

Climate Leadership Plan

Appendix A Mitigation Technical Report

December 13, 2021



Table of Contents

- Climate Leadership Plan 1
- Overview 3
- Introduction 4
- Methodology 4
- Key Metrics 6
- Results: Community 7
- Scenario Comparison 7
- Business as Planned Scenario 9
- Stretch Scenario 10
- Aggressive Scenario 12
- Interim Carbon Reduction Pathway 14
- Interim Carbon Reduction Pathway Technical Analysis 15
- Community Carbon Budget 19
- Carbon Reduction Pathway for Municipal Operations 21
- Sector: Buildings & Energy Production 21
- Sector: Transportation 21
- Sector: Offsets 21
- Corporate Carbon Budget 22

Figures

- Figure 1: Carbon Reduction Scenario Modelling Process 4
- Figure 2: Carbon Reduction Scenarios 8
- Figure 3: Carbon Reduction Pathway Emissions Waterfall 16
- Figure 4: Energy Use by Fuel Type: All Sectors 17
- Figure 5: Energy Use by Fuel Type: Transportation 17
- Figure 6: Energy Use by Fuel Type: Buildings 17
- Figure 7: Marginal Abatement Cost Curve 19
- Figure 8: Community Carbon Budget - 1.5 Degree Pathway 20
- Figure 9: Corporate Carbon Budget – 1.5 Degree Pathway 22

Tables

- Table 1: 2018 Energy Costs by Fuel Type 7
- Table 2: Scenario Key Metrics 8
- Table 3: 2040 Emissions Change by Objective 16
- Table 4: Cumulative Cost Impacts by Objective 18

Overview

Introduction

This Technical Appendix summarizes the quantitative analysis conducted to determine the emissions reduction potential of the actions and objectives included in the Climate Leadership Plan. In the initial stages of Plan development, three scenarios were modeled to support informed decision-making regarding potential actions with significant impact on emissions, as well as the emissions reduction trajectory of the many current initiatives underway in Kingston out to the year 2040 as the time horizon of the Plan. A summary of each scenario is presented in the sections below, as is additional technical material and analysis for the final carbon reduction pathway outlined within the Plan.

Methodology

Carbon reduction scenario modelling involved four steps, as summarized in steps below.

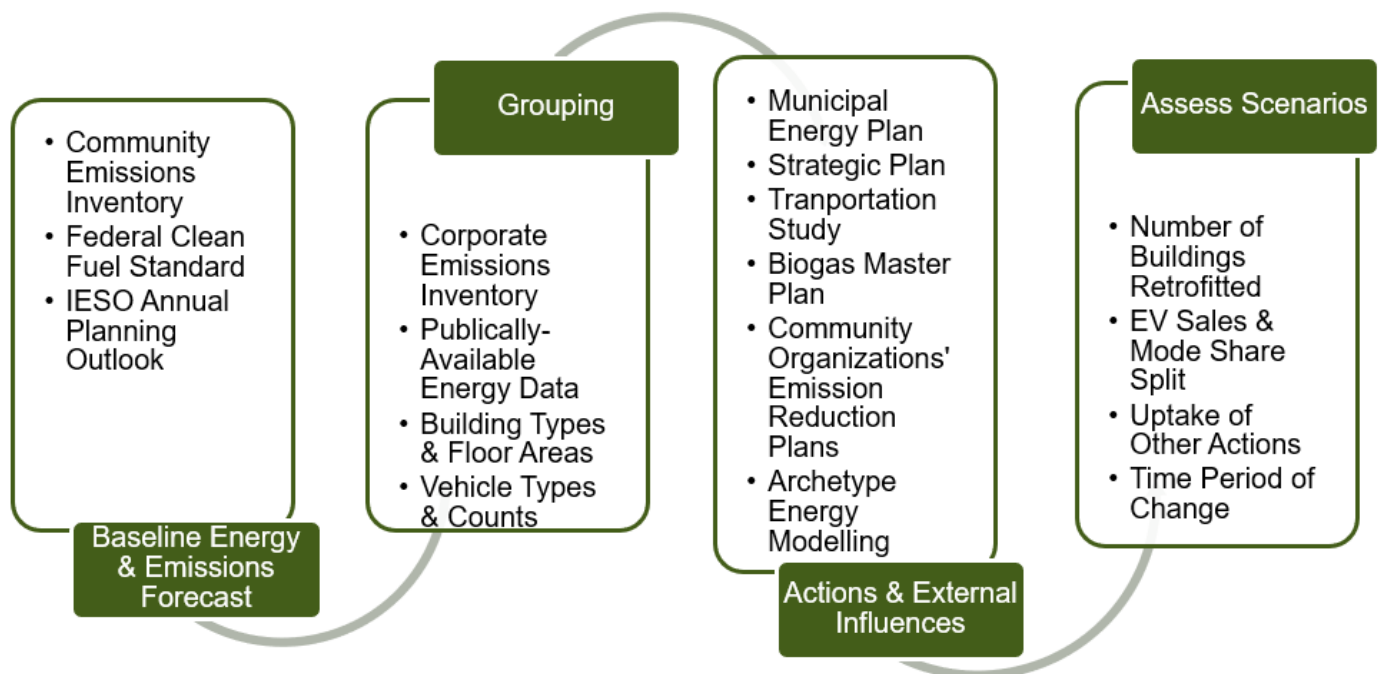


Figure 1: Carbon Reduction Scenario Modelling Process

Baseline Energy & Emissions

In the first stage, the current energy consumption and emission sources outlined in Kingston's 2018 Community GHG Inventory and 2018 Corporate GHG inventory were modeled by sector, source and scope:

- **Scope 1 Emissions:** GHG emissions from sources located within the city boundary, particularly from on-site combustion of fossil fuels.
- **Scope 2 Emissions:** GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling used within the city boundary.
- **Scope 3 Emissions:** All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city. In Kingston's community inventory, Scope 3 emissions are limited to transportation of food and carbon storage related to forested land use included in the Food and Forestry sector.

Future emission factors for each energy source were also assigned to reflect anticipated changes in the emissions intensity of each fuel. For fossil fuels, the Federal Clean Fuel Standard is expected reduce emissions intensity by 10-12%. For electricity, the IESO Annual Planning Outlook (2019) forecasts an increase in emission intensity from the current 20 g/kWh to 84 g/kWh by the year 2040. These emission factors are summarized under the Business as Planned scenario.

