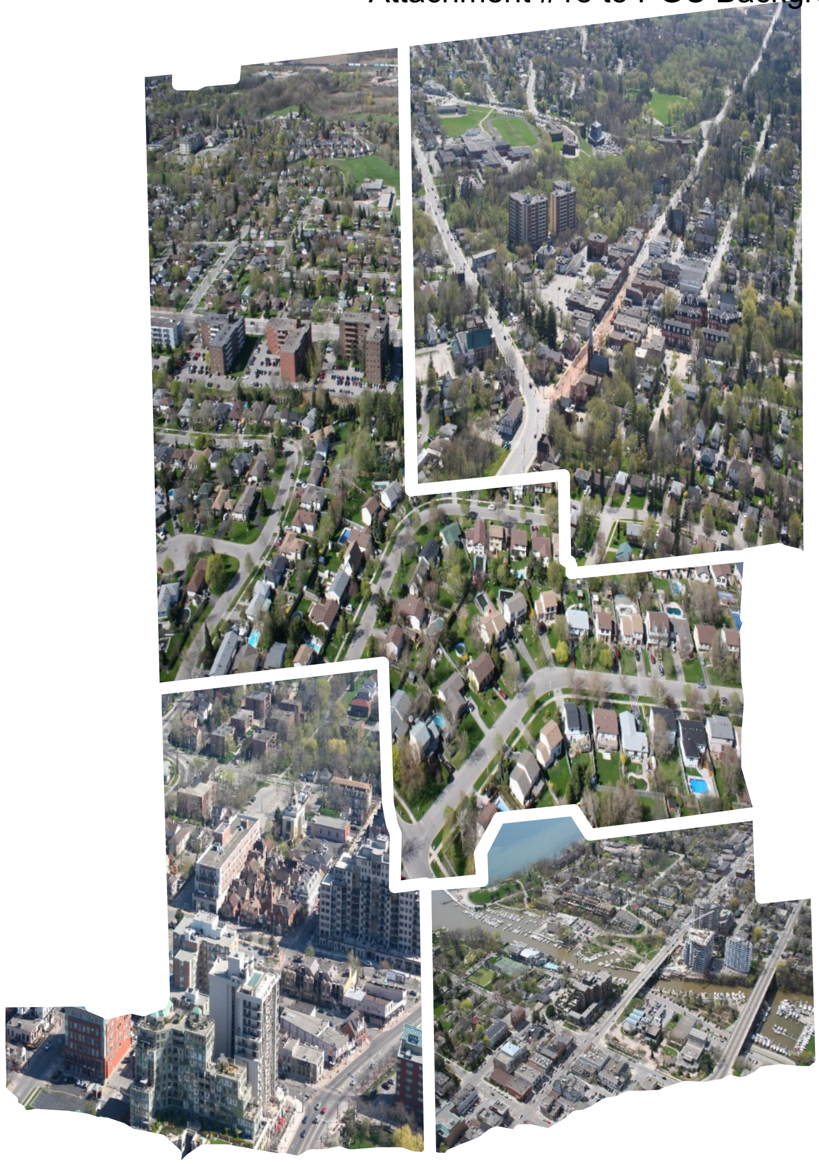

Appendix E

Greenhouse Gas Emissions Assessment

February 2022

Regional Official Plan Review

SSG SUSTAINABILITY SOLUTIONS GROUP

Halton REGION

Disclaimer and Liability

Reasonable skill, care and diligence has been exercised to assess the information acquired during the preparation of this analysis, but no guarantees or warranties are made regarding the accuracy or completeness of this information. This document, the information it contains, the information and basis on which it relies, and associated factors are subject to changes beyond the authors' control. The information provided by others is believed to be accurate but has not necessarily been verified.

This analysis includes strategic-level estimates of Halton Region that should not be relied upon for design or other purposes without verification. The authors do not accept responsibility for the use of this analysis for any purpose other than that stated above, and do not accept responsibility to any third party for the use, in whole or in part, of the contents of this document. This analysis applies to Halton Region and cannot be applied to other jurisdictions without analysis. Any use by Halton Region, its sub-consultants or any third party, or any reliance on or decisions based on this document, are the responsibility of the user or third party.

A Note on the Impact of Coronavirus (COVID-19)

The analysis in this document was completed during the COVID-19 pandemic in Canada. The longevity of the socio-economic changes the pandemic created is difficult to predict. Some changes may be here to stay, while others may revert once conditions are safe again, while still others may become a hybrid of old and new conditions. The uncertainty presents a challenge for long-term modelling assumptions. Some key points to consider in the context of COVID-19 include:

- It is a global health crisis: The pandemic has radically transformed societies and economies, resulting in tragedy and disrupting work and home life everywhere.[1]
- The impacts of coronavirus are unclear: The negative impact of COVID-19 on people, workplaces, and the economy, as well as the duration of those impacts, presents many uncertainties. The recovery will be affected by a combination of factors such as public health guidance for opening up society, the evolution of the pandemic, the design of public policy responses, and the continuing response by global institutions.
- The climate emergency remains: A decline in activity has resulted in a short term reduction in GHG emissions but concentrations of GHG emissions in the atmosphere continue to climb and global temperatures continue to increase.[2] The pandemic has also disrupted international efforts to address climate change.
- There are challenges and opportunities: In the short term, the impacts of COVID-19 both challenge and reinforce actions outlined in this document.
- Substantively addressing climate change is more relevant than ever: Investments made now lock in the emissions effects of those investments for decades.
- Alignment with green stimulus: As Canada initiates efforts to recover from the impact of the coronavirus, there is an opportunity to stimulate the economy with investments that simultaneously address the climate crisis. This document describes investment opportunities that will generate jobs, stimulate businesses, reduce GHG emissions, and provide local benefits.

[1] World Health Organisation (2020). World health statistics 2020: monitoring health for the SDGs, sustainable development goals. Retrieved from: https://apps.who.int/iris/bitstream/handle/10665/332070/9789240005105-eng.pdf
[2] World Meteorological Organisation (2020). The Global Climate in 2015-2019. Retrieved from: https://library.wmo.int/doc_num.php?explnum_id=10251

Glossary

GHG	Greenhouse gas
Emissions	Understood to mean “greenhouse gas emissions” in this report
tCO2e	Tonnes carbon dioxide equivalent (other greenhouse gases such as methane, sulphur dioxide, nitrous oxide, and fluorinated gases are converted to carbon dioxide equivalents)
ktCO2e	Kilotonnes carbon dioxide equivalents (1000 tonnes)
Stationary emissions	Emissions produced by fossil fuel using activities in buildings, infrastructure, and stationary processes
GC4	Growth Concept 4
PGC	Preferred Growth Concept
GC3B	Growth Concept 3B
EVs	Electric vehicles (understood to include zero- and low-emissions vehicles in this report)

Contents

Executive Summary

The Halton Region Preferred Growth Concept GHG Emissions Analysis compares greenhouse gas (GHG) emissions differences between Growth Concept 4 (GC4), the Preferred Growth Concept (PGC), and Growth Concept 3B (GC3B). Differences in urban boundary expansion extent, employment, housing mix, and transportation result in differing community-wide GHG emissions production over the next 30 years (the timeline of this study) for each growth concept.

The energy and emissions modelling performed to assess the growth concepts indicates that in a given year there are only modest differences in emissions between the three growth concepts. However, cumulatively, over the next 30 years, the PGC produces 3,298 kilotonnes carbon dioxide equivalent (ktCO2e) fewer emissions than GC4, while GC3B produces 5,706 ktCO2e fewer emissions. This is equivalent to 772,000 and 1,336,000 typical homes' worth of emissions production over 1 year, respectively. These figures include the effects of carbon sequestration from greenspace, forested lands, and sequestering agricultural lands, which is roughly 10,000 ktCO2e annually in each growth concept.

Table A. Total cumulative emissions differences between GC4, the PGC, and GC3B, including the contribution of natural carbon sequestration (ktCO2e, 2016-2051).

Sector	GC4	PGC vs GC4	GC3B vs GC4	GC3B vs PGC
Residential buildings	39,260,834	-712	-1,443	-732
Non-res buildings	39,338,869	-1,284	-1,991	-707
Transportation	56,071,044	-885	-1,757	-873
Waste	14,100,227	-92	-158	-66
Fugitive	1,451,519	-36	-63	-27
Land carbon sequestration	-9,856,290	-289	-293	-4
TOTAL	**140,366,202**	**-3,298**	**-5,706**	**-2,408**

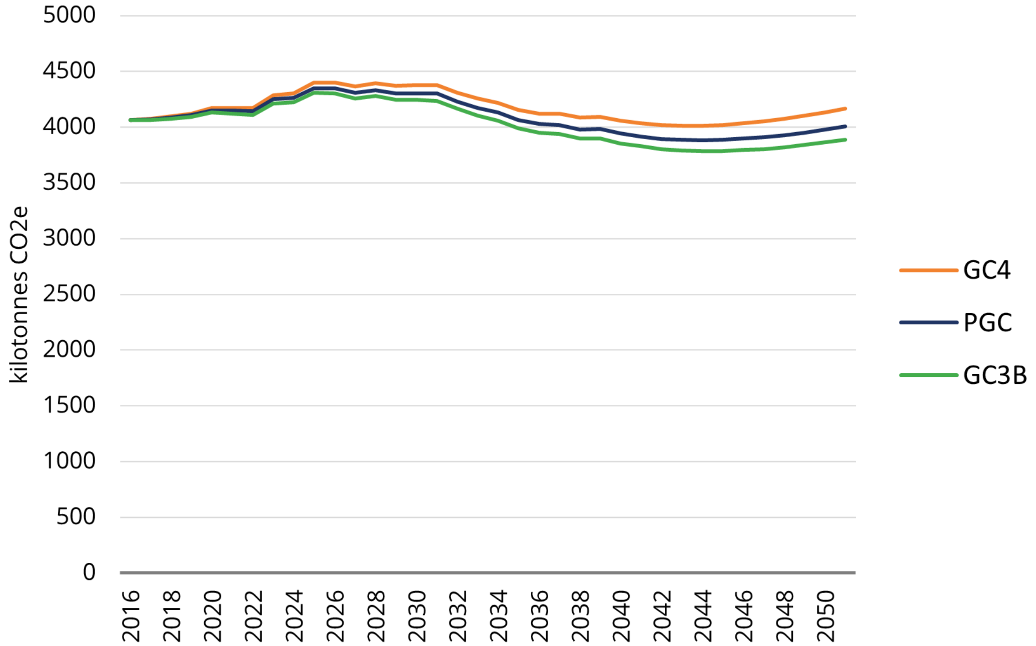

Figure A. Total emissions for PGC, GC4, and GC3B, including the effects of carbon sequestration from greenspace, forested lands, and sequestering agricultural lands.

