2019-2020

Carbon Emissions Inventory for the Greater Toronto and Hamilton Area

Photo by Harry Choi Photography

TAF The Atmospheric Fund

DECEMBER 2021

AUTHORS:
Maryam Shekarrizfard and Juan Sotes

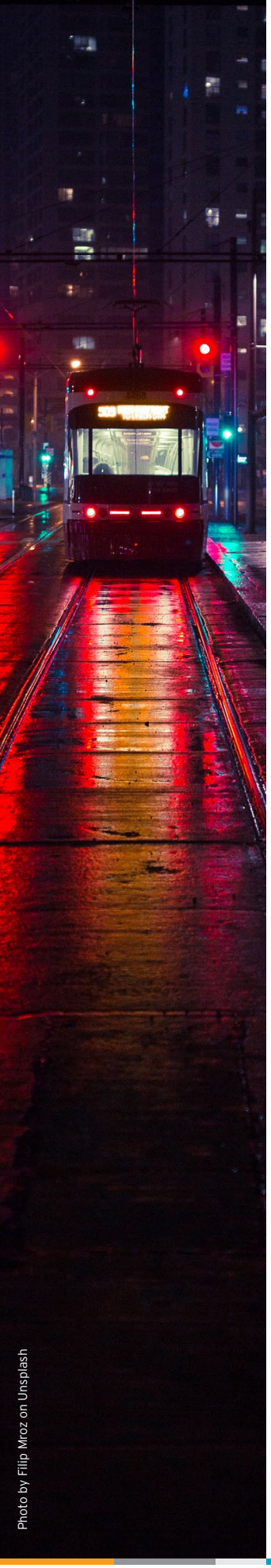


Photo by Filip Mroz on Unsplash

Table of Contents

Acknowledgments

This report has been made possible in part thanks to the data and advice from members of the Carbon Data Network and from:

- Alectra Utilities
- British Columbia Ministry of Energy, Mines, and Petroleum Resources
- British Columbia Ministry of Environment and Climate Change Strategy
- City of Hamilton
- City of Toronto
- Clean Air Council
- Durham York Energy Centre
- Elexicon Energy
- Enbridge Gas
- Environmental Commissioner of Ontario
- Friends of the Greenbelt Foundation
- Google Environmental Insights Explorer
- Hydro One
- ICLEI Local Governments for Sustainability
- Ontario Ministry of the Environment and Climate Change
- Region of Durham
- Region of Halton
- Region of Peel
- Region of York
- Resource Productivity and Recovery Authority
- Toronto and Region Conservation Authority
- Toronto Hydro
- Torrie Smith Associates
- University of Toronto

Suggested citation: The Atmospheric Fund 2021. 2019-2020 Carbon Emissions Inventory for the Greater Toronto and Hamilton Area

Land Acknowledgment

TAF acknowledges that the land on which we work is part of the Treaty Lands and Territory of the Mississaugas of the Credit. The area also encompasses traditional territories of the Huron-Wendat, Haudenosaunee, Erie, Neutral, Anishinaabe, Mississaugas of Scugog Island First Nation, Chippewas of Georgina Island First Nation, and the Mississaugas of the Credit First Nations.

Foreword

Beyond commitments and targets, governments, citizens, and businesses need to double-down on climate action implementation.

The first look at carbon emissions for the Greater Toronto and Hamilton Area (GTHA) since the global pandemic includes two years of data from 2019-2020. Since 2018 data was released, there has been a seismic shift in public consciousness about climate change due to signals like increasing extreme weather, international reports from the IPCC and IEA showing that emissions reductions need to go faster, and most recently, an unprecedented level of media activity and public engagement on the proceedings of COP26 demonstrated a renewed global resolve to achieve Paris targets. But with each passing year, it will get more difficult to track a realistic pathway to net zero. Faster investments and implementation are needed now.

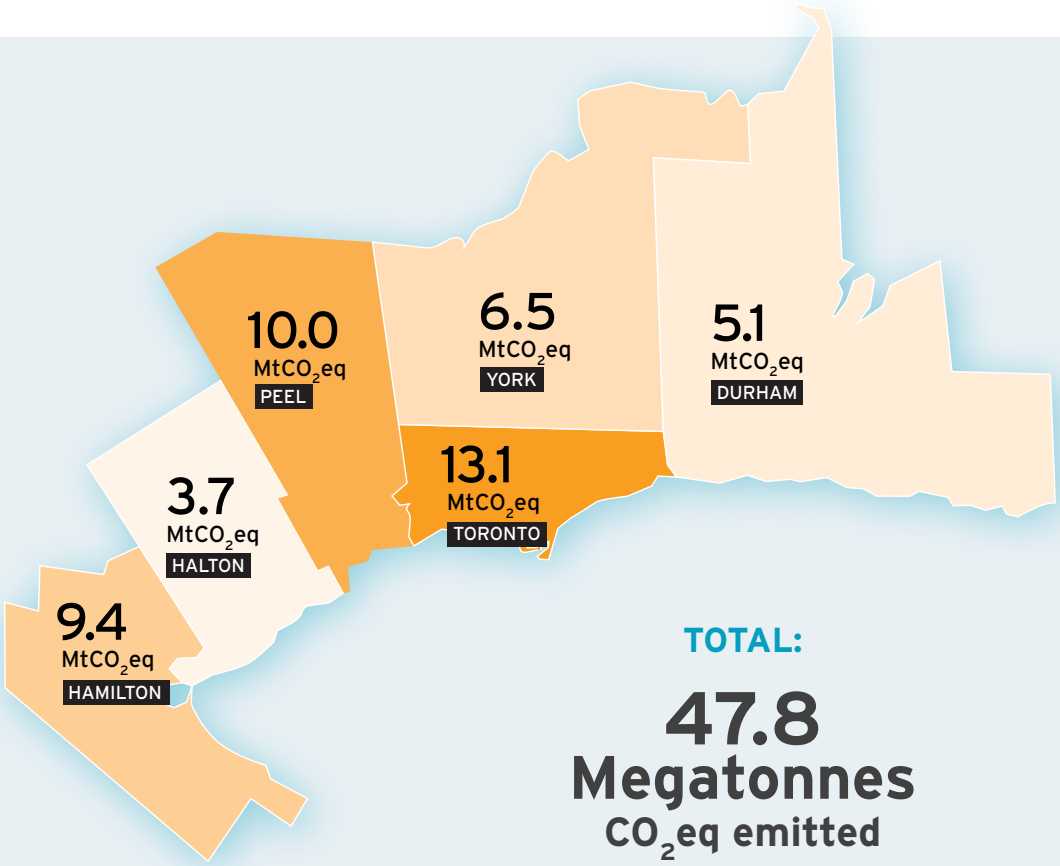
Emissions actually rose 2% between 2015 to 2019, digging the region into a deeper hole. While 2% sounds like a relatively harmless increase, to get on track to net zero by 2050 the region should be achieving sustained annual reductions of at least 7% and counting. Each year that we fail to meet the trajectory toward our climate targets, it puts more pressure on future years and future generations to make more radical societal transformations. Think of it as a 'carbon budget' that we cannot afford to spend too quickly - by 2035 we are on track to release all the carbon we should up to 2050.

2020 emissions fell by 13% as the pandemic drove a historic reduction in transportation demand and industrial output. However, these reductions are expected to be transient, with a major increase in emissions forecasted for 2021. The pandemic response shows we can pull together and spur catalytic society-wide action, but pandemics are not a climate action strategy. The impact on transport emissions shows both the potential and the limitations of transportation demand management. Public health concerns and restrictions drove an unprecedented increase in virtual offices and online shopping, contributing to a remarkable 21% reduction in local transport emissions. Some of these changes will stick, contributing to ongoing emissions reductions. But total vehicle kilometers traveled will almost certainly never be lower than they were in 2020, illustrating how essential electrification of transportation is to a net zero future. Industrial emissions fell 13% in 2020, but similarly, halting industry itself will not be an effective climate strategy. We must look at other mechanisms to decarbonize our local industries.

The data reveals that a massive acceleration in climate action and investment is needed to achieve a net zero future. As the GTHA's climate agency, TAF is supporting players across the region to develop and implement solutions with incredible potential to reduce carbon and make life better for all of us. We have highlighted some of these success stories in the report, to show that the climate crisis is solvable, with technology and investment ready to be deployed today. What's missing is bold leadership to break through the inertia that is paralyzing the region's climate emergency response. This type of leadership will be needed in spades to ensure we achieve a fair, healthy, resilient net zero future.

Bryan Purcell, VP Policy & Programs

2019-2020 Carbon Emissions
in the GTHA



TOTAL:

47.8 Megatonnes
CO_2eq emitted

44%
of Ontario's total carbon emissions from GTHA

Emissions decreased
2019
-0.4%
and 2020:
-13.4%

Figure 1: Emissions by region 2020

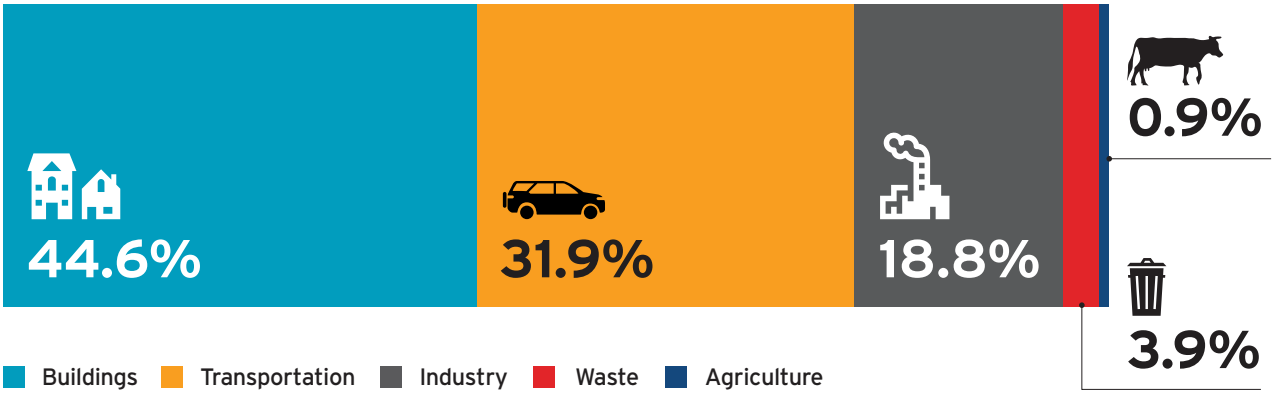


Figure 2: Emissions by sector 2020

#GTHAemissions

2019-2020 CARBON EMISSIONS IN THE GTHA (continued)

Total GTHA Emissions CO_2eq (Megatonnes)
(Not weather normalized)

	2019	2020	% change 2020-2019
Building	23.45	21.32	-9%
Transportation	19.22	15.25	-21%
Industrial	10.33	8.97	-13%
Waste	1.81	1.84	2%
Agriculture	0.43	0.42	-2%
Total GTHA	**55.23**	**47.81**	**-13%**

Figure 3: Total emission change 2019-2020

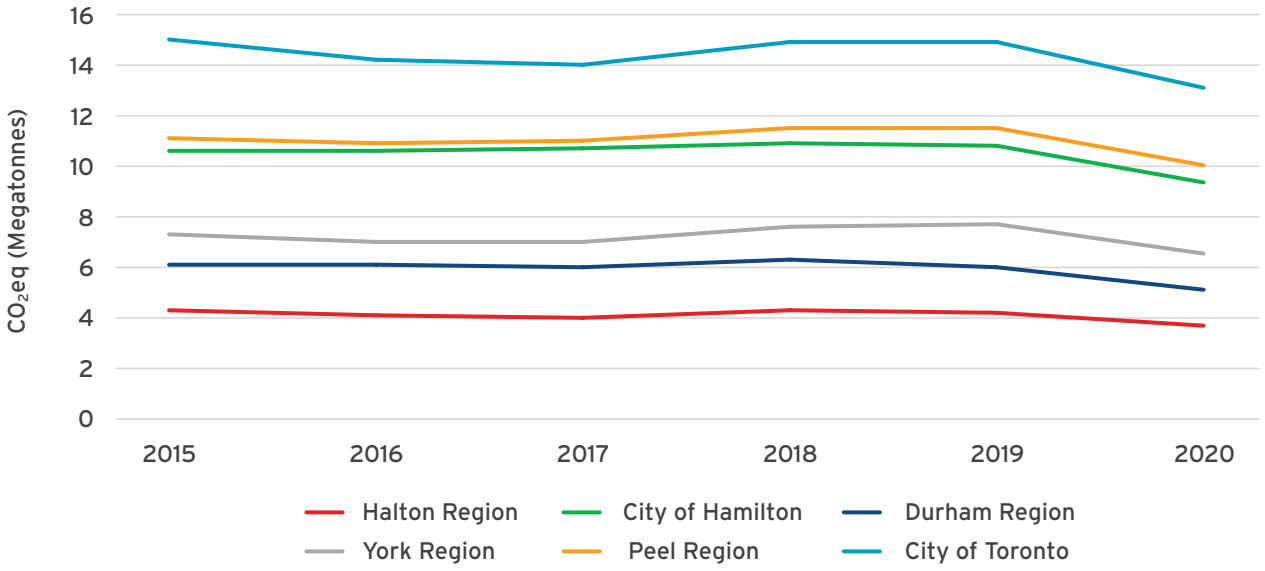


Figure 4: Emissions 2015-2020 by region

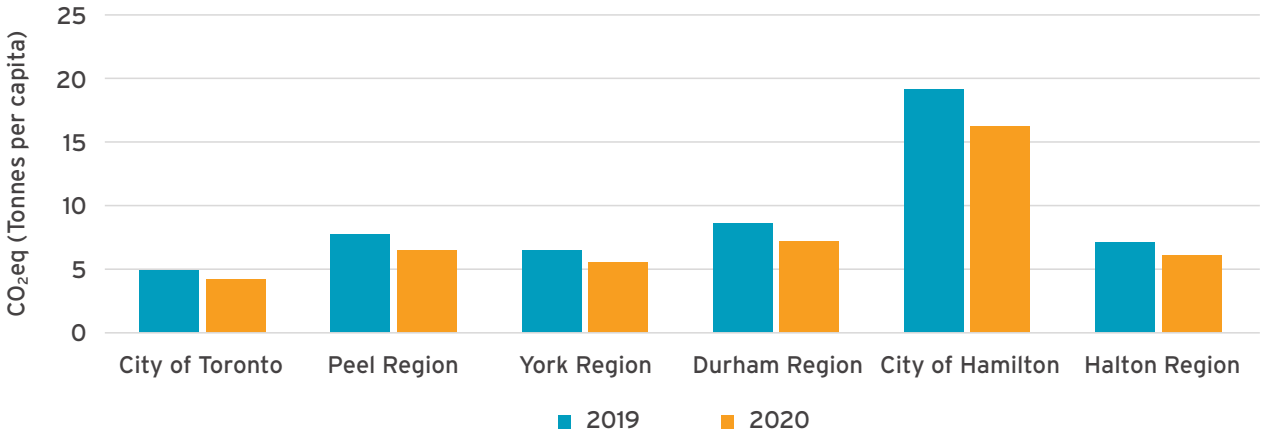


Figure 5: Emissions 2019 and 2020 per capita

Summary

CARBON EMISSIONS IN THE GREATER TORONTO AND HAMILTON AREA

Emissions increased about 2% between 2015 and 2019

Emissions in the GTHA decreased by 0.4% in 2019 and 13.4% in 2020, largely due to a massive disruption in the transportation sector and a warm winter. Five-years of data shows a relatively flat line – we're now about 2.0% above 2015 emissions, notwithstanding the 2020 anomaly. The data shows that the GTHA and Ontario are not on track to reduce emissions in line with local or international 2030 climate commitments.