Grouping

To evaluate current emission sources in greater detail, specific sub-groups were created in the model to assess the likely emissions share of specific building and vehicle types. Various data sources were used at this stage, including:

- Publicly available energy data from the Ontario's Broader Public Sector database and the federal National Pollutant Inventory Report;
- Building floor area for dwellings from Statistics Canada and commercial floor area from the City of Kingston Commercial Land Review (2016);
- Energy consumption by building type provided by Utilities Kingston, Enbridge and Hydro One; and,
- Ministry of Transportation data on number of vehicles by vehicle type registered in Kingston.

External Influences and Potential Actions

In the third step, a number of potential actions to reduce emissions were defined. These actions included in progress, under development, and potential initiatives, as well as external influences such as climate change. The average magnitude of energy change and Scope 3 emissions change for various building retrofits, renewable energy production, new vehicles, transportation mode share, land use changes were developed based on the following:

- Municipal Energy Study (2015)
- Transportation Master Plan (2015)
- Community Organizations' Emission Reduction Plans: CFB Kingston, Correctional Services Canada, Queen's University, St. Lawrence College, INVISTA, Cataraqui Region Conservation Authority
- Archetype Energy Modelling: Derived from previous modeling and costing studies into both retrofit and new construction packages for one-family homes, MURBs and other industrial, commercial and institutional buildings.

Scenarios

Finally, actions were grouped into four scenarios as follows:

- Business as Planned: Evaluated the GHG impact of external influences such as emission factors and climate change, natural efficiency changes, low-to-moderate adoption rates for new technology such as electric vehicles, and in progress community and City actions.
- Stretch: Evaluated the GHG impact of external influences, in progress actions, and future programs currently under development designed to promote production of renewable natural gas and increase adoption rates for deeper building retrofits, electric vehicles, and active transportation. Combined these actions should achieve a 30-40% GHG reduction by 2030.
- Aggressive: Evaluated the level of action necessary to achieve a 75-80% reduction in GHGs by 2040, with procurement to fill the remaining gap to achieve carbon neutrality. This level of reduction can only be achieved through maximizing adoption rates (90% or higher) of

significant deep retrofits of existing buildings, electric vehicles, local generation of renewable energy, and conversion of industrial processes to clean energy sources.

- Interim Carbon Reduction Pathway: As detailed throughout the Climate Leadership Plan, the actions in the interim carbon reduction pathway were selected based on their feasibility, emissions reduction potential, and priority within the community based on widespread engagement. This pathway is referred to as interim as the Plan will be updated and re-evaluated every five years as part of the continuous improvement process.

Each scenario included customized assumptions regarding level of uptake (i.e. the percentage of buildings undergoing retrofits, the kilometers travelled by each possible mode of transportation, the percentage of electric vehicles), as well as the expected time period of change.

Key Metrics

A number of key metrics for each scenario are presented throughout the following results section, which have been calculated as follows:

- Annual emissions reduction: Emissions reduction as of 2040, as compared to the 2011 baseline.
- Cumulative emissions reduction: Sum of total emissions reduction between 2022 and 2040, as compared to the Business as Planned scenario.
- Per capita emissions: Average emissions per person in 2040, based on projected population growth
- Fossil fuel reduction: % of 2040 energy supplied from fossil fuel sources compared to current fossil fuel energy use
- Local renewable energy fraction: % of 2040 energy generated from on-site photovoltaics, biogas produced and consumed locally, or other clean energy sources within the municipal boundary
- Purchased clean energy fraction: % of 2040 energy purchased from clean energy sources outside of the municipal boundary, particularly renewable natural gas
- Annual energy cost change: Energy cost savings or increases as of 2040, calculated from the following non-escalated energy costs outlined in the 2018 inventory for ease of comparison to current costs.

Table 1: 2018 Energy Costs by Fuel Type

Fuel Type	\$/GJ
Electricity	\$37.16
Natural Gas	\$9.83
Fuel Oil	\$32.22
Propane	\$34.69
Gasoline	\$38.00
Diesel	\$33.16
Biodiesel	\$39.79
Renewable Natural Gas	\$24.83
Power Purchase Agreements	\$51.05

Results: Community

Scenario Comparison

The results of each scenario analyzed are summarized in Figure 2 and Table 2 below. In the annual emissions reduction chart presented in Figure 2, the Business as Planned scenario is shown as a light grey area, representing the total emissions between 2022 and 2040 if no further actions beyond planned and funded initiatives are implemented. When compared to Kingston’s 2011 emissions baseline, emissions in this “upper bound” scenario are shown to decline by 28% by 2040. By comparison, emissions in the “lower bound” Aggressive scenario are shown to decline by 75% by 2040, representing the maximum community potential for emissions reduction using today’s technology.

The Interim Carbon Reduction Pathway modeled for Kingston falls between the Stretch scenario (45% reduction) and Aggressive. Based on the initiatives selected for inclusion in the Climate Leadership Plan, Kingston’s emissions are projected to decline by 64% by 2040. Additional emissions reduction sources will therefore need to be identified to achieve Council’s carbon neutral goal. Opportunities for reducing emissions beyond the Interim Pathway include changes in provincial energy policy that would reduce emissions from Ontario’s electricity supply, new technology such as carbon capture, or purchase of carbon offsets if the target remains carbon neutrality rather than net zero.