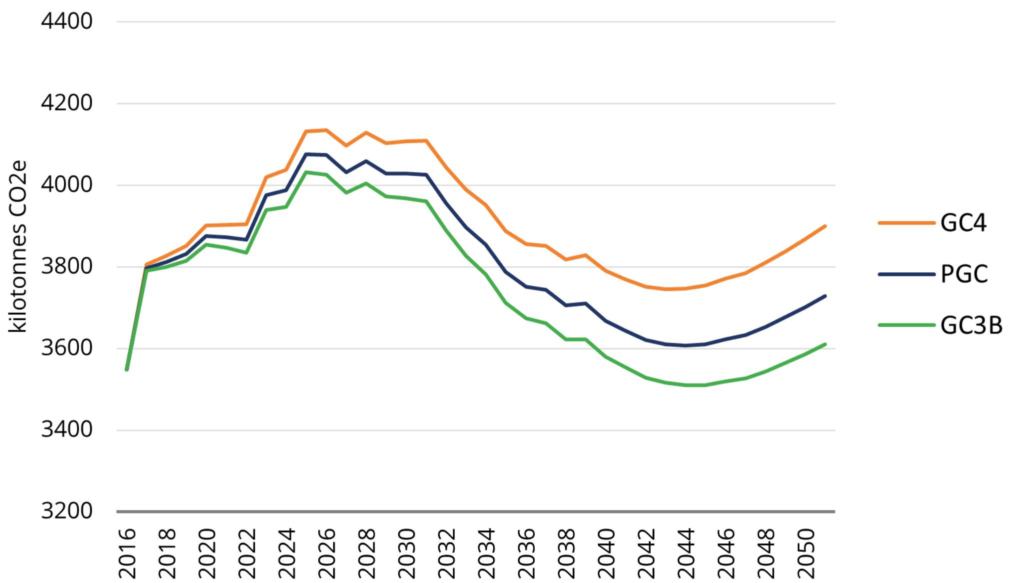

Figure B. Detail of Figure A.

Between 2016 and 2051, cumulative buildings emissions under the PGC are 1,996 ktCO2e lower than under GC4 while GC3B is 3,434 ktCO2e lower than GC4. PGC has fewer single detached homes and more row houses than GC4, with more compact development. GC3B has even fewer single detached homes and more apartment buildings, also with compact development. Compact, multi-unit dwellings are typically more energy efficient, producing fewer emissions from energy use.

Cumulative transportation emissions between 2016 and 2051 are 885 ktCO2e lower under PGC than under GC4, and 1,757 ktCO2e lower under GC3B. More compact development results in fewer and shorter vehicle trips, producing fewer emissions from fuel use.

Even under PGC implementation, an emissions reduction challenge remains. 3.7 megatonnes of emissions remains in the year 2051—far from the now common target of net-zero emissions by 2050 that the Intergovernmental Panel on Climate Change and climate change emergency declaring local governments are committing to.

Introduction

Halton Region has been investigating land-use Growth Concepts as a part of its Regional Official Plan Review to help determine how the Region will plan to accommodate a forecast of 1.1 million people and 500,000 jobs by 2051. Climate change mitigation outcomes of future land-uses are important considerations in the deliberation for a Preferred Growth Concept that will guide development in the region for decades to come. To this end, three Growth Concepts developed for Official Plan consideration were modelled for their energy use and greenhouse gas (GHG) emissions production over the next 30 years to determine the energy and emissions differences between the directions. This report presents the modelling results and discusses the implications of both land-use concepts.

The assessment builds upon a previous study undertaken by SSG and whatIf? Technologies that evaluated the emissions impacts of four different Growth Concepts with varying levels of densification and new housing unit locations over the next three decades. This report presents the results of modelling efforts far more advanced, sophisticated, and substantive than the previous, high-level effort. It is expected that there are variations between these two efforts.

The Regional Official Planning Process

The Provincial Planning Act requires a review of the Regional Official Plan every five years. The current review period began in 2014 and culminates in 2023. To develop the plan, the Region is considering different Growth Concepts with varying levels of intensification, densification, and urban boundary expansion.

The Climate Mitigation Context

Halton Region, as well as its constituent municipalities (City of Burlington, Town of Halton Hills, Town of Oakville, Town of Milton), are among hundreds of municipalities across Canada that have declared climate emergencies. The Town of Halton Hills, in particular, stands out for its aspirations—its goal of net-zero community emissions by 2030 is among the most ambitious in Canada. The City of Burlington's climate action plan sets a community target of net-zero emission by 2050. The Town of Milton has a community energy plan. The Town of Oakville has a Community Energy Strategy.

A Note on Comparing Emissions for Alternative Land-use Plans

Land-use and development approaches have historically had proven, substantial effects on emissions production. Distributed housing development typically results in greater emissions compared to the same number of homes built in a central, multi-unit focused development style. Home energy use and emissions production are typically less when floor areas are smaller and thermal energy is better conserved with shared walls. Vehicle energy use and emissions production are also typically higher in less dense developments, as trips to work, schools, and amenities are generally longer.

The energy use and emissions production differences between distributed and compact developments are narrowing in recent years. As new buildings are mandated to be more energy efficient under improved building codes and more electric vehicles are sold, using less and cleaner energy, emissions associated with buildings and vehicle trips are decreasing—whether buildings are compactly developed or distributed. Distributed developments still typically use more energy and have higher emissions than compact developments, but the difference continues to narrow.

This is, of course, not an argument for low density developments. There are myriad arguments for smart, compact, neighbourhood-oriented developments that contain a mix of land uses and function as complete communities. Among these are improved access to amenities, improved physical health, and household energy cost savings, to name a few.

The Growth Concepts

The analysis compared energy use and emissions production for Regional Official Plan Review Growth Concept 4 (GC4), the Preferred Growth Concept (PGC), and Growth Concept 3B (GC3B). The three Growth Concepts differ in terms of residential unit mix, employment numbers, location of new development, and land-use intensification and densification assumptions, which affect the amount of new urban area land to be designated for new community or employment uses.

GC4 plans for 3,300 hectares of currently agricultural areas to be urbanized. However, most new housing will be accommodated within the existing urbanized area. The majority of new housing units will be ground-related (for example, single-detached, semi-detached, row/townhouses).

The PGC and GC3B achieve higher dwelling densification compared to Growth Concept 4. In addition, these concepts involve less urban boundary expansion and accommodate more growth within the Region's existing urban area.

GC3B provides no new land for housing and most new housing is in high density developments. There is also no new Community Area land or Employment Area land provided, and no development of prime agricultural lands. This scenario considers 24,000 fewer jobs located in Halton Region, requiring reduced commercial and employment building development, and more commuting outside the region to employment areas.

GC4 represents meeting the minimum standards of the Growth Plan related to intensification and densities. While it is not represented as a true 'business-as-usual' scenario, it provides a useful standard to assess how both the PGC and the GC3B perform comparatively.

Energy and Emissions Assessment Methodology

The Starting Place: Base Year Emissions Inventory

The emissions inventory approach used in this analysis follows the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC Protocol), a global framework describing how municipalities can estimate and report local emissions, enabling them to benchmark emissions trends and reduction progress against their peers. Consistently applied, the framework also allows the aggregation of municipal emissions inventories for provincial emissions totals, and provincial aggregations for national-level emissions totals (which federal governments use to report on their obligations to the United Nations Framework Convention on Climate Change [UNFCCC]).

The GPC defines three "scopes" of emissions, as illustrated in Figure 1. This analysis includes all emissions in scopes 1 and 2, as well as scope 3 emissions for energy transmission and distribution, and waste disposed of outside the Region's boundary. This emissions inventory Scope consideration is known as GPC Basic+. The emissions inventory base year is 2016—a federal census year for which there is accurate demographic, energy, and emissions data.

This analysis does not include a comparison of embodied carbon - the emissions released in producing and installing building and infrastructure construction materials (typically scope 3).

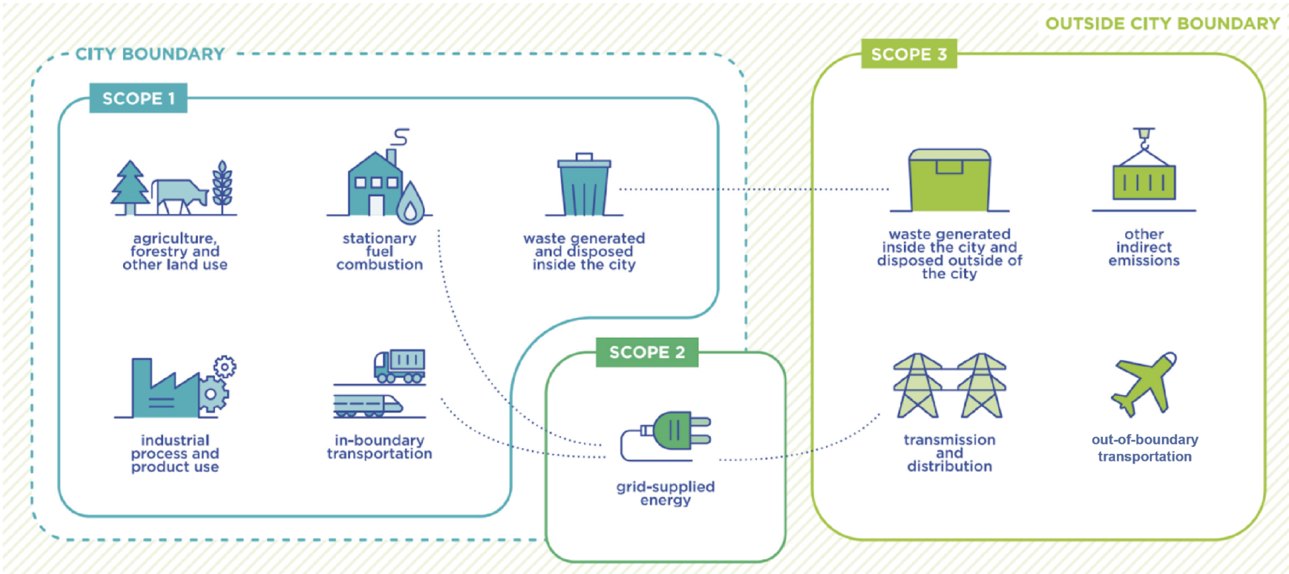

Figure 1. Emissions scopes as they relate to geographic and inventory boundaries.[3] "City" in this image can be replaced with "region" for the purposes of this study.

