Modelling Toronto's Low Carbon Future

Technical Paper #1: BAP Results

November 10, 2016

SSG SUSTAINABILITY SOLUTIONS GROUP

whatIf?

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TransformTO Modelling Advisory Group

TransformTO Project Team

Executive Summary

The purpose of this analysis is to understand the drivers of emissions and the basis on which the model, CityInSight, has been built from the ground up to reflect the current and future context of the City of Toronto. This analysis in turn will help inform the development of actions to further reduce emissions.

The report describes the integration of the major urban systems to develop a GHG baseline for 2011 and a projection, Build As Planned (BAP). The BAP projection covers the time period from 2012 to 2050 and is designed to illustrate energy use and greenhouse gas emissions for the City of Toronto, if no additional policies, actions or strategies are implemented; that is, it reflects plans, policies, programs and/or projects at the municipal, provincial and federal levels that have been funded (i.e. provincial electric vehicle incentives) or are currently being implemented (i.e. federal fuel efficiency regulations). It does not reflect the Ontario Climate Action Plan in its entirety, as a number of initiatives described within have not currently been implemented or funded (eg. the commitment to net zero energy in Part 9 buildings).

The emissions and energy results presented in this report include those for Toronto as a geographical city (ie. the community within the geographical city boundary), not the City of Toronto as a corporation (ie. the municipal corporation of the City of Toronto).

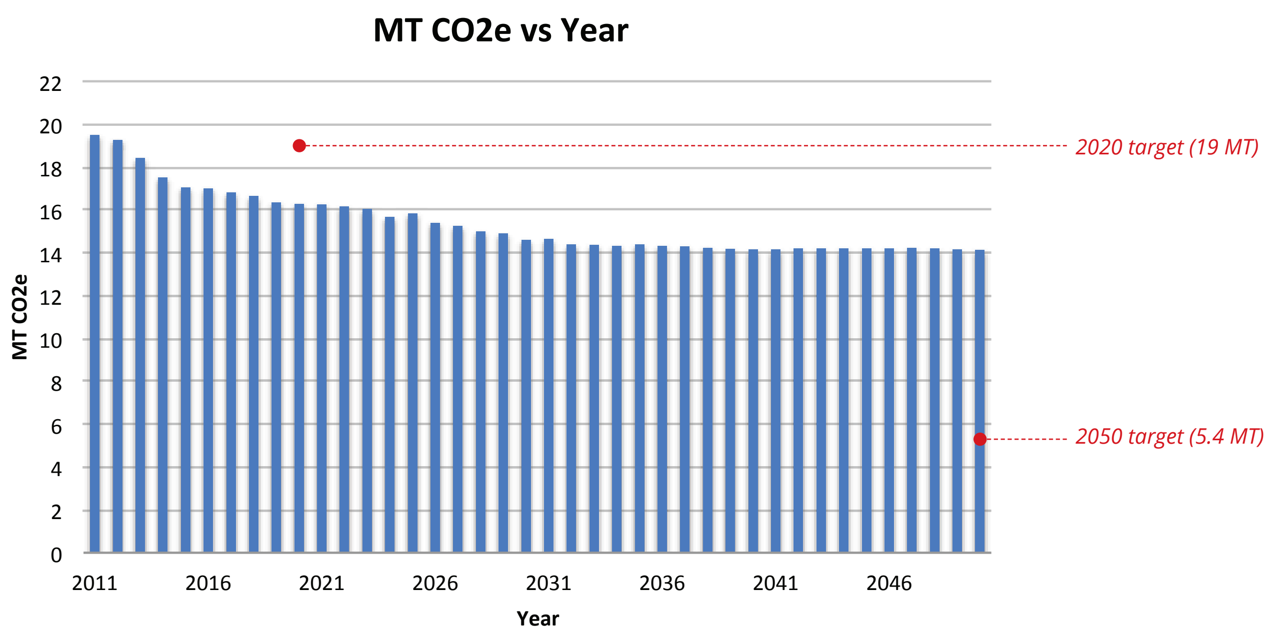


Figure 1. Projected GHG emissions for the City of Toronto, 2011-2050..

MMain findings:

- While population continues to grow, the BAP projections indicate that emissions have a decreasing trajectory, amounting to 16.3 MT CO2e in 2020, and 14.1 MT CO2e in 2050. The primary drivers for this reduction are:
  - Continued decline of grid electricity emissions factor
  - Improving vehicle fuel efficiency standards
  - Decrease in heating degree days (due to a warming climate), partially offset by an increase in cooling degree days.
  - Increase in energy retrofits of existing buildings

- Increased efficiency in new construction
- Increasing numbers of electric vehicles in overall stock of vehicles
- Increasing diversion rates in solid waste.

- The BAP projections indicate that the 2020 target (19MT) will be met, if the assumptions in the BAP (based on currently approved plans and policies) are implemented (Figure 1); but the 2050 target (5,4 MT) will not be met.
- While the City's short term target benefits from greening of the Provincial grid and vehicle fuel efficiency standards, the 2050 target represents a major challenge as the remaining major opportunities are more intransigent.
- The emissions factor for the Provincial grid (electricity) continues to decline. This creates an emissions reduction opportunity for fuel switching for vehicles (private and transit) away from gasoline to electricity.
- Out of all fuel sources, natural gas is the most significant source of emissions; this creates an emissions reduction opportunity for fuel switching to electricity for space heating, as the emissions factor for electricity continues to decline and technologies such as heat pumps to support this transition are available.
- Significant efforts to fuel switch to electricity will require new generation capacity with renewables to ensure that the emissions factor for electricity continues to decline.
- Existing buildings (pre-2011) have a major impact on GHG emissions; the incremental effect of high efficiency new buildings is small, but decreases the upward pressure of an increasing population on the GHG curve. An ambitious retrofit program will be critical.
- Vehicular mode share for external trips is ≈70% (inbound) and 86% (outbound); there is an opportunity to shift this mode share. Outside of the downtown core, the vehicular mode share remains relatively high, even for internal trips.
- Generally, trip lengths are not projected to decline; in spite of a focus on transit oriented development.
- Solid waste emissions are driven by the existing landfills; emissions from new additional waste are overshadowed by the emissions from the waste sitting in closed landfills, which taper off towards the end of the time period considered.

While it appears likely that the City will achieve its 2020 target, depending on how the baseline year is addressed, the magnitude of 2050 target is much more challenging. City-scale investments in buildings and transportation systems can easily last 50 years or more: the key message is therefore, not to linger before focusing on the longer game.

1. Introduction

The City of Toronto's Environment and Energy Division (EED) and Toronto Atmospheric Fund (TAF) are undertaking efforts to model energy and greenhouse gas (GHG) emissions as part of a city-wide project called TransformTO, The modelling aspects of TransformTO, known as *Modelling Toronto's Low Carbon Future*, include developing an action plan for reaching the City's 2020 GHG reduction target, and a decision-support framework focused on achieving Toronto's 2050 GHG reduction target.

The first part of the project involves developing a Build-As-Planned (BAP) scenario to quantify the emissions reductions potentials of Scope 1 and Scope 2 emissions to the year 2050. In order to develop and quantify the BAP scenario, two prior steps are required which include:

- **Data collection:** A data request is compiled and data is collected from various sources. Assumptions are identified to supplement any gaps in observed data. A data, methods and assumptions manual ensures transparency of data and assumptions used.
- **Model calibration and baseline:** The model is built from the ground up starting with people, putting people in dwellings, putting jobs in buildings, developing a surface model of the buildings, identifying how people move around and then undertaking other analysis on waste, industry and land-use. At each stage the bottom-up model is calibrated against observed data, and a baseline year is established.

This document, *Technical Paper #1: BAP Results*, includes modelling results for both the baseline year 2011, and a Build-As-Planned (BAP) scenario out to 2050.

2. About Modelling

The modelling for the baseline year 2011, and BAP scenario out to 2050 were completed using CityInSight.

CityInSight is a comprehensive energy, emissions and finance model developed by Sustainability Solutions Group (SSG) and whatIf? Technologies Inc. (whatIf?) . CityInSight uses the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC Protocol), an international standard for greenhouse gas emissions as an accounting framework.

For detailed information on the modelling approach, and a summary of the data and assumptions used as the foundation for the energy and emissions modeling, refer to *Modelling Toronto's Low Carbon Future: Data, Methods and Assumptions Manual (DMA).*

3. Baseline Results

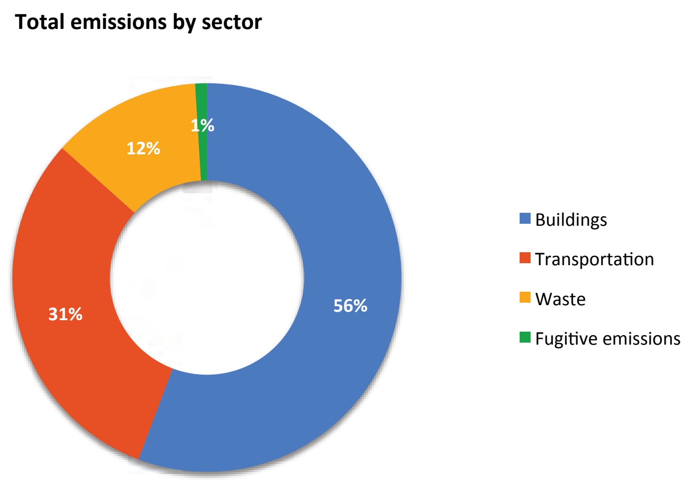
3.1 Total emissions

Total modelled emissions for the City of Toronto for the baseline year 2011 amount to 19.58 Mt (megatonne) of carbon dioxide equivalent (CO2e). A breakdown of emissions by sector are shown in Table 1. The buildings sector stands out as a dominant contributor to overall emissions, accounting for 56% of total emissions (Figure 2). This is followed by transportation at 31%, and to a lesser extent, waste and wastewater. In addition to the major sectors, fugitive emissions from natural gas systems amount to 0.19 Mt CO2e. Fugitive emissions account for unintentional emissions associated with the transportation and distribution of natural gas within the city (through equipment leaks, accidental releases etc.) that is used within the buildings sector.

Refer to Appendix 1 for a breakdown of sector emissions by scope and gas according to the GPC Protocol reporting standard.

Table 1. Total emissions for Toronto, 2011.

Sector	tonne CO2e
Buildings	10,872,000
Transportation	6,024,000
Waste	2,421,000
Fugitive emissions	190,000
TOTAL	**19,507,000**

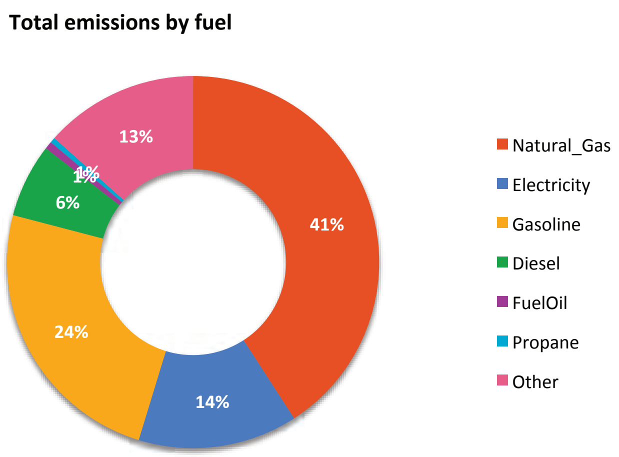


Total emissions ≈ 19,507,000 tonne CO2e

Figure 2. Toronto emissions by sector, 2011.

The buildings and transportation sectors together account for 16,896,000 tonne CO2e; the emissions within these sectors as a direct result of fuel consumption (in comparison with waste, where emissions are as a result of the decomposition of waste).

Of the emissions within buildings and transport, natural gas accounts for 41% (Figure 3). Natural gas is both the largest contributor to total emissions within the buildings sector, and the city overall. Gasoline is the second largest contributor at 24%, and the largest contributor to emissions within the transportation sector.



Total buildings & transport emissions ≈ 16,896,000 tonne CO2e

Figure 3. Toronto emissions by fuel, 2011.

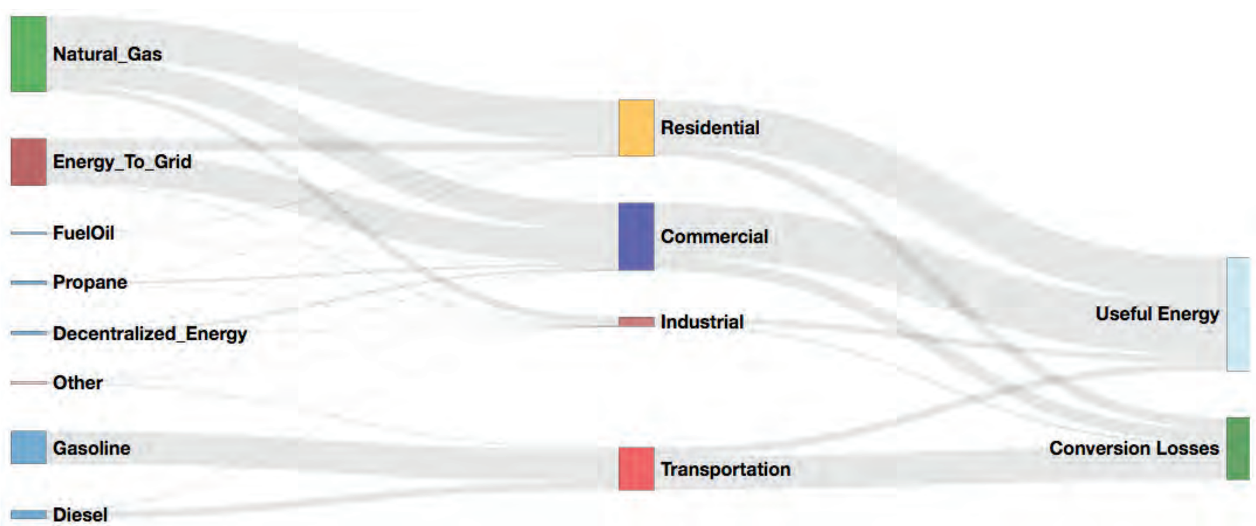


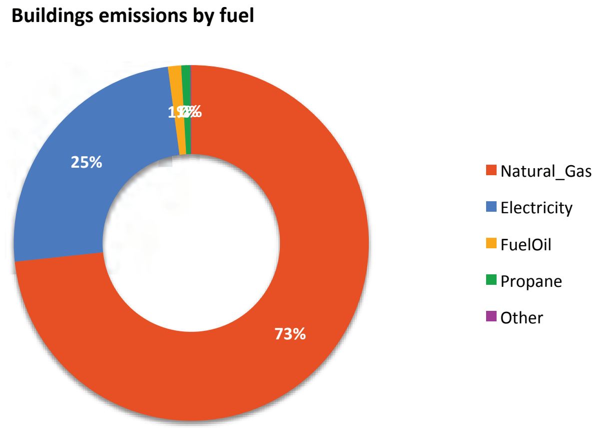
Figure 4. Toronto emissions by fuel, 2011.

3.2 Buildings

3.2.1 Total buildings emissions

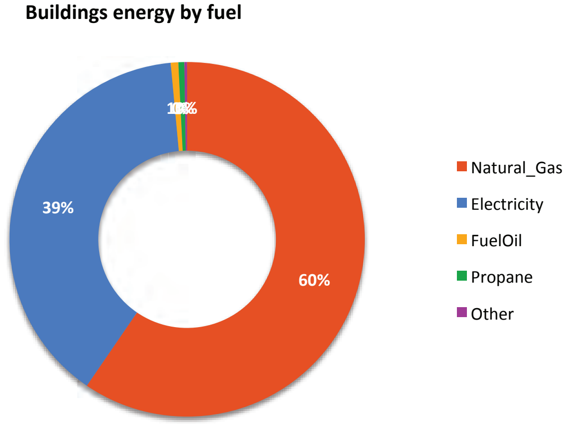
The buildings sector accounts for 10,872,000 tonne CO_2e, approximately 56% of total emissions for the city. Note that the “buildings” category includes residential and non-residential buildings, as well as energy industries, that is, the production of energy. Stationary energy is therefore a more encompassing term; it is also how the GPC classifies this sector.