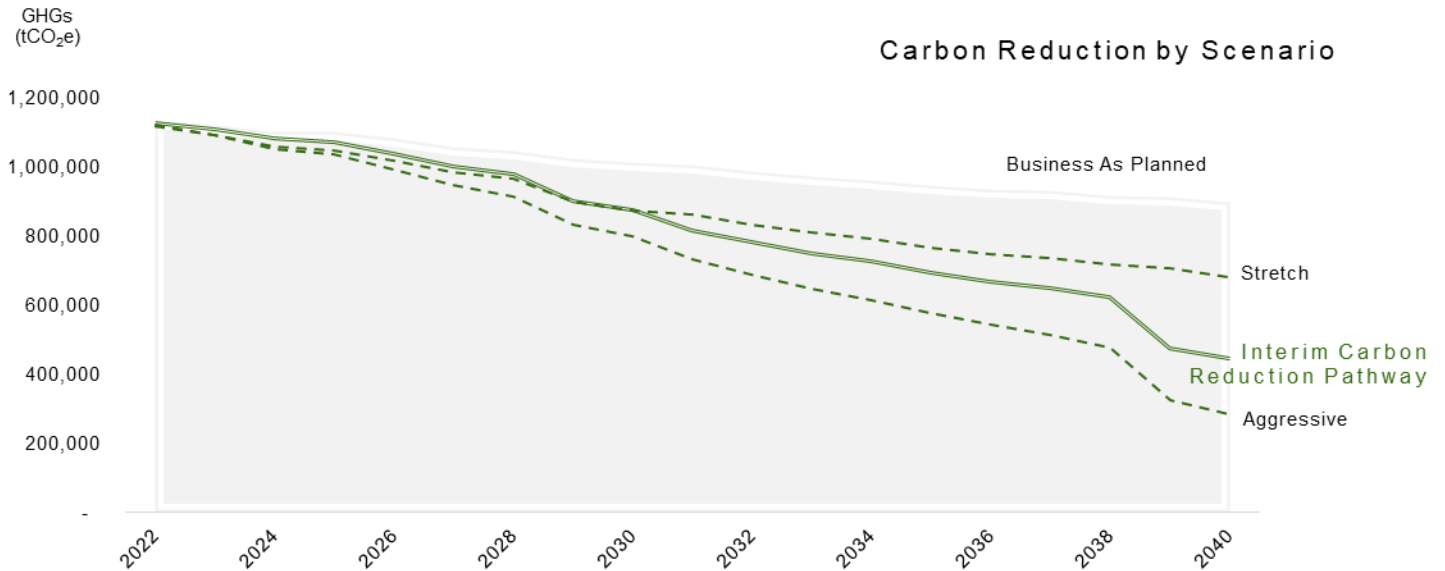


Figure 2: Carbon Reduction Scenarios

The key metrics table provides an overview of the detailed outcomes for each scenario. Additional information on the specific actions and assumptions modeled within each pathway is also presented in the following sections.

Table 2: Scenario Key Metrics

Key Metric	Current (2018)	Business as Planned	Stretch (2040)	Aggressive (2040)	Final Carbon Reduction Pathway (2040)
Annual Emissions (tonnes)	1,290,000 (-6%)	930,000 (-28%)	720,000 (-45%)	320,000 (-75%)	470,000 (-64%)
Cumulative Emissions (millions of tonnes)	30 N/A	25 N/A	21 (-16%)	13 (-47%)	16 (-37%)
Per Capita Emissions (tonnes)	7.0	5.2	4.0	1.7	2.6
Fossil Fuels	16 million GJ	-32%	-49%	-90%	-75%
Local Renewable Energy Fraction	-	1%	1%	24%	13%
Purchased Clean Energy Fraction	-	-	1%	21%	19%
Annual Energy Cost	\$516 million	-27%	-34%	-46%	-38%

Business as Planned Scenario

- Annual Emissions: -28%
- Cumulative Emissions: 25,200,000 t
- Per Capital Emissions: 5.2 t
- Fossil Fuels: -32%
- Local Renewable Energy: 1%
- Purchased Clean Energy: 0%
- Energy Cost:-27%

The Business as Planned scenario is designed to evaluate the GHG impact of external influences such as changes in electricity grid emission factors and climate change; natural efficiency changes driven by required renewal of building systems and changes in minimum requirements for new vehicles and buildings; low-to-moderate adoption rates for new technology such as electric vehicles; and community and City actions that are already in progress. The list below summarizes the actions, external factors, and assumptions for the Business as Planned scenario. Dates indicated below represent the start date of each action, with completion assumed by 2040.

Sector: General

Population Growth

- 0.5% per year (City of Kingston Population, Housing and Employment Growth Forecast, 2016 to 2046, Base Case, March 2019)

Electricity Emission Factors

- 2018: 30 g/kWh (2018 Community GHG Inventory)
- 2040: 84 g/kWh (IESO Annual Planning Outlook Data Tables, Reference Case, January 2020)

Sector: Buildings & Energy Production

New Buildings

- 2020: 100% of new builds at 15-25% energy savings vs. current code (30% of total new area)
- 2025: 100% of new builds 25-50% energy savings (25% of total new area)
- 2030: 100% of new builds at 50-80% energy savings (45% of total new area)

Existing Buildings

- 2040: Typical efficiency upgrades at 20-40% carbon savings for 80% of building stock

Local Renewable Energy

- 2040: 108,000 GJ on-site electricity generation

Purchased Clean Energy

- 2022: 1900 tonnes municipal offsets to meet 15% corporate reduction target

Current Community Actions

- 2020: CFB Kingston Heating Electrification

- 2020: INVISTA Industrial Effluent Treatment
- 2022: Federal Clean Electricity Commitment

Sector: Waste

Diversion Rate

- 2025: 65% (City Council target)

Sector: Transportation

Mode Share

- 2034: 17% Active, 10% Transit (reflects half of 2015 Transportation Master Plan targets)

Passenger Vehicles

- 2040: 16% EVs (Canada's Energy Future 2018, Reference Case)
- ICE vehicles meet 2025 Federal Fuel Efficiency Standard, turnover of 7% per year

Commercial Vehicles

- 2040: 10% EVs

Work from Home

- 2040: 9% (50% increase from 2016 Census, Statistics Canada)

Sector: Food and Forestry

Increase Forested Area

- 2040: 280 ha additional area (CRCA, 50 Million Trees Program)

Local Food

- 2040: 4% local food, 5% decrease in emission factor for imported food

Stretch Scenario

- Annual Emissions: -45%
- Cumulative Emissions: -16%
- Per Capital Emissions: 4.0 t
- Fossil Fuels: -49%
- Local Renewable Energy: 1%
- Purchased Clean Energy: 1%
- Energy Cost: -34%

The Stretch scenario includes all Business as Planned actions and assumptions, adding in new community-scale programs and policies which are currently under development. These new initiatives will promote low carbon fuel sources and increase adoption rates for deeper building retrofits, electric vehicles, and active transportation. Even with these future actions, the emissions reduction in the Stretch scenario is not sufficient to achieve Kingston's community targets. The list below summarizes the actions, external factors, and assumptions for the Stretch scenario.