The Target Year: 2051

Quantitative modelling analysis using SSG's and whatIf? Technologies' CityInSight model details what is likely to happen with Halton Region's energy use and emissions production under each Growth Concept between 2016 and 2051.

CityInSight models all energy and emissions related sectors across the region while describing the relationships between the sectors (e.g. transportation, buildings, energy, waste and wastewater, etc.) A scenario modelling tool, CItyInSight can assess combinations of policies, actions, strategies, and land-uses over time. The model is GIS integrated, allowing all energy and emissions assessments to be mapped.

CityInSight projects how energy flows and emissions production will change in the long term by modelling potential change in the context (e.g. population, development patterns), projecting energy services demand intensities, and projecting the composition of energy system infrastructure, often with stocks. Stock-turnover in the model accounts for penetration rates of new technologies over time constrained by assumptions such as new

[3] Image source: Consumption-Based Inventories of C40 Cities. https://www.c40.org/researches/consumption-based-emissions

stock, market shares, and stock retirements. Examples of outputs of the projections include energy mix, mode split, VKT, energy costs, household energy costs, emissions, and others.

Scenarios Assumptions

Population growth is traditionally a primary driver of energy use and emissions production. With more people come more homes, more retail, commercial, and office spaces, more vehicles and trips, etc. Thus there is typically more energy use and more emissions production as the population grows. Increasingly energy efficient buildings and vehicle electrification over the next 30 years has a tempering effect - homes, buildings, and vehicles are using less energy and less of that energy is provided by fossil fuels. So, population growth is resulting in less new energy use and emissions production than it has historically.

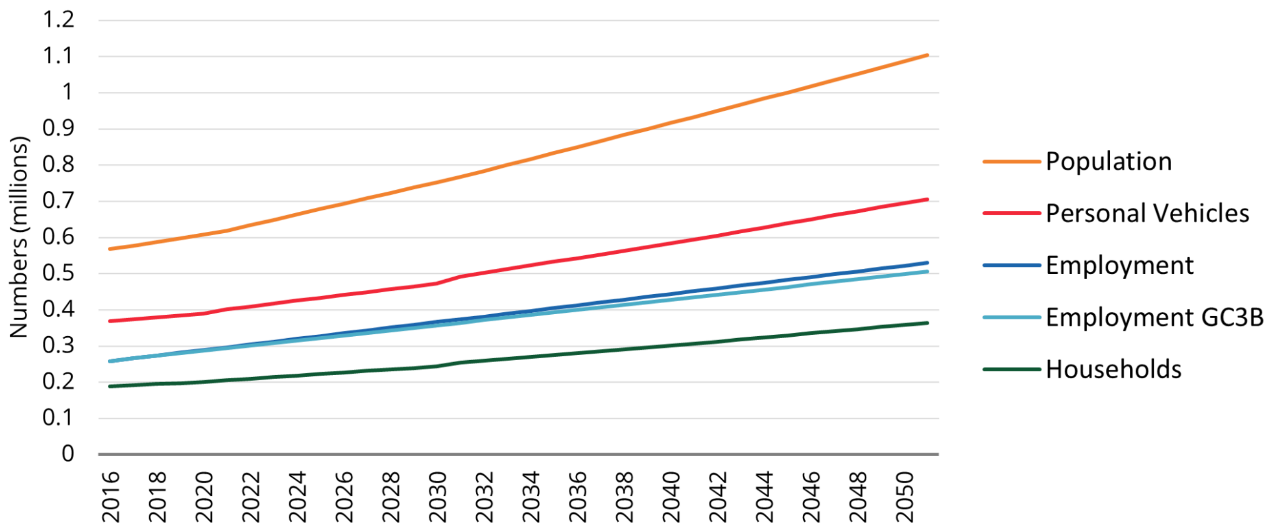

Figure 2. Anticipated population, vehicle, employment, and household growth in Halton Region between 2016 and 2051.

Other modelling assumptions were derived from the characteristics of the Growth Concepts descriptions. The following table compares the modelling assumptions used for each scenario.

Table 1. Emissions sector modelling assumptions comparison of Growth Concept 4 and the Preferred Growth Concept, 2016-2051.

	Growth Concept 4 (base case)	Preferred Growth Concept	Growth Concept 3B
Population			
Population growth	2016: 565,540 2051: 1,100,000		
Employment			
Regional employment allocation	2016: 263, 250 2051: Major Office: 74,100 Population Related: 209,400 Employment Land: 206,400 Rural: 10,100 Total: 500,000	2016: 263, 250 2051: Major Office: 89,800 Population Related: 208,470 Employment Land: 192,700 Rural: 9,230 Total: 500,200	2016: 263,250 2051: Major Office: 74,100 Population Related: 209,400 Employment Land: 182,400 Rural: 10,100 Total: 476,000
Buildings			
Homes	2016: 192,980 2051: 367,540		
Building growth	By 2051: 90,000 new ground related units and 84,000 apartment units	By 2051: 77,673 new ground related units and 96,887 apartment units	By 2051: 56,000 new ground related units and 118,000 apartment units
Building performance	2016-2020: 20% better than OBC 2012 2020-2026: 15% better than OBC 2020 Non-residential: Energy performance under code improves by 10% every five years.		
Renewable Energy Generation			
Rooftop solar PV	Existing instances of solar household PV installations held constant: 17.071 MW for IESO contracts		
Ground mount solar	Existing ground-mounted solar projects of 0.578 MW held constant.		
District Energy Generation	A Geothermal CHP system will be used to provide heat and electricity to a maximum of 2,589 units connecting to the district heating system at Vision Georgetown. This system is expected to be installed in 2035.		
Wind	None		

	Growth Concept 4 (base case)	Preferred Growth Concept	Growth Concept 3B
Transportation*			
Transit	Mode share follows Halton Region transportation modelling results for Growth Concept 4. Electrify transit by 2035.	Mode share follows Halton Region transportation modelling results for PGC. Electrify transit by 2035.	Mode share follows Halton Region transportation modelling results for GC3, with modifications for fewer in-region jobs. Electrify transit by 2035.
Active transport	Mode share is consistent with the transportation analysis undertaken for the Preferred Growth Concept for the IGMS.		
Private/ Personal- use vehicles	Personal-use vehicles: 100% of new vehicles are electric by 2035. Commercial vehicles: The share of sales of electric commercial vehicles rises linearly from 0.2% in 2019 to 1.5% by 2030. The same corresponding annual growth is maintained over the following years.		
Waste**			
Waste generation	No change.		
Waste diversion	Baseline waste diversion rate 57.4% (2010), 65% by 2016, to increase to 70% (2025).		
Waste treatment	No change.		
Industry and Agriculture			
Industrial efficiencies	No change.		
Agriculture	3,300 ha converted for new urban area development.	2,150 ha converted for new urban area development.	No land converted for new urban area development.

*The transportation assumptions used for modelling are not derived from the parallel IGMS study and thus may not be comparable to that effort.

**Emissions associated with waste collection and hauling are included in transportation modelling.

Growth Concepts Energy and Emissions Assessment

Overall Emissions

Annual Emissions

Energy-using activities in Halton Region generated 4,063 ktCO2e of emissions in the 2016 base year—the equivalent of what is emitted by about 950,000 average homes' annual energy use or 1.2 million cars' annual fuel use.[4] Without substantial decarbonizing actions, modelling indicates that annual emissions in Halton Region are projected to increase slightly to 4,165 ktCO2e in the year 2051, following the land uses proposed in Preferred Growth Concept 4. Following the Preferred Growth Concept, emissions will decrease slightly to 4,004 ktCO2e in the year 2051. Growth Concept 3B sees a larger emissions decrease at 3,886 ktCO2e in the year 2051. These figures do not include the effects of carbon sequestration, which is discussed later.

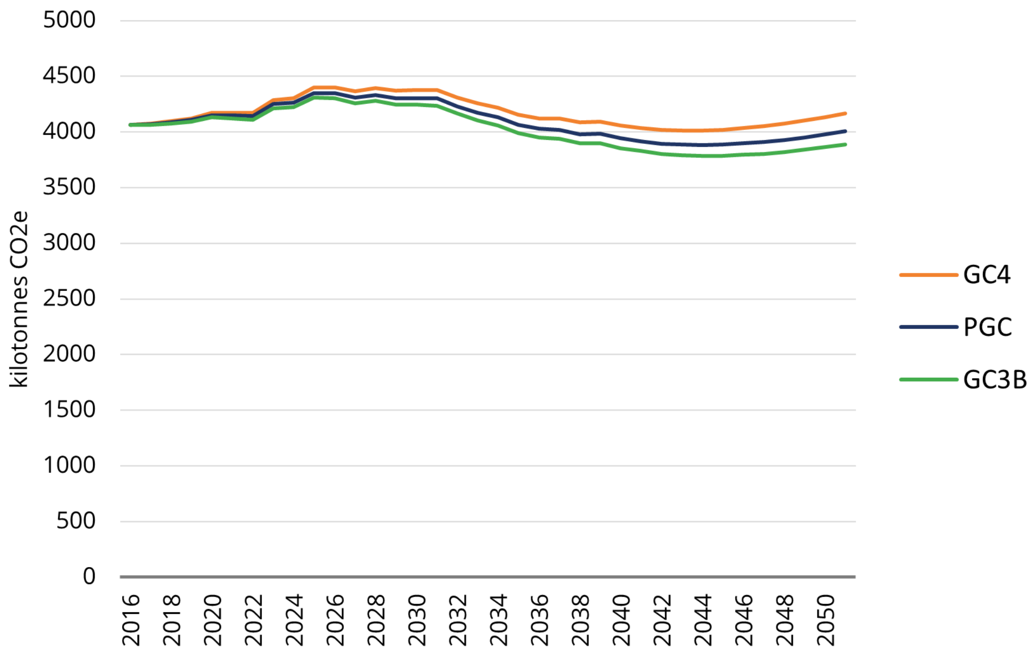

Figure 3. Comparison of GC4, PGC, and GC3B year-over-year total emissions, 2016-2051 (not including carbon sequestration).