By 2035 we are on track to release all the carbon we can up to 2050

What's happening with emissions sources?

- **Buildings**
  - **Natural gas** consumption decreased 0.7% in 2019 and 10.0% in 2020.
  - **Electricity** (from buildings and industry): decreased 2.3% in 2019 and increased 2.1% in 2020. Despite 1% decrease in consumption, there was a 2.1% increase in emissions. Heat waves (resulting in heightened electricity use during peak times) makes a significant impact on emissions from electricity.
- **Transportation** emissions went up 1.0% in 2019 and down 20.7% in 2020.
- **Industrial emissions** decreased 1.5% in 2019 and 13.1% in 2020.

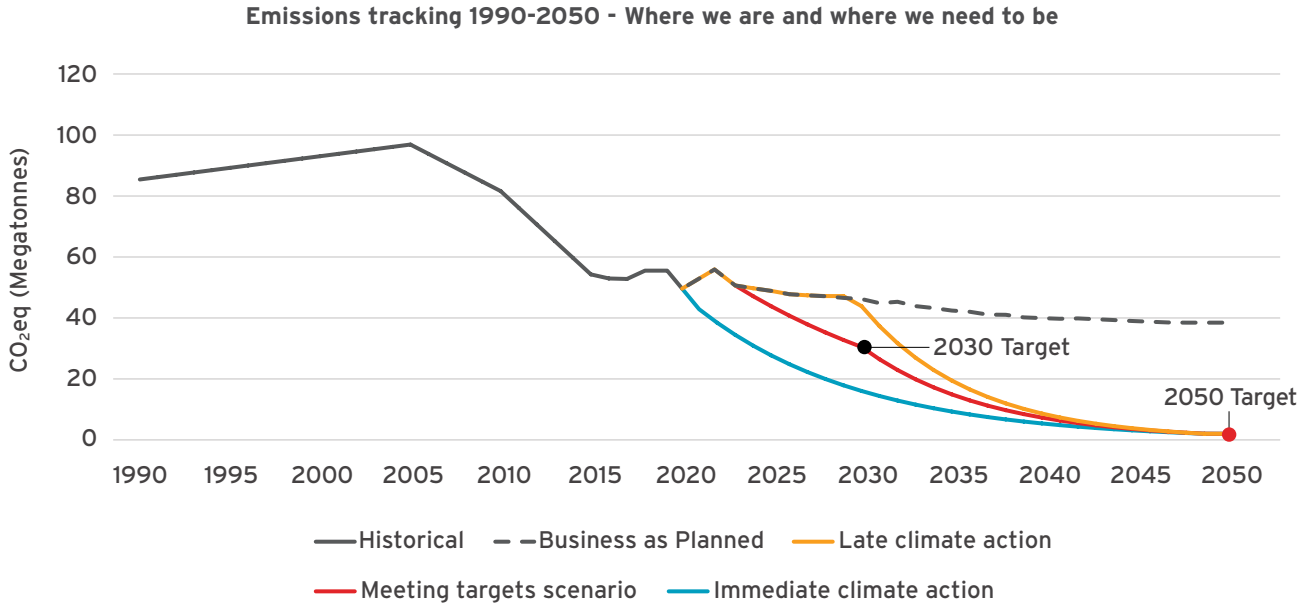


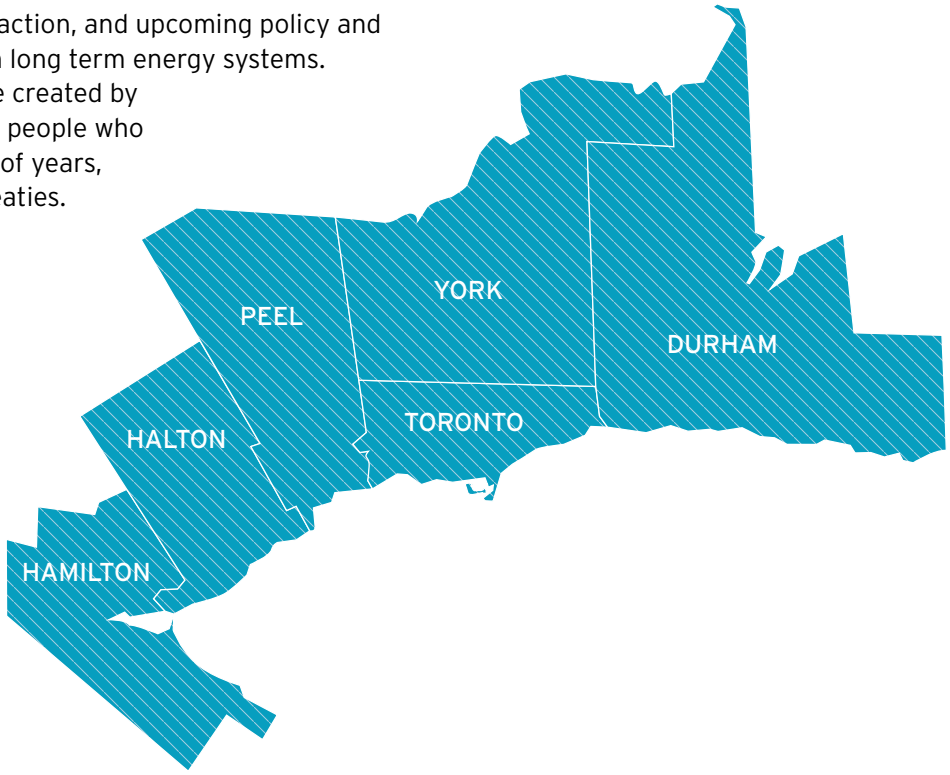
Figure 6: Total emission change 2019-2020[i]

[i] 2030 target extraoplated to the GTHA from TransformTO modelling

ABOUT THE GREATER TORONTO AND HAMILTON AREA

The Greater Toronto and Hamilton Area (GTHA) in Canada includes the city of Toronto, the city of Hamilton, and the regional municipalities of Halton, Peel, York, and Durham. This contiguous urban region of around 8,244.42-square kilometres is home to a population of about 7.7 million. It is Canada's commercial, distribution, and financial core. Almost half of the emissions in the province of Ontario come from this region. As the second largest financial centre in North America, it is a strategic market to watch. These are some of the country's leading cities on climate action, and upcoming policy and investment decisions will be influential on long term energy systems. TAF acknowledges these boundaries were created by settlers and do not reflect the Indigenous people who have occupied these lands for thousands of years, nor the traditional lands, territories or treaties.

As the **second-largest financial centre** in North America, the GTHA is a strategic market to watch



Carbon Emissions by Sector

- Buildings (which use natural gas for space and water heating and electricity) and transportation (which uses gasoline and diesel) are the largest emitting sectors in every municipality in the GTHA, except for Hamilton where industrial emissions (mainly from steel and other manufacturing) are the largest.
- Waste and agriculture are less significant across the mostly urban and suburban region, but still offer opportunity for progress on emission reduction.
- GTHA municipalities have similar emissions profiles. Industry in Hamilton and agriculture in Durham are some of the only deviations from the regional comparisons. This highlights the value of collaboration across the region to implement climate solutions.
- Sectoral emissions haven't changed significantly, except for transportation and industrial emissions in 2020 dipping due to the pandemic response and related economic impacts.

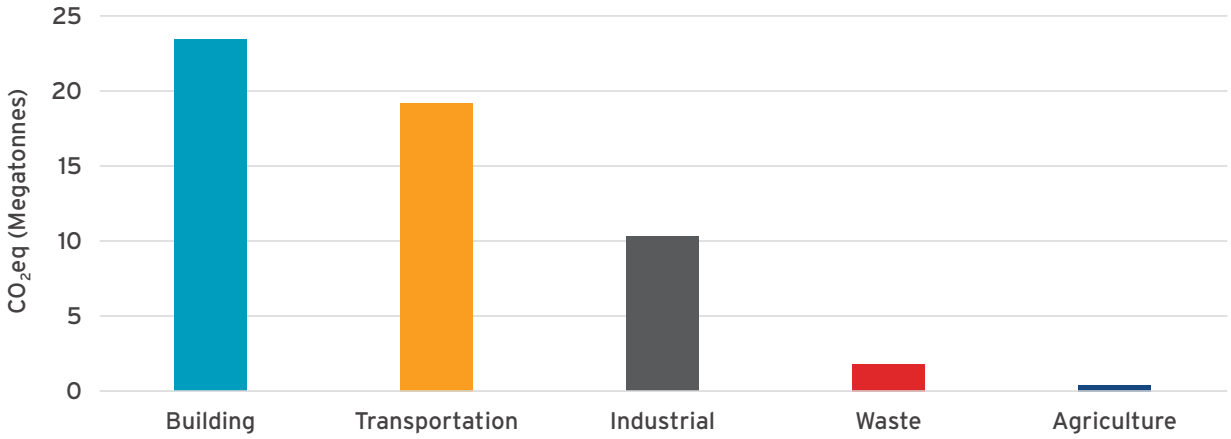


Figure 7: Emissions by sector 2019

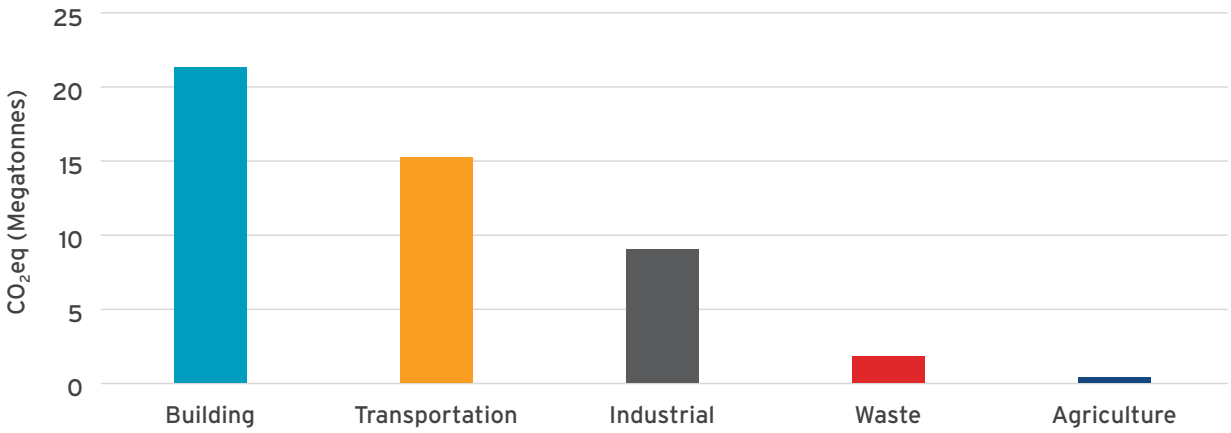


Figure 8: Emissions by sector 2020

BUILDINGS

Buildings make up 44.6% of GTHA emissions, and come primarily from:

- Natural gas (91.6%) consumed on-site for space and water heating.
- Electricity (8.4%) electricity generated using natural gas.

Natural gas

Natural gas (methane) is a fossil fuel and it is the most significant source of emissions in the GTHA

- Natural gas makes up 40.9% of the GTHA's emissions.
- Natural gas emissions decreased 0.7% in 2019 and 10.0% in 2020. Most fluctuation in natural gas emissions are due to weather (weather normalized data shows a 2.6% decrease from 2019 to 2020), demonstrating that we're not taking the necessary actions to reduce emissions in this sector.
- Even modest decreases, such as the ones seen over the past two years, are not enough.
- Achieving net zero by 2050 will require phasing out virtually all natural gas from both heating and power production. If we account for the upstream emissions associated with production and transmission of natural gas, emissions are even larger than reflected in this inventory.

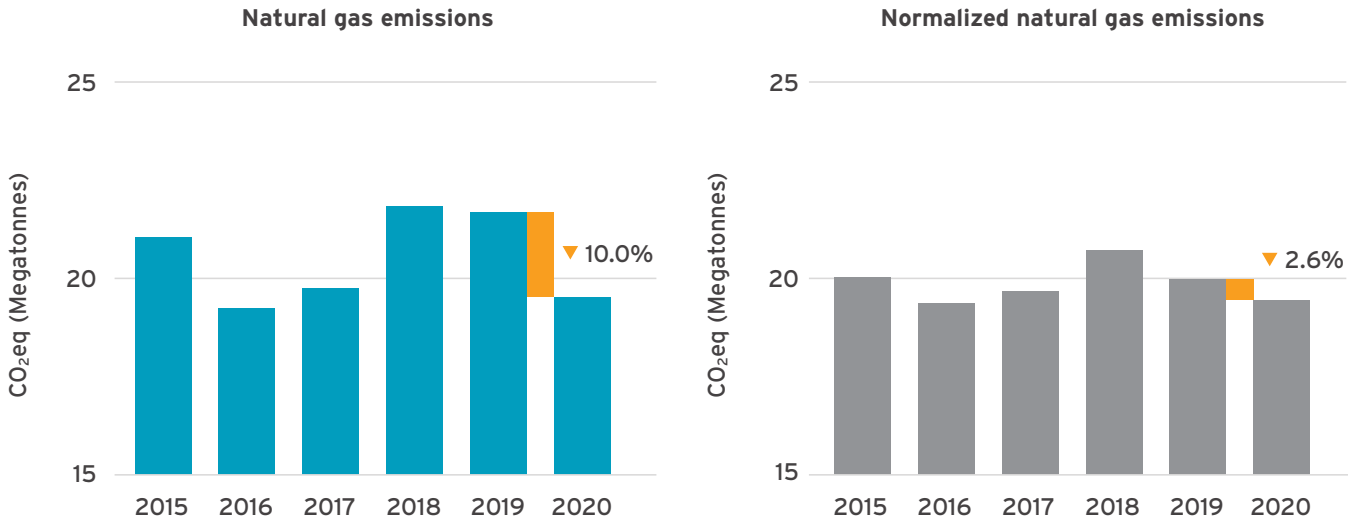


Figure 9: Natural gas emissions 2015-2020 and weather normalized

Ontario's electricity grid is **increasingly supplied with natural gas** generation. This is a big problem.

- Electricity is responsible for 3.7% of the GTHA's emissions and is used in buildings, industry, and a small amount for transportation.
- Emissions from electricity decreased 2.3% in 2019 and increased 2.1% in 2020 due to a very hot summer. In fact, July of 2020 affected the average emissions factors for the entire year.

Electricity emissions are forecasted to triple by 2030.[1] Increasing temperatures, nuclear reactors coming offline for refurbishment, and growing demand as we necessarily electrify vehicles and heating – these are a confluence of factors that put our aging electricity grid at risk and will result in staggering increases in electricity emissions if met with natural gas as planned. Governments, utilities, and the system operator must make necessary investments to modernize the grid, develop distributed energy resources, invest in storage, peak-shifting, and conservation. It is also important that institutions and practitioners use appropriate emissions factors[2] to represent a clearer picture of the impacts of interventions.

Electricity emissions fell 55.0% between 2015 and 2017, but then increased by 56.5% between 2017-2020. City of Toronto consumption has decreased the most – down 6.4% since 2015. York Region has the biggest increase, up 5.5% since 2015. There was no major change in other regions.