Natural gas accounts for almost three quarters (73%) of emissions within the buildings sector, followed by electricity at 25% (Figure 5). When looking at energy consumption, natural gas and electricity usage have a narrower difference, with natural gas accounting for 60% and electricity accounting for 39% of energy use (Figure 6). The higher emissions for natural gas compared with electricity are as a result of natural gas having a much higher emissions factor than Ontario’s relatively “clean” electrical grid.



Total building emissions ≈ 10,872,000 tonne CO_2e

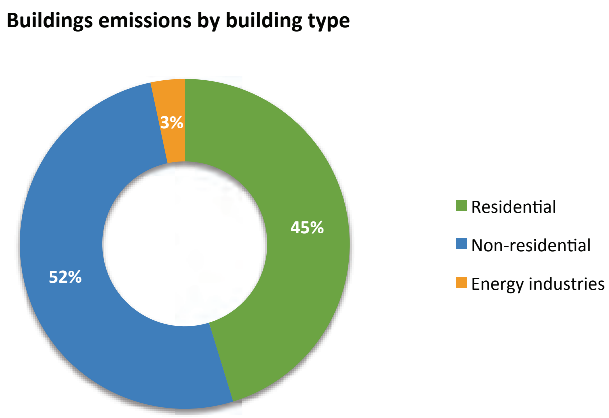
Figure 5. Buildings emissions by fuel, 2011.



Total building energy use ≈ 272,153,000 GJ

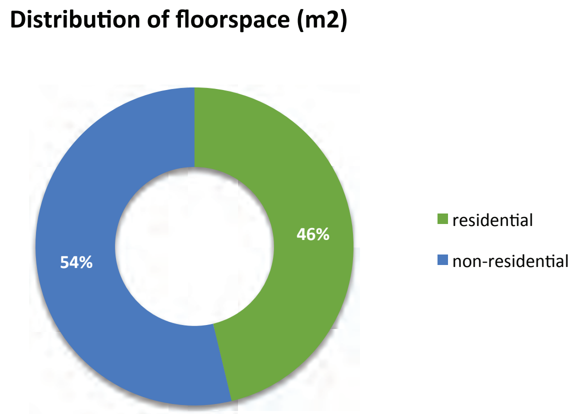
Figure 6. Buildings energy use by fuel, 2011.

The source of buildings emissions are relatively equally distributed between residential and non-residential buildings, with non-residential buildings accounting for just over half (52%) of total buildings emissions (Figure 7). This aligns relatively well with the distribution of residential and non-residential floorspace within the city (Figure 8). Emissions associated with energy industries (energy production, eg. district energy) make up 3%.



Total building emissions ≈ 10,872,000 tonne CO_2e

Figure 7. Buildings emissions by building type, 2011.



Total floorspace ≈ 256,890,000 m2

Figure 8. Buildings floorspace, 2011.

Figure 9 illustrates the distribution of buildings emissions across the city; darker zones represent higher levels of emissions within that zone. Downtown Toronto exhibits higher levels of emissions; this is congruent with the higher building densities that are common in these areas, which drives energy consumption. The buildings in the downtown area are comprised mostly of commercial and high-rise residential floorspace. In contrast, there are certain zones outside of the downtown area (towards the northwest corner of the city), that have higher levels of emissions, but do not exhibit the same level of building densities. These emissions in these zones are driven by non-residential building uses (eg. manufacturing, energy production).

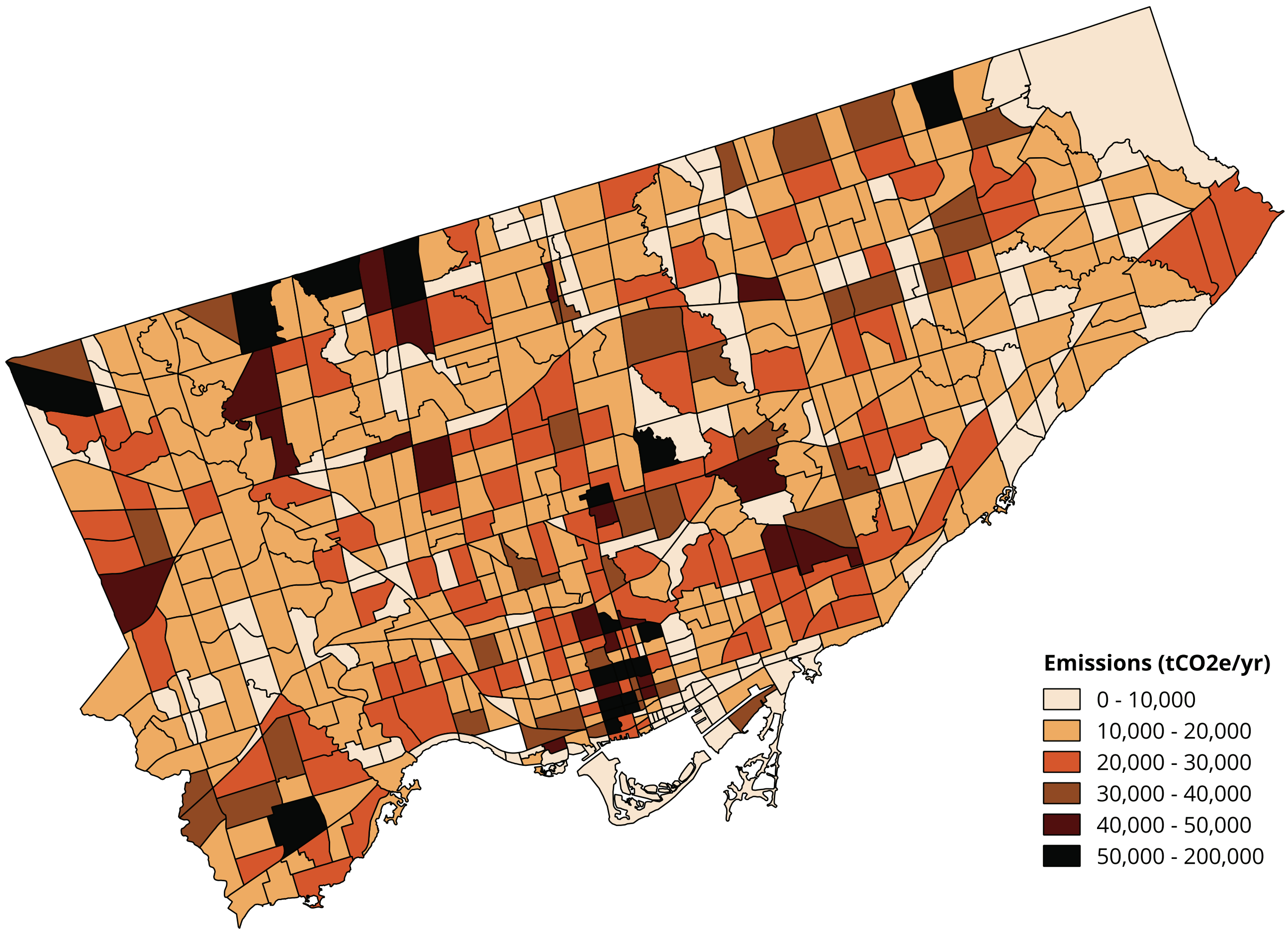
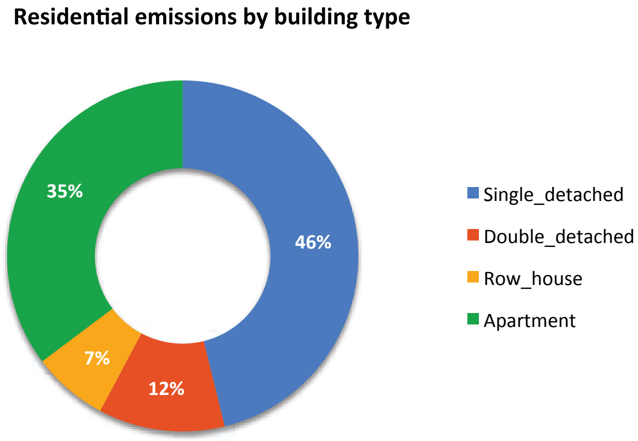


Figure 9. Buildings emissions by zone.

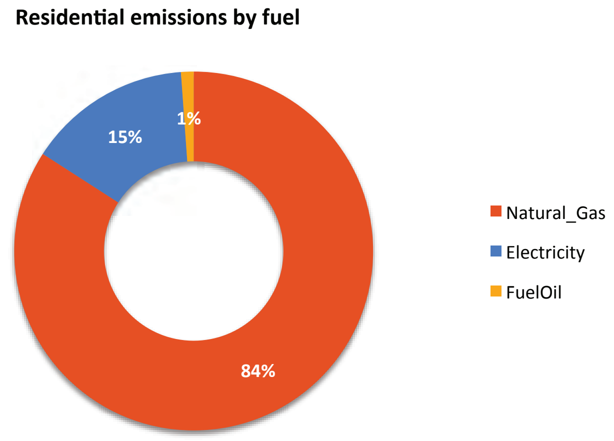
3.2.2 Residential buildings

Residential buildings account for 4,920,500 tonne CO2e. Single family homes account for 46% of emissions, followed closely by apartments with 35% (Figure 10). Residential emissions are significantly dominated by the use of natural gas (Figure 11), accounting for 84% of residential emissions. Together, space heating and water heating account for 78% of energy consumption in residential buildings (Figure 12).



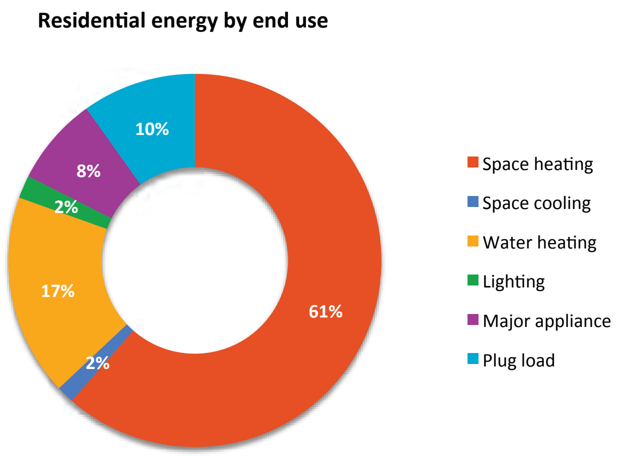
Residential emissions ≈ 4,920,500 tonne CO2e

Figure 10. Residential emissions by buildings type, 2011.



Residential emissions ≈ 4,920,500 tonne CO2e

Figure 11. Residential emissions by fuel, 2011.

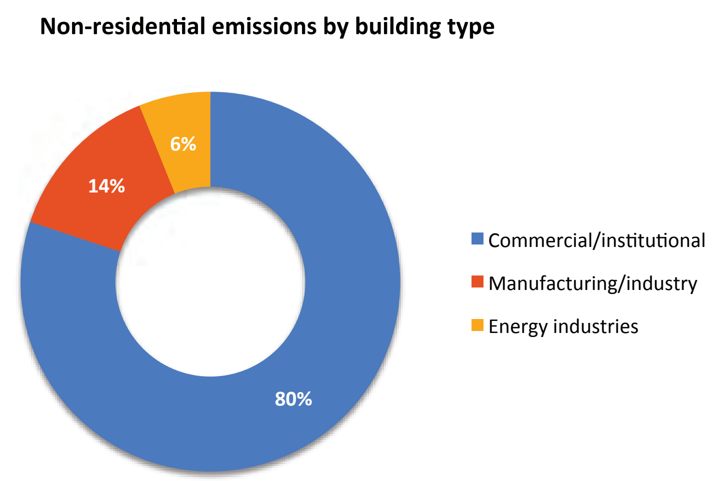


Residential energy consumption ≈ 113,582,000 GJ

Figure 12. Residential energy by end use, 2011.

3.2.3 Non-residential buildings and energy industries

Non-residential buildings and energy industries account for 5,950,500 tonne CO2e. Commercial and institutional buildings account for majority of emissions (80%) (Figure 13), with manufacturing and industries at 14%, and energy industries at 6%.

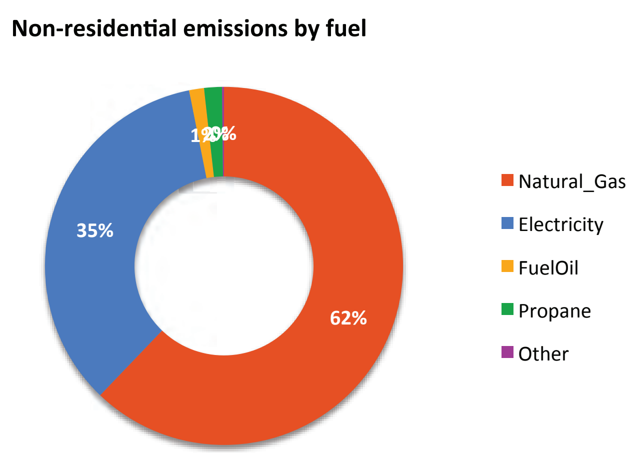


Total non-res and energy industry emissions ≈ 5,951,500 tonne CO2e

Figure 13. Non-res emissions by building type, 2011.

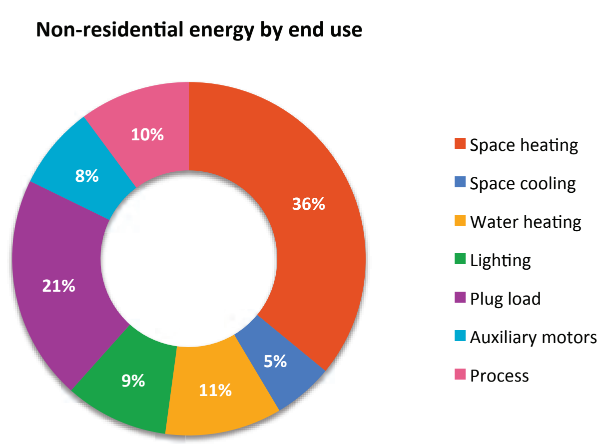
Energy industries account for 363,000 tonne CO2e, and include the emissions from the production of energy within the city boundary, which includes district energy. These emissions are exclusively from the use of natural gas.

When looking at non-residential buildings (commercial, institutional, manufacturing and industry), they account for 5,588,500 tonne CO2e. Similar to residential, non-residential emissions are significantly dominated by the use of natural gas (Figure 14), accounting for 62% of non-residential emissions. In stark contrast to residential buildings, energy end use in non-residential buildings is more widely distributed (Figure 15). Space heating remains dominant (36%), but higher proportions are seen in plug loads (21%), lighting (9%), and process (10%).



Non-residential emissions ≈ 5,588,500tonne CO2e

Figure 14. Non-res emissions by fuel, 2011.

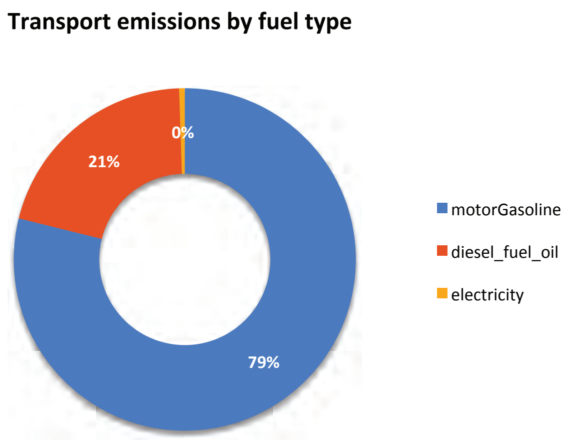


Non-residential energy consumption ≈ 151,295,000 GJ

Figure 15. Non-res energy consumption by end use, 2011.

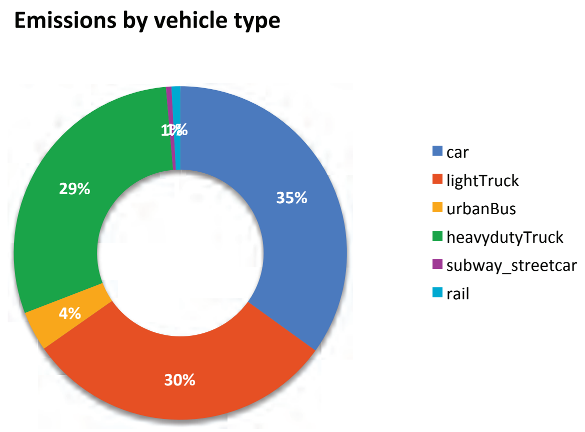
3.3 Transportation

The transportation sector accounts for 6,023,900 tonne CO_2e, approximately 30% of total emissions for the city. Emissions within the transport sector are dominated by gasoline (79%) (Figure 16). A very small portion (0.5%) of emissions were associated with electric vehicle stock; this was attributed entirely to electric transit (streetcars and subways), as personal EV uptake was negligible in 2011. Majority of emissions come from personal vehicles (61%) (Figure 18); however, when looking at vehicle stocks, cars (35%), light trucks (30%) and heavy duty vehicles (30%) contribute to total emissions more equally (Figure 17). This is as a result of a large proportion of light trucks being owned as personal vehicles.



