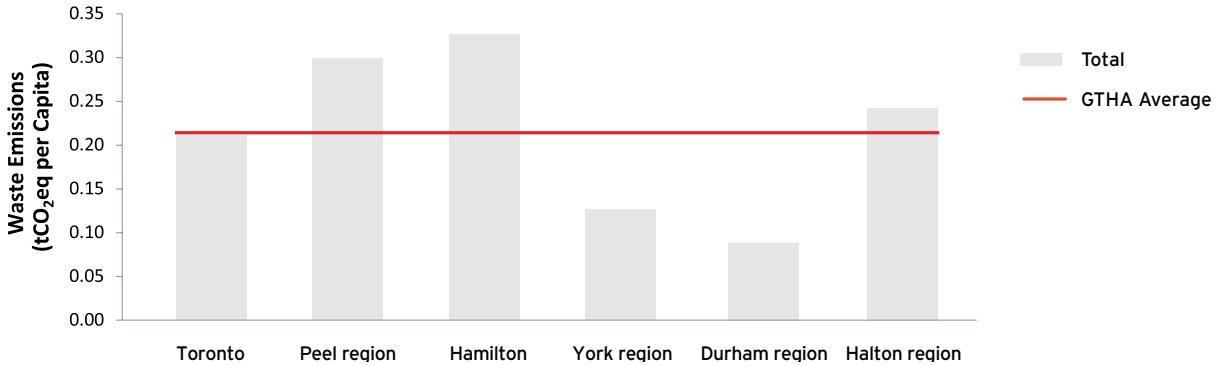
Hamilton and Peel Region have the highest industrial emissions per capita, respectively. These two municipalities account for 89 per cent of the GTHA's 8.9 million tonnes of carbon dioxide equivalent of industrial emissions.

Figure 10: Industrial Emissions per Capita by Municipality



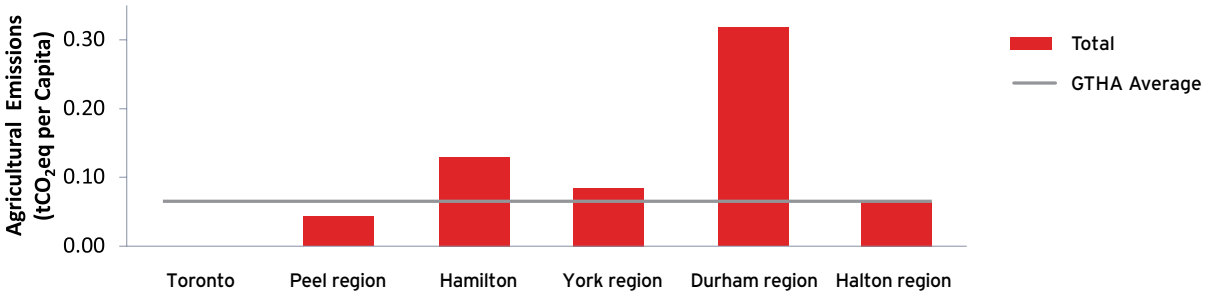
Durham and York Regions have significantly lower waste emissions per capita than the GTHA average; Hamilton and Peel Region have significantly more waste emissions per capita than the GTHA average. Durham and York send waste to a waste-to-energy incinerator, which would explain the significantly lower waste emissions.

Figure 11: Waste Emissions per Capita by Municipality



Durham Region has the highest agricultural emissions and agricultural emissions per capita in the GTHA. Overall, this sector only contributes 0.5 millions tonnes of carbon dioxide equivalent. This pales in comparison of Ontario's province-wide agricultural emissions of 9.7 million tonnes of carbon.

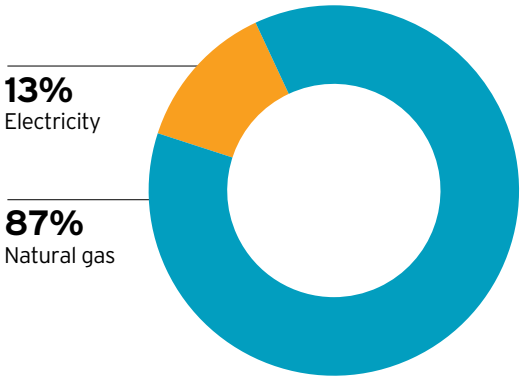
Figure 12: Agricultural Emissions per Capita by Municipality



Buildings

With 87 per cent, the lion's share of building-related emissions in the GTHA stem from natural gas use. Natural gas is now mainly used for space and water heating. Electricity emissions have declined dramatically since the phase out of coal-fired power generation in Ontario.

Figure 13: Proportion of GTHA Building Emissions by Energy Type



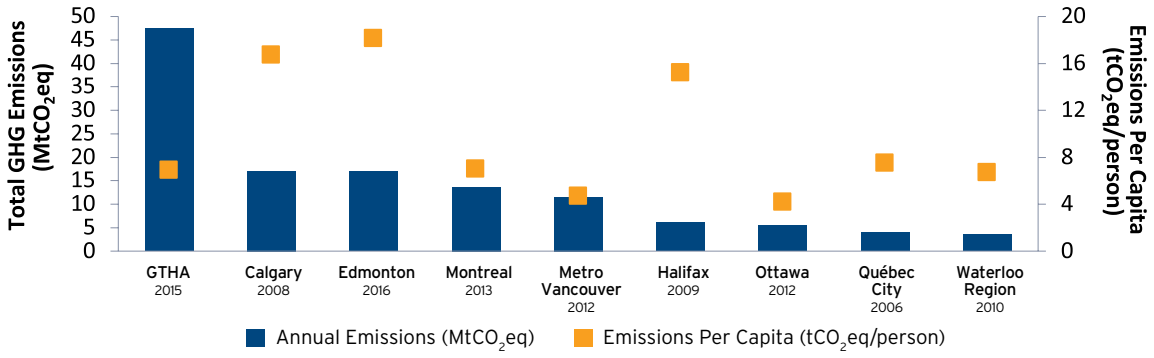
The GTHA dwarfs major cities across Canada when it comes to total emissions. However, the region fares relatively well on a per capita basis.

PROVINCIAL AND NATIONAL COMPARISONS

While the GTHA comprises 51 per cent of Ontario's population, the region generates 29 per cent of Ontario's total emissions and 38 per cent of Ontario's emissions in the particular sectors examined in this emissions inventory (Environment and Climate Change Canada, 2017). At the national scale, the GTHA generates 6.6 per cent of Canada's total emissions despite being home to 19 per cent of the population and generating 21 per cent of the country's GDP. However, it should be noted that Canada's emissions inventory includes a number of sources that are not included in this regional inventory, such as land use change and aviation.