Photo by Chromatograph on Unsplash

TALKING ABOUT THE WEATHER

TAF adjusts the data to normalize weather, but the weather itself is significant. Temperatures are getting warmer on average, and extreme weather more frequent. Warmer winters reduce natural gas demand for heating, but hot summer periods put a strain on electricity grids, adding emissions because natural gas plants provide peak demand. The changing climate is a vicious cycle for emissions, and as extreme weather intensifies more investment is needed in community resilience.

Electricity (continued)

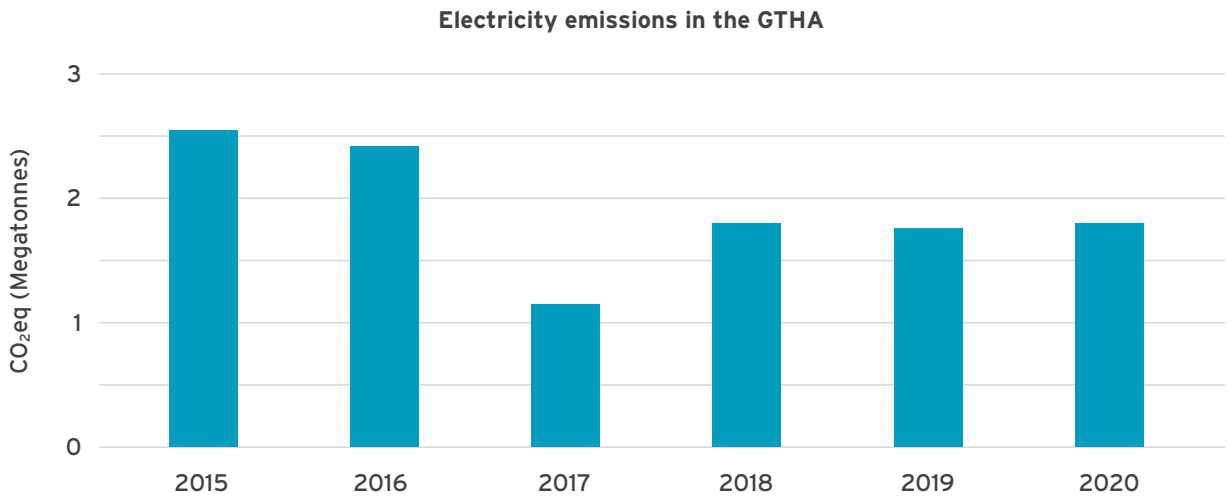


Figure 10: Electricity emissions in GTHA 2015-2020

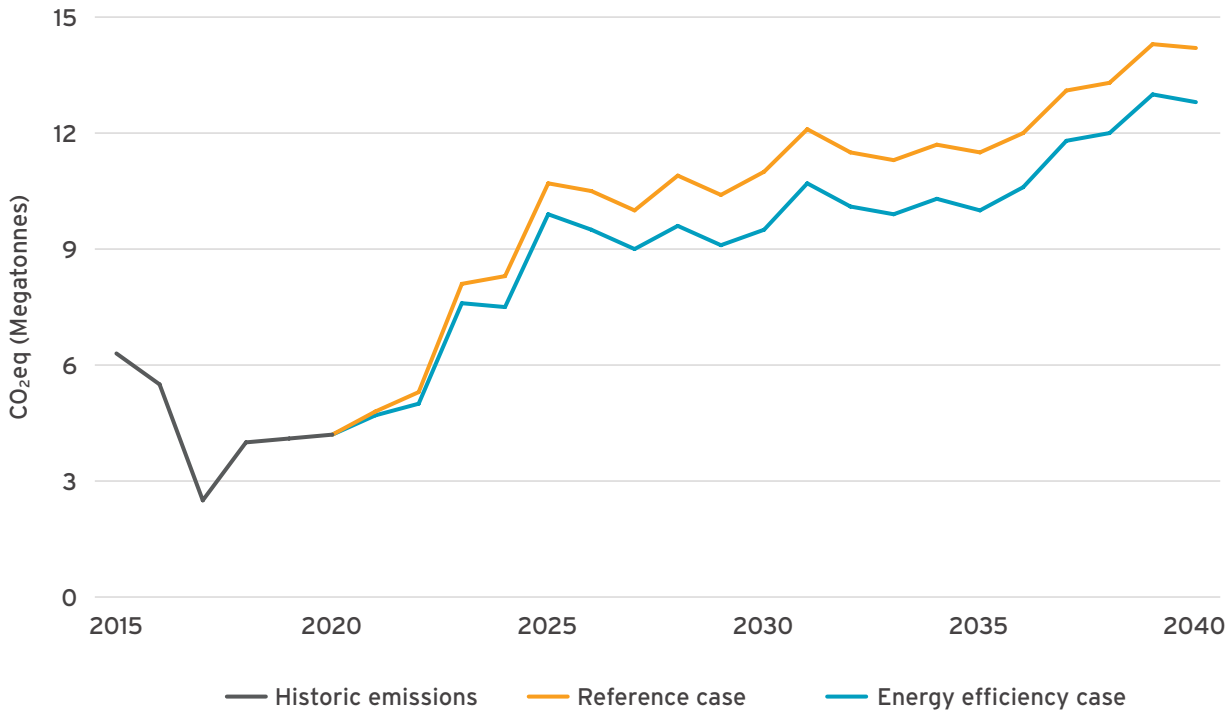
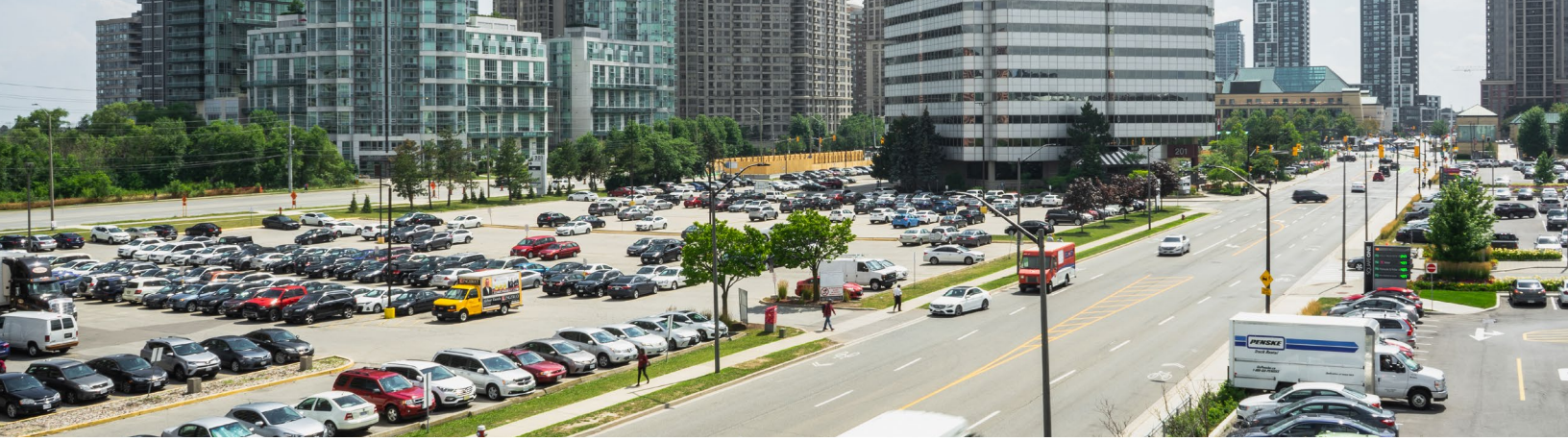


Figure 11: IESO forecasted electricity emissions in Ontario



TRANSPORTATION

Prior to the temporary dip during the pandemic, transportation emissions were alarmingly increasing

- Transportation is responsible for about 35.0 of the GTHA's emissions in 2019 and 32.0% in 2020 (which come primarily from gasoline and diesel).
- Emissions decreased 20.7% in 2020, entirely due to the pandemic response, but we are already seeing preliminary data for 2021 showing a bounce back toward 2019 levels.

Between 2015 and 2019, emissions primarily from cars and trucks increased 5.8%, a rate more than 1% a year. The biggest increases were in Hamilton (+9.5%), Peel (+9.5%), and York (+9.3%), while the lowest increase was in City of Toronto (0.5%).

In 2020, emissions from private vehicles (-21.5%) reduced more than commercial vehicles because activities such as construction were less impacted by the lockdown, and online sales and deliveries increased. Diesel emissions (light commercial trucks) decreased by 11.0%.

One positive impact was the increase in active transportation, up an incredible 50% in the GTHA. It will be important to sustain gains in active transportation, remote work policies, and restore and grow transit ridership.

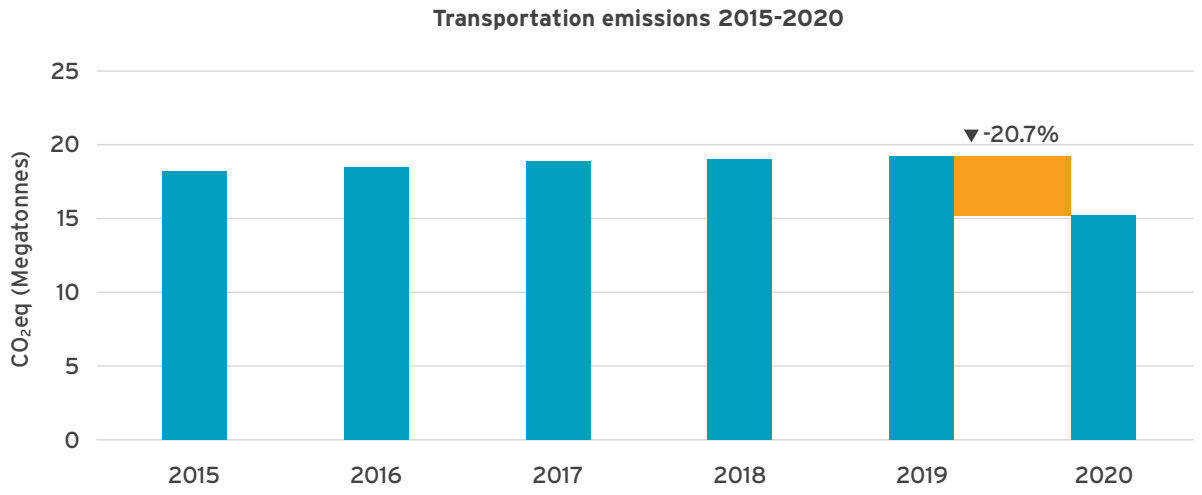


Figure 12: Transportation emissions 2015-2020

TRANSPORTATION (continued)

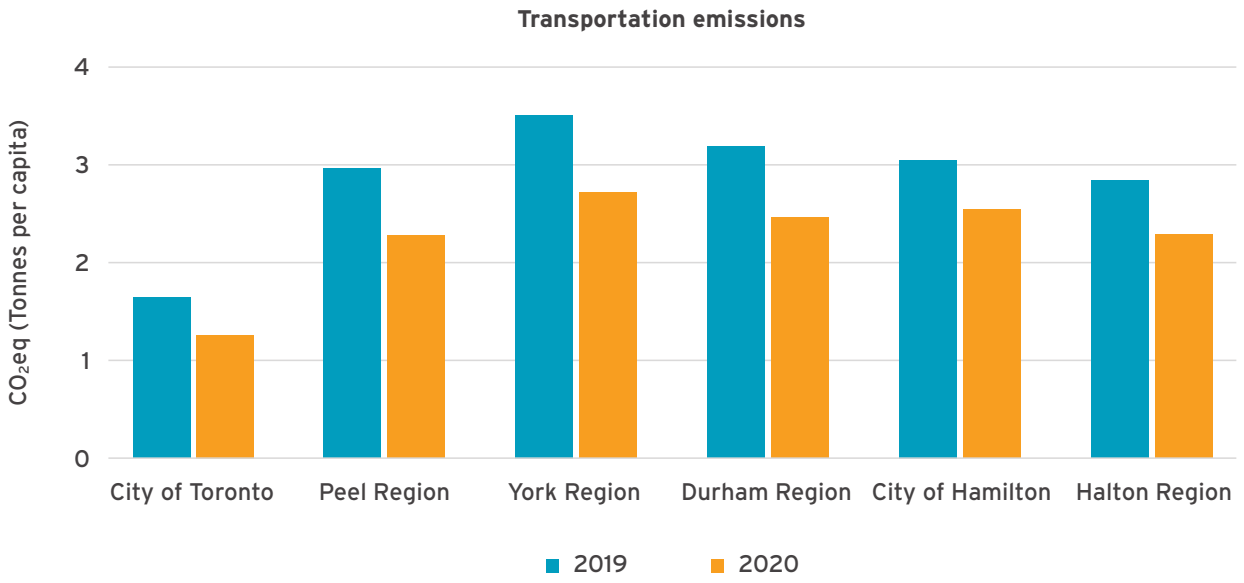


Figure 13: Transportation emissions per capita

ACTIVE TRANSPORTATION CHANGE 2019-2020

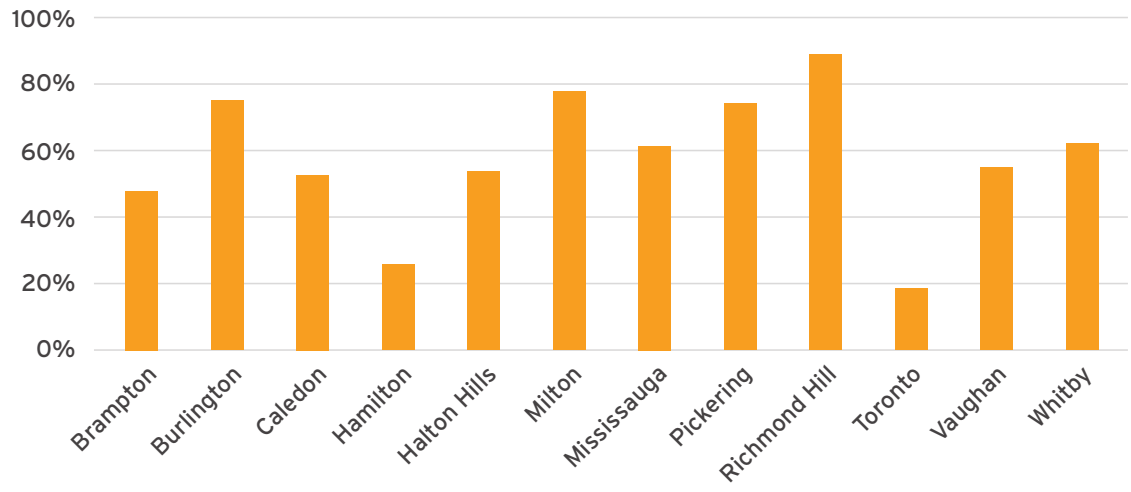


Figure 14: Active transportation via Google Environmental Insights Explorer

SPOTLIGHT ON TRANSPORTATION EMISSIONS: PANDEMIC EFFECTS

Transit ridership

According to the TTC, Toronto transit ridership has only bounced back to 45% of pre-pandemic levels as of Fall 2021, which is a huge problem for carbon emissions if many of those riders shift to personal vehicles in the long-term. Investment in transit is a crucial strategy to reduce urban emissions from transportation.