[4] NRCan Greenhouse Gas Emissions Calculator: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/calculator/ghg-calculator.cfm

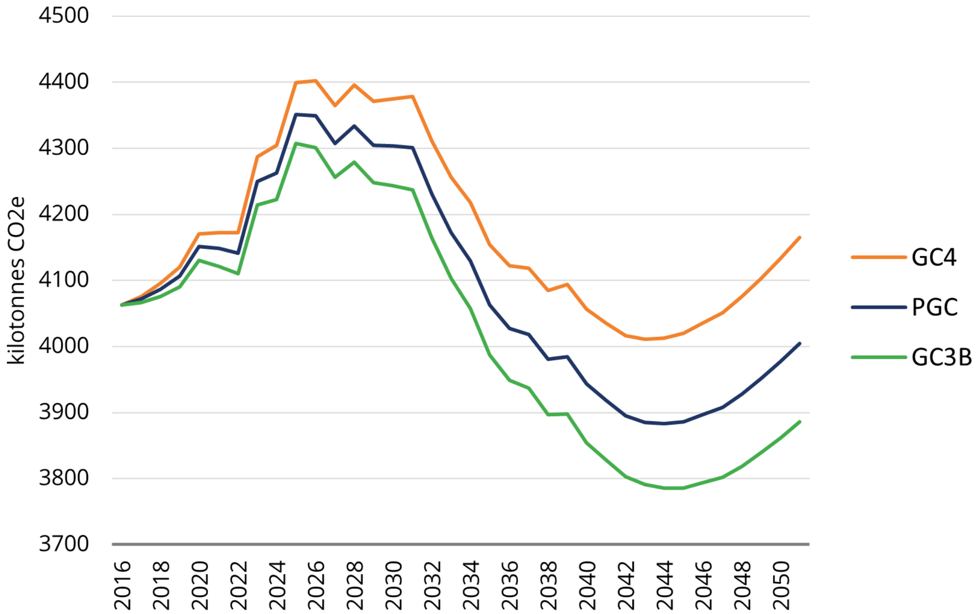

Figure 4. Detail of Figure 3.

Figure 5 shows the PGC's emissions by sector. Emissions in the residential and industrial sectors grow the most, as population, housing, and industrial businesses are added to the region. Emissions from waste and commercial buildings grow slightly. Transportation emissions, on the other hand, decrease substantially, despite increased vehicle ownership. This is due to increased electric vehicle uptake, aided by current and projected federal incentive programs, as well as the federal mandate to ban all fossil fuel vehicle sales by 2035.

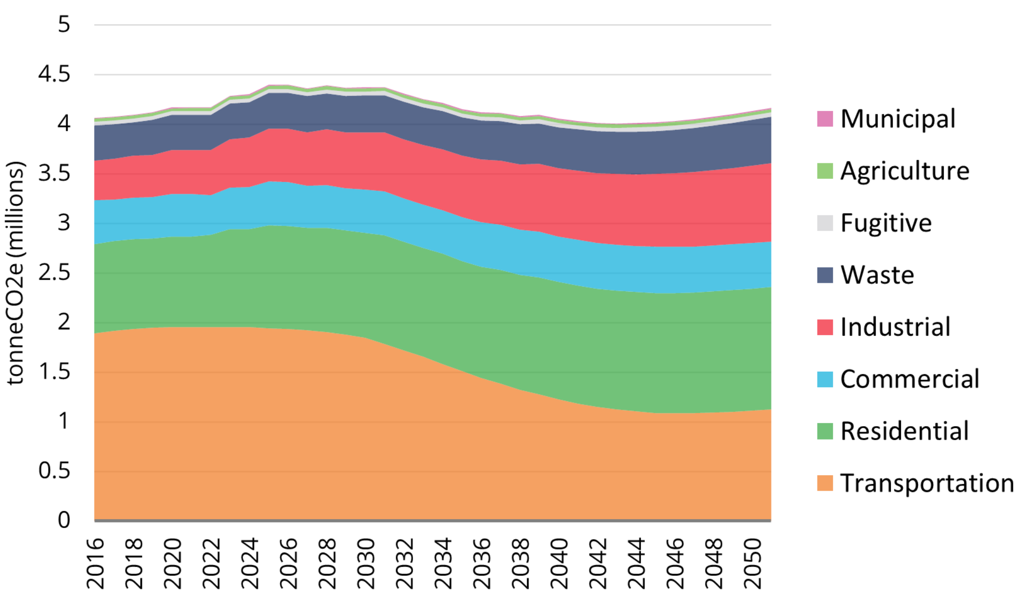

Figure 5. Preferred Growth Concept emissions by sector, 2016-2051.

Table 2 details the total emissions differences by sector between the Growth Concepts in the year 2051. These are further detailed in the following sections.

Table 2. GHG emissions differences between GC4, PGC, and GC3B, by sector, in the year 2051 (not including carbon sequestration), tCO2e.

Sector	GC4	PGC vs GC4	GC3B vs GC4	GC3B vs PGC
Residential buildings	1,235,047	-46,463	-85,982	-39,519
Non-residential buildings	473,196	+22,321	+772	-21,549
Industrial	788,908	-91,851	-109,365	-17,514
Transportation	1,123,870	-36,881	-70,437	-33,556
Waste	466,624	-5,773	-10,642	-4,870
Fugitive	44,399	-1,997	-3,512	-1,514
TOTAL	**4,132,044**	**-170,701**	**-289,253**	**-118,552**

In the year 2051, the PGC emits 170,701 tCO2e less than GC4. GC3B emits another 118,552 tCO2e less, owing to developing more homes as apartments instead of ground related homes (less energy use) and the absence of 24,000 jobs and their related retail, commercial, and office spaces (less energy use and less commuting to the region from outside the region).

Cumulative Emissions

While the annual difference in emissions between the three growth concepts may seem minimal, the cumulative difference during the 30-year period is substantial. Between 2016 and 2051, the PGC results in 3,009 ktCO2e fewer emissions than GC4 (equivalent to 705 thousand homes' annual emissions or 922 thousand cars' annual fuel use emissions). GC3B avoids an additional 2,404 ktCO2e relative to PGC (equivalent to an additional 563 homes' annual emissions or an additional 737 thousand cars' annual emissions). These differences are significant because climate change is shaped by cumulative emissions in the atmosphere, rather than just the emissions in any given year. Consequently, the PGC and GC3B position Halton Region to make a greater contribution to global climate change mitigation efforts.

Table 3. Cumulative emissions differences of the growth concepts, 2016-2051 (not including carbon sequestration). Total cumulative emissions reductions from PGC-GC4 + GC3B-PGC do not precisely sum to the GC3B-GC4 difference due to rounding in the calculations.

Sector	GC4	PGC vs GC4 ktCO2e, 2016-2051	GC3B vs GC4 ktCO2e, 2016-2051	GC3B vs PGC ktCO2e, 2016-2051
Residential buildings	39,260,834	-712	-1,443	-732
Non-residential buildings	39,338,869	-1,284	-1,991	-707
Transportation	56,071,044	-885	-1,757	-873
Waste	14,100,227	-92	-158	-66
Fugitive	1,451,519	-36	-63	-27
TOTAL	**150,222,492**	**-3,009**	**-5,413**	**-2,404**

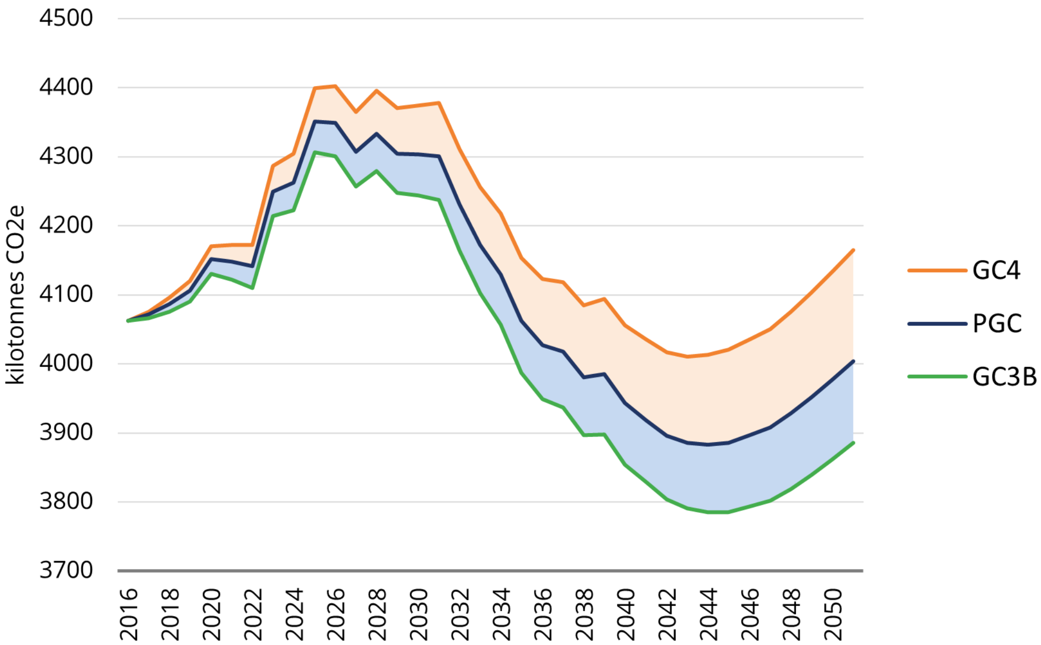

Figure 6. Detail of Figure 3, showing cumulative emissions difference between the growth concepts, 2016-2051 (not including carbon sequestration).

Carbon Sequestration Considerations

The total emissions considered so far has been that resulting from fossil fuel use activity across the region. The green spaces and some (not all) agricultural lands in the region provide carbon sequestration services, absorbing emissions from the atmosphere, primarily through the biological processes of vegetation.

