

PE19.4
Attachment B

TransformTO

CLIMATE ACTION FOR A HEALTHY,
EQUITABLE, PROSPEROUS TORONTO

Results of Modelling
Greenhouse Gas
Emissions to 2050

April, 2017

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Abbreviations

AV	Autonomous vehicle
BAP	Business as planned scenario
BBP	Better Buildings Partnership
CO ₂	Carbon dioxide
CDD	Cooling degree days
CH ₄	Methane
EED	Energy and Environment Division
EV	Electric vehicle
DE	District energy
GHG	Greenhouse gas emissions
GPC	Global Protocol for Community Scale Greenhouse Gas Emissions Inventories
GWP	Global warming potential
HDD	Heating degree days
LCS	Low carbon scenario
MAC	Marginal abatement curve
MAG	Modelling Advisory Group
MCA	Multi-criteria analysis
NPV	Net present value
PV	Photovoltaic
RE	Renewable energy
RNG	Renewable natural gas
SCC	Social cost of carbon
SSG	Sustainability Solutions Group
TAF	The Atmospheric Fund
TGS	Toronto Green Standard
VKT	Vehicle kilometres travelled



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Executive Summary

Purpose of TransformTO

TransformTO: Climate Action for a Prosperous, Equitable and Healthy Toronto is a community-wide, cross-corporate initiative of the City of Toronto and The Atmospheric Fund. TransformTO was designed to engage residents, other stakeholders, experts, and all City operations in identifying ways to reduce Toronto's greenhouse gas emissions (GHGs) by 30 percent by 2020, and by 80 percent by 2050, against 1990 levels.

Through a process of technical modelling, a literature review of co-benefits and co-harms, and community input, TransformTO has identified a viable pathway to 80% reductions by 2050 using currently available technologies.

This pathway identifies opportunities for collaborative and sustained efforts by the City, the private sector, higher levels of government and Toronto residents in achieving the required scale of greenhouse gas reductions.

Purpose of Report

This report builds on analysis completed in previous documents, which can be found on the TransformTO website:

- a. results from detailed technical modelling of Toronto's core urban systems on a pathway to achieve 80% reduction in GHG emissions over 1990 levels,
- b. results from a literature review on the impact of low carbon actions on health, equity and prosperity,
- c. results of a City-wide engagement and consultation with key stakeholders, and
- d. the findings of an expert Modelling Advisory Committee (MAG).

Project Approach

The City of Toronto hired Sustainability Solutions Group (SSG) to use technical modelling to:

1. Analyze how GHG emissions would change over time in key sectors including buildings, transportation, waste, energy sources, and land use as a result of current federal, provincial, and municipal policies and programs.
2. Evaluate the potential impact of various low-carbon actions and scenarios such as energy efficiency retrofits, increased walking and cycling and improved transit infrastructure on reducing GHG emissions.
3. Analyze potential co-benefits and co-harms of low carbon actions on public health, the local economy and social equity.

CityInSight, an energy and emissions model developed by SSG and whatlf? Technologies was used to support the analysis. CityInSight uses a GHG accounting framework based on the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC), a standard that is designed to enable comparability between cities globally.

The analysis began by considering the drivers that contribute to current greenhouse gas emissions, answering the question “where are we now?” A baseline GHG inventory tabulated emissions resulting from buildings, transportation, energy production, and waste in the year 2011. Emissions associated with changes in land cover and carbon sequestration were not included in this analysis.^{1,2}

Two scenarios were defined: Business as Planned (BAP) and Low Carbon Scenario (LCS). The BAP explored energy and emissions projections for the city given current and planned policies and actions by municipal, provincial and federal governments. The LCS explored additional actions in order to achieve an 80% emissions by 2050.³

The actions development process for the LCS involved research of low carbon actions and best practices in reducing GHG emissions at the city scale. Arup, (a consulting partner to the project), developed a comprehensive list of

1 Changes in land cover (from greenfield to brownfield) to 2050 is assumed negligible; new growth is targeted to already developed areas in the form of densification/infill.

2 Annual net carbon sequestration of the City's urban forest accounts for 36,500 t CO₂e, less than 0.2% of baseline emissions (Every Tree Counts, City of Toronto, 2013).

