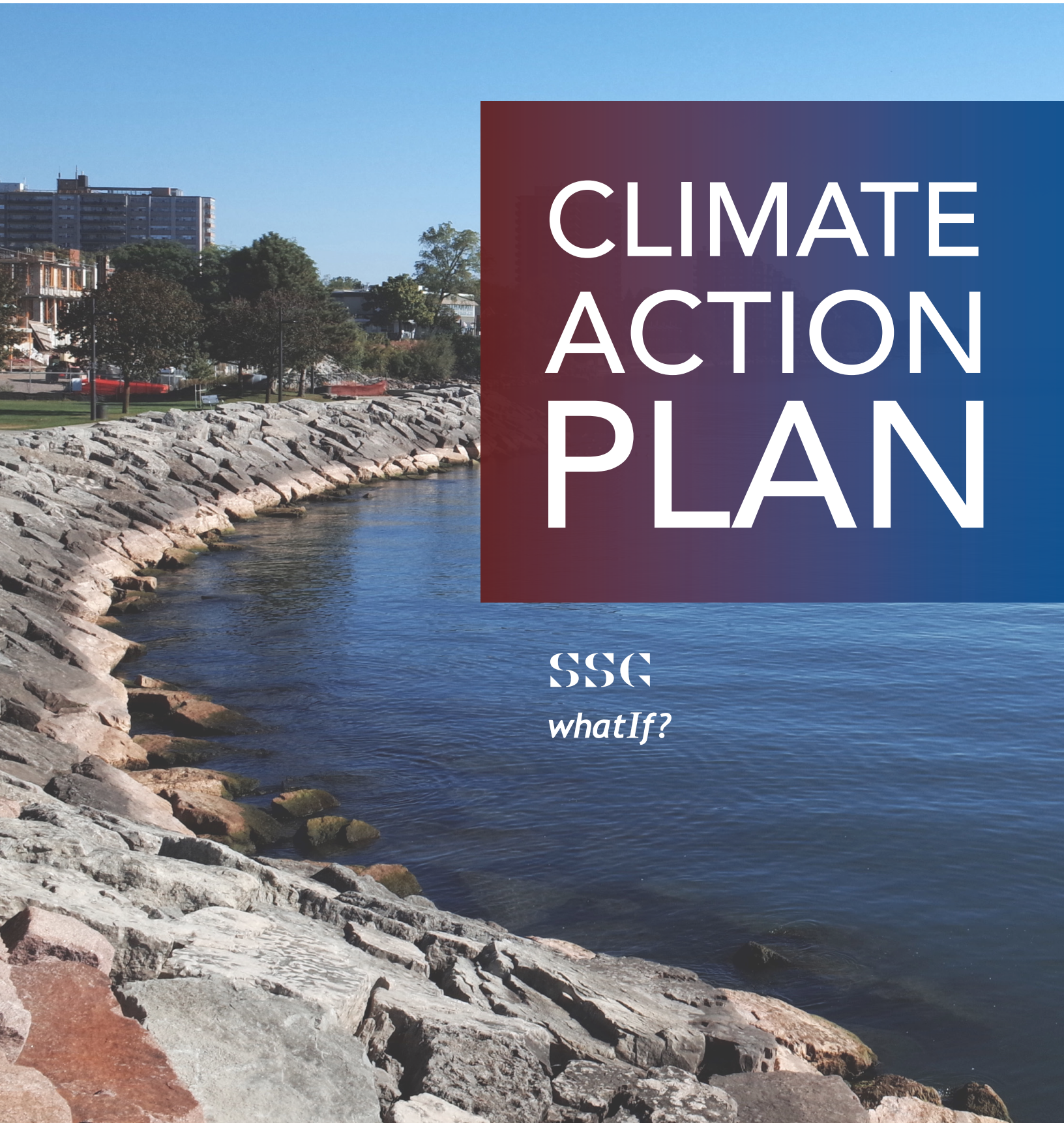
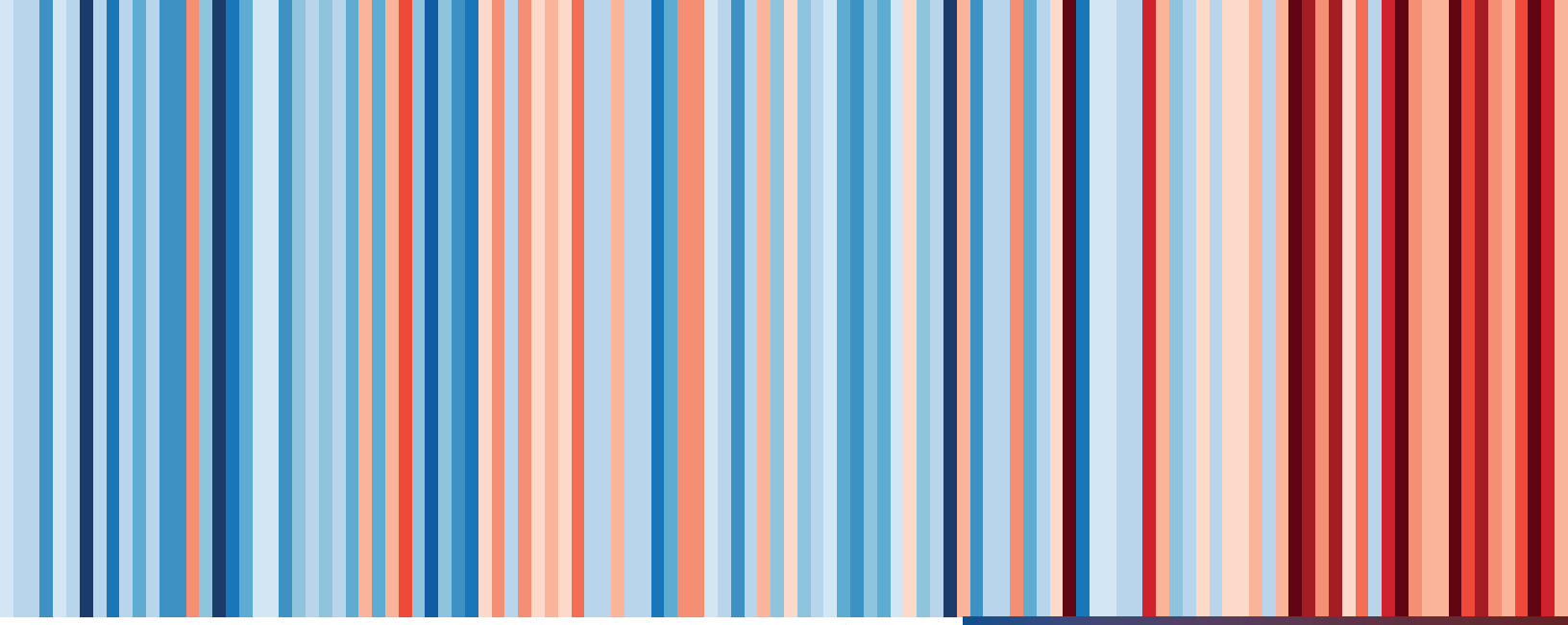
CITY OF Burlington



CLIMATE ACTION PLAN

SSG

whatIf?



Warming Stripes for Canada from 1901-2018. Annual average temperatures for Canada from 1901-2018 using data from Berkeley Earth. Source: showyourstripes.info

Disclaimer

This analysis has been undertaken to identify a low carbon energy pathway for the community of Burlington. Reasonable skill, care and diligence have 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 factors associated with implementation of the pathway are subject to changes that are beyond the control of the authors. The information provided by others is believed to be accurate, but has not been verified.

The population and employment projections that inform the analysis are based on information from the June 26, 2015 Region Official Plan Consolidation to 2031 at the time the document was published, and further projections from 2031 to 2050 are an estimate for the purpose of the Burlington Climate Action Plan, and were developed by the authors of this report for this exercise, and do not constitute projections for the purposes of land use planning.

This analysis includes high level estimates of costs and revenues 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 does 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 the City of Burlington and cannot be applied to other jurisdictions without analysis. Any use by the City of Burlington, project partners, 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.

Glossary

Term	Definition
Adaptation (to climate change)	Adjusting to actual or expected climate impacts to reduce negative effects on people, society, infrastructure, and the environment
Air Source Heat Pump	An efficient system to transfer latent heat from outside of a building to inside the building, or vice versa, typically using electricity as a fuel source
BAU	Business as Usual
BCAP	Burlington Climate Action Plan
CO_2e	Carbon dioxide equivalent, a standardized measurement of greenhouse gases based on the warming potential of given gases compared with carbon dioxide
District Energy	A network of hot and cold water pipes that are used to heat and cool connected buildings more efficiently than if each building had their own heating/cooling systems
GHG	Greenhouse gases
Ground Source (Geothermal) Heat Pump	A central heating or cooling system that transfers heat to or from the ground, where the earth is used as a heat source and sink.
$KtCO_2e$	Kilotonne carbon dioxide equivalent; equal to 1,000 tonnes
LCS	Low carbon scenario
LIC	Local improvement charge
Mitigation (of climate change)	Human interventions to reduce the sources and enhance the sinks of GHGs
$MtCO_2e$	Megatonne carbon dioxide equivalent; equal to 1,000,000 tonnes
PACE	Property Assessed Clean Energy is a funding mechanism that allows individuals to make upgrades to their property.
RNG	Renewable natural gas
Solar thermal	Solar thermal technologies capture heat energy from the sun, and use it for heating or to produce electrical energy
Solar PV	Solar photovoltaic technologies produce electricity from solar radiation
VKT	Vehicle kilometres travelled

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EXECUTIVE SUMMARY

Climate change is the defining challenge of our time. The way in which societies confront this challenge over the coming decade will determine whether we have a safe and sustainable world, for now and into the future. In April 2019, the City of Burlington joined other Canadian and global municipalities in their declarations of a climate emergency. This declaration sets a strong direction for the City and the community to mitigate GHG emissions. It acknowledges the necessity to act now to avoid further economic, ecological and societal impacts, and resolves that Burlington will

1. Address the operations of the corporation of the municipality as well as the functioning of the entire community; and
2. Include a plan for a thorough and complete consultation with stakeholders and the community; and
3. Increase action and ambition for the City's climate change-related activities; and
4. Include performance metrics to track progress and timelines for achieving key deliverables/major milestones, and a strategy to report back publicly on progress.

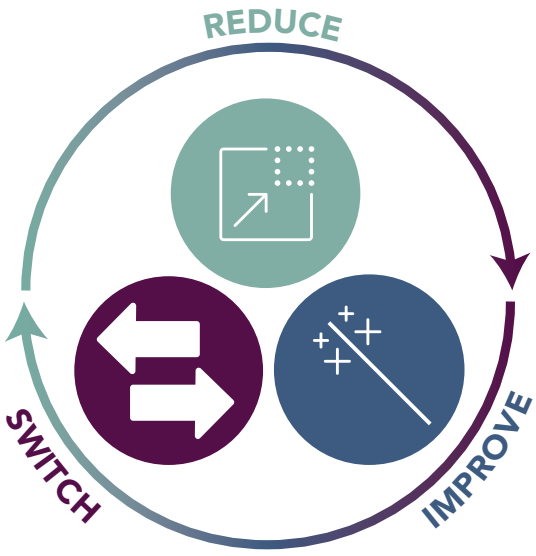
The leadership of City Council in declaring a climate emergency in response to the climate change concerns expressed by citizens is consistent with the shift among municipalities worldwide to take bold action to reduce emissions while creating resilient, high quality of life, and prosperous communities.

The City is undertaking numerous policies and initiatives to address the impacts of climate change, and to reduce the energy consumption and greenhouse gas (GHG) emissions of the City's operations and the community. In 2018, Burlington partnered with the City of Hamilton to complete the Bay Area Climate Change Inventory and Forecast, which accounted for the energy use and GHG emissions of Hamilton and Burlington in 2016, and projected future energy use and GHG emissions to 2050 both in a Business-as-Usual (BAU) scenario, and as a Low Carbon Scenario (LCS). The Climate Action Plan incorporates the LCS as a pathway and evaluates the financial opportunities, programs and policies to enable the pathway.

The modelling of the LCS used for this analysis represents one possible pathway for a low carbon future for the City of Burlington. Changes in the timing, scope, and scale of implementation will affect the real-world results, as will changes in technology that could not be captured in this model. The actions for the LCS pathway are summarized in Table 2.

Transitioning the Energy System

A framework of **reduce, improve and switch** is used to help frame the actions in the LCS. This approach is adapted from similar approaches such as the well-known Reduce-Reuse-Recycle (from the waste sector) and Avoid-Shift-Improve[1] (from the transportation sector). The focus is first on reducing or avoiding consumption of energy, second, on improving the efficiency of the energy system (supply and demand), and third, on fuel switching to low carbon or zero carbon renewable sources. This approach minimizes the cost of the energy transition by avoiding installing capacity that is not subsequently required as a result of energy efficiency measures.



In terms of reduction, overall energy consumption in the City declines from 127 GJ/capita/year in 2016 to 56 GJ/capita/year by 2050, indicating a more efficient use of energy. Electric vehicles are much more efficient than combustion-powered vehicles, and so the adoption of electric vehicles is a major contributor to the greater efficiency and lower conversion losses in the LCS. Additionally, the reduction in heating degree days reduces the need for building heating, and is not matched by the increase in cooling degree days requiring more frequent building cooling.

A second aspect of community energy and climate action planning includes prioritizing interventions in terms of a hierarchy based on what lasts longest, and are therefore most difficult to change.[2] The first priority is land use planning and infrastructure, including density, mix of land uses, energy supply infrastructure and transportation infrastructure. The second is major production processes, transportation modes and buildings, including industrial processes choice of transportation modes, and building and site design. The final priority is converting to energy-using equipment including for transit vehicles, motors,

1 GIZ. (2011). *Sustainable urban transport: Avoid-shift-improve*. Retrieved from http://www.sutp.org/files/contents/documents/resources/E_Fact-Sheets-and-Policy-Briefs/SUTP_GIZ_FS_Avoid-Shift-Improve_EN.pdf

2 Jaccard, M., Failing, L., & Berry, T. (1997). From equipment to infrastructure: community energy management and greenhouse gas emission reduction. *Energy Policy, 25*(13), 1065–1074.

appliances and HVAC systems.

This hierarchy explicitly concentrates the efforts on spheres of influence where there are fewer options to intervene in the future and it decreases the emphasis on the easier interventions which are likely to have greater short term returns.

Boosting Burlington's Economy

In the short term, annual energy-related expenditures in the LCS are somewhat higher than in the BAU scenario, as the up-front investments in efficiency and renewables required to significantly reduce GHG emissions generate savings over the long term. By 2029, the savings from these investments result in the annual net costs of the LCS dropping below the BAU scenario out to 2050. After 2029, the gap between the LCS and BAU continues to widen, and by 2050 the annual savings from the LCS reach $600 million. By 2050, the cumulative savings from the LCS as compared to the BAU scenario reach $6.7 billion and are still growing.

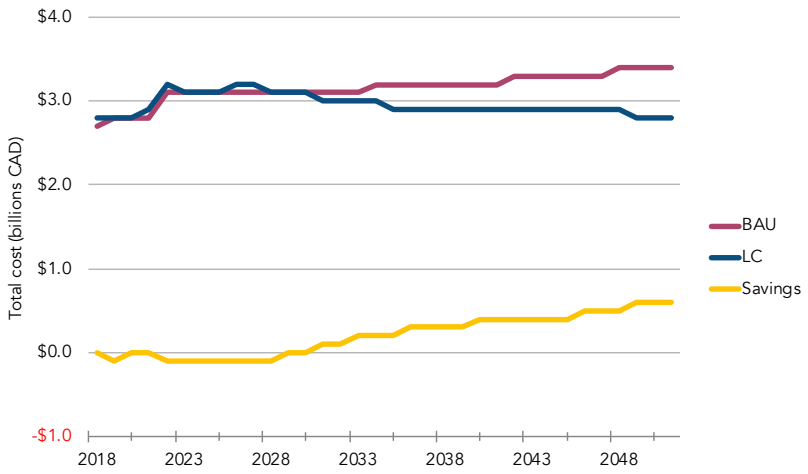


Figure 1. Total annual costs in the BCAP scenarios, 2016 CAD.

Additionally, the investments required result in new job opportunities. 21,300 person-years of employment are created between 2020 and 2050 in the LCS pathway, with 5,600 of those person-years in the renewable energy sector. Annual person-years by category can be seen in the following chart.

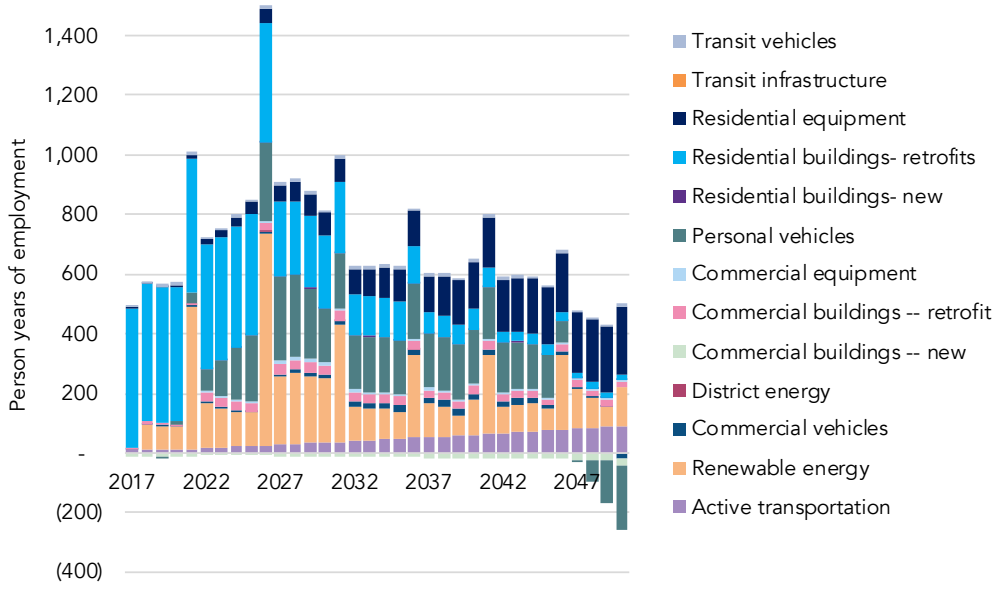


Figure 2. Employment generation in Burlington for the LCS pathway. Personal vehicles show negative values at the end of the period because EVs need less maintenance.

The Role of the Public Sector

Despite a compelling economic case for many of the actions incorporated within the LCS, these actions are not being advanced by the private sector, for a variety of reasons. The public sector has three key roles in overcoming these barriers to enable the implementation of the BCAP:

1. Identify the implementation strategies that maximize social benefits;
2. Create enabling conditions for private sector participation, for those cases in which private sector participation maximizes social benefit; and
3. Provide support for, or directly deliver those actions which are not delivered by the private sector.

