Hamilton and Burlington Low-Carbon Scenario and Technical Report 2016 to 2050

COMPLETED AS PART OF THE BAY AREA CLIMATE CHANGE OFFICE,
CENTRE FOR CLIMATE CHANGE MANAGEMENT AT MOHAWK COLLEGE
GREENHOUSE GAS INVENTORY AND FORECAST

SSG SUSTAINABILITY SOLUTIONS GROUP

whatIf?

TERMS AND ACRONYMS

ACRONYM	DESCRIPTION
BAU	Business as usual
BF	Blast furnace
CDD	Cooling degree day
DMA	Data, methods and assumptions
GHG	Greenhouse gas
GJ	Gigajoule
HDD	Heating degree day
HELP	Home Energy Loan Program
ICI	Institutional, commercial and industrial
LC	Low-carbon
LIC	Local improvement charge
MWh	Megawatt hour
OBC	Ontario Building Code
PACE	Property assessed clean energy
PJ	Petajoule
PV	Photovoltaics
RNG	Renewable natural gas
TGS	Toronto Green Standard

CONTENTS

EXECUTIVE SUMMARY

This report provides an analysis of energy, GHG emissions and energy costs from 2016 to 2050 for the cities of Burlington and Hamilton, which collectively are described as the Bay Area.

The GHG emissions baseline was developed using SSG's energy, emissions, land-use, and financial model, CityInSight. This model was used to develop a baseline for 2016, and Business-as-Usual (BAU) and Low-Carbon (LC) scenarios. CityInSight ensures a physically coherent and highly detailed representation of each scenario that is calibrated against local conditions; in other words, the scenarios are realistic and possible futures for the Bay Area.

The BAU scenario represents a continuation of current trends and policies. The LC scenario includes detailed actions that improve the efficiency of dwellings and buildings, fuel switches to electricity for heating and vehicles, increases local renewable energy including district energy, additional transit and active transportation and reduced waste generation.

Figure 1 illustrates the total GHG emissions for the Bay Area (Burlington and Hamilton combined), which are 9.8 MtCO2e in 2016 and are relatively flat until 2050. Fuel efficiency standards and a decreased requirement for heating as a result of climate change offset a population increase. The low-carbon scenario results in a decline to 1.6 MtCO2e by 2050, a reduction of 84% over 2016.

Figure 2 shows the split between the two cities. Hamilton's GHG emissions are 87% of the total, with 8.6 MtCO2e versus 1.3 MtCO2e from Burlington. Nearly 70% of Hamilton's GHG emissions are associated with the steel industry.

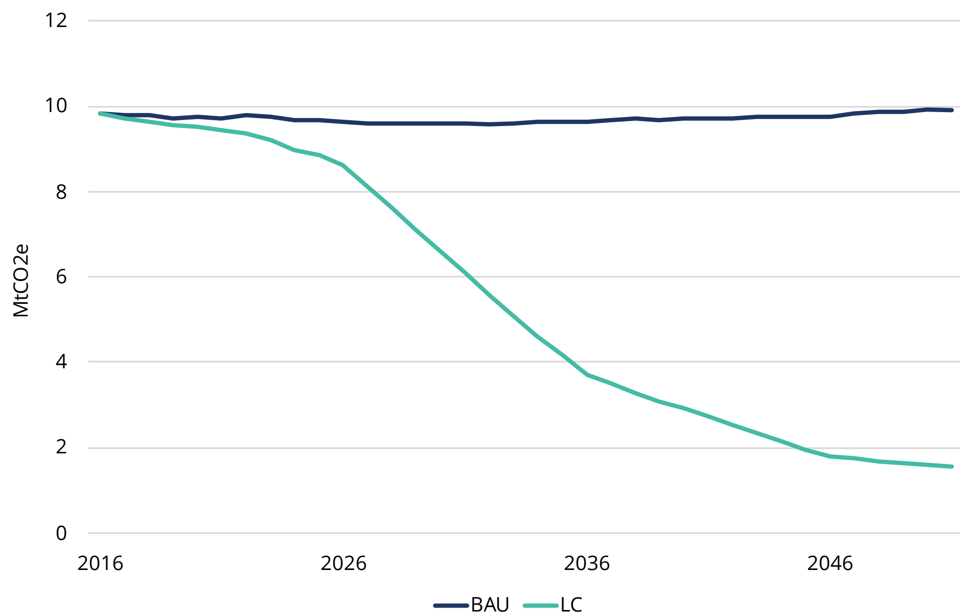


Figure 1. Total GHG emissions (MtCO2e) for the Bay Area (Burlington and Hamilton).

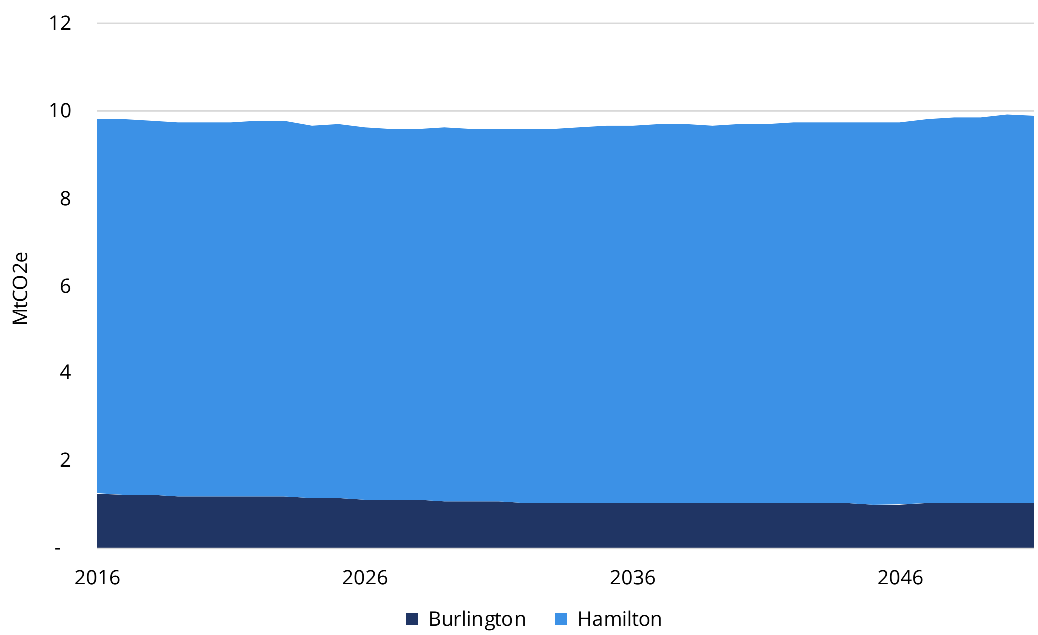


Figure 2. Total GHG emissions (MtCO2e) for Burlington and Hamilton, BAU scenario.

Figure 3 shows energy consumption for both municipalities on a per capita basis with the steel sector removed for the City of Hamilton. As a result the difference between the two municipalities on an energy basis is relatively small, a 100-120 GJ/capita. This difference narrows further in the low-carbon scenario, declining to 40 GJ/capita by 2050.

The GHG impacts of the low-carbon scenario are illustrated in Figure 4. GHG emissions from Burlington decline to 130 ktCO2e, whereas GHG emissions in Hamilton fall to 1.5 MtCO2e, with much of the remaining GHG emissions being associated with the steel industry.

In terms of deep emissions reductions, the key opportunities are efficiency gains wherever possible followed by fuel switching away from natural gas to electricity and from gasoline to electricity and further decarbonisation of electricity.

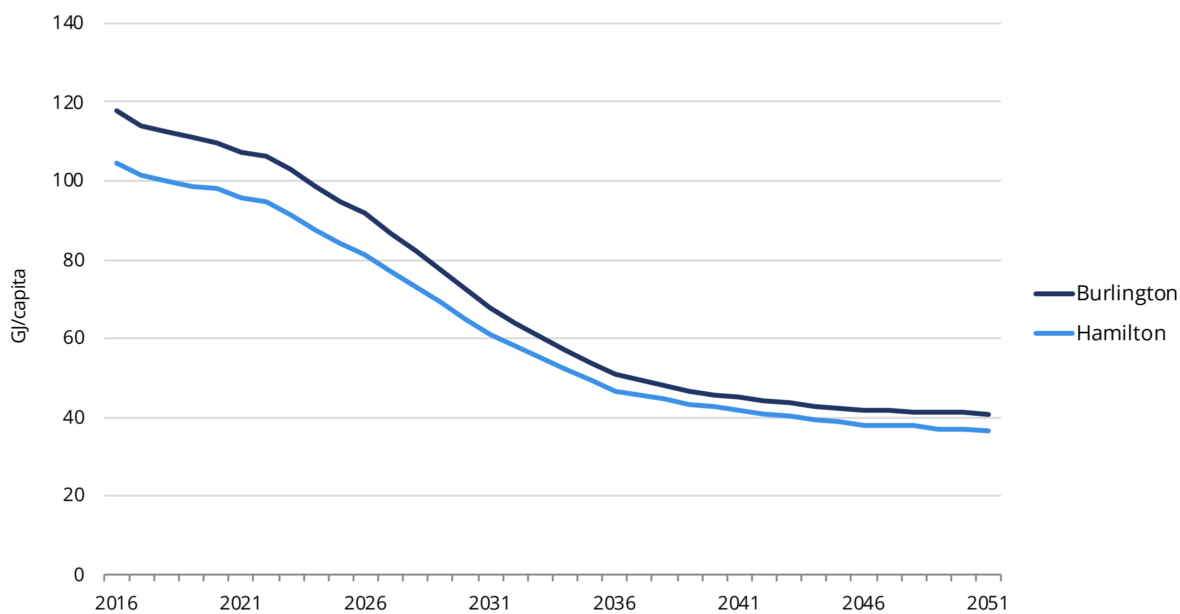


Figure 3. Per capita energy consumption by city, excluding industrial energy for the LC scenario.

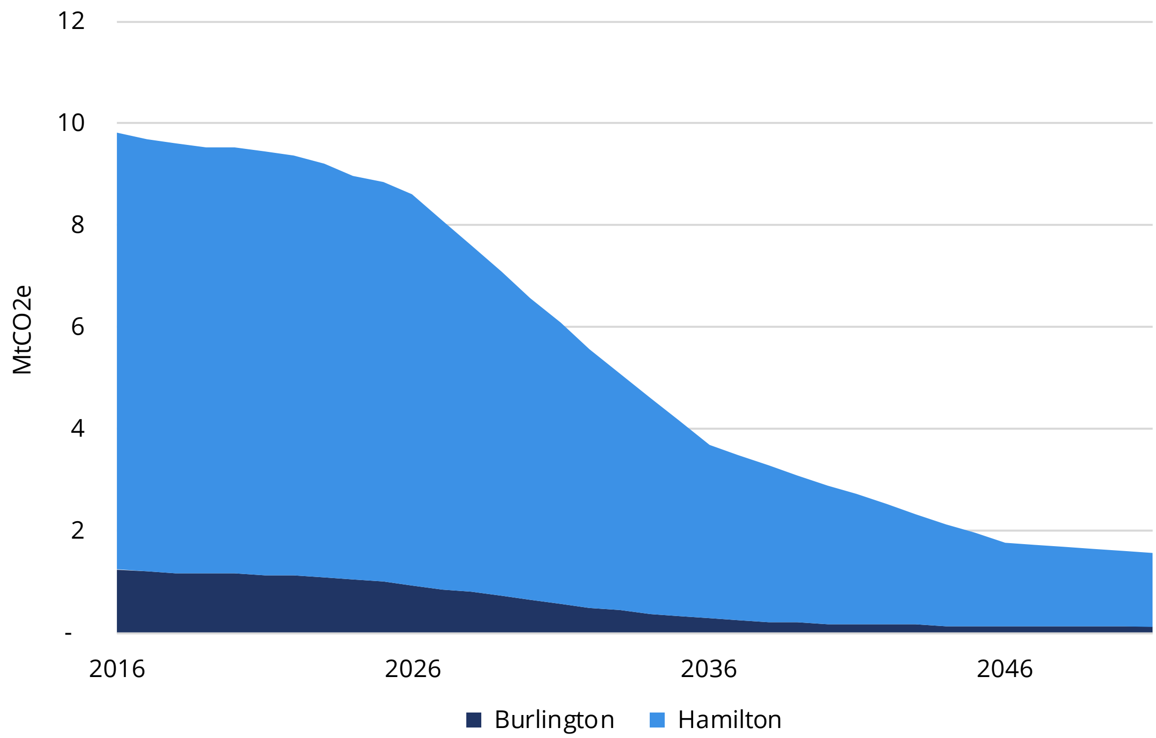


Figure 4. Total GHG emissions (MtCO2e) for Burlington and Hamilton, LC scenario.

Total energy expenditures for the Bay Area in 2016 were $2.2 billion; in the BAU scenario, this climbs to $2.8 billion by 2050 versus $1.8 billion in the low-carbon scenario (Figure 5). The annual financial savings can be used to finance the transition. Over the period, the avoided energy expenditures resulting from the low-carbon scenario totals $20 billion. An additional $9 billion is saved from reduced expenditures on the carbon tax in the LC scenario relative to the BAU scenario between 2019 and 2050, because the reduced GHG emissions result in lower carbon taxes.

The implementation of the LC scenario requires a scaling up of action and ambition; this analysis indicates that this pathway is physically possible and will result in considerable energy savings. Regional coordination over the Bay Area can result in avoided duplication of programs that will deliver these savings. For example, requirements for enhanced building energy performance for new construction reduce the need for future retrofits and can be jointly developed between the two cities. A similar story applies to a local improvement charge (LIC) program to support energy retrofits. A vehicle to stimulate local generation of renewable energy, a cooperative can also be jointly coordinated, as a can a program which purchases and supports the deployment of electric vehicles.

Targets for GHG emissions have been identified by decade out until 2050 for each of the cities and the Bay Area as a whole. GHG emissions targets by sectors can also be specified in order to align with the low-carbon scenario. In addition to the decadal targets, a carbon budget is also specified; a carbon budget represents the cumulative GHG emissions associated with the low-carbon pathway over the period from 2018 to 2050. The carbon budget, like a financial budget, is an envelope of GHG emissions from which the city subtracts its annual GHG emissions to identify whether or not the overall trajectory is on track. Additionally, a carbon budget allows the City or Bay Area to align with the global carbon budget, which seeks to limit warming to either 1.5° or 2°.

The 2050 GHG target for the Bay Area is 1.6 MtCO2e, a significant drop over the 2016 total of 9.8 MtCO2e. The cumulative total, or carbon budget, between 2018 and 2050 is 176 MtCO2e.

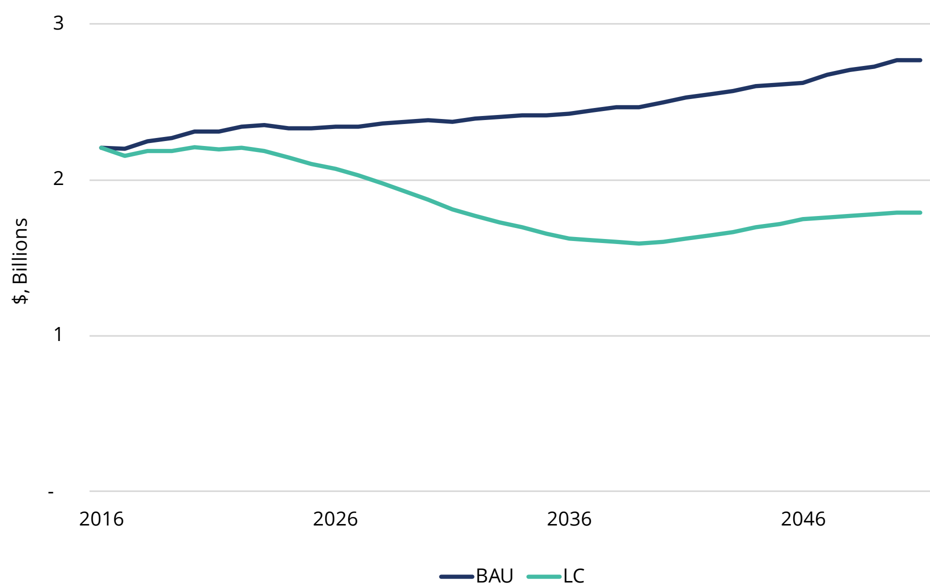


Figure 5. Total energy expenditures, Bay Area

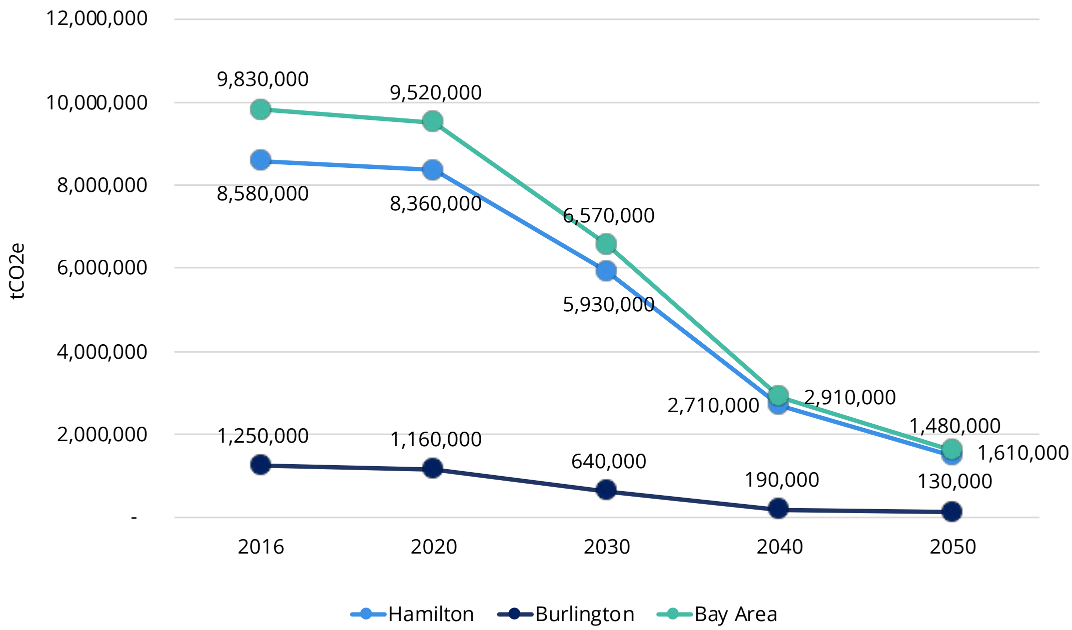


Figure 6. GHG emissions targets, Bay Area and municipalities

INTRODUCTION

Mohawk College, located in Hamilton, Ontario, has partnered with the City of Hamilton and the City of Burlington to host a Centre for Climate Change Management (CCCM). The CCCM is a regional response to climate change that supports sustainability and the implementation of Burlington's Community Energy Plan and Hamilton's Climate Change Action Plan.

To facilitate understanding of the energy and GHG profiles of the two cities, each has been analyzed separately in order to assess the differences in their industry, policies and populations.

The GHG emissions baseline was developed using a systems dynamics model called CityInSight, which evaluates energy, and GHG emissions. This model was used to develop a baseline and Business-as-Usual and Low-Carbon scenarios for each municipality.

The emissions baseline applies the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories accounting framework (GPC Protocol). The GPC uses the municipal boundary as the inventory boundary. Appendices 1 & 2 provide summaries on the scope of reporting on GHG emissions according to the requirements of the GPC.

The Business-as-Usual (BAU) scenario illustrates the impact of continuing current practices on energy consumption and GHG emissions out until 2050. The Low-Carbon (LC) scenario shows the impacts on energy use and GHG emissions from low-carbon actions in buildings, transportation and waste sectors for each municipality.

In this comparison, the demographic projections are held constant in the LC and the BAU scenarios. Because these projections of population growth, and the resulting changes to employment and households are consistent, the influence of the low-carbon actions is highlighted.

The two municipalities have distinct objectives related to energy and GHG emissions. The goal for the City of Hamilton is for GHG emissions to be 80% below 1990 levels by 2050. The City of Burlington's Community Energy Plan has five stated goals:

1. 5% annual community energy reduction from 2014 by 2031.
2. An overall annual reduction of per capita community energy use of 4% or 5.3 GJ/person per annum.
3. Sustainable local generation (including both renewable and district energy): 12.5 MW by 2031.

4. Reduce annual energy consumption by 2.4 GJ/person in new housing construction, resulting in a 34% reduction (per person) when compared to Burlington's existing residential building stock.

5. Achieve a 20% modal split by 2031 for transportation, and reduce annual fuel use by 20.9 GJ/person by 2031.

CITY OF BURLINGTON DEMOGRAPHICS

POPULATION

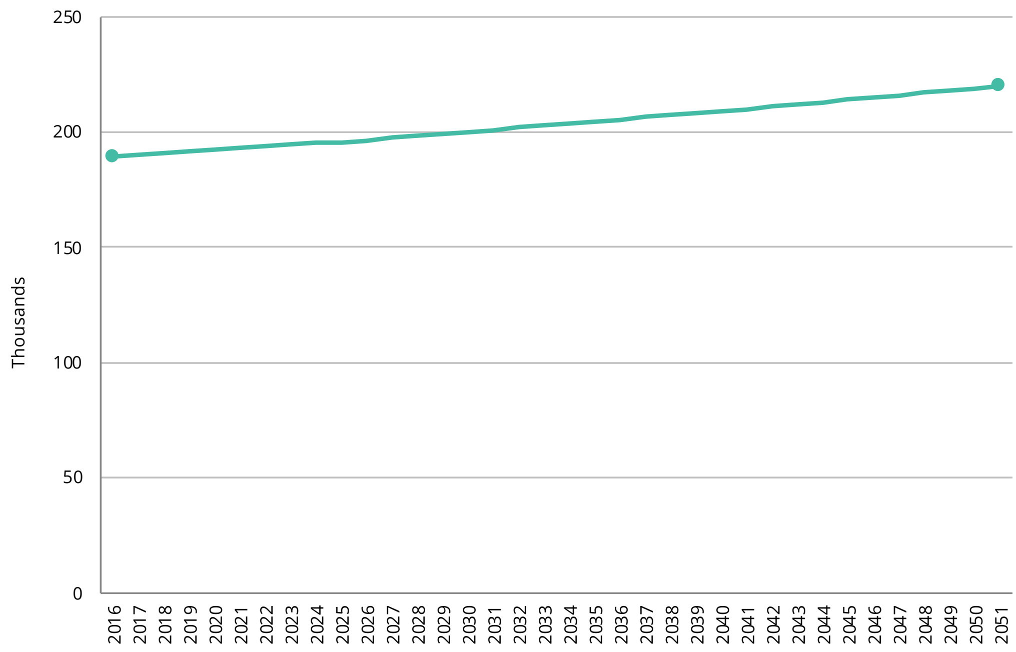


Figure 7. Projected population, Burlington, 2016-2050.

EMPLOYMENT

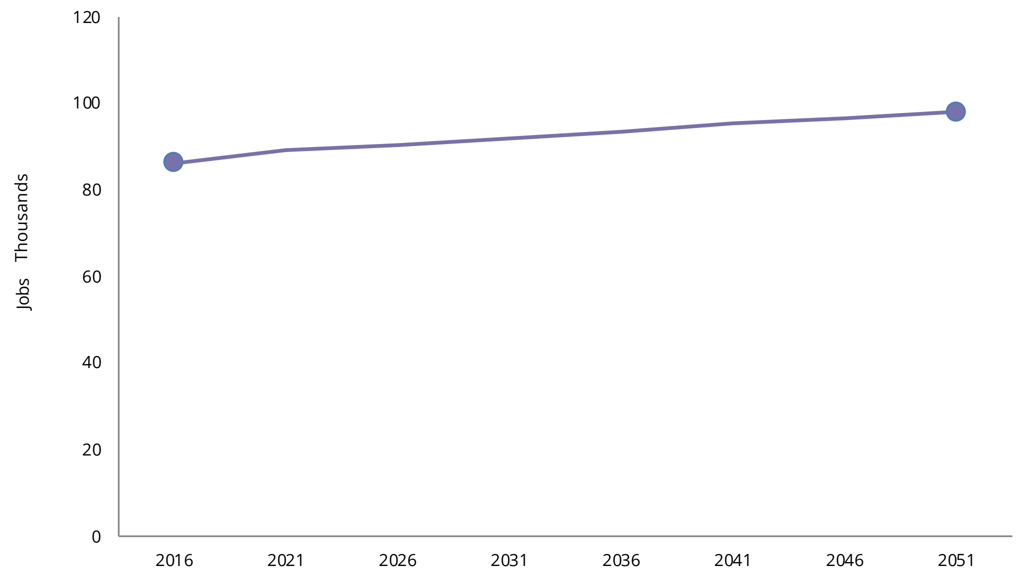


Figure 8. Projected employment, Burlington, 2016-2050.

Demographic information helps to contextualise the baseline of energy use and GHG emissions within a community. Three key pieces of information are the population, rate of employment, and number of households. Data sources, and the assumptions made to project demographic data to 2050 are described in detail on page 38, in the Data, Methods and Assumptions (DMA) manual.

The 2016 census data[1] for population and employment were adjusted for the estimated undercount by age. Growth rates provided by the Regional Municipality of Halton for the City of Burlington[2] were used from 2016 to 2031. The Ontario Growth Plan for the Greater Golden Horseshoe 2017[3] growth rates for the Region of Halton were used between 2031 and 2041, and after 2041, growth rates were held constant until 2050.

The population in 2016 was 189,000 people; this is projected to increase 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.

1 Statistics Canada. 2017. Burlington, CY [Census subdivision], Ontario and Halton, RM [Census division], Ontario (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017

2 Regional Municipality of Halton Best Planning Estimates of Population, Occupied Dwelling Units and Employment, 2011-2031, 2011.

3 Ontario Ministry of Municipal Affairs, 2017. Growth Plan for the Greater Golden Horseshoe (2017).

CITY OF HAMILTON DEMOGRAPHICS

POPULATION

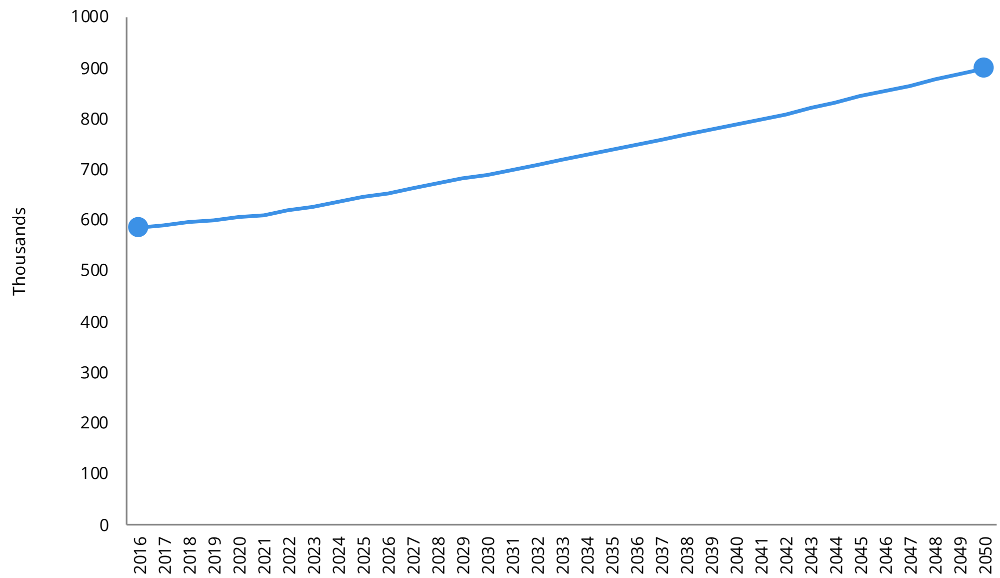


Figure 9. Projected population, Hamilton, 2016-2050.

EMPLOYMENT

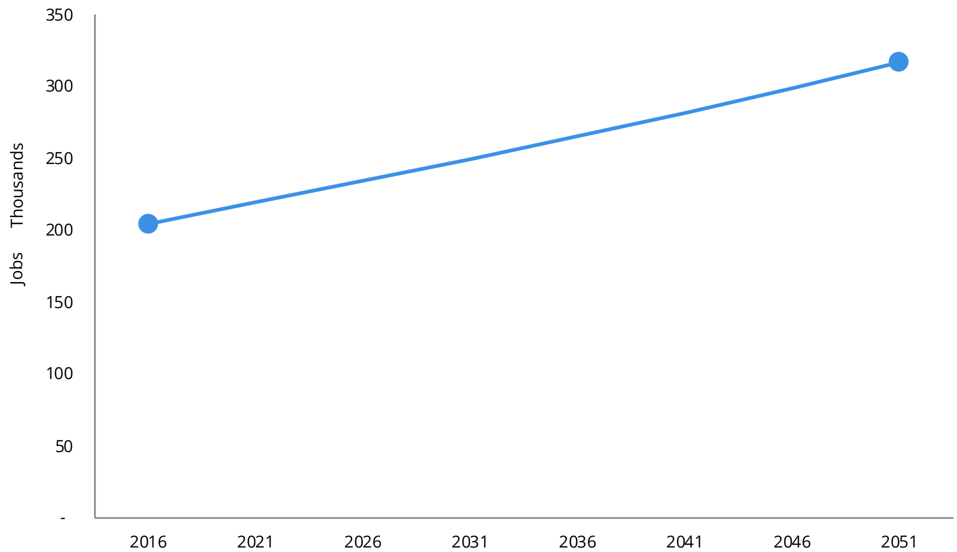


Figure 10. Projected employment, Hamilton, 2016-2050.

A similar approach was used for the City of Hamilton. The 2016 census data[4] for population and employment were adjusted for the estimated undercount, and to reflect the place of work of employees. Population growth rate projections from 2016 to 2041 came from the GRIDS2 report[5], and the 2041 growth rate was held constant from 2041 to 2050.

The population in 2016 was 585,617 people, which is projected to increase to 898,800 by 2050, an increase of 53%.

The total number of jobs in 2016 was 204,360, which is projected to grow to 316,750 by 2050.

4 Statistics Canada. 2017. Hamilton, C [Census subdivision], Ontario and Hamilton, CDR [Census division], Ontario (table). Census Profile. 2016 Census. Statistics Canada Catalogue no. 98-316-X2016001. Ottawa. Released November 29, 2017.

5 City of Hamilton, 2006. GRIDS2 Growth Summary 2006-2016.

PART 1: BUILDING A LOW-CARBON SCENARIO

The low-carbon (LC) scenario is a projection over the time period from 2017 to 2050. It is designed to illustrate the anticipated energy use and greenhouse gas emissions for the Cities of Hamilton and Burlington if the Cities implement the actions to address energy and emissions described in Tables 1 and 2 between 2017-2050.

Note that a scenario, as it is applied in this context, is an internally consistent view of what the future might turn out to be—not a forecast, but one possible future outcome. Similar to the BAU scenario, the LC scenario projection is one of many possible views of the future; in this case, one that assumes that several policies, actions or strategies to address energy and emissions are implemented between 2017-2050.

Low-carbon scenarios were developed for both municipalities using a common approach. A scenario is not a forecast, but rather is one possible future outcome. Scenarios are coherent in describing the relationships between different variables and reflecting an evolution of current physical stocks such as buildings and vehicles. In other words, scenarios as developed in this analysis, cannot reflect a physically impossible trajectory.

LOW-CARBON ACTIONS

A low-carbon future for both Hamilton and Burlington requires changes across all aspects of the community, including new and existing buildings, transportation, industry, and waste management. In order to model these changes, a catalogue of actions was developed, based on research of best practices of municipal actions.

This catalogue was reviewed with city staff and additional refinement and analysis was undertaken to develop a list of actions relevant for each of the cities. This process was informed by the results of the BAU analysis, which provided insight on the major drivers of GHG emissions in both cities, and therefore helped to identify areas with potential for GHG emissions reductions.

In total, 21 actions were identified for Burlington, and 23 were identified for Hamilton. These are described in Tables 1 and 2, respectively. Modelling assumptions and parameters were developed for each action. These assumptions were derived from a detailed review of academic literature, and the application or modelling of the action in other similar cities. The assumptions underlying the actions are explained in more detail in Tables 1 and 2, which also show the assumptions in the BAU scenario for the two cities for comparison.

Each action was modeled using CityInSight in two steps: assumptions for each of the actions were modelled to quantify the emissions reduction impact against the BAU scenario; and then an integrated scenario was developed, whereby all the actions are modelled together to capture feedback between and among the actions.

The feedback between the actions can significantly influence the emissions reductions associated with an action. For example, when modelled against the BAU scenario, a shift to increased walking mode share represents reduced gasoline if a vehicle trip is avoided. However, In the integrated scenario, the introduction of electric vehicles means that the elimination of a vehicle trip results in reduced electricity consumption, which represents significantly less GHG emissions reductions.

Because of the feedback between the actions, the sequence in which the actions are implemented in the model influences the outcome associated with a particular action. In general, actions that reduce consumption and maximise efficiency are prioritized and deployed prior to actions related to fuel switching and local energy generation. Examples include prioritising mode share shifts to walking and cycling prior to electrification of the vehicle fleet, or prioritizing retrofits and improved building codes to buildings before switching to renewables. Figure 11 illustrates a schematic of the sequencing of actions, grouped into two general categories, as they were implemented in the model.

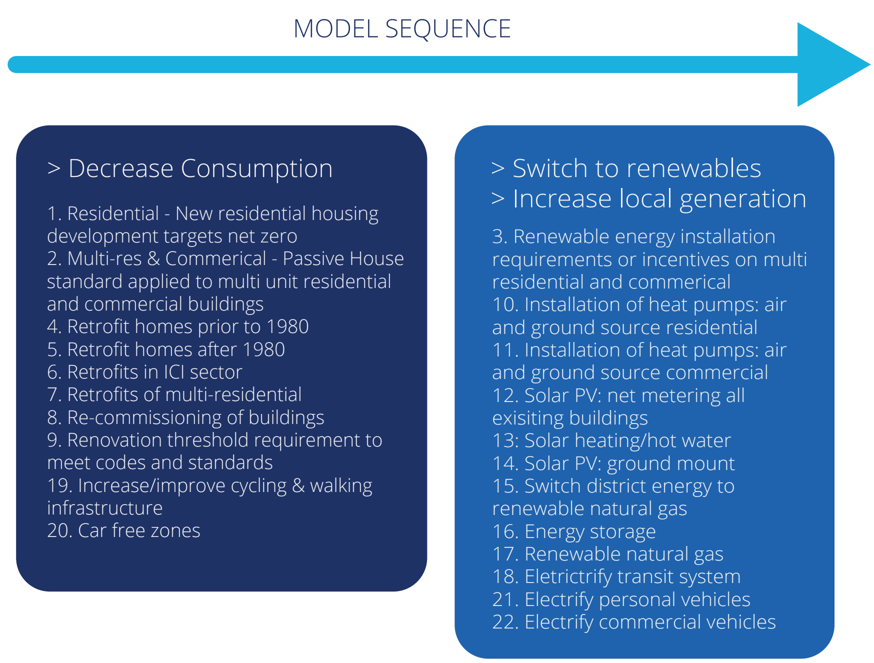


Figure 11. Sequencing schematic of actions in modelling.

Several underlying assumptions were unchanged (from the BAU) in the low-carbon scenario; these include the population and employment projections, building growth projections, climate projections (heating and cooling degree days), the provincial grid emissions factors, and vehicle fuel efficiency standards.

These assumptions are held constant in the LC scenario for one of two reasons:

1. They are underlying drivers that are not associated with the implementation of a low-carbon action are required to be held constant in order to provide a consistent comparison between the LC scenario and the BAU;
2. They are drivers of energy and emissions that the Cities have very little influence over, and as such, do not have the ability to implement action to address these areas.

Table 1. BAU and Low-Carbon actions and assumptions for the City of Burlington.

CITY OF BURLINGTON	BAU ASSUMPTION	LOW-CARBON 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.
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	LOW-CARBON 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	2 MW of district energy capacity added to the commercial and institutional buildings in the downtown core.
Energy storage	No storage deployed.	250 MWh by 2050.
Renewable natural gas	No additional production.	Local production is maximised and additional renewable natural gas is imported to displace natural gas consumption in buildings.
TRANSPORTATION		
Expanded transit	Transit mode share remains constant.	Transit mode share increases to 5% of internal trips.
Active modes	Walking and cycling mode share remains constant.	Active mode share increases to 10% of internal trips.
Electrify transit system	No additional electrification.	100% transit system is electric by 2030.
Electrify municipal fleet	No additional electrification.	100% of the fleet is electric by 2030.
Electrify personal vehicles	~5% of personal use vehicles are electric by 2035; 10% by 2050.	100% of new personal use 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.

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

CITY OF HAMILTON	BAU ASSUMPTION	LOW-CARBON 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 OBC levels of performance.	Incrementally increase the number of buildings that achieve Passive House levels of performance to 100% by 2030.
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.
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.
Solar 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 and 10% for multi-unit and commercial buildings.	80% of all buildings by 2050 have solar PV systems that provide on average 30% of consumption for building electrical load for less than 5 storeys and 10% for multi-unit buildings greater than 5 storeys and commercial buildings.