Figure 14 shows the GTHA is the largest emitter by far when compared to other large municipalities across Canada. However, the region fares reasonably well on a per capita basis. It is difficult to make direct comparisons since many cities do not have updated emissions inventories and also use different methodologies. For example, the emissions intensity of the electricity system and local climate influence the emissions intensity per capita.

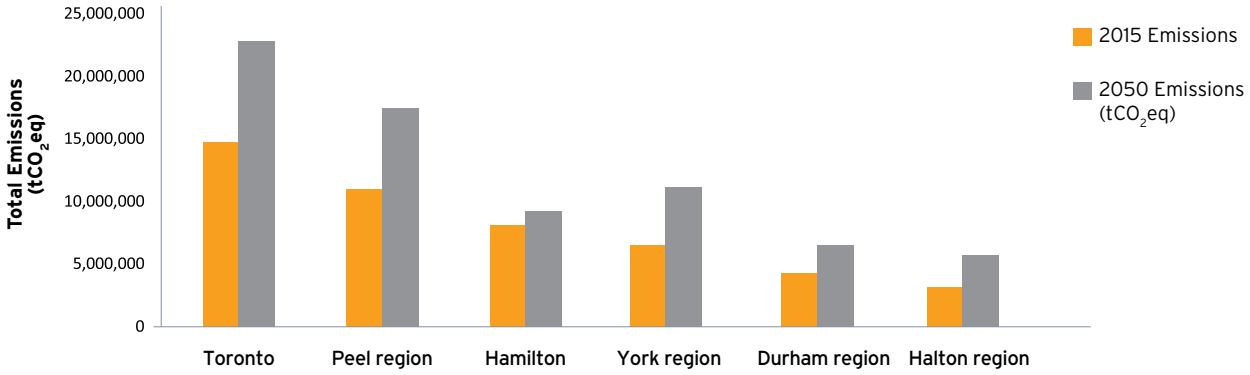
Figure 14: Total Emissions and Emissions per Capita by Canadian Municipality



Offsetting Population Growth

Absolute reductions of carbon emissions in the GTHA are particularly challenging given expected population growth estimates in the region. By extrapolating Ontario Ministry of Finance projections, between 2016 and 2050, the GTHA's population is projected to increase by just over four million people or 58 per cent (Ministry of Finance, 2017). If we multiply emissions per capita by population projections in all sectors except agricultural and industrial (which were assumed to not change significantly for simplicity), we can estimate the future proportion of emissions from each single-tier and upper-tier municipality driven by the projected population growth. Figure 15 demonstrates that Toronto's carbon emissions would grow by about five million tonnes and the GTHA's by 25 million tonnes by 2050 based on the estimated population growth. Significant changes are required to offset these additional pressures on municipal carbon budgets. To pare down per capita emissions, we need to achieve drastic improvements in building energy efficiency, reduce the amount of waste we send to landfill, and expand the low-carbon electrification of vehicles and building heating.

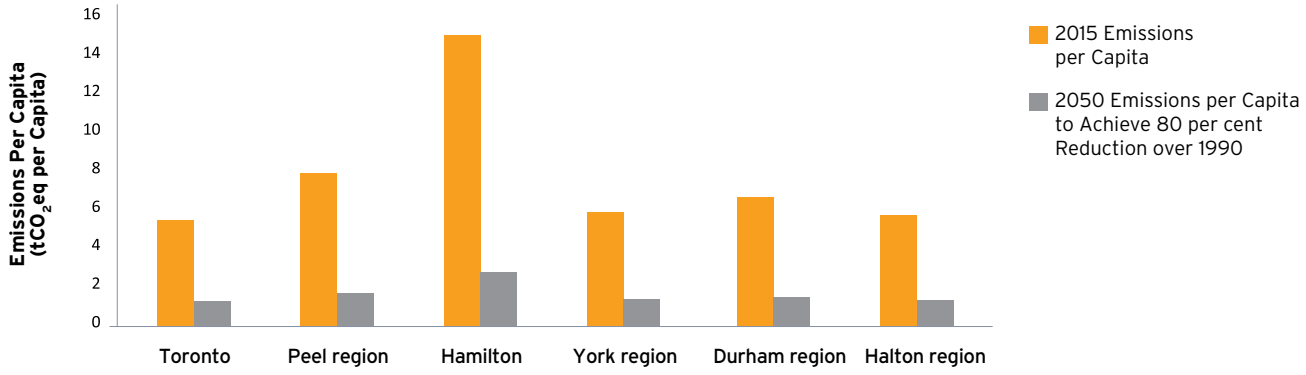
Figure 15: Projected Municipal Emissions for 2050 Assuming Constant 2015 Emissions per Capita



Given the expected rapid population growth, what emissions reductions are necessary by 2050 to meet our climate goals? The Province of Ontario's overarching climate goal is to reduce emissions by 80 per cent by 2050 (over 1990), a target that is also reflected in a number of municipal climate plans, such as Toronto's TransformTO strategy (Ministry of Environment and Climate Change, 2015). We calculated a set of target per capita emissions for each of the GTHA's upper and single-tier municipalities to achieve a matching 80 per cent reduction by 2050 as shown in Figure 16 shows. Our calculation presumes emissions reductions of 15 per cent were achieved by 2015, so only an additional 65 per cent of reductions is required.

GTHA-wide per capita emissions need to be reduced from 6.9 tonnes of carbon dioxide equivalent per capita to 1.5 tonnes by 2050 in order to see an 80 per cent reduction in total emissions compared to 1990. While each municipality may prioritize different approaches based on local circumstances, some strategies may be applicable across multiple municipalities.

Figure 16: Emissions per Capita 2015 vs. 2050 in Line with Provincial Emissions Target



Interpretations and Recommendations

The results from the regional inventory reinforce our existing knowledge and provide new information to guide approaches for emissions reductions.