A mapping process was undertaken to identify programs or policies that will support or enable the actions identified in the LCS. In most cases, each program can support multiple actions.

Table 1. Short-term implementation program actions

Programs	Description
Program #1: Burlington Low Carbon New Building Guideline: Enhanced energy performance for new buildings.	Staff will update the existing Sustainable Building and Development Guidelines, researching best practices in other jurisdictions and legislative authority. It will include a tiered set of performance measures that will require, incentivize and/or encourage new buildings to be built to a low carbon standard. Financing mechanisms will be explored.
Program #2: Burlington Deep Energy Retrofit Program: Transforming existing buildings.	The deep retrofits program will transform the energy efficiency of existing buildings. Staff will assess best practices in other jurisdictions, including a financing package which may utilize the LIC (Local Improvement Charge) or PACE (Property Assessed Clean Energy) mechanisms. Stakeholders will be engaged, including utilities, senior government agencies, industry and post secondary institutions. Partnerships and collaborations with third parties will also be considered. Retrofits may be targeted to groups of buildings, such as neighbourhoods, or sectors (restaurants, grocery stores, etc.) to generate economies of scale. Renewable energy will also be eligible under the program including solar PV and thermal (for hot water), air and ground-source heat pumps, and energy storage.
Program #3: Renewable Energy Co-operative: Stimulating local renewable energy projects.	The cooperative is a partnership between local groups, agencies and individuals to invest in local renewable energy projects. The co-operative will advocate for, develop, commission and finance projects, depending on which strategy is appropriate to a particular context. Different technologies and approaches will be considered, including district energy, solar, storage and geothermal. Financing options will be researched and may come from community bonds, loans and grants from various levels of government.

Programs	Description
Program #4: Integrated Mobility Plan: Transit service improvements to reach mode share targets.	The Integrated Mobility Plan (IMP) will develop an innovative strategy that supports future mobility planning with an emphasis on **people movement.** The Plan will be cognizant of the city's current demographics, recognizing the unique mobility needs of an aging population, while looking towards the future through a lens that focuses on maximizing the people-carrying capacity of our transportation network compared to road expansion. The resultant strategy will position Burlington to respond to technology changes and emerging mobility options, while balancing the needs of our citizens and providing equitable mobility in a safe, reliable and sustainable manner. The IMP will enable council and city administration to make future decisions relating to mobility and prioritize funding in a manner that ensures future success and continued livability.
Program #5: Electric Mobility and Equipment: Encouraging the adoption of electric mobility and equipment.	A technical working group will be established with representatives from relevant organizations and stakeholders. The working group will develop a strategy to support infrastructure investments, education and outreach, and municipal policies to support electric mobility options. Electric mobility may include electric vehicles, bikes, scooters and other means of mobility. Electric equipment may include landscaping equipment such as lawn mowers, trimmers and leaf blowers, as well as others where relevant.
Program #6: Waste Reduction Initiative: Engaging the community.	Waste management is primarily delivered by the Region of Halton, and is therefore outside of the direct influence of the City. The City will support the region to engage the community to first reduce waste and secondly, properly divert waste.

Programs	Description
Program #7: Industrial Innovation Program: Reducing energy demands by industry.	This program will support organizations that work with local businesses to improve energy efficiency in their operations and identify opportunities for the City to incentivize energy efficiency in the industrial sector..

Tracking Progress

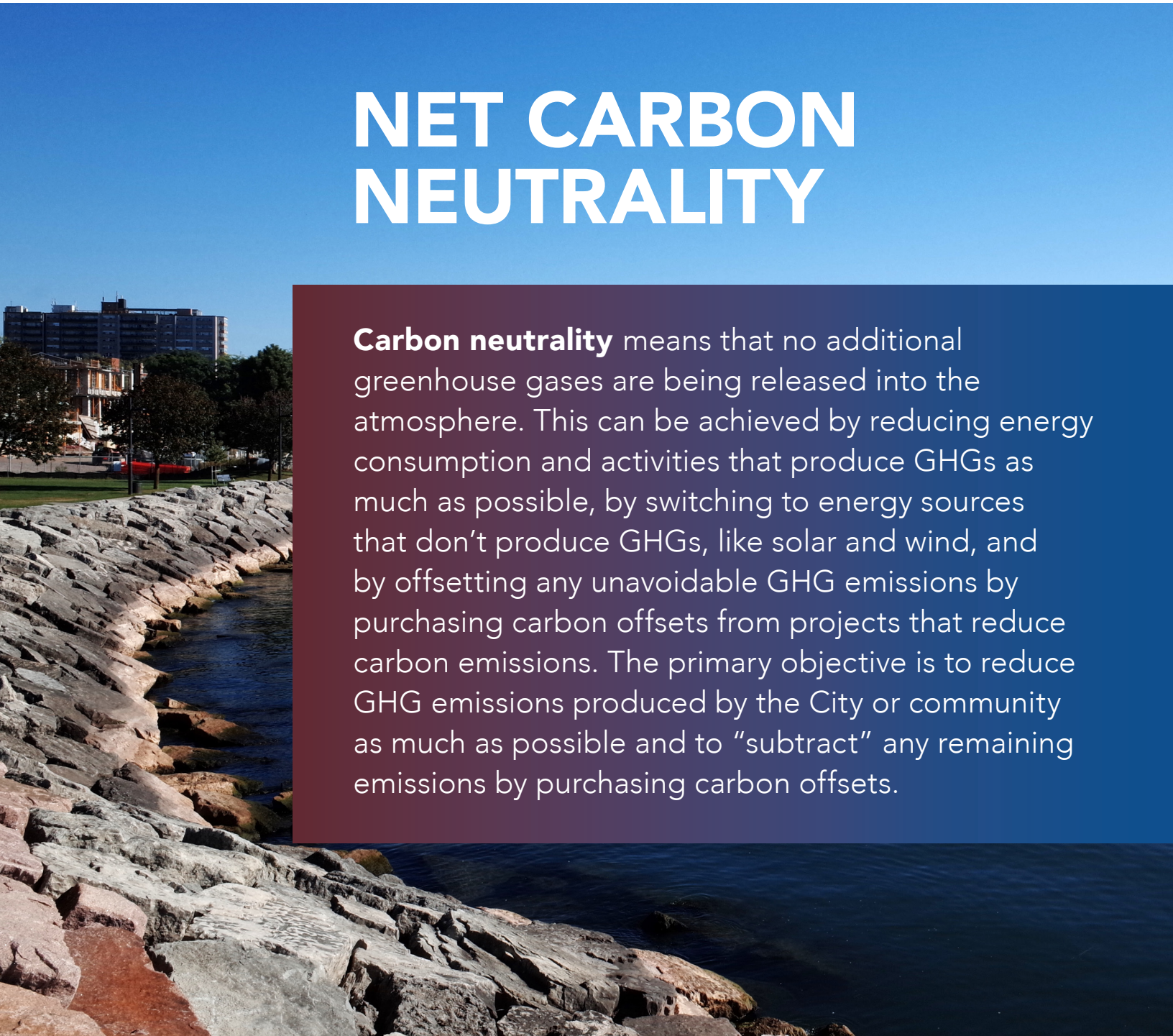
Tracking the effectiveness of the programs in the BCAP helps to manage the risk and uncertainty associated with the efforts, as well as external forces such as evolving senior government policy and new technologies which can disrupt the energy system. Key motivations for monitoring and evaluation include the following:

- Identify unanticipated outcomes.
- Adjust programs and policies based on their effectiveness.
- Manage and adapt to the uncertainty of climate change.
- Manage and adapt to emerging technologies.

Specific activities which have been identified to support the implementation of the BCAP include an annual work plan and review, an annual indicator report, an update of the GHG inventory every two years and an update of the BCAP every five years.

INTRODUCTION

This document represents the first phase of the Climate Action Plan for the community of Burlington, with a focus on mitigating greenhouse gases (GHGs) and reducing energy consumption. The City has set a goal in its Strategic Plan to work towards being a net carbon neutral community. The second stage of this Climate Action Plan will focus on climate adaptation, identifying ways for Burlington to improve its resiliency and adapt to the changing climate. Phase 2 will be completed by early 2021.



NET CARBON NEUTRALITY

Carbon neutrality means that no additional greenhouse gases are being released into the atmosphere. This can be achieved by reducing energy consumption and activities that produce GHGs as much as possible, by switching to energy sources that don't produce GHGs, like solar and wind, and by offsetting any unavoidable GHG emissions by purchasing carbon offsets from projects that reduce carbon emissions. The primary objective is to reduce GHG emissions produced by the City or community as much as possible and to "subtract" any remaining emissions by purchasing carbon offsets.

The City of Burlington

The City of Burlington covers 186 km^2 at the northwestern end of Lake Ontario. The city is in the Regional Municipality of Halton, at the western end of the Greater Toronto Area, within the intensively developed Greater Golden Horseshoe area of Southern Ontario.

For the purpose of this plan, population growth in Burlington was modelled to increase from 189,000 people in 2016 to 219,000 by 2050, an increase of 16%. The total number of jobs in 2016 was 86,000 and by 2050, this is projected to increase to 98,000[3].

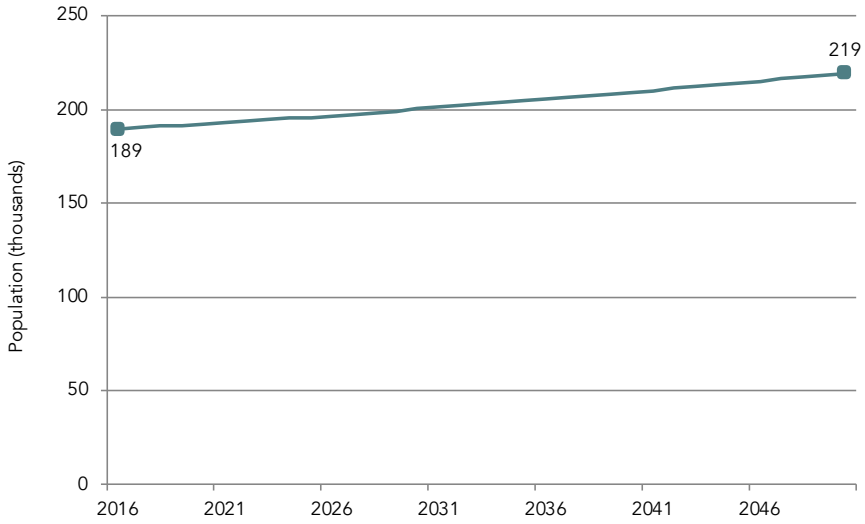


Figure 3. Population growth in Burlington from 2016-2050[4]

Like many municipalities in the region, Burlington has a diversity of industries and employers, including manufacturing, financial services, food processing and packaging, IT, life and earth sciences, manufacturing and fabrication, and transportation.[5] No one of these industries dominates the energy use and emissions production in Burlington.

Burlington has a humid continental climate with four distinct seasons over which the temperature fluctuates greatly from mid-summer to mid-winter. The climate is greatly affected by Lake Ontario, resulting in cold winters, and noticeable variability in the weather over short distances.[6]

3 Methods and assumptions for these baseline numbers and projections are found in Appendix A, at the end of this document.

4 Population growth projection as outlined in the Bay Area Climate Change Inventory and Forecast, 2018, adjusted for census undercount.

5 Economic Development Burlington. Major Employers. Accessed Oct 2019: https://bedc.ca/major-employers/

6 https://en.wikipedia.org/wiki/Burlington,_Ontario

Climate Change and Burlington

The City of Burlington is already experiencing the impacts of climate change, including the ice storm that hit the region in December 2013, the localized flooding in 2014, large and unpredictable winter storms in 2019, and an increase in invasive species.[7]

The city is expected to see more days above 30°C, increasing from an estimated 29 days in 2020 to 48 days in 2050, accompanied by an increased number of heat waves, and the heat waves will last longer. Cold days are expected to steadily decrease over time and the mean temperature is expected to increase. Total annual precipitation will increase slightly, but the region will see more days with heavy precipitation (20 mm or more), increasing from 7 days a year in 2020, to 9 days a year by 2050. This precipitation will also shift to more freezing rain and ice in winter. The frost-free season will expand, which will extend the growing season, but also result in changes to pests and invasive species success, and changes to precipitation patterns which can change crop planting patterns and crop success.[8] More frequent higher intensity storms are expected, which will increase stress and wear on current infrastructure designed to handle the more predictable storms in the past. The impacts of climate change will affect people, infrastructure, industry, and natural systems within Burlington.

7 City of Burlington, 2019. City of Burlington Climate Emergency Declaration. Accessed Oct 2019: https://www.burlington.ca/en/live-and-play/resources/Environment/Climate-Emergency/Final-Burlington-Climate-Emergency-Declaration-12-pt-font.pdf

8 Canadian Climate Atlas, 2019. Climate Atlas Report Municipality: Hamilton. Accessed Oct 2019: https://climateatlas.ca/data/city/451/hwlen_2030_85/line

Climate Impacts	Variable[9]
Heat	Increased average temperature More hot days (above 30C) More hot nights (above 20C) More and longer heat waves
Cold	Fewer days below 0C Fewer freeze-thaw cycles
Precipitation	Increased annual precipitation Increased heavy precipitation days (more than 20mm)

A Call to Action

In April, 2019 the City of Burlington declared a climate emergency. This declaration acknowledges the necessity to act now to avoid further economic, ecological and societal impacts, and resolves that Burlington will

1. Address the operations of the corporation of the municipality as well as the functioning of the entire community;
2. Include a plan for a thorough and complete consultation with stakeholders and the community;
3. Increase action and ambition for the City's climate change-related activities; and
4. Include performance metrics to track progress and timelines for achieving key deliverables/major milestones, and a strategy to report back publicly on progress.

Burlington's Strategic Plan for 2015-2040 includes three Key Strategic Directions with direct or indirect impacts on GHG emissions:

1. A City that Grows: this reflects the vision for smooth well-planned growth for the city

    - Development of mixed-use areas and employment lands are a priority. *More people who live in Burlington also work in Burlington.*

9 Ibid.

- Active transportation and public transit are developed throughout the city, including downtown with pedestrian-focused streets.
- Incentives for energy-efficient buildings are provided, including the renovation of existing buildings.

2. A City that Moves: maximizing the efficiencies and strategic growth of transportation networks and infrastructure

   - Development of walkable neighbourhoods.
   - Connection improvement between public transit and active transportation systems.
   - Automobiles are replaced by these modes where possible.

3. A Healthy and Greener City: the city recognizes that climate change is a significant issue, and is working with the community and all levels of government toward the goal of the Burlington community being net carbon neutral

   - Every resident of Burlington lives within a 15 to 20-minute walk from parks or green spaces.
   - The City's operations are net carbon-neutral (by 2040).
   - The City's urban forest and tree canopy has increased and continues to thrive.
   - District energy, microgeneration, and storage technologies will be explored.

Council's 2018 – 2022 workplan, From Vision to Focus, also provides key initiatives which relate to the Climate Action Plan. Priorities include the completion of this plan to address the climate emergency declaration; completion of the Burlington Transit 5-year Business Plan and the Integrated Mobility Plan, among other actions.

The 2020 – 2024 Burlington Transit Business Plan will guide the implementation of transit service improvements over the next five years. This plan includes goals to increase transit use: " Over the five year life of this business plan, transit mode share is targeted to reach 8.3 percent by 2024, translating to 6,356,818 annual rides (a 98 percent growth in ridership from 2019; or 19.6 percent per year."

The Burlington Official Plan, still in the final approval phases, outlines the long-term vision of Burlington, regulating both the public and private sectors on land use, development, and resource management within the City of Burlington, with

the goal of a cohesive community vision. Within this Plan, the City aims to:

1. Increase community resiliency to climate change through mitigation and adaptation measures, and through the maintenance and restoration of the Natural Heritage System;
2. Work towards the goal of the city community being net carbon neutral; and
3. To enhance air quality.

The City will reach these goals by designating Mixed Use Intensification Areas (Policy 8.1), encouraging development that promotes walking, cycling and transit, encouraging energy generation from renewable sources and the use of community energy storage, encouraging energy efficient buildings, developing a Climate Action Plan, and maintaining natural infrastructure and water resources (Policy 4.1).[10]

The Cycling Plan[11] and Integrated Mobility Plan complements the Official Plan, focusing on achieving the transit and active transportation goals outlined in the Official Plan, and on land use planning as it relates to cycling and walking infrastructure, transit, and transportation infrastructure. The Integrated Mobility Plan is under development and, when implemented, will result in safe, accessible transit and transportation options that allow for a variety of mobility options throughout the city.[12]

The Burlington Corporate Energy and Emissions Management Plan 2019-2024[13] was approved in 2019 with 65 actions to reach targets set for 2020, 2024 and 2040 for city operations (primarily buildings and fleet). Actions include electrification, solar PV expansion, geothermal, energy audits to identify deep energy retrofits, training and awareness. The City will update the Corporate Sustainable Buildings policy (for city buildings) in 2020 and the Community Sustainable Building and Development Guidelines (for private development) by 2021. In addition, the City has implemented numerous initiatives and actions to reduce corporate energy use and GHG emissions, including adding eight plug-in electric vehicles to the municipal fleet, adding 33 EV charging ports on city property, using geothermal heating and a green roof on the Joseph Brant Museum, and designing the City View Park Pavilion and the Skyway Area redevelopment to include renewable energy sources.

10 City of Burlington, 2019. Burlington Official Plan. Accessed Oct 2019: https://www.burlington.ca/uploads/21493/Doc_636610358428491805.pdf

11 City of Burlington, 2019. Cycling Plan. Accessed Oct 2019: https://www.burlington.ca/en/services-for-you/cycling-plan.asp

12 City of Burlington, 2019. Transportation Plan. Accessed Oct 2019: https://www.burlington.ca/en/services-for-you/Transportation-Master-Plan.asp

13 City of Burlington, 2019. The Burlington Corporate Energy and Emissions Management Plan 2019-2024. Accessed Oct 2019: https://www.burlington.ca/en/live-and-play/resources/Environment/Energy/Burlington-CEEMP-2019-2024.pdf

A Vision for the Future

What would Burlington look like in 2050 if the city follows the steps towards a low carbon future? Here, we share this vision of a sustainable, livable, and healthy Burlington.

Where we live in 2050

The house doesn't use much energy, just 20% of what houses use in 2015. The roof is covered with solar PV panels, with a capacity of 4 kW. The dwelling is heated with radiant floors, using waste heat from nearby industries transported through pipes underground; cooling is also provided in the summer through the same pipes.

Moving around in 2050

In most neighbourhoods in the City, it is easy to walk to a school, park, grocery store, restaurant and other key destinations. If you are going somewhere less than 5 km away, you are likely to cycle. Entire road lanes are physically separated for cyclists and cycling is integrated into the culture of the City. Cycling lanes/paths are plowed before vehicular roads in the winter because of the demand. A personal transportation planner from the City visited your household and helped you identify the best transportation options for trips for work and leisure, while saving money and increasing convenience. Private vehicles are easily accessible for all ages for trips that are too complex for transit and too far for walking or cycling. Transit is much more extensive than in 2016 with an enhanced bus and train system.

Going to work in 2050

Many more people will walk (17%), cycle (28%) and take transit (23%) to work and less will drive (32%). If they do drive, they are unlikely to own the vehicle, but will rely on shared electric and autonomous vehicles provided by the transit agency. Some people travel to work only four days a week. The workplace will incorporate more shared office spaces and flexible work location options, and floor space per employee will decline. Offices will be efficient, designed to high standards if new and retrofitted if not. Indoor air quality will be improved. The building will generate energy with solar PV on the roof and facades, and will likely 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 21,300 new person-years of employment. A major new industry is focused on upgrading the energy efficiency of buildings. Companies involved in this industry undertake major construction projects, retrofitting one neighbourhood at a time. Businesses involved in the retrofits include expertise in finance, law, construction and engineering. Other sectors that grow significantly include renewable energy, particularly solar PV, energy storage and district energy.

A LOW-CARBON ACTION PLAN

Climate Change Inventory and Forecast

In 2018, Mohawk College, located in Hamilton, Ontario, partnered with the City of Hamilton and the City of Burlington to host the Centre of Climate Change Management (CCCM). The CCCM is a regional response to shared goals around climate change action and sustainability. The CCCM includes the Bay Area Climate Change Office (BACCO) which has a mandate to collaboratively implement Burlington's Climate Action Plan and Hamilton's Climate Change Action Plan.

A key part of this partnership was the development of a greenhouse gas inventory and forecast for each city. This inventory and forecast outlined a low-carbon pathway for the City of Burlington to reduce energy consumption and lower greenhouse gas emissions. This pathway included a series of actions, modelled in sequence, and a comparison of the outcomes of implementing this pathway to continuing current actions. This analysis serves as the foundation for the Burlington Climate Action Plan (CAP).

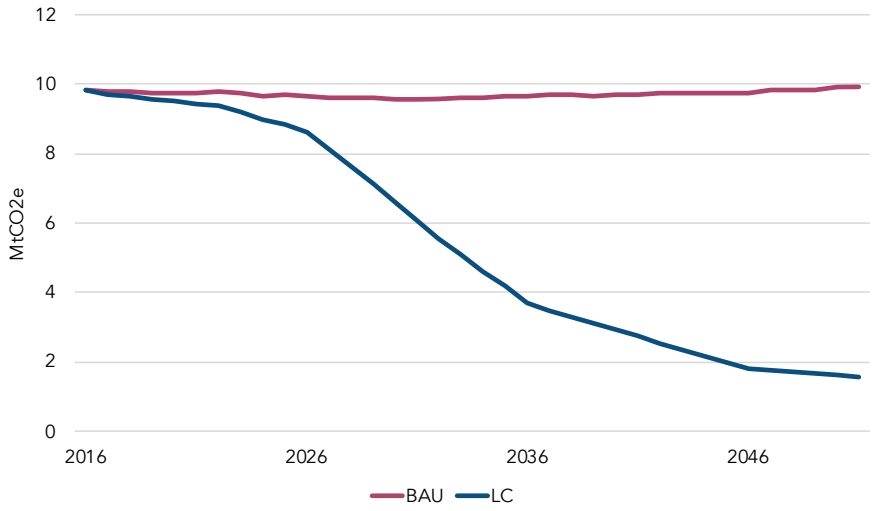


Figure 4. Total GHG emissions ($MtCO_2e$) for the Bay Area (Burlington and Hamilton).

Low-Carbon Plan

Two scenarios were developed in order to compare what might happen if no new policies or programs are implemented to what a low-carbon future could look like for Burlington. The Business as Usual (BAU) scenario represents current patterns of energy consumption and extrapolates these out until 2050, while accounting for population increases, federal fuel efficiency standards and the impacts of climate change on heating requirements in buildings. The low carbon scenario (LCS) is a composite of ambitious actions designed to reduce GHG emissions in Burlington through reduced energy consumption and switching to lower carbon solutions.

The assumptions and actions for both the BAU and LCS are summarized in Table 2, below.

Table 2. BAU and Low Carbon actions and assumptions for the City of Burlington.

City of Burlington	BAU assumption	LCS assumption
BUILDINGS		
New buildings growth		
Floor space	*Floor space per employee held constant.*	*Floor space per employee decreased by 25% by 2050 in offices.*
New buildings energy performance		
Residential	*Apply 2017 Ontario Building Code (OBC) levels of performance.*	*Incrementally increase the number of buildings that achieve passive house levels of performance to 100% by 2030.*
Industrial, commercial and institutional (ICI)	*Apply 2017 OBC levels of performance.*	*Incrementally increase the number of buildings that achieve passive house levels of performance to 100% by 2030.*
Existing buildings energy performance		
Retrofit homes built prior to 2017	*No retrofits.*	*98% of pre-2017 dwellings retrofit by 2050, with retrofits achieving thermal and electrical savings of 50%. Savings are greater for older buildings than newer buildings.*
Retrofits of commercial and industrial	*No retrofits.*	*98% of pre-2017 dwellings retrofit by 2050, with retrofits achieving average thermal and electrical savings of 50%. Savings are greater for older buildings than newer buildings.*

City of Burlington	BAU assumption	LCS assumption
Recommissioning of commercial and institutional buildings	*No retrofits.*	*Every building is recommissioned on a ten-year cycle, achieving energy savings of 15% on pre-2017 building stock.*
End use		
Space heating	*Baseline shares of heating systems are maintained.*	*Air source heat pumps are added to 40% of residential buildings and 30% of commercial buildings by 2050. Ground source heat pumps are added to 20% of residential and 25% of commercial buildings by 2050.*
Water heating	*Scale up to 10% of residential buildings by 2050, and 10% of commercial buildings by 2050. Achieves 50% of solar hot water load.*	*Scale up to 80% of residential buildings by 2050, and 50% of commercial buildings by 2050. Achieves 50% of solar hot water load.*
ENERGY GENERATION		
Solar PV	*Scale up so that 10% of all buildings by 2050 have solar PV systems which provide on average 30% of consumption for building electrical load for less than 5 storeys; 10% for multi-unit and commercial buildings.*	*80% of all buildings by 2050 have solar PV systems which provide on average 30% of consumption for building electrical load for less than 5 storeys; 10% for multi-unit buildings greater than 5 storeys and commercial buildings*

City of Burlington	BAU assumption	LCS assumption
Solar PV - ground mount	*0.5 MW per year between 2018 and 2050; ~20 hectares (ha).*	*5 MW per year between 2018 and 2050; ~120 ha.*
District Energy	*N/A*	*Zero emissions district energy is introduced into the downtown core by 2030.*
Energy storage	*No storage deployed.*	*250 MWh by 2050.*
Renewable natural gas	*No additional production.*	*Local production is maximized and additional renewable natural gas is imported to displace natural gas consumption in buildings.*
TRANSPORTATION		
Expanded transit	*Transit mode share remains constant.*	*Transit service and routes expanded; mode share impact as per other cities.* *Transit mode share increases to 20% of internal trips.*
Active modes	*Walking and cycling mode share remains constant.*	*Mode shift 50% of trips less than 1km to walking by 2050; mode shift 50% of trips between 1 and 5 km to cycling by 2050.* *Active mode share increases to 15% of internal trips.*
Electrify transit system	*No additional electrification.*	*100% electric transit system by 2040.*
Electrify municipal fleet	*No additional electrification.*	*100% of the fleet is electric by 2040.*

City of Burlington	BAU assumption	LCS assumption
Electrify personal vehicles	*~5% of personal use vehicles are electric by 2035; 10% by 2050.*	*100% of new passenger vehicles are electric beginning in 2030.*
Electrify commercial vehicles	*25% of the vehicle fleet is electric by 2050.*	*All commercial vehicles are electric by 2050.*
WASTE		
Waste generation	*Waste generation is held constant.*	*Waste generation is reduced by 50% per capita by 2050.*
Waste diversion	*Waste diversion rates are held constant.*	*Diversion rates are increased by 50% per capita by 2050.*

The Pathway

The GHG emissions trajectory for each of the scenarios is illustrated in Figure 5. Even in the BAU scenario, GHG emissions are reduced, primarily as a result of a decreased heating load due to climate change and the increased fuel efficiency of vehicles as a result of federal fuel efficiency standards. In the LCS, by 2050 annual emissions are 0.9 $MtCO_2e$ lower than in the BAU scenario, an 88% reduction, falling from 1.2 $MtCO_2e$ in 2020 to 0.1 $MtCO_2e$ in 2050.

Figure 5 shows the emissions reductions targets in 5 year intervals from 2025 to 2050 along the LCS curve for the City of Burlington.

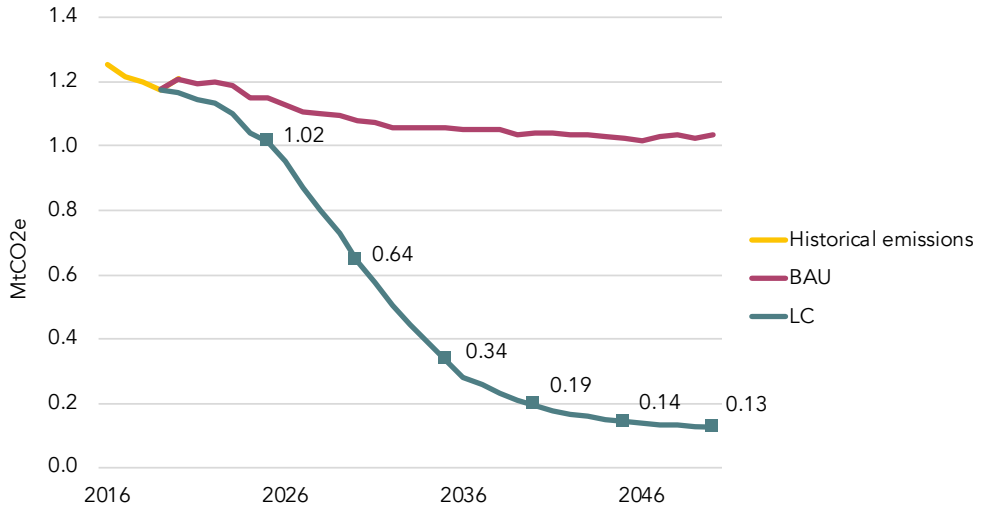


Figure 5. Annual GHG emissions for both scenarios, 2016–2050

The proportionate emissions reductions from each action are distributed on a year over year basis to generate a wedge diagram, illustrated below. The wedge diagram shows the contribution of each action to the overall LCS emissions reduction trajectory. As there are dependencies and feedback cycles between the actions, which are captured by the model, the wedge diagram is a simplified representation of the results.

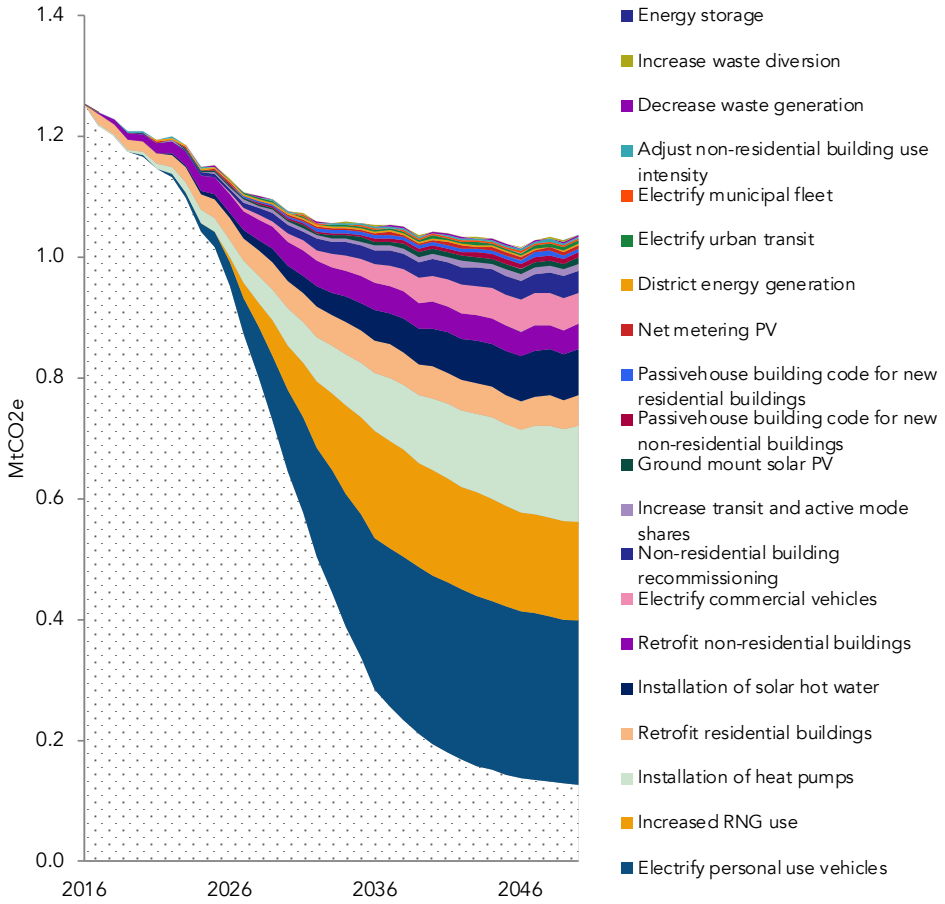


Figure 6. Emission reductions by action from 2016 baseline projected to 2050 for the City of Burlington.

Major opportunities for GHG reductions include switching personal use vehicles to electric vehicles, increased use of RNG captured from waste and other sources, efficiency requirements in new commercial, institutional and industrial buildings, the installation of heat pumps which displace natural gas with electricity, and installation of solar hot water for heating.

Table 3. Interim GHG reduction targets

Year	Annual GHG emissions (Mt CO_2e)	% decrease from 2016 baseline
2016	1.25	0%
2025	1.02	-19%
2030	0.64	-49%
2035	0.34	-73%
2040	0.19	-84%
2045	0.14	-89%
2050	0.13	-90%

GHG targets in the context of the global carbon budget

Burlington's Strategic Plan 2015-2040 states that the City will work toward being a net carbon neutral community, which was reiterated in council's Vision to Focus 2018-2022 document. Based on the analysis through the modelling process for this plan, the target year 2050 has been set for Burlington to become a net carbon neutral community, with an interim target of reducing emissions to 50% below 2016 levels by 2030. In order to meet the 2050 goal, the City will need to offset approximately 126 $ktCO_2e$ of emissions through purchasing carbon offsets, or through further actions to reduce emissions.

In simple words, the carbon budget is the total CO_2e left to emit in order to prevent dangerous levels of climate change. C40, a network of large cities in the world, developed an approach to allocate per capita emissions for cities, which is coherent with global carbon budgets that are likely to limit warming to 1.5 degrees and 2 degrees.

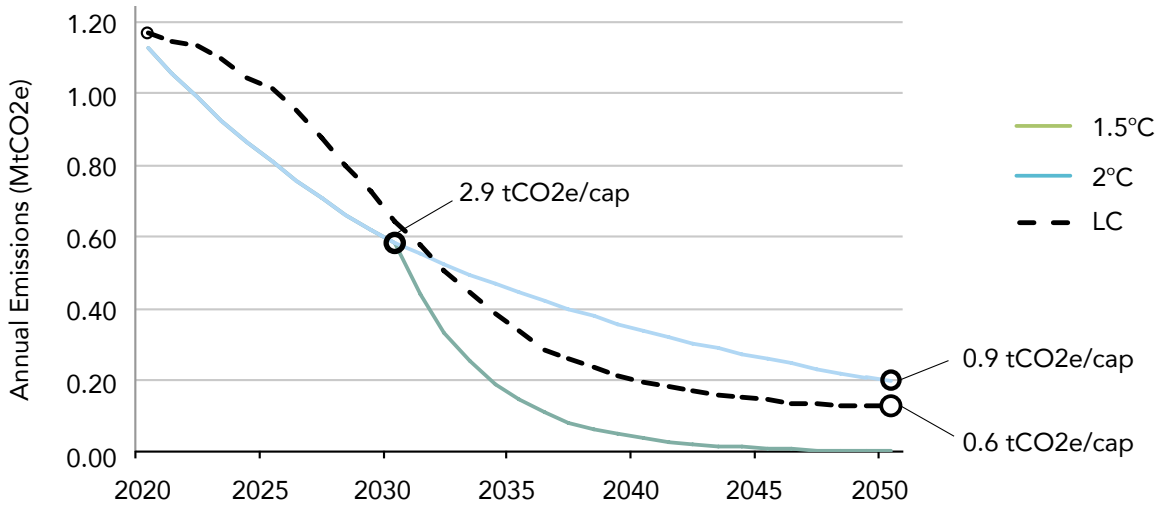


Figure 7. 1.5 and 2°C carbon trajectories for the City of Burlington

The total carbon budget for the City of Burlington between 2020 and 2050, which results from adding up all the annual budgets, is 11 $MtCO_2e$ for the 1.5°C scenario and 16 $MtCO_2e$ for the 2°C scenario. The results indicate that additional efforts beyond the LCS are required to reduce GHG emissions by 0.12 $MtCO_2eq$ (0.6tCO_2e/cap) for the 1.5°C pathway.

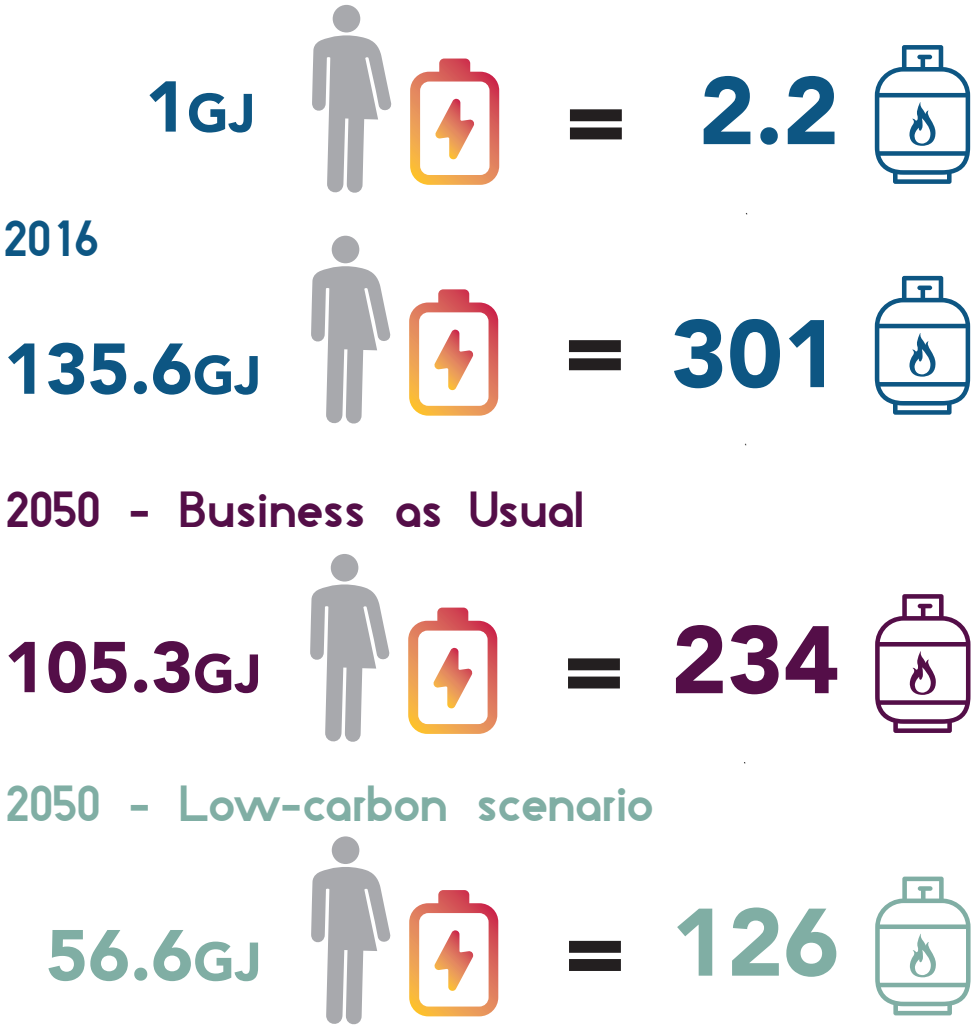
Table 4. Annual carbon budget results

Year	1.5 degrees [$ktCO_2e$]	LCS [$ktCO_2e$]	2.0 degrees [$ktCO_2e$]	BAU Scenario [$ktCO_2e$]
2016	1,253	1,253	1,253	1,253
2020	1,130	1,167	1,130	1,207
2030	580	644	580	1,077
2040	36	195	338	1,043
2050	2	126	197	1,037
2019- 2050	10,903	15,474	16,015	33,432

In the context of a climate emergency, the pathway to reach an emissions target is as critical to consider as the target, because the total emissions produced until 2050 will vary greatly depending on how quickly action is taken. In order to achieve the reductions needed to meet 1.5 C pathway, GHG emissions must be curtailed as soon as possible. If Burlington's current emissions patterns do not decrease, as shown in the BAU scenario, the carbon budget will run out in 8.5 years, the same amount of time as the remaining in the global carbon budget. The LCS reduces this total by 54% to 15.5 $MtCO_2e$, which is a slightly greater reduction than the 2°C budget of 16.0 $MtCO_2e$. For the 1.5°C target the carbon budget is 10.9 $MtCO_2e$; achieving this level of reduction requires actions beyond those considered in the BCAP.

Energy

Annual per capita energy use



Scenario	Energy per capita (GJ)	BBQ tanks[14]
2016	135.6	301
2050 BAU	105.3	234
2050 LCS	56.6	126

Emissions

14 1 standard 20 lb BBQ tank holds the equivalent of 0.45GJ of energy

Annual per capita emissions

2016

Approximately 0.64 times around the earth.

The circumference of the Earth in kilometers is 40,075 km



2050 Business as usual

Approximately the distance to Cairo, Egypt and back.

Cairo is about 9,258km from Burlington.



2050 Low-carbon scenario

Approximately the driving distance to Winnipeg, Manitoba.

The driving distance between Burlington and Winnipeg is 2170.54km.



Scenario	Emissions per capita (tCO_2e)	Km driven by average car[15]
2016	6.6	25,970
2050 BAU	4.7	18,490
2050 LCS	0.6	2,360

The LCS reduces emissions to 126,000 tCO_2e in 2050. This is equivalent to the

15 https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

emissions from 26,750 passenger vehicles driven for one year[16]. The 1.5 degree scenario described above would mean restricting 2050 emissions to 2,000 tCO_2e in 2050, which is equivalent to the emissions from 425 passenger vehicles driven for a year.

The Role of the Municipalities

The transition to a low-carbon energy system relies on municipalities.[17] Municipalities and regions in Canada have direct or indirect control over 40-50% of greenhouse gas emissions.[18] If municipalities are not built to stringent low carbon standards, land-use planning and infrastructure investments can lock in energy and GHG intensive patterns of development which inhibit or make cost prohibitive efficient and low carbon alternatives.[19] Alternatively, compact urban form increases the feasibility of district energy and the introduction or improvement of public transit, in addition to reducing the financial cost and the GHG impact of providing municipal services such as roads, water and wastewater conveyance, ambulance, fire protection, school transportation, and even provision of home-based health care.

Recognizing the role of municipalities, the Province has embedded climate change into land-use planning policy. Although the Provincial Policy Statement (PPS) of 2014 required consideration of climate change directly with respect to the impact of land-use patterns on GHG emissions, the new proposed PPS (under review) only refers to planning for the impacts of climate change. However, the new growth plan, A Place to Grow: a growth plan for the Greater Golden Horseshoe (2019) requires municipalities to develop policies in their official plans that will reduce greenhouse gas emissions, and address climate change adaptation goals. It encourages municipalities to develop strategies to reduce greenhouse gas emissions and address the impacts of climate change.

16 Ibid.

17 The Global Commission on the Economy and Climate. (2014). *Better growth, better climate: The new climate economy report*. Retrieved from http://newclimateeconomy.report/2014/wp-content/uploads/2014/08/NCE-cities-web.pdf; Seto, K. C., Dhakal, S., Bigio, A., Blanco, H., Delgado, G. C., Dewar, D., … others. (2014). Human settlements, infrastructure and spatial planning. Retrieved from http://pure.iiasa.ac.at/11114/; International Energy Agency. (2016). *Energy technology perspectives 2016: Towards sustainable urban energy systems*.

18 Torrie, R. (2015). Low carbon futures in Canada – the role of urban climate change mitigation: Briefing on urban energy use and greenhouse gas emissions. Stockholm Environment Institute. Retrieved from https://data.bloomberglp.com/dotorg/sites/2/2015/10/Low-Carbon-Futures-in-Canada.pdf

19 Erickson, P., & Tempest, K. (2015). *Keeping cities green: Avoiding carbon lock-in due to urban development*. Stockholm Environment Institute. Retrieved from https://www.sei-international.org/mediamanager/documents/Publications/Climate/SEI-WP-2015-11-C40-Cities-carbon-lock-in.pdf

Municipalities rely on funding programs from both the federal and provincial governments to support municipal investments and activities to reduce GHG emissions. The multiple roles of municipalities are as follows:

- **A leader:** Municipalities should show leadership with their own facilities, fleet, and activities in adopting and implementing low carbon actions.
- **A mobilizer:** Municipalities can engage people, municipalities and other organizations around a vision, goals, objectives and targets. Examples include a community engagement program and a bulk purchase of renewable energy on behalf of citizens.
- **An innovator:** Municipalities can directly or indirectly support innovation by reducing risk through investments, partnerships or policies that support low carbon projects or enterprises. An example is the provision of electric vehicle charging infrastructure.
- **A collaborator:** There are multiple opportunities for collaboration in the energy transition; with other levels of government, transit authorities, utilities, municipalities, regions, businesses, non-profit organizations, neighbourhoods and governments in other parts of the world. Collaboration can take the form of shared targets or policies or joint projects or investments. An example is a coordinated retrofit program between municipalities and utilities.
- **An investor:** Municipalities can use their access to low interest capital to make investments directly in areas such as building retrofits and renewable energy technologies. Alternatively, and in tandem, the City can enable investments by third parties. An example is local improvement charges as a way to finance building retrofits.
- **An implementer:** Through policies and incentives, municipalities can support businesses and households in the energy transition. An example is the implementation of a district energy system to supply thermal energy (heating and cooling) to a group of buildings.
- **An incubator:** Municipalities can cultivate the development of new technologies or applications that enable the low carbon economy by supporting and attracting new and existing businesses and creating a hub or ecosystem in which the businesses and organizations support each other. An example is a low carbon business park or incentives for different levels of building performance that stimulate innovation by builders.

BUILDING THE ECONOMY

Economic Impact

Reducing GHG emissions is positive for the economy. The economic impact of the LCS results from the stimulus created by the investments required to implement these actions, and the long-term savings in fuel and electricity costs. Jobs are created as new infrastructure is needed and new technologies are introduced and therefore new markets appear and grow.

In Burlington 21,300 person-years of employment will be created in total if the LCS pathway is followed, with 5,600 of those person-years in the renewable energy market. Annual person-years by category can be seen in the following chart.

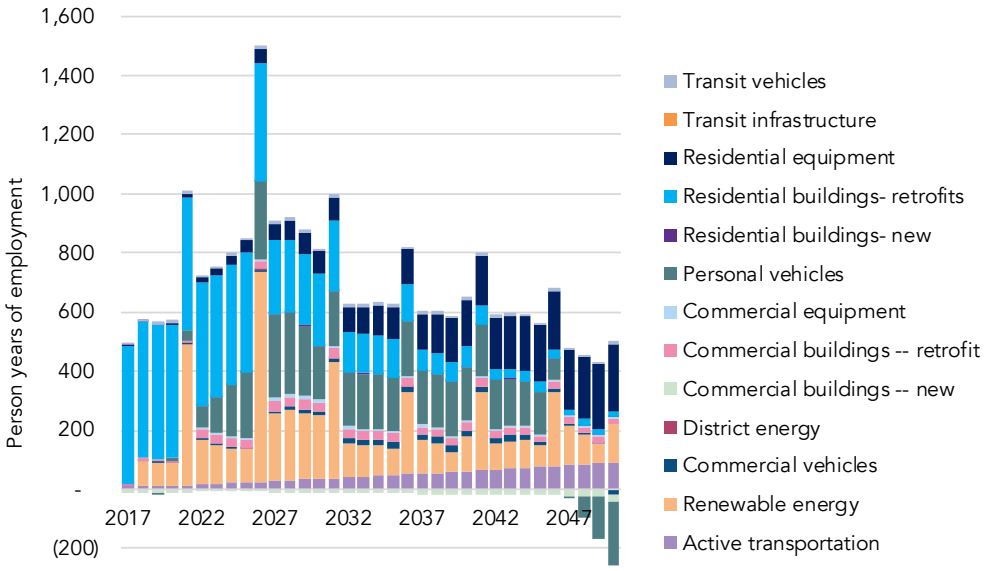


Figure 8. Employment generation in Burlington for the LCS pathway. Personal vehicles show negative values at the end of the period because EVs need less maintenance.

Likewise, given the approach of "Reduce-Improve-Switch", actions increasing the efficiency of energy use generates savings in the long term that are directly beneficial to households. In the BAU scenario, household energy expenditures are projected to decline because vehicles become more efficient due to national fuel efficiency standards and because of decreased heating requirements as the climate becomes milder due to climate change. The LCS involves shifting away from natural gas and gasoline to electricity, a more costly energy source. The increased cost of electricity, however, is more than offset by the increased efficiency of homes as required by building codes and of vehicles as a result of the efficiency of electric motors. By 2050, a household spends $2,700 on energy, just over half of the expenditures in the BAU scenario. Over the period between 2020 to 2050, the LCS saves households an average of $57,000 on energy expenditures.

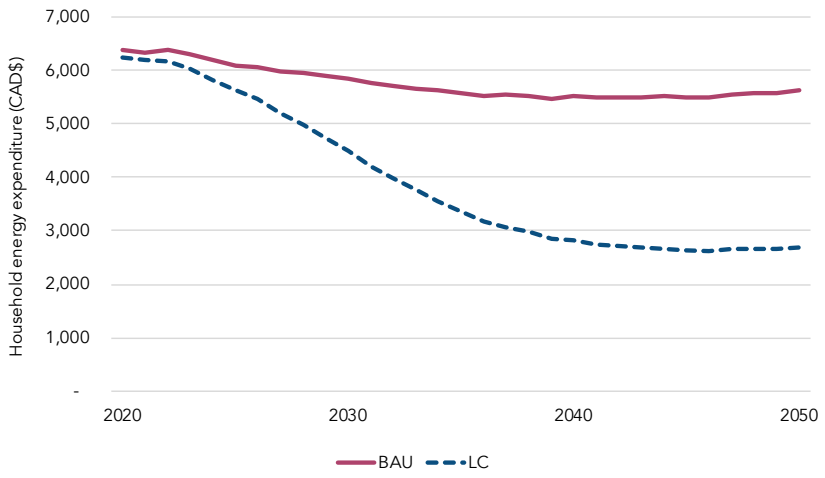


Figure 9. Annual household expenditures on energy for homes and transportation, 2020–2050

In terms of budget, in 2016, households, businesses and governments in Burlington spent a total of $700 million on fuel and electricity, and in a business-as-usual future this total is projected to slightly increase to $760 million by 2050, considering an increased population, efficiency gains, and increasing energy prices. The actions in the LCS reduce this total by 36% or $270 million. Beyond these savings, some of the actions in the LCS generate savings in other areas, such as reduced operating and maintenance costs. In total, the LCS reduces costs for the Burlington economy by approximately $6.7 billion in constant dollars on expenditures of $100 billion over the period. The savings occur as a result of reduced operating costs, primarily energy expenditures and lower cost of carbon.

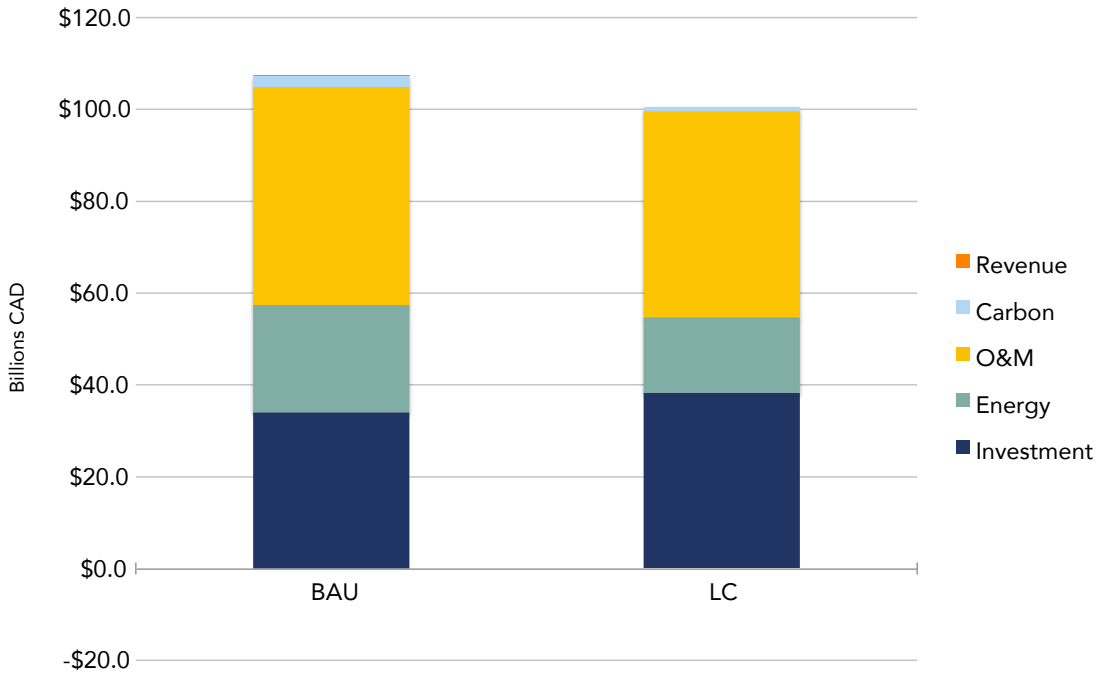


Figure 10. Total expenditures for all the period, for each scenario. Investment is increased in LCS but is offset with savings in energy and O&M.

The incremental investments to put Burlington in the LCS - about $125 million per year on average - can be compared with the $700 million per year that is already being spent on fuel and electricity, a figure that is projected to grow to $760 million per year in the business-as-usual outlook.

Investment Opportunities

Most of the actions evaluated are GHG reduction investment opportunities, in that the actions result in both GHG reductions and financial returns – a win-win situation. The exceptions are heat pumps, energy storage, and passive house building code for new non-residential buildings.

The marginal abatement cost curve (MACC) graph provides at-a-glance emissions reductions versus costs/savings for each LCS action. It is a measure of the cumulative cost or savings of reducing emissions for a particular action over the 2020-2050 time period.

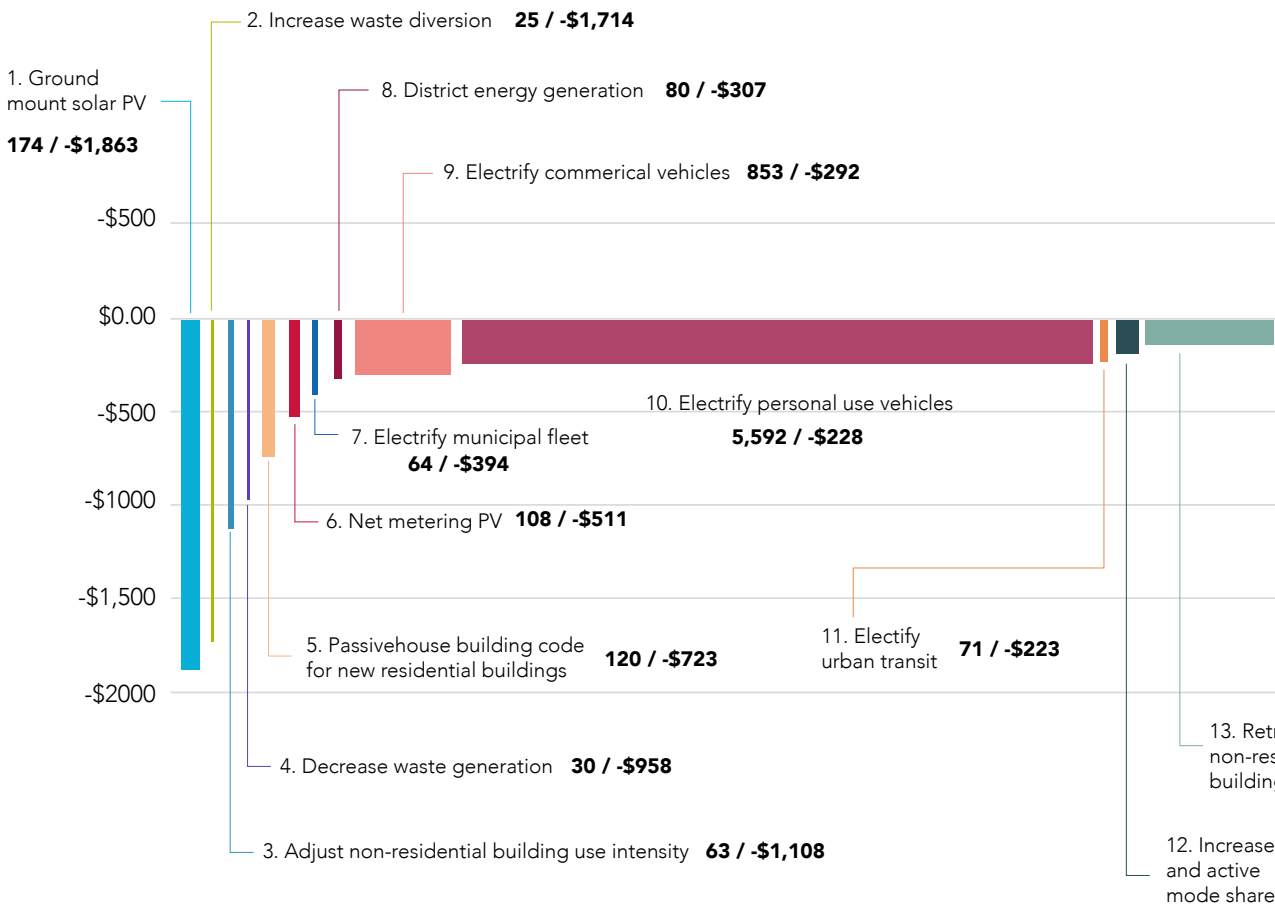
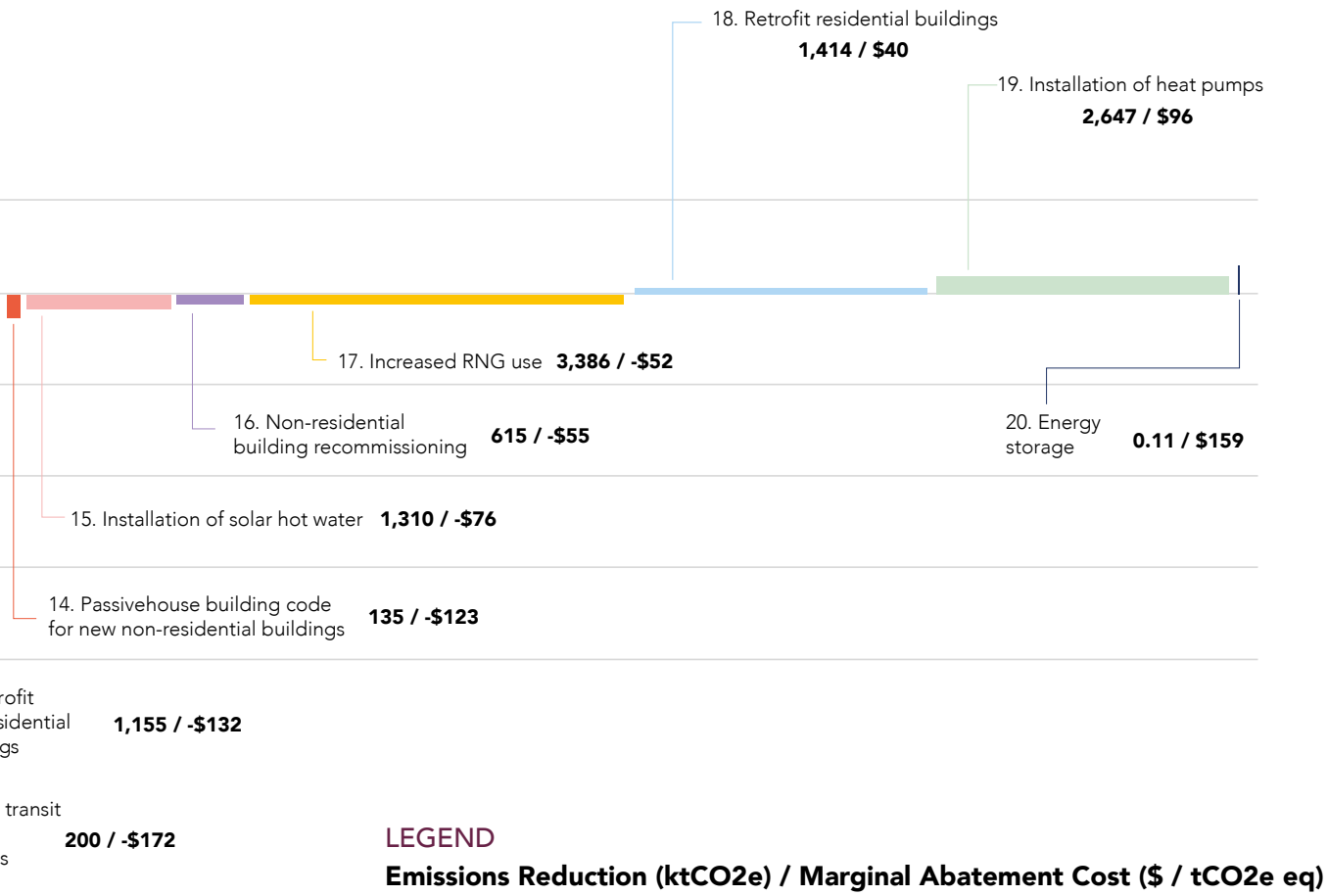


Figure 11. Marginal Abatement Cost Curve (MACC) for all the actions in the LCS. The width of the bars represents the cumulative ktCO2 reduction during all the LCS timeframe, while the height represents the cost in net present value per tCO_2e reduced.

The MACC divides the total costs or savings of an action, as represented by the net present value (NPV), by the total emissions reductions associated with that action over its lifetime. The result is a cost or savings per tonne of emissions reduced for each action.

An action costs money overall if its cost per tonne of emissions saved is positive. An action saves money if its cost per tonne of emissions saved is negative. The marginal abatement costs in Figure 11 are shown for all actions.

The amount of GHG reductions for each action varies considerably, and this is described in the implementation section below. An analysis of the internal rate of return (IRR) also indicated opportunities for investment, with actions ranging from 2.5% to greater than 20%.



IMPLEMENTATION

Burlington's role

With direct or indirect control over at least 40-50% of GHG emissions produced, municipalities have a unique influence over demands resulting in GHG emissions, and the pathway to a low or zero carbon future. Municipalities are integrated systems in which an action in one sector influences emissions in another sector. Influences include elements like the location and shape of buildings, building energy performance, renewable energy generation, district energy (heat density), and travel behaviours (i.e. whether destinations are accessible by walking, cycling or transit).

Municipalities also play a key role in implementing and facilitating the implementation of policies of higher levels of government, as illustrated in Table 4. Reaching the GHG emission targets outlined in this report assumes that the LCS will be implemented fully and on schedule, which will require that senior levels of government are supportive of the policies and funding required to enact the LCS.

Table 5. Municipal energy and emissions policy roles.[20,21]

Municipal government role	Municipal role examples	Corresponding national or provincial government role

Policy architect & leader: Primary body responsible for policy design, formulation, application, implementation and enforcement	• Land-use planning
	• Design/development of local transit systems or transportation policies
	• Development of infrastructure projects
	• Waste management regulations
		• Establish national policy frameworks
		• Enable municipal government action through:
		  • Capacity building and information sharing
		  • Access to funding
		  • Legal and policy alignment

Critical implementer: Responsible for key application, implementation, or enforcement actions related to a policy	• Building code implementation and compliance-checking • Implementation of regionally coordinated, cross-jurisdictional infrastructure projects or transportation policies	• Policy design and/or standard setting • Regional coordination • Enabling city government implementation role

20 Adapted from: Broekhoff, D., Erickson, P., & Lee, C. M. (2015). *What cities do best: Piecing together an efficient global climate governance*. Stockholm Environment Institute Seattle, WA, US. Retrieved from http://ledsgp.org/wp-content/uploads/2015/12/SEI-WP-2015-15-Cities-vertical-climate-governance.pdf

21 The regional government, Halton Region, is responsible for waste management and collection, and water and wastewater treatment and distribution.

Municipal government role	Municipal role examples	Corresponding national or provincial government role
Complementary partner: Undertakes separate, complementary actions that contribute to the effectiveness, uptake, penetration, or success of a policy led by higher levels of government	• Complementary information and outreach, green standards development and implementation, certification and incentive programs for improved building energy efficiency and reduced GHG emissions through urban design measures. • Permitting or active installation of electric vehicle charging stations • Permitting, tax incentives and/ or subsidies for commercial and residential distributed energy resources	• Policy design and/or standard-setting • Primary implementation and enforcement • Coordination/integration of actions within and across different levels of government • Enabling municipal government complementary actions (through capacity building, funding or legal reform).

Land-use planning and infrastructure investments shape patterns of development and their energy and emissions implications. This provides an opportunity for municipalities to make efficient low carbon alternatives affordable. Compact urban form increases the feasibility of district energy which requires greater energy demand concentrated in smaller areas. Further, this form can introduce more rapid and frequent public transit and reduce financial costs and GHG emissions resulting from increased municipal services such as roads, conveyance of water and wastewater, ambulance, fire protection, and even provision of home-based health care. Land use decisions, including density, urban form, and mixed uses, can therefore enable, inhibit or prevent the transformation to a low or zero carbon economy.

Recognizing all this, municipalities around the world are taking decisive action implementing climate solutions. Since the climate conference of parties (COP) in Copenhagen, the C40 Cities Climate Leadership Group estimates that cities

have taken 10,000 climate actions and have identified 2,300 high-impact actions that could save 450 $MtCO_2e$ by 2020.[22] In June 2017, in response to the U.S. President withdrawing from the Paris Climate Agreement, a bipartisan group of mayors from over 250 U.S. cities unanimously backed a commitment for the country's cities to run entirely on renewable energy sources by 2035.[23]

Programs

The BCAP represents a major new effort by Burlington to invest in the energy system, an investment that will result in dramatically reduced greenhouse gas emissions, lower energy costs for households and businesses, the creation of new businesses and jobs, reduced air pollution and other co-benefits.

Implementing the BCAP is a complex, multi-faceted endeavour with multiple partners and new programs that require:

- Financing and innovative financial instruments
- Training and mobilization of required human resources (e.g. building retrofits)
- Changes to municipal policies
- Infrastructure to support energy technologies such as EVs
- Innovative partnerships and business models
- Behavioural change to adapt to and implement the changes outlined in the LCS

In order to identify the programs and policies that will support implementation, the BCAP is governed by the following principles:

- **Leadership and Vision**. Provide the "big picture" of a future vision of a sustainable energy future for Burlington, and lead by example.
- **Engagement**. The objectives of the BCAP can only be achieved by the active engagement of the stakeholders that affect the level and pattern of energy use in the community.
- **Alignment**. Identify and exploit the alignment between BCAP objectives and stakeholder objectives.
- **Leverage**. Strategic use of local government financial, regulatory and planning resources to leverage accelerated progress toward BCAP objectives.

22 Hundreds of US mayors endorse switch to 100% renewable energy by 2035 https://www.theguardian.com/environment/2017/jun/26/hundreds-of-us-mayors-vow-not-to-wait-for-trump-on-clean-energy

23 This analysis refers to urban populations and not all local governments in Canada.

Based on these principles and the objectives identified in the stakeholder engagement process, seven programs of activity are identified which enable the GHG reductions identified as a result of the actions modelled in the LCS. The ability of the program to scale up over time and address multiple actions are also criteria which guided program development. Table 5 illustrates the relationship between the LC themes (bundled actions), the programs and cumulative GHG reductions associated with the relevant LC actions. A coordinated effort for the industrial sector needs to be developed between relevant industries, the gas utility and the IESO and municipal governments to reduce industrial emissions.

Table 6. Programs of activity[24]

Theme	Program	Cumulative GHG reductions in LCS compared to BAU, 2020-2050 ($ktCO_2e$)
New Buildings	Burlington Low Carbon New Building Guideline	318
Existing buildings	Burlington Deep Energy Retrofit Program	7,140
Energy End Use		
Energy Generation	Renewable Energy Cooperative	3750
Waste		
Transport	Integrated Mobility Plan	200
	Electric Mobility and Equipment Program	6,580
Waste	Waste Reduction Initiative	55
Industry	Industrial Innovation Program	TBD

24 Variation in totals is due to rounding.

A Note on Trees

The seven key program areas in this plan do not include an action area related to planting trees and protecting natural heritage resources in the community to support carbon sequestration. Trees do sequester carbon in varying quantities, based on the species and the age of the tree, however, research also shows that trees can only achieve so much, particularly in an urban context. Massive tree plantings on a global scale could also have an unintended impact on food security (reduced land for agriculture) and natural ecosystems.

In order to stabilize the climate, significant effort is required to reduce the use of fossil fuels. The seven program areas in this plan are focused on areas that will have the most impact in Burlington, transitioning from the use of fossil fuels with low carbon buildings, sustainable mobility options, increased use of renewable energy, reduced waste and innovation in industry.

While urban tree planting may not be the sole solution to reduce atmospheric carbon, there are several benefits delivered by trees, especially in an urban area, such as improving air quality and providing cooling resources, reducing the urban heat island effect and energy needed to cool buildings, and improving physical and mental health of residents. Trees also reduce erosion and slow down fast flowing water. The second part of the Climate Action Plan will focus on improving resiliency in the face of climate impacts such as rising temperatures and the increased frequency of severe storms and flooding events. Therefore, it is expected that actions related to tree planting will be included in the next phase of the Climate Action Plan.

Recognizing the importance of trees in Burlington, council has approved a tree canopy target of 35% by 2041 in the 2018 – 2022 Burlington Plan – 'From Vision to Focus'. The Urban Forestry Management Plan will be completed in 2020. Council has also recently approved a private tree by-law to protect trees on private property in the urban area and increased funding to support community tree planting.

Program 1: Burlington Low Carbon New Building Guideline

Objective: Increasing the performance of new buildings is more cost effective than trying to retrofit them after they have been constructed. Providing a clear pathway and incentives to the building industry gives certainty and stimulates innovation.

Design: Staff will update the existing Sustainable Building and Development Guidelines, researching best practices in other jurisdictions and legislative authority. The Guidelines will include a tiered set of performance measures that will require, incentivize and/or encourage new buildings to be built to a low carbon standard. Financing mechanisms will be explored that help reduce upfront costs.

City's Role: Update the Sustainable Development and Building Guidelines

Connections: From Vision to Focus (council work plan)

Timeline: 2021

Responsibility: Community Planning and Building and By-law Departments

Potential Partners for Collaboration: Other municipalities; Clean Air Partnership

References: Toronto's Green Standard; Passivhaus standards; Canada Green Building Council Net Zero standards.

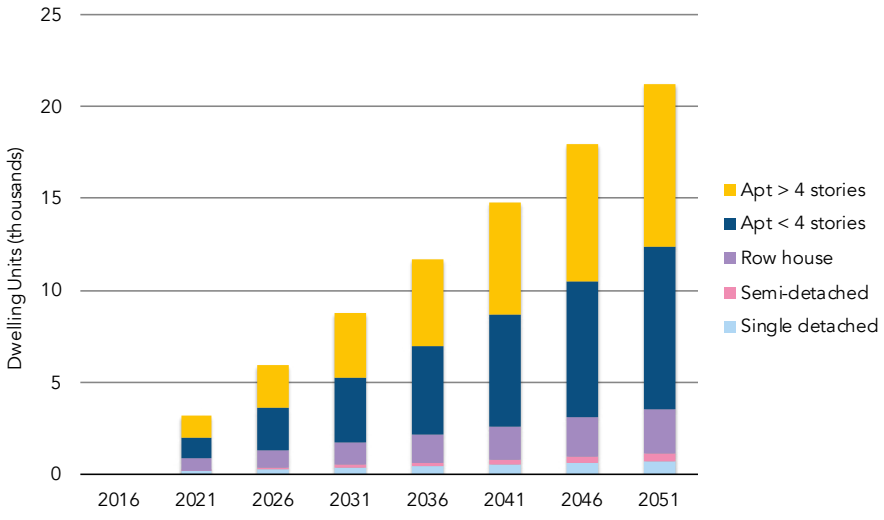


Figure 12. Residential dwelling units built to net zero energy, cumulative to 2051

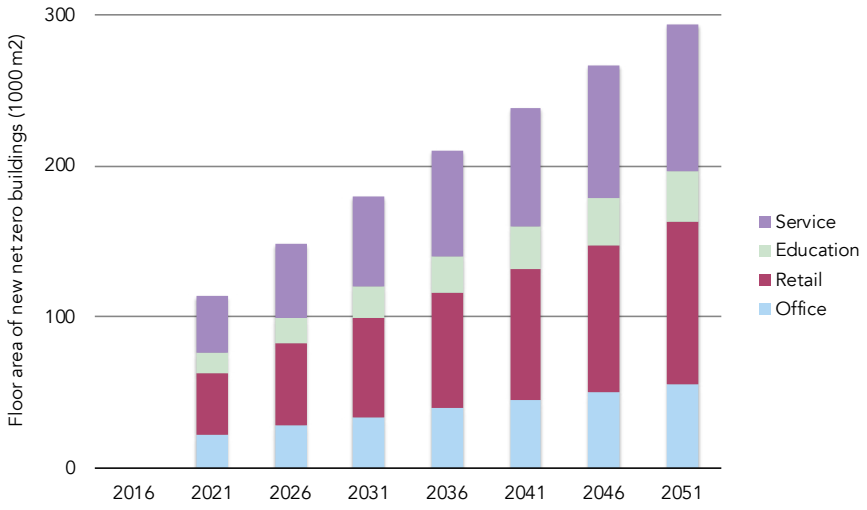


Figure 13. Commercial floor space that achieves net zero energy, cumulative to 2051

LCP Actions	Cumulative emissions reductions ($ktCO_2e$)	Percent of total GHG emissions	Incremental costs (2020–2050), 2016$, present value	Incremental savings (2020–2050), 2016$, present value	Net present value (2020–2050), 2016$, present value
1. Floor space per employee decreased by 25% by 2050 in offices.	63.0	0.3 %	$0	$-69.8 million	$-69.8 million

LCP Actions	Cumulative emissions reductions ($ktCO_2e$)	Percent of total GHG emissions	Incremental costs (2020–2050), 2016$, present value	Incremental savings (2020–2050), 2016$, present value	Net present value (2020–2050), 2016$, present value
2. Incrementally increase the number of net zero new homes to 100% by 2030.	119.8	0.7%	$154 million	$-240 million	$-86.3 million
3. Incrementally increase the number of multi-residential buildings which achieve Passivhaus levels of performance to 100% by 2030.					
4. Incrementally increase the number of ICI buildings which achieve Passivhaus levels of performance to 100% by 2030.	135.0	0.7%	$38 million	$-54 million	$-17 million

Program 2: Burlington Deep Energy Retrofit Program

Objective: The preferred scenario involves retrofitting nearly all the residential, commercial and institutional buildings in the City over a period of 30 years. This objective requires a new and enhanced focus on deep, whole-building retrofits, as well as a new industry and aligns with the Comprehensive Residential Retrofit program previously recommended in the Burlington Community Energy Plan.

Design: The deep energy retrofit program will transform the energy efficiency of existing buildings. Staff will assess best practices in other jurisdictions, including a financing package which may utilize the LIC (Local Improvement Charge) or PACE (Property Assessed Clean Energy) mechanisms. Stakeholders will be engaged including utilities, senior government agencies, industry and post secondary institutions. Partnerships and collaborations with third parties will also be considered. Retrofits may be targeted to groups of buildings, such as neighbourhoods or sectors (restaurants, grocery stores, agriculture, etc.). Renewable energy will also be eligible under the program including solar PV and thermal (for hot water), air and ground-source heat pumps and energy storage.

City's Role: Implementing agency to deliver program or partner/collaborate with a 3rd party to deliver program.

Connections: Former Community Energy Plan: Consider incentives or financing programs, such as using Local Improvement Charges to assist residents to finance retrofits.

Timeline: 2022

Responsibility: Sustainability staff

Potential Partners for Collaboration: Other interested municipal governments; utilities, builders and contractors; suppliers and retailers; architects; post-secondary institutions; Clean Air Partnership

References: City of Toronto HELP program; Guelph's GEERS program (pending approval); TRCA's work with York Region municipalities; The Clean Air Partnership's Climate Action Support Centre

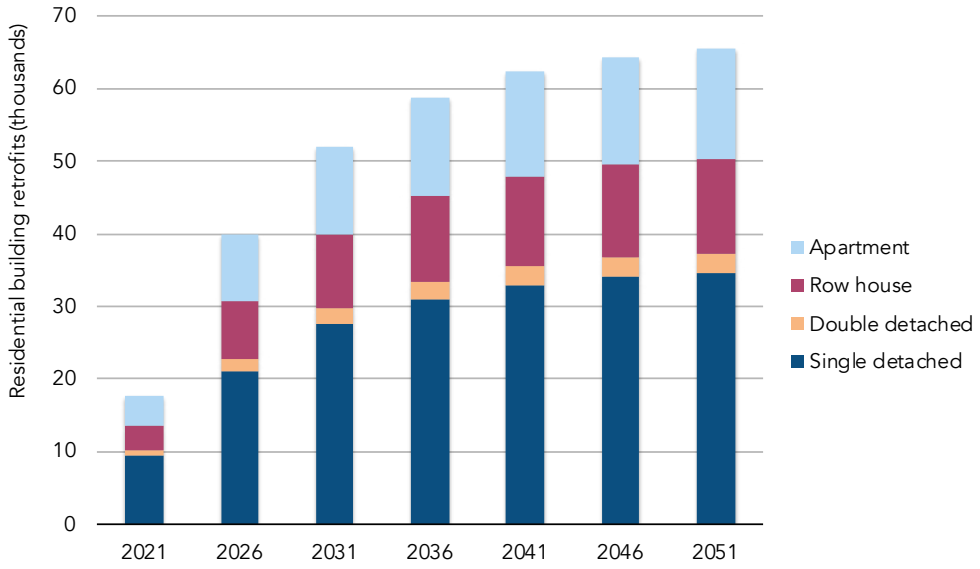


Figure 14. Number of dwellings retrofit in five-year increments, cumulative to 2050

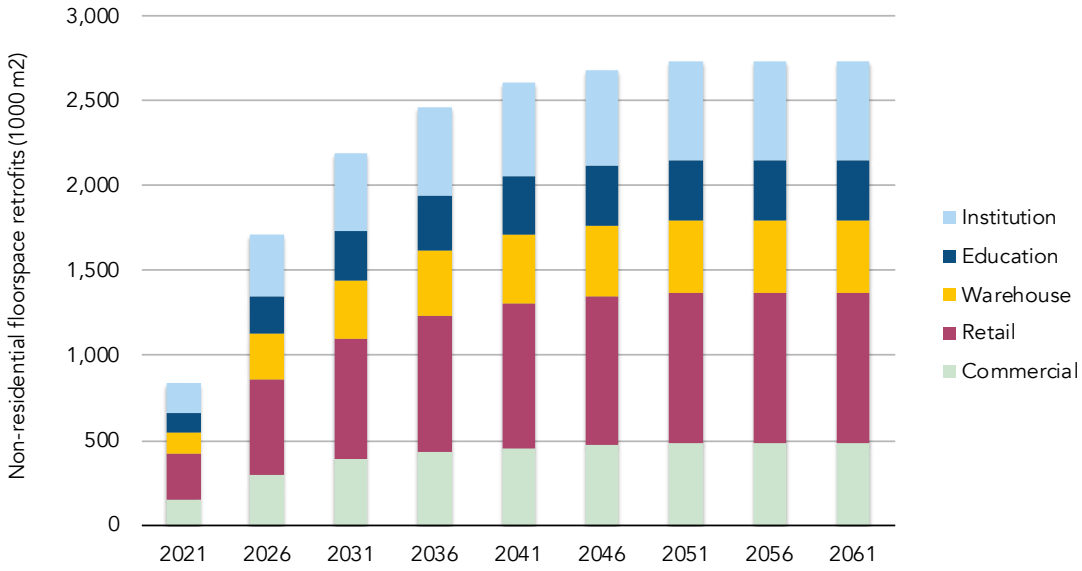


Figure 15. Non-residential floor space retrofit in five-year increments, cumulative to 2050

LCP Actions	Cumulative emissions reductions ($ktCO_2e$)	Percent of total GHG emissions (2018–2050)	Incremental costs (2020–2050), 2016$, present value	Incremental savings (2020–2050), 2016$, present value	Net present value (2020–2050), 2016$, present value
5. Retrofit old (pre-1980) homes	1,413.5	7.8	$605 million	$-547 million	$58 million
6. Retrofit new (post-1980) homes					
7. Retrofit non-residential buildings	1,154.6	6.4	$123 million	$-275 million	$-151 million
8. Non-residential building recommissions	615.1	3.4	$56 million	$-90 million	$-33 million
9. Installation of heat pumps	2,647.2	14.7	$372 million	$-118 million	$253 million
10. Installation of solar hot water	1,310.4	7.3	$93.2 million	$-193 million	$-99 million

Program 3: Renewable Energy Cooperative

Objective: The renewable energy cooperative will coordinate and advance the renewable energy objectives of the BCAP, using an entrepreneurial approach. In addition to the renewable energy mandate, the cooperative's mandate will include developing local expertise, stimulating the local economy and providing energy security and resilience.

Design: The co-operative is envisioned as a partnership with local groups, agencies and individuals to advocate for, develop, commission and finance projects, depending on which strategy is appropriate to a particular context. Different technologies and approaches will be considered, including district energy, increased use of renewable natural gas, solar PV, energy storage, biomass, and geothermal heating/cooling. Financing options will be researched and may come from community bonds, loans and grants from various levels of government.

City's Role: Collaborate with potential partners and facilitate the development of a co-op to operate as a 3rd party entity

Connections: Former Community Energy Plan – increase sustainable local energy generation in Burlington.

Timeline: 2022

Responsibility: Sustainability Staff

Potential Partners for Collaboration: Burlington Hydro; Enbridge; IESOI BurlingtonGreen; Green Venture; Halton Region; The Atmospheric Fund; Renewable Energy Associations

References: Toronto Renewable Energy Cooperative; Ottawa Renewable Energy Cooperative; Oxford Community Energy Cooperative

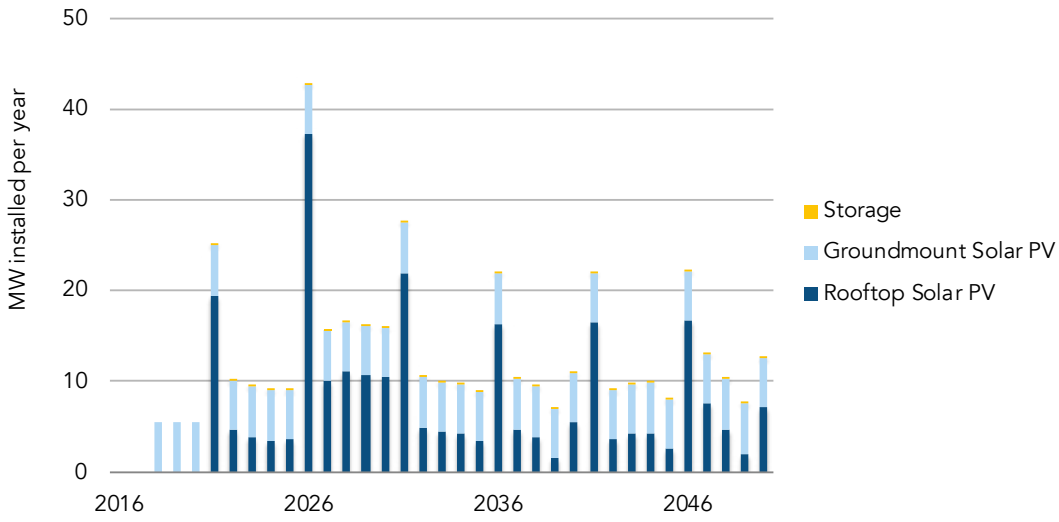


Figure 16. Annual renewable energy installations, 2018–2050

LCP Actions	Cumulative emissions reductions ($ktCO_2e$)	Percent of total GHG emissions (2018–2050)	Incremental costs (2020–2050), 2016$, present value	Incremental savings (2020–2050), 2016$, present value	Net present value (2020–2050), 2016$, present value
11. Net metering solar PV	107.6	0.6%	$169 million	$-224 million	$-55 million
12. Ground mount solar PV	174.0	1.0%	$129 million	$-453 million	$-324 million
13. District energy	79.8	0.4%	$13 million	$-38 million	$-24 million
14. Energy storage	0.1	0.0%	$312,000	$-296,000	$17,000
15. Increased RNG use, including maximizing RNG from waste streams	3386.0	18.8%	$3.1 million	$-181 million	$-178 million

Program 4: Integrated Mobility Plan

Objective: The Integrated Mobility Plan will develop an innovative strategy that supports future mobility planning with an emphasis on **people movement**. The Plan will be cognizant of the city's current demographics, recognizing the unique mobility needs of an aging population, while looking towards the future through a lens that focuses on maximizing the people-carrying capacity of our transportation network compared to road expansion. The resultant strategy will position Burlington to respond to technology changes and emerging mobility options, while balancing the needs of our citizens and providing equitable mobility in a safe, reliable and sustainable manner. The IMP will enable council and city administration to make future decisions relating to mobility and prioritize funding in a manner that ensures future success and continued livability.

Design: The desired outcome of this project is to develop a "road map" for the next 10-years while the city transitions from its suburban roots to an urbanized community; providing the framework for a future transportation network that successfully meets regional mode share targets and provides equitable access to mobility for all residents. Key challenges to be addressed include quantifying impacts of congestion (current and future impact if no shift to travel behaviour is achieved), how to mitigate impacts of traffic growth, and how to successfully achieve the mode share targets through the creation of an integrated transportation network.

City's Role: Strategic planning and operating transit system

Connections: From Vision to Focus- Increasing Burlington Transit service levels and growing overall ridership (1% annually). Burlington Transit's 5 year Business Plan; Integrated Mobility Plan; Cycling Plan; Rural Active Transportation Plan

Timeline: 2021- 20% modal split

Responsibility: Burlington Transit; Transportation Department

Partners for Collaboration:

Ministry of Transportation, Metrolinx, & Halton Region.

LCP Actions	Cumulative emissions reductions ($ktCO_2e$)	Percent of total GHG emissions (2018–2050)	Incremental costs (2020–2050), 2016$, present value	Incremental savings (2020–2050), 2016$, present value	Net present value (2020–2050), 2016$, present value
16. Expanded transit services to increase mode share	200.1	1.1%	$98 million	-133 million	$-34 million
17. Increased active transportation mode share					

Program 5: Electric Mobility and Equipment Program

Objective: Implement measures and policies to support electric mobility options in Burlington and electrify gas-powered equipment.

Design: A technical working group will be established with representatives from relevant organizations and stakeholders to develop a strategy to support infrastructure investments, education and outreach, and municipal policies to support electric mobility and equipment options. Electric mobility may include electric vehicles, bikes, scooters and other means of mobility. Electric equipment may include landscaping equipment such as lawn mowers, trimmers and leaf blowers, as well as others where relevant.

City's Role: Convert fleet, and implement infrastructure.

Connections: Former Community Energy Plan – Monitor electric vehicle market and investigate the feasibility of electric charging stations at city facilities, including downtown parking lots; Green Fleet Strategy.

Responsibility: Sustainability Staff; Transportation; Transit (bus fleet); Roads, Parks & Forestry; and Fire Departments

Potential Partners for Collaboration: Burlington Hydro; BurlingtonGreen (Make the Switch program)

References: City of Calgary EV Strategy; City of Toronto EV Strategy; Framework for Municipal Zero Emission Vehicle Deployment (Pollution Probe & Delphi Group)

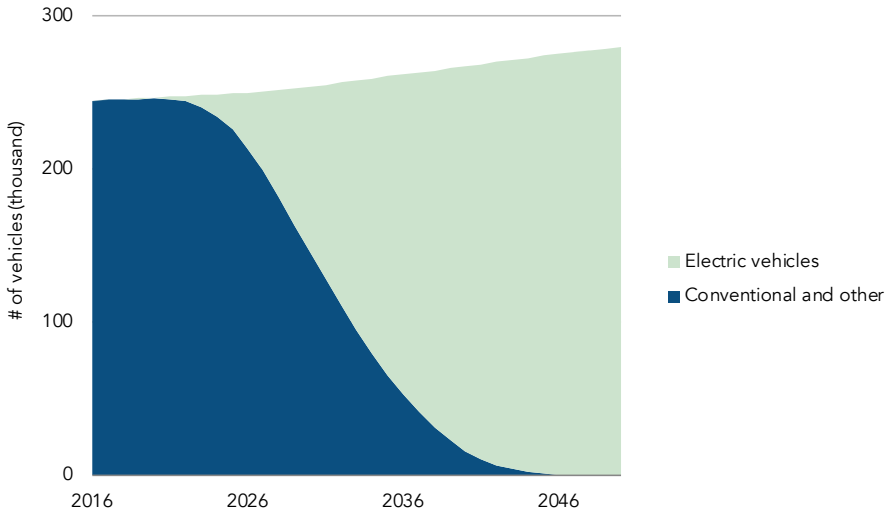


Figure 17. Conventional vs electric vehicles projection for Burlington, 2016–2050

LCP Actions	Cumulative emissions reductions ($ktCO_2e$)	Percent of total GHG emissions (2018–2050)	Incremental costs (2020–2050), 2016$, present value	Incremental savings (2020–2050), 2016$, present value	Net present value (2020–2050), 2016$, present value
18. Electrify urban transit	71.4	0.4%	$13 million	$-29 million	$-16 million
19. Electrify municipal fleets	63.9	0.4%	$17 million	$-42 million	$-25 million
20. Electrify light duty personal and commercial use vehicles	5,591.2	31%	$728 million	$-2.00 billion	$-1.27 billion
21. Electrify other commercial use vehicles	853.3	4.7%	$39 million	$-289 million	$-249 million

Program 6: Waste Reduction Initiative

Objective: Develop educational programs to increase waste diversion and reduce overall waste production by the community.

Design: Waste management services are primarily delivered by the Region of Halton. The city will support the region to engage the community to first reduce waste and secondly, properly divert waste

City's Role: Show leadership through its services and operations to reduce and divert waste

Connections: Halton Region is the lead jurisdiction for waste, Halton Region Waste Management Strategy

Timeline: Ongoing

Responsibility: Halton Region Waste Management; City of Burlington

Potential Partners for Collaboration: BurlingtonGreen

LCP Actions	Cumulative emissions reductions ($ktCO_2e$)	Percent of total GHG emissions (2018–2050)	Incremental costs (2020–2050), 2016$, present value	Incremental savings (2020–2050), 2016$, present value	Net present value (2020–2050), 2016$, present value
22. Decrease waste generation	30.1	0.2%	$0	$-29 million	$-29 million
23. Increase waste diversion	25.1	0.1%	$0	$-43 million	$-43 million

Program 7: Industrial Innovation Program

Objective: Support organizations that work with local businesses to improve energy efficiency in their operations Increase process motors and electrical efficiency by 50% by 2050

Design: TBD upon consultation with industry stakeholders.

City's Role: Facilitate support through the IESO and Enbridge

Timeline: Ongoing

Responsibility: IESO and Enbridge

Potential Partners for Collaboration: Burlington Economic Development Corporation; Sustainable Hamilton Burlington; BurlingtonGreen

IMPLEMENTATION OF PROGRAMS

The City of Burlington has identified three top priority program areas, out of the seven described above, to focus initial efforts, resources, and funding. Focusing on these three programs first will result in immediate GHG emissions reductions, and energy savings. Lessons learned through these initial projects will provide learnings and motivation as the focus of the City expands to include the remaining four programs. While the focus will be on the three top priority areas, work will continue on the other programs, including updating the Sustainable Development and Building guidelines, as well as developing an Integrated Mobility Plan.

The top priority areas are:

Program 2: Burlington Deep Energy Retrofit Program

Immediate focus for 2020 – 2022

- Work in partnership with the Bay Area Climate Change Council (BACCC) and community stakeholders on this topic.
- Support a roundtable discussion hosted by BACCC on this topic with local experts.
- Develop an implementation team of local experts
- Support the partnership of the IESO (Independent Electricity System Operator), AMO (Association of Municipalities of Ontario), the City of Toronto and the Clean Air Partnership in their efforts to develop a regional approach to deep energy retrofits in Ontario.
- Review options to utilize the Local Improvement Charge mechanism as other municipalities have done.
- Monitor the federal government's commitment to support deep energy retrofits in the 2020 budget.
- Increase awareness of residents and businesses – what is involved in a deep energy retrofit?

Potential funding sources and mechanisms

- The Federation of Canadian Municipalities received two contributions from

the Federal Government for two retrofit funding programs, the Community EcoEfficiency Acceleration ($300 million) and Sustainable Affordable Housing Innovation ($300 million). Details on these funds have not yet been released.

- Natural Resources Canada has been directed to develop a plan to improve energy efficiency and resiliency of homes, including up to $40,000 in interest free loans to homeowners and free energy audits.
- Municipalities can provide financing which is tied to dwellings as opposed to homeowners in order to align payments with avoided energy costs.

Implementation milestones

	Implementation milestone (cumulative)					
Action	2025	2030	2035	2040	2045	2050
Retrofit old homes (actions 5 & 6)						
# single detached dwellings retrofit	21,098	27,534	31,067	33,007	34,073	34,657
# double detached dwellings retrofit	1,638	2,138	2,412	2,563	2,646	2,691
# row house dwellings retrofit	7,924	10,341	11,668	12,396	12,797	13,016
# apartment dwellings retrofit	9,180	11,980	13,518	14,362	14,826	15,080
Total dwellings retrofit	39,841	51,993	58,665	62,329	64,340	65,445
Retrofit non-residential buildings (action 7)						
m^2 commercial floorspace retrofit	301,912	386,484	432,918	458,414	472,412	480,098
m^2 retail floorspace retrofit	557,639	713,845	799,610	846,701	872,556	886,752
m^2 warehouse floorspace retrofit	267,518	342,455	383,600	406,190	418,594	425,404
m^2 education floorspace retrofit	225,453	288,606	323,281	342,320	352,773	358,513
m^2 institution floorspace retrofit	362,376	463,884	519,618	550,220	567,022	576,247

	Implementation milestone (cumulative)					
Action	2025	2030	2035	2040	2045	2050
Total m^2 floorspace retrofit	1,714,898	2,195,274	2,459,028	2,603,844	2,683,357	2,727,014
Installation of heat pumps (action 9)						
# residential heat pumps installed	36,534	60,826	96,123	135,786	180,470	226,548
m^2 commercial floorspace served by heat pumps	528,479	891,151	1,232,238	1,611,632	1,999,754	2,334,506
Installation of solar hot water (action 10)						
# residential solar hot water systems installed	1,546	7,103	13,341	20,443	28,039	36,011
m^2 commercial floorspace served by solar hot water	763,358	1,277,317	1,833,330	2,280,611	2,307,408	2,334,506

Program 3: Renewable Energy Cooperative

Immediate focus for 2020 – 2022

- Host a roundtable of experts to discuss opportunities and barriers of expanding renewable energy in Burlington
- Create a task force of experts in the field
- Create a how to guide for homeowners for residential renewable energy installations
- Research the feasibility of developing a renewable energy cooperative in Burlington, consisting of individual members or organisational members (such as utilities and municipalities), or a combination of both (multi-stakeholder cooperative).

Potential funding sources and mechanisms

- In the start-up phase, the cooperative will require funding to establish the organisation and develop projects. For this purpose, the cooperative can solicit funds either as contributions or loans from its members
- For a renewable energy project, cooperatives will also borrow funds, which is paid back with revenues from selling the energy. Cooperatives can also

partner with other renewable energy developers on projects to reduce the financing requirement

- Other renewable energy cooperatives have raised funds by accepting investments from individual members or member organisations, depending on the structure

Implementation milestones

	Implementation milestone (cumulative)					
Action	2025	2030	2035	2040	2045	2050
Net metering solar PV (action 11)						
MW installed	35	115	154	186	217	255
Ground mount solar PV (action 12)						
MW installed	44	72	99	127	154	182
District energy (action 13)						
MW installed	1.0	1.5	2.0	2.0	2.0	2.0
Energy storage (action 14)						
MW installed	0.05	0.1	0.15	0.2	0.25	0.3
Increasing RNG use, including maximizing RNG from waste streams (action 15)						
GJ RNG consumed	2,242	1,267,950	3,700,399	5,360,067	5,978,959	6,163,563

Program 5: Electric Mobility and Equipment Program

Immediate focus for 2020 – 2022

- Host a roundtable of experts to discuss opportunities and barriers of electric mobility in Burlington
- Create a task force of experts
- Continue to support the expansion of charging infrastructure in Burlington
- Work with community stakeholders to engage the community
  - Test drive events with Plug'n Drive
  - Information about the benefits of EVs, e-equipment and e-bikes

Potential funding sources and mechanisms

- EV purchases for fleets can be integrated into asset planning and

incremental capital costs can be financed with a revolving loan fund, or by applying a life cycle costing purchasing policy that reflects lower operational costsIncentives for personal and commercial EVs can be provided through dedicated infrastructure (parking, lanes, charging locations) which can be incorporated into existing infrastructure budgets

- Strategies such as EV free zones can be financed through tariffs on non-EVs

Implementation milestones

	Implementation milestone (cumulative)					
Action	2025	2030	2035	2040	2045	2050
Electrify urban transit (action 18)						
% total vehicles as EV	9%	24%	39%	5%3	68%	82%
% new vehicles as EV	55%	100%	100%	100%	100%	100%
Electrify municipal fleet (action 19)						
% total vehicles as EV	8%	24%	46%	70%	88%	97%
% new vehicles as EV	30%	55%	80%	100%	100%	100%
Electrify light duty personal and commercial use vehicles (action 20)						
% total vehicles as EV	15%	50%	80%	96%	100%	100%
% new vehicles as EV	66%	100%	100%	100%	100%	100%
Electrify other commercial use vehicles (action 21)						
% total vehicles as EV	2%	5%	9%	15%	21%	26%

COMMUNITY ENGAGEMENT STRATEGY

Engagement and Communications[25]

The City of Burlington contracted LURA Consulting to facilitate public and stakeholder feedback on the BCAP. Over the summer of 2019, various opportunities were provided for engagement. Key engagement activities included: pop-up engagements at local events; online survey; in-person workshops with stakeholders and members of the public; and a drop-in open house.

In addition to facilitating and reporting on the engagement for the development of the Climate Action Plan (outlined above), LURA was also tasked with developing a Community Engagement Strategy for the implementation of the plan. The purpose of this strategy is to encourage and support the widespread adoption and implementation of the actions and programs outlined in the Climate Action Plan. Successful implementation of the Plan will require action from all of us - residents, businesses and government.

In total, 21 actions were identified for Burlington. Stakeholder and community engagement completed to date has focused on the program areas and related actions outlined below. These actions were selected for their relevance to the respective audiences and was not meant to indicate priority over other actions.

Program Area	Related Action(s)
Active Transportation / Transit	• Choosing sustainable transportation options like walking, cycling or transit

25 Lura Consulting BCAP Engagement Strategy, 2019.

Program Area	Related Action(s)
Electric Mobility	• Electrify commercial vehicles • Switching to electric vehicles (personal)
Existing Buildings	• Complete deep retrofits of commercial and industrial buildings • Use heat pumps and/or solar hot water in industrial, commercial and institutional (ICI) buildings • Retrofitting your home to be more energy efficient • Installing a heat pump or solar hot water heater at home
Renewable Energy	• Use solar PV for energy generation in ICI buildings

The following considerations were highlighted in stakeholder and public engagement sessions:

- Provide information on both how and why individuals/businesses should implement climate action, with a focus on capacity-building
- Develop and communicate the business case or return-on-investment associated with the suggested actions
- Highlight the benefits to the specific individual or business
- Preferred communications tactics included receiving information online (website, email, newsletters, social media) and via in-person events

Community Stakeholders

The City of Burlington is not acting alone in tackling climate change head-on. The Burlington community is made up of citizens, businesses, institutions, non-profits, faith-based groups, sports, arts and recreational organizations and many more. The following lists the key stakeholders who have been involved in the former Community Energy Plan and are now involved in the community Climate Action Plan.

Burlington Economic Development Corporation (BEDC) has a mandate to enhance the growth prospects of local companies and attract new firms to the community. Its focus is on growing the economic base to sustain a competitive and prosperous community.

Role: To foster synergies and look for opportunities with local businesses to improve energy efficiency and promote local technologies and services in the energy field.

BurlingtonGreen is a citizen led, non-partisan -registered charity that works to protect the environment, mitigate climate change and create a healthier, more environmentally responsible community through awareness, advocacy and action. BurlingtonGreen is known for their annual city-wide dual component Community Clean Up Green Up (tree planting) event, the greening of community events through proper waste sorting, their popular youth environmental network, Eco Film events, and many other initiatives.

Role: Engage the community in actions to reduce greenhouse gas emissions through its programs such as 'Eco Score' as well as 'Make the Switch' – which educates Burlington residents on the benefits of electric vehicles, taking public transit and installation of heat pumps.

Burlington Hydro Inc. (BHI) is a regulated local electrical distribution company (LDC) serving the City of Burlington with approximately 67,000 customers. Burlington Electricity Services Inc. (BESI) is its non-regulated sister company, engaging in sector related business activities such as EV charging stations.

Role: In 2017 BESI entered into an agreement with the City of Burlington to convert its street lighting to LED technology. BESI is also involved in expansion of electric vehicle charging infrastructure in the city, providing programs to homeowners (detached and townhomes) as well as working with multi-residential buildings.

Burlington Sustainable Development Committee is a volunteer citizen advisory committee to city council, established in 1990. This committee has two mandates – to provide advice and guidance to city council on planning and policy initiatives to support a sustainable development community. It also engages and educates the community on sustainability initiatives and actions through events, on topics such as green buildings, renewable energy, energy conservation, green living, and local food.

Role: Continue to provide advice and guidance to city council on sustainable development issues and engage and educate the community on issues related to climate change.

The Centre for Climate Change Management at Mohawk College (CCCM) is mobilizing support and facilitating solutions to reduce greenhouse gas emissions, and to adapt to the impacts of our changing climate. Through collaboration with decision-makers, influencers and passionate citizens, the CCCM is embarking on action to ensure a thriving, low-carbon economy.

Role: Continue to engage students, faculty, community and businesses through the following programs:

- Bay Area Climate Change Office
- Industry Partnership Initiative
- Campus Carbon Management Initiative
- Office of Campus Sustainability and Climate Change

Halton Catholic District School Board

There are 14 elementary schools and 3 secondary schools in Burlington under the jurisdiction of the Halton Catholic District School Board, delivering educational programs to students in Burlington.

Role: Engage and educate students about the impacts of climate change and actions that students and families can take. HCDSB schools participate in the Eco School program. Ontario EcoSchools is an environmentally educative program that aims to help school communities across the province to develop their ecological literacy and environmental practices. The goal of the program is for schools to reduce their eco footprints and to teach staff, students and parents to be environmentally responsible citizens. The school board can also show community leadership by improving the energy efficiency of the schools and implementing renewable energy projects where possible.

Halton Environmental Network (HEN)

HEN is an incorporated non-profit organization operating in Halton Region (Oakville, Burlington, Milton, Halton Hills). HEN supports and enhances the capacity for local climate action and environmental sustainability across our community. HEN brings together relevant parties to drive change and facilitates communication, cooperation, resources and alignment with Community members, Conservation Authorities, Non-profits, Faith-Based Organizations) Government, and Educational Sector.

Role: HEN engages the community through workshops, community educational outreach programs, and waste diversion and mitigation initiatives for organizations and businesses and at events.

Halton District School Board

There are 35 elementary schools and 9 secondary schools in Burlington under the jurisdiction of the Halton District School Board, delivering educational programs to students in Burlington. The board delivers other programs such as adult continuing education and night school at Gary Allan High School.

Role: Engage and educate students about the impacts of climate change and actions that students and families can take. HDSB schools participate in the EcoSchool program (see above under Halton Catholic District School Board).

McMaster University – Department of Engineering & McMaster Institute for Energy Studies

The research that the institute is involved in such as energy harvesting, thermal energy recovery, micro thermal networks and energy storage will help to support the development of smart community energy systems as Burlington grows and develops.

Role: Continue its research and relate the applicability to Burlington in future development and support pilot projects. The city will also support and participate in research projects where relevant to its strategic goals.

Region of Halton

The Region of Halton is the regional government and is responsible for providing services such as water and wastewater treatment, distribution and collection, waste management services, and health and social services, among others.

Role: The region has a leadership role to play on climate change by ensuring its own operations are delivered in an efficient way to reduce the overall carbon footprint. The region does extensive community outreach on areas related to waste reduction and diversion, water efficiency and conservation, and the linkages between climate change and health.

Royal Botanical Gardens

The Royal Botanical Gardens (RBG) is the largest botanical garden in Canada with 400 acres of display gardens. The RBG also shows stewardship by protecting and restoring 2,450 acres of nature sanctuaries containing environmentally sensitive habitats, where approximately 50 listed species-at-risk have made their home. It is actively involved in teaching and educating the public and school children about the importance of plants, nature and maintaining sustainable biodiversity, and how to be environmental stewards in their community.

Role: Continue to engage the public and school children on being environmental stewards to reduce the impacts of climate change, particularly on the natural environment and biodiversity.

Sustainable Hamilton Burlington

Sustainable Hamilton Burlington is a non-profit social enterprise serving the cities of Hamilton and Burlington. It works with local businesses and non-profit organizations to take leadership and adopt a sustainable approach to their operations through collaborative learning, measurable action and recognition of success.

Role: Continue to work in the business and non-profit sector to achieve positive change to reduce the collective carbon footprint and waste.

Enbridge

Enbridge Gas Inc. delivers natural gas to homes, businesses and industries in communities across Ontario.

Role: Enbridge delivers residential conservation programs as well as programs to businesses. Residential programs include a home reno rebate program, a low income 'weatherization' program, and support to builders to improve energy efficiency of new homes. Programs for businesses include incentives for energy efficiency equipment, incentives to help fund engineering feasibility studies, and building optimization programs to help improve building efficiency, among others.

Partnerships and Collaboration

Centre for Climate Change Management at Mohawk and The Bay Area Climate Change Office & Council

The Centre for Climate Change Management at Mohawk (CCCM) is a multi-sector partnership between the cities of Hamilton and Burlington, Sustainable Hamilton Burlington and Mohawk College. The governance model, particularly for the Bay Area Climate Change Office (BACCO) and Council supports the implementation of a community driven plan to grow the economy while reducing emissions and building resilience to adapt to a changing climate.

There are currently 15 member organizations and individuals on Bay Area Climate Change Council. A strength of the council is the diverse background and experience of the membership. The council will collectively promote the adoption of deep greenhouse gas emissions mitigation strategies and climate change adaptation initiatives, prioritizing the following actions:

- Advocating for the adoption of progressive climate change policies;
- Supporting deep energy retrofits for homes and residential buildings;
- Advancing transportation strategies to reduce greenhouse gas emissions; and,
- Collaborating on low carbon supply chain solutions to support access to local food and reduce waste throughout the food supply chain.

Halton Climate Collective

The Halton Climate Collective (HCC) was initiated by and is led by the Halton Environmental Network (HEN). The HCC is a group of local organizations focused on collectively transforming the community of Halton into a low carbon, climate resilient community. The purpose of the collective is to align actions and leverage expertise to reduce climate change, secure funding opportunities and promote a collective approach to addressing climate change. Organizations represented on the collective include:

- City of Burlington
- Conservation Halton
- Halton Environmental Network
- Town of Halton Hills
- Town of Milton
- Town of Oakville
- Halton Catholic District School Board
- Halton District School Board
- Region of Halton; and
- University of Waterloo

Sustainable Hamilton Burlington

Sustainable Hamilton Burlington is a non-profit social enterprise serving the cities of Hamilton and Burlington. It works with local businesses like Walker Emulsions, Wolseley Distribution and Zip Signs (Burlington businesses) and non-profit organizations to take leadership and adopt a sustainable approach to their operations through collaborative learning, measurable action and recognition of success. This includes supporting organizations in setting and working towards carbon reduction targets. The cities of Hamilton and Burlington are members of SHB in part to show leadership to other local organizations and businesses to improve sustainability and adopt a low carbon approach to their operations.

Clean Air Partnership and Clean Air Council

The Clean Air Partnership (CAP) is a charitable environmental organization launched in June 2000. CAP's mission is to help municipalities become sustainable, resilient, vibrant communities where resources are used efficiently, the air is clean to breathe and greenhouse gas emissions are minimized. The Clean Air Council is a program administered by CAP and is a network of 28

municipalities and health units from across Ontario. Since 2000, Clean Air Council members have been working collaboratively on the development and implementation of clean air, climate change, sustainability and resilience actions. The City of Burlington has been an active member on the Clean Air Council for several years.

QUEST Community Energy Planning and Implementation Network

QUEST (Quality Urban Energy System for Tomorrow) is a national non-government organization that works to accelerate the adoption of efficient and integrated community-scale energy systems in Canada by informing, inspiring and connecting decision makers. This organization commissions research, communicates best practices, convenes government, utility, and private sector leaders, and works directly with local authorities to implement on the ground solutions.

Participating in QUEST's Community Energy Planning and Implementation Network (CEPIN) provides Burlington the opportunity to network with peer municipalities on community energy planning, sharing best practices, lessons learned and other information, with access to senior levels of government and utilities on energy issues. The network assists Burlington staff to stay informed about changing policies and programs related to community energy planning as well as best practices being implemented by other organizations.

International Urban Cooperation Program

Burlington has been participating in the European Union's International Urban Cooperation program since 2017, partnered with Växjö, Sweden to share solutions to common challenges such as sustainable development, community energy systems and climate change. The program is part of a long-term strategy by the EU to foster sustainable urban development in cooperation with both the public and private sectors. Burlington and Vaxjo have been working together to share information and lessons learned on their respective areas of focus using an ecosystem approach to planning for urban parks and the redevelopment of an industrial area. Information is being shared through skype meetings and webinars on topics such as the fossil fuel free city; storm water management; tall wood buildings; and community engagement activities.

Showcase Cities and Global Covenant of Mayors for Energy and Climate Canada

The City of Burlington is one of 25 Canadian municipalities participating in the Showcase Cities Program. The program is designed to help municipalities make the transition to the Global Covenant of Mayors for Climate and Energy (GCoM - Canada).

GCoM Canada is a collaboration between the Federation of Canadian Municipalities, ICLEI Canada, C40 Cities, the Global Covenant of Mayors Secretariat and the International Urban Cooperation Project, supported by funding from the European Union. The initiative combines two leading domestic climate programs, the Partners for Climate Protection (PCP) and Building Adaptive and Resilient Communities (BARC) with the leading global climate program. The purpose of this collaboration is to further advance Canadian local climate action by adding value, international opportunities/profile and streamlined support and reporting for members.

Burlington has joined over 9,000 cities, representing more than 800 million people worldwide and over 10% of the total global population by committing to take part in the GCoM program.

MONITORING AND EVALUATION

Tracking the effectiveness of the actions in the BCAP helps to manage the risk and uncertainty associated with these efforts, as well as external forces such as evolving senior government policy, and new technologies which can disrupt the energy system. Key motivations for monitoring and evaluation include the following:

- Identify unanticipated outcomes.
- Adjust programs and policies based on their effectiveness.
- Manage and adapt to the uncertainty of climate change.
- Manage and adapt to emerging technologies.

Specific activities which have been identified to support the implementation of the BCAP include an annual work plan and review, an annual indicator report, an update of the GHG inventory every two years and an update of the BCAP every five years.

Table 7. Monitoring and evaluation activities

Activity	Purpose	Description	Frequency
1. Annual work plan and review	Review work to-date and set annual priority actions	Annual report with prioritized actions	Annual
2. Annual indicator report	Track effectiveness of actions	Annual report on set of indicators with an analysis of the results	Annual
3. Inventory	Update energy and GHG emissions profile	Re-calculate the GHG emissions and energy inventory	Every 2 years
4. Update the BCAP	Update the BCAP to reflect changing conditions	Review each action and the progress being achieved. Identify new actions.	Every 5 years

Annual Work Plan and Review

An annual work plan identifies all relevant activities to achieve the actions and policies in the plan, the responsible parties, the budget and the schedule. The results of the previous year's work plan should be reviewed to inform the development of subsequent work plans. The work plan is prepared by the BCAP coordinating body, as identified by the BCAP partners.

Annual Indicator Report

There are two aspects involved in the application of indicators: collecting data on indicators (monitoring) and interpreting the results of those indicators (evaluation). Over time, the City can also evaluate its effectiveness in embedding the knowledge and wisdom gained through this process into the organization.

From the perspective of the BCAP, there are multiple purposes for which data is collected: to evaluate the effectiveness of the actions, to evaluate the impact of the actions on the community, and to evaluate the uptake of the lessons from the evaluation.

The City can launch its implementation report on Earth Day each year.

Table 8. Types of indicators

Indicator Category	Question
1. Effectiveness indicators	Are the actions achieving their objectives?
2. Impact indicators	What is the impact of the actions on the community?

Effectiveness Indicators

These indicators are designed to evaluate whether or not policies or actions are having an effect; they vary from municipality to municipality according to the specifics of the community energy and emissions plan. The results of the indicators are then compared against the assumption in the modelling to monitor whether or not the community is on track with projections. Indicators should be developed for each policy or mechanism.

Impact Indicators

The City should develop a set of indicators that track macro trends and drivers of GHG emissions in the City. These are designed to be reported on each year.

Table 9. Indicators

Indicator	Trend	Data sources
Total new dwellings by type	An indication of the growth of the building stock.	Building permits
Average total floor area of new dwellings	An indication as to whether there is more or less floor space to heat or cool.	Building permits
Diversity of dwelling types	An indication of the types of dwellings and whether or not they have shared walls.	Building permits
Total new non-residential floorspace by type	An indication of the growth of the building stock.	Building permits
Total demolitions	An indication of the change in the building stock.	Demolition permits

Indicator	Trend	Data sources
Percentage of non-residential floorspace within 400m of a transit stop	An indication as to whether commercial development is occurring in areas more appropriate for walking, cycling and transit.	Building permits and GIS analysis
Number of new dwellings that are within 400m of a transit stop	Indication of transit accessibility.	GIS layers of transit and building footprint
Annual or monthly energy price by fuel (electricity, gasoline, diesel, natural gas) ($/GJ)	Energy costs are an important indicator of opportunities for energy savings and renewable energy, household, municipal and business energy costs.	Available from the utilities
Total energy consumption by sector for electricity (GJ)	An indication of trends in energy use in buildings.	Available from the utilities
Total solar PV installs (# of installations)	An indication of extent of decentralized renewable energy.	Building permits or utilities
Total gasoline sales ($)	An indication of GHG emissions from vehicles.	Available for purchase from Kent Group Ltd.
Total transit trips	An indication of whether non-vehicular trips are increasing.	Available from B.T. and Metrolinx

Indicator	Trend	Data sources
Length of physically separated cycling lanes, new cycling infrastructure, and new sidewalks	An indicator of opportunity for people of all ages to cycle and use active transportation modes.	City
Mode share	An indication of the use of transit/active transportation	City
Volumes of types of waste processed at recycling and waste management facilities	An indicator of uptake of waste diversion strategies, and of overwall waste production	Region
Number of EV, PHEV and BEV vehicle sales compared to total vehicle sales	An indicator of adoption EVs in the market	Province

CONCLUSION

The BCAP is a pathway to a low carbon future. This pathway requires new investments by the public sector, the private sector and households, and will stimulate a new economy.

Municipal interventions will be foundational. These efforts will unlock key strategies to advance the LCS, including creating policies to support district energy, land-use planning, supporting advanced building performance standards, financing retrofits and renewable energy, and education and support.

The low carbon pathway nearly achieves Burlington's GHG targets. New opportunities will need to be incorporated into the BCAP in order to address the gap between the City's GHG targets and the LCS.

Recommendation #1: The City and partners continue to test novel approaches and identify new strategies to reduce GHG emissions as part of the monitoring and evaluation of the BCAP.

Implementation focuses on six program areas. The transition requires efforts firstly to reduce energy consumption through high performance building codes and land-use planning, secondly to improve the energy system by retrofitting existing buildings, and thirdly to switch to renewable energy, primarily electricity and to a lesser degree renewable natural gas. The BCAP outlines specific actions and programs that will implement those actions.

Recommendation #2: The partners of the BCAP will develop a five-year implementation plan based on the six program areas identified in the BCAP.

The City of Burlington is not alone. Many other cities and regions around the world are exploring similar pathways, and there are opportunities to compare notes and learn from successes and challenges going forward.

Land-use policy will enable implementation. Energy and GHG gains that occur as a result of land-use planning are essentially free in that they require no investment and deliver a range of other co-benefits. Therefore, municipalities

should continue to advance intensification strategies as an enabling strategy to reduce GHG emissions. Other policies in the Official Plan will also support the delivery of the programs and the implementation of the actions.

Recommendation #3: The BCAP be both recognized and enabled by the forthcoming revisions of the Burlington Official Plan.

The BCAP is an economic development strategy. There are opportunities for new and existing businesses in the fields of heat pumps, building retrofits, renewable energy, district energy, energy storage and others yet to be determined.

Major investments are required. This transition requires significant capital investments, an additional amount of $4.3 billion for all the timeline of the LC pathway, compared with the BAU scenario. However, these investments are offset mainly by reduced fuel expenditures later on, reaching savings of $ 6.7 billion over the same period. The incremental capital costs of the LCS are 4% of the total expenditures made annually on buildings, transportation and waste management in the City.

Recommendation #4: Work with financial partners to develop a BCAP capitalization strategy.

The LCS actions modelled have varying return on investments and risk profiles. Some investments will be more suited to the public sector, whereas others will be more appropriate for private businesses. Determining which action is best associated with which entity has yet to be done but there are many promising investment opportunities.

New jobs will be created. The investments in the energy system will generate employment in building design, retrofits, district energy, renewable energy, electric vehicle manufacturing and other sectors. A total of 21,300 direct person years of employment will be created over the period as a result of the implementation of the LCS.

The low carbon pathway will evolve. As new technologies emerge and new approaches to deployment are developed, the approach to implementing the actions will change. The earlier the City of Burlington can undertake the investments contemplated in the pathway, the greater financial and environmental benefits will be for the community as a whole. Delay will result in, for example, increasing household energy costs for a longer period.

APPENDIX 1. MODELLING AND METHODOLOGY

Population and Employment Assumptions and Projections

City-wide population is modelled using the standard population cohort-survival method, disaggregated by single year of age and gender. It accounts for various components of change: births, deaths, immigration and emigration. The age structured population is important for analysis of demographic trends, generational differences and implications for shifting energy use patterns.

The 2016 population includes an estimated census undercount, based on estimates for the census undercount by age and gender. The Statistics Canada 2016 Census is used as the basis for this year.

The employment numbers are adjusted to reflect the place of work of employees.

The population and employment growth rates in the BPE (2011) were used to project to 2031, and held fixed from 2031-2050 (growth rates held fixed; not population and employment). The Regional Municipality of Halton Best Planning Estimates of Population, Occupied Dwelling Units, and Employment 2011-2031 for the City of Burlington were used for these projection estimates.

Carbon Budget Methods

In this context, a carbon budget for Burlington was developed using the per capita figures of 2.9 tCO_2e for 2030, and 0.9 tCO_2e and 0 tCO_2e for 2050 respectively, using the C40 report as reference.[26] A logistic function was used to extrapolate per capita GHG emissions between 2019 and 2030, and 2030 and 2050 using a convergence point of 2.9 tCO_2e in 2030, resulting in an annual per capita budget for CO_2e emissions. Future population projections were then multiplied against the per capita GHG emissions factor to generate total GHG emissions year over year.

Financial Modelling

The actions in the LCS require investments that result in savings and, in the case of local electricity generation, revenues; it is a classic case of pay now to save later. Incremental expenditures, (as compared with the business-as-usual case) in buildings, vehicles and other energy-related equipment and infrastructure increase costs in the short term in return for long term savings. By 2050, cumulative investment in the LCS reaches $38 billion with a present value in 2016 of $23.5 billion.

On the other side of the ledger are the fuel and electricity cost savings, the monetary value of the carbon reductions resulting from carbon pricing, and savings from a lower O&M cost. The largest contribution to the value of the LC comes from lower energy bills; by 2050, fuel and electricity expenditures in Burlington are a $0.4 billion per year lower than in the business-as-usual scenario. In that same category, cumulative savings reach $6.9 billion, with a present value in 2016 of $3.5 billion.

Carbon pricing effectively increases the value of fuel and electricity savings, and especially fuel savings, modestly in the first half of the program but more significantly in the later years as the effective carbon price increases. In 2050, the carbon "premium" from the LC reaches $99 million and the cumulative premium over the period totals $1.5 billion, with a present value of $0.7 billion.

Finally, the LCS pathway includes investments in local energy generation facilities in Burlington that generate a minor stream of revenue.

The above four categories of Investments, Energy Savings, Carbon Credits, and Energy Generation Revenue are summarized in Figure A1 below, which presents the LC scenario figures relative to BAU. On an annual basis, the investments

26 (C40, 2017, p. 40)

exceed the savings and revenues until the breakeven point in 2029 and then the net benefits begin to exceed the annual costs by an ever widening margin. By 2050, the annual net payback from the plan reaches $0.6 billion per year. By that point the cumulative investment reaches $4.3 billion as compared to the cumulative benefits of $6.8 billion. Additionally, as illustrated in Figure A2, the net present value of the costs and benefits of the Low Carbon Pathway is $2.9 billion.

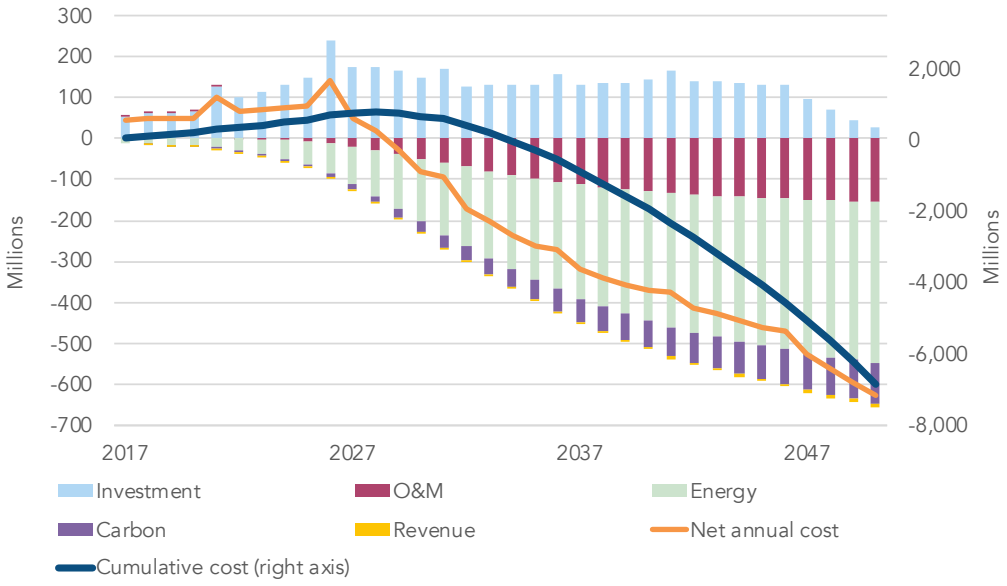


Figure A1. Expenditures, savings and revenues from the LCS, relative to business-as-usual. (Values are presented as costs in this figure, so expenditures are above the line and savings and revenue are below the line).

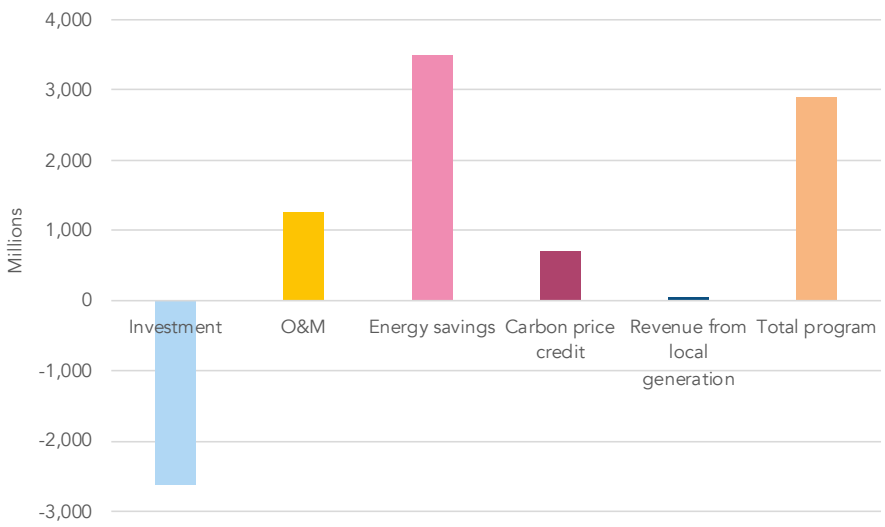


Figure A2. Net present value of expenditures, savings and revenues from the LCS, relative to the BAU scenario. (This figure shows present value, so costs are shown below the line, and revenues and savings above the line.)

Home Energy Retrofits and Heat Pumps

Residential retrofits to improve the building envelope, to reduce energy demand, and to switch to low- or zero-carbon fuel sources are an essential part of the low-carbon pathway for Burlington. Facilitation of the wide-spread adoption of these modifications may require support or incentives to encourage the level of uptake required to achieve deep GHG emissions reductions, as not all retrofits or conversions will be financially positive or neutral.

The cost of heat pumps, as well as other interventions, were assessed over the period from 2019-2050. Assumptions about the size and timing of installing heat pumps in commercial buildings are less accurate than for residential buildings; Burlington does not have a large commercial building stock.

Electricity price projections used in the modelling are obtained from Canada's Energy Regulator, and project that electricity will be more than ten times more expensive than natural gas in the future. Added to this is the complexity of

investment required in Ontario's electricity grid, which could result in even higher electricity prices. This increase is the primary driver of the additional cost for heat pumps combined with the capital cost, which is higher than a conventional boiler or furnace- the combination of low natural gas prices and low capital costs, make the financial case for heat pumps challenging. Ground-source and air-source heat pumps are bundled together in the modelling, which has the effect of lowering the costs of ground-source heat pumps, and raising the cost of air-source systems. Air-source heat pumps will have a better return on investment, and no hybrid or other heat pump types were evaluated.

The cost of retrofits in the model averages between $50,000 and $60,000 per unit, resulting in energy savings of 50% savings. This level of retrofit on one dwelling today will likely be more in the range of $80-$100,000, so the modelling assumption is based on the development of a retrofit industry that achieves economies of scale. Energy savings needs to be significant to provide a return on an investment of $60,000. Retrofits that result in energy savings of 20-30% can be more financially compelling, but once insulation in exterior walls and windows need to be replaced the return on investment is longer. Retrofit investment for the entire plan is $600 million while the savings are $550 million over a 30 year projection, with a margin of error associated with the assumptions for the modelling.

APPENDIX 2. ASSUMPTIONS TABLES

Electricity cost[27]

$ / kWh	Residential	Commercial		$ / kWh	Residential	Commercial
2016	0.1490	0.1222		2035	0.1704	0.1397
2017	0.1520	0.1246		2036	0.1705	0.1398
2018	0.1550	0.1271		2037	0.1706	0.1399
2019	0.1580	0.1296		2038	0.1709	0.1401
2020	0.1612	0.1322		2039	0.1710	0.1403
2021	0.1620	0.1329		2040	0.1712	0.1404
2022	0.1628	0.1335		2041	0.1762	0.1439
2023	0.1637	0.1343		2042	0.1770	0.1445
2024	0.1645	0.1349		2043	0.1779	0.1452
2025	0.1653	0.1356		2044	0.1787	0.1458
2026	0.1661	0.1362		2045	0.1796	0.1464
2027	0.1669	0.1369		2046	0.1804	0.1471
2028	0.1678	0.1377		2047	0.1813	0.1477
2029	0.1687	0.1383		2048	0.1821	0.1483
2030	0.1695	0.1390		2049	0.1830	0.1489
2031	0.1697	0.1392		2050	0.1839	0.1496

27 (National Energy Board, 2016)

$ / kWh	Residential	Commercial		$ / kWh	Residential	Commercial
2032	0.1698	0.1393				
2033	0.1700	0.1394				
2034	0.1702	0.1396				

Natural Gas cost[28]

$ / m3	Residential	Commercial		$ / m3	Residential	Commercial
2016	0.318	0.229		2035	0.369	0.274
2017	0.333	0.242		2036	0.370	0.275
2018	0.338	0.247		2037	0.372	0.276
2019	0.342	0.250		2038	0.373	0.277
2020	0.345	0.253		2039	0.374	0.278
2021	0.349	0.256		2040	0.375	0.279
2022	0.351	0.258		2041	0.383	0.284
2023	0.354	0.260		2042	0.385	0.286
2024	0.355	0.261		2043	0.387	0.287
2025	0.356	0.263		2044	0.389	0.289
2026	0.357	0.264		2045	0.391	0.291
2027	0.359	0.265		2046	0.393	0.292
2028	0.360	0.266		2047	0.395	0.294
2029	0.361	0.267		2048	0.397	0.295
2030	0.363	0.268		2049	0.399	0.297
2031	0.364	0.269		2050	0.401	0.298
2032	0.365	0.270				

28 (National Energy Board, 2016)

$ / m3	Residential	Commercial		$ / m3	Residential	Commercial
2033	0.366	0.272				
2034	0.368	0.273				

Gasoline cost[29]

$ / L			$ / L	
2016	1.17		2035	1.50
2017	1.21		2036	1.51
2018	1.25		2037	1.52
2019	1.26		2038	1.53
2020	1.29		2039	1.54
2021	1.31		2040	1.55
2022	1.33		2041	1.60
2023	1.35		2042	1.62
2024	1.36		2043	1.64
2025	1.38		2044	1.65
2026	1.39		2045	1.67
2027	1.41		2046	1.68
2028	1.42		2047	1.70
2029	1.44		2048	1.71
2030	1.46		2049	1.73
2031	1.47		2050	1.75
2032	1.48			
2033	1.49			

[29] (National Energy Board, 2016)

$ / L			$ / L	
2034	1.49			

Biogas Cost[30]

$ / GJ				
2016	$18.80		2035	$12.10
2017	$13.10		2036	$12.08
2018	$12.70		2037	$12.07
2019	$12.30		2038	$12.06
2020	$12.20		2039	$12.05
2021	$12.20		2040	$12.04
2022	$12.20		2041	$11.42
2023	$12.20		2042	$11.34
2024	$12.20		2043	$11.26
2025	$12.20		2044	$11.18
2026	$12.20		2045	$11.10
2027	$12.20		2046	$11.01
2028	$12.20		2047	$10.93
2029	$12.10		2048	$10.85
2030	$12.10		2049	$10.77
2031	$12.10		2050	$10.69
2032	$12.10			
2033	$12.10			
2034	$12.10			

30 (Navigant consulting, 2016)

Carbon Price[31]

$ / tonne CO_2eq				
2019	20		2038	80
2020	30		2039	83
2021	40		2040	85
2022	50		2041	88
2023	52		2042	90
2024	53		2043	93
2025	55		2044	96
2026	56		2045	99
2027	58		2046	102
2028	60		2047	105
2029	61		2048	108
2030	63		2049	111
2031	65		2050	114
2032	67			
2033	69			
2034	71			
2035	73			
2036	76			
2037	78			

[31] (Office of the Parliamentary Budget Officer, 2016)