Sector: General

Population Growth

- Per the Business as Planned Scenario

Emission Factors

- Per the Business as Planned Scenario

Sector: Buildings & Energy Production

New Buildings

- 2020-24: 15-25% energy savings for 88% of new builds constructed to minimum code in these years; 50-80% energy savings for 12% of new builds at due to Kingston's Green Standard CIP
- 2025-29: 25-50% energy savings for 84% of new builds; 50-80% energy savings for 16% of new builds due to the Green Standard CIP
- 2030-40: 50-80% energy savings for all new builds due to code change

Existing Builds

- 2040: Typical efficiency upgrades at 20-40% carbon savings for 54% of building stock; Fuel switching with NG backup at 50-70% carbon savings for 18% of building stock; Full fuel switch at 65-85% carbon savings for 8% of building stock

Local Renewable Energy

- 2040: 120,000 GJ on-site electricity generation, local biogas produced and sold externally

Purchased Clean Energy

- 2022: 1900 tonnes municipal offsets to meet 15% corporate reduction target
- 2022: 150,000 GJ federal clean electricity procurement
- 2040: 6600 tonnes municipal offsets to meet corporate carbon neutral target

Community Actions

- Current Community Actions per the Business as Planned Scenario
- 2022: Federal portfolio efficiency & carbon reduction plans
- 2022: Queen's Climate Action Plan, non-DES actions
- 2022: St. Lawrence College 80% emission reduction target

Sector: Waste

Diversion Rate

- 2040: 70%

Sector: Transportation

Mode Share

- 2034: 20% Active, 15% Transit (2015 Transportation Master Plan targets)

Passenger Vehicles

- 2040: 64% EVs (Canada's Energy Future 2018, Technology Case)
- ICE vehicles meet 2025 Federal Fuel Efficiency Standard, turnover of 7% per year

Commercial Vehicles

- 2040: 50% EVs

Work from Home

- 2040: 12% WFH

Sector: Food and Forestry

Forested Area

- 2040: 1440 ha additional

Local Food

- 2040: 6% local food, 25% decrease in emission factor for imported food

Aggressive Scenario

- Annual Emissions: -75%
- Cumulative Emissions: -47%
- Per Capital Emissions: 1.7 t
- Fossil Fuels: -90%
- Local Renewable Energy: 24%
- Purchased Clean Energy: 21%
- Energy Cost: -46%

The Aggressive scenario represents the maximum technical potential for emissions reduction across the community using today's technology. Unprecedented transformation of buildings, transportation systems, and energy supply has the potential to reduce emissions by 75%, leaving 25% of emissions to be addressed through clean energy and carbon offset procurement. The list below summarizes the actions, external factors, and assumptions for the Aggressive scenario.

Sector: General

Population Growth

- Per the Business as Planned Scenario

Emission Factors

- Per the Business as Planned Scenario

Sector: Buildings & Energy Production

New Buildings

- 2020: 15-25% energy savings for 88% of new builds meeting code in this period; 50-80% energy savings for 12% of new builds at due to Kingston's Green Standard CIP

- 2025: 50-80% energy savings for all new builds after this date
- 2030: 50-80% energy savings for all new builds after this date due to code change

Existing Builds

- 2040: Deep carbon retrofits at 75-95% carbon savings for 80% of building stock

Local Renewable Energy

- 2040: 2,800,000 GJ on-site electricity generation, 68,000 GJ local biogas

Purchased Clean Energy

- 2022: 130,000 GJ federal clean electricity purchases
- 2040: 290,000 GJ federal RNG purchases
- 2040: 2,200,000 GJ industrial RNG or hydrogen purchases

Community Actions

- Current Community Actions per the Business as Planned Scenario
- 2022: Queen's Climate Action Plan including zero carbon DES
- 2022: St. Lawrence College 80% emission reduction target
- 2040: Federal carbon neutral portfolio (including purchased RNG)

Sector: Waste

Diversion Rate

- 2040: 76% (Maximum divertable material, City of Kingston Information Report EITP-19-003, March 2019)

Sector: Transportation

Mode Share

- 2040: 23% Active, 20% Transit

Passenger Vehicles

- 2040: 90% EVs
- ICE vehicles meet 2025 Federal Fuel Efficiency Standard, turnover of 7% per year

Commercial Vehicles

- 2040: 75% EVs

Work from Home

- 2040: 18% WFH

Sector: Food and Forestry

Forested Area

- 2040: 2880 ha additional

Local Food

- 2040: 10% local food, 37% decrease in the emission factor for imported food

Interim Carbon Reduction Pathway

- Annual Emissions: -64%
- Cumulative Emissions: -37%
- Per Capital Emissions: 2.6 t
- Fossil Fuels: -75%
- Local Renewable Energy: 13%
- Purchased Clean Energy: 19%
- Energy Cost:-38%

As detailed throughout the Climate Leadership Plan, the actions in the Interim Carbon Reduction Pathway have been selected based on broad considerations including feasibility of implementation, alignment with community priorities, likely pace of change, current availability of technology, emissions impact and capital cost. The list below summarizes the actions, external factors, and assumptions for this scenario. Further details are presented following the summary.

Sector: General

Population Growth

- Per the Business as Planned Scenario

Emission Factors

- Per the Business as Planned Scenario

Sector: Buildings & Energy Production

New Buildings

- 2020: 15-25% energy savings for 88% of new builds meeting code in this period; 50-80% energy savings for 12% of new builds at due to Kingston's Green Standard CIP
- 2025: 25-50% energy savings for 84% of new builds in this period; 50-80% energy savings for 16% of new builds due to the Green Standard CIP
- 2030: 50-80% energy savings for all new builds after this date due to code change

Existing Builds

- 2040: Typical efficiency upgrades at 20-40% carbon savings for 54% of building stock; Fuel switching with NG backup at 50-70% carbon savings for 18% of building stock; Full fuel switch at 65-85% carbon savings for 8% of building stock

Local Renewable Energy

- 2040: 1,600,000 GJ on-site electricity generation, 68,000 GJ local biogas

Purchased Clean Energy

- 2022: 130,000 GJ federal clean electricity purchases
- 2040: 290,000 GJ federal RNG purchases

- 2040: 2,200,000 GJ industrial RNG or hydrogen purchases

Community Actions

- Current Community Actions per the Business as Planned Scenario
- 2022: Queen’s Climate Action Plan including zero carbon DES
- 2022: St. Lawrence College 80% emission reduction target
- 2040: Federal carbon neutral portfolio (including purchased RNG)