Urban freight

Urban delivery is on the rise and the trend is going to dramatically impact emissions in the GTHA. According to Pembina Institute, between 2016 and 2020, e-commerce sales made by Canadians grew by more than 350%, and freight emissions are expected to surpass passenger-transport emissions by 2030.[3] We'll need policies and investments in place in the GTHA to electrify fleets and other innovations to decarbonize this sector.

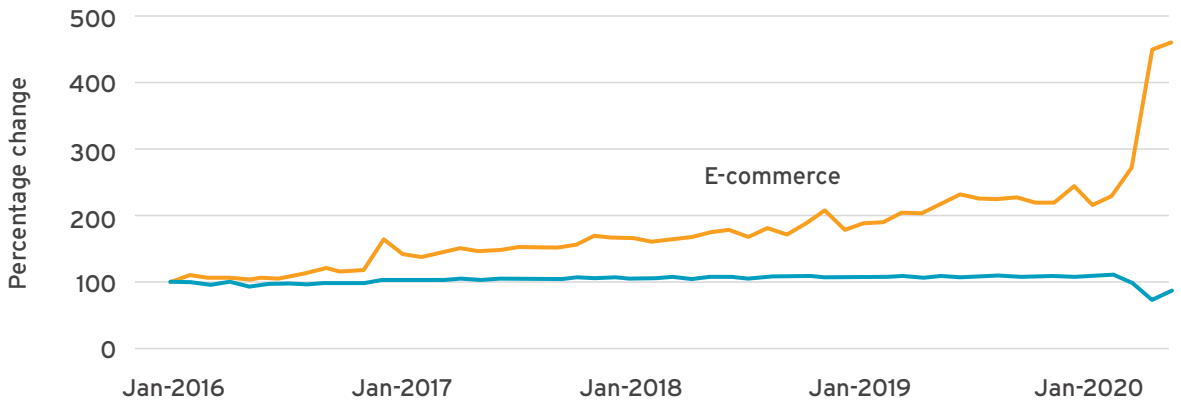


Figure 15: Growth of e-commerce sales in Canada via Statistics Canada

INDUSTRY

After transportation, industrial emissions saw the greatest temporary impact from the pandemic

- Industry makes up about 19.0% of the GTHA's emissions from burning fossil fuels including natural gas and petroleum, and from emissions related to processing materials and producing goods.
- In 2020 the data shows a 14% reduction in emissions from cement, and 19% reduction from steel manufacturing.

About half of the region's industrial emissions come from steel and other manufacturing in Hamilton (53.3% of Hamilton's total emissions). Durham and Peel also have substantial industrial emissions.

There were assumptions and some uncertainty with the 2020 data. Statistically, we cannot draw any conclusions from the result.

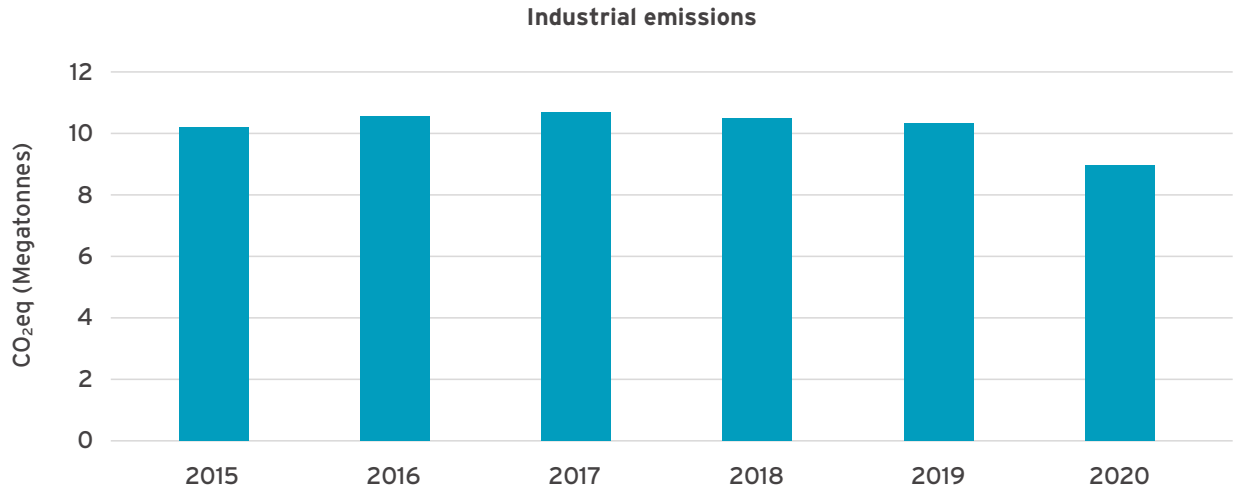


Figure 16: Industrial emissions 2015-2020

WASTE

- Waste emissions (3.9%) come from methane produced from the organic material in landfills.
- Waste emissions stayed relatively flat in 2019 and increased at least 2.0% in 2020. It is possible we are seeing an increase in residential waste as more people are staying home.

Waste emissions are much more significant if we use a 20-year carbon equivalency for methane, because methane is about three times more potent in the short term than when using the 100-year time frame used in inventories. Waste is the least reliable and comparable source of emissions in our inventory due to primary data and methodology limitations, but we see enough consistent data to know that most regions have increasing waste emissions.

WASTE (continued)

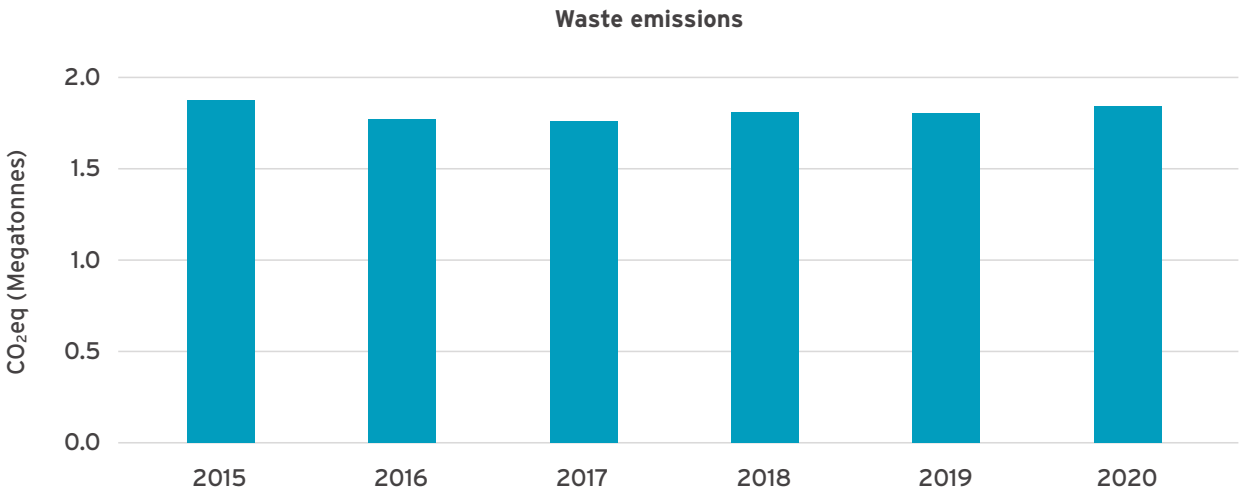


Figure 17: Waste emissions 2015-2020

AGRICULTURE

- Agriculture emissions make up only 0.8% of the GTHA's emissions, and they are mostly in Durham Region.
- Emissions decreased 5.5% in 2019 and decreased 2.0% in 2020.

Agriculture emissions reflected in this inventory are just a fraction of our food consumption emissions. Toronto agricultural emissions are so low that any methodological update in the data triggers high percentage change, but no significant conclusions can be drawn from the 42.0% change.

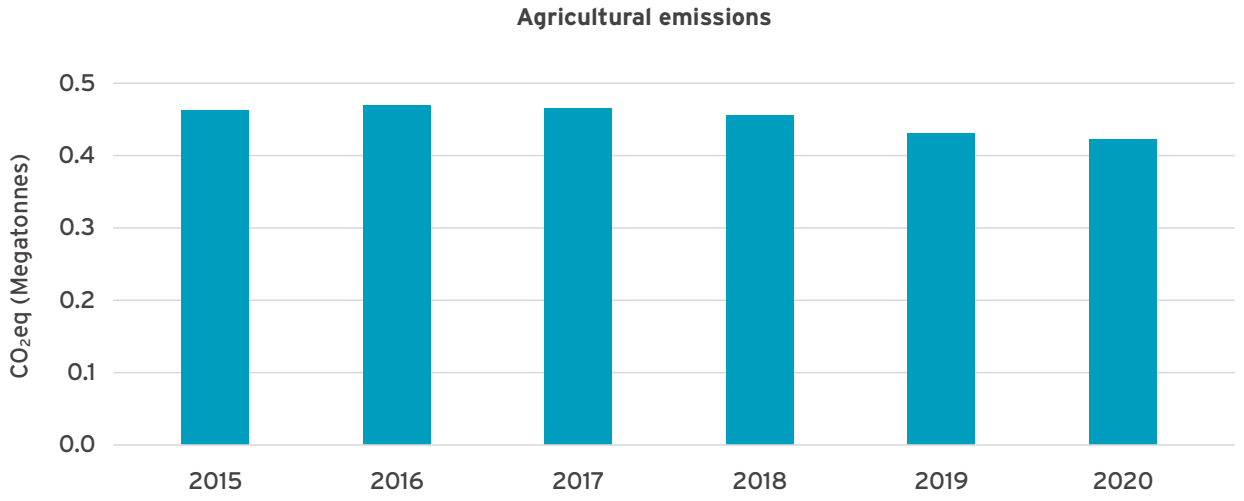


Figure 18: Agricultural emissions 2015-2020

Emissions inventories don't show the full impact of our consumption

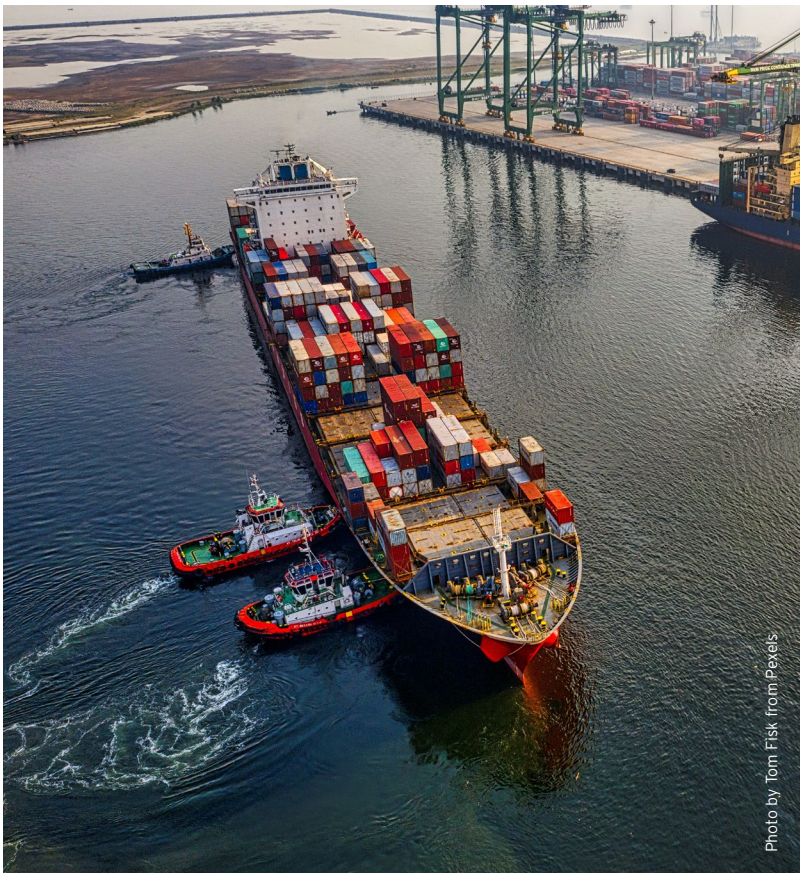


Photo by Tom Fisk from Pexels

Our city inventories are not accounting for all consumption, some of which generates emissions in other countries where many goods are produced, manufactured, and grown. In fact, according to C40, 85% of emissions associated with goods and services are generated outside cities.[4] Municipalities, businesses, and individuals need to account for these emissions more fully, especially considering urban and suburban habits related to aviation, food and consumption, and the embodied carbon in building materials. TAF assesses Scope 3 emissions where possible at a project level through our policy work and grantmaking. However, due to limited data sources, we cannot yet include a comprehensive accounting of Scope 3 sources in the regional inventory.

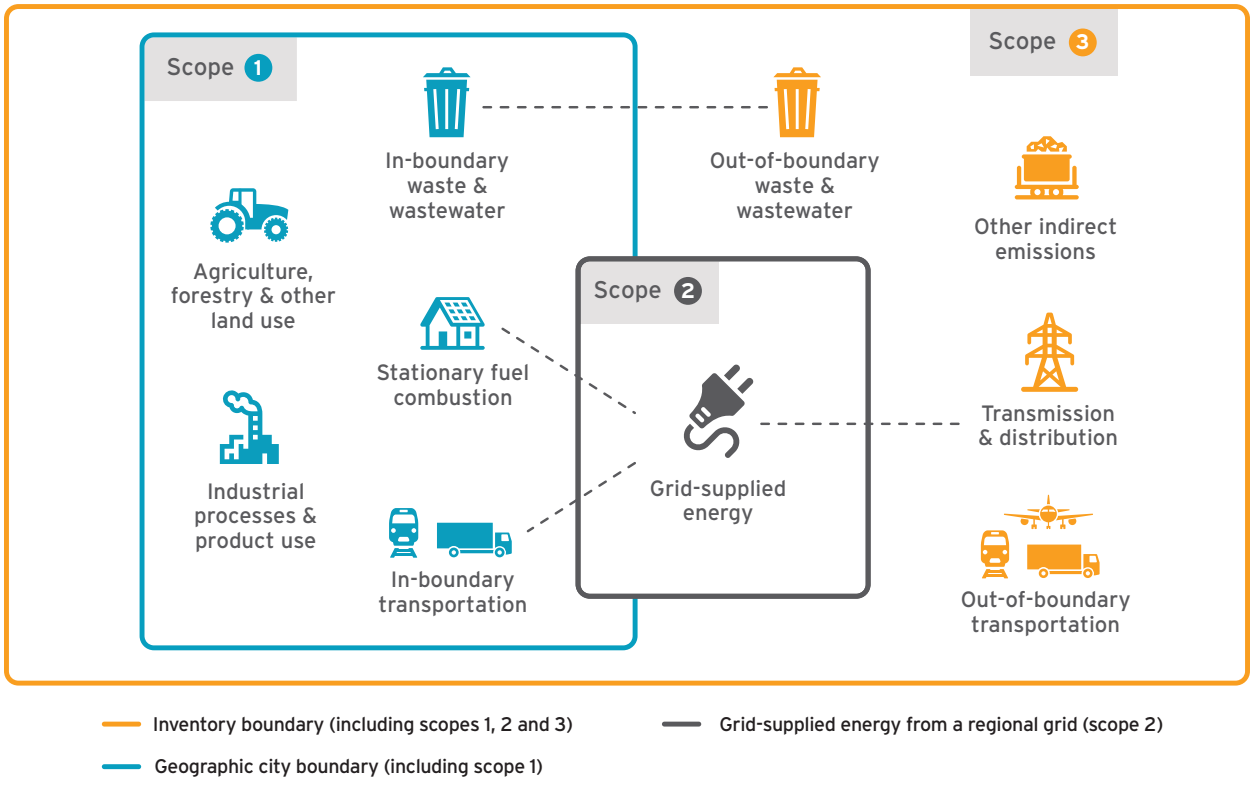
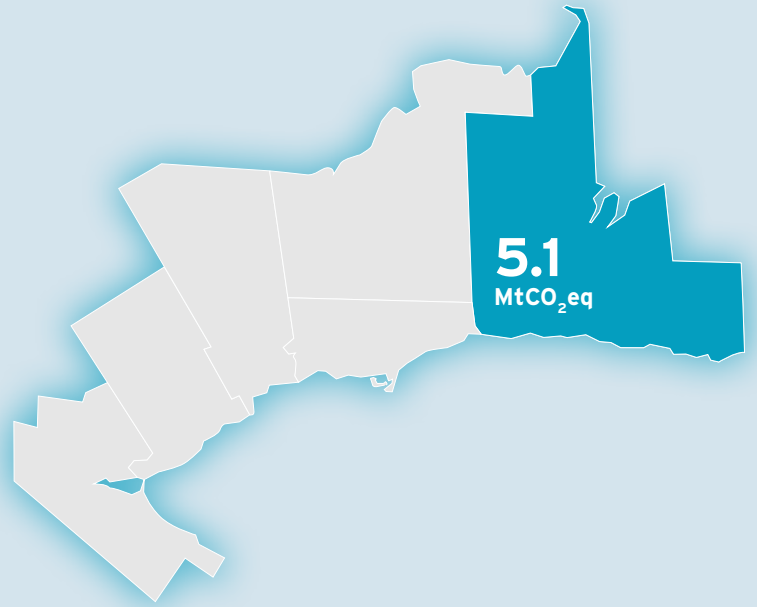


Figure 19: Definition of scope 1, 2, and 3 emissions sources

Durham

Durham includes the cities of Oshawa and Pickering, the towns of Whitby and Ajax, the Municipality of Clarington, and the Townships of Scugog, Uxbridge, and Brock.