CITY OF HAMILTON	BAU ASSUMPTION	LOW-CARBON ASSUMPTION
Solar PV - ground mount	0.5 MW per year between 2018 and 2050: ~20 ha.	5 MW per year between 2018 and 2050: ~120 ha.
District Energy	N/A	16.3 MW of district energy capacity added to the commercial and institutional buildings in the downtown core.
Energy storage	No storage deployed.	250 MWh by 2050.
Renewable natural gas	No additional production.	Local production is maximised and additional renewable natural gas is imported to displace natural gas consumption in buildings.
TRANSPORTATION		
Expanded transit	Transit mode share remains constant.	Transit mode share increases to 5% of internal trips.
Active modes	Walking and cycling mode share remains constant.	Active mode share increases to 10% of internal trips.
Electrify transit system	No additional electrification.	100% of the transit system is electric by 2030.
Electrify municipal fleet	No additional electrification.	100% of the fleet is electric by 2030.
Electrify personal vehicles	~5% of personal use vehicles are electric by 2035; 10% by 2050.	100% of new personal use 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
INDUSTRY		
Industrial efficiencies	Baseline efficiencies are held fixed.	Increase process motors and electrical efficiency by 50% by 2050
Steel industry production and inputs	Production and inputs are held fixed	Production of steel is maintained at current levels (almost 4 million tons crude steel per year), but two out of three blast furnaces are shut down (one in 2030 and one in 2040) and production is moved from blast furnaces to electric arc furnaces. One blast furnace is still operating in 2051, and the electric arc furnaces are charged with 70% scrap/30% hot metal. Fuels in this case shift away from coal, coke, oil, to more natural gas and electricity.

LOW-CARBON SCENARIO RESULTS

Each action, when modeled sequentially, is responsible for a reduction in GHG emissions, as compared to the BAU scenario.

Figures 12 and 13 illustrate the impacts of the low-carbon actions, relative to the BAU scenarios for Burlington and Hamilton, respectively. The light grey area represents the remaining GHG emissions following the introduction of the actions, and the reduction from each action is represented by a different colour.

GHG emissions in Burlington in 2050 are 87% below the BAU 2050 levels, and 90% below 2016 baseline levels. In the low-carbon scenario, GHG emissions in Hamilton are 83% below 2050 levels in the BAU scenario, and 83% below 2016 baseline levels.

The source of the GHG reductions is described in more detail in subsequent sections of the report.

TOTAL EMISSIONS REDUCTIONS- BURLINGTON

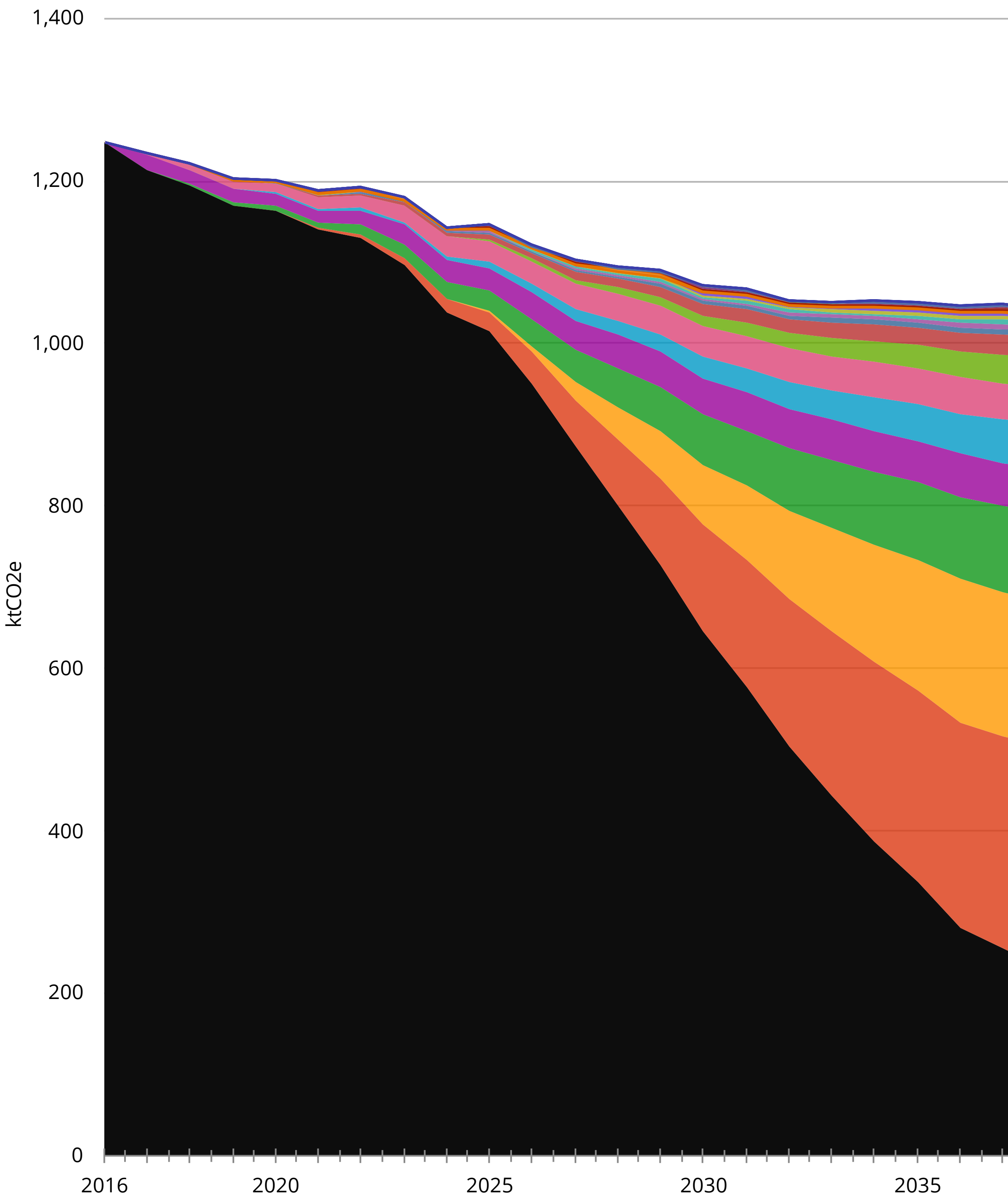
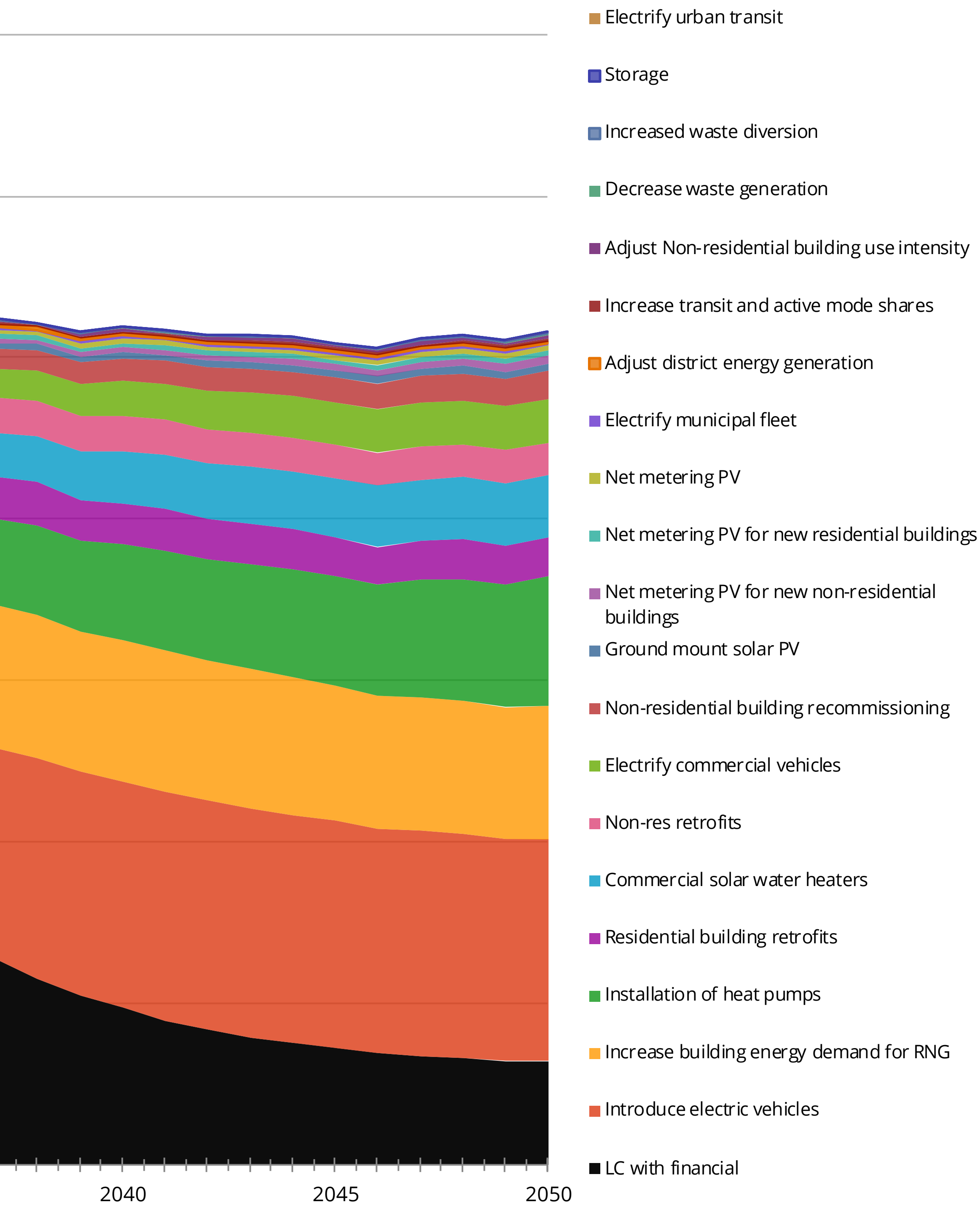


Figure 12. Emission reductions by action from 2016 baseline—City of Burlington


2040
2045
2050
Electrify urban transit
Storage
Increased waste diversion
Decrease waste generation
Adjust Non-residential building use intensity
Increase transit and active mode shares
Adjust district energy generation
Electrify municipal fleet
Net metering PV
Net metering PV for new residential buildings
Net metering PV for new non-residential buildings
Ground mount solar PV
Non-residential building recommissioning
Electrify commercial vehicles
Non-res retrofits
Commercial solar water heaters
Residential building retrofits
Installation of heat pumps
Increase building energy demand for RNG
Introduce electric vehicles
LC with financial

TOTAL EMISSIONS REDUCTIONS- HAMILTON

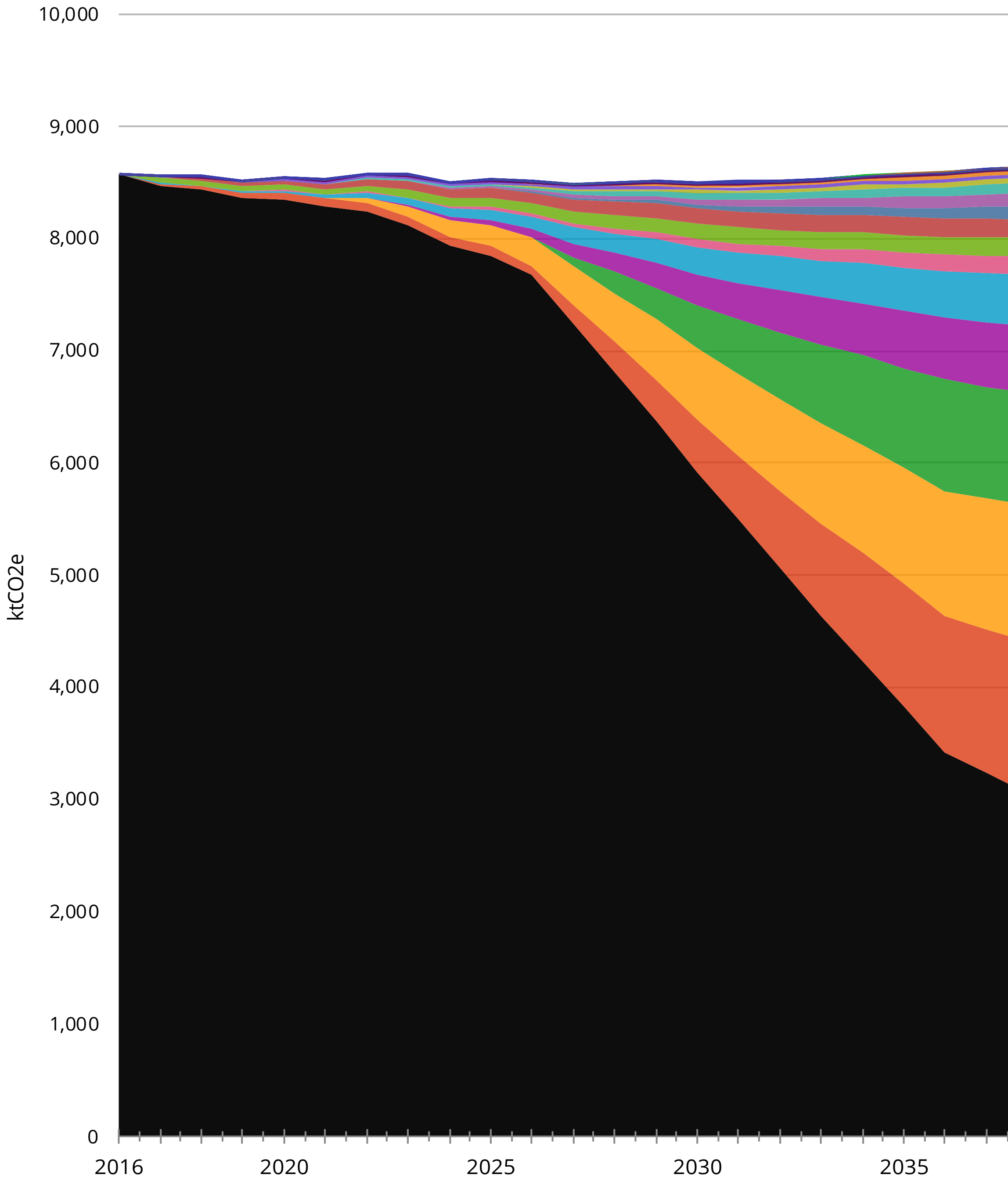
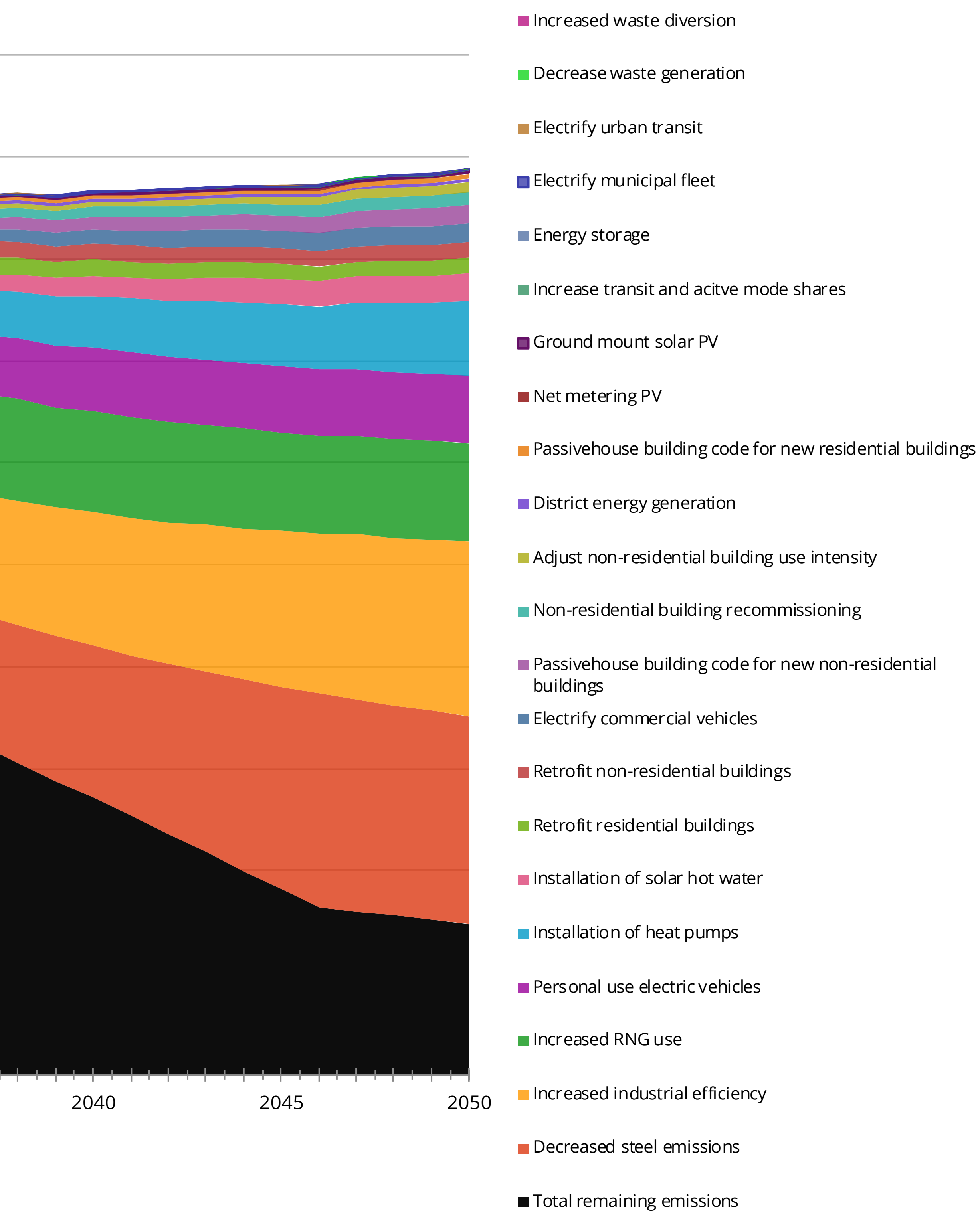


Figure 13. Emission reductions by action from 2016 baseline—Hamilton.


2040
2045
2050
Increased waste diversion
Decrease waste generation
Electrify urban transit
Electrify municipal fleet
Energy storage
Increase transit and acitve mode shares
Ground mount solar PV
Net metering PV
Passivehouse building code for new residential buildings
District energy generation
Adjust non-residential building use intensity
Non-residential building recommissioning
Passivehouse building code for new non-residential buildings
Electrify commercial vehicles
Retrofit non-residential buildings
Retrofit residential buildings
Installation of solar hot water
Installation of heat pumps
Personal use electric vehicles
Increased RNG use
Increased industrial efficiency
Decreased steel emissions
Total remaining emissions

PART 2: CITY OF BURLINGTON LOW-CARBON RESULTS

COMMUNITY ENERGY

ENERGY BY SECTOR

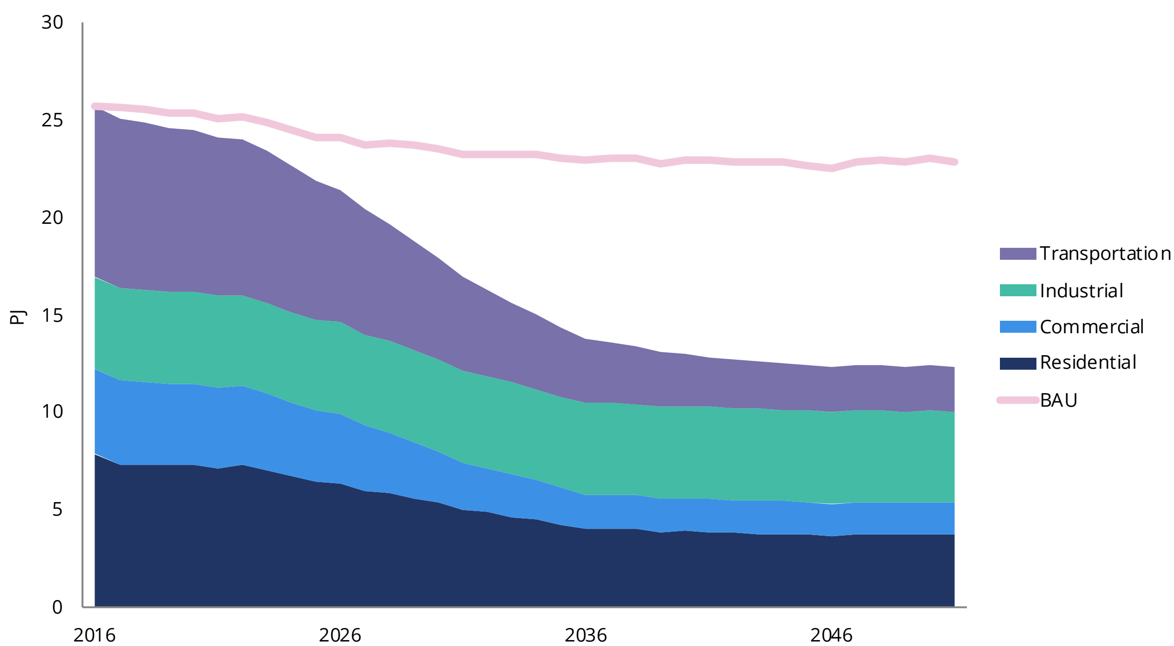


Figure 14. Projected LC energy consumption (PJ) by sector, Burlington, 2016-2050.

ENERGY BY FUEL

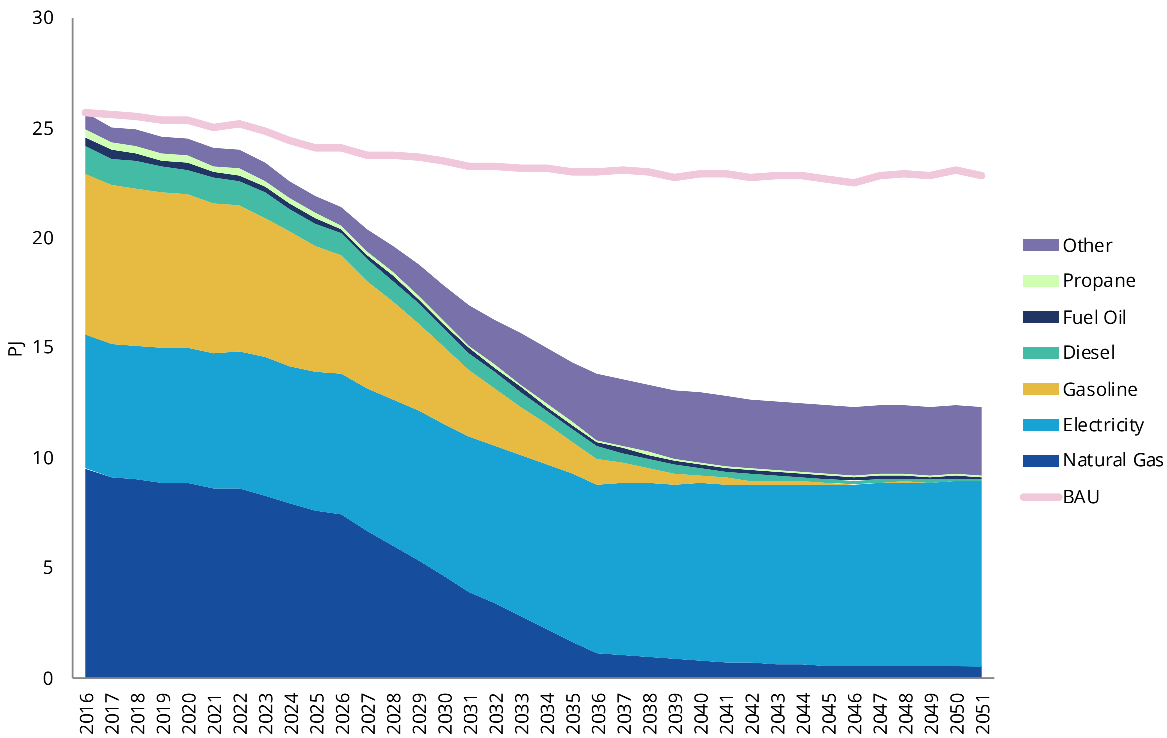


Figure 15. Projected LC energy consumption (PJ) by fuel, 2016-2050.

The largest reduction in energy use comes from the transportation sector (62% decrease over the BAU in 2050), followed by the residential sector (52% decrease over the BAU in 2050).

Improvements to vehicle efficiency standards drive some of the decrease in transportation energy use, as was seen in the BAU, but the majority of the energy savings are from the electrification of the personal and commercial vehicles and a reduction in vehicle use (transit and active transportation use increasing).

Building retrofits, improvements in the efficiency of new buildings, increased use of heat pumps and solar hot water, and electrification all contribute to the reduction in residential energy use.

Energy use in 2016 is 37% natural gas, 29% gasoline, and 24% electricity. In the LC scenario, gasoline is almost entirely removed as a fuel source, and electricity and renewable natural gas (the “other” category) account for 68% and 25%, respectively, of the energy consumption. Natural gas consumption decreases by 94% in the LC scenario.

PER CAPITA ENERGY

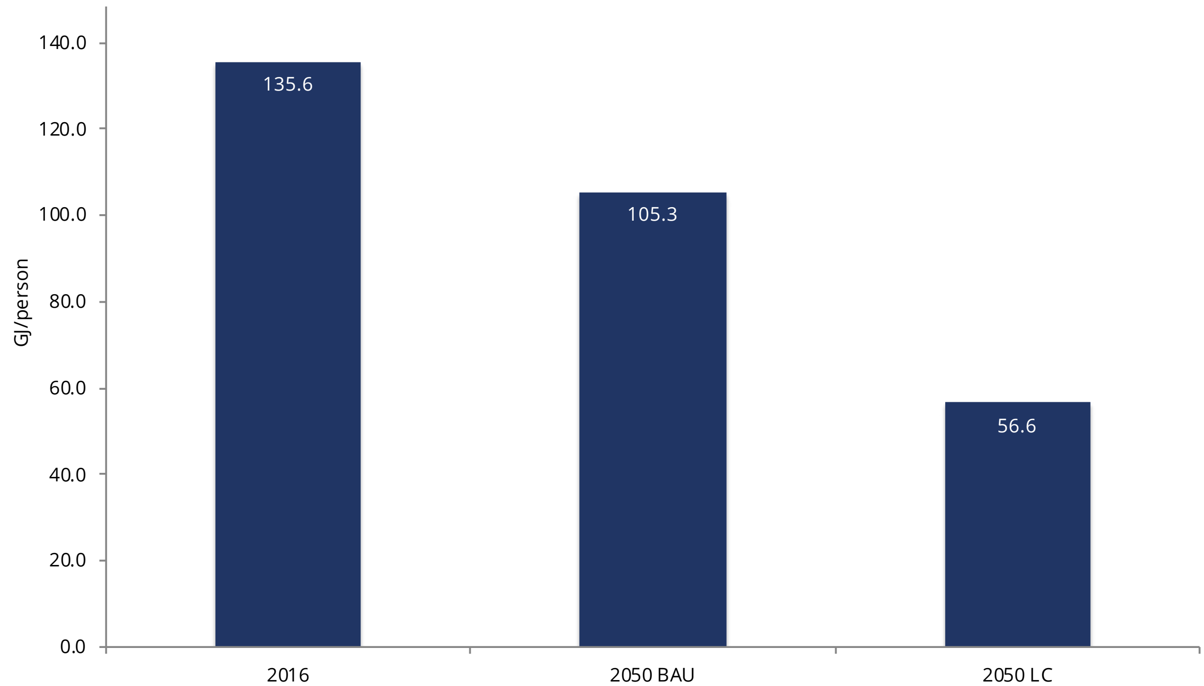


Figure 16. Projected energy per capita energy use (GJ/person), 2016, 2050 BAU and 2050 LC, Burlington.

Overall, the LC scenario results in a total energy use decrease from 26 PJ in 2016, to 12 PJ in 2050. This is a 52% reduction from the 2016 baseline, and a 46% reduction over the BAU in 2050.

Per capita energy use decreases by 58% from the baseline, and 46% over the BAU in 2050. Table 3 shows full details of the reduction in energy use by sector and by fuel type.

Table 3. Energy consumption- Burlington.

ENERGY BY SECTOR (GJ)	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050 LC**
Transportation	8,774,475	34.1%	6,012,086	26.1%	2,285,335	18.4%	-74.0%	-62.0%
Residential	7,841,338	30.5%	7,837,371	34.0%	3,761,312	30.3%	-52.0%	-52.0%
Industrial	4,703,504	18.3%	4,703,504	20.4%	4,703,503	37.9%	0.0%	0.0%
Commercial	4,376,880	17.0%	4,514,377	19.6%	1,655,005	13.3%	-62.2%	-63.3%
Total	**5,696,197**		**23,067,338**		**12,405,155**		**-51.7%**	**-46.2%**
ENERGY BY FUEL (GJ)	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050 LC**
Natural Gas	9,512,172	37.0%	9,096,332	39.4%	531,290	4.3%	-94.4%	-94.2%
Gasoline	7,314,276	28.5%	4,839,761	21.0%	2,389	0.0%	-100.0%	-100.0%
Electricity	6,128,322	23.8%	7,033,714	30.5%	8,430,508	68.0%	37.6%	19.9%
Diesel	1,229,201	4.8%	816,054	3.5%	112,705	0.9%	-90.8%	-86.2%
Other	763,034	3.0%	802,163	3.5%	3,119,826	25.1%	308.9%	288.9%
Fuel Oil	376,836	1.5%	248,236	1.1%	138,664	1.1%	-63.2%	-44.1%
Propane	372,356	1.4%	231,078	1.0%	69,774	0.6%	-81.3%	-69.8%
Total	**25,696,197**		**23,067,338**		**12,405,155**		**-51.7%**	**-46.2%**
ENERGY PER CAPITA (GJ/ CAP)	**135.6**		**105.3**		**56.6**		**-58.3 %**	**-46.2%**

ENERGY FLOW AND CONVERSIONS

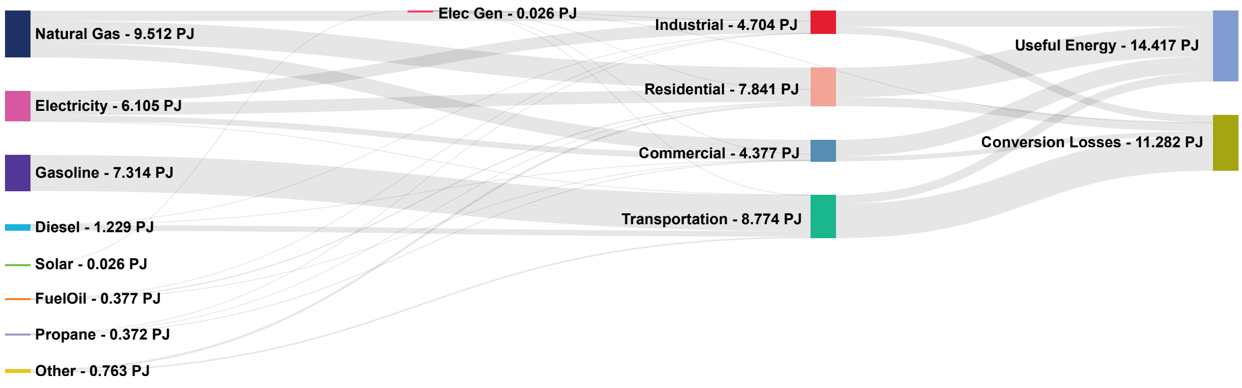


Figure 17. 2016 Energy Flow—Burlington.

The Sankey diagrams for 2016 (Figure 17) and the 2050 LC scenario (Figure 18) show the energy flow by fuel and sector for the City of Burlington. The ratio of useful energy to conversion losses in 2016 is 1.3:1, and in 2050 this climbs to 4.0:1.

Local generation of electricity increases from 0.03 PJ to 2.3 PJ in 2050, and a district energy network is added (thermal network).

The Sankey also shows a significant decline in natural gas between 2016 and 2050 in the low-carbon scenario, while electricity consumption is flat, despite the increase in population and employment.

In terms of sectors, transportation shows the biggest drop from 9 PJ to just over 2 PJ, with smaller declines in commercial and residential buildings.

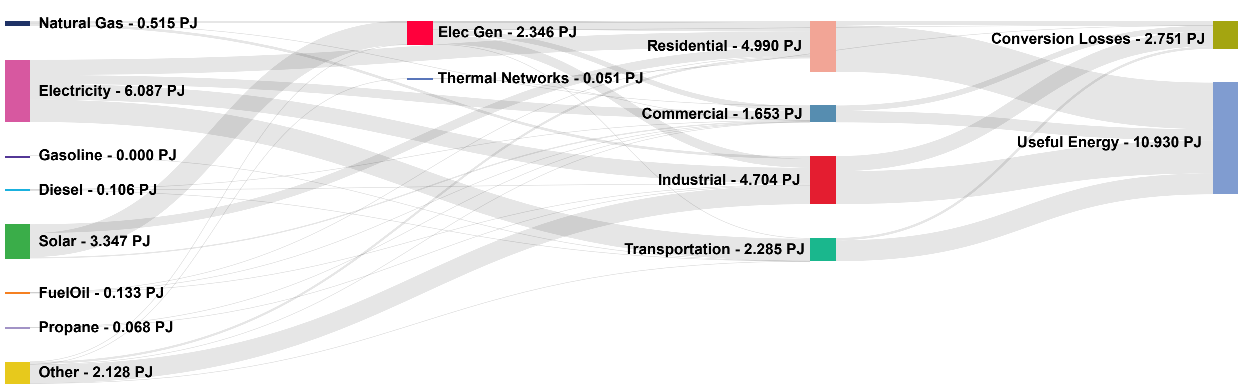


Figure 18. Energy flow, 2050 (LC)— Burlington.

COMMUNITY EMISSIONS

EMISSIONS BY SECTOR

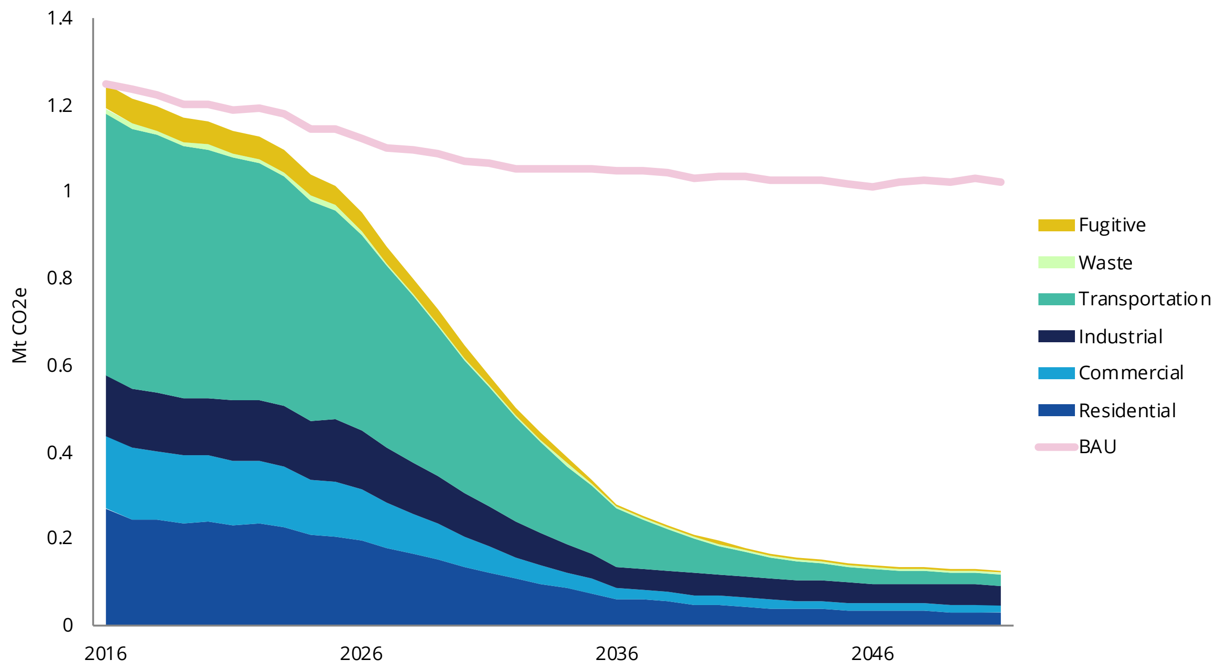


Figure 19. Projected LC emissions (MtCO2e) by sector in Burlington, 2016-2050.