We knew that buildings and transportation are the two most significant sources of emissions in Toronto and this remains true for the GTHA. Across all levels of government, we need significant planning, resources, and action to reduce emissions in these two sectors

Building emissions mainly come from the use of natural gas – a much cheaper fuel per unit of energy than electricity in Ontario. Deep reductions in the buildings sector will require prioritization of high-impact measures that increase the efficiency of space and water heating (e.g. better building envelopes and high-efficiency boilers) and convert heating to cleaner fuels such as electricity (e.g. through heat pumps) or renewable natural gas. While we move towards net-zero energy homes and buildings through improved buildings standards, regulatory changes are needed for existing buildings as well. Updates to the Ontario Building Code should require energy efficiency retrofits when owners renovate existing homes and commercial buildings.

To reduce transportation-related carbon emissions, the electrification of mobility must become a priority for governments and stakeholders across the region. Electricity is a more cost-effective and low-carbon solution to power vehicles over gasoline (Plug 'N Drive, 2017). However, we must carefully plan and ensure that the additional loads from the electrification of both the buildings and transportation sectors don't lead to more natural gas-fired electricity generation (and with it a significantly higher electricity emissions factor).

We must quickly transition away from fossil fuels for space heating and mobility to cut regional building and transportation emissions in a meaningful way.

Based on the correlation between residential density and transportation emissions, increased density, new complete communities and improved transit infrastructure can also lead to transportation emissions reduction, at least on a per capita basis. The provincial Greenbelt Plan and Growth Plan support and commit to these initiatives (Government of Ontario, 2017; Government of Ontario, 2017). In spite of this, new solutions (such as ways to significantly increase telecommuting and carpooling) are still necessary as the population projections for Hamilton and the regional municipalities would not increase their density beyond Toronto's by 2050.

While industry is the third-largest sector contributing to emissions in the GTHA, industrial emissions are concentrated in a few facilities. Notably, Hamilton and Peel house industrial facilities which generate around 89 per cent of the GTHA's industrial emissions. Therefore,

targeted reduction strategies could be an effective approach. A recently announced federal energy efficiency program called ENERGY STAR Challenge for Industry offers some inspiration (Natural Resources, 2018). The voluntary program encourages industrial operations to cut their energy intensity by 10 per over the next five years. Moving forward, government should consider making such energy efficiency targets for industrial operations mandatory.

Converting agricultural and food waste into renewable natural gas represents an important opportunity to reduce emissions.

Durham Region has the highest agricultural emissions in the GTHA. One potential opportunity to reduce emissions: harnessing the methane from agricultural sources and using it to offset natural gas use. While the local emissions are about one per cent of total emissions, further research on the consumption emissions may provide data on how to reduce emissions associated with food production and consumption (as explained before, this inventory doesn't include the emissions from products and services used or expended within the jurisdiction, i.e. Scope 3 emissions).

When excluding the industrial sector, Hamilton and Toronto have the lowest emissions per capita out of the municipalities in the GTHA. This is in line with our analysis, as Hamilton has the lowest building emissions per capita in the region and Toronto has the lowest transportation emissions per capita. Further investigation can help understand the contributing factors and assess the applicability across the region and beyond.

When we compared emissions per capita across major cities in Canada, we found that cities in provinces with coal fired power plants (Calgary, Edmonton, and Halifax) have significantly higher carbon emissions than those without. It is difficult to do further comparison on different metrics between major Canadian cities because some cities do not break down their emissions into sectors and there is no consistency of sector types.

Planned Inventory Improvements

The GTHA emissions inventory provides an effective way to understand the region's relative emission sources. The annual inventory will help us identify trends over time which will help inform reduction work. Continuously improving the quality of the data used to build the inventory will improve its accuracy and granularity. Analysis of the overall results will reveal areas warranting further examination or research.

More local data, such as transit ridership numbers, will help us get a better understanding of transportation emissions.

We are committed to working with partners to maintain the emissions inventory over time, provide an annual update, and work collaboratively to continuously improve this process in ways that offers useful input for region-wide and local municipal emissions reduction strategies.

Based on analysis of this year's inventory, we have identified several areas for potential improvement.

1. **Deeper understanding of each source of emissions.** Further analysis could indicate what proportion of building emissions come from commercial, residential, and multi-residential buildings, which could help target each sector with specific strategies. However, in order to gain these insights, we would need data that is consistently available across the GTHA.

   Local transit ridership numbers could enhance our understanding of transportation emissions, but analysis for region-wide GO Transit ridership needs to be carefully considered.

2. **City level information.** The current inventory is broken down geographically by upper/single tier municipalities. Data and inventories on the lower municipality level would enable those local authorities to be more targeted with their policies and strategies. Lower-tier municipalities would be able to layer in their local knowledge and contexts to increase the effectiveness of their emissions reductions approaches.

   In addition, the current Households and the Environment Survey breaks down heating system and type of energy by Census Metropolitan Area (CMA) (Statistics Canada, 2015). The Toronto CMA groups together York, Peel, Halton, and some of Durham Region and thus we could not gain insights into each region using this source. We would find this and other data more useful if information was provided on a census division or census subdivision level.

Pickering GO Station. Copyright Queen's Printer for Ontario, photo source: Ontario Growth Secretariat, Ministry of Municipal Affairs.

3. **Baseline consistency.** A retroactive calculation of past emissions in order to set a consistent baseline across the region would assist in setting and tracking progress towards targets. It will likely be challenging to obtain data as far back as 1990 for the entire GTHA. Additionally, local governments must also agree upon appropriate regional emissions targets.

4. **Future modelling.** A more sophisticated forecasting of emissions could help us understand future changes to local municipalities and sectors. This modelling could help inform the kinds of reductions needed to meet local emissions goals.

5. **Expanded scope.** Some additional fuels (e.g. heating oil, propane, compressed natural gas), additional sectors, and scope 3 emissions (e.g. land use change and forestry) could be included in future inventories as data becomes available.

NEXT STEPS

We will publish an annual update to this regional emissions inventory. In collaboration with regional stakeholders, we will seek to address potential improvements to the inventory in response to the interests and needs of potential users. We welcome opportunities for collaboration in data collection, analysis, and emissions reduction strategy development and implementation.

We will use the regional inventory to inform approaches to achieve region-wide emissions reductions. For example, we will seek opportunities to host and/or participate in dialogue with key stakeholders including utilities, municipal and provincial representatives, non-profit organizations, and businesses to co-develop reduction initiatives.

Conclusion

Since we used a consistent methodology and data from the same year (2015) across the GTHA, our regional inventory provides numerous insights that were previously not possible.

Buildings and transportation are the largest emissions sources in the GTHA, requiring all municipalities to work together on reducing fossil fuel usage.