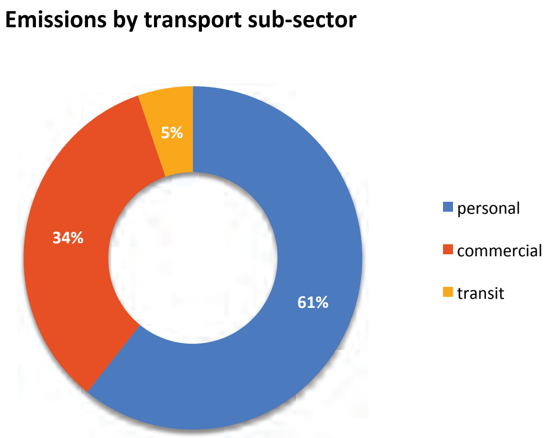
Transportation emissions ≈ 6,023,900 tonne CO_2e

Figure 16. Transport emissions by fuel, 2011.



Transportation emissions ≈ 6,023,900 tonne CO_2e

Figure 17. Transport emissions by vehicle type, 2011.



Transportation emissions ≈ 6,023,900 tonne CO_2e

Figure 18. Transport emissions by sub-sector, 2011.

Mode share is significantly dominated by personal vehicle use (Figure 19); however, higher shares of active transport and transit are more common for internal trips. As trip distances increases when travelling outside of the city boundary (Figure 20), vehicle trips (ie. vehicle mode share) increases.

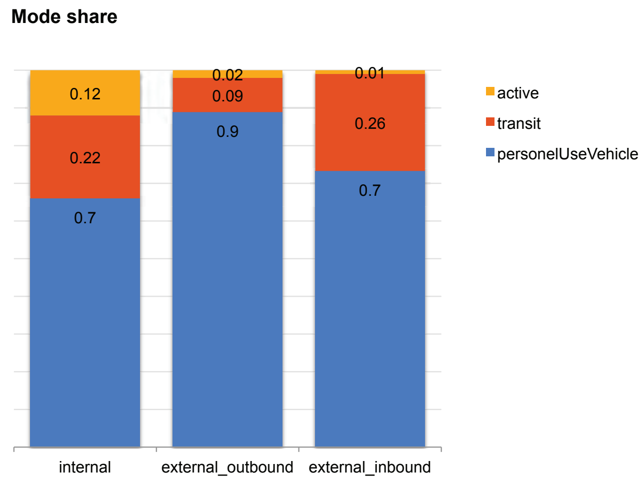


Figure 19. Mode share, 2011.

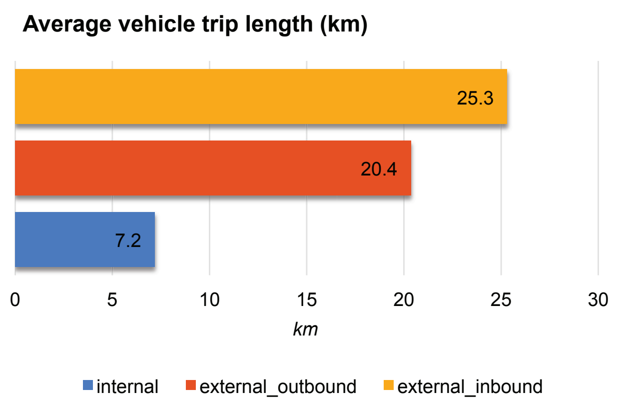
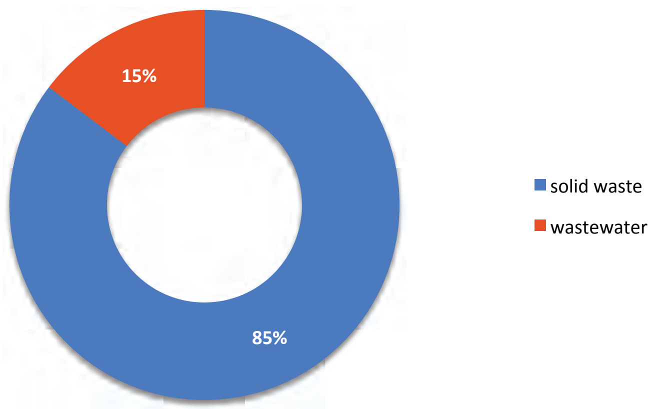


Figure 20. Average vehicle trip length, 2011.

3.4 Waste

The waste sector accounts for 2,421,100 tonne CO2e, approximately 12% of total emissions for the city. Within the sector, emissions from solid waste account for 85%, with the remaining 15% coming from wastewater (Figure 21).

Total waste emissions by waste type



Waste emissions ≈ 2,421,100 tonne CO2e

Figure 21. Waste emissions by sub-sector, 2011.

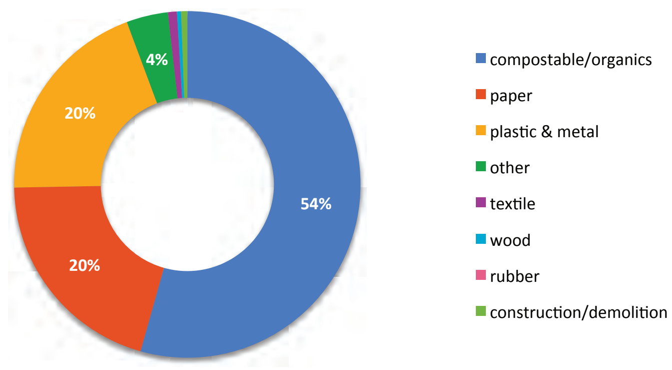
3.4.1 Solid waste

In 2011, Toronto produced over 1 million tonnes of solid waste. More than half consisted of compostable materials (54%), followed by paper (20%) and plastic and metal (20%) (Figure 22). Of this waste, more than half (52%) was sent to landfills, with the remainder being biologically treated (25%), and recycled (23%), and (Figure 23). Biological treatment refers to waste that is treated in a sorting facility through composting and/or anaerobic digestion. Biological treatment emissions are from the Disco Road Organics Processing Facility.

The emissions from this solid waste amount to 2,065,800 tonne CO2e. These emissions come predominantly from landfills (98%), with the remainder from biological treatment (Figure 24). The recycling of solid waste results in zero waste emissions; the emissions associated with the energy used at recycling facilities is accounted for under the buildings sector. Similarly, emissions associated with the transportation of waste are accounted for under the transportation sector.

Landfill emissions include those from both open and closed landfills, including Green Lane, Keele Valley, Brock, Beare and Thackeray.

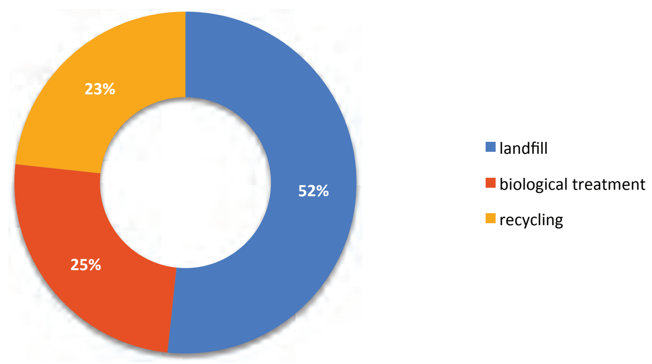
Solid waste tonnage composition



Tonnage of waste ≈ 1,017,340 tonne

Figure 22. Waste tonnage composition, 2011.

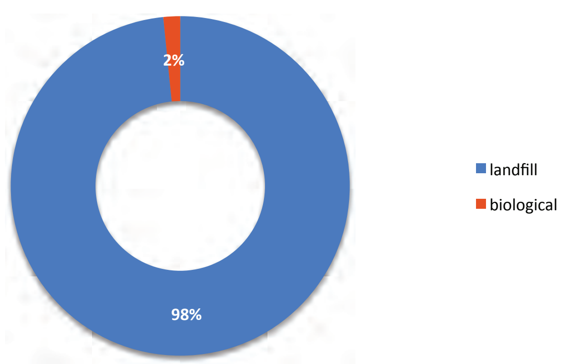
Solid waste tonnage by treatment type



Tonnage of waste ≈ 1,017,340 tonne

Figure 23. Waste tonnage by treatment type, 2011.

Solid waste emissions by treatment type



Solid waste emissions ≈ 2,065,800 tonne CO2e

Figure 24. Waste emissions by source, 2011.

3.4.2 Wastewater

Wastewater emissions amount to 355,300 tonne CO2e, which makes up 15% of total waste emissions for the city (Figure 21). These emissions are as a result of the wastewater treatment of approximately 441,200,000 cubic meters of wastewater that is treated at the Ashbridges, Highland, Humber, and North Toronto wastewater treatment plants.

4. BAP Modelling Process

The Build As Planned (BAP) scenario is a projection over the time period from 2012 to 2050 designed to illustrate energy use and greenhouse gas emissions for the City of Toronto, if no additional policies, actions or strategies are implemented (above those that are currently underway).

The development of the BAP involved a comprehensive review of city policies in the relevant domains, identification of projections that have been developed for specific sectors, a review of Provincial policies, and more than a dozen interviews and discussions with City departments on their plans and activities. The results of this work are summarized in the following sections and a bibliography of documents reviewed is attached at the end of this document.

- The following hierarchy of decision-making was used for developing the Build as Planned scenario:
- Calibrate model and develop 2011 baseline using observed data and filling in gaps with assumptions where necessary;
- Input existing projected quantitative data to 2050 where available:
  - Population, employment & households projections from City by transportation zone
  - Build out (buildings) projections from City by transport zone
  - Transport modelling from City
- Where quantitative projections are not carried through to 2050 (eg. completed to 2041), extrapolate the projected trend to 2050.
- Where specific quantitative projections are not available, develop projections through:
  - Analysing current on the ground action in the City (reviewing actions plans, engagement with staff etc.), and where possible, quantifying the action;
  - Analysing existing policy that has potential impact for the city, and where possible, quantifying the potential impact.

4.1 The city is divided into zones

Zones allow for the exploration of what happens in a smaller unit of geography, as well as providing a structure to describe how people move from one location to another. The 625 transport zones in Toronto were used as the primary unit of analysis (Figure 25); transportation zones are used extensively by the City for projections and analysis.

Figure 25. Transport zones in Toronto.

4.2 Population

4.2.1 How many people?

The population projection provided by the City of Toronto was developed for the SmartTrack analysis and is aligned with the Provincial Growth Plan forecast. In the SmartTrack family of scenarios, the population and employment projection used is labelled "Low" and does not include SmartTrack transit options. The projection is categorized by age and sex year over year, and begins with the base year of 2011.

Figure 26 includes the population by four different age categories over time- notice how a spike in the number of two year olds in 2014 is reflected 20 years later in 2024 in the 22 year old category. In addition to following these bumps over time, the scenario also makes assumptions for fertility, mortality, immigration and emigration. In terms of impact on greenhouse gas emissions, the age composition of the population influences the floor space required; for example, a bump in the number of school-aged children drives floor space for schools. In total, the population is projected to increase from 2.721 million in 2011[1] to 3.40 million in 2041. Figure 27 illustrates the resident population as well as the student population (which is 101,500) by 2050.

Because the TransformTO extends until 2050, CityInSight's cohort-survival population model was used to project the population from 2041 to 2050 - keeping assumptions for immigration, emigration, fertility rates and mortality rates constant or trend-projected - by which point the population increases to 3.497 million.

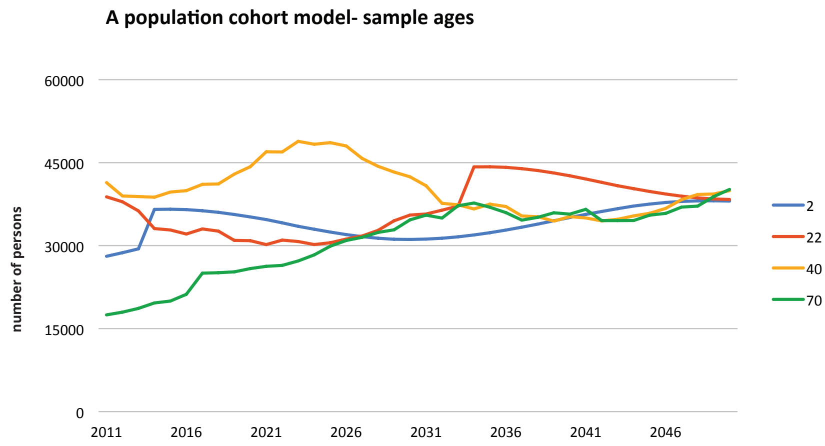


Figure 26. Population over time for different age categories.

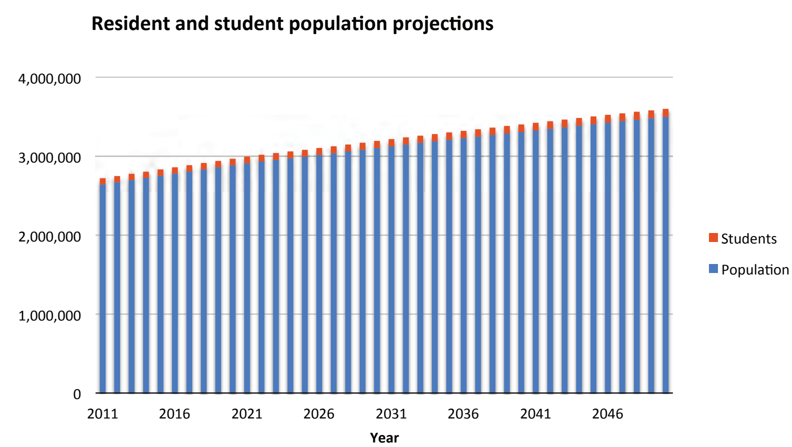


Figure 27. Projected total population.

1 This estimate accounts for census undercount and external students.

4.2.2 Where do people live?

The "Low" scenario converts the projected population into apartments and ground-related housing by traffic zone according to the existing housing stock, potential housing supply and the land-use policies of the Official Plan (pre 2014 Feeling Congested update). In order to provide more detail on the categories of buildings, in the BAP scenario, new dwellings in each transportation zone were distributed amongst dwelling types according to the same proportion of the existing dwelling mix in that zone. For example, the projection provided by the City provides the categories of ground-related dwellings and apartments and these categories are further segregated into the categories that CityInSight uses according to the pre-existing mix of residential buildings types in a zone.

Figure 28 shows new density added to the City by 2050 by apartments buildings of greater than 4 stories. There is a concentration of new development downtown and new development in the Port Lands is also evident; a smaller concentration of new density is found in North York. In comparison, Figure 29 indicates that there are very few single family dwellings added (Note that the same scale applies to both figures). Approximately 95% of new dwellings units between 2011 and 2050 are expected to be apartments, with just under 85% of total new units in apartments greater 4 stories (Figure 30).