EMISSIONS BY SOURCE

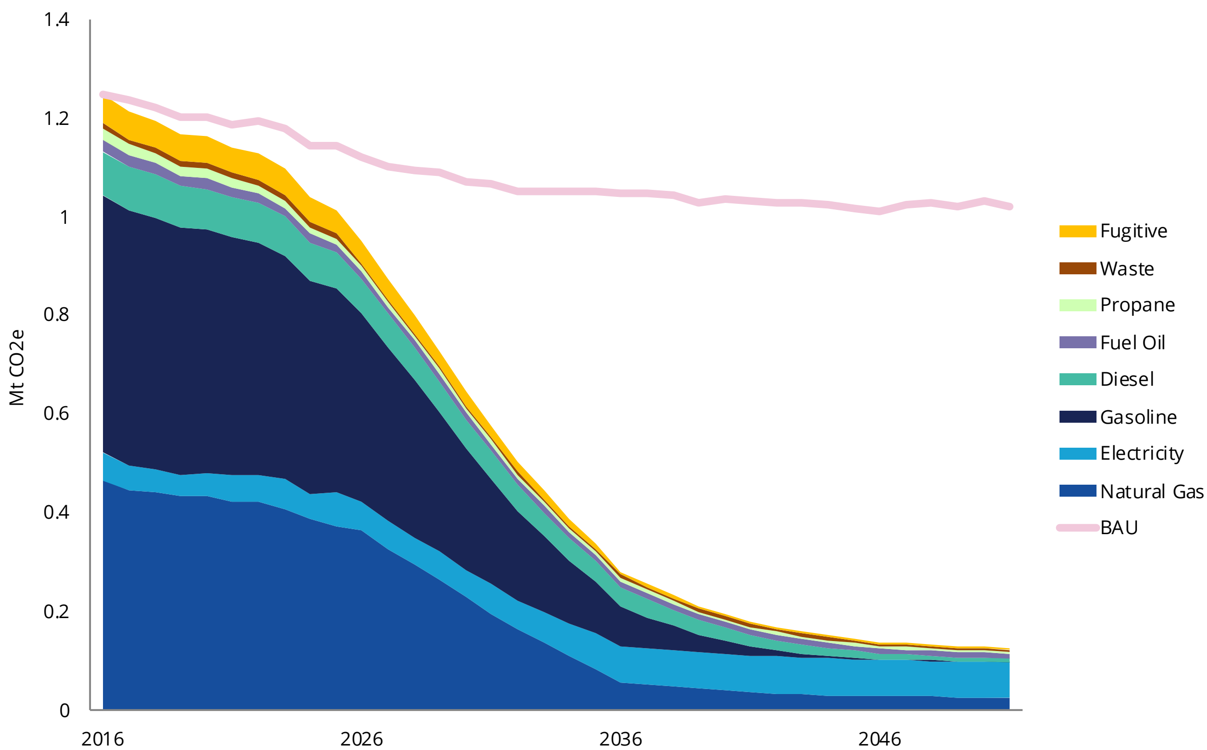


Figure 20. Projected LC emissions (MtCO2e) by source in Burlington, 2016-2050.

Total GHG emissions decline from 1.25 MtCO2e in 2016 to 0.13 MtCO2e in the 2050 LC scenario, representing a decrease of 90%.

All sectors show a reduction in GHG emissions ranging from 55% in waste, to 96% in transportation. Energy efficiency measures combined with the shift to electricity as a fuel source are the primary sources of reductions in GHG emissions.

The LC scenario illustrates a shift from carbon-intensive fuel sources, specifically gasoline (42% of 2016 emissions) and natural gas (37% of 2016 emissions), to low or zero emissions sources. As a result of the shift to electricity, GHG emissions from electricity increase by 31% from 2016 to 2050 in the low-carbon scenario.

PER CAPITA EMISSIONS

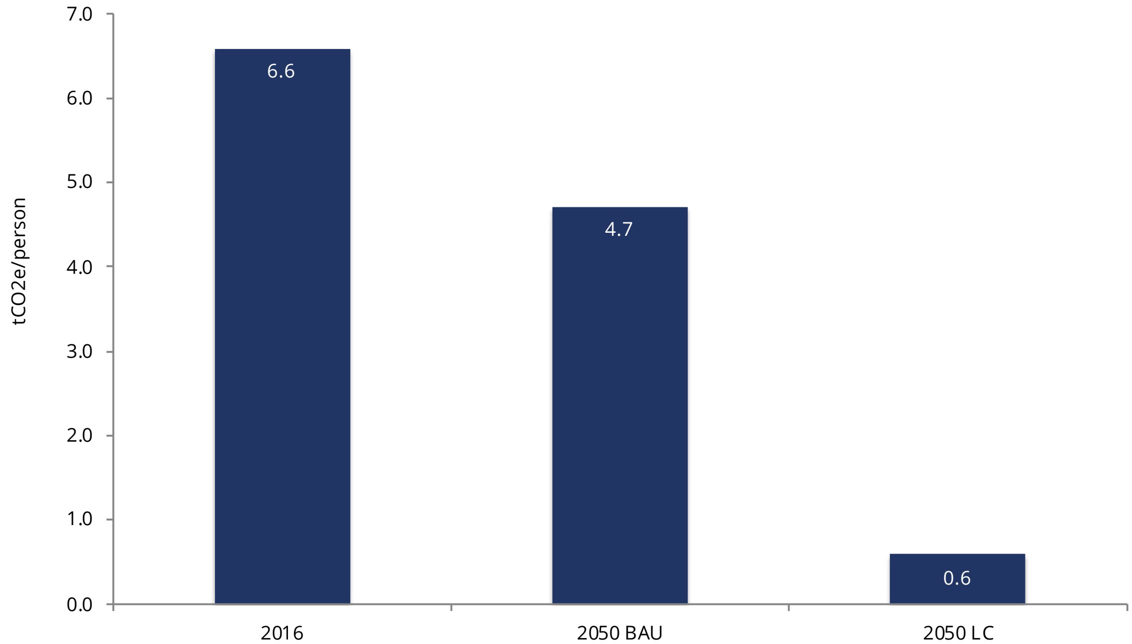


Figure 21. Projected emissions per capita (tCO2e/person), Burlington.

GHG emissions decline from 6.6 tCO2e per person in 2016, to 0.6 tCO2e in 2050 in the LC scenario. This is a 90% decrease from 2016 to the 2050 LC scenario, and an 88% decrease between the BAU and LC scenarios in 2050.

Table 4 provides a comparison of the total GHG emissions for Burlington in 2016, and the two scenarios in 2050.

Table 4. Community GHG emissions - Burlington.

EMISSIONS BY SECTOR (tCO2e)	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/- 2016-2050 LC	% +/- 2050 BAU-2050 LC
Transportation	602,533	48.3%	399,743	38.8%	27,399	21.3%	-95.5%	-93.1%
Residential	269,052	21.6%	245,945	23.8%	32,135	25.0%	-88.1%	-86.9%
Commercial	169,334	13.6%	171,097	16.6%	15,956	12.4%	-90.6%	-90.7%
Industrial	138,659	11.1%	144,344	14.0%	45,311	35.2%	-67.3%	-68.6%
Fugitive	57,835	4.6%	55,307	5.4%	3,230	2.5%	-94.4%	-94.2%
Waste	10,706	0.9%	15,077	1.5%	4,760	3.7%	-55.5%	-68.4%
Total	**1,248,119**		**1,031,513**		**128,791**		**-89.7%**	**-87.5%**
EMISSIONS BY SOURCE (tCO2e)	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050 LC**
Gasoline	521,222	41.8%	345,203	33.5%	149	0.1%	-100.0%	-100.0%
Natural Gas	466,414	37.4%	446,023	43.2%	26,049	20.2%	-94.4%	-94.2%
Diesel	87,877	7.0%	58,402	5.7%	8,224	6.4%	-90.6%	-85.9%
Fugitive	57,835	4.6%	55,307	5.4%	3,230	2.5%	-94.4%	-94.2%
Electricity	55,348	4.4%	80,173	7.8%	72,439	56.2%	30.9%	-9.6%
Fuel Oil	25,942	2.1%	17,195	1.7%	9,673	7.5%	-62.7%	-43.7%
Propane	22,774	1.8%	14,133	1.4%	4,267	3.3%	-81.3%	-69.8%
Waste	10,706	0.9%	15,077	1.5%	4,760	3.7%	-55.5%	-68.4%
Total	**1,248,119**		**1,031,513**		**128,791**		**-89.7%**	**-87.5%**
EMISSIONS PER CAPITA (tCO2e/ PERSON)	**6.6**		**4.7**		**0.6**		**-91.1 %**	**-87.5 %**

BUILDING SECTOR: ENERGY

BUILDING ENERGY USE BY FUEL

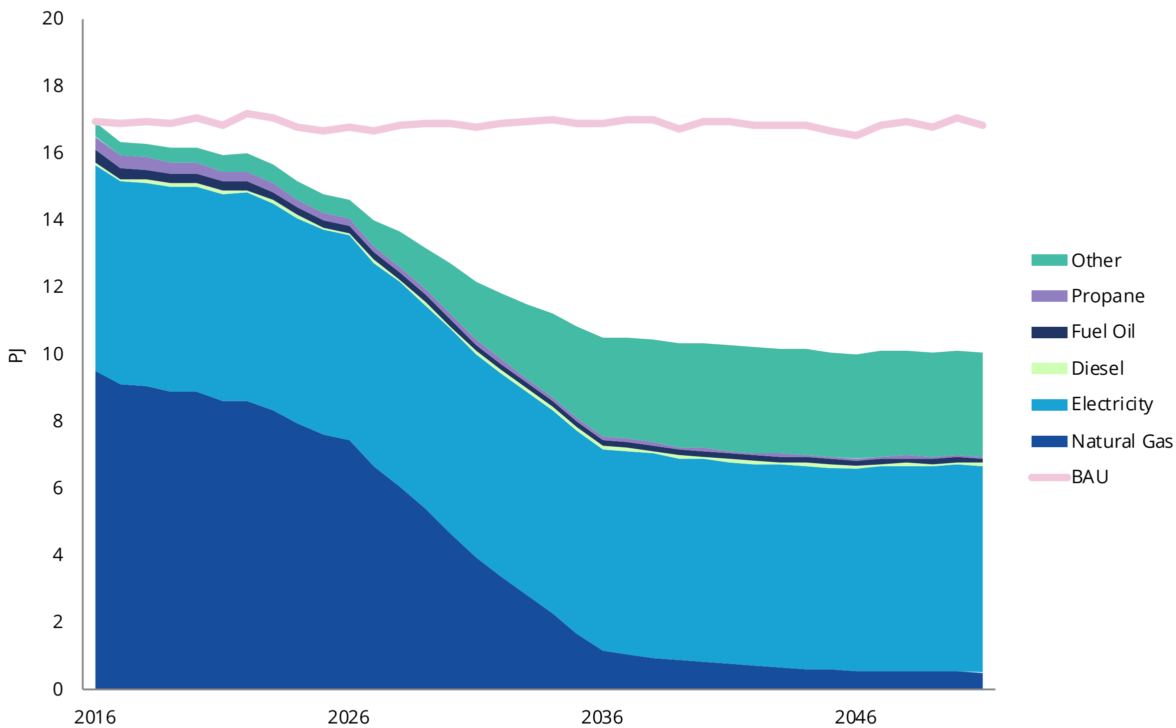


Figure 22. Projected LC building energy use (PJ) by fuel, Burlington, 2016-2050.

BUILDING ENERGY BY END USE

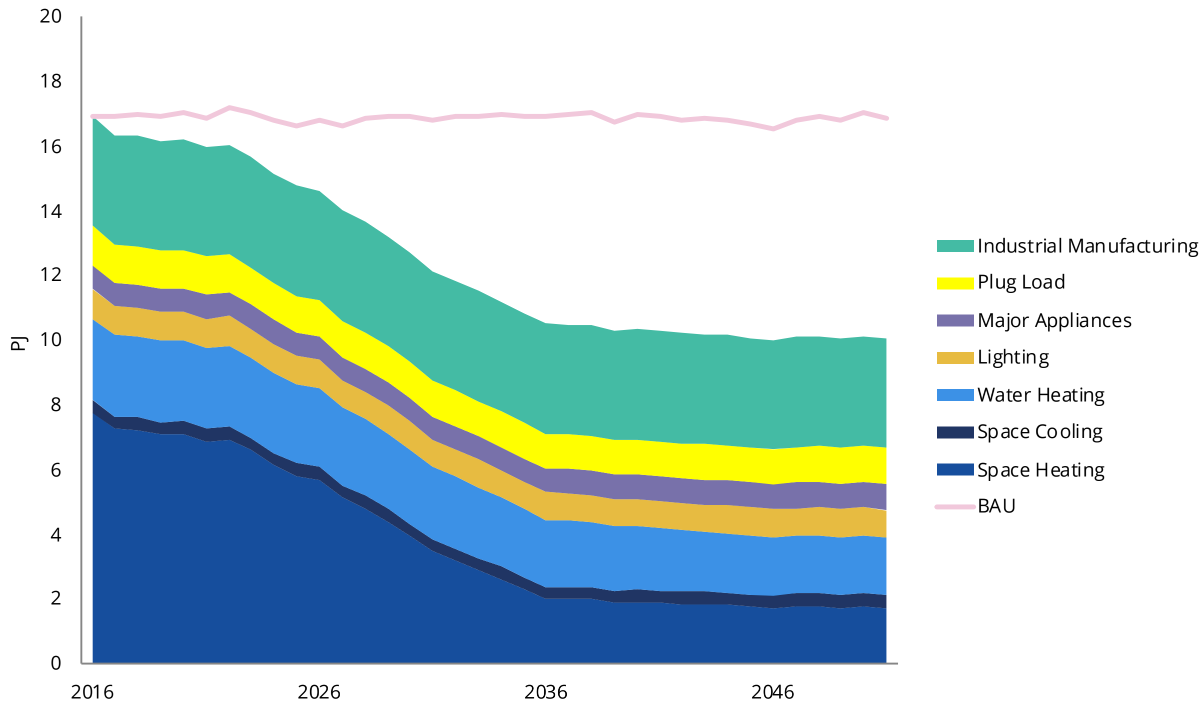


Figure 23. Projected LC building energy use (PJ) by end use, Burlington, 2016-2050.

The buildings sector sees an overall reduction of energy use from 17 PJ in 2016 to 10 PJ in 2050 under the LC scenario. Electricity consumption remains constant over this period despite an increase in population and buildings while natural gas, propane and fuel oil decrease. The “other” category, which includes local energy sources including solar, biogas, and district energy, grows to account for 31% of the energy used by the building sector by 2050. This local generation represents a significant local investment, resulting in employment opportunities.

The overall decrease of 40% in building energy use is a result of retrofits to existing buildings, and improvements to the energy efficiency of new residential buildings. The reduction in energy consumption for space heating accounts for 77% of the energy savings. Fuel switching for space heating results in a shift from natural gas boilers to air source and ground source heat pumps in residential and commercial buildings.

The reduction in heating degree-days is the primary reason energy use isn’t projected to increase in the BAU scenario as the population grows. The same reduction in heating degree-days is applied to the LC scenario, but in this case is combined with fuel switching and retrofits.

BUILDING ENERGY USE BY BUILDING TYPE AND FUEL

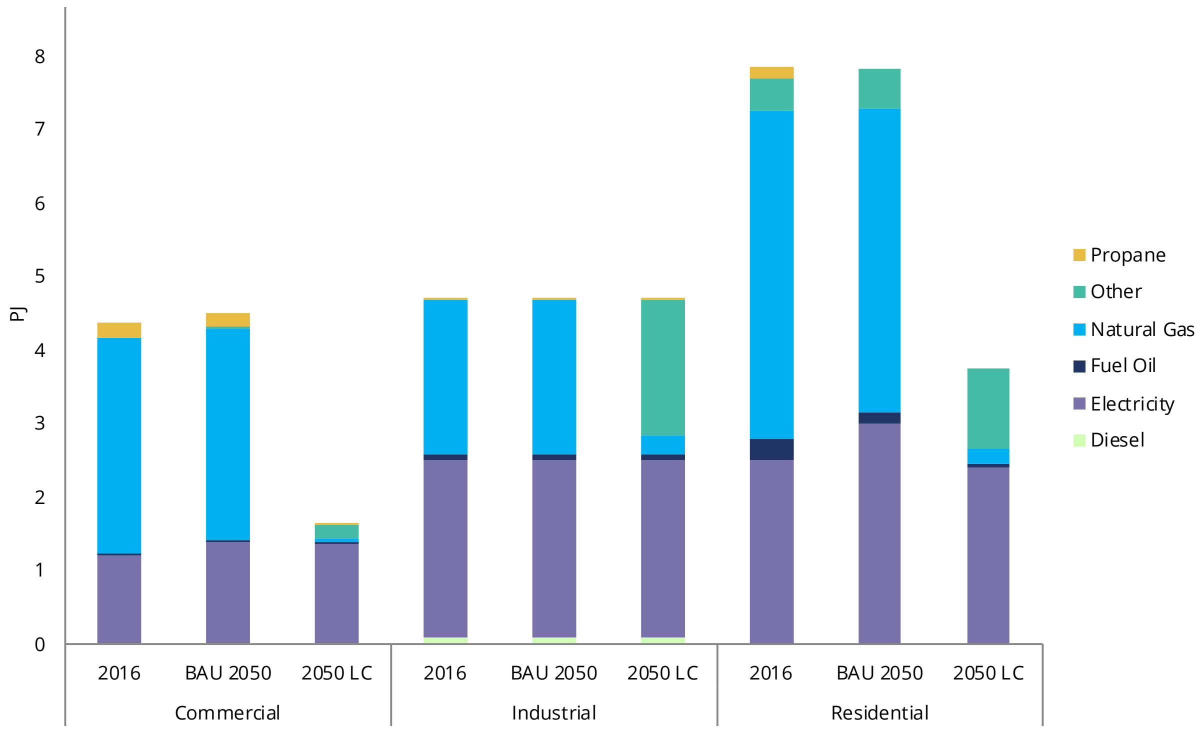


Figure 24. Projected building energy use (PJ) by building type and fuel, Burlington.

BUILDING ENERGY USE BY BUILDING TYPE AND END USE

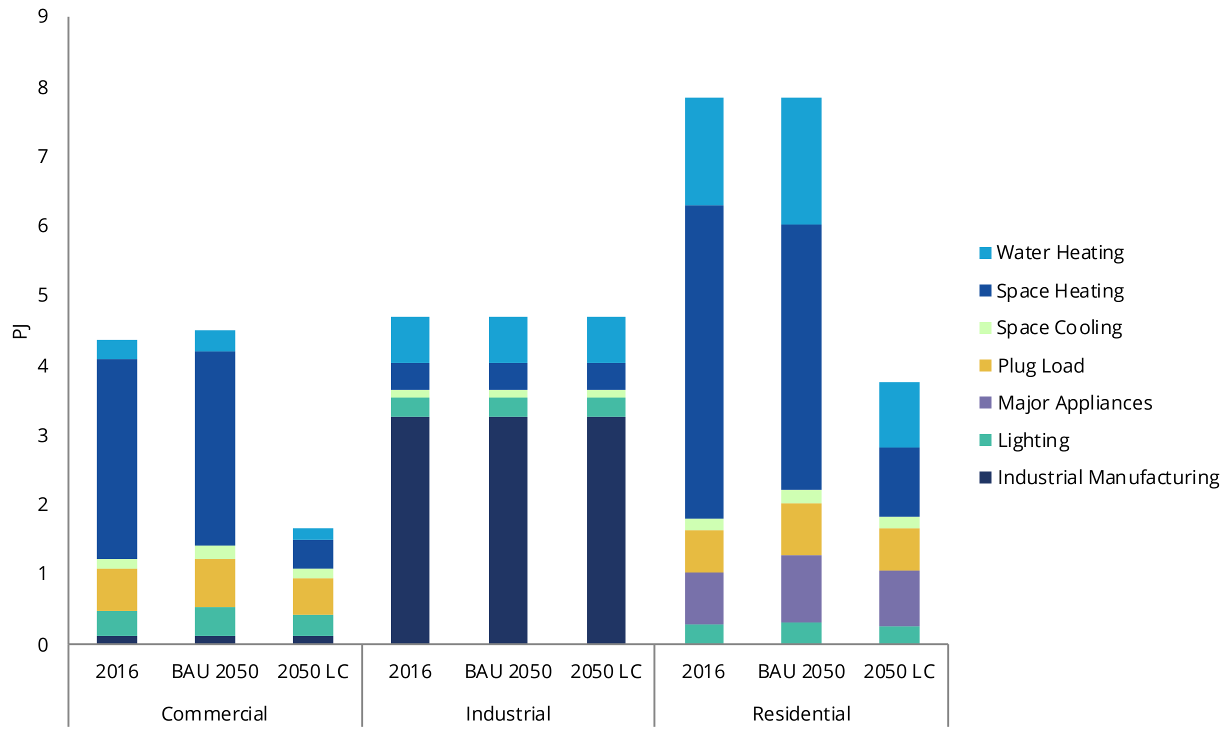


Figure 25. Projected building energy use (PJ) by building type and end use, Burlington.

The increased use of electricity as the primary fuel source applies to all sectors of buildings. The residential and industrial sectors show a shift to "other" fuel sources, which include renewable natural gas and locally-generated electricity.

By 2030, 100% of new buildings are projected to achieve Passive House levels of performance, and existing buildings will be retrofitted to achieve 50% reduction in electrical consumption.

For commercial buildings, the LC scenario projects a reduction in floor space per employee of 25% by 2050, as well as building efficiencies for both new and existing buildings.

Residential buildings account for the majority of building energy use, and are the primary focus for reductions in energy consumption within the buildings sector.

PER HOUSEHOLD ENERGY

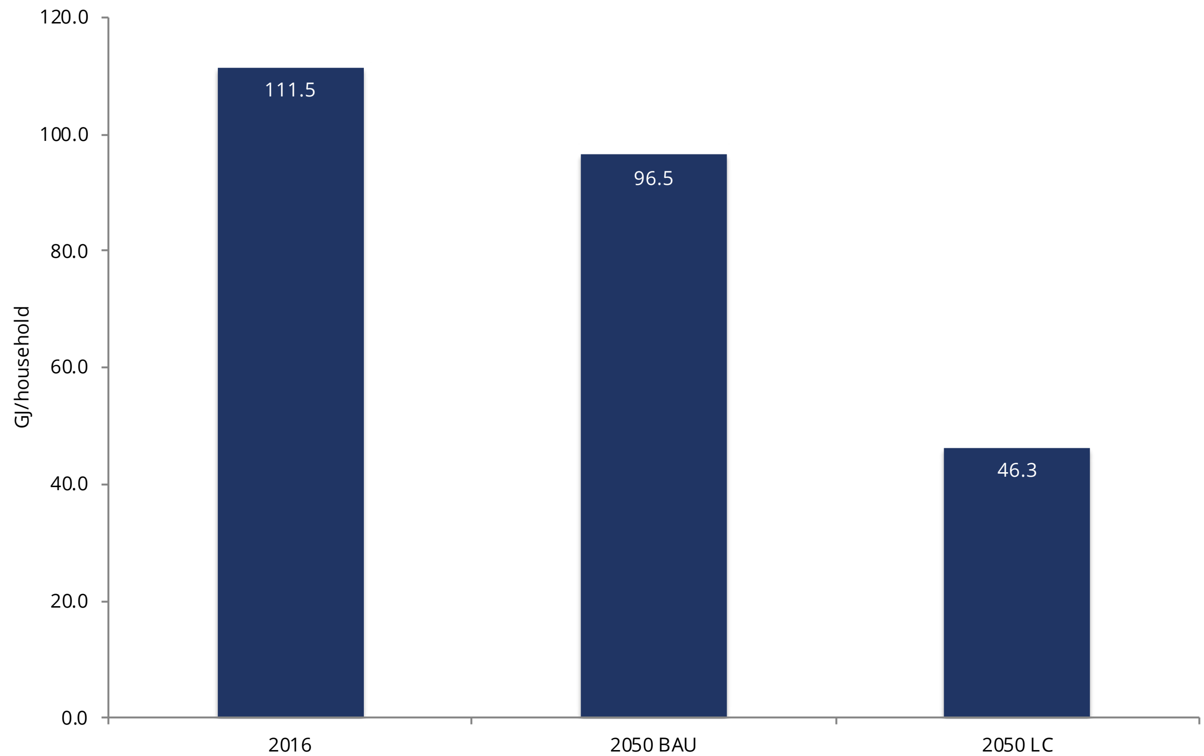


Figure 26. Projected residential energy per household (GJ/household), Burlington.

Residential energy use per household declines from 112 GJ to 46 GJ between 2016 and 2050 in the LC scenario, a reduction of 58%. This reduction exceeds Burlington's goal of a reduction of 34% in new housing constructions when compared with the existing housing stock.

Table 5. Buildings sector energy - Burlington.

BUILDINGS ENERGY (GJ) BY BUILDING TYPE	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/- 2016-2050 LC	% +/- 2050 BAU-2050LC
Residential	7,841,338	46.3%	7,837,371	46.0%	3,761,312	37.2%	-52.0%	-52.0%
Commercial	4,376,880	25.9%	4,514,376	26.5%	1,655,005	16.4%	-62.2%	-63.3%
Industrial	4,703,503	27.8%	4,703,503	27.6%	4,703,503	46.5%	0.0%	0.0%
Total	16,921,722		17,055,251		10,119,820		-40.2%	-40.7%
BUILDINGS ENERGY (GJ) BY FUEL	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Natural Gas	9,512,172	56.2%	9,096,331	53.3%	531,290	5.2%	-94.4%	-94.2%
Electricity	6,128,167	36.2%	6,799,310	39.9%	6,171,513	61.0%	0.7%	-9.2%
Other	442,802	2.6%	590,908	3.5%	3,119,190	30.8%	604.4%	427.9%
Fuel Oil	376,836	2.2%	248,236	1.5%	138,664	1.4%	-63.2%	-44.1%
Propane	372,356	2.2%	231,078	1.4%	69,774	0.7%	-81.3%	-69.8%
Diesel	89,389	0.5%	89,389	0.5%	89,389	0.9%	0.0%	0.0%
Total	**16,921,722**		**17,055,251**		**10,119,820**		**-40.2%**	**-40.7%**
BUILDINGS ENERGY (GJ) BY END USE	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Space Heating	7,757,125	45.8%	6,992,890	41.0%	1,791,735	17.7%	-76.9%	-74.4%
Industrial Manufacturing	3,382,228	20.0%	3,384,590	19.8%	3,384,525	33.4%	0.1%	0.0%
Water Heating	2,494,457	14.7%	2,806,254	16.5%	1,781,365	17.6%	-28.6%	-36.5%
Plug Load	1,232,075	7.3%	1,426,571	8.4%	1,110,337	11.0%	-9.9%	-22.2%
Lighting	928,918	5.5%	1,004,614	5.9%	850,989	8.4%	-8.4%	-15.3%
Major Appliances	737,439	4.4%	953,042	5.6%	806,313	8.0%	9.3%	-15.4%
Space Cooling	389,479	2.3%	487,290	2.9%	394,557	3.9%	1.3%	-19.0%
Total	**16,921,722**		**17,055,251**		**10,119,820**		**-40.2%**	**-40.7%**

BUILDING SECTOR: EMISSIONS

BUILDING EMISSIONS BY FUEL SOURCE

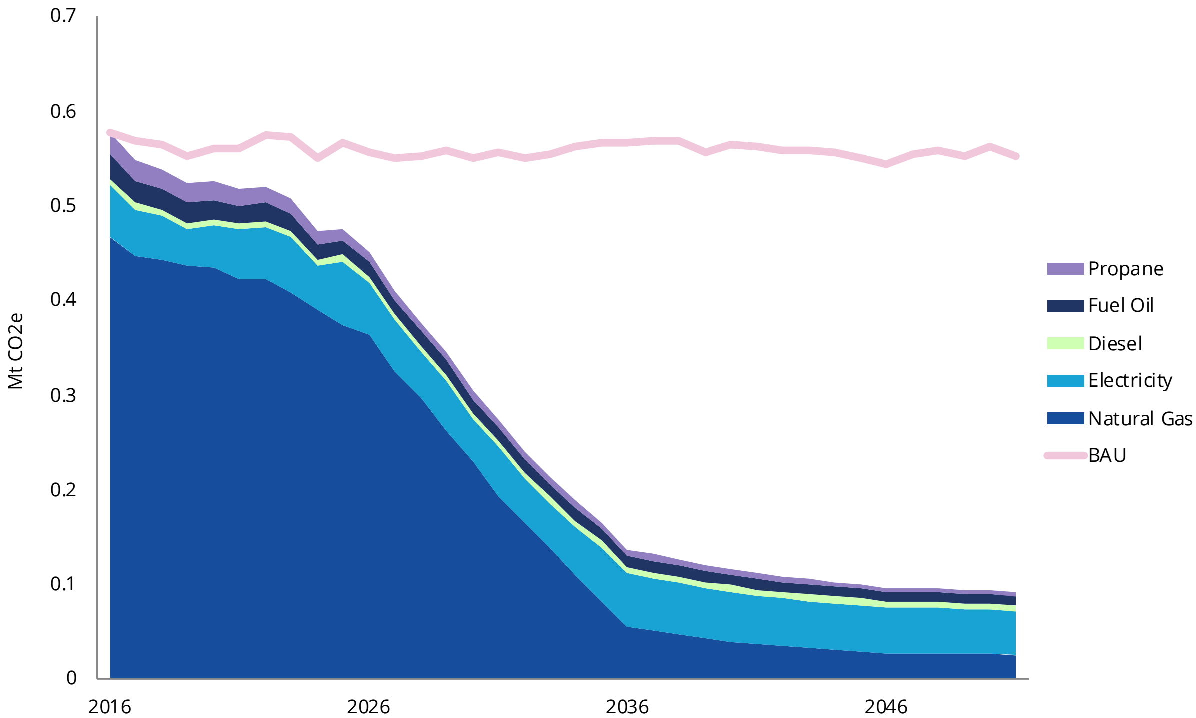


Figure 27. Projected LC building emissions (MtCO2e) by source, Burlington, 2016-2050.

BUILDING EMISSIONS BY END USE

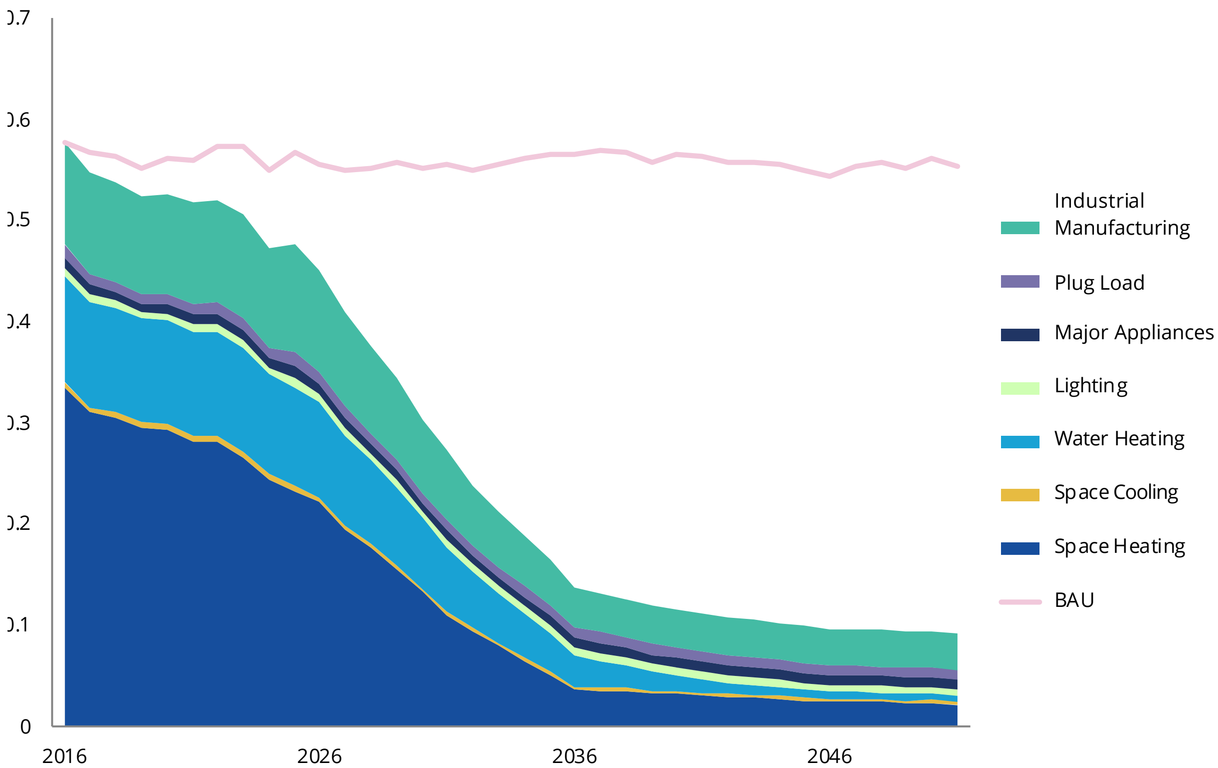


Figure 28. Projected LC building emissions (MtCO2e) by end use, Burlington, 2016-2050.

The shift away from carbon-intensive fuel sources, particularly natural gas, results in an emissions reduction of 84% by 2050 against the 2016 baseline. Reduction in overall consumption of energy through retrofits and Passive House standards for new residential and commercial buildings drive the reduction in GHG emissions, followed by the switch to low- and zero-emission fuel sources.

The switch to heat pumps for space heating, and solar for water heating are the primary drivers of GHG emissions reductions in the City. These are augmented by the decreased demand for energy from more efficient buildings.

BUILDING EMISSIONS BY BUILDING TYPE AND FUEL

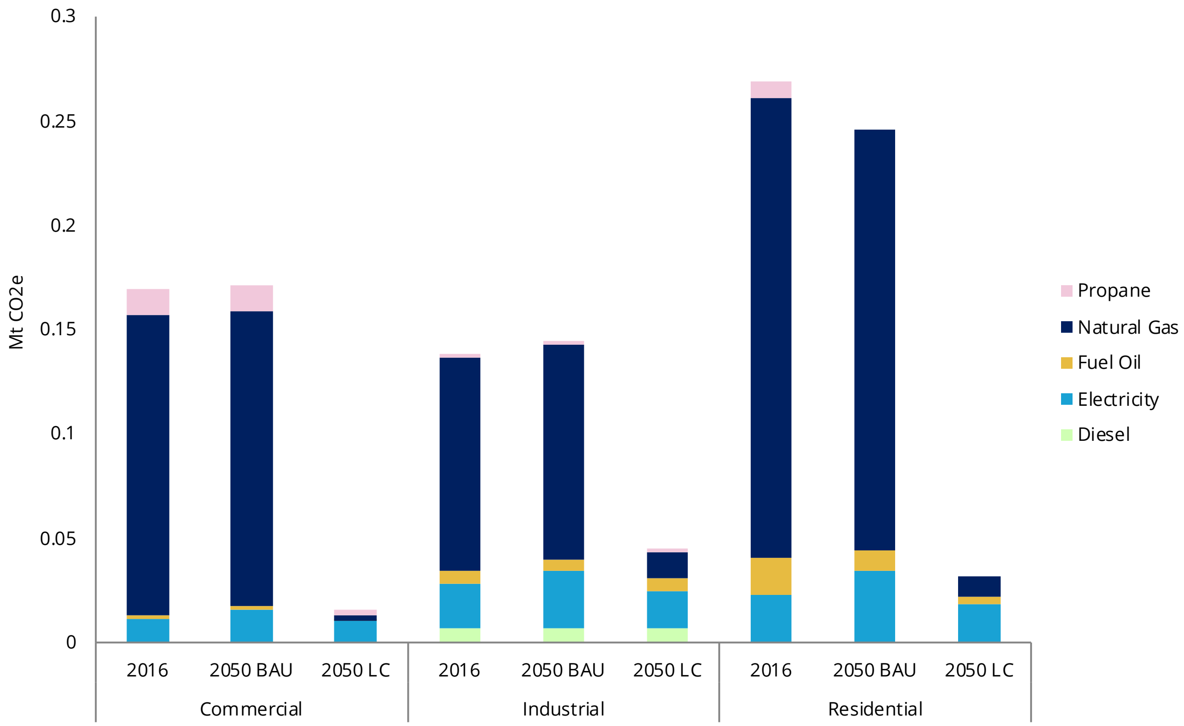


Figure 29. Projected building emissions (MtCO2e) by building type and source, Burlington.

BUILDING EMISSIONS BY BUILDING TYPE AND END USE

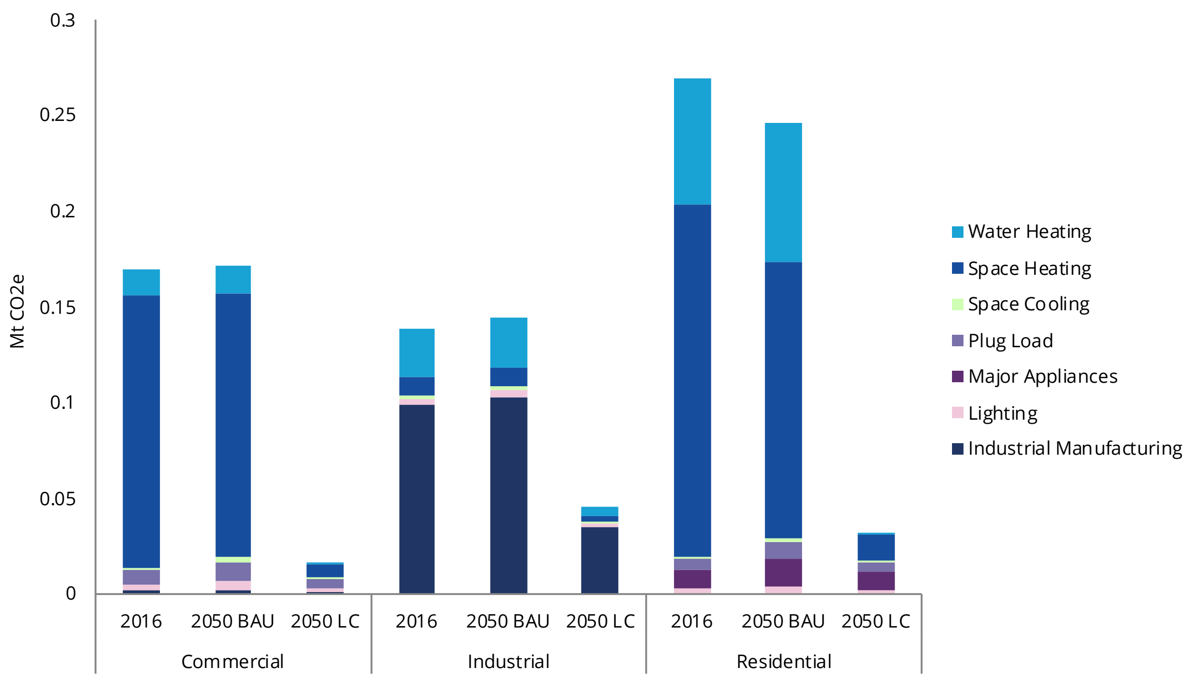


Figure 30. Projected building emissions (MtCO2e) by building type and end use, Burlington.