The key takeaways:

- Buildings and transportation are the largest sources of emissions across the GTHA. Thus, all municipalities in the region must work together to collaborate on efforts that significantly reduce natural gas, gasoline, and diesel consumption;
- The entire region has grown rapidly and will continue to see significant growth in the coming years. Deep decarbonisation of the GTHA in a time of rapid growth will require a new vision and strategy to achieve major reductions in per capita emissions;
- Outside the City of Toronto, we can reduce transportation emissions by increasing population density. Sound urban planning, investment in transit infrastructure, and new reduction strategies for lower density development are important factors to success;
- The industrial sector is a promising area to explore targeted emissions reduction strategies. Since emissions are concentrated in a small number of facilities, single projects and initiatives could result in regionally significant impacts;
- While the GTHA is a significant contributor to provincial and national emissions, it has below average emissions per capita compared to other major Canadian cities; and
- We will reap further benefits as the regional inventory is maintained over time and annual inventories help to identify emissions reduction trends. Future research would benefit from the integration of more explanatory and temporal analyses.

Overall, our analysis of this regional inventory provides a well-defined picture of the GTHA's significant and varied emissions and opportunities for deep reductions. Despite local differences, we found many commonalities across the region in both the major sources of emissions and the key challenges to deep reductions. Furthermore, a region-wide lens might create better responses to these challenges, rather than at the individual municipal level. Our findings highlight the need for and value of regional collaboration and dialogue as we transition to a low-carbon GTHA.

REFERENCES

City of Toronto. (2015, August 15). *Technical Memorandum No. 1 Current System Summary*. Retrieved 2017, https://www.toronto.ca/wp-content/uploads/2017/10/967e-SW_Technical-Memo-No-1-FINAL-AODA.pdf

Dodman, D. (2009). *URBAN DENSITY AND CLIMATE CHANGE*. Retrieved 11 3, 2017, from United Nations Climate Change Learning Partnership: https://www.uncclearn.org/sites/default/files/inventory/unfpa14.pdf

Durham Region. (2015). *Durham York Energy Centre fires up operation*. Retrieved 2017, from Durham Region: https://www.durham.ca/news.asp?health=no&type=NR&nr=dnews/2015/Feb13151.htm

Durham York Energy Centre. (n.d.). *Quick Technical Facts About the DYEC*. Retrieved 2017, from Durham York Energy Centre: https://www.durhamyorkwaste.ca/Home/QuickFacts.aspx

Environment and Climate Change Canada. (2015). *Facility and GHG Information*. Retrieved from Environment and Climate Change Canada: http://www.ec.gc.ca/ges-ghg/donnees-data/index.cfm?do=facility_info&lang=en&ghg_id=G10805&year=2015

Environment and Climate Change Canada. (2017). *National Inventory Submissions 2017*. Retrieved 10 2017, from United Nations Framework Convention on Climate Change: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php

Gately, C. K., Hutyra, L. R., & Wing, I. S. (2015). *Cities, traffic, and CO2: A multidecadal assessment of trends, drivers, and scaling relationships*. Retrieved 11 3, 2017, from Proceedings of the National Academy of Sciences of the United States of America: http://www.pnas.org/content/112/16/4999.abstract

Government of Canada. (2017). *National Inventory Submissions* 2017. Retrieved 2017, from United Nations Framework Convention on Climate Change: http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/10116.php

Government of Ontario. (2016). *Ethanol in gasoline*. Retrieved 2018, from Ontario: https://www.ontario.ca/page/ethanol-gasoline

Government of Ontario. (2017). *Greenbelt Plan (2017)*. Retrieved 2017, from Ontario Ministry of Municipal Affairs and Housing: http://www.mah.gov.on.ca/Page13783.aspx

Government of Ontario. (2017). *Greenhouse gas emissions reporting by facility*. Retrieved 2017, from Ontario: https://www.ontario.ca/data/greenhouse-gas-emissions-reporting-facility

Government of Ontario. (2017). *Greenhouse gas emissions reporting by facility*. Retrieved 2017, from Government of Ontario: https://www.ontario.ca/data/greenhouse-gas-emissions-reporting-facility

Government of Ontario. (2017). *Growth Plan for the Greater Golden Horseshoe*. Retrieved 2017, from Munistry of Municipal Affairs: https://www.placestogrow.ca/index.php?option=com_content&task=view&id=9

ICLEI, WRI, C40. (2014). *The Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC)*. Retrieved 2016, from ICLEI - Local Governments for Sustainability: http://www.iclei.org/activities/agendas/low-carbon-city/gpc.html

Kelleher, M., Christina, S., & Torrie, R. (2015). *Greenhouse Gas Emissions and the Ontario Waste Management Industry*. Retrieved 2017, from Ontario Waste Management Association: http://www.owma.org/articles/greenhouse-gas-emissions-and-the-ontario-waste-management-industry

Ministry of Finance. (2017). *Ontario Population Projections Update, 2016–2041*. Retrieved 2017, from Ontario Ministry of Finance: https://www.fin.gov.on.ca/en/economy/demographics/projections/table4.html

Ministry of the Environment and Climate Change. (2015). *Guide and Director's Directions - Renewable Fuel Content Requirements for Petroleum Diesel Fuel*. Retrieved January 18, 2018, from Ministry of the Environment and Climate Change: http://www.downloads.ene.gov.on.ca/envision/env_reg/er/documents/2015/012-4413_FinalGuide.pdf

Ministry of the Environment and Climate Change. (2015). *Climate Change Strategy*. Retrieved 2018, from: https://www.ontario.ca/page/climate-change-strategy#section-5

Mohareb, E. (2012). *Quantifying the Transition to Low-Carbon Cities*. Retrieved 2017, from T-Space: https://tspace.library.utoronto.ca/bitstream/1807/32774/6/Mohareb_Eugene_201206_PhD_thesis.pdf

Natural Resources Ontario. (2018). *ENERGY STAR Challenge for Industry*. Retrieved 2018, from: http://www.nrcan.gc.ca/energy/efficiency/industry/cipec/20051

Plug 'N Drive. (2017). *Benefits of Driving Electric*. Retrieved 2017, from Plug 'N Drive: http://plugndrive.ca/benefits-driving-electric

Resource Productivity & Recovery Authority. (2016). *Datacall*. Retrieved 2017, from Resource Productivity & Recovery Authority: http://www.rpra.ca/Library/WDO-Historical/Municipal-Information/Residential-GAP-Diversion-Rates