Sector: Waste

Diversion Rate

- 2040: 70%

Sector: Transportation

Mode Share

- 2034: 20% Active, 15% Transit (2015 Transportation Master Plan targets)

Passenger Vehicles

- 2030: 25% EVs
- 2040: 90% EVs
- ICE vehicles meet 2025 Federal Fuel Efficiency Standard, turnover of 7% per year

Commercial Vehicles

- 2040: 50% EVs

Work from Home

- 2040: 18% WFH

Sector: Food and Forestry

Forested Area

- 2040: 2880 ha additional

Local Food

- 2040: 6% local food, 25% decrease in emission factor for imported food

Interim Carbon Reduction Pathway Technical Analysis

Within the Climate Leadership Plan, the specific actions included in the Interim Carbon Reduction Pathway have been grouped into nine key objectives. The annual emissions reduction associated with each objective as of 2040 is summarized in the table below. These values represent the emissions change resulting only from new actions, with existing Business as Planned initiatives contributing a further reduction of 150,000 tonnes. The reduction potential of each objective is summarized in the waterfall figure below. A further 2% reduction results from afforestation, not

included as a key objective in the Plan. External influences such as a higher emission factor for electricity factor and the impact of climate change are also shown in the waterfall. As the climate warms, Kingston’s annual heating degree days are projected to decline by approximately 11%, while cooling degree days will increase by 12%. Due to the higher efficiency of building cooling systems compared to heating systems, the net impact is a 3% reduction in community emissions. Changes in mode share and electric vehicle uptake have been considered together in this summary, as their reduction potential is highly interdependent. Just as on site PV offers almost no carbon reduction benefit in regions with extremely low emissions intensity grids (i.e. Quebec, B.C.), reducing kilometers travelled by a low emissions intensity electric vehicle offers lesser emissions benefits compared to reducing kilometers travelled today’s internal combustion vehicles.

Table 3: 2040 Emissions Change by Objective

Objective	2040 Emissions Change (tonnes)
1 Renewable Energy Generation and Storage	-36,000
2 Retrofit Existing Homes	-57,000
3 Retrofit Existing Commercial Buildings	-31,000
4 Retrofit Existing Municipal & Institutional Buildings	-73,000
5 Advance Zero Carbon New Construction	-1,000
6 Biogas & Alternative Fuels	-145,000
7 Reduce Car Dependence & 8 Electric Vehicles	-220,000
9 Local Food	-11,000
Total	-574,000

2040 Carbon Reduction Waterfall

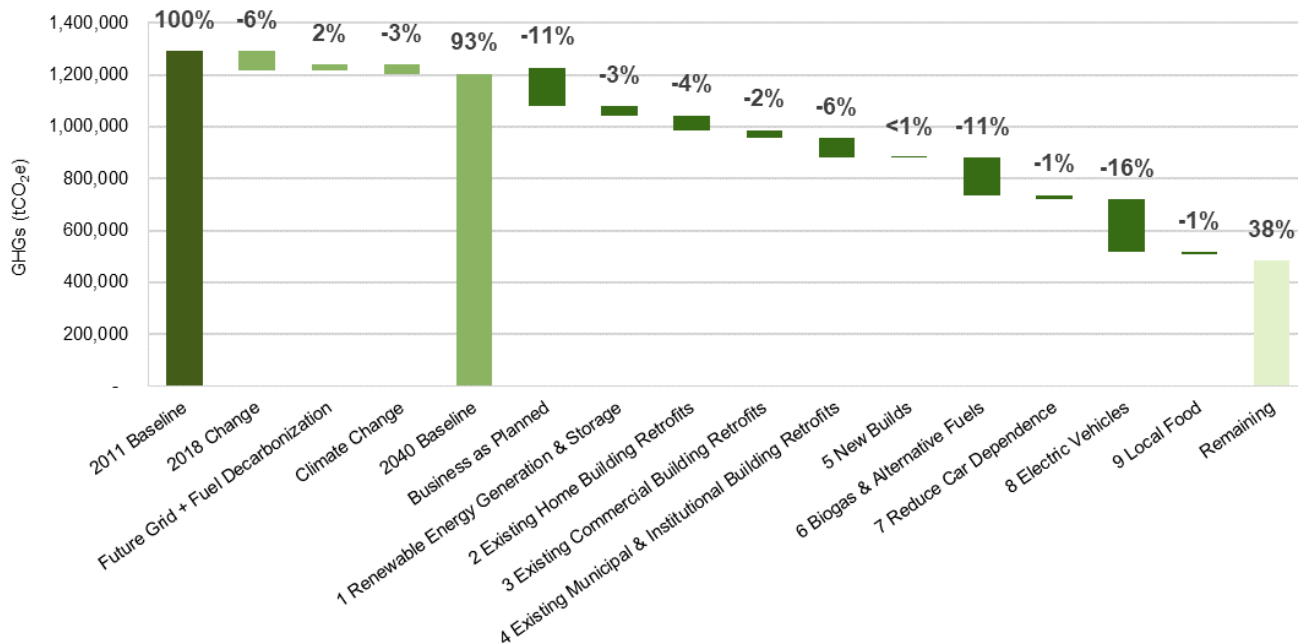


Figure 3: Carbon Reduction Pathway Emissions Waterfall

Implementation of the actions within the Climate Leadership Plan will require substantial transformation of Kingston’s energy supply, as detailed in the figures below. An overall 75% decrease

in fossil fuel consumption is driven by building heating electrification, adoption of low carbon fuels for industrial processes, and electric vehicles. Externally-sourced low carbon fuels such as renewable natural gas appear as the light green 'Other Renewable Energy' bars in the 2040 summaries below.