In 2016, natural gas is the dominant fuel source across all sectors. By switching to electricity for space and water heating, and reducing overall consumption, GHG emissions are reduced across all sectors, but most markedly in the residential sector.

Total emissions are reduced by 84% between the 2016 baseline, and 2050 in the LC scenario.

Space heating and water heating are the primary sources of GHG emissions in 2016, followed by industrial manufacturing. Switching technologies to heat pumps and solar hot water, and fuels, from natural gas to electricity, GHG emissions are decreased overall.

PER HOUSEHOLD EMISSIONS

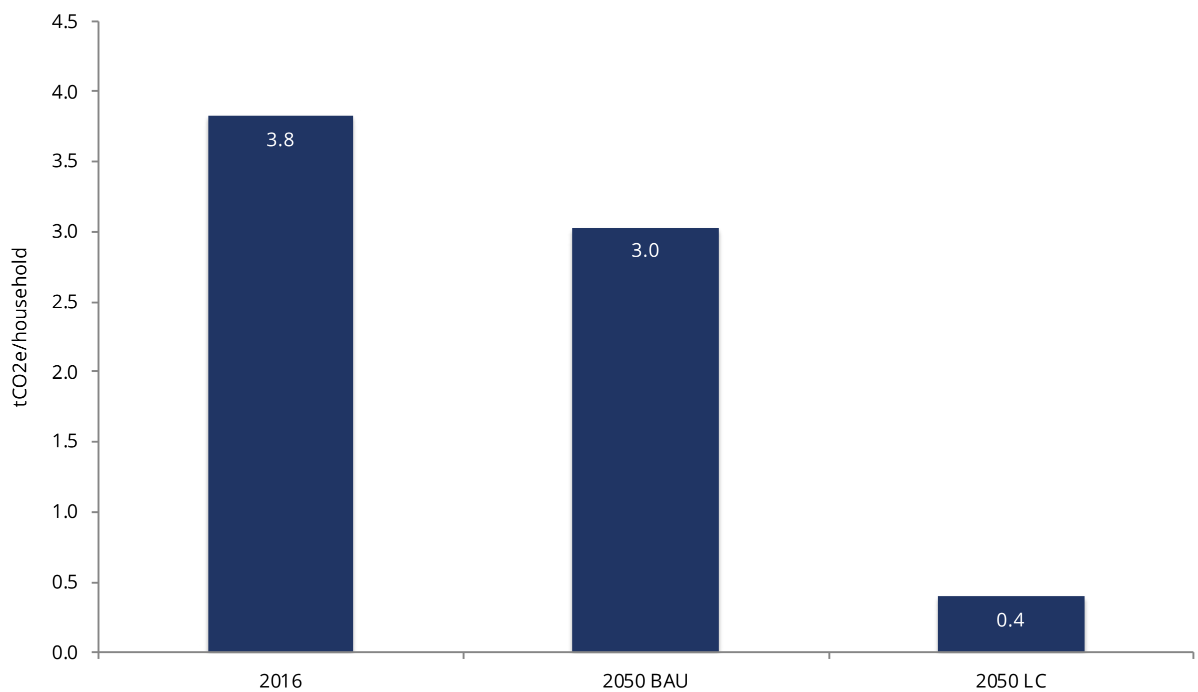


Figure 31. Projected emissions per household (tCO2e/household), Burlington.

Residential GHG emissions decrease by 88% by 2050 in the LC scenario. These emissions savings are a result of retrofits to existing buildings to maximize energy efficiency, Passive House standards for new houses, use of energy efficient heating sources, and overall shift away from fossil fuels. Details of the buildings emissions results are shown in Table 6.

Table 6. Buildings sector GHG emissions, Burlington.

BUILDINGS EMISSIONS (tCO2e) BY BUILDING TYPE	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/- 2016-2050 LC	% +/- 2050 BAU-2050LC
Residential	269,052	46.6%	245,945	43.8%	32,134	34.4%	-88.1%	-86.9%
Commercial	169,334	29.3%	171,097	30.5%	15,956	17.1%	-90.6%	-90.7%
Industrial	138,659	24.0%	144,344	25.7%	45,311	48.5%	-67.3%	-68.6%
Total	577,045		561,386		93,401		-83.8%	-83.4%
BUILDINGS EMISSIONS (tCO2e) BY FUEL	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Natural Gas	466,415	80.8%	446,023	79.5%	26,049	27.9%	-94.4%	-94.2%
Electricity	55,347	9.6%	77,468	13.8%	46,846	50.2%	-15.4%	-39.5%
Fuel Oil	25,942	4.5%	17,195	3.1%	9,673	10.4%	-62.7%	-43.7%
Propane	22,774	3.9%	14,133	2.5%	4,267	4.6%	-81.3%	-69.8%
Diesel	6,567	1.1%	6,567	1.2%	6,567	7.0%	0.0%	0.0%
Total	**577,045**		**561,386**		**93,401**		**-83.8%**	**-83.4%**
BUILDINGS EMISSIONS (tCO2e) BY END USE	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Space Heating	334,595	58.0%	291,534	51.9%	23,028	24.7%	-93.1%	-92.1%
Water Heating	104,930	18.2%	112,949	20.1%	6,035	6.5%	-94.2%	-94.7%
Industrial Manufacturing	101,114	17.5%	105,213	18.7%	35,837	38.4%	-64.6%	-65.9%
Plug Load	12,962	2.2%	18,223	3.2%	9,380	10.0%	-27.6%	-48.5%
Major Appliances	9,852	1.7%	14,740	2.6%	9,736	10.4%	-1.2%	-33.9%
Lighting	8,390	1.5%	11,446	2.0%	6,460	6.9%	-23.0%	-43.6%
Space Cooling	5,203	0.9%	7,282	1.3%	2,927	3.1%	-43.8%	-59.8%
Total	**577,045**		**561,386**		**93,401**		**-83.8%**	**-83.4%**

TRANSPORTATION SECTOR ENERGY

TRANSPORTATION ENERGY BY FUEL

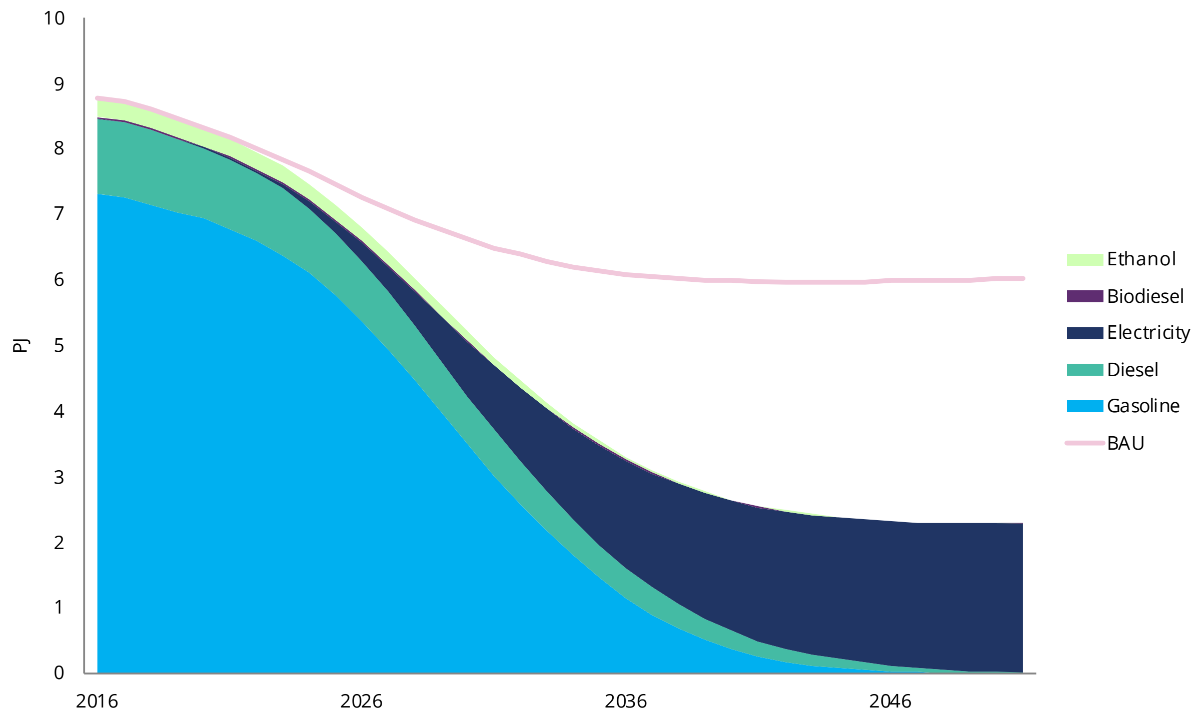


Figure 32. Projected LC transportation energy use (PJ) by fuel, Burlington, 2016-2050.

TRANSPORTATION ENERGY BY VEHICLE TYPE

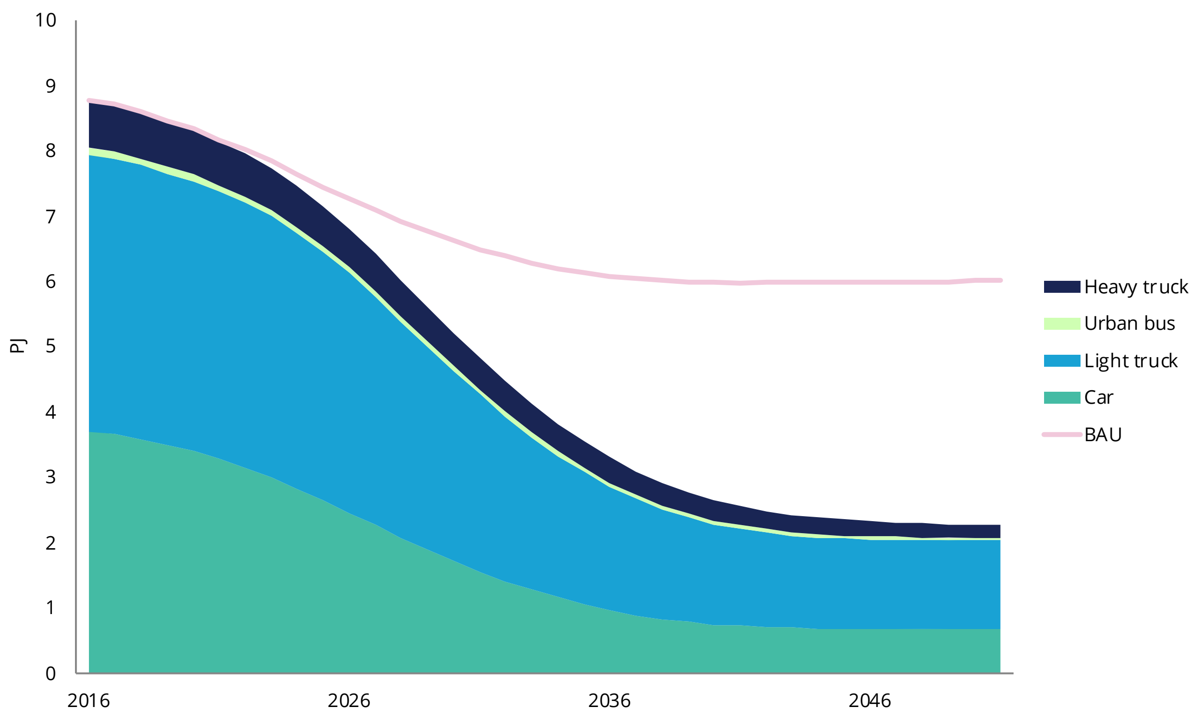


Figure 33. Projected LC transportation energy use (PJ) by vehicle type, Burlington, 2016-2050.

Transportation energy consumption declines by 74% in 2050 in the LC scenario against the 2016 baseline, and by 62% in comparison with the 2050 BAU. Fossil fuels are entirely, or almost entirely, eliminated as a fuel source, and are replaced by electricity.

In addition to fuel switching, energy consumption is reduced by behavioural changes such as increasing the use of transit and active transportation, which displace vehicular trips.

Light trucks and cars represent the majority of the vehicle market in 2016, and market trends predict that light trucks will become dominant, representing 59% of the energy demand in 2050.

All vehicle classes become more efficient, which accounts for the decline in energy consumption in the BAU scenario, in spite of the growing population. This trend is enhanced in the in the LC scenario, as a result of increased electrification of the vehicle fleet and the greater efficiency of electric vehicles relative to the internal combustion engine.

TRANSPORTATION ENERGY BY VEHICLE TYPE & FUEL

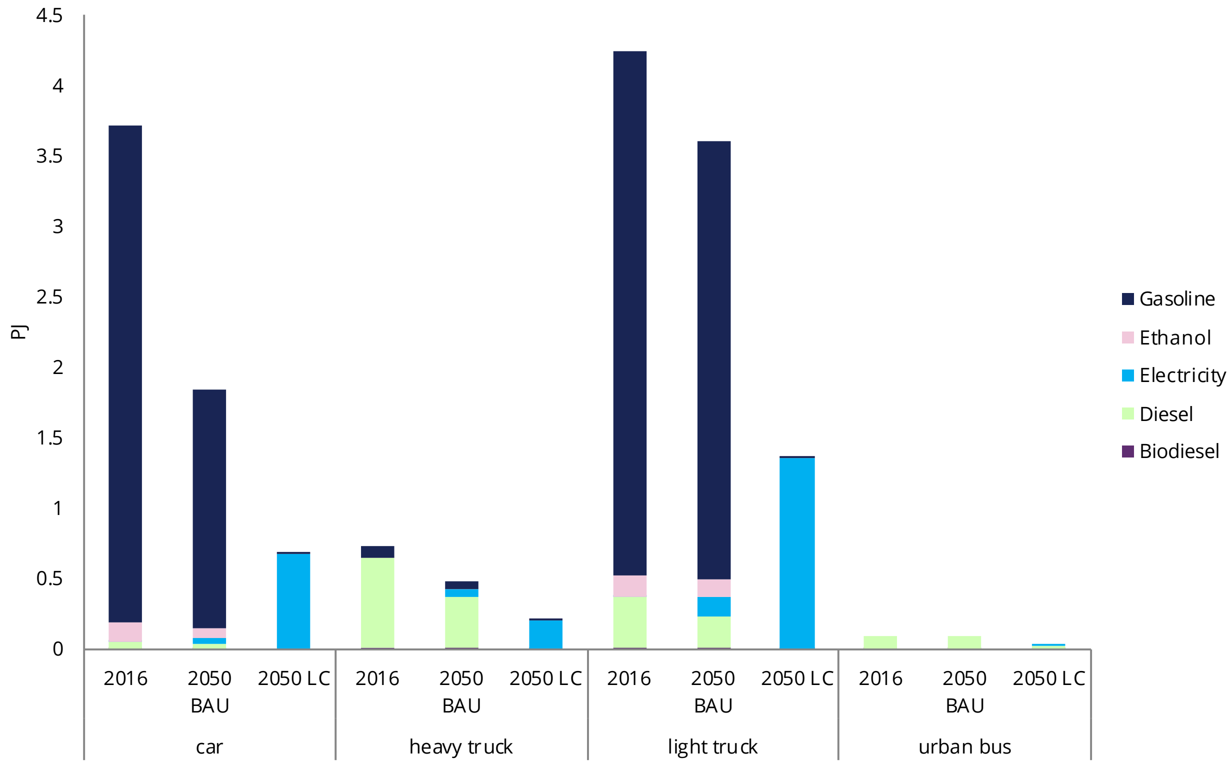


Figure 34. Projected transportation energy use (PJ) by vehicle type and fuel, Burlington.

Cars and light trucks consume 91% of the transportation energy demand in 2016, and 90% of the energy demand in the 2050 LC scenario. The impact of the efficiency of electric vehicles is apparent when the BAU is compared against the LC scenario in 2050 for both cars and light trucks, with energy savings exceeding 50%.

Table 7. Transportation sector energy, Burlington.

TRANSPORTATION ENERGY (GJ) BY FUEL	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/- 2016-2050 LC	% +/- 2050 BAU-2050LC
Gasoline	7,314,276	83.4%	4,839,761	80.5%	2,389	0.1%	-100.0%	-100.0%
Diesel	1,139,812	13.0%	726,665	12.1%	23,316	1.0%	-98.0%	-96.8%
Ethanol	293,820	3.3%	194,417	3.2%	96	0.0%	-100.0%	-100.0%
Biodiesel	26,412	0.3%	16,839	0.3%	540	0.0%	-98.0%	-96.8%
Electricity	155	0.0%	234,404	3.9%	2,258,994	98.8%	1457806.9%	863.7%
Total	**8,774,476**		**6,012,086**		**2,285,335**		**-74.0%**	**-62.0%**
TRANSPORTATION ENERGY (GJ) BY VEHICLE TYPE	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/ 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Light truck	4,238,706	48.3%	3,599,872	59.9%	1,363,445	59.7%	-67.8%	-62.1%
Car	3,710,492	42.3%	1,837,579	30.6%	679,352	29.7%	-81.7%	-63.0%
Heavy truck	727,887	8.3%	477,244	7.9%	203,202	8.9%	-72.1%	-57.4%
Urban bus	97,390	1.1%	97,390	1.6%	39,336	1.7%	-59.6%	-59.6%
Total	**8,774,476**		**6,012,086**		**2,285,335**		**-74.0%**	**-62.0%**

TRANSPORTATION SECTOR EMISSIONS

TRANSPORTATION EMISSIONS BY SOURCE

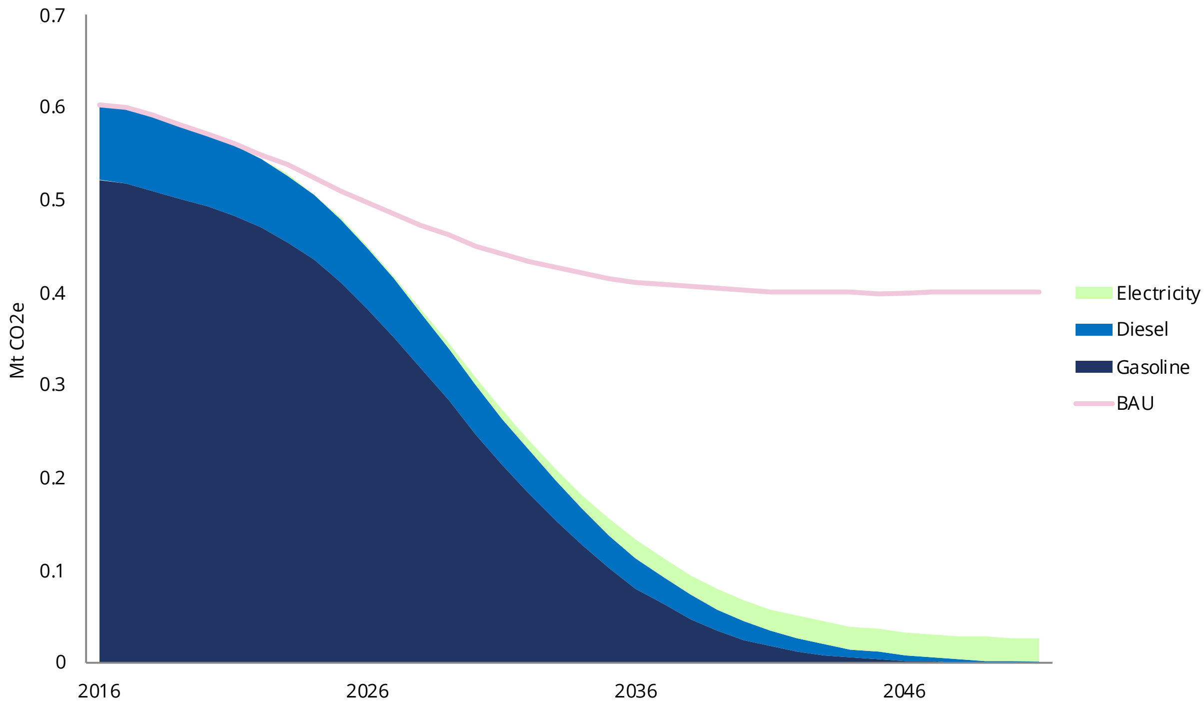


Figure 35. Projected LC transportation GHG emissions (MtCO2e) by source, Burlington, 2016-2050.

TRANSPORTATION EMISSIONS BY VEHICLE TYPE

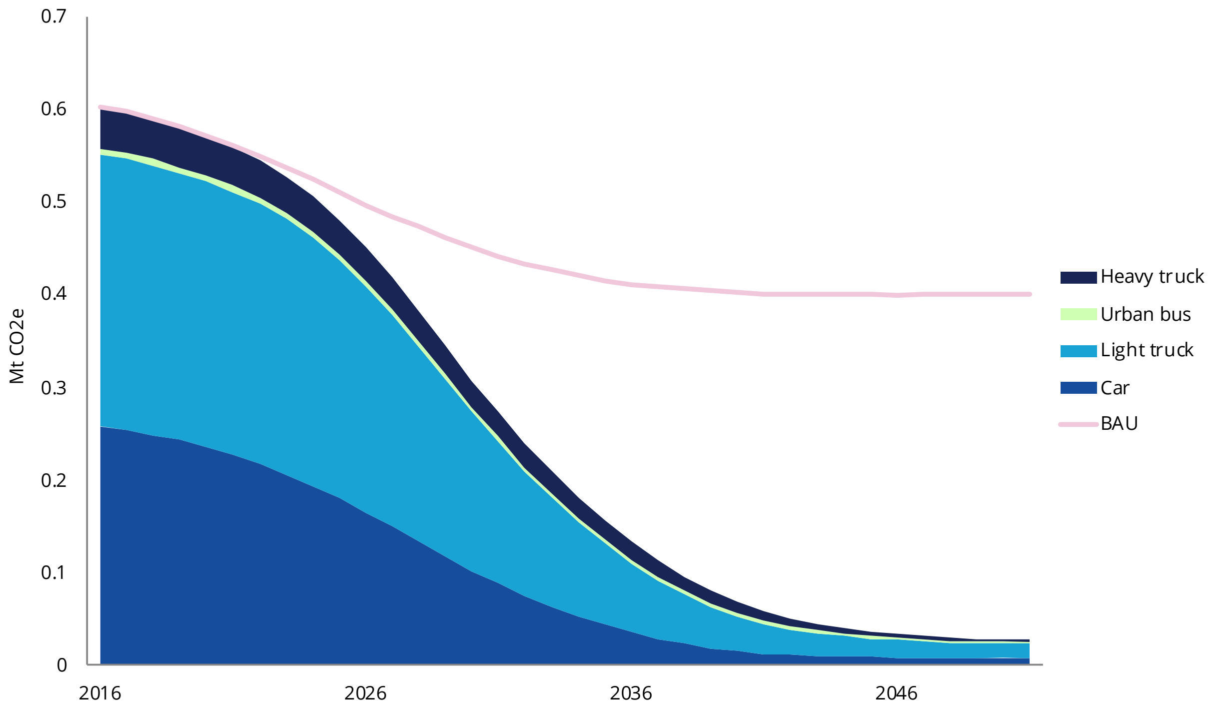


Figure 36. Projected LC transportation GHG emissions (MtCO2e) by vehicle type, Burlington, 2016-2050.

GHG emissions from transportation in 2016 are dominated by gasoline (87%), with lesser contributions from diesel (14%). By switching to electric vehicles for all classes, GHG emissions are reduced by 96% in the LC scenario. While actions that reduce vehicle use and increase the mode share of transit and active transportation contribute to the reduction in GHG emissions, the elimination of carbon-intensive fuel sources is critical to achieving these levels of emissions reductions.

The market share of light trucks is projected to increase, and they represent 57% of the GHG emissions in 2050 in the LC scenario. GHG emissions fall from 43% in 2016 to 28% in 2050 in the LC scenario, because of improved efficiency standards, and switching to electric vehicles by 2030.

Total GHG emissions from vehicles decrease by 96% between 2016 and 2050 in the LC scenario, a decrease of 93% over 2050 in the BAU scenario.

TRANSPORTATION EMISSIONS BY SOURCE AND VEHICLE TYPE

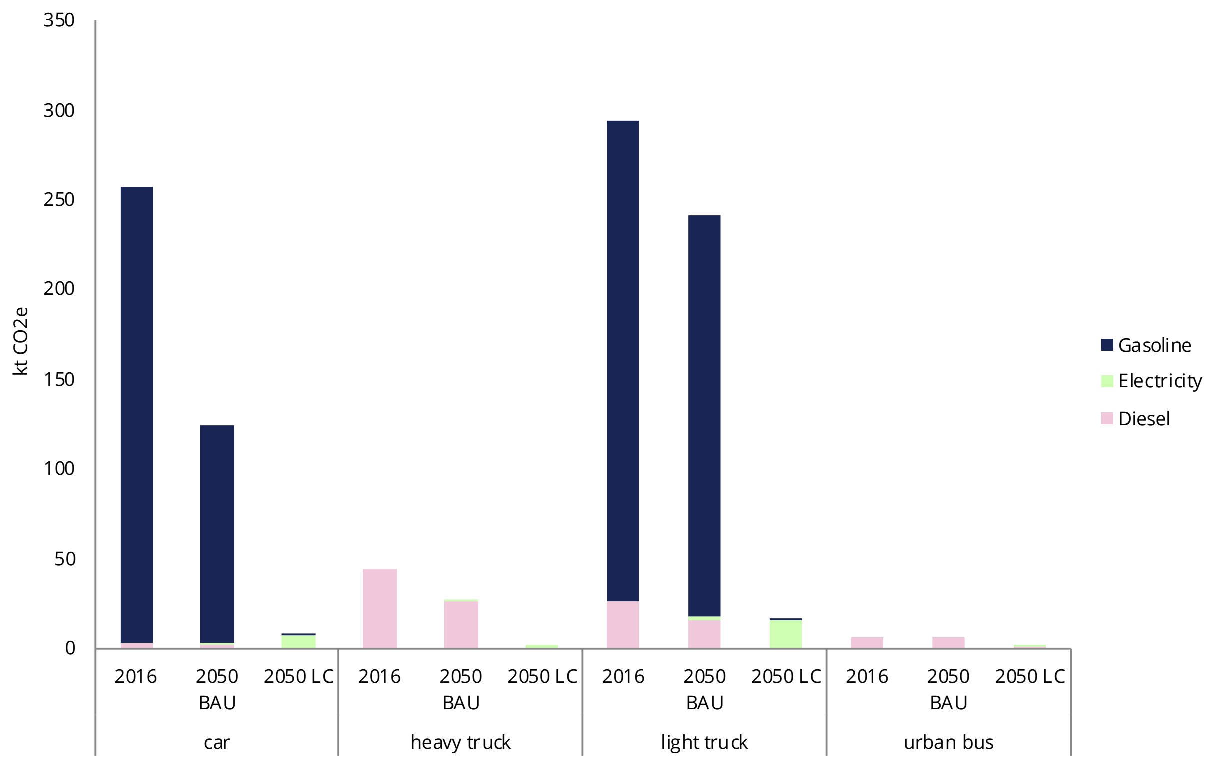


Figure 37. Projected transportation GHG emissions (ktCO2e) by source and vehicle type, Burlington.

In 2016, cars and light trucks are the primary source of GHG emissions (92%), producing a combined 551 ktCO2e. While they are still the dominant source of GHG emissions (85%) by 2050 in the LC scenario, total emissions from cars and light trucks drops to 23 ktCO2e.

Table 8. Transportation sector GHG emissions- Burlington.

TRANSPORTATION EMISSIONS (tCO2e) BY FUEL	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/- 2016-2050 LC	% +/- 2050 BAU-2050LC
Gasoline	521,222	86.5%	345,203	86.4%	149	0.5%	-100.0%	-100.0%
Diesel	81,310	13.5%	51,835	13.0%	1,657	6.0%	-98.0%	-96.8%
Electricity	1	0.0%	2,705	0.7%	25,593	93.4%	1828755.6%	846.3%
Total	**602,533**		**399,743**		**27,399**		**-95.5%**	**-93.1%**
TRANSPORTATION EMISSIONS (tCO2e) BY VEHICLE TYPE	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Light truck	293,783	48.8%	241,573	60.4%	15,656	57.1%	-94.7%	-93.5%
Car	257,244	42.7%	124,597	31.2%	7,697	28.1%	-97.0%	-93.8%
Heavy truck	44,749	7.4%	26,814	6.7%	2,440	8.9%	-94.5%	-90.9%
Urban bus	6,758	1.1%	6,758	1.7%	1,606	5.9%	-76.2%	-76.2%
Total	**602,533**		**399,743**		**27,399**		**-95.5%**	**-93.1%**

WASTE SECTOR EMISSIONS

WASTE EMISSIONS BY TYPE

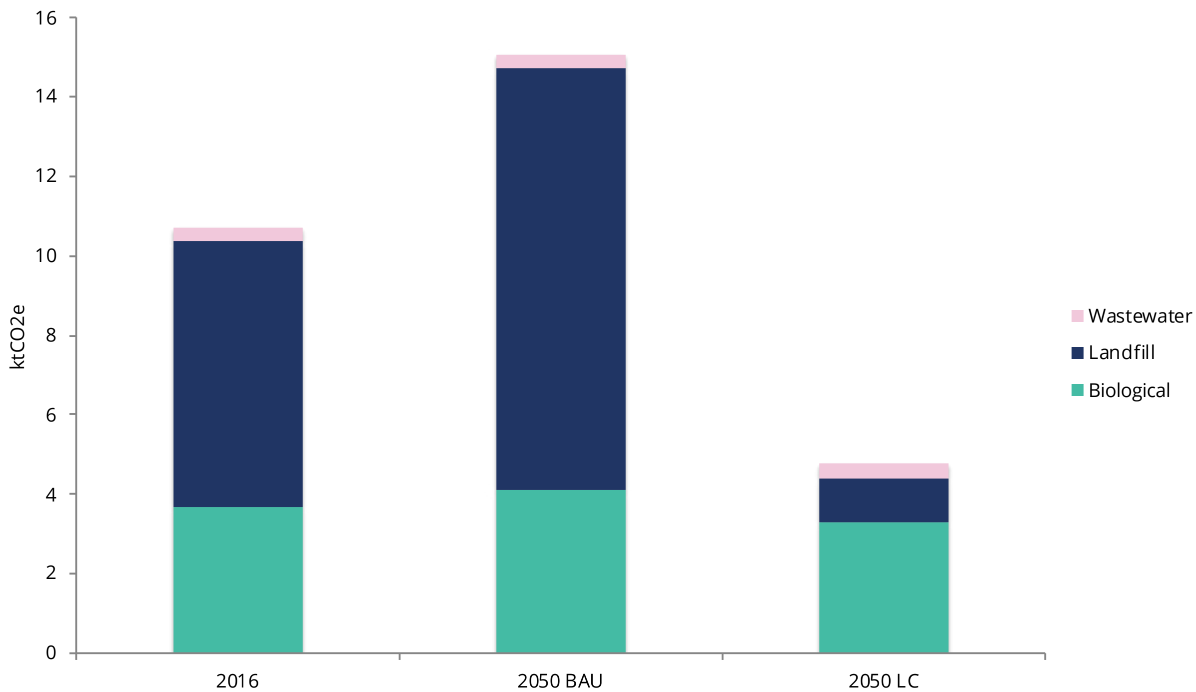


Figure 38. Projected waste GHG emissions (tCO2e), Burlington.

The LC scenario assumes that waste generation will decrease by 50% per capita by 2050, and that diversion rates will increase by 50% per capita in the same time period. Wastewater GHG emissions are consistent between the BAU and the LC scenarios, as the production rates of this waste do not change. The reduction in GHG emissions in landfills is the result of increased capture of biogas, as well as the reduction in per capita waste production. Biological sources include compost, yard waste, and other organic matter.

ENERGY EXPENDITURES

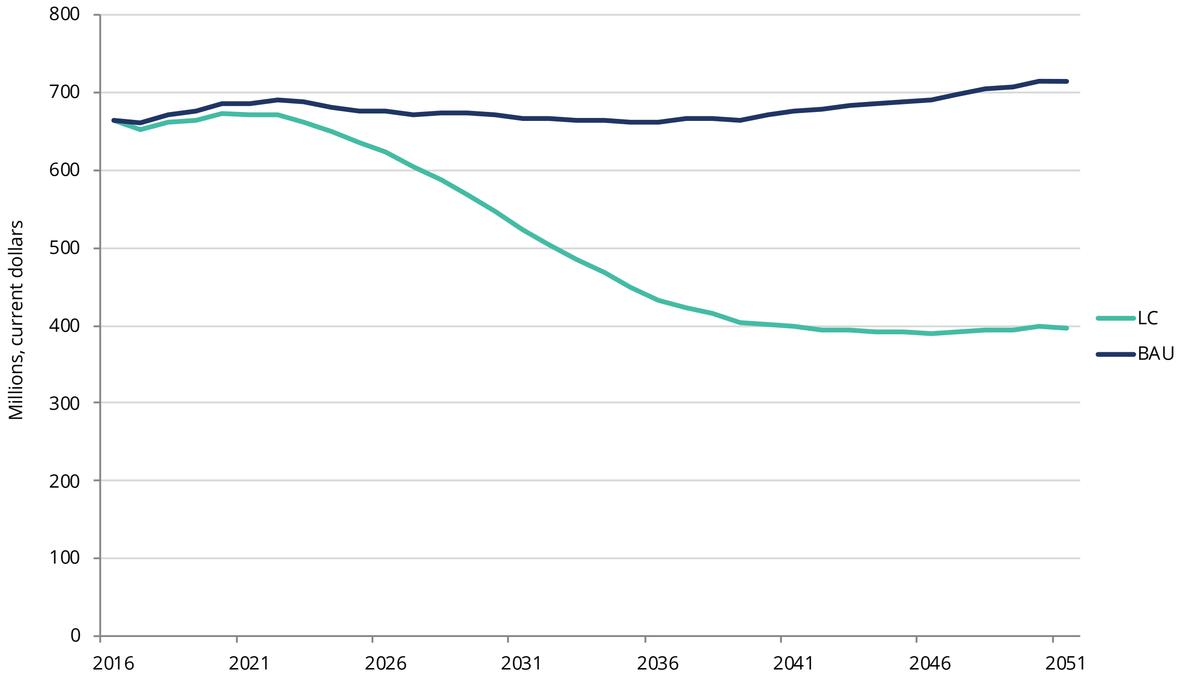


Figure 39. Total energy expenditures for BAU and LC, 2016-2050, Burlington.

Total energy expenditures in Burlington were $660 million in 2016, climbing to $714 million in 2050 in the BAU scenario. The LC scenario results in annual energy expenditure savings of $317 million by 2050. Cumulative savings between 2018 and 2050 on energy expenditures are $5.7 billion. Figure 33 shows that the energy expenditures in Burlington are roughly split between electricity and natural gas and as natural gas is phased out due to electrification of heating and transportation, the share of electricity grows to nearly 100% by 2050.

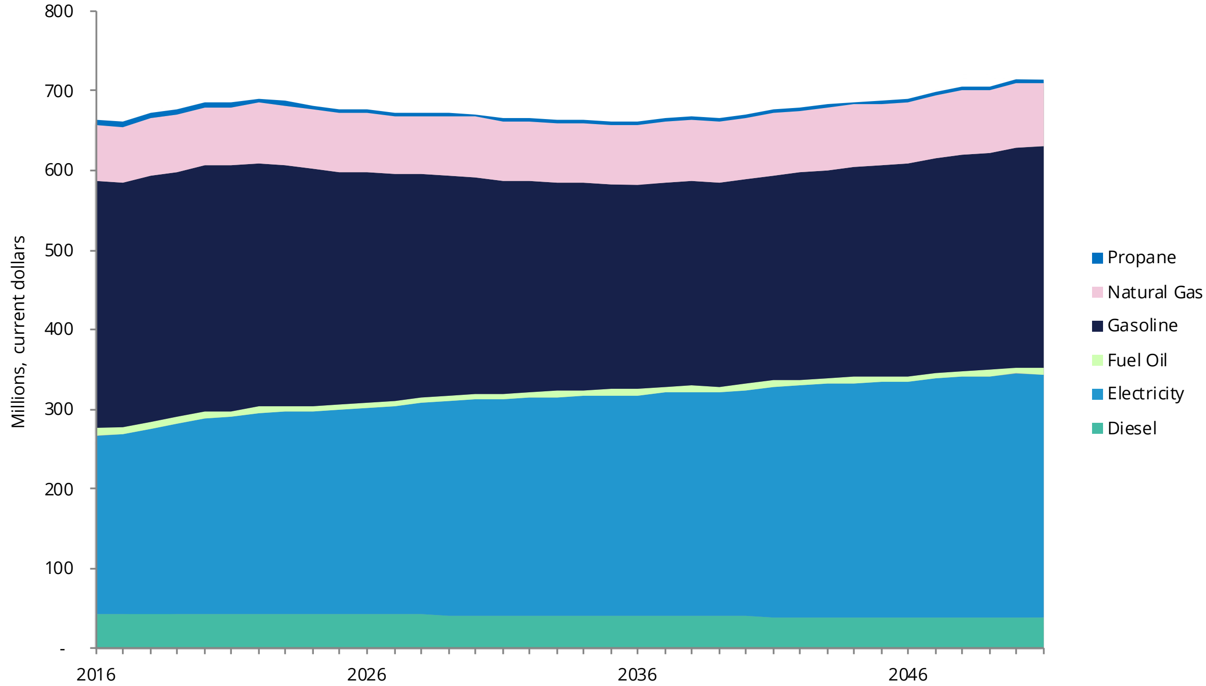


Figure 40. BAU energy costs by fuel type, Burlington.