Statistics Canada. (2013). *Gross domestic product (GDP) at basic prices, by census metropolitan area (CMA)*. Retrieved 10 31, 2017, from Statistics Canada: http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=3810036&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid=

Statistics Canada. (2014). *Disposal of waste, by source, Canada, provinces and territories*. Retrieved 2017, from Statistics Canada: http://www5.statcan.gc.ca/cansim/a26?lang=eng&id=1530041

Statistics Canada. (2014). *Disposal of waste, by source, Canada, provinces and territories*. | Retrieved 2017, from Statistics Canada: http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1530041&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid=

Statistics Canada. (2015). *Households and the environment survey, primary heating system, Canada, provinces and census metropolitan areas (CMA)*. Retrieved 2017, from Statistics Canada: http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1530145&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid=

Statistics Canada. (2016). *Population and Dwelling Count Highlight Tables, 2016 Census*. Retrieved 10 25, 2017, from Statistics Canada: http://www12.statcan.gc.ca/census-recensement/2016/dp-pd/hlt-fst/pd-pl/Table cfm?Lang=Eng&T=301&S=3&O=D

Statistics Canada. (2017). *2016 Census of Agriculture*. Retrieved 2017, from Statistics Canada: https://www.statcan.gc.ca/eng/ca2016

Statistics Canada. (2017). *Table 153-0145 Households and the environment survey, primary heating system, Canada, provinces and census metropolitan areas (CMA)*. Retrieved 2017, from Statistics Canada: http://www5.statcan.gc.ca/cansim/a47

Toronto Environmental Alliance. (2016). *Reports: Zero Waste Toronto & Organics First*. Retrieved 2017, from Toronto Environmental Alliance: http://www.torontoenvironment.org/zerowaste

United States Environmental Protection Agency. (n.d.). *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*.
Retrieved 2017, from United States Environmental Protection Agency: https://www3.epa.gov/warm/pdfs/chapter1.pdf

United States Environmental Protection Agency. (2014). *Emission Factors for Greenhouse Gas Inventories*.
Retrieved 2017, from United States Environmental Protection Agency:
https://www.epa.gov/sites/production/files/2015-07/documents/emission-factors_2014.pdf

World Resources Institute. (n.d.). *Global Protocol for Community-Scale Greenhouse Gas Emission Inventories*.
Retrieved 2018, from:
https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

APPENDIX A - CHART VALUES

This appendix provides chart values for the figures included in the regional inventory.

Table 1: Absolute Emissions by Municipality and Sector

Municipality	Emissions (tCO_2eq)					
	Buildings	Transportation	Industrial	Waste	Agricultural	TOTAL
Toronto	8,920,069	4,740,290	538,721	571,314	1,219	**14,771,613**
Peel Region	4,544,215	3,678,922	2,271,286	412,696	59,843	**10,966,962**
Hamilton	1,036,160	1,299,686	5,526,977	175,097	69,102	**8,107,022**
York Region	3,202,266	3,069,994	23,625	140,268	93,040	**6,529,193**
Durham Region	1,848,779	1,774,873	421,798	56,814	203,007	**4,305,271**
Halton Region	1,424,164	1,430,920	118,898	133,002	34,682	**3,141,667**
GTHA Total	20,975,653	15,994,686	8,901,305	1,489,191	460,893	**47,821,727**
Ontario	39,410,000	48,300,000	21,800,000	8,600,000	9,700,000	**127,810,000**

Table 2: Relative Emissions by Municipality and Sector

Municipality	Emissions					
	Buildings	Transportation	Industrial	Waste	Agricultural	TOTAL
Toronto	60%	32%	4%	4%	0%	**100%**
Peel Region	41%	34%	21%	4%	1%	**100%**
Hamilton	13%	16%	68%	2%	1%	**100%**
York Region	49%	47%	0%	2%	1%	**100%**
Durham Region	43%	41%	10%	1%	5%	**100%**
Halton Region	45%	46%	4%	4%	1%	**100%**
GTHA Total	**44%**	**33%**	**19%**	**3%**	**1%**	**100%**
Ontario	**31%**	**38%**	**17%**	**7%**	**8%**	**100%**

Table 3: Per Capita Emissions by Municipality and Sector

Municipality	Emissions per Capita (tCO_2eq)							
	2015 Population	Buildings	Trans-portation	Industrial	Waste	Agricultural	TOTAL	TOTAL (Excluding Industrial)
Toronto	2,708,269	3.3	1.8	0.2	0.2	0.0	5.5	**5.3**
Peel Region	1,381,739	3.3	2.7	1.6	0.3	0.0	7.9	**6.3**
Hamilton	536,917	1.9	2.4	10.3	0.3	0.1	15.1	**4.8**
York Region	1,109,909	2.9	2.8	0.0	0.1	0.1	5.9	**5.9**
Durham Region	645,862	2.9	2.7	0.7	0.1	0.3	6.7	**6.0**
Halton Region	548,435	2.6	2.6	0.2	0.2	0.1	5.7	**5.5**
GTHA Total	**6,931,131**	**3.0**	**2.3**	**1.3**	**0.2**	**0.1**	**6.9**	**5.6**

Table 4: Per Capita Emissions by Municipality for Natural Gas and Electricity Consumption

Municipality	Emissions (tCO_2eq)	
	Natural Gas	Electricity
Toronto	2.9	0.40
Peel Region	2.9	0.37
Hamilton	2.5	0.34
York Region	2.6	0.30
Durham Region	1.5	0.44
Halton Region	2.2	0.37
GTHA Total	**2.6**	**0.38**

Table 5: Per Capita Emissions, Population and Land Area by Municipality

Municipality	Transportation Emissions per Capita (tCO_2eq/person)	2016 Land Area (km^2)	2015 Population	Population Density (population/km^2)
Toronto	1.8	630.2	2,708,269	4,334
Peel Region	2.7	1246.95	1,364,753	1,108
Hamilton	2.4	480.6	533,523	1,117
York Region	2.8	1762.13	1,094,432	630
Durham Region	2.7	2523.8	638,314	256
Halton Region	2.6	964.05	539,083	569

Table 6: Total GTHA Emissions for Natural Gas and Electricity Consumption

Municipality	Natural Gas	Electricity	TOTAL
GTHA Total Emissions (tCO_2eq)	18,362,494	2,613,159	**20,975,653**
GTHA Total Emissions (% of Total Building Emissions)	87.5%	12.5%	**100%**