Population (2020): 705,880
GTHA emissions: 11%
Land Area: 2,524 km^2
GTHA population: 9.1%



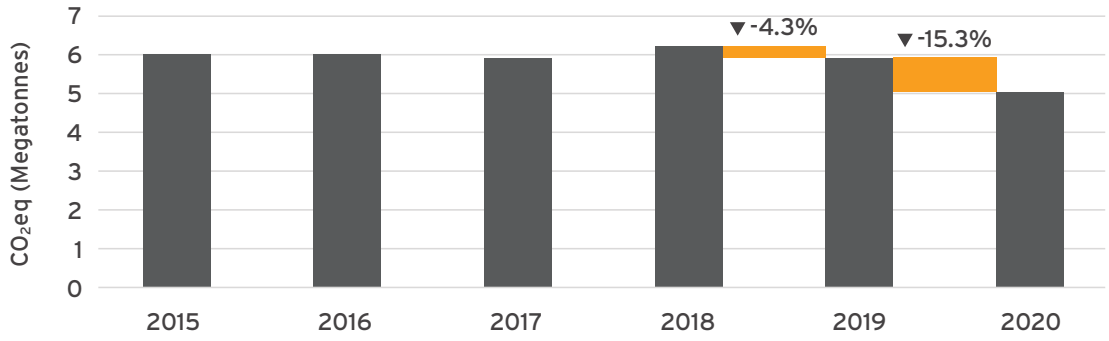


Figure 20: Total Durham emissions 2015-2020

Figure 21: Percent emissions by sector 2020

Durham Region Spotlight:

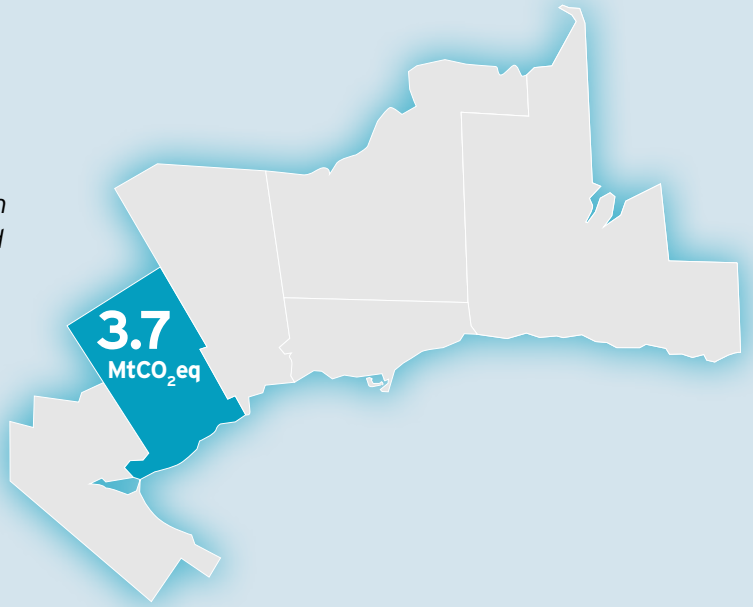
- The biggest source of emissions in Durham is transportation.
- 46% of agricultural emissions in the GTHA come from Durham.
- Emissions decreased 4.3% in 2019 and 15.3% in 2020. The 2020 decrease is a result of pandemic-related impacts and expected to be temporary.

Innovation in Durham: The vast majority of housing stock in Durham Region is owner-occupied single-detached houses, and so the case for residential retrofits has a lot of potential. The region will launch the Durham Home Energy Savings Program in 2022, which will be a one-stop-shop to assist homeowners in conducting deep energy retrofits This program will support Durham's long-term objective to retrofit all existing residential buildings in the region by 2050.[5]

Halton

Halton includes the City of Burlington and the towns of Oakville, Milton, and Halton Hills.

Population (2020): 603,100
GTHA emissions: 8%
Land Area: 964 km²
GTHA population: 7.8%



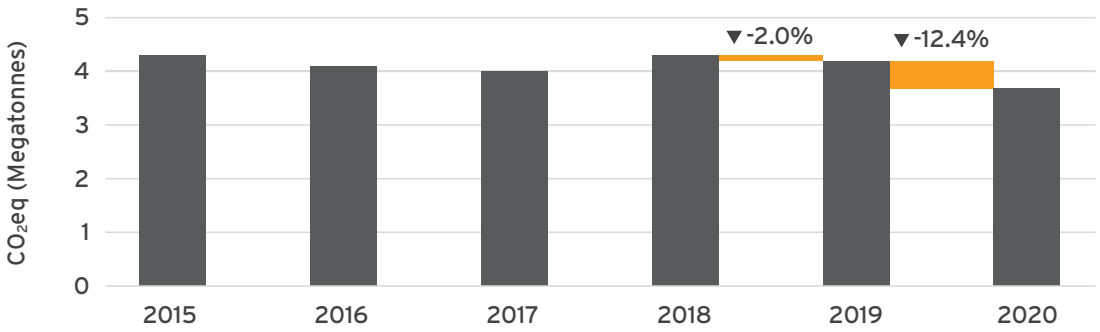


Figure 22: Total Halton emissions 2015-2020

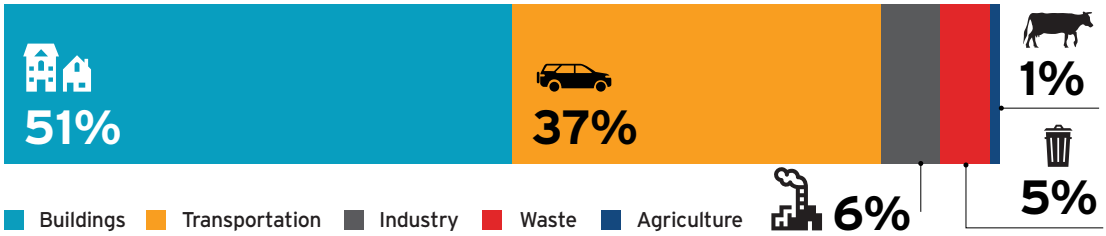


Figure 23: Percent emissions by sector 2020

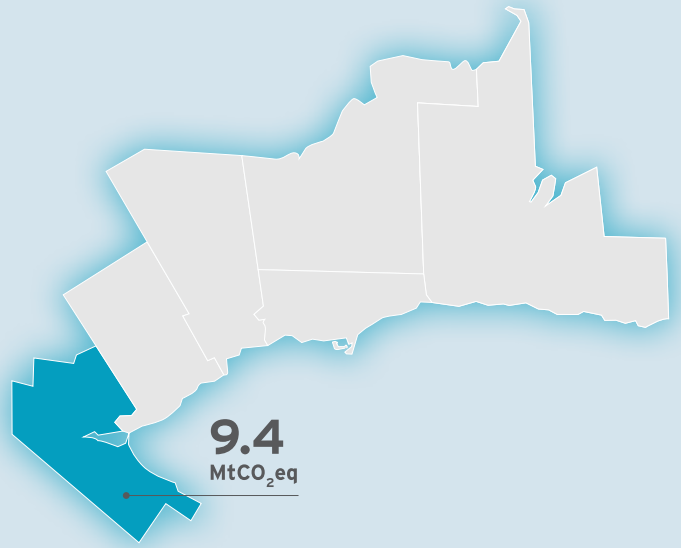
Halton Region Spotlight:

- Halton has the second highest building emissions per capita in the region, 51% of the emissions profile.
- Emissions decreased 2.0% in 2019 and 12.4% in 2020. The 2020 decrease is a result of pandemic-related impacts and expected to be temporary.

Innovation in Halton: The Town of Halton Hills successfully passed Green Development Standards in 2021, which is an important step to curb growth in building emissions. This policy would have a higher impact in the region if it were expanded to the other municipalities: Oakville, Burlington, and Milton.

Hamilton

Population (2018): 576,439
GTHA emissions: 19%
Land Area: 481 km^2
GTHA population: 7.5%



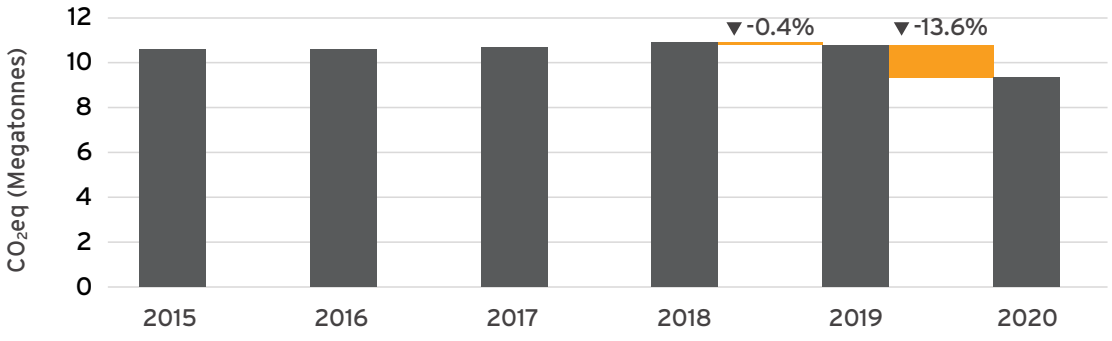


Figure 24: Total Hamilton emissions 2015-2020

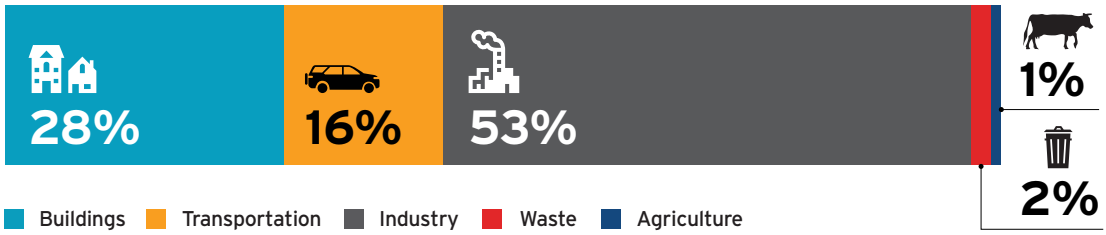


Figure 25: Percent emissions by sector 2020

Hamilton Spotlight:

- Hamilton has the largest per capita emissions in the GTHA.
- 53.0% of Hamilton's emissions come from industry, representing 55.6% of the GTHA's industrial emissions.
- Emissions decreased less than 1.0% in 2019 and 13.6% in 2020. The 2020 decrease is a result of pandemic-related impacts and expected to be temporary.
- Hamilton had a moderate drop in emissions from transportation in 2020 when compared to other regions.

Innovation in Hamilton: The federal government is investing $400 million in Hamilton-based steel manufacturer ArcelorMittal Dofasco toward its $1.7 billion project to phase out coal-fired steelmaking at its facilities. ArcelorMittal Dofasco is the country's largest producer of flat-rolled steel and the largest private-sector employer in Hamilton.[6] The project would reduce greenhouse gas emissions by up to 3 million tonnes per year by 2030, about a third of Hamilton's emissions.

Peel

Peel includes the cities of Brampton and Mississauga and the Town of Caledon

Population (2020): 1,535,950
GTHA emissions: 21%
Land Area: 1,247 km^2
GTHA population: 19.9%

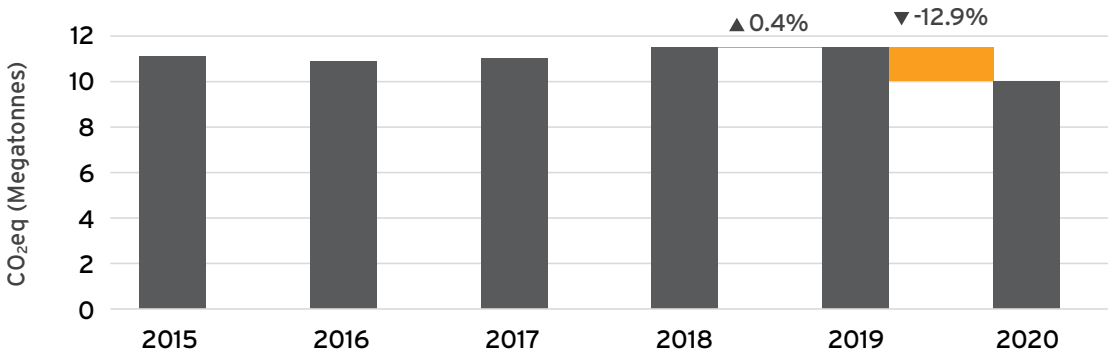


Figure 26: Total Peel emissions 2015-2020

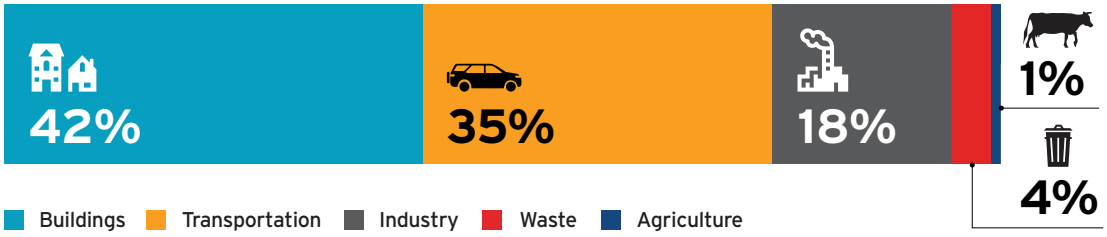


Figure 27: Percent emissions by sector 2020

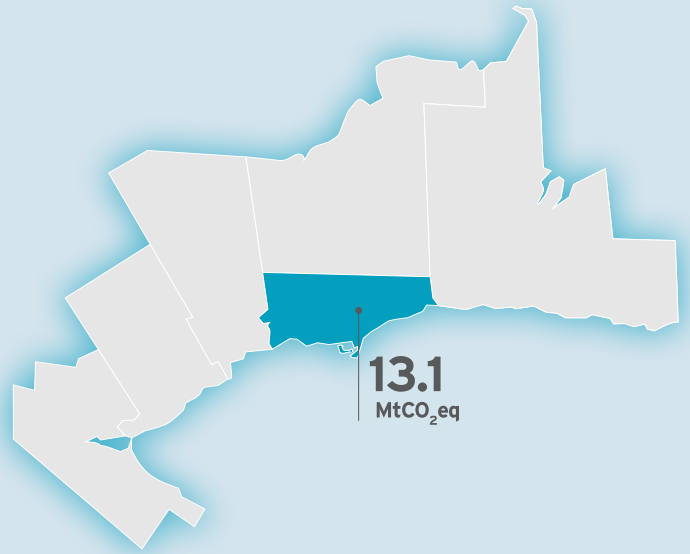
Peel Region Spotlight:

- Peel has the second biggest population, and second largest emissions in the GTHA after Toronto.
- Emissions increased less than 1% in 2019 and decreased 12.9% in 2020. The 2020 decrease is a result of pandemic-related impacts and expected to be temporary.