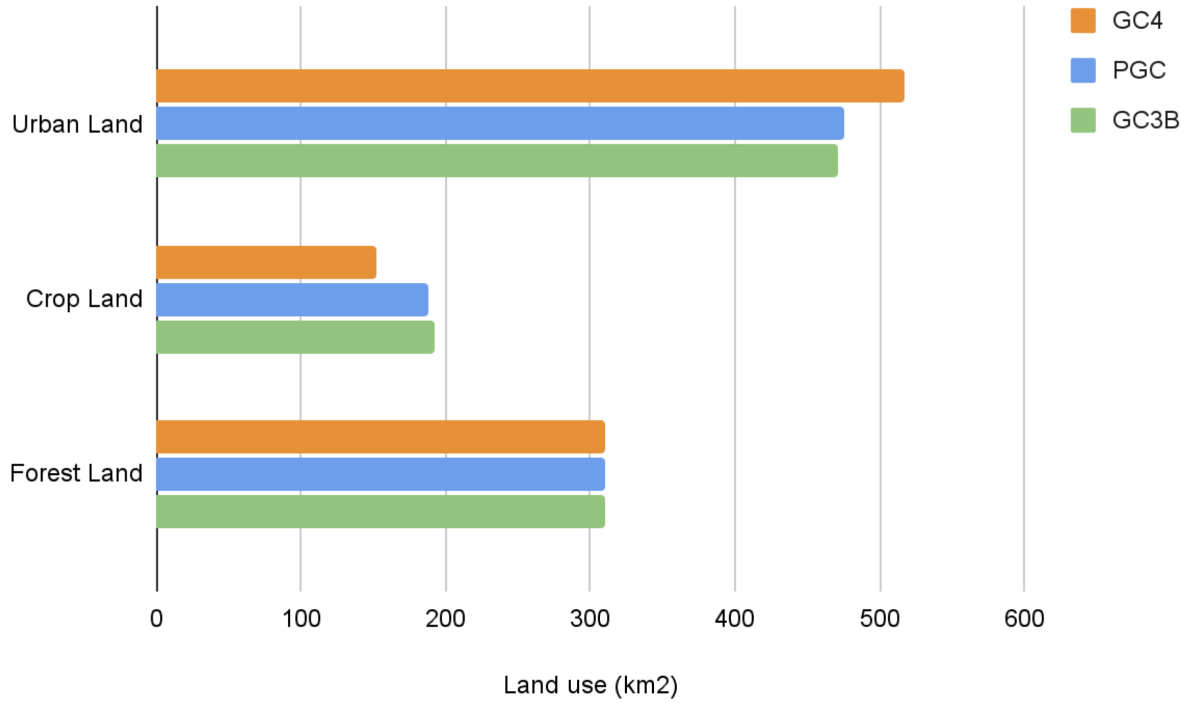

Figure 7. Growth concepts land use comparison, 2051.

These carbon sinks materially affect the total emissions of the region. When compared to CG4, both the PGC and GC3B reduce land-use emissions an extra ~10 ktCO2e in the year 2051 (2,340 homes' worth of annual emissions or 3,000 cars' worth of annual fuel use emissions). Cumulatively, the PGC and GC3B each sequester over 10,000 ktCO2e between 2016 and 2051.

The emissions reductions related to carbon sequestration across the region are added to the differences between the Growth Concepts in Table 4.

Table 4. Total cumulative emissions differences between GC4, the PGC, and GC3B, including the contribution of natural carbon sequestration (ktCO2e, 2016-2051).

Sector	GC4	PGC vs GC4	GC3B vs GC4	GC3B vs PGC
Residential buildings	39,260,834	-712	-1,443	-732
Non-res buildings	39,338,869	-1,284	-1,991	-707
Transportation	56,071,044	-885	-1,757	-873
Waste	14,100,227	-92	-158	-66
Fugitive	1,451,519	-36	-63	-27
Land carbon sequestration	-9,856,290	-289	-293	-4
TOTAL	**140,366,202**	**-3,298**	**-5,706**	**-2,408**

Over the next 30 years, the PGC produces 3,298 kilotonnes carbon dioxide equivalent (ktCO2e) fewer emissions than GC4 while GC3B produces 5,706 ktCO2e fewer emissions. This is equivalent to 772,000 and 1,336,000 typical homes' worth of emissions production over 1 year.

The total emissions of each Growth Concept,including the effect of carbon sequestration, are presented in Figures 8 and 9.

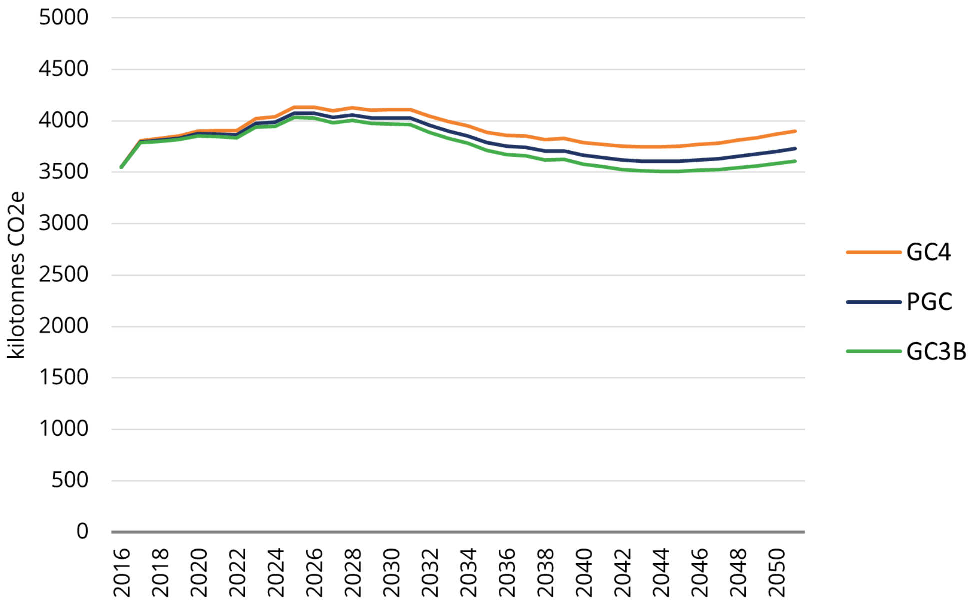

Figure 8. Total emissions for PGC, GC4, and GC3B, including the effects of carbon sequestration from greenspace, forested lands, and sequestering agricultural lands.

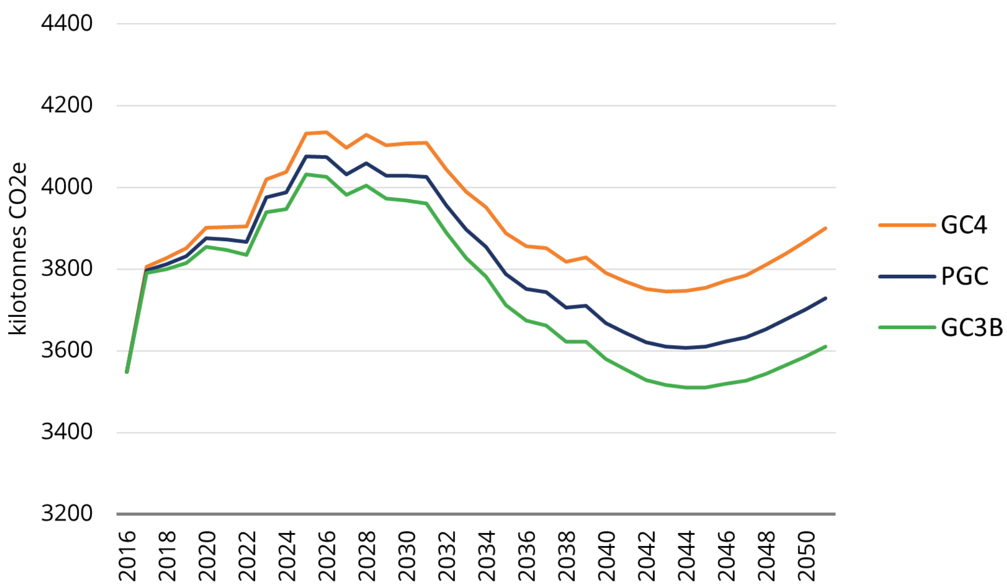

Figure 9. Detail of Figure 8.

Buildings Emissions

The PGC and GC3B have lower building emissions than GC4. Total buildings emissions include those from residential, commercial, retail, office, industrial, and agricultural buildings. In the year 2051, annual building emissions are 24 ktCO2e lower under the PGC than GC4, and 85 ktCO2e lower under GC3B. Between 2016 and 2051, cumulative buildings emissions under the PGC are 1,996 ktCO2e lower than under GC4 while GC3B is 3,434 ktCO2e lower than GC4.

Residential

Residential building emissions differences between Growth Concepts are primarily due to differing land-use densification intensities and building type mix. In the PGC and GC3B, more people live in row houses and apartments, which have a lower floor space per household and shared walls, resulting in lower energy use per unit and thus fewer emissions. These Growth Concepts also have less new urban area development than GC4, preserving vegetated areas and their carbon sequestration services. GC3B has much less retail, commercial, and office buildings as well.

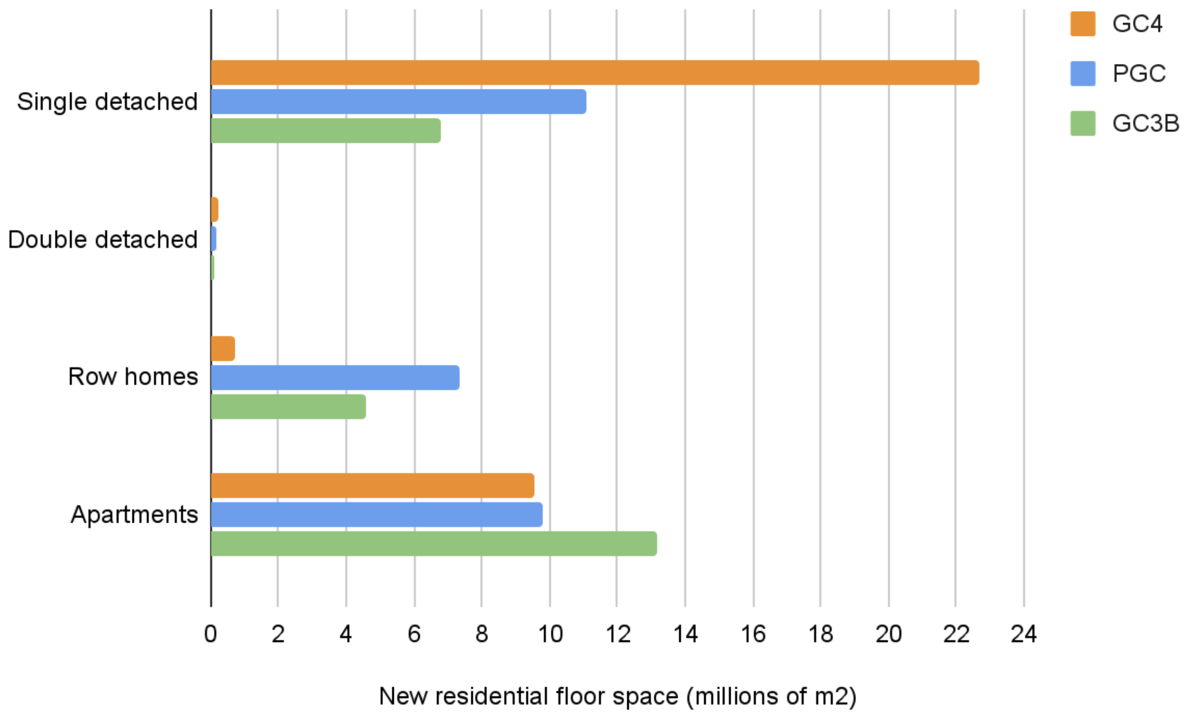

Figure 10. Growth Concepts' projected residential floor space, by housing type, 2051.

Non-Residential

Non-residential building emissions are lower in the PGC and GC3B because different growth and employment patterns lead to different distribution of non-residential building types.

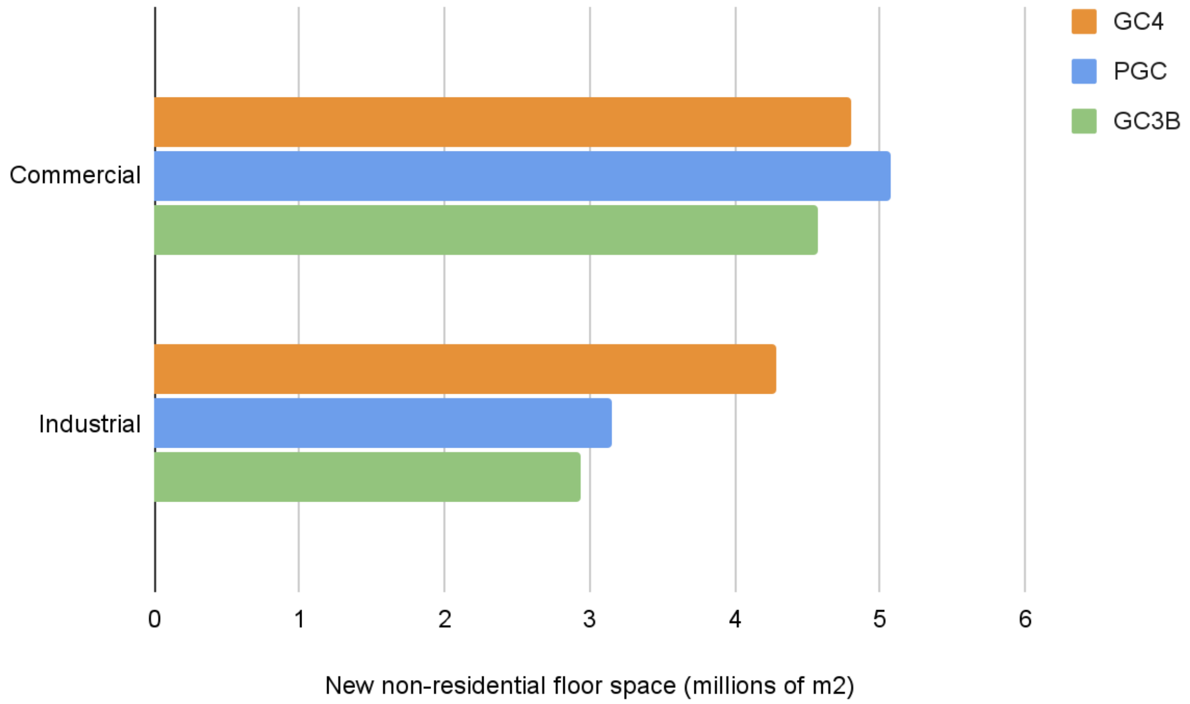

Figure 11. Growth Concept's projected total commercial, industrial, and manufacturing floor space (metres squared), 2051.

The PGC emissions by building type are summarized in Figure 12. Residential buildings are responsible for over half of total buildings' emissions in 2016 and roughly half in 2051. Commercial buildings' emissions increase slightly over the time period as new building stock is added. The addition of industrial buildings over the time period results in emissions almost doubling in that sector by 2051. Civic and agricultural buildings see modest increases over the next 30 years, with modest associated emissions increases.

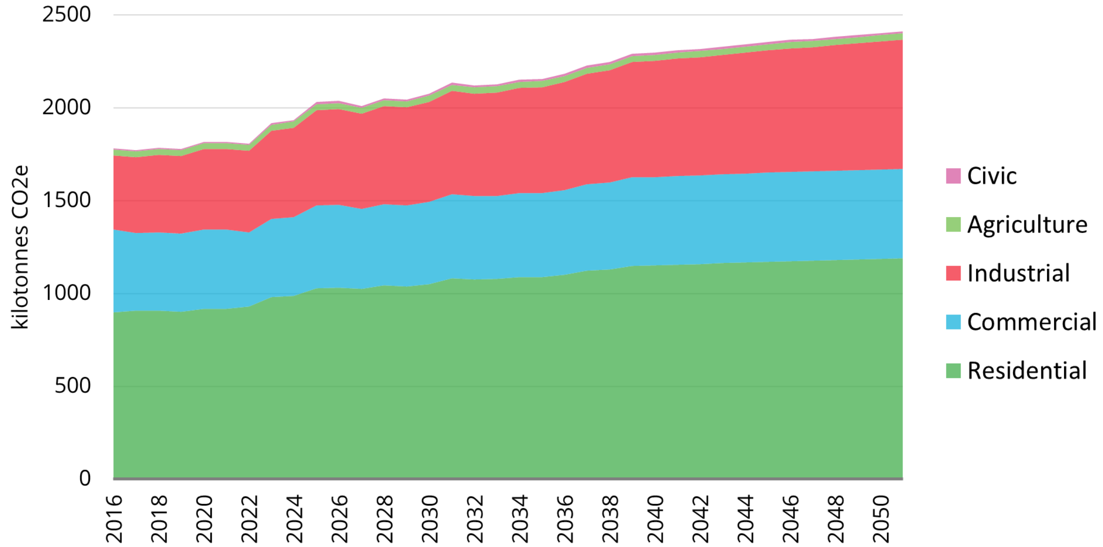

Figure 12. Modelled PGC buildings emissions by building type, 2016-2051.

The PGC building emissions by end use is shown in Figure 13. Space heating uses almost half of all building energy used in 2016 and is responsible for the majority of buildings emissions. This stays almost flat over the time period to 2051 despite new buildings being built as new buildings are more thermal energy efficient than existing building stock and because heating requirements are anticipated to decrease as winters warm due to climate change. Industrial building emissions increase with industrial building stock, which tends to have high energy loads, typically using natural gas. The rest of the building end uses see slight increases in emissions with new building stocks. Notably, space cooling energy demand and emissions production increase as summers warm due to climate change.

Figure 14 shows PGC building emissions by fuel source. Natural gas use in building heating and industrial processes accounts for almost 60% of total energy use and 80% of emissions. Natural gas and electricity use increase with added building stock over the time period.

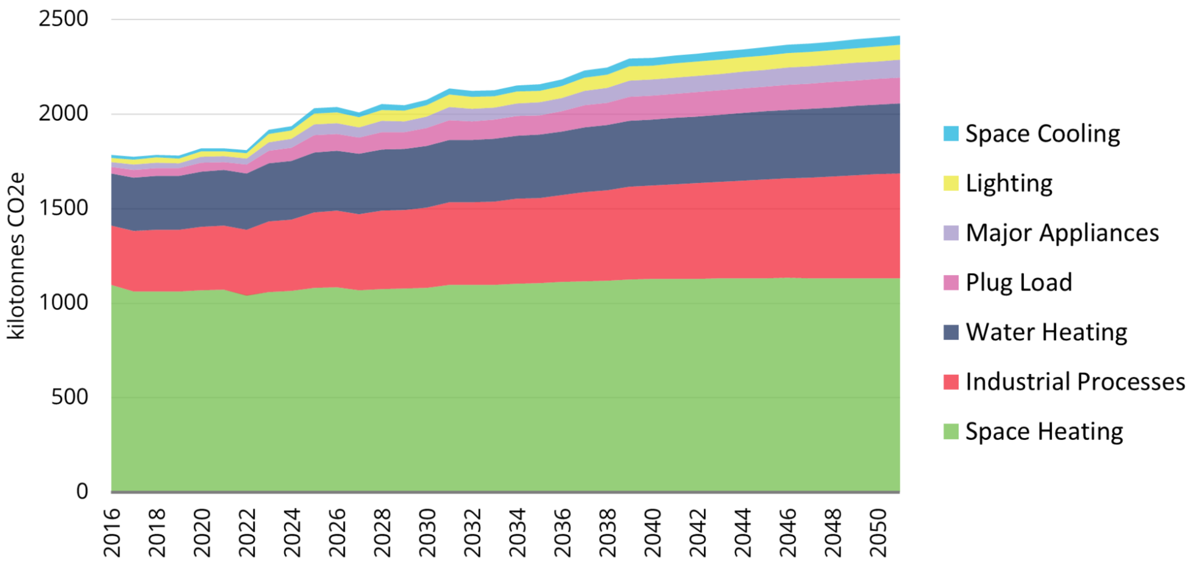

Figure 13. PGC building emissions by end use, 2016-2051.

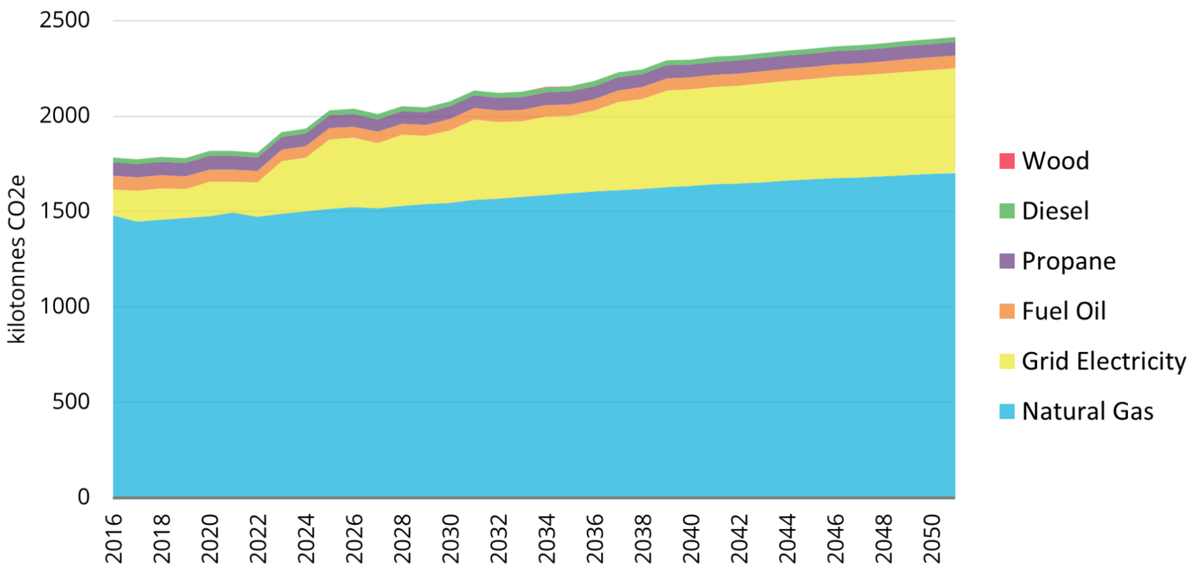

Figure 14. PGC building emissions by fuel type, 2016-2051.

Transportation Emissions

There are 37 ktCO2e fewer emissions in 2051 under the PGC than under GC4, and 70 ktCO2e fewer under GC3B. Cumulative transportation emissions between 2016 and 2051 are 885 ktCO2e lower under PGC than under GC4, and 1,757 ktCO2e lower under GC3B.

Transportation emissions drop under the PGC and GC3B in great part because of an expected shift toward electric and zero- and low-emissions vehicles. The modelling assumes that 100% of new vehicles will be electric starting in 2035 (as per federal mandate) under both growth concepts. Electric vehicle energy use produces far fewer emissions than fossil fuel-powered vehicles. Thus, even as development increases, transportation emissions drop.

At the same time, transportation emissions are lower under the PGC and GC3B because average vehicle trips are typically shorter than under GC4 (Figure 15). As a result of densification, people travel shorter distances, on average, to get to and from work, schools, and other locations. The exception is the home to work travel under GCB3, which is increased due to fewer new jobs in the region than under GC4 and the PGC, forcing more commuting.

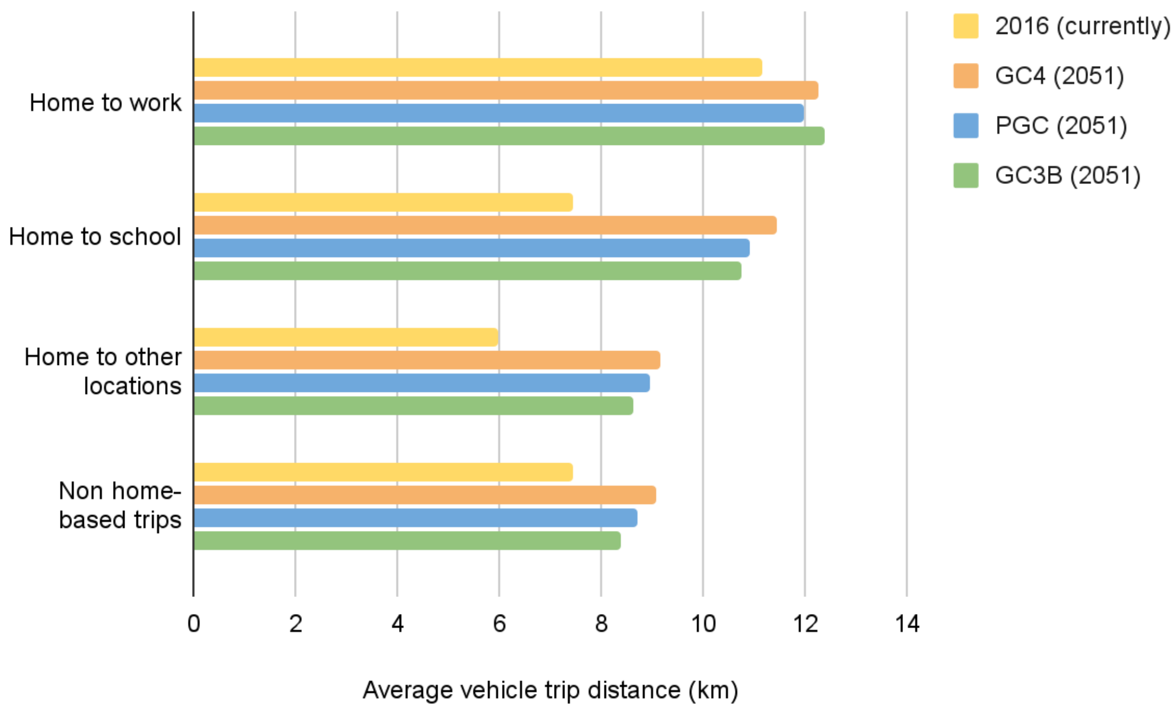

Figure 15. Modelled average vehicle trip distance for each Growth Concept in 2051 vs the average current distance.

EVs start to be a substantial part of total vehicle ownership in the late 2020s and into the 2030s. By 2051, almost half of the energy used by vehicles will be drawn from the electricity grid. Since EVs use energy much more efficiently than gas-powered vehicles, they require less energy to operate. Gas use declines sharply in the 2030s, but there is still some in use by gas vehicles still on the road in 2051. Diesel use declines less as heavy duty vehicles are slower to electrify. Also, the growing population is accompanied by increased freight delivery to homes and retailers, increasing diesel demand.

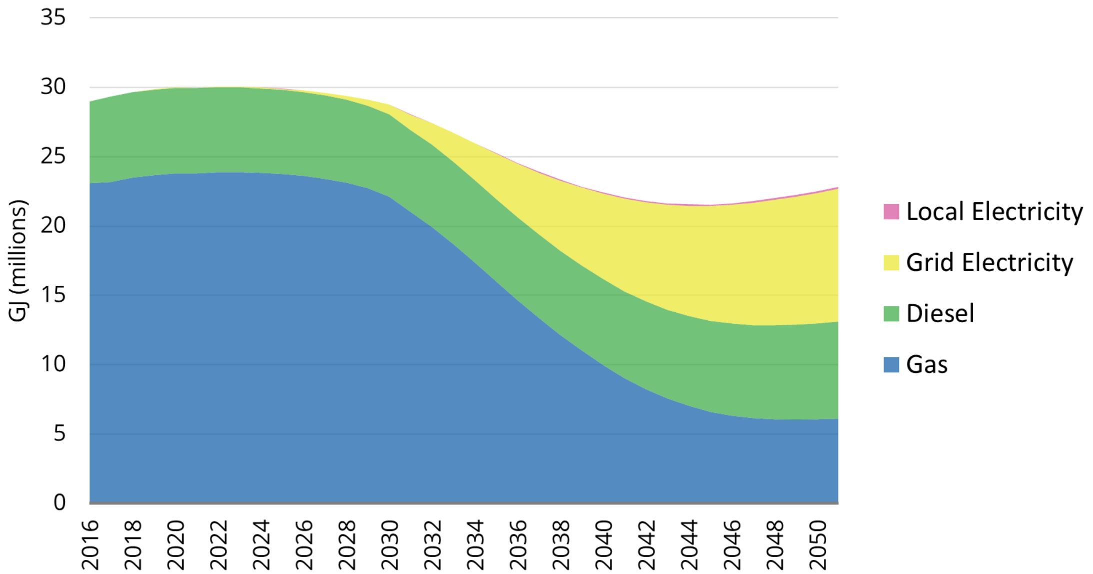

Figure 16. PGC vehicle energy use by fuel type, 2016-2051.

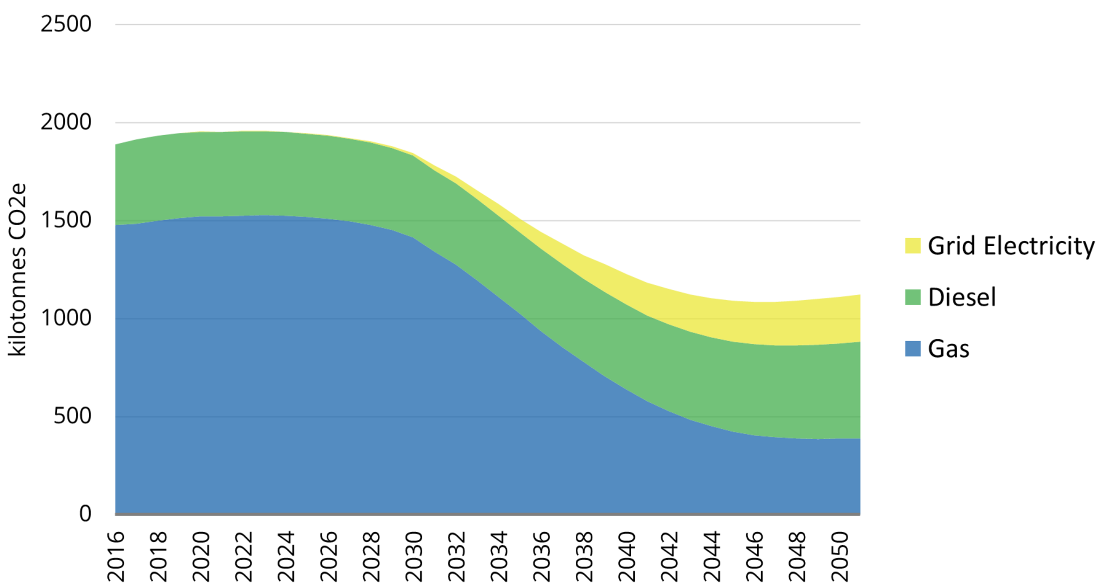

Figure 17. PGC vehicle emissions production by fuel type, 2016-2051.

