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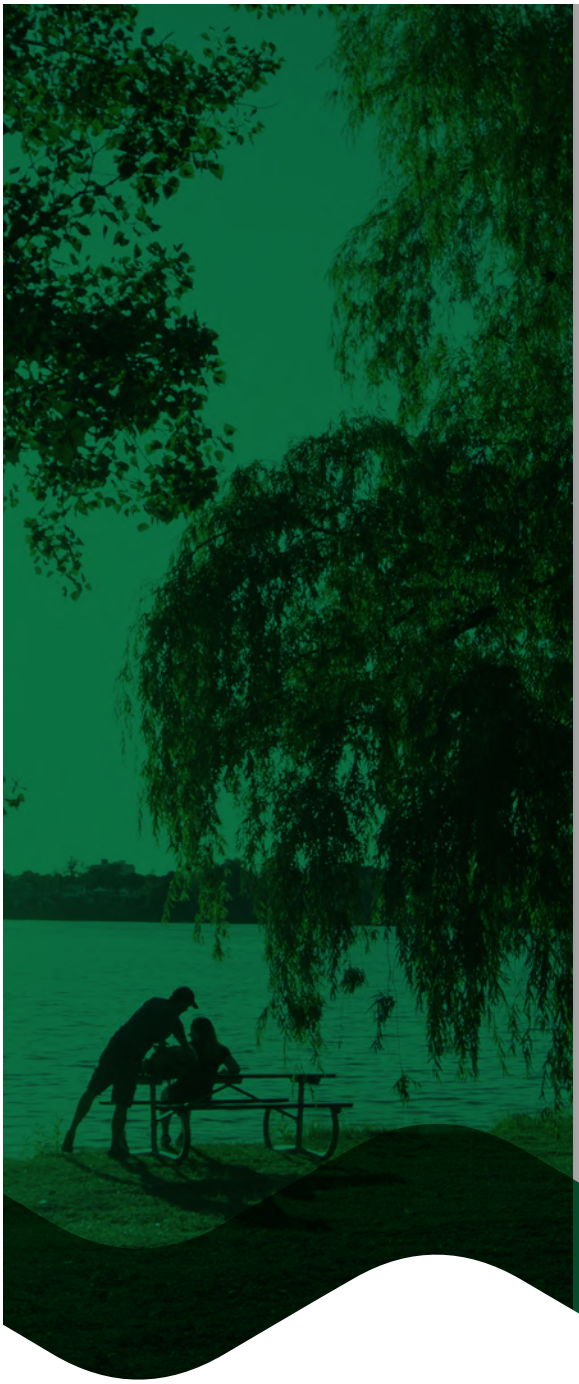
Climate Change
Action Plan 2.0

December 2024



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Executive Summary

The City of Peterborough is committed to tackling climate change by mitigating community emissions and adapting to the inevitable impacts of a changing climate. The City first committed to climate action in 2016 with the development of a joint regional plan that covered the City of Peterborough and Peterborough County and its eight member townships (Asphodel-Norwood, Cavan Monaghan, Douro-Dummer, Havelock-Belmont-Methuen, North Kawartha, Otonabee South-Monaghan, Selwyn, and Trent Lakes), as well as Curve Lake First Nation and Hiawatha First Nation. The 2016 Climate Action Plan committed to the following actions:

1. Reducing greenhouse gas emissions;
2. Reducing the use of fossil fuels;
3. Lowering energy consumption; and
4. Adapting to climate change impacts.

The Climate Change Action Plan 2.0 examines Peterborough's greenhouse gas (GHG) emissions, starting with a baseline year of 2021 and projecting those emissions to 2050 under different mitigation scenarios. To frame climate action, we first need to understand the emission snapshot from 2021 (Figure ES1). The following key insights were obtained from this snapshot:

- The most emitting sector is **transportation**. In the transportation sector, emissions primarily come from the use of gasoline and diesel in private cars, light- and heavy-duty trucks, and off-road vehicles.
- The second most emitting sector is **buildings**, both residential and commercial. In the buildings sector, emissions come almost exclusively from natural gas used for space and water heating.

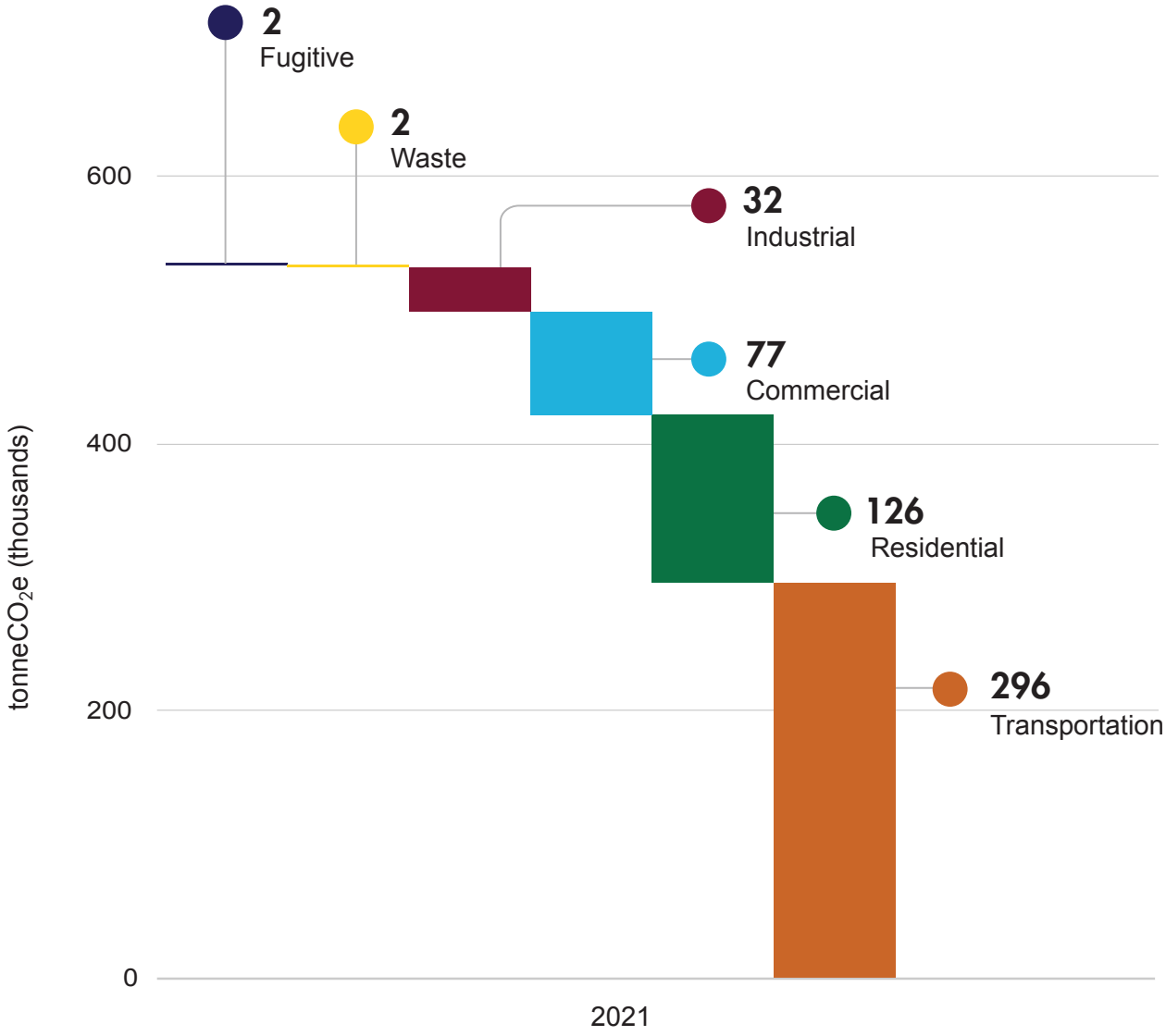

Figure ES1. Emissions snapshot of the City of Peterborough in 2021.
Source: SSG analysis.

To tackle these emissions, Peterborough needs to commit to deep political, economic, and social transformations, referred to here as "Big Moves." Seven Big Moves are recommended to achieve meaningful emission reductions in the long term, targeting all emitting sectors. These Big Moves respond to Peterborough's new climate goal of aligning with the Paris Agreement and its new climate vision outlined in the box below.

Peterborough is a sustainable and resilient community that:

- Provides a high quality of life for all residents through increased clean transportation, reduced energy poverty, a net-zero ready and affordable housing stock, and a green local economy and jobs;
- Integrates a climate action lens into city planning and policies decisions; and
- Protects and builds on its natural beauty and green infrastructure systems and honours its heritage as an innovator by advancing clean energy and technology solutions.

Thus, the CCAP 2.0 is composed of the following elements:

Table ES.1. Overview of the Plan. Source: SSG.

7 Big Moves	3 Mitigation Scenarios
17 Actions	15 Implementation Recommendations

Table ES.2. List and description of the Big Moves. Source: SSG.

Big Move	Description
Land Use Big Move	Transform urban design and land use to implement mitigation actions, aiming to achieve a sustainable, compact city.
Green Buildings Big Move	Reduce emissions in the built environment by minimizing energy use and switching from high-emitting fuels to electricity for space and water heating and cooling.
Energy Supply Big Move	Transition to a low-carbon energy system by shifting from fossil fuels to renewable energy generation, prioritizing local production.
Sustainable Transportation Big Move	Promote active transportation and public transit, electrifiy private and commercial vehicles, and move away from fossil fuels in freight and off-road vehicles.
Industry Big Move	Reduce the amount of energy used by the industrial sector to make a more environmentally friendly Peterborough.
Waste Big Move	Accelerate Peterborough's ambition to prevent and reduce waste generation, use circular economy principles, and value and recirculate waste in the economy.
Forestry and Carbon Capture Big Move	Enhance forest management and implement carbon capture strategies to increase carbon sequestration.

Mitigation scenarios were analyzed and explored to consider these Big Moves across different timelines and targets. The three scenarios explored were Net-Zero 2050 (NZ2050), Net-Zero 2040 (NZ2040), and Alternative Fuels (AltFuels). The NZ2050 and NZ2040 scenarios have the same mitigation measures but differ in their timelines for action implementation, while the AltFuels Scenario explores mitigation actions related to the adoption of hydrogen in heavy trucks and the use of renewable natural gas to replace conventional natural gas.

Each scenario presents different challenges due to the implementation timelines and costs. NZ2040 is the most ambitious, achieving the largest GHG reductions by 2050[1]. This scenario requires the highest investments but also garners the highest savings. The most cost-effective scenario is NZ2050 (Table ES.3), achieving the most GHG reductions at the lowest cost by 2050. Additionally, the NZ2050 has a negative marginal abatement cost of $209, meaning that each tonne of CO_2e reduced results in $209 in savings. With the additional technology, the AltFuels Scenario has higher investment costs for similar GHG reductions as the NZ2050 scenario.

Table ES.3. Cost summary for each scenario. Source: SSG analysis.

Total	**NZ2050**	**NZ2040**	**Alternative Fuels**
Costs of investment ($ million)	$2,219	$3,057	$2,351
Savings from investment ($ million)	-$3,168	-$3,785	-$3,014
Total costs ($ million)	-$949	-$728	-$663
Benefit rate (benefit/costs)	1.4	1.2	1.3
Marginal abatement costs ($/$tCO_2e$)	-$209	-$127	-$122
Total GHG emission reduction ($ktCO_2e$)	**4,859**	**6,193**	**5,144**

[1] Note that all scenarios are analyzed up to 2050, although the NZ2040 reaches most of the mitigation targets by 2040.

Across the scenarios, the most impactful measures are the ones targeting the buildings and transportation sectors and addressing policy gaps. Recommendations for climate action implementation in Peterborough are outlined in the box below.

Buildings

The Green Buildings Big Move focuses directly on enhancing the energy efficiency of existing and new buildings and promotes switching from fossil fuels to clean energy. To achieve meaningful emission reductions, Peterborough should prioritize increasing the energy efficiency of buildings even before switching to clean fuels. Decreasing the amount of energy used for electric and thermal purposes in new buildings alone could result in up to 980 $ktCO_2e$ of cumulative reductions between 2024 and 2050, with an additional 861 $ktCO_2e$ achieved through retrofitting existing residential buildings.

A first step toward this goal is to develop Green Development Standards (GDSs) aligned with Canada's National Energy Code in collaboration with developers and relevant stakeholders. Adopting GDSs will help Peterborough be prepared for the national government's net-zero building code and demonstrate strong leadership and commitment to climate action.

Transportation

Peterborough has several policies aimed at reducing emissions in the transportation sector, including the Transportation Master Plan and the Cycling Master Plan. Additionally, Canada has committed to increasing the market share of electric vehicles (EVs). Complementing these efforts, the Sustainable Transportation Big Move aims to reduce emissions across all types of transportation modes. The City has an opportunity to further reduce emissions by addressing sectors that currently lack specific policies, particularly off-road vehicles and heavy and freight transportation. In this context, switching to cleaner fuels in off-road vehicles and freight transportation is a key step toward achieving Peterborough's CCAP 2.0 goals.

Regarding current efforts, the Transportation Master Plan is a key policy enabling the transition to a low-carbon transportation sector and is the most cost-effective action. Therefore, it should be the first action implemented city-wide, even before the electrification of the transit fleet and personal vehicles because it maximizes operational and investment savings.

Peterborough is encouraged to pursue additional complementary actions. The most relevant of these is to prioritize urban design and land-use principles that advance the City's goal to be a compact city. Denser urban areas are more connected and sustainable, with increased access to services and amenities, transit routes, and active transportation infrastructure. Additionally, promoting and developing cleaner energy sources, such as solar power, in Peterborough can reduce grid emissions and increase energy independence. Renewable energy production is a shared responsibility, and there are several mechanisms to increase its adoption among residents, including utility and municipal rebates, solar cooperatives, and bulk purchasing through community and neighbourhood associations.

Implementing the CCAP 2.0 will bring diverse co-benefits to the city and its residents. Energy use decreases by up to 50% by 2050 compared to 2021 levels due to the proposed actions, saving Peterborough households, businesses, and industries an estimated $2 billion on energy bills between 2024 and 2050 for any mitigation scenario. Moreover, the Plan presents an opportunity for Peterborough to create over 16,000 new green jobs in sectors that contribute to a low-carbon economy, such as renewable energy, building retrofits, and active transportation infrastructure. Mitigation measures proposed in the Plan, particularly those related to nature-based solutions, build a more resilient Peterborough. An increased urban tree canopy can potentially reduce air temperatures by up to 1.2°C, and it helps prevent flooding, while storing water in the soil to aid in aquifer restoration and recharge.

Considering the scenarios and concrete actions the Climate Change Action Plan 2.0 establishes for the City of Peterborough, the NZ2050 Scenario best reflects Peterborough's ambition, resources, and context, and Peterborough is encouraged to implement mitigation actions as soon as possible. Note that each tonne of CO_2 emitted costs society more than $266, reflecting overall economic damages and mitigation costs, and this will only increase if the current emissions trend continues[2]. Thus, acting now will lead to higher emissions reductions and enable the City to enjoy the benefits and co-benefits associated with each action, including financial savings and a healthier, more livable city.

[2] Government of Canada. Social cost of greenhouse gas emissions. [Government Announcement]. Climate Science, 2021b. https://www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/social-cost-ghg.htmla

Key Terms

Glossary

Term	Definition
Baseline	The starting point to measure changes in the amount of emissions produced over time.
Carbon-free grid	An electricity grid where the power that is generated and distributed only comes from renewable sources.
Carbon sequestration	The process of capturing and storing carbon from the atmosphere through natural or anthropogenic methods.
CityInSight model	SSG's modelling tool to explore future emission pathways based on demographic, building, and energy use data, etc. It provides a detailed analysis of the impact of actions on reducing energy use and emissions, as well as a financial analysis of the implementation of these actions.
Consumption-based emissions	Emissions from the volume of goods consumed by a population.
CO_2e (Carbon dioxide equivalents)	A single unit of measurement that allows the impact of releasing different greenhouse gases into the atmosphere to be evaluated on a common basis. Carbon dioxide equivalents are calculated using Global Warming Potential factors that represent the impact of each greenhouse gas type (such as methane [CH4] and nitrous oxide [N2O]) relative to that of carbon dioxide.
Decarbonize	To eliminate the release of GHGs from a process or system into the atmosphere. This includes swapping out any fossil fuel sources for renewable energy.
GHGs (Greenhouse gases)	Compound gases that trap heat and emit longwave radiation into the atmosphere, causing the greenhouse effect.

Term	Definition
Heat pump	A highly efficient heating and cooling system that transfers thermal energy from the ground or air to warm a building during the winter and cool it during the summer.
Net zero	A balance between the amount of greenhouse gases released and the amount taken out of the atmosphere.
Net-zero building	A building that is highly energy efficient and produces on site or procures carbon-free and/or renewable energy in an amount sufficient to offset the annual carbon emissions associated with its operations or simply eliminates carbon emissions altogether.
Off-road	It refers to any vehicle or fuel-consuming equipment that is not licensed to operate on roads or highways, including vehicles for agriculture purposes, recreational vehicles, lawn and garden maintenance equipment, snow removal equipment, and generator sets.
Renewable energy	A naturally occurring energy source that is not finite or exhaustible. It includes sources such as sunlight, wind, and geothermal heat.
Scenario	Data analysis that demonstrates potential futures.
ZEV (Zero-emission vehicle)	A vehicle that does not produce tailpipe emissions or other pollutants from the onboard source of power. Includes electric vehicles.

Abbreviations

Acronym	Definition
BAP	Business as Planned
BAU	Business as Usual
CAP	Climate Action Plan
CAT	Climate Action Tracker
CCAP 1.0	Climate Action Plan 2016
CCAP 2.0	Climate Change Action Plan 2.0 (or "Plan")
CDR	Carbon dioxide removal
CEF	Green Municipal Fund's Community Efficiency Financing
CER	Clean Energy Regulations
CGHAP	Canada's Greener Homes Affordability Program
CH4	Methane
CHHI	Clean Home Heating Initiative
City	Corporation of the City of Peterborough
COP	Conference of the Parties
CoPHI	City of Peterborough Holdings Inc.
FCM	Federation of Canadian Municipalities
GDS	Green Development Standard
GHGs	Greenhouse gases
GJ	Gigajoules
GROW	Green Resource Organics Works
HEEP	Home Energy Efficiency Program
IC&I	Institutional, commercial and industrial

Acronym	Definition
IPCC	Intergovernmental Panel on Climate Change
ktCO2e	1,000 metric tonnes of carbon dioxide equivalent
LCS	Low-Carbon Scenario
LIC	Local Improvement Charge
MACC	Marginal Abatement Cost Curve
MURB	Multi-units residential buildings
NDC	Nationally determined contribution
NPV	Net present value
NZER	Net-zero energy ready
PV	Photovoltaic
RNG	Renewable natural gas
SAF	Sustainable Aviation Fuels
SDG	Sustainable Development Goals
SWQMP	Storm Water Quality Master Plan
tCO_2e	Metric tonnes of carbon dioxide equivalent
UNFCCC	United Nations Framework Convention on Climate Change
VKT	Vehicle kilometers travelled
VOCs	Volatile Organic Compounds
WMMP	Waste Management Master Plan
WMO	World Meteorological Organization
WWTP	Waste Water Treatment Plant
ZEV	Zero-emission vehicle

How to Read This Plan

This Plan informs decision-making regarding GHG mitigation in Peterborough, which will affect all sectors, including transportation, the built environment, land use, energy generation and consumption, industry, and natural systems. The Climate Change Action Plan 2.0 (CCAP 2.0) provides guidance in each of these sectors with "Big Moves" that are policy guidelines for reducing emissions, and it includes implementation strategies that outline schedules, actors, definitions, and specific steps for taking action. Big Moves and implementation strategies are aligned with municipal, provincial, and national policies and regulations to ensure that all guidance in this Plan is actionable and legal. Appendices in the Plan present additional information on engagement and data processing. This Plan also includes contextual commentary to provide background and describe the purpose of the Big Moves and implementation strategies.

1. Introduction

The City of Peterborough is committed to tackling climate change by mitigating the community's emissions, and it recognizes the need to adapt to the inevitable impacts of a changing climate. The first binding commitment was in the 2016 Climate Change Action Plan (CCAP 1.0), which covered the City of Peterborough, Peterborough County and its eight member townships (Asphodel-Norwood, Cavan Monaghan, Douro-Dummer, Havelock-Belmont-Methuen, North Kawartha, Otonabee South-Monaghan, Selwyn, and Trent Lakes), and the Curve Lake First Nation and Hiawatha First Nation. The CCAP 1.0 committed to the following actions:

1. Reducing greenhouse gas emissions;
2. Reducing fossil fuel use;
3. Lowering energy consumption; and
4. Adapting to a changing climate.

The 2016 Climate Action Plan accounted for corporate and community emissions and set a goal of reducing emissions by 30% by 2031 relative to 2011 levels. In 2019, the Peterborough City Council announced its Climate Emergency Declaration, which set more aggressive emissions reduction targets for the city, targeting a 45% reduction in GHG emissions by 2030 and net-zero emissions by 2050 in response to calls for urgent action from the Intergovernmental Panel on Climate Change (IPCC).

Even with mitigation commitments from local and national governments, more ambitious and immediate action is needed, as current trends indicate that global warming is very likely to reach the tipping point of 1.5°C in the near term and will possibly warm by more than 3°C by the end of this century (i.e., 2100), which will have catastrophic effects on human health, food systems, the economy, and the environment. Current warming has already impacted human and natural systems through global sea-level rise, heatwaves, extreme climate events (e.g., heavy precipitation), cyclones, etc., and Peterborough has already felt the effects of global warming. Such impacts will only worsen at higher warming levels (see Figure 1). Under a warming climate of 1.5°C above pre-industrial levels, corals are projected to decline about 70–90%, and under a 2.0°C warming, this rate increases to >99%. Terrestrial ecosystems also face increasing risks of transformation related to species losses and extinction (insects, plants, and vertebrates) due to climate change at 2°C compared to 1.5°C.

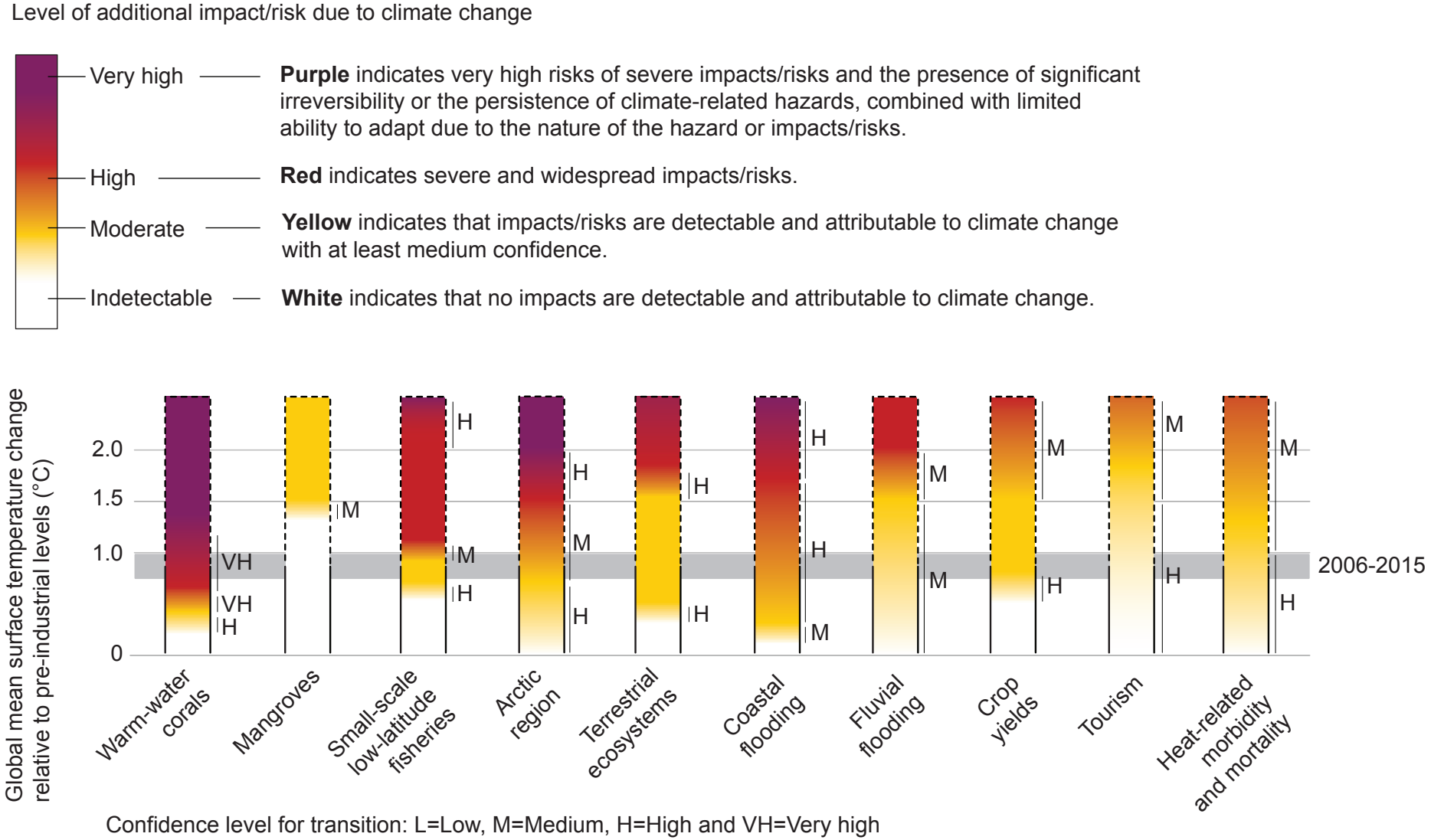

Figure 1. Impacts and risks for different natural, managed, and human systems under different warming levels. Source: Adjusted from (IPCC, 2018)[3].

[3] IPCC, 2018: Summary for Policymakers. Global Warming of 1.5°C. https://www.ipcc.ch/sr15/

Why Do Corals Matter?

Corals are animals responsible for building the well-known coral reefs, and they come in many diverse forms, sizes, and colours. Due to the habitats they create, they are known as the rainforests of the sea. They are among the species known as keystone species, which means that a large number of species depend on them to maintain a healthy and stable ecosystem, or "… Their contribution to ecosystem function is disproportionate to their numerical abundance or biomass"[4]. As such, they provide habitats for thousands of species, which means that their declining rates will have a profound impact on marine species (e.g., fish, algae) and, consequently, on the net productivity of the ocean.

[4] National Oceanic and Atmospheric Administration. Wildlife Health Sanctuary Sentinel Site Issue. https://sanctuaries.noaa.gov/science/sentinel-site-program/wildlife-health.html

City of Peterborough Climate Action Goal

With this in mind, this updated Climate Change Action Plan 2.0 (CCAP 2.0) establishes a set of concrete and ambitious actions for the City of Peterborough to undertake to achieve its targeted emissions reductions of 45% by 2030 and net-zero emissions by 2050. Actions focus on the main emission sectors and consider the implementation costs associated with each action.

Implementing the CCAP 2.0 will bring diverse co-benefits to the city of Peterborough and its residents. If actions proposed in the Plan are implemented, energy use reduces up to 50% by 2050. According to the modelling exercise with the CityInSight model, Peterborough households, as well as businesses and industries, will be directly impacted, seeing savings on their energy bills of about $2 billion[5] between 2024 and 2050.

In terms of employment, the implementation of Peterborough's Climate Change Action Plan 2.0 creates more than 15,000 new jobs, assuming the more ambitious actions are undertaken (this refers to the Net-Zero 2040 Scenario [NZ2040]). Green jobs include industries such as building and construction, transportation, renewable electricity generation, and transmission and distribution, as the city will need workers to retrofit buildings to code, build out bike networks, and install renewable energy sources. This represents an opportunity for the city of Peterborough and its residents to move towards a more sustainable economy that provides liveable wages and stable employment.

These actions align with the 2020 Community Climate Change Resiliency Strategy aimed at preparing Peterborough for climate change and helping it adapt to climate impacts. The co-benefits of actions such as increasing tree canopy coverage include reducing run-off and preventing flooding events, as well as reducing heat island effects by providing shade and natural cooling. For every 1% increase in tree canopy coverage, air temperature is reduced by approximately 0.035°C. For the City of Peterborough, this translates into an air temperature reduction up to 1.2°C, which could help reduce heat-related deaths, as well as a reduced demand for energy for cooling.

[5] Net present value discounted at 3%.

Paradigm of Actions

A Paradigm of Actions that **Avoid, Reduce, Replace, Remove** is proposed to reach the City's goals. The Paradigm of Actions builds on other environmental frameworks, such as "Reduce, Reuse, Recycle" from the waste sector and "Avoid, Shift, Improve" from the transportation sector, to mitigate GHG emissions. This framework provides guidance on an overall approach to community energy and emissions planning, as shown in the following section. In this framework, actions **avoid** producing emissions altogether, **reduce** inevitable emissions, and **replace** fossil fuels by switching to renewable energy. The final actions **remove** carbon emissions through natural sequestration as much as possible and, if necessary, they **offset** residual emissions if no feasible technologies or solutions are available. This paradigm is summarized in Figure 2.

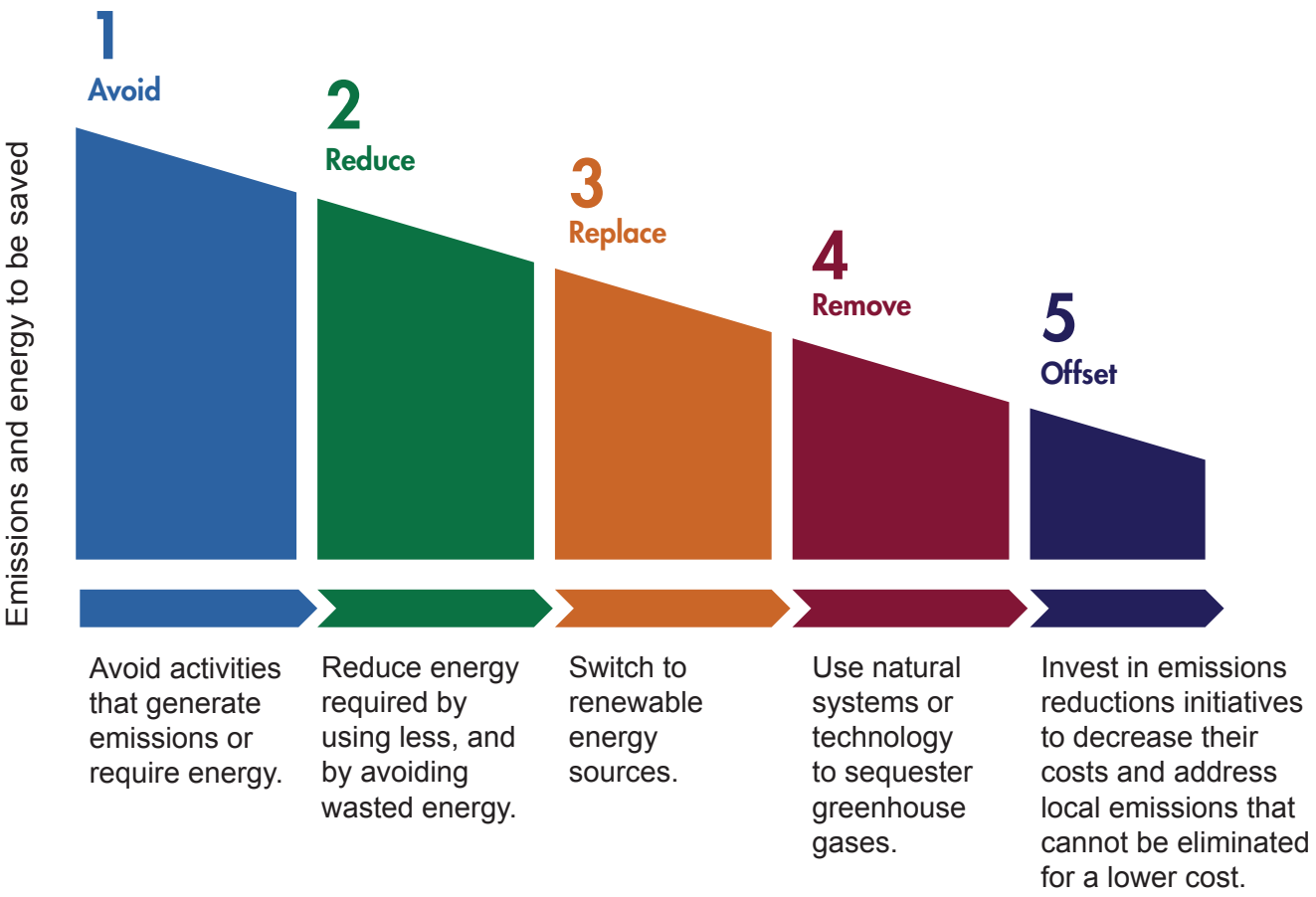

Figure 2. Paradigm of actions for climate change mitigation. Source: SSG.

Climate Change Action Plan Process

The development of this CCAP 2.0 was a collaboration process involving technical work and the engagement of different interested and affected parties and city staff.

Technical Work

Technical work involved performing a context review of the City of Peterborough, including a review of all policies that may impact or intersect with climate action, as well as a review of the previous CCAP 1.0. The main outcomes from this review informed the modelling process to establish the Business-as-Usual (BAU) and Business-as-Planned (BAP) scenarios (for more details, see the following sections).

The context review served as a starting point for creating a catalogue of climate actions suitable for the City. This catalogue was based on the expertise of SSG and a jurisdictional scan that provided insights into what other cities in Canada are doing. The catalogue was reviewed multiple times and, based on the current policies and in alignment with a science-based approach, implementation rates were defined. These rates were adjusted to accurately reflect the City's context and ambitions. All of this work was supported by an engagement process, described below.

Engagement

At the outset of the project, SSG developed an engagement process to ensure interested and affected parties (the term used instead of "stakeholders") had opportunities to inform the engagement activities and provide input on GHG mitigation measures. Interested and affected parties were identified through the pre-engagement process and consultation with the City of Peterborough. Parties included, but were not limited to, representatives from businesses and the economic development community; non-profits and community organizations; equity-denied and Black, Indigenous, and People of Colour (BIPOC) community groups; the building, development, and real estate sectors; and a statistically representative sample of the public.

In accordance with the City's "duty to consult" Indigenous peoples, city staff initiated contact with the Curve Lake First Nation and Hiawatha First Nation at the outset of the project. While a response was not received, the City continues to build relationships with First Nations communities and identify opportunities for reconciliation in climate action.

The full Engagement Strategy detailing each phase (outlined in the Figure 3) is available in Appendix B.

Figure 3. Diagram of engagement phases. Source: SSG analysis.

Engagement by the Numbers

- Twenty-two people participated in three workshops (with nine people participating in both).
- Eight people participated in one focus group and two phone interviews.
- One submission on behalf of the Green Economy Peterborough Advisory Committee.
- Five hundred people participated in a phone survey.
- Fifty-four people responded to an online questionnaire.

Themes Covered

Seven key themes emerged throughout the engagement process. These included themes that applied across different sectors and topics, as well as sector-specific considerations. Twenty-five recommendations were made for the following themes:

1. **Improve public engagement and support:** There is an overall desire to improve the sense of community ownership of the CCAP 2.0. Greater ownership will bolster Council support and, ultimately, Plan implementation.

2. **Identify and advocate for resources:** Resources are needed to fund CCAP 2.0 actions. Engagement participants emphasized continuing to advocate at the provincial and federal levels.
3. **Build equity among populations and across generations:** There is a need to ensure CCAP 2.0 benefits are felt among underserved populations, including youth.
4. **Improve Transportation—active, public, and private:** People are interested in improving active transportation and public transit options. The move toward greater adoption of EVs would require extensive financial support.
5. **Improve current and future housing:** Financial incentives, when carefully designed, can help propel specific actions, such as improving energy efficiency in homes.
6. **Rethink Energy:** There are opportunities for on-site and community-scale energy generation, especially with solar and ground-source heat, as well as for shifting away from natural gas. These opportunities are relatively new compared to other possible actions and are ready for research and development.
7. **Engage businesses:** Businesses are an influential sector of the community, with strong opportunities to mitigate emissions in their operations. Many are ready to act but are unsure where to start.

Participants were invited to complete an online evaluation after each workshop and focus group (four sessions total). Of the 15 people who completed an evaluation, 14 indicated they agreed or strongly agreed with the following statements:

- I feel that I better understand the approach to climate action planning.
- I feel that this session was well facilitated.
- There was enough information presented for me to participate effectively.

Workshop open-ended feedback directly informed the following workshop.

Recommendations for each theme have been integrated into the Engagement Summary (see Appendix B).

2. Peterborough's Past and Present

Global, National, and Local Urgency

The climate crisis is one of the biggest challenges humanity has ever faced, and there is vast evidence that it is anthropogenically caused by the emission of greenhouse gases (GHG). In 2019, our planet was 1.1°C warmer than in pre-industrial times (1850–1900)[6], and our current lifestyles contribute to continuing this trend. The year 2023 was the warmest year on record since historical observations began, with a global mean near-surface temperature of 1.4°C[7], and 2024 is likely to be even warmer[8]. Cumulative GHG emissions from 1850 to 2019 were 2,400 gigatonnes of carbon dioxide equivalent ($GtCO_2e$), and more than 40% of these emissions were generated between 1990 and 2019. The remaining global carbon budget to limit the temperature increase to 1.5°C and avoid the worst impacts of climate change is 500 $GtCO_2e$ (beginning in 2020), although historical cumulative emissions account for four-fifths of the total carbon budget for limiting global warming to 1.5°C. For perspective, in 2020 the global net emissions were 54.5 $GtCO_2e$ and in 2022 they were 57.2 $GtCO_2e$[9], which means that at that rate of emissions, the global carbon budget would be reached by 2030.

According to the Intergovernmental Panel on Climate Change, impacts from climate change disproportionately affect vulnerable communities, which contribute the least to climate change. To date, climate change has caused substantial damages and increasingly irreversible losses, impacting land and ocean ecosystems, increasing food insecurity and water scarcity, widening the occurrence of food-borne and water-borne diseases, and causing avoidable loss of human lives from natural disasters like floods, droughts, heat waves, and storms.

The Climate Policy Initiative estimates that to keep the global temperature below 1.5°C, an annual investment of $5.4 trillion to $11.7 trillion USD is needed up to 2030, and a continued annual investment of $9.3 trillion to $12.2 trillion is required up to 2050, which translates to an average total of $300 trillion between 2020 and 2050. This is disproportionately lower than the cost of inaction, which

[6] IPCC. Summary for Policymakers. In Climate Change 2023: Synthesis Report. A Report of the Intergovernmental Panel on Climate Change (Sixth edition), 2023.

[7] WMO. Provisional State of the Global Climate 2023. World Meteorological Organization, 2023. https://wmo.int/files/provisional-state-of-global-climate-2023

[8] CopernicusEU. "Copernicus: May 2024, Streak of Global Records for Surface Air and Ocean Temperatures Continues | Copernicus," 2024. https://climate.copernicus.eu/copernicus-may-2024-streak-global-records-surface-air-and-ocean-temperatures-continues

[9] UNEP. "UNEP Emissions Gap Report 2023". 2023. https://www.unep.org/interactives/emissions-gap-report/2023/

is projected to be more than $1,266 trillion between 2025 and 2100 (Alberti, 2024). In addition, mitigation measures bring net benefits and co-benefits, such as improving air quality through the reduction of particulate matter emissions, improving human health, decreasing heat-related deaths, providing new sources of employment, and boosting local economies and economies of scale. The World Health Organization estimates that exposure to air pollution results in a global cost of $8.1 trillion per year, equivalent to 6.1% of global GDP[10] (Awe, Y. et. al, 2022). Furthermore, globally, heat waves are expected to produce the largest economic impact and most losses due to increased mortality, decreased productivity, heat-related illnesses, and major pressure on healthcare systems. Health-related diseases alone are projected to cost the global economy up to $7.1 trillion by 2050[11].

In this context, both the remaining carbon budget and the detrimental climate impacts demand rapid climate action be taken, and national and local governments are committing to making the necessary changes. In 2015, during the Conference of the Parties (COP 25) of the United Nations Framework Convention on Climate Change (UNFCCC), 196 parties signed the Paris Agreement, an international agreement to limit the global temperature increase to 2°C and make an effort to reach 1.5°C by reducing GHG emissions. Canada committed to the Paris Agreement, presenting its first Nationally Determined Contribution (NDC) in 2017[12] and updating its commitments in 2021[13]. However, even with current policies and national reduction targets, global GHG emissions are not currently on the path to meet the Paris Agreement's 1.5°C target (see Figure 2). The gap exists due to the lack of ambition and implementation of mitigation policies and measures by many countries. Some parties have not yet committed to science-based net-zero

[10] Awe,Yewande Aramide; Larsen,Bjorn Klavdy; Sanchez-Triana,Ernesto. "The Global Health Cost of PM 2.5 Air Pollution : A Case for Action Beyond 2021 (English)". International Development in Focus Washington, D.C. : World Bank Group. http://documents.worldbank.org/curated/en/455211643691938459/The-Global-Health-Cost-of-PM-2-5-Air-Pollution-A-Case-for-Action-Beyond-2021

[11] World Economic Forum & Wyman, A. "Quantifying the Impact of Climate Change on Human Health". 2024. https://www.weforum.org/publications/quantifying-the-impact-of-climate-change-on-human-health/

[12] Government of Canada. Canada's 2017 Nationally Determined Contribution submission to the United Nations Framework Convention on Climate Change, 2017. https://unfccc.int/sites/default/files/NDC/2022-06/Canada%20First%20NDC-Revised%20submission%202017-05-11.pdf

[13] Government of Canada. Canada's 2021 nationally Determined Contribution under the Paris Agreement, 2021a. https://unfccc.int/sites/default/files/NDC/2022-06/Canada%27s%20Enhanced%20NDC%20Submission1_FINAL%20EN.pdf

emission targets by 2050 (science-based targets[14]) and continue to subsidize and deploy fossil fuels, which only worsens the current GHG emissions situation, making it increasingly difficult to achieve ambitious targets.

Figure 4 displays the historical emissions up to 2022 at a global scale, including all emitting and absorbing sectors, such as energy, industry, waste, agriculture, and forestry. Figure 4 also displays the needed emission pathway to limit global warming to 1.5°C above pre-industrial levels (green line) up to 2030. This pathway requires ambitious actions and the implementation of mitigation solutions. In contrast, the blue dotted line represents the emission pathway the Earth will follow if all current policies and NDCs were to be fully implemented. The gap between the blue and green lines reaches approximately 20 $GtCO_2e$ by 2030, which is almost half of the global total emissions by 2022 (59 $GtCO_2e$).

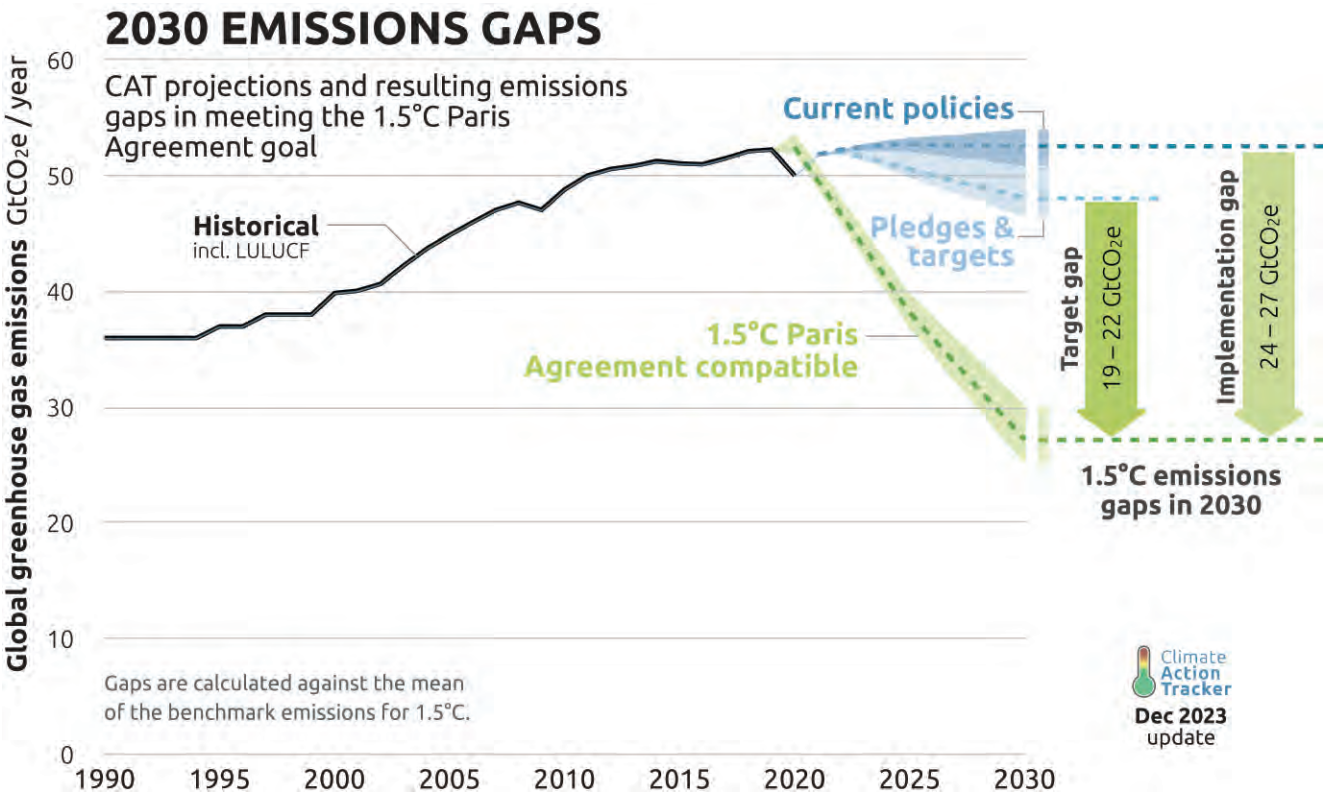

Figure 4. The 2030 emissions gaps.[15] Source: (CAT, 2024).[16]

[14] The term science-based targets refers to long-term strategies that align with the Paris Agreement target.

[15] https://climateactiontracker.org/global/cat-emissions-gaps/

[16] Copyright © 2022 Climate Action Tracker by NewClimate Institute and Climate Analytics. All rights reserved. The content provided by this website is protected by copyright.

Cities are where most economic and production activities occur, where most people live, and where most emissions are produced. For instance, in Ontario, less than 20% of the population lives in rural areas[17], and in Peterborough, dwellings represent 23% of the total community emissions[18]. As such, cities play a fundamental role in climate mitigation, as they are the key to implementing climate action on the local level. The City of Peterborough recognizes the need to take immediate action in addressing this global challenge, as well as its responsibility in helping Canada reach its commitment to reduce greenhouse gas emissions. The City took early action in 2016 by approving its first Climate Action Plan, and it strengthened its commitment in 2019 by declaring a climate emergency and setting goals to achieve a 45% reduction of GHG emissions by 2030 (compared to 2011 levels) and net-zero emissions by 2050.

In order for progress to be made quickly, all levels of government must use the authority they have to expedite change. While each national government sets its country's commitment following international treaties and is responsible for enabling action through national policies, regulations, and funding, cities are at the forefront of implementation and are usually responsible for decision-making or influencing decisions about their transportation systems, waste management systems, land-use and urban planning, green spaces, and, in some cases, building and energy codes. Peterborough has the opportunity to be a city leader in taking ambitious action.

Net-Zero Emissions

Net-zero emissions, or "net zero," is the balance between all emissions released by human activities (i.e., driving, heating and cooling buildings, producing and processing waste) and removing carbon from the atmosphere through carbon removal (i.e., carbon sequestration from forests and carbon capture). For cities, this most often looks like drastically reducing the amount of carbon their jurisdiction is responsible for and promoting carbon sequestration through urban forests and native habitat restoration via land-use planning.

[17] Ontario. Socioeconomic facts and data about rural Ontario [Database]. Rural and the North, 2023. https://www.ontario.ca/page/socioeconomic-facts-and-data-about-rural-ontario

[18] City of Peterborough. "Community Mitigation: Climate Action in Peterborough." City of Peterborough official website. Climate Change and Environment, 2021. https://www.peterborough.ca/en/city-hall/climate-action-in-peterborough.aspxo

Current or Upcoming City Policies and Initiatives

The City is currently implementing policies and undertaking climate action initiatives that directly and indirectly support GHG mitigation in the highest emitting sectors: buildings, transportation, energy, waste, and land use. These actions have been supported by other levels of government, as well as by other stakeholders, such as utilities services.

In regards to the building sector, some efforts have been local (such as the Central Area Urban Design Standards completed in 2023), containing recommendations for buildings in regards to renewable energy generation, intensification of residential uses, encouraging a transit-supportive city and pedestrian-oriented areas, active transportation infrastructure, etc.

Peterborough also requires building developers to adhere to the latest provincial building code in Ontario, and it is worth noting that although municipalities follow provincial codes, they have the jurisdiction to develop Green Development Standards (GDSs). According to its Official Plan (City of Peterborough, Official Plan 2023, p.170), Peterborough is considering a GDS, and voluntary requirements that go beyond provincial building codes are possible through the standard, supported by corresponding incentives to developers to adhere to higher standards. A few examples of GDSs in the region are Whitby, Clarington, and Mississauga, which have developed their own GDSs and can act as examples for Peterborough. GDSs complement the current National Energy Code, which mostly focuses on energy efficiency (e.g., insulation, LED lightning, heat pumps), while also covering on-site renewables, green building materials, and other elements that contribute to both mitigation and adaptation, such as green roofs, drought-resistant plants and trees, and light-coloured paving.

Canada's Net-Zero Energy Ready (NZER) Building Code 2020 proposes reaching reductions in the sector through a tiered approach. This approach consists of four tiers of energy performance in which Tier 1 is the least demanding and Tier 4 is the most stringent. A Tier 4 building is so efficient that it consumes only as much energy as it produces through its on-site renewables. A nearly net-zero building requires high energy efficiency performance standards and complementary measures such as on-site renewables and green building materials to reduce embedded carbon and inputs during the construction phase.

The City is developing a Home Energy Efficiency Program (HEEP) to reduce home energy consumption and GHG emissions via energy efficiency, renewable energy generation (e.g., solar panels), and other low-carbon measures by providing supportive retrofit financing options for participants (e.g., loans). The Federation of Canadian Municipalities (FCM) supports the program through the Green Municipal Fund's Community Efficiency Financing (CEF). Currently, this program aims to help approximately 600 households retrofit their homes, creating total reductions in GHG emissions of 825 tonnes of CO_2 per year and saving over 28,000 GJ of energy over four years.

Utilities and service providers in the city also offer alternatives such as Provincial Smart Homes Services, which provides up to $10,000 in rebates for new heat pumps. Similarly, the Home Efficiency Rebate Plus Program, hosted by Enbridge Gas in coordination with Natural Resources Canada (known as Canada's Greener Homes Program)[19], provided clients in Ontario with rebates for retrofits and heat pumps. Moreover, to support the transition to cleaner energy sources and higher energy efficiency in existing buildings, Peterborough launched the Clean Home Heating Initiative (CHHI) in 2022, offering $3,000 to $4,500 rebates to homeowners to install a dual-source heat pump linked to a smart control. This initiative was administered by Enbridge and funded by the provincial government.

In terms of energy generation, Peterborough Utilities generates almost 150,000 MWh of clean energy each year (from hydropower generation, ground and rooftop solar photovoltaic arrays, a co-generation plant at the wastewater treatment plant, and Peterborough's waste management facility). The Peterborough Waste Management Facility, Bensfort Road Landfill, generates 1.6 MW of electricity from recovered methane gas. The City's Official Plan states that the City would consider identifying opportunities to provide centralized, integrated energy systems, such as district energy for heating and cooling. In addition, the City built the Community Solar Energy Map, which identifies the most suitable places for solar power installation on commercial and residential buildings. This tool is helpful for distributed generation through solar photovoltaic (PV) panels on rooftops.

[19] Note that this program is under review and it is expected to be replaced by a new version.

What is the **Updated Official Plan of Peterborough**

Peterborough's Official Plan is a strategy for the long-term growth and development of the city. As the principal planning document, the goals, objectives, and policies described in the Plan are used to guide the City's land-use decisions. In addition to giving direction on where different land uses (i.e., residential, commercial, industry) and amenities (i.e., schools, parks) will be located, the Official Plan also has climate actions embedded into it: "The intent of this Plan is to support energy efficiency, improved air quality, reduced greenhouse gas emissions and climate change adaptation through sustainable land-use patterns and the integration of green infrastructure." As such, this Climate Change Action Plan aligns with policies adopted in the City's Official Plan.

Other utilities are also taking a step forward to using cleaner fuels by piloting projects to explore other low-carbon energy sources that will benefit Peterborough, such as Enbridge's utility-scale hydrogen gas production for transportation and natural gas and battery energy storage systems being created to lower grid emissions. For example, Enbridge helped establish a utility-scale facility of hydrogen gas (H2) production in Markham, Ontario[20]. The hydrogen produced is blended with natural gas and injected into the current pipelines. Future projections aim for exclusive H2 pipelines.

Regarding the transportation sector, the City is working on greening its fleet and adding charging infrastructure. Peterborough has supported the growth of charging infrastructure throughout the city in places like Riverview Park & Zoo and Del Crary Marina. Currently, there are 72 ports, of which approximately 30 are public. This translates into 8.5 ports per 10,000 inhabitants, which is above Canada's national per capita average of only seven ports per 10,000 habitants[21]. Together with British Columbia and Quebec, Ontario is leading the charge in installation of EV charging ports, increasing the number of ports more than three times in only

[20] Enbridge. "Clean Hydrogen Enters the Markham Energy Mix." Enbridge Blog, 2022. https://www.enbridge.com/stories/2022/january/hydrogen-blending-project-enbridge-gas-cummins-operational-markham-ontario

[21] ChargeHub. "Peterborough, Ontario EV Charging Stations Info." Ontario, n.d. https://chargehub.com/en/countries/canada/ontario/peterborough.html

five years (2018–2023)[22]. At a national level, due to population growth and the penetration of electric vehicles, following Canada's commitment to electrification will require between 84,900 DCFC ports and 830,000 L2 ports by 2050 nationwide, depending on access to home charging[23].

The City also supports educational programs, such as the On the Bus program for Grade 3 students[24]. It is a free program that takes students on a trip around the city to show them the transportation options and the active transportation connections. The program focuses on introducing students to and encouraging them to use public transit. GreenUp developed a similar program for Grade 8 students and offers a wide range of educational material on public transit and cycling. Another ongoing initiative supported by GreenUp is the Shifting Gears transportation challenge, which promotes active transportation, transit, carpooling, and remote work.

The new Transportation Master Plan, released in 2022, set the goal of having 10% of all trips be made by transit in 2051. To encourage more ridership, the Plan increased service frequency to every 15 minutes on key corridors and every 20 to 30 minutes along all other routes. Transit service has undergone recent changes to increase service hours and routes, opting for a grid transit model. The Transportation Master Plan also states that the public transit fleet will move towards low-emission vehicles but has yet to set dates and targets for electrification.

At the national level, Canada has set goals in the new Electric Vehicle Availability Standards to increase zero-emission light-duty vehicle sales[25]. This standard requires that auto manufacturers and importers meet annual zero-emission vehicle (ZEV) sales targets. The target, which begins in 2026, is for at least 20% of new vehicles sold to be ZEVs, increasing to 60% of new car sales by 2030 and to 100% of new car sales in 2035.

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[22] Zhang, Arthur. "Ev Charging Infrastructure Is Spreading Rapidly across Canada." Canadian Climate Institute Data website. 440 Metonnes Canada, 2023. https://440megatonnes.ca/insight/ev-charging-infrastructure-is-spreading-rapidly-across-canada/#:~:text=PEI%20has%20by%20far%20the,charging%20ports%20per%2010%2C000%20people

[23] Dunsky & NRC. "Canada's Public Charging Infrastructure Needs: Updated projections". https://natural-resources.canada.ca/sites/nrcan/files/energy/cpcin/2022-ev-charging-assesment-report-eng.pdf

[24] GreenUp. "On the Bus," n.d. https://greenup.on.ca/program/on-the-bus/

[25] Environment and Climate Change Canada. "Canada's Electric Vehicle Availability Standard (Regulated Targets for Zero-Emission Vehicles)." Government of Canada. Canada.ca, 2023. https://www.canada.ca/en/environment-climate-change/news/2023/12/canadas-electric-vehicle-availability-standard-regulated-targets-for-zero-emission-vehicles.html

The Waste Management Master Plan (WMMP) sets the City's waste diversion goals to reduce the amount of waste that ends up in landfills. The Plan commits to increasing the City's diversion rate to 75% by 2030, including diverting plastics, metal, and other recyclable materials, as well as organics. In October 2023, the WMMP introduced clear garbage bags and garbage pickup every two weeks, and it reduced the number of bags for curb pick up. Also in October 2023, under these commitments Peterborough began to implement a city-wide organic waste collection and composting program, GROW (Green Resource Organics Works).

The City has an Urban Forest Strategic Plan that targets protecting and enhancing the tree canopy to help with flooding and carbon capture. The Official Plan aims to implement the Urban Forest Strategic Plan and achieve 35% tree canopy coverage by 2051. In addition, the Official Plan mandates implementing the Restoration and Enhancement Strategy, which guides stewardship activities and suggests priority areas for enhancement.

The City has also implemented Bylaw N° 21-074, which regulates the removal of trees on private land within the city. The bylaw requires residents to obtain a permit in advance of any work related to tree removal of a physiologically mature unit. A second bylaw is Bylaw N° 17-121 of Woodland Conservation. It regulates the injury or destruction of all trees within woodlands, including trees within plantation woodlands located within the city, whether the woodland is located on private property or on land owned by the City. These bylaws support the City's efforts to preserve and conserve its urban forest and tree canopy.

Finally, in 2023, the City completed its Tree Protection and Urban Forestry Guidelines, which clarify the City's requirements for tree protection at development sites. The guidelines support the implementation of the Official Plan, as well as other policies, by consistently applying tree and woodland compensation requirements to offset the loss of the tree canopy and the urban forest benefits associated with development and land-use change (City of Peterborough, 2023).[26]

[26] Streamline Development Approval Funding Program Update, Report IPGPL23-001.

Canada's National Commitment on Climate Change

Canada is committed to reducing its emissions by 40–45% below 2005 levels by 2030 and achieving net-zero emissions by 2050. To accomplish this, it has implemented various mechanisms, such as carbon pricing tools, funding, and regulations.

The country's climate vision for the future is outlined in its Net-Zero 2050 target, as well as in the Emission Reduction Plan 2030 and Canada's Climate Actions for a Healthy Environment and a Healthy Economy. All of these documents report a set of actions aimed at achieving the 2030 and 2050 goals.

One approach is carbon pricing, which refers to economic instruments used to put a price on carbon pollution. In Ontario, this mechanism is implemented through a fuel charge and a provincial output-based pricing system for industries. Another measure is the sales mandate, which ensures that 100% of light-duty vehicle sales will be zero-GHG-emissions vehicles by 2035. A third effort is outlined in the Clean Energy Regulations (CER), which establish performance standards to reduce GHG emissions from fossil-fuel-generated electricity, starting in 2035.

Emissions Snapshot

In 2021, the city of Peterborough's community-wide estimated emissions were 537.3 kilotonnes of carbon dioxide equivalent ($ktCO_2e$) (Figure 5),[27] with the transportation and residential sectors being the largest contributors.

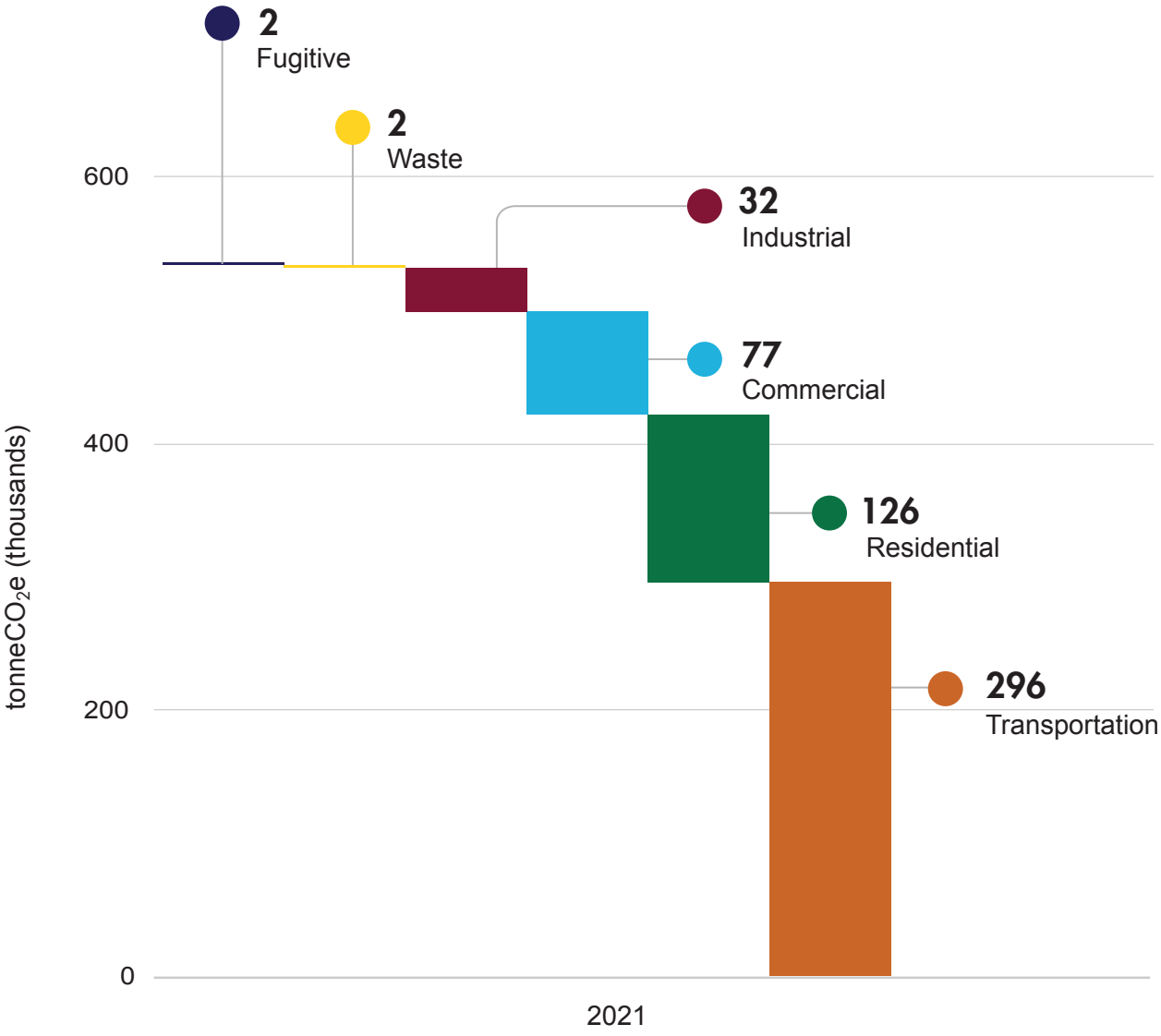


Figure 5. Modelled 2021 GHG emissions in the city of Peterborough.
Source: SSG analysis.

[27] The emissions were estimated based on bottom-up data from the City of Peterborough. For more details about this calculation, please consult the DMA report in the Appendix Section.

Most of these emissions are caused by fossil fuel use (Figure 6), such as using diesel or gasoline in private vehicles (Figure 7) and using natural gas for residential heating (Figure 8).

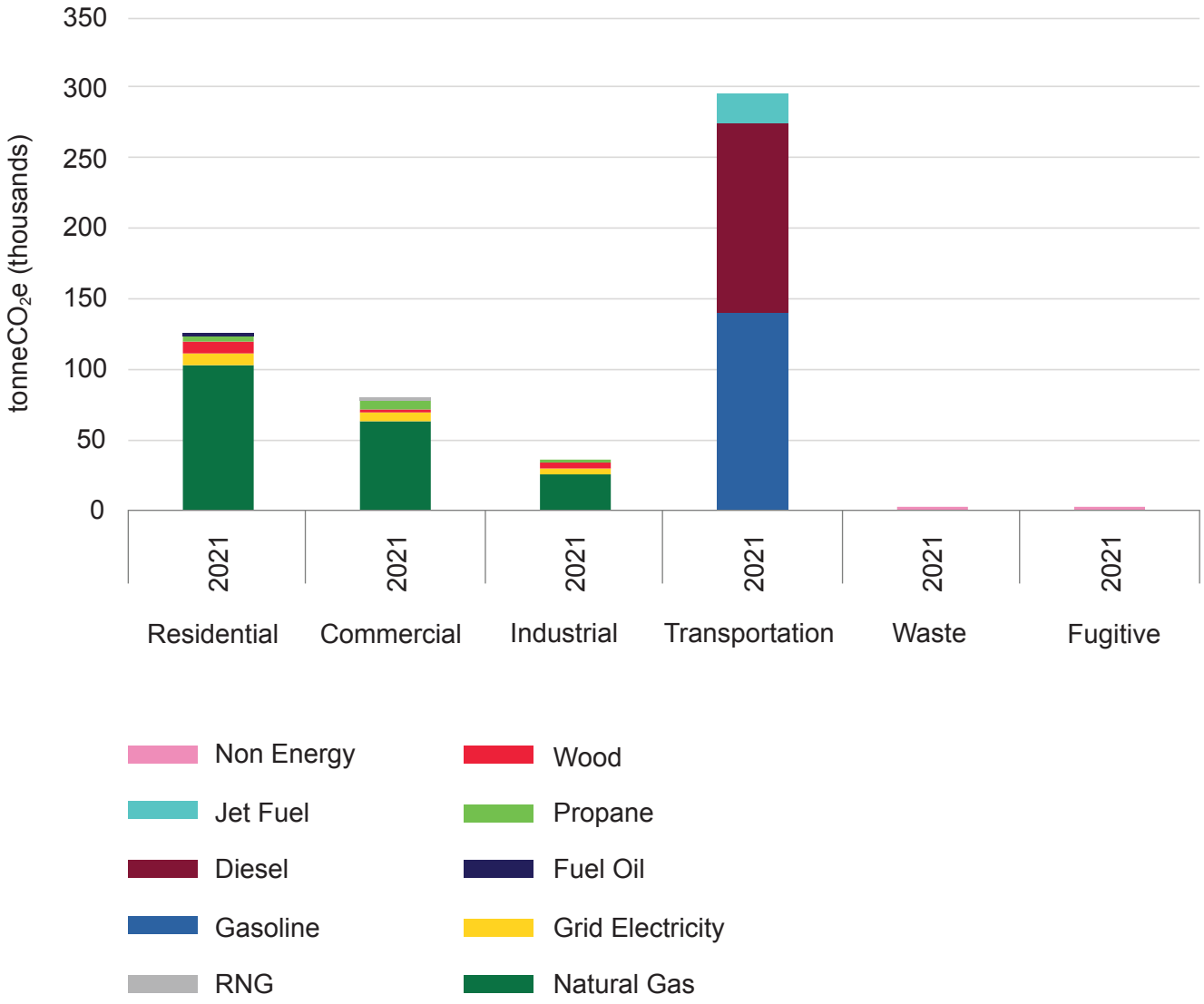


Figure 6. Modelled 2021 GHG emissions in the city of Peterborough, by fuel type and sector. Source: SSG analysis.