Innovation in Peel: As the densest region after Toronto, Peel has an opportunity to reduce transportation emissions by building transit and electrifying transportation. Peel is in the process of developing a region-wide EV strategy to be completed in 2022,[7] and MiWay is partnering with the Canadian Urban Transit Research and Innovation Consortium on a hydrogen fuel-cell electric bus pilot project.[8]

Toronto

Population (2020): 3,121,150
GTHA emissions: 27%
Land Area: 630 km^2
GTHA population: 40.4%



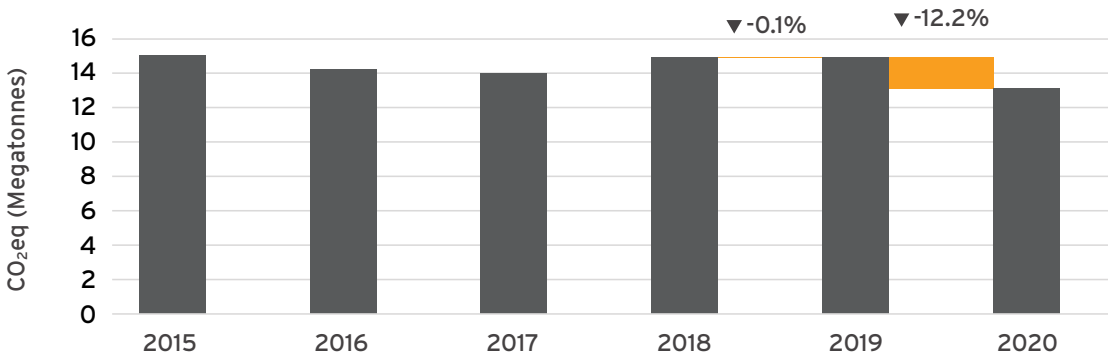


Figure 28: Total Toronto emissions 2015-2020

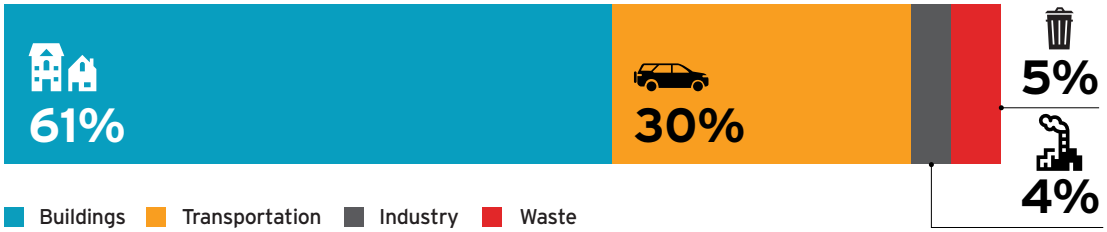


Figure 29: Percent emissions by sector 2020

Toronto Spotlight:

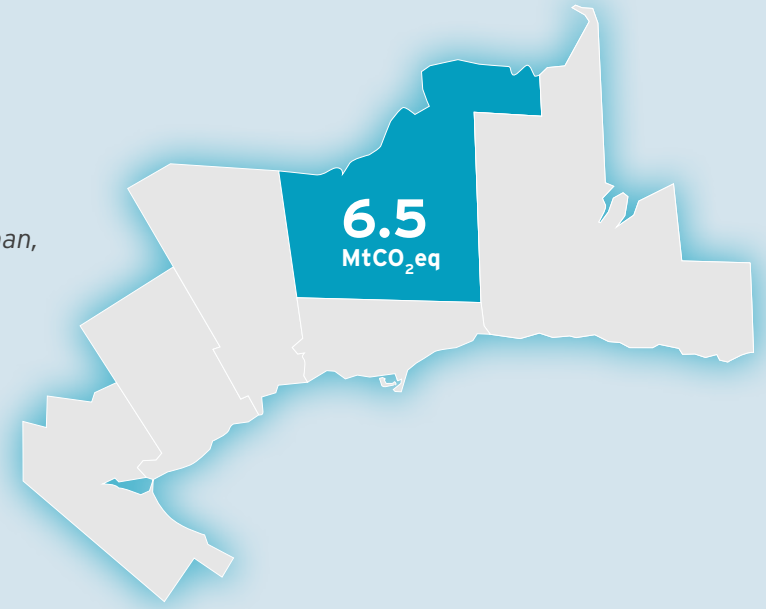
- Toronto is the densest area in the GTHA, with the highest overall emissions but the lowest emissions per capita in the region.
- Emissions decreased less than 1% in 2019 and 12.2% in 2020. The 2020 decrease is a result of pandemic-related impacts and expected to be temporary.
- Toronto was successful in reaching its 2020 target of reducing emissions 30% below 1990 levels by 2020, a massive undertaking. However, reaching 65% reduction by 2030 and the new net zero by 2040 target will require accelerated action and significantly more investment than is in play today.

Innovation in Toronto: 61% of Toronto emissions came from buildings in 2020, so buildings represent a major opportunity to decarbonize. Toronto is the first municipality in the region to commit to developing mandatory emissions performance standards for buildings as part of the Net Zero Existing Buildings Strategy.[9] Detailed policy development will need to be completed in 2022, and will provide a model that other cities can adapt.

York

York Region includes the cities of Markham, Richmond Hill, and Vaughan, and the towns of Aurora, East Gwillimbury, Georgina, Newmarket, and Whitchurch-Stouffville, and the Township of King.

Population (2020): 1,187,800
GTHA emissions: 14%
Land Area: 1,762 km^2
GTHA population: 15.4%



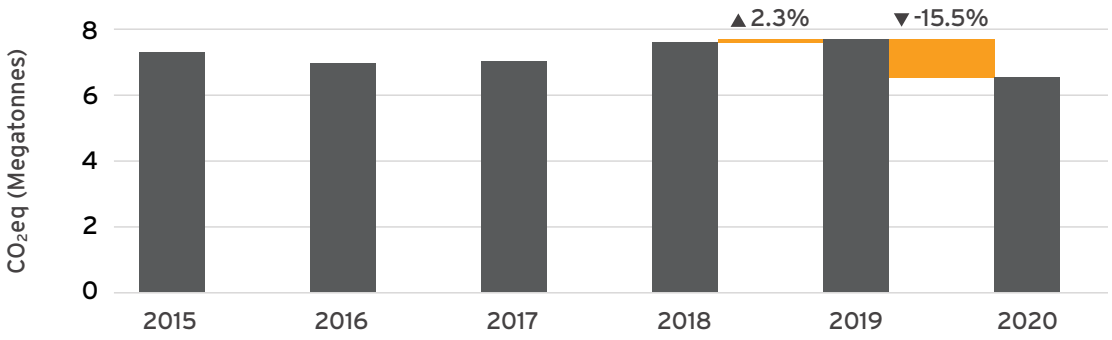


Figure 30: Total York emissions 2015-2020

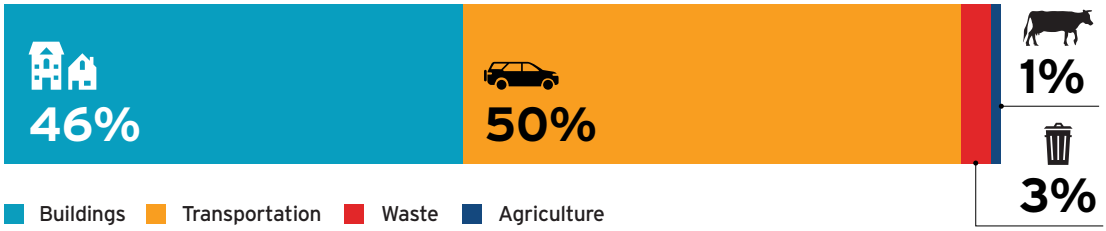


Figure 31: Percent emissions by sector 2020

York Region Spotlight:

- York Region has the highest transportation emissions per capita in the region.
- Emissions increased 2.3% in 2019 and decreased 15.5% in 2020. The 2020 decrease is a result of pandemic-related impacts and expected to be temporary.

Innovation in York Region: Alectra, the local utility in York Region is running several innovative grid modernization programs that enable distributed energy resources and improve the resilience of the grid.[10]

Recommendations for Policymakers

BUILDINGS

POLICY	VISION FOR A NET ZERO FUTURE
Advance net zero new buildings. Natural gas and electricity consumption increases with population growth, so all new buildings should be built to net zero-ready standards. Policy mechanisms include municipal green development standards and national and provincial building codes. **Develop energy performance standards for existing buildings.** All buildings in the GTHA will have to be retrofitted to reach net zero. Policy mechanisms required to pick up the pace of retrofits include creation of a provincial and federal retrofit code and developing municipal standards.	Homes and workplaces are built to 21st century standards. These buildings will accommodate EV charging, be more affordable to operate, more resilient to extreme weather, and increase indoor environmental health and comfort for residents and occupants. They'll also add good, green jobs.
Procure all cost-effective conservation of natural gas. Direct Enbridge to secure all cost-effective conservation. Policy mechanisms include improving and accelerating the Demand Side Management Framework.	Efficient natural gas usage means affordable energy bills and better indoor air quality for people, and reduced greenhouse gas emissions.

ELECTRICITY

(Buildings, industry, and transportation)

Phase out gas fired electricity and modernize the grid as soon as possible. Develop a federal clean electricity standard to mandate a net zero imperative and ensure a reliable, smart, and green grid for Ontarians. **Procure electricity conservation.** Direct IESO to secure all cost-effective conservation of electricity. Policy mechanisms include the Conservation and Demand Management Framework.	A modern electricity grid is resilient, affordable, responsive, and features greater distributed energy resources including renewable energy and other innovations.

TRANSPORTATION

Implement Zero Emissions Vehicle mandate. Implement a mandatory Federal ZEV mandate with progressively increasing fuel efficiency standards, mandatory incremental sales targets, and plan to increase the supply of ZEVs for purchase.	Reducing emissions from the transport industry is vital for healthy cities and lowering our GHG emissions as we increasingly electrify our systems.
Adopt the Federal Clean Fuel Standard. the Clean Fuel Standard must be strengthened and delivered on schedule and include a "guardrail" in order to meet emissions targets.	Transportation emissions plummet by 2030, and a robust market for Zero Emissions Vehicles provide new jobs for workers and create new opportunities for investment.
Invest in clean transportation infrastructure: including electric transit, active transportation, and EV charging infrastructure	Convenient and equitable access to EV charging, transit, 15-minute cities, and active transportation facilities reduces air pollution and makes communities safer and more vibrant and strengthens local economies.

APPENDIX A

Methodology

TAF generally follows the guidelines in the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories and attempts 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.

The results in this inventory may differ from results in the emissions inventories published by individual municipalities or specific regions. This is due to differences in data sources and methodologies. For example, TAF's approach for estimating transportation and waste emissions is different from the approach taken by the City of Toronto for the TransformTO project, which explains the discrepancies in the results. Further, our methodology is affected by the availability of comparable data from every GTHA region.

Results from emissions inventories are conditioned by the methodology employed, information available and assumptions made, in a complex process which sometimes doesn't provide an optimal solution. One solution is not necessarily better than another, so comparing results from two different inventories is usually misleading.

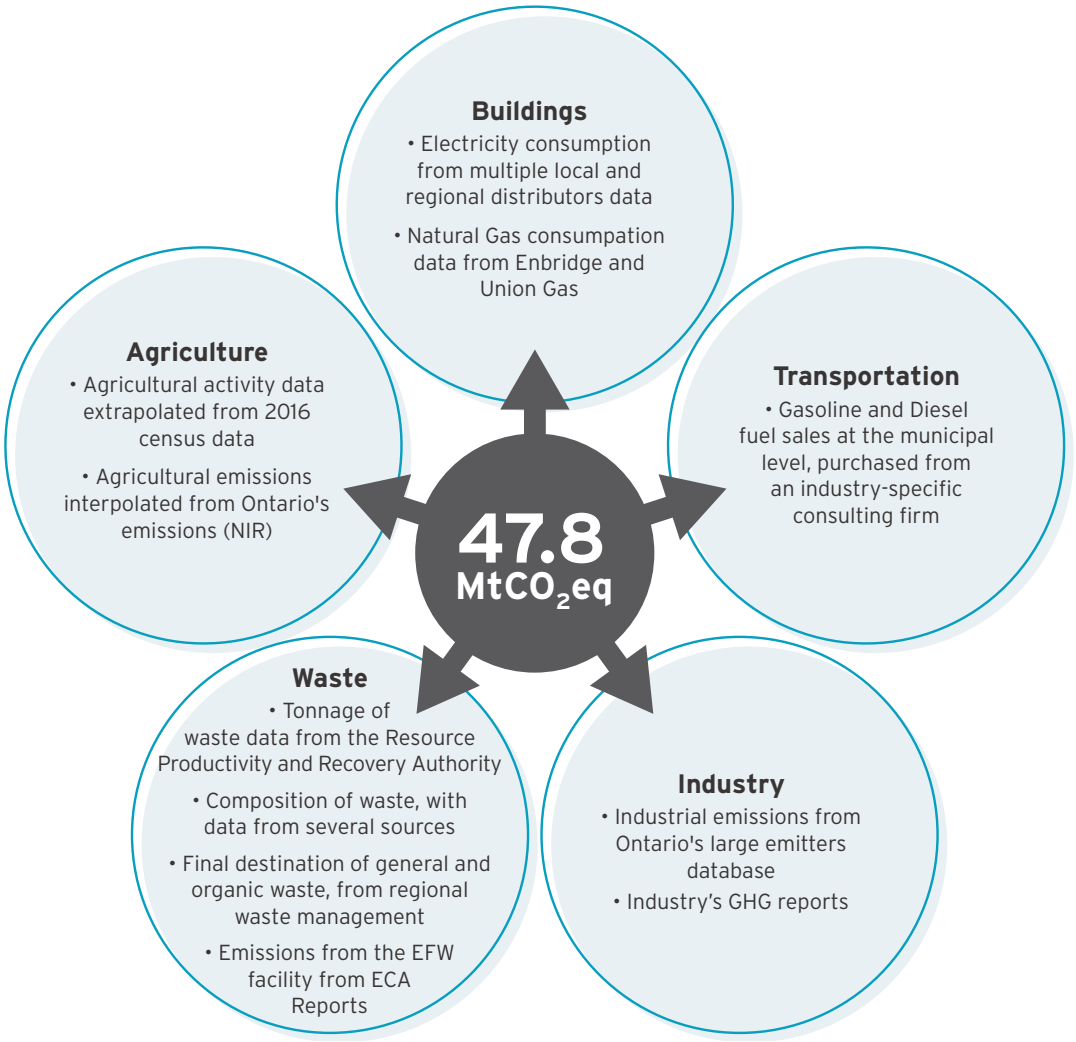


Figure A1: Overview of the sources of emissions used to compile this inventory (2020 emissions)

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, 83.8% of residential energy use and 93.3% of commercial and institutional energy use comes from these two energy sources.[11] Cities likely use an even higher proportion of energy use from natural gas and electricity, given that these services have long been available and easily accessible in urban areas. TAF does not calculate propane, heating oil, wood, and coal emissions as we estimate 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.