Table 7: Comparison of Major Urban Centres' Emissions

Municipality	Population	Total Annual Emissions ($MtCO_2eq$)	Emissions Per Capita (tCO_2eq/person)	Year
GTHA	6,894,086	47.4	6.9	2015
Calgary	1,020,000	17.0	16.7	2008
Edmonton	932,546	16.9	18.1	2016
Montreal	1,959,987	13.7	7.0	2013
Metro Vancouver	2,463,677	11.5	4.7	2012
Halifax	398,167	6.1	15.2	2009
Ottawa	1,288,665	5.4	4.2	2012
Quebec City	534,750	4.0	7.5	2006
Waterloo Region	541,900	3.6	6.7	2010

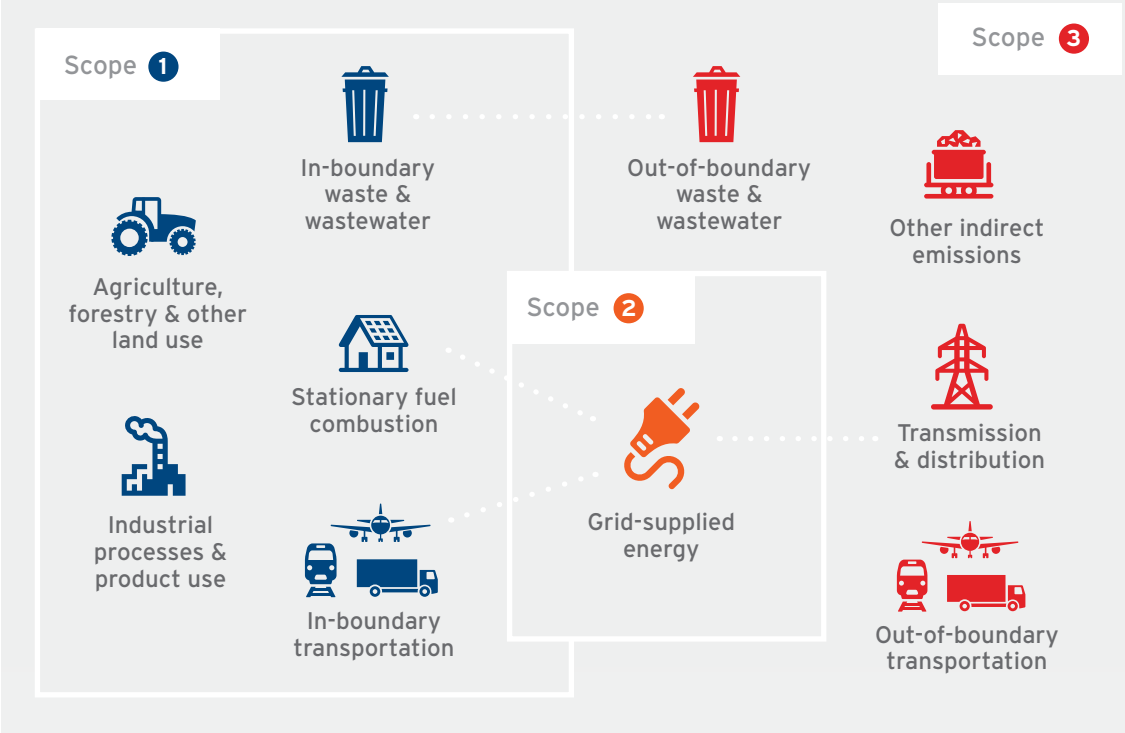
Table 8: Overview of Projected Emissions by Municipality

Municipality	2015 Per Capita Emissions (tCO_2eq/person)	Percentage of GTHA Emissions (2015)	2050 Projected Population	2050 Projected Emissions (tCO_2eq)	Percentage of GTHA Emissions (2050)	Per Capita Emissions to Achieve 80% reduction by 2050 (tCO_2eq/person)
Toronto	5.5	31%	4,248,262	22,864,114	34.30%	1.3
Peel Region	7.9	23%	2,419,618	17,453,682	26.19%	1.7
Hamilton	15.1	17%	781,508	9,250,877	13.88%	2.8
York Region	5.9	14%	1,912,814	11,167,997	16.76%	1.4
Durham Region	6.7	9%	1,026,396	6,473,757	9.71%	1.5
Halton Region	5.7	7%	1,015,708	5,687,553	8.53%	1.3
GTHA Total	**6.9**	**100%**	**11,404,307**	**72,897,980**	**100.00%**	**1.5**

APPENDIX B – METHODOLOGY

In general, we followed the guidelines in the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories and attempted to use as many primary sources of data as possible (ICLEI, WRI, C40, 2014). The regional inventory includes scope 1 and 2 emissions. We will continue to improve our methodology over time.

Figure 17: Definition of Scope 1, 2, and 3 Emissions Sources



The following table is a summary of each sector, the data sources, and things of note.

Table 9: Data Sources by Sector

Sector	Included Data Sources	Notes	Exclusions
Buildings	Reporting and Record Keeping Requirements, Enbridge Gas, Union Gas, and Local Distribution Companies provided natural gas and electricity consumption. Emissions factors for electricity and natural gas are taken from Canada's 2017 National Inventory Report for the year 2015 and are 43 gCO_2eq/kWh and 1,899 gCO2eq/m^3, respectively.	This sector includes all electricity and natural gas usage which may include EV charging, street lighting, and transit operations which form a small share of the emissions and aren't disaggregated for simplicity.	Fuel oil, propane, heating oil, and other fuels assumed to be minor and not included due to data limitations.
Transportation	Kent Group provided gasoline and diesel sales. Emissions factors for gasoline and diesel are taken from Canada's 2017 National Inventory Report and are 2,300 gCO_2eq/L and 2,700 gCO_2eq/L, respectively.	Gasoline and diesel emissions are attributed to the municipality the fuel is purchased in due to data availability. It is acknowledged that fuel purchased in one municipality may be consumed in another. Five per cent of gasoline is renewable. Two per cent of diesel is renewable.	Private sales, railway, marine, aviation emissions and freight emissions where trailers fuel up at unsupervised stations are not accounted for due to data limitations.
Waste	Resource Productivity and Recovery Ontario provided waste tonnage. Toronto Environmental Alliance provided residential waste composition while Kelleher and Associates provided non-residential waste composition.	Ratio between residential and non-residential waste disposed of as reported for Ontario by Statistics Canada is applicable to the GTHA.	Emissions from wastewater are assumed to be zero as they are biogenic and combusted on site while sludge end-uses are unaccounted for.
Agriculture	Canada's National Inventory Report and Statistics Canada provided agricultural emissions and agricultural activity, respectively.	Emissions can be interpolated based on cattle headcounts and farm land area	Upstream emissions from fertilizer production as it is considered out of scope.
Industrial	Ontario Large Emitter Database provided emissions for industrial emitters.	Emissions from electricity generation and district heating are included in the buildings data and double counting is insignificant.	Industrial process emissions less than 25,000 $tCO_2eq/year/$.