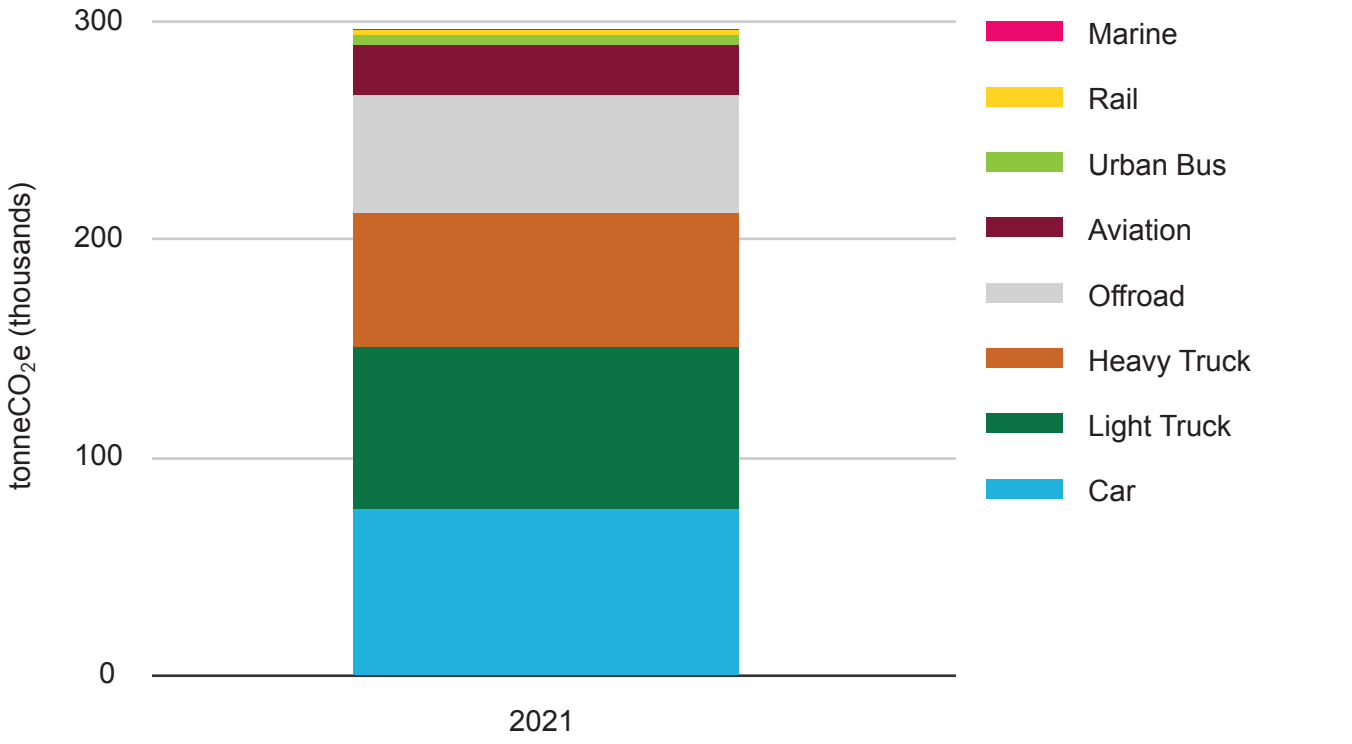


Figure 7. Modelled 2021 GHG emissions in the City of Peterborough, by vehicle type for the transportation sector. Source: SSG analysis.

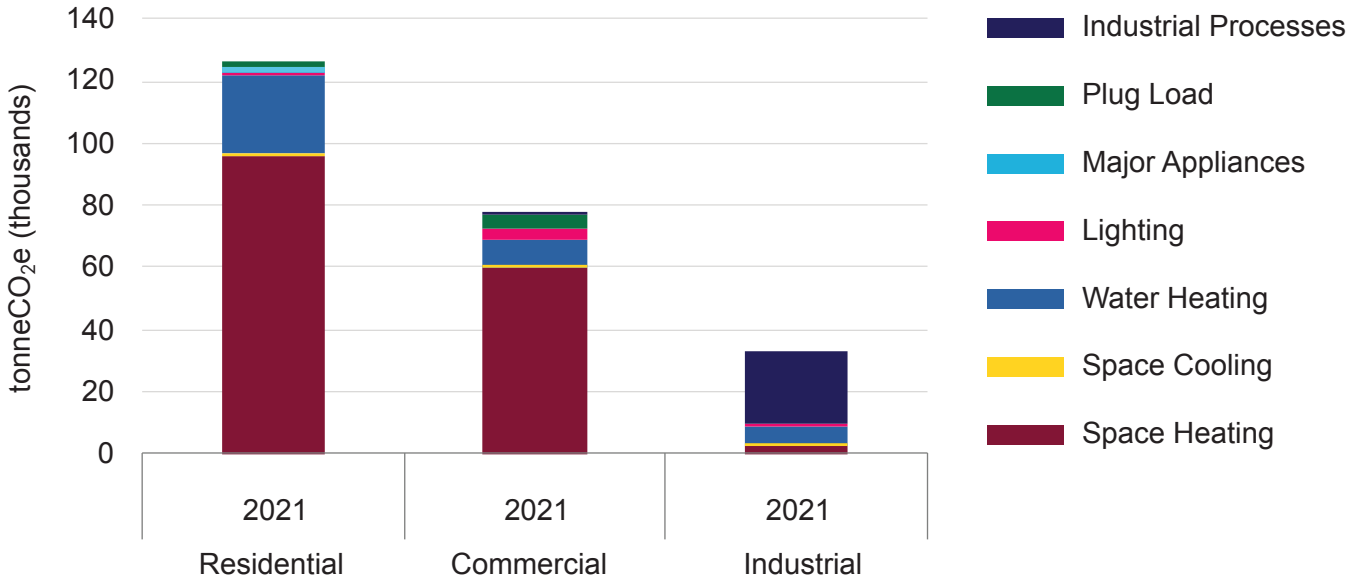


Figure 8. Modelled 2021 GHG emissions in the city of Peterborough by end-use type for the building sector. Source: SSG analysis.

The following are the key findings from these emissions snapshots:

- The transportation sector accounts for 55% of the city's total emissions, with 296.1 ktCO_2e. These emissions are almost equally distributed between cars (26%), light trucks (25%), and heavy-duty (20%) and off-road vehicles (19%).
- The residential and commercial sectors are the second and third largest sources of emissions with 23% and 14%, respectively. The main activity producing these emissions is space heating, contributing more than 67% of total emissions for these sectors. Natural gas contributes more than 80% of the total emissions for the building sector.
- Finally, the industrial sector contributes 6% of the city's total emissions, and this is mostly related to energy consumption for industrial processes (72%), followed by water use and treatment (18%) and space heating (6%).

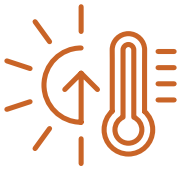
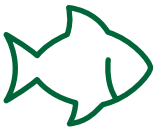
The total emissions means that each resident has a carbon emission of 5.32 tCO_2e by 2021. This is well below Canada's per capita emission of more than 13 tCO_2e/person[28].

[28] International Energy Agency. "Canada - Countries & Regions." IEA, 2022. https://www.iea.org/countries/canada/emissions

Climate Change Impacts in Peterborough

As global GHG emissions increase and the climate continues to change due to a warming world, the probability of climate hazards impacting Peterborough increases, as outlined in Table 1.

Table 1. Climate hazards anticipated due to the changing climate in the city of Peterborough.

Climate hazard	Impact
Extreme heat 	• 43 more days above 30°C by 2080 • Summer days that are 5°C hotter on average
Precipitation 	• 13% increase in average annual precipitation, with drier summers but wetter winters and springs • 14% increase in precipitation on the wettest day by 2080 (i.e., more flooding)
Water temperatures 	• Increased water temperatures negatively impact wetlands, habitats, and biodiversity
Water security 	• Reduced snowpack and more rainfall cause a 20%–70% increase in run-off in winter • Longer growing season

These climate threats will manifest in different ways, such as flooding, ice storms, wind storms, summer storms, drought, and heat waves, some of which the city has already experienced. According to the Climate Atlas of Canada, the city of Peterborough's mean temperatures will increase in a high-emissions scenario[29] from a historical average mean annual temperature of 6.5°C to 8.8°C, as displayed in Figures 9 and 10.

[29] For more information on the climate models, please see here: https://climateatlas.ca/map/canada/annual_meantemp_2030_85#z=8&lat=43.91&lng=-79.31&city=414

To cope with these climate change impacts, Peterborough has designed and implemented different policies and strategies, including the following:

- **Central Area Flood Mitigation Project:** This is a floodwater diversion project to increase the stormwater capacity in the downtown, redirecting water flows away from Jackson Creek into Little Lake during extreme weather events.
- **Curtis Creek Flood Reduction Activities and Master Plan:** Initiative to improve Curtis Creek channel by widening the course, stabilizing bank erosion, etc.
- **Rain Garden Subsidy:** Allows homeowners to place garden beds under rooftop downspouts to absorb and filter run-off water.
- **Flood Reduction Subsidy Program:** Funding for designated priority areas that suffered damage during 2002, 2004, and 2012 flooding events, partly covering the cost of labour and materials related to flood reduction activities.
- **Storm Water Quality Master Plan (SWQMP):** Strategy focused on reducing the amount of pollution carried by the municipal storm drainage system to local creeks and the Otonabee River. It includes maintaining stormwater ponds, removing sediments, potentially modifying ponds, providing awareness and outreach programs, performing system surveillance, etc.
- **Urban Forest Strategic Plan:** The 2011 Plan aims to maintain, conserve, protect, and maximize the benefits of urban forests, recognizing forests as key to the city's green infrastructure.
- **Community Climate Change Resiliency Programming:** Guides adaptation efforts, especially focusing on reducing flood risk, protecting and enhancing natural heritage, supporting agricultural communities, and preparing for extreme weather events.

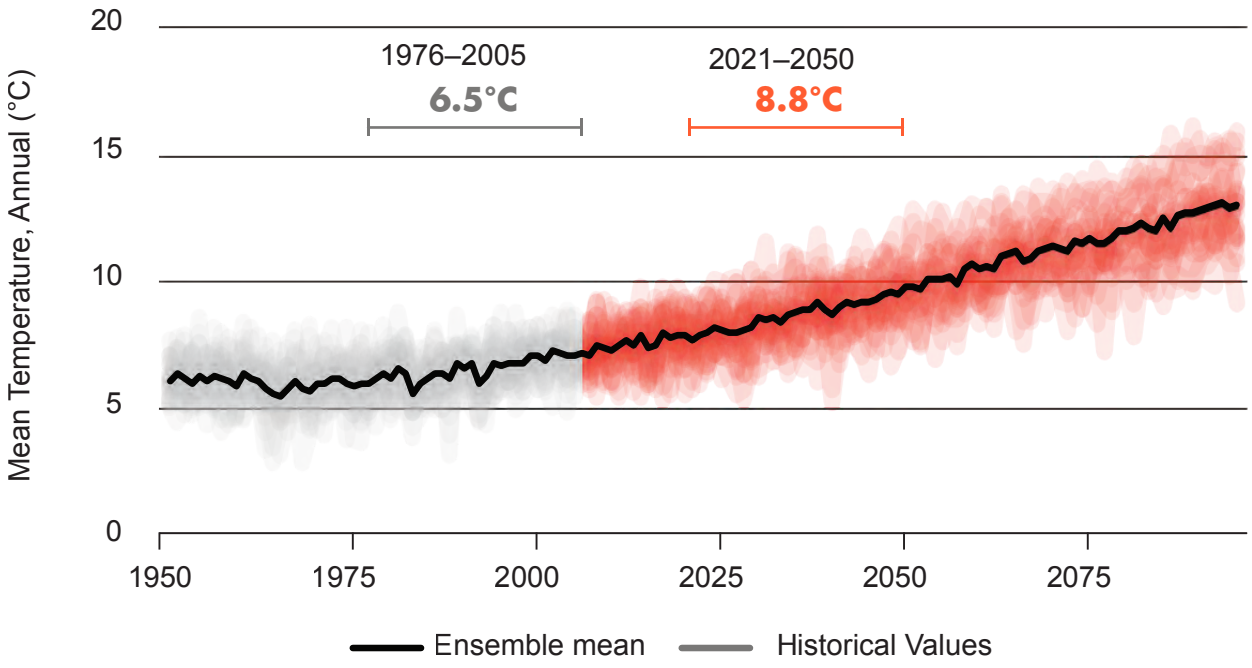


Figure 9. Historical and modelled annual mean temperature for the city of Peterborough under a High-Emission Scenario. Source: Adjusted from Canada's Climate Atlas.

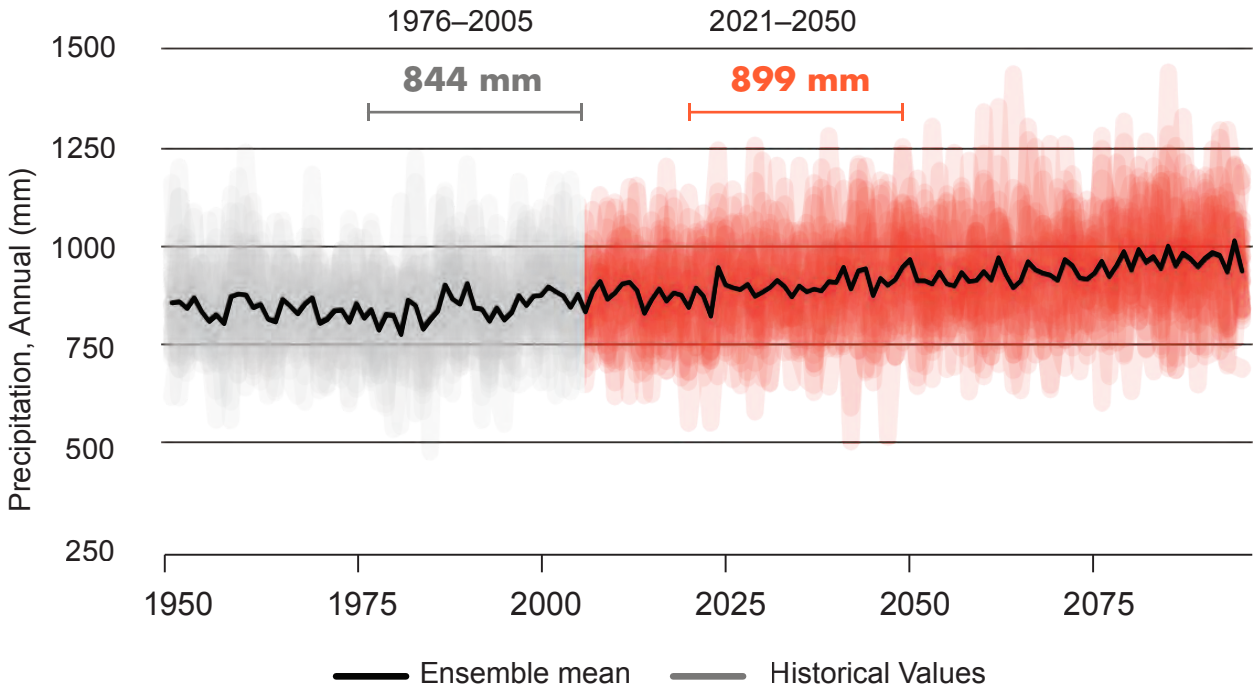


Figure 10. Historical and modelled annual mean precipitation for the city of Peterborough under a High-Emission Scenario. Source: Adjusted from Canada's Climate Atlas.

3. Peterborough's Future

Scenario modelling for the City of Peterborough was developed to align with the Official Plan and the policies and programs described above. This Climate Change Action Plan 2.0 also aims to align with the 2019 Climate Emergency Declaration's goal to achieve a 45% emissions reduction by 2030, compared to 2011 levels, and net zero by 2050. The following are the main results of this modelling work:

- GHG mitigation actions for buildings, energy supply, transportation, industry, waste, and urban forestry and carbon capture that are applicable to Peterborough.
- Financial analysis of the mitigation actions for different scenarios.
- Implementation recommendations per sector and overall recommendation of finance strategy.
- Co-benefits of the implementation of mitigation actions.

To explore these future pathways, an analysis was performed in SSG's CityInSight model, which relies on demographic, building, and energy-use data and other inputs. The model uses a holistic approach, integrating the analysis of energy, emissions, and finance elements, and it provides a detailed analysis of the action impacts in reducing energy use and emissions, both across time and spatially. The model also provides insights on the interactions and feedbacks between the mitigation actions, such as the need for additional electricity generation due to the increased adoption of electric vehicles and the electrification of buildings.

System Approach

Each city is a complex model with a multitude of variables and their respective relationships. To get an accurate representation of the city, CityInSight uses the stocks and flows to understand all the main emitting sectors (Figure 11). For example, when looking at space heating, the model tracks the stock or quantity and type of space-heating equipment and the flow or the retirement of this equipment based on its end-of-life cycle. Additionally, the stocks and flows impact the financial analysis, as replacing a natural gas boiler with another boiler will have different costs than replacing a boiler with a heat pump. Additionally, a heat pump saves energy costs because natural gas is not being purchased, which is considered in the model.

Some flows are more static than others. For example, the current building stock is expected to last until 2050, whereas vehicles only have a lifecycle of 10–15 years, resulting in multiple replacements between 2025 and 2050.

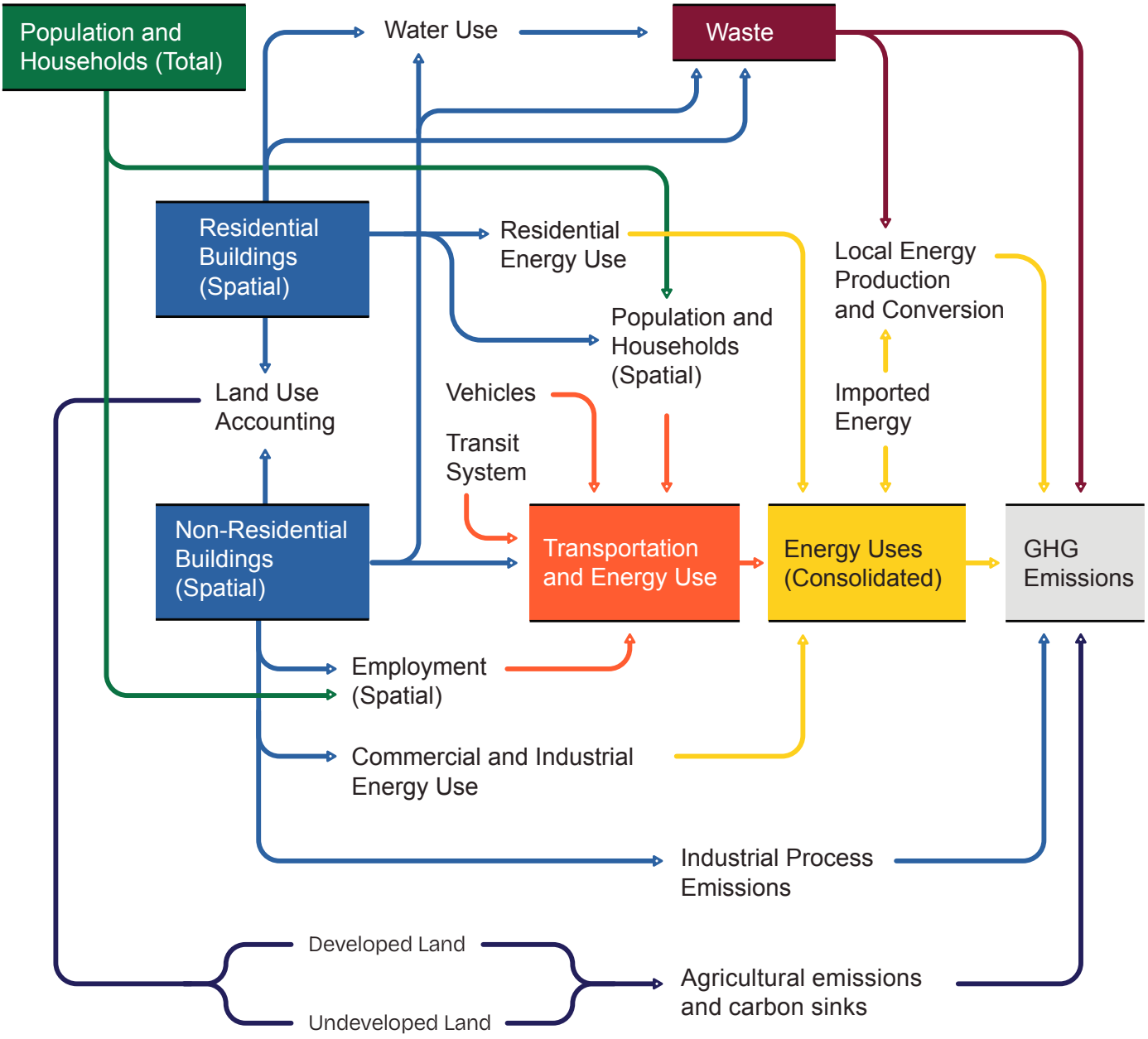


Figure 11. Illustration of the CityInSight model components and relationships.
Source: SSG analysis.

Modelling the Future

The following five scenarios were modelled to provide a complete picture of Peterborough's current reality and to assess the potential of mitigation actions:

- **Business-as-Usual (BAU) Scenario:** Describes what would happen if no additional actions or policies are undertaken at the local, provincial, and national levels. The emissions trajectory follows the current trends considering population and employment growth projections.
- **Business-as-Planned (BAP) Scenario:** Incorporates local, provincial, and national policies and actions that are currently planned and approved. The scenario assumes these policies will be implemented and shows their emissions trajectory up to 2050.
- **Net-Zero 2050 (NZ2050) Scenario:** Aims to reach net zero by 2050. Analyzes the implementation of current approved policies and additional mitigation measures.
- **Net-Zero 2040 (NZ2040) Scenario:** Aims to reach net zero by 2040. Describes a more ambitious implementation timeline for the actions outlined in the NZ2050 Scenario.
- **Alternative Fuels (AltFuels) Scenario:** Presents a future in which alternative fuels are in place and explores a more ambitious target for electrification, penetration of hydrogen in the transportation sector, and the use of methane captured in the waste sector as a replacement for natural gas.

The following steps were taken to develop these different modelling scenarios:

Step 1: Defining the base year for Peterborough: The selected base year was 2021 because it provides the latest available data from Canada's national census database at the local scale. Bottom-up data for buildings (i.e., size, shape) and transportation (i.e., driving distances) were calibrated with observed energy consumption data from utilities and other sources to ensure the model properly describes the situation in the city of Peterborough.

Step 2: Projecting GHG emissions under a Business-as-Usual Scenario: This scenario was designed to reflect what would happen if the City put no additional effort or investment into climate action. It captures population growth and current patterns of activity. Some existing climate actions at upper levels of government are considered, mostly those already in place (not planned), such as building codes, federal fuel efficiency standards, and the national carbon pricing mechanisms.

Step 3: Projecting current climate action through the Business-as-Planned Scenario: The BAP Scenario reflects what the City has planned but not yet implemented, including projects and plans already approved. Projects and planning described in the Official Plan, the Housing and Homeless Plan 2019, the Green Resource Organics Works composting program, etc. are included in this scenario.

Step 4: Identifying and quantifying GHG reduction actions: A catalogue of actions was explored based on the best practices for municipal action and current mitigation actions implemented by Peterborough and through consultations with the city division and engagement activities with other stakeholders.

Step 5: Defining the net-zero target for 2050 and 2040: Two net-zero pathways were constructed to explore the potential pathways to achieving net zero by 2050 and by 2040. The pathway to 2050 proposes actions such as increasing energy efficiency in buildings, retrofitting existing buildings, continuing to divert organic waste from disposal streams, and increasing active transportation. The scenario to achieve net zero by 2040 models the same actions at an accelerated pace.

Step 6: Defining an alternative scenario in which alternative fuels are used by 2050: In the context of emerging hydrogen-based technologies and the growing H2 industry in the region, a third scenario was explored to include other fuels instead of full electrification of some of the activities. This scenario includes using H2 buses for transit and freight transport.

Step 7: Cleaning the electricity grid: A great portion of the remaining GHG emissions are a result of the fossil fuel use in electricity generation in the grid. Moving towards renewable generation locally and on site will help the transition to a more self-sufficient future, securing access to clean electricity and reducing the dependency on fossil fuels.

Step 8: Closing the gap to reaching 1.5°C: The residual emissions can be removed through a combination of strategies, such as facilitating carbon sequestration through forestation and afforestation, using carbon dioxide removal (CDR) technologies, and/or offsetting carbon emissions with carbon credits.

Residual Emissions

Residual emissions are emissions remaining after all mitigation efforts have been implemented.

Peterborough Projections

Demographics are the basis of projecting a community's emission trends. Data such as population growth, employment rates, and number of households and personal vehicles provides insight into the city's future emissions. Most of the baseline information was collected from the National Census in 2021 and projected trends from the Official Plan in 2023 were used, which provides estimates to 2051.

Based on this information, the city of Peterborough will experience a 21% population increase by 2050 relative to 2021 (from 86,588 up to 139,852 people) (Figure 12).[30] Employment is expected to grow by 8,820 jobs from 42,899 jobs in 2021. Dwellings are expected to increase 52% by 2050, reaching a total of 55,782 compared to 36,795 in 2021. Personal vehicles will also increase relative to population growth, from 51,513 vehicles in 2021 to 79,017 by 2050, slightly increasing the number of vehicles per household from 1.39 to 1.41 between 2021 and 2050. This trend aligns with the expected increase in dwellings (Figure 13), in which a large increase in apartment units and a moderate pace increase in semi-detached and single detached units are expected.

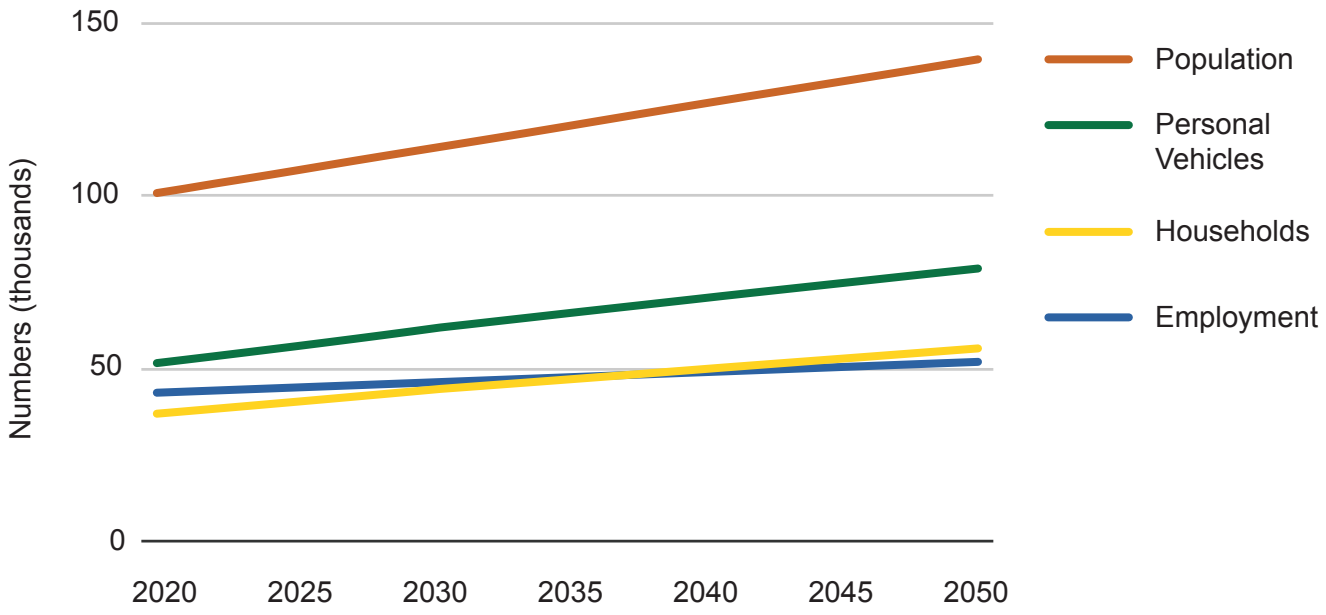


Figure 12. Projections of population, employment, households, and vehicles in the BAP Scenario. Source: SSG analysis.

[30] The undercounted population is up to 14,375 students, not considered in the Census data. The graph in Figure 9 includes the undercounted population for a total population of 100,963 for Peterborough in 2021.

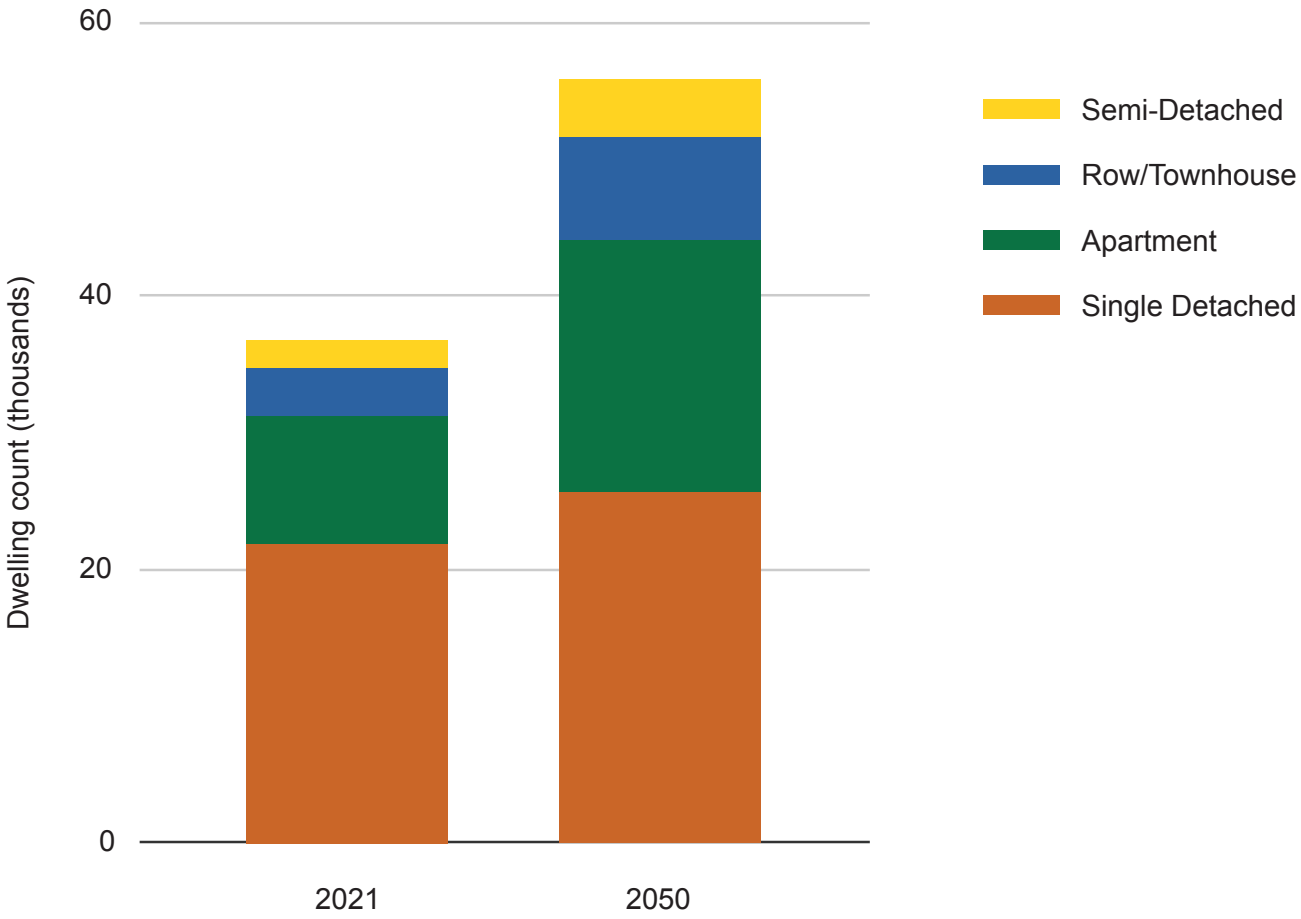


Figure 13. Residential dwellings by unit type for the baseline year (2021) and target year (2050). Source: SSG analysis.

Figures 14 and 15 show the energy use by sector and fuel type under this demographic projection. Residential and commercial sectors will increase their energy use, while the transportation sector's use will slightly decrease due to national policies to promote EV sales. The baseline energy use for 2021 is 11.1 million gigajoules (GJ), and it increases to 13.1 million GJ by 2050.

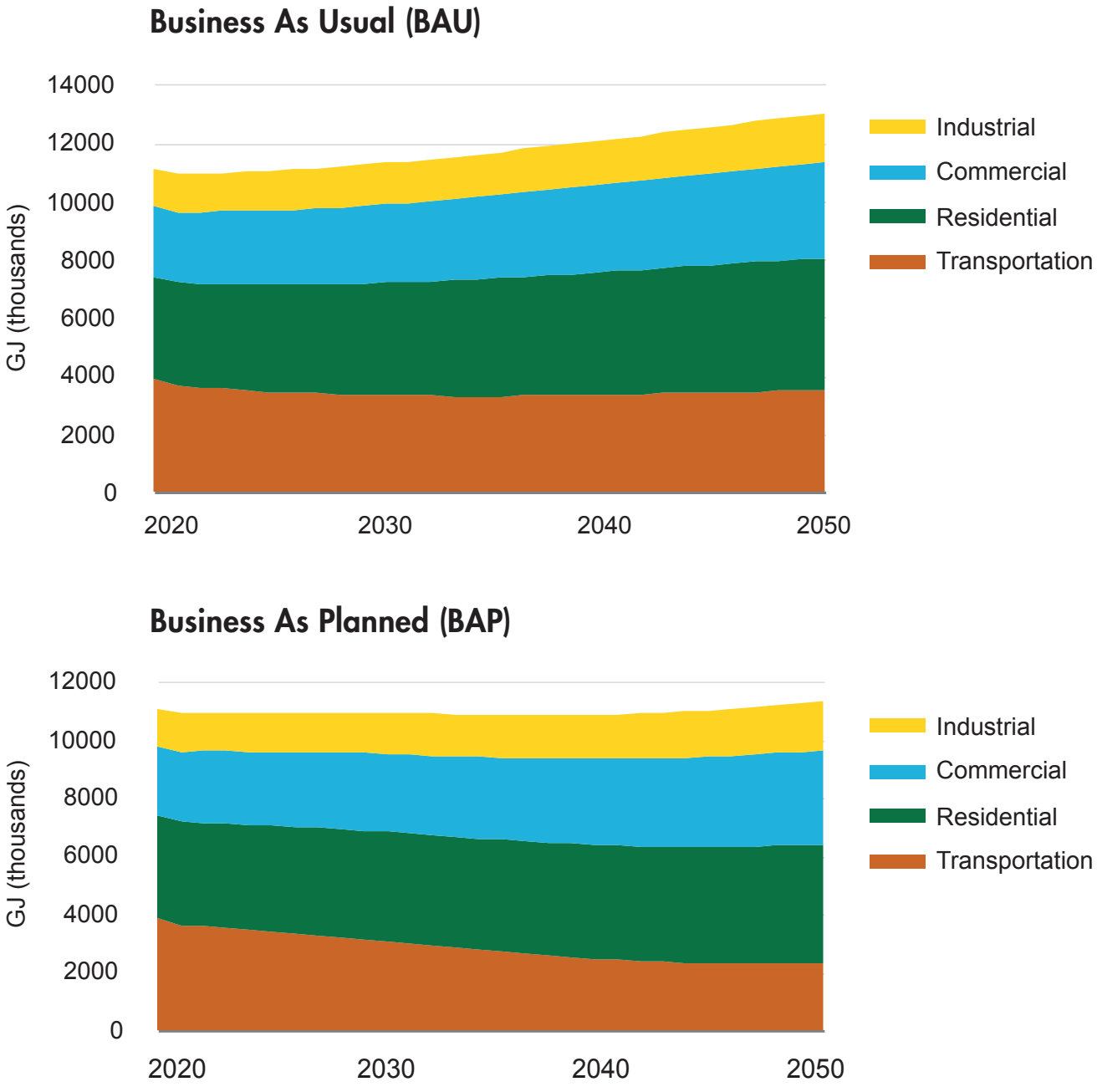


Figure 14. Total energy consumption by sector in the BAU Scenario (top) and BAP Scenario (bottom). Source: SSG analysis.

Under the BAU Scenario, the use of fossil fuels such as natural gas and fuel oil is expected to increase. There is also an increase in electricity use due to the electrification of transportation and electricity use in space heating for the residential and commercial sectors. A larger increase in electricity consumption is expected under a Business-as-Planned Scenario due to the replacement of natural gas and gasoline.

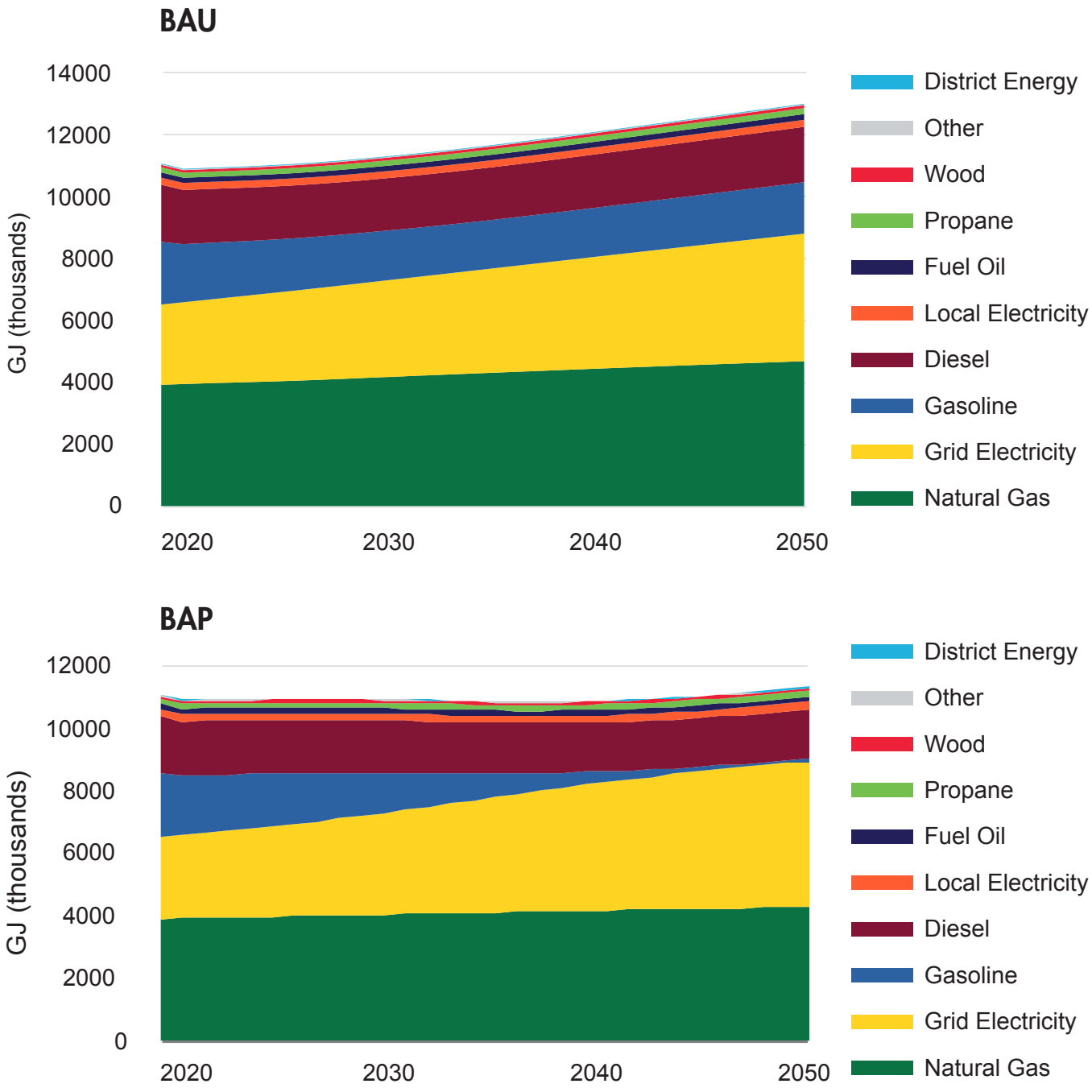


Figure 15. Total energy consumption by fuel type in the BAU Scenario (top) and BAP Scenario (bottom). Source: SSG analysis.

Figures 16 and 17 show the resulting emissions from the current trends, where transportation and the residential and commercial sectors are still the main contributors to Peterborough's community-wide emissions.

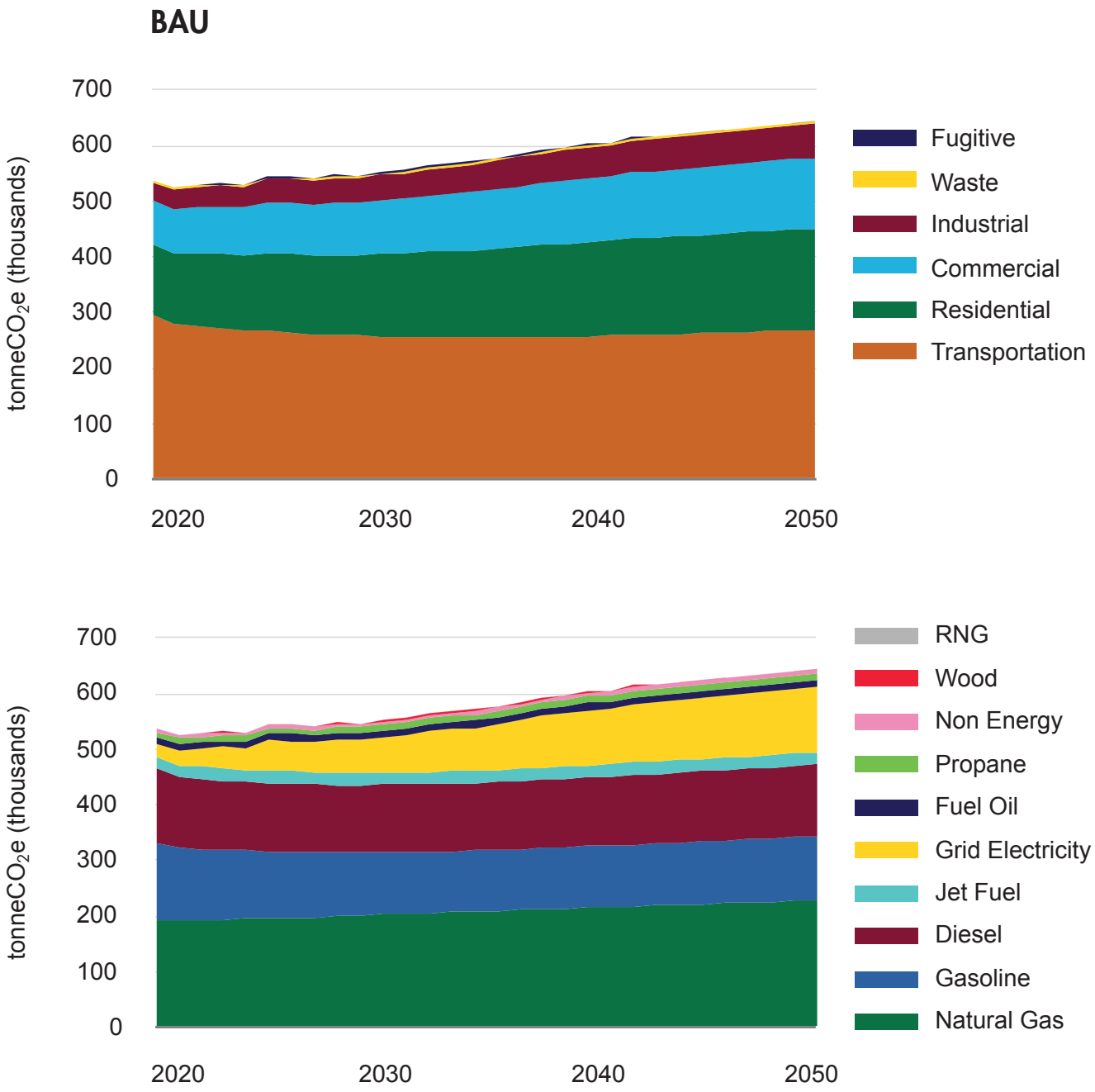


Figure 16. Total emissions by sector (top) and fuel type (bottom) in the BAU Scenario. Source: SSG analysis.

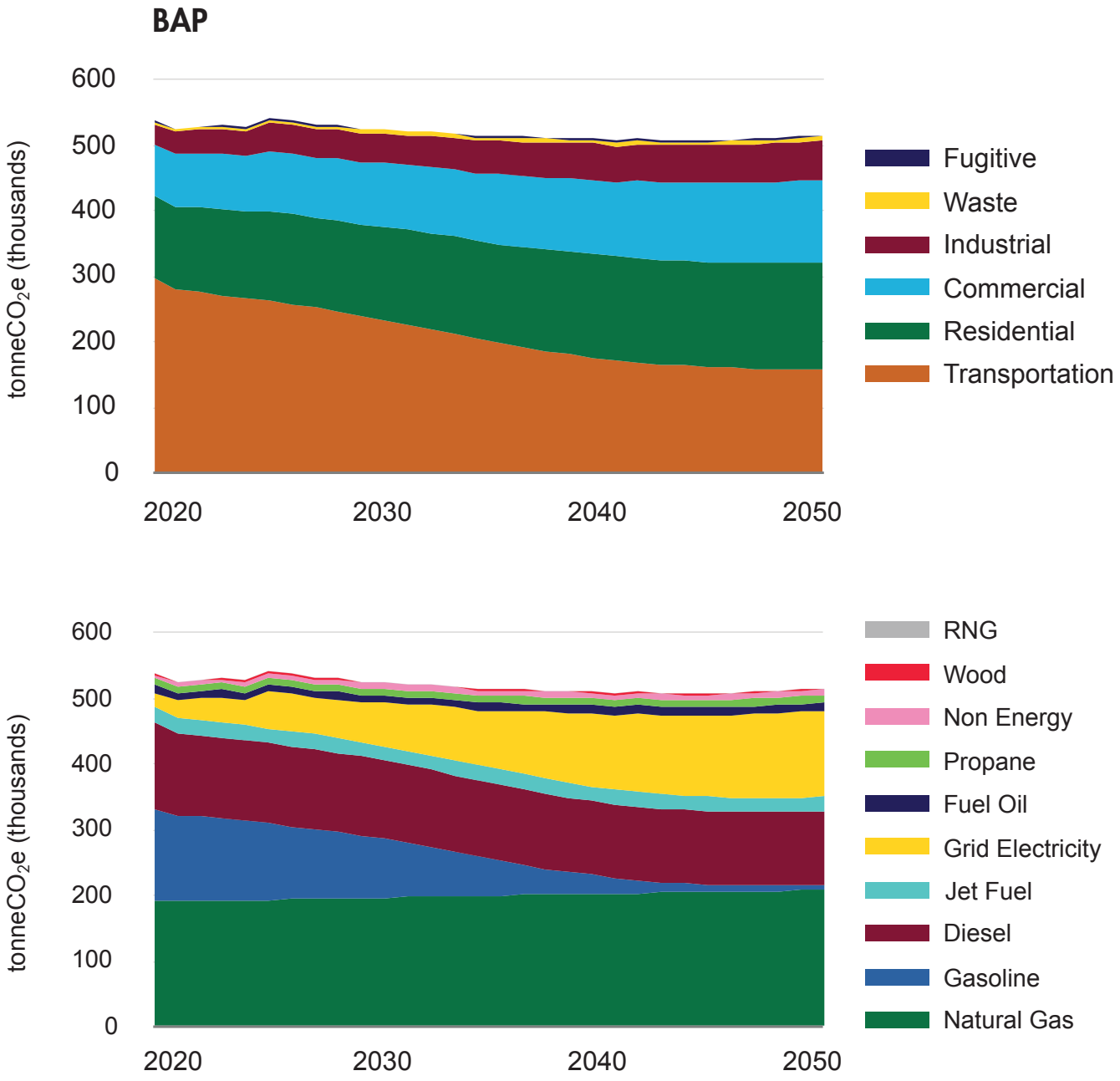


Figure 17. Total emissions by sector (top) and fuel type (bottom) in the BAP Scenario. Source: SSG analysis.

4. A Pathway to Net Zero

Even if all GHG emissions are limited around the globe, climate change impacts due to historical emissions are already locked in the atmosphere. To avoid further and unmanageable impacts, urgent action from all government levels must be taken. Each tonne of CO_2 emitted costs society more than $266, reflecting overall economic damages and mitigation costs, and this will only increase if the current emissions trend continues[31].

Figure 18 shows the importance of urgent action. The later actions are implemented, the more emissions will be released into the atmosphere by 2050, making it more difficult to reach meaningful reductions and locking in emissions that cannot be eliminated and which could have been avoided, ultimately resulting in higher global temperature increases in 2030 and 2050.

Figure 18. Diagram example of GHG emissions for different action timing. Source: SSG analysis.

Scientists have demonstrated that limiting global warming to 1.5°C instead of 2°C will make a tremendous difference in the type of impacts faced globally, and delaying action only further shrinks the remaining carbon budget. It is necessary to deploy all types of technologies and solutions to achieve the 1.5°C limit, even the more expensive ones, as it will cost more in the long run to repair damages due to climate change.

The City's vision for climate action is described in the box below.

[31] Government of Canada. Social cost of greenhouse gas emissions. [Government Announcement]. Climate Science, 2021b. https://www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/social-cost-ghg.htmla

Peterborough is a sustainable and resilient community that:

- Provides a high quality of life for all residents through increased clean transportation, reduced energy poverty, net-zero-ready and affordable housing stock, and a green local economy and jobs;
- Integrates a climate action lens into city planning and policies decisions; and
- Protects and builds on its natural beauty and green infrastructure systems and honours its heritage as an innovator by advancing clean energy and technology solutions.

Figure 19 displays the modelled scenarios for the city of Peterborough. The Net-Zero 2050 Scenario (NZ2050) achieves a reduction of 13% by 2030 from 2021 levels, emitting 467 $ktCO_2e$. The Net-Zero 2040 Scenario (NZ2040) achieves a reduction of 22% by 2030 from 2021 levels, emitting 422 $ktCO_2e$. With a 14% reduction, the Alternative Fuels Scenario achieves a slightly higher emissions reduction than the NZ2050, limiting the emission level to 460 $ktCO_2e$ by 2030. All three scenarios reach almost the same emission level by 2050, with up to a 70% reduction from 2021 levels. By 2050, the emission levels for each scenario are as follows:

- **NZ2050: 170.5 $ktCO_2e$**
- **NZ2040: 171.4 $ktCO_2e$**
- **AltFuels: 160.2 $ktCO_2e$**

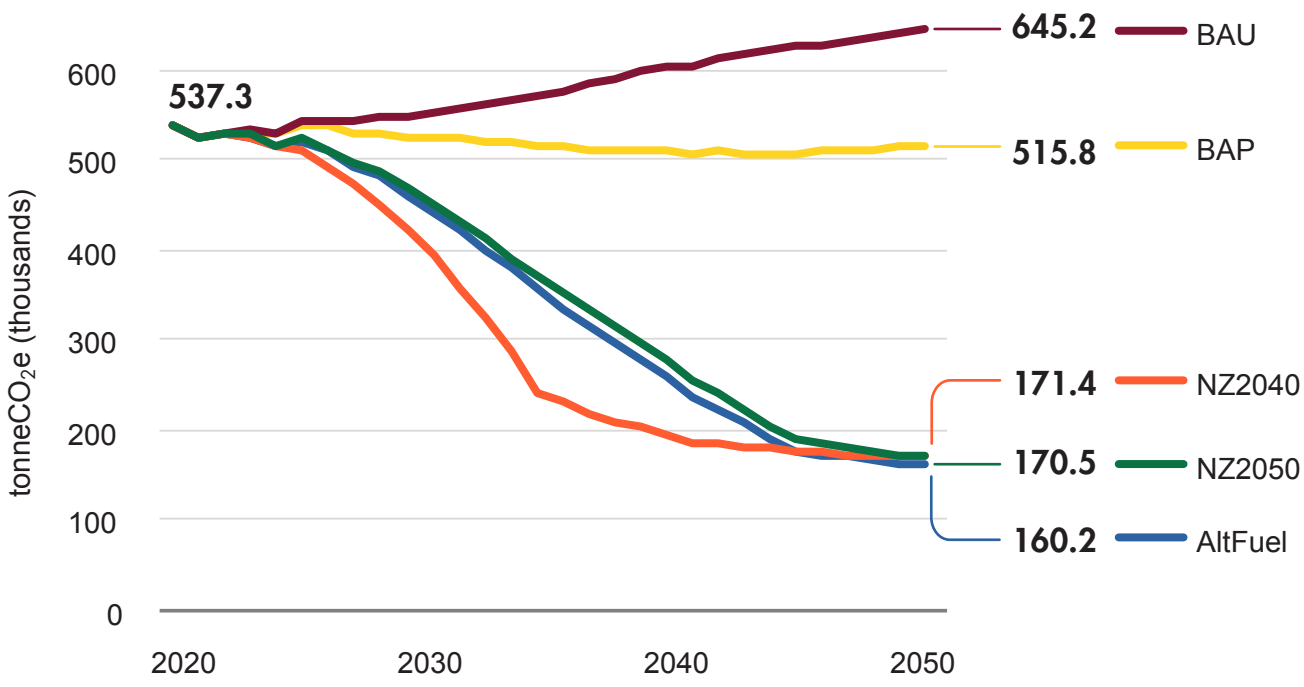


Figure 19. Overview of the net-zero scenarios. Source: SSG analysis.

Under all scenarios, Peterborough's residents will reduce their emissions per capita from 5.3 tCO_2e per year to between 1.1 and 1.2 tCO_2e by 2050. The emissions per capita are reduced more quickly in the NZ2040 Scenario. While the net-zero scenarios largely reduce per capita emissions, the BAU Scenario only reduces per capita emissions to 4.6 tCO_2e/year and the BAP to 3.7 tCO_2e/year (Figure 20).

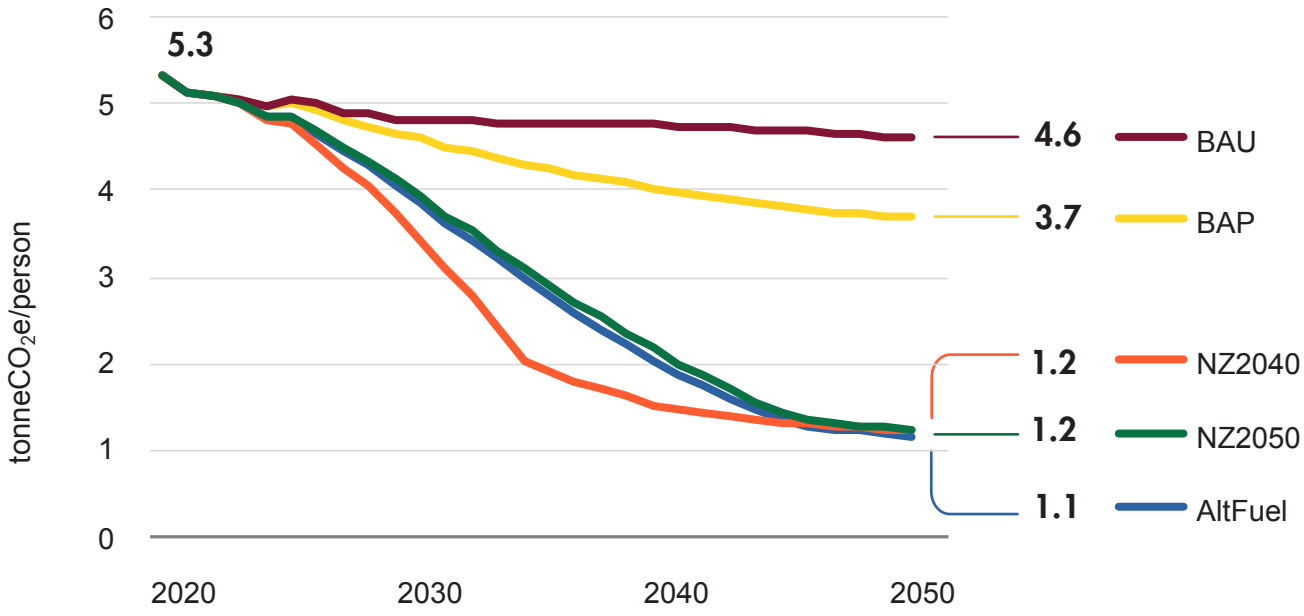


Figure 20. Overview of emissions per capita for the different scenarios. Source: SSG analysis.

In addition to being used for assessing the GHG reduction required to achieve the City's goals, including the necessary grid decarbonization, the scenarios are compared to the pathway aligned with the goal to limit global warming to 1.5°C relative to pre-industrial levels, which follows the Paris Agreement.[32] Out of the three low-carbon scenarios (NZ2050, NZ2040, and AltFuels scenarios), NZ2040 gets closest to the 1.5°C trajectory.

[32] The pathway was obtained from the platform Climate Action Tracker, which assesses countries' efforts to achieve their goals and the Paris Agreement.

Zero Grid Electricity Emissions

Currently, energy generation systems rely largely on Ontario's provincial grid, and some additional electricity is provided by the Peterborough Waste Management Facility (i.e., Bensfort Road Landfill Gas Plant). Current projections of the Ontario grid, which generates electricity with nuclear, gas/oil, and hydro sources, show an increase in GHG emissions. Projections for the provincial grid show an increased reliance on natural gas for future generation, which ultimately results in higher emissions from the grid (Figures 21 and 22).

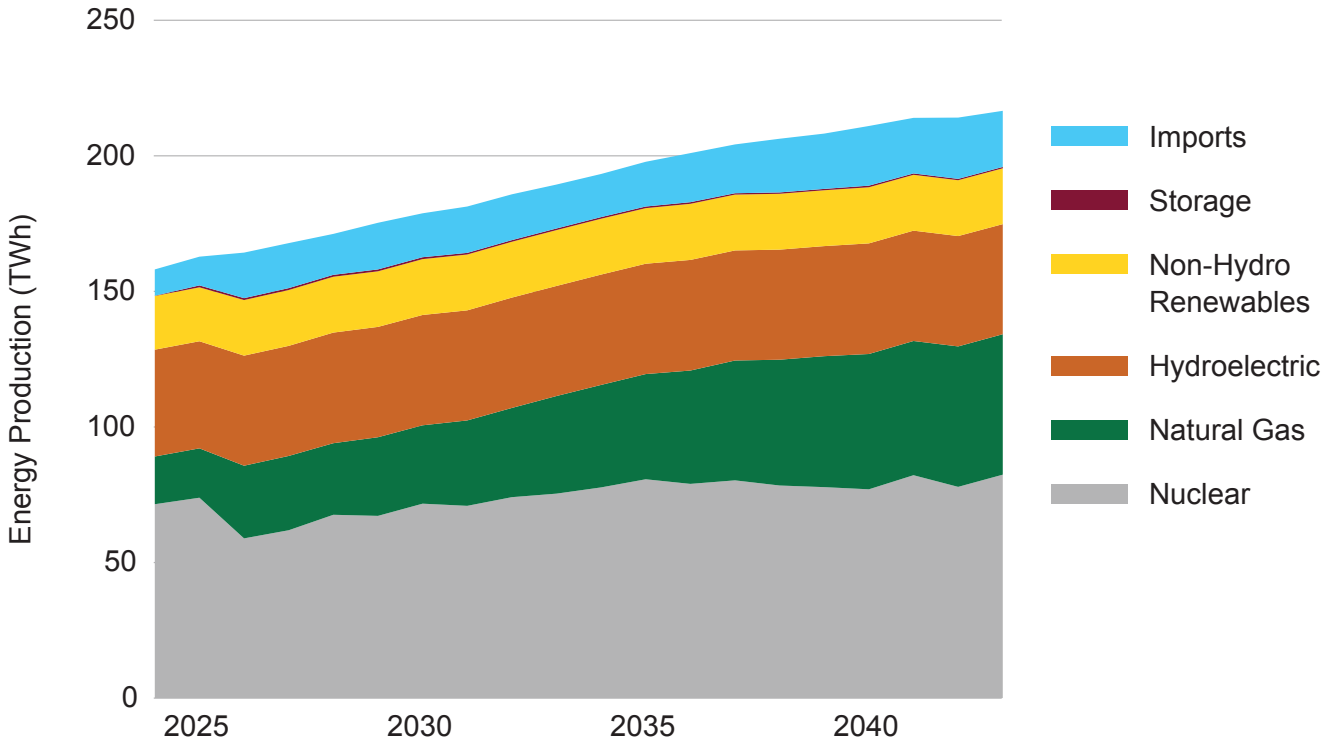


Figure 21. The 2022 Annual Planning Outlook Energy Production Outlook, Case 2. Source: Independent Electricity System Operator.

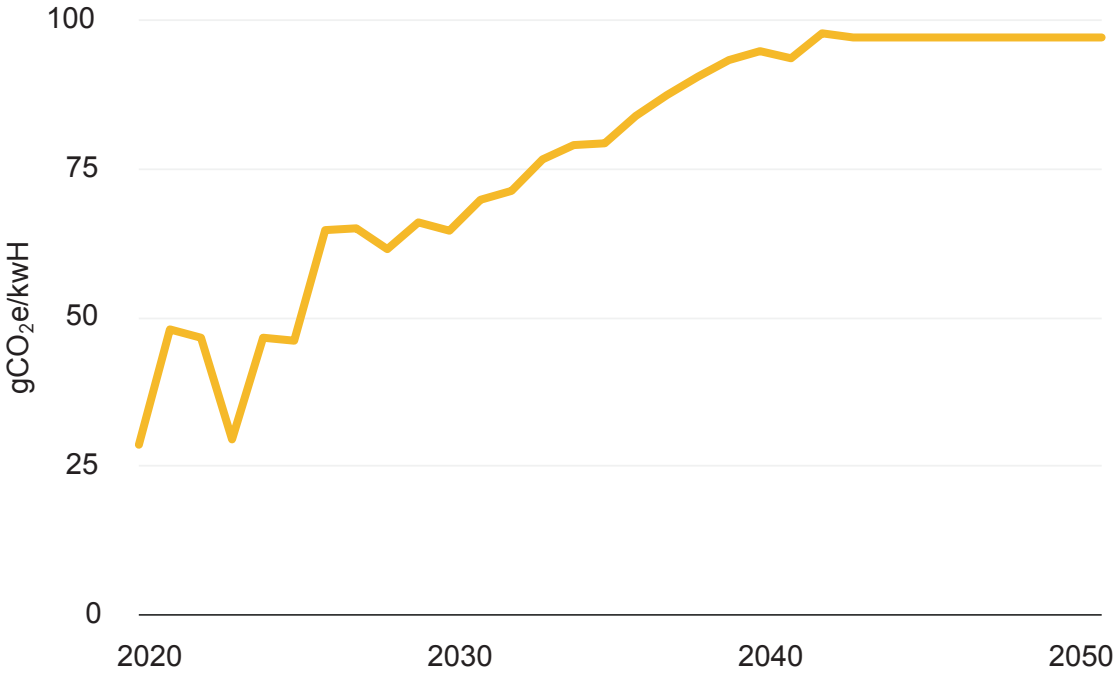


Figure 22. Grid electricity emissions factor for all scenarios. Source: SSG analysis.

Canada has a national commitment to reach net zero by 2050, which includes implementing mitigation measures in the electricity system. Under a scenario of national net-zero emissions, the country will need to greatly increase its wind, solar, and hydropower generation; however, it is likely the new mix will also include natural gas, nuclear, and biomass/geothermal sources.

Grid decarbonization is a key element in achieving further emissions reductions in all scenarios. This may appear as a challenge at a local level due to the lack of jurisdiction and provincial commitment to move towards this goal; however, Canada proposed a target to reach a net-zero electricity supply mix by 2035. Decarbonization pathways for Ontario have been explored by The Atmospheric Fund[33], demonstrating that the Province can move to a clean energy mix in an affordable way by incorporating renewables instead of increasing its natural gas use, reducing emissions to keep electricity prices steady, and using already existing natural gas plants instead of expanding production.

[33] The Atmospheric Fund. "Scenarios for a Net-Zero Electricity System in Ontario." Power Advisory, 2022. https://taf.ca/publications/scenarios-for-a-net-zero-electricity-system-in-ontario/

Paris Agreement Compatible Pathway

The Climate Action Tracker (CAT) initiative was used to understand how the City is aligned with the Paris Agreement's pathway to global warming. The CAT assesses countries' mitigation commitments and policies against what is needed to meet their fair share and what is needed for full decarbonization domestically. Two assessment frameworks are used to evaluate a country's mitigation actions and climate ambition:

- The **effort-sharing assessment** methodology applies state-of-the art scientific literature on how to compare the fairness of government efforts and NDC proposals against the level and timing of emissions reductions consistent with the Paris Agreement.
- To assess whether a country is on track for full decarbonization domestically, the CAT downscales global least-cost climate mitigation pathways to a national level. These are called **modelled domestic pathways**.

Since the CAT provides an emissions trajectory at the national level, the modelling exercise downscaled the national trajectory to a city level. The emissions trajectory necessary for Peterborough to be compatible with the Paris Agreement's most ambitious target to limit global warming to 1.5°C above the pre-industrial levels is shown in Figures 22 and 23 as the "CAT 1.5°C Paris Agreement compatible" dotted line. Quickly undertaking the most ambitious and impactful actions would better align Peterborough with the Paris Agreement.

Fair Share

There is no absolute way to define a fair contribution to reducing GHG emissions for countries. For some, **fair** means that those who have historically contributed the most to the problem should make the greatest effort in contributing to the solution. Others understand **fair** as those who have greater capability to act (in terms of financial and technological resources) contribute more to the solutions. Oftentimes those that historically contributed more to climate change and those who have the highest capability to act are one and the same.

The CAT initiative includes both viewpoints by equally weighing the fair-share categories and creating a range of GHG estimates for each country based on these categories and the descriptions of fair contribution from the literature. Different levels of ambition are created based on the countries' fair-share estimates and are related to a temperature increase outcome. The initiative uses this methodology to assess what temperature our planet would reach if all governments presented equally ambitious targets.

Note that since there are many ways to determine what is fair, one jurisdiction could be considered fair under one category (e.g., historical responsibility) and not under another category. In addition, following a fair contribution pathway to reducing GHG emissions does not always align with the level of effort required to limit global warming.

Scenario Emissions Trajectories

Figures 23, 24, and 25 use wedge diagrams for each of the scenarios to represent the emissions reductions for the implemented actions (differentiated by implementation rates and timings). The diagrams also present the emissions reduction achieved with a low-emission grid. Table 2 displays the mitigation actions, subactions and descriptions. The Ontario grid will move towards renewable energy generation by 2050, largely replacing fossil fuel use.