3 For a detailed description on scenario types, see: Börjeson, L., Höjer, M., Dreborg, K. H., Ekvall, T., & Finnveden, G. (2006). Scenario types and techniques: towards a user's guide. *Futures*, 38(7), 723-739.

actions, drawing from their expertise, and involvement in the development of the C40 Climate Action in Megacities v2.0 & v3.0 reports.⁴ This initial list also included details of each action, examples of where the action has been implemented, and a review of the potential co-benefits.

The approaches of reduce-improve-switch and low carbon city planning guided the identification of a final list of actions and the sequencing of actions in CityInSight. The stocks and flows logic underpinning CityInSight reflects the inertia associated with buildings or vehicles as well as the interactivity between actions, so sequencing has an impact on the relative effect of actions in reducing emissions. Actions were implemented beginning in the year 2017 in the LCS.

The final step of the scenarios analysis involved assessing the potential impacts of LCS actions on social, economic and health outcomes.

TransformTO Results

The results of the TransformTO scenario analysis indicate that deep emissions reductions on the order of 80% or more by 2050 are technically feasible using presently available technologies. In addition to GHG emissions reductions, these actions can result in economic and social benefits aligned with the City's existing strategies.

The results of the analysis for the baseline and two scenarios are summarized in Table 1.

⁴ C40's Climate Action in Megacities is available at https://issuu.com/c40cities/docs/cam_3.0_2015

Table 1. Summary results, GHG emissions (Mt CO₂e)⁵

	1990	2011	2020	2050	THE GAP IN 2050
Baseline & Targets	27 (baseline)		18.9 (target 30x20)	5.4 (target 80x50)	
2011 Inventory		19.7			
BAP			15.7	12.6	7.2
% reduction over 1990			42%	53%	
LCS			14.8	3.9	-1.5
% reduction over 1990			45%	86%	

Achieving the City of Toronto’s emissions reductions target is dependent firstly on scaling up efforts in existing programs and policies such as the Toronto Green Standard, Better Buildings Partnership, Hi-Rise and HELP, and secondly on introducing additional efforts that will require new investments.

The co-benefits analysis suggests that in addition to achieving the objective of GHG emissions reductions, the actions explored in the LCS can also be an economic development strategy, a healthy city plan, a competitiveness and innovation plan, an active transportation strategy, and an energy plan, all in one. With careful consideration, the LCS approach can be a poverty alleviation strategy, and an inclusion strategy. Many of the emissions reduction actions analyzed synergistically support or contribute to other City objectives on economic development and equity, as illustrated by the examples in Table 2.

5 The BAP numbers were adjusted from those in the 2016 Staff Report to incorporate the impacts of decreased heating degree days (HDD) on energy used in commercial buildings, as the previous results had only applied the change in HDD to residential buildings. As HDD increase, particularly towards 2050, there is a decrease in emissions due to a decrease in space heating, which is partially offset by an increased demand for air conditioning. The update also includes the treatment of GHG emissions from biogas and biodiesel as biogenic emissions, or carbon neutral, and the reclassification of some vehicle classes, which had a minor impact on fuel use in transportation in 2050.

Table 2. Examples of City strategies or objectives supported or enhanced by the Low Carbon Scenario approach^{6,7,8,9,10,11,12}

POLICY DIRECTION	THEME	LOW CARBON PATHWAY
Feeling Congested: Official Plan amendment (2014)	Land-use planning	Supports integration of transit with land-use, active transportation and increased efficiency of goods movement.
Toronto Official Plan	Land-use planning	Supports development patterns of compact centres, mobility hubs, and corridors connected by regional transit, enhanced transit, an improved pedestrian environment, improved affordable housing, economic development and new employment opportunities.
Collaborating for Competitiveness (2013)	Economic development	Supports business investment and new employment.
Toronto Strong Neighbourhood Strategy 2020	Equity	Provides opportunities to improve quality of life through improved accessibility, housing quality and energy security in neighborhoods.
TO Prosperity: Poverty Reduction Strategy.	Poverty	Provides new opportunities for quality employment, enhanced transit and accessibility and improved quality and energy efficiency of housing.
Toronto Walking Strategy	Active transportation	Supports increased active transportation, including walking.
Active City: Designing for Health	Health	Supports the principles identified as critical to an active city.