Buildings

Natural gas and electricity consumption are the two main sources of emissions from buildings in the GTHA. These sources typically fall under the umbrella term of "Stationary Energy" but we will refer to them as "Buildings" in this document to make the concept more relatable. According to Natural Resources Canada's Comprehensive Energy Use Database 89.2 per cent of residential energy use and 94.9 per cent of commercial/institutional energy use comes from these two energy sources. Cities likely use an even higher proportion of energy use comes from natural gas and electricity, given that these services have long been available and easily accessible in urban areas. As such, we did not calculate propane, heating oil, wood, and coal emissions as we estimated that they make up an insignificant portion of the emissions in buildings in the GTHA and could not easily obtain reliable data on their emissions.

We obtained natural gas consumption data from Enbridge, Union Gas, and the Region of Durham's emissions inventory. We did not account for leakage of natural gas during local distribution and upstream emissions from the mining and refinement of natural gas.

We obtained electricity data from the Ontario Energy Board's Reporting and Record Keeping Requirements (RRR), and local distribution companies (LDC). The RRR reports electricity distribution by LDC, with some LDCs providing electricity to more than one municipality. Electricity consumption for some small municipalities in some regions were interpolated based on a strong correlation between historic population and consumption values for the GTHA (municipalities with interpolated electricity consumption are Georgina, Whitchurch-Stouffville, East Gwillimbury, and Scugog).

Electricity consumption could include sources that are not associated with buildings such as EV charging, street lighting, or transit operations. We did not disaggregate those sources due to inconsistencies in available data across the region. Further, we did not factor electricity imports and exports into this inventory, but Ontario exports significantly more electricity than it imports, particularly to jurisdictions with greater emissions intensity such as New York and Michigan.

The natural gas and electricity consumption values were multiplied by emissions factors from Canada's National Inventory Report, 0.001899 tCO_2eq/m^3 of natural gas and 0.000043 tCO_2eq/kWh, respectively.

Transportation

We calculated transportation emissions from gasoline and diesel fuel sales data from Kent Group Limited. Kent Group Limited's coverage is about 99 per cent of public gas stations in the GTHA (Caledon, King and Georgina fuel sales were not available, but will be available 2017 onwards).

Ontario's renewable fuel standard requires at least five per cent of gasoline sold to be from a renewable source so it was assumed five per cent of gasoline sales were ethanol with a 34 per cent reduction in emissions (United States Environmental Protection Agency, 2014; Government of Ontario, 2016). Similarly with diesel and the Greener Diesel regulation, two per cent of diesel sales were assumed to be bio-based with a 30 per cent reduction in emissions (Ministry of the Environment and Climate Change, 2015).

Fuel sales occurring in each municipality were allocated to that municipality's emissions inventory. We took this approach for simplicity, although it is also reasonable to attribute the emissions to the municipality in which the fuel is consumed. We analyzed the Tomorrow Survey origin-destination data from 2011 to identify the potential difference an alternative methodology might make. Ultimately, we felt that the data was too outdated, did not consider all road vehicles, and only showed minor differences. However, the results are provided below in Table 1. The Fuel Sales Adjustment value can be multiplied by the fuel sales from that municipality to adjust for the travel

behaviour between municipalities. Generally, the Durham and York Region's population travel more outside those regions, while Peel Region attracts travel. The 2016 Transportation Tomorrow Survey data may be considered for future inventories.

Table 10: Factors for Adjusting Fuel Sales based on Transportation Tomorrow Survey Data

Municipality	Toronto	Durham	York	Peel	Halton	Hamilton
Fuel Sales Adjustment	101.1 %	96.1%	92.3%	109.3%	109.8%	101.5%

The fuel sales data may not account for private sales, railway, marine, transit, or local aviation emissions. Freight emissions where trailers fuel up at unsupervised stations are also not accounted for. The table below shows emissions by municipality and emissions split between gasoline and diesel.

Table 11: Transportation Fuel Emissions by Top-Tier Municipality in the GTHA

Top-Tier Municipality	Gasoline Emissions (tCO_2eq)	Diesel Emissions (tCO_2eq)	Total Fuel Emissions (tCO_2eq)	Note
Toronto	4,400,178	338,071	**4,738,250**	Toronto + East York + Etobicoke + Scarborough + North York + York
Peel Region	3,297,272	379,360	**3,676,632**	Aggregate
York Region	2,806,499	261,914	**3,068,413**	Aggregate
Durham Region	1,667,653	106,576	**1,774,230**	Aggregate
Hamilton	1,208,853	90,288	**1,299,141**	Aggregate
Halton Region	1,291,845	138,241	**1,430,086**	Aggregate

Table 12: Transportation Fuel Emissions by Lower-Tier Municipality in the GTHA

Lower-Tier Municipality	Gasoline Emissions (tCO_2eq)	Diesel Emissions (tCO_2eq)	Total Fuel Emissions (tCO_2eq)	Note
Mississauga	1,818,545	265,536	**2,084,080**	
Brampton	1,379,625	100,901	**1,480,526**	
Oshawa	842,846	45,337	**888,183**	Includes Whitby
Markham	2,307,374	223,813	**2,531,187**	
Vaughan	-	-	-	
Richmond Hill	-	-	-	
Oakville	487,333	34,523	**521,856**	
Burlington	433,650	36,479	**470,129**	
Whitby	-	-	-	Included in Oshawa
Ajax	569,173	38,718	**607,892**	Includes Pickering
Milton	231,048	20,465	**251,512**	
Pickering	-	-	-	Included in Ajax
Clarington	127,011	9,333	**136,344**	Includes Bowmanville
Newmarket	310,903	25,126	**336,029**	
Caledon	-	-	-	
Halton Hills	139,814	46,775	**186,589**	Includes Georgetown + Hornby
Aurora	188,222	12,975	**201,198**	
Georgina	-	-	-	
Whitchurch-Stouffville	-	-	-	
East Gwillimbury	-	-	-	
Scugog	79,883	6,769	**86,652**	Includes Port Perry
Uxbridge	48,740	6,418	**55,158**	
King	-	-	-	
Brock	-	-	-	
Bolton	81,818	10,771	**92,589**	Part of Caledon
Nobleton	17,285	2,152	**19,437**	Part of King

Waste

We used the methane commitment approach to calculate emissions from waste, meaning that the estimated lifetime emissions of waste disposed in a given year is attributed entirely to that year even though the emissions will occur over many years (ICLEI, WRI, C40, 2014). Waste emissions are attributed to the municipality that produced the waste, not where waste is disposed of. Captured and flared methane is considered biogenic methane and estimated to be net zero emissions. The formulas for this method can be found in the Greenhouse Gas Protocol for Community-Scale Emissions Inventories.