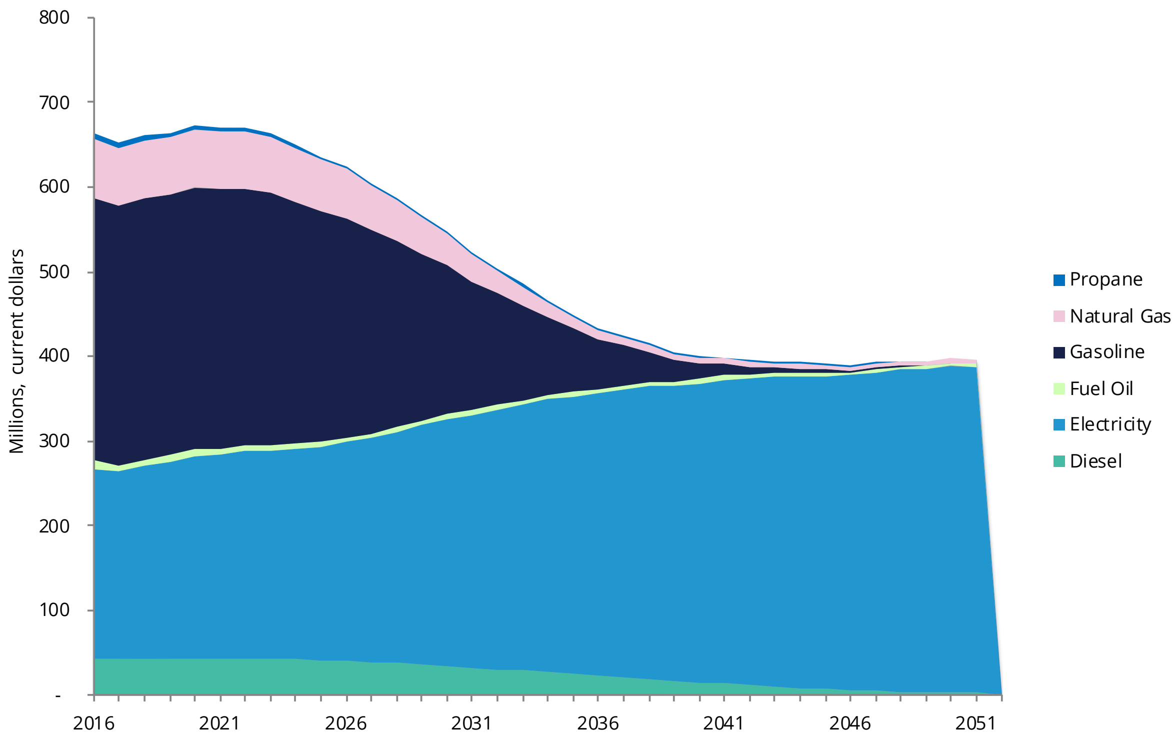


Figure 41. LC energy costs by fuel type, Burlington.

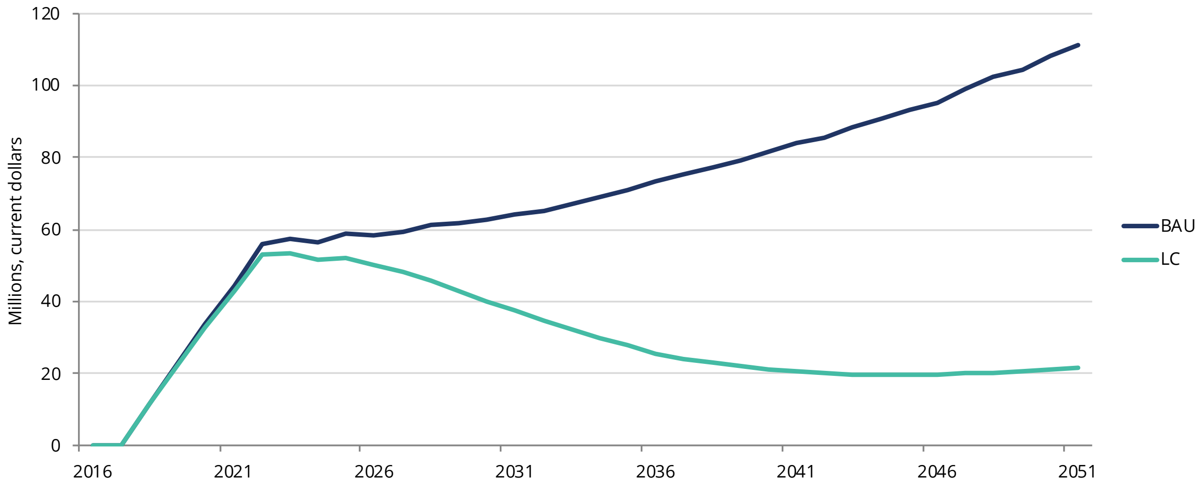


Figure 42. Total cost of carbon emissions, BAU vs LC, Burlington.

The costs associated with the Federal carbon tax were also evaluated. In 2019, carbon tax expenditures total $23 million per year, climbing to $110 million per year by 2050 in the BAU. In the low-carbon scenario, carbon tax expenditures fall to $25 million in 2050, a savings of $90 million. Cumulative savings between 2019 and 2050 are $1.3 billion between 2019 and 2050. Figures 43 and 44 illustrate the impact of the carbon tax on various sectors. In the BAU scenario, transportation expenditures increase because of the reliance on fossil fuels, while the opposite is evident in the low-carbon scenario, when carbon tax expenditures fall to zero in the transportation sector.

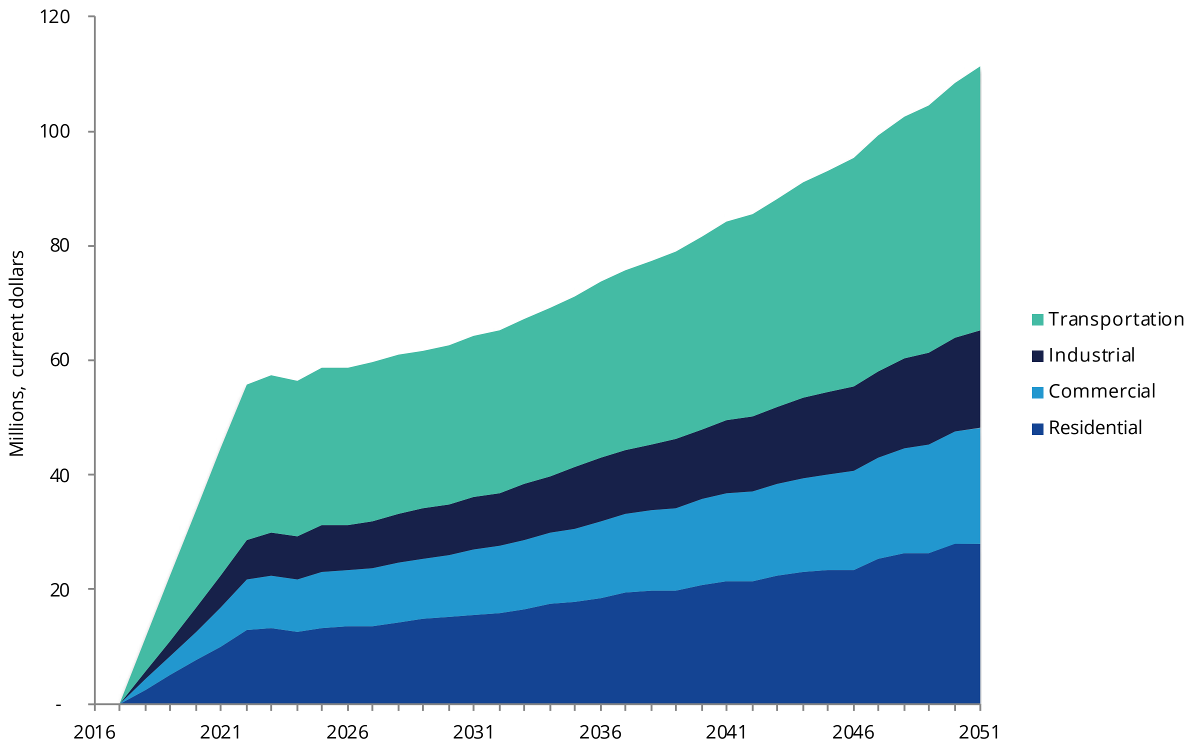


Figure 43. BAU emission costs by fuel type, Burlington.

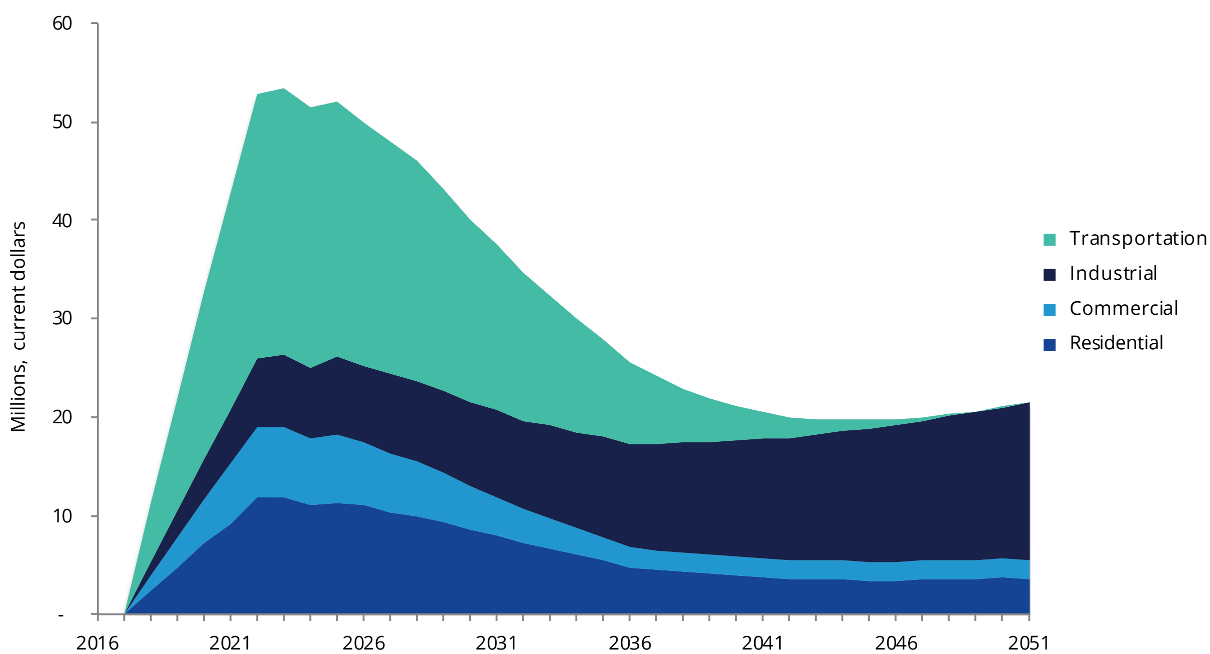


Figure 44. LC emission costs by fuel type, Burlington.

PART 3: CITY OF HAMILTON LOW-CARBON RESULTS

COMMUNITY ENERGY AND EMISSIONS

ENERGY BY SECTOR

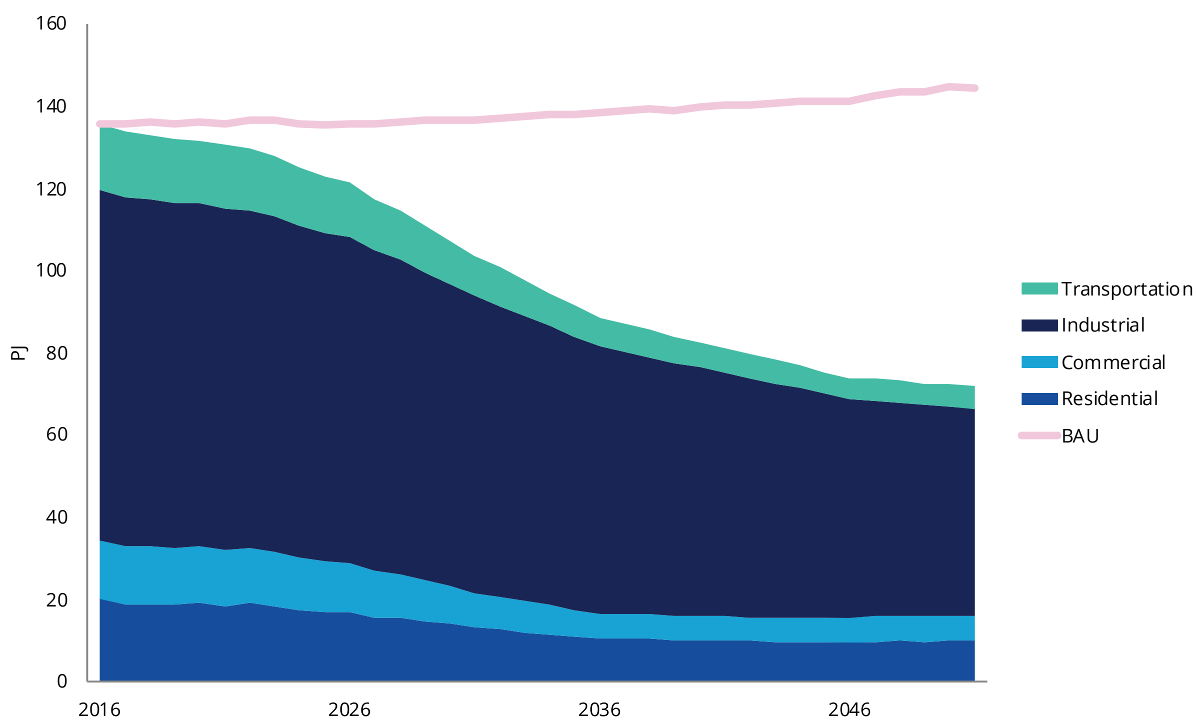


Figure 45. Projected LC energy consumption (PJ) by sector, Hamilton, 2016-2050.

ENERGY BY FUEL

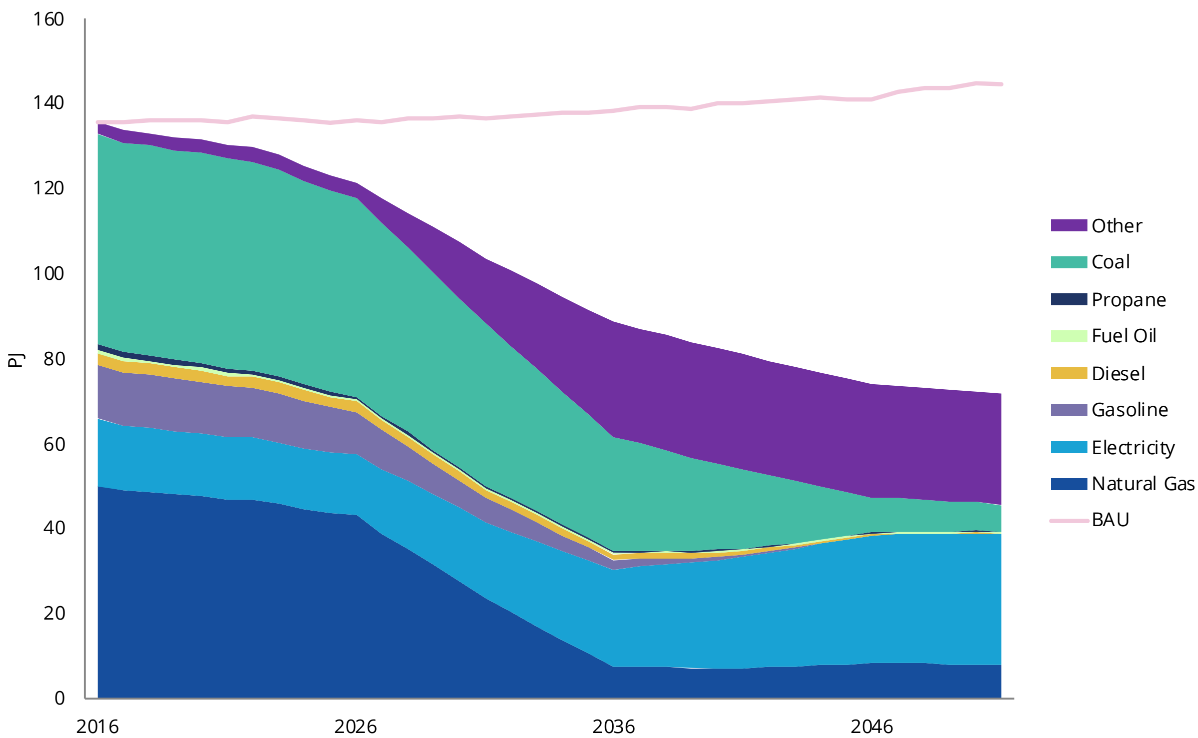


Figure 46. Projected LC energy consumption (PJ) by fuel, Hamilton 2016-2050.

The industrial sector is the primary energy consumer in Hamilton, accounting for 63% of energy use in 2016. Efficiencies in this sector, as well as a reduction in steel manufacturing account for the 40% decrease in energy consumption by 2050 in the LC scenario.

Improvements to vehicle efficiency standards drive some of the decrease in transportation energy use, but the majority of the energy savings are from the electrification of the personal and commercial vehicles and a reduction in vehicle use (transit and active transportation use increasing).

Building retrofits, improvements in the efficiency of new buildings, increased use of heat pumps and solar hot water, and electrification contribute to the reduction in residential energy use.

Energy use in 2016 is 37% natural gas, 36% coal (in the steel industry), 12% electricity, and 9% gasoline. In the LC scenario, electricity becomes the dominant energy source (43%), and fossil fuels are reduced by 84% to 100%, depending on the fuel type. Coal use is reduced by 87% in the LC scenario.

PER CAPITA ENERGY

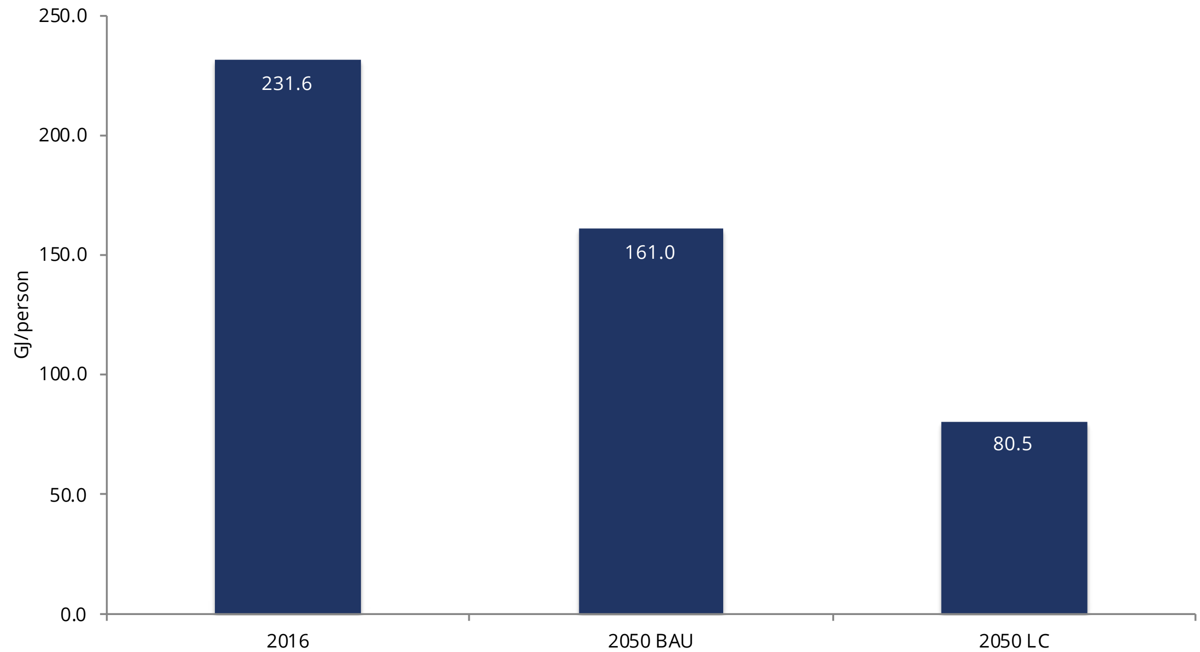


Figure 47. Projected energy per capita (GJ/person), 2016, 2050 BAU and 2050 LC, Hamilton.

Overall, the LC scenario results in a total energy use decrease from 136 PJ in 2016, to 72 PJ in 2050. This is a 47% reduction from the 2016 baseline, and a 50% reduction over the BAU in 2050.

Per capita energy use decreases by 65% from the baseline, and 50% over the BAU in 2050. When industrial energy is removed, the per capita energy use drops to 56 GJ/person in 2050, a decrease of 76% from 2016, and 65% over the BAU in 2050. Table 10 shows full details of the reduction in energy use by sector and by fuel type.

Table 9. Community energy consumption, Hamilton.

ENERGY BY SECTOR (GJ)	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/- 2016-2050 LC	% +/- 2050 BAU-2050 LC
Industrial	85,246,721	62.8%	89,009,643	61.5%	50,854,324	70.3%	-40.3%	-42.9%
Residential	20,234,366	14.9%	22,701,528	15.7%	9,976,934	13.8%	-50.7%	-56.1%
Transportation	16,022,809	11.8%	14,213,034	9.8%	5,416,976	7.5%	-66.2%	-61.9%
Commercial	14,133,156	10.4%	18,816,133	13.0%	6,123,469	8.5%	-56.7%	-67.5%
Total	135,637,053		144,740,338		72,371,704		-46.6%	-50.0%
ENERGY BY FUEL (GJ)	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050 LC**
Natural Gas	50,087,377	36.9%	57,451,517	39.7%	8,086,846	11.2%	-83.9%	-85.9%
Coal	49,411,059	36.4%	49,435,449	34.2%	6,645,300	9.2%	-86.6%	-86.6%
Electricity	15,719,196	11.6%	19,676,183	13.6%	30,750,112	42.5%	95.6%	56.3%
Gasoline	12,669,000	9.3%	10,947,700	7.6%	7,257	0.0%	-99.9%	-99.9%
Other	2,856,859	2.1%	3,395,892	2.3%	26,258,901	36.3%	819.2%	673.3%
Diesel	2,822,480	2.1%	2,214,033	1.5%	222,530	0.3%	-92.1%	-89.9%
Propane	1,185,520	0.9%	1,042,217	0.7%	195,116	0.3%	-83.5%	-81.3%
Fuel Oil	885,562	0.7%	577,348	0.4%	205,643	0.3%	-76.8%	-64.4%
Total	**135,637,053**		**144,740,338**		**72,371,704**		**-46.6%**	**-50.0%**
ENERGY PER CAPITA (GJ/CAP)	**231.6**		**161.0**		**80.5**		**-65.2 %**	**-50.0%**

ENERGY FLOW AND CONVERSIONS

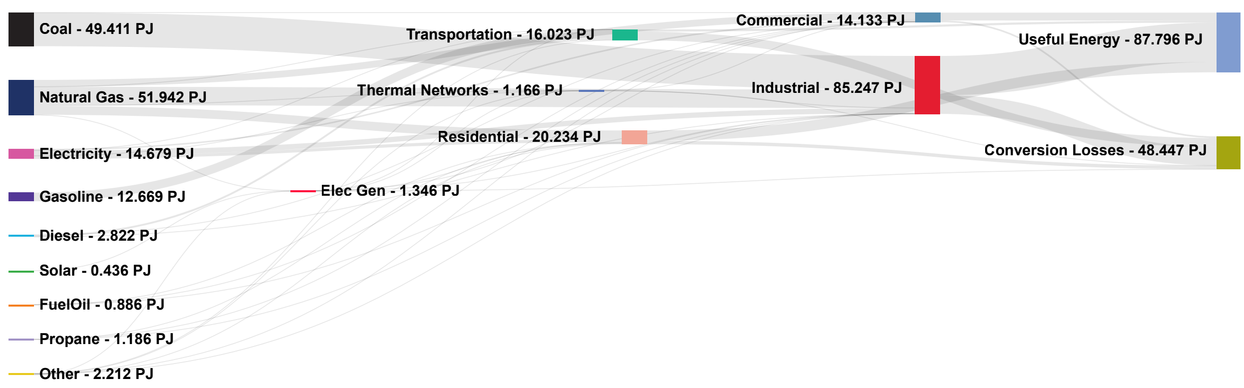


Figure 48. 2016 Energy Flow- Hamilton.

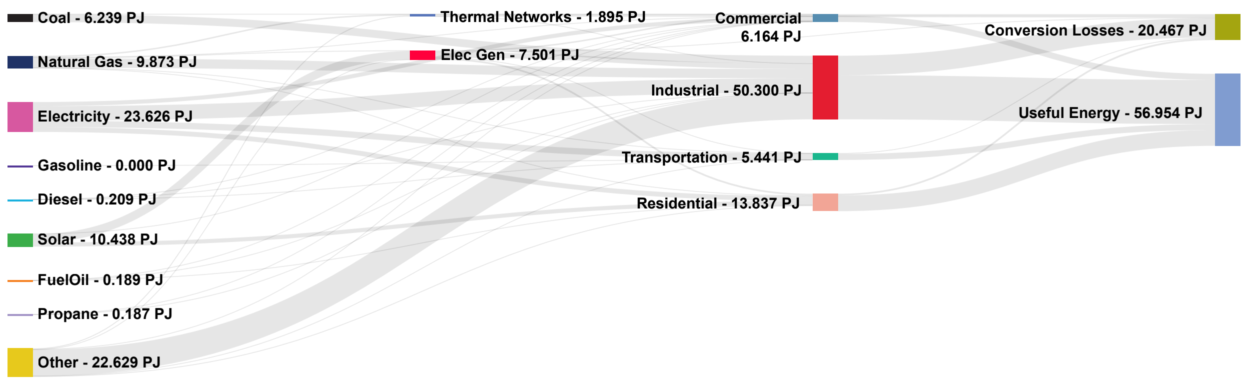


Figure 49. Energy flow, 2050 (LC)- Hamilton.

The Sankey diagrams for 2016 (Figure 48) and the LC scenario in 2050 (Figure 49) show the energy flow by fuel and sector for the City of Hamilton. The ratio of useful energy to conversion losses is 1.8:1 in 2016, and in 2050 this climbs to 2.8:1, indicating a gain in the efficient use of energy.

Local generation of electricity increases from 1.3 PJ to 7.5 PJ in 2050, and the district energy network (thermal network) increases from 1.2 PJ to 1.9 PJ.

The Sankey also shows a significant decline in coal and natural gas between 2016 and 2050, and an increase in electricity use.

The drop from 85 PJ to 50 PJ in the industrial sector has the biggest impact on energy use in Hamilton.

COMMUNITY EMISSIONS

EMISSIONS BY SECTOR

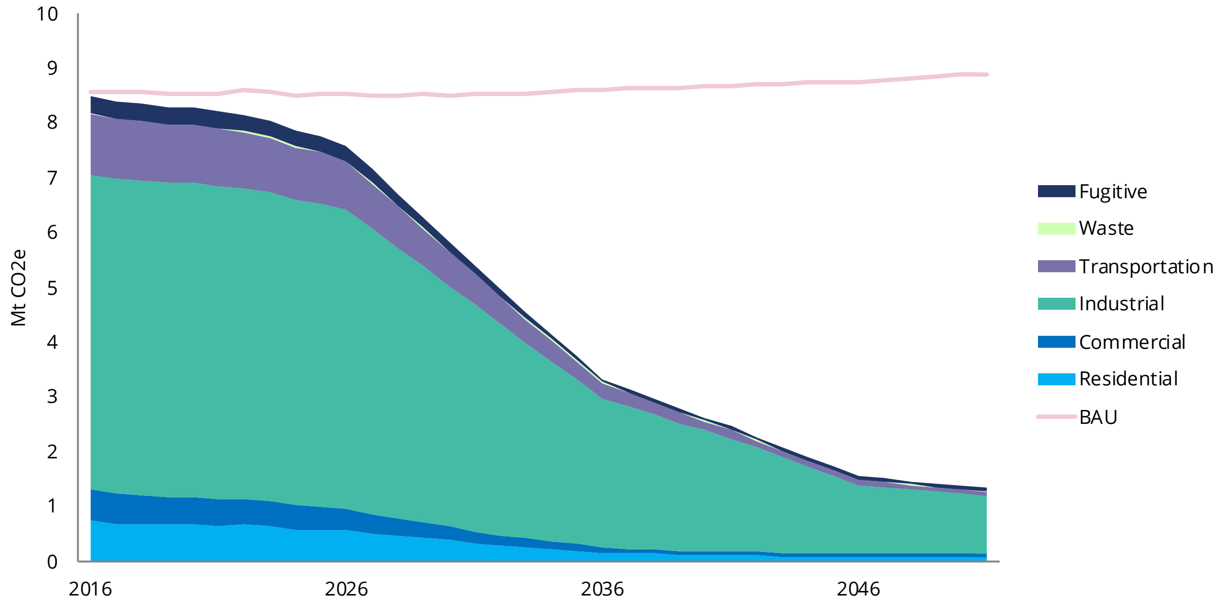


Figure 50. Projected LC emissions (MtCO2e) by sector in Hamilton, 2016-2050.

EMISSIONS BY SOURCE

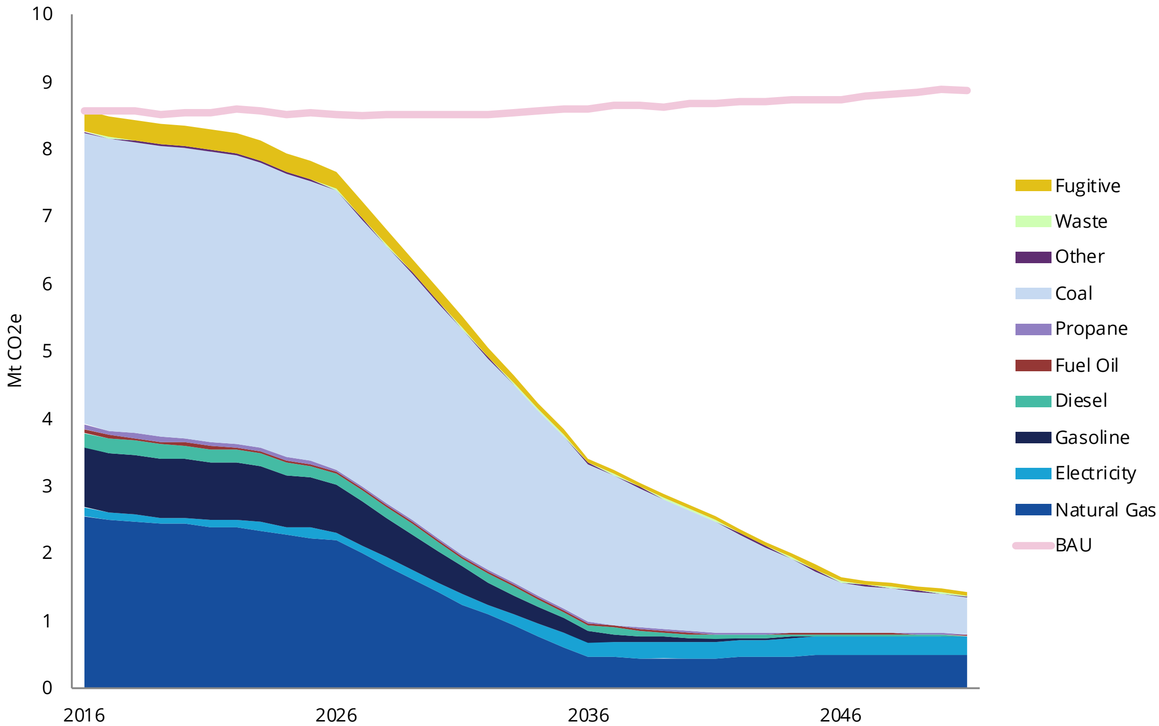


Figure 51. Projected LC emissions (MtCO2e) by source, in Hamilton, 2016-2050.

Total GHG emissions decline from 8.6 MtCO2e in 2013 to 1.5 MtCO2e in 2050 in the LC scenario, a decrease of 83%.

All sectors except waste show a reduction in GHG emissions ranging from 81% in industry to 94% in transportation. The waste sector shows an increase of 27% from 2016 to 2050 in the LC scenario, driven by population growth. This sector shows a reduction of 13% over the BAU scenario because of reduced waste generation, and increased capture of methane.

The LC scenario illustrates a reduction in carbon-intensive fuel sources, specifically coal (50% of 2016 emissions), natural gas (30% of 2016 emissions) and gasoline (10% of 2016 emissions), and a switch to low or zero emissions sources. As a result of electrification, GHG emissions from electricity increase by 112% from 2016 to 2050 in the low-carbon scenario.

PER CAPITA EMISSIONS

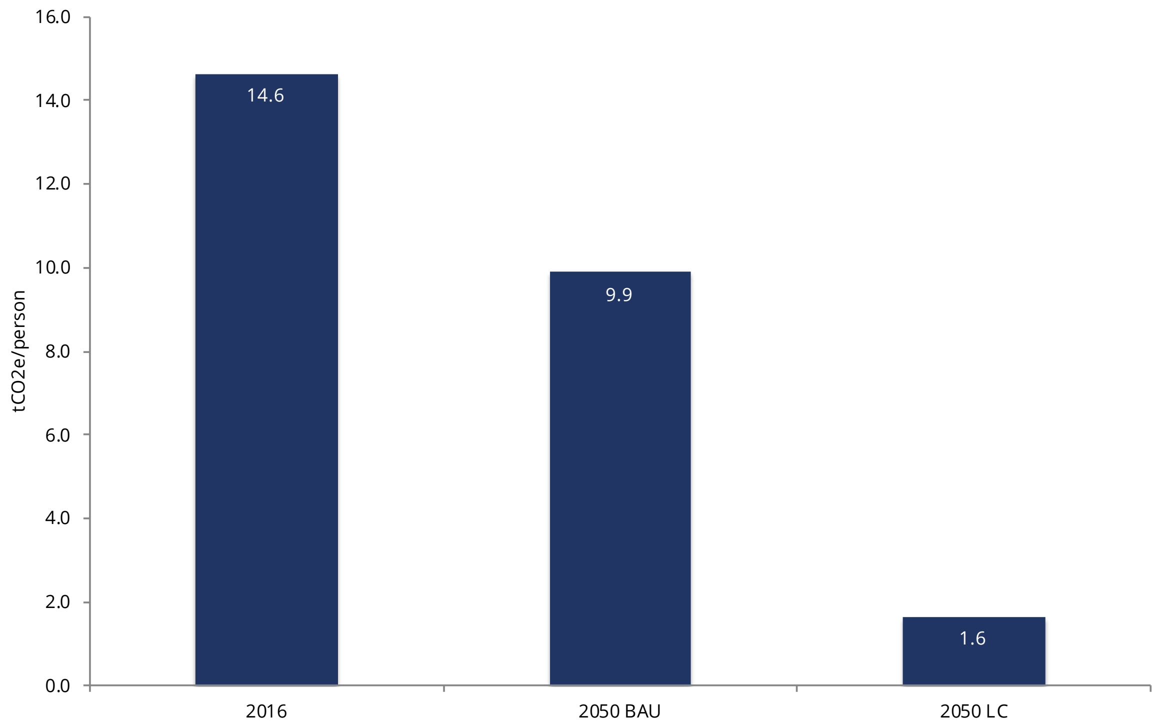


Figure 52. Projected emissions per capita (tCO2e/person), Hamilton.

GHG emissions decline from 14.6 tCO2e per person in 2016, to 1.6 tCO2e in 2050 in the LC scenario. This is a 89% decrease from 2016 to 2050 in the LC scenario, and an 83% decrease between the BAU and LC scenarios in 2050. Table 10 provides a comparison of the total GHG emissions for Hamilton in 2016, and the two scenarios in 2050.

Table 10. Community emissions results- Hamilton.

EMISSIONS BY SECTOR (tCO2e)	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/- 2016-2050 LC	% +/- 2050 BAU-2050 LC
Industrial	5,747,685	67.0%	5,952,081	67.0%	1,098,561	74.3%	-80.9%	-81.5%
Transportation	1,096,430	12.8%	938,692	10.6%	71,724	4.8%	-93.5%	-92.4%
Residential	749,898	8.7%	771,762	8.7%	82,212	5.6%	-89.0%	-89.3%
Commercial	566,942	6.6%	755,545	8.5%	61,212	4.1%	-89.2%	-91.9%
Fugitive	315,811	3.7%	360,585	4.1%	60,443	4.1%	-80.9%	-83.2%
Energy Industries	90,968	1.1%	90,988	1.0%	90,901	6.1%	-0.1%	-0.1%
Waste	11,264	0.1%	16,526	0.2%	14,334	1.0%	27.2%	-13.3%
Total	**8,578,997**		**8,886,180**		**1,479,387**		**-82.8%**	**-83.4%**
EMISSIONS BY SOURCE (tCO2e)	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050 LC**
Coal	4,323,437	50.4%	4,325,570	48.7%	581,459	39.3%	-86.6%	-86.6%
Natural Gas	2,546,767	29.7%	2,907,825	32.7%	487,507	33.0%	-80.9%	-83.2%
Gasoline	898,352	10.5%	777,840	8.8%	454	0.0%	-99.9%	-99.9%
Fugitive	315,811	3.7%	360,585	4.1%	60,443	4.1%	-80.9%	-83.2%
Diesel	201,454	2.3%	158,095	1.8%	15,925	1.1%	-92.1%	-89.9%
Electricity	133,086	1.6%	219,032	2.5%	281,444	19.0%	111.5%	28.5%
Propane	72,510	0.8%	63,744	0.7%	11,934	0.8%	-83.5%	-81.3%
Fuel Oil	60,602	0.7%	39,736	0.4%	14,146	1.0%	-76.7%	-64.4%
Other	15,716	0.2%	17,227	0.2%	11,742	0.8%	-25.3%	-31.8%
Waste	11,264	0.1%	16,526	0.2%	14,334	1.0%	27.2%	-13.3%
Total	**8,578,997**		**8,886,180**		**1,479,387**		**-82.8%**	**-83.4%**
Emissions per capita (tCO2e/ person)	**14.6**		**9.9**		**1.6**		**-88.8 %**	**-83.4 %**

BUILDINGS SECTOR: ENERGY

BUILDING ENERGY USE BY FUEL

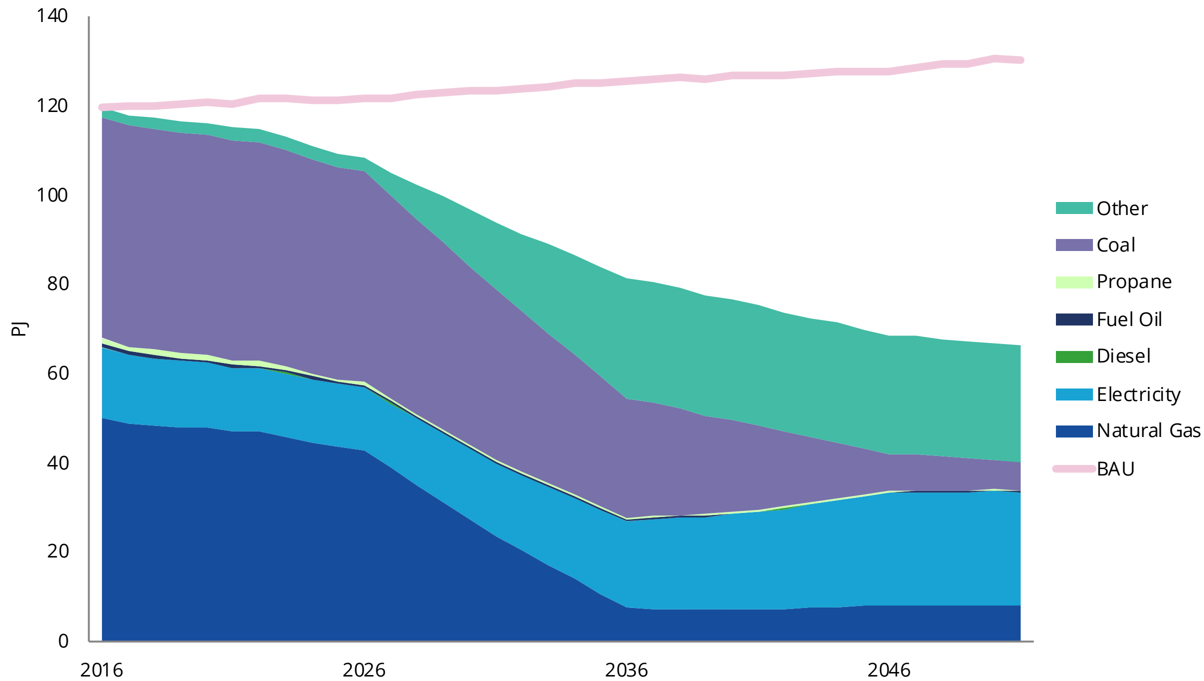


Figure 53. Projected LC building energy use (PJ) by fuel, Hamilton, 2016-2050.

BUILDING ENERGY BY END USE

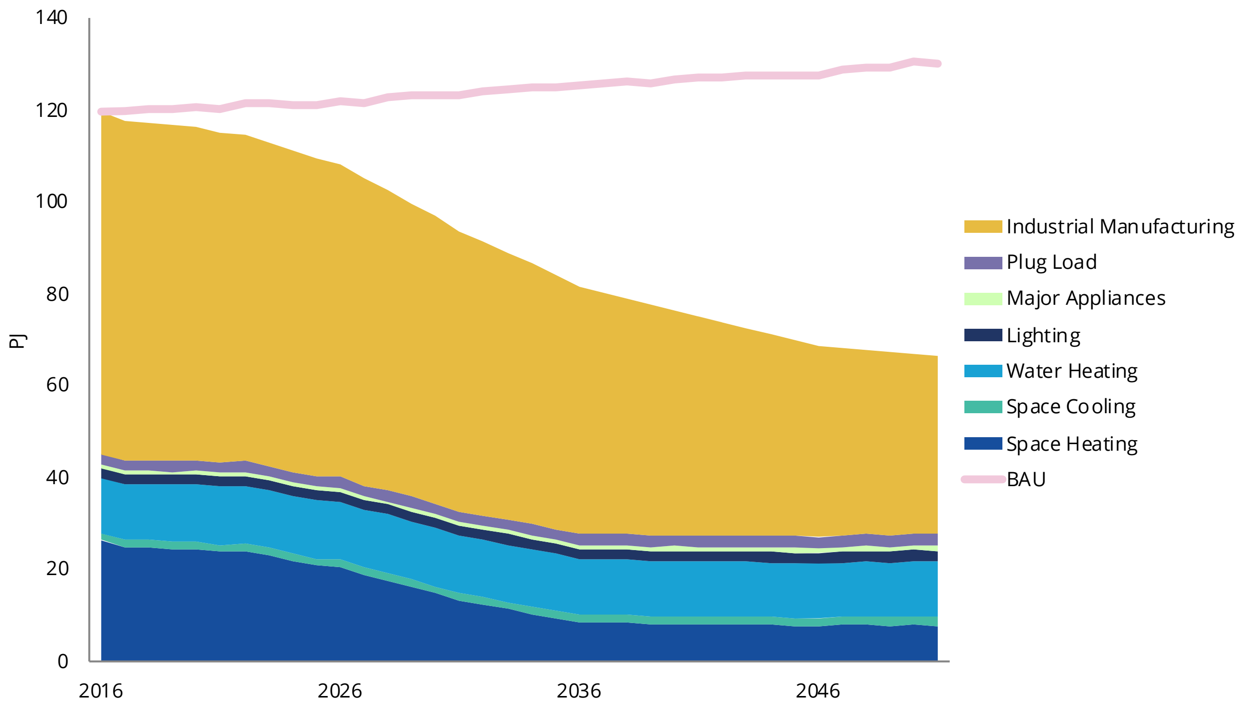


Figure 54. Projected LC building energy use (PJ) by end use, Hamilton, 2016-2050.

The buildings sector sees an overall reduction of energy use from 119 PJ in 2016 to 67 PJ in 2050 under the LC scenario. Electricity consumption increases by 63% over this period, but coal, natural gas, propane, diesel, and fuel oil decrease. The "other" category, which includes solar PV, renewable natural gas, and district energy grows to account for 39% of the energy used by the building sector by 2050.

The overall decrease of 44% in building energy use is a result of a reduction in coal use in industrial manufacturing, retrofits to existing buildings, and improvements to the energy efficiency of new residential buildings. The reduction in energy consumption for industrial manufacturing accounts for 58% of the energy savings, space heating accounts for 12% of the energy savings, and the increased use of solar hot water accounts for an 18% reduction in energy use. Space heating shifts to the use of air source and ground source heat pumps in residential and commercial buildings.

The reduction in heating degree-days was the primary reason energy use increased only a small amount in the BAU scenario as the population grew. The same reduction in heating degree-days is applied to the LC scenario, along the other actions.

BUILDING ENERGY USE BY BUILDING TYPE AND FUEL

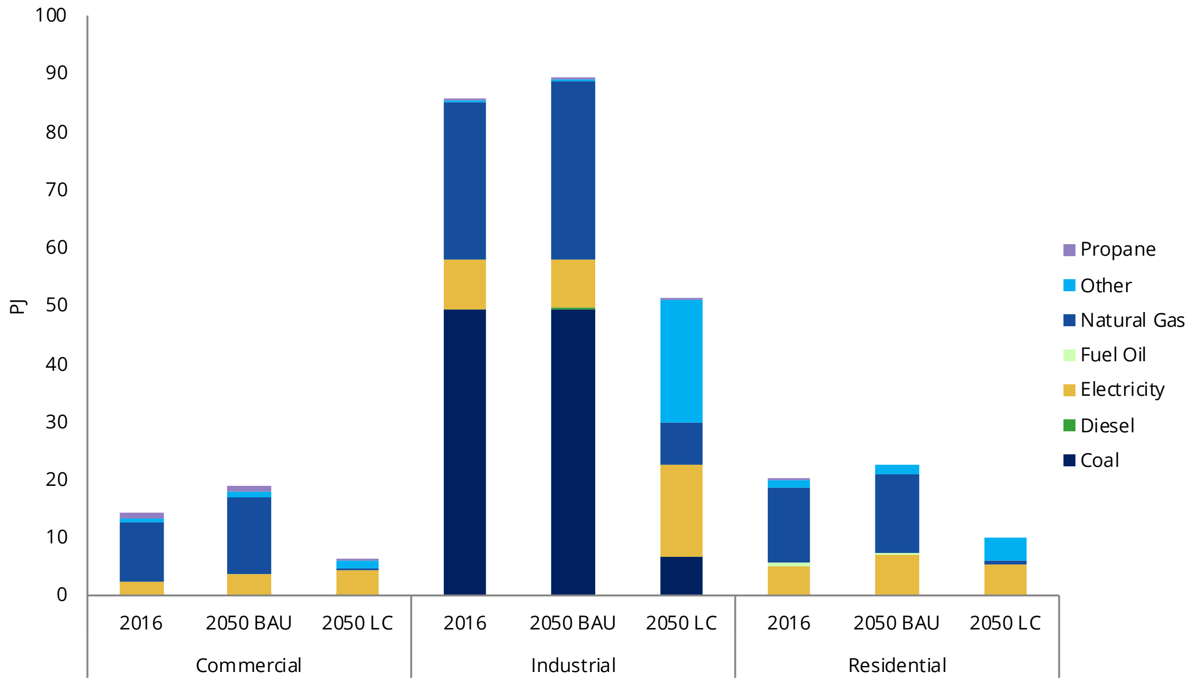


Figure 55. Projected building energy use (PJ) by building type and fuel, Hamilton.

BUILDING ENERGY USE BY BUILDING TYPE AND END USE

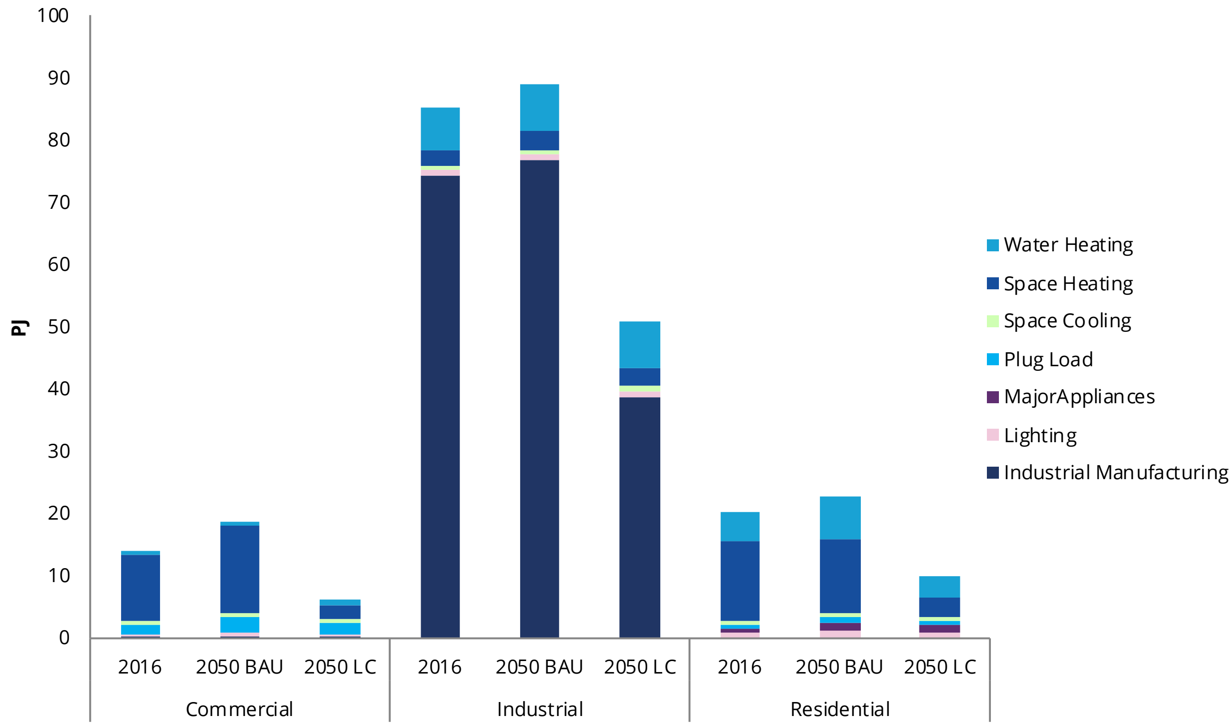


Figure 56. Projected building energy use (PJ) by building type and end use, Hamilton.

The increased use of electricity as the primary fuel source applies to all sectors of buildings. The residential and industrial sectors show a shift to “other” fuel sources, including biogas and locally-generated electricity, with a reduction of coal use by the industrial sector.

By 2030, 100% of new buildings are projected to achieve Passive House levels of performance, and existing buildings are retrofitted to achieve 50% reduction in electrical consumption.

For commercial buildings, the LC scenario projects a reduction in floor space per employee of 25% by 2050, as well as building efficiencies for both new and existing buildings.

While industrial buildings account for the majority of building energy use, all sectors are targeted to reduce overall energy consumption.

PER HOUSEHOLD ENERGY

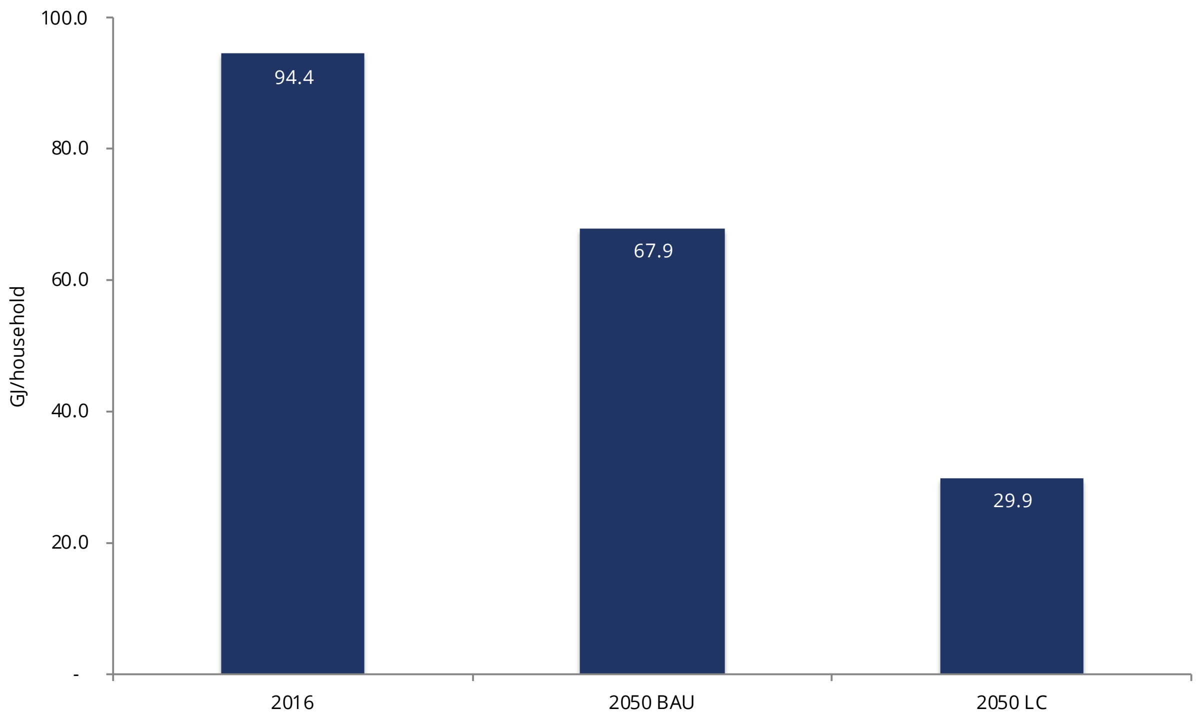


Figure 57. Projected residential energy per household (GJ/household), Hamilton.

Residential energy use per household declines from 94 GJ to 30 GJ between 2016 and 2050 in the LC scenario, a reduction of 68%.

Table 11. Buildings sector energy- Hamilton.

BUILDINGS ENERGY (GJ) BY BUILDING TYPE	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/- 2016-2050 LC	% +/- 2050 BAU-2050LC
Industrial	85,246,722	71.3%	89,009,634	68.2%	50,854,322	76.0%	-40.3%	-42.9%
Residential	20,234,365	16.9%	22,701,528	17.4%	9,976,934	14.9%	-50.7%	-56.1%
Commercial	14,133,156	11.8%	18,816,129	14.4%	6,123,469	9.1%	-56.7%	-67.5%
Total	**119,614,244**		**130,527,291**		**66,954,725**		**-44.0%**	**-48.7%**
BUILDINGS ENERGY (GJ) BY FUEL	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Natural Gas	50,068,489	41.9%	57,432,617	44.0%	8,067,117	12.0%	-83.9%	-86.0%
Coal	49,411,059	41.3%	49,435,446	37.9%	6,645,299	9.9%	-86.6%	-86.6%
Electricity	15,718,922	13.1%	19,059,713	14.6%	25,537,507	38.1%	62.5%	34.0%
Other	2,283,939	1.9%	2,906,511	2.2%	26,254,597	39.2%	1049.5%	803.3%
Propane	1,185,520	1.0%	1,042,217	0.8%	195,116	0.3%	-83.5%	-81.3%
Fuel Oil	885,562	0.7%	577,348	0.4%	205,643	0.3%	-76.8%	-64.4%
Diesel	60,753	0.1%	73,439	0.1%	49,448	0.1%	-18.6%	-32.7%
Total	**119,614,244**		**130,527,291**		**66,954,725**		**-44.0%**	**-48.7%**
BUILDINGS ENERGY (GJ) BY END USE	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/ 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Industrial Manufacturing	74,441,332	62.2%	77,121,304	59.1%	39,065,408	58.3%	-47.5%	-49.3%
Space Heating	26,333,528	22.0%	28,937,516	22.2%	7,995,828	11.9%	-69.6%	-72.4%
Water Heating	12,102,880	10.1%	15,109,045	11.6%	11,991,537	17.9%	-0.9%	-20.6%
Plug Load	2,317,607	1.9%	3,367,141	2.6%	2,618,609	3.9%	13.0%	-22.2%
Lighting	2,159,332	1.8%	2,640,426	2.0%	2,385,106	3.6%	10.5%	-9.7%
Space Cooling	1,501,792	1.3%	2,170,364	1.7%	1,842,710	2.8%	22.7%	-15.1%
Major Appliances	757,772	0.6%	1,181,495	0.9%	1,055,527	1.6%	39.3%	-10.7%
Total	**119,614,244**		**130,527,291**		**66,954,725**		**-44.0%**	**-48.7%**

BUILDINGS SECTOR: EMISSIONS

BUILDING EMISSIONS BY FUEL SOURCE

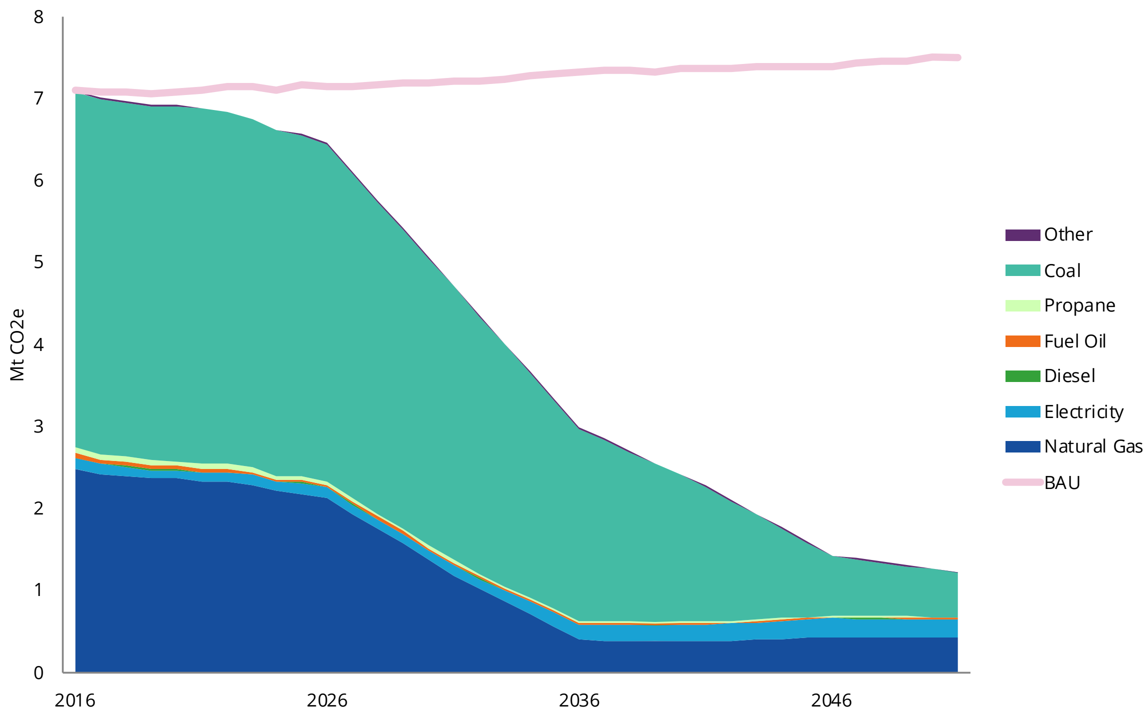


Figure 58. Projected LC building GHG emissions (MtCO2e) by source, Hamilton, 2016-2050.

BUILDING EMISSIONS BY END USE

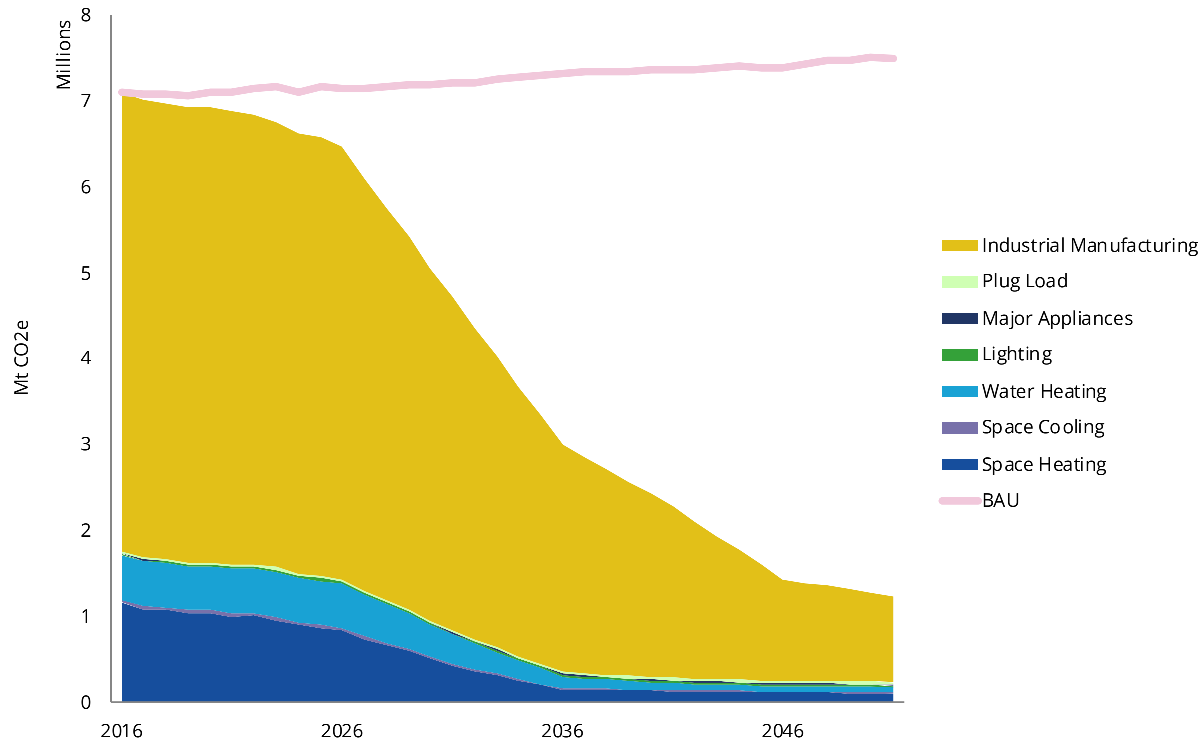


Figure 59. Projected LC building GHG emissions (MtCO2e) by end use, Hamilton, 2016-2050.

The shift away from carbon-intensive fuel sources, particularly coal and natural gas, results in GHG emissions reduction of 46% from the 2016 baseline. The reduction in overall consumption of energy through retrofits and Passive House standards for new residential and commercial buildings drives the reduction in non-industrial emissions, followed by the switch to low- and zero-emission fuel sources.

The switch to heat pumps for space heating, and solar for water heating result in a shift from a fossil fuel source to a low or zero GHG emissions source. These reductions are augmented by the decreased demand for energy as a result of more efficient buildings, as well as the reduction in GHG emissions from industrial manufacturing by fuel switching, and a decreased volume of steel produced.

BUILDING EMISSIONS BY BUILDING TYPE AND FUEL

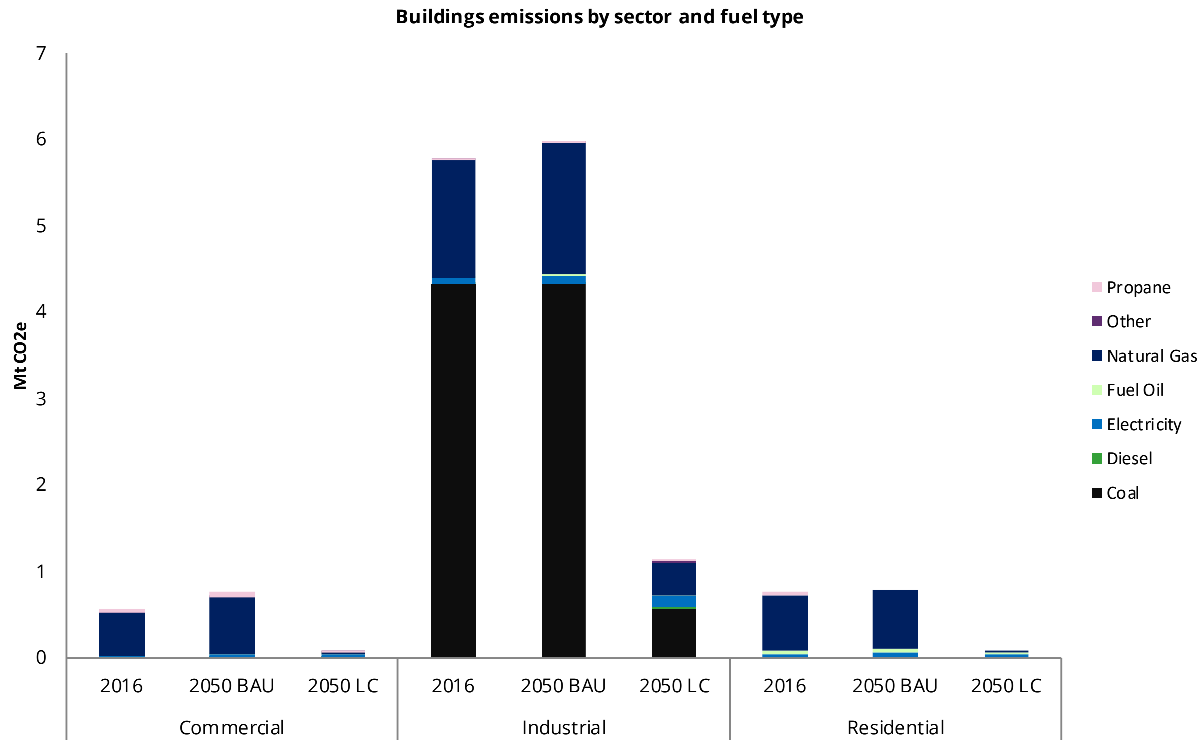


Figure 60. Projected building GHG emissions (MtCO2e) by building type and source, Hamilton.

BUILDING EMISSIONS BY BUILDING TYPE AND END USE

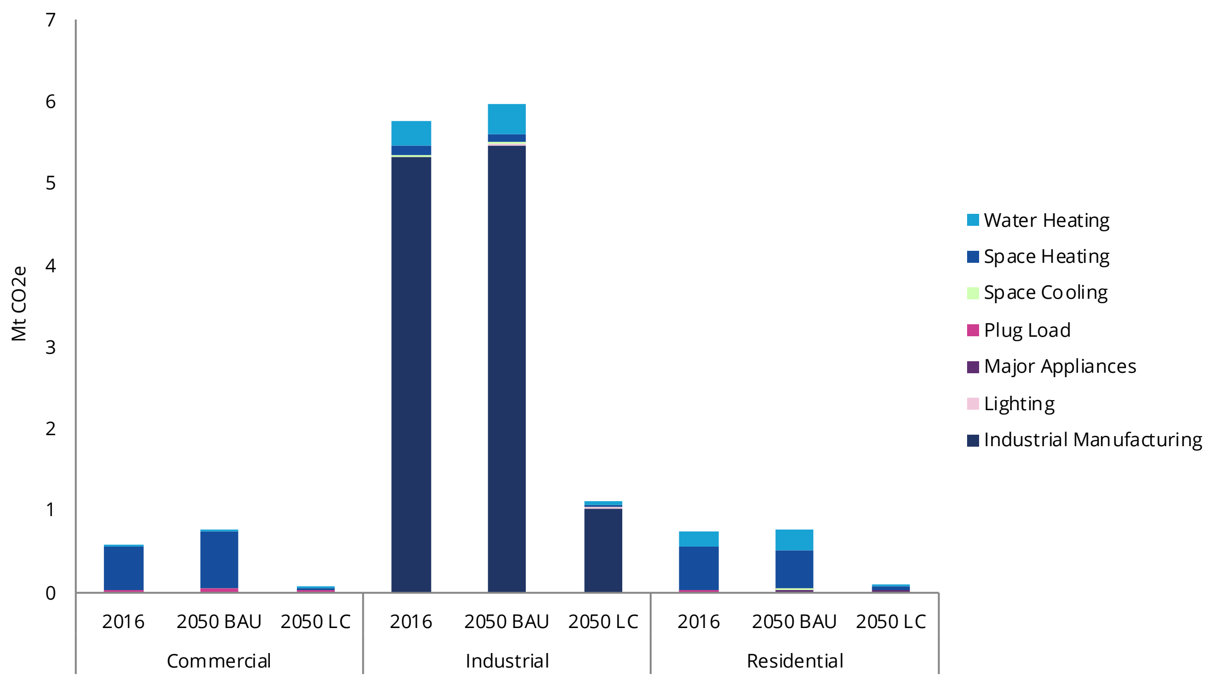


Figure 61. Projected building emissions (MtCO2e) by building type and end use, Hamilton.

In 2016, coal is the dominant source of GHG emissions in the buildings sector, which is reduced by 81% in the LC scenario. Natural gas is the primary fuel source for residential and commercial buildings. By switching to electricity and reducing overall consumption, GHG emissions are reduced by 88% in these sectors.

Total GHG emissions are reduced by 82% between the 2016 baseline, and the 2050 LC scenario.

Industrial manufacturing accounts for 75% of GHG emissions in 2016, and is reduced by 81% in the LC scenario.

Space heating and water heating are the primary non-industrial source of GHG emissions in 2016. By switching to heat pumps and solar hot water, and changing from natural gas to electricity as the primary fuel source, GHG emissions are reduced by 91% and 89% for space heating and water heating, respectively.

PER HOUSEHOLD EMISSIONS

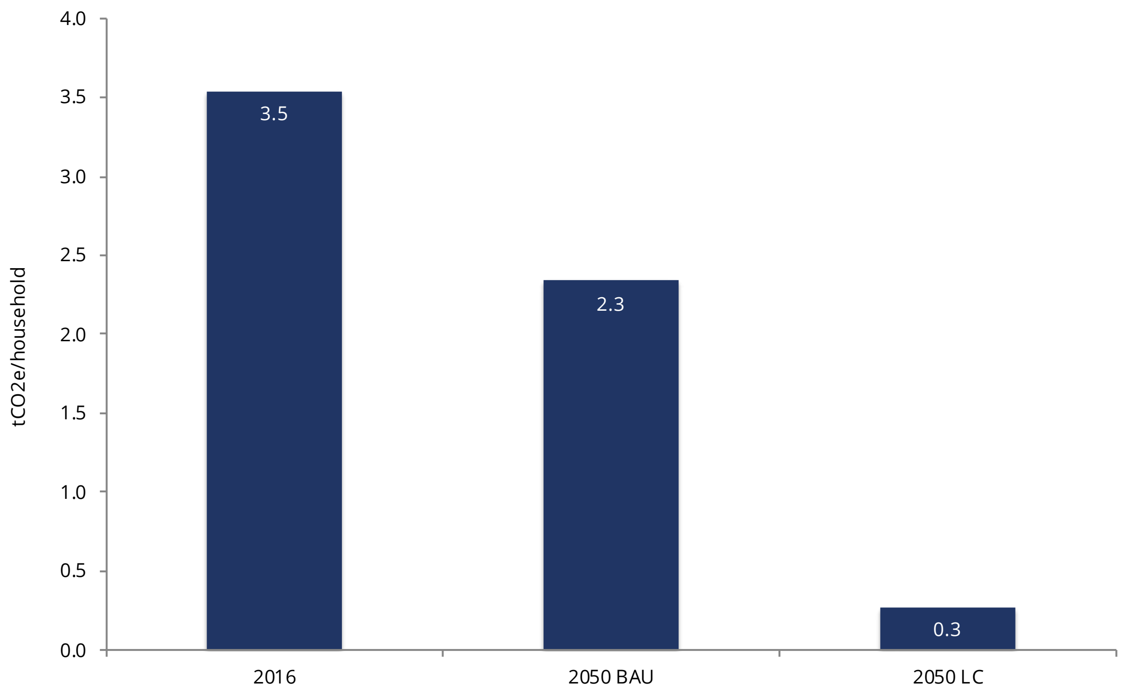


Figure 62. Projected residential emissions per household (tCO2e/household), Hamilton.

Residential GHG emissions decrease by 88% by 2050 in the LC scenario. These emissions savings are a result of retrofits to existing buildings to maximize energy efficiency, Passive House standards for new houses, use of energy efficient heating sources, and fuel switching away from fossil fuels.

Details of the buildings emissions results are shown in Table 12.

Table 12. Buildings sector emissions- Hamilton.

BUILDINGS EMISSIONS (tCO2e) BY BUILDING TYPE	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/- 2016-2050 LC	% +/- 2050 BAU-2050LC
Industrial	5,762,966	81.2%	5,964,617	79.4%	1,119,659	87.7%	-80.6%	-81.2%
Residential	758,992	10.7%	782,054	10.4%	89,366	7.0%	-88.2%	-88.6%
Commercial	571,418	8.1%	761,112	10.1%	67,075	5.3%	-88.3%	-91.2%
Total	**7,093,376**		**7,507,783**		**1,276,100**		**-82.0%**	**-83.0%**
BUILDINGS EMISSIONS (tCO2e) BY FUEL	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/ 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Coal	4,323,437	61.0%	4,325,570	57.6%	581,460	45.6%	-86.6%	-86.6%
Natural Gas	2,483,632	35.0%	2,844,234	37.9%	429,588	33.7%	-82.7%	-84.9%
Electricity	133,017	1.9%	211,877	2.8%	223,599	17.5%	68.1%	5.5%
Propane	72,510	1.0%	63,744	0.8%	11,934	0.9%	-83.5%	-81.3%
Fuel Oil	60,602	0.9%	39,736	0.5%	14,146	1.1%	-76.7%	-64.4%
Other	15,716	0.2%	17,227	0.2%	11,742	0.9%	-25.3%	-31.8%
Diesel	4,463	0.1%	5,395	0.1%	3,633	0.3%	-18.6%	-32.7%
Total	**7,093,376**		**7,507,783**		**1,276,100**		**-82.0%**	**-83.0%**
BUILDINGS EMISSIONS (tCO2e) BY END USE	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Industrial Manufacturing	5,332,512	75.2%	5,474,249	72.9%	1,033,250	81.0%	-80.6%	-81.1%
Space Heating	1,159,078	16.3%	1,267,244	16.9%	106,836	8.4%	-90.8%	-91.6%
Water Heating	515,916	7.3%	627,681	8.4%	57,445	4.5%	-88.9%	-90.8%
Space Cooling	32,074	0.5%	45,307	0.6%	14,990	1.2%	-53.3%	-66.9%
Plug Load	25,727	0.4%	45,872	0.6%	27,263	2.1%	6.0%	-40.6%
Lighting	18,273	0.3%	29,352	0.4%	20,883	1.6%	14.3%	-28.9%
Major Appliances	9,797	0.1%	18,078	0.2%	15,434	1.2%	57.5%	-14.6%
Total	**7,093,376**		**7,507,783**		**1,276,100**		**-82.0%**	**-83.0%**

TRANSPORTATION SECTOR ENERGY

TRANSPORTATION ENERGY BY FUEL

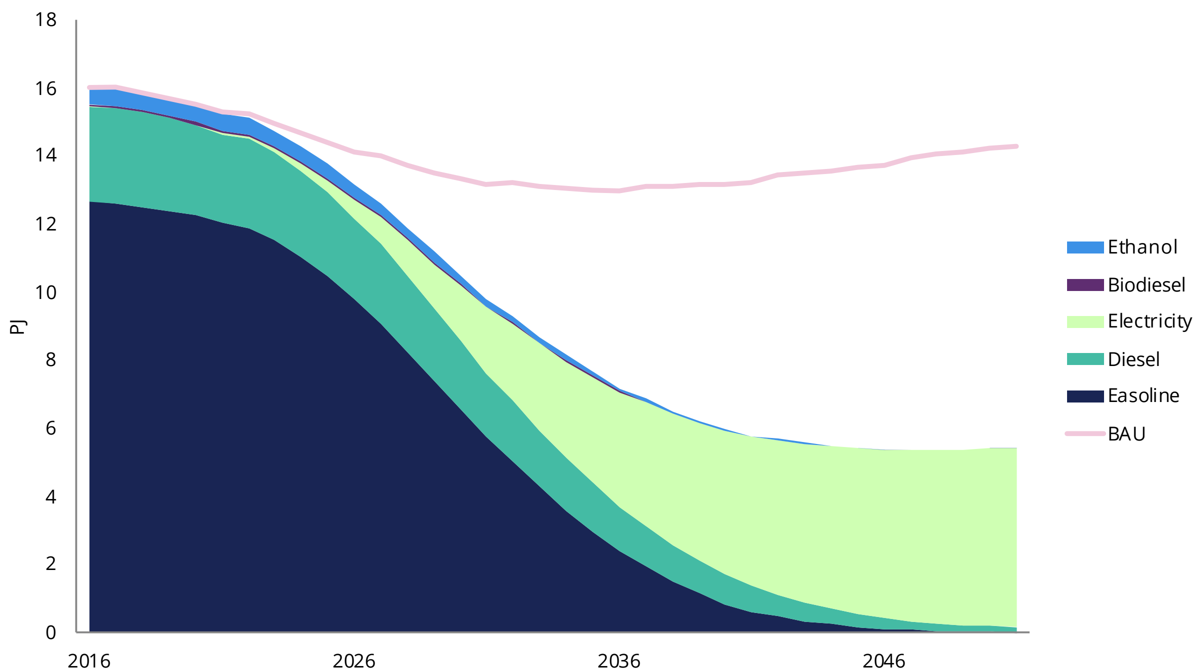


Figure 63. Projected LC transportation energy use (PJ) by fuel, Hamilton, 2016-2050.

TRANSPORTATION ENERGY BY VEHICLE TYPE

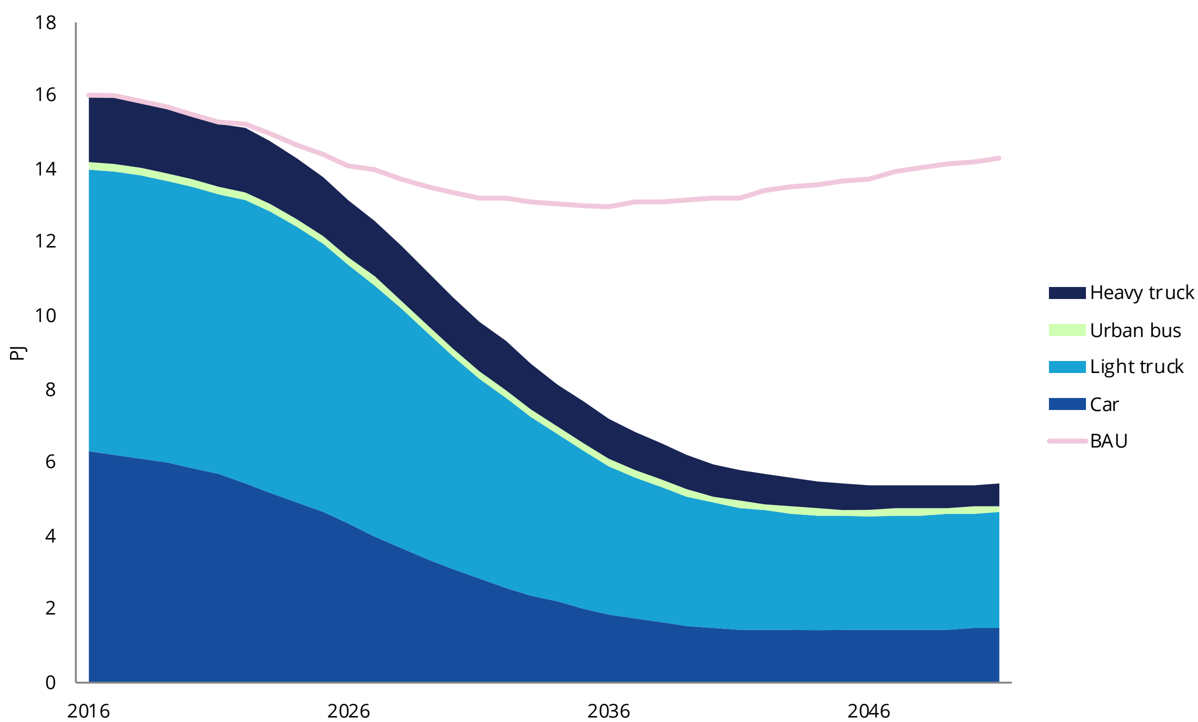


Figure 64. Projected LC transportation energy use (PJ) by vehicle type, Hamilton, 2016-2050.

Transportation energy consumption declines by 66% in 2050 in the LC scenario over the 2016 baseline, and by 62% in comparison with the 2050 BAU. Fossil fuels are entirely, or almost entirely, eliminated as a fuel source, and are replaced by electricity.

In addition to fuel switching, energy consumption is reduced by behavioural changes like mode-shifting to transit and active transportation.

Light trucks and cars represent the majority of the vehicle market in 2016, and market trends predict that light trucks will become dominant, representing 58% of the energy demand in 2050.

All vehicle classes become more efficient, which accounts for the decline in energy consumption in the BAU scenario, in spite of the growing population. This is also reflected in the reduced energy consumption in the LC scenario.

TRANSPORTATION ENERGY BY VEHICLE TYPE & FUEL

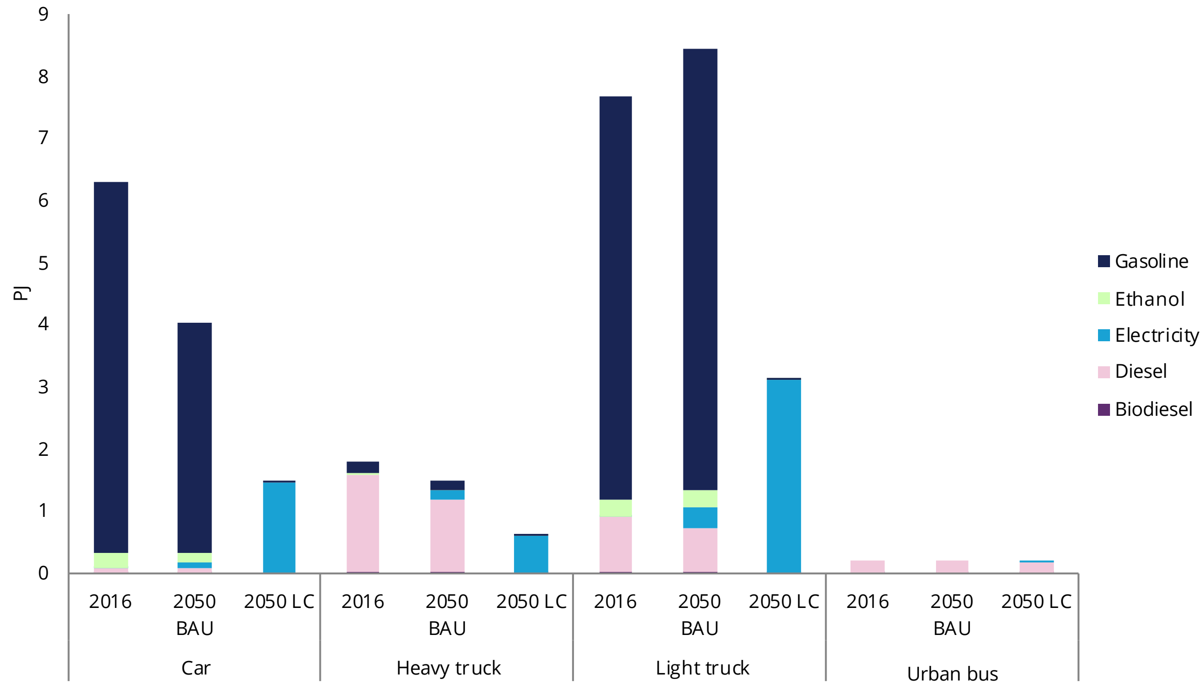


Figure 65. Projected transportation energy use (PJ) by vehicle type and fuel, Hamilton.

Cars and light trucks consume 87% of the transportation energy demand in 2016, and 85% of the energy demand in the LC scenario in 2050.

Table 13. Transportation sector energy - Hamilton

TRANSPORTATION ENERGY (GJ) BY FUEL	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/- 2016-2050 LC	% +/- 2050 BAU-2050LC
Gasoline	12,669,002	79.2%	10,947,703	77.1%	7,257	0.1%	-99.9%	-99.9%
Diesel	2,761,727	17.3%	2,140,594	15.1%	173,083	3.2%	-93.7%	-91.9%
Ethanol	508,923	3.2%	439,777	3.1%	291	0.0%	-99.9%	-99.9%
Biodiesel	63,996	0.4%	49,603	0.3%	4,011	0.1%	-93.7%	-91.9%
Electricity	274	0.0%	616,470	4.3%	5,212,606	96.6%	1905353.8%	745.6%
Total	**16,003,923**		**14,194,148**		**5,397,247**		**-66.3%**	**-62.0%**
TRANSPORTATION ENERGY (GJ) BY VEHICLE TYPE	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/- 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Light truck	7,668,791	47.9%	8,441,118	59.5%	3,134,777	58.1%	-59.1%	-62.9%
Car	6,306,739	39.4%	4,045,665	28.5%	1,470,016	27.2%	-76.7%	-63.7%
Heavy truck	1,805,299	11.3%	1,484,272	10.5%	613,523	11.4%	-66.0%	-58.7%
Urban bus	223,094	1.4%	223,094	1.6%	178,932	3.3%	-19.8%	-19.8%
Total	**16,003,923**		**14,194,148**		**5,397,247**		**-66.3%**	**-62.0%**

TRANSPORTATION SECTOR EMISSIONS

TRANSPORTATION EMISSIONS BY SOURCE

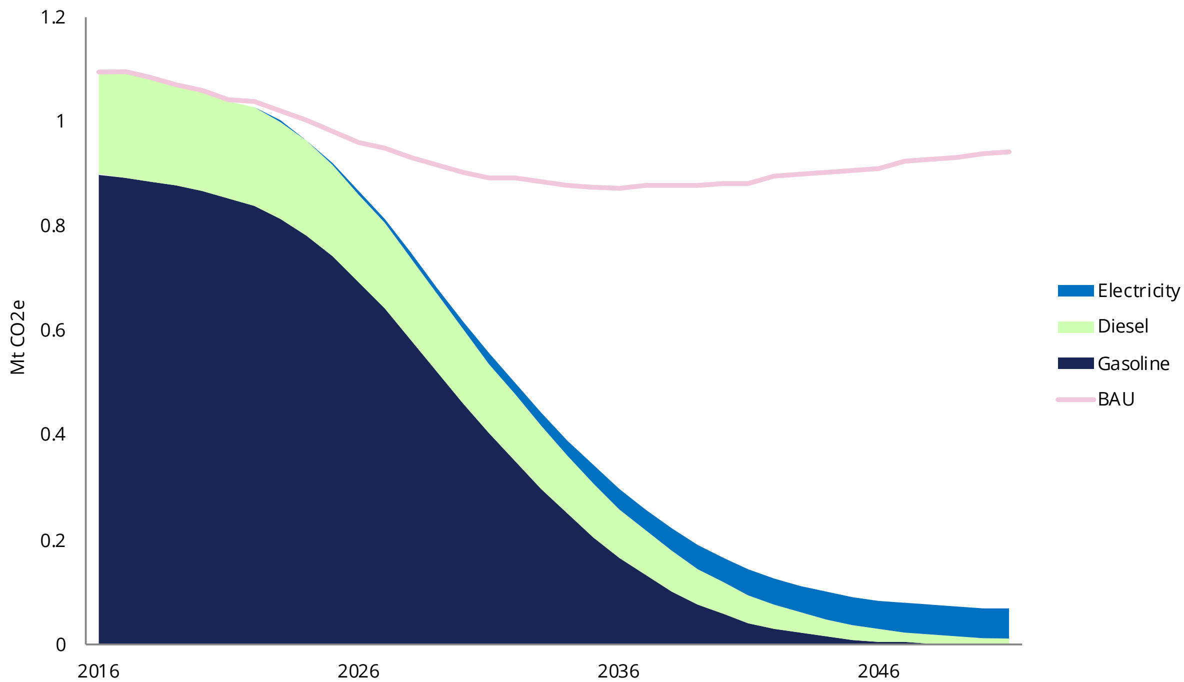


Figure 66. Projected LC transportation GHG emissions (MtCO2e) by source, Hamilton, 2016-2050.

TRANSPORTATION EMISSIONS BY VEHICLE TYPE

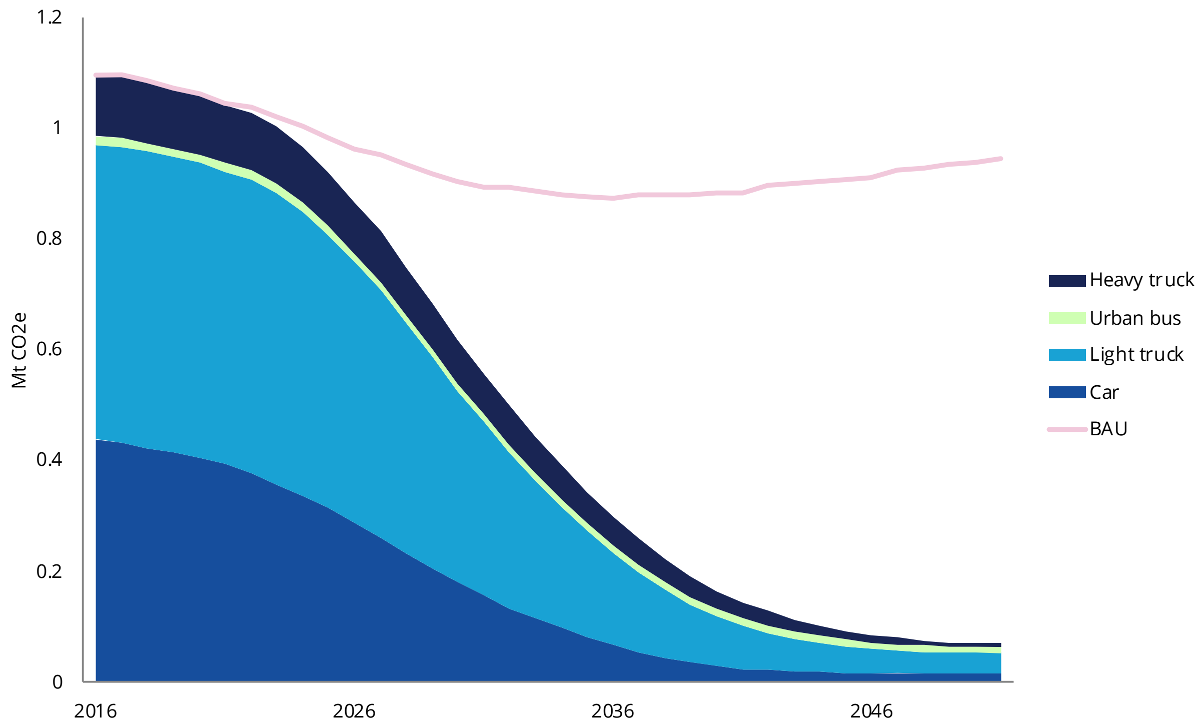


Figure 67. Projected LC transportation GHG emissions (MtCO2e) by vehicle type, Hamilton, 2016-2050.

GHG emissions from transportation are dominated by gasoline (82%), with lesser contributions from diesel (18%) in 2016. By switching to electric vehicles for all classes, GHG emissions are reduced by 94% in the LC scenario by 2050. While reduced vehicle use and increased transit and active transportation contribute to the reduction in GHG emissions, the elimination of carbon-intensive fuel sources is critical to achieving these levels of emissions reductions.

The market share of light trucks is projected to increase, representing 50% of the GHG emissions in 2050. GHG emissions fall from 531 ktCO2e from light trucks in 2016 to 35 ktCO2e in 2050 because of improved efficiency standards, and the uptake of electric vehicles by 2030.

Total GHG emissions from vehicles decrease by 94% between 2016 and 2050 in the LC scenario, a decrease of 93% from the BAU scenario.

TRANSPORTATION EMISSIONS BY SOURCE AND VEHICLE TYPE

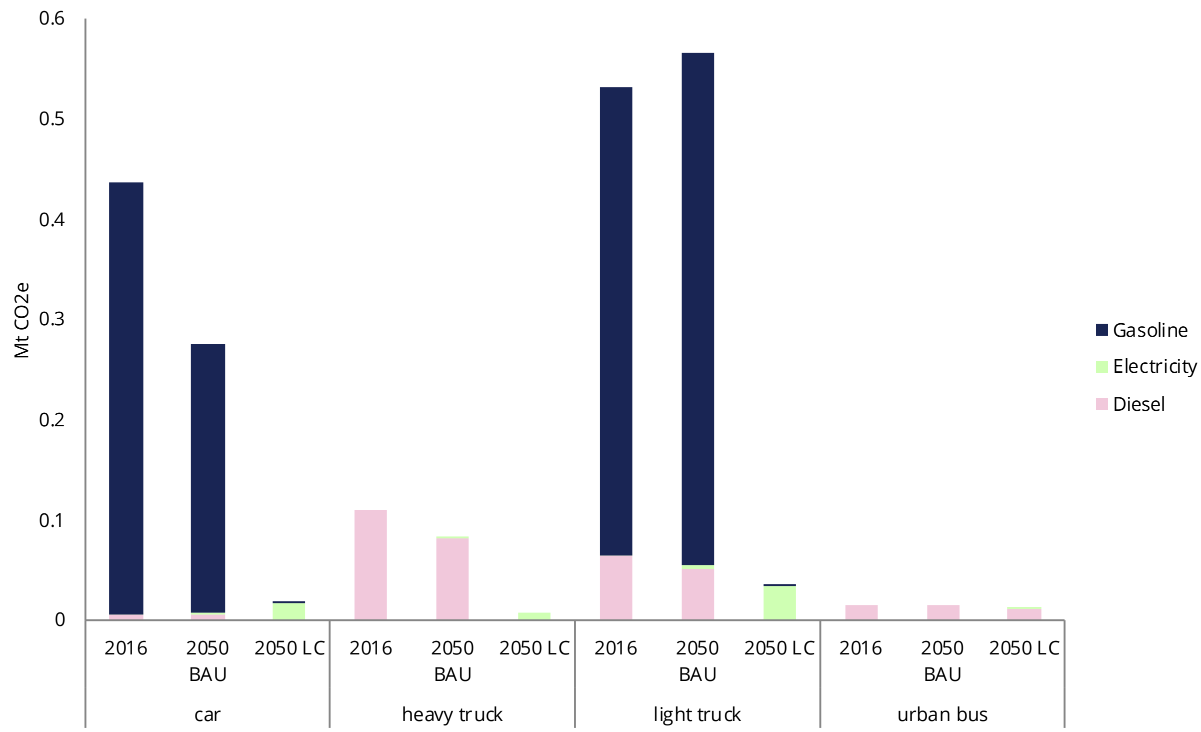


Figure 68. Projected transportation GHG emissions (MtCO2e) by source and vehicle type, Hamilton.

In 2016, cars and light trucks are the primary source of GHG emissions (88%), producing a combined 969 ktCO2e. While they are still the dominant source of GHG emissions (73%) by 2050 in the LC scenario, total emissions from cars and light trucks drops to 52 ktCO2e.

Table 14. Transportation sector emissions- Hamilton.

TRANSPORTATION EMISSIONS (tCO2e) BY FUEL	2016	SHARE 2016	2050 (BAU)	SHARE 2050	2050 (LC)	SHARE 2050	% +/ 2016-2050 LC	% +/- 2050 BAU-2050LC
Gasoline	898,352	82.0%	777,840	82.9%	454	0.6%	-99.9%	-99.9%
Diesel	196,991	18.0%	152,700	16.3%	12,292	17.4%	-93.8%	-91.9%
Electricity	3	0.0%	7,302	0.8%	57,845	81.9%	2,278,214.1%	692.1%
Total	**1,095,345**		**937,843**		**70,591**		**-93.6%**	**-92.5%**
TRANSPORTATION EMISSIONS (tCO2e) BY VEHICLE TYPE	**2016**	**SHARE 2016**	**2050 (BAU)**	**SHARE 2050**	**2050 (LC)**	**SHARE 2050**	**% +/ 2016-2050 LC**	**% +/- 2050 BAU-2050LC**
Light truck	531,787	48.5%	564,793	60.2%	35,426	50.2%	-93.3%	-93.7%
Car	437,236	39.9%	274,335	29.3%	16,314	23.1%	-96.3%	-94.1%
Heavy truck	110,842	10.1%	83,234	8.9%	7,230	10.2%	-93.5%	-91.3%
Urban bus	15,480	1.4%	15,480	1.7%	11,621	16.5%	-24.9%	-24.9%
Total	**1,095,345**		**937,843**		**70,591**		**-93.6%**	**-92.5%**

WASTE SECTOR EMISSIONS

WASTE EMISSIONS BY TYPE

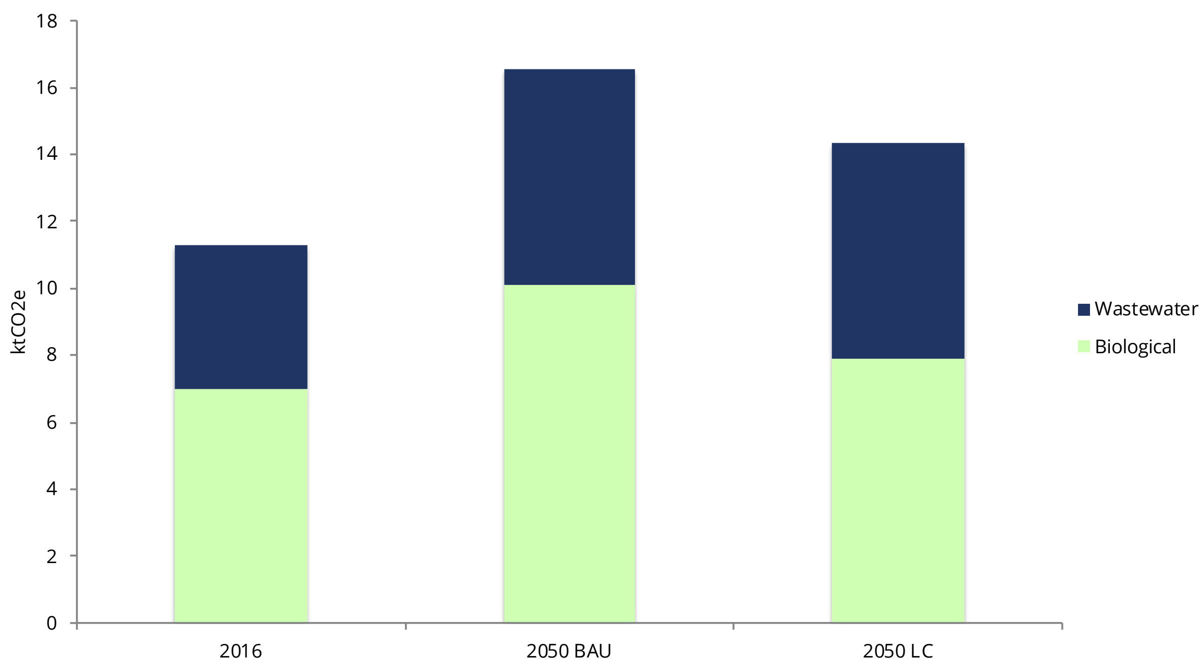


Figure 69. Projected waste emissions (tCO2e), Hamilton.

The LC scenario assumes that waste generation will decrease by 50% per capita by 2050, and that diversion rates will increase by 50% per capita in the same time period. Wastewater GHG emissions change little between the BAU and the LC scenarios. The reduction in GHG emissions in landfills is the result of increased capture of methane, as well as the reduction in per capita waste production.

ENERGY EXPENDITURES

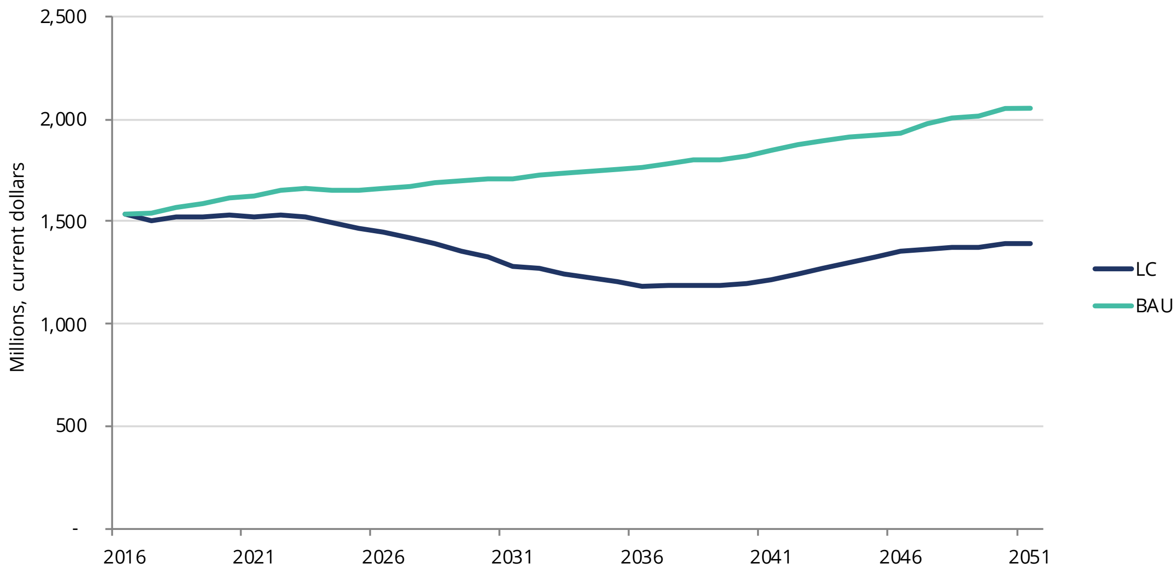


Figure 70. Total energy expenditures for BAU and LC, Hamilton, 2016-2050.

Total energy expenditures in Hamilton were $1.54 million in 2016, climbing to $2.05 billion in 2050 in the BAU scenario. The LC scenario results in annual energy expenditure savings of $650 million by 2050. Cumulative savings between 2018 and 2050 on energy expenditures are $14 billion. Figure 71 shows that the energy expenditures in Hamilton are roughly split between electricity and natural gas and as natural gas is phased out due to electrification of heating and transportation, expenditures on electricity double by 2050.

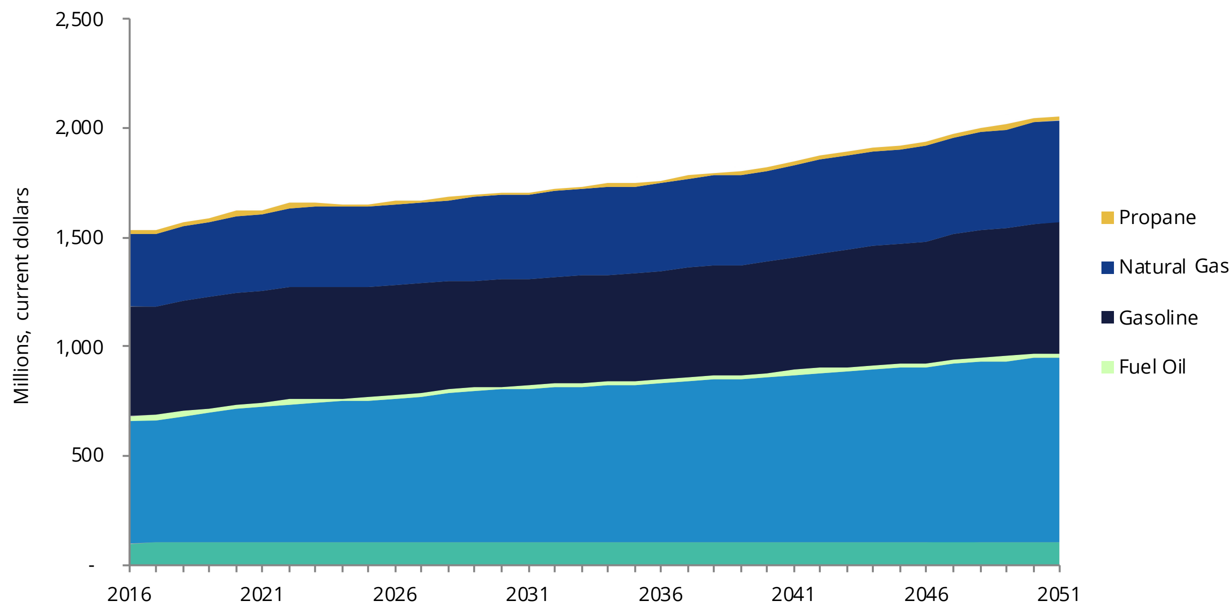


Figure 71. BAU energy costs by fuel type, Hamilton

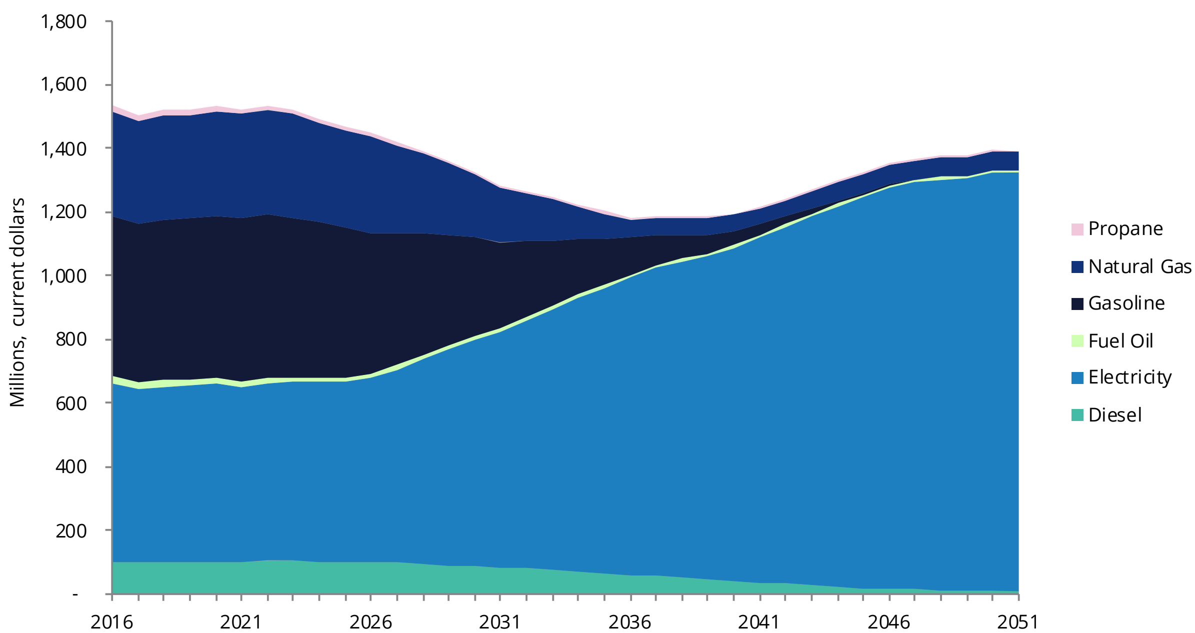


Figure 72. LC energy costs by fuel type, Hamilton.

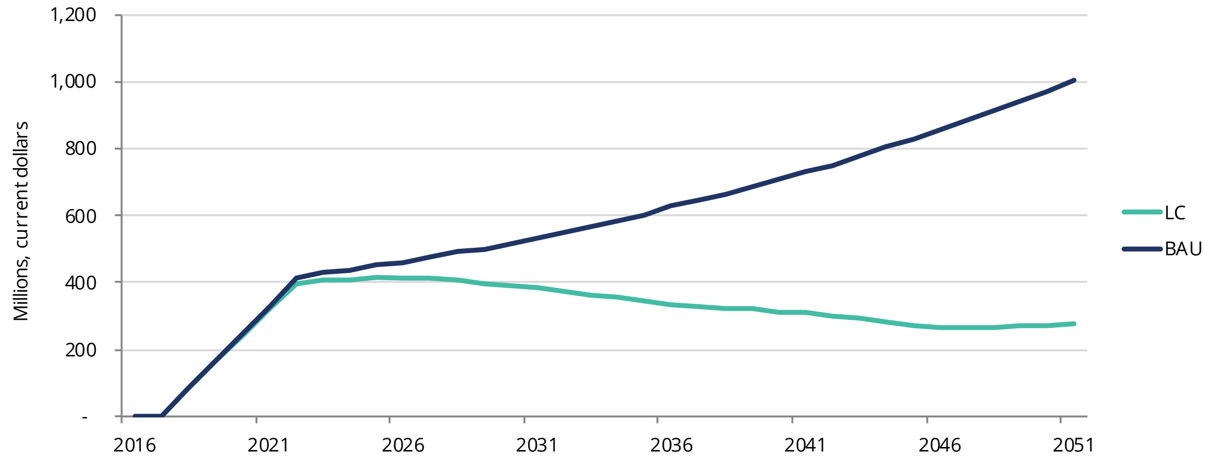


Figure 73. Total cost of carbon emissions. Hamilton, BAU vs LC.

The costs associated with the Federal carbon tax were also evaluated. In 2019, carbon tax expenditures total $164 million per year, climbing to $1 billion per year by 2050 in the BAU. In the low-carbon scenario, carbon tax expenditures fall to $277 million in 2050, a savings of $730 million. Cumulative savings between 2019 and 2050 are $9 billion between 2019 and 2050. Figures 74 and 75 illustrate the impact of the carbon tax on various sectors. Carbon tax expenditures are dominated by the industrial sector. In the low-carbon scenario, carbon tax expenditures in the industrial sector decline by more than half, and other sectors head towards zero.

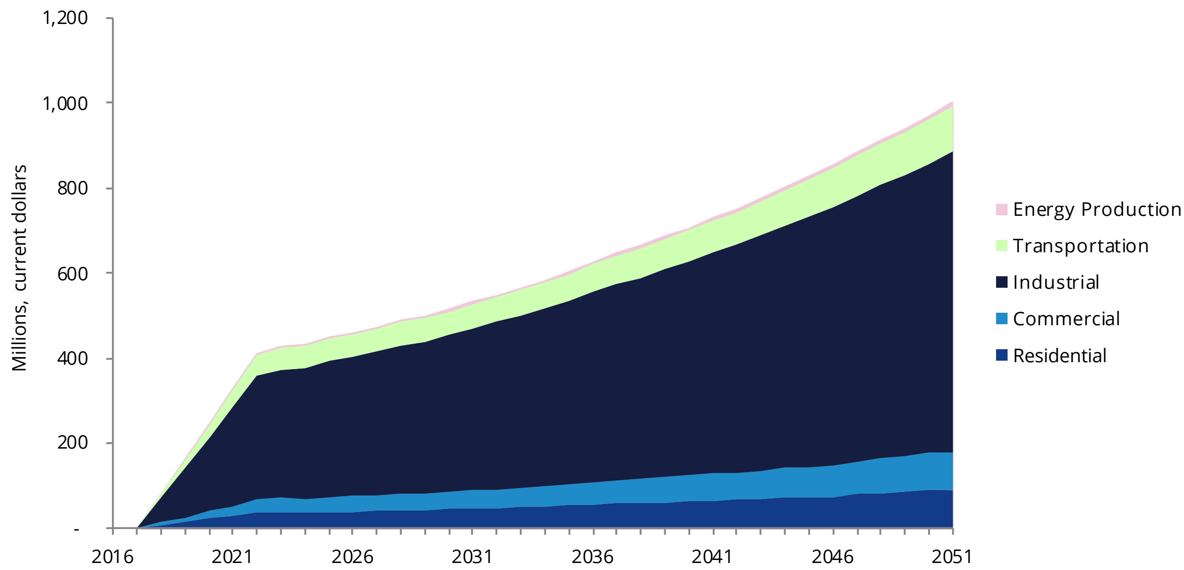


Figure 74. BAU emission costs by fuel type, Hamilton.

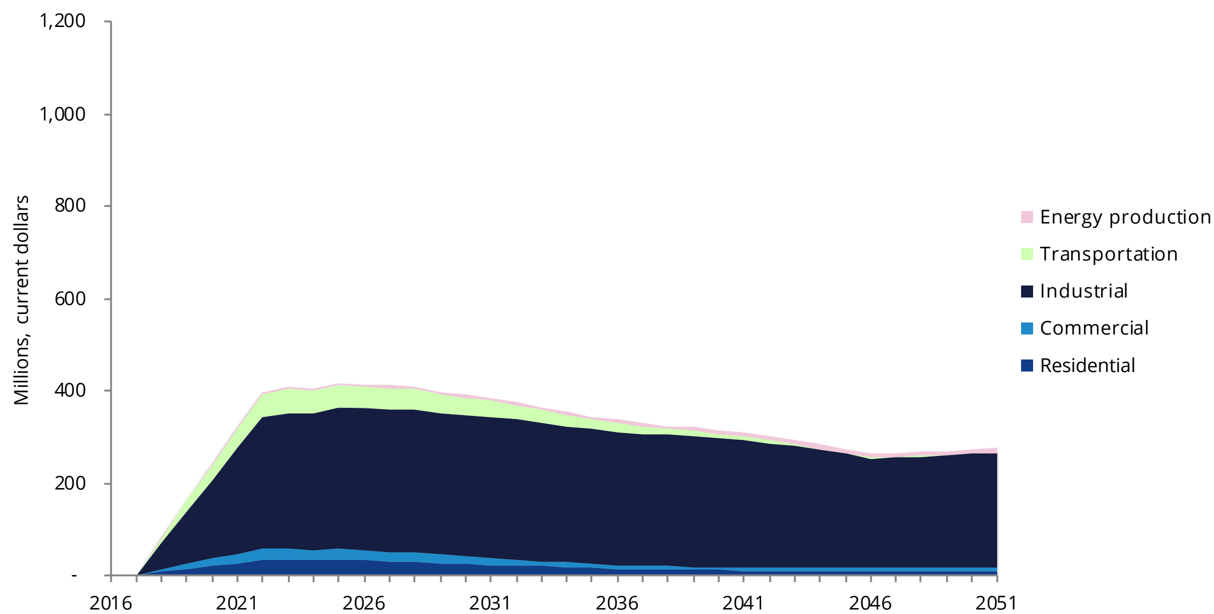


Figure 75. LC emission costs by fuel type, Hamilton.

PART 4: SHORT, MEDIUM AND LONG-TERM ACTION RECOMMENDATIONS

TARGETS

Targets for GHG emissions have been identified by decade out until 2050 for each of the cities and the Bay Area as a whole. GHG emissions targets by sectors can also be specified in order to align with the low-carbon scenario. In addition to the decadal targets, a carbon budget is also specified; a carbon budget represents the cumulative GHG emissions associated with the low-carbon pathway over the period from 2018 to 2050. The carbon budget, like a financial budget, is an envelope of GHG emissions from which the city subtracts its annual GHG emissions to identify whether or not the overall trajectory is on track. Additionally, a carbon budget allows the City or Bay Area to align with the global carbon budget, which seeks to limit warming to either 1.5° or 2°. The latest science indicates that in order to restrict warming to less than 2°, the global carbon budget is approximately 1,000 GtCO2, assuming a 66% degree of confidence.[6] Restricting GHG emissions to 1.5° implies an even more strict budget of 400 GtCO2.[7,8]

The 2050 GHG target for the Bay Area is 1.6 MtCO2e, a significant drop over the 2016 total of 9.8 MtCO2e. The cumulative total, or carbon budget, between 2018 and 2050 is 176 MtCO2e.

6 Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., Church, J. A., ... & Edenhofer, O. (2014). IPCC fifth assessment synthesis report-climate change 2014 synthesis report.
7 Carbon countdown (2016). Carbon Brief. Analysis: Only five years left before 1.5C carbon budget is blown. Retrieved from: https://www.carbonbrief.org/analysis-only-five-years-left-before-one-point-five-c-budget-is-blown
8 Note that Hamilton and Burlington's targets have not been aligned with the global carbon budget as part of this project.

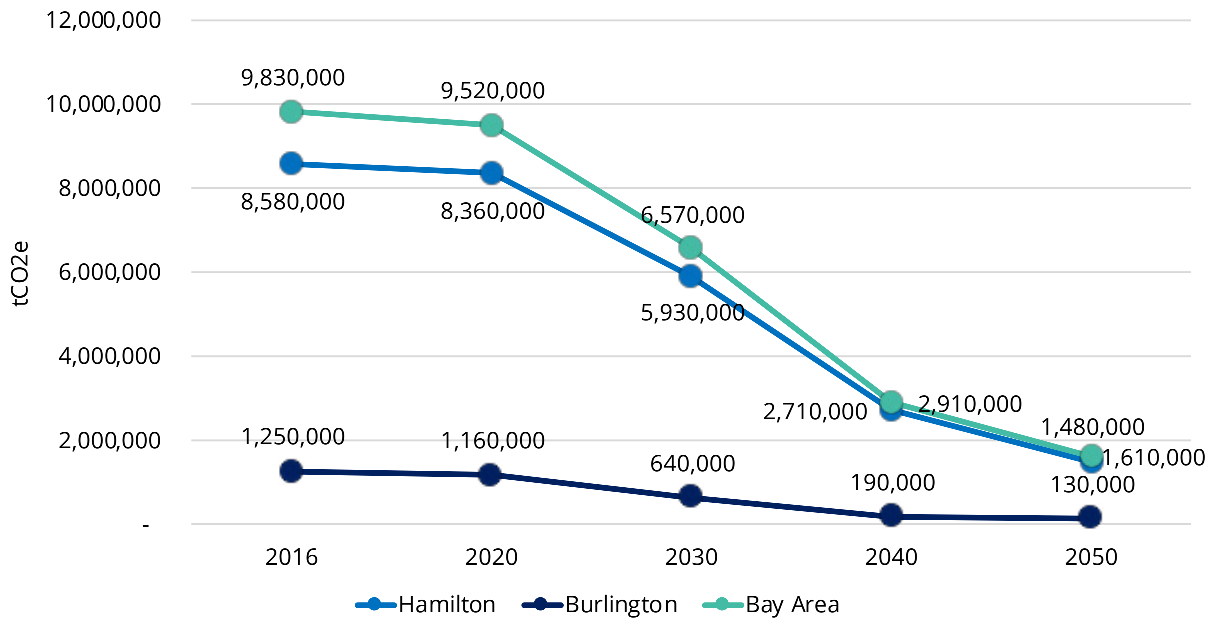


Figure 76. GHG targets for Hamilton, Burlington and the Bay Area.

CO-BENEFITS

In many cases, actions that reduce GHG emissions in cities correspond or directly overlap with actions that create a vibrant community, improve public health outcomes, reduce municipal operating and capital costs, and support innovation; these are no-regrets policies.[9] Actions that reduce GHGs are synergistic with a wide range of other public goods, and in fact, these actions can be justified from the perspective of any of a number of public goods. One review of more than a dozen studies on GHG mitigation policies found that the co-benefits of reduced air pollution—a single co-benefit—often equaled or exceeded the benefit of the GHG reduction itself.[10]

The transition to a low-carbon economy represents a massive economic opportunity. One analysis pegged the global economic opportunity of investments in low-carbon urban actions at $16.6 trillion[11]—the financial savings resulting from energy savings and lower cost generation in transportation, buildings and waste sectors. The value of energy savings is such that energy efficiency has been re-conceptualized as the "first fuel", in recognition that the energy use avoided by International Energy Agency countries was larger than any other supply-side resource including oil, gas, coal and electricity. In addition to seizing the economic opportunity, actions to reduce GHG

9 Kamal-Chaoui, L., & Robert, A. (2009). Competitive cities and climate change. Retrieved from http://www.oecd-ilibrary.org/governance/competitive-cities-and-climate-change_218830433146
10 OECD. (2000). Ancillary Benefits and Costs of Greenhouse Gas Mitigation. OECD Publishing.
11 Gouldson, A. P., Colenbrander, S., Sudmant, A., Godfrey, N., Millward-Hopkins, J., Fang, W., & Zhao, X. (2015). Accelerating low-carbon development in the world's cities. Retrieved from http://eprints.whiterose.ac.uk/90740/

emissions also support competitiveness and innovation, reduce municipal operating costs and capital costs and reduce household and business energy costs.

Table 15 describes the co-benefits associated with the low-carbon actions evaluated for the Bay Area.

Table 15. Co-benefits of low-carbon actions.

CO-BENEFITS/ CO-HARMS	IMPACT OVERVIEW	BUILDINGS	TRANSPORTATION	ENERGY	WASTE
Health					
Air quality	Improvement in air quality		Improved: reduced combustion of gasoline in vehicles	Improved: reduced natural gas combustion	Improved: some reduced emissions from waste treatment processes
Physical activity	Increased active transportation mode share		Improved: high increase in walking and cycling trips		
Decreasing noise	Decreased engine noise	Improved: insulation in buildings reduces exterior noise	Improved: decreased engine noise from combustion engines		
Increasing accessibility	Destinations are more accessible		Improved: dwellings are centred around transit corridors and hubs		
Improved buildings	Building quality is improved	Improved: indoor environments from retrofits		Improved: energy performance is enhanced	

ECONOMIC PROSPERITY

Co-benefits/ co-harms	Impact overview	Buildings	Transportation	Energy	Waste
Employment	New employment opportunities are created	Improved: new jobs will be created in retrofits and as a result of enhanced building codes	Improved: new jobs will be created in manufacturing EVs and other high tech sectors; jobs will be lost in maintenance. Jobs may also be lost as autonomous vehicles replace drivers of cabs and delivery vehicles and the overall vehicle fleet is smaller	Improved: new jobs will be created in supplying and installing and maintaining, solar PV, heat pumps, district energy	Improved: new jobs will be created in recycling and waste diversion
Household incomes	Energy costs for households decline	Improved: operations costs of buildings declines	Improved: household energy costs from transportation decline	Negative: Household energy costs decrease as a result of efficiency measures	
Economic development	Major new economic sectors emerge	Improved: new investment opportunities in retrofits	Improved: new investment opportunities in vehicle fleets	Improved: new investment opportunities in renewable energy and district energy	Improved: new investment opportunities waste diversion
Municipal finances	Municipal finances associated with existing services are more stable; New services are required	Unknown: conditional on the policies and mechanisms to support retrofits	Unknown: conditional on the policies and mechanisms to support EVs and mode shifts	Improved: opportunities to generate financial returns from renewable energy generation	Likely improved: solid waste management costs will decline and revenue will be generated from waste
Innovation	The Low-Carbon Scenario will stimulate innovation	Improved: scaled up approaches to renovations, retrofits and green building technology	Improved: electric vehicles and autonomous vehicles	Improved: mass deployment of renewable energy systems	Improved: waste diversion strategies
Reputation	The reputation of the City is enhanced	Improved: high performance buildings are constructed in the Bay Area	Improved: the area has an enhanced transit system	Improved: renewable energy and district energy increase exposure	Improved: reduced waste goes to landfill

ECONOMIC PROSPERITY

Social capital	People interact more as a result of mixed-use development and increased walking and cycling		Improved: people interact more when walking or cycling		

EQUITY

Co-benefits/ co-harms	Impact overview	Buildings	Transportation	Energy	Waste
Poverty	Household energy costs increase but the cost of transportation decreases	Improved: social housing is retrofit: operating costs of housing decline	Improved: cost of moving around the city declines due to enhanced walking, cycling and transit, and overall VKT declines	Negative: opportunities to participate in the renewable energy economy may be limited for those in poverty; district energy can provide secure and cost effective heating and cooling	
Elderly	Accessibility for the elderly increases. The built environment is healthier	Improved: buildings are healthier	Improved: walking and transit infrastructure is improved. Autonomous vehicles represent a new option for travel	Improved: air conditioning is widespread reducing the impacts of heat waves.	
Children	Accessibility for children increases. The built environment is healthier	Improved: buildings are healthier	Improved: walking and transit infrastructure is improved: autonomous vehicles represent a new option for travel		
Intergenerational equity	The burden on future generations is decreased. Stranded costs are avoided	Improved: damage from climate change is reduced	Improved: damage from climate change is reduced	Improved: damage from climate change is reduced: stranded costs are avoided	Improved: damage from climate change is reduced

PROGRAMS

The low-carbon scenario will require a major effort by the municipalities, businesses and other partners in the Bay Area. This effort will lead to dramatically reduced greenhouse gas emissions, lower energy costs for households and businesses, the creation of new businesses, reduced air pollution and improved quality of life.

Examples of programs that will support the implementation of the actions in low-carbon scenario are described in Table 17.

Table 16. Programs that support the low-carbon pathway.

THEME	PROGRAMS
Program #1: Low-carbon new buildings	Develop a program for new construction that parallels the Toronto Green Standard (TGS). TGS provides a clear pathway for significantly increasing the performance of new buildings and an incentive program offsets part or all of the incremental costs of increased performance. The Bay Area municipalities can build directly on the City of Toronto's experience, avoiding considerable start-up costs. In order to apply the TGS, municipalities need to have the necessary provisions in their Official Plans and site plan control by-laws. The TGS model does not apply to single family dwellings, so a new approach would be required for this component of the building stock.
Program #2: Deep retrofit program	The deep retrofits program is envisioned as a partnership with utilities, industry and higher education. Building on examples such as Toronto's Home Energy Loan Program (HELP), Bridgewater's PACE Clean Energy and Halifax's Solar City, a program can be developed using the PACE or LIC mechanism and combined with incentives from other levels of government and the utilities. Retrofits can be targeted to groups of buildings, such as neighbourhoods, sectors (restaurants, grocery stores, etc) as opposed to individual buildings to pool risk and develop larger, more sophisticated projects. Renewable energy including district energy, solar PV, energy storage and ground-source heat pumps can be included in the program.
Program #3: Renewable energy co-operative	In order to scale up local renewable energy generation, a new mechanism is required that includes municipalities, utilities and other partners; an economic development entity focussed on renewable energy. The cooperative model is appropriate structure to support the renewable energy targets evaluated in the low-carbon scenario. The co-operative can advocate for, develop, commission and finance projects, depending on which strategy is appropriate to a particular context. The co-operative can be technology agnostic, with a mandate to work on district energy, wind, solar, storage and geothermal. Financing will come from community bonds, loans and grants from various levels of government. A similar approach is being used by the GridSmartCity Cooperative, a joint effort of 12 electricity utilities.
Program #4: Electric vehicles joint venture	The municipalities can undertake on a joint strategy to support electric vehicles. The mandate will be to coordinate infrastructure investments, bulk purchases, educational activities, municipal policies relating to charging stations and incentives. The joint venture can be established as a technical working group with representatives from each of the relevant organisations.

THEME	PROGRAMS
Program #5: Education and outreach	In order to support the implementation of the low-carbon scenario broad based and targeted stakeholder education is critical. Aspects of the effort both educate and build capacity. Building on a similar program by the Town of Bridgewater, two specific components can include: Energy Partnership: A learning and action program for local businesses and organizations that encourages innovative energy solutions and increases the collective knowledge of energy sustainability. Energy Partners can hold bi-monthly workshops to learn about energy issues and how to address them in practical ways. Energy Laboratory: A project incubator for innovative energy projects that demonstrate practical approaches to achieving a local energy economy. A panel of judges will evaluate projects and award small grants to support and encourage innovation.

TIMELINE OF ACTIVITIES (2018-2020)

A sample timeline of activities is proposed over the next three years in order to launch the low-carbon scenario. This timeline is designed to achieve some quick wins in order to build momentum, to develop and articulate key mechanisms that will support implementation.

Table 17. Implementation timeline.

PROGRAMS	PROGRAM LAUNCH	PROGRAM DEVELOPMENT COST ESTIMATE (EXCL. STAFF TIME)	STAFF REQUIREMENTS	SHORT TERM TASKS
Program #1: Low-carbon new buildings	January, 2019	$200,000	0.5 FTE	Review of the TGS, legal review, OP update, bylaw development, development cost charge rebate structure
Program #2: Deep retrofit program	October 2019	$300,000	0.5 FTE	Financial analysis, risk evaluation, marketing design, program scoping.
Program #3: Renewable energy co-operative	December, 2019	$100,000	1 FTE	Legal structure, membership outreach, governance/bylaw development, project development.
Program #4: Electric vehicle joint venture	March, 2019	$75,000	No additional staff	Coordination; memorandum of understanding; infrastructure gaps and opportunities assessment

PROGRAMS	PROGRAM LAUNCH	PROGRAM DEVELOPMENT COST ESTIMATE (EXCL. STAFF TIME)	STAFF REQUIREMENTS	SHORT TERM TASKS
Program #5: Education and outreach	2018	$100,000	1 FTE	Webpage; branding; infographics; hiring of coordinator

REPORTING

Tracking the effectiveness of the actions in the low-carbon scenario contributes to managing 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 low-carbon scenario are described in Table 19.

Table 18. Monitoring and evaluation activities

ACTIVITY	PURPOSE	DESCRIPTION	FREQUENCY
Annual work plan and review	Review work to-date and set annual priority actions	Annual report with prioritized actions	Annual
Inventory	Update energy and GHG emissions profile	Re-calculate the GHG emissions and energy inventory	Every 2 years
Update the modelling	Update the modelling to reflect changing conditions	Review each action and the progress being achieved. Identify new actions.	Every 5 years

PART 5. EMISSIONS FACTORS

EMISSIONS FACTORS

CATEGORY	DESCRIPTION	COMMENT
Natural gas	49 kg CO_2e/GJ	Environment and Climate Change Canada. National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada. Part 2. Tables A6-1 and A6-2, Emission Factors for Natural Gas.
Electricity	2016: CO_2: 28.9 g/kWh CH_4: 0.007 g/kWh N_2O: 0.001 g/kWh 2050: CO_2: 37.4 g/kWh CH_4: 0.009 g/kWh N_2O: 0.001 g/kWh	National Energy Board. (2016). Canada's Energy Future 2016. Government of Canada. Retrieved from https://www.neb-one.gc.ca/nrg/ntgrtd/ftr/2016pt/nrgyftrs_rprt-2016-eng.pdf
Gasoline	g/L CO_2: 2316 CH_4: 0.32 N_2O: 0.66	Environment and Climate Change Canada. National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada. Part 2. Table A6–12 Emission Factors for Energy Mobile Combustion Sources
Diesel	g/L CO_2: 2690.00 CH_4: 0.07 N_2O: 0.21	Environment and Climate Change Canada. National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada. Part 2. Table A6–12 Emission Factors for Energy Mobile Combustion Sources

CATEGORY	DESCRIPTION	COMMENT
Fuel oil	Residential g/L CO_2: 2560 CH_4: 0.026 N_2O: 0.006 Commercial g/L CO_2: 2753 CH_4: 0.026 N_2O: 0.031 Industrial g/L CO_2: 2753 CH_4: 0.006 N_2O: 0.031	Environment and Climate Change Canada. National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada. Part 2. Table A6–4 Emission Factors for Refined Petroleum Products
Propane	g/L Transport CO_2: 1515.00 CH_4: 0.64 N_2O: 0.03 Residential CO_2: 1515.00 CH_4 : 0.027 N_2O: 0.108 All other sectors CO_2: 1515.00 CH_4: 0.024 N_2O: 0.108	Environment and Climate Change Canada. National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada. Part 2. Table A6–3 Emission Factors for Natural Gas Liquids Table A6–12 Emission Factors for Energy Mobile Combustion Sources
Coal	0.088 kg CO_2e/MJ	Environment and Climate Change Canada. National Inventory Report 1990-2015: Greenhouse Gas Sources and Sinks in Canada. Part 2. Table A6–3 Emission Factors for Natural Gas Liquids
Waste	Landfill emissions are calculated from first order decay of degradable organic carbon deposited in landfill. Derived emission factor in 2016 = 0.015 kg CH_4/tonne solid waste (assuming 70% recovery of landfill methane); 0.050 kg CH_4/tonne solid waste not accounting for recovery.	Landfill emissions: IPCC Guidelines Vol 5. Ch 3, Equation 3.1

CATEGORY	DESCRIPTION	COMMENT
Wastewater	CH_4: 0.48 kg CH_4/kg BOD N_2O: 3.2 g / (person * year) from advanced treatment 0.005 g /g N from wastewater discharge	CH_4 wastewater: IPCC Guidelines Vol 5. Ch 6, Tables 6.2 and 6.3; MCF value for anaerobic digester N_2O from advanced treatment: IPCC Guidelines Vol 5. Ch 6, Box 6.1 N_2O from wastewater discharge: IPCC Guidelines Vol 5. Ch 6, Section 6.3.1.2

APPENDIX 1

CITY OF BURLINGTON GPC EMISSIONS SCOPE TABLE, 2016

GPC ref No.	Scope	GHG Emissions Source	Inclusion
I		STATIONARY ENERGY SOURCES	
I.1		Residential buildings	
I.1.1	1	Emissions from fuel combustion within the city boundary	Yes
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes
I.2		Commercial and institutional buildings/facilities	
I.2.1	1	Emissions from fuel combustion within the city boundary	Yes
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes
I.3		Manufacturing industry and construction	
I.3.1	1	Emissions from fuel combustion within the city boundary	Yes
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes
I.4		Energy industries	
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary	No
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	No
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	No
I.4.4	1	Emissions from energy generation supplied to the grid	No
I.5		Agriculture, forestry and fishing activities	
I.5.1	1	Emissions from fuel combustion within the city boundary	No
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary	No
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	No

GPC ref No.	Scope	GHG Emissions Source	Inclusion
I.6		Non-specified sources	
I.6.1	1	Emissions from fuel combustion within the city boundary	No
I.6.2	2	Emissions from grid-supplied energy consumed within the city boundary	No
I.6.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	No
I.7		Fugitive emissions from mining, processing, storage, and transportation of coal	
I.7.1	1	Emissions from fugitive emissions within the city boundary	No
I.8		Fugitive emissions from oil and natural gas systems	
I.8.1	1	Emissions from fugitive emissions within the city boundary	Yes
II		TRANSPORTATION	
II.1		On-road transportation	
II.1.1	1	Emissions from fuel combustion for on-road transportation occurring within the city boundary	Yes
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	Yes
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	Yes
II.2		Railways	
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary	No
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways	No
II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No
II.3		Water-borne navigation	
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	No
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation	No
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No
II.4		Aviation	
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary	No

GPC ref No.	Scope	GHG Emissions Source	Inclusion
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation	No
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No
II.5		Off-road	
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary	No
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation	No
III		WASTE	
III.1		Solid waste disposal	
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	Yes
III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary	Yes
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary	No
III.2		Biological treatment of waste	
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary	Yes
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary	No
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary	No
III.3		Incineration and open burning	
III.3.1	1	Emissions from solid waste generated and treated within the city boundary	No
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary	No
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary	No
III.4		Wastewater treatment and discharge	
III.4.1	1	Emissions from wastewater generated and treated within the city boundary	Yes
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary	No

GPC ref No.	Scope	GHG Emissions Source	Inclusion
III.4.3	1	Emissions from wastewater generated outside the city boundary	No
IV		INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	
IV.1	1	Emissions from industrial processes occurring within the city boundary	No
IV.2	1	Emissions from product use occurring within the city boundary	No
V		AGRICULTURE, FORESTRY AND LAND USE (AFOLU)	
V.1	1	Emissions from livestock within the city boundary	No
V.2	1	Emissions from land within the city boundary	No
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary	No
VI		OTHER SCOPE 3	
VI.1	3	Other Scope 3	No

CITY OF HAMILTON GPC EMISSIONS SCOPE TABLE, 2016

GPC ref No.	Scope	GHG Emissions Source	Inclusion
I		STATIONARY ENERGY SOURCES	
I.1		Residential buildings	
I.1.1	1	Emissions from fuel combustion within the city boundary	Yes
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes
I.2		Commercial and institutional buildings/facilities	
I.2.1	1	Emissions from fuel combustion within the city boundary	Yes
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes
I.3		Manufacturing industry and construction	
I.3.1	1	Emissions from fuel combustion within the city boundary	Yes
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary	Yes
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	Yes
I.4		Energy industries	
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary	Yes
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	Yes
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	Yes
I.4.4	1	Emissions from energy generation supplied to the grid	No
I.5		Agriculture, forestry and fishing activities	
I.5.1	1	Emissions from fuel combustion within the city boundary	No
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary	No
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	No
I.6		Non-specified sources	
I.6.1	1	Emissions from fuel combustion within the city boundary	No
I.6.2	2	Emissions from grid-supplied energy consumed within the city boundary	No
I.6.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	No
I.7		Fugitive emissions from mining, processing, storage, and transportation of coal	

GPC ref No.	Scope	GHG Emissions Source	Inclusion
I.7.1	1	Emissions from fugitive emissions within the city boundary	No
I.8		Fugitive emissions from oil and natural gas systems	
I.8.1	1	Emissions from fugitive emissions within the city boundary	Yes
II		TRANSPORTATION	
II.1		On-road transportation	
II.1.1	1	Emissions from fuel combustion for on-road transportation occurring within the city boundary	Yes
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	Yes
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	Yes
II.2		Railways	
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary	No
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways	No
II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No
II.3		Water-borne navigation	
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary	No
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation	No
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No
II.4		Aviation	
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary	No
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation	No
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	No
II.5		Off-road	
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary	No
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation	No
III		WASTE	
III.1		Solid waste disposal	

GPC ref No.	Scope	GHG Emissions Source	Inclusion
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary	Yes
III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary	Yes
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary	No
III.2		Biological treatment of waste	
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary	Yes
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary	No
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary	No
III.3		Incineration and open burning	
III.3.1	1	Emissions from solid waste generated and treated within the city boundary	No
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary	No
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary	No
III.4		Wastewater treatment and discharge	
III.4.1	1	Emissions from wastewater generated and treated within the city boundary	Yes
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary	No
III.4.3	1	Emissions from wastewater generated outside the city boundary	No
IV		INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)	
IV.1	1	Emissions from industrial processes occurring within the city boundary	No
IV.2	1	Emissions from product use occurring within the city boundary	No
V		AGRICULTURE, FORESTRY AND LAND USE (AFOLU)	
V.1	1	Emissions from livestock within the city boundary	No
V.2	1	Emissions from land within the city boundary	No
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary	No
VI		OTHER SCOPE 3	
VI.1	3	Other Scope 3	No

APPENDIX 2

CITY OF BURLINGTON GPC EMISSIONS REPORT, 2016

			in tonnes			
GPC ref No.	Scope	GHG Emissions Source	CO2	CH4	N2O	Total CO2e
I		STATIONARY ENERGY SOURCES				
I.1		Residential buildings				
I.1.1	1	Emissions from fuel combustion within the city boundary	244,805	5	5	246,358
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	20,094	5	1	20,4259
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	2,233	1		2,269
I.2		Commercial and institutional buildings/ facilities				
I.2.1	1	Emissions from fuel combustion within the city boundary	157,259	3	4	158,419
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	9,664	2		9,823
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	1,074			1,091
I.3		Manufacturing industry and construction				
I.3.1	1	Emissions from fuel combustion within the city boundary	115,975	2	3	116,921
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary	19,247	4	1	19,564
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	2,139	1	0	2,174
I.4		Energy industries				
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary				
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary				

			in tonnes			
GPC ref No.	Scope	GHG Emissions Source	CO2	CH4	N2O	Total CO2e
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations				
I.4.4	1	Emissions from energy generation supplied to the grid				
I.5		Agriculture, forestry and fishing activities				
I.5.1	1	Emissions from fuel combustion within the city boundary				
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary				
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption				
I.6		Non-specified sources				
I.6.1	1	Emissions from fuel combustion within the city boundary				
I.6.2	2	Emissions from grid-supplied energy consumed within the city boundary				
I.6.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption				
I.7		Fugitive emissions from mining, processing, storage, and transportation of coal				
I.7.1	1	Emissions from fugitive emissions within the city boundary				
I.8		Fugitive emissions from oil and natural gas systems				
I.8.1	1	Emissions from fugitive emissions within the city boundary	13	1,701		57,835
II		TRANSPORTATION				
II.1		On-road transportation				
II.1.1	1	Emissions from fuel combustion for on-road transportation occurring within the city boundary	366,825	36	86	393,657
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	1			1
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	191,947	22	54	208,875

			in tonnes			
GPC ref No.	Scope	GHG Emissions Source	CO2	CH4	N2O	Total CO2e
II.2		Railways				
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary				
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways				
II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption				
II.3		Water-borne navigation				
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary				
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation				
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption				
II.4		Aviation				
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary				
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation				
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption				
II.5		Off-road				
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary				
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation				
III		WASTE				
III.1		Solid waste disposal				

			in tonnes			
GPC ref No.	Scope	GHG Emissions Source	CO2	CH4	N2O	Total CO2e
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary				
III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary		196		6,679
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary				
III.2		Biological treatment of waste				
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary		66	5	3,698
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary				
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary				
III.3		Incineration and open burning				
III.3.1	1	Emissions from solid waste generated and treated within the city boundary				
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary				
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary				
III.4		Wastewater treatment and discharge				
III.4.1	1	Emissions from wastewater generated and treated within the city boundary			1	329
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary				
III.4.3	1	Emissions from wastewater generated outside the city boundary				
IV		INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)				
IV.1	1	Emissions from industrial processes occurring within the city boundary				
IV.2	1	Emissions from product use occurring within the city boundary				

			in tonnes			
GPC ref No.	Scope	GHG Emissions Source	CO2	CH4	N2O	Total CO2e
V		AGRICULTURE, FORESTRY AND LAND USE (AFOLU)				
V.1	1	Emissions from livestock within the city boundary				
V.2	1	Emissions from land within the city boundary				
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary				
VI		OTHER SCOPE 3				
VI.1	3	Other Scope 3				

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			in tonnes			
GPC ref No.	Scope	GHG Emissions Source	CO2	CH4	N2O	Total CO2e
I		STATIONARY ENERGY SOURCES				
I.1		Residential buildings				
I.1.1	1	Emissions from fuel combustion within the city boundary	703,511	13	13	707,971
I.1.2	2	Emissions from grid-supplied energy consumed within the city boundary	37,1241	9	1	37,735
I.1.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	4,125	1	0	4,193
I.2		Commercial and institutional buildings/facilities				
I.2.1	1	Emissions from fuel combustion within the city boundary	542,244	10	12	546,3071
I.2.2	2	Emissions from grid-supplied energy consumed within the city boundary	18,271	4	1	18,571
I.2.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	2,030	0	0	2,063
I.3		Manufacturing industry and construction				
I.3.1	1	Emissions from fuel combustion within the city boundary	5,643,734	136	97	5,677,230
I.3.2	2	Emissions from grid-supplied energy consumed within the city boundary	62,382	14	2	36,409
I.3.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption	6,931	2	2	7,045
I.4		Energy industries				
I.4.1	1	Emissions from energy used in power plant auxiliary operations within the city boundary	90,370	2	2	90,901
I.4.2	2	Emissions from grid-supplied energy consumed in power plant auxiliary operations within the city boundary	95	0	0	60

			in tonnes			
GPC ref No.	Scope	GHG Emissions Source	CO2	CH4	N2O	Total CO2e
I.4.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption in power plant auxiliary operations	7	0	0	7
I.4.4	1	Emissions from energy generation supplied to the grid				
I.5		Agriculture, forestry and fishing activities				
I.5.1	1	Emissions from fuel combustion within the city boundary				
I.5.2	2	Emissions from grid-supplied energy consumed within the city boundary				
I.5.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption				
I.6		Non-specified sources				
I.6.1	1	Emissions from fuel combustion within the city boundary				
I.6.2	2	Emissions from grid-supplied energy consumed within the city boundary				
I.6.3	3	Emissions from transmission and distribution losses from grid-supplied energy consumption				
I.7		Fugitive emissions from mining, processing, storage, and transportation of coal				
I.7.1	1	Emissions from fugitive emissions within the city boundary				
I.8		Fugitive emissions from oil and natural gas systems				
I.8.1	1	Emissions from fugitive emissions within the city boundary	69	9,287	0	315,811
II		TRANSPORTATION				
II.1		On-road transportation				
II.1.1	1	Emissions from fuel combustion for on-road transportation occurring within the city boundary	777,077	78	176	832,079
II.1.2	2	Emissions from grid-supplied energy consumed within the city boundary for on-road transportation	2			2

			in tonnes			
GPC ref No.	Scope	GHG Emissions Source	CO_2	CH_4	N_2O	Total CO_2e
II.1.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption	242,919	28	69	264,349
II.2		Railways				
II.2.1	1	Emissions from fuel combustion for railway transportation occurring within the city boundary				
II.2.2	2	Emissions from grid-supplied energy consumed within the city boundary for railways				
II.2.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption				
II.3		Water-borne navigation				
II.3.1	1	Emissions from fuel combustion for waterborne navigation occurring within the city boundary				
II.3.2	2	Emissions from grid-supplied energy consumed within the city boundary for waterborne navigation				
II.3.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption				
II.4		Aviation				
II.4.1	1	Emissions from fuel combustion for aviation occurring within the city boundary				
II.4.2	2	Emissions from grid-supplied energy consumed within the city boundary for aviation				
II.4.3	3	Emissions from portion of transboundary journeys occurring outside the city boundary, and transmission and distribution losses from grid-supplied energy consumption				
II.5		Off-road				

			in tonnes			
GPC ref No.	Scope	GHG Emissions Source	CO2	CH4	N2O	Total CO2e
II.5.1	1	Emissions from fuel combustion for off-road transportation occurring within the city boundary				
II.5.2	2	Emissions from grid-supplied energy consumed within the city boundary for off-road transportation				
III		WASTE				
III.1		Solid waste disposal				
III.1.1	1	Emissions from solid waste generated within the city boundary and disposed in landfills or open dumps within the city boundary				
III.1.2	3	Emissions from solid waste generated within the city boundary but disposed in landfills or open dumps outside the city boundary				
III.1.3	1	Emissions from waste generated outside the city boundary and disposed in landfills or open dumps within the city boundary				
III.2		Biological treatment of waste				
III.2.1	1	Emissions from solid waste generated within the city boundary that is treated biologically within the city boundary		124	9	7,005
III.2.2	3	Emissions from solid waste generated within the city boundary but treated biologically outside of the city boundary				
III.2.3	1	Emissions from waste generated outside the city boundary but treated biologically within the city boundary				
III.3		Incineration and open burning				
III.3.1	1	Emissions from solid waste generated and treated within the city boundary				
III.3.2	3	Emissions from solid waste generated within the city boundary but treated outside of the city boundary				
III.3.3	1	Emissions from waste generated outside the city boundary but treated within the city boundary				

			in tonnes			
GPC ref No.	Scope	GHG Emissions Source	CO2	CH4	N2O	Total CO2e
III.4		Wastewater treatment and discharge				
III.4.1	1	Emissions from wastewater generated and treated within the city boundary			14	4,260
III.4.2	3	Emissions from wastewater generated within the city boundary but treated outside of the city boundary				
III.4.3	1	Emissions from wastewater generated outside the city boundary				
IV		INDUSTRIAL PROCESSES AND PRODUCT USE (IPPU)				
IV.1	1	Emissions from industrial processes occurring within the city boundary				
IV.2	1	Emissions from product use occurring within the city boundary				
V		AGRICULTURE, FORESTRY AND LAND USE (AFOLU)				
V.1	1	Emissions from livestock within the city boundary				
V.2	1	Emissions from land within the city boundary				
V.3	1	Emissions from aggregate sources and non-CO2 emission sources on land within the city boundary				
VI		OTHER SCOPE 3				
VI.1	3	Other Scope 3				