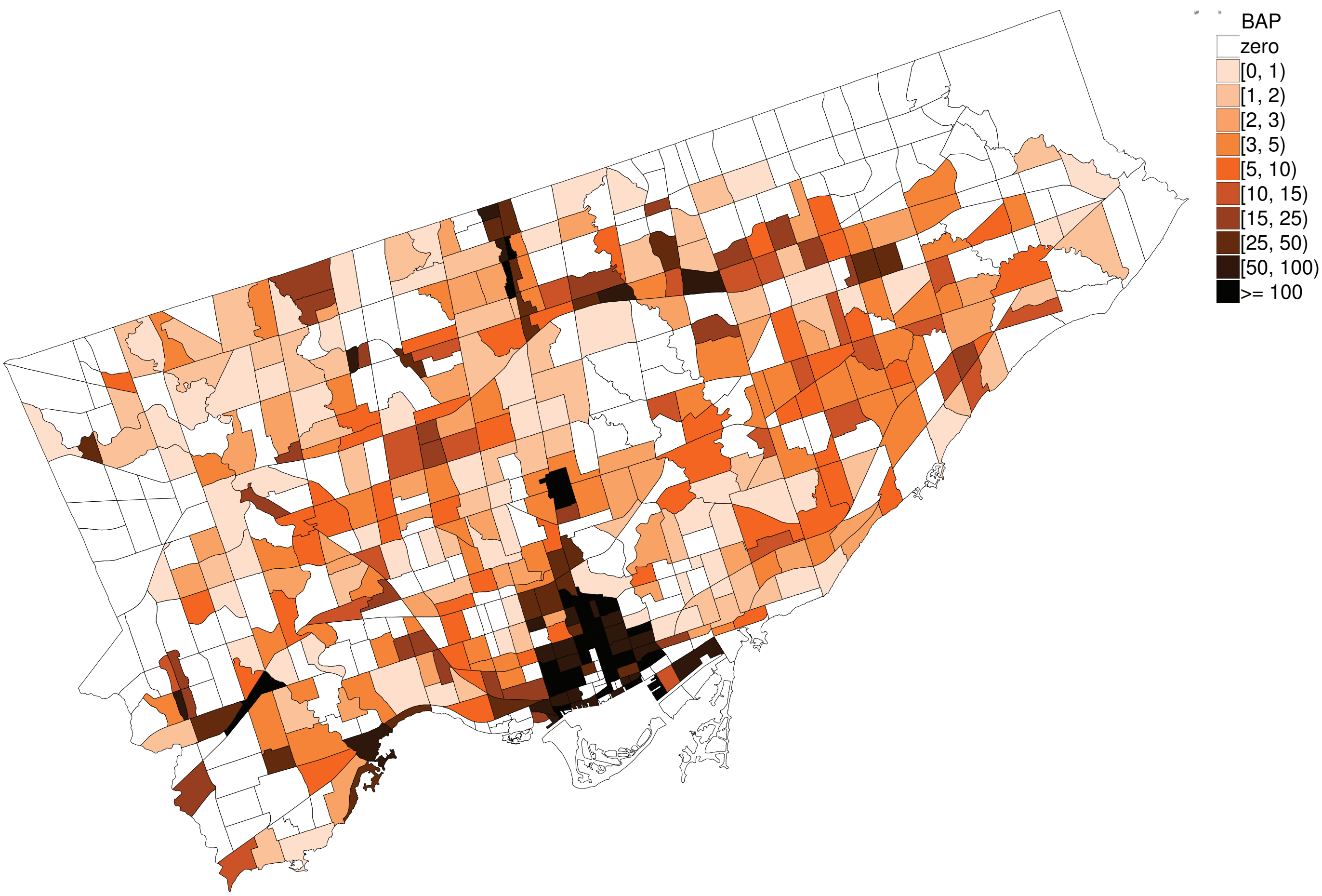


Figure 28. Additional apartments > 4 stories from 2016 to 2050 (dwelling units/hectare).

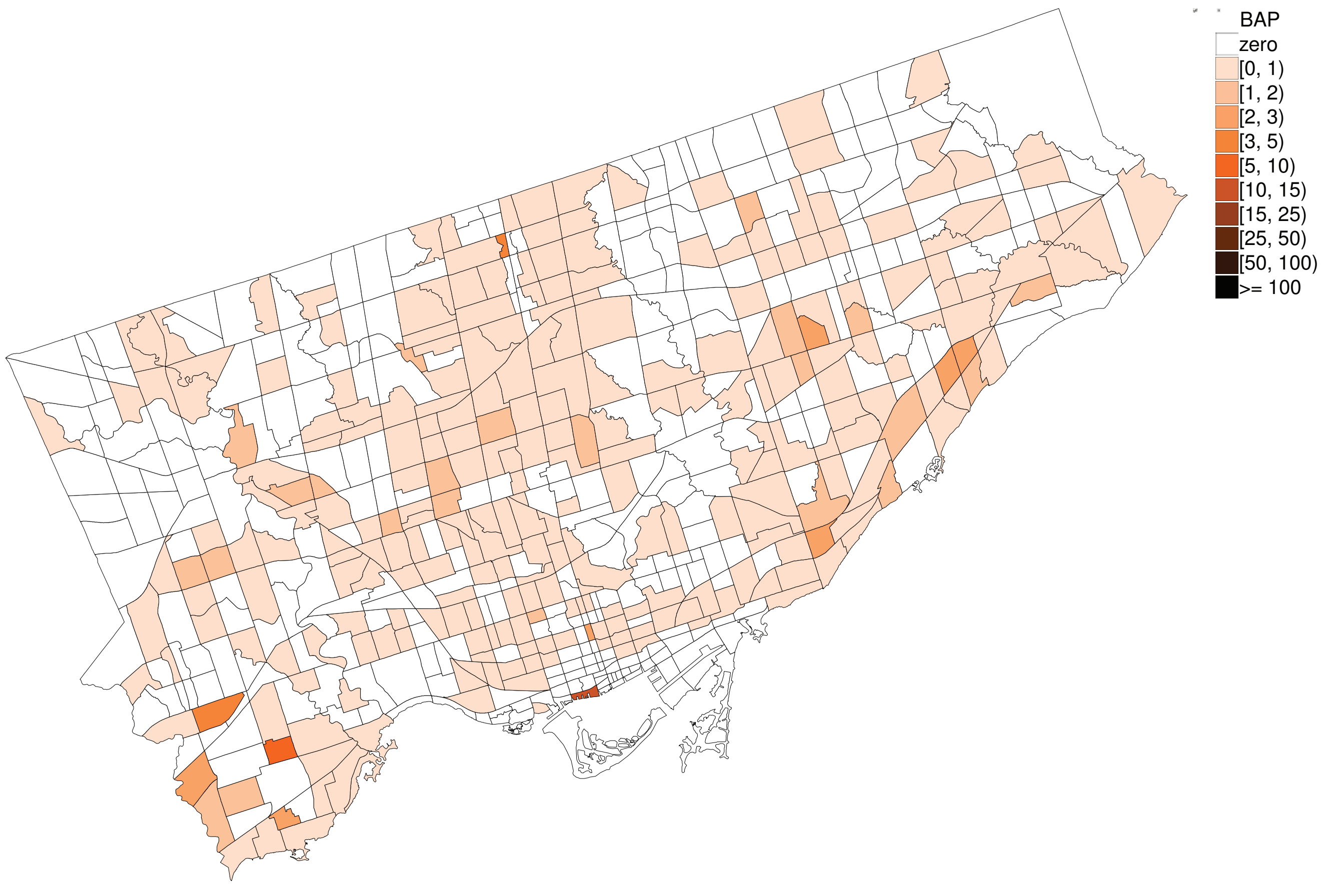


Figure 29. Additional single family dwellings from 2012 to 2050 (dwelling units/hectare).

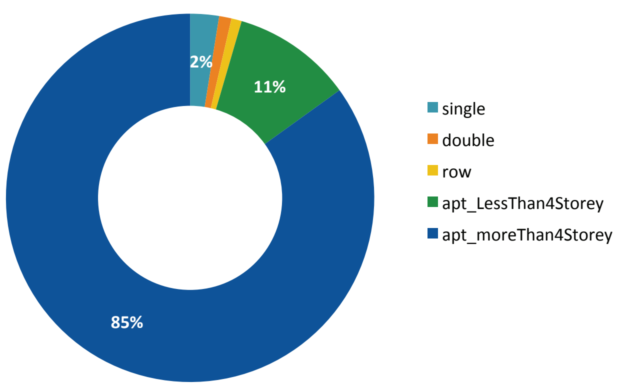


Figure 30. Cumulative new dwelling units by 2050 (%).

4.3 Employment

4.3.1 How many jobs? What kind of jobs?

Employment projections are derived from work conducted by Strategic Projections Inc. for the City of Toronto's Employment Uses Policy Study (2012); the "Medium" scenario was used, which reflects the projections from the Provincial Growth Plan. The City's projections began with 2011 numbers from the National Household Survey (Statistics Canada), and adjustments were made using 2006 census data and municipal employment surveys. Employment is projected to increase from 1.572 million in 2011 to 2.69 million in 2050 in the City's projections scenario (Figure 31).

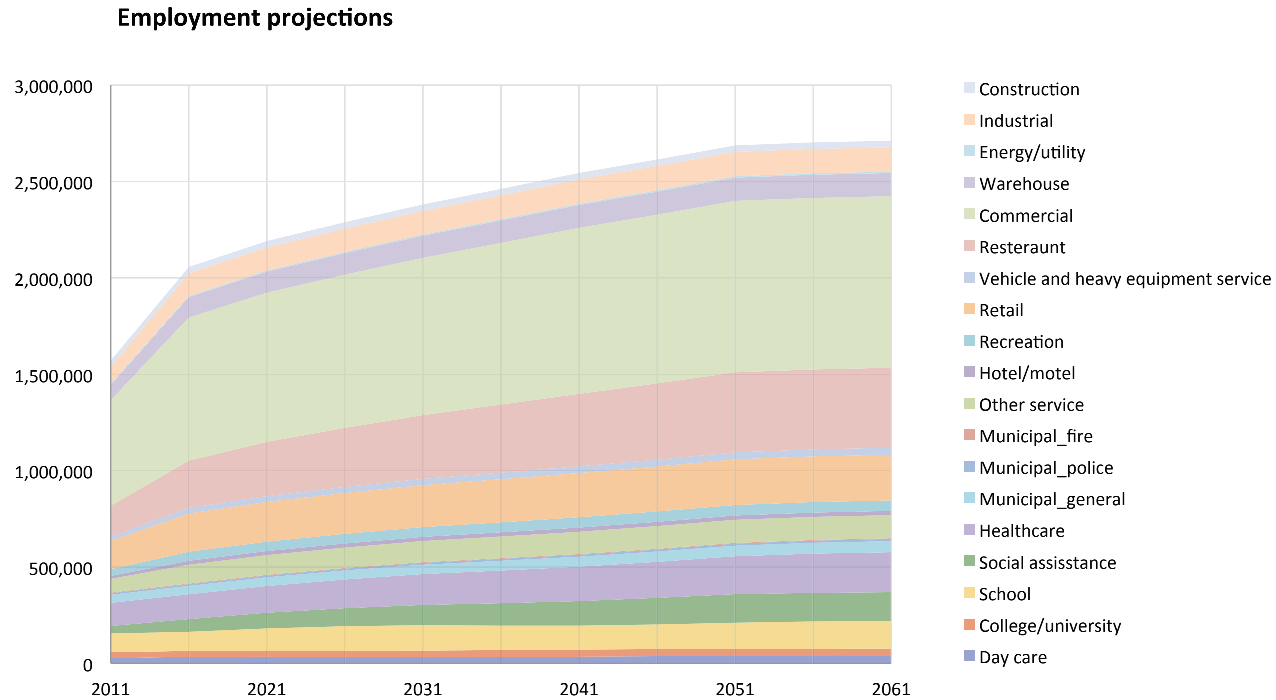


Figure 31. Jobs by category, 2011 to 2050.

4.3.2 Where are the jobs?

The employment projections provided by the City use three categories for places of work: work at home; usual place of work and no usual place of work. Jobs in the first two categories were allocated to transportation zones, but jobs in the third category cannot be tied to a particular place. Once total jobs were allocated to zones, they were parcelled out to different types of jobs based on the 2011 mix for that zone, as the job projections only included total number of jobs (they did not include a breakdown of job types to 2041). Therefore, if a zone was 80% office employment in 2011, that zone would continue to have 80% office employment in 2021, 2031 and so on.

The City made additional adjustments to this forecast, particularly for the Port Lands area, due to planned redevelopment. Floor space was then allocated based on an area/employee ratio for each employment type, again derived from historical ratios. Figure 32 illustrates the starting point in 2011 for floor space density of museums and art galleries, one of 46 different buildings types, as an example of the detail at which the analysis is undertaken. Note that the scale is not linear; in other words, the dark colours represent a much greater density of floor space than the lighter colours.

The analysis does not include any assumptions for job removals. As jobs drive floor spaces, it is likely that the results slightly overstate required floor space.

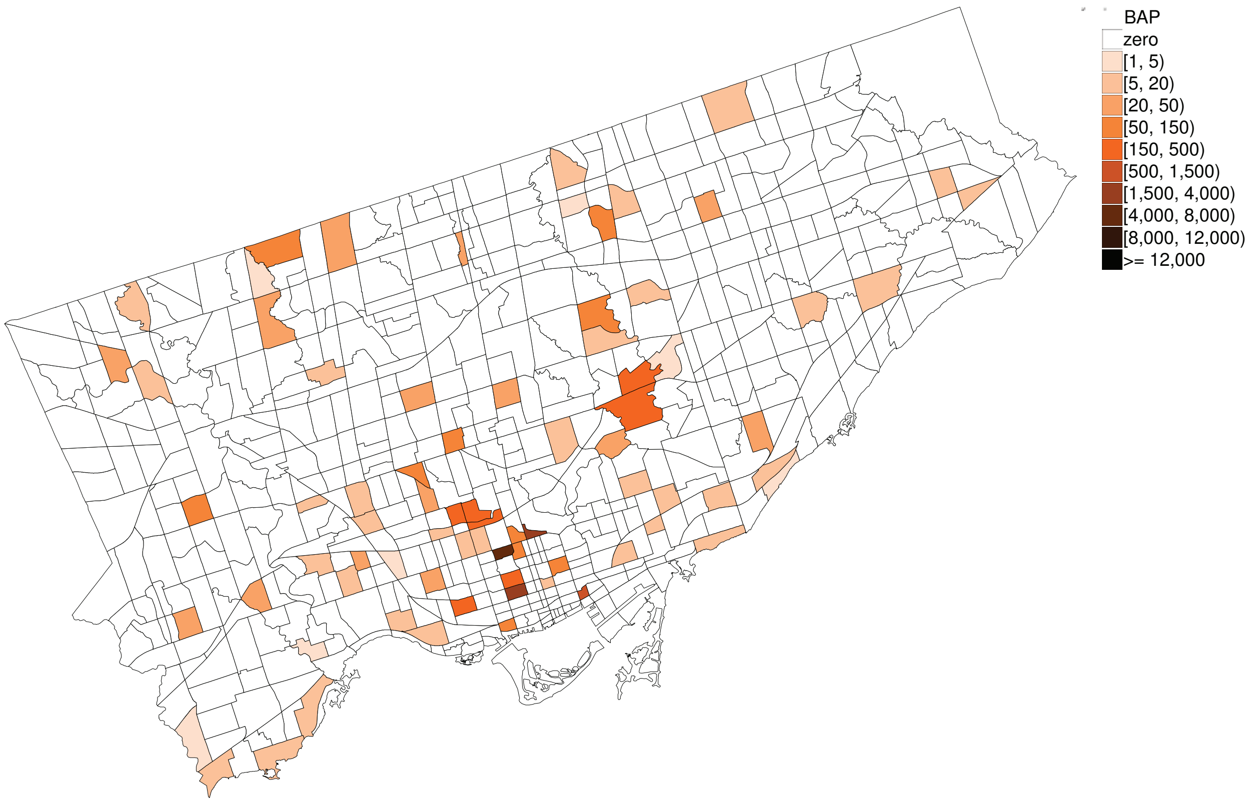


Figure 32. Sample of building type: density of floor space for museums and art galleries, 2011 (m2/ha).