The methane commitment method requires two main points of data: Waste tonnage disposed of in landfill (MSW), and the degradable organic carbon (DOC) portion of the waste. Residential waste tonnage was obtained from the Resource Productivity & Recovery Authority's (RPRA) 2016 data. Data is provided by municipality or upper-tier municipality. Commercial and industrial waste tonnage is extrapolated from the RPRA data using Statistics Canada CANSIM Table 153-0041 which showed for every tonne of residential waste disposed 1.5187 tonnes of non-residential waste was disposed of in 2014 (Statistics Canada, 2014).

DOC values were calculated by using standard factors for each type of waste disposed of requiring waste audit/ composition data to be available. Assumptions were made when 'other' was listed as a category in the waste audit.

The following table summarizes the data available to TAF:

Table 13: Waste Composition Data Sources and Values

Municipality	Source	Sector	Year	Methane Generation Potential (L_0) (tCH_4 per tWaste)	DOC	DOC Category					
						Food (A)	Garden/Plant (B)	Paper (C)	Wood (D)	Textiles (E)	Industrial Waste (F)
Toronto	Toronto Environmental Alliance (Toronto Environmental Alliance, 2016)	Single Family	2015	0.054	0.1619	0.41	-	0.2	-	0.06	0.04
Toronto	Toronto Environmental Alliance (Toronto Environmental Alliance, 2016)	Multi-family	2015	0.064	0.1926	0.54	-	0.24	-	0.04	0.04
Toronto	City of Toronto Long Term Waste Strategy (City of Toronto, 2015)	Single Family	2010-2011	0.048	0.144	0.38	0.03	0.1	0.05	0.05	0.05
Toronto	City of Toronto Long Term Waste Strategy (City of Toronto, 2015)	Multi-family	2010-2011	0.054	0.1609	0.55	0.03	0.14	0.02	0.02	0.02
Durham Region	AMO Durham Region Integrated System Plastics & Municipal Sustainability 2015	Residential	2011	0.07	0.2245	0.23	0.06	0.035	-	-	-
Halton Region	Halton Region Solid Waste Management Strategy	Single Family	2017	0.028	0.0835	0.34	0.01	0.065	-	-	0.03
Halton Region	Halton Region Solid Waste Management Strategy	Multi-family	2017	0.035	0.106	0.41	-	0.1	-	-	0.03
Durham Region	Personal Communication from Stephen Laird	Single Family	2011	0.030	0.09036	0.4088	-	0.0651	-	-	0.02
Ontario	Personal Communication from Ralph Torrie	Non-residential	2014	0.070	0.2114	0.22	0.02	0.35	0.08	-	-
Ontario	National Inventory Report 2017	-	2008-2015	0.082	0.21	-	-	-	-	-	-
GTHA	Quantifying the Transition to Low-Carbon Cities by Eugene Mohareb (Mohareb, 2012)	-	2009	-	0.161	-	-	-	-	-	-

For the residential sector, we used the waste composition provided by the Toronto Environmental Alliance to calculate the DOC as the data was collected in the same year of the inventory. The single family and multi-family compositions were weighted based on the proportion of each building type in the GTHA to create one single DOC value that could be applied across the region for residential waste.

The non-residential waste composition was provided by Torrie Smith Associates and Kelleher Environmental as supplemental data to their report on Greenhouse Gas Emissions and the Ontario Waste Management Industry (Kelleher, Christina, & Torrie, 2015).

The efficiency of landfill gas recovered is assumed to be 75 per cent taken from the US EPA (United States Environmental Protection Agency). Canada's National Inventory report estimates a reduction of emission of about 38 per cent from landfill gas recovery but the percentage is presumed to be much higher than that in the GTHA area hence the use of the US EPA's value (Government of Canada, 2017). OX, F, DOC, and MF values use the appropriately recommended values of 0.1, 0.5, 0.6, and 1, respectively (ICLEI, WRI, C40, 2014).

The GTHA has one energy-from-waste facility, the Durham York Energy Centre. In 2015 the facility emitted: 55,459.25 tCO_2, 38.6 tCH_4, and 5.21 tN_2O (Environment and Climate Change Canada, 2015). 21.4 per cent of the facility's capacity is used to process York Region waste while the remaining 78.6 per cent is used to process Durham Region waste. We used these proportions in our emissions analysis (Durham York Energy Centre). The facility also produces 17.5 MWh of electricity which offsets an insignificant amount of emissions (about 0.7 tonnes in 2015) (Durham Region, 2015).

We assumed zero emissions from wastewater since the methane in digester gas is biogenic, which is either flared or used to offset natural gas required by the plant in heating or processes. A credit is not calculated for the digester gas used to offset natural gas use because the avoided natural gas use is already excluded from the natural gas consumption values. We did not account for the emissions from the end-uses of wastewater sludge.

Agriculture

We estimated agricultural emissions by proportioning Ontario's agricultural emissions in Canada's National Inventory Report based on Statistics Canada's agricultural census. Livestock emissions were proportioned based on the head count of cattle and emissions from manure management and agriculture soils were proportioned based on area of farm land.

We did not include resource inputs such as the manufacturing of fertilizer. Additionally, we did not calculate emissions from land use change or forestry activities due to insufficient data.

Industrial

We took the industrial emissions from Ontario's 2015 greenhouse gas emissions reporting by large emitters (>25,000 tCO_2eq/year) (Government of Ontario, 2017). We assumed the emissions from power generating facilities were already included in the electricity grid emissions and combined heat and power plants' emissions were captured by the natural gas consumption data, thus we excluded those two sources. By excluding these two sectors, most of the remaining emissions should be from industrial processes. However, some electricity and natural gas emissions may be double counted as the large emitter's data reporting does not disaggregate the sources of emissions.