6 City of Toronto. (2014). "Feeling Congested?" Recommended Official Plan amendment for selected transportation policies: Official Plan Comprehensive Review. Retrieved from <http://www.toronto.ca/legdocs/mmis/2014/pg/bgnd/backgroundfile-71992.pdf>

7 City of Toronto. (2015). Toronto Official Plan. Retrieved April 13, 2017, from <http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=03eda07443f36410VgnVCM10000071d60f89RCRD>

8 City of Toronto. (2013). Collaborating for competitiveness: A strategic plan for accelerating economic growth and job creation in Toronto. Retrieved from https://www1.toronto.ca/static_files/economic_development_and_culture/docs/Collaborating_for_Competitiveness_FINAL-v7.pdf

9 City of Toronto. (2015). Toronto Strong Neighbourhoods Strategy.

10 City of Toronto. (2015). TO Prosperity: Toronto poverty reduction strategy. Retrieved from https://www1.toronto.ca/City%20Of%20Toronto/Social%20Development,%20Finance%20&%20Administration/Strategies/Poverty%20Reduction%20Strategy/PDF/TO_Prosperty_Final2015-reduced.pdf

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

12 Gladki Planning Associates, & DTAH. (2014). Active City: Designing for Health. Retrieved from <http://www1.toronto.ca/City%20Of%20Toronto/Toronto%20Public%20Health/Healthy%20Public%20Policy/Built%20Environment/Files/pdf/ActiveCityReportMay292014.pdf>

There are economic benefits

Many of the actions analyzed deliver significant economic returns. Actions accounting for 67% of the emissions reductions in the LCS result in a net financial savings for each tonne of carbon dioxide reduced, while those responsible for the remaining 33% of the reductions result in a net cost.¹³ Barriers exist to realizing some financial opportunities, such as the split incentive, in which one party invests in an action while another realizes the financial return. Many of the actions represent financial opportunities that the City is uniquely able to unlock, for example large-scale energy efficiency retrofits. Some actions also require sustained efforts by other levels of government, such as the electrification of the vehicle fleet.

New employment opportunities are created

Investments required to support the actions considered in the LCS will generate an estimated 327,000 additional and direct person-years of employment between 2017 and 2050. Many of these will be created in emerging sectors such as energy storage, decentralized energy generation and electric vehicle manufacturing. Some employment will be shifted, for example from fossil fuels to renewable energy, and certain jobs will be made obsolete, such as vehicle mechanics who specialize in combustion engines.

Energy expenditures will be lower in the long term

In addition to new investment opportunities, the LCS results in lower energy costs for businesses and households. Energy efficiency gains exceed the increased energy costs of fuel switching from natural gas to electricity in most areas of the city by 2050. Dwellings in all but four neighbourhoods experience cost savings for heating, cooling and electricity by 2050. Due to extensive district energy and the use of renewable energy, these costs are also resilient against fluctuations in global commodities.

Damage from climate change is reduced globally

Damage can be attributed to each tonne of carbon dioxide emitted using economic models and avoided damages associated with climate change are therefore one of the most significant benefits of actions to reduce GHG emissions. These avoided costs, which are of global benefit, are estimated to total \$11 billion between 2016 and 2050, using the Social Cost of Carbon accounting method.¹⁴

¹³ The marginal abatement cost analysis is described in Section 6.4. The analysis incorporates a price of carbon beginning at \$10/tCO₂e in 2018 and climbing to \$114/tCO₂e by 2050.

¹⁴ For a detailed description of the Social Cost of Carbon see Section 6.3.1.

Health outcomes are improved

As fossil fuels are phased out, many air pollutants will be reduced or eliminated, reducing premature deaths and hospitalizations, which were estimated at 280 and 1,090 respectively in 2014 in Toronto.¹⁵ Other health benefits from reduced air pollution include decreased mortality from cardiovascular disease, and decreased prevalence of asthma and allergic diseases. There are also health benefits resulting from increased levels of active transportation. Kilometres walked or cycled in the LCS increases to just under 2 km per person per day in 2050 versus 0.6 km per person per day in the BAP scenario, an increase of 320%.