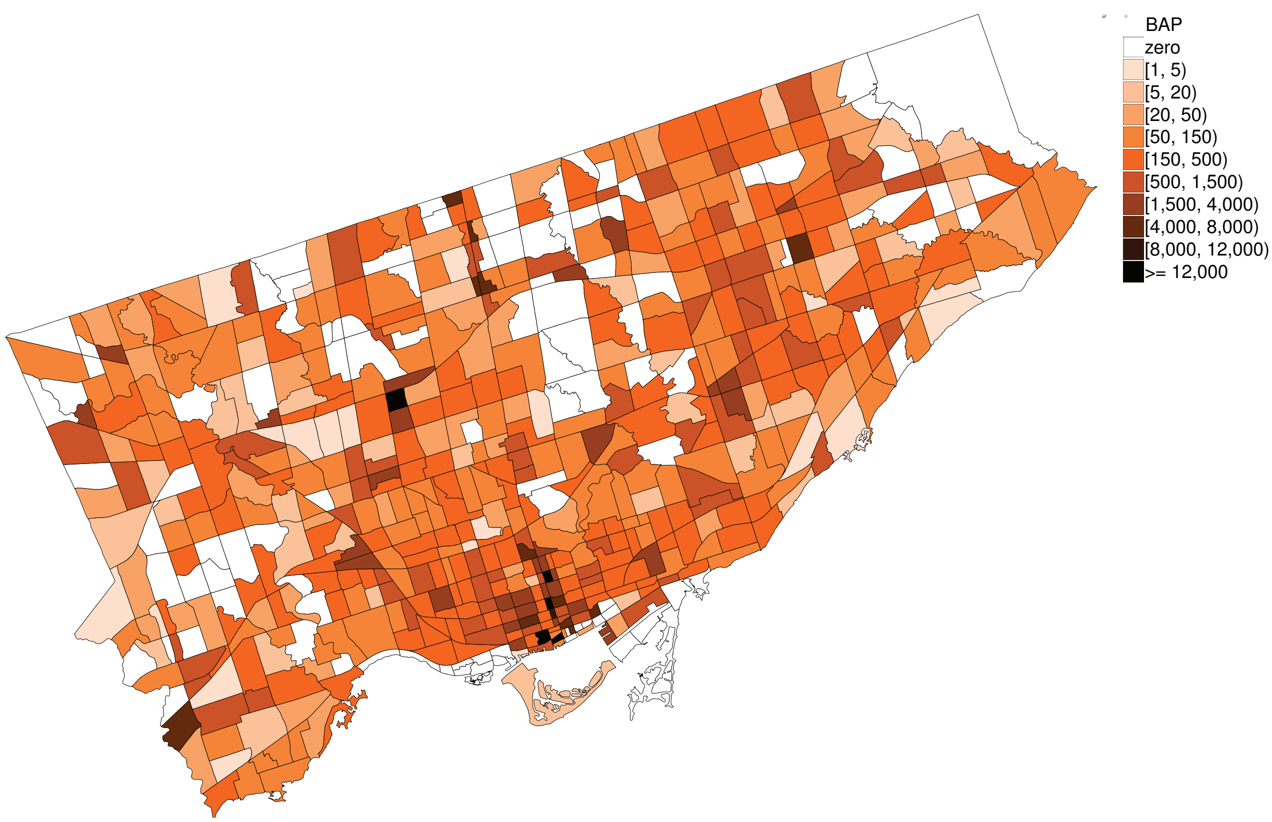


Figure 33. Sample of retail floorspace projection, 2050 (m2/ha).

4.4 Energy consumption

4.4.1 How much energy do buildings use?

In addition to the type of buildings, a key consideration is their energy performance. Buildings are divided into two categories; new construction and existing buildings. The City of Toronto currently has specific requirements for the energy performance of new buildings under the Toronto Green Standard, which was updated in 2014 to Version 2. Existing buildings, however are not required to achieve specific energy performance levels. A certain percentage of buildings are retrofitted each year and must upgrade energy performance to the current building code requirements when they do so. Additionally buildings are retrofitted in order to achieve conservation programming targets required by the Province.

The City of Toronto, as a result of the Toronto Green Standard program, has detailed energy performance data on new buildings, classified by type, with additional analysis undertaken by the Toronto Atmospheric Fund.[2] This information was used to develop physical characteristics for residential and non-residential building types considered in this analysis, which was then calibrated against observed energy data provided by the electricity and natural gas utilities in 2011. These physical characteristics, for example thermal performance of the building envelope, were then adjusted to achieve energy use intensities for different building types that address each of the performance levels described in Table 2.

Table 2. Buildings energy performance assumptions for new construction.

Standard	Application	2010-2013	2014-2050
Toronto Green Standard Tier 1	Part 9 buildings with > 5 dwelling units and all Part 3 buildings	85% of new construction	Starts at 85% of new construction and declines to 0% by 2050.
Toronto Green Standard Tier 2		15% uptake of Tier 2 v1 for new construction	Starts at 15% uptake of Tier 2 v2 increasing to 100% by 2050 for new construction.
Ontario Building Code	Part 9 buildings with < 5 units including single family dwellings	Ontario Building Code- EnerGuide 80 (beginning in 2012).	
Ontario Building Code	Existing buildings	Apply retrofits that reduce the heat load by 1.75%; this is distributed between different fuels based on fuel mix for different buildings.[3] Retrofitted buildings meet Ontario Building Code (2012) energy efficiency requirements.	

2 City of Toronto. (2016). Green Standard Tier 1 Energy Data Consolidated (unpublished).

3 Acadia Centre. (2014). Energy efficiency: Engine of economic growth in Canada: A macroeconomic modeling & tax revenue impact assessment. Retrieved from http://acadiacenter.org/wp-content/uploads/2014/11/ENEAcadiaCenter_EnergyEfficiencyEngineofEconomicGrowthinCanada_EN_FINAL_2014_1114.pdf

4.4.2 Major appliances, plug load, lighting and space conditioning

Residential energy use was modelled by evolving a technology stock that is deployed to provide the demanded energy services including heating, cooling, cooking, lighting, other appliances and other plug loads The stock data is obtained from Natural Resources Canada and includes the categories listed in Table 3.

Table 3. Stocks of equipment that consume energy.

<table>
<tr>
<td>Major appliances
- Refrigerator
- Freezer
- Dishwasher
- Clothes washer
- Clothes dryer (electricity or natural gas)
- Range (electricity, natural gas or propane)</td>
<td>Lighting
- Incandescent
- Compact flourescent
- Fluorescent
- Halogen
- LED</td>
<td rowspan="2">Space heating
- Oil furnace (normal, mid or high efficiency)
- Gas (normal, mid or high efficiency)
- Electric
- Heat pump (electric or gas)
- Geothermal
- Wood
- LPG
- Coal and other
- Wood/electric
- Wood/oil
- Solar/electric
- Solar/gas
- Solar/oil
- Gas/electric
- Oil/electric</td>
</tr>
<tr>
<td>Plug load (minor appliances)</td>
<td>Space cooling
- Central
- Heat pump
- Room</td>
</tr>
</table>

In all cases (except for minor appliances) the stock was modelled by age and by energy star rating, or an energy consumption metric specified for that particular appliance or furnace. The detailed inventory of stocks enables the model to calculate the energy use by fuel type, and in the calibration process, the demand for the energy services is adjusted until energy use from all of the buildings matches the energy use in Statistics Canada's Report on Supply and Demand (RESD).[4] Efficiencies of new technologies and energy consumption for appliances and heating and cooling equipment were held constant at 2011 levels.

4 Statistics Canada. (2016). Report on energy supply and demand in Canada (No. 57–003–X). Retrieved from http://www.statcan.gc.ca/pub/57-003-x/57-003-x2016002-eng.pdf

4.4.3 What about the influence of climate?

Energy use in Toronto is significantly influenced by the coldness of the winter and to a lesser degree, the heat of the summer. To account for the influence of climate change, energy use is adjusted according to the number of heating and cooling degree days identified in a projection for the City. Because the projection only includes the time periods of 2000-2009 and 2040-2049, a trend line was interpolated between those two periods[5] (Figure 34).

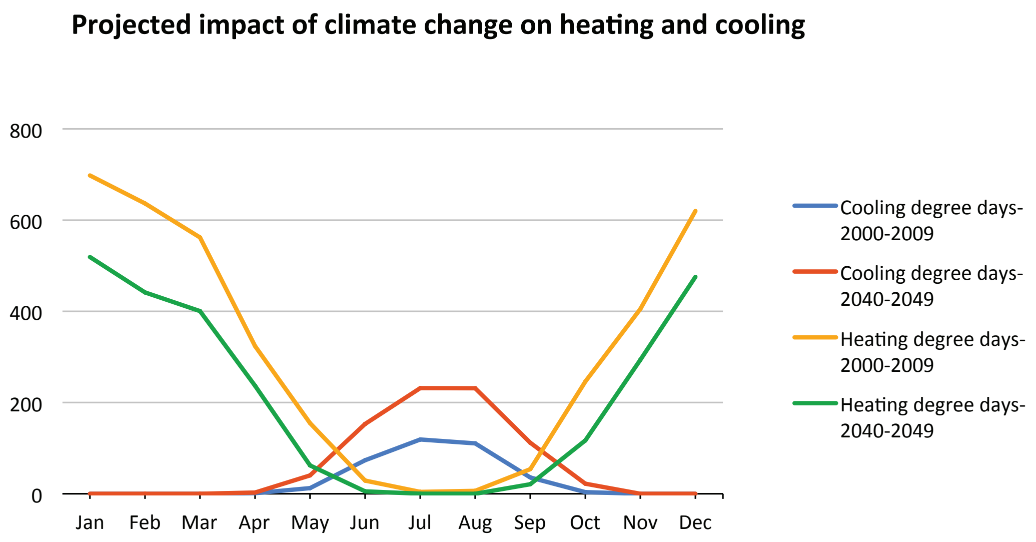


Figure 34. Heating and cooling degree days in 2000-2009 and 2040-2049.

5 SENES Consultants Ltd. (2011). Toronto's future weather and climate driver study: Volume 2- data tables (200-2009 and 2040-2049). City of Toronto. Retrieved from http://www1.toronto.ca/city_of_toronto/environment_and_energy/key_priorities/files/pdf/tfwcds-volume2-datatables.pdf

4.5 Transportation

4.5.1 How do people get around?

The City provided modelled origin-destination matrices for each of the transportation zones, which describe how many trips start and end in each zone by trip purpose and mode out until 2041. Base year trips were generated from the Transportation Tomorrow Survey[6] and are categorised as home-to-work, home-to-school, home-to-other and non-home-based.

Trip categories are described in Table 4, and conceptually depicted in Figure 35.

Table 4. Trip categories.

Trip type	Description
homeWork	Trips occurring between home and work location.
homeSchool	Trips occurring between home and school location.
homeOther	Trips occurring between home and other locations, for example, shopping or recreation.
nonHomeBased	Trips occurring between all locations that do not include home, for example, between work and shopping.
Internal	Trips that start and finish within the city boundary.
External outbound	Trips that start within the city boundary, and finish outside of the city boundary (eg. start in Toronto and finish in Mississauga).
External inbound	Trips that start outside the city boundary, and finish inside of the city boundary (eg. start in Vaughan and finish in Toronto).

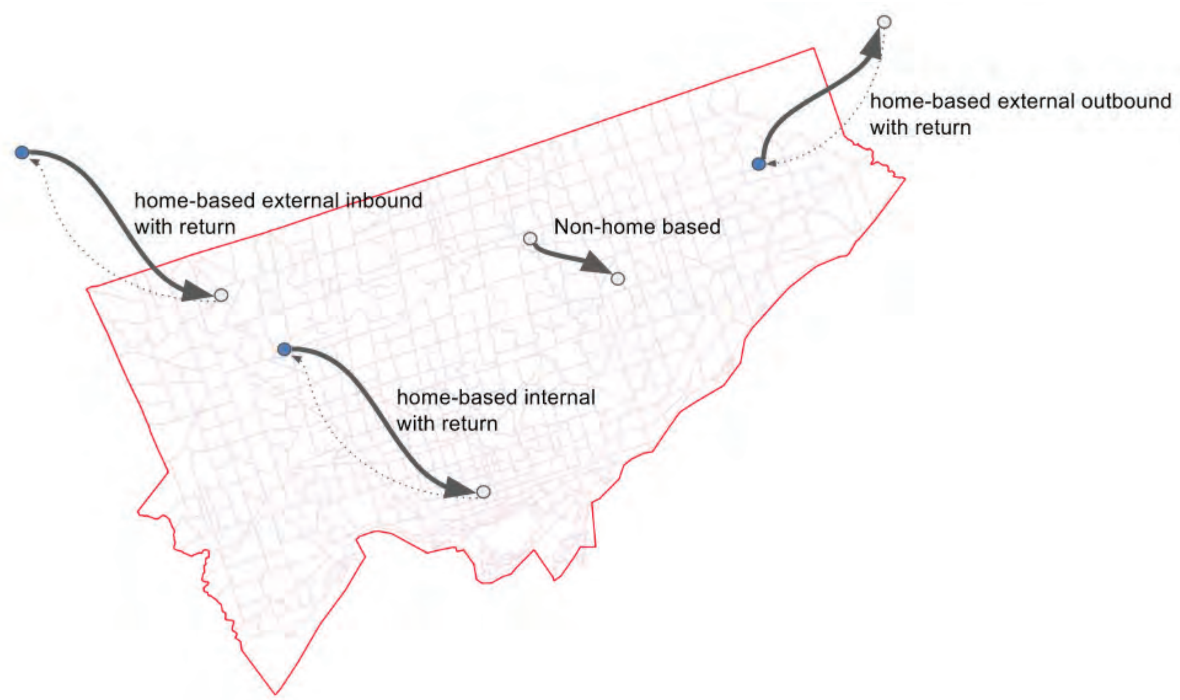


Figure 35. Conceptual diagram of trip categories.

6 Government of Ontario. (2016). Transportation tomorrow survey. Retrieved September 12, 2016, from http://www.transportationtomorrow.on.ca/

Figure 36 shows that home to work trips are significantly longer than any other trip types within the City boundary.

External trips are much longer than internal trips (Figure 37), however in general over the time period, external trips account for less than half of the per resident VKT.

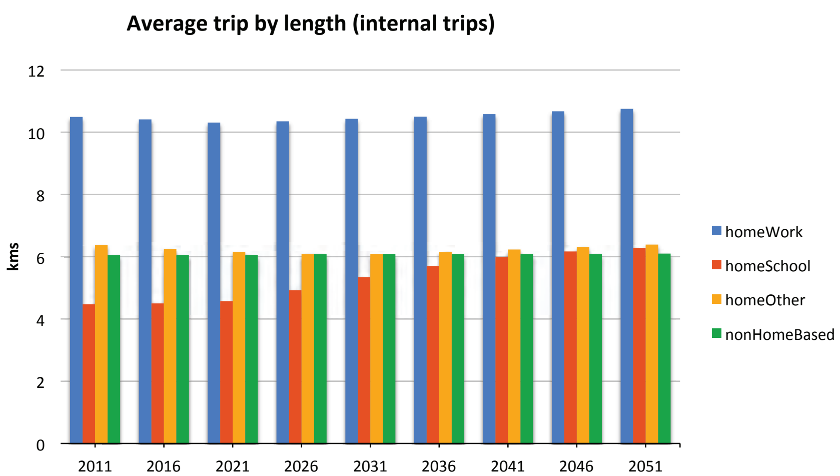


Figure 36. Trip length by type, internal trips (2011-2050).

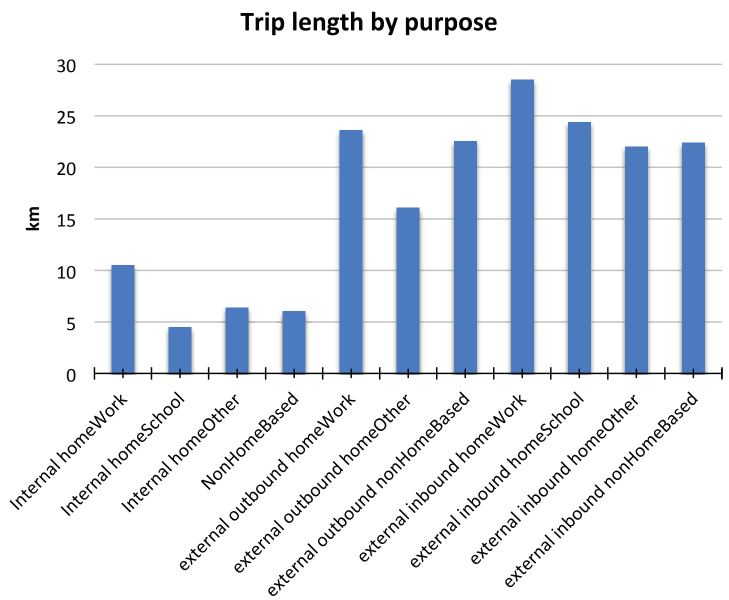


Figure 37. Trip length by type, internal and external trips (2011).