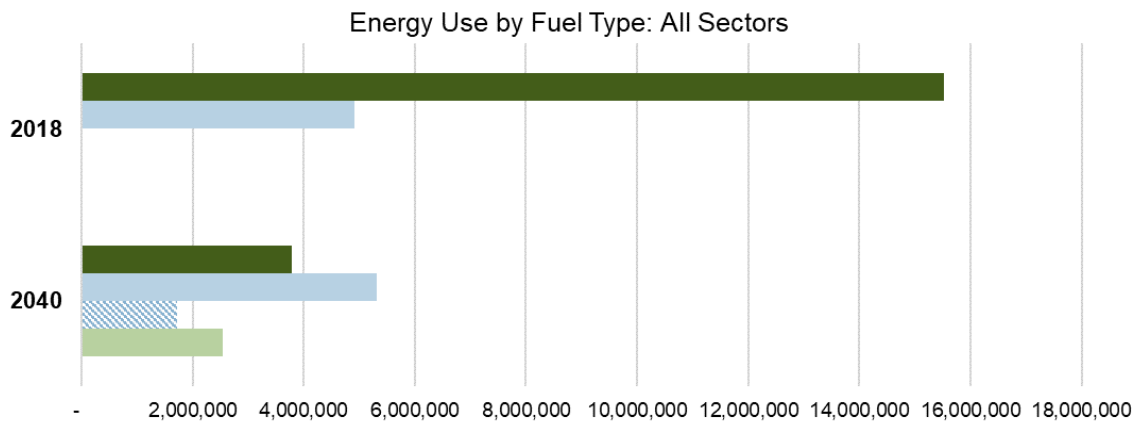


Figure 4: Energy Use by Fuel Type: All Sectors

■ Fossil Fuel Energy ■ Grid Electricity ▨ Local Renewable Energy ■ Other Renewable Energy

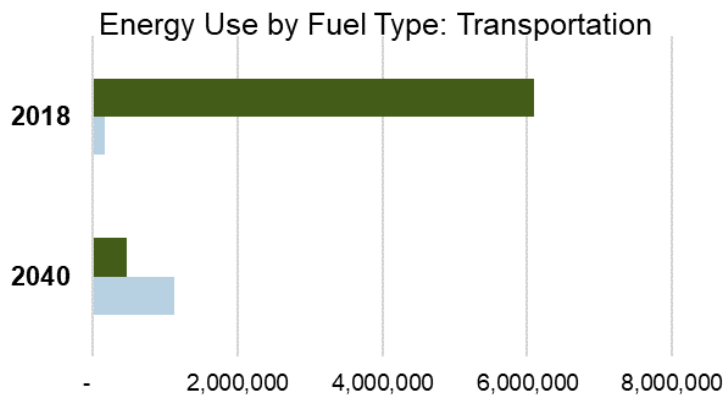


Figure 5: Energy Use by Fuel Type: Transportation

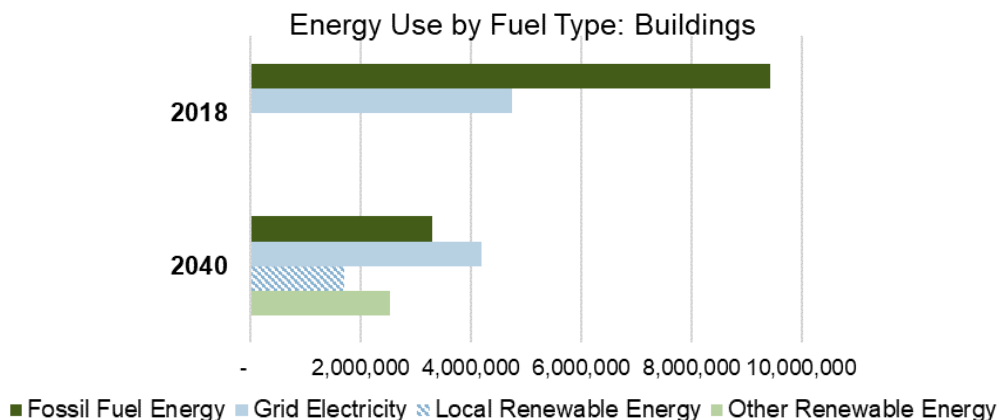


Figure 6: Energy Use by Fuel Type: Buildings

Due to the much greater efficiency of heat pumps (which use 2-4 times less energy than fossil fuel heating) and EVs (which use approximately 5 times less energy than internal combustion vehicles), only a moderate increase in grid electricity consumption is shown above. Energy efficiency measures and local production of renewable electricity – summarized as a blue hatched bar in the figures – will also help to mitigate the impact of broad-scale electrification. Metering arrangements will matter,

however, as the summaries presented here reflect net metering arrangements in which renewable production directly reduces grid consumption at the building level. Virtual net metering of large-scale photovoltaic arrays will not directly reduce grid-supplied electricity in the same way.

The table on the following page summarizes the financial outcomes of each objective. In line with the emissions reductions previously presented, the capital costs represent investments over and above those carried in the Business as Planned scenario (i.e. incremental costs). Energy savings have been standardized to a 25 year period to facilitate comparison between actions starting at various times through an incremental lifecycle cost analysis. Energy cost change incorporates 2% annual escalation over 2018 utility rates and a carbon price in line with the current federal backstop price (i.e. increasing from \$50/tonne in 2022 to \$170/tonne by 2030 and remaining static in subsequent years). Additional job creation driven by retrofits and local food production are also summarized, based on an average of 11 person-hours of employment per million dollars of building-related investment, and 23 jobs per million dollars of local food.

Table 4: Cumulative Cost Impacts by Objective

Objective	Incremental Capital Cost (\$M)	25 Year Energy Cost Change (\$M)	ILCC/tonne	Annual Job Creation
1 Renewable Energy Generation and Storage	\$820	(\$820)	\$0	500
2 Retrofit Existing Homes	\$720	\$87	\$570	440
3 Retrofit Existing Commercial Buildings	\$1,900	(\$47)	\$2,400	1200
4 Retrofit Existing Municipal & Institutional Buildings	\$2,300	(\$108)	\$1,200	1400
5 Advance Zero Carbon New Construction	\$20	(\$2)	\$720	12
6 Biogas & Alternative Fuels	\$30	\$1200	\$340	18
7 Reduce Car Dependence	\$0	(\$60)	(\$180)	0
8 Electric Vehicles	\$0	(\$60)	(\$180)	0
8 Electric Vehicles	\$670	(\$1600)	(\$180)	0
9 Local Food	\$0	-	\$0	400
Total	\$6,500	(\$1,400)		4000

The marginal abatement cost curve presented below summarizes total GHG reduction for each objective on the x-axis, and incremental lifecycle cost per tonne of GHG reduction on the y-axis. Three actions – active transportation plus electric vehicles, renewable energy production, and local food production – offer incremental lifecycle costs per tonne of \$0 or less. Biogas and alternative fuels are roughly double the federal carbon price at \$340/tonne. The most expensive objectives are retrofits of every building type and net zero new builds.

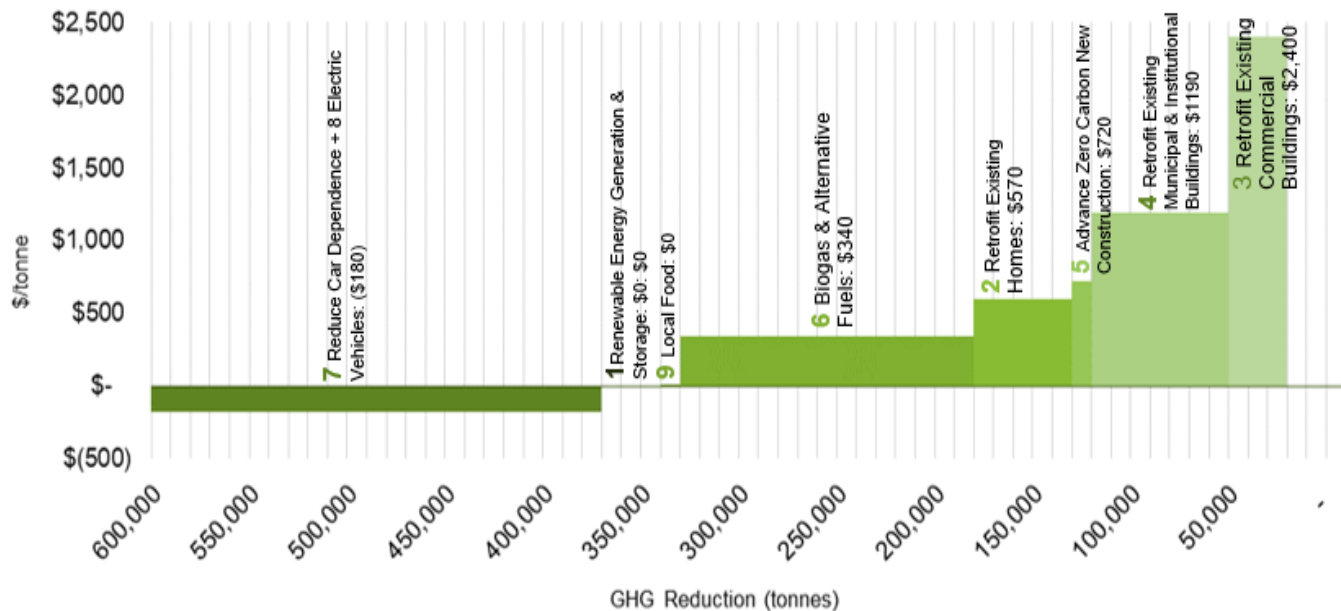


Figure 7: Marginal Abatement Cost Curve

Community Carbon Budget

A carbon budget is an amount of greenhouse gases that can be emitted over a particular time. Rather than focusing on the annual reduction achieved in 2040 or 2050, a carbon budget encourages early action to achieve near-term milestones and thereby reduce or avoid emissions that would otherwise accumulate in the earth’s atmosphere prior to the end goal target year. Based on the 2015 Paris Agreement and recent UN IPCC modeling, ensuring our collective emissions levels limit global warming to 1.5 °C above the pre-industrial era is of critical importance to avoid catastrophic impacts from climate change.

Two methodologies exist to define municipal carbon budgets in line with 1.5 °C of warming. The Science-Based Target Initiative Absolute Emissions Contraction approach assumes that all organizations should reduce their absolute emissions at the same rate, irrespective of size, historic emissions or other factors. The minimum reduction required for targets to be in line with 1.5 °C of warming is 4.2% in annual linear terms. The C40 Cities Contraction and Convergence approach considers the rate of reduction required to bring global emissions to a safe level (contraction) by requiring each to bring its emissions per capita to a level which is equal for all countries (convergence). A summary of modelling completed for Kingston by ICLEI is summarized below, contrasted against current community reduction targets as well as the emissions remaining in the CLP’s Interim Carbon Reduction Pathway scenario, including future emissions reductions. Of note, both carbon budget methodologies suggest a much steeper decline by 2030 to avoid catastrophic warming.

Community Carbon Budget: 1.5 Degree Pathway

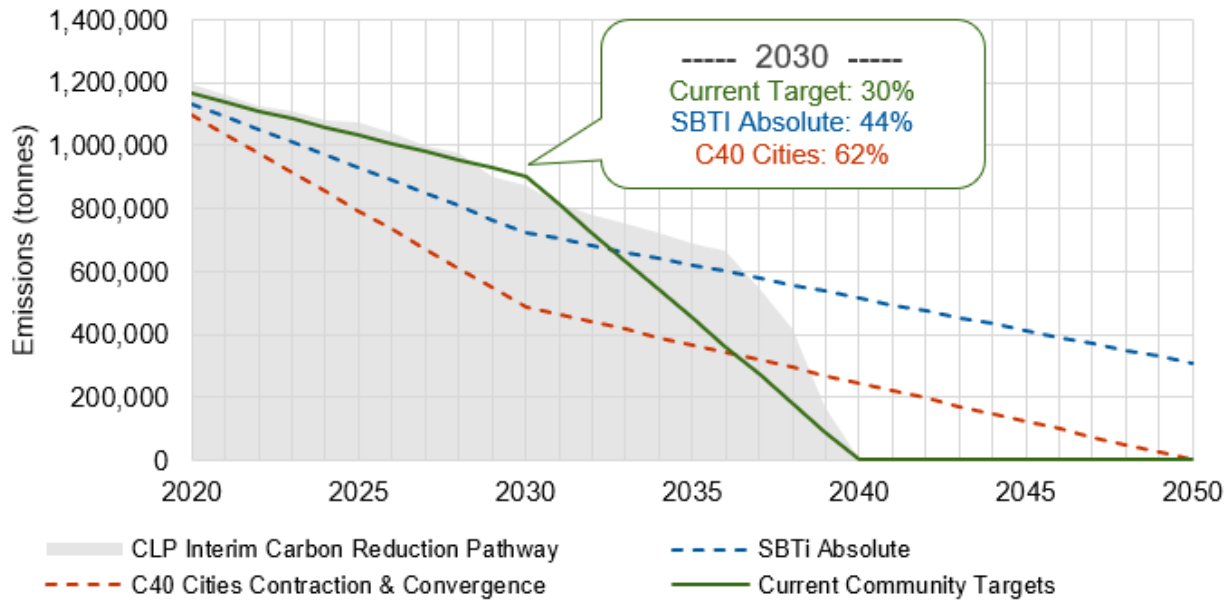


Figure 8: Community Carbon Budget - 1.5 Degree Pathway

Model (1.5 Degree)	2022-2050 Emissions (million tonnes)
CLP Reduction Pathway	14.7
Current Community Targets	13.1
SBTi Absolute Reduction	18.1
C40 Cities Contraction & Convergence	11.2

Carbon Reduction Pathway for Municipal Operations

The list below summarizes actions included in the Interim Carbon Reduction Pathway which are directly related to municipal operations by the Corporation of the City of Kingston. These actions were developed through consultation with each City department as well as actions outlined in the City's Strategic Plan. Further details are presented following the summary.

Sector: Buildings & Energy Production

New Buildings

- 2022: 50-80% energy savings for all new builds after this date due to City's Net Zero commitment

Municipal Facilities (Excluding Wastewater & Water Treatment)

- 2022: 2-3% reduction in emissions through typical efficiency upgrades
- 2026: 15% reduction in emissions through fuel switching, PV and retrofits
- 2040: 11% divestment of overall floor area due to 50% reduction in required office space associated with work from home, 26% of remaining facilities fuel switch, 74% undergo deep retrofits

Local Renewable Energy

- 2040: 32,000 GJ on-site electricity generation (new builds and suitable existing rooftops during roof replacement, other sites as required)

Sector: Transportation

Mode Share

- 2034: 15% Transit mode share and population growth increases transit vehicle energy consumption

Transit Buses

- 2022: 3% EVs (two electric buses)
- 2040: 100% EVs
- Biodiesel procurement for all FF use until full electrification achieved

Fleet Vehicles

- 2040: 50% EVs (passenger vehicles, solid waste vehicles, cargo vans)

Sector: Offsets

All Sectors

- 2040: 6600 tonnes of offsets to achieve a 100% reduction in corporate emissions (Offset cost of \$165,000 in 2040 assuming a \$25/tonne rate)

Based on the fairly aggressive actions detailed above, corporate emissions are projected to decline by 70% as of 2040 when compared to 2018 emissions, prior to procurement of offsets. Compared to 2011, the 2040 reduction is 74%. Costing for building retrofits has already been developed by Facilities Management, and purchase of electric buses and fleet vehicles has been assessed by

Transportation. Costs for development of active transportation infrastructure are detailed in the 2019-2023 Active Transportation Implementation Master Plan. Compared to the costing analyses already developed by the City, the high-level costing estimate developed using the general methodology employed in this Plan has significantly reduced accuracy and is therefore not presented.

Corporate Carbon Budget

A summary of carbon budget modelling completed by ICLEI for the City of Kingston’s corporate emissions is summarized below. Current corporate reduction targets as well as the emissions remaining in the CLP’s Final Carbon Reduction Pathway scenario for the municipality are also presented. Note that the steep decline between 2039 and 2040 in the grey CLP data series is due to purchase of carbon offsets, which are not an allowable reduction measure in the Science-Based Target Initiative approach, although they can be counted towards the City’s more general goal of carbon neutrality.

Corporate Carbon Budget: 1.5 Degree Pathway

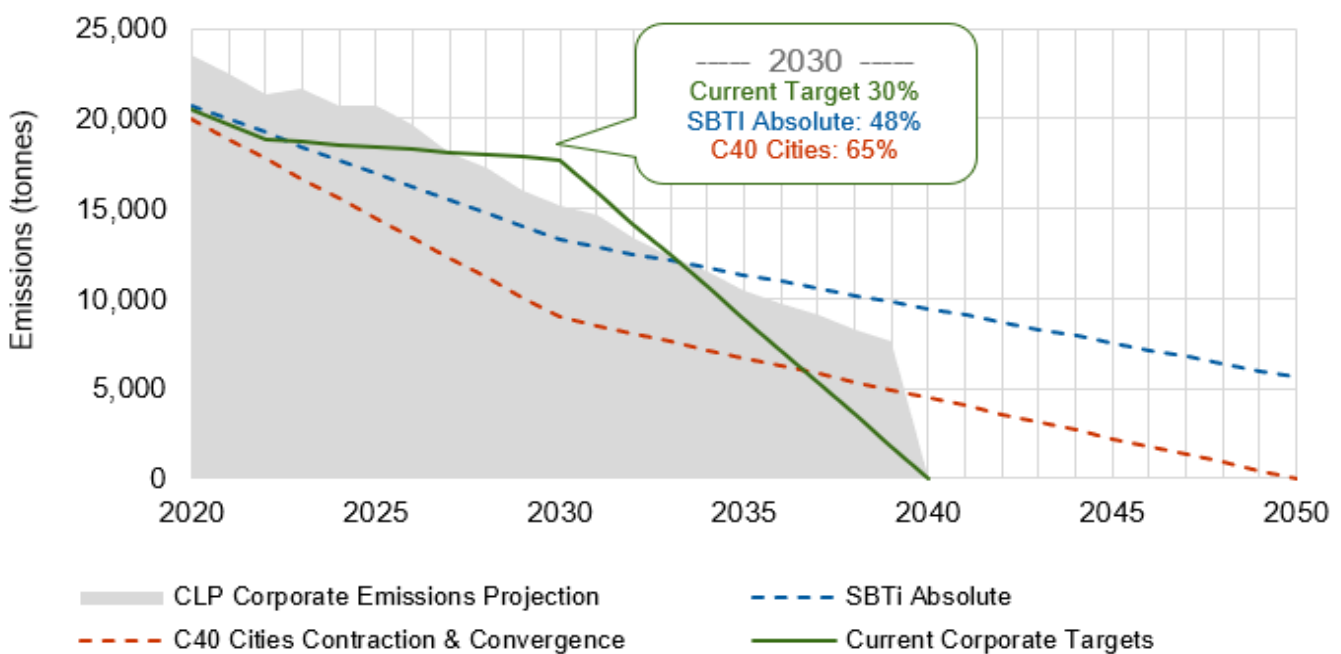


Figure 9: Corporate Carbon Budget – 1.5 Degree Pathway

Model (1.5 Degree)	2022-2050 Emissions (million tonnes)
CLP Reduction Pathway	0.27
Current Corporate Targets	0.24
SBTi Absolute Reduction	0.33
C40 Cities Contraction & Convergence	0.21