TAF obtains natural gas consumption data from Enbridge Gas. We do not account for leakage of natural gas during local distribution and upstream emissions from the mining and refinement of natural gas. Natural gas consumption in 2020 has been extrapolated for City of Hamilton and Halton Region based on changes in consumption in other regions, since the data available for those two regions was deemed unreliable. Those values will be updated in future inventories if more data is made available.

TAF obtains 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 LDCs, with some LDCs providing electricity to more than one municipality. Electricity consumption for some small municipalities was interpolated based on a strong correlation between historic population and consumption values for the GTHA. Municipalities with interpolated electricity consumption are Caledon, Georgina, Whitchurch-Stouffville, East Gwillimbury, Pickering, Clarington, and Scugog.

Electricity consumption could include sources that are not associated with buildings such as EV charging, street lighting, or transit operations. TAF does not disaggregate those sources due to inconsistencies in available data across the region. Further, we do not consider electricity imports and exports in 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 are multiplied by emissions factors from Canada's 2021 National Inventory Report featuring 2019 GHG emissions. The 2019 natural gas and electricity emission factors are 0.001888 tCO_2eq/m^3 and 0.000030 tCO_2eq/kWh respectively. The 2019 natural gas emissions factor was used for 2020. Electricity emission factor of 0.000031 tCO_2eq/kWh was used for 2020.[12]

Transportation

TAF calculates transportation emissions using gasoline and diesel fuel sales data from Kent Group Limited. Kent Group Limited's coverage is about 99% of public gas stations in the GTHA. Diesel fuel from bulk contracts and cardlock sales is not included in this dataset, underestimating diesel emissions in the region; while gasoline sales in the GTHA account for 42% of Ontario's total consumption (an expected value based on population and economic activity), our diesel data accounts only for 10% of the province's consumption.[13] This value has not been extrapolated because retail diesel trends are not typically correlated with retail gasoline trends, increasing the uncertainty associated with any possible estimation. The transportation emissions data does not account for private sales, railway, marine, transit, or local aviation emissions.

Ontario's renewable fuel standard requires at least 5% of gasoline sold to be from a renewable source so it was assumed that 5% of gasoline sales were ethanol with a 34% reduction in emissions (United States Environmental Protection Agency, 2014; Ministry of Environment and Energy[14]). Similarly, due to the Greener Diesel regulation, 4% of diesel sales were assumed to be bio-based with a 30% reduction in emissions.[15]

Fuel sales occurring in each top-tier municipality are allocated to the respective municipality's emissions inventory. We took this approach for simplicity. A reasonable alternative method would be to attribute the emissions to the municipality in which the fuel is consumed. We analyzed the Transportation Tomorrow Survey[16] origin-destination data from 2016 to identify the potential difference an alternative methodology might make, but the effect of including the origin-destination

variable is negligible in the overall results for each region.

The figures below show emissions by municipality and emissions split between gasoline and diesel for 2019 and 2020. National Inventory Report's gasoline and diesel's emission factors for 2019 were used for both 2019 and 2020 transportation emission estimation.[17]

Fuel sales data accounts for 90% of total transportation emissions in the GTHA including gasoline passenger cars and trucks, gasoline commercial vans and pick up trucks, and diesel light commercial trucks. However, it excludes the diesel from heavy commercial trucks which account for 7% of transportation emissions (the remaining is associated with transit emissions).[18] We multiply fuel sales emissions by 1.08 to account for heavy commercial trucks in the GTHA. While we use this value for 2020, it is reasonable to assume that the pandemic hasn't affected freight and private transportation to the same degree. If the value for freight is proved to be higher, the results will be updated in subsequent inventories.

Top-Tier Municipality	Year	Gasoline Emissions (tCO_2eq)	Diesel emission (tCO_2eq)	Total Fuel Emissions (tCO_2eq)
Durham Region	2019	1,918,942	149,466	2,068,408
Durham Region	2020	1,475,337	133,527	1,608,865
Halton Region	2019	1,412,005	161,560	1,573,564
Halton Region	2020	1,139,273	140,976	1,280,249
Hamilton	2019	1,470,309	131,327	1,601,637
Hamilton	2020	1,235,295	123,363	1,358,657
Peel Region	2019	3,733,324	359,085	4,092,409
Peel Region	2020	2,926,951	322,673	3,249,624
Toronto	2019	4,303,019	342,249	4,645,268
Toronto	2020	3,347,357	300,331	3,647,688
York Region	2019	3,503,314	345,105	3,848,419
York Region	2020	2,697,190	303,999	3,001,188
GTHA	2019	16,340,913	1,488,792	17,829,705
GTHA	2020	12,821,402	1,324,869	14,146,271

Figure A2: Transportation fuel emissions by top-tier municipality in the GTHA 2019 and 2020

Waste

TAF uses the methane commitment approach to calculate emissions from waste. Using this method, 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 landfills and the degradable organic carbon (DOC) portion of the waste. Residential waste tonnage is extrapolated from previous years, since the Resource Productivity & Recovery Authority (RPRA) (Resource Productivity & Recovery Authority, 2016) data wasn't available at the time of writing the report. Recalculations will be made next year with the actual data if needed. Commercial and industrial waste tonnage is extrapolated using Statistics Canada CANSIM Table 153-0041 which showed for every tonne of residential waste disposed

1.53 tonnes of non-residential waste were disposed of in 2018 (Statistics Canada, 2018). This proportion would have changed due to the impacts of lockdown measures in 2020, where a shift from commercial to residential waste is expected and already reported in preliminary data in some regions.

DOC values are calculated by using standard factors for each type of waste disposed of requiring waste audit and composition data to be available. Assumptions are made when 'other' is listed as a category in the waste audit. The following figure summarizes the data available to TAF:

Source	Sector	Year	Methane Generation Potential (LO) (tCH_4 per tWaste)	DOC	DOC CATEGORY					
					Food (A)	Garden/ Plant (B)	Paper (C)	Wood (D)	Textiles (E)	Industrial Waste (F)
Toronto Environmental Alliance (Toronto Environmental Alliance, 2016)	Single Family	2015	0.054	0.1619	0.41	N/A	0.2	N/A	0.06	0.04
Toronto Environmental Alliance (Toronto Environmental Alliance, 2016)	Multi-family	2015	0.064	0.1926	0.54	N/A	0.24	N/A	0.04	0.04
Torrie Smith Associates (2017)	Non-residential	2014	0.070	0.2114	0.22	0.02	0.35	0.08	N/A	N/A

Figure A3: Waste composition data sources and values

For the residential sector, TAF uses the waste composition provided by the Toronto Environmental Alliance to calculate the DOC as the data was collected in 2015, a year that is covered by 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 is 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%, as suggested by the US EPA (United States Environmental Protection Agency). Canada's National Inventory report estimates a reduction of emission of about 38% from landfill gas recovery, but the percentage in the GTHA is presumed to be much higher than that based on the quantity of methane the region's landfills capture, hence our use of the US EPA's value (Government of Canada, 2019). OX, F, DOCf, 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 two energy-from-waste facilities, the Durham York Energy Centre and Peel region's Emerald Energy from Waste Inc. In 2019, the Durham York Energy Centre facility emitted 71,070 TCO_2eq (Environment and Climate Change Canada, 2017). 23% of the facility's capacity is used to process York Region waste while the remaining 77% is used to process Durham Region waste. We used these proportions in our emissions analysis (Durham York Energy Centre). In 2019, the facility generated 114,066 MWh of electricity of which 96,734 MWh were exported to the grid[19]. The Emerald facility's emission is accounted in industrial emissions due to the lack of information on the amount of waste sent to incineration.

We also include CH4 and N2O emissions from organic waste treatment, both aerobic and anaerobic. Organic waste data was obtained from the Resource Productivity & Recovery Authority (RPRA) (Resource Productivity & Recovery Authority, 2016). The type of organic waste processing is determined by reviewing the waste management plans of each region and through direct consultation with waste management areas. The emission factors applied are 4 g CH4/kg waste and 0.3 g N2O /kg waste for aerobic digestion (composting) and 1 g CH4/kg waste and 0 g N2O /kg waste for anaerobic digestion.

We assumed zero emissions from wastewater since the methane in digester gas is biogenic, which is either flared or used to offset the 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 do not account for the emissions from the end-uses of wastewater sludge.

Agriculture

TAF estimates agricultural emissions by proportioning Ontario's agricultural emissions in Canada's National Inventory Report based on Statistics Canada's Census of Agriculture. Livestock emissions are proportioned based on the head count of cattle and emissions from manure management, and agriculture soils are proportioned based on area of farmland.

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

Industrial

Industrial emissions are from Ontario's 2019 greenhouse gas emissions reporting by large emitters (>25,000 tCO_2eq/year and smaller emitters that report voluntarily) (Ministry of Environment, Conservation and Parks, 2021[20]).

For 2020, since the large emitters database wasn't available at the time of writing this report, emissions from the main industrial sources in the regions have been directly obtained from the facilities when possible. Other sources such as Climate Trace, with national-level data, are used to fill the data gaps. Uncertainty associated with one third of our industrial emissions is high, therefore recalculations will be made next year with the actual data if needed.

TAF assumes the emissions from power generating facilities are already included in the electricity grid emissions and combined heat and power plants[21] emissions are captured by the natural gas consumption data, thus we exclude those two sources. By excluding these two sectors, most of the remaining emissions should be from industrial processes. However, some natural gas emissions may be double counted as large emitter's reporting does not disaggregate the sources of emissions.

APPENDIX B

Recalculation

To make meaningful comparisons between different years, it is necessary to ensure consistency in the data set and methodology over time. Given that some of the data have been updated, the emissions inventory results for 2015, 2016,2017 and 2018 have been recalculated.

	RECALCULATED EMISSIONS				PERCENTAGE CHANGE			
	2015	2016	2017	2018	2015	2016	2017	2018
Natural gas	21,049,448	19,255,041	19,751,547	21,838,093	0.00%	0.00%	-0.58%	-0.58%
Electricity	2,542,945	2,417,875	1,145,382	1,796,754	-0.05%	0.04%	0.20%	0.02%
Transportation	18,163,156	18,508,291	18,891,421	19,038,781	0.00%	0.00%	0.00%	0.00%
Waste	1,876,358	1,768,428	1,762,405	1,810,852	0.00%	0.00%	0.00%	0.00%
Industrial	10,196,112	10,542,031	10,697,094	10,487,855	0.00%	0.13%	0.13%	0.13%
Agriculture	462,636	469,239	465,509	455,911	0.00%	0.00%	2.56%	0.00%
Total GTHA	**54,290,655**	**52,960,905**	**52,713,358**	**55,428,245**	**0.00%**	**0.03%**	**-0.17%**	**-0.20%**

Figure B1: The recalculated emissions inventory results for 2015, 2016, 2017 and 2018

All changes due minor data updates.

APPENDIX C

Weather Normalization

Natural gas and electricity consumption are very sensitive to weather conditions. In the GTHA, natural gas is commonly used as a fuel for space and water heating in the residential and commercial sectors, therefore there is a direct correlation between the daily temperature and natural gas consumption.

To address this variable and make more meaningful comparisons between years, TAF uses a weather normalization method. Weather normalization is achieved by calculating a normalization factor which compares a given year's total heating degree days (HDD) against a 30-year average. An HDD is calculated by taking the difference between the average temperature of any given day and 18°C[3]. For example, if the average temperature of one day is 10°C, this will account for 8 HDD. When this is done for every day of the year, it provides a total value of HDD (Figure C1).

	Heating Degree Days (18°C)
2015	3,769.00
2016	3,464.00
2017	3,518.00
2018	3,765.00
2019	3,929.00
2020	3,516.00
Average 1981-2010	**3,498.20**

Figure C1: The heating degree days varied between 2015 and 2020

The change in HDD for the years covered by this inventory is outlined below in Figure C2.

	Change % in HDD
2015 - 2016	-8.09%
2016- 2017	1.56%
2017-2018	7.02%
2018- 2019	4.36%
2019-2020	-10.51%

Figure C2: The change in heating degree days between 2015 and 2020

There was a significant reduction in the number of HDDs between 2019 and 2020, and this should be reflected in the normalized values for natural gas consumption. Weather normalization also requires estimating the fraction of natural gas used for heating. A report from the Ontario Energy Board and IESO[22] provides the following values:

Natural gas use for space heating	
Commercial	74%
Industrial	79%
Residential	41%

Figure C3: The amount of natural gas used for heating varies by building type

To estimate the fraction of natural gas used for heating in each region, we applied the proportion of residential, industrial and commercial natural gas consumption obtained from Enbridge gas utility data.

	NATURAL GAS USE 2019			Average Use for Space Heating
	Residential	Commercial	Industrial	
Durham	56%	21%	23%	66%
Halton (Burlington data only)	42%	23%	35%	63%
Hamilton	28%	23%	49%	58%
Peel	47%	28%	25%	66%
Toronto	58%	30%	12%	70%
York	63%	29%	8%	71%
GTHA Total				**67%**

Figure C4: The type of buildings in each GTHA region determines the average use of natural gas for space heating.

The fraction of natural gas use that is weather normalized corresponds with the average proportion of natural gas used for space heating. This fraction is divided by the yearly HDD and multiplied by the 30-year average. The normalization results are outlined in Figure C5.

	NATURAL GAS EMISSIONS					
	2015	2016	2017	2018	2019	2020
Durham	1,653,306	1,512,345	1,558,629	1,730,598	1,652,314	1,412,912
Halton	2,052,527	1,816,493	1,816,916	2,070,185	1,960,597	1,752,507
Hamilton	2,653,362	2,580,736	2,542,727	2,736,596	2,761,975	2,468,829
Peel	4,028,241	3,729,888	3,853,472	4,244,362	4,228,430	3,846,196
Toronto	7,839,606	7,084,041	7,322,227	8,062,242	8,063,496	7,321,338
York	2,822,406	2,531,537	2,657,575	2,994,110	3,024,673	2,730,610
GTHA Total	**21,049,448**	**19,255,041**	**19,751,547**	**21,838,093**	**21,691,483**	**19,532,392**

	NORMALIZED NATURAL GAS EMISSIONS					
	2015	2016	2017	2018	2019	2020
Durham	1,574,753	1,522,219	1,552,490	1,642,300	1,521,871	1,407,762
Halton	1,960,007	1,827,744	1,809,760	1,964,561	1,805,818	1,746,119
Hamilton	2,542,243	2,595,588	2,532,712	2,596,970	2,543,930	2,459,830
Peel	3,837,092	3,754,209	3,838,294	4,027,809	3,894,615	3,832,176
Toronto	7,445,410	7,132,988	7,293,386	7,650,894	7,426,921	7,294,652
York	2,677,982	2,549,338	2,647,107	2,841,346	2,785,889	2,720,657
GTHA Total	**20,037,487**	**19,382,242**	**19,673,749**	**20,723,880**	**19,979,043**	**19,461,195**

Figure C5: The emissions and weather normalized emissions for each GTHA region

As shown in the Natural Gas section of the report, normalization has a significant effect on the calculated change in natural gas emissions between 2015 and 2020.