Trips were generated according to the number of people living and employed in each zones. Mode of travel was selected depending on the destination and the accessibility to different modes for that destination as well as other factors, within the City's transportation model. Figure 38 and Figure 39 illustrate the vehicular mode share across the city and, with results in 2050 showing a slight decline in many of the transportation zones outside of the city core as new transit options come online.

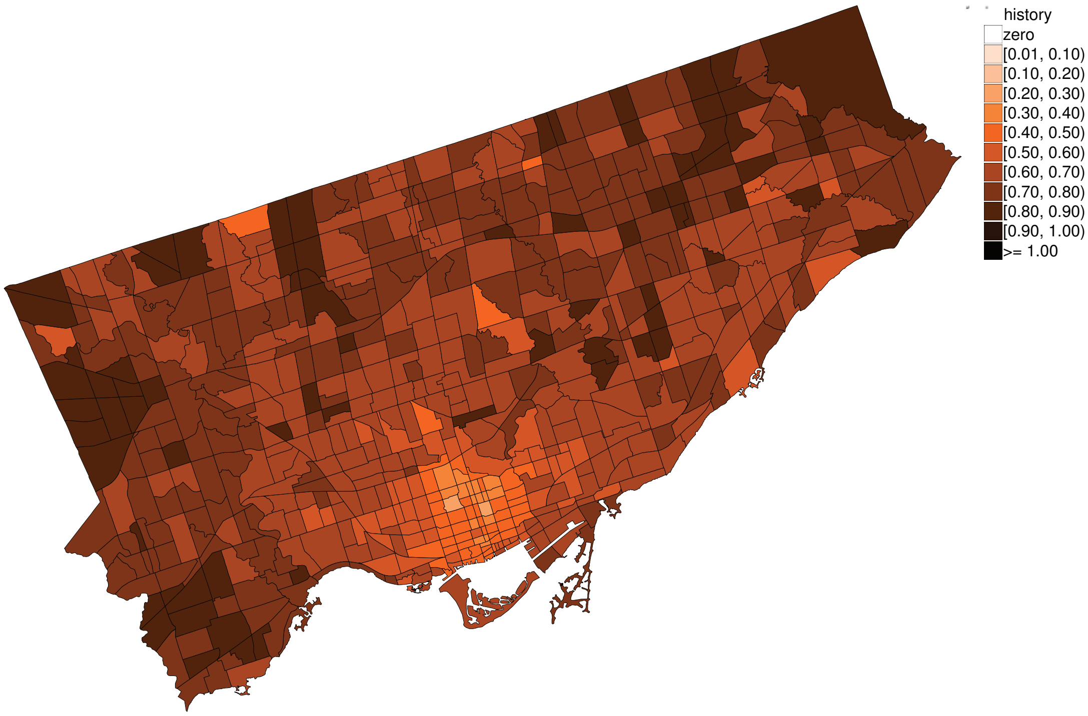


Figure 38. Vehicular mode share by zone (internal trips only), 2011.

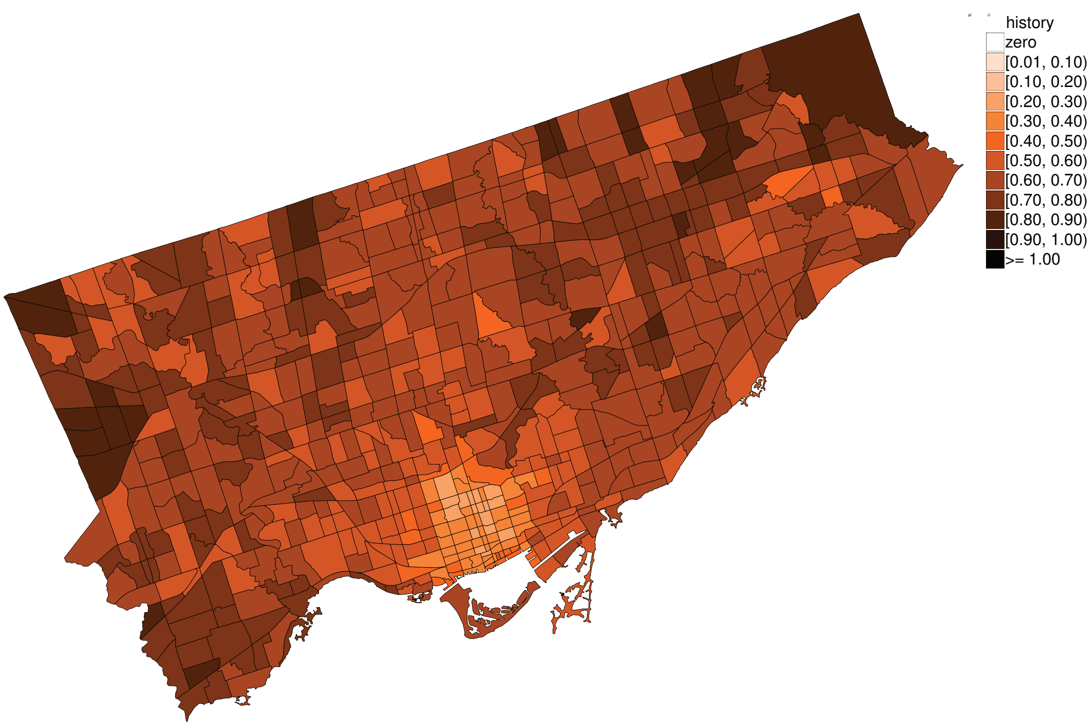


Figure 39. Vehicular mode share by zone (internal trips only), 2050.

Vehicular travel continues to be the dominant mode until 2050 (Figure 40), accounting for approximately 60% of the trips within the City boundaries, 70% of external inbound trips and 86% of external outbound trips in 2050.

After the mode was specified, vehicle kilometres travelled was calculated (Figure 41), which, when combined with vehicle types as described below, was translated into energy consumption and GHG emissions.

The City's transportation projections provide a mode share for vehicles, transit and active transportation; however, they do not account for City policies and strategies to support walking or cycling, for example the Toronto Walking Strategy[7] or the Ten Year Cycling Network Plan.[8]

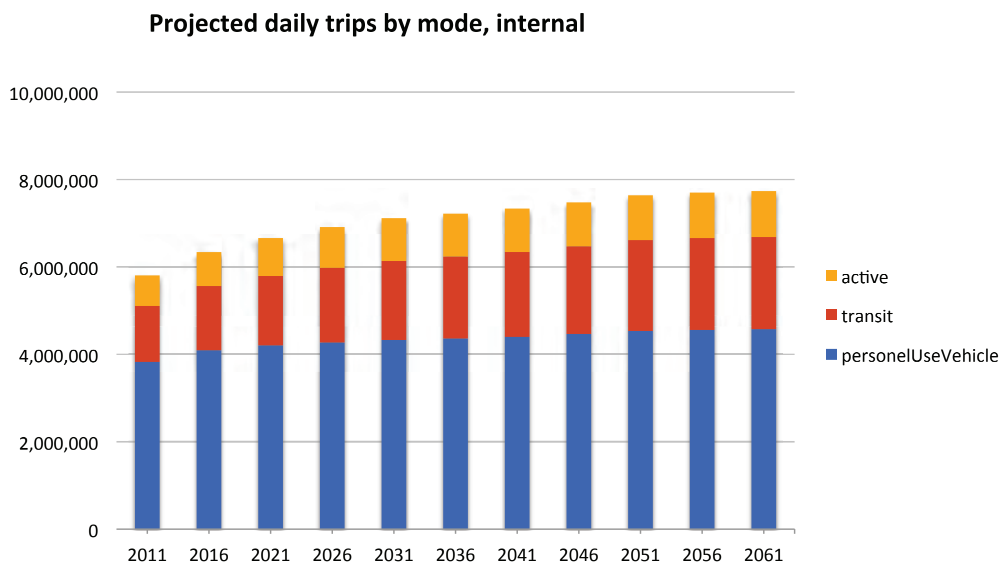


Figure 40. Mode split projections for trips within the City boundary.

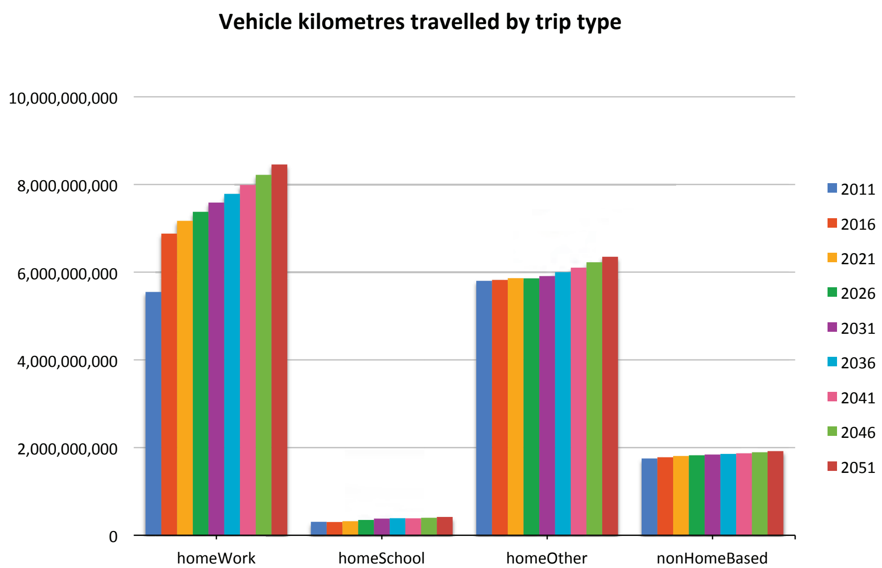


Figure 41. VKT projections by trip type.

7 City of Toronto. (2009). Toronto walking strategy. Retrieved from http://www1.toronto.ca/City%20Of%20Toronto/Transportation%20Services/Walking/Files/pdf/walking-strategy.pdf

8 City of Toronto. (2016). Ten year cycling network plan (Staff report). Retrieved from http://www.toronto.ca/legdocs/mmis/2016/pw/bgrd/backgroundfile-92811.pdf

4.5.2 What kind of vehicles do people have?

The model constructs a detailed representation of the stocks of vehicles by their age, including personal and commercial light duty, commercial medium duty, and commercial heavy duty road vehicles, using data on the stock composition from CANSIM and Natural Resources Canada's Demand and Policy Analysis Division[9], which are then scaled proportionately to Toronto. The model simulates vehicle stock turnover and the introduction of new fuel types and technologies over time. Each vehicle is described in terms of its engine and fuel type. The light duty vehicle types are shown in Table 5.

Table 5. Vehicle types.

Personal light duty vehicles	Public transit vehicles	Commercial vehicles
- Cars - SUVs and trucks	- Buses - Subway/LRT - Commuter rail	Light duty - Taxis - Delivery vehicles Medium duty - "heavy duty" pick-up and vans

Each of these vehicles types is then assigned an engine technology, which can be an internal combustion engine (ICE), an hybrid ICE, a fuel cell, a plug-in hybrid (PIHB), or an electric engine. Subsequently these power sources can be fueled by gasoline, diesel, propane, hydrogen, compressed natural gas, liquid natural gas or electricity.

Fuel use for each of these vehicle types and engine/fuel combinations was calibrated with historic data in order to track with fuel use consumption reported by Statistics Canada's Report on Energy Supply and Demand (RESD). The BAP scenario incorporates the implementation of harmonised fuel efficiency standards that apply to Canada including the CAFE Standards for Light-Duty Vehicles, MYs 2022-2025[10] and Phase 1 (2014-2018) and 2 (2018-2027) of Fuel Efficiency and GHG Emission Program for Medium- and Heavy-Duty Trucks.[11] Electric vehicles and plug-in hybrids are assumed to escalate to 4% of new cars and trucks by 2020, climbing to 1 million vehicles in Ontario by 2035.[12] Figure 42 shows the mix of light duty vehicles by fuel type.

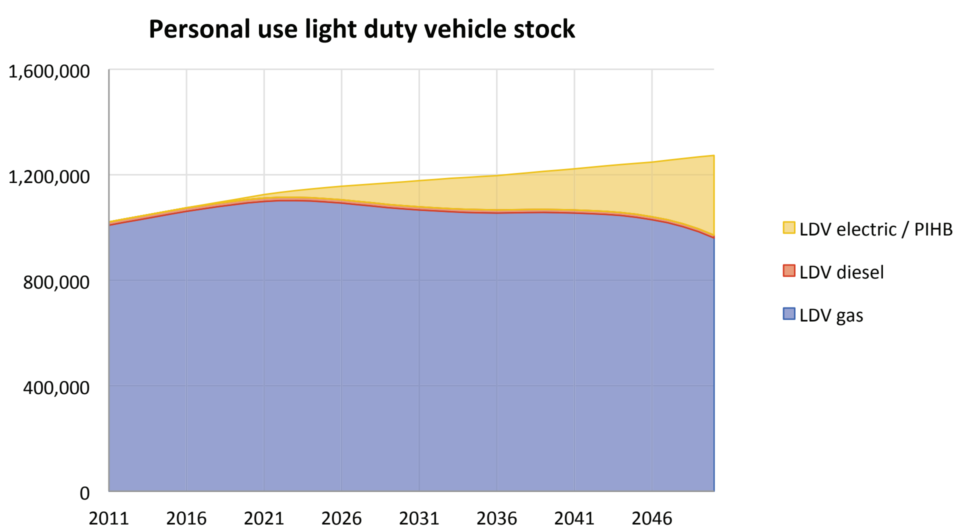


Figure 42. Personal use light duty vehicle stock.

9 Natural Resources Canada. (n.d.). Energy Use in Canada: NEUD Publications. Retrieved September 15, 2016, from http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/publications.cfm?attr=0

10 EPA. (2012). EPA and NHTSA set standards to reduce greenhouse gases and improve fuel economy for model years 2017-2025 cars and light trucks. Retrieved from https://www3.epa.gov/otaq/climate/documents/420f12050.pdf

11 For detailed information on the fuel standards, see: http://www.nhtsa.gov/fuel-economy

12 A target of 5% is described in the Ontario Climate Change Action plan (2016). 4% represents a cautious interpretation of that target.

4.5.3 What does the transit system look like?

By 2031, the City's transit system was assumed to include the Scarborough Subway Extension with 3 stops[13] on McCowan Road, GO's Regional Express Rail, Eglinton Crosstown Rail Transit, Finch West Rail Transit, Sheppard East Rail Transit and Toronto-York Spadina Subway Extension. No further expansion in the transit system was assumed between 2031 and 2050. The Toronto Transit Commission subway cars and streetcars were assumed to continue to run on electricity while buses are assumed to be diesel without any improvements in efficiency. The analysis assumes that 86% of GO train VKT will be fueled by electricity beginning in 2031, which is held constant until 2050.

4.6 Energy production

4.6.1 How is energy generated?

The future trajectory for energy generation was derived from a national energy model developed by whatIf? Technologies called CanESS, which analyses the energy system nationally and by province. CanESS was calibrated against historical data, including on population, economy, residential energy use, commercial energy use, transportation energy use, industrial energy use, resource production, and energy production, so that when the model is run over historic time, the energy use and emissions outputs match the energy use by sector and by fuel as reported in the Report on Energy Supply and Demand from Statistics Canada.[14] Other data sources used in the calibration process include additional CANSIM tables, the Energy Efficiency Trends Analysis Table, the National Inventory Report from Environment Canada[15] and expert estimates when observed data was not available.

Figure 43 illustrates energy use by sector in GJ; the dominant sector is commercial buildings. Figure 44 illustrates the dominance of natural gas, which, in residential buildings, is used for space heating (Figure 45). A decrease in gasoline consumption (Figure 44) is due to improved fuel efficiency standards combined with an incremental uptake of electric vehicles, which also contributes to the increase in electricity consumption. Energy for residential space heating (Figure 45) decreases due to a combination of efficiency improvements (through new construction and retrofits), and the impact of decreasing heating degree days.