Implementation strategies influence the social and economic benefits

Some social and economic benefits associated with the actions considered in the LCS are dependent on the manner in which actions are implemented. For example, an action requiring a significant capital investment will enhance or decrease equity according to the structure of the investment mechanism. Careful consideration needs to be given to determine which activities should be undertaken by the private sector, the City or other entities, and to whom the returns should be directed.

Impacts vary by neighbourhood

Impacts of emissions reduction actions are also spatially distributed. Some neighbourhoods benefit to different degrees, depending on the characteristics of the built environment. For example, greater opportunities for financial savings are available in neighbourhoods in which people drive further than in those in which people already walk and cycle for many of their trips.

Actions need to be considered as part of an integrated energy system

The analysis highlights the importance of the city as an integrated energy system. Actions in one sector influence actions in another sector, with implications for financial returns and GHG emissions reductions. District energy is one of the best examples; if district energy systems are designed without considering the impact of building energy efficiency retrofits, the capacity of the district energy system will be greater than the demand, creating a potential stranded investment and reducing or eliminating the financial opportunity of district energy. There may also be a disincentive for building retrofits if the district energy system is developed prior to the retrofits. As another example, the additional electrical demand resulting from the electrification of the vehicle fleet will require upgrades to the capacity of the distribution system, which can be avoided or minimized if building energy

15 City of Toronto. (2014). Path to healthier air: Toronto air pollution burden of illness update.

efficiency retrofits and the enhanced building code are introduced in tandem. The importance of considering the urban energy system as an integrated whole requires coordination and innovation in planning and governance structures, which historically have been structured in silos according to specific sectors, such as transportation or buildings.

Technology will help, but there is an imperative for action now

Future technological developments may enable further GHG emissions reductions, for example as the efficiency of solar panels increase, or solar panels are integrated into other building materials. Relying on technological progress has limitations, however, as many of the investments that the City makes or enables today have long term implications, locking in patterns of GHG emissions and locking up capital.

Climate change, lowered fuel efficiency standards & dirtier electricity are key risks

Key risks that could impede the ability of the City to achieve its 2050 target were identified using sensitivity analysis as part of the modelling. Risks include changes in buildings' heating or cooling loads resulting from climatic changes, revised fuel efficiency standards, and increased fossil fuel generation in the Provincial electricity grid, which would jeopardize the emissions reduction value of fuel switching efforts in the building and transportation sectors.

In conclusion, the LCS provides a viable roadmap to Toronto's 80x50 GHG emissions reduction target. The City has already made some progress, but no time should be lost in scaling up the effort.



Toronto in 2050

following
TransformTO

A house in 2050

The average new house built in 2050 is smaller than its counterpart in 2015, reduced from 89 m² (954 ft²) in 2015 to 53 m² (570 ft²), and the dwelling is more likely to be an apartment. The house uses just 20% of the energy houses use in 2015 and emits near zero GHG emissions. All new dwellings after 2030 are within walking distance of a subway or light-rail train. The roof is covered with solar photovoltaic (PV) panels, with an average capacity of approximately 4 kW. The dwelling is heated with radiant floors, using waste heat transported through underground pipes from nearby industries; cooling is also provided in the summer through the same pipes.

Moving around in 2050

In most neighbourhoods, it is easy to walk to a school, park, grocery store, restaurant and other key destinations. Residents are likely to walk or cycle to destinations less than 5 km away. Entire road lanes are physically separated for cyclists and cycling is integrated into the culture of the city. Due to demand, cycling roads are plowed before vehicular roads in the winter. City personal transportation planners visit households to teach residents how to identify their best transportation options for trips for work and leisure, while saving money and increasing convenience. Transit is extensive, with new subway lines and an enhanced bus and train system. There are fewer privately owned-vehicles. Residents have access to shared vehicles that are electric, affordable and autonomous: they can be booked by both young people and the elderly.