	CHANGE IN EMISSIONS PER CAPITA				
	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020
Durham	-10%	1%	7%	-7%	-15%
Halton	-13%	-2%	10%	-8%	-12%
Hamilton	-3%	-3%	6%	-1%	-12%
Peel	-9%	1%	5%	-1%	-12%
Toronto	-10%	1%	4%	-3%	-11%
York	-12%	4%	10%	-2%	-10%
GTHA Total	**-10%**	**1%**	**6%**	**-3%**	**-12%**

	CHANGE IN NORMALIZED EMISSIONS PER CAPITA				
	2015-2016	2016-2017	2017-2018	2018-2019	2019-2020
Durham	-4%	0%	2%	-9%	-8%
Halton	-8%	-3%	5%	-11%	-4%
Hamilton	1%	-4%	1%	-4%	-5%
Peel	-3%	0%	0%	-4%	-5%
Toronto	-5%	0%	-1%	-6%	-4%
York	-6%	2%	5%	-4%	-3%
GTHA Total	**-4%**	**0%**	**1%**	**-6%**	**-4%**

Figure C6: Weather normalization alters the quantity by which natural gas emissions increased or decreased per capita

Even after normalization, the data still shows similar trends in all GTHA regions for the increase or decrease in natural gas emissions between 2015 and 2020. This implies that the current method for normalization doesn't completely avoid the influence of weather in the comparison – it is very unlikely that all regions would have the same trends in their natural gas consumption if weather was not an influencing factor. There is still uncertainty associated with the normalization data, and there are known problems with the method. However, we still consider the normalization results to enable a better comparison between years of emissions data.

APPENDIX D

Results

	2019 EMISSIONS BY SECTOR (tCO_2eq)							
	Natural Gas	**Electricity**	**Transportation**	**Residential Waste**	**Non-residential Waste**	**Industrial**	**Agricultural**	**2019 Emissions**
Durham	1,652,314	126,630	2,229,666	65,257	91,589	1,672,161	197,663	6,035,280
Halton	1,960,597	134,888	1,696,243	64,053	100,516	222,695	28,802	4,207,795
Hamilton	2,761,975	133,106	1,726,504	83,406	135,626	5,918,721	67,416	10,826,754
Peel	4,228,430	365,792	4,411,464	162,841	264,566	2,029,379	51,466	11,513,938
Toronto	8,063,496	723,935	5,007,425	259,309	376,506	482,002	1,810	14,914,482
York	3,024,673	270,725	4,148,451	75,940	126,648	520	83,644	7,730,600
GTHA Total	**21,691,483**	**1,755,075**	**19,219,755**	**710,807**	**1,095,450**	**10,325,478**	**430,802**	**55,228,849**

	2020 EMISSIONS BY SECTOR (tCO_2eq)							
	Natural Gas	**Electricity**	**Transportation**	**Residential Waste**	**Non-residential Waste**	**Industrial**	**Agricultural**	**2020 Emissions**
Durham	1,412,912	131,441	1,734,296	65,856	92,430	1,482,742	193,710	5,113,386
Halton	1,752,507	144,428	1,380,060	64,773	101,645	216,014	28,226	3,687,653
Hamilton	2,468,829	143,288	1,464,582	85,010	138,233	4,985,003	66,068	9,351,012
Peel	3,846,196	373,631	3,502,973	167,863	272,725	1,819,859	50,437	10,033,684
Toronto	7,321,338	716,470	3,932,071	264,491	384,030	467,542	1,774	13,087,716
York	2,730,610	283,159	3,235,169	76,345	127,323	504	81,971	6,535,081
GTHA Total	**19,532,392**	**1,792,417**	**15,249,151**	**724,337**	**1,116,385**	**8,971,665**	**422,186**	**47,808,533**

Figure D1: Absolute emissions by municipality and sector

	2019 PER CAPITA EMISSIONS					
	Buildings	**Transportation**	**Industrial**	**Waste**	**Agricultural**	**2019 Per capita emissions**
Durham	2.5	3.2	2.4	0.2	0.3	8.6
Halton	3.5	2.8	0.4	0.3	0.0	7.1
Hamilton	5.1	3.1	10.5	0.4	0.1	19.1
Peel	3.1	3.0	1.4	0.3	0.0	7.7
Toronto	2.9	1.6	0.2	0.2	0.0	4.9
York	2.8	3.5	0.0	0.2	0.1	6.5
GTHA Total	**3.1**	**2.5**	**1.4**	**0.2**	**0.1**	**7.3**

	2020 PER CAPITA EMISSIONS					
	Buildings	**Transportation**	**Industrial**	**Waste**	**Agricultural**	**2020 Per capita emissions**
Durham	2.2	2.5	2.1	0.2	0.3	7.2
Halton	3.1	2.3	0.4	0.3	0.0	6.1
Hamilton	4.5	2.5	8.6	0.4	0.1	16.2
Peel	2.7	2.3	1.2	0.3	0.0	6.5
Toronto	2.6	1.3	0.1	0.2	0.0	4.2
York	2.5	2.7	0.0	0.2	0.1	5.5
GTHA Total	**2.8**	**2.0**	**1.2**	**0.2**	**0.1**	**6.2**

Figure D2: Per Capita Emissions by Municipality and Sector

2019	PER CAPITA	
	Natural Gas	**Electricity**
Durham	2.4	0.2
Halton	3.3	0.2
Hamilton	4.9	0.2
Peel	2.8	0.2
Toronto	2.6	0.2
York	2.6	0.2
GTHA Total	**2.9**	**0.2**

2020	PER CAPITA	
	Natural Gas	**Electricity**
Durham	2.0	0.2
Halton	2.9	0.2
Hamilton	4.3	0.3
Peel	2.5	0.2
Toronto	2.4	0.2
York	2.3	0.2
GTHA Total	**2.5**	**0.2**

Figure D3: Per Capita Emissions by Municipality for Natural Gas and Electricity Consumption

Endnotes

1 IESO, 2020. Annual Planning Outlook.

2 The Atmospheric Fund, 2021. A Clearer View of Ontario's Emissions.

3 Pembina Institute, 2021. https://www.pembina.org/media-release/urban-delivery-primed-go-electric-canadian-cities-if-supported

4 C40 Cities, 2018. Consumption Based GHG Emissions for C40 Cities.

5 Durham region, 2018. Low Carbon Pathway.

6 Government of Canada, 2021. ArcelorMittal Dofasco's low-carbon technology.

7 Region of Peel, 2021. Climate Change and Energy Management.

8 City of Mississauga, 2021. Hydrogen Fuel Cell Electric Bus Pilot Project.

9 City of Toronto, 2021. The City of Toronto's net zero existing buildings strategy.

10 Alectra, 2021. Grid innovation.

11 NRCan, 2018. Commercial/institutional sector.

12 The Atmospheric Fund, 2021. A Clearer View of Ontario's Emissions.

13 Statistics Canada, 2018. Sales of fuel used for road motor vehicles.

14 Pembina Institute, 2021. https://www.pembina.org/media-release/urban-delivery-primed-go-electric-canadian-cities-if-supported

15 Government of Ontario, 2017. Greener diesel regulation.

16 University of Toronto Data Management Group, 2018. Transportation Tomorrow Survey Reports.

17 UNFCCC, Canada 2021. National Inventory Report.

18 University of Toronto, TEPs model.

19 Durham York Energy Centre report, 2019.

20 Government of Ontario, 2019. Greenhouse gas emissions reporting by facility.

21 Ibid

22 IESO, 2019. Conservation Achievable Potential Study.

References

City of Toronto. (2015, August 15). *Technical Memorandum No. 1 Current System Summary*. Retrieved 2017, from http://www1.toronto.ca/City%20Of%20Toronto/Solid%20Waste%20Management%20Services/Long%20Term%20Waste%20Strategy/Pdf/Technical%20Memo%20No%201-FINAL%20-%20AODA.pdf:

City of Toronto. (2017, December 5). 2016 Census: education, labour, journey to work, language of work, mobility and migration. Retrieved 2019, from the City of Toronto: https://www.toronto.ca/wp-content/uploads/2017/12/94ce-2016-Census-Backgrounder-Education-Labour-Journey-to-work-Language-Mobility-Migration.pdf

Durham Region. (2018). Waste Management Annual Report. Retrieved 2019, from Durham York Energy Centre: https://www.durhamyorkwaste.ca/Assets/PublicOutreach/2019EnvironmentalAssessment/40038_DR_WASTE_AR_ACCESSIBLE_J2019_FINAL.pdf

Durham York Energy Centre, A. (n.d.) About Durham-York Energy Centre. Retrieved 2019, from Durham York Energy Centre: https://www.durhamyorkwaste.ca/Home/Home.aspx

Durham York Energy Centre, B. (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. (2017). *Facility and GHG Information*. Retrieved from Environment and Climate Change Canada: o 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. (2019). National Inventory Report 1990 – 2017: Greenhouse Gas Sources and Sinks in Canada. Retrieved 2019, from the Government of Canada: http://publications.gc.ca/collections/collection_2019/eccc/En81-4-1-2017-eng.pdf

FleetCarma. (2018). Electric vehicles sales update Q3 2018, Canada. Retrieved 2019 from FleetCarma: https://www.fleetcarma.com/electric-vehicles-sales-update-q3-2018-canada/

Government of Canada. (2019). *National Inventory Submissions 2019*. 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, September 13). Ethanol in gasoline. Retrieved January 18, 2018, from Ontario: https://www.ontario.ca/page/ethanol-gasoline

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

ICLEI, WRI, C40. (2014, December 8). *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

The International Energy Agency. (2018). *Fuel Economy in Major Car Markets, Country database for Canada*. Retrieved 2019, from The International Energy Agency: https://www.iea.org/topics/transport/gfei/#controls

Kelleher, M., Christina, S., & Torrie, R. (2015, November). *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 the Environment and Climate Change. (2015, December). *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

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

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

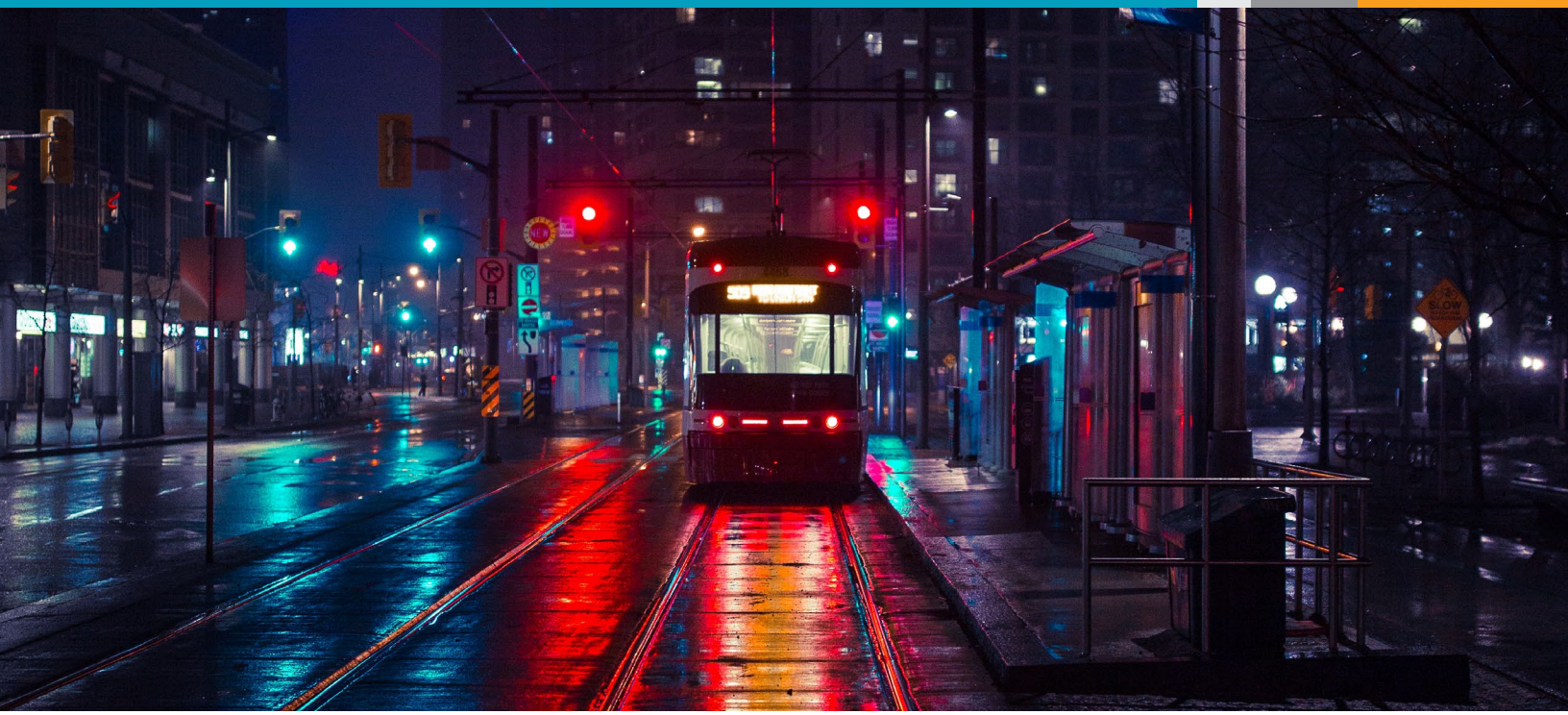
Statistics Canada. (2017). *Disposal of waste, by source, Canada, provinces and territories*. Retrieved 2017, from Statistics Canada: http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1530041&&pattern=&stByVal=1&p1=1&p2=31&tabMode=dataTable&csid=

Statistics Canada. (2019). Table 20-10-0002-01, New motor vehicle sales, by type of vehicle. Retrieved 2019, from Statistics Canada: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=2010000201&pickMembers%5B0%5D=1.7

Toronto Environmental Alliance. (2016, February). *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, April 4). *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



About The Atmospheric Fund

The Atmospheric Fund (TAF) is a regional climate agency that invests in low-carbon solutions for the Greater Toronto and Hamilton Area and helps scale them up for broad implementation. We are experienced leaders and collaborate with stakeholders in the private, public and non-profit sectors who have ideas and opportunities for reducing carbon emissions. Supported by endowment funds, we advance the most promising concepts by investing, providing grants, influencing policies and running programs. We're particularly interested in ideas that offer benefits in addition to carbon reduction such as improving people's health, creating local jobs, boosting urban resiliency, and contributing to a fair society.

For questions or more information about this publication, please contact

MARYAM SHEKARRIZFARD
Carbon & Co-Benefits Quantification Manger
mshekarrizfard@taf.ca

Media contact

JULIE LEACH
Communications Manager
jleach@taf.ca

TAF The Atmospheric Fund