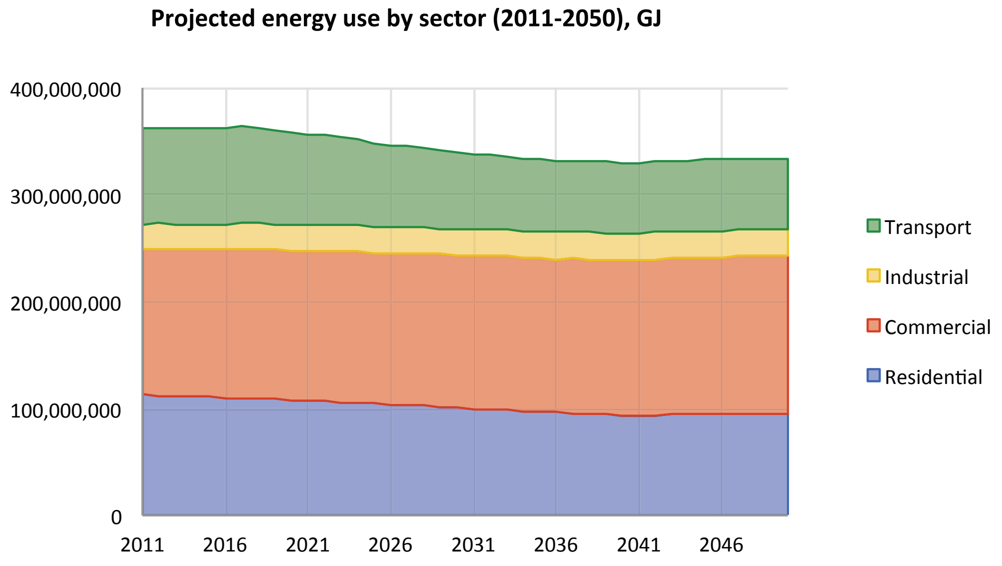


Figure 43. Projected energy use by sector, GJ (2011-2050).

13 Since this projection was created, the City has decided to move forward with one stop.

14 Statistics Canada. (2016). Report on energy supply and demand in Canada (No. 57–003–X). Retrieved from http://www.statcan.gc.ca/pub/57-003-x/57-003-x2016002-eng.pdf

15 Government of Canada. (2016). National inventory report 1990-2014: Greenhouse gas sources and sinks in Canada- Part 1.

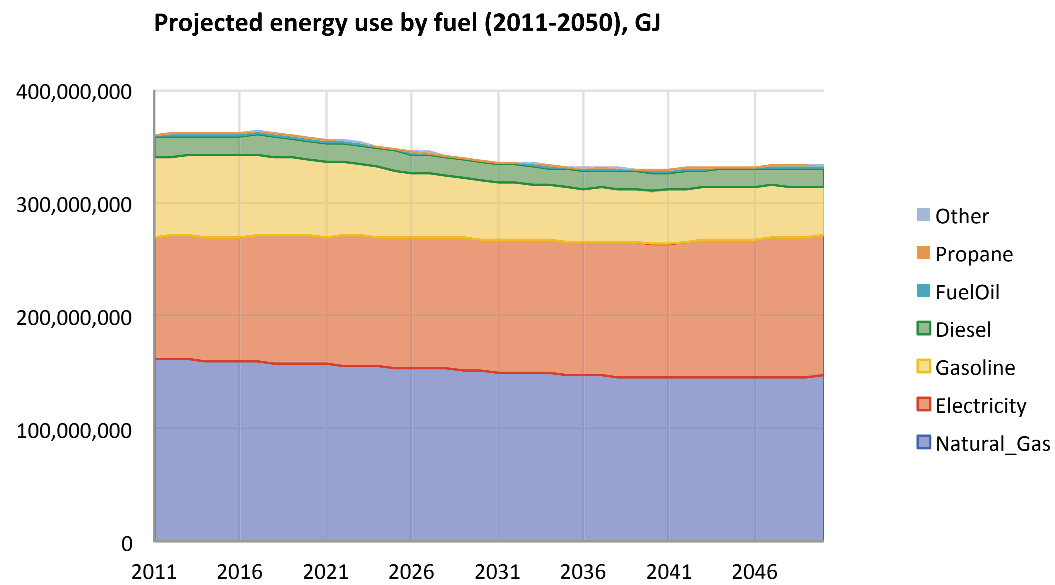


Figure 44. Projected energy use by fuel type, GJ, (2011-2050).

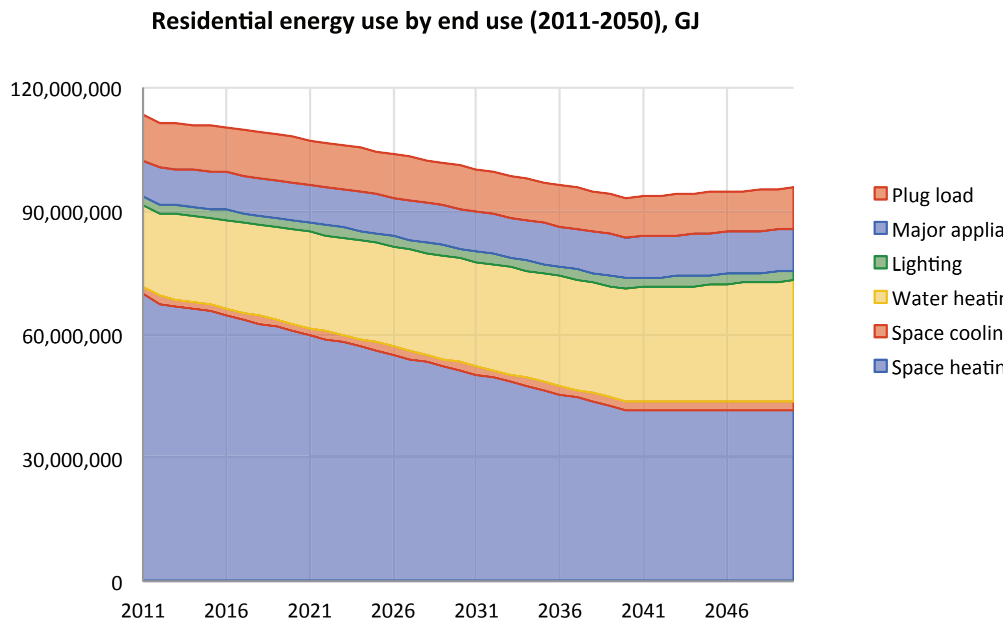


Figure 45. Projected energy use by end-use in the residential sector, GJ (2011-2050).

In order to develop the BAP projection, each of the model inputs for the energy system was either fixed at the level of the last year in history (currently 2013), or alternatively if there was a clear trend in the historic data, that trend is used to project into the future. The projection is typically not linear, but was rather a saturation projection where the trend was levelled off after a certain number of years, depending on the relevant variable.

4.6.2 The electrical grid

The historical data for the electrical grid is obtained from a variety of sources including Statistics Canada's CANSIM tables for total capacity and generation, along with Environment Canada's National Inventory Report (NIR) specifically for the years from 2011 to 2014.

For the BAP scenario, the electricity generation input variables were set on the basis of NEB's Energy Future 2016, beginning in 2015.[16] A subsequent comparison with electricity capacity data for each generation technology from IESO[17] showed a very good match for Ontario, although some decommissionings or added new generation capacity occurred one or two years earlier or later. Despite those minor differences, a comparison of CanESS with NIR (Table 6) shows that CanESS provides a good representation of the carbon intensity of the grid capacity in Ontario and was therefore used to develop carbon intensity projections for the Ontario grid.

Table 6. Emissions factor comparison between the National Inventory Report and CanESS

Year / kg CO2e/mWh	NIR	CanESS
2012	95	101
2013	66	70
2014	41	33

For current and future generation capacity, coal capacity was phased out in 2014, Pickering units are decommissioned between 2022 and 2024, while refurbishments of the remaining nuclear facilities mostly occurs in the 2020s.[18] Wind, solar and also natural gas show increases in capacity from 2016 to 2025, as projected by IESO. From 2015 onwards there is a slight increase in carbon intensity as nuclear loses some of its share. Post 2035 it is assumed that fossil fuel based electricity generation (natural gas) is maintained at 2035 levels, and all increases in capacity, required due to increases in demand, is non-fossil fuel based.

IESO's (published) projection ends at 2035. Based on current knowledge, there are no projections available post 2035, and hence, no indication of any plans to phase out the existing natural gas capacity post 2035, or that natural gas capacity (the only carbon based electricity generation in Ontario) will increase its share post 2035. As such, it is assumed that natural gas capacity will simply maintain its share of the generation mix. As a result the carbon intensity of the Ontario grid remains constant post 2035 when electricity is generated by a mix of nuclear, natural gas, waterpower, bionenergy, wind, and solar. Figure 46 illustrates the projected emissions factor for the electricity grid in Ontario.

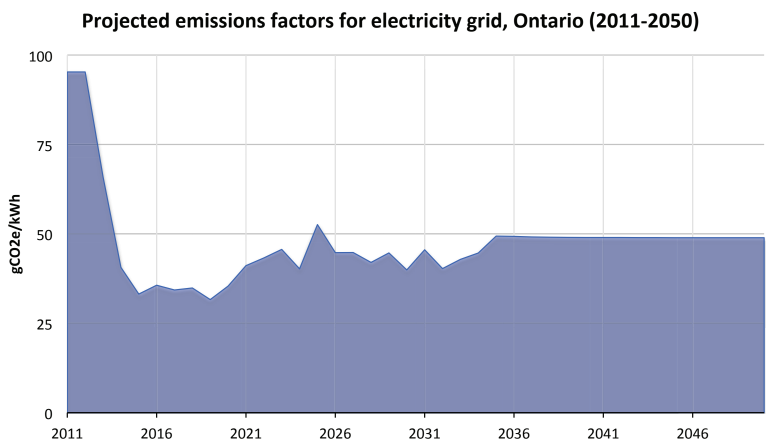


Figure 46. Projected emissions factor for electricity grid, Ontario (2011-2050).

16 National Energy Board. (2016). Canada's energy future 2016. Government of Canada. Retrieved from https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2016pt/nrgyftrs_rprt-2016-eng.pdf

17 IESO (2016) MODULE 4:Supply Outlook. Retreived from http://ieso.ca/Documents/OPO/MODULE-4-Supply-Outlook-20160901.pptx

18 Ibid.

4.7 Waste

4.7.1 How much waste is produced?

The Long Term Waste Strategy was approved by City Council in July, 2016, which established a target of 70% diversion of residential waste by 2026, and of materials collected by the City from industrial, commercial and institutional customers.[19] An overall target is the diversion of 200,000 tonnes by 2026. The baseline residential and non-residential waste generation projections (2014-2050) were used from a Technical Memo that informed the Long Term Waste Strategy.[20]

The City is planning to generate renewable natural gas from Keele Valley Landfill, Disco Road Organics Processing Facility and Dufferin Organics Processing Facility. The BAP scenario assumed that Keele, Disco and Dufferin are in operation by 2020 and Green Lane Landfill is in operation by 2025. In total these facilities generate approximately 1 million GJ of fuel per year.[21]

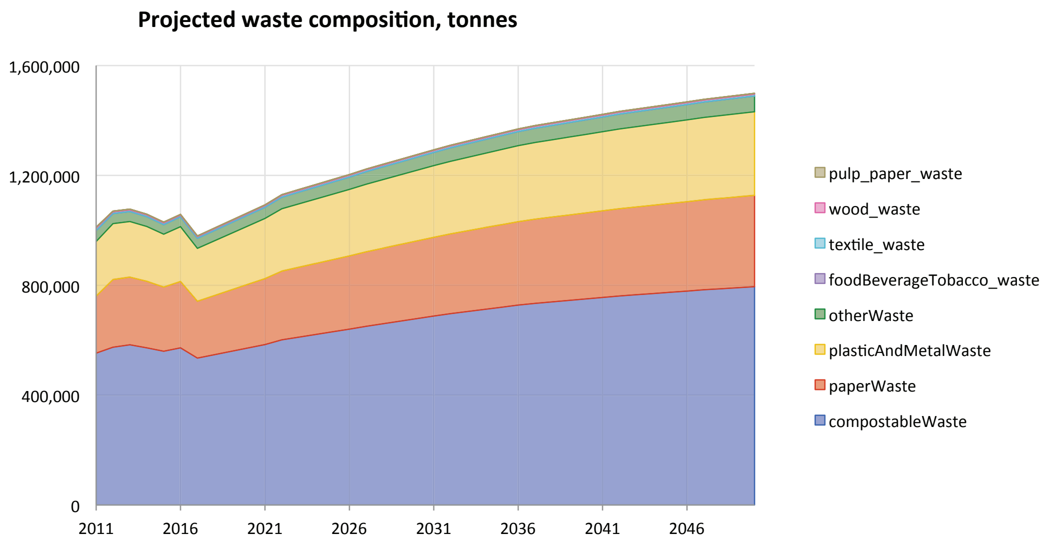


Figure 47. Projected waste composition, tonnes (2011-2050).

19 City of Toronto. (2016). Long-term waste management strategy. Retrieved from http://www.toronto.ca/legdocs/mmis/2016/pw/bgrd/backgroundfile-94038.pdf

20 HDR. (2015). Technical memorandum no.2 Needs assesssment: Vision & guiding principles; gaps, challenges and/or opportunities; and long-term projections. City of Toronto. Retrieved from http://www1.toronto.ca/City%20Of%20Toronto/Solid%20Waste%20Management%20Services/Long%20Term%20Waste%20Strategy/Tech%20Memorandum%20No%202%20-%20FINAL%20-%20AODA.pdf

21 City of Toronto. (2016, April). Authority to enter into renewable natural gas projects. Retrieved July 16, 2016, from http://www.toronto.ca/legdocs/mmis/2016/pw/bgrd/backgroundfile-92679.pdf

5. BAP Results

Figure 48 shows the total projected GHG emissions in MT for the City of Toronto from 2011 to 2050. Emissions fall from 19.51 MT CO2e in 2011 to 16.3 MT in 2020 and then decline slightly to plateau around 14.14 MT out until 2050. The immediate dip after 2011 can be attributed to the phase out of coal in the electricity system as well as reduced use of natural gas for electricity generation. A steadier and more prolonged decline results from the fuel efficiency standards combined with an incremental uptake of electric vehicles.

The impact of coal phaseout is apparent in the GHG emissions from each fuel type for residential buildings (Figure 49), and even more dramatically for commercial buildings (Figure 50). The opportunity for emissions reductions by fuel switching from natural gas to electricity is also highlighted, particularly in residential buildings.

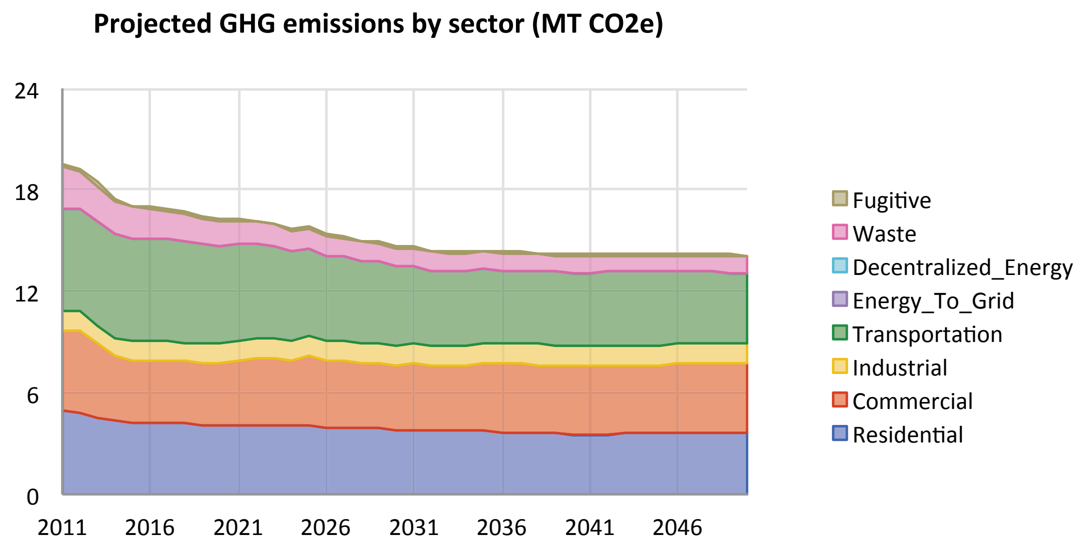


Figure 48. Projected GHG emissions by sector (MT CO2e).