How to Read the Wedge Diagram

For each scenario modelled, the resulting emissions diagram is displayed as a wedge diagram. In this diagram, the total emissions line at the top of the graph represents the emission level of the Business-as-Planned (BAP) Scenario from 2021 to 2050. Each mitigation measure is presented as a wedge in the diagram, contributing to GHG reduction over this period relative to the BAP Scenario. Each mitigation action adds to the reductions achieved by previous measures.

Note that the BAP Scenario considers mitigation actions at various levels of government. For example, in the transportation sector, Canada has set a target for electric vehicle sales by 2035. This means that these graphs show the additional reduction in GHG emissions that the City is expected to achieve with this Plan. This approach applies to all emitting sectors, and the policies included in the BAP Scenario are those described in the Peterborough's Past and Present section.

The wedge diagram is read from the bottom to the top in terms of actions. This means that the first action to implement is "compact cities," followed by the implementation of "Building Codes" in industrial, residential, and commercial buildings, and so on.

The grey area represents the carbon liability, which is the residual carbon emissions of Peterborough after implementing all mitigation actions. These are the remaining carbon emissions that need to be addressed to achieve net-zero emissions.

The blue dotted line represents the emission reduction achieved if the electricity grid were to be zero-emissions. Finally, the red dotted line shows the emissions trajectory required to align with the Paris Agreement and limit global warming to 1.5°C by the end of the century.

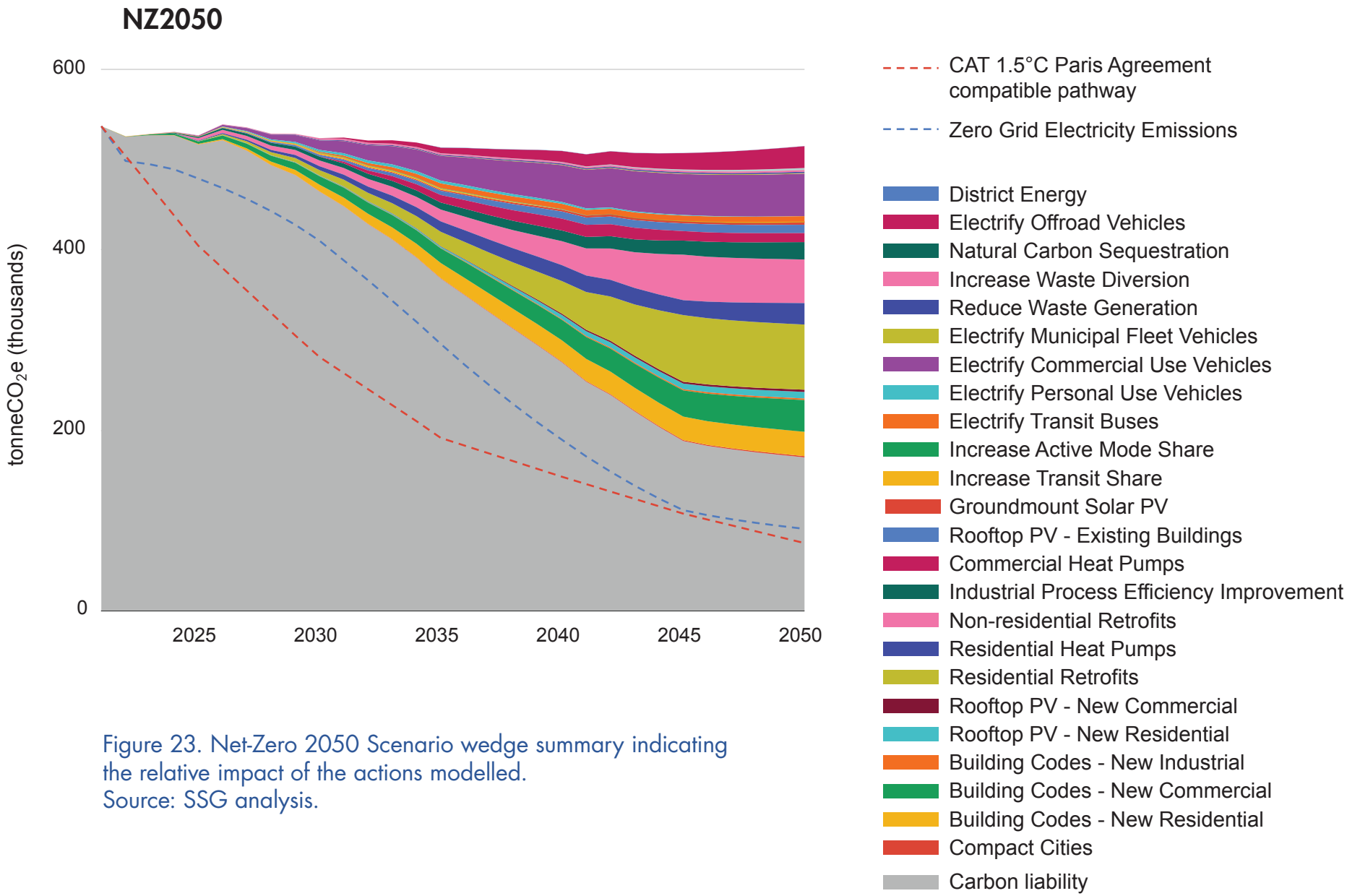


Figure 23. Net-Zero 2050 Scenario wedge summary indicating the relative impact of the actions modelled.
Source: SSG analysis.

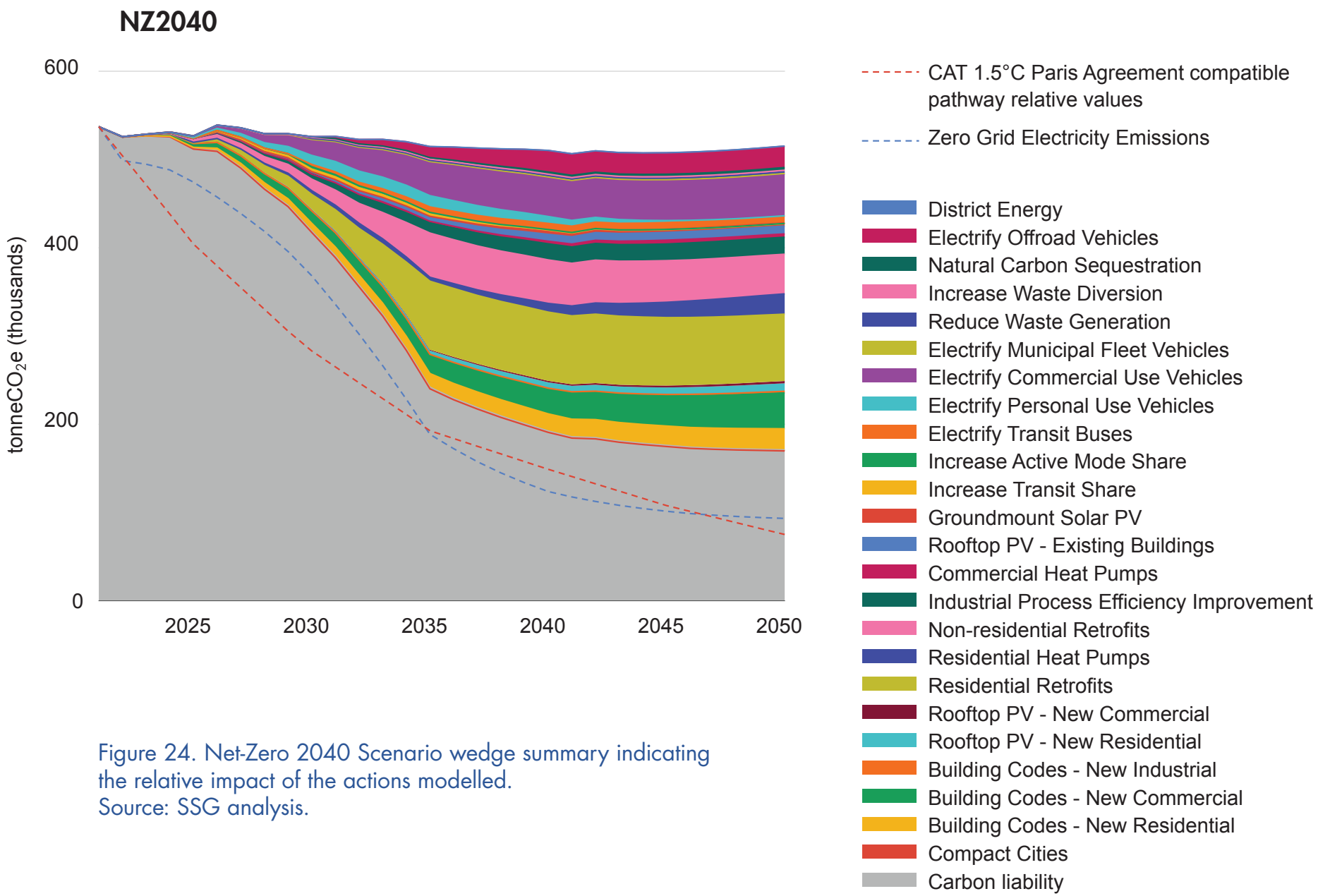


Figure 24. Net-Zero 2040 Scenario wedge summary indicating the relative impact of the actions modelled.
Source: SSG analysis.

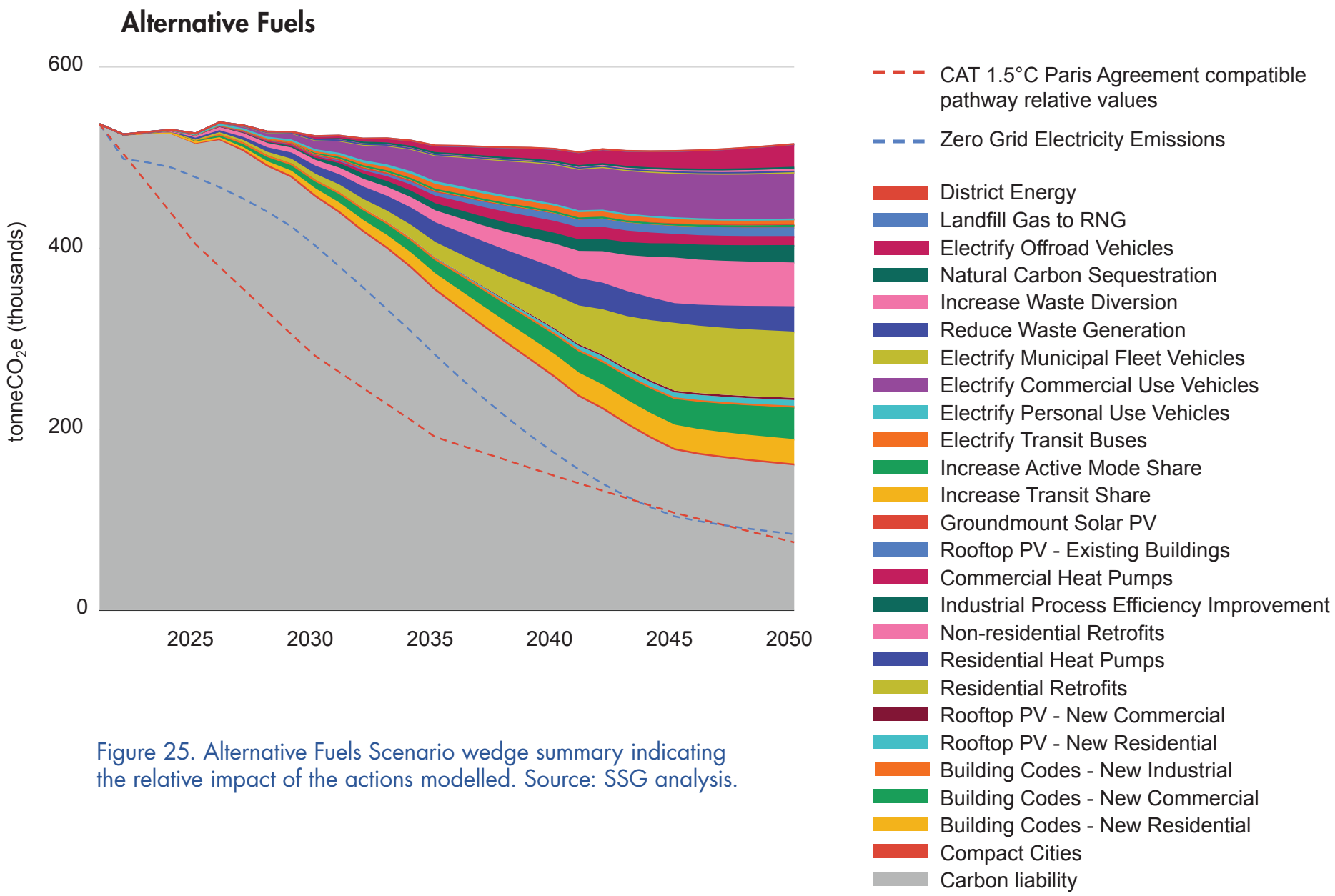


Figure 25. Alternative Fuels Scenario wedge summary indicating the relative impact of the actions modelled. Source: SSG analysis.

Table 2. Description of each action in the wedge diagram. Source: SSG analysis.

Big Move	Action	Wedge Action	Description
Land Use 	Low-carbon zones and ecodistricts	NA	Low-carbon zones are specialized zones that aim to lower the carbon footprint of the operations within that zone. They provide a testing ground for pilot projects and policies.
	Compact cities	Compact cities	The compact city is an urban planning and design concept that ensures residents have access to all services and amenities (i.e., jobs, grocery stores, parks, transit) within a walking/biking distance from their homes to reduce reliance on personal-use vehicles and encourage active transportation use while improving residents' quality of life.

Big Move	Action	Wedge Action	Description
Green Buildings 	Energy efficiency	Building codes (residential, commercial, and industrial)	These actions are based on complying with the National Energy Code and follow the tiers approach established in Canada's Net-Zero Energy Ready Building Code for new buildings. Therefore, it means that Peterborough adopts the national codes and then assesses the need for Green Development Standards.
		Residential retrofits	Retrofitting existing buildings is key to achieving significant energy savings and emissions reductions. It refers to any measure to enhance building envelope and reduce energy use.
		Non-residential retrofits	Similar to Residential retrofits, it refers to any measure to enhance buildings envelope and reduce energy use in commercial and industrial buildings.
	Switching to clean fuels	Residential and commercial heat pumps	Switching to clean fuels involves replacing equipment that uses fossil fuels with equipment powered by electricity (i.e., replacing a natural gas boiler with an electric heat pump).

Big Move	Action	Wedge Action	Description
Energy Supply 	Local zero-carbon generation at a community scale	Ground-mount solar PV	This measure aims to encourage the development of solar farms and ground-mount solar.
	On-site generation at a building scale	Rooftop solar PV in existing and new buildings (residential and commercial)	On-site renewable energy is a way to supply some or all of the required energy for a building or facility while also reducing its reliance on fossil fuels.

Big Move	Action	Wedge Action	Description
Sustainable Transportation 	Fuel switching for private vehicles	Electrify personal-use vehicles	It refers to the adoption of electric vehicles for personal use.
	Public transit improvements	Increase transit share	Improving transit infrastructure, services, and operations encourages residents to use public transportation more frequently, resulting in significantly lower carbon emissions.
		Enhancing fuel economy in transit—Electrifying transit buses	It refers to transforming the current fleet of buses to electric alternatives, and low-carbon options.
	Fuel switching in freight	Electrify commercial- and municipal-use vehicles	Electrification of freight system fleets and/or switched from conventional fuels to hydrogen to reduce their emissions.
	Increasing active transportation	Increase active mode share	This measure, along with the improvement of public transit, aims to increase the share of people using alternative transportation for their everyday activities.
	Tackling off-road emissions	Electrify off-road vehicles	Electrification of equipment and vehicles, for instance, by replacing diesel-based snow blowers with electric ones or using wireless equipment with batteries.

Big Move	Action	Wedge Action	Description
Industry 	Increasing industrial efficiency	Industrial process efficiency improvement	Increasing industrial efficiency through implementing various energy efficiency mechanisms, including improvements in water and heating and cooling processes.
Waste 	Waste prevention and diversion	Reduce waste generation	Reducing waste generation per resident.
		Increase waste diversion	It refers to any activity that aims to reuse, recycling/ composting and energy recovery of waste.
	Energy recovery and landfill management	Landfill gas to renewable natural gas (RNG)	Energy recovery is possible by using the landfill gas generated from the anaerobic decomposition of the organic matter sent to the landfill. Landfill gas capture and combustion systems can reduce the methane emitted from landfills and convert it to carbon dioxide with energy generation.
	Wastewater energy recovery	District energy	Wastewater is one source of thermal energy that can be harnessed for either residential use in nearby communities or for industrial purposes. Thermal energy generation can be used as district energy to provide space and water heating for a set of building or industrial units.

Big Move	Action	Wedge Action	Description
Forestry and Carbon Capture 	Increasing urban forests	Natural carbon sequestration	Natural carbon sequestration helps communities capture greenhouse gases they could not otherwise eliminate.

What Happens Between the BAU and the BAP?

As mentioned above, the Business-as-Usual (BAU) Scenario represents Peterborough's emissions if no additional actions are taken beyond what has already been accomplished. In contrast, the Business-as-Planned (BAP) Scenario illustrates the reductions that could be achieved if policies, regulations, and plans are implemented as intended. In this context, the City has several policies in place, such as the Updated Official Plan, Transportation Master Plan, and Waste Management Master Plan. At the national level, the most significant effort is the set of policies and regulations aimed at decarbonizing the transportation sector, including a target for 100% of light vehicle sales to be zero-emissions by 2035. Figure 26 shows the GHG emission reduction from the BAU to the BAP and highlights the large contribution of light-duty vehicles to GHG reductions in the long term. In this context, the electrification of private vehicles is a key step in decarbonization at any government level and provides the largest contribution to achieving the BAP trajectory.

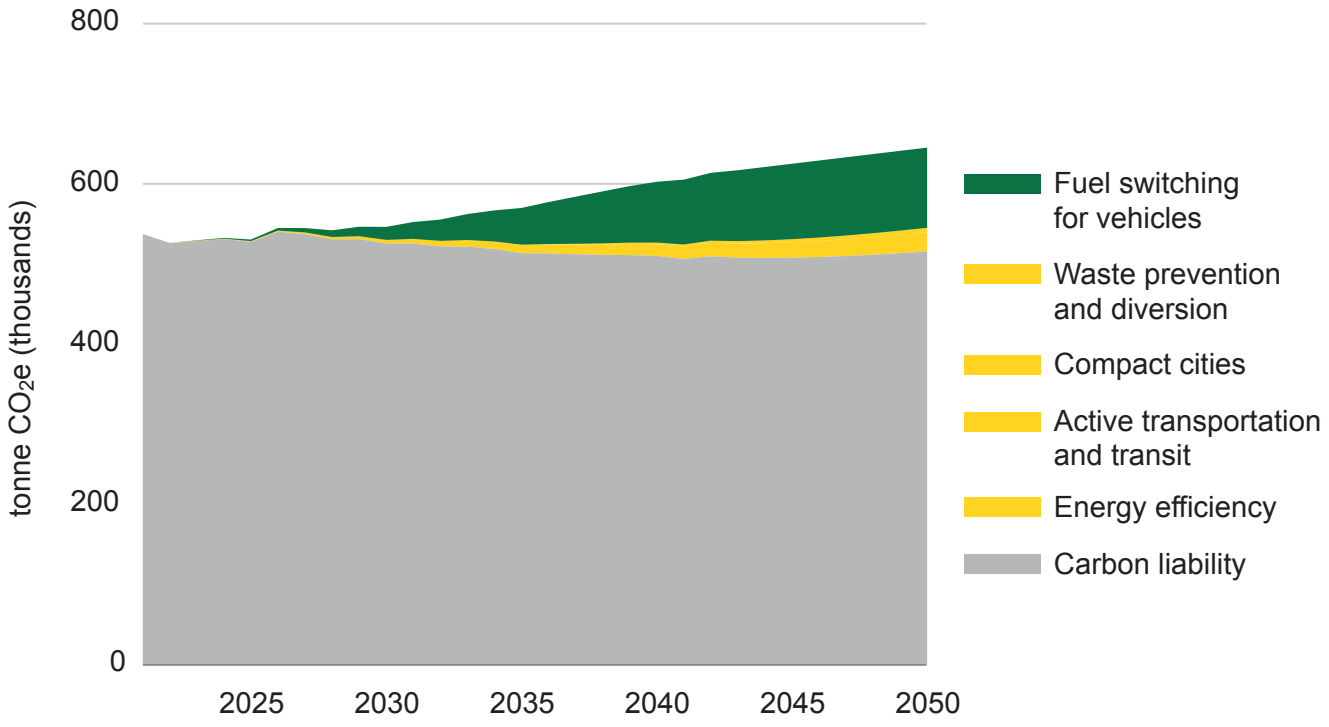


Figure 26. Emission reductions between the BAU and BAP scenarios and the contribution of zero-emissions vehicles penetration by 2035. Source: SSG analysis.

Peterborough's Residual Emissions

The three technical scenarios for the city of Peterborough show that in 2050 it may be difficult to eliminate some residual emissions coming from the following sectors:

- **Buildings:**
  - Industrial (31–32 $ktCO_2e$)
  - Commercial (27–32 $ktCO_2e$)
- **Transportation:**
  - Off-road (31 $ktCO_2e$)
  - Aviation (22 $ktCO_2e$)

The three low-carbon scenarios assume there will be 160 to 171 $ktCO_2e$ of residual emissions in 2050. These emissions primarily come from unresolved buildings and transportation emissions.

To tackle a portion of the GHG emissions from industrial and commercial buildings, it is recommended that Peterborough implements a voluntary Green Development Standard, which forms part of the implementation strategy for a municipality's action.

In the transportation sector, remaining emissions come from off-road machinery and vehicles, and aviation. Off-road vehicles and machinery range in size and use. This includes everything from heavy-duty equipment like bulldozers, excavators, backhoes, etc. to utility vehicles like quads and ATVs, as well as landscaping equipment like lawn mowers, gas-powered weed whackers, and others. Since off-road machinery is such a wide range of equipment, some emissions would remain residual due to a limited technological advancement and/or market availability of low-carbon technologies.

However, the City does have some levers it can pull to reduce these residual off-road emissions. First, leading by example will be crucial. The City should prioritize purchasing electric or zero-emissions utility vehicles, landscaping equipment, and heavy-duty machinery where possible. This will demonstrate the City's commitment to reaching net zero in its own corporate emissions and encourage the local market to adopt these new technologies. Additionally, collaborating with off-road machinery/vehicle dealerships in Peterborough to coordinate group-buy programs or incentives can also increase the portfolio of electric alternatives in the local markets.

Peterborough may also follow the example of other municipalities by setting up a program that targets emissions from diesel use in non-road vehicles, such is the case of the Clean Air Construction Program of the City of Portland. The program consists of two measures to reduce diesel emissions from construction projects. The first aims to limit idling, requiring city contractors to shut down non-road diesel equipment after five minutes of inactivity and post "Five Minute Limit" signs on vehicles and in high traffic areas to ensure workers are aware of the policy. The second measure requires city contractors to install an emission control device that maximizes diesel particulate matter reductions at the time of retrofit for off-road diesel-powered equipment greater than 25 horsepower and all on-road diesel dump trucks and concrete mixers (The City of Portland, 2020). The program began in 2020 with restrictions to idling and began restricting the use of diesel equipment in 2022. Policy implementation from 2022 to 2025 restricts equipment use based on the tier[34] of the engine unless retrofitted with an emission control device.

Reducing aviation emissions requires a higher-level commitment from nations and the world. Canada has an Aviation Climate Action Plan for 2022–2030 (Figure 27), in which it commits to the following efforts[35]:

- Development and adoption of green aerospace technologies;
- Improvements in ground and air operations;
- Sustainable aviation fuels (SAF); and
- Out-of-sector reductions (carbon removals and offsetting)

[34] The tiers structure is used by the US National Environmental Protection Agency and defines the diesel-emissions standards of on- and off-road engines. The higher the tier (i.e. Tier 4) the more strict the standard and, vice versa, Tier 0 has the least strict standard.

[35] Government of Canada. "Canada's Aviation Climate Action Plan 2022-2030." Minister of Transport, 2022. https://tc.canada.ca/sites/default/files/2022-11/canada-aviation-climate-action-plan-2022-2030.pdf

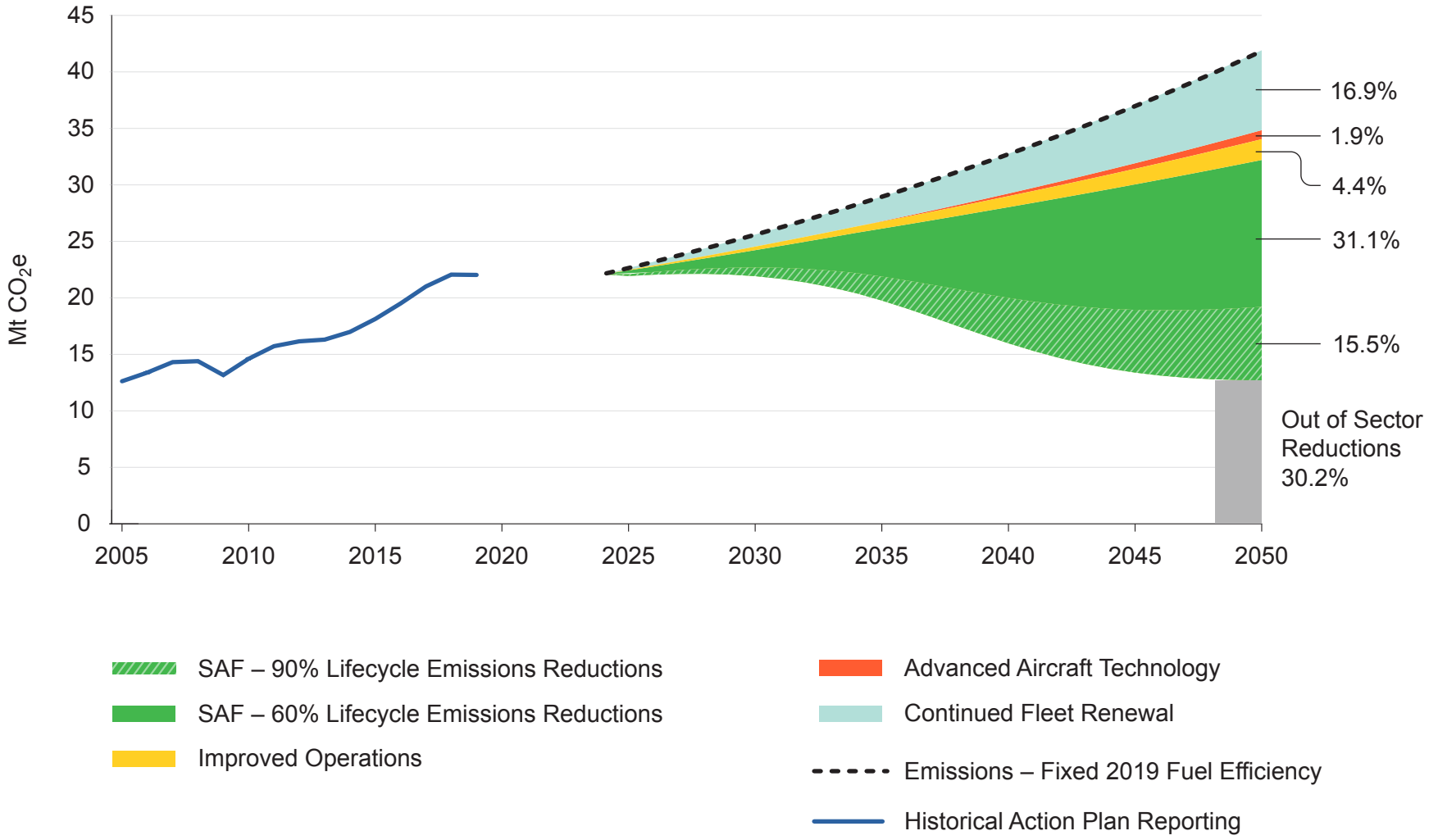


Figure 27. The 2050 Canadian Aircraft Emissions Forecast—A Vision to Net Zero. Source: (Government of Canada, 2022)[36].

[36] Government of Canada. "Canada's Aviation Climate Action Plan 2022-2030." Minister of Transport, 2022. https://tc.canada.ca/sites/default/files/2022-11/canada-aviation-climate-action-plan-2022-2030.pdf

Though municipalities have less control over these emissions, national commitments indicate the aviation sector will move towards a low-carbon future. For Peterborough, a starting point should be partnering with airport operators and aviation companies to develop an ambitious climate action plan that begins with reducing building emissions, installing renewable energy generation on site, and electrifying airport vehicles and equipment when possible. Furthermore, the plan would propel feasibility studies and the exploration of sustainable aviation fuel use to prepare the airport to transition to clean aviation options as the national government commitments are rolled out. Another alternative to potentially include in the plan is the use of incentives to reduce emissions, such as decreasing fees for airlines that use higher proportions of sustainable aviation fuel or even potentially increasing the airport fees for private flights (e.g., landing, aircraft tiedown).

While the City of Peterborough is prioritizing actions to maximize GHG emission reductions, it also recognizes there will be a need to compensate for remaining residual emissions to achieve a net-zero balance. Alternatives to reduce residual emissions are natural sequestration, the deployment of carbon capture and storage technologies (if available), and purchasing carbon offsets, which is least recommended, as these have not been shown to be as effective.

5. City of Peterborough's Big Moves

The modelling of actions follows the Paradigm of Actions described in the sections above and considers the stocks and flows and the most cost-effective implementation strategies. The implementation of each action should also follow this logic. Cumulative emission reductions for each action are listed in Table 3.

While actions related to land use do not appear to have substantial emissions reductions, they do represent a driver of change for transportation and building actions as compact cities encourage residents to use active transportation (walking, biking, and transit) more by increasing density and access to services and jobs.

To improve energy generation efforts, building codes should be updated to include targets for energy-efficient buildings and encourage the electrification of key systems like space and water heating before introducing solar power. By prioritizing efficiency, residents will be more likely to invest in appropriately sized electric equipment, such as heat pumps, rather than oversized options that waste energy. The same approach applies to on-site energy generation; it should occur after building upgrades (like roof replacements) and the installation of heat pumps. This sequence helps manage electricity demand for new residential and transportation uses. Figure 28 illustrates that grid electricity consumption (measured in gigajoules) in net-zero scenarios initially rises with electrification efforts, but decreases when building retrofits and stricter construction standards are implemented effectively.

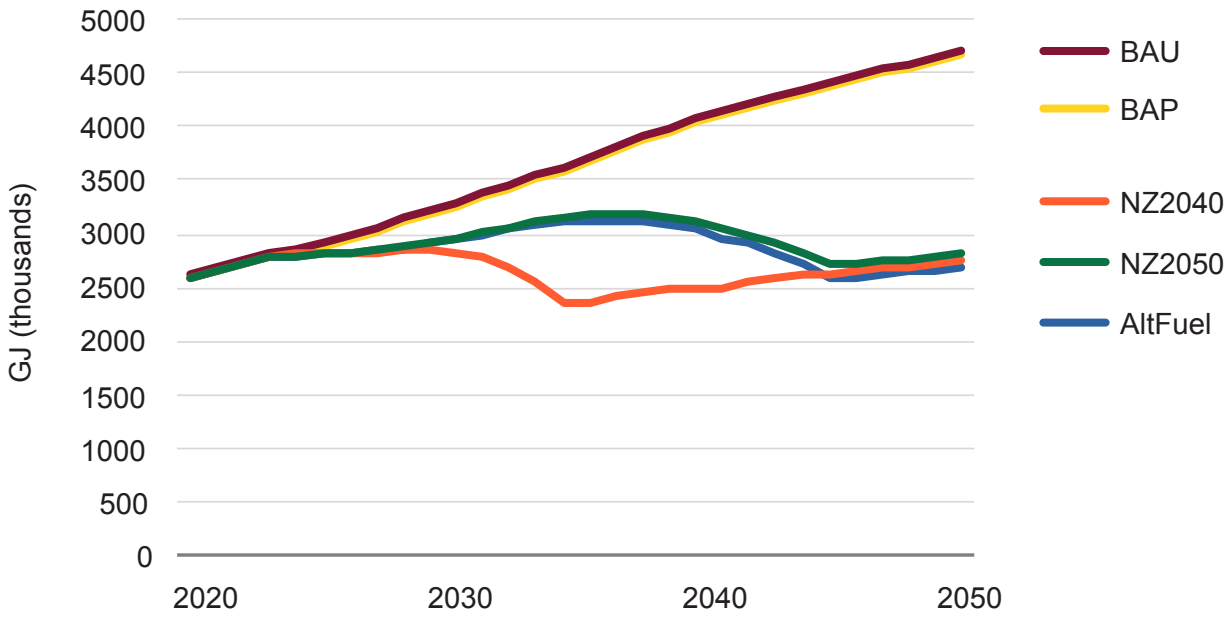


Figure 28. Electricity use from the grid for the different scenarios.
Source: SSG analysis.

Table 3. Summary of actions and descriptions for all scenarios.

Big Move	Action	Net-Zero 2050 Cumulative emissions reduction 2024–2050 ($ktCO_2e$)	Net-Zero 2040 Cumulative emissions reduction 2024–2050 ($ktCO_2e$)	Alternative Fuels Cumulative emissions reduction 2024–2050 ($ktCO_2e$)
Land Use	Low-carbon zones and ecodistricts	NA	NA	NA
	Compact cities	18	-37[37]	18
Green Buildings	Energy efficiency	2,467	3,455	2,467
	Switching to clean fuels	525	314	707
Energy Supply	Local zero-carbon generation at a community scale	45	57	45
	On-site generation at a building scale	261	308	264

[37] The land-use assumptions for this action result in a larger number of high-density dwelling units and therefore, more dwelling units overall compared to the BAP Scenario. More dwelling units causes increased energy use and higher emissions. The Land Use section of this report describes the co-benefits of this action beyond emissions.

Big Move	Action	Net-Zero 2050 Cumulative emissions reduction 2024–2050 ($ktCO_2e$)	Net-Zero 2040 Cumulative emissions reduction 2024–2050 ($ktCO_2e$)	Alternative Fuels Cumulative emissions reduction 2024–2050 ($ktCO_2e$)
Sustainable Transportation	Fuel switching for private vehicles	39	171	39
	Improving public transit	11	34	11
	Enhancing fuel economy in transit	112	137	115
	Fuel switching in freight	776	893	835
	Increasing active transportation	6	26	6
	Tackling off-road emissions	255	377	255
Industry	Increasing industrial efficiency	263	344	263
Waste	Waste prevention and diversion	59	64	59
	Energy recovery and landfill management	NA	NA	37
	Wastewater energy recovery	3	3	3

Big Move	Action	Net-Zero 2050 Cumulative emissions reduction 2024–2050 ($ktCO_2e$)	Net-Zero 2040 Cumulative emissions reduction 2024–2050 ($ktCO_2e$)	Alternative Fuels Cumulative emissions reduction 2024–2050 ($ktCO_2e$)
Forestry and carbon capture	Increasing urban forests	19	48	19
Total		**4,859**	**6,193**	**5,144**

Source: SSG Analysis.

Big Moves In-Depth

This section presents the main drivers of climate actions for the city of Peterborough. Each driver is described in general terms, with a more detailed description provided in the sections below. For each Big Move, there will also be co-benefits related to action implementation, highlighting cross-cutting positive impacts such as economic and social benefits for the city.

In addition, a financial analysis was performed to analyze the implementation costs and the potential savings associated with the Big Moves. Five aggregate categories are used to track the financial performance of the low-carbon actions in this analysis: capital expenditures, energy expenditures (savings or additional costs), carbon expenditures (costs or savings), operation and maintenance, and revenue generation (associated with renewable energy production facilities and income from transit fare). Administrative costs associated with implementing programs are excluded, as well as any energy system infrastructure upgrades that may be required. Similarly, the broader social costs that are avoided from mitigating climate change, such as avoided health costs or avoided damages from climate change, are not included in this financial analysis. Each of these categories is presented in terms of annual flows during the implementation timelines of each action. Although, in many cases, revenue will be expected further beyond the timeline of the CCAP 2.0. The definitions that follow help explain the analysis.

Capital Expenditures: Expenses or costs to purchase, maintain, or improve assets, such as buildings, vehicles, equipment, or land. In some cases, this may be related to the costs and expenses of programmatic funding. This is usually referred to as "Total investment" in the text, which includes the overall investment, both from the City and private investors.

Energy Expenditures: Costs/savings for purchasing and producing energy.

Carbon Expenditures: Costs/savings associated with burning fossil fuels and emitting carbon.

Operation and Maintenance: Costs related to replacing, improving, or expanding existing assets (i.e., the cost to repair buses).

Revenue: Amount of money received (i.e., inflows) by the government from taxes and non-tax sources. In most cases, it is associated with renewable energy production facilities and income from transit fare.

In addition, the **Total Net Costs** refers to all public and private investments as well as operating costs for implementing and maintaining mitigation actions. It reflects the difference of the annual streams (costs versus revenues and savings).

Each Big Move is also described in terms of its marginal abatement costs and highlights the co-benefits of implementation.

Marginal Abatement Costs: Measure the cost of reducing one tonne of CO_2e. These costs include all expenses, returns, and savings associated with the implementation of a mitigation measure. Positive marginal abatement costs indicate that the implementation of a measure incurs an overall cost, meaning it requires additional investment. In contrast, negative marginal abatement costs signify that the measure results in net savings or benefits, meaning it is more cost-effective or generates a financial return. (For more details on marginal abatement costs, see the Opportunities section.)

Co-Benefits: Refers to all positive outcomes resulting from the implementation of actions, which may or not be financially assessed. Depending on the action, co-benefits may include new jobs, savings in energy bills, and improvements in air quality.

Moving Towards Sustainable Development

In 2015, the United Nations adopted the 2030 Sustainable Development Agenda, composed of 17 interconnected goals (Sustainable Development Goals or SDGs) to achieve a more peaceful and prosperous planet. Canada is committed and continuously working to advance these goals. Climate action is a key driver to the success of these goals.

As the City of Peterborough implements the climate action measures outlined in this Plan, it is also contributing to the achievement of the SDGs. Each Big Move will outline which SDGs are being addressed as a part of implementing that action. SDGs 1, 2, 5, 16, 17 are being addressed in other areas of the City's activities.

The 17 Sustainable Development Goals are as follows:

1  No Poverty

2  Zero Hunger

3  Good Health and Well-Being

4  Quality Education

5  Gender Equality

6  Clean Water and Sanitation

7  Affordable and Clean Energy

8  Decent Work and Economic Growth

9  Industry, Innovation, and Infrastructure

10  Reduced Inequalities

11  Sustainable Cities and Communities

12  Responsible Consumption and Production

13  Climate Action

14  Life Below Water

15  Life on Land

16  Peace, Justice, and Strong Institutions

17  Partnerships for the Goals

Land Use Big Move

SDGs that are being addressed by this Big Move.

- 3 Good Health and Well-Being
- 8 Decent Work and Economic Growth
- 10 Reduced Inequalities
- 11 Sustainable Cities and Communities
- 13 Climate Action

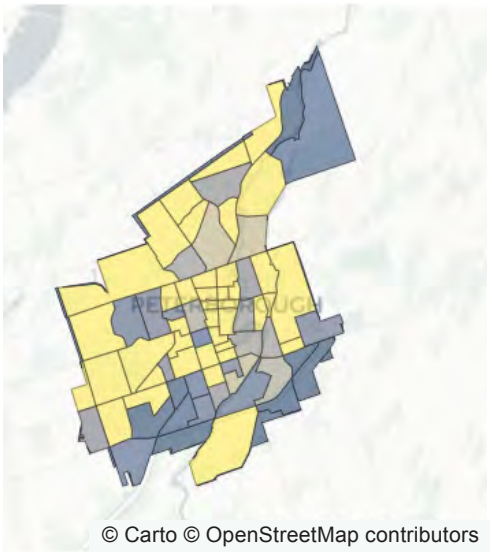
Overview

The continued population growth requires actions that optimize resources and reduce the carbon footprint on a per-resident basis. A few strategies for land-use planning that aim to achieve lower-emissions neighbourhoods include planning for more compact cities and low-carbon zones.

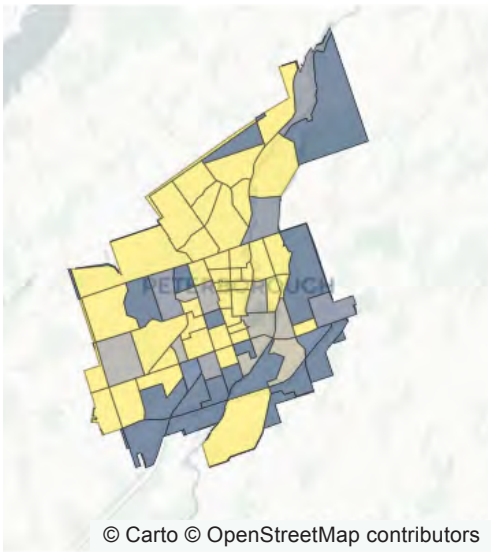
Emissions from this sector come from buildings and transportation, and these will change in tandem with land-use and planning changes. In this regard, two main mitigation measures for Peterborough are:

- Carbon-zones and ecodistricts and
- The compact city.

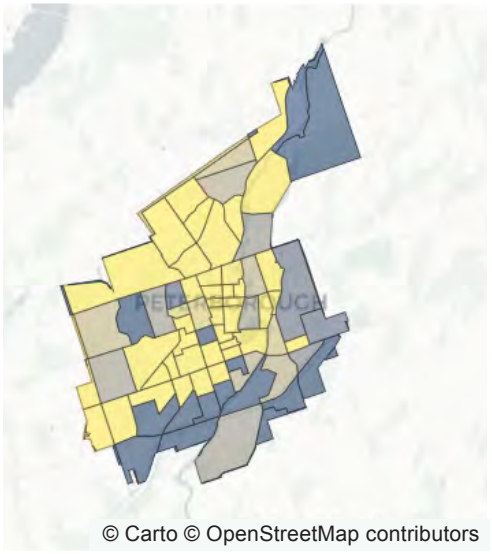
This set of actions will ultimately result in higher-density areas throughout the city by 2050, as shown in Figure 29. New dwellings will be clustered in the city centre and northern areas to reach densification targets proposed by the 2023 Official Plan in both the 2040 and 2050 net-zero scenarios. To achieve this, apartments will be the focus of new development with some single- and semi-detached units expected near the downtown.



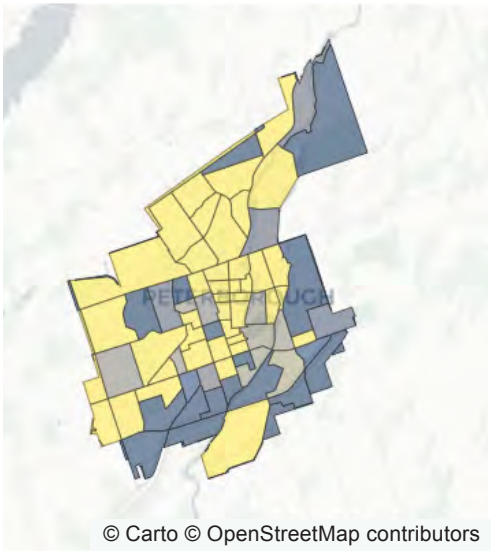
BAU scenario



NZ2050 scenario



NZ2040 scenario



AltFuels scenario

Figure 29. New dwelling units by zone by 2050 (dwelling count per hectare). Source: SSG analysis.

Key Actions

Low-Carbon Zones and Eco-Districts

Low-carbon zones are specialized zones that aim to lower the carbon footprint of the operations within that zone. They provide a testing ground for pilot projects and policies. Ecodistricts, whether existing or new developments, take a master plan approach to sustainability, optimizing key resources (such as energy, waste, and water) across operations instead of at a building scale.

This action has no specific target and is closely related to land management, transportation, and building actions.

Compact Cities

The compact city, or 15-minute community/city, is an urban planning and design concept that ensures residents have access to all services and amenities (i.e., jobs, grocery stores, parks, transit) within a 15-minute walking distance from their home to reduce reliance on personal-use vehicles and encourage active transportation use while improving residents' quality of life.

Peterborough's Official Plan promotes the complete communities concept that prioritizes compact and mixed-use development in Strategic Growth Areas like designated Urban Growth Centres and major transit station areas.

Population and job density is increasing in different zones of Peterborough. Table 4 shows the targets for each designated area in the different scenarios.

Table 4. Population density targets.

Area	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
New residential neighbourhood within the Designated Greenfield Area	60 residents and jobs combined per hectare by 2051	60 residents and jobs combined per hectare by 2040	60 residents and jobs combined per hectare by 2051

Area	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
Overall Designated Greenfield Area	50 residents and jobs combined per hectare by 2051	50 residents and jobs combined per hectare by 2040	50 residents and jobs combined per hectare by 2051
Strategic Growth Areas (including the Urban Growth Centre)	160 residents and jobs combined per hectare by 2031	160 residents and jobs combined per hectare by 2028	160 residents and jobs combined per hectare by 2031

Co-Benefits

Co-benefits from these actions range from increased health and economic prosperity to social equity.

Health co-benefits: Planning for compact cities enhances access to services for residents and reduces the need to use vehicles, resulting in lower levels of air pollution and increased active transportation, which have health benefits. Intensification may also create new opportunities for the development of green spaces.

Economic prosperity: Providing services for compact cities presents new business opportunities for locals and increases foot traffic for the Designated Urban Growth Centres and retail centres.

Social equity: Increasing accessibility to services and amenities improves residents' quality of life, promotes a sense of community and ownership of public spaces, and increases socialization and community cohesion. This is especially relevant for elderly residents and residents with disabilities and children and can transform the city into a more equitable place to live for people of all income ranges.

A relevant co-harm to be aware of is the potential increase in housing costs as denser areas become more desirable places for people to live, increasing the risk of gentrification. Policy mechanisms and programs can help prevent this from happening.

The ecodistricts and low-carbon zones also bring social equity co-benefits, mostly related to an increase in the access to living areas, upgrading the living standard and increasing the attractiveness of the city.

Implementing Change

To achieve the Big Moves and Key Actions, Peterborough will need to directly implement or enable the following high-priority strategies.

1. Accelerate the implementation of the Official Plan Update 2023 and secondary plans

Role of the City: Implementer

Type of implementation action: Regulation

Peterborough has made substantial efforts in improving urban development and community well-being in the adoption of the Official Plan Update in 2023 and has already developed strategies to accelerate the implementation of the new plan. As a part of this Implementation Strategy, the City will conduct intensification studies, work on a Secondary Plan, and develop a Community Planning Permit Bylaw for Strategic Growth Areas. It is recommended that the City expedite the intensification studies and require higher density targets beyond the ones proposed by the Official Plan Update. By adopting higher intensification/density targets and a comprehensive strategy including development applications and incentives, developers will have clear guidance and objectives for how to build a more sustainable Peterborough. Ambitious intensification targets will improve residents' accessibility to amenities and services, which will enable additional actions in this Climate Change Action Plan 2.0 such as increased building efficiency and expanded transit use.

In this context, it is recommended the following key actions are undertaken:

- Develop a Secondary Plan and Community Planning Permit Bylaw for Strategic Growth Areas that increase density based on an intensification study (recommended at least 160 residents and jobs per hectare by 2031).
- Include Green Development Standards (see Green Buildings) in the Community Planning Permit System Bylaw. Bylaw should advance and align with:
  - Urban Design Guidelines for Central Area and Mixed-Use Corridors and
  - Objectives of the Transportation Master Plan to improve access and proximity to active and transit infrastructure.

Timeline: Implementation of Secondary Plan and Community Planning Permit Bylaw to begin in 2026.

Actors involved: City of Peterborough, project developers and builders, community members, and utilities (if needed).

Indicators:

Density targets:

- Number of residents residing in Strategic Growth Areas, Overall Designated Greenfield, New Designated Greenfield
- Number of development projects achieving density targets in Strategic Growth Areas, Overall Designated Greenfield, New Designated Greenfield
- Number of development projects **not** achieving density targets
- Average income of residents in Strategic Growth Areas (to ensure higher-density neighbourhoods with access to more services and amenities are economically diverse)

Sustainable Urban Design:

- Number of neighbourhoods/development projects implementing Urban Design Guidelines, Community Planning Permit Bylaw, and/or Green Development Standards
- Location of development projects adhering to Urban Design Guidelines, Community Planning Permit Bylaw, and/or Green Development Standards
- Average income of the communities where the development projects are implementing Urban Design Guidelines, Community Planning Permit Bylaw, and/or Green Development Standards to ensure equitable access to amenities and services.

Costs: No costs are foreseen to implement this action.

Enablers: The Planning Act acts as a facilitator of the implementation of the Official Plan and zoning bylaws.

2. Parking and land-Use studies to support a compact city and the goals proposed in the Official Plan

Role of the City: Implementer

Type of implementation action: Planning

To better understand Peterborough's livability and its evolving environment, the City should conduct an investigation into parking practices, underused land, and brownfield land management. These studies could provide valuable insights into how the city uses resources, manages growth, and creates spaces that benefit the community and the environment. Studies will guide the City in making more informed land-use decisions around parking in the future and will support the City in any efforts to reduce parking minimums or requirements.

The following actions are recommended:

- Perform a Parking Management Study to:
  - Define Central area restricted parking and enhance transit connections by exploring reduced parking space and/or allowing underground or alternative parking options.
  - Set a target to gradually move from low to high parking restrictions.[38]
  - Create parking spots for electric vehicles in accordance with the Electromobility Strategy suggested in the Sustainable Transportation section.
  - Design and increase availability of protected bike parking spots; for instance, through the Central Area Master Plan Update, which could consider measures to promote more protected bicycle parking spaces.
  - Increase parking rates/fares in the downtown area.
  - Set parking requirements and targets for EV charging in residential and commercial buildings.

[38] Examples of parking restrictions: decrease on-road parking availability, provide preference signals and defined spaces for cycling infrastructure, increase pedestrian sidewalks, and provide transit priority.

- Perform a land-use study for sustainable development of underused sites and brownfield, considering the following elements:
    - Set rules and define uses towards sustainable development for underused sites and brownfields. By setting the definition of sustainable development, the City can consider land recovery for:
        - Creating solar farms;
        - Cleaning activities; and
        - Repurposing as green spaces, and others.
    - Engage communities next to the corresponding sites to collect ideas and validate potential land uses.
    - Develop a piloting project with a selected brownfield/underused site in collaboration with nearby communities.
    - Depending on the use, lift barriers to implement the project by amending the zoning bylaw.

Timeline: Undertake parking study and Land-Use study in conjunction with Secondary Plan—start date 2025.

Actors involved: The municipality.

Indicators:

- Parking study and Land-Use study completed
- Parking study recommendations incorporated into Secondary Plan as well as Central Area and other master plans
- Increased EV charging for public and private parking
- Land-use study for sustainable development completed
- Increased acreage of underused lands and brownfields
- Number of hectares used under sustainable development purposes

Costs: Consultant work: $200,000.

Enablers: The Planning Act serves as a facilitator of the implementation of the Official Plan and zoning bylaws.

Green Buildings Big Move

SDGs that are being addressed by this Big Move.

1	No Poverty
3	Good Health and Well-Being
4	Quality Education
6	Clean Water and Sanitation
7	Affordable and Clean Energy
8	Decent Work and Economic Growth
9	Industry, Innovation, and Infrastructure
10	Reduced Inequalities
11	Sustainable Cities and Communities
12	Responsible Consumption and Production
13	Climate Action

Overview

Buildings represent 46% of the city's total modelled emissions in 2021, with up to 236 $ktCO_2e$. This includes residential, commercial, municipal, and industrial buildings. The largest source of emissions is natural gas use, contributing up to 190 $ktCO_2e$, mostly for space heating. Emissions for 2021 and 2050 for the different scenarios are shown in Figure 30.

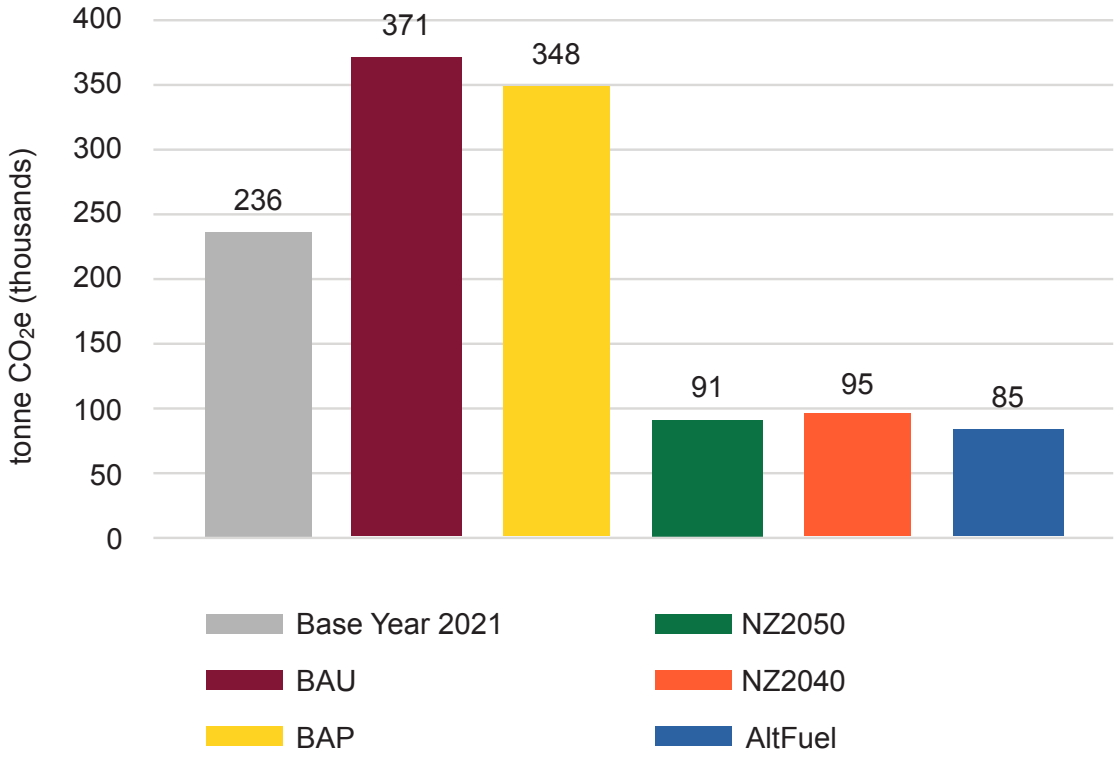


Figure 30. Building sector emissions for 2050 for the three modelled scenarios, in addition to the BAU and BAP. Source: SSG analysis.

The mitigation actions for the building sector are:

- Increase energy efficiency in buildings and
- Switch fuels.

Figures 31, 32, and 33 present the emissions reductions year over year for low-carbon scenarios, and Table 5 shows the emissions reductions per each action by 2030 and 2050.

Table 5. Cumulative emissions reductions for Green Buildings actions. Source: SSG analysis.

Action	Cumulative emissions reductions in the NZ2050 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the NZ2040 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the Alternative Fuels Scenario ($ktCO_2e$)	
	2024–2030	2024–2050	2024–2030	2024–2050	2024–2030	2024–2050
Energy efficiency	104	2,467	185	3,455	104	2,467
Switching to clean fuels	14	525	12	314	28	707
Total	**118**	**2,992**	**197**	**3,769**	**132**	**3,174**

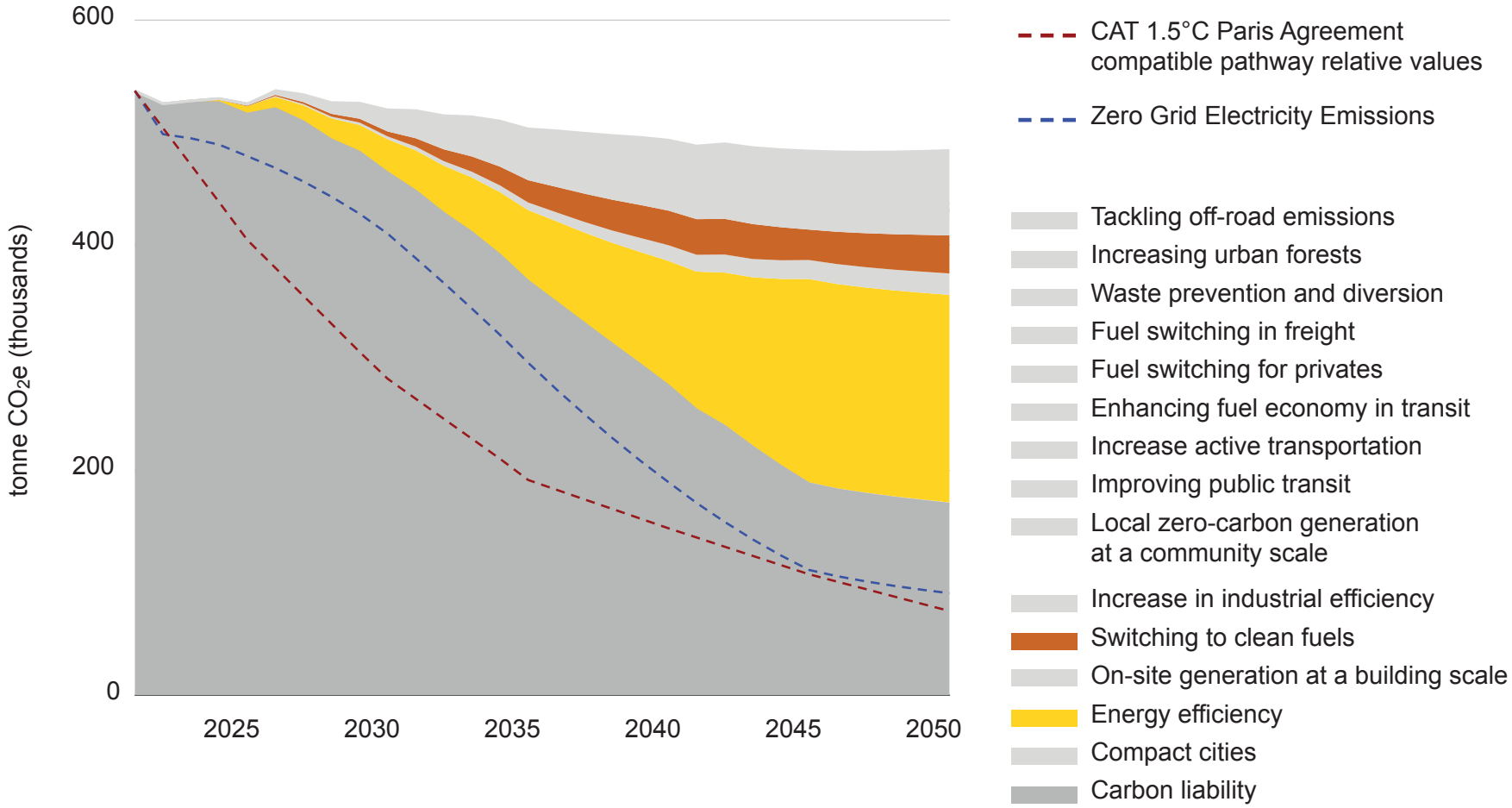


Figure 31. Emissions reductions for the NZ2050 Scenario for the Green Buildings Big Move. Source: SSG analysis.

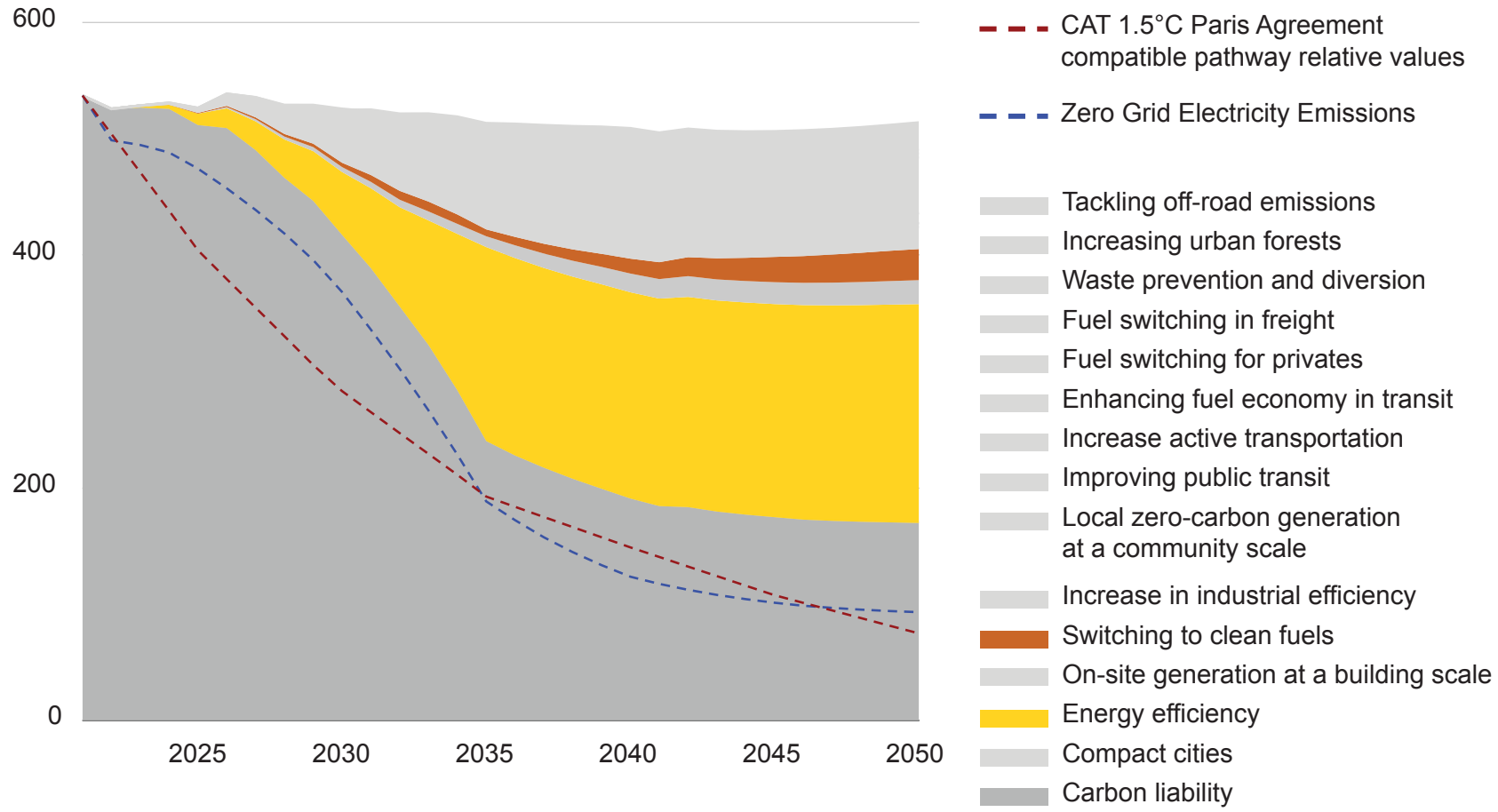


Figure 32. Emissions reductions for the NZ2040 Scenario for the Green Buildings Big Move. Source: SSG analysis.

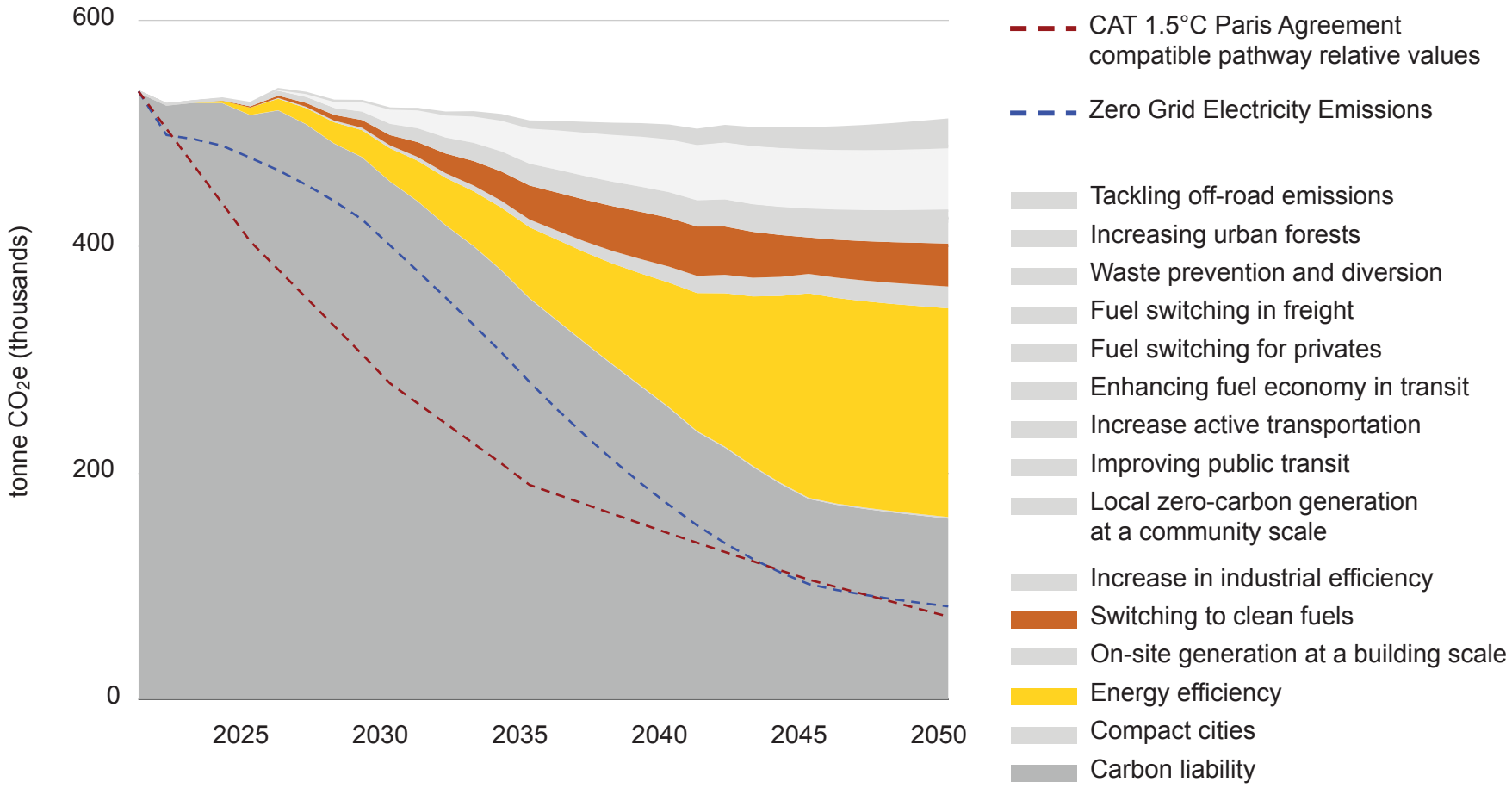


Figure 33. Emissions reductions for the Alternative Fuels Scenario for the Green Buildings Big Move. Source: SSG analysis.

Key Actions

Increase Energy Efficiency

Adopt Canada's Energy Code for New Buildings

Buildings contribute a large proportion of the GHG emissions in cities and an even larger proportion when accounting for fuel and electricity consumption, as well as construction emissions. Part of these emissions are already locked in for existing buildings, but municipalities still have the chance to reduce mid- and long-term emissions in the development of new buildings. Two important tools local governments can use to move toward decarbonizing buildings are building codes and Green Development Standards. Building codes allow governments to set energy and emissions performance requirements for the lifecycle of buildings, especially for new buildings where these requirements can be implemented in a more cost-effective way compared to the cost of retrofitting buildings. As such, Peterborough will adopt Ontario's building code amendments in 2025 that are to be aligned with the tiered national building code that requires all new buildings be built to net-zero energy-ready standards by 2030. It is unclear how ambitious Ontario's new building code will be, and it is recommended Peterborough begin developing Green Development Standards to accelerate net-zero ready development in the city.

These actions are based on complying with the National Energy Code, and they follow the tiers approach established in Canada's Net-Zero Energy Ready Building Code. For the intermediate years (before 2030), the City will partially follow Toronto's implementation of its Green Development Standard by increasing its energy performance requirements every two years. The target is Net-Zero Energy Ready for 100% of new buildings by 2030. The National Energy Code requires a percentage reduction from the baseline energy use of a **reference building**. It adds the flexibility to achieve reductions with different energy performance tiers, which are listed in Table 6.

Table 6. Energy efficiency targets for buildings.

Energy Performance Tier	Percent Building Energy Target (%)	Percent Improvement (%)
1	≤ 100%	≥ 0%
2	≤ 75%	≥ 25%
3	≤ 50%	≥ 50%
4	≤ 40%	≥ 60%

Tier 1 refers to the baseline, while Tiers 2, 3, and 4 are energy-use targets relative to the baseline (i.e., 75% energy of the baseline building, or 25% improvement compared to the baseline). There are two ways of achieving energy-ready status for all tiers. The first way is to reduce the energy use of new buildings compared to that of the baseline building. For instance, Tier 2 buildings only require 75% (or less) of the energy required by the baseline building. The second way is based on improvement—the energy use requirements of Tier 2 buildings are improved by at least 25% compared to the respective baseline building.

This action applies to new buildings with escalated targets of the percent of buildings that will comply with each tier, each year. In the first year of implementation, it is expected that 80% of new buildings will comply with the Tier 1 level, while the rest will comply with the most stringent target (Tier 4). In the periods that follow, these targets will advance to include a larger proportion of buildings in the higher tiers. Thus, for the fraction of buildings not meeting the Tier 4 targets during the intermediate periods before 2030, Toronto's Green Development Standard timeline will be implemented, in which buildings increase tiers every two years. For 2030 and later, the Tier 4 targets will apply to all new buildings. Table 7 describes the implementation periods and their associated targets.

Table 7. Implementation timelines and penetration rates of energy efficiency measures in buildings.

Net-Zero 2050 Scenario	Net-Zero 2040 Scenario	Alternative Fuels Scenario
by 2024:	**by 2024:**	**by 2024:**
Tier 1 for 80% of new buildings	Tier 1 for 80% of new buildings	Tier 1 for 80% of new buildings
Tier 4 for 20% of new buildings	Tier 4 for 20% of new buildings	Tier 4 for 20% of new buildings
by 2026:	**by 2025:**	**by 2026:**
Tier 2 for 60% of buildings	Tier 2 for 60% of buildings	Tier 2 for 60% of buildings
Tier 4 for 40% of buildings	Tier 4 for 40% of buildings	Tier 4 for 40% of buildings
by 2028:	**by 2027:**	**by 2028:**
Tier 3 for 60% of building	Tier 3 for 60% of building	Tier 3 for 60% of building
Tier 4 for 40% of buildings	Tier 4 for 40% of buildings	Tier 4 for 40% of buildings
by 2030:	**by 2028:**	**by 2030:**
Tier 4 for 100% of buildings	Tier 4 for 100% of buildings	Tier 4 for 100% of buildings

Green Development Standards

To promote environmentally, socially, and economically sustainable design, municipalities can create voluntary or mandatory Green Development Standards. Green Development Standards are used at the planning and design stage of project development and are managed by planning departments, thus they do not interfere with existing provincial building codes. GDSs tend to focus on minimizing energy use and greenhouse gas emissions, adapting to a changing climate, protecting and enhancing the natural environment, and creating walkable communities. To meet the requirements, applicants are required to demonstrate how they meet each sustainability metric. When adopting a GDS, municipalities show their support for the market acceleration of the 2020 national model codes, which will require all new buildings to be built to net-zero ready standards in 2030.

Most recently in Ontario, Caledon began implementing GDSs in 2024.

Energy Efficiency and Retrofit Measures for Existing Buildings

Existing buildings are major energy consumers and sources of GHG emissions relative to overall community energy use and emissions. Most buildings that exist today will still be in use in 2050, making them key to a low-carbon transition. Retrofitting existing buildings is key to achieving significant energy savings and emissions reductions, such as the type of actions covered by the HEEP program.

This action is divided into two categories: residential buildings and commercial and industrial buildings. Table 8 outlines the proposed targets.

Table 8. Retrofitting targets and timelines for existing buildings.

	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
	Residential, Commercial, and Industrial	**Residential, Commercial, and Industrial**	**Residential, Commercial, and Industrial**
Thermal savings	50%	50%	50%
Electrical savings	30%	30%	30%
Percentage of buildings	100% by 2045	100% by 2035	100% by 2045

Switching to Clean Fuels

Emissions from fossil fuels, such as diesel, gasoline, and natural gas, constitute the largest portion of emissions, particularly natural gas for residential and commercial use. In practical terms, switching to clean fuels involves replacing equipment that uses fossil fuels with equipment powered by electricity (i.e., replacing a natural gas boiler with an electric heat pump). Electrification in the region must consider the grid capacity and be accompanied by on-site renewable energy generation (e.g., solar rooftops).

Due to the dependency on natural gas for space and water heating, this measure proposes a gradual transition (between 2024 and 2050) to using thermal and electric heat pumps and water heaters in all types of residential and non-residential buildings.

Table 9 describes the targets for introducing heat pumps to replace natural gas space heating in existing commercial and residential buildings.

Table 9. Targets to adopt heat pumps and electric water heaters in existing buildings.

	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
Heat pumps and electric water heaters for existing commercial	50% by 2045	60% by 2045	100% by 2045
Heat pumps and electric water heaters for existing residential	50% by 2045	60% by 2045	100% by 2045

Financial Analysis

From 2024 to 2050, the total public and private investment required for the Green Buildings Big Move is $1,331 million (Table 10, Figures 34, 35, and 36), and the total emissions reduction is more than 2,900 ktCO_2e. Key results from the financial analysis are:

- Higher action implementation rates mean higher investments but also higher emissions reductions;
- The most cost-effective scenario is the NZ2040 Scenario, in which each tonne of CO_2e reduced costs -$178. In other words, this scenario achieves a total of $178 savings for each tonne of GHG reduced;
- The capital investments of this Big Move are driven by the residential building retrofit action due to the higher costs of retrofitting a building versus including sustainable elements during the construction phase;
- Retrofitting results in larger financial gains due to a reduction in fuel consumption costs, which is reflected in energy savings;
- The most cost-effective measure in the NZ2050 Scenario is the adoption of a Green Building Code and its implementation on both industrial (-$826/t$CO_2e$) and commercial buildings (-$417/t$CO_2e$). This is closely followed by retrofitting non-residential buildings, which has a marginal abatement cost of -$392/t$CO_2e$, and installing heat pumps in commercial buildings (-$222/t$CO_2e$). This means that planning for future building emissions is a key step towards decarbonization of the city. Following the implementation of strict construction requirements, the City will need to advance in retrofitting existing buildings (commencing with non-residential), even before incorporating renewable energy and electrification;
- This action has positive marginal abatement costs for residential buildings, including the marginal abatement costs of residential retrofits ($3/t$CO_2e$), new building codes for residential buildings ($36/t$CO_2e$), and the adoption of heat pumps for residential uses ($55/t$CO_2e$). These numbers reflect the need to start with retrofitting before the installation of heat pumps to maximize the costs and energy demand;

- Retrofitting residential buildings has positive abatement costs in the NZ2050 and AltFuels Scenario ($3/tCO$_2$e), while for the NZ2040 Scenario this number is negative, up to -$47/tCO$_2$e, which highlights the relevance of implementing this action in a timely manner in order to enjoy the savings related to a reduction in fuel use.

Table 10. Total investment, GHG reduction, and marginal abatement costs for the Green Buildings Big Move. Source: SSG analysis.

Scenario	Total Investment ($)	Total GHG Reduction (ktCO$_2$e)	Marginal Abatement Cost ($/tCO$_2$e)
NZ2050	1,331,000,000	2,992	-161
NZ2040	1,522,000,000	3,769	-178
Alternative Fuels	1,412,000,000	3,800	-123

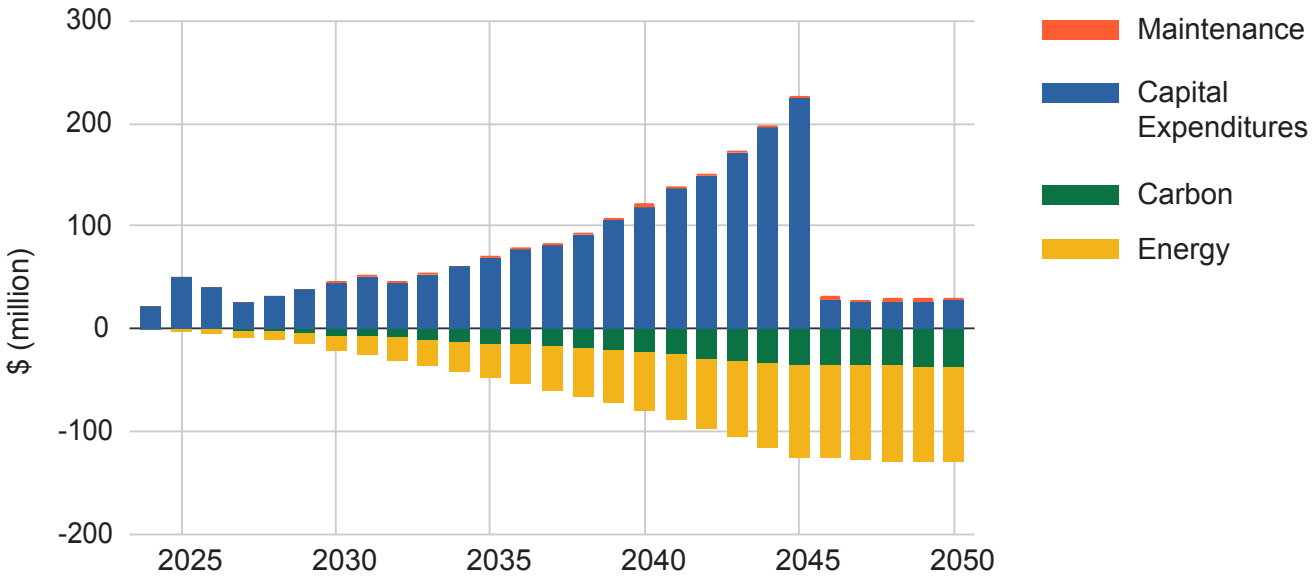


Figure 34. Year-over-year investments and returns of the Net-Zero 2050 Scenario for the Green Buildings Big Move. Source: SSG analysis.

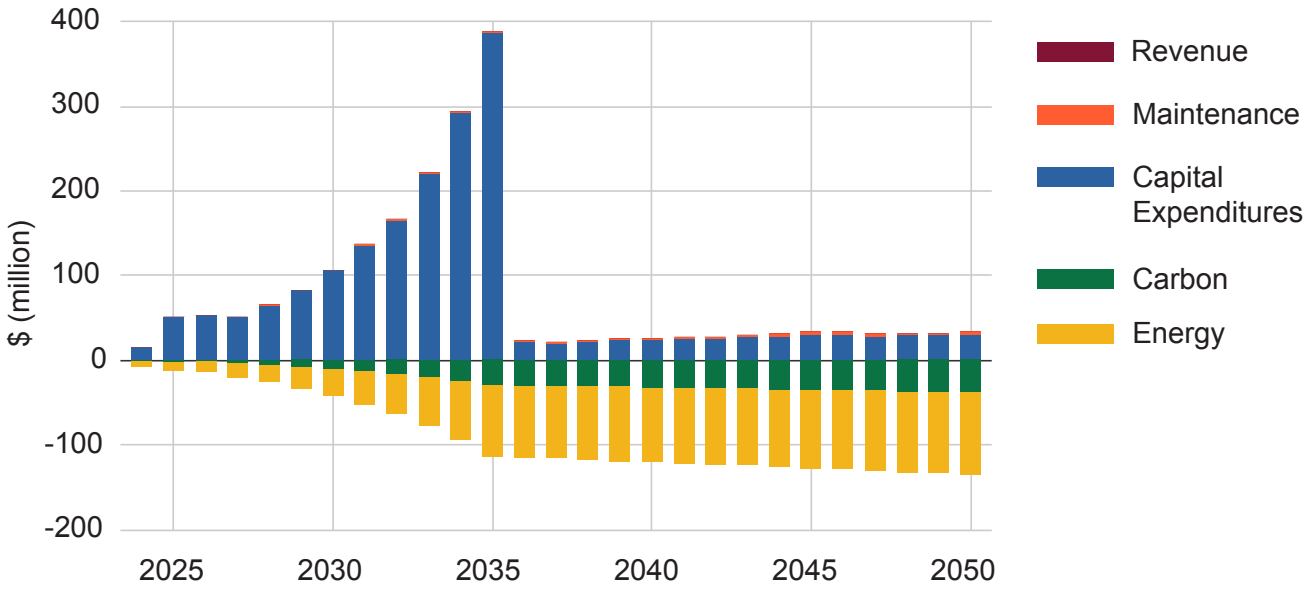


Figure 35. Year-over-year investments and returns of the Net-Zero 2040 Scenario for the Green Buildings Big Move. Source: SSG analysis.

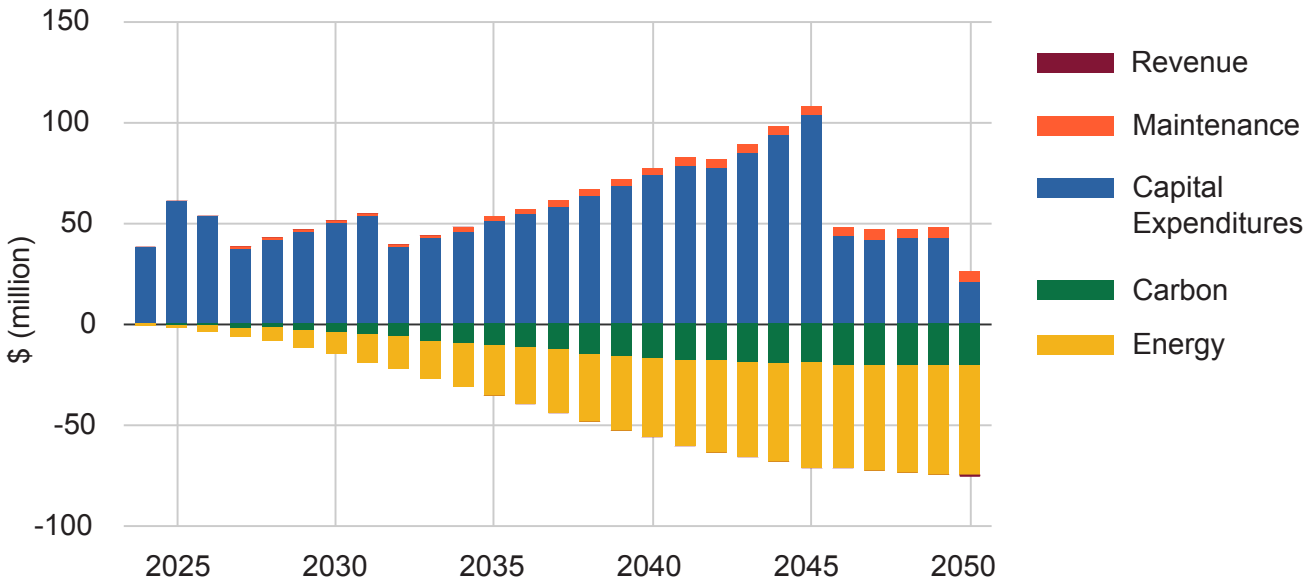


Figure 36. Year-over-year investments and returns of the Alternative Fuels Scenario for the Green Buildings Big Move. Source: SSG analysis.

Co-Benefits

Improving energy efficiency and switching to clean fuels in the building sector provide a set of co-benefits related to health, social equity issues, and economic development.

Health benefits: Electrification of heating and cooling systems reduces indoor air pollution and overall air pollution. Households with cleaner indoor environments reduce residents' risk of suffering from respiratory problems and cardiovascular diseases in the long term.

Economic development: Activities related to the new building codes lead to new jobs due to an increase in retrofitting needs, potentially creating 11,000 new jobs between 2024 and 2050. New opportunities for local innovation may also result from this transformation. For instance, supplying equipment locally and developing municipal-scale solutions, such as templates for improving home envelopes, can spur industry to take action. Another co-benefit for the city, its residents, and its building developers is being seen as climate action leaders due to the creation of high-performance buildings, which draw new industry and technology production to the city.

Social equity issues: Energy efficiency measures are no-regret actions, since energy efficiency lowers the demand for energy, thus lowering energy bills. This is particularly beneficial for low-income households. Building envelope improvements also support building adaptation, as the structure is able to cope with climate change impacts such as extreme weather events. The city of Peterborough is projected to experience an increasing number of days with temperatures over 30°C and an increase in heat waves. In this context, proper building insulation is necessary for achieving community adaptation goals.

Reducing the energy bills of low-income and disadvantaged communities will free up household finances that were previously devoted to paying for utilities and could contribute to poverty alleviation. Peterborough's downtown is home to a large portion of renters facing very high home energy cost burdens. This population spends more than 10% of their after-tax income on home energy only and could benefit from these initiatives[39].

[39] Canadian Urban Sustainability Practitioners. "Energy Poverty Canada." Data and Tools. Energy Poverty, 2024. https://energypoverty.ca/

Green building actions for the less ambitious scenario (NZ2050) result in energy savings across all sectors that surpass $1,245 million for the 2024–2050 period, though savings will extend and increase past the modelled timeline. Of this total savings, residential retrofits account for $438 million in savings and switching space heating from natural gas to electric heat pumps provides an additional $115 million in savings.

Implementing Change

In parallel to implementing the Official Plan, Peterborough needs to work on setting minimum requirements for new and existing buildings. To achieve this, we have outlined the following most relevant actions the municipality needs to take to advance in reducing GHG emission in the building sector:

1. Design and implement a voluntary Green Development Standard

Role of the City: Implementer

Type of implementation action: Regulation

To prevent locking in carbon emissions in Peterborough's future residential and commercial infrastructure, the City should establish targets for minimum technical requirements for construction. A key approach to achieving this is developing a Green Development Standard. Initially, the City should create and implement a voluntary GDS while advocating for the Ontario government to adopt new national codes. Adopting a voluntary GDS will provide the City with valuable experience and readiness for future federal updates and drive innovation in green building practices, improve energy efficiency, reduce long-term operational costs and emissions, and enhance the overall sustainability of new developments.

Key activities the municipality can do are:

- Designing a voluntary GDS:
- Advocate for Ontario's government to adopt more ambitious building codes that align with national net-zero building codes.
- Perform a market readiness study.

- Use the Clean Air Partnership's step-by-step guide for municipalities in Ontario to use as a resource in designing their GDS. It recommends the following steps:
- Declaration from Council with goals and objectives. A working team is established.
- Conduct analysis with community inputs and develop metrics, resources, and tools for the GDS.
- Update planning and review process. Train staff. Begin implementation of GDS.
- Monitor and track progress. Review annually to make adjustments.
- Provide incentives, if possible.
- Consider expediting permitting, collaborating with financial institutions to create loans for developers with special interest rates (lower than average or flexible repayments), and increasing built spaces for projects achieving higher scoring GDS applications.
- Pilot the GDS in new social housing developments.
- Metrics should include standards for solar generation, EV-ready charging, and green infrastructure.

Timeline:

Advocating for higher building standards to begin in 2025.

Perform a market readiness study in 2025.

Plan and design the GDS to start in 2026.

Actors involved: City of Peterborough, project developers and builders, and community members.

Indicators:

- Market readiness study completed
- Year GDS designed/2026
- Year GDS is implemented
- Number of projects voluntarily following GDS requirements

- Number of social housing projects following GDS requirements

Costs: Market readiness and building code compliance study: $200,000. Consultant study to design the Green Development Standard: $200,000.

Enablers: Federal government encourages other levels of government to adopt highest levels of the tiered National Energy Code. The Codes Acceleration Fund, provided by the federal government, supports different levels of government to adopt energy codes and deploy technical capacity building efforts.

2. Run, expand, and extend the HEEP program

Role of the City: Implementer and investor

Type of implementation action: Funding program

The recommended steps to expand the HEEP program are:

1. Perform a market analysis to understand Peterborough's local market, demographics, archetyping, characterizing energy and carbon intensities, etc.
2. Plan the extension and expansion of the HEEP program by analyzing any legal barriers, looking for funding sources, and defining eligibility criteria of applicants.
3. Implement.
4. Monitor and Evaluate.

As part of the planning phase, Peterborough should evaluate:

- Economic pathways to continue the program based on Local Improvement Charge (LIC) revenues and other sources. It should also consider:
    - Setting a more ambitious funding target. To accelerate the adoption of sustainable practices in existing houses, the City can double the funding amount by 2028, reaching up to $16 million in total.

- Peterborough should also update the applicability of the program to include the following recommendations:
    - Target equity-denied communities and financially challenged families by allocating a percentage of the funding specifically for them.
        - Facilitate applying for the program during the property sale by collaborating with financial institutions to explore incorporating retrofit activities into the mortgage. This approach can enable financing for energy improvements as part of the transaction, potentially increasing the home's attractiveness and value.
- As part of the market analysis, assess the opportunities and challenges of expanding the program to non-residential buildings.

Archetyping Buildings

A building archetype refers to the set of characteristics and qualities that represent a set of buildings or houses. Identifying building archetypes is key to pinpointing underserved homes and communities facing significant energy burdens and who are unlikely to access current funding. It also helps determine which types of buildings are most suitable for installing solar panels, thereby accelerating the replication of these installations across similar houses or buildings.

The Clean Air Partnership's "Residential Archetyping for Energy Efficiency Programs" guide was designed to support municipalities.

Timeline:

Perform a market analysis in 2026.

Plan and design the HEEP extension to start in 2027.

Actors involved: City of Peterborough, financial institutions, business associations, the Chamber of Commerce, and the Federation of Canadian Municipalities.

Indicators:

- Market analysis completed
- Number of houses retrofitted
- Total funding loaned (including third-party and LIC) per year/Total HEEP funding
- Total funding granted to low-income and equity-denied communities/Total HEEP funding

Costs: Market analysis: $200,000.

Proposed program extension to double current budget: $16 million.

Enablers: The municipality can leverage its experience with HEEP and plan for the Green Municipal Fund's Community Efficiency Financing program offered by the Federation of Canadian Municipalities for an extension of the program. It can also support the adoption of clean technologies by providing residents with information about Canada's Greener Homes Affordability Program (CGHAP) launched in 2024. Solar adoption can be achieved either through the HEEP or considering the support from the Community Efficiency Financing by the Green Municipal Fund, helping municipalities deliver energy financing programs for low-rise residential properties.

3. Preparing Peterborough for future needs (training, courses, guides, etc.)

Role of the City: Incubator

Type of implementation action: Capacity building, and education and outreach

Design and develop training programs with local educational institutions to expand technical capacities in auditing, building construction, and building retrofit, as well as operation and maintenance activities.[40] Peterborough can consider a starting point of targeting 100 people/year for training purposes, benefiting directly from municipalities' efforts to increase technical capacities. To achieve this, the municipality will have to work collaboratively with relevant actors offering training

[40] These activities refer to the operation and maintenance of new technologies, such as heat pumps, incorporated in buildings.

courses, such as local colleges, trade schools, local training centres, and building developers. Moreover, the City needs to seek funding from the federal government to develop and implement training programs and sessions.

Timeline:

Collaboration with relevant actors to start in 2025.

Actors involved: City of Peterborough, project developers and builders, community members, and trade school and college.

Indicators:

- Number of trainees per year/100

Costs: No foreseen costs are expected from this action.

Enablers: The municipality can support the application to the Deep Retrofit Accelerator Initiative (DRAI) from the Government of Canada, as well as inform about free online training courses from the Canadian Standard Association about the national energy code. Providing a list of training alternatives on buildings and other sectors to local suppliers and developers. Finally, supporting the application to the Sectoral Workforce Solutions Program.

Energy Supply Big Move

SDGs that are being addressed by this Big Move.

1	No Poverty
3	Good Health and Well-Being
4	Quality Education
7	Affordable and Clean Energy
8	Decent Work and Economic Growth
11	Sustainable Cities and Communities
12	Responsible Consumption and Production
13	Climate Action

Overview

Energy generation to power and heat buildings is a major source of GHG emissions in cities across Canada, including Peterborough. Ontario continues to rely on natural gas to generate electricity, which means that even when home space and water heating systems are electrified, emissions will still be produced from grid electricity generation.

The proposed mitigation measures for this sector are:

- Local zero-carbon energy generation at a community scale and
- On-site energy generation at a building scale.

It is worth noting that higher emissions reductions can be achieved by reducing provincial grid emissions, but this is out of the City's jurisdiction. This measure is shown by a dotted light blue line in Figures 37, 38, and 39. These figures show year-over-year emissions reductions from the implementation of mitigation measures in the Energy supply sector, and Table 11 displays the cumulative emission reductions per scenario.

Table 11. Cumulative emissions reductions for Energy Supply actions. Source: SSG analysis.

Action	Cumulative emissions reductions in the NZ2050 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the NZ2040 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the Alternative Fuels Scenario ($ktCO_2e$)	
	2024–2030	2024–2050	2024–030	2024–2050	2024–2030	2024–2050
Local zero-carbon generation at a community scale	1.84	45	2	57	1.84	45
On-site generation at a building scale	8.03	261	13	308	8.06	264
Total	**10**	**305**	**15**	**366**	**10**	**309**

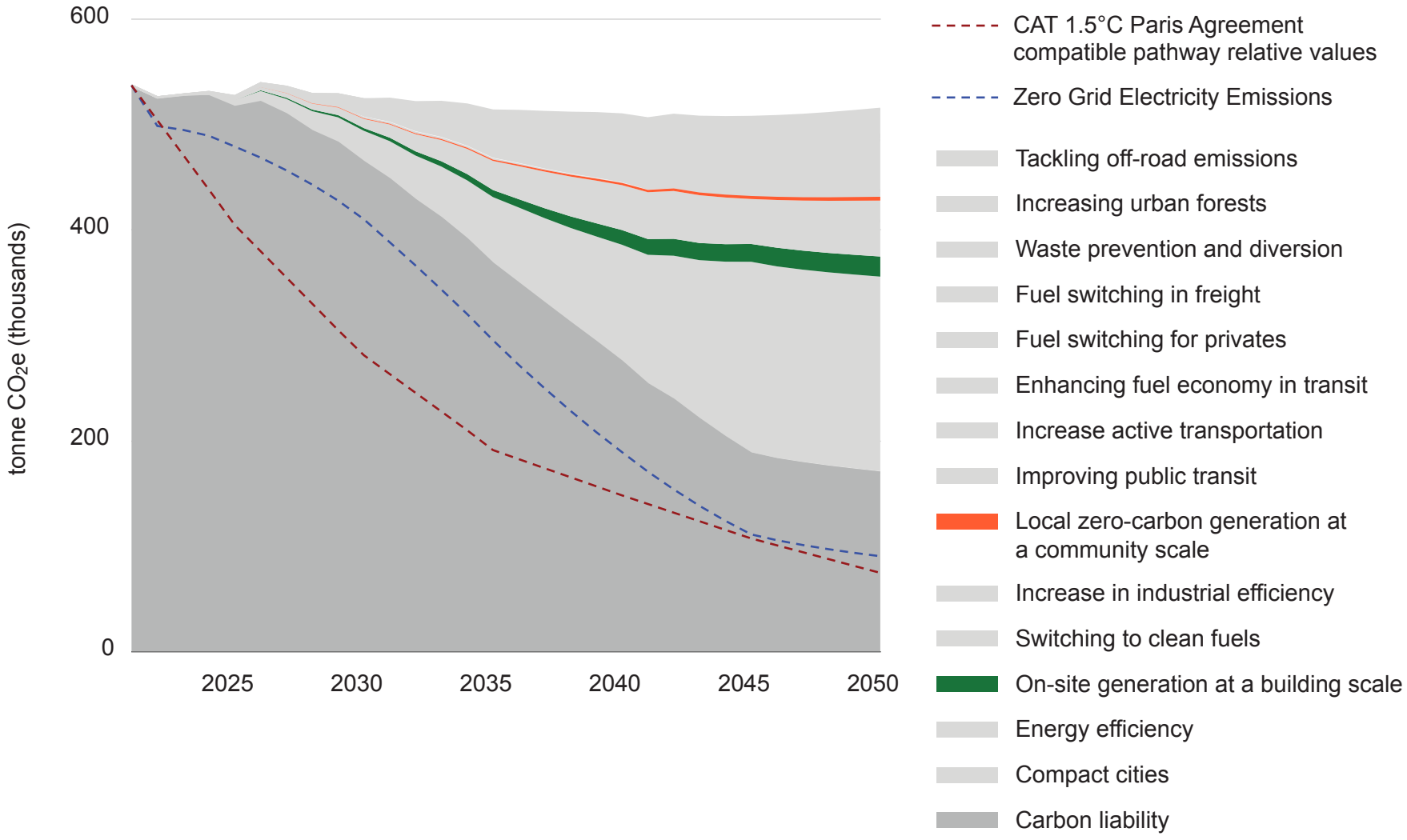


Figure 37. Emissions reductions for the NZ2050 Scenario for the Energy Supply Big Move. Source: SSG analysis.

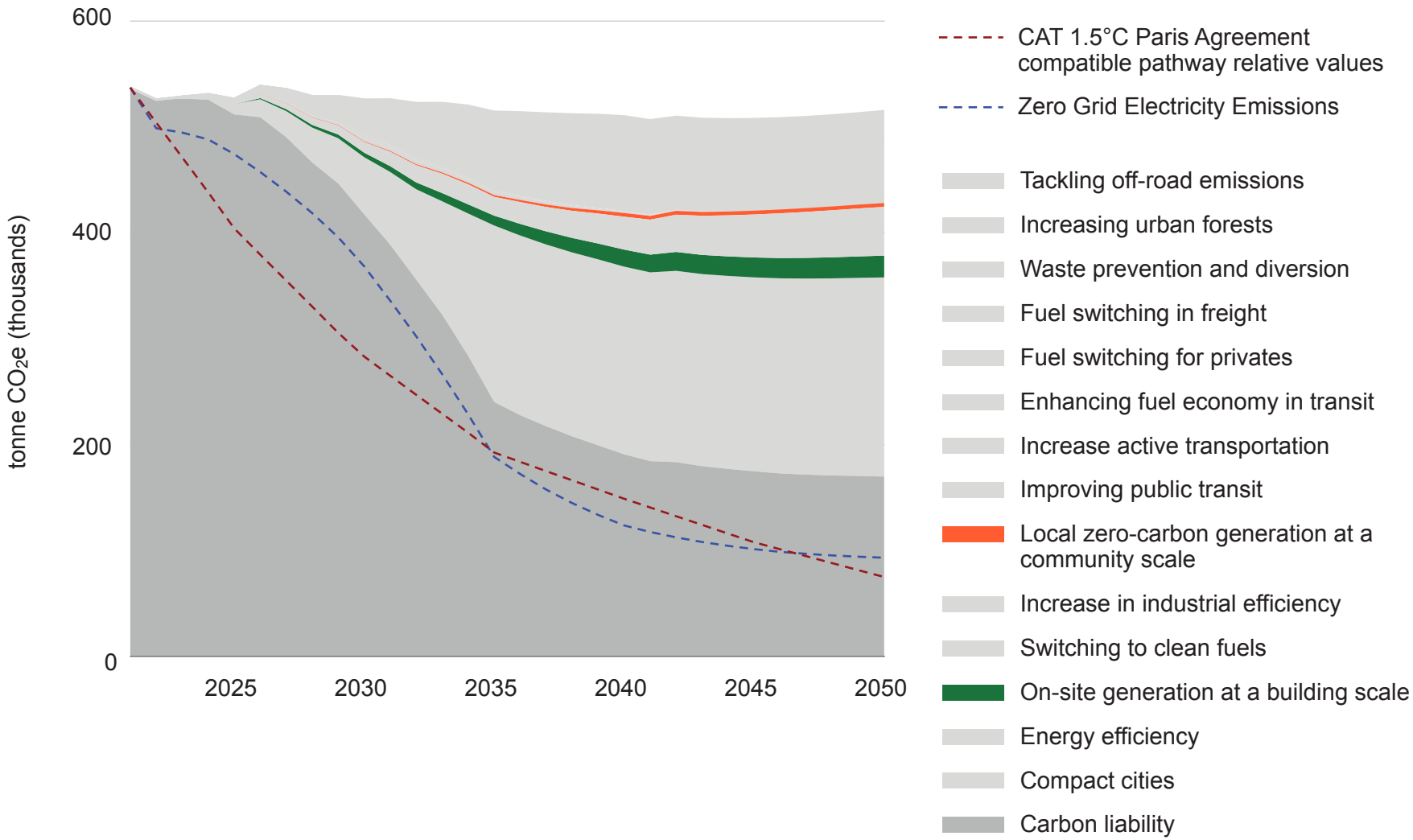


Figure 38. Emissions reductions for the NZ2040 Scenario for the Energy Supply Big Move. Source: SSG analysis.

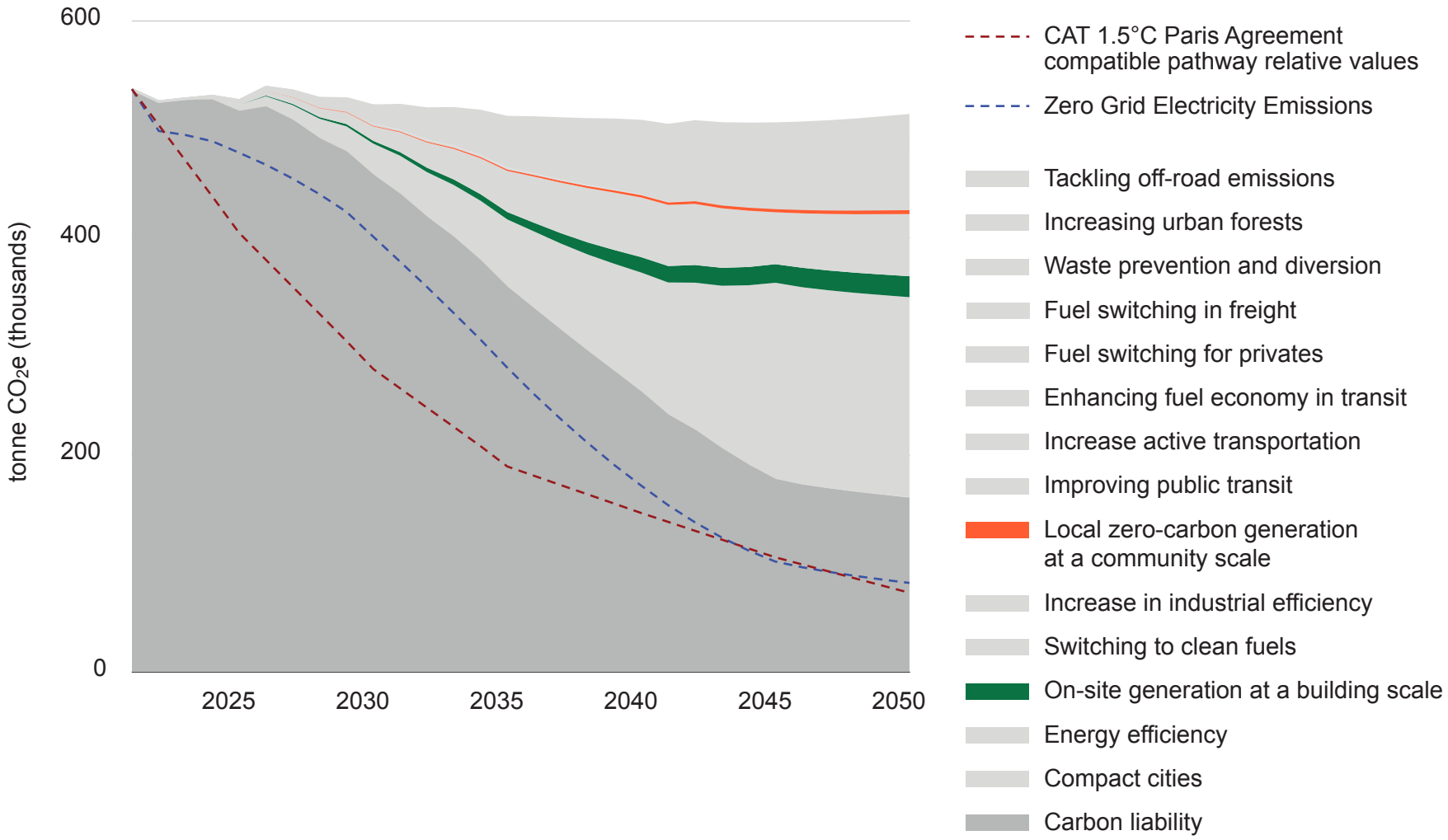


Figure 39. Emissions reductions for the Alternative Fuels Scenario for the Energy Supply Big Move. Source: SSG analysis.

Key Actions

Local Zero-Carbon Energy Generation at a Community Scale

Increasing renewable energy generation at the community scale lowers emissions and increases city resiliency and self-sufficiency. This measure aims to encourage the development of solar farms and ground-mount solar. Currently, the city has a solar generation capacity of 18 MW, and the new target is to increase capacity by 150% by 2050. Table 12 shows the solar generation increase and the total generation capacity targeted by the Net-Zero 2050, the Net-Zero 2040, and the Alternative Fuels scenarios.

Table 12. Solar generation increase targets.

	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
Percentage of increase	150% by 2050	150% by 2040	150% by 2050
Total additional generation (MW)	27 MW by 2050	27 MW by 2040	27 MW by 2050

What is a Ground-Mount Solar System?

A ground-mount solar system is a large setup of solar panels installed on the ground, often in open fields or on land that is not being used for other purposes. These systems capture sunlight to generate electricity, which can be used by nearby homes and businesses.

Community-scale solar projects are similar but usually involve a group of people or organizations coming together to invest in and share the electricity produced by these solar panels. This way, even those who cannot install solar panels on their own roofs can still benefit from solar energy. Overall, these projects help increase clean energy use in the community and can lower electricity costs.

Going solar at a community scale may be facilitated by municipal or local programs and also through co-ops. Solar co-ops are groups of people who combine their purchasing power to save money and adopt solar generation locally. Solar co-ops help neighbours save money by supporting bulk purchasing, as well as by providing information on installing solar panels, finding reputable and certified installers, and financing options. Solar co-ops make renewable energy more accessible for folks that cannot afford solar on their own.

On-Site Energy Generation at a Building Scale

On-site renewable energy is a way to supply some or all of the required energy for a building or facility while also reducing its reliance on fossil fuels. On-site renewable systems used by residential and non-residential energy consumers has increased in recent years. The increased availability of tax incentives, credits, and grants for renewable energy has contributed to this growth, as have financing mechanisms, such as the Residential Power Purchase Agreement and leasing options for solar. In addition, market prices of renewable technologies have significantly decreased along with the large rate of adoption across the globe[41].

[41] Intergovernmental Panel on Climate Change. "AR6 - Figure 3: Summary for Policy Makers," 2024. https://www.ipcc.ch/report/ar6/wg3/figures/summary-for-policymakers/figure-spm-3/

Adoption of renewables is already part of Peterborough's HEEP program, and the updated Official Plan also commits to encouraging private buildings to produce at least 5% of their building energy requirements through on-site generation. This action aims to increase the adoption of renewables, especially solar PV. Currently the city generates less than 1 MW of solar capacity; however, the solar generation potential is more than 300 MW according to the city's solar potential study and the Google EIE tool. Thus, this action proposes accelerating the adoption of solar generation for the city, targeting both new and existing residential and commercial buildings, as described in Table 13.

Table 13. On-site solar generation targets.

Targets	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
Load coverage for all new homes	75% by 2041	75% by 2036	75% by 2041
Load coverage for all existing homes	30% by 2046	30% by 2041	30% by 2046
Load coverage for all new commercial buildings	25% by 2041	25% by 2036	25% by 2041
Load coverage for all existing commercial buildings	10% by 2046	10% by 2041	10% by 2046
Total installed rooftop solar capacity	161 MW by 2050	174 MW by 2050	163 MW by 2050

Financial Analysis

The total investment required to implement all the energy supply actions (zero carbon generation at the community level and on-site solar generation) is about $200 million between 2024 and 2050 in the NZ2050 Scenario (Table 14). The total investment increases in the NZ2040 Scenario as the need for immediate and timely action increases. However, in all scenarios, operational savings and gains broadly overcome investment by almost $100 million. Figures 40, 41, and 42 show the year-over-year investment returns for each scenario.

Table 14. Total investment, GHG reduction, and marginal abatement costs for the Energy Supply Big Move. Source: SSG analysis.

Scenario	Total Investment ($)	Total GHG Reduction ($ktCO_2e$)	Marginal Abatement Cost ($/$tCO_2e$)
NZ2050	197,000,000	305	-305
NZ2040	231,000,000	366	-267
Alternative Fuels	199,000,000	309	-304

Key insights of the financial analysis include the following:

- Due to the scale of implementation required to install solar rooftops on residential buildings, this action requires the largest total investment of all the scenarios for solar rooftops for new buildings and existing ones.
- Ground-mount solar has a smaller penetration rate, but capital investments for ground-mount solar projects tend to cost less for individuals due to economies of scale. As such, supporting bulk purchasing through municipal efforts or using cooperative approaches to encourage community members to adopt ground-mount solar could play a fundamental role in reducing implementation costs.
- In terms of the overall costs of implementing these actions, capital investment for energy generation is the largest cost, and operational savings come almost exclusively from energy savings due to the reduction in fuel and energy consumption.
- In the NZ2050 Scenario, the marginal abatement costs of these actions are all negative, which means that implementing these actions will bring net benefits to society.
- The most cost-effective action in the NZ2050 and AltFuels scenarios is the installation of solar rooftops in commercial buildings, which has a marginal abatement cost of -$492/$tCO_2e$. This is closely followed by the installation of solar rooftops in new residential buildings (-323$/$tCO_2e$), ground-mount solar generation (-$312/$tCO_2e$), and the adoption of on-site PV solar in existing residential buildings (-$257/$tCO_2e$).

- In the NZ2040 Scenario, the marginal abatement costs decrease due to a faster implementation rate. In this scenario, capital investment is driven up in a shorter period of time, while emissions reductions decrease at a slower rate. However, the implementation of these actions still brings overall net benefits due to operational savings.

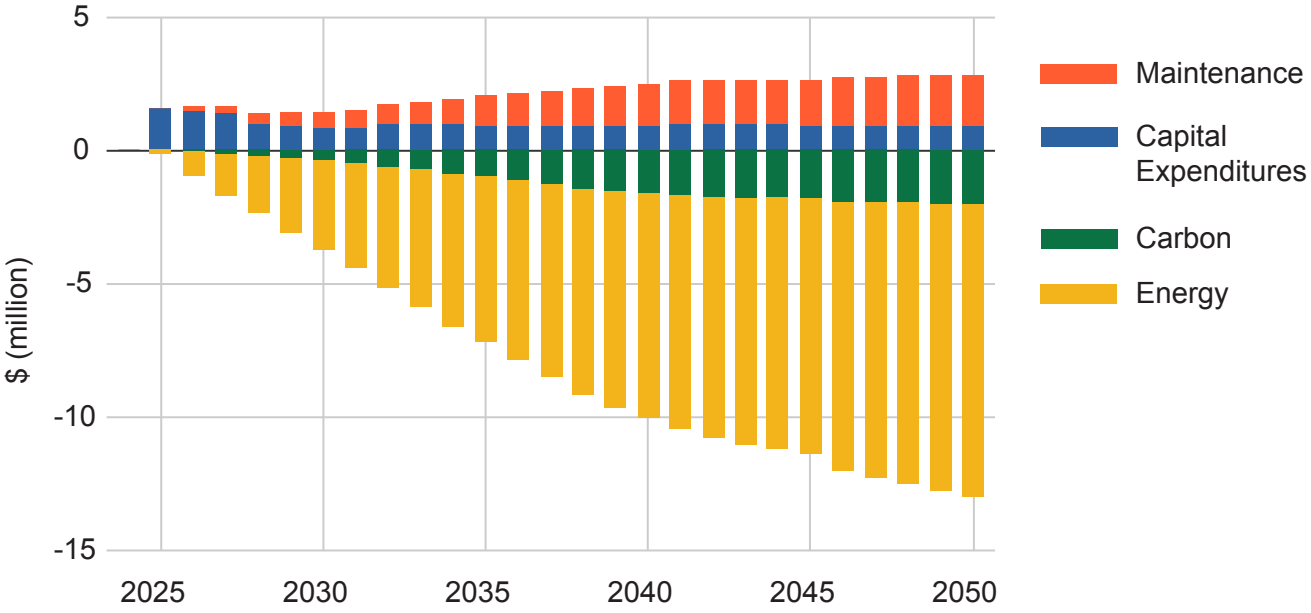


Figure 40. Year-over-year investments and returns of the Net-Zero 2050 Scenario for the Energy Supply Big Move.[42] Source: SSG analysis.

[42] Revenue from electricity generation is not included, as it is offset by household expenditures.

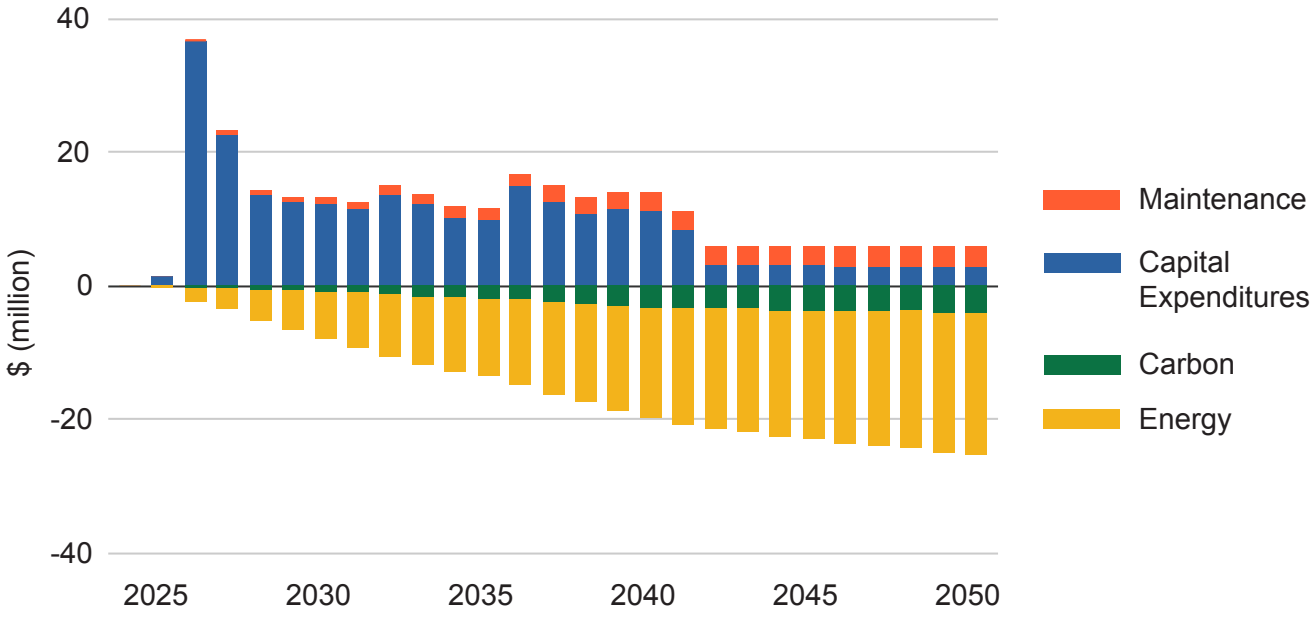


Figure 41. Year-over-year investments and returns of the Net-Zero 2040 Scenario for the Energy Supply Big Move. Source: SSG analysis.

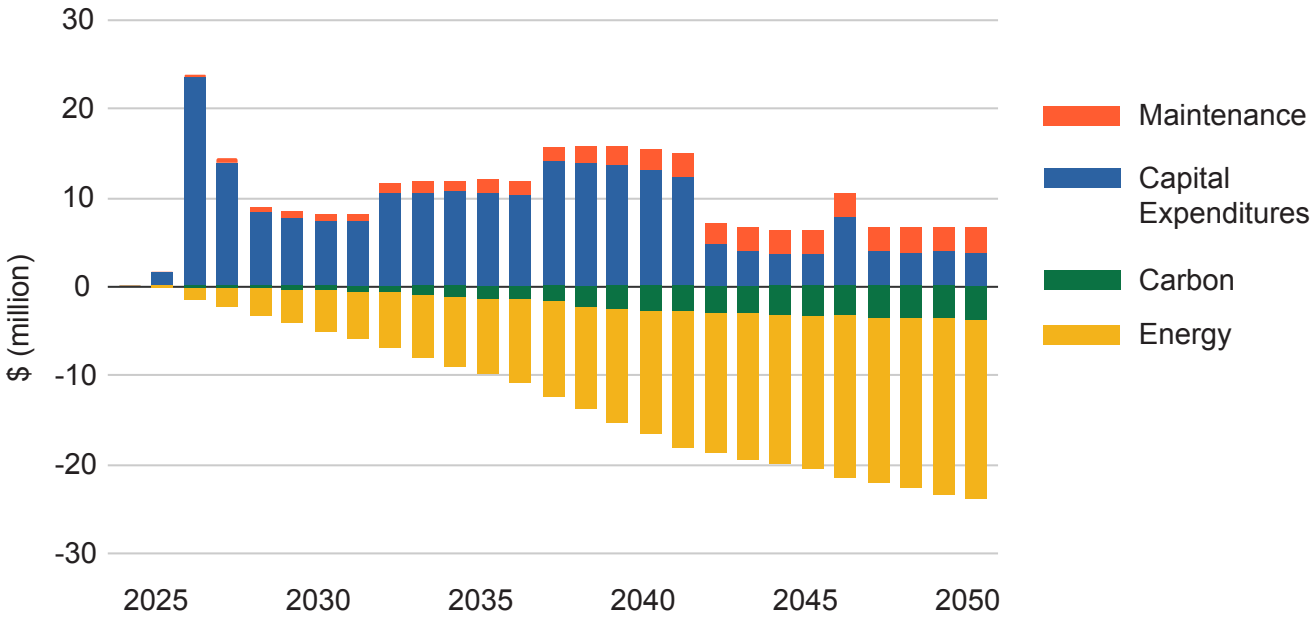


Figure 42. Year-over-year investments and returns of the Alternative Fuels Scenario for the Energy Supply Big Move. Source: SSG analysis.

Co-Benefits

Economic co-benefits: New and existing buildings will need to have solar panels installed, which will increase the renewable energy market and create new employment opportunities. A higher demand for solar rooftop panels will create more than 800 new jobs between 2024 and 2050 in the NZ2050 and Alternative Fuels scenarios and almost 900 new jobs in the NZ2040 Scenario. Policies and programs requiring or encouraging on-site solar installation and community renewable energy projects will increase the local renewables market and the number of energy operators required to meet the local capacity demand.

Social equity co-benefits: The use of on-site renewable energy for residential buildings will financially benefit households since they will be less dependent on the electricity grid, reducing electricity and fuel consumption costs. In this context, implementing on-site renewables brings an additional (to green buildings actions) savings of more than $187 million. Developing programs that target low- and moderate-income homeowners will support the equitable distribution of on-site renewable energy opportunities.

Additionally, the City should collaborate with local educational institutions, such as Trent University and Fleming College, to expand training and professional programs focused on renewable energy. This will create more job opportunities for a diverse population in Peterborough. Furthermore, financial support will be necessary for low-income households and students to access new career pathways in sustainable fields, such as renewable energy and green buildings. The City can advocate for this support from financial institutions and other levels of government.

Implementing Change

In addition to developing compact cities and moving toward green buildings, the City of Peterborough should also support the energy transition. The municipality has an important role in achieving this, and it should implement the following most important actions to promote the Energy Supply Big Move:

1. Work with suppliers, utilities, and the community to provide incentives for solar adoption

Role of the City: Collaborator

Type of implementation action: Education and outreach

Collaborate with Peterborough Utilities and local solar panel suppliers, community members, and businesses in ways that promote the adoption of both on-site and/or community solar projects. The municipality has the opportunity to act as a collaborator to increase networking opportunities. Peterborough should promote and accelerate the implementation of renewable energy in the city, and the following actions are alternatives to do so:

- Set up an ongoing advisory service at the municipal office to assist community members and businesses in acquiring Power Purchase Agreements and information about local solar co-ops and the incentives available.
- Work with stakeholders in ways that promote bulk purchasing of solar panels through planning networking events, workshops, seminars, and by designing a communication strategy for solar adoption.

Timeline:

Establishing the ongoing advisory service by 2026.

Launch the communication strategy by 2027.

Begin ongoing networking events by 2026.

Actors involved: City of Peterborough, solar suppliers, Peterborough Utilities, solar co-operatives, environmental groups, neighbourhood associations, other community groups, City of Peterborough Holdings Inc. (CoPHI), and Hydro One.

Indicators:

- Ongoing advisory service established
- Communication strategy launched
- Number of participants per networking event

- Number of community solar projects developed in the city of Peterborough annually
- Number of houses adopting on-site projects in the city annually
- Solar generation per year (kWh/year)

Costs: Staff hours for ongoing service to inform about Power Purchase Agreement, etc.

Communication strategy: $20,000.

Enablers: Net metering mechanisms: The Net Metering Program is established by the Ministry of Energy and is governed by Regulation O. Reg. 541/05: NET METERING.

2. Municipal buildings supplied with solar generation (on-site and ground-mount solar)

Role of municipality: Innovator

Type of implementation action: Intervention

Since the energy transition should occur at all scales and involve as many energy-consuming users as possible, the City needs to adopt solar panels in its buildings wherever feasible or make an effort to supply all municipal buildings with solar energy generation (e.g., ground-mounted solar). Covering 100% of the buildings with solar energy generation is a key step toward a more sustainable city, and the municipality will benefit from reduced energy costs. To achieve this, the City should:

- Partner with Peterborough Utilities to perform a feasibility study to evaluate the solar potential for municipal buildings and ground-mounted solar systems. As a starting point, it should consider municipal buildings in the City of Peterborough only (about 45 buildings), excluding those that do not use electricity;
- Install solar panels in selected buildings; and
- Provide solar generation from ground-mounted solar projects to municipal buildings without on-site generation.

Timeline:

Feasibility study for solar potential in municipal buildings by 2026.

Installation of solar panels: 100% buildings (according to the results of the study) by 2035.

Actors involved: City of Peterborough, solar suppliers, and Peterborough Utilities.

Indicators:

- Number of municipal buildings with solar panels/total municipal buildings in 2035;
- Total solar generation (kWh) in municipal buildings per year/Total electricity use in municipal buildings annually.

Costs:

Estimated total costs, considering electricity consumption in 2024, of all municipal buildings is a total capital investment of $3.3 million in solar panels.

Ground-Mount Solar Generation for Municipal Buildings: Feasibility Study Consultant Work: $50,000.

Enablers: Net metering mechanisms: The Net Metering Program is established by the Ministry of Energy and is governed by Regulation O. Reg. 541/05: NET METERING.

Sustainable Transportation Big Move

SDGs that are being addressed by this Big Move.

3	Good Health and Well-Being
8	Decent Work and Economic Growth
10	Reduced Inequalities
11	Sustainable Cities and Communities
12	Responsible Consumption and Production
13	Climate Action

Overview

Transportation represents 53% of the city's total modelled emissions for 2021, with up to 273.7 $ktCO_2e$ being emitted and up to 296 $ktCO_2e$ when including aviation emissions (Figure 43). This includes light-duty personal-use vehicles, public transit buses, municipal fleets, off-road vehicles,[43] heavy-duty equipment, and rail and marine vehicles. Transportation emissions are caused mostly by diesel and gas use, where each fuel type generates nearly 50% the total transportation emissions. Only a small portion of transportation emissions comes from the grid and electricity generation (less than 6%).

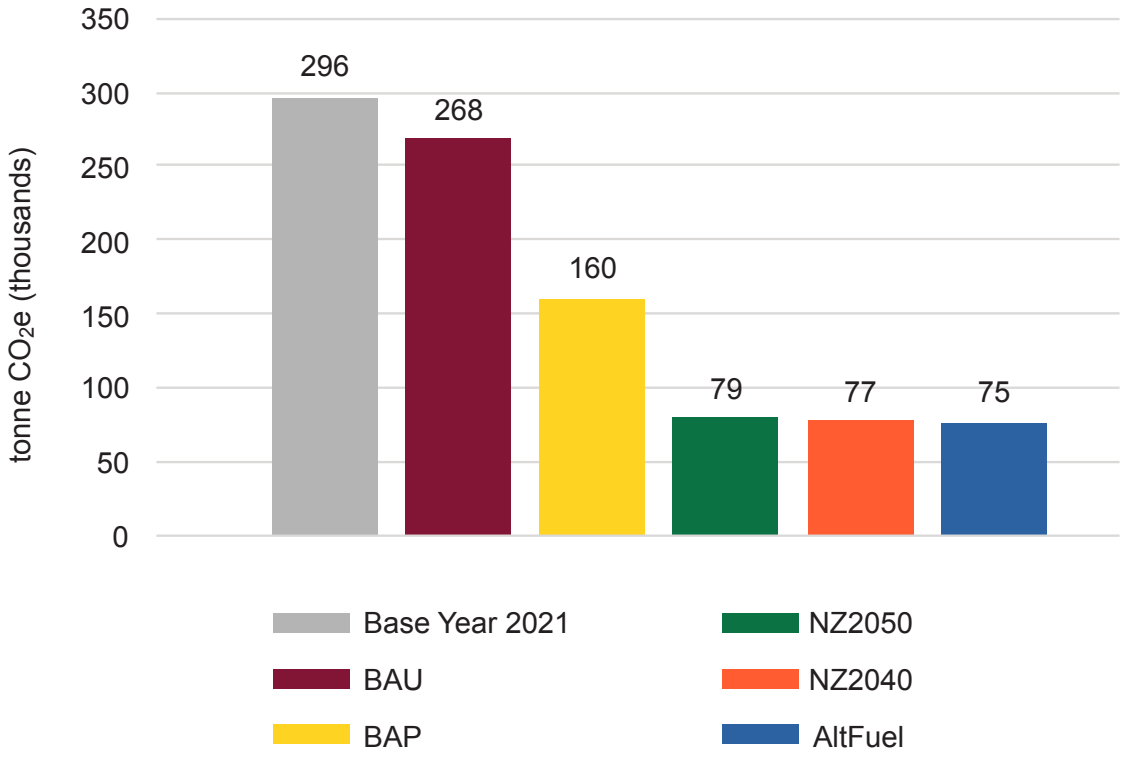


Figure 3. Transportation sector emissions for 2050 for the three modelled scenarios in addition to the BAU and BAP scenarios. Source: SSG analysis.

The mitigation actions for the transportation sector are:

- Fuel switching for private and municipal transportation;
- Improving public transit infrastructure, operations, and services;
- Enhancing fuel economy in public transit;
- Fuel switching in freight transport;
- Increasing active transportation; and
- Tackling off-road emissions.

Figures 44, 45, and 46 present the year-over-year emissions reductions due to the implementation of mitigation actions in the transport sector, relative to the BAP Scenario.[44] Table 15 shows the same information but the cumulative emissions reductions by different time horizons and scenarios. The biggest opportunities to reduce emissions in this sector come from the electrification of private transportation and freight systems. Note that light-duty vehicle electrification is included under the Business-as-Planned Scenario, as it is a national effort. Therefore, GHG emissions reductions for private vehicles might appear small in the wedge diagram. The national effort to electrify vehicles aims to achieve 100% of light-duty vehicle sales being zero-emissions by 2035 (details of GHG emissions reductions are provided in the subsection What Happens Between BAU and BAP?). However, reducing the number of trips made by car is the first step towards achieving a more sustainable city and will require enhancing the public transit system and providing infrastructure and programs to promote active transportation.

[44] Please refer to the "How to Read the Wedge Diagram" box to better understand how GHG emissions reductions are estimated.

Table 15. Cumulative emissions reductions for Sustainable Transportation actions. Source: SSG analysis.

	Cumulative emissions reductions in the NZ2050 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the NZ2040 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the Alternative Fuels Scenario ($ktCO_2e$)	
Action	**2024–2030**	**2024–2050**	**2024–2030**	**2024–2050**	**2024–2030**	**2024–2050**
Fuel switching for private vehicles	5.50	39	32	171	5.50	39
Improving public transit	6.15	11	11	34	6.15	11
Enhancing fuel economy in transit	1.25	112	3	137	1.28	115
Fuel switching in freight	29.97	776	54	893	31.39	835
Increasing active transportation	0.97	6	9	26	0.97	6
Tackling off-road emissions	0.00	255	0	377	0.00	255
Total	**44**	**1,200**	**108**	**1,638**	**45**	**1,262**

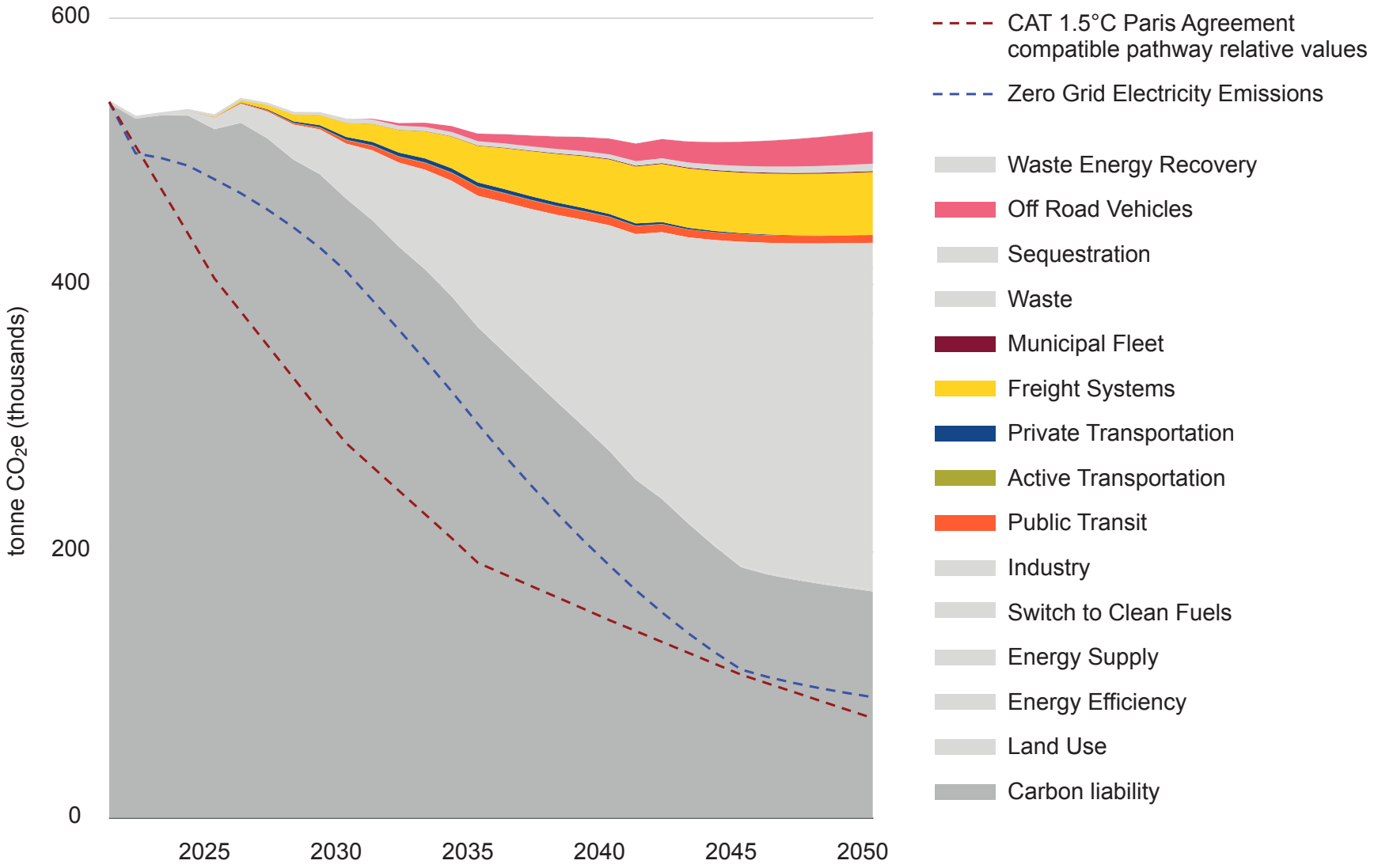


Figure 44. Emissions reductions for the Net-Zero 2050 Scenario for the Sustainable Transportation Big Move. Source: SSG analysis.

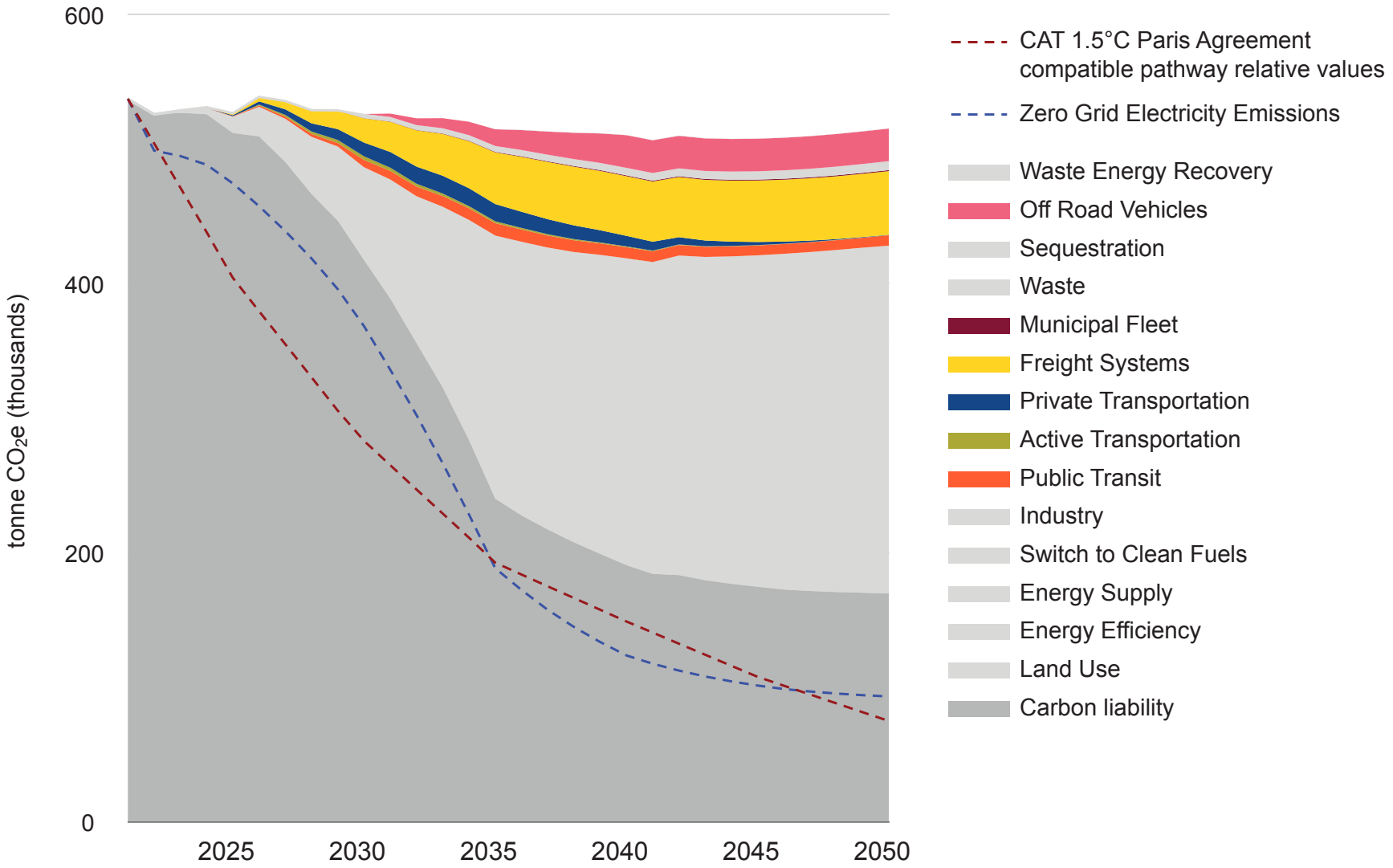


Figure 45. Emissions reductions for the Net-Zero 2040 Scenario for the Sustainable Transportation Big Move. Source: SSG analysis.

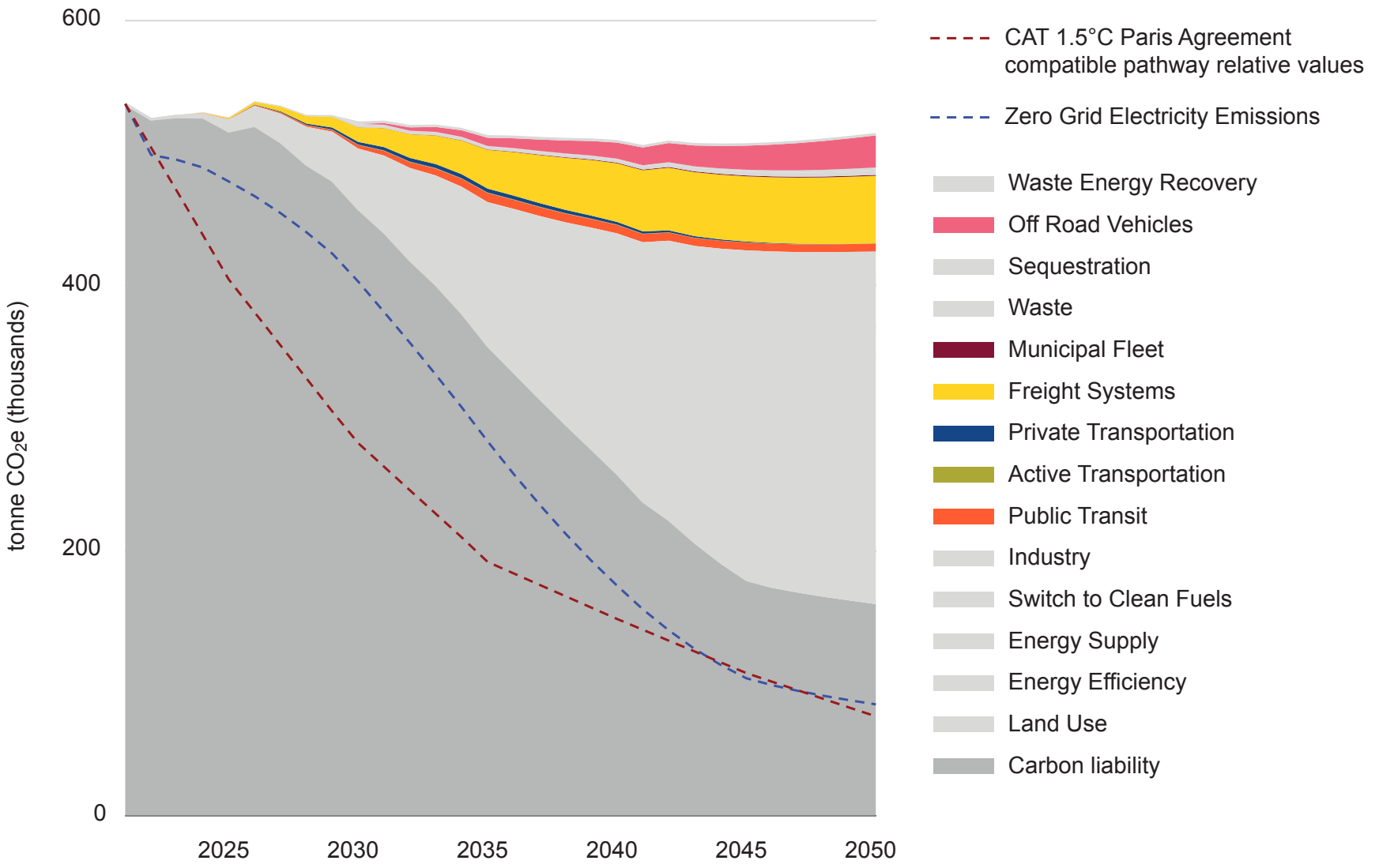


Figure 46. Emissions reductions for the Alternative Fuels Scenario for the Sustainable Transportation Big Move. Source: SSG analysis.

Key Actions

Public Transit Improvements

Improvement of Public Transit Infrastructure, Operations, and Services

Improving transit infrastructure, services, and operations encourages residents to use public transportation more frequently, resulting in significantly lower carbon emissions per capita associated with transportation as the number of trips made by car is reduced. Table 16 outlines the percentage in public transit trips by 2050 for the Net-Zero 2050, Net-Zero 2040, and Alternative Fuels scenarios.

Table 16. Public transit percentage share targets.

	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
2050	20%	30%	20%

For both short and long trips, public transit share modes will increase relative to the current baseline, having the greatest share for trips of 7 km to 10 km, which may be too long for walking and cycling. Figure 47 shows how this transition impacts the overall vehicle kilometres travelled (VKT). One key policy the City is pursuing to achieve this goal is the Transportation Master Plan, whose implementation will significantly contribute to reducing reliance on personal-use vehicles and lowering GHG emissions.

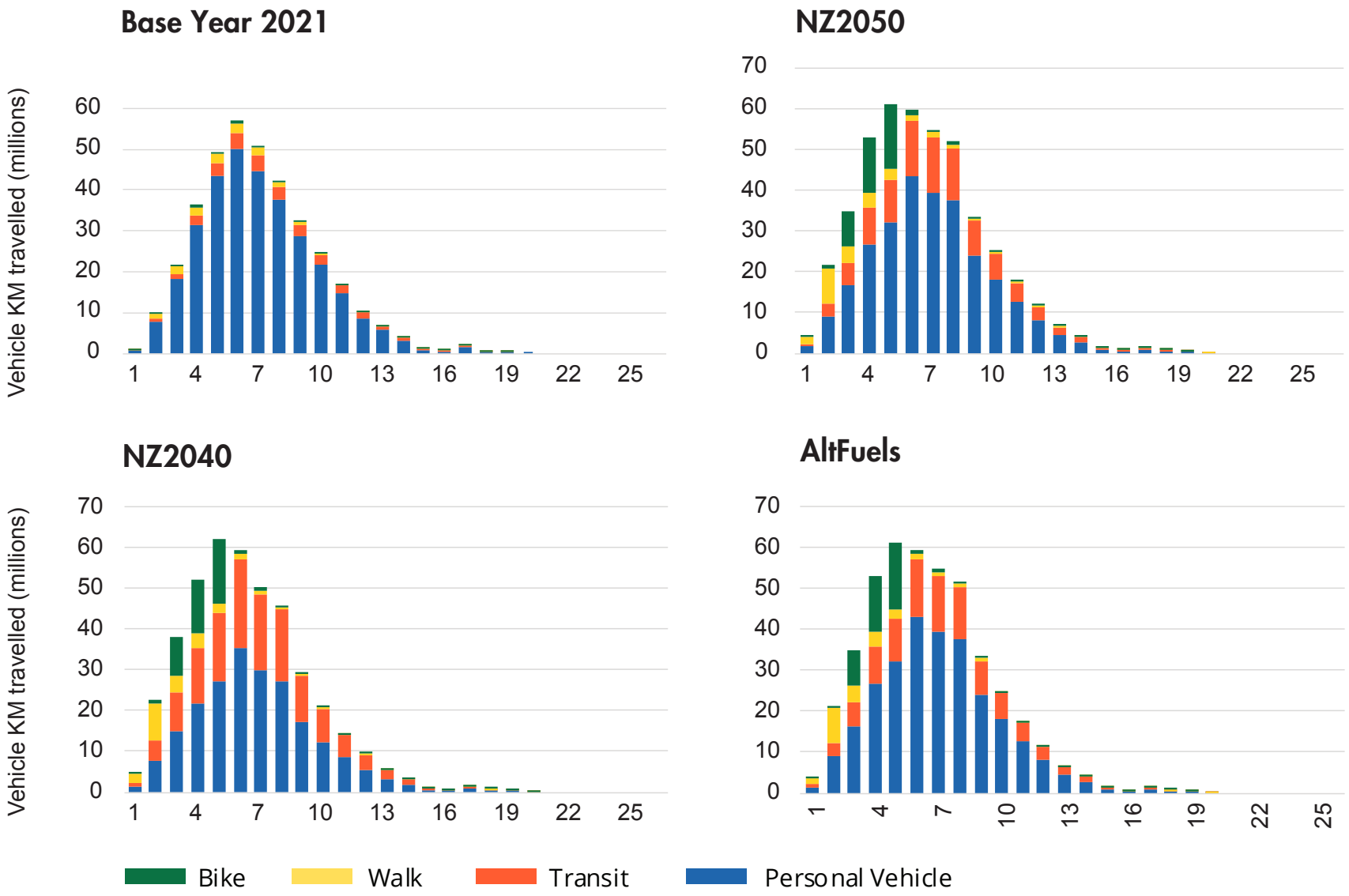


Figure 47. Vehicle kilometres travelled per mode share for all scenarios and the base year 2021. Source: SSG analysis.

Enhancing Fuel Economy in Public Transit

In addition to improving public transit infrastructure and operations, transforming the fleet itself is necessary to move Peterborough towards a low-carbon, healthy, and liveable future. Fuel-switching, either moving to electricity or hydrogen, will be required to reduce emissions in the transportation sector.

The goal is to transition away from conventional transit vehicles to zero-emission vehicles so 100% of the public transit fleet is ZEVs by 2035, which aligns with national goals for increasing private EV sales and timelines. Table 17 shows these targets for all three low-carbon scenarios.

Table 17. Percentage of zero-emission units in the transit fleet in the NZ2050, NZ2040, and AltFuels scenarios.

	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
2030	25%	50%	25%
2035	100%	100%	100%

In the NZ2050 and NZ2040 scenarios, the target is to switch to electric buses, while in the Alternative Fuels Scenario, the aim is to use a mix of zero-emission vehicles, including those using hydrogen. Table 18 displays the use percentages of the fuel types modelled in the Alternative Fuels Scenario.

Table 18. Mix of low-carbon alternatives for the transit fleet.

Electric	Hydrogen
70%	30%

In terms of emissions and their role in the urban transportation system, adopting hydrogen-fuelled buses (see Figure 48)[45] reduces emissions at a higher rate than electric bus adoption. Note that as both fuels require clean upstream technologies to maximize emissions benefits, the analysis assumes that the hydrogen used in this action is coming from electrolysis powered by renewable energy (also known as green hydrogen). Moreover, electric buses will be zero-emission vehicles if the grid they are connected to does not use natural gas and coal to generate energy. For buses charging on Ontario's electricity grid, emissions will be associated with the province's electricity generation mix, but if the City adopts a Renewable Generation Purchase Agreement for its electric bus fleet, this action could further reduce emissions.

The City has made progress in this area, and the Alternative Fuel Study for Transit Vehicles will support these efforts. The study will inform recommendations for transit fuel and infrastructure needs to support the new expansion of services and the replacement of the existing fleet.

[45] Grid electricity refers to electricity supplied through the main power grid, while local electricity refers to electricity generated from renewable sources adopted by the City. This can include electricity produced by local solar generation or through power purchase agreements for renewable energy.

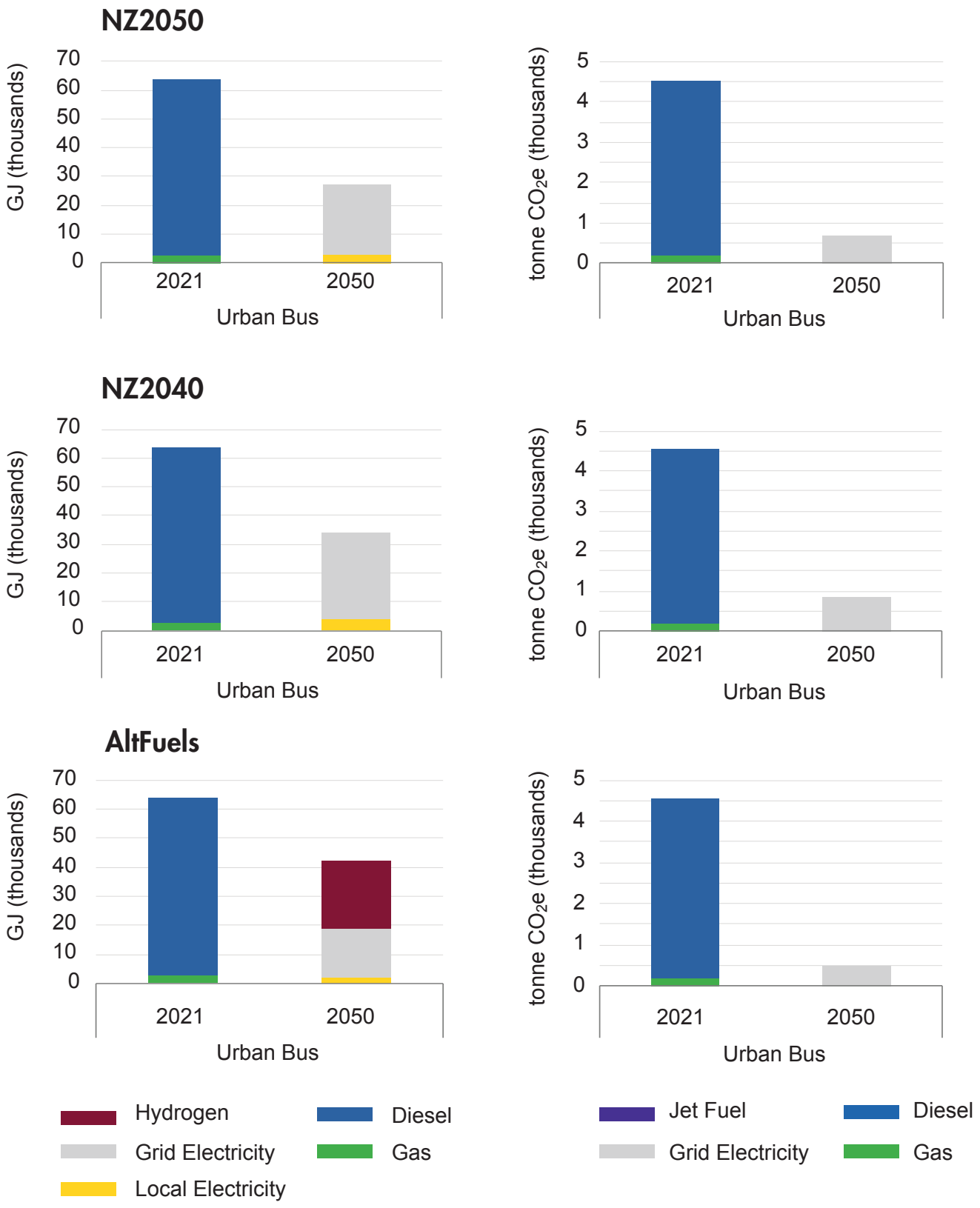


Figure 48. Transportation energy (left) and emissions (right) for each scenario and for the base year. Source: SSG analysis.

Increase Active Transportation

Improvements to and expansion of active transportation infrastructure increase the number of people that choose to walk, bike, roll, and otherwise commute in an active way. In less dense and more suburban environments, these actions can increase the incidence of short task-oriented active trips that might otherwise be performed by private vehicle (e.g., trips to local shops and schools). As such, this measure would have a larger impact and more success in well-designed and compact cities, such as those that follow the 15-minute city principles.

This measure, along with the improvement of public transit, aims to increase the share of people using alternative transportation for their everyday activities. As such, this action will increase the number of biking or walking trips, which aligns with the actions proposed in Peterborough's Transportation Master Plan. The NZ2040 Scenario has a more ambitious target than the NZ2050 and AltFuels scenarios.

Table 19 presents the active transportation targets based on the percentage of total trips made by bike and walk.

Table 19. Target of active transportation percentage of trips.

	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
Cycling	12% by 2041	20% by 2031	12% by 2041
Walking	13% by 2041	13% by 2031	13% by 2041
Total active mode	25% by 2041	33% by 2031	25% by 2041

Active transportation plays a fundamental role in short-distance travel, for which walking and cycling are the preferred modes of transport. At distances of less than 4 km, walking may significantly contribute to displacing cars. For city of Peterborough residents (Figure 49), walking also plays a role in moving around, even in the 2021 base year; thus, strategies to expand this trend are needed. Conversely, cycling represents a lower share than walking, and educational and outreach programs will be needed to secure its adoption in the long term.

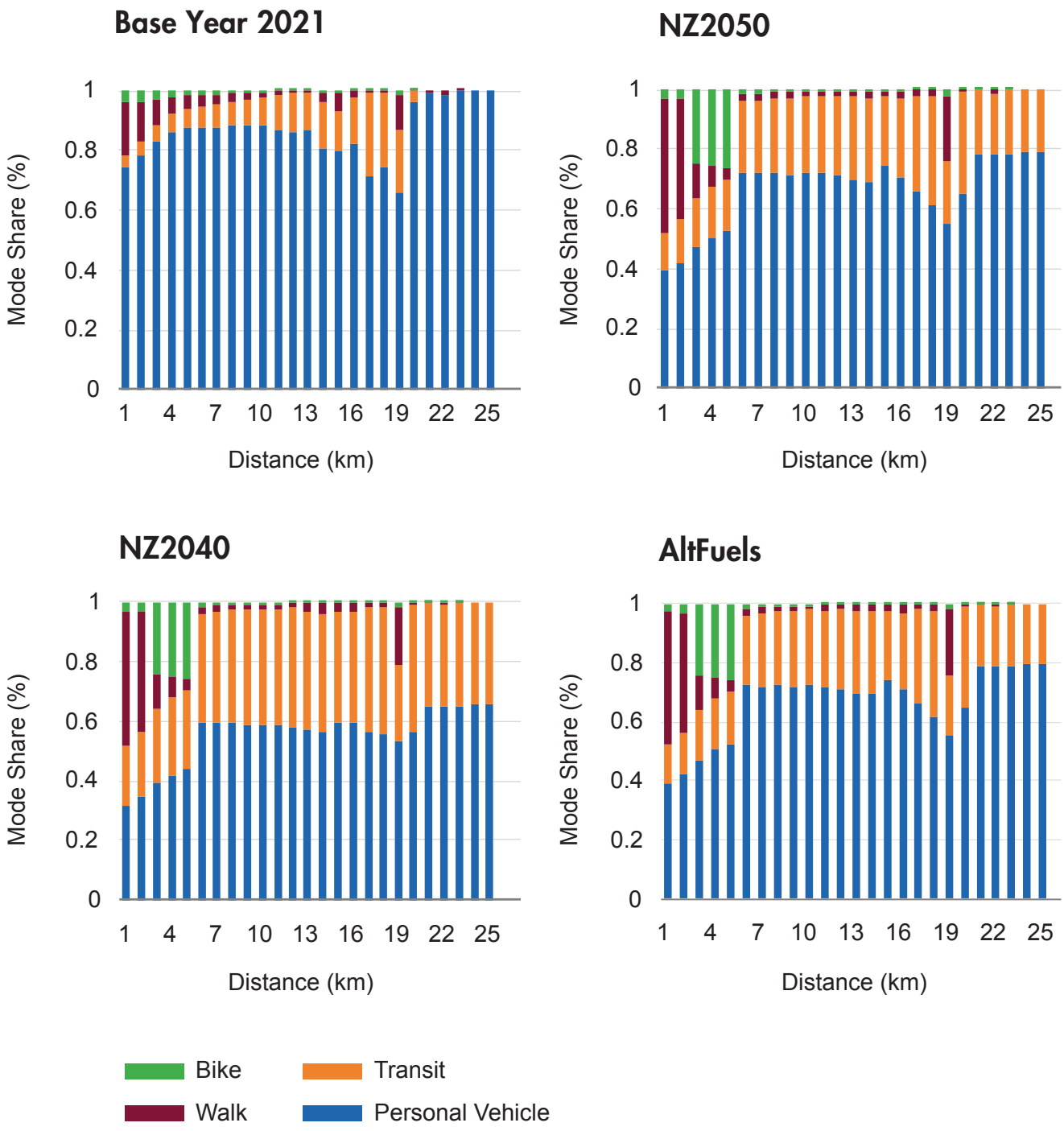


Figure 49. Mode share for the three modelled scenarios compared to the base year, 2021. Source: SSG analysis.

Fuel Switching for Private Transportation

Fossil fuel consumption by private vehicles can be reduced through several technological, infrastructural, behavioural, and management mechanisms. For example, the supply of electric vehicle charging stations supports the greater uptake of electric vehicles, especially for urban travel. Additionally, financial incentives and disincentives can influence people to choose more sustainable transportation options.

The City of Peterborough will follow the federal targets to increase electric vehicle sales, aiming for 100% EV light-duty cars and passenger truck sales by 2035. Federal targets follow national mandates to accelerate the penetration of EVs, under the Electric Vehicle Availability Standard (20% by 2026, 60% by 2030).

Table 20 shows the EV light-duty and passenger truck sales percentages for the 2026, 2030, and 2035 target years in the NZ2050, NZ2040, and AltFuels scenarios.

Table 20. Targets of EV light-duty and passenger truck sales percentages.

Target Year	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
2026	25% by 2026	50% by 2026	25% by 2026
2030	70% by 2030	100% by 2030	70% by 2030
2035	100% by 2035	100% by 2030	100% by 2035

Reducing emissions from private vehicles and light trucks provides one of the largest reductions in GHG emissions (Figure 50). Moving away from fossil fuels is key to successfully implementing climate action at the local level. Local-level emissions reductions come from using electric vehicles rather than gas- and diesel-powered vehicles for trips not taken using public transportation.

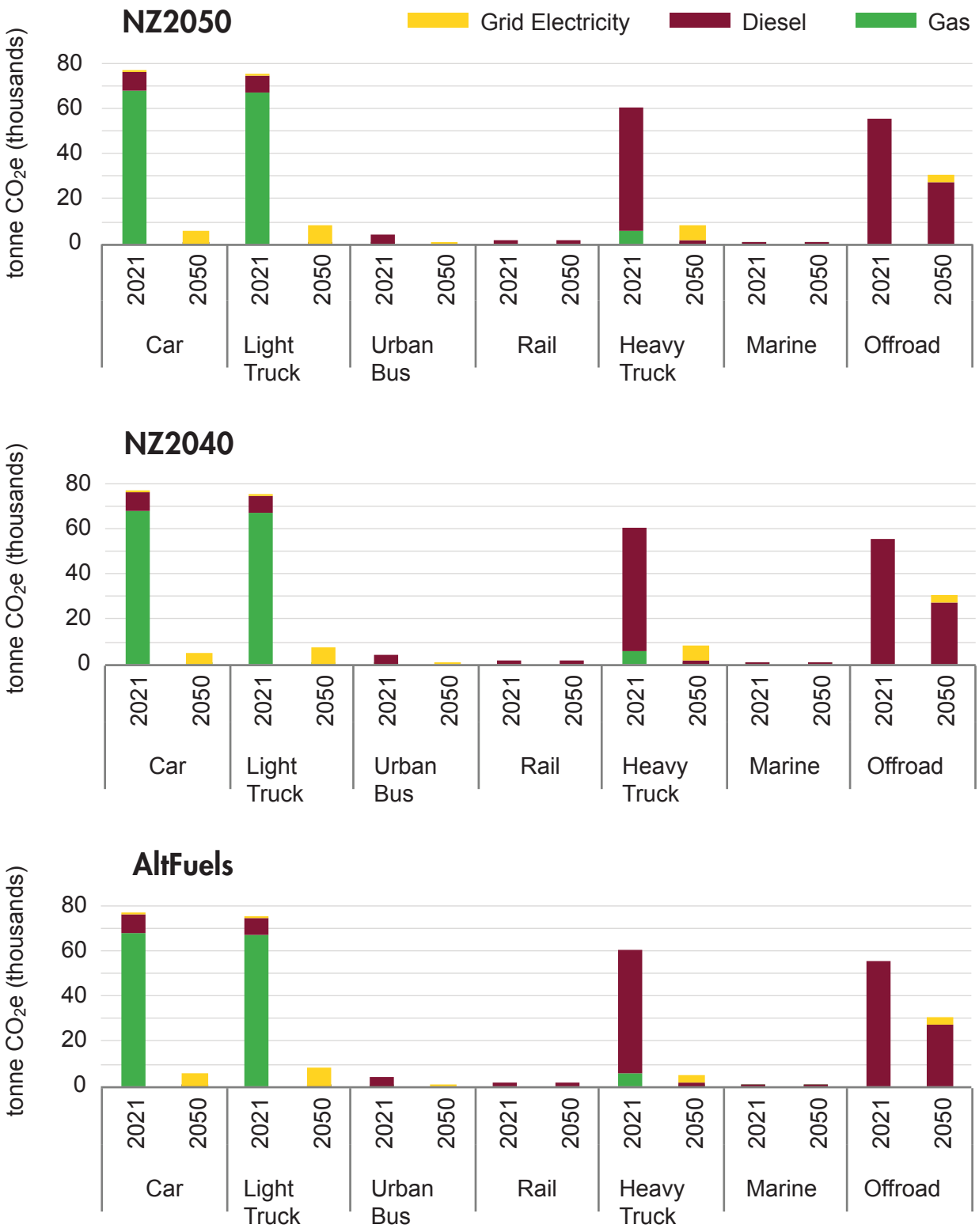


Figure 50. GHG emissions for the years 2021 and 2050 for all scenarios, by fuel type and vehicle type. Source: SSG analysis.

Fuel Switching in Freight Transport and Municipal Fleets

Fuel consumption in the freight sector contributes to the total emissions produced in the transportation sector, and similar to other vehicles (light-duty, transit, and commercial), freight system fleets can be electrified and/or switched from conventional fuels to hydrogen to reduce their emissions. Freight systems refers to all on-road heavy-duty and municipal vehicles.

This measure promotes the use of zero-emission heavy-duty vehicles and considers both electric and hydrogen fleets. Table 21 outlines the percentage of zero-emission units in heavy-duty fleets in the NZ2050, NZ2040, and AltFuels scenarios.

Table 21. Targets of percentage of zero-emission units in heavy-duty fleets.

Year	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
2030	25%	50%	25%
2035	70%	100%	70%
2045	100%	100%	100%

In the Net-Zero 2050 Scenario, the target is to switch to electric vehicles, while in the Alternative Fuels Scenario, the target is related to using a mix of zero-emission vehicles, including electric and hydrogen vehicles. Table 22 indicates the penetration rate for the electricity and hydrogen fuel types.

Table 22. Penetration rate of electricity and hydrogen in heavy-duty fuels for the AltFuels Scenario.

Electric	Hydrogen
50%	50%

Figure 51 shows the GHG emissions of all scenarios year over year. Together with private cars, freight transportation significantly contributes to the overall emissions for the transportation sector. However, private cars have a set of policies in place that contribute to emissions reduction, while the City does not have policies to reduce emissions from freight. Both Canada and Ontario have targets in place to increase electromobility use for passenger travel but have not yet set a target for freight transportation, which accounts for more than a third of the total GHG emissions produced by the transportation sector. Similarly, Peterborough has no explicit policies for tackling emissions produced by freight transportation and heavy-duty vehicles. In the long term, this single measure accounts for 766 $ktCO_2e$ (2024–2050) of the total 940 $ktCO_2e$ in the NZ2050 Scenario.

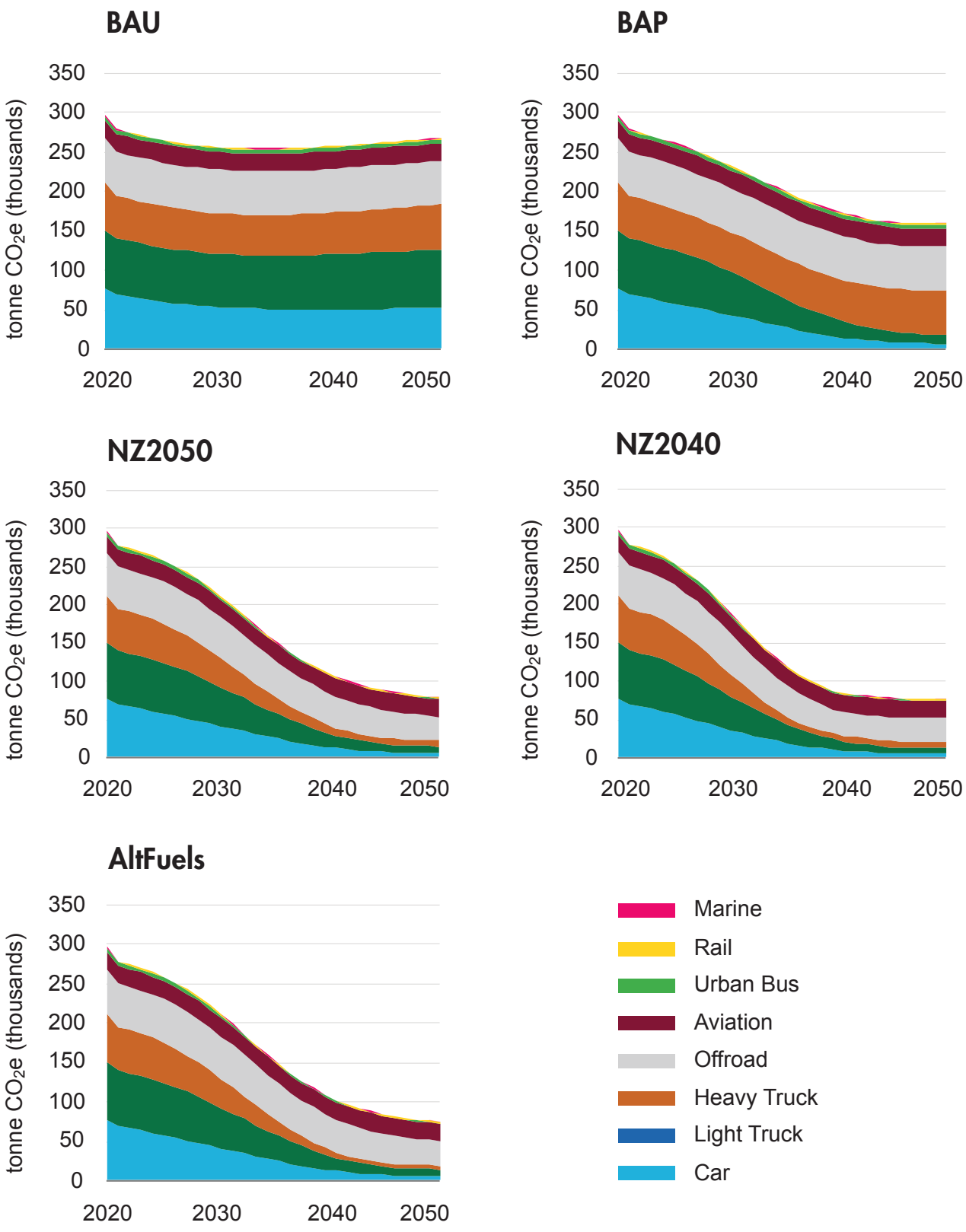


Figure 51. Transportation emissions by vehicle type. Source: SSG analysis.

Tackling Off-Road Emissions

In most cases, off-road vehicles and equipment use fossil fuel combustion as their main source of energy. Reducing emissions from this sector can be achieved through the electrification of equipment and vehicles, for instance, by replacing diesel-based snowblowers with electric ones or using wireless equipment with batteries.

A wide range of equipment, machinery, and vehicles is used for off-road activities; thus, full electrification is limited due to a lack of available technologies. However, a large portion of off-road equipment may be replaced by electric alternatives. Table 23 shows the scenario targets for this measure.

Table 23. Targets of off-road equipment replaced with low-carbon alternatives.

	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
2040	-	50%	-
2050	50%	-	50%

Electrification results in a total reduction of 255 $ktCO_2e$ for the whole implementation period for both the NZ2050 and AltFuels scenarios, which is 27% of the total transportation sector emissions. For the NZ2040 Scenario, there is a total reduction of 377 $ktCO_2e$ of the total accumulated emissions from the transportation sector (1,638 $ktCO_2e$).

Financial Analysis

The total investment in the Sustainable Transportation Big Move and its related actions is around $300–$350 million between 2024 and 2050 for the NZ2050 and Alternative Fuels scenarios (Table 24). Larger investments are required for the NZ2040 Scenario due to an increased ambition (targeting 30% transit share). However, in all three scenarios, the implementation of each described mitigation action complements the others, resulting in overall net benefits. This means that the resulting operational savings and energy and carbon reductions overcome the overall investment required, producing economic benefits in the long term. Figures 52, 53, and 54 show the year-over-year investment and returns for each scenario.

Table 24. Total investment, GHG reduction, and marginal abatement costs for the Sustainable Transportation Big Move. Source: SSG analysis.

Scenario	Total Investment ($)	Total GHG Reduction ($ktCO_2e$)	Marginal Abatement Cost ($/tCO_2e$)
NZ2050	301,000,000	944	-607
NZ2040	562,000,000	1,261	-409
Alternative Fuels	333,000,000	1,007	-302

Key insights from the Sustainable Transportation Big Move are as follows:

- The total investment in this Big Move is driven by the increased share of transit and active transportation, primarily due to the high costs of infrastructure. The electrification of private cars accounts for only 12% of the total investment needed by the City to achieve a greener transportation system.[46]
- Be aware that in all scenarios, the savings from increasing transit and active transportation modes are not fully reflected in the analysis, as there are social benefits that need to be accounted for in the future. Some of these social benefits include reduced travel times, lower accident costs, health benefits, and reductions in particulate matter pollution.
- Electrifying the transit fleet will mean investing in electric buses and electric charging infrastructure from private and public sectors. Notwithstanding this, in the NZ2050 and NZ2040 scenarios, the economic gains that result from implementing this action are almost $24 million higher than the investment needed for the period from 2024 to 2050.

[46] Be aware that the financial analysis compares the scenarios' costs to the costs of the BAP Scenario, as a point of reference. The BAP Scenario already considers Canada's sales target of 100% EVs by 2035.

- In contrast, the Alternative Fuels Scenario requires a larger investment than the NZ2050 Scenario, particularly due to the penetration of hydrogen vehicles in the transit fleets. The use of hydrogen vehicles in the fleet requires an investment in different buses and an investment in infrastructure, and operation and maintenance. These costs are high compared to those of electric vehicles, since electric vehicles are a more widely used technology and are currently more financially viable[47,48].
- Private vehicle electrification in the city of Peterborough will require a total investment of $37 million dollars between 2024 and 2050 under the penetration rates set by the NZ2050 and Alternative Fuels scenarios, primarily driven by the installation of home EV chargers. This investment increases by $5 million in the NZ2040 Scenario due to the adoption of more EVs sooner, requiring the timely installation of charging infrastructure. However, in terms of savings, the NZ2040 Scenario provides large energy savings due to a decreased use of fuels, which ultimately results in higher economic gains compared to the investment needed. In this context, the marginal abatement cost for this mitigation effort is negative in the NZ2040 Scenario (net benefits, -$387/$tCO_2e$) and positive in the NZ2050 and AltFuels scenarios (net costs, $331/$tCO_2e$).
- For both the NZ2050 and the AltFuels scenarios, the most cost-effective action is the increased use of transit (-$4,311/$tCO_2e$). The same action results in a savings of -$2,437/$tCO_2e$ in the NZ2040 Scenario. This should be the first action implemented city-wide, even before the electrification of the transit fleet and personal vehicles because it maximizes operational and investment savings. In addition, Peterborough has already planned to increase the transit share with its Transportation Master Plan, and accelerating its implementation is a key step forward.

[47] IPCC. "Asia." In Climate Change 2022: Impacts, Adaptation and Vulnerability, Vol. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Sixth Assessment Report, 2022. https://www.ipcc.ch/report/ar6/wg3/figures/chapter-10/figure-10-7

[48] IPCC. Summary for Policy-makers. In Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University, 2022. Press. https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SPM.pdf

- The second most cost-effective measure is the electrification of commercial vehicles and freight transport. Its marginal abatement cost is -$739/tCO$_2$e in the NZ2050 Scenario, driven by savings in operation and maintenance as well as fuel use. Reducing fossil fuel use in the heavy-duty sector is cost-efficient and provides the second largest GHG emissions reductions (after energy efficiency in buildings) across all scenarios. Therefore, considering both cost-effectiveness and mitigation goals, the City should, in parallel with the implementation of its current transportation policies, facilitate and promote the adoption of electric alternatives in the freight sector. Many mechanisms can be put in place to encourage businesses and industries to switch to electric vehicles, and more details available in the Implementation Section.
- Finally, electrifying municipal fleets is a cost-effective measure in all scenarios, with a marginal abatement cost of around -$710/tCO$_2$e.

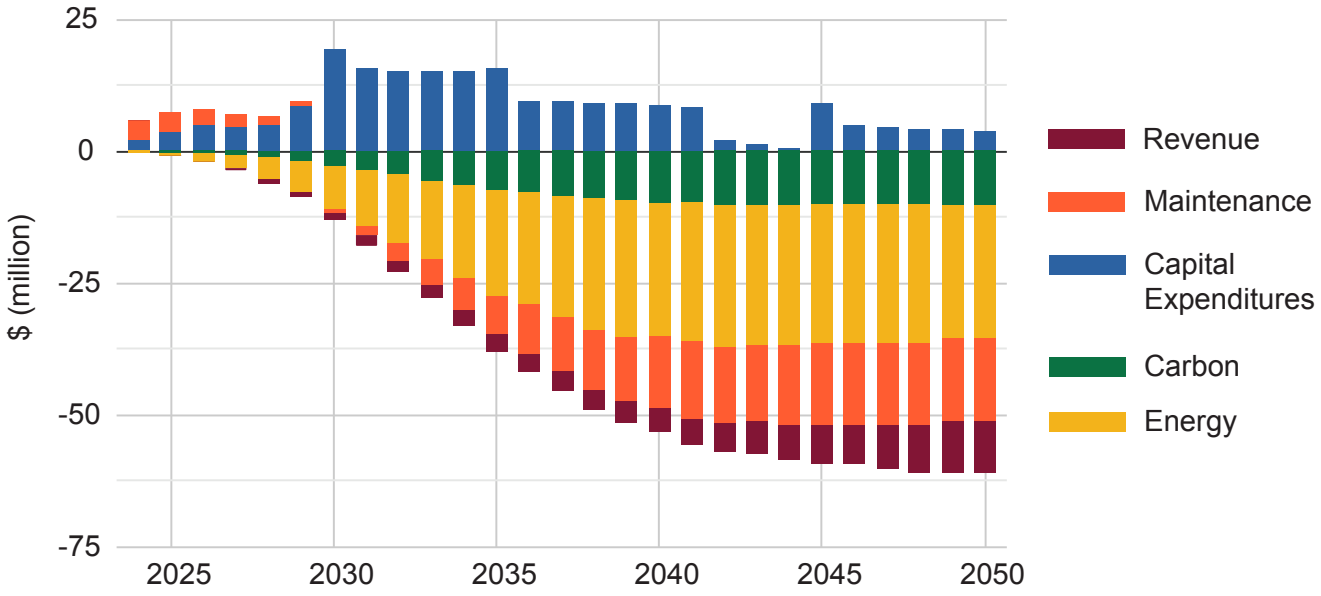


Figure 52. Year-over-year investments and returns of the Net-Zero 2050 Scenario for the Sustainable Transportation Big Move.[49] Source: SSG analysis.

[49] Revenue in this analysis is considered an inflow in the cash flow analysis, due to income from transit fares.

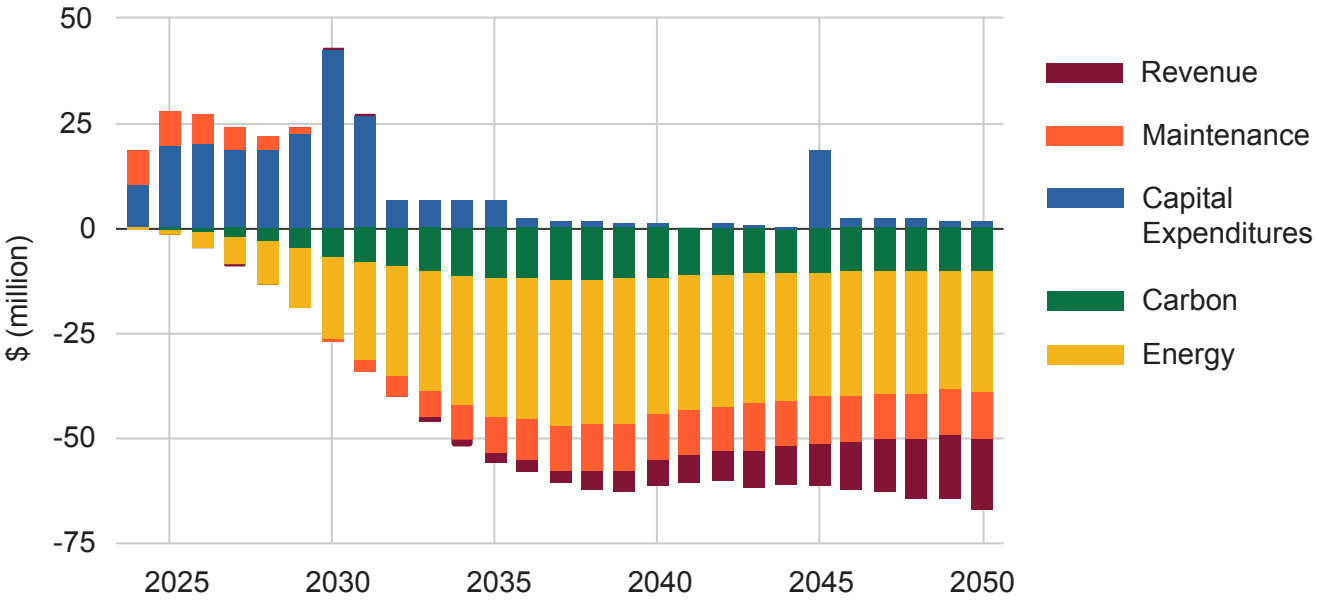


Figure 53. Year-over-year investments and returns of the Net-Zero 2040 Scenario for the Sustainable Transportation Big Move. Source: SSG analysis.

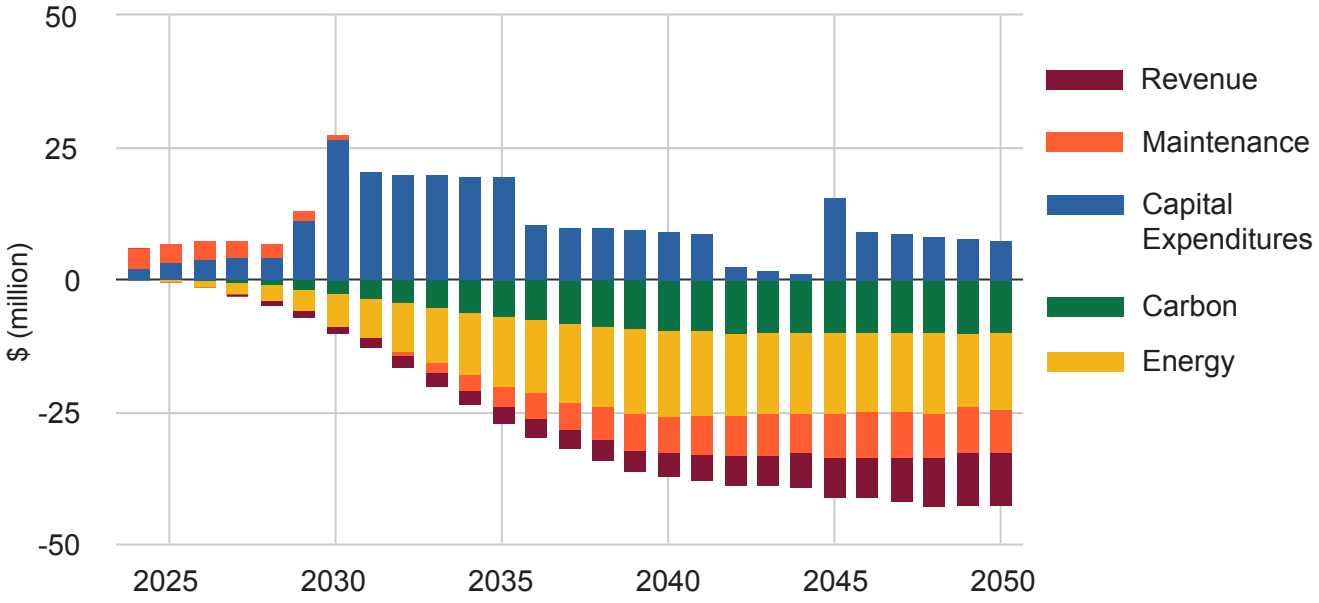


Figure 54. Year-over-year investments and returns of the Alternative Fuels Scenario for the Sustainable Transportation Big Move. Source: SSG analysis.

These insights highlight the importance of increasing active transportation and public transit to move towards a low-carbon future for the city of Peterborough. They also demonstrate the importance of providing municipal financial support to low-income communities to help households tackle the capital investment barriers associated with electrifying private vehicles.

Co-Benefits

The mix of actions for this Big Move provides a set of community co-benefits that range from healthier living environments to a more equitable city. In terms of economic development, changes in employment produce both positive and negative outcomes.

Health co-benefits: To begin with, decreasing the use of passenger vehicles and replacing this mode share with public transit and active transportation translates into a reduction of air and noise pollution. High traffic zones are prone to high levels of particulate matter (PM10 and PM2.5). According to the World Health Organization, air pollution is strongly linked to heart diseases, as well as lung and pulmonary diseases and cancer. The most significant pollutant contributing to these health issues is particulate matter from fuel combustion. In the case of noise pollution, it is linked to stress-related illnesses, hearing loss, sleep disruption, etc.

Adopting active transportation modes is linked to improved human well-being since it increases active movement and may contribute to increased social capital. Spending more time outdoors walking and cycling results in increased social interaction.

Economic co-benefits: Adopting new modes of transportation by switching to electric vehicles or walking and cycling, combined with a city designed to provide services at walkable and cyclable distances, also impacts household economies. The fixed costs of vehicle maintenance are significant regardless of the use level, and having more alternatives for transportation presents opportunities for savings at a household level. Some households may benefit by reducing transportation costs by walking and cycling and reducing fuel costs by choosing public transit. Depending on the distance to work, education, and other destinations, electric vehicles can also provide operational savings due to a reduction in fuel consumption and maintenance costs.

To some extent, increasing the bus fleet also positively impacts employment opportunities and new technologies, such as electric vehicles, and charging stations present opportunities for locals to acquire new professional skills associated with battery maintenance and charging port infrastructure construction, operation, and maintenance. The transition will also result in job losses due to a reduced demand for conventional vehicle maintenance. However, overall, this Big Move results in more than 1,600 new jobs between 2024 and 2050 in the NZ2050 Scenario and an additional 300 new jobs in the AltFuels Scenario (1,900 total). In the NZ2040 Scenario, more than 1,500 new jobs are created.

Social equity co-benefits: Increasing transit availability and implementing the concept of compact cities impacts household economies, especially those households facing poverty and transportation cost burdens.

A key element for a just transition in terms of employment is developing or promoting electromobility training sessions for new workers, maintenance and operation of vehicles, and stations targeting low-income households facing unemployment.

This measure complements the action of increasing the public transit mode share, and although buses are not the main sources of GHG emissions for this sector, electrification does contribute to achieving further reductions and producing co-benefits, including reducing local air pollution related to fossil fuel combustion in gas- and diesel-powered vehicles, resulting in a city with cleaner air. Other co-benefits include the reduction of noise pollution and an improved user experience for residents. The latter refers to the advanced technological features of the new electrical buses, which include air conditioning, the ability to charge smartphones, increased security for users when stepping onto and off the bus, and mobility mechanisms to enhance accessibility.

Implementing Change

According to the modelling and financial results, increasing transit share and fuel switching in freight transportation are the two most cost-effective actions the city can undertake. Peterborough is already on track to increase transit and active transportation mode share through the adoption of the Transportation Master Plan and the Cycling Master Plan. Both plans propose ambitious targets to encourage residents to take fewer trips in personal-use vehicles. To achieve targets in the CCAP 2.0, the City should continue to implement these policies as planned. Considering

that Peterborough has not yet addressed emissions from freight and commercial vehicles or off-road machinery and vehicles, actions targeting these vehicle types present the greatest opportunities for emissions reductions in the transportation sector overall. As such, the municipality should put significant effort into promoting fuel switching (i.e., fleet electrification) in these vehicle types.

1. Task force with freight and commercial transportation sector

Role of municipality: Collaborator

Type of implementation action: Education and outreach, regulation

The municipality can support the transition to sustainable transportation in the following way:

- Creating a task force with relevant stakeholders to discuss the barriers and opportunities of electrification in the freight transportation sector and to support collaboration among participants. Due to the nature of the freight sector and the involvement of stakeholders beyond the city boundaries, collaboration with other municipalities is encouraged. The task force should discuss at least the following policy recommendations:
    - Develop a decarbonization strategy for freight and commercial vehicles.

      Aiming to tackle emissions from freight and commercial vehicles, the Task Force should create a decarbonization strategy based on the barriers and opportunities discussed with stakeholders. A decarbonization strategy can identify low-emission zones where freight and commercial traffic is restricted based on fuel type, vehicle size, or time of day, and it can align with current land-use policies.

      Another key recommendation as part of the strategy is to consider creating a last-mile delivery program, which would:

        - Provide incentives and rebates for delivery companies to purchase e-cargo bikes for deliveries in downtown and growth areas. A total annual budget cap should be set for this goal.

    - Support an EV car-sharing program for businesses to share EV delivery vehicles and/or shared charging infrastructure.

— Host events with stakeholders to facilitate networking, provide peer-to-peer learning, present available technologies, and boost local adoption of low-carbon alternatives.

Timeline:

Establishing the taskforce to start in 2027.

Hosting events to start in 2027.

Actors involved: City of Peterborough, academy and education, Green Economy Peterborough, Peterborough Chamber of Commerce, and other industries.

Indicators:

- Number of electric or low-carbon vehicles operating as last-mile delivery vehicles.
- Reduction in average vehicle emissions within the low-emission zones (%).

Costs:

Incentives for cargo e-bikes in the form of rebates up to $1,000, only for businesses.

Freight Mitigation Strategy consultant work: $100,000.

Enablers: Not identified.

2. Engaging with contractors to reduce off-road emissions

Role of municipality: Collaborator and innovator

Type of implementation action: Procurement policy

The City has the opportunity to lead by example and reduce off-road GHG emissions in city projects. To achieve this, the municipality needs to work closely with project developers and contractors to develop vehicle efficiency and anti-idling requirements for heavy-duty vehicles and machinery on government construction and job sites. Using Portland's Clean Air Construction Program as an example, Peterborough can:

- Set a "Five-Minute Idling Limit" restriction, encouraging contractors to shut down non-road equipment during periods of inactivity and placing signs in high-traffic areas.
- Require contractors on city projects to meet certain vehicle efficiency standards or retrofit machinery to meet requirements and install emission control devices. See Portland's tiered approach to requiring this in contracting.

Timeline:

Starting collaboration with contractors in 2025 and pilot policies in 2026.

Actors involved: City of Peterborough and project developers and builders.

Indicators:

- Percentage of city projects following the "Five-Minute Idling Limit" restriction.
- Percentage of off-road vehicles/machinery with emission control devices.

Costs: Engagement cost: $20,000.

Enablers: The City has the power and right to set procurement and contracting policies aligned with adopted climate commitments and policies. For contractors, the Green Freight Program, the Zero-Emission Trucking Program, and the Zero Emission Vehicle Infrastructure Program led by the federal government are available.

3. Develop an Electromobility Strategy

Role of municipality: Implementer

Type of implementation action: Policy

To support current policies and the implementation of CCAP 2.0, the City of Peterborough should develop an Electromobility Strategy that includes:

- Goals and Alignment: Establish an overall goal and align it with regional electromobility trends, ensuring consistency with CCAP 2.0 objectives.
- Stakeholder Engagement: involve a wide range of groups, including low-income and disadvantaged communities, businesses, community organisations, and educational institutions. Establishing a working group and a dedicated table for collaboration will help create a space for stakeholders to contribute ideas and shape the direction of the strategy.
- Infrastructure Assessment: A detailed assessment should be conducted to evaluate the supply and demand for EV and e-bike charging ports, complemented by an analysis of the feasibility of hydrogen fuelling stations for other zero-emission vehicle (ZEV) types. Charging habits—such as whether residents charge their vehicles at home, work, or while shopping—should also be analysed to better understand usage patterns and plan for future growth.
- Plan for infrastructure expansion: exploring opportunities to convert the existing streetlight network into Level 1 and Level 2 charging stations, especially in underserved areas or "charging deserts." Public places such as parks, libraries, recreation centres, and other community facilities should be prioritised for the installation of Level 2, Level 3, and e-bike charging stations, ensuring equitable access across the city.
- Provide policies and incentives, such as requiring EV-ready chargers in all new residential construction and ensure that at least 25% of parking spaces in new commercial developments are equipped for EVs, which can also be incorporated into the City's Green Development Standards to promote long-term sustainability.

— Incentives will further boost adoption:

- Offer property tax incentives for EV-charging installations.
- Provide subsidies for EV purchases for low-income households.
- Coordinate EV bulk-buying programs.
- Incentivize retirement of internal combustion engine (ICE) vehicles.

Timeline:

Starting consulting work by 2025.

Actors involved: City of Peterborough, community members, Chamber of Commerce, PKED, DBIA, Individual businesses, developers and contractors, Hydro One, and GreenUP.

Indicators:

- Year of implementation of the strategy
- Number of charging ports type within City boundaries
- Percentage of electric vehicles sold each year out of the total
- Number of charging ports in underserved areas

Costs: Consultant work: $100,000.

Enablers: Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations (SOR/2010-201) and new mandates to reach 60% sales by 2026, and through the Zero-Emission Vehicles (iZEV) Program for EV adopters (benefits to the point-of-sale).

Industry Big Move

SDGs that are being addressed by this Big Move.

3	Good Health and Well-Being
8	Decent Work and Economic Growth
9	Industry, Innovation, and Infrastructure
11	Sustainable Cities and Communities
12	Responsible Consumption and Production
13	Climate Action

Overview

The industrial sector consumes a significant amount of energy to produce the goods and raw materials we use every day. It is challenging to create specific measures to improve energy efficiency due to the sheer range of production mechanisms and technologies. The industrial sector contributed 33 $ktCO_2e$ in 2021 (Figure 55), which is 6% of the total city emissions and is mostly related to the use of natural gas and grid electricity for industrial processes.[50]

[50] Note that emissions from industrial buildings are included in the Green Buildings Big Move.

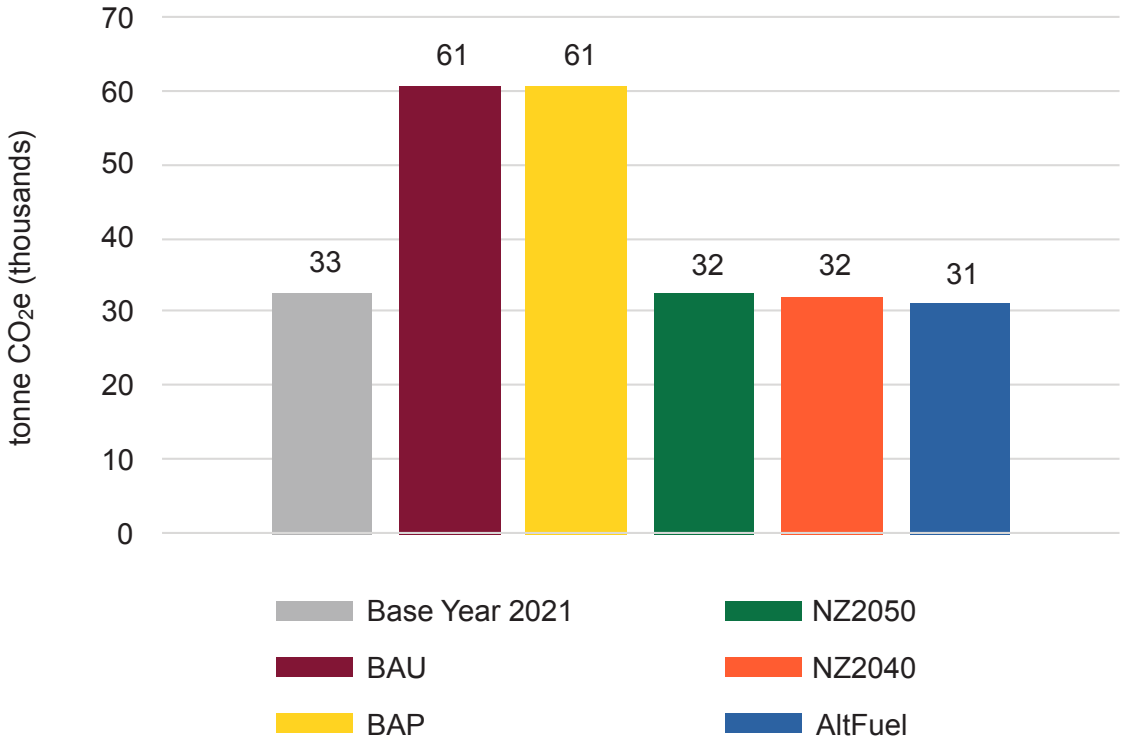


Figure 4. Industrial sector emissions for 2050 for the three modelled scenarios in addition to the BAU and BAP scenarios. Source: SSG analysis.

In this context, the measure considered is to increase industrial efficiency by 50% by implementing various energy efficiency mechanisms. Figures 56, 57, and 58 show the total emissions reductions year over year for all low-carbon scenarios , and Table 25 provides a summary.

Table 25. Cumulative emissions reductions for Industry actions. Source: SSG analysis.

Action	Cumulative emissions reductions in the NZ2050 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the NZ2040 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the Alternative Fuels Scenario ($ktCO_2e$)	
	2024–2030	2024–2050	2024–2030	2024–2050	2024–2030	2024–2050
Increase in industrial efficiency	17.96	263	25	344	17.96	263
Total	**18**	**263**	**25**	**344**	**18**	**263**

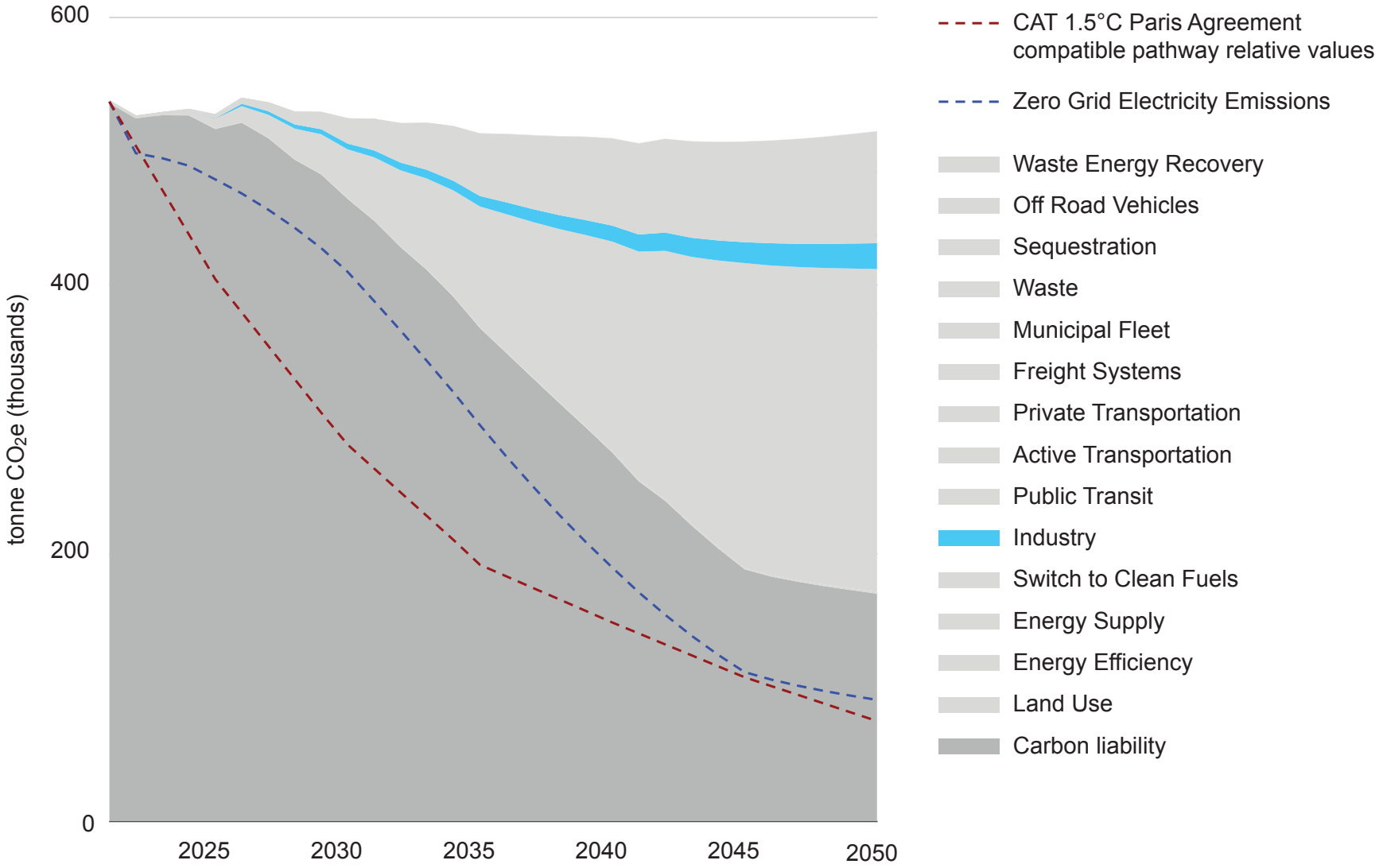


Figure 56. Emissions reductions for the Net-Zero 2050 Scenario for the Industry Big Move. Source: SSG analysis.

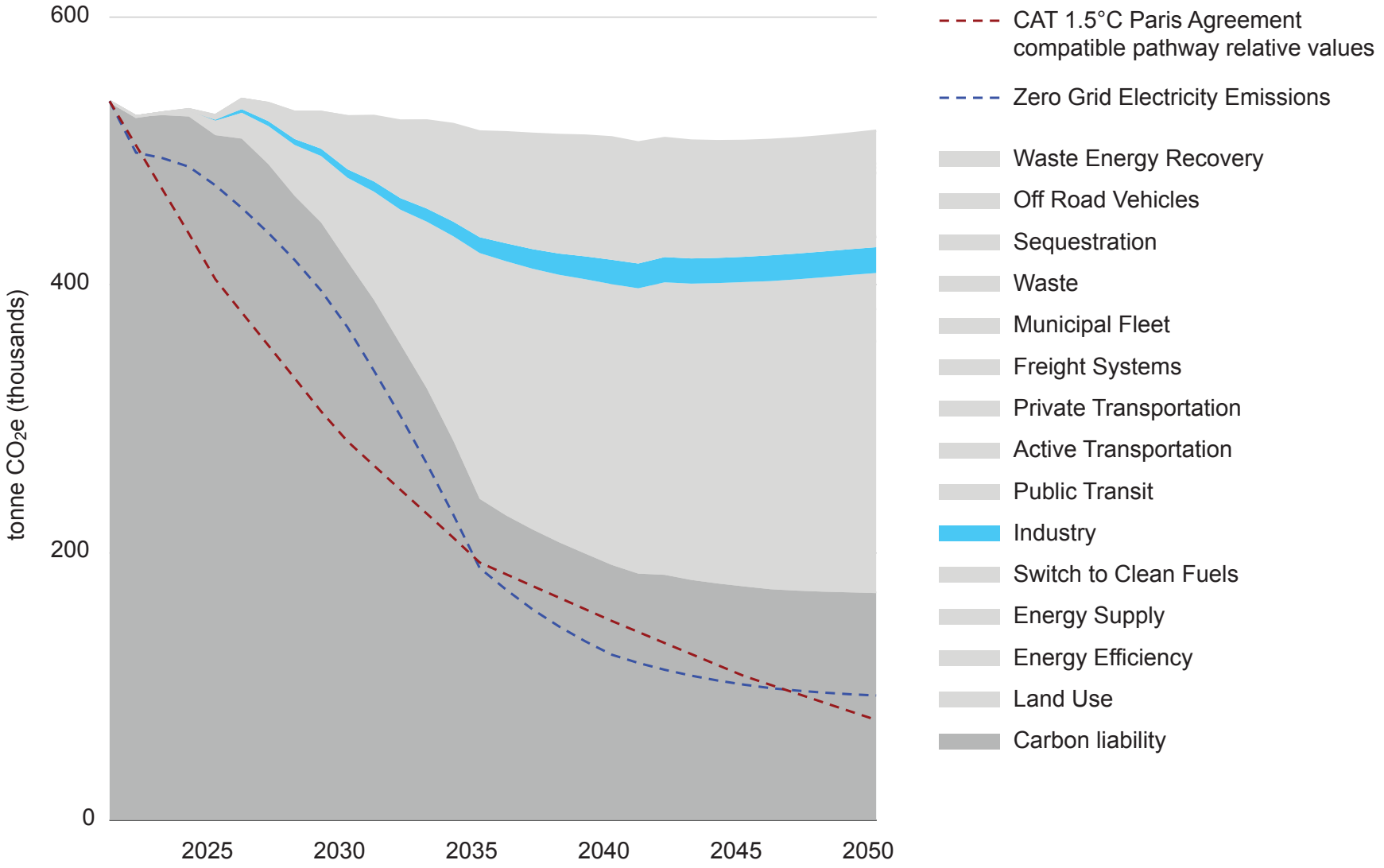


Figure 57. Emissions reductions for the Net-Zero 2040 Scenario for the Industry Big Move. Source: SSG analysis.

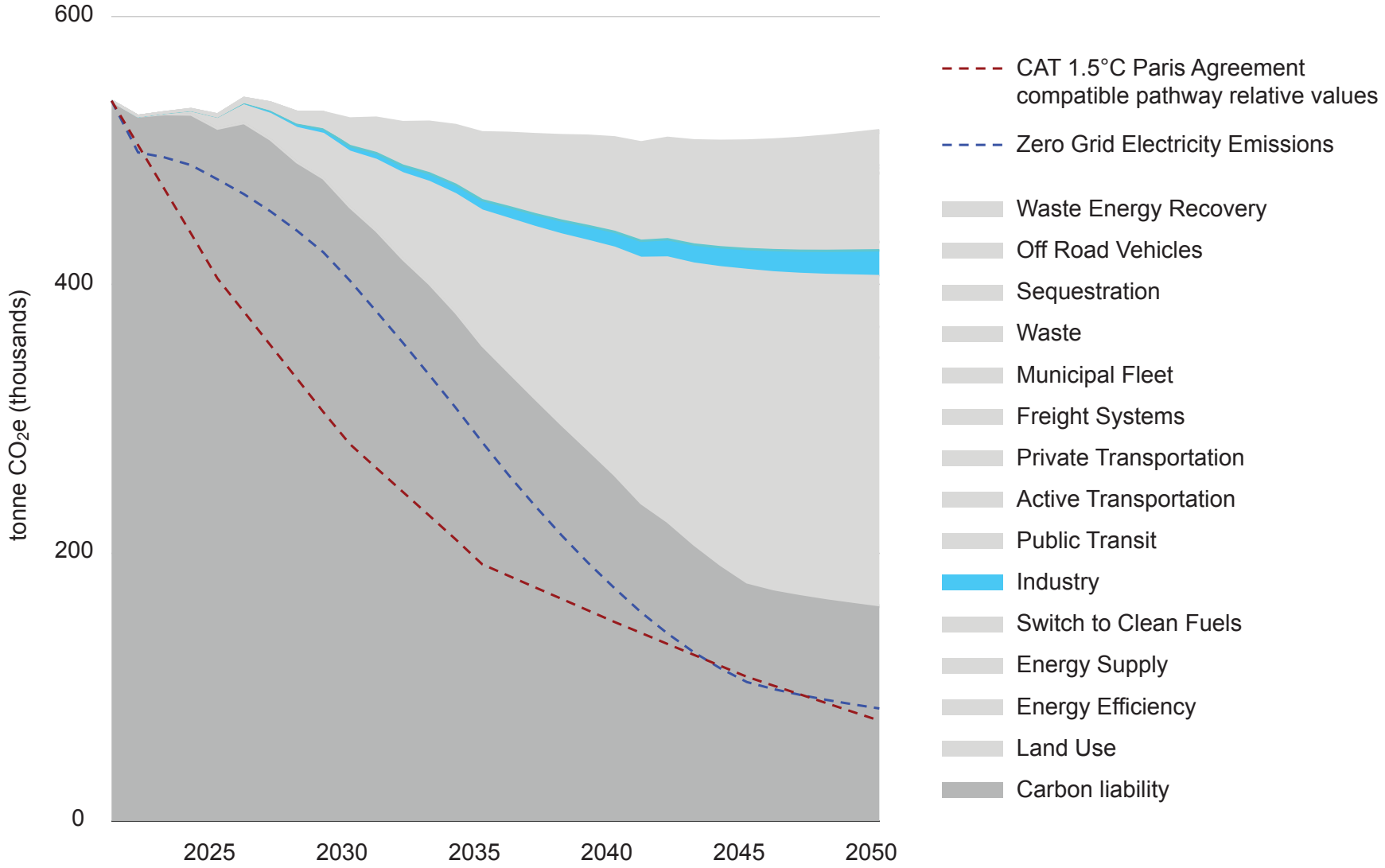


Figure 58. Emissions reductions for the Alternative Fuels Scenario for the Industry Big Move. Source: SSG analysis.

Key Actions

Increase in Industrial Efficiency

Increasing industrial efficiency by 50% requires implementing various energy efficiency mechanisms, including improvements in lighting, space heating and cooling, water heating, and process heating. Table 26 indicates the target percentage and year of the NZ2050, NZ2040, and AltFuels scenarios.

Table 26. Industrial efficiency targets.

Net-Zero 2050	Net-Zero 2040	Alternative Fuels
50% by 2050	50% by 2040	50% by 2050

In terms of energy needs, overall, the industrial sector requires less energy for its processes than the energy required by the residential and commercial sectors (Figure 59); however, a big portion of its requirement is provided by the grid.

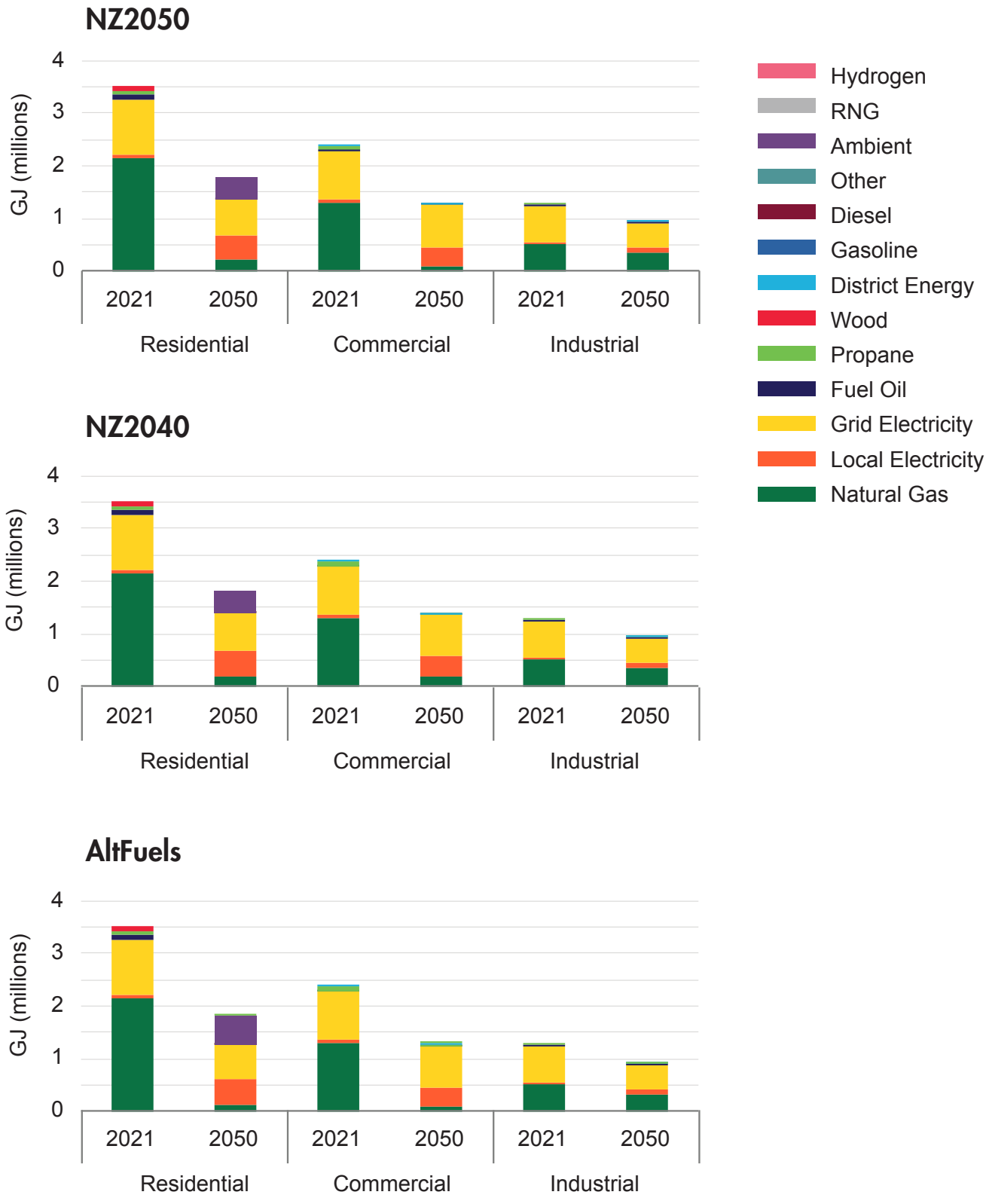


Figure 59. Total energy use by sector by fuel type for all three scenarios.
Source: SSG analysis.

Financial Analysis

The total investment needed to reduce GHG emissions in the private industrial sector by implementing energy efficiency measures and switching to green fuels or energy is about $20 million between 2024 and 2050 (Table 27). Economic gains from these actions are tenfold the capital investment. This means that mitigation efforts result in overall net benefits for the industrial sector (Figures 60, 61, and 62), including savings due to decreased fuel consumption (-$82 million) and reduced carbon expenditures due to reduced GHG emissions (-$25 million) in the NZ2050 and AltFuels scenarios, and 30% additional savings in the NZ2040 scenario.

Table 27. Total investment, GHG reduction, and marginal abatement costs for the Industry Big Move. Source: SSG analysis.

Scenario	Total Investment ($)	Total GHG Reduction ($ktCO_2e$)	Marginal Abatement Cost ($/tCO_2e$)
NZ2050	19,000,000	263	-345
NZ2040	20,500,000	344	-368
Alternative Fuels	18,500,000	263	-347

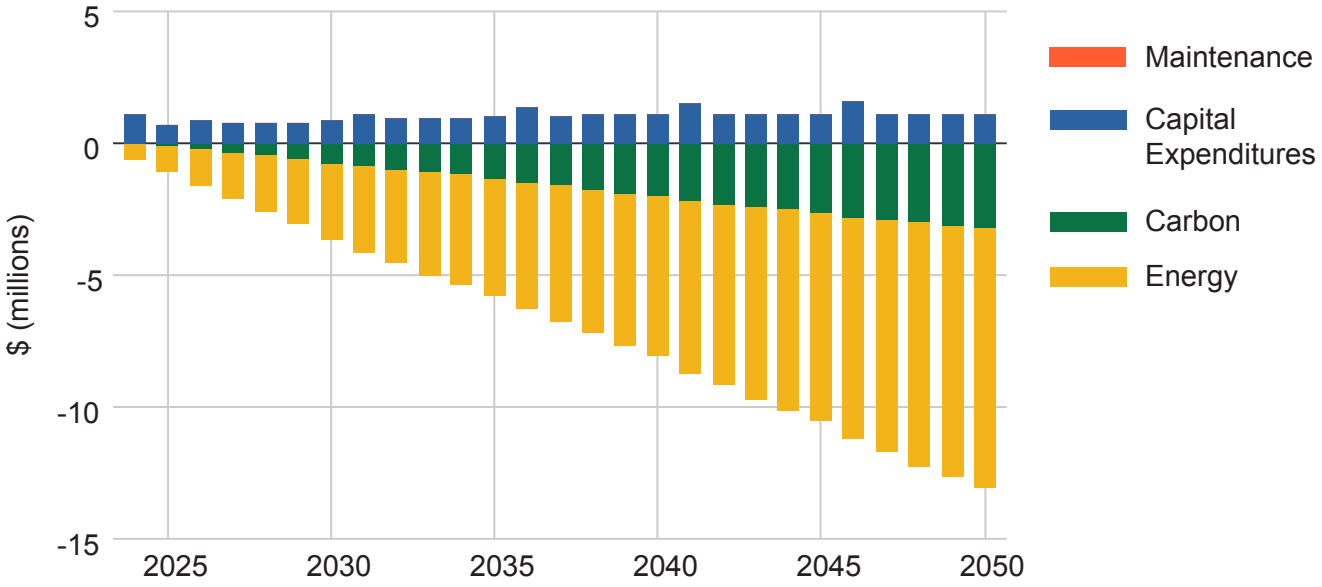


Figure 60. Year-over-year investments and returns of the Net-Zero 2050 Scenario for the Industry Big Move. Source: SSG analysis.

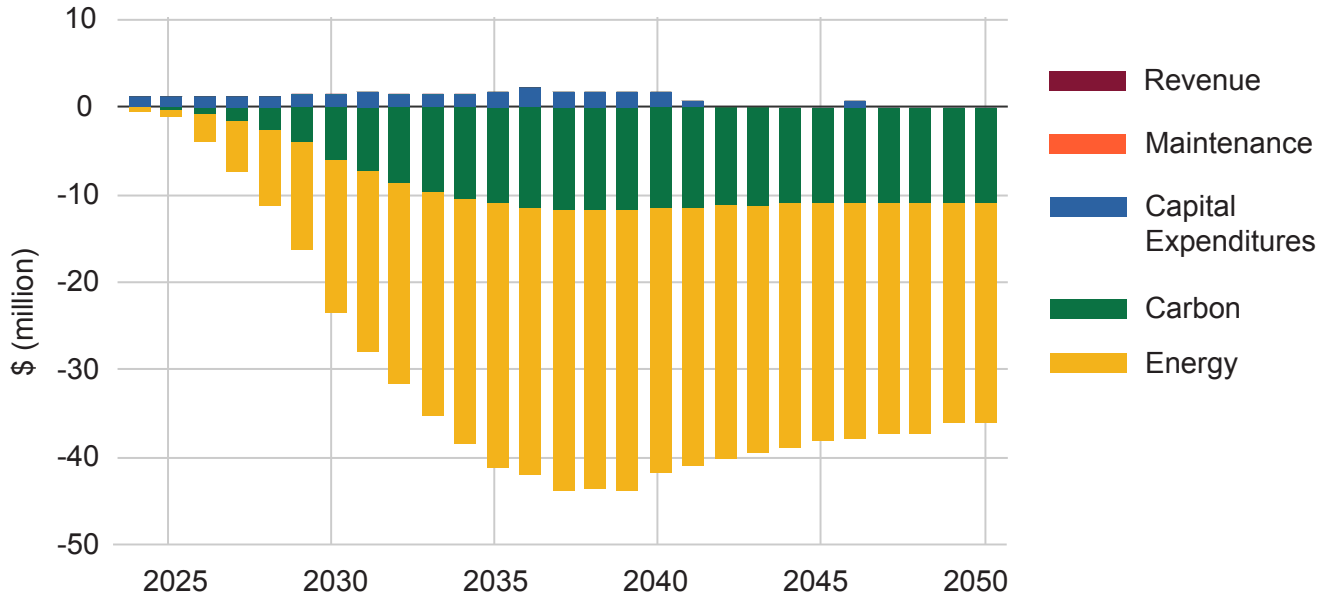


Figure 61. Year-over-year investments and returns of the Net-Zero 2040 Scenario for the Industry Big Move. Source: SSG analysis.

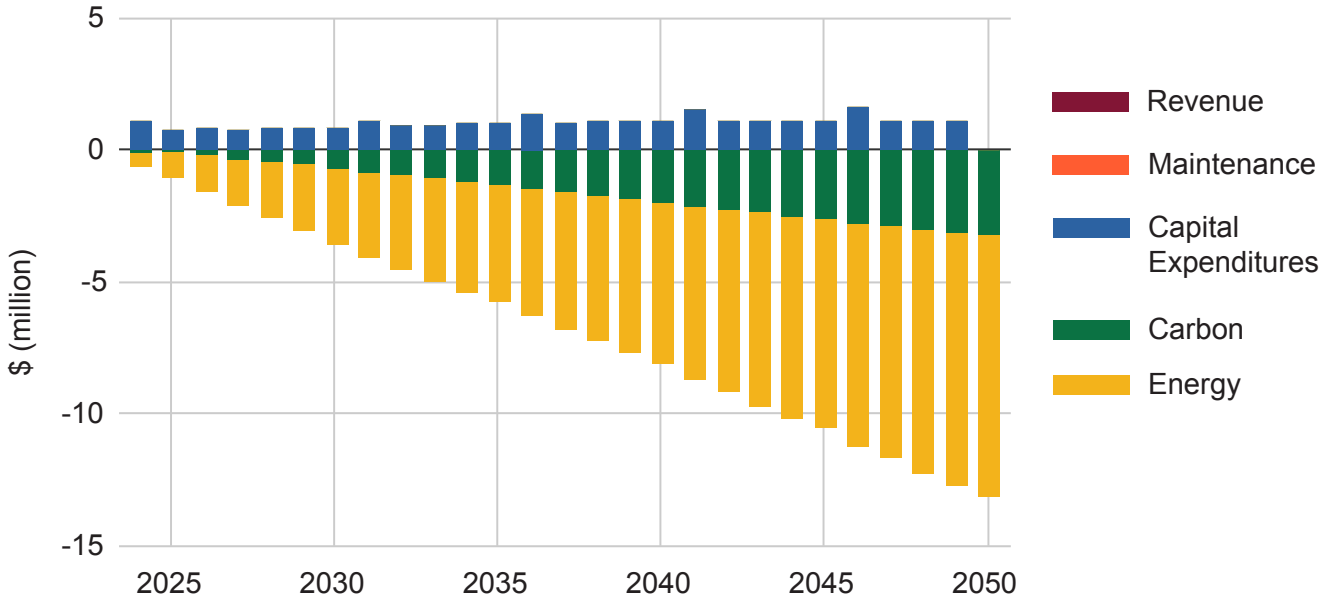


Figure 62. Year-over-year investments and returns of the Alternative Fuels Scenario for the Industry Big Move. Source: SSG analysis.

Co-Benefits

Broadly speaking, energy efficiency in all cases represents savings in energy costs, and it also reduces demand from the grid, which contributes to a more resilient energy system. In addition, employing measures to reduce energy use and GHG emissions has positive impacts on the reputation of the industrial sector.

Implementing Change

The given the roles and responsibilities of local governments do not provide them much power to regulate the private sector, which means one of the main actions to promote changes in the industrial sector is collaboration.

1. Create a working group with the industrial sector to work on energy efficiency measures

Role of municipality: Collaborator

Type of implementation action: Education and outreach

Local governments play a crucial role in getting everybody, including the private sectors, on board with climate action. The City of Peterborough should collaborate closely with the commercial and industrial sectors to promote and support transformation and climate action. The following key actions outline the steps the municipality needs to take to advance climate action in the industrial sector:

- Develop partnerships: Connect with industries, including freight transportation and heavy-duty vehicle operators, to share information and communicate the goals of the Climate Change Action Plan 2.0.
- Establish an ongoing working group with representatives of the private sector to integrate their perspectives of climate action and understand their needs.
- Develop an "industry energy efficiency challenge" for working group members, in which participants set one- and five-year targets for energy reduction. Support working group members in achieving targets through technical expertise, collective knowledge sharing, and incentives, where possible. Encourage participating industry members to create their own corporate climate action plan.
- Advocate for energy-efficient practices for industrial processes, and provide support through organizing and hosting events with local and external suppliers and Green Economy Peterborough.
- Host networking events, at least once per year for the first three years, to build relationships between industrial and educational services (e.g., Trent University and hubs) to foster research, development, and innovation.

Timeline:

Establish an ongoing working group to start by 2025.

Implement an "industry energy efficiency challenge" by 2026.

Actors involved: City of Peterborough, academy and education, Green Economy Peterborough, Peterborough Chamber of Commerce, and industries.

Indicators:

- Year working group established
- Number of industries participating in the industry energy efficiency challenge
- Number of networking events hosted by the municipality in collaboration with the working group
- Number of industries with climate action plans
- Number of industries implementing energy efficiency measures
- Percentage of energy use reduction per year per industry participating in the working group

Costs: No costs are foreseen to implement this action.

Enablers: Energy Efficiency Act and energy efficiency regulations and providing information about funding opportunities to industrial actors.

Waste
Big Move

SDGs that are being addressed by this Big Move.

3	Good Health and Well-Being
6	Clean Water and Sanitation
7	Affordable and Clean Energy
8	Decent Work and Economic Growth
11	Sustainable Cities and Communities
12	Responsible Consumption and Production
13	Climate Action

Overview

The waste sector produced 0.5% of the city's total modelled emissions in 2021, which was equal to 2.64 $ktCO_2e$. This includes solid waste and wastewater. Solid waste alone is the largest contributor to the total emissions from the waste sector, contributing 2.3 $ktCO_2e$ due to final disposal (Figure 63).

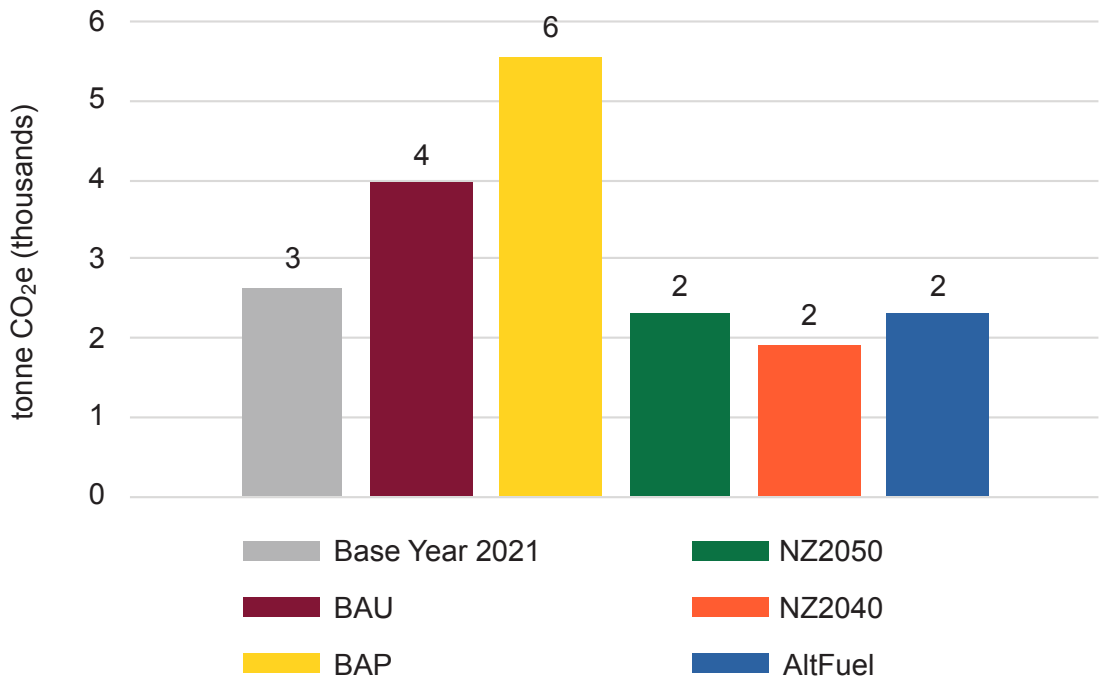


Figure 2. Waste sector emissions for 2050 for the three modelled scenarios in addition to the BAU and BAP scenarios. Source: SSG analysis.

The following measures are considered effective for achieving emissions reductions in the city of Peterborough's waste sector:

- Waste prevention and diversion;
- Waste energy recovery and landfill management; and
- Wastewater energy recovery.

This sector contributes less to GHG reduction compared to other sectors because the City is on track to implement mitigation measures such as residential composting and increasing waste treatment and diversion rates. The year-over-year emissions reductions are shown in the wedges diagrams in Figures 64, 65, and 66, and the cumulative emission reductions are in Table 28.

Table 28. Cumulative emissions reductions for Waste actions. Source: SSG analysis.

Action	Cumulative emissions reductions in the NZ2050 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the NZ2040 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the Alternative Fuels Scenario ($ktCO_2e$)	
	2024–2030	2024–2050	2024–2030	2024–2050	2024–2030	2024–2050
Waste prevention and diversion	6.52	59	2	64	6.52	59
Energy recovery and landfill management	NA	NA	NA	NA	1.87	37
Wastewater energy recovery	0	3	0	3	0	3
Total	**7**	**62**	**2**	**67**	**8**	**99**

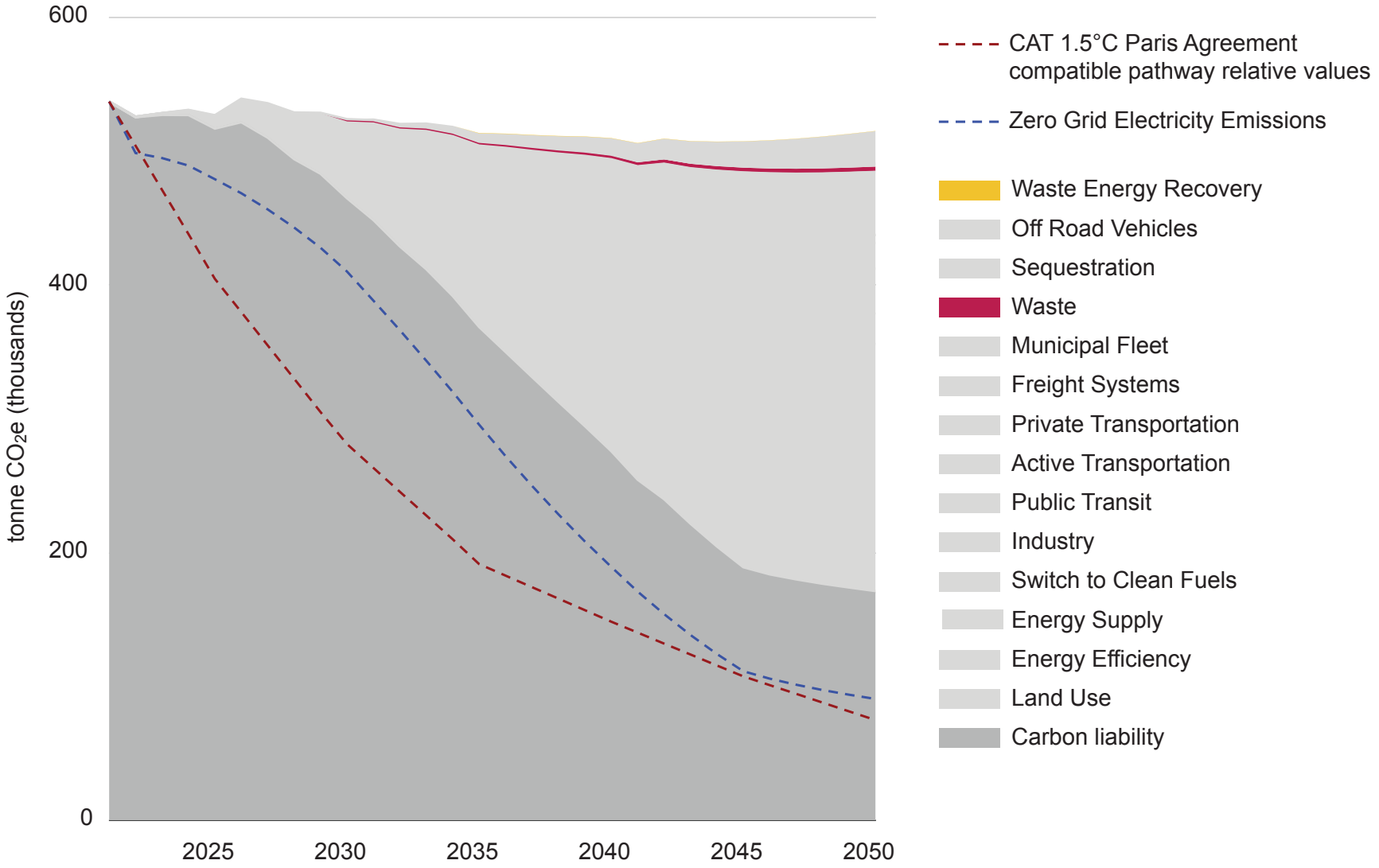


Figure 64. Emissions reductions for the Net-Zero 2050 Scenario for the Waste Sector Big Move. Source: SSG analysis.

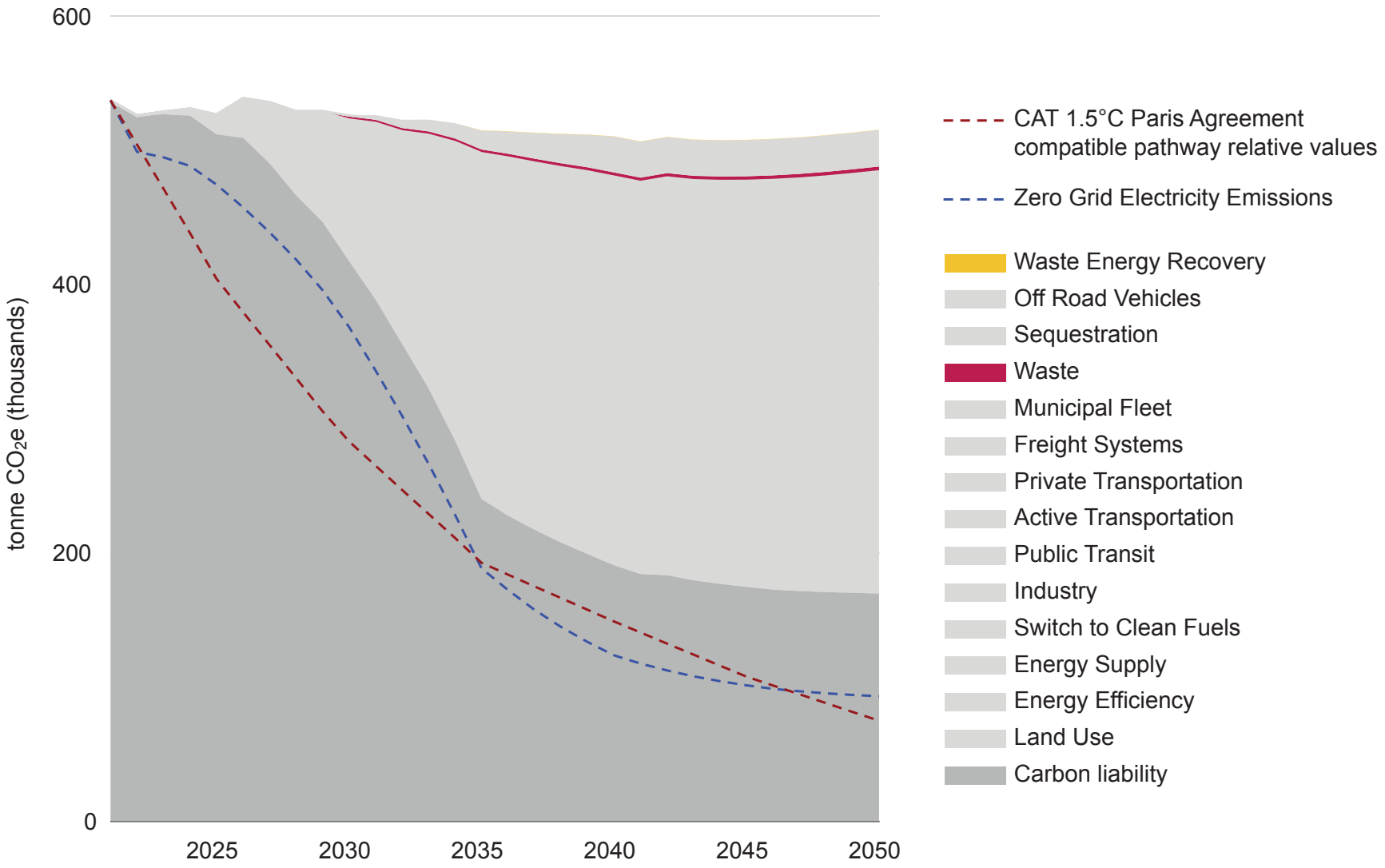


Figure 65. Emissions reductions for the Net-Zero 2040 Scenario for the Waste Sector Big Move. Source: SSG analysis.

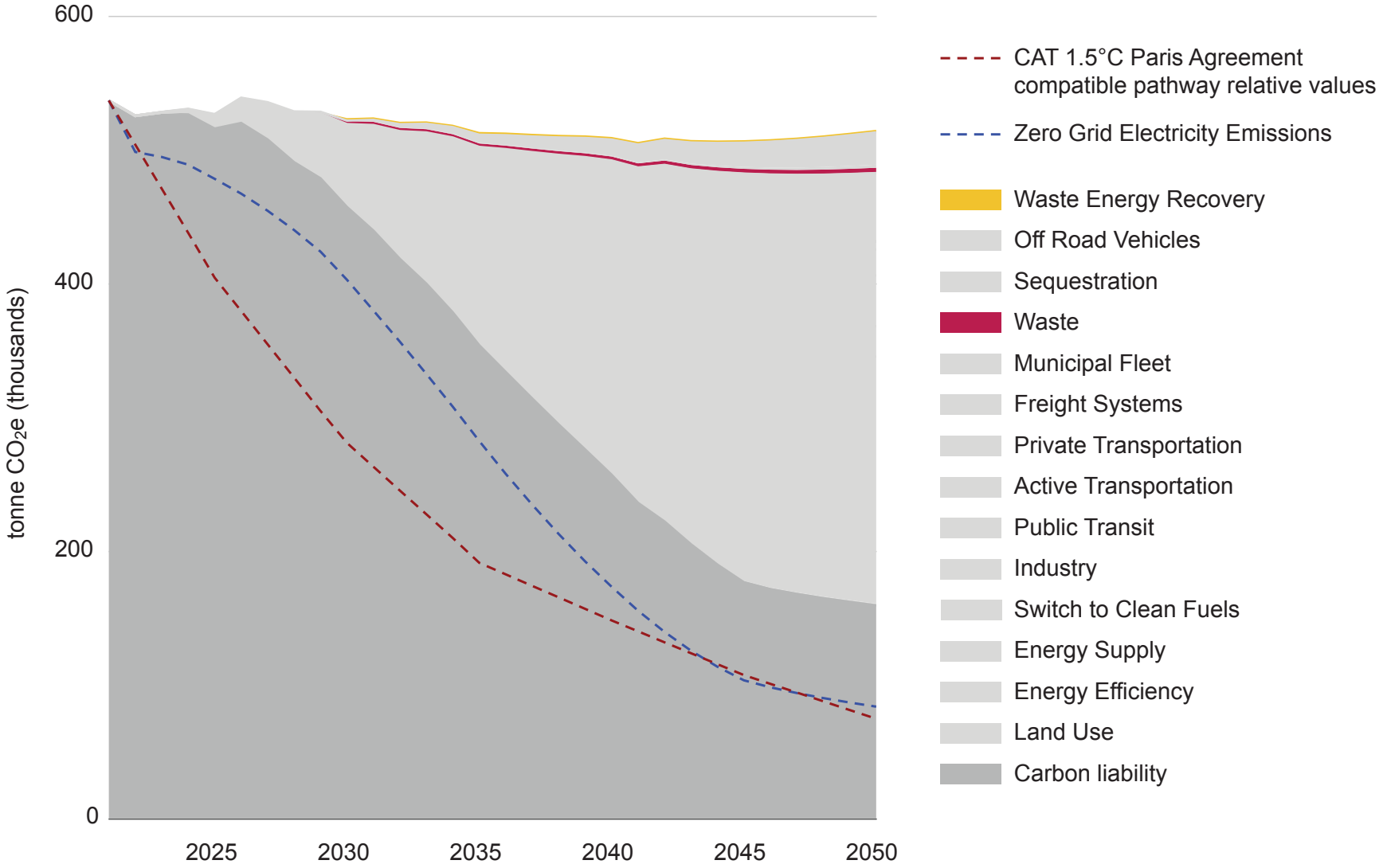


Figure 66. Emissions reductions for the Alternative Fuels Scenario for the Waste Sector Big Move. Source: SSG analysis.

Key Actions

Waste Prevention and Diversion

A holistic waste management strategy focuses on a waste hierarchy that prioritizes waste reduction, then reuse and recycling/composting and energy recovery, and, finally, disposal. Numerous cities are striving to achieve zero-waste goals (i.e., 100% diversion rates). Opportunities include outreach programs, strict separation policies, incentives/disincentives to promote recycling/organic composting, and bans on certain waste streams. The City of Peterborough has done an exemplary job with waste management, especially when it comes to waste diversion, and as a result, measures in the solid waste sectors involve keeping up on the City's target and extending it to longer-term horizons, as shown in Table 29.

Table 29. Targets of waste diversion.

Target Year	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
By 2030	75%	95%	75%
By 2040	95%	95%	95%

In addition to waste diversion, a complementary target is added based on reducing the waste generation per capita according to the 2021 levels, which are 413 kg per capita per year. Waste generation reduction targets per capita are listed in Table 30.

Table 30. Waste generation reduction percentage per capita.

Target Year	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
By 2030	20%	30%	20%
By 2040	30%	40%	30%

The results of waste prevention and diversion from the landfill for all three scenarios represent a diversion from the BAP trend. The decrease in waste generation per capita significantly contributes to this reduction. This follows the circular economy principles of:

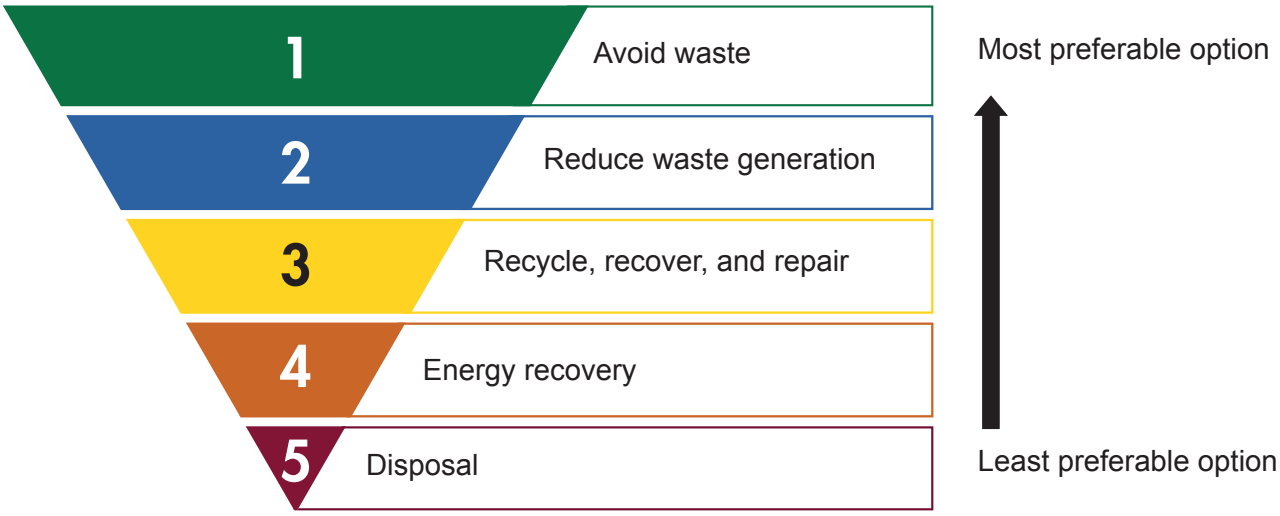


Figure 67 shows the emissions resulting from implementing prevention and diversion strategies.

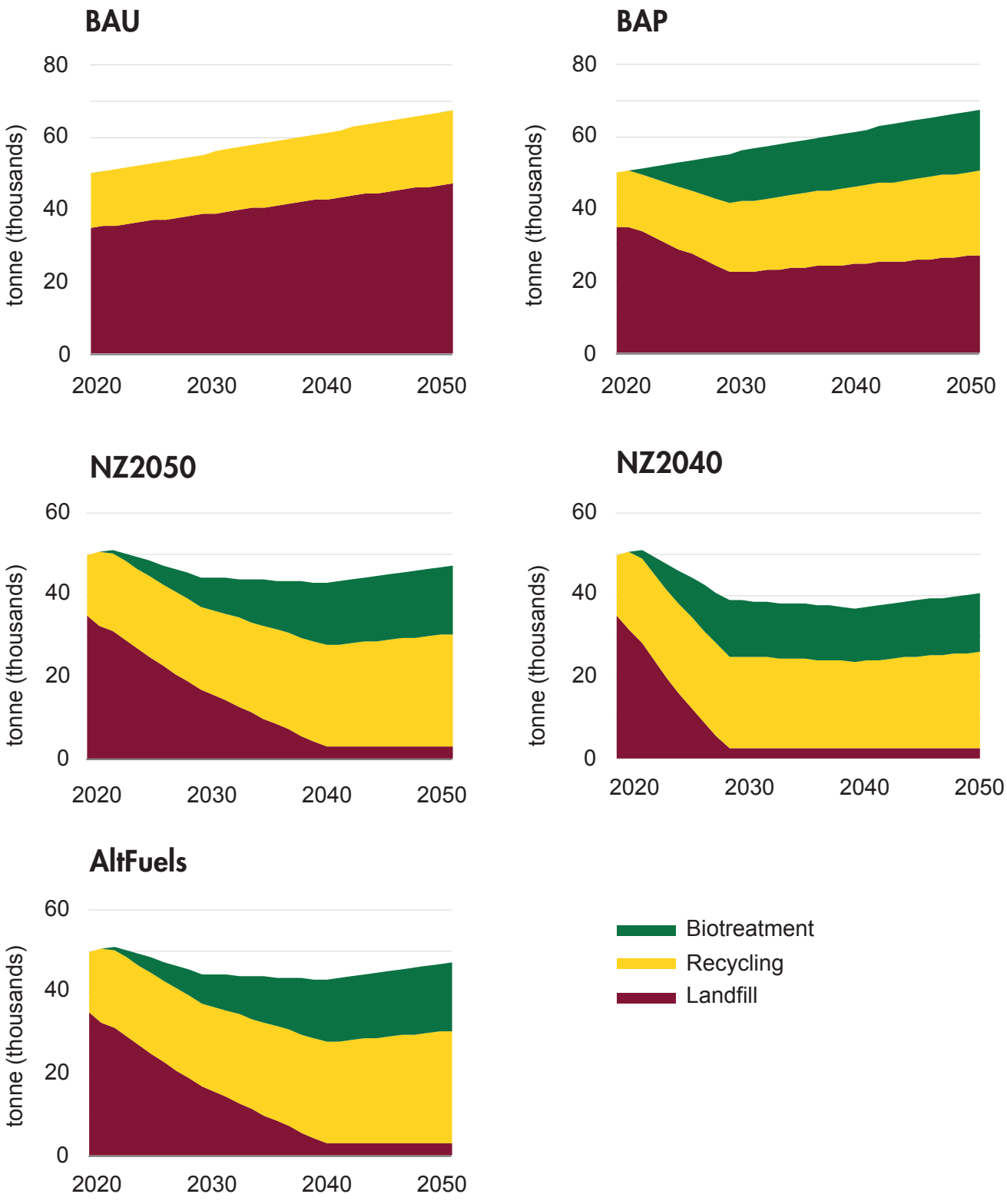


Figure 67. Waste tonnage by waste treatment for all scenarios for solid waste.
Source: SSG analysis.

Energy Recovery and Landfill Management

Following the circular economy principles, the steps for managing waste are to prevent consumer waste generation, reduce it, recycle and recover resources and materials, and dispose of any remaining waste. In the case of final disposal, energy recovery is possible by using the landfill gas generated from the anaerobic decomposition of the organic matter sent to the landfill. Landfill gas is almost 50% methane, which is the main component of natural gas, and is called renewable natural gas (RNG). RNG can be used to generate electricity and can be sold for residential, commercial, or industrial use.

Landfill gas capture and combustion systems can reduce the methane emitted from landfills and convert it to carbon dioxide with energy generation. Methane combustion with energy generation can reduce GHG emissions by displacing fossil-fuel-sourced energy to generate heat and electricity.

Due to the current energy generation from landfill gas in the Bensfort Road Landfill Gas Plant, the only scenario with a different course of action is the Alternative Fuels Scenario. The NZ2050 and the NZ2040 scenarios maintain the current practices. These measures recommend continuing to generate electricity in the landfill site.

In the Alternative Fuels Scenario, the generated landfill gas is upgraded to renewable natural gas and sold as a commodity, displacing the current demand for natural gas in the city. This scenario sets a target to fully use the landfill for biofuel production instead of energy generation.

District Energy From Wastewater Treatment

Wastewater treatment plants decompose biological waste from residual water flows usually coming from urban residential units. Wastewater is one source of thermal energy that can be harnessed for either residential use in nearby communities or for industrial purposes. Thermal energy generation can be used as district energy to provide space and water heating for a set of building/industrial units.

Currently, the City of Peterborough operates the Peterborough Wastewater Treatment Plant (WWTP), which has an annual average daily flow capacity of 68,200 m3/day. Although wastewater treatment plants are a desirable infrastructure feature in any city due to their role in reducing the environmental impacts of water discharge, they usually are a source of GHG emissions. The WWTP recovers biogas and uses it as a combined source of heat and power within the plant itself. As such, this action looks to recover thermal energy from the wastewater flows and use it for industrial purposes.

The modelled action assumes a sewage heat recovery unit with a heating capacity of 0.56 MW and a 1.8-MW natural-gas-fired boiler to provide heating during peak demand periods. The thermal energy generated by this plant is 2,500 MWh, and it is supplied to the industrial buildings within a 3 km distribution loop from the plant.

Financial Analysis

Implementing waste management and energy generation actions in the waste sector results in positive marginal abatement costs across all scenarios (Table 31). This is primarily due to the high costs associated with a district energy system. In the NZ2050 and NZ2040 scenarios, the total investment needed to implement a district energy system using wastewater is approximately $5 million. This cost significantly increases in the Alternative Fuels Scenario due to the need to upgrade the renewable natural gas generated from the landfill and due to its sale as a commodity. The capital investment in and the operation and maintenance of this technology requires substantial funding. Currently, the City manages landfill gas to generate electricity, and upgrading landfill gas to RNG would essentially require a complete redevelopment of the existing system. Additionally, small emission reductions are achieved through these mitigation actions, primarily due to the electricity requirements of a wastewater treatment plant, which results in the displacement of local electricity generation used for other purposes.

Table 31. Total investment, GHG reduction, and marginal abatement costs for the Waste Sector Big Move. Source: SSG analysis.

Scenario	Total Investment ($)	Total GHG Reduction ($ktCO_2e$)	Marginal Abatement Cost ($/tCO_2e$)
NZ2050	4,500,000	3	1,037
NZ2040	5,500,000	3	1,724
Alternative Fuels	22,000,000	40	192

Co-Benefits

Waste management systems provide environmental and health-related co-benefits, especially for communities located nearby disposal sites. Moreover, owners of private and municipal waste sites benefit economically.

Health and environment co-benefits: Diverting waste from disposal sites means fewer tonnes of organic waste will be buried to anaerobically decompose. Decomposition of organic waste (food residues, yard and wood, textiles, paper and cardboard) under circumstances with low oxygen availability, such as in landfills, generates not only methane as the main landfill gas, but also volatile organic compounds (VOCs). VOCs are widely characterized as carcinogenic, teratogenic,[51] and mutagenic agents. Some studies suggest that VOCs cause adverse health impacts ranging from headaches to lung cancer, since their main target is the respiratory system[52]. VOCs are also reportedly linked to tropospheric ozone formation and photochemical smog[53]. In other words, they are responsible for worsening air quality in the surrounding environment.

Last but not least, landfill sites also emit hydrogen sulphide (H2S), which is known for its rotten-egg-like odour. The effects of hydrogen sulphide are more commonly experienced at poorly managed sites; however, even exposure to low levels can cause irritability, headaches, asthmatic symptoms, etc. Thus, reducing the amount of organics sent to landfills helps decrease the risk of exposing residents to poor air quality.

Economic benefits: Waste prevention and disposal diversion benefit site owners by increasing the lifetime of the landfill and delaying the need for an expansion and its associated costs. In addition, diverting organics from landfills ultimately results in less methane generation, which reduces workers' exposure to the operating risks associated with poor site management. Methane can be used as fuel; thus, a fire risk exists when sites are poorly managed and no landfill gas capture systems are in place.

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[51] Substance that interferes with fetal development during pregnancy.

[52] Pan, Qi, Qing-Yu Liu, Jing Zheng, Yan-Hong Li, Song Xiang, Xiao-Jie Sun, and Xiao-Song He. "Volatile and Semi-Volatile Organic Compounds in Landfill Gas: Composition Characteristics and Health Risks." Environment International 174 (April 1, 2023): 107886. https://doi.org/10.1016/j.envint.2023.107886

[53] Nair, Abhilash T., Jaganathan Senthilnathan, and S. M. Shiva Nagendra. "Emerging Perspectives on VOC Emissions from Landfill Sites: Impact on Tropospheric Chemistry and Local Air Quality." Process Safety and Environmental Protection 121 (January 1, 2019): 143–54. https://doi.org/10.1016/j.psep.2018.10.026

Lastly, in most cases, waste management occurs locally; therefore, recycling activities provide new sources of employment and boost the local economy. Additionally, recycling practices generate revenue instead of incurring costs, as occurs with waste disposal.

Implementing Change

Peterborough is doing an exemplary job with waste management. To keep on track with this work and increase its impacts, the City should take the following actions:

1. Expand recycling and composting collection to commercial businesses through institutional, commercial and industrial (IC&I) program

Role of municipality: Collaborator

Type of implementation action: Incentive, and education and outreach

The City of Peterborough launched its GROW composting program community-wide in 2023, targeting residential buildings. The City's efforts to manage waste have led to significant behavioural changes among residents and have proven effective so far. To further enhance these efforts and achieve even higher GHG emission reductions, Peterborough needs to expand its collection and composting program to include non-residential buildings. Achieving this goal will require the municipality to:

a. Establish a working group with businesses and retailers to understand the opportunities and barriers for recycling and composting in IC&I collection;
b. Provide free blue and green dumpsters to commercial IC&I collection sites, initially focusing on downtown and other strategic growth areas;
c. Educate IC&I commercial clients about composting and recycling in the workplace and how to properly dispose of different materials;
d. Give away free in-store blue and green bins to local businesses to use in store, restaurants, lunchrooms, etc.;
e. Consider discounting recycling and composting collection for the first year; and
f. Send quarterly waste audits to IC&I commercial clients.

Timeline:

Working group established by 2026.

Provision of blue and green dumpsters to start in 2026 and gradually cover different areas over the next five years.

Actors involved: City of Peterborough, waste management operators, local businesses and commerce, and community members.

Indicators:

- Number of commercial businesses participating in the program
- Number of green and blue dumpsters distributed
- Number of blue and green bins provided to businesses
- Total tonnage of compost collected from commercial businesses
- Total tonnage of recycling collected from commercial businesses

Costs: Educational campaign and efforts: $20,000.

Green and blue bins to be determined depending on the number of businesses.

Enablers: Not identified.

2. Expand recycling and composting collection to multi-unit residential buildings (MURBs) through IC&I program.

Role of municipality: Implementer

Type of implementation action: Incentive and education and outreach

In the context of expanding Peterborough's GROW program, the collection and management of organic waste should also consider multi-unit residential buildings. Similar actions to those mentioned for commercial businesses will need to be taken by the municipality, although the target residents differ. The municipality can extend this program by starting with the following actions:

a. Establish a working group with multi-unit residential building owners, rental agents, and residents to understand the opportunities and barriers for recycling and composting in these buildings.
b. Provide free blue and green dumpsters to multi-unit residential buildings for organic waste collection.
c. Consider offering discounted recycling and composting collection services for the first year.
d. Educate building owners, rental agents, and residents about composting and recycling, and how to properly dispose of different materials.
e. Distribute free kitchen composting bins and in-home blue bins to residents participating in educational events and to rental agents to give away when leases are signed.

Timeline:

Working group established by 2026.

Provision of blue and green dumpsters to MURB for organic waste collection to start in 2026 and gradually cover different areas over the next five years.

Actors involved: City of Peterborough, waste management operators, local businesses and commerce, and community members.

Indicators:

- Number of participating buildings
- Number of green and blue dumpsters distributed
- Number of kitchen bins provided
- Total tonnage of compost collected from MURBs
- Total tonnage of recycling collected from MURBs

Costs: Green and blue bins to be determined depending on the number of MURBs.

Enablers: Not identified.

3. Keep going with outreach programs

Role of municipality: Implementer

Type of implementation action: Incentive and education and outreach

The City should implement and extend its outreach programs and campaigns to educate the community about best practices for the prevention, reduction, and recycling of waste, as well as their benefits. By better connecting with the community, the municipality can collaborate with waste management partners and local groups to promote circular economy practices. To achieve behavioural changes in the long term, the municipality will need to:

- Host regular workshops and seminars with relevant partners on the benefits of waste management, prevention, and reduction.
- Organize and host regular events to engage with residents, such as sustainability fairs and community clean-ups.
- Partner with local businesses and launch a "Zero Waste Challenge."
- Design a communication campaign using social media to inform and educate different segments of the population.
- Partner with schools and neighbourhoods to collect feedback from residents.

Timeline:

Launch communication campaign by 2025.

Launch "Zero Waste Challenge" in 2025.

Ongoing outreach.

Actors involved: City of Peterborough.

Indicators:

- Number of local businesses participating in "Zero Waste Challenge"

Costs: Cost for Zero Waste Business Challenge and Waste outreach: $25,000.

Enablers: Not identified.

Forestry and Carbon Capture Big Move

SDGs that are being addressed by this Big Move.

3	Good Health and Well-Being
11	Sustainable Cities and Communities
13	Climate Action
14	Life Below Water
15	Life on Land

Overview

Urban forests represent the only carbon-negative sector in the city of Peterborough (Figure 68). This means that urban forests absorb (or have the potential to absorb) more carbon than they emit. Increasing urban forests has an impact on emissions in the long term.

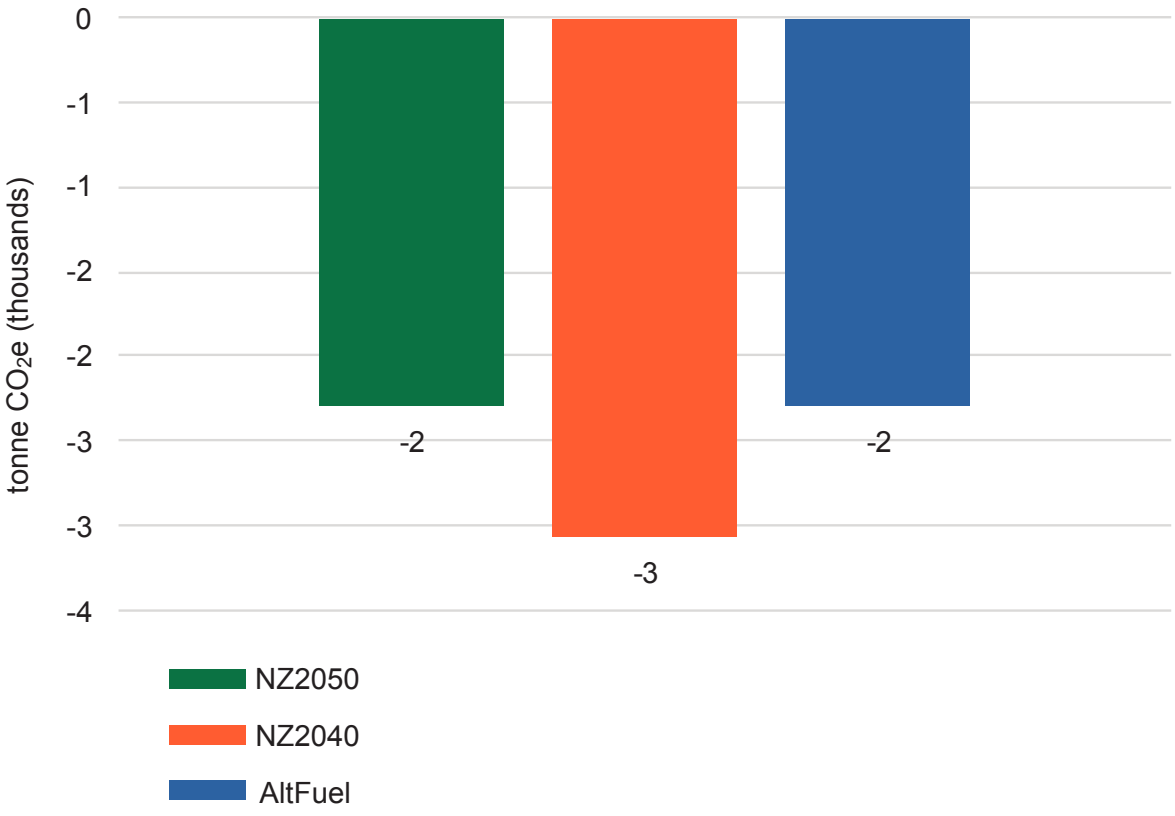


Figure 68. Forestry sector GHG emissions in 2050 for the three modelled scenarios. Source: SSG analysis.

In terms of emissions reductions, urban forestry is not the largest contributor, but it does help the City achieve a more holistic strategy to mitigation, including the implementation of carbon capture measures. It is worth noting that the urban tree canopy not only contributes to mitigating climate change, but also helps mitigate impacts such as the heat island effect and river run-off.

Carbon-Negative Emissions

When we talk about emissions, we usually picture gases being emitted from different sources, such as cars and industry chimneys. These emissions accumulate in the atmosphere, and their significant increase due to anthropogenic activities has unequivocally caused climate change due to an increase in the global temperature.

In contrast, when we refer to carbon-negative emissions, we are referring to removals of GHGs from the atmosphere. These removals occur both artificially and naturally. Vegetation is one of the main carbon-removal sectors. Both terrestrial and marine forests play a fundamental role in absorbing carbon dioxide, using it as food and generating oxygen in return.

There are also anthropogenic activities that remove carbon dioxide from the atmosphere. Some are based on natural solutions like reforestation and afforestation, and others are technological solutions that store carbon in terrestrial, geological, and oceanic reservoirs and have not been widely practiced.

Natural systems that store CO_2 are susceptible to climate change impacts, which means that improper forest management, wildfires, and other natural disturbances can affect the mitigation potential of forests.

In urban contexts, the tree canopy also provides carbon removals, but to a lesser extent than that provided by natural forests and oceanic systems. However, they still are a key element in climate change, as they integrate both mitigation and adaptation. In urban settlements, the tree canopy reduces emissions and pollution and helps communities cope with climate change impacts by decreasing the urban heat island phenomenon and reducing the risks of flooding and wind speed.

Figures 69, 70, and 71 display the year-over-year emissions reductions of the Forestry sector for all low-carbon scenarios (NZ2050, NZ2040, and AltFuels). Table 32 summarizes this information.

Table 32. Cumulative emissions reductions for Forestry and Carbon Capture actions. Source: SSG analysis.

	Cumulative emissions reductions in the NZ2050 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the NZ2040 Scenario ($ktCO_2e$)		Cumulative emissions reductions in the Alternative Fuels Scenario ($ktCO_2e$)	
Action	**2024–2030**	**2024–2050**	**2024–2030**	**2024–2050**	**2024–2030**	**2024–2050**
Increasing urban forests	0.52	19	2	48	0.52	19
Total	**1**	**19**	**2**	**48**	**1**	**19**

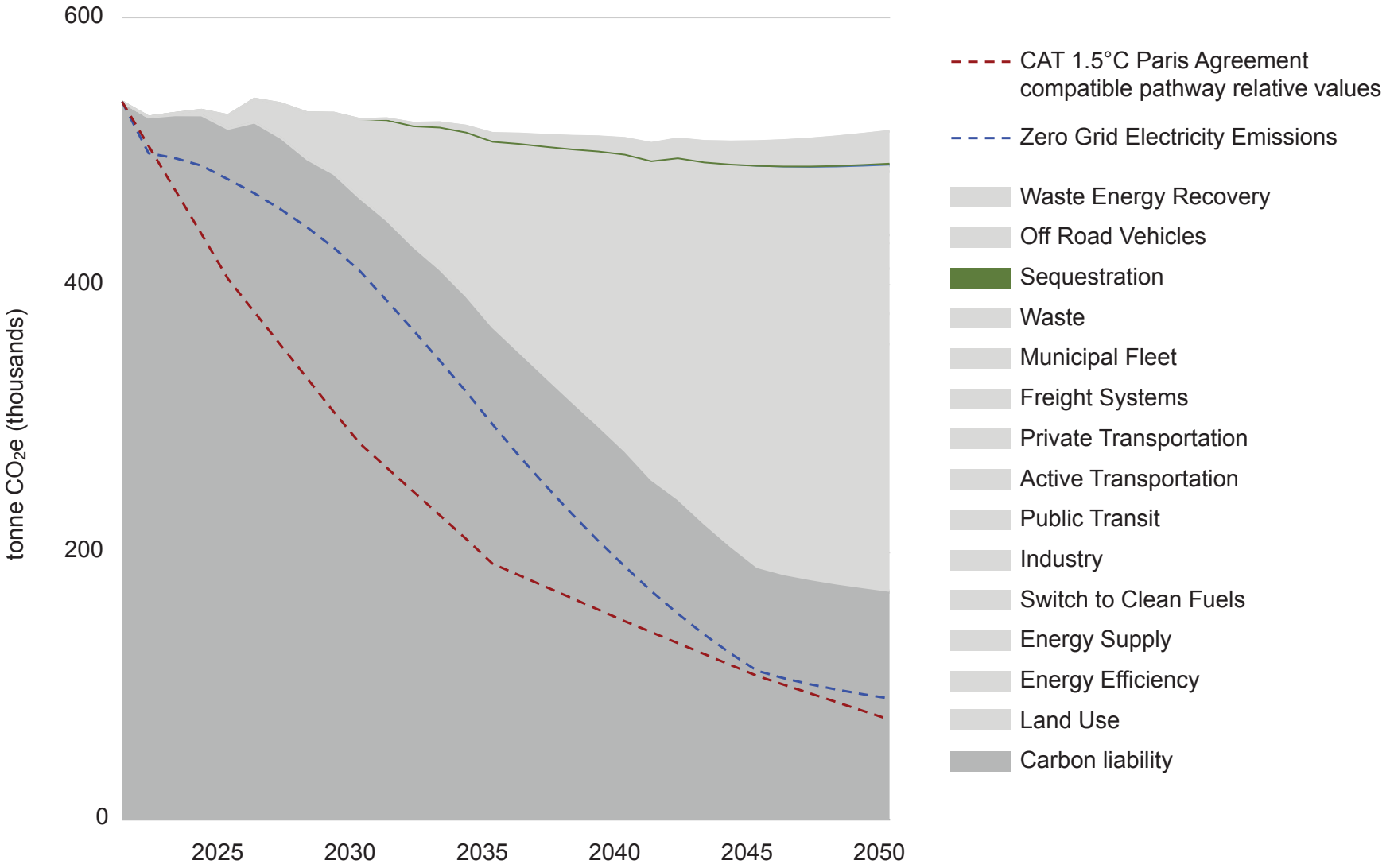


Figure 69. Emissions reductions for the Net-Zero 2050 Scenario for the Forestry and Carbon Capture Big Move. Source: SSG analysis.

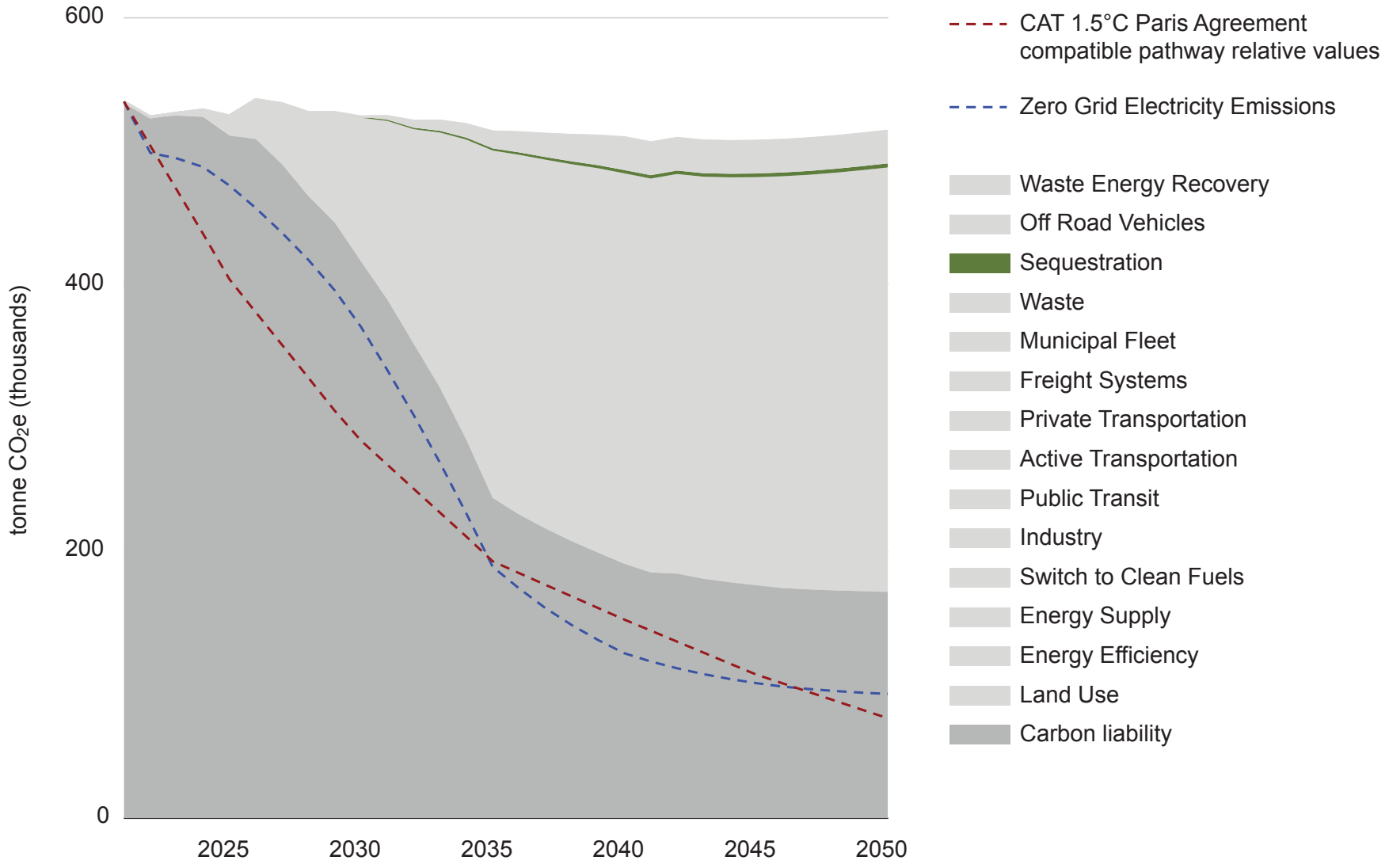


Figure 70. Emissions reductions for the Net-Zero 2040 Scenario for the Forestry and Carbon Capture Big Move. Source: SSG analysis.

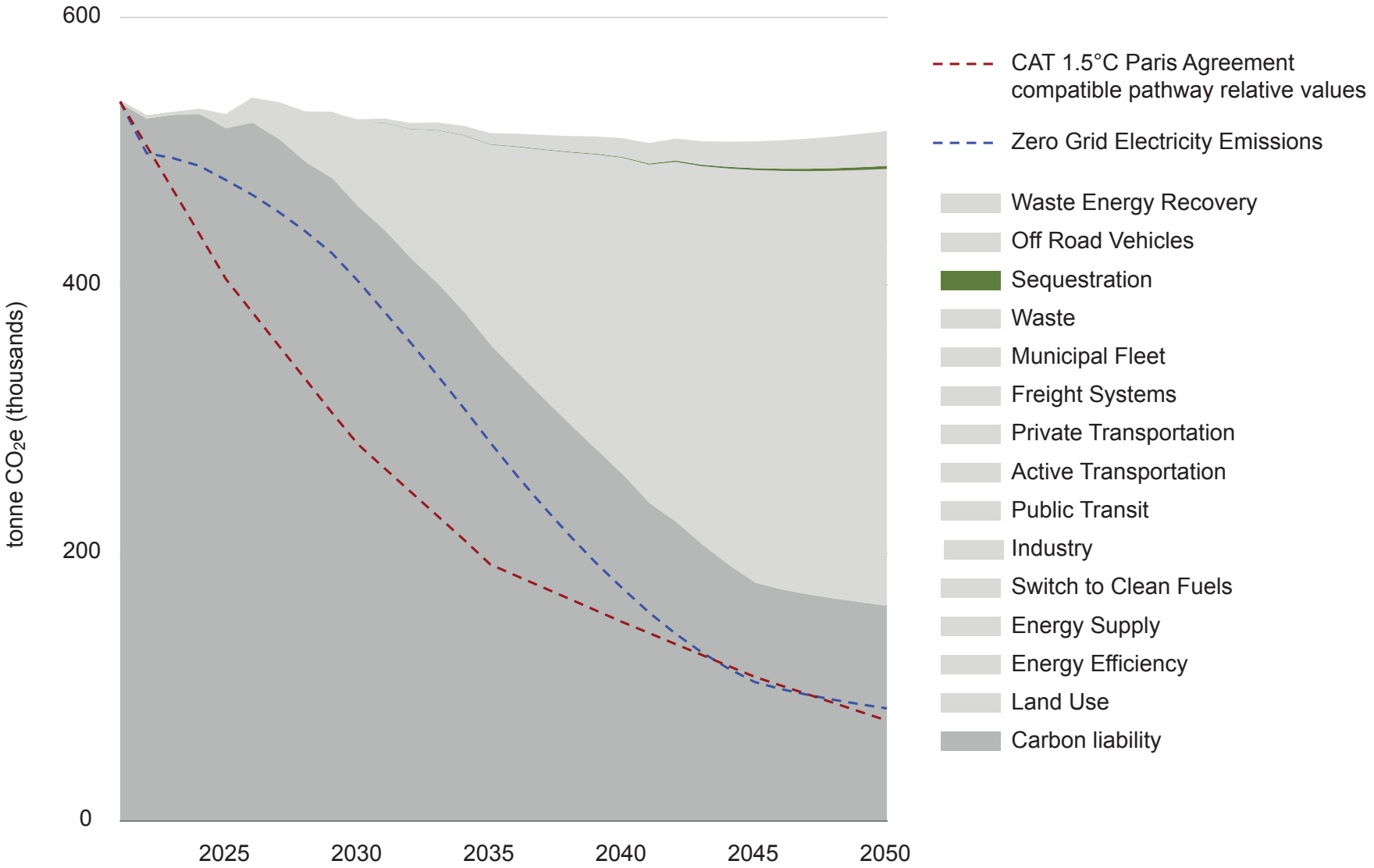


Figure 71. Emissions reductions for the Alternative Fuels Scenario for the Forestry and Carbon Capture Big Move. Source: SSG analysis.

Key Actions

Natural carbon sequestration by trees, community gardens, green roofs, and conservation and restoration of wetland helps communities capture greenhouse gases they could not otherwise eliminate. Natural sequestration is unlikely to provide a significant overall reduction of a community's GHG emissions, but it provides significant co-benefits, such as improved local health and well-being and improved soil health.

Targets such as increasing the urban forest area coverage in the city and providing more shading to sidewalks and public spaces are based on the Official Plan guidelines and the proposed targets for intermediate years. Currently, only 16% of the city area is urban forest. Table 33 describes the percentage of city area (hectare) covered by urban forests in the three scenarios.

Table 33. Targets of urban forest coverage.

Target Year	Net-Zero 2050	Net-Zero 2040	Alternative Fuels
2040	20%	35%	20%
2051	35%	40%	35%

Figure 72 shows the resulting emissions trajectories for the city of Peterborough for each of the low-carbon scenarios.

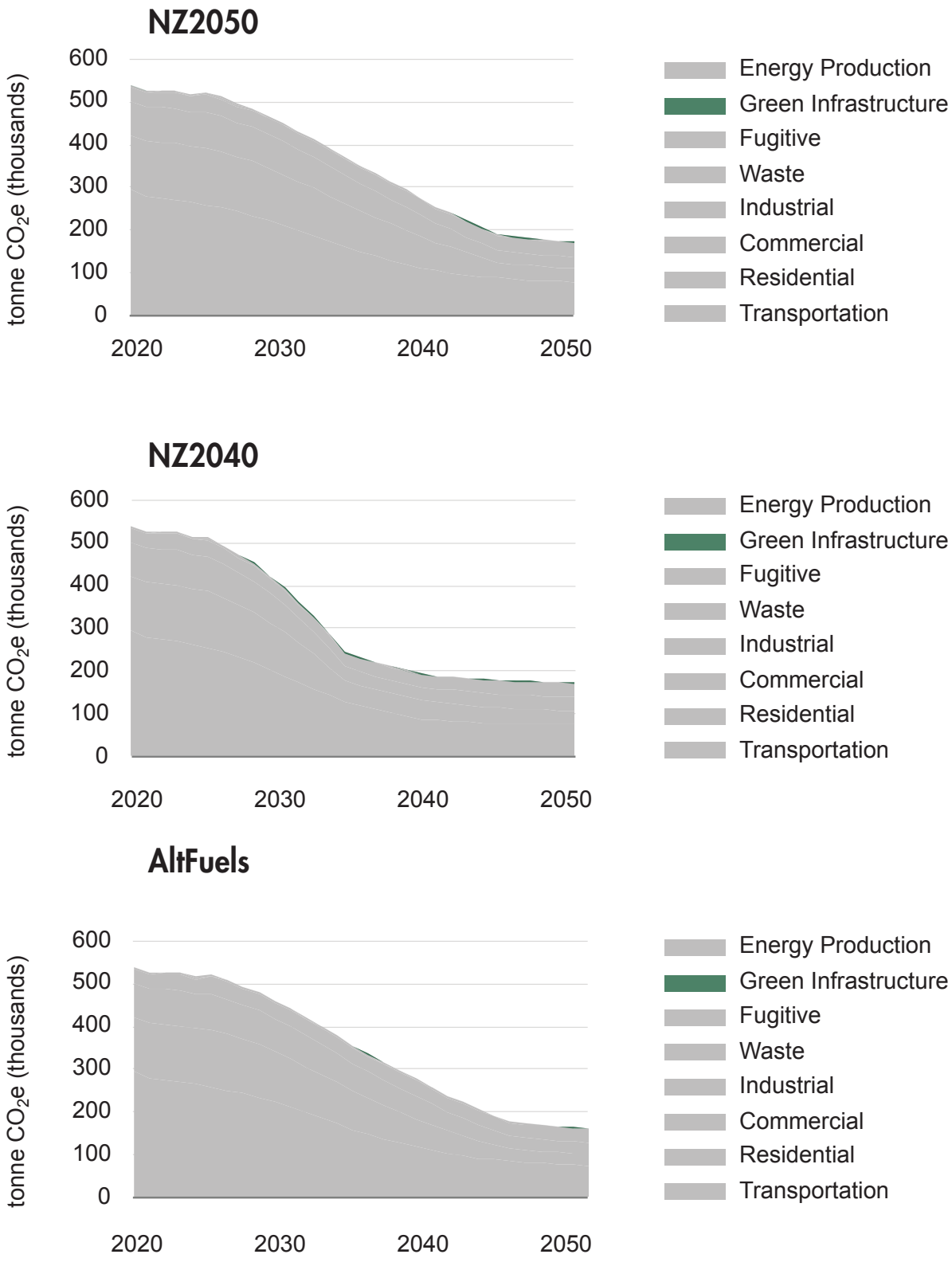


Figure 72. Urban forest emissions for the 2024–2050 period for all three scenarios. Source: SSG analysis.

Financial Analysis

In most cases, urban forestry activities are only based on investments and operational costs due to their non-productive nature. This means that increasing urban forests provides benefits that cannot be translated into monetary value. As such, no monetary gains occur from implementing urban forests, although investment in new land to expand urban forests is needed. Table 34 presents the total investment for this action.

Table 34. Total investment, GHG reduction, and marginal abatement costs for the Industry Big Move. Source: SSG analysis.

Scenario	Total Investment ($)	Total GHG Reduction ($ktCO_2e$)	Marginal Abatement Cost ($/tCO_2e$)
NZ2050	39,000,000	19	2,023
NZ2040	64,000,000	48	1,340
Alternative Fuels	39,000,000	19	2,023

In this context, land investment is the key driver of financial needs, and the more forested land there is, the more negative emissions that can be achieved. However, be aware that carbon sequestration in urban settings is limited, and key actions to prevent a warmer planet are primarily related to a decrease in the use of fossil fuels, with carbon sequestration being only a complementary action to Peterborough's efforts. To put this into perspective, if 100% of Peterborough was urban forests, the cumulative mitigation potential would be up to 194, which is less than 4% of the total emissions reductions in the NZ2050 Scenario. The marginal abatement cost of the NZ2050 and AltFuels scenarios is $\$12/tCO_2e$, which means it costs $12 to reduce each tonne of CO_2e by foresting the city of Peterborough. The marginal abatement cost for the NZ2040 is $\$8/tCO_2e$ lower than that of the other scenarios since the increase in mitigation abatement increases more than the costs of land.

Finally, it is worth noting that although the marginal abatement costs are positive—meaning that implementation will incur net costs—carbon sequestration remains a desirable action due to its co-benefits for health, equity, and adaptation.

Co-Benefits

Forests are valuable climate change measures because they mitigate GHG emissions and support adaptation to a changing climate. In particular, urban forests benefit cities and their residents by moderating climate, reducing building energy use, providing shadowing to mitigate high temperatures, improving air quality, providing recreation opportunities, positively impacting physical and mental health, and providing wind control, flood prevention, and erosion control.

In terms of the heat island effect, each percentage increase in tree canopy coverage may result in a 0.035°C reduction in air temperature. Therefore, Peterborough's goal to have 20% tree canopy coverage by 2051 in the NZ2050 Scenario translates into an air temperature reduction of up to 1.2°C locally. For the more ambitious targets outlined in the NZ2040 Scenario, the air temperature decreases by 1.4°C. This contributes to reducing the mortality risks associated with high temperatures. In Ontario, some studies suggest an increase in the mortality risk with temperatures over 32°C[54] (Clemens et al., 2021).

Urban forests and urban plants may also be part of the green infrastructure in the city. Green infrastructure refers to natural and semi-natural areas and features in urban and rural settings that aim to provide ecosystem services and enhance biodiversity. Features that form part of the green infrastructure range from parks, open spaces, and playing fields to woodlands, trees, allotments, private gardens, and green roofs and walls. A more complex but inclusive form of urban design with environmental features can also incorporate water systems, known as "blue infrastructure," which includes rivers, streams, rain gardens, and other elements. One key benefit of green infrastructure is its stormwater management capabilities, which help reduce run-off by absorbing rainfall and alleviating pressure on sewers. Furthermore, reducing run-off results in less water percolating beneath the surface and prevents untreated water from entering natural water bodies, thereby contributing to maintaining water quality.

When targeting the implementation of green infrastructure, Peterborough should also consider different mechanisms to increase tree canopy coverage in various areas. For some areas, a more collaborative approach is recommended, encouraging

[54] Clemens, Kristin K., Alexandra M. Ouédraogo, Lihua Li, James A. Voogt, Jason Gilliland, E. Scott Krayenhoff, Sylvie Leroyer, and Salimah Z. Shariff. "Evaluating the Association between Extreme Heat and Mortality in Urban Southwestern Ontario Using Different Temperature Data Sources." Scientific Reports 11 (April 14, 2021): 8153. https://doi.org/10.1038/s41598-021-87203-0

private tree planting, while in higher-need neighbourhoods, the municipality should provide incentives and long-term collaboration. While this approach guides the City toward achieving equity-based results and helps prevent green gentrification,[55] the needs of and barriers faced by neighbourhoods should continuously be monitored.

The HealthyPlan.City initiative helps us explore the inequities in urban tree cover across neighbourhoods in Peterborough. It highlights that 51% of visible minority individuals (3,878 people) and 54% of low-income individuals (2,747 people) live in areas where additional resources targeting tree canopy cover could improve equity in the city (see Figure 73). Equity priority refers to areas with higher-than-median proportions of vulnerable populations that also have less access to environmental benefits. Peterborough should consider prioritizing collaboration with the neighbourhoods coloured red on the maps or at least target implementing tree planting activities.

[55] Gentrification refers to the implementation of an environmental planning agenda that results or leads to the exclusion and displacement of politically disenfranchised residents.

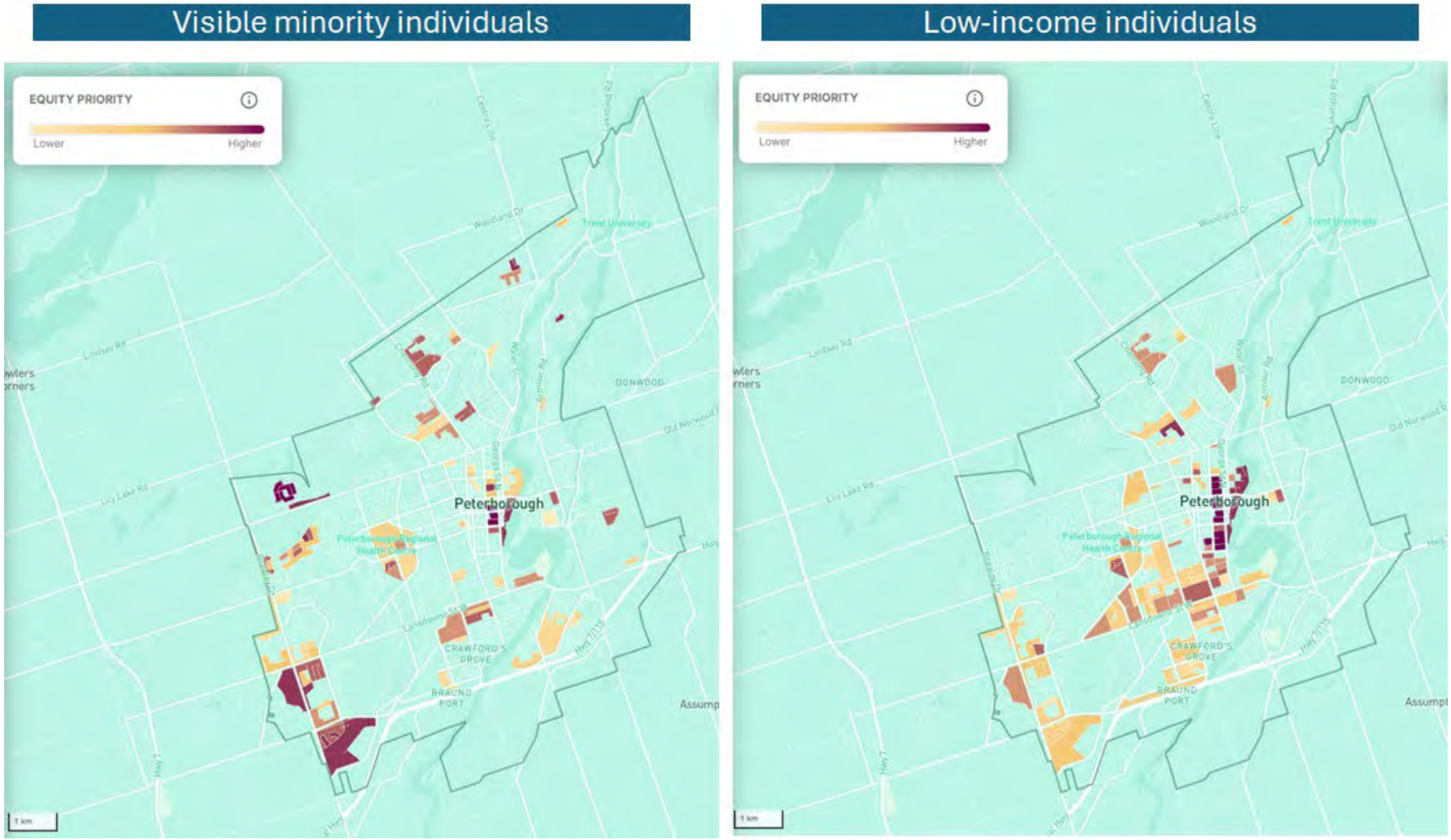


Figure 73. Mapping inequities of urban tree canopy in Peterborough for visible minority and low-income individuals. Source: HealthyPlan.City

Implementing Change

1. Establish annual tree planting targets and reporting while implementing the Urban Forestry Strategic Plan

Role of municipality: Implementer

Type of implementation action: Policy

Tree planting activities usually mean carbon sequestration in the future; thus, planning for such reductions is an important step Peterborough needs to take. The City has an Urban Forest Strategic Plan, and the following actions can support its implementation and get the City on track to achieve its goals by the middle of this century:

- Set annual tree planting goals, targeting low-income neighbourhoods to ensure equitable access to the benefits of trees and a diverse selection of species, and report on progress annually.
- Host tree planting events and provide seeds and/or tree samples to participants.
- Monitor, track, and report on the tree canopy inventory for the city of Peterborough and identify ecosystem services from the current tree coverage.

Timeline:

Targets set by 2025.

Actors involved: City of Peterborough and private landowners.

Indicators:

- Number of trees planted per year according to the targets set.
- Percentage of types of trees and native plants planted.
- Number of trees benefitting at-risk populations (i.e., low-income neighbourhoods, senior housing, schools, etc.).

Costs: Referential costs of tree planting are: $420 for the sapling + $1,050 for installation.

Enablers: Tree Removal Bylaw and Urban Forestry Strategic Plan.

2. Coordinated planting and guiding green infrastructure

Role of Municipality: Implementer

Type of implementation action: Policy

A list of recommended actions to help Peterborough get on track with green infrastructure and increase planting activities are listed below:

- Collaborate with Public Works and other departments to incorporate native planting (trees, bushes, other vegetation) into street repaving, major street/water main repairs, infrastructure upgrades, and improvements to bus stops, as well as cycling and walking paths.
- Create a guide for green infrastructure to recommend nature-based solutions for development throughout the city, with specific solutions required or incentivized for flood-prone areas.
- Remove barriers to new tree planting in public and open spaces.

Timeline:

Start piloting inclusion of tree canopy in public works projects by 2026.

Actors involved: City of Peterborough, Public Works, developers and community groups, and eventually the Green Infrastructure Ontario Coalition.

Indicators:

- Year Green Infrastructure Guide is created.
- Average time needed for requesting new trees in the city.
- Number of projects per year that follow the Green Infrastructure Guide.

Costs: Green Infrastructure Guide: $25,000.

Enablers: Tree Removal Bylaw, Urban Forestry Strategic Plan, and the Planning Act.

3. Outreach program continuation

Role of municipality: Implementer

Type of implementation action: Policy

- Design a communication strategy that details the benefits of urban trees for the city and its residents.
- Contact residential property owners (targeting landlords and MURB building owners) to facilitate volunteer planting days in neighbourhoods with limited tree canopy coverage, ensuring equitable access to the benefits of trees (i.e., shade, improved air quality, etc.). Offer free tree/native plants planting and coordinate volunteer planting days to support these neighbourhoods, providing neighbours an opportunity to participate in and learn about tree care and maintenance. Offer this service at least bi-annually (every two years).
- Provide an annual budget for outreach activities and volunteer planting days.

Timeline:

Design and implement the communication strategy by 2026.

Actors involved: City of Peterborough, neighbourhood associations, and community groups.

Indicators:

- Number of people contacted by the campaign.
- Number of trees planted.
- Number of participants in tree planting volunteer events.

Costs: Outreach program design $50,000.

Set an annual budget for community tree planting–consider starting with $1,000/year.

Enablers: Tree Removal Bylaw and Urban Forestry Strategic Plan.

6. The Opportunities

The implementation of any mitigation action requires major investments, including electric fleets and vehicles, building retrofits, and solar panels, in all sectors. Notwithstanding this, these low-carbon transitions will result in operational, energy, and carbon savings and even revenue generation.

Net present value: Estimates the overall current value of a series of cash flows, including all future cash flows. It encompasses the assessment of the dollar value for both the initial costs and the costs and benefits for the duration of the life of a project/action, discounted to a present value.

Total investment: Refers to the sum of investment and savings.

Total savings from investment: Savings and economic benefits from implementing the actions. It refers to savings on emissions, energy use, maintenance, and fuel.

The overall costs of implementing the mitigation actions are presented in Table 35 and Figure 74. Implementing any of these scenarios brings overall savings to the City of Peterborough. The NZ2050 Scenario provides the greatest benefits relative to the implementation costs, mostly due to a lower investment. Notwithstanding this, all the scenarios provide similar benefit rates, and emissions reductions are a key element that complements the assessment of their performances.

Table 35. Total costs ($ million) of each modelled scenario in net-present value (NPV). Source: SSG analysis.

Total	NZ2050	NZ2040	Alternative Fuels
Costs of investment ($ million)	$2,219	$3,057	$2,351
Savings from investment ($ million)	-$3,168	-$3,785	-$3,014
Total costs ($ million)	-$949	-$728	-$663
Benefit rate (benefit/costs)	1.4	1.2	1.3

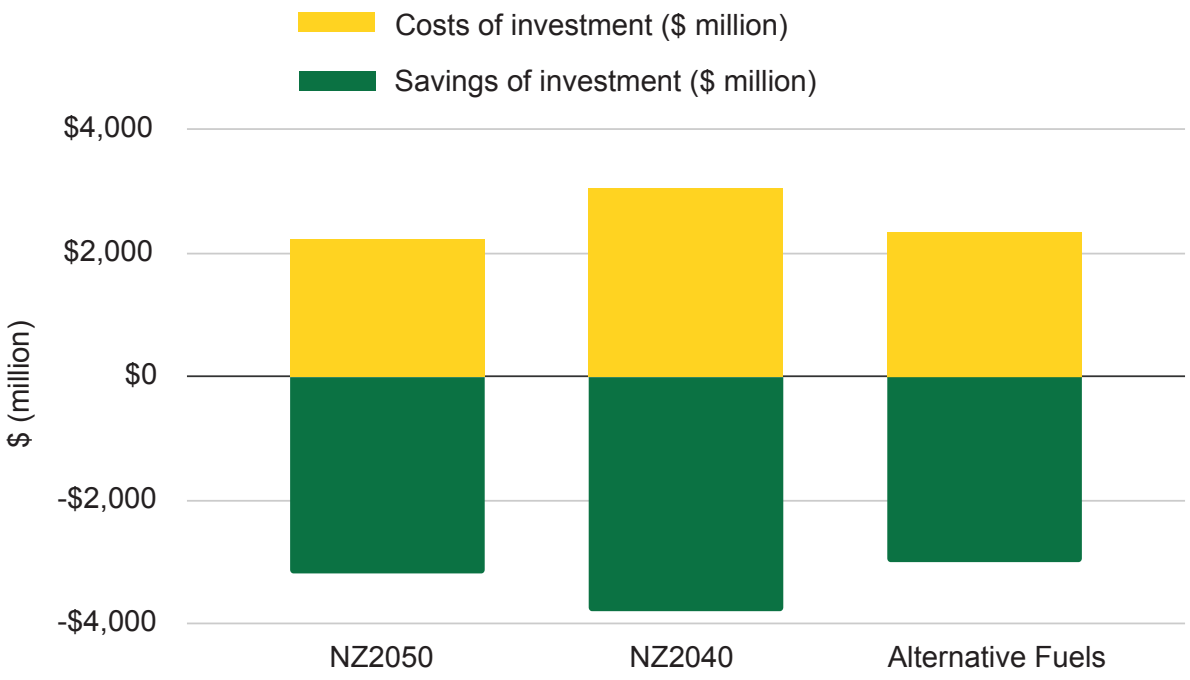


Figure 74. Total costs and gains of investment for each modelled scenario, NPV. Source: SSG analysis.

Large Investments Come With Large Savings

NZ2050 Scenario

The net cost of this Low- Carbon Scenario (LCS) is -$949 million. The negative sign means that implementing all these actions between 2040 and 2050 results in overall savings since operational, energy and carbon savings overcome capital investments.

Annual capital expenditure for the next five years (2025–2029, $81 million) totals less than 2% of Peterborough's GDP by 2020 ($4,901 million)[56] (Government of Canada, 2023).

In 2045, savings start to exceed costs on an annual basis.

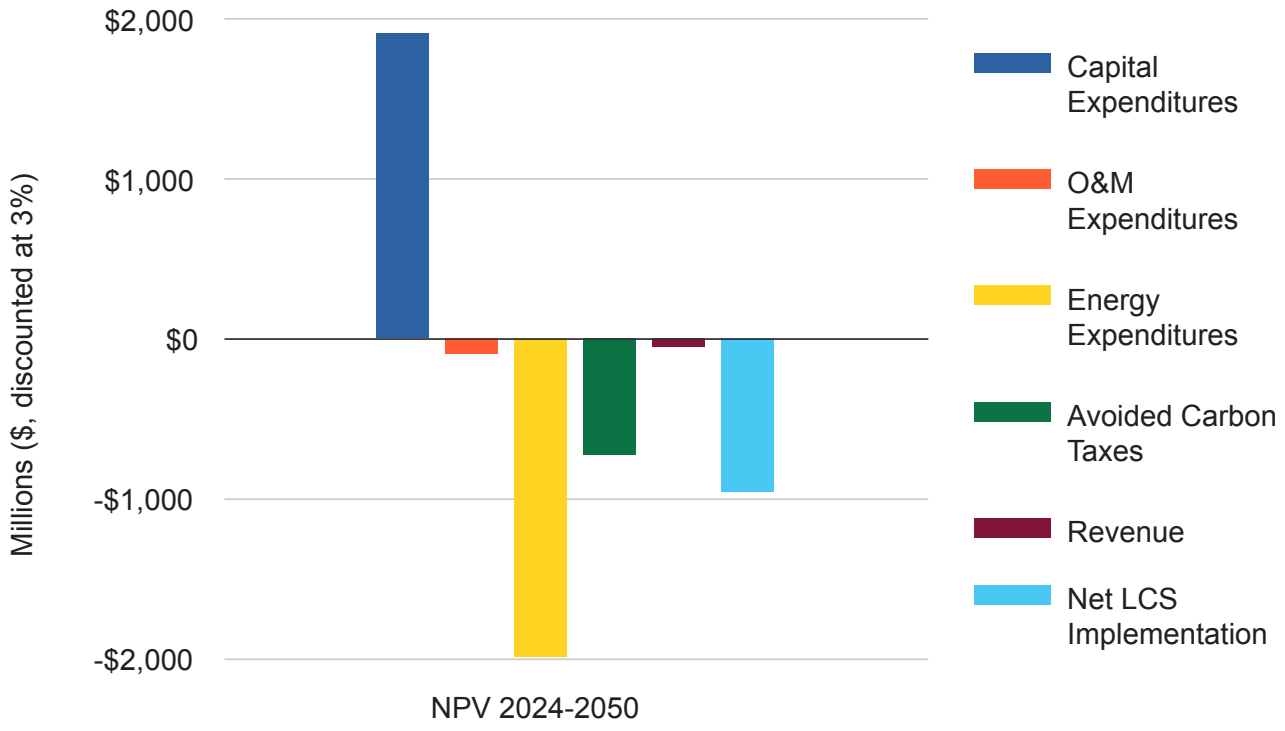


Figure 75. Cumulative investment and returns—NZ2050 Scenario. Source: SSG analysis.

[56] Government of Canada, Statistics Canada. "Gross Domestic Product (GDP) at Basic Prices, by Census Metropolitan Area (CMA)," 2023. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610046801

NZ2050 Scenario

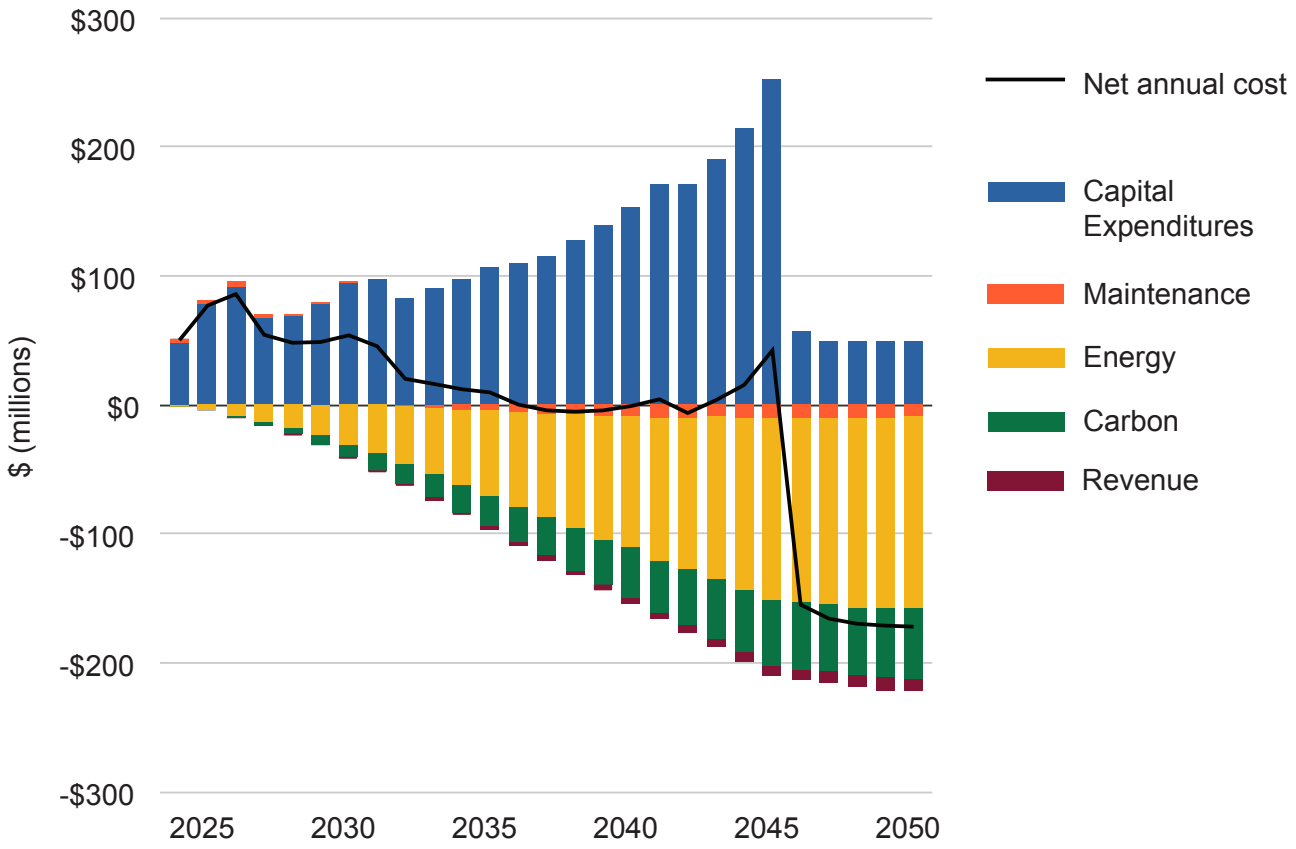


Figure 76. Year-over-year Low-Carbon Scenario investment and returns—NZ2050 Scenario. Source: SSG analysis.

NZ2040 Scenario

The net cost of this Low- Carbon Scenario (LCS) is -$728 million. The negative sign means that implementing all these actions between 2030 and 2050 results in overall savings since operational, energy, and carbon savings overcome capital investments.

Annual capital expenditure for the next five years (2025–2029, $193 million) totals less than 4% of Peterborough's GDP by 2020 ($4,901 million).

In 2036, savings start to exceed costs on an annual basis.

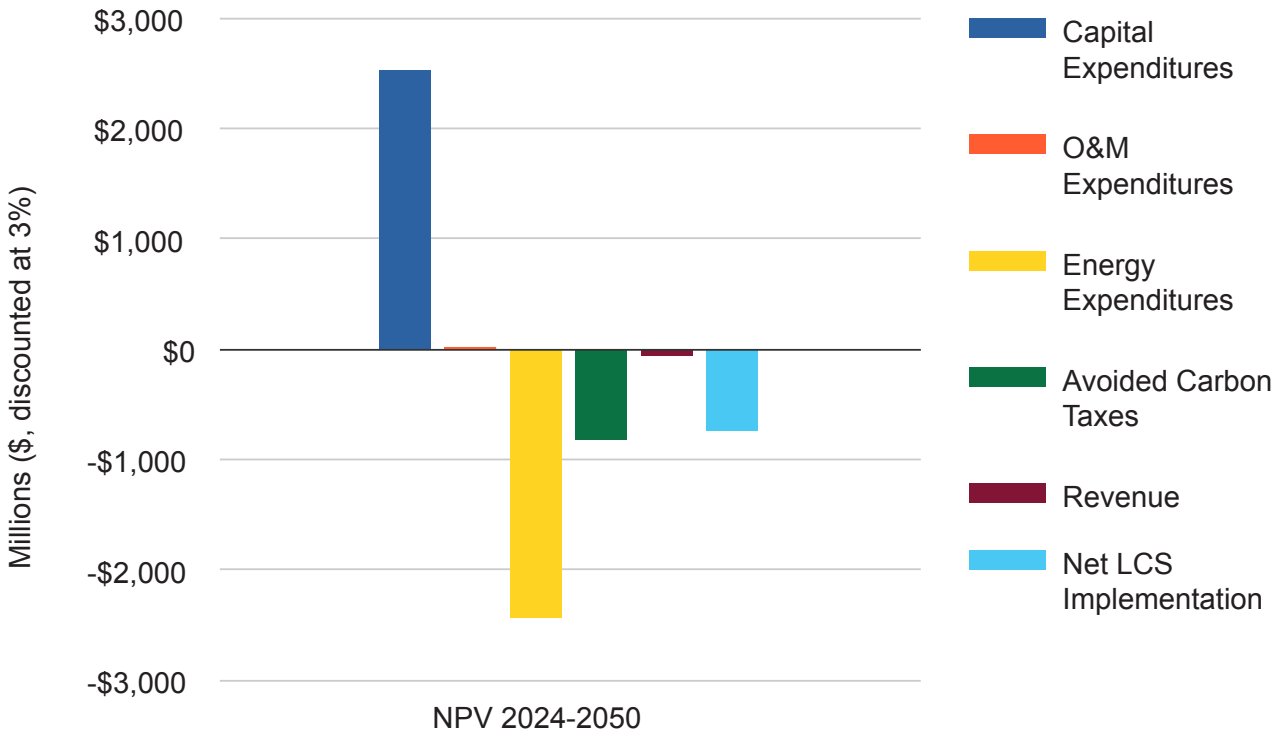


Figure 77. Cumulative investment and returns—NZ2040 Scenario.
Source: SSG analysis.

NZ2040 Scenario

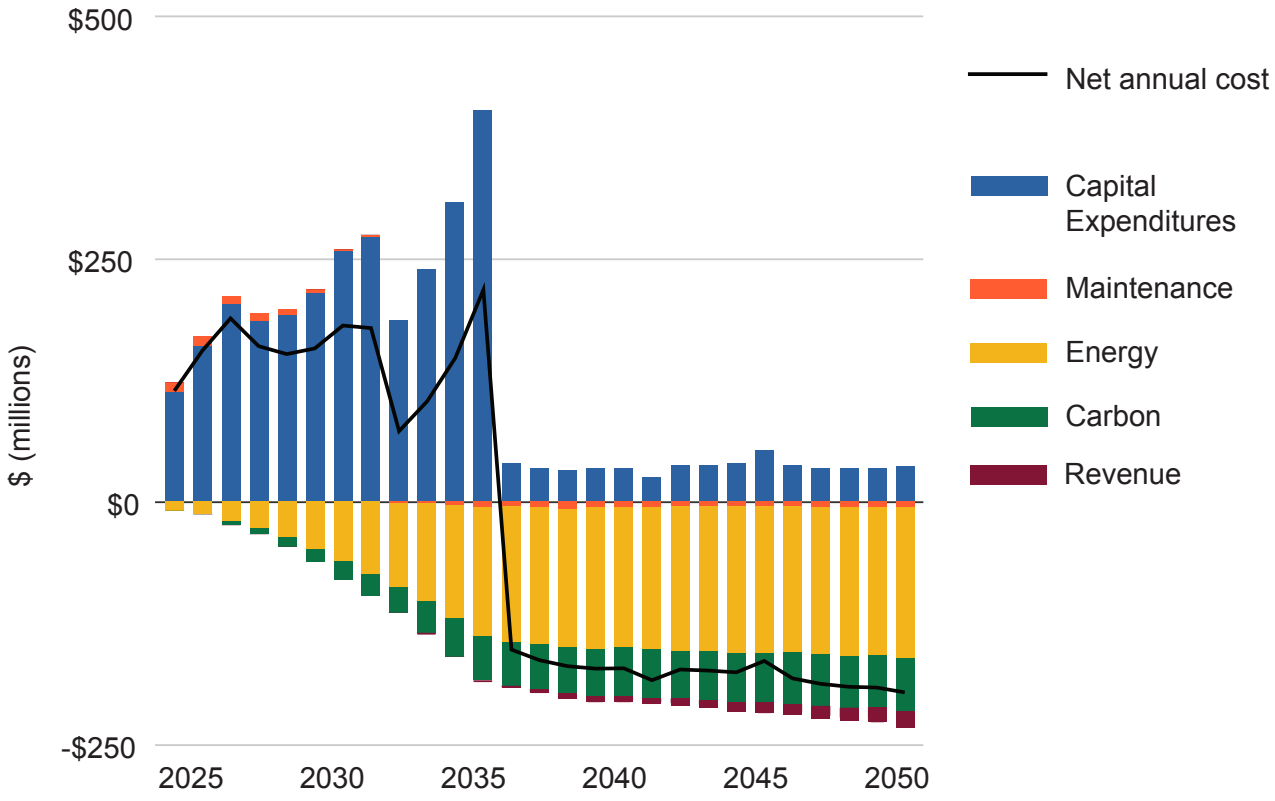


Figure 78. Year-over-year Low-Carbon Scenario investment and returns—NZ2040 Scenario. Source: SSG analysis.

Alternative Fuels Scenario

The net cost of this Low- Carbon Scenario (LCS) is -$663 million. The negative sign means that implementing all these actions between 2040 and 2050 results in overall savings since operational, energy, and carbon savings overcome capital investments.

Annual capital expenditure for the next five years (2025–2029, $82 million) totals 2% of Peterborough's GDP by 2020 ($4,901 million).

From 2046, savings start to exceed costs on an annual basis.

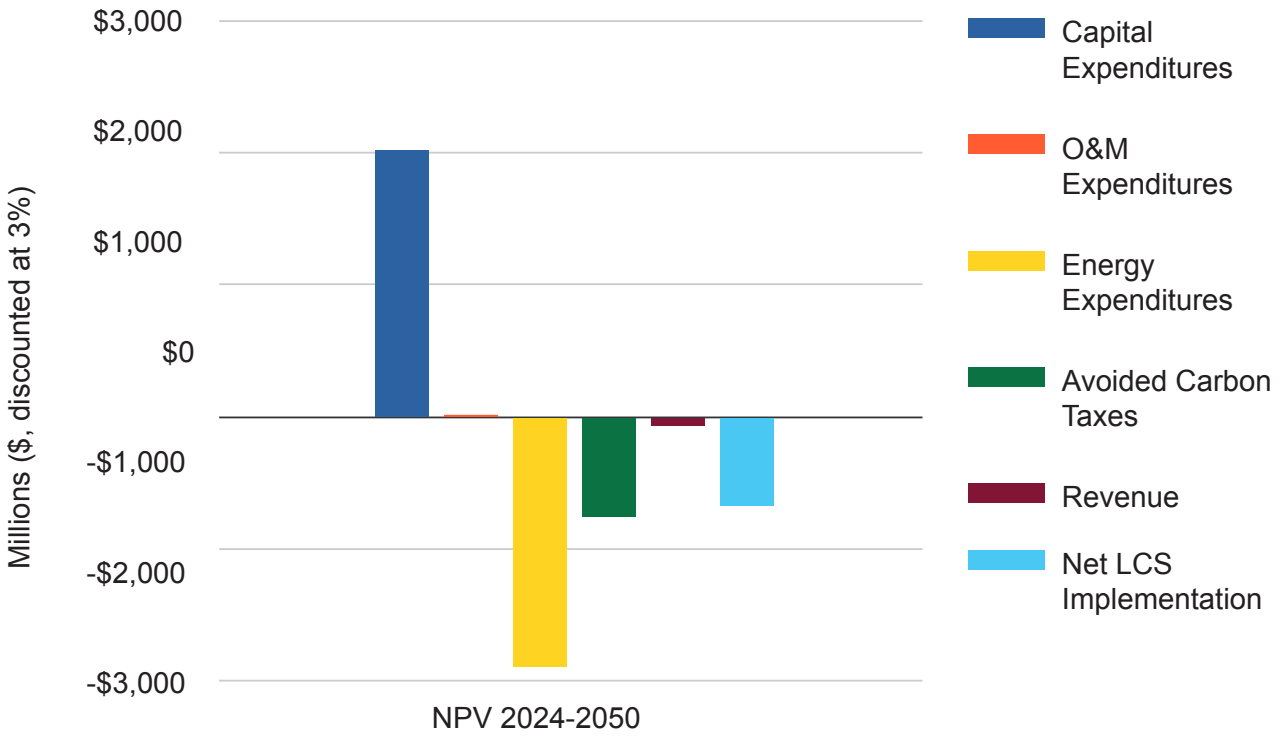


Figure 79. Cumulative investment and returns—Alternative Fuels Scenario.
Source: SSG analysis.

Alternative Fuels Scenario

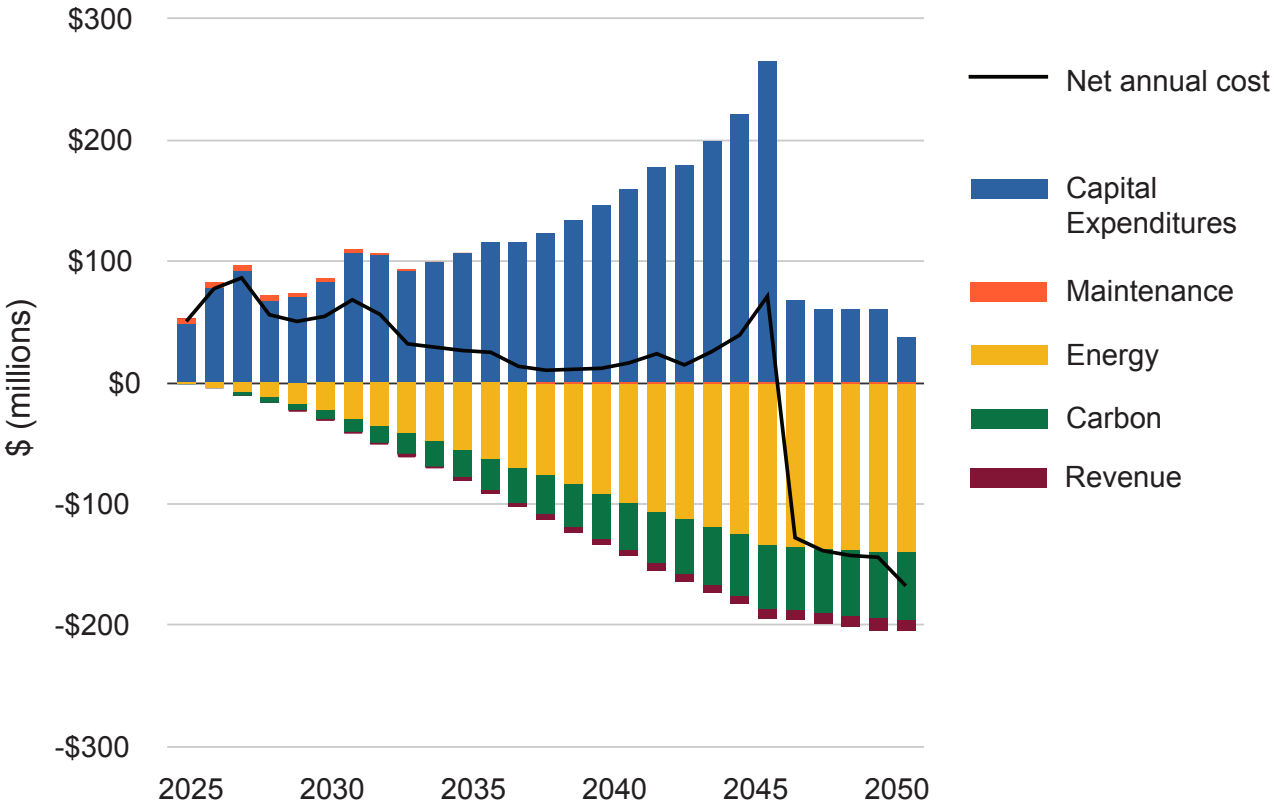


Figure 80. Year-over-year Low-Carbon Scenario investment and returns—Alternative Fuels Scenario. Source: SSG analysis.

Sustainable Transportation and Green Buildings Are the Key

The total costs are negative for all the sectors except land use. It is worth noting that land- use investments and actions are enabling actions used to achieve GHG reductions in other sectors. Land use sets the basis for urban planning, which means that this Big Move accounts for investment in construction projects to achieve a more dense city, which later supports access to public transit for residents and contributes to achieving a compact Peterborough.

The largest savings in all three scenarios comes from implementing the Sustainable Transportation and Green Buildings Big Moves (Figures 81, 82, and 83), the net costs of which account for more than -$573 million and -$480 million, respectively (for the NZ2050). These have the greatest impact on overall costs. In the NZ2040 Scenario, again, both the Sustainable Transportation and Green Buildings Big Moves contribute the most to the overall net costs with even larger savings, achieving -$516 million and -$671 million in total for transportation and buildings, respectively. The contributions are lower in the Alternative Fuels Scenario; however, they still equate to about -$304 million from Sustainable Transportation and -$467 million from Green Buildings.

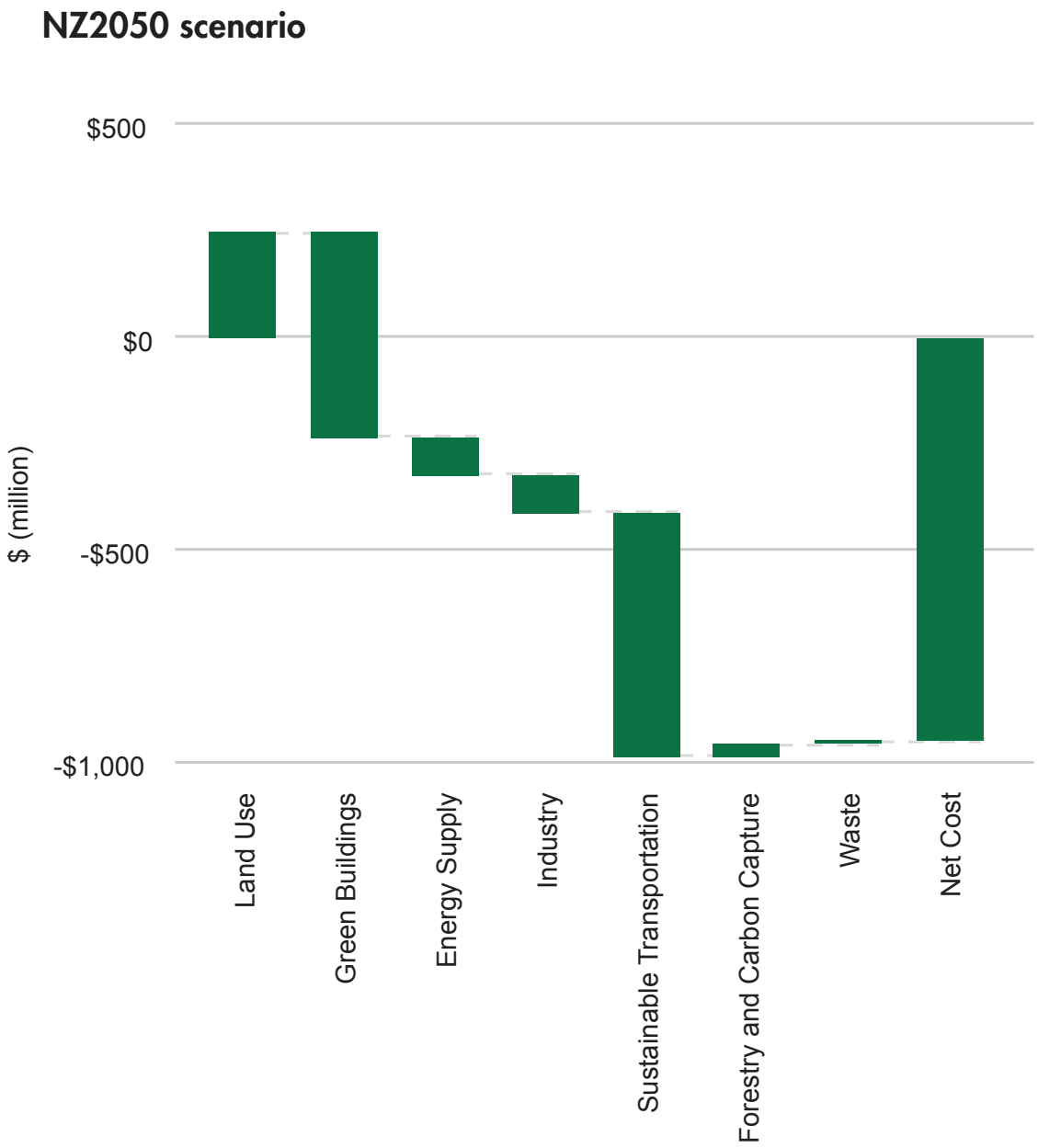


Figure 81. Total costs ($ million) by Big Move for the NZ2050 Scenario.
Source: SSG analysis.

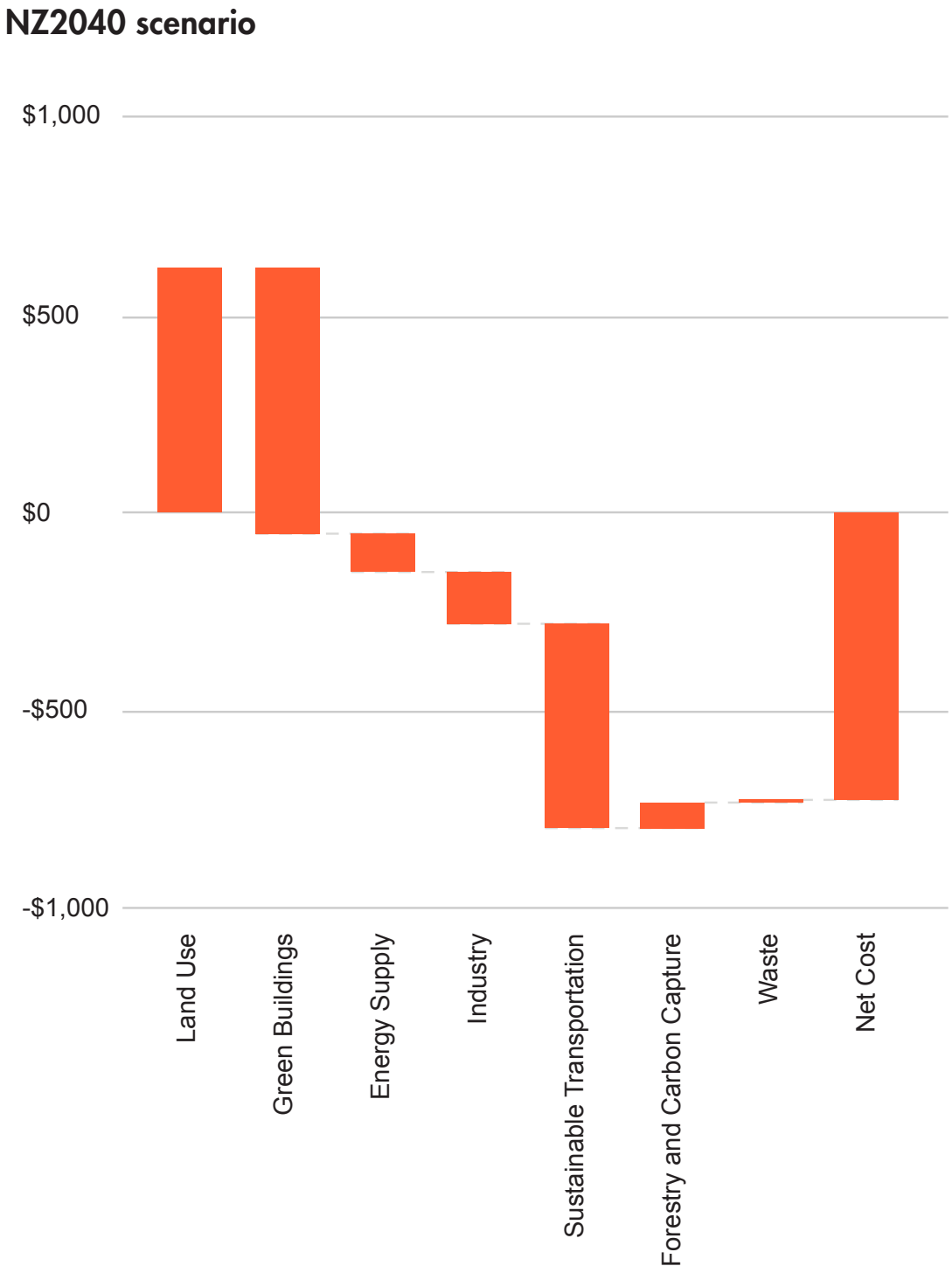


Figure 82. Total costs ($ million) by Big Move for the NZ2040 Scenario.
Source: SSG analysis.

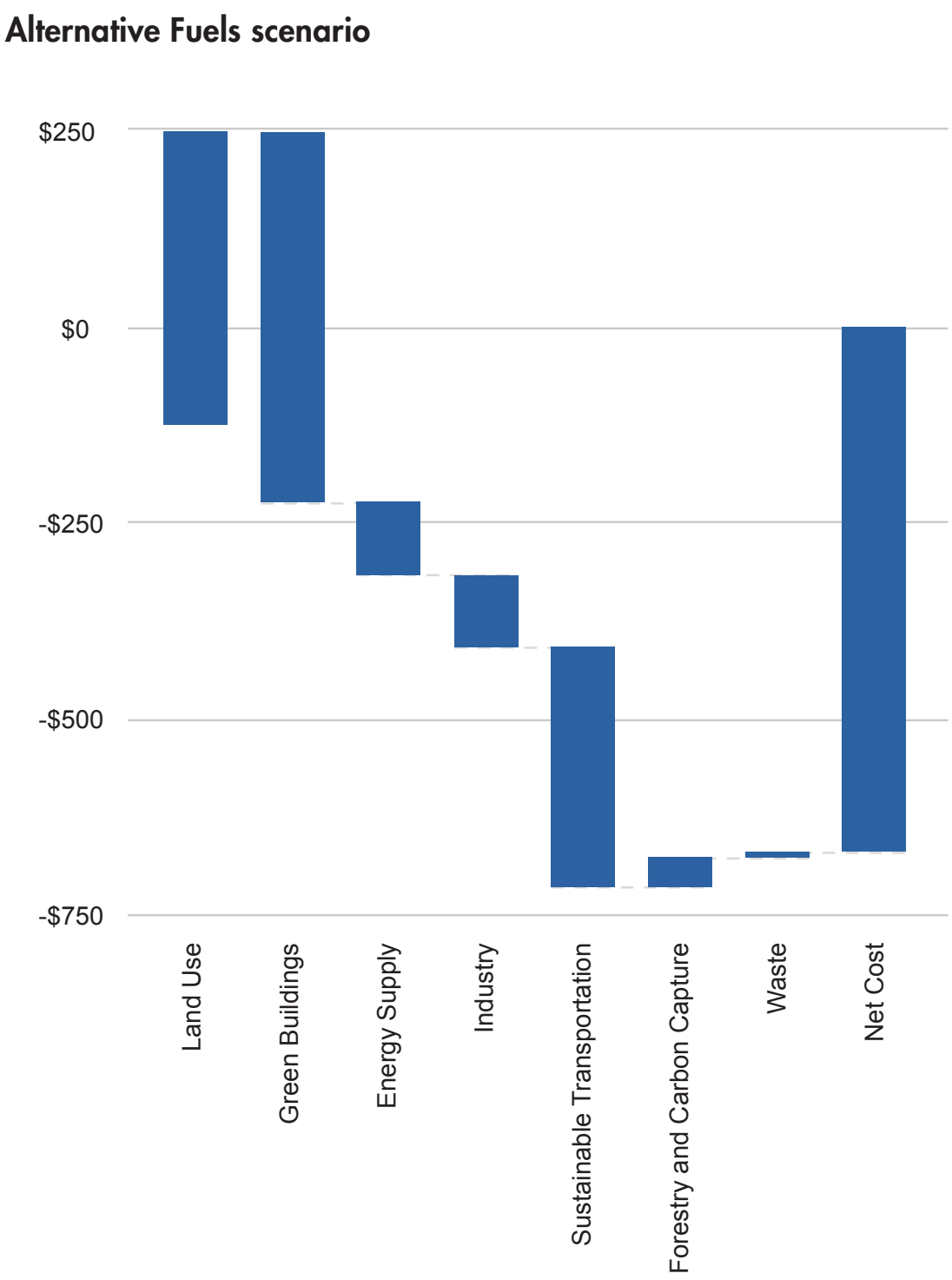


Figure 83. Total costs ($ million) by Big Move for the Alternative Fuels Scenario. Source: SSG analysis.

Cost Effectiveness on the Front

A marginal abatement cost curve (MACC) is a visual graphic that displays the financial modelling results for each scenario. It conveys the economic co-benefits (costs or savings) and the potential GHG reduction of each action. The curve organizes these actions from the most cost effective (larger benefits or savings) to the least cost effective (larger costs), which allows the identification of those policies or actions that are desirable due to their overall savings and those that will need funding support or larger efforts to implement them. The marginal abatement costs are calculated by dividing the net present value of a specific action by the GHG emission reductions achieved by the action during its lifetime.

It is worth noting that marginal abatement cost curves are only one of the inputs for analyzing mitigation options and their implementation challenges because they do not account for all the benefits and costs of action implementation. For example, a cost-effective action would mean that implementing it will bring net savings to society; however, this does not consider institutional barriers or financial constraints due to capital expenditures. On the other hand, some actions may appear as less cost-effective than others, meaning they have an overall net cost, but this does not account for non-monetary benefits such as noise reduction and mental health co-benefits , which may result in net gains or even net benefits. In this context, MACCs do not provide information on the time dimension of the measure. In other words, the curve organization does not imply a time implementation order and does not highlight which actions require more urgent implementation. Finally, since the Climate Change Action Plan 2.0 aims to propose a plan for the city, although it is Council that is responsible for implementation, the curve does not differentiate for distributional impacts[57], which refers to who bears the costs and enjoys the benefits.

Table 36 shows the marginal abatement costs of all low-carbon scenarios, as well as their total costs and mitigation potential. Figures 84, 85, and 86 display all modelled actions, organized according to their marginal abatement costs. Table 37 lists the total costs of each action, their mitigation potential, and their marginal abatement costs.

[57] Saujot, Mathieu, and Benoit Lefèvre. "The next Generation of Urban MACCs. Reassessing the Cost-Effectiveness of Urban Mitigation Options by Integrating a Systemic Approach and Social Costs." Energy Policy 92 (May 1, 2016): 124–38. https://doi.org/10.1016/j.enpol.2016.01.029

Table 36. Marginal abatement costs in $/tCO$_2$e of each modelled scenario. Source: SSG analysis.

	Total Costs ($ million)	Total GHG Reduction (kt CO$_2$e)	Marginal Abatement Costs ($/tCO$_2$e)
NZ2050	-$950	4,544	-$209
NZ2040	-$728	5,752	-$127
Alternative Fuels	-$664	5,456	-$122

How to Read a MAC Curve

A marginal abatement cost curve visually represents the cost-effectiveness of different strategies (actions or measures) for reducing greenhouse gas emissions. In the graph, the x-axis typically shows the amount of emissions reduced (measured in ktCO$_2$e), while the y-axis displays the cost or savings per unit of reduction ($/tCO$_2$e). The total emissions reductions in the x-axis matches the total cumulative emissions reductions of each scenario. Each bar on the curve represents a specific abatement measure, with those lower on the y-axis being more cost-effective and those higher up being more expensive. The curve helps identify which measures offer the greatest reductions at the lowest cost.

In the graph, the list of actions is organized and the name of each action is described and linked to its corresponding bar. In parentheses, the total net costs of the action are displayed first (million dollars [$]) and the cumulative emission reductions in ktCO$_2$e second.

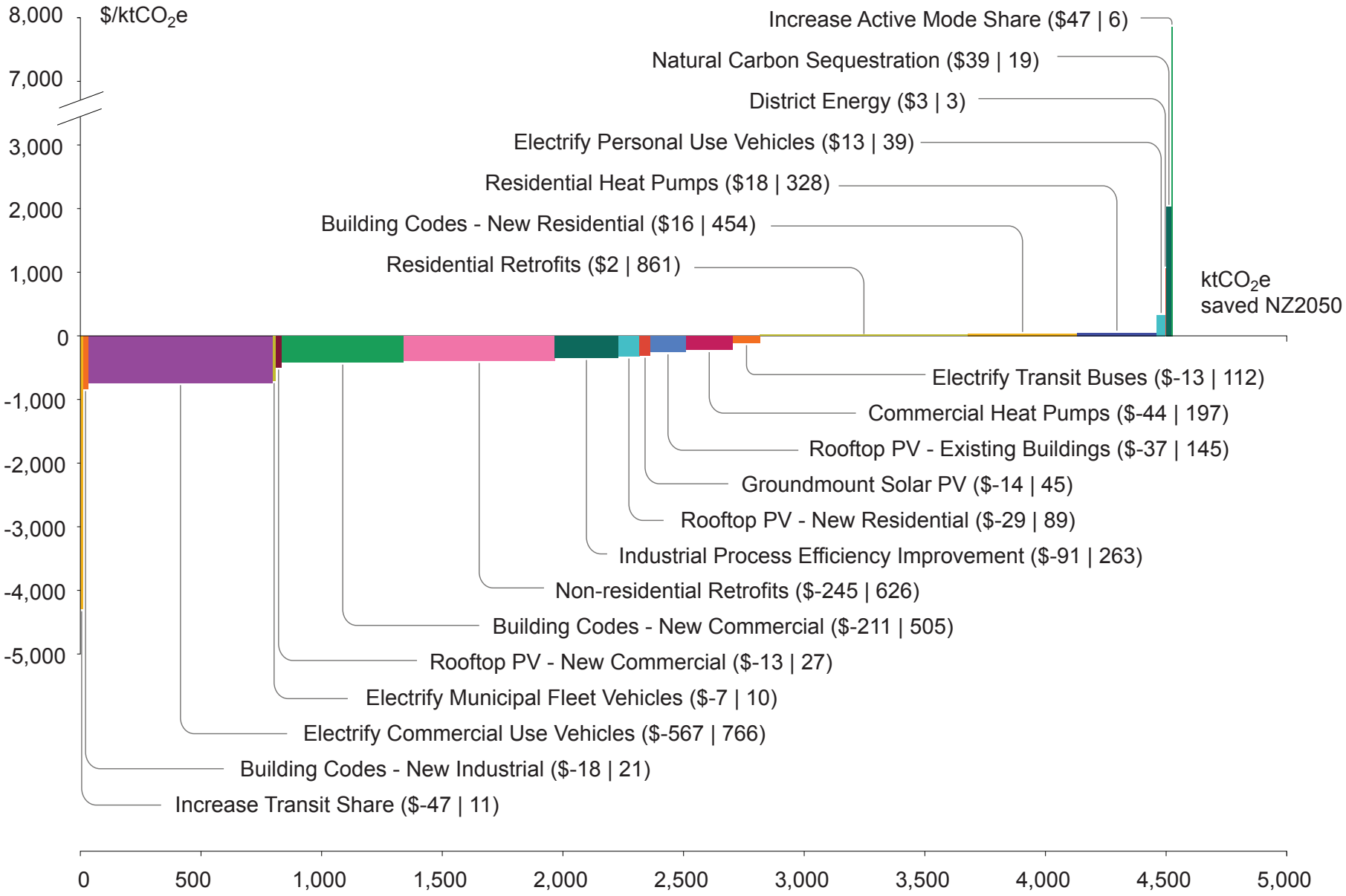


Figure 84. Marginal abatement cost curve for the NZ2050 Scenario. Source: SSG analysis.

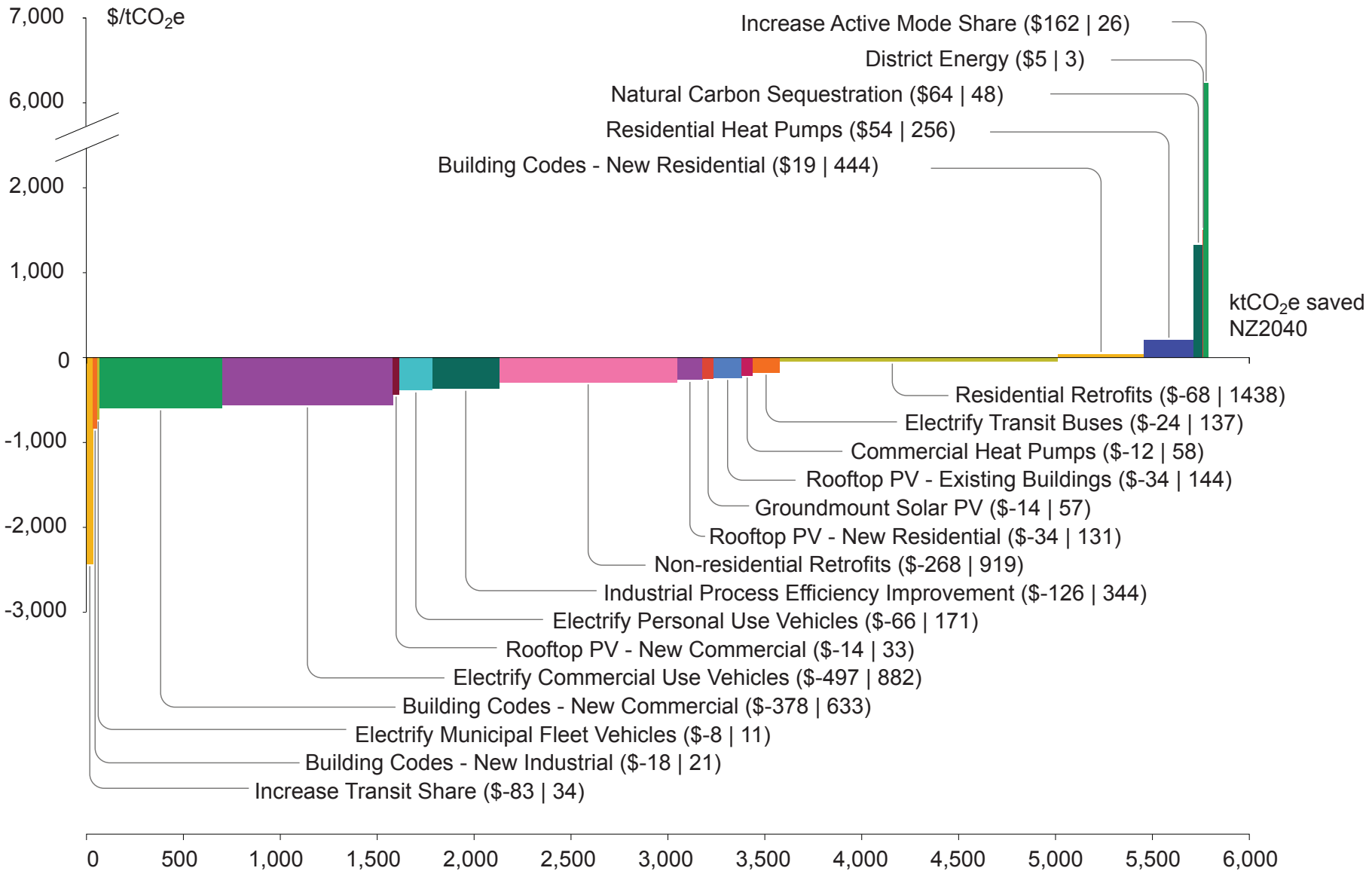


Figure 85. Marginal abatement cost curve for the NZ2040 Scenario. Source: SSG analysis.

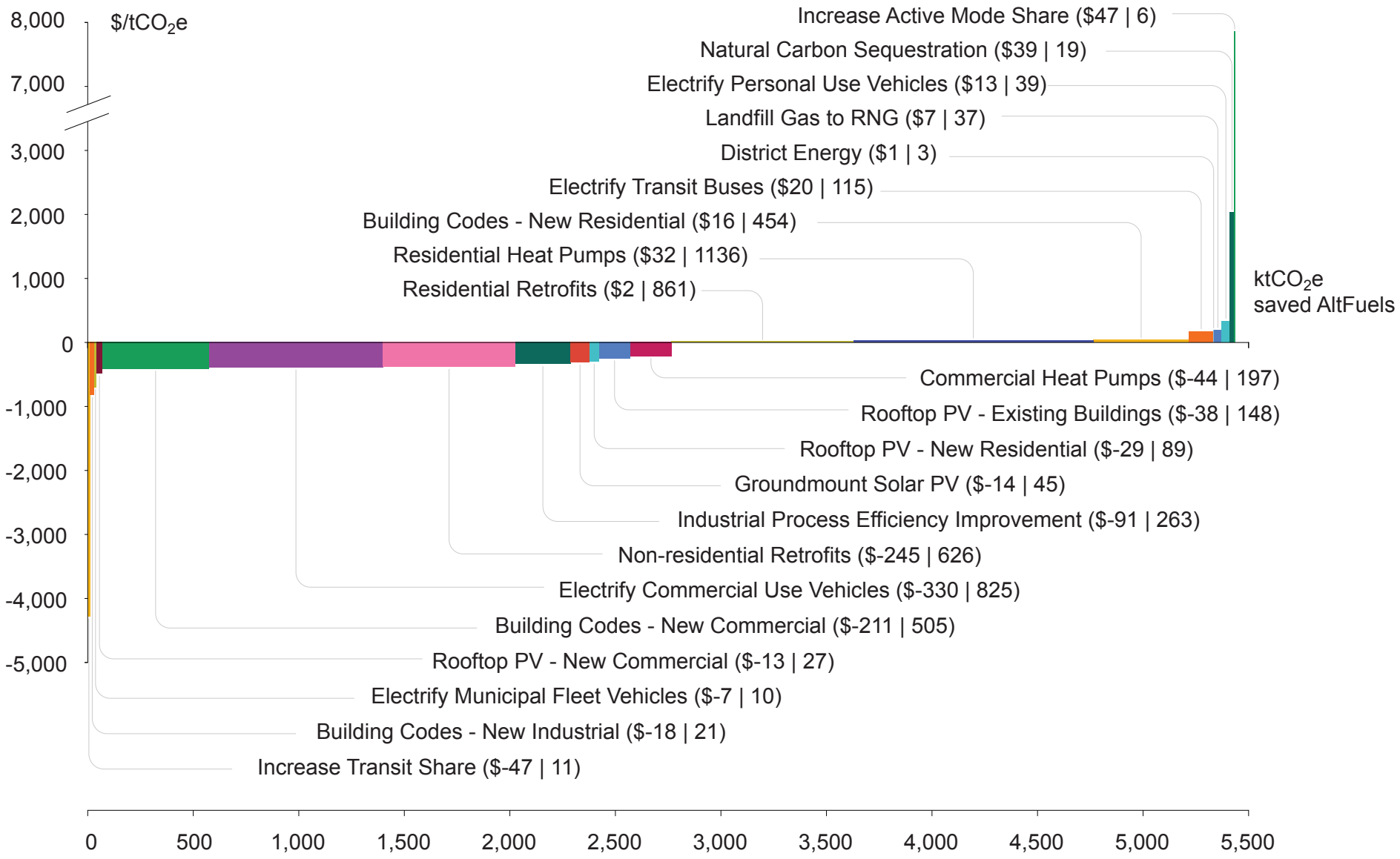


Figure 86. Marginal abatement cost curve for the Alternative Fuels Scenario. Source: SSG analysis.

Table 37. Marginal abatement costs by action by scenario ($/tCO$_2$e). Source: SSG analysis.

Mitigation Action	NZ2050 ($/tCO$_2$e)	NZ2040 ($/tCO$_2$e)	Alternative Fuels ($/tCO$_2$e)
Increase Transit Share	-4,311	-2,437	-4,310
Building Codes—New Industrial	-826	-821	-826
Electrify Commercial-Use Vehicles	-739	-563	-400
Electrify Municipal Fleet Vehicles	-716	-722	-715
Rooftop PV—New Commercial	-492	-431	-492
Building Codes—New Commercial	-417	-598	-417
Non-Residential Retrofits	-392	-292	-391
Industrial Process Efficiency Improvement	-345	-368	-347
Rooftop PV—New Residential	-323	-262	-323
Ground-Mount Solar PV	-312	-246	-312
Rooftop PV—Existing Buildings	-257	-240	-256
Commercial Heat Pumps	-222	-212	-222
Electrify Transit Buses	-112	-177	173

Mitigation Action	NZ2050 ($/tCO$_2$e)	NZ2040 ($/tCO$_2$e)	Alternative Fuels ($/tCO$_2$e)
Residential Retrofits	3	-47	3
Building Codes—New Residential	36	44	36
Residential Heat Pumps	55	212	28
Electrify Personal-Use Vehicles	331	-387	331
District Energy	1,037	1,724	192
Natural Carbon Sequestration	2,023	1,340	2,023
Increase Active Mode Share	7,569	6,345	7,569

All mitigation actions above "Residential Heat Pumps" in the NZ2050, and "Electrify Personal-Use Vehicles" in the Alternative Fuels and NZ2040 scenarios are more cost-effective than bearing the costs of climate damages ($266/tCO$_2$e).[58] In all scenarios, more than half of these actions represent net benefits from implementation, meaning that even without considering climate change, implementing these actions brings overall savings and benefits to the City of Peterborough's sectors and residents.

[58] Canada's social cost of carbon is $266 per tonne of CO_{2e}.

Low-Carbon Scenarios Bring Co-Benefits

Implementing mitigation actions creates a whole set of co-benefits, such as reduced energy bills due to the implementation of energy efficiency measures and cleaner air related to the adoption of electric vehicles, which also improves the health and quality of life of the city's residents (see Figure 87).

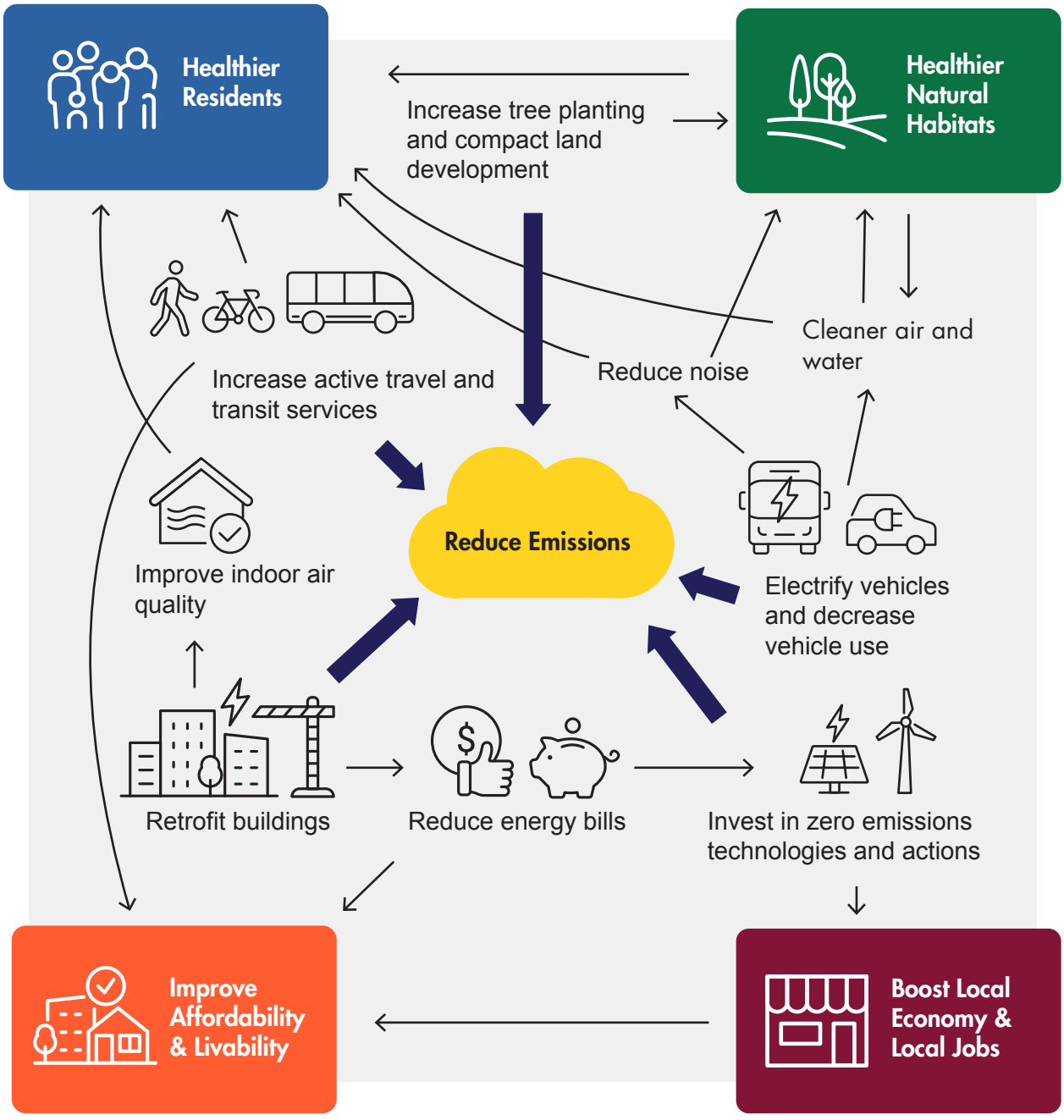


Figure 87. Key benefits to reducing GHG emissions through mitigation actions.
Source: SSG analysis.

Considering equity in the low-carbon transition will also guarantee that no one is left behind. The City of Peterborough will commit to ensuring all policies and programs developed in the context of this Climate Change Action Plan 2.0 have an equity lens. This is translated into lifting barriers for low-income households, minorities (women, BIPOC, LGBTQ+ communities), the unemployed, immigrants, and others facing a wide variety of burdens to ensure they can access greener transportation alternatives, increase their access to green spaces, and reduce their energy bills and to ensure they are part of the decision-making process through a proper engagement plan.

A low-carbon future will also bring economic prosperity for the city of Peterborough, creating new jobs for local residents (Figures 88, 89, and 90), strengthening residents' resilience to climate impacts, and creating new markets and new capacities in sustainable areas for locals. One of the largest contributing factors to the creation of new jobs is the need to retrofit existing residential and non-residential buildings. Over the 2024-2050 period, the NZ2050 and Alternative Fuels scenarios will create more than 16,000 new jobs, and the NZ2040 Scenario will create more than 17,000 jobs in areas such as construction; energy generation; electric vehicle manufacturing, operation, and maintenance; and energy efficiency.

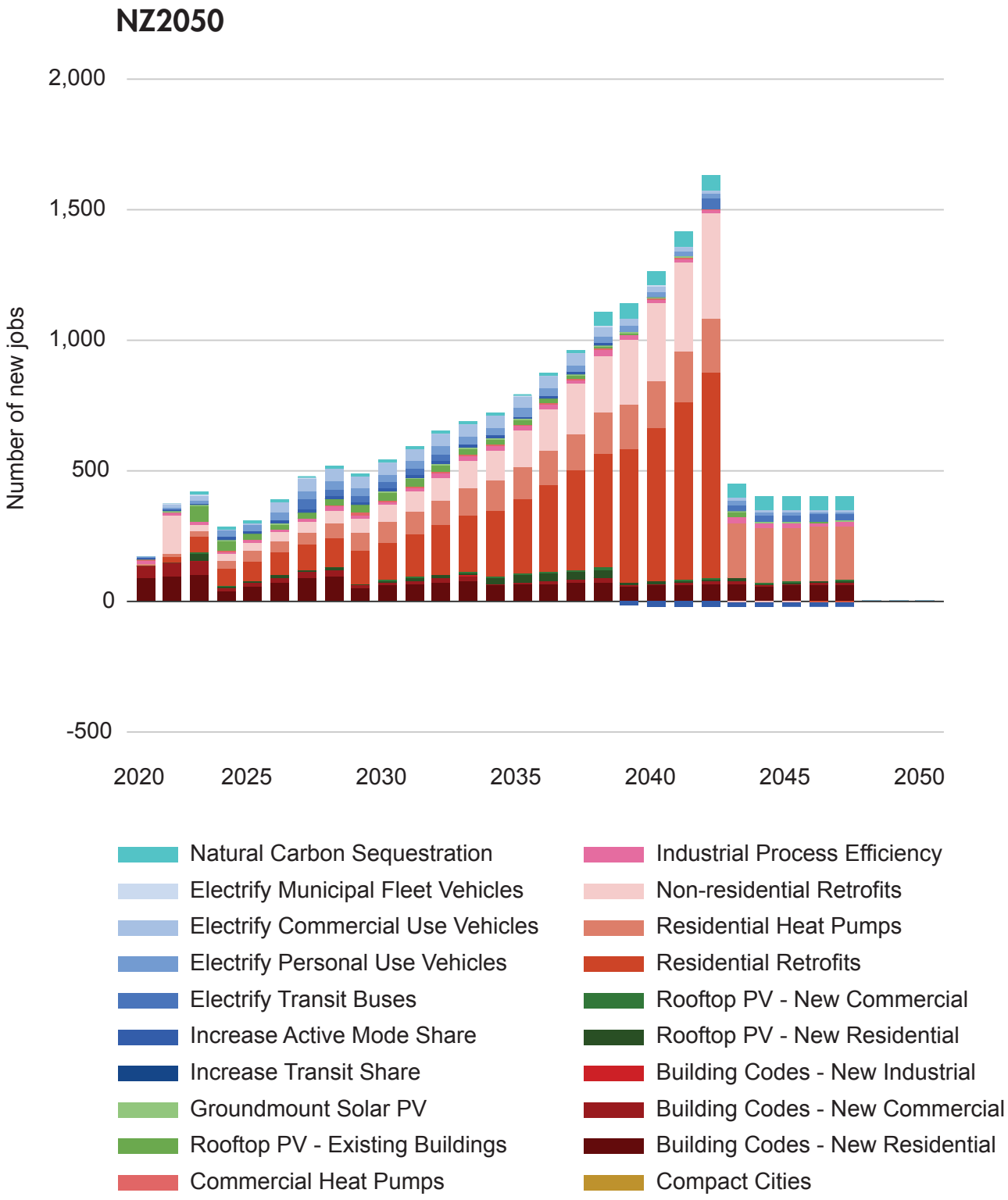


Figure 88. Total new jobs year over year for the NZ2050 Scenario.
Source: SSG analysis.

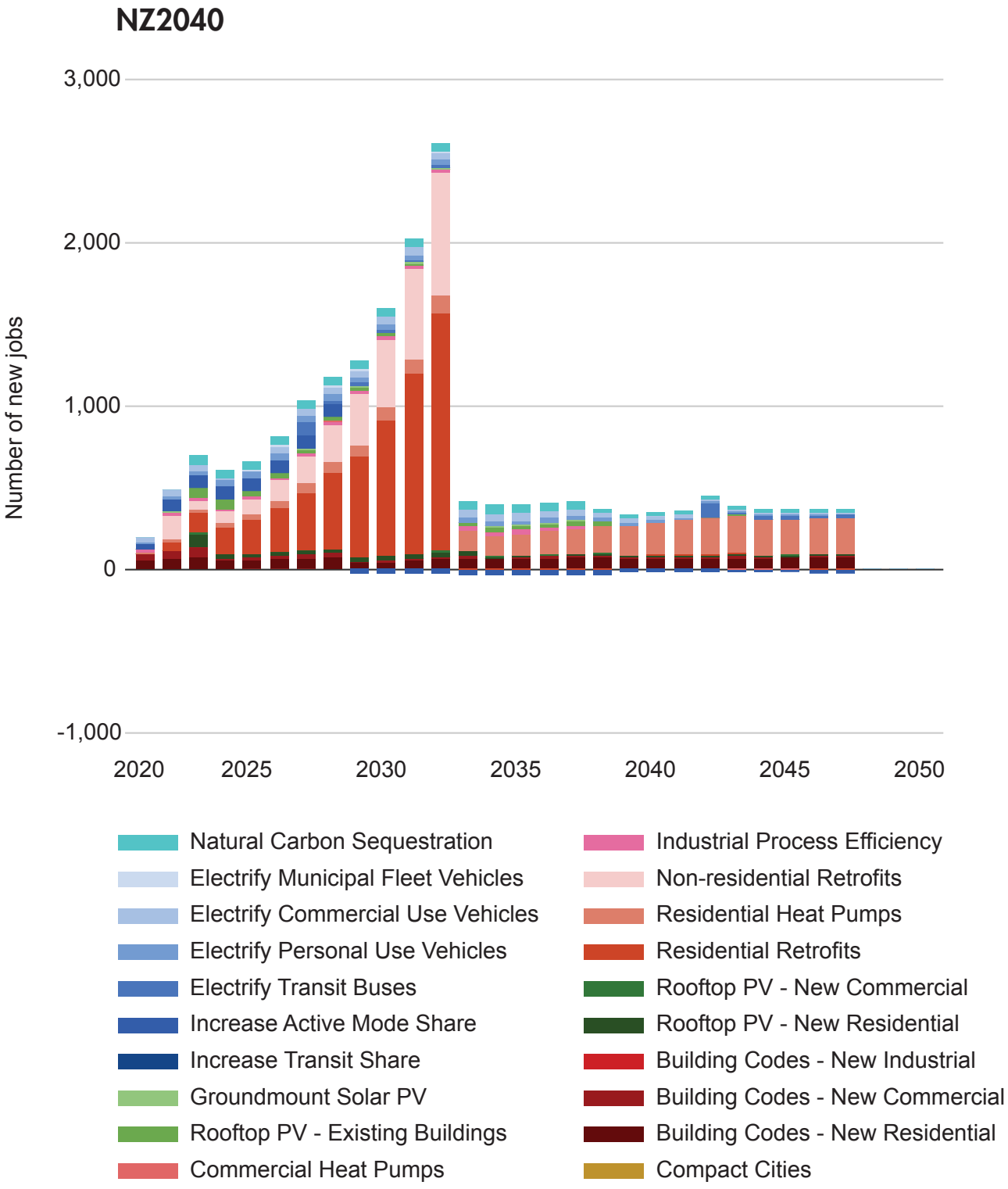


Figure 89. Total new jobs year over year for the NZ2040 Scenario.
Source: SSG analysis.

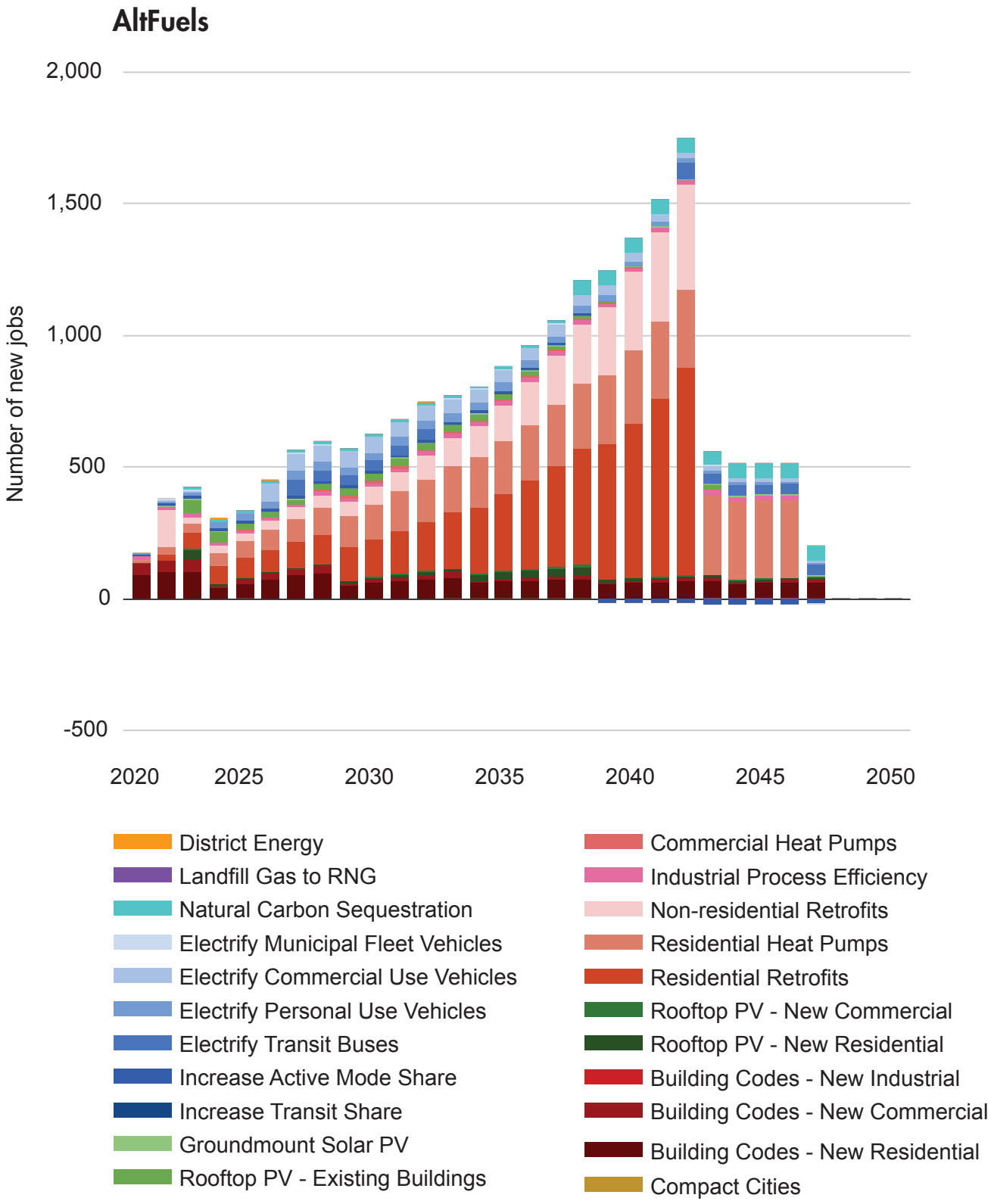


Figure 90. Total new jobs year over year for the Alternative Fuels Scenario.
Source: SSG analysis.

Energy savings from household retrofits and heat pumps equal more than $310 million between 2024 and 2050, directly impacting household finances and reducing the energy burden. The City of Peterborough will implement the HEEP program and will consider these burdens and focus its programs on advancing climate action in low-income areas and communities that have been historically marginalized. Part of these efforts will consider lifting the barriers to applying for support, especially in the census tracts outlined in Table 38.

Table 38. Census tracts in the city of Peterborough facing different burdens. Source: SSG analysis based on data from Canadian Urban Sustainability Practitioners, 2024[59].

Census tracts with more than 8% of Indigenous households	Census tracts with more than 20% of households with income below the after-tax Low Income Measure	Census tracts with more than 20% of households with a very high home energy cost burden 10%+
#5290007.00	#5290007.00	#5290007.00
#5290005.00	#5290005.00	#5290010.00
#5290010.00	#5290010.00	#5290004.00
	#5290008.00	#5290005.00

[59] Canadian Urban Sustainability Practitioners. "Energy Poverty Canada." Data and Tools. Energy Poverty, 2024. https://energypoverty.ca/

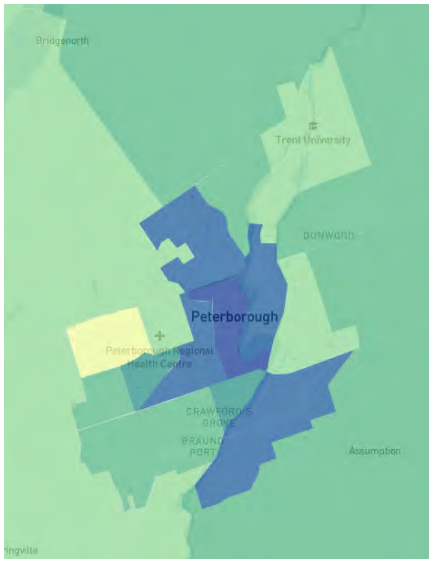
These census tracts face energy poverty, comprise the higher share of Indigenous households and low-income earners, and consist of the areas with poorer housing conditions that require major repairs (Figure 91).

Very high home energy cost burden 10%+: Households spending 10% or more of their after-tax income on home energy as a percentage (%) of all households.

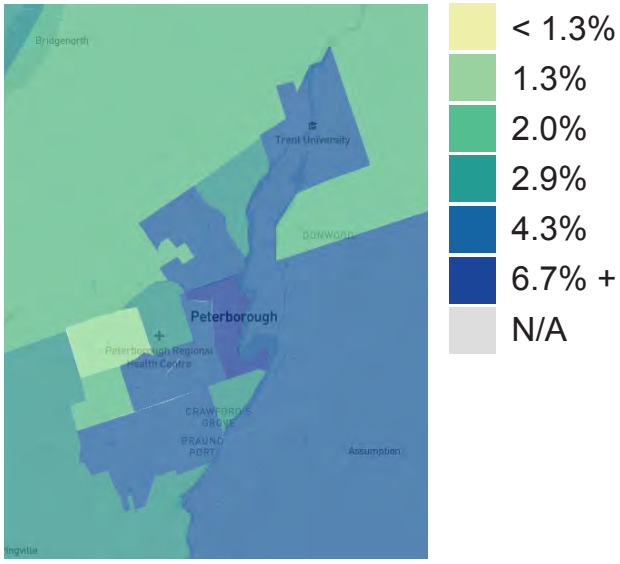
Households with income below the after-tax Low Income Measure: Households with income below the after-tax Low Income Measure as a percentage (%) of all households.

Indigenous households: Households with at least one person aged 18+ who is of Aboriginal identity. "Aboriginal identity" refers to identification with the Aboriginal peoples of Canada, including those who are First Nations (North American Indian), Métis, or Inuk (Inuit), and/or those who are Registered or Treaty Indians (that is, registered under the Indian Act of Canada), and/or those who have membership in a First Nation or Indian band. Aboriginal peoples of Canada are defined in the Constitution Act, 1982, Section 35 (2) as including the Indian, Inuit, and Métis peoples of Canada.

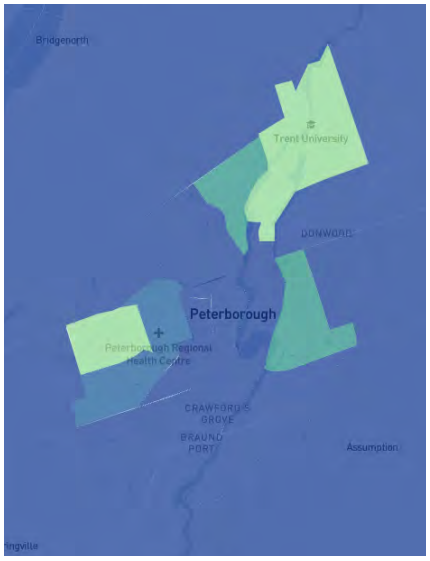
Housing condition—major repairs: Households in a dwelling requiring major repairs (%). The "major repairs needed" category includes dwellings needing major repairs, such as dwellings with defective plumbing or electrical wiring and dwellings needing structural repairs to walls, floors, or ceilings.



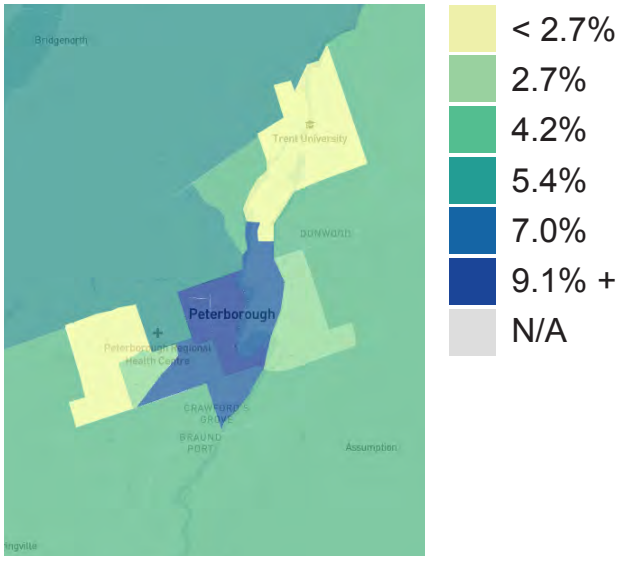
Households with income below the after-tax Low Income Measure



Indigenous households



Very high home energy cost burden 10%+



Housing condition - Major repairs

Figure 91. Mapping the city of Peterborough census tracts with low-income households, Indigenous households, and households with very high energy burden and poor housing conditions. Source: (Canadian Urban Sustainability Practitioners, 2024)[60].

[60] Canadian Urban Sustainability Practitioners. "Energy Poverty Canada." Data and Tools. Energy Poverty, 2024. https://energypoverty.ca/

Challenges of the Peterborough Energy System

Increasing electricity consumption poses a significant challenge for Peterborough's energy system, particularly heating and cooling. One potential solution to replace natural gas in the residential sector is the deployment of renewable energy sources, such as solar power, at the community and on-site levels. In the transportation sector, all scenarios emphasize the importance of transitioning to electric vehicles and moving away from gasoline and diesel. In contrast, full electrification in the industrial sector is more challenging; therefore, this sector will continue to rely on fuels like natural gas, with efforts focused on enhancing the efficiency of industrial processes to reduce greenhouse gas emissions.

To achieve a sustainable and reliable energy system in Peterborough, it is essential to implement measures that increase energy efficiency while transitioning to clean fuels. By doing so, the new demand created by electrification can be met as the city maximizes its energy efficiency. Figures 92, 93, 94, and 95 show how the energy system needs to transition to a low-carbon and more efficient system.

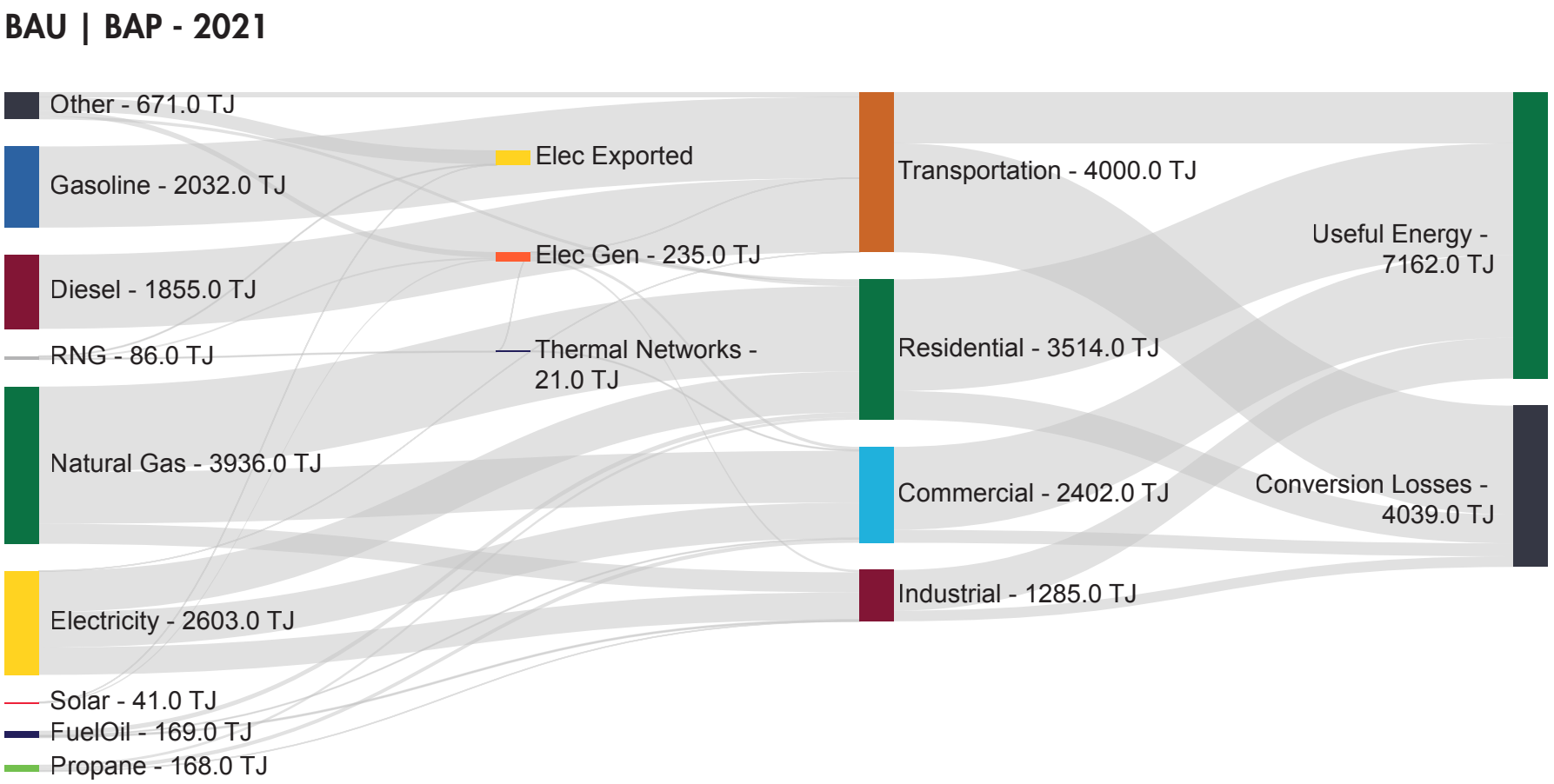


Figure 92. Illustration of the energy system flows in 2021. The coloured bars show the amounts of energy in terajoules (TJ), and the thickness of the light grey flowing lines show the quantities of energy distributed for different uses.

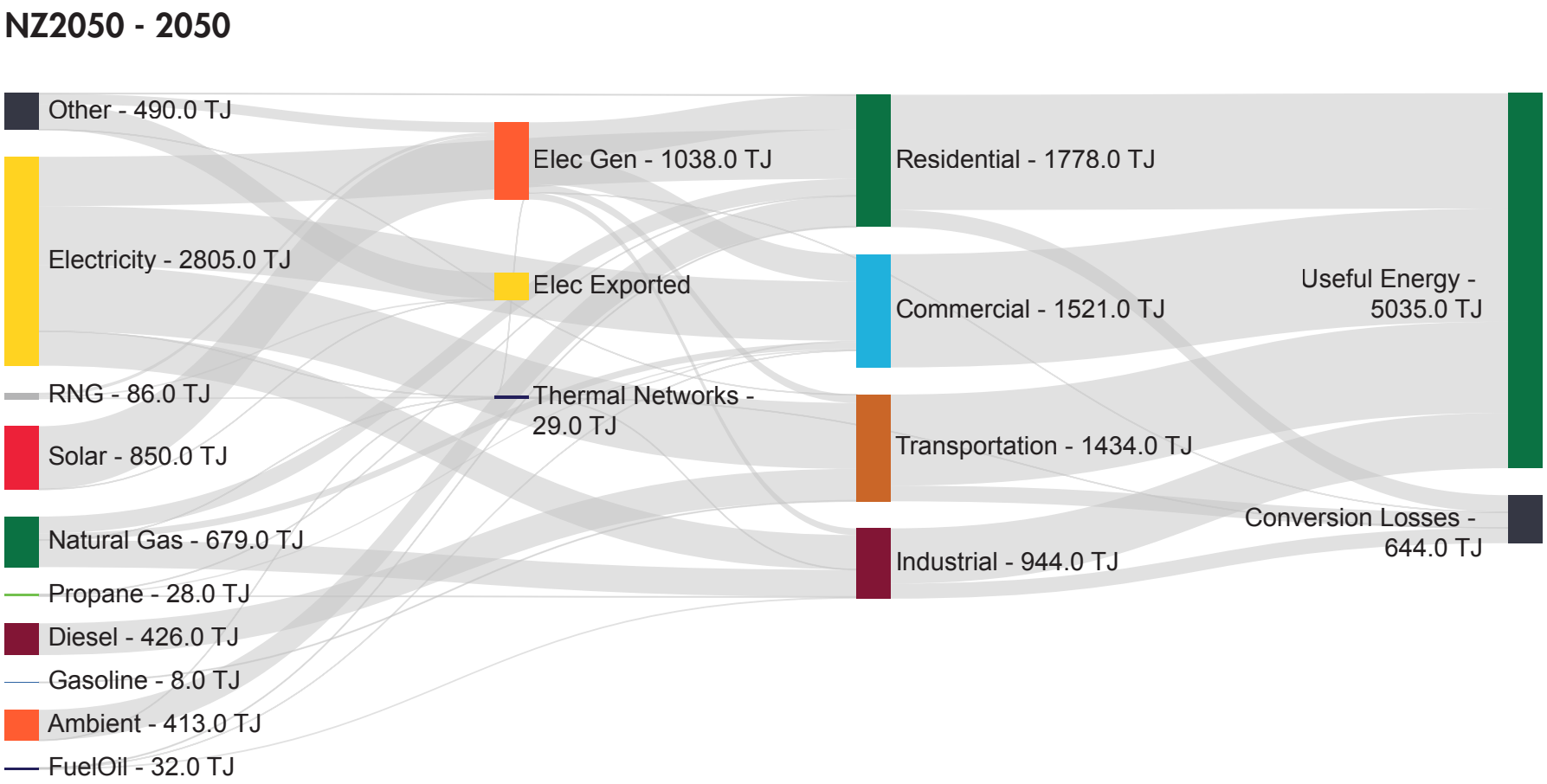


Figure 93. Illustration of the energy system flows in 2050 for the NZ2050 Scenario.

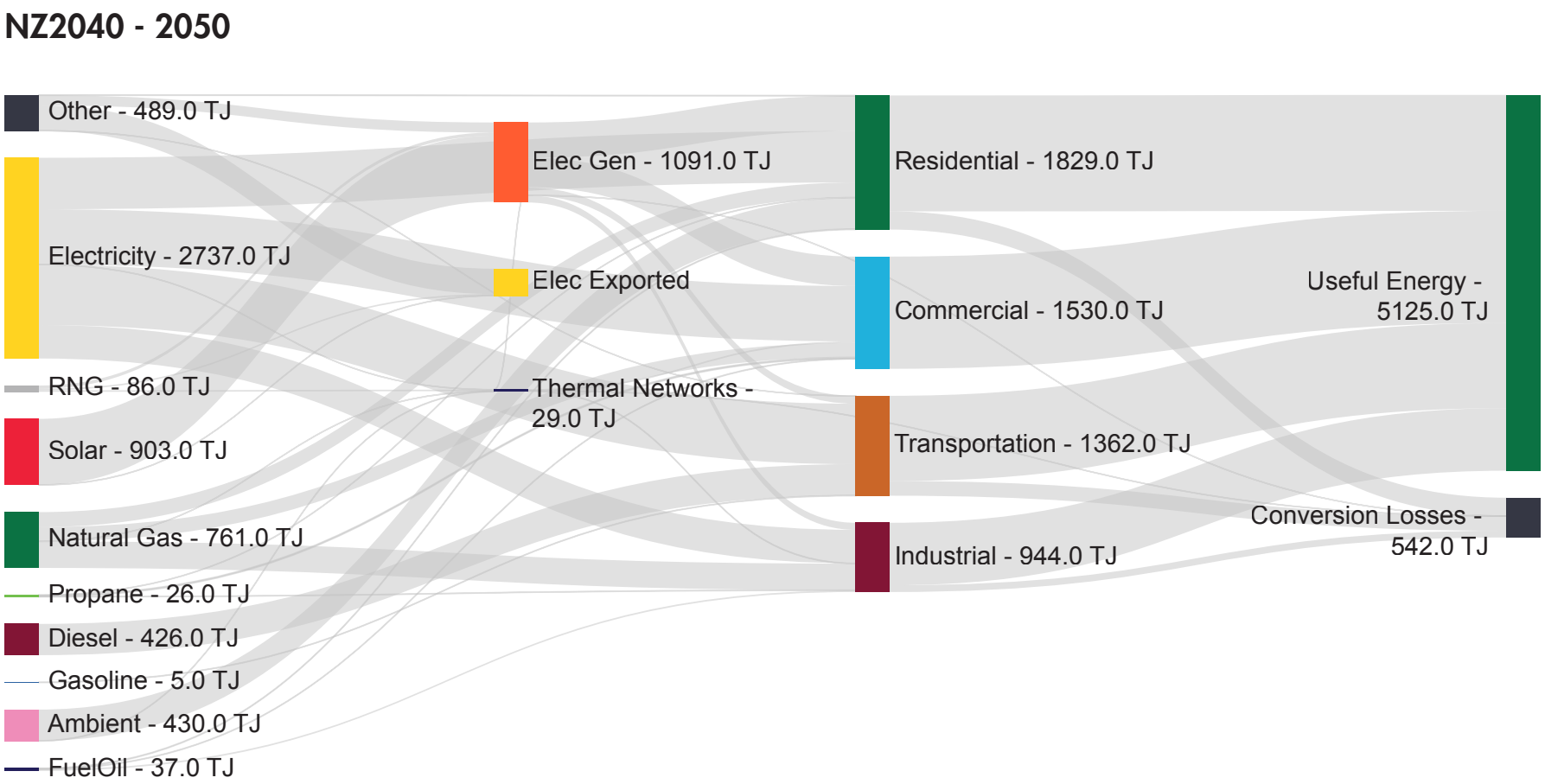


Figure 94. Illustration of the energy system flows in 2050 for the NZ2040 Scenario.

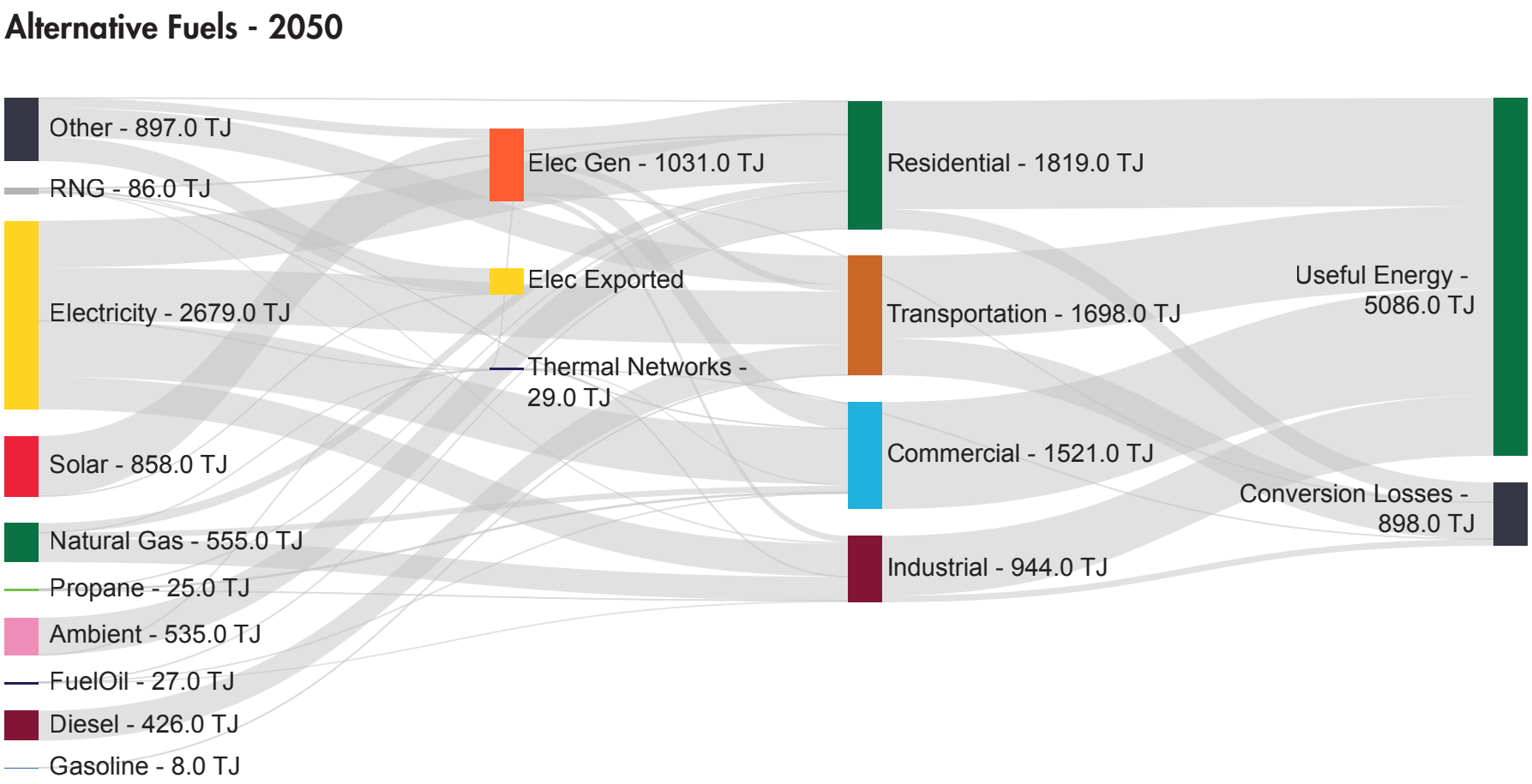


Figure 95. Illustration of the energy system flows in 2050 for the Alternative Fuels Scenario.

The Costs of Inaction: Social Cost of Carbon

Greenhouse gas emissions reduction actions come with intergenerational equity challenges. Mitigating in the present will mean coping with limited future impacts that human societies and ecosystems can bear. However, there will still be climate change impacts for both current and future generations due to the nature of greenhouse gases, which can last for centuries in the atmosphere. This means that each tonne of carbon dioxide emitted today will last for up to two centuries (200 years) and it accumulates with the historical GHG emissions of our past generations.

Since GHGs accumulate in the atmosphere, each tonne of carbon is additional to the current concentrations, and thus, the impacts of climate change are not linear, but exponential and so are the damages. In other words, one tonne of carbon emitted a decade ago does not cost society the same as a tonne of carbon emitted today. The costs to society of emitting an additional tonne of CO_2 can be explored through the Social Cost of Carbon.

The cumulative Social Cost of Carbon (Figure 96) between 2024 and 2050 for the City of Peterborough's Business-as-Usual Scenario is $4,209 million. Implementing the NZ2050 Scenario's mitigation efforts will reduce the Social Cost of Carbon to $2,424 million, $2,348 million for the Alternative Fuels Scenario, and a bit more than $2,073 million for the most ambitious scenario (NZ2040). This emissions reduction positively impacts future generations by reducing the burdens of climate change.

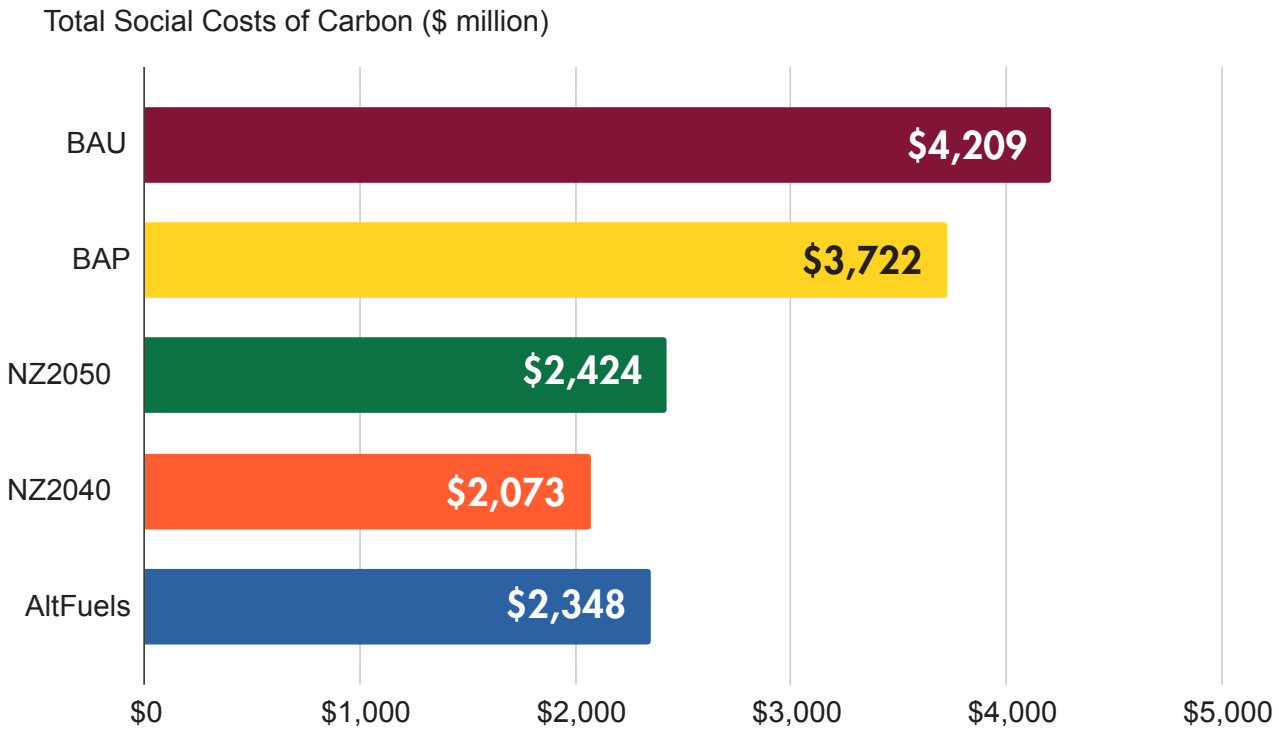


Figure 96. Social Cost of Carbon for each of the scenarios. Source: SSG analysis.

Where Does the Money Come From?

Financing is one of the key challenges faced by municipalities seeking to meet ambitious climate action commitments. To create new economic opportunities and spur investment in the green economy, new funding strategies are needed from the public and private sectors. These strategies can include public initiatives such as revolving funds with low interest for entire projects, funds for early-stage projects (thereby attracting further private sector investment for design and construction), loan guarantees, community bonds, and tax rebates. Private sector strategies have included creating specially tailored Energy Service Agreements where initial costs are paid back through energy savings on the building utility bills.

Table 39 lists other sources of funding, depending on the action type. Complementing these efforts, other levels of governments are also key enablers to support the City of Peterborough to transition to a low-carbon future. Some of these enabling actions are:

- Provincial authorities shall adhere to national commitments (i.e., EV sales target, Canada's new Energy Code) or beyond, for which the City of Peterborough can advocate for provincial authorities.
- The government of Ontario shall accelerate the availability of financial, regulatory, and legal mechanisms to support local governments in achieving its 2030 GHG mitigation goal (37% below 1990 levels by 2030).
- Ontario needs to advance to a zero-carbon energy generation system in collaboration with other jurisdictions to support decarbonization pathways, as well as to assess the need for new infrastructure and energy generation to satisfy new electricity demand.
- The federal government generates larger revenue generation opportunities and funding streams than local governments and has the responsibility to offer these funding alternatives to local governments in the context of Canada's commitment to reduce GHG emissions by 2030 and 2050.

Table 39. Funding sources available for each of the mitigation actions.
Source: SSG analysis.

Big Move	
Green Buildings	
Action Name	**Energy efficiency in buildings**
Enabler	Enabled by the federal government and encouraged by other levels of government to adopt and go beyond the National Code. Energy Star Canada Program supported by Natural Resources Canada and aligned with the National Building Code. Bylaw number 17-067: Bylaw to require owners of lodging houses and rental dwelling units to obtain a business licence: Requirements of complying with the building code to obtain a business licence or licenced rental premises. Program backed up by the Canadian Net-Zero Emissions Accountability Act.
Funding Source	Codes Acceleration Fund Green Municipal Fund's Community Efficiency Financing program by the Federation of Canadian Municipalities Deep Retrofit Accelerator Initiative (DRAI) from the Government of Canada Free online training course from the Canadian Standard Association about the National Energy Code Long list of training alternatives on buildings here and other sectors here Sectoral Workforce Solutions Program Support from the Oil to Heat Pump Affordability Program For homeowners: Oil to Heat Pump Affordability Program For municipalities: Sustainable Affordable Housing Fund from the Green Municipal Fund

Big Move	
Energy Supply	
Action Name	Local zero-carbon energy generation at a community scale
Enabler	City of Peterborough Holdings Inc. (CoPHI) and Peterborough Utility Group.
Funding Source	Smart Renewables and Electrification Pathways Program for utilities, electricity generation operators, and municipalities

Big Move	
Energy Supply	
Action Name	On-site energy generation
Enabler	Net metering mechanisms: The Net Metering Program is established by the Ministry of Energy and is governed by the Regulation O. Reg. 541/05: NET METERING Working with Peterborough Utilities Inc. to confirm the applicability of net metering for homes. Depends on the funding available. HEEP program there are two ways: 1. Granting a # of solar panels per total loans given. 2. Planning loans for future budgets. Net metering mechanisms: The Net Metering Program is established by the Ministry of Energy and is governed by the Regulation O. Reg. 541/05: NET METERING. Coordinating the training sessions with Peterborough Utilities Inc. to allow for continuity of the training in real projects.
Funding Source	Support from the Community Buildings Retrofit Initiative Private investment Support to design and expand the program from the Community Efficiency Financing by the Green Municipal Fund: $300 million initiative helps municipalities deliver energy financing programs for low-rise residential properties Smart Renewables and Electrification Pathways Program for utilities, electricity generation operators, and municipalities

Big Move	
Sustainable Transportation	
Action Name	**Public transit improvements**
Enabler	GreenUp previous experience in the "On the Bus" program for Grade 3 students
Funding Source	Municipally funded in collaboration with GreenUp Canada Infrastructure Program led by Province of Ontario Gas Tax Program Private operators alternatives: Canadian Infrastructure Bank (CIB) pipeline

Big Move	
Sustainable Transportation	
Action Name	**Increase active transportation**
Enabler	Cycling infrastructure (dedicated and protected lanes, lighting) Active transportation recognized by the City as a way of "public transportation." Cycling infrastructure (dedicated and protected lanes, lighting). Approved Transportation Master Plan Canada's National Active Transportation Strategy Canada Infrastructure Plan
Funding Source	City funding Active Transportation Fund—Capital projects for infrastructure (benefitting pedestrians and cyclists, not motorized and not for bike-share programs). Covers from 40% to 100% and up to $50 million per project. Planning projects for stakeholder engagement stream from the Active Transportation Fund

Big Move	
Sustainable Transportation	
Action Name	**Fuel switching for private transportation**
Enabler	Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations (SOR/2010-201) and new mandates to reach 60% sales by 2026 Electricity and Gas Inspection Act (EGIA) and Temporary dispensation program for electric vehicle supply equipment
Funding Source	Municipally funded Other funding available: Zero-Emission Vehicles (iZEV) Program for other non-low income EV adopters

Big Move: Industry	
Action Name	**Increase in industrial efficiency**
Enabler	Energy Efficiency Act and Energy Efficiency Regulations Directory of energy efficiency programs for industry
Funding Source	For the industrial sector, there are funding options from the federal government: Green Industrial Facilities and Manufacturing Program Canadian Industry Partnership for Energy Conservation (CIPEC)

Big Move: Forestry	
Action Name	**Urban forestry**
Enabler	Tree removal bylaw and Urban Forestry Strategic Plan
Funding Source	N/A

7. Implementation Recommendations

This Climate Change Action Plan 2.0 provides three different pathways to achieve meaningful emissions reductions for the City of Peterborough, with solutions that also stimulate the local economy by encouraging investment in buildings, electromobility, and industry and provide benefits to all residents.

Implementing the Plan will require action and leadership from the public and private sectors, as well as engagement and the promotion of active community participation. It will also require the scaling up and extension of the current efforts through current and new policies and programs.

Implementation of each action will consider the need for new workforce members and highly skilled labour, and many actions will include capacity-building activities, such as training courses and workshops in collaboration with the relevant stakeholders, as well as through partnerships with local educational institutions to create new technical programs to support this new demand for jobs. Holding equity as a central focus in terms of implementing the mitigation actions and building capacity activities will enable a just transition to a low-carbon future. An equity focus ensures that underserved and historically marginalized communities are adequately involved in the low-carbon transformation and are better off as a result of this Plan.

Timely action in deploying the resources for city of Peterborough residents, as well as for policy implementation will achieve higher cumulative greenhouse gas reductions. Delaying actions increases the risks and damages associated with climate change.

Implementation of these actions will have many faces and will involve many types of actions. Municipal leadership will ensure these efforts align with the overall goal of the CCAP 2.0. Urban planning is a key element in facilitating the implementation of other actions, and the City of Peterborough will implement the Official Plan 2023 to lift the current barriers to densifying the city, and it will create secondary plans with the new density targets for each area. Building emissions are a second key element of climate action and the City shall start with a voluntary Green Development Standard and plan increased targets to align with Canada's NZER Building Code. This action will also help prepare Peterborough for future regulation changes from provincial governments and help it be a leader in climate action.

An equity focus will be put in place by assessing the opportunity to include Green Development Standards for social housing and rental units as a minimum requirement. The City can support moving toward green buildings by extending the current HEEP program beyond 2028, doubling its funding available, and determining a percentage of the funding to grant to low-income households.

The City, along with partners such as GreenUp and the Chamber of Commerce, are key to facilitating and supporting networks between suppliers, local operators, non-governmental organizations, private companies (e.g., utilities), and community members to facilitate the implementation of new technologies such as heat pumps, solar panels, and electric vehicles.

Complementing these efforts, the City will ensure the total vehicle kilometres travelled per resident is reduced, starting by developing a study to explore the options to limit parking in the City's downtown and other areas and promoting a more bike-friendly environment by implementing measures to increase the protected bicycle parking spaces in the Central Area through the Central Area Master Plan, and evaluating new areas.The City will also account for the exclusive parking spaces requirements (e.g., for bikes) via the Community Planning Permit System to ensure residential units facilitate the ownership and use of low-emission transportation alternatives. Implementing a bike sharing program will also contribute to the mode shift, and the City will start with a piloting program of at least 50 bikes.

Piloting programs will be key to communicating and advocating for public transit use for all residents and will be combined with communication and engagement plans to ensure residents are familiarized with the new changes in the transit fleets, routes, services, and times. Acceleration of the Transportation Master Plan will also result in movement toward a low-carbon transit fleet.

Peterborough should collaborate with the industrial sector to encourage the implementation of energy efficiency measures for buildings and industrial processes. By creating a working table with business members (starting with the Chamber of Commerce), the City will explore climate action and the opportunities to expand the HEEP program for the industrial sector.

In addition, current policies need to continue their implementation, such as the Waste Management Master Plan, which provides recycling and composting services to residents. These efforts will be complemented with an outreach program to prevent waste generation among communities and businesses, and circular economy principles will be at the forefront of this action.

Carbon-negative emissions are also part of Peterborough's effort to reduce GHG emissions and increase the City's climate resilience; thus, part of the effort to implement the Urban Forest Strategic Plan and achieve the forest canopy cover involves investing in land and creating guidelines for builders and project developers to implement nature-based solutions and increase the tree coverage in new projects.

Since financing is at the heart of the implementation, the City should seek to collaborate with financial institutions and other levels of government to enable funding streams, and to advocate for new funding sources for community members and businesses.

Finally, we recommend that Peterborough regularly report progress to Council and the community. Key indicators suggested to monitor progress include:

- GHG emissions per year, per sector, and per capita;
- Energy use per capita and energy savings from 2021 baseline;
- Percentage of electricity generated by renewables and installed solar generation capacity per year;
- Number of trips made by car, transit, and active transportation; and
- Tonnes of waste generation per capita per year compared to the 2021 baseline and tonnes of waste diverted to recycling and composting facilities per year.

8. Conclusion

In 2022, the United Nations Secretary-General António Guterres called for climate action, warning that we are on track to climate disaster. His warning calls for urgent and timely action and highlights the current unprecedented disasters we are already experiencing. Urgent and timely action is needed to limit global warming to below the 1.5°C committed to in the Paris Agreement. Due to the nature of greenhouse gases and their half-life, each additional tonne of CO_2 emitted today will accumulate for decades to centuries in the atmosphere, contributing to climate change. Cumulative emissions are harder and harder to tackle when action is delayed, requiring us to not only reduce our emissions but also remove them from the atmosphere.

A massive deployment of technologies and solutions and the willingness to persevere are needed to achieve meaningful reductions that align with the 1.5°C pathway. The scenario that achieves the largest emissions reductions is the Net-Zero 2040 Scenario, reducing up to 6,193 ktCO_2e over the 2024–2050 period, and it is also the scenario that aligns the most with the Paris Agreement. The Alternative Fuels Scenario reaches 5,144 ktCO_2e over the same period, and the Net-Zero 2050 Scenario reduces 4,859 ktCO_2e over the whole period.

Implementing any of these scenarios will require a large capital investment but will result in significant net savings due to reductions in operational and maintenance costs, energy, fuel, and carbon emissions. The most cost-effective scenario is the Net-Zero 2050 Scenario with a marginal abatement cost of -$209/t$CO_2$e, followed by the Net-Zero 2040 Scenario, with a marginal abatement cost of -$127/t$CO_2$e, and finally the Alternative Fuels Scenario with -$122/t$CO_2$e.

There are seven Big Moves to help the City of Peterborough move toward a decarbonized future: Land Use, Green Buildings, Energy Supply, Sustainable Transportation, Industry, Waste, and Forestry and Carbon Sequestration. Peterborough should emphasize climate action through the implementation of measures in the Green Buildings and Sustainable Transportation Big Moves to achieve the largest emissions reductions. Their implementation will be strongly influenced by the Land Use Big Move, which sets the stage for urban planning and removes barriers to creating a more sustainable city. Land-use actions are the first step to preventing the lock-in of emissions, reducing the costs of future retrofitting and decreasing the energy needed for the low-carbon transformation.

Since buildings and transportation are the main emitting sectors in Peterborough, replacing and reducing the use of fossil fuels for space heating and gasoline and diesel for transportation are key steps. By implementing mitigation actions in these sectors, the city is adopting a no-regret approach, which means that the actions are cost-effective even without considering climate change, resulting in net benefits for everyone. As Peterborough residents move away from fossil fuels, households will reduce their energy and transportation costs and benefit from a cleaner environment, a boosted local economy, and more equitable access to clean technologies.

Equity considerations should be included in the policies and programs developed by the City to achieve its climate goals. The City should also provide financial and technical support to underserved and marginalized communities, ensuring that no one is left behind. Moreover, Peterborough needs to work on reducing barriers for these communities and facilitating their participation in the new local economy, while ensuring that education and opportunities are equitably accessible to all residents.

Appendices

A. Description of the CityInSight Framework

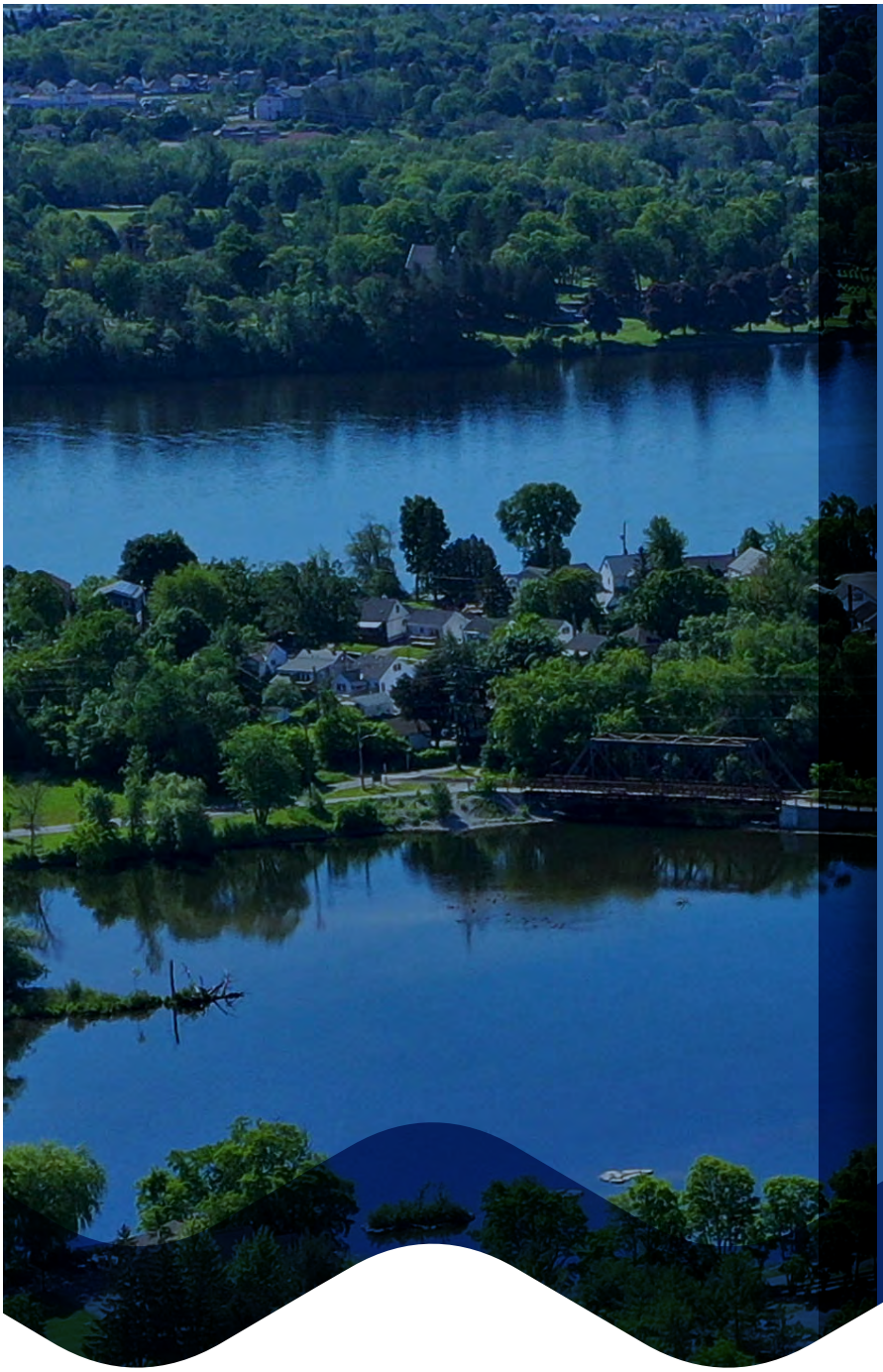
Data, Methods, and Assumptions (DMA) Manual

[external document]

B. Engagement Summary

Summary of Findings and Recommendations

[external document]



peterborough