Going to work in 2050

Many more people will walk (17%), cycle (28%) and take transit (23%) to work, while fewer will drive (32%) compared to 2011 (when trips by walking and cycling totaled 12% and vehicular trips were 66% of the total).¹ Drivers are unlikely to own a vehicle, relying on shared autonomous vehicles provided by vehicle-sharing companies. Some people travel to work only four days a week. The workplace incorporates more shared office space and there is less floor space per employee. Offices are energy efficient, designed to high standards of energy performance if new and retrofitted to these standards if not. Indoor environmental quality is improved. The building generates energy from solar PV on the roof and facades, and is likely to be connected to a district energy system for heating and cooling.

Jobs in 2050

There are many new types of employment in 2050 and the low carbon transition is estimated to directly result in an average of 10,000 new person years of employment per year. A major new industry is focused on upgrading the energy efficiency of buildings. Companies involved in this industry undertake major construction projects for entire neighbourhoods and incorporate expertise in finance, law, construction and engineering. Other sectors that are growing significantly include renewable energy, particularly solar PV, energy storage and district energy. The automotive industry has shifted to produce only electric vehicles.

1. These percentages refer to trips internal to the City's boundaries only.

“ At the 21st Conference of the Parties (COP21) in Paris in late 2015 cities took their place as leaders in responding to the threat of climate change. C40 cities, having already taken more than 10,000 climate actions, demonstrated their leadership in reducing carbon emissions and adapting to climate change, by setting ambitious goals through their commitments to the Compact of Mayors. ”

C40 Cities Climate Leadership Group, of which the City of Toronto is a member.

1. Introduction

In 2007, Toronto City Council unanimously adopted city-wide greenhouse gas reduction targets of 30% by 2020 and 80% by 2050, below 1990 levels. At the same time, Council also adopted 60 recommended actions in the Climate Change Action Plan to move the city in the direction of meeting these goals. Although these actions have been largely initiated, on their own they and at their current scale, they will not achieve Toronto's target for 2050.

TransformTO is a renewal of the effort to achieve these targets. A collaborative effort between the City of Toronto and The Atmospheric Fund, TransformTO engages the community in reducing Toronto's GHG emissions. While the primary objective is to reduce GHG emissions, an integral component of the project was to apply the lens of health, equity and prosperity in assessing emissions reductions actions and strategies.

At the 21st Conference of the Parties (COP21) in Paris in late 2015 cities took their place as leaders in responding to the threat of climate change. C40 cities,¹⁶ having already taken more than 10,000 climate actions, demonstrated their leadership in reducing carbon emissions and adapting to climate change, by setting ambitious goals through their commitments to the Compact of Mayors.¹⁷

TransformTO builds on extensive previous efforts by the City, including the Power to Live Green, Toronto's Sustainable Energy Strategy (2009), the Climate Change Action Plan (2007), the Climate Change Adaptation Plan: Towards a Resilient City (2014), and annual GHG inventories. In parallel to TransformTO, the City is undertaking ResilientTO, a process to enhance the City's resilience to the impact of climate change and extreme weather.

In December, 2016, the Government of Canada, together with the provinces and territories, launched the Pan-Canadian Framework on Clean Growth and Climate Change. The Pan-Canadian Framework is a plan to achieve a 30% GHG emissions reduction over 2005 levels by 2030, a target to which Canada has committed under the 2015 Paris Agreement. Also in 2016 and prior to the announcement of the Framework, the Government of Ontario's Climate Action Plan was released, describing policies and actions specific to Ontario. The Government of Ontario has a target of 15% reduction below 1990 levels by 2020, 37% by 2030 and 80% by 2050.

The work of the City of Toronto through TransformTO supports and, in many cases, enhances the efforts outlined in both the Pan-Canadian Framework and the Climate Action Plan, providing a detailed pathway to achieve significant GHG emissions reductions.

¹⁶ The City of Toronto is a member of the C40 Cities Climate Leadership Group (C40). C40 connects more than 86 of the world's greatest cities, representing over 650 million people and one quarter of the global economy. Created and led by cities, C40 is focused on tackling climate change and driving urban action that reduces greenhouse gas emissions and climate risks, while increasing the health, wellbeing and economic opportunities of urban citizens.

¹⁷ C40 (2016). Unlocking climate action in megacities. Retrieved March, 2017 from: <http://www.c40.org/researches/unlocking-climate-action-in-megacities>