City of London

Pathways to Prosperity: Climate Action and the Energy Transition in London

Final Report

Prepared by
Sustainability Solutions Group

Prepared for
City of London

June 2025

Aerial view of London, Ontario. Image adapted from Photo by Harold Stiver/stock.adobe.com

Acknowledgements

Land Acknowledgement

The City of London acknowledges that it is situated on the traditional lands of the Anishinaabek, Haudenosaunee, Lūnaapéewak, and Attawandaron. We acknowledge all the treaties that are specific to this area: the Two Row Wampum Belt Treaty of the Haudenosaunee Confederacy/Silver Covenant Chain; the Beaver Hunting Grounds of the Haudenosaunee NANFAN Treaty of 1701; the McKee Treaty of 1790; the London Township Treaty of 1796; the Huron Tract Treaty of 1827 with the Anishinaabeg; and the Dish with One Spoon Covenant Wampum of the Anishinaabek and Haudenosaunee.

This land continues to be home to diverse Indigenous people (First Nations, Métis, and Inuit) whom we recognize as contemporary stewards of the land and vital contributors to society. We hold the natural world in our highest esteem and honour the wonderment of all things within Creation. We bring our minds together as one to share good words, thoughts, and feelings and sincerely send them out to each other and to all parts of Creation. We are grateful for the natural gifts in our world, and we encourage everyone to be faithful to the natural laws of Creation.

The Chippewas of the Thames First Nation, the Oneida Nation of the Thames, and the Munsee-Delaware Nation are neighbours to London, and they live as sovereign Nations with individual and unique languages, cultures, and customs.

This land acknowledgement is a first step toward reconciliation. Awareness means nothing without action. It is important that everyone takes the necessary steps toward decolonizing practices. We encourage everyone to be informed about the traditional lands, Treaties, history, and cultures of the Indigenous people local to their region.

Province Acknowledgement

The City of London acknowledges that this plan was prepared with support from the Government of Ontario through its Municipal Energy Plan funding.

Consulting Team

Carla Gallardo

Marcus Williams

Deryn Crockett

Amber Nicol

Chris Strashok

Yuill Herbert

Table of Contents

Executive Summary

London is implementing several actions in response to the Municipal Council's 2019 climate emergency declaration, including approving and implementing its Climate Emergency Action Plan (CEAP) (2022). The Plan sets a goal to reach net-zero community emissions by 2050 and defines three milestones: decrease relative to 2005 emissions, decrease 55% by 2030, decrease 65% by 2035, and decrease 75% by 2040.

This document explores possibilities for a plan for the City of London to move forward with its CEAP. London has already seen a decrease in emissions, and we projected that by implementing current measures, these will continue decreasing. However, the City needs to implement further actions to reach its climate targets. In that context, we modelled four scenarios:

- **Business-as-Usual (BAU):** A reference scenario that shows what would happen if no climate actions are taken.
- **Current Measures:** A reference scenario that considers current climate actions, so it illustrates what would happen if only current actions, plans, and policies are implemented.
- **Net Zero:** A low-carbon scenario that answers the question, "What would happen if climate actions are taken along with current measures, but we rely strongly on carbon capture technologies and less on electrification?"
- **Zero Carbon:** Another low-carbon scenario that seeks to answer the question, "What would happen if climate actions are taken along with current measures, relying strongly on electrification and biofuels?"

If no actions are taken to reduce GHG emissions (BAU Scenario), as the population increases, emissions would increase by 24% between 2021 and 2050. On the other hand, current measures are expected to reduce emissions by 38% in that same period. This is far from reaching London's targets.

Both low-carbon scenarios modelled would achieve more than **80% emissions reductions by 2050**, with the Zero Carbon Scenario getting there faster. Per capita emissions would significantly decrease in the Net Zero and Zero Carbon scenarios, falling from 6.3 tCO_2e in 2021 to 0.7 and 0.8 tCO_2e by 2050, respectively. Neither of these scenarios would achieve the 2030 target, which is more challenging because Ontario's electricity grid is expected to become more emissions-intensive (due to natural gas) between 2025 and 2033. However, the 2035 and 2040 targets are achievable.

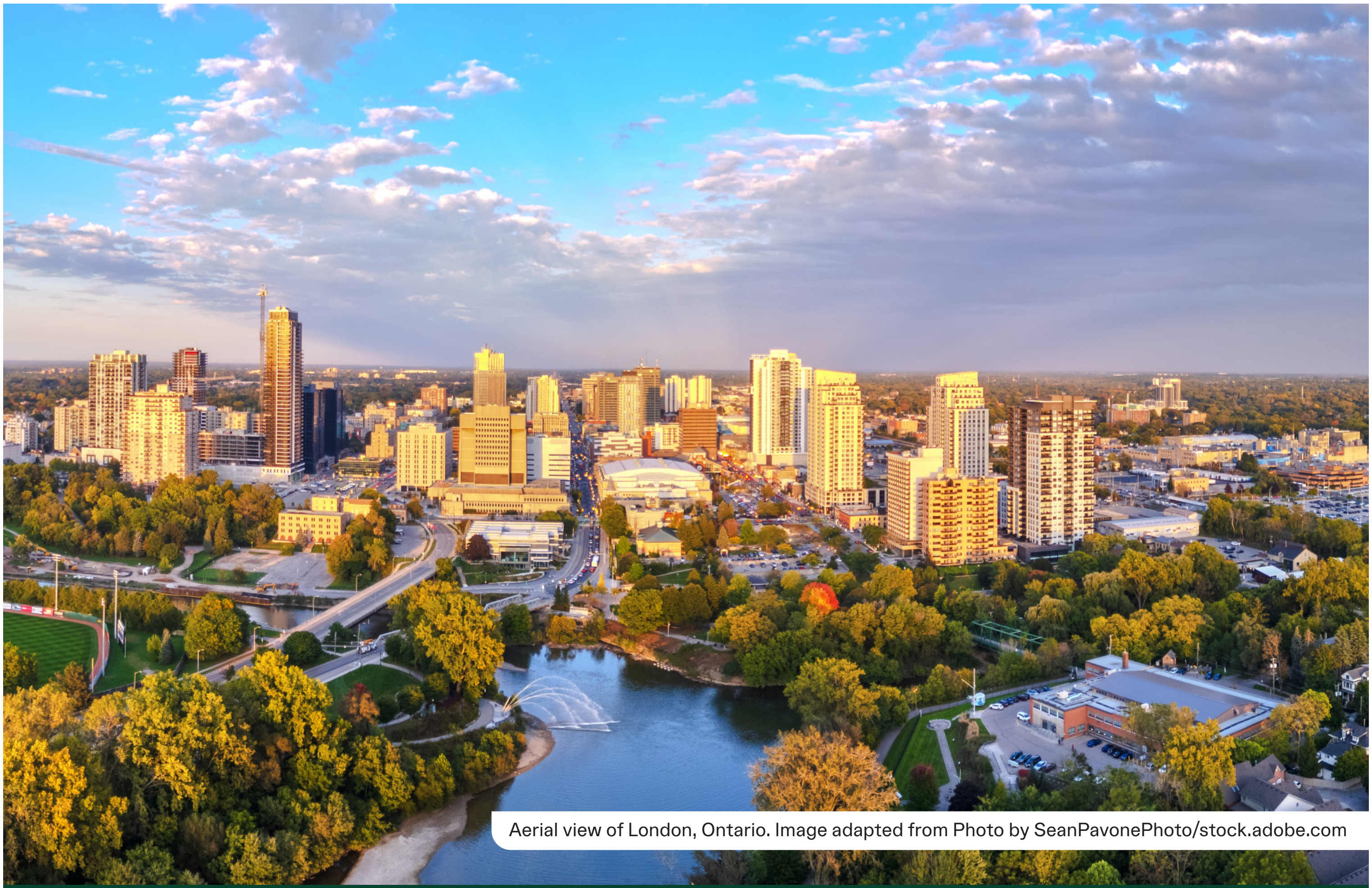
An important difference between the low-carbon scenarios is the depth of electrification measures and technological carbon capture and storage (CCS). The Net Zero Scenario relies less on electrification and more on carbon capture than the Zero Carbon Scenario. Without this measure, it would not reach the 2040 CEAP target. This is important to mention because there may be limited storage potential in London, so the financial viability of this strategy for large emitters is uncertain. Therefore, deferring the implementation of available clean technologies, such as electrification, in favour of less certain options is a risky approach for London in terms of attaining its climate targets.

By 2050 some residual emissions will remain. Potential strategies to address these emissions include increasing natural or technological carbon sequestration, purchasing carbon offsets, increasing efforts to electrify industry, and generating more renewable energy locally.

The financial implications of implementing the low-carbon scenarios indicate a business case for climate action. Investing in mitigation actions will bring net benefits to the city of London. These benefits are referred to as "profitable" (when revenue exceeds expenses). Combined with current measures, the Net Zero Scenario generates $7.2 billion in financial returns, while the Zero Carbon Scenario generates $14.3 billion.

Over 25 years, $2.5 billion in community-wide investment will be required to implement the current measures. This is approximately 0.4% of London's 2021 gross domestic product (GDP). The Net Zero Scenario will require an additional investment of $9 billion over the same period, which is **less than 2% of London's 2021 GDP**, and implementing the Zero Carbon Scenario will require a $6.5 billion investment, or **1.3% of London's 2021 GDP**.

Combined with current measures, the Net Zero and Zero Carbon scenarios are financially viable pathways to significantly reduce London's greenhouse gas (GHG) emissions and meet its GHG targets. Although this will require substantial investment and coordination between the different levels of governments and citizens, businesses, and other entities, the financial savings and other benefits far outweigh the costs.



Aerial view of London, Ontario. Image adapted from Photo by SeanPavonePhoto/stock.adobe.com

1 Introduction

London has implemented several actions in response to the Municipal Council's 2019 climate emergency declaration, including approving and implementing its Climate Emergency Action Plan (CEAP) (2022). This plan addresses mitigation and adaptation through 200 actions. The Plan's goal is to achieve net-zero community emissions by 2050. This means that London aims to decarbonize its economy by reducing GHG emissions to as close to zero as possible and balancing out any remaining human-driven emissions by implementing an equivalent amount of carbon removals. Carbon removals or sequestration can be achieved by restoring natural lands and soils or through direct air capture and storage technology.

The City has outlined three milestones to achieve its goal of net-zero emissions by 2050: reduce emissions 55% by 2030, 65% by 2035, and 75% by 2040, relative to 2005 emissions.London emits almost 3,000 kilotonnes per year of CO_2e, equivalent to 6.3 tonnes of CO_2e per person. Considering historical emissions, London is in a downward trend, having decreased its emissions by almost a quarter. However, the city needs to further decrease its emissions to reach the CEAP milestones. How can this be achieved? This project seeks to answer this question.