Other Emissions

The modelling analysis also assessed two other major sources of emissions: solid waste emissions and fugitive emissions. The PGC and GC3B see fewer annual solid waste emissions (-6 and -11 ktCO2e in 2051, respectively) and cumulative solid waste emissions (-92 and -158 ktCO2e from 2016 to 2051, respectively) compared to GC4. Residential solid waste scales with population, so these differences are not attributable to household waste variances. Rather, they are due to having less total non-residential floorspace, which results in decreased waste generated from retail, office, commercial, and industrial sources.

The PGC and GC3B also have fewer fugitive emissions (natural gas escape during its distribution) than GC4 (-2 and -3.5 ktCO2e, in 2051 respectively), due to decreased natural gas use in buildings. Cumulative fugitive emissions between 2016 and 2051 are lower by -36 ktCO2e under the PGC and -63 ktCO2e under GC3B.

Co-benefits

In addition to lowering emissions, increased densification in the PGC and GC3B scenarios offers several co-benefits. Compact communities mean shorter distances to travel to and from work, school, and other destinations, which makes it easier to commute by walking and cycling. This can increase the overall level of physical activity, creating positive public health outcomes.[5]

In addition to reducing emissions, the proposed changes to transportation also have positive implications for public health. The increased uptake of electric vehicles in both Growth Concepts will decrease air pollution related to vehicle exhaust emissions.[6]

The greater limitation on new urban area development proposed in the PGC and GC3B would enable the Region to preserve more green space. This would enable greater public access to green space, which can enable higher levels of physical activity and improve mental health. Green space also offers a number of environmental benefits, such as reducing the likelihood of flooding, improving air quality, and providing cooling and shade.[7]

Of course, a detriment to the region under GC3B would be the reduction of 24,000 new jobs, creating a lost opportunity for local economic benefits.

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[5] Sohail, A.Goodman, A. et al. (2020) A comparison of the health and environmental impacts of increasing urban density against increasing propensity to walk and cycle in Nashville, USA, *Cities & Health*, 4:1, 55-65, DOI: 10.1080/23748834.2019.1659667

[6] Choma, E., Evans, J. S. et al. (2020). Assessing the health impacts of electric vehicles through air pollution in the United States. *Environment International*, 144, 106015. https://doi.org/10.1016/j.envint.2020.106015

[7] Kingsley, M., & EcoHealth Ontario (2019). Commentary - Climate change, health and green space co-benefits. Commentaire - Changements climatiques, santé et avantages connexes des espaces verts. *Health promotion and chronic disease prevention in Canada : research, policy and practice*, *39*(4), 131–135. https://doi.org/10.24095/hpcdp.39.4.04

Conclusions

In any given year over the next 30 years, the difference between emissions in GC4, the PGC, and GC3B exist, but are modest compared to total emissions in either concept. This follows from developments with increasingly energy efficient homes and electrifying vehicles—emissions produced by new homes and electric vehicles are much less than existing building stock and fossil fuel powered vehicles. Technological advancement will have a substantial role in reducing GHG emissions but land use patterns do impact GHG emissions in some way.

However, there is a substantial difference between the concepts in cumulative emissions production. The PGC and GC3B have fewer cumulative emissions over the next 30 years than the GC4 business-as-usual scenario. Cumulative emissions are an important consideration in urban development. New infrastructure always creates 'lock-in': once built, the infrastructure is used for decades and is difficult to modify. The emissions resulting from infrastructure use - whether in buildings, transportation or other sectors - are easier to avoid through climate smart planning now than to try to reduce through future actions.

The modelled total emissions graphs in this report show that even under PGC implementation an emissions reduction challenge remains in Halton Region. 3.7 megatonnes of emissions remains in the year 2051—far from the now common target of net-zero emissions by 2050 that the Intergovernmental Panel on Climate Change and climate change emergency declaring local governments are committing to. Additional efforts are needed in land-use planning, vehicle electrification, mobility planning, retrofitting existing building stocks for greatly improved energy efficiency, industrial decarbonization, and in other sectors across the region to achieve the required emissions reductions. In doing so, the Region will help avoid the worst expected impacts of climate change while improving air quality, increasing accessibility, decreasing energy costs, and improving quality of life for residents and frequenters of the area.

Appendix A
Emissions Factor Assumptions

Fuel emissions factors				
source: Environment and Climate Change Canada, National Inventory Report				
	Energy Units		Physical Units	
	kg CO2e / TJ	MJ/L		
Natural_Gas	48,672.51	0.039	1,898	g/m3 CO2e
Gasoline	66,341.72	35	2,322	g/L CO2e
Fuel Oil	71,022.48	38.8	2,756	g/L CO2e
Propane	61,165.63	0.019	1,162	g/m3 CO2e
Diesel	71,992.01	38.3	2,757	g/L CO2e
Grid Electricity Emissions Factor				
source: IESO. (2020). Annual Planning Outlook.				
g/kWh				
	2016	2030	2040	2051
CO2	28.9	68.69	82.32	82.32
CH4	0.01	0.02	0.02	0.02
N2O	0	0	0	0
CO2e	29.24	69.37	83	83
GHG Global Warming Potentials				
source: IPCC 5th Assessment Report - 2014				
CO2	1			
CH4	34			
N2O	298			
Land Use Emission Factors				
Category	tCO2 / year			
Settlement	-0.66			
Cropland	0.01			
Forestland	-7.9			
Cropland to Settlement	19	in year of conversion		
Forestland to Settlement	274.5	in year of conversion		

Appendix B
Buildings Energy Use Intensity and Efficiency Improvement Assumptions

Residential								
Energy use intensity (MJ / sqm)								
	2016	2021	2026	2031	2036	2041	2046	2051
Total	537.77	482.06	404.05	368.56	326.43	293.98	263.44	236.79
Single Detached	500.31	439.35	376.55	339.73	303.09	272.51	243.63	218.86
Double Detached	643.61	564.12	494.22	450.51	400.89	360.43	328.77	295.87
Rowhouse	597.12	515.43	448.29	408.14	366.33	330.19	305.48	275.62
Apartment	633.15	536.38	470.15	424.7	382.3	344.54	310.39	279.28
% improvement								
		2021	2026	2031	2036	2041	2046	2051
Single Detached		10%	16%	9%	11%	10%	10%	10%
Double Detached		12%	14%	10%	11%	10%	11%	10%
Rowhouse		12%	12%	9%	11%	10%	9%	10%
Apartment		14%	13%	9%	10%	10%	7%	10%
Commercial								
	2016	2021	2026	2031	2036	2041	2046	2051
EUI (MJ/sqm)	1226.09	993.62	807.37	676.83	578.63	491.43	414	345.24
% improvement		19%	19%	16%	15%	15%	16%	17%
Industrial								
		2021	2026	2031	2036	2041	2046	2051
% improvement		10%	10%	10%	10%	10%	10%	10%

Appendix C
Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories

Halton Region 2016 GPC Emissions Inventory Report, 2021

Table 4.3 GHG Emissions Report - pg. 42 GPC

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

GPC ref No.	Scope	GHG Emissions Source	Inclusion	Reason for exclusion (if applicable)	CO2 (in tonnes CO2e)	CH4 (in tonnes CO2e)	N2O (in tonnes CO2e)	Total CO2e (in tonnes CO2e)	
I		**STATIONARY ENERGY SOURCES**							
I.1		**Residential buildings**							
I.1.1	1	Emissions from fuel combustion within the city boundary	**Yes**		835,808	541	4,960	841,309	
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	**Yes**		68,315	717		69,032	
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	**Yes**		6,435	68		6,503	
I.2		**Commercial and institutional buildings/facilities**							
I.2.1	1	Emissions from fuel combustion within the city boundary	**Yes**		392,271	255	2,618	395,145	
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	**Yes**		34,840	366		35,206	
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	**Yes**		3,282	34		3,317	
I.3		**Manufacturing industry and construction**							
I.3.1	1	Emissions from fuel combustion within the city boundary	**Yes**		395,154	261	2,116	397,530	
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary	**Yes**		43,291	454		43,746	Buildings
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	**Yes**		4,078	43		4,121	**1,795,908**
I.4		**Energy industries**							
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary	**Yes**	NR					
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	**Yes**	NR					Local energy
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	**Yes**	NR					**0**
I.4.4	1	Emissions from energy generation supplied to the grid	**Yes**	NR					
I.5		**Agriculture, forestry and fishing activities**							
I.5.1	1	Emissions from fuel combustion within the city boundary	**Yes**	NR	29,215	10	162	29,387	
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary	**Yes**	NR	1,412	15		1,427	
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	**Yes**	NR	133	1		134	
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**		40	37,370		37,410	**37,410**
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**		1,529,918	2,705	12,304	1,544,927	
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	**Yes**		214	2		217	
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**		406,142	829	1,239	408,210	
II.2		**Railways**							
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary	**Yes**	NR					
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways	**Yes**	NR					
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**	NR					
II.3		**Water-borne navigation**							
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	**Yes**	N/A					
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation	**Yes**	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	**Yes**	N/A					
II.4		**Aviation**							
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary	**Yes**	N/A					
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation	**Yes**	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	**Yes**	N/A					
II.5		**Off-road**							
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary	**Yes**	NR					Transportation
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation	**Yes**	NR					**1,953,353**
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	**Yes**			158,223		158,223	
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**						
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary	**No**	N/A					
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**						

III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary	**Yes**	N/A		9,486	6,236	15,722	
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary	**No**	N/A					
III.3		**Incineration and open burning**							
III.3.1	1	Emissions from solid waste generated and treated within the city boundary	**Yes**	N/A					
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary	**Yes**	N/A					
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary	**No**	N/A					
III.4		**Wastewater treatment and discharge**							
III.4.1	1	Emissions from wastewater generated and treated within the city boundary	**Yes**			179,589	880	180,469	
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary	**Yes**						Waste & WW
III.4.3	1	Emissions from wastewater generated outside the city boundary	**No**	N/A					**354,413**
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**	N/A					
V.2	1	Emissions from land within the city boundary	**No**	N/A	-268,896			-268,896	Land
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary	**No**	N/A					**-268,896**
VI		**OTHER SCOPE 3**							
VI.1	3	Other Scope 3	**No**	N/A					
							TOTAL	**3,903,136**	