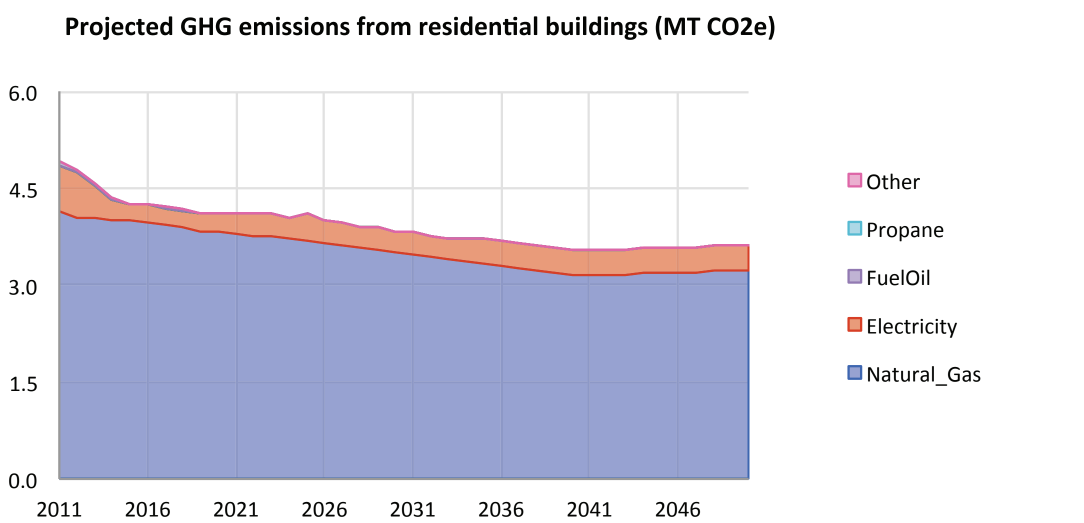


Figure 49. Projected GHG emissions for residential buildings (MT CO2e).

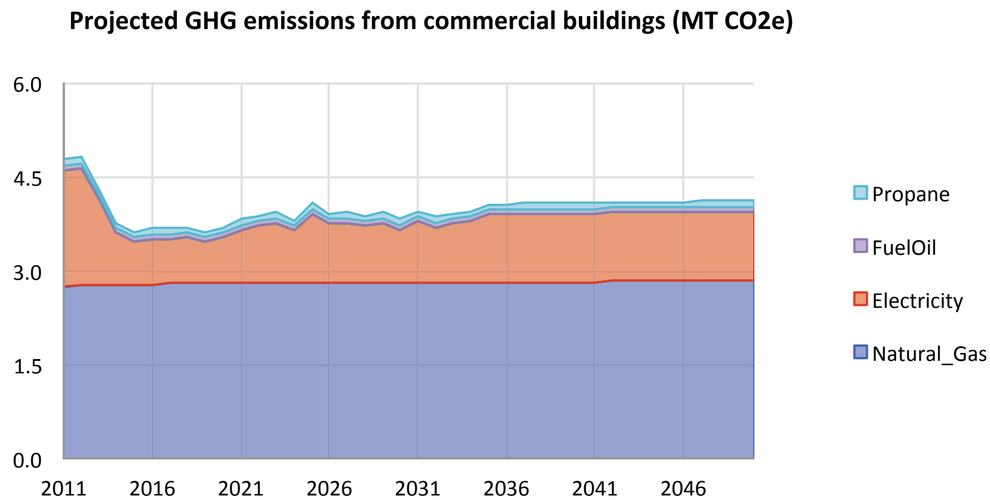


Figure 50. Projected GHG emissions from commercial buildings (MT CO2e).

6. BAP Analysis

The population of Toronto is expected to grow to just under 3.5 million by 2050. This gdrives rowth in population is accompanied by increases in residential dwellings, and non-residential space Alongside With this growth The results above have been summarized in the main findings below:

» *Emissions are decreasing over time towards 2050*

While population continues to grow, the BAP projections indicate that emissions have a decreasing trajectory, amounting to 16.3 MT CO2e in 2020, and 14.1 MT CO2e in 2050.

The primary drivers for this reduction are:

- **Continued decline of grid electricity emissions factor**

Coal capacity was phased out in 2014; wind, solar and also natural gas show increases in capacity from 2016 to 2025; refurbishments of the remaining nuclear facilities mostly occurs in the 2020s; post 2035, fossil fuel based electricity generation (natural gas) is maintained at 2035 levels (natural gas maintains its share of the generation mix), and all increases in capacity, required due to increases in demand, are non-fossil fuel based. As a result the carbon intensity of the Ontario grid remains constant post 2035 where electricity is generated by a mix of nuclear, natural gas, hydropower, bionenergy, wind, and solar.

- **Improving vehicle fuel efficiency standards**

The fuel economy of cars, light trucks, and medium- and heavy-duty trucks increases through the implementation of harmonised fuel efficiency standards that reduces energy consumption to 2050.

- **Decrease in heating degree days (due to a warming climate), partially offset by an increase in cooling degree days.**

The number of heating degree days (the number of degrees that a day's average temperature is below 18^{o} Celsius, at which buildings need to be heated) decreases as the climate continues to warm. This results in a reduction in the amount of energy required for space heating, which is predominantly supplied by natural gas, resulting in a reduction in emissions. This increase is partially offset by an increase in the number of cooling days (the temperature at which buildings start to use air conditioning for cooling), which results in an increase in energy usage, supplied by electricity.

- **Increase in energy retrofits of existing buildings**

An incremental increase in energy retrofits in existing buildings results in a reduction in energy consumption in existing buildings stock.

- **Increased efficiency in new construction**

Energy performance requirements incrementally increase through improvements in building code standards for new construction resulting in lower energy intensities for new floorspace; in other words, new buildings use incrementally less energy on a per square metre basis.

- **Increasing numbers of electric vehicles in overall stock of vehicles**

A higher proportion of the electric vehicle stock results in a reduction in emissions as vehicles switch from carbon intensive gasoline and diesel to increasingly cleaner electricity, with accompanying efficiency gains.

- **Increasing diversion rates in solid waste.**

Higher proportions of the waste stream are diverted to recycling and reuse, resulting in reduced emissions from new waste going to landfills.

» *The 2020 reduction target is met, but not the 2050 target.*

The BAP projections indicate that the 2020 target (19 MT) will be met (based on the currently approved plans and policies) are implemented (Figure 51); but the 2050 target (5.4 MT) will not be met.

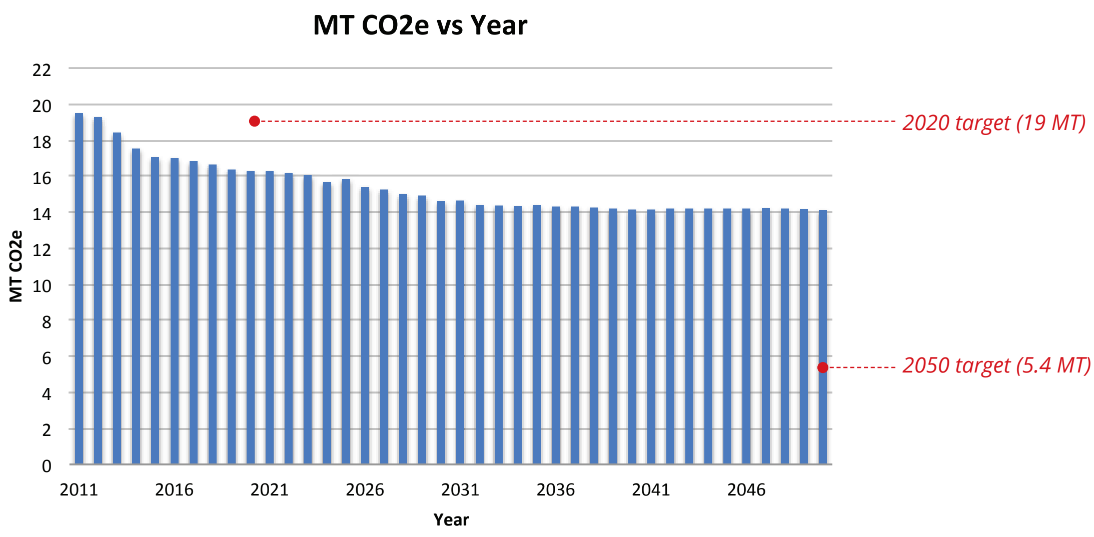


Figure 51. Projected GHG emissions for the City of Toronto, 2011-2050.

» *The city has benefitted from provincial policy and standards*

The City's has benefitted significantly from the greening of the Provincial grid and vehicle fuel efficiency standards, both of which have being implemented at the provincial level, and have not been driven by the City itself. In addition, while the City's short term target has benefitted from the aforementioned, the 2050 target represents a major challenge as the remaining major opportunities are more intransigent, and challenging at the municipal level.

» *Switching to electricity provides a significant emissions reduction opportunity*

- The emissions factor for the Provincial grid (electricity) continues to decline. This creates an emissions reduction opportunity for fuel switching for vehicles (private and transit) away from carbon intensive gasoline to increasingly cleaner electricity.
- Out of all fuel sources, natural gas is the most significant source of emissions; this creates an emissions reduction opportunity for fuel switching to electricity for space heating, as the emissions factor for electricity continues to decline and technologies such as heat pumps to support this transition are available.

» *New electricity generation capacity from renewables is needed*

- Significant efforts to fuel switch to electricity will require new generation capacity with renewables to ensure that the emissions factor for electricity continues to decline, as well as ensuring sufficient electrical capacity is available.

» *Retrofitting is key*

- Existing buildings (pre-2011) have a major impact on GHG emissions; the incremental effect of high efficiency new buildings is small, but decreases the upward pressure of an increasing population on the GHG curve. An ambitious retrofit program will be critical.

» *Vehicle mode share and trip length remains high*

- Vehicular mode share for external trips is ≈70% (inbound) and 86% (outbound); there is an opportunity to shift this mode share. Outside of the downtown core, the vehicular mode share remains relatively high, even for internal trips.
- Generally, trip lengths are not projected to decline; in spite of a focus on transit oriented development.

» *Solid waste emissions are driven by the existing landfills*

- Solid waste emissions are driven by the existing landfills; emissions from new additional waste are overshadowed by the emissions from the waste sitting in closed landfills, which taper off towards the end of the time period considered.

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Appendix 1 GPC Protocol emissions report, 2011

GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	Comments	in tonnes CO2	CH4	N2O	Total CO2e		
I		**STATIONARY ENERGY SOURCES**									
I.1		**Residential buildings**									
I.1.1	1	Emissions from fuel combustion within the city boundary	**Yes**			4,168,439	81	76	4,193,957		
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	**Yes**			645,005	137	14	653,761		
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	**Yes**			71,667	15	2	72,640		
I.2		**Commercial and institutional buildings/facilities**									
I.2.1	1	Emissions from fuel combustion within the city boundary	**Yes**			2,886,981	56	58	2,906,004		
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	**Yes**			1,652,974	352	35	1,675,412		
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	**Yes**			183,664	39	4	186,157		
I.3		**Manufacturing industry and construction**									
I.3.1	1	Emissions from fuel combustion within the city boundary	**Yes**			737,167	15	14	741,862		
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary	**Yes**			69,991	15	1	70,942		
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	**Yes**			7,777	2		7,882		
I.4		**Energy industries**									
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary	**Yes**		District energy	356,905	7	6	359,002		
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	**Yes**			3,637	1		3,686		
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	**Yes**			404			410	Buildings (incl. Portlands)	Buildings (excl. Portlands)
I.4.4	1	Emissions from energy generation supplied to the grid	**Yes**		Portlands Energy Centre	472,267	123	12	480,087	**11,351,802**	**10,871,715**
I.5		**Agriculture, forestry and fishing activities**									
I.5.1	1	Emissions from fuel combustion within the city boundary	**No**	NR							
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary	**No**	NR							
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	**No**	NR							
I.6		**Non-specified sources**									
I.6.1	1	Emissions from fuel combustion within the city boundary	**No**	NR							
I.6.2	2	Emissions from grid-supplied energy consumed within the city boundary	**No**	NR							
I.6.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	**No**	NR							
I.7		**Fugitive emissions from mining, processing, storage, and transportation of coal**									
I.7.1	1	Emissions from fugitive emissions within the city boundary	**No**	NR							
I.8		**Fugitive emissions from oil and natural gas systems**								Fug. emissions	
I.8.1	1	Emissions from fugitive emissions within the city boundary	**Yes**			205	5,592		190,322	**190,322**	
II		**TRANSPORTATION**									
II.1		**On-road transportation**									
II.1.1	1	Emissions from fuel combustion for on-road transportation occurring within the city boundary	**Yes**		Includes personal, commercial & buses	4,504,944	419	1,004	4,818,439		
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	**Yes**		No significant EV stock in 2011						
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	**Yes**		For personal vehicles within GTA only.	1,031,097	119	292	1,122,069		
II.2		**Railways**									
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary	**Yes**		Includes GO; excludes Via	45,792	3	18	51,339		
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways	**Yes**		Includes subway and streetcar	28,454	6	1	28,840		
II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	**Yes**		Only includes transmission & distribution losses; not enough data to estimate transboundary trips	3,162	1		3,204		
II.3		**Water-borne navigation**									
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	**No**	N/A							
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation	**No**	N/A							
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	**No**	N/A							
II.4		**Aviation**									
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary	**No**	N/A							
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation	**No**	N/A							
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	**No**	N/A							
II.5		**Off-road**									
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary	**No**	NR						Transport	
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation	**No**	NR						**6,023,891**	
III		**WASTE**									
III.1		**Solid waste disposal**									
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	**No**	NR							
III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary	**Yes**				59,787		2,032,754		
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary	**No**	NR							
III.2		**Biological treatment of waste**									
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary	**Yes**				637	38	33,039		
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary	**No**	NR							
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary	**No**	NR							
III.3		**Incineration and open burning**									
III.3.1	1	Emissions from solid waste generated and treated within the city boundary	**No**	NR							
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary	**No**	NR							
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary	**No**	NR							
III.4		**Wastewater treatment and discharge**									
III.4.1	1	Emissions from wastewater generated and treated within the city boundary	**Yes**				9,915	61	355,331		
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary	**No**	NR						Waste & WW	
III.4.3	1	Emissions from wastewater generated outside the city boundary	**No**	NR						**2,421,123**	
IV		**INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)**									
IV.1	1	Emissions from industrial processes occurring within the city boundary	**No**	ID							
IV.2	1	Emissions from product use occurring within the city boundary	**No**	ID							
V		**AGRICULTURE, FORESTRY AND LAND USE (AFOLU)**									
V.1	1	Emissions from livestock within the city boundary	**No**	NR							
V.2	1	Emissions from land within the city boundary	**No**	NR							
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary	**No**	NR							
VI		**OTHER SCOPE 3**									
VI.1	3	Other Scope 3	**No**	N/A							
								TOTAL	**19,507,051**	excl. Portlands	

Reason for exclusion:

N/A	Not applicable; Not included in scope
ID	Insufficient data
NR	No relevant or limited activities identified
Other	Reason provided under Comments

Sector		Total by Scope (tCO2e)				Total	Total by city-induced reporting level (tCO2e)	
		Scope 1	Scope 2	Scope 3	Other Scope 3		BASIC	BASIC+
Stationery Energy	Energy use (all I emissions except I.4.4)	8,391,147	2,403,801	267,089		11,062,037	10,794,948	11,062,037
	*Energy generation supplied to the grid (I.4.4) **	480,087				480,087		
Transportation (all II emissions)		4,869,778	28,840	1,125,274		6,023,891	4,898,618	6,023,891
Waste	Generated in the city (all III.X.1 and III.X.2)	388,370		2,032,754		2,421,123	2,421,123	2,421,123
	Generated outside city (all III.X.3)							
IPPU (all IV emissions)								
AFOLU (all V emissions)								
Total		14,129,382	2,432,641	3,425,116	0	**19,987,139**	18,114,689	19,507,051
		(All territorial emissions)					*(All BASIC emissions)*	*(All BASIC & BASIC+ emissions)*

Sources required for BASIC reporting	green
Sources required for BASIC+ reporting (green & blue)	green & blue
Sources included in Other Scope 3	orange
Sources required for territorial but not for BASIC/BASIC+ reporting	pink
Non-applicable emissions	grey

* represents Portlands

SSG SUSTAINABILITY SOLUTIONS GROUP

whatIf?