While the City tracks the progress of the CEAP actions and the GHG emissions to date, a quantitative assessment of the actions' impacts in terms of emissions and financials is necessary to visualize strategies to leverage actions in the medium and long term. This project comprises a modelling exercise to evaluate how two low-carbon futures could be implemented in London.

Aerial view of London, Ontario. Image adapted from Photo by leonardo/stock.adobe.com

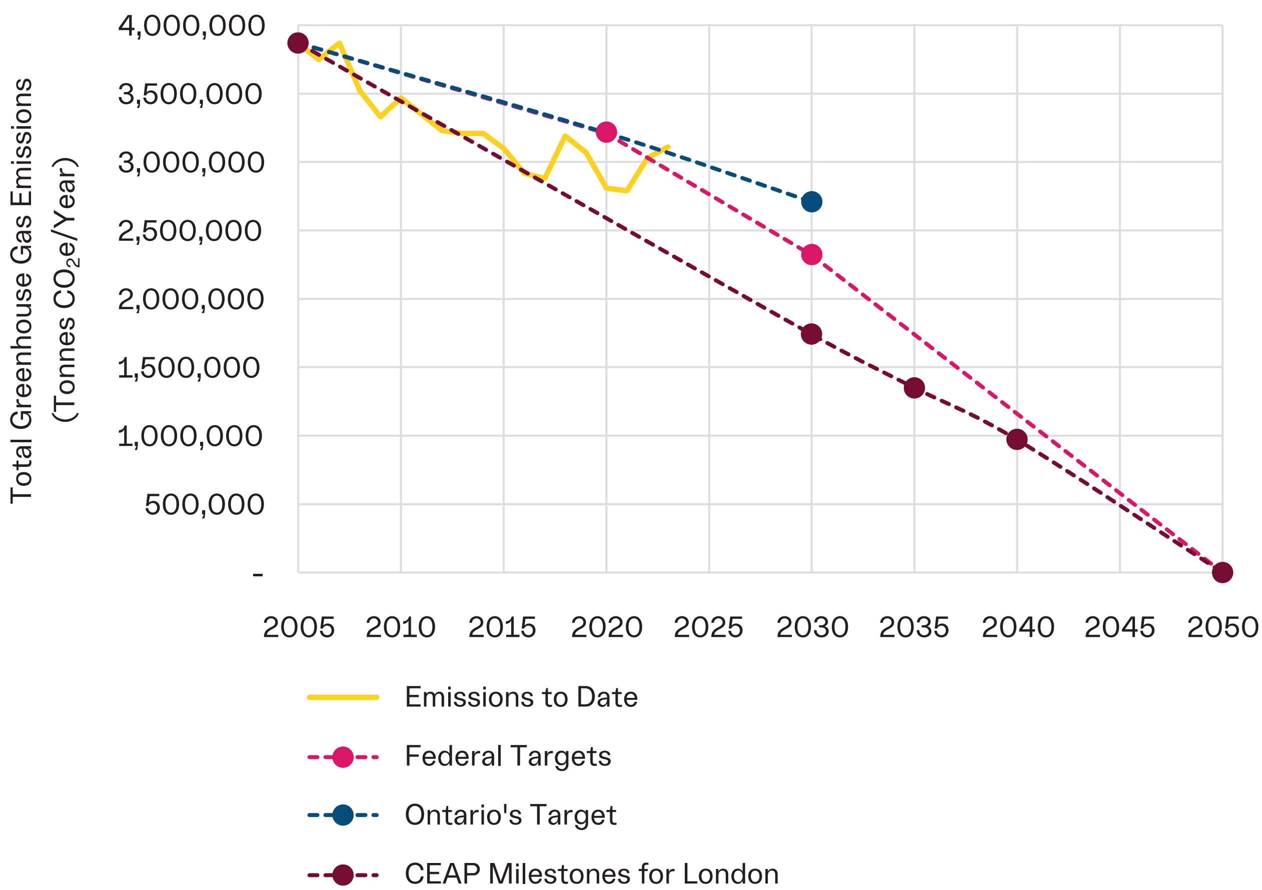
2

Climate Targets in London

The London Climate Emergency Action Plan defines community milestone targets for GHG emissions in 2030, 2035, and 2040 to reach net-zero[1] emissions by 2050. These targets are relative to emissions in 2005. The community milestone targets approved by the Municipal Council are to reduce emissions 55% by 2030, 65% by 2035, and 75% by 2040. These are also referred to as science-based targets. They highlight the "fair share" level of decarbonization that cities in North America need to achieve to keep the global temperature increase below 1.5 °C or well below 2 °C compared to pre-industrial levels, as outlined in the Paris Agreement.

Figure 1 shows the GHG emissions targets. These are compared to historical emissions up to 2023 and include targets at the provincial and federal levels.

Figure 1. Community emissions and emissions targets for London, Ontario, and Canada (London CEAP Progress Report, 2024).



1 Reaching net-zero emissions means that London "either emits no greenhouse gas emissions or offsets its emissions, for example, through actions such as tree planting or employing technologies that can capture carbon before it is released into the air." (Government of Canada, 2024).

As demonstrated in Figure 1, historical emissions trends can be explained with information from past events, such as the impact of the COVID pandemic on transportation emissions in 2020 and 2021 or the impact of the emissions' intensity of electricity generation in the province. When the targets were defined in 2022, the impacts of short-term events such as the COVID pandemic were clear. Therefore, it was important for the City to have short- and medium-term targets to ensure progress toward a net-zero target by 2050. With the current emissions trajectory above the trendline to meet London's goals, it is important to measure and project how actions can steer emissions toward a net-zero trajectory for the future.

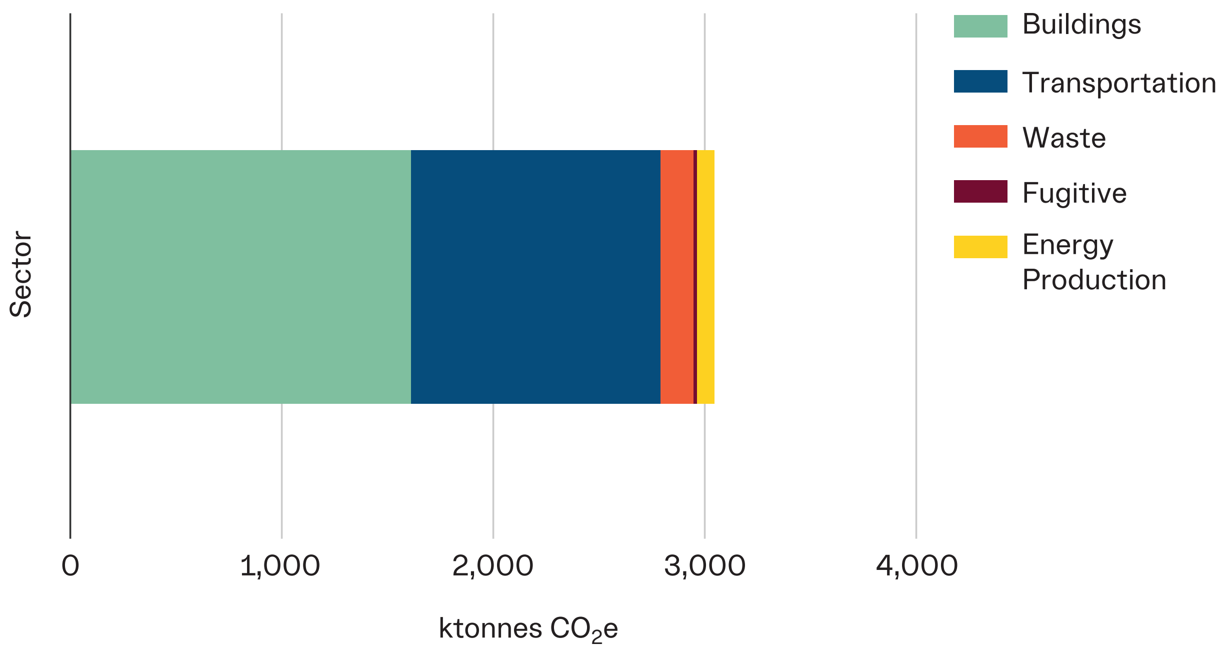
Walter J. Blackburn Memorial Fountain. Image adapted from Photo by Paul Roedding/stock.adobe.com

3

The Current State of Greenhouse Gas Emissions in London

In 2022 London emitted almost 3,000 kilotonnes of CO_2e, equivalent to 6.3 tonnes of CO_2e per person. These emissions are categorized into three main emission sectors: buildings, transport, and waste. We also accounted for fugitive[2] and energy production emissions.[3] Buildings and transport account for 92% of emissions in London, waste contributes to 5%, energy production to 2.5%, and fugitive emissions contribute to only 0.6% of total emissions (Figure 2).

Figure 2. London emissions (kilotonnes of CO_2e) in 2022 by sector.

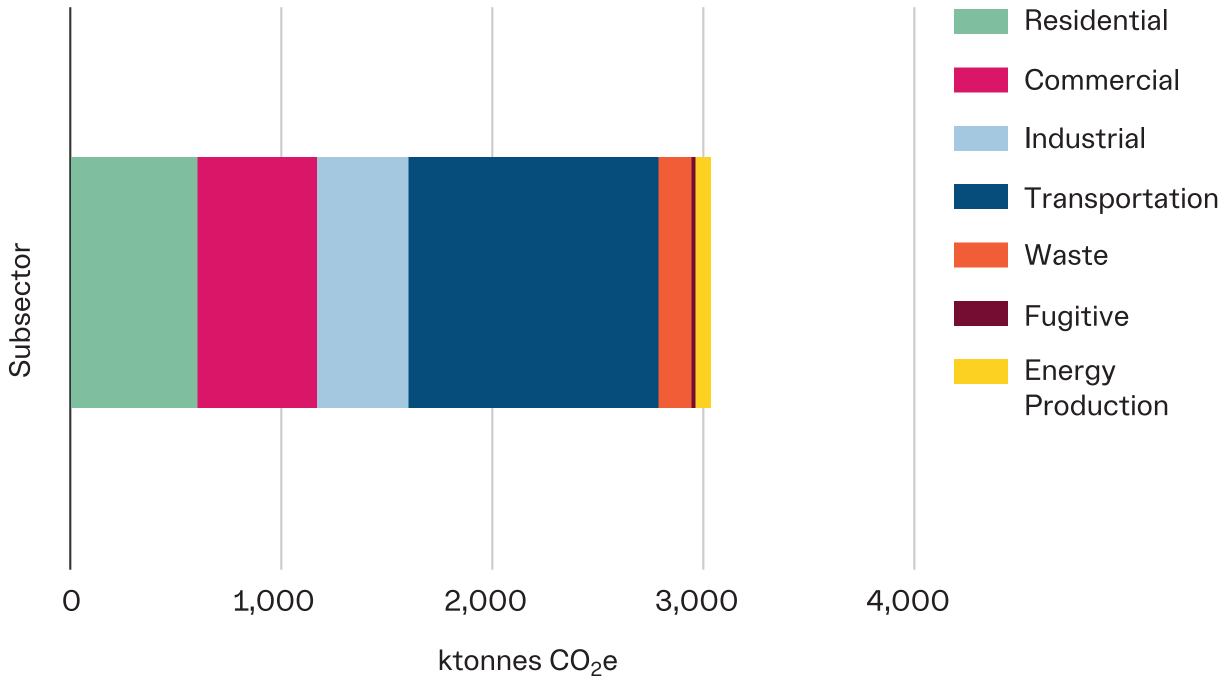


2 Losses in natural gas and electricity systems.

3 The inventory does not include greenhouse gas emissions from inland water bodies, which might be an issue for GHG emissions in places with low pollution controls. (Upadhyay et al, 2023).

Disaggregating emissions from buildings, most emissions are from the residential and the commercial subsectors at 38% and 35%, respectively. The industrial subsector accounts for 27% of the building sector's emissions (Figure 3).

Figure 3. London emissions (kilotonnes of CO_2e) in 2022 by subsector.



In 2022, London consumed 57 million gigajoules of energy, equivalent to 120 gigajoules per person. This energy was mainly used for space heating, transportation, and industrial processes (Figure 4). Almost 80% of the energy consumed came directly from fossil fuels such as natural gas, gasoline, diesel, propane, and fuel oil (Figure 5).

Figure 4. London energy end uses (million GJ) in 2022.

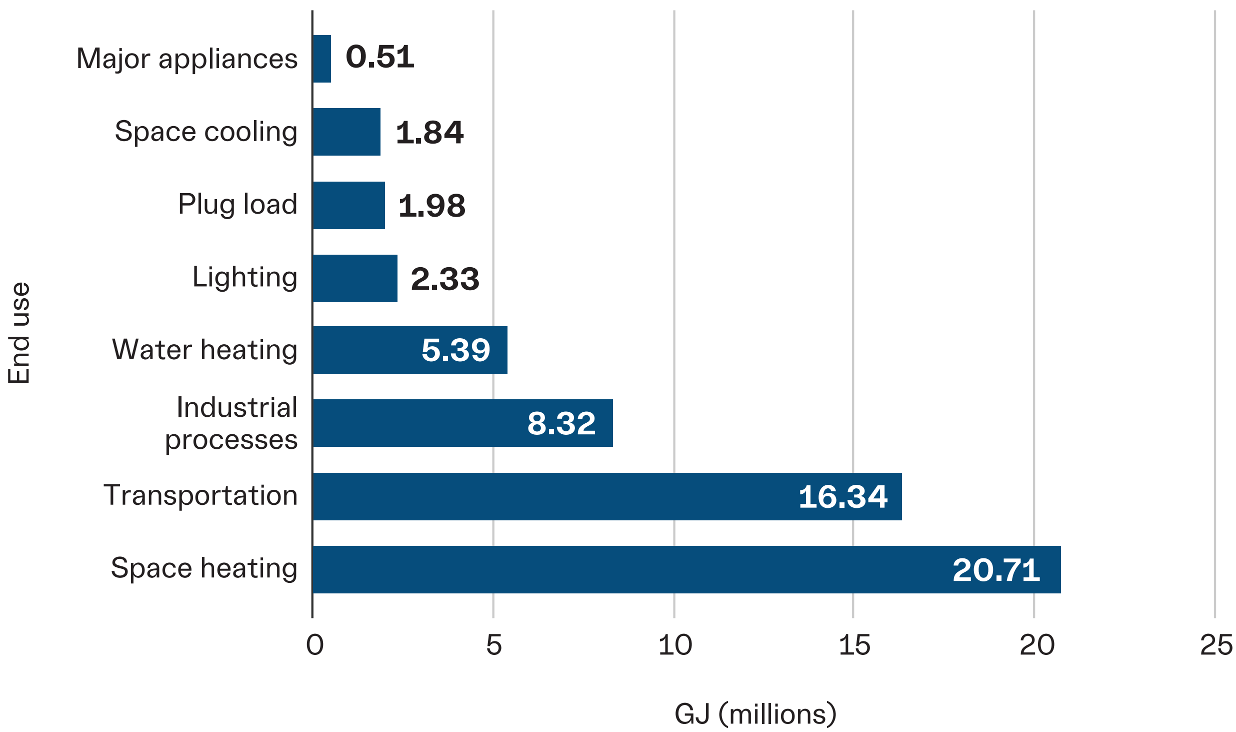
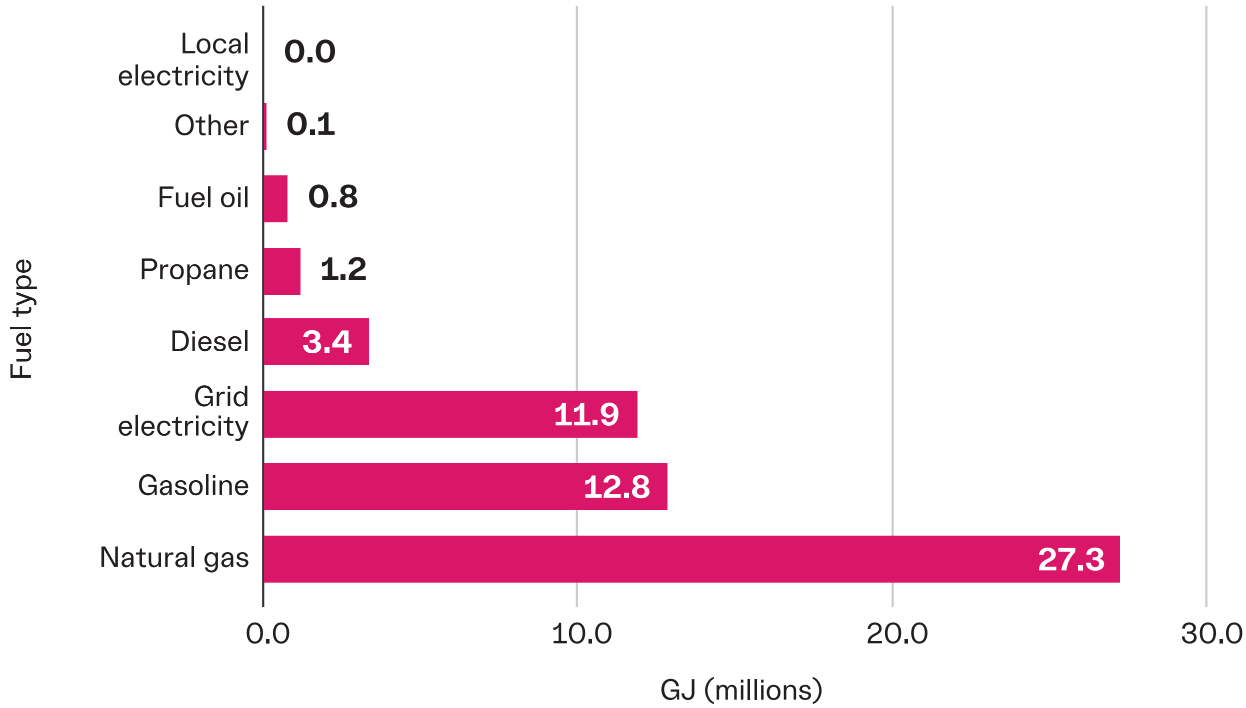


Figure 5. London energy use (million GJ) by fuel type in 2022.




Solar Power Tree in London, Ontario. Image adapted from Photo by Heather/stock.adobe.com

4

How Can London Move Forward?

Four scenarios were developed and modelled to explore the potential futures for London. These scenarios are not predictions, but plausible, evidence-based projections on how the future may evolve based on data and assumptions about the key drivers for emissions and critical trends in London. The first scenario explores an extrapolation of current conditions with projected population growth the second shows the impact of current climate change policies, and the last two scenarios simulate the impact of extending the current policies into more ambitious reduction schemes (Table 1).

Table 1. Descriptions of modelled scenarios.

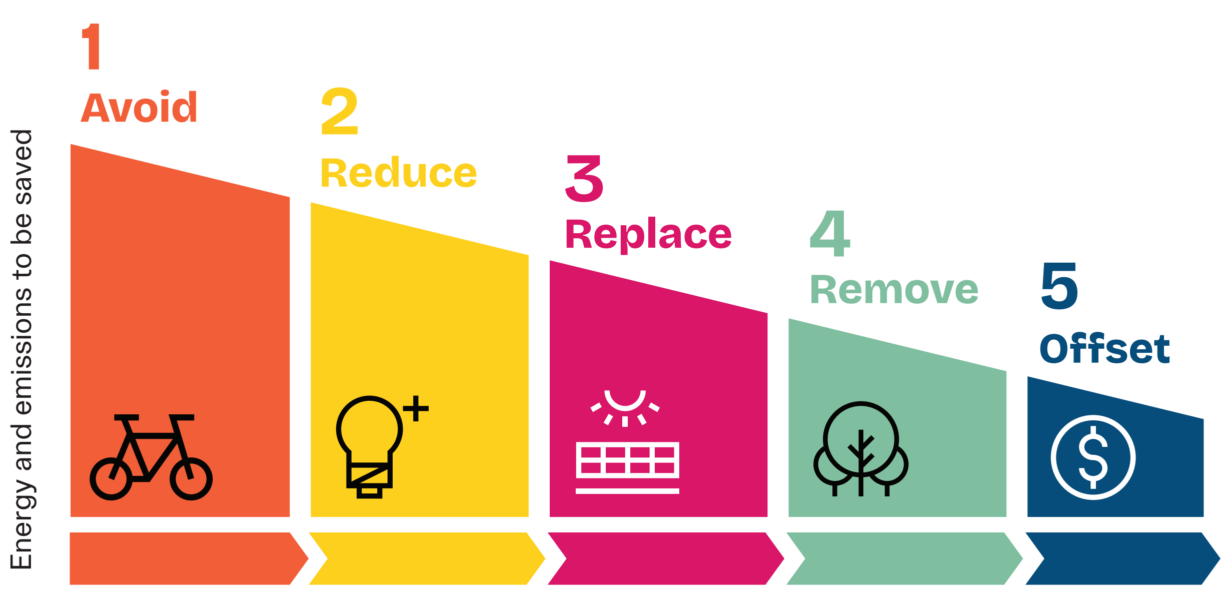
Scenario	Description
Business-as-Usual (BAU)	A reference scenario that illustrates the impact of population growth without additional effort or investment into climate action. This scenario answers the question, "What would happen if no actions are taken?"
Current Measures	A reference scenario that extrapolates current demographic patterns into the future but takes into account existing and approved federal, provincial, and local plans, legislation, and targets that would affect energy use and emissions. It assumes no additional climate action interventions. This scenario answers the question, "What would happen if only current actions, plans, and policies are implemented?"
Net Zero	A low-carbon scenario that selects and models actions to decrease GHG emissions and improve energy efficiency across all sectors, with a target of achieving net-zero emissions by 2050. In this scenario, there are actions toward transitioning to electrification and renewables, while carbon capture is used by industry to offset some residual fossil fuel emissions. This scenario answers the question, "What would happen if climate actions are taken along with current measures, but we rely strongly on carbon capture technologies and less on electrification?"
Zero Carbon	A low-carbon scenario that selects and models actions to dramatically decrease GHG emissions and improve energy efficiency across all sectors, with a target of achieving net-zero emissions by 2050. In this scenario, there is a stronger and faster transition to electrification and renewables, limiting the use of fossil fuel. Industry makes more efforts to switch from using fossil fuels, increase efficiency, and plant trees to capture carbon. This scenario answers the question, "What would happen if climate actions are taken along with current measures, relying strongly on electrification and biofuels?"

Modelling was completed using demographic, building, transportation, and energy-use data analyzed in the ScenaCommunity model (see Appendix). ScenaCommunity is an integrated energy, emissions, and finance model that allows a deeper understanding of the relationships between energy use, emissions, and population behaviour. ScenaCommunity provides a detailed analysis of the impacts of actions to reduce energy use and GHG emissions in both time and space and evaluates complex interactions between actions to more accurately reflect the impact of potential actions on the future.

Overall, the modelled actions reduce energy consumption and fossil fuel use in buildings; to decarbonize fuels[4], electrify vehicles and switch to sustainable transport modes; divert waste from landfills; increase the capacity of local renewable energy generation; use cleaner natural gas; electrify and reduce energy consumption in industry; and store CO_2.

The goals behind these actions follow a mitigation hierarchy (Figure 6) and are classified as such (Table 2). A mitigation hierarchy helps determine which actions to prioritize. The "Avoid" actions seek to avoid emissions in the first place, for example, by walking or biking to work instead of driving. "Reduce" refers to decreasing the energy use when emissions cannot be avoided, like retrofitting our houses to use less energy for heating them. "Replace" takes over when avoid and reduce are not options. It means to use renewable energy sources instead of fossil fuels. "Remove" is about capturing carbon from the atmosphere by using natural or technological sequestration. Emissions that cannot be eliminated locally using these four approaches can be temporarily addressed by purchasing offsets.

Figure 6. Mitigation hierarchy for actions.



4 This refers to reducing the share of fossil fuels used by including the use of renewable or low-carbon fuels.

Table 2 outlines mitigation actions by sector and type and shows a short name that will identify the action in the Results Section of this report. Table 3 provides a more detailed description of the actions, as well as the modelling assumptions of each scenario. Please note that percentage reductions in the table are relative to the baseline year (2021).

Table 2. Summary of actions modelled by sector.

Sector	Type	Action	Short Action Name
Buildings	Reduce	Reducing energy consumption in new buildings	New residential buildings
			New non-residential buildings
		Retrofitting existing buildings	Residential retrofits
			Non-residential retrofits
	Replace	Switching fossil fuels used for heating	Residential heat pumps
			Residential hot water heat pumps
Transportation	Avoid and Replace	Increasing active transportation and transit use	Mode shift
		Decreasing inbound and outbound trips	Reduce trips
	Replace	Electrifying personal-use vehicles	Personal electric vehicles (EVs)
		Electrifying commercial vehicles	Commercial EVs
		Electrifying transit	Transit EVs
	Replace	Decarbonizing fuels	Decarbonizing transportation fuels
			Decarbonizing aviation fuels
Energy	Replace	Increasing rooftop solar energy	Rooftop solar
		Generating wind energy	Wind
		Using cleaner natural gas	Renewable Natural Gas (RNG) procurement
			Hydrogen

Sector	Type	Action	Short Action Name
Waste	Avoid	Reducing waste generation rates	Waste diversion targets
	Replace	Increasing waste diversion rates	
Industry	Reduce	Improving energy efficiency in industrial processes	Industrial efficiency
	Replace	Switching fossil fuels in industrial processes	Industrial electrification
Sequestration	Remove	Using carbon capture and storage in industrial processes	CCS
		Planting trees for local sequestration	Tree planting

Table 3. Actions modelled in each scenario.

Action	Current Measures	Net Zero	Zero Carbon
Reducing energy consumption in new buildings	By 2030 new buildings reach a tier 2 energy performance (25% energy intensity reduction).	By 2030 new buildings are Net-Zero Energy Ready[5] (NZEr) and by 2035 they are Net-Zero Energy[6] (NZE).	By 2030 new buildings are NZE.
Retrofitting existing buildings	Forty percent of residential buildings are retrofitted by 2050, decreasing energy use by 25% in 2025 and 50% by 2050. Eighteen percent of non- residential buildings will be retrofitted by 2050.	All buildings are retrofitted by 2050: pre- and post-1990 buildings reduce energy consumption by 40% and 60%, respectively.	All buildings are retrofitted by 2050, reducing energy consumption by 60%.
Switching fossil fuels used for heating	Each year 1,400 homes implement air-source heat pumps (ASHP) with natural gas backup (14% of the stock by 2050).	All existing buildings use hybrid heating systems by 2035: 80% ASHP and 20% cold climate (CC) ASHP.	All heat system sales for small existing buildings are CC-ASHP by 2030, while all large buildings use ASHP by 2045.
	By 2030 new commercial buildings use ASHP (with gas backup).	By 2030 new commercial buildings use CC-ASHP (with gas backup).	By 2030 new commercial buildings use CC-ASHP (with electricity backup).

5 A NZEr building is designed, modelled, and constructed the same as one that is NZE but does not yet have on- or off-site renewable energy components in place.

6 A NZE building can produce as much clean energy as it consumes, using on-site (or near-site) renewable energy systems to produce the remaining energy it needs. They are expected to be 80% more energy efficient than a new building constructed to today's building code minimum (Efficiency Canada).

Action	Current Measures	Net Zero	Zero Carbon
Electrifying personal-use vehicles	Federal commitment, percentage of new light-duty vehicles sold that are zero-emission: 2026: 20% 2030: 60% 2035: 100%	Higher targets than federal commitment. Percentage of new light-duty vehicles sold that are zero-emission: 2026: 25% 2030: 70% 2035: 100% (BEV/PHEV[7]=77%)	Higher targets than federal commitment. Percentage of new light-duty vehicles sold that are zero-emission: 2026: 50% 2030: 100% (100% BEVs)
Electrifying commercial vehicles	Light-duty vehicles follow the same targets as personal vehicles. Medium- and heavy-duty vehicles keep being gas- and diesel-powered combustion engines.	Light-duty vehicles follow the same targets as personal vehicles. Medium- and heavy-duty vehicles reach 80% and 50% of electrification by 2050, respectively.	Light-duty vehicles follow the same targets as personal vehicles. Medium- and heavy-duty vehicles reach 100% and 70% of electrification by 2050, respectively.
Electrifying transit	Thirty-five buses are electrified by 2026 (15%). Percentage of fleet that is electrified: By 2030: 50% By 2035: 100%	Percentage of fleet that is electrified: By 2030: 80% By 2035: 100%	Percentage of fleet that is electrified: By 2030: 80% By 2035: 100%
Increasing active transportation and transit use	By 2050, 32.5% walk, cycle, and use transit.	By 2050, 32.5% walk, cycle, and use transit.	By 2050, 40% walk, cycle, and use transit. The additional 7.5% compared to only implementing current measures is from walking and cycling.

7 Battery Electric Vehicles (BEVs) are powered solely by an electric battery and Plug-in Hybrid Electric Vehicles (PHEVs) use an electric motor to assist gas-powered engines. They have a gas tank and a charging port.

Action	Current Measures	Net Zero	Zero Carbon
Decrease inbound and outbound trips	No action	Inbound and outbound trips to and from London by car decrease 10%.	No action
Decarbonizing transportation fuels	Fuel carbon intensity decreases according to provincial regulation. Renewable content: By 2030: 15% in gasoline by 2030 By 2020: 4% in diesel	Fuel carbon intensity decreases further from current policies, with a renewable content of 35% by 2035.	Fuel carbon intensity decreases further from current policies. Renewable content: By 2035: 70% By 2050: 100%
Decarbonizing aviation fuels	No action	By 2050, 40% of jet fuel comes from bioenergy and 30% is supplied with hydrogen-based aviation fuel.	By 2050, 40% of jet fuel comes from bioenergy and 30% is supplied with hydrogen-based aviation fuel.
Increasing rooftop solar energy	Install rooftop capacity: By 2035: 38 MW	Install rooftop capacity: By 2035: 293 MW By 2050: 585 MW	Install rooftop capacity: By 2035: 614 MW By 2050: 1,227 MW
Generating wind energy	No action	No action	Install 54 MW of capacity by 2050.

Action	Current Measures	Net Zero	Zero Carbon
Using cleaner natural gas	Landfill gas (LFG) is used to generate renewable natural gas by 2040.	LFG is used to generate RNG by 2040. An anaerobic digestion (AD) unit generates biogas from 40% of wastewater treatment biosolids by 2035 and diverted organics by 2040. RNG generated from landfill and AD is injected into the grid. Also, natural gas (NG) includes 7% hydrogen: 50% green by 2030 and 70% green by 2050.	LFG is used to generate RNG by 2030. An AD unit generates biogas and biochar from 40% of biosolids by 2035 and diverted organics by 2040. RNG generated by landfill and AD is injected into the grid. Also, NG includes 10% hydrogen: 50% green by 2030 and 70% green by 2050.
Increasing waste diversion rates	Provincial targets for households and non-residential waste reach the following diversions rates: By 2020: 30% By 2030: 50% By 2050: 80%	Same as current measures.	Exceed provincial targets for households and non-residential waste, reaching the following diversions rates: By 2020: 30% By 2030: 60% By 2050: 90%
Reducing waste	No action	No action	Additional 10% reduction in waste generation rates by 2040.
Switching fossil fuels in industrial processes	No action	Ten percent of fossil fuels are replaced with electricity by 2035.	Fossil fuels replaced with electricity reach 20% by 2035 and 40% by 2050.

Action	Current Measures	Net Zero	Zero Carbon
Improving energy efficiency in industrial processes	No action	No increase in energy efficiency.	Thirty percent increase in energy efficiency by 2050.
Implementing carbon capture and storage in industrial processes		CCS is used in industrial processes to offset 99% of emissions by 2050 and 100% of London District Energy (LDE) plant emissions by 2035.	No CCS implemented.
Planting trees for local sequestration	Increase in carbon capture relative to 2008 levels: By 2030: 25% By 2035: 28% By 2050: 40%	No additional trees.	Increase in carbon capture relative to 2008 levels: By 2030: 28% By 2035: 31% By 2050: 40%

How Far Can We Get?

Figure 7 shows annual GHG emissions for each modelled scenario between 2021 and 2050, as well as the CEAP targets in 2030, 2035, 2040, and 2050.

As the population increases, in the Business-as-Usual Scenario, GHG emissions increase by 24% between 2021 and 2050. Current measures decrease emissions by 38% in that same period, and overall energy consumption decreases by 1%.

The Net Zero and Zero Carbon scenarios achieve a more than 80% reduction from 2021 levels by 2050, with approximately 500 ktCO_2e annual emissions remaining in 2050 in both scenarios. The actions evaluated in both low-carbon scenarios constitute a pathway to nearly eliminate the GHG emissions generated within London by 2050. Remaining sources of emissions come from fossil fuel use, mainly diesel and natural gas, depending on the scenario.

None of the scenarios reach the 2030 target, which might be more difficult to accomplish given that emission factors of the electricity grid in Ontario are projected to increase between 2025 and 2033 due to increased reliance on natural gas power plants (TAF, 2024). The Zero Carbon Scenario reaches the 2035 target, while the Net Zero Scenario reaches the 2040 target. An important difference between these low-carbon scenarios is the depth of electrification measures and the use of technological carbon capture and storage. The Net Zero Scenario relies less on electrification than the Zero Carbon Scenario, and it uses carbon capture instead. Without this measure, the Net Zero Scenario would not reach the 2040 CEAP target (Figure 7). This is important because carbon capture and storage in London may be constrained by limited storage potential[8] and low financial viability for large emitters. Therefore, deferring the implementation of available clean technologies, such as electrification, is a riskier approach for reaching London's climate targets.

8 There are just a few wells around London, according to Petroleum Well. Moreover, there are 11 CO_2 storage facilities in Canada associated with CCS projects under development. These are located in Western Canada only (Market Snapshot, Canada Energy Regulator, 2025).

Figure 7. Projected emissions in London (kilotonnes of CO_2e) between 2021 and 2050.

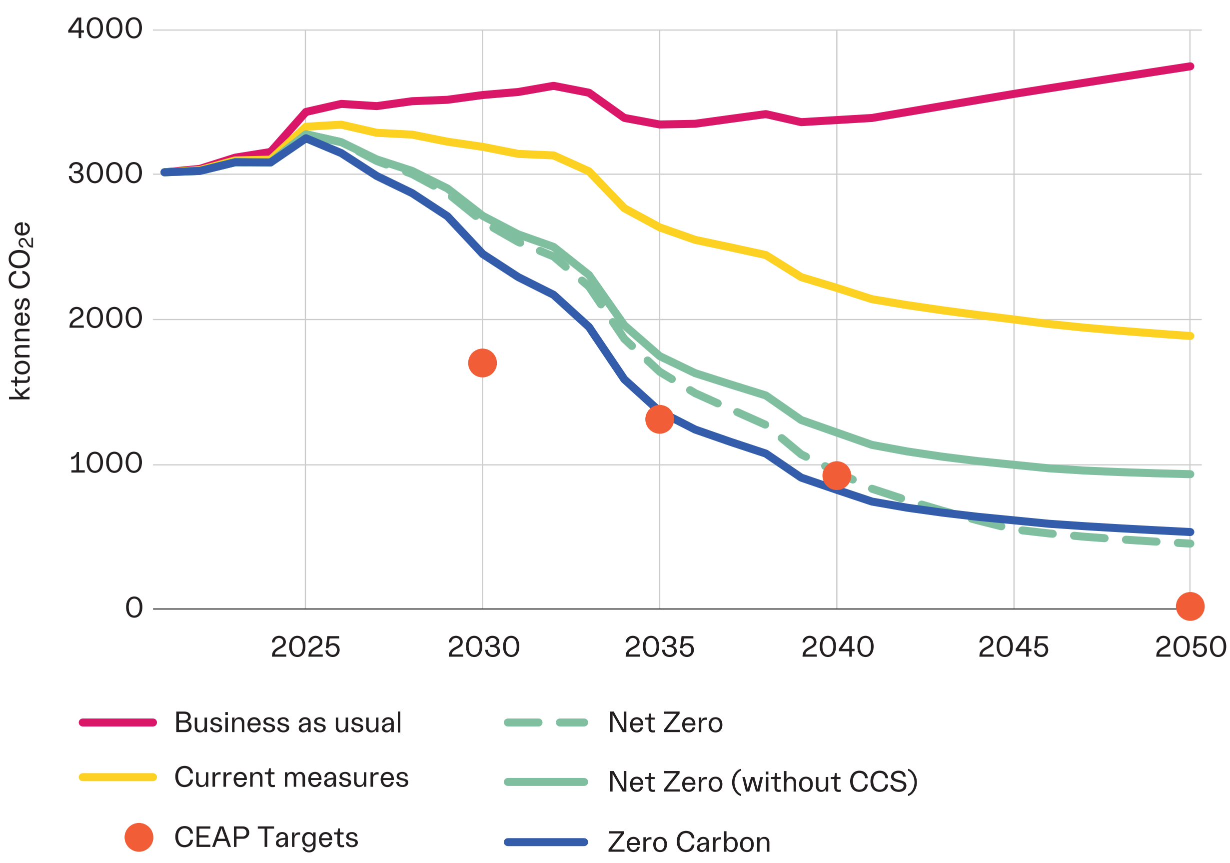


Table 4 demonstrates the GHG reductions per person (i.e., per capita) achieved by each scenario in London. The Net Zero and Zero Carbon scenarios reduce per capita GHG emissions from 6.3 tCO_2e in 2021 to 0.7 and 0.8 per capita in 2050, respectively. The per capita GHG emissions are reduced more quickly in the Zero Carbon Scenario. In comparison, current measures reduce per capita emissions by 3.5 tCO_2e, reaching 2.8 tCO_2e by 2050, whereas the Net Zero and Zero Carbon scenarios reduce per capita emissions by 5.6 and 5.5 tCO_2e, respectively.

Table 4. Per capita emissions in each modelled scenario.

Baseline (2021) Per Capita Emissions (tCO_2e/person)	2050 Per Capita Emissions (tCO_2e/person)			
	BAU	Current Measures	Net Zero	Zero Carbon
6.3	5.5 ↓ 13%	2.8 ↓ 56%	0.7 ↓ 89%	0.8 ↓ 87%

Current Measures

Figure 8 shows GHG emissions reductions by grouped actions for the Current Measures Scenario. Transportation actions are the most important for GHG emissions reductions, accounting for 60% of the emissions reduced between 2021 and 2050. The second most important reduction (35%) occurs in buildings, while actions from the waste sector account for 4% of GHG reductions. Finally, using renewable energy and planting trees for carbon sequestration result in minimal reductions. Under the Current Measures Scenario, by 2050 the carbon liability amounts to 1,886 kilotonnes of CO_2e.

Figure 9 shows emissions reductions by actions. The most important transportation action is electrifying personal vehicles, followed by decarbonizing transportation fuels, and electrifying commercial vehicles.[9] Local transportation initiatives, such as the mode shift and electrifying transit, account for almost 4.3% and 1.4% of reductions in the 2021–2050 period, respectively.

In the buildings sector, reducing energy consumption in new buildings decreases emissions by 17% in the 2021–2025 period. This is based on the assumption that Ontario's building energy code is harmonized to the 2020 national tiered approach, aiming to achieve tier 2 performance by 2030. Heat pumps are the second most important action in the Current Measures Scenario, reducing 14% of emissions. This is partly enabled by residential retrofits, which contribute to 4% of emissions reductions. Retrofitting buildings leverages the efficiency of heat pumps, which is why it is important that these actions are implemented jointly.

9 Vehicle electrification responds to federal government commitments to new zero-emission light-duty vehicles, while the decarbonization of fossil fuels considers that the fuel carbon intensity is projected to decrease according to current provincial policies (Ontario's Cleaner Transportation Fuels regulation) that define the renewable content in gasoline and diesel.

Figure 8. London emissions in the 2020–2050 period for the Current Measures Scenario by grouped actions.

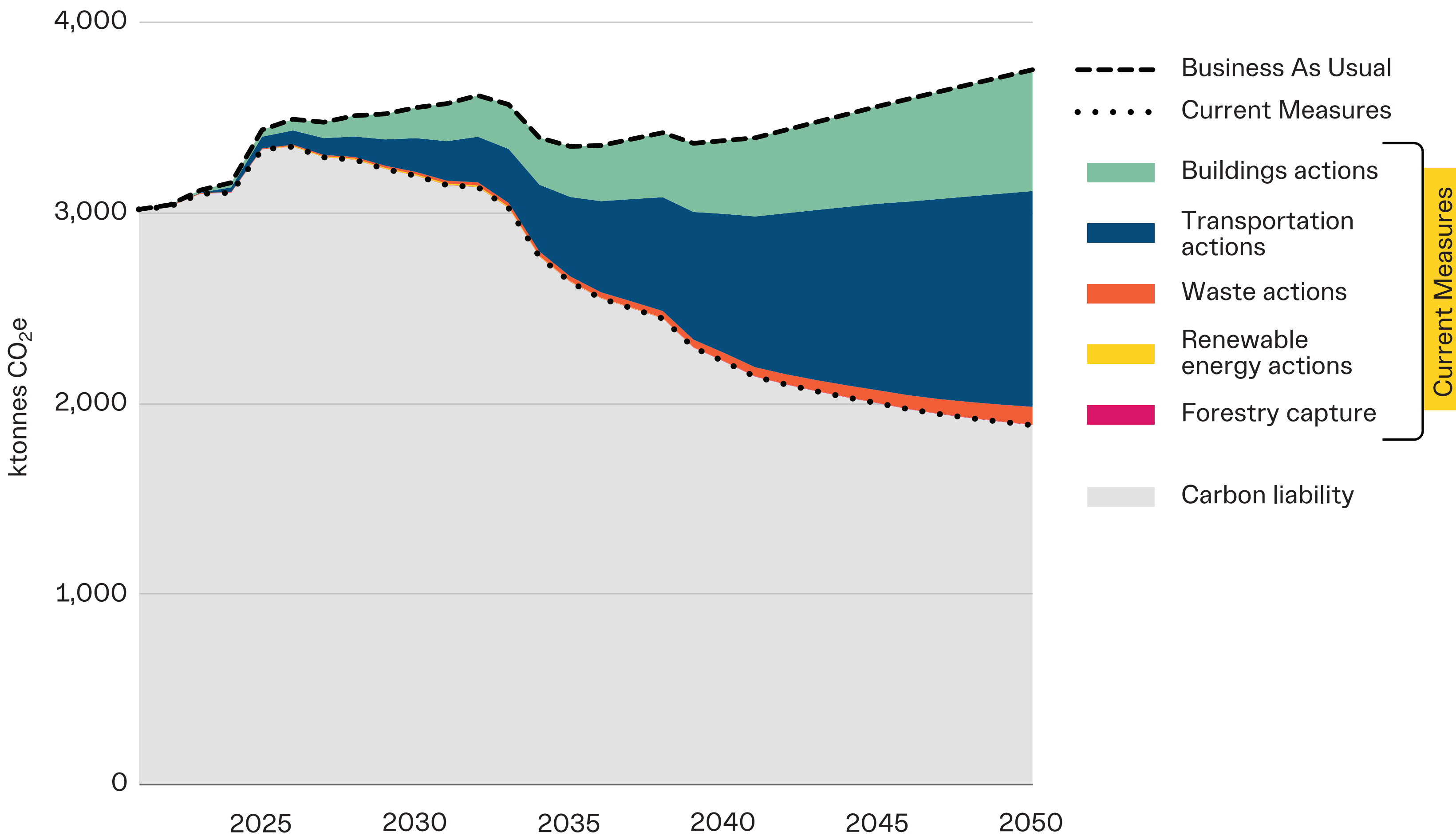
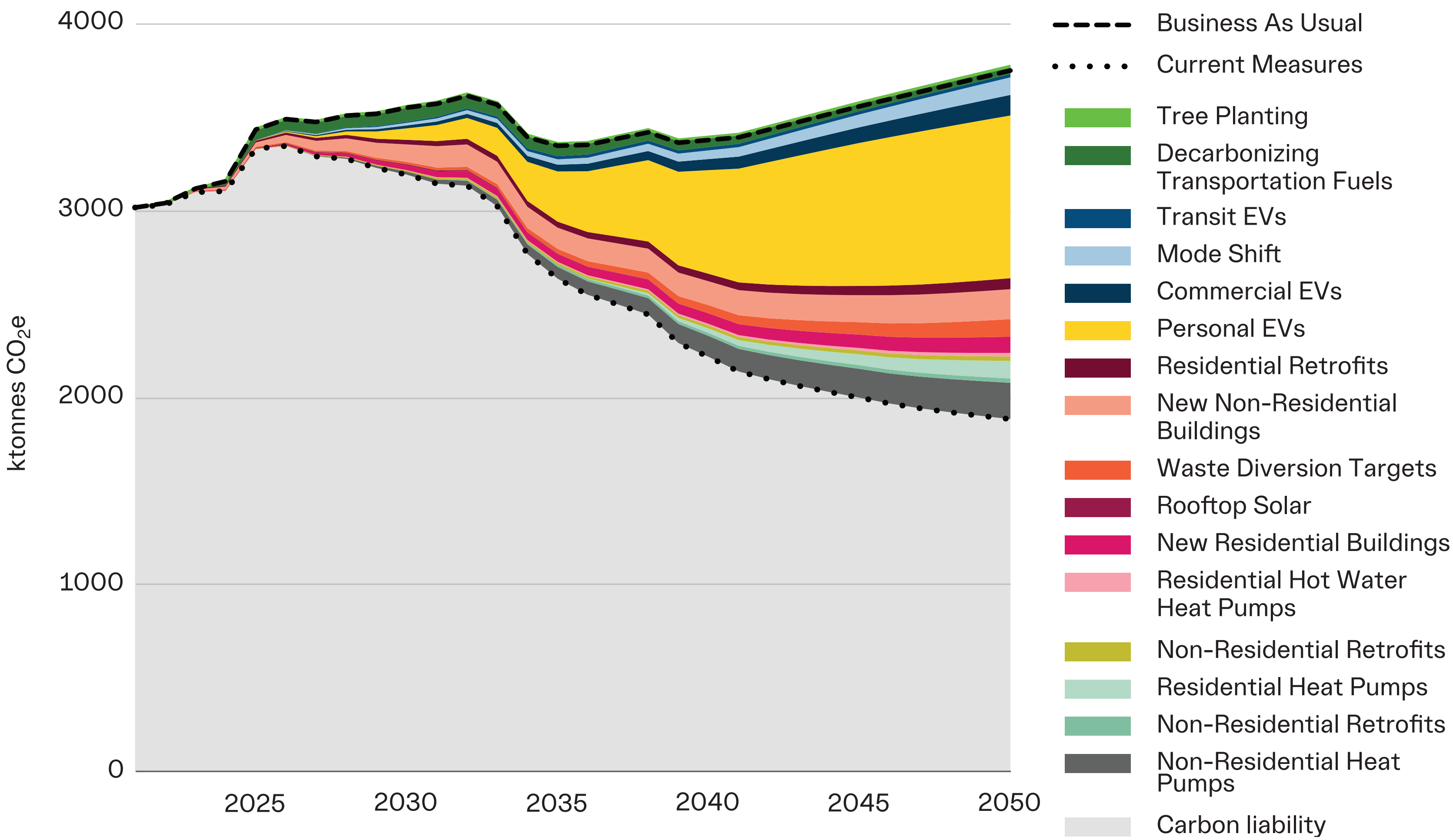


Figure 9. London emissions in the 2020–2050 period for the Current Measures Scenario by action.



Net Zero

Figure 10 shows GHG emissions reductions by grouped actions for the Net Zero Scenario. Building retrofits and conversion of buildings' energy systems to low-carbon fuel sources contribute the most to reductions, accounting for 58% of emissions reduced in the 2021–2050 period. The second most important reduction (25%) occurs in the industrial sector, with carbon capture and storage reducing 90% of industries' emissions. Transportation actions are third in terms of reductions, contributing to 12%. Last are renewable energy and waste actions, which reduce emissions by 5% and 0.2%, respectively. In the Net Zero Scenario, carbon liability amounts to 452 kilotonnes of CO_2e by 2050.

Figure 11 shows emissions reductions by actions. Important actions in the buildings sector are switching the fossil fuels used for heating by installing heat pumps, increasing energy efficiency in existing buildings through retrofitting, and increasing energy efficiency standards for new buildings. More than half the reductions occur in the non-residential sector due to the use of heat pumps for heating and retrofits. Retrofitting the non-residential sector accounts for 73% of the reductions produced by retrofitting buildings.

For transportation, the most relevant actions are decarbonizing transportation fuels and electrifying vehicles, accounting for 83% of the sector's total reductions. Decarbonizing transportation fuels comprises almost 40% of the sector's reductions, while electrifying commercial vehicles is important because it comprises 29% of the transportation reductions.

Figure 10. London emissions in the 2020–2050 period for the Net Zero Scenario by grouped actions.

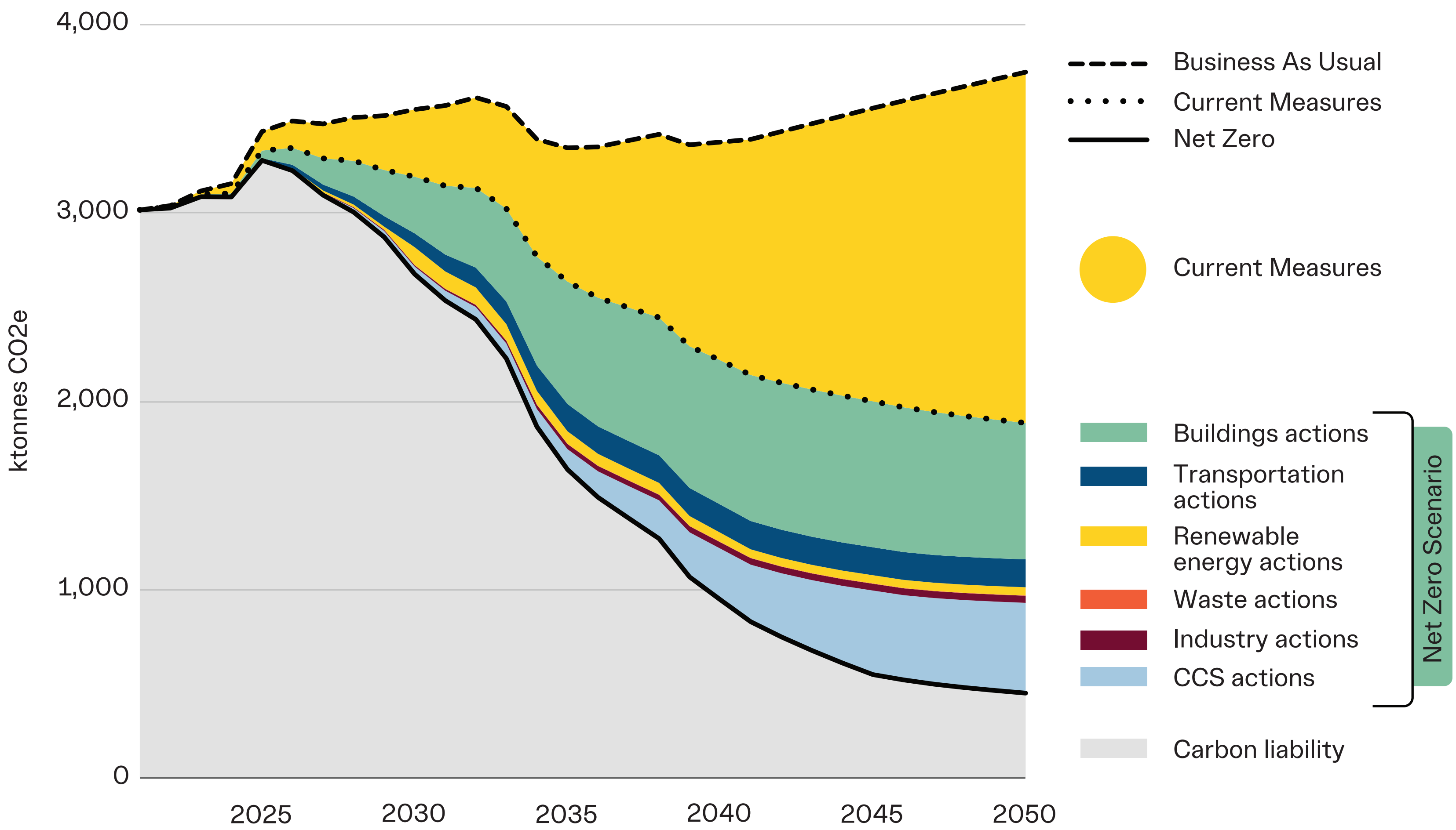
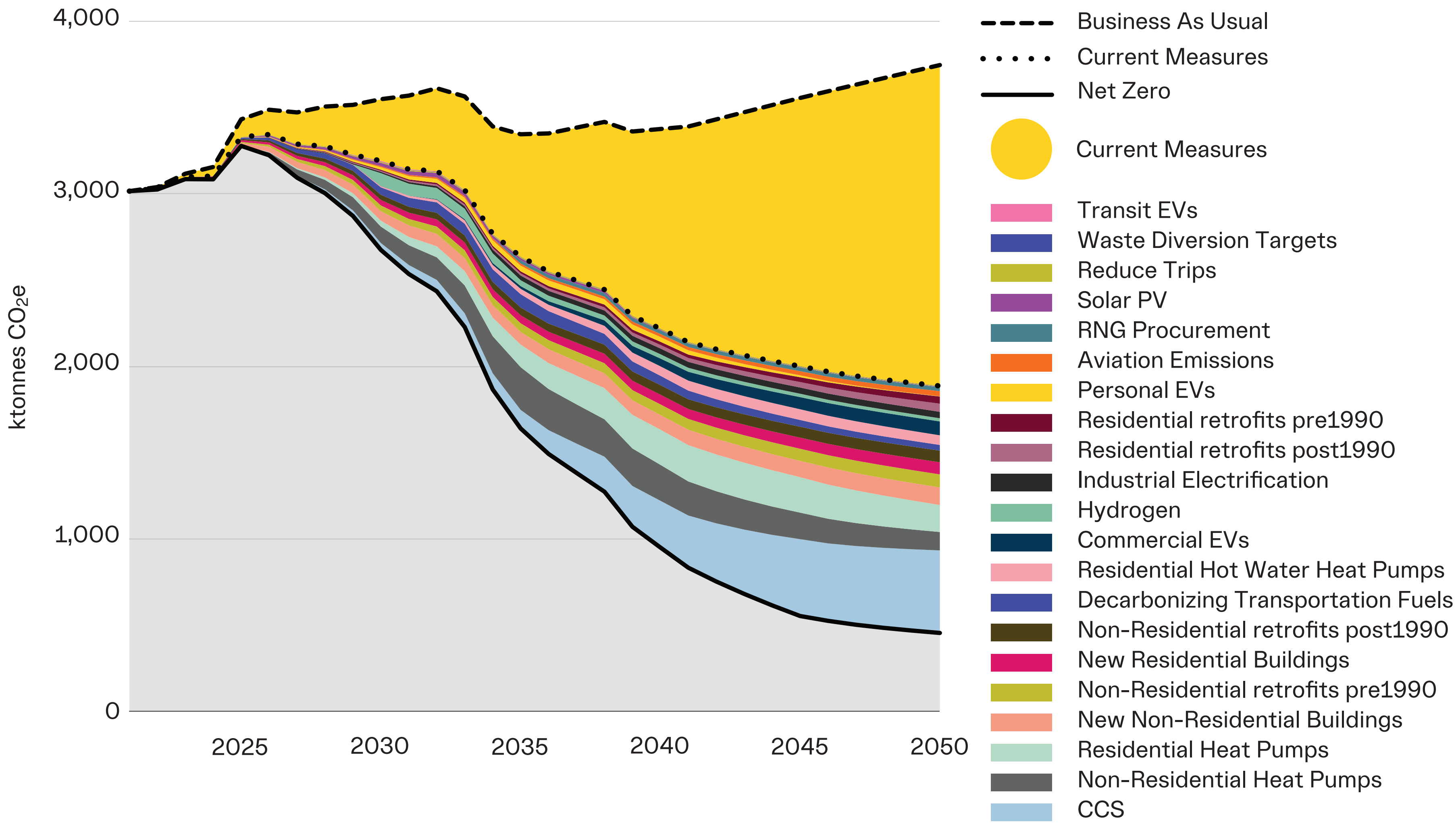


Figure 11. London emissions in the 2020–2050 period for the Net Zero Scenario by action.



Zero Carbon

Figure 12 shows GHG emissions reductions by grouped actions for the Zero Carbon Scenario. In this scenario, building actions contribute the most to reductions, accounting for 55% of the emissions reduced between 2021 and 2050. The second most important reduction occurs in the transportation sector (29%), followed by low-carbon actions in the industrial sector (9%). In 2050 the Zero Carbon Scenario reaches a carbon liability of 545 kilotonnes of CO_2e.

Figure 13 shows emissions reductions by actions. In the buildings sector, results follow the same pattern as in the Net Zero Scenario—the most important actions are switching the fossil fuels used for heating, increasing energy efficiency in existing buildings through retrofitting, and increasing energy efficiency standards for new buildings. As well, more than half the reductions occur in the non-residential sector, where retrofits and heating create most of the reductions. Retrofitting the non-residential sector is very relevant because it accounts for 75% of the reductions from retrofitting buildings.

For transportation, the most relevant actions are electrifying vehicles and decarbonizing transportation fuels, which produce 90% of the reductions. In this scenario, personal vehicle electrification results in 76% of the reductions from vehicle electrification. The third most important action in transportation is switching to sustainable transportation modes, which results in 5% of the sector's reductions.

Lastly, industrial emissions are reduced by electrifying industrial processes and increasing process efficiency. Electrification reduces 62% of total reductions in industry.

Figure 12. London emissions in the 2020–2050 period for the Zero Carbon Scenario by grouped actions.

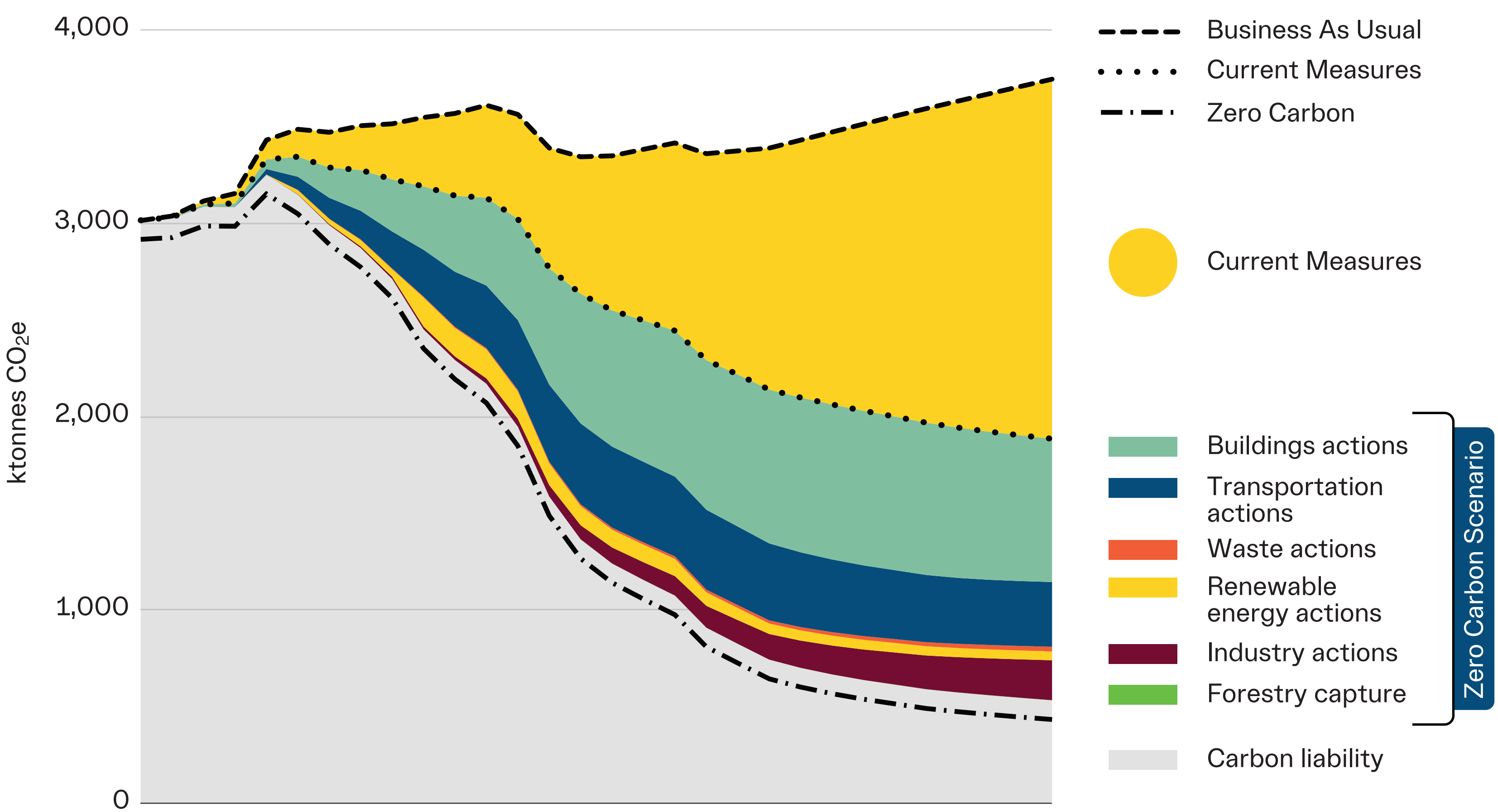
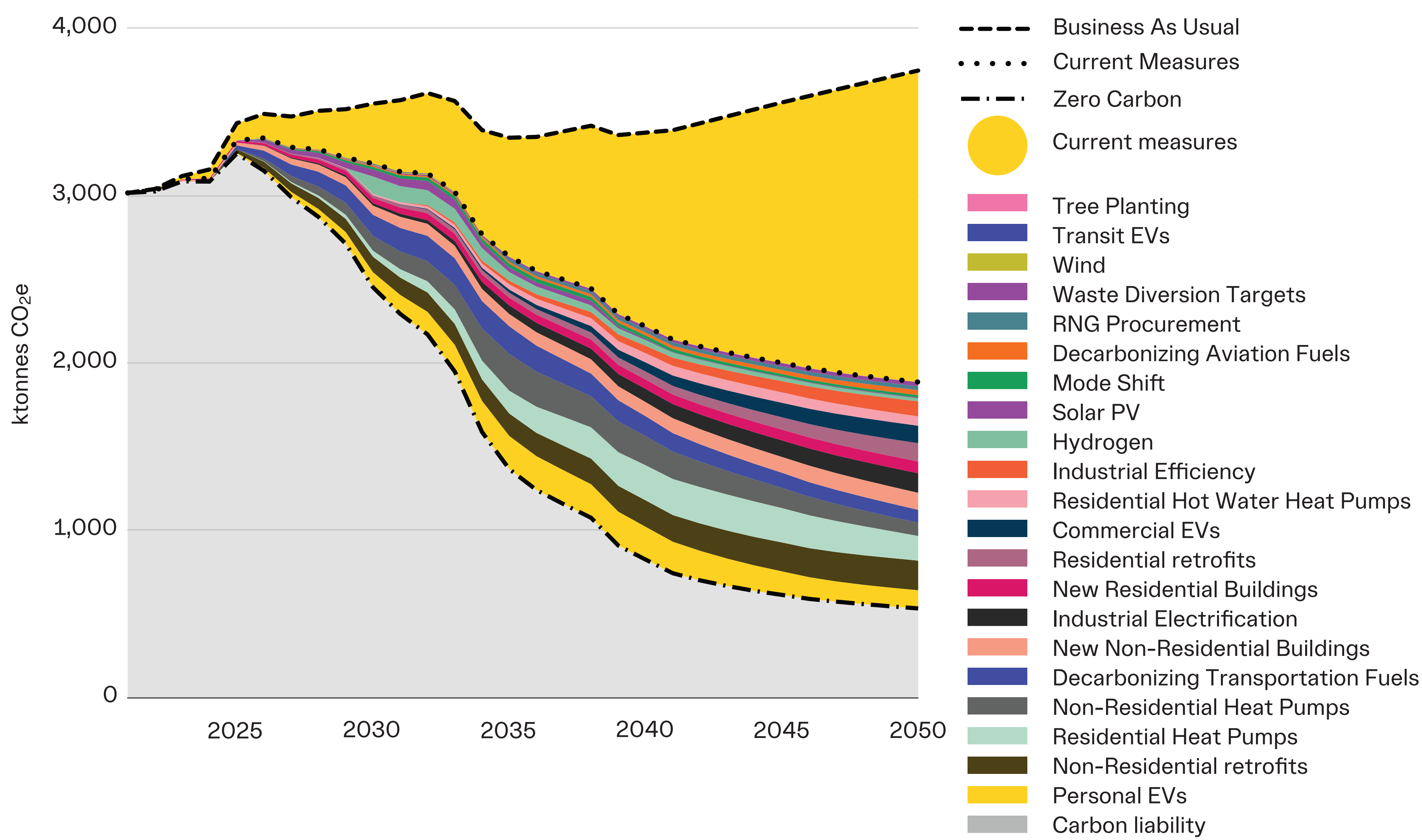


Figure 13. London emissions in the 2020–2050 period for the Zero Carbon Scenario by action.



Comparison of Low-Carbon Scenarios

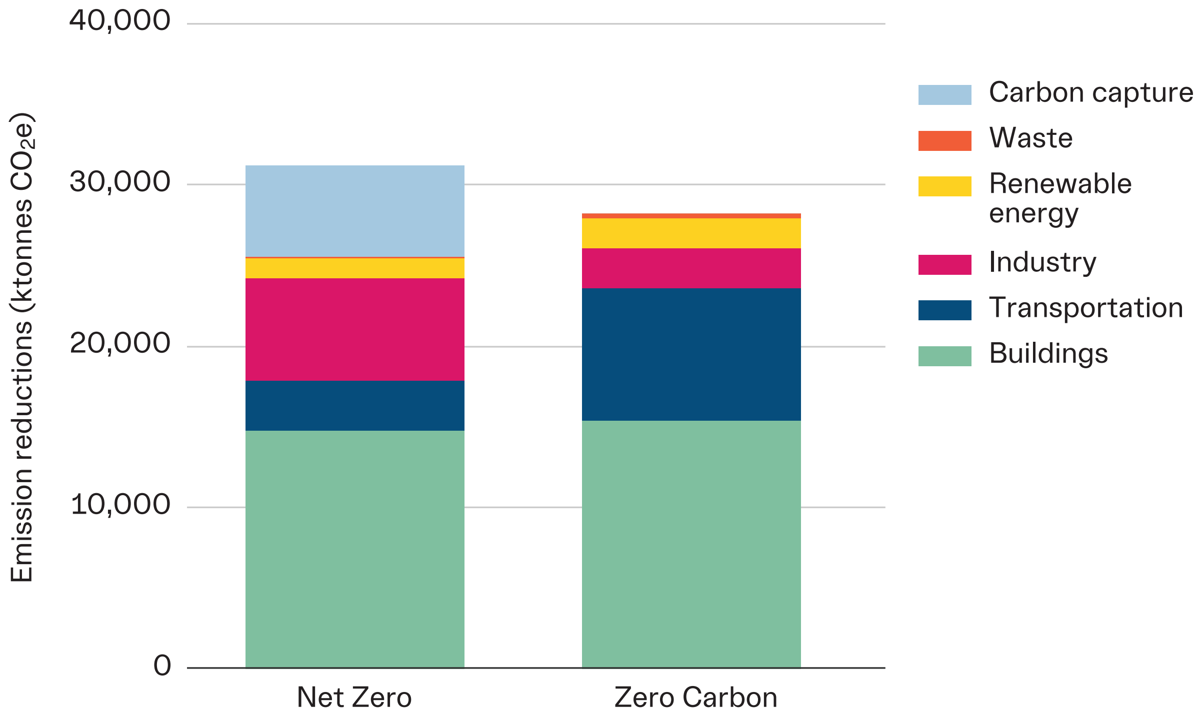
Both scenarios reduce a similar amount of GHGs in the 2025–2050 period (Figure 14). The main difference is in the speed and depth of the transportation, industry, and renewable energy actions.

The following actions reduce emissions more rapidly in the Zero Carbon Scenario than in the Net Zero Scenario:

- Electrifying personal and commercial-use vehicles. Reductions in the Zero Carbon Scenario are three times greater than in the Net Zero Scenario.
- Increasing waste diversion rates, which reduces the waste generated, results in triple the reductions of the Net Zero Scenario.Increasing rooftop solar energy. The installed capacity in the Zero Carbon Scenario is double that of the Net Zero Scenario, resulting in double the emissions reductions..
- Switching fossil fuels in industrial processes results in 2.5 times the emissions reductions compared to the Net Zero Scenario.
- Decarbonizing transportation fuels results in double the emissions reductions compared to the Net Zero Scenario.

The Net Zero Scenario decreases industrial emissions by using carbon capture in industrial processes. This action is shown separately to compare it with carbon sequestration in forests in the Zero Carbon Scenario and to illustrate the potential of actions that avoid GHG emissions in industry.

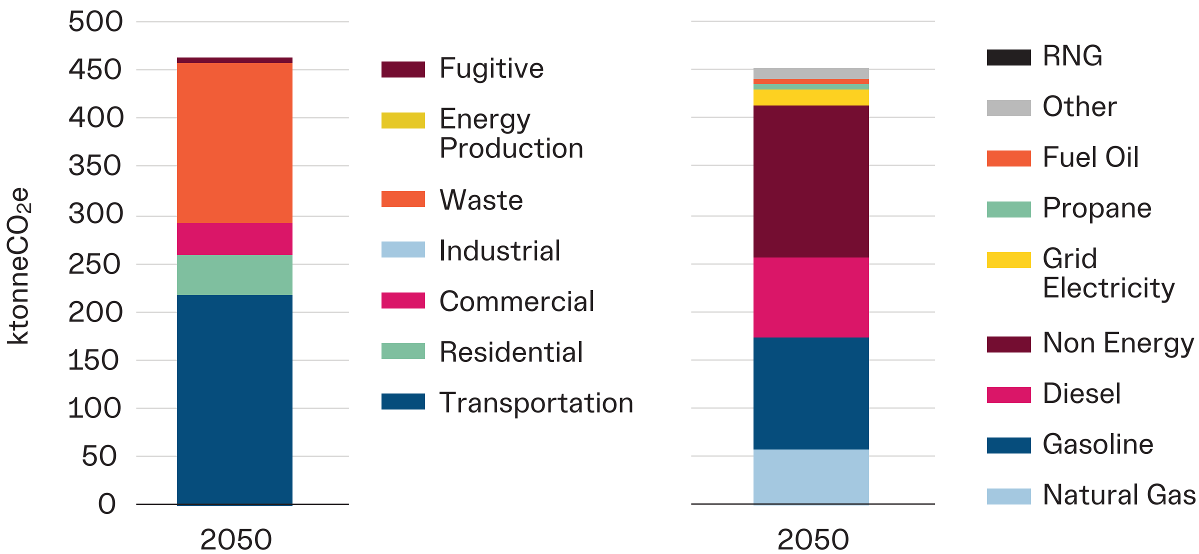
Figure 14. Cumulative emissions reductions (kilotonnes of CO_2e) in the low-carbon scenarios for the 2021–2050 period by sector.



Both scenarios have residual emissions, also known as a carbon liability. This amounts to 450 kilotonnes of CO_2e in the Net Zero Scenario and 550 kilotonnes of CO_2e in the Zero Carbon Scenario (Figures 15 and 16). Some technologies might evolve differently than modelled, resulting in additional opportunities for emissions reductions, and others may become cost-competitive with high-carbon technologies, accelerating their adoption rate. To address projected residual emissions, London can apply market-based mechanisms to achieve a net-zero balance, if necessary. Such strategies include increasing natural or technological carbon sequestration and purchasing carbon offsets. In the Zero Carbon Scenario, an approach could include increasing efforts to electrify industry or locally generating more renewable energy.

Residual emissions have different characteristics in each scenario. In the Net Zero Scenario, these emissions are from transportation because there is still a stock of PHEV and conventional gas- and diesel powered engines in 2050. So while this scenario decarbonizes fuels, it does not compensate for the use of fossil fuels. Diesel and gasoline are responsible for more than half (56%) of the remaining emissions in 2050. Waste also significantly contributes to residual emissions (34%) because landfill emissions are difficult to abate[10].

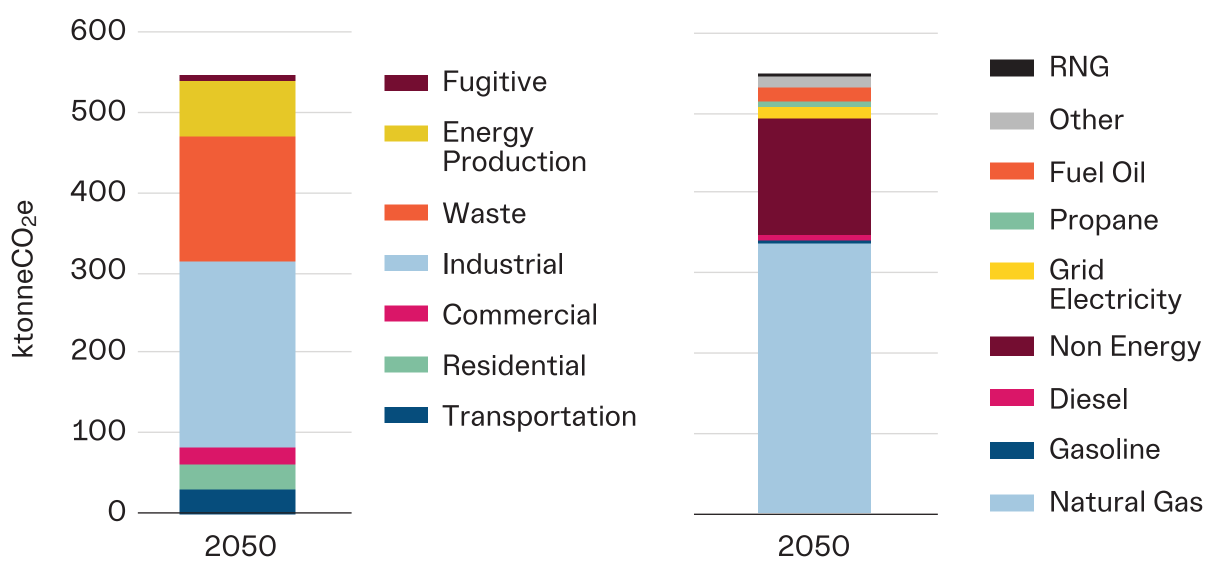
Figure 15. Remaining emissions (kilotonnes of CO_2e) in the Net Zero Scenario, by sector (left) and fuel type (right), by 2050.



10 Landfill gas is generated from the anaerobic decomposition of the organic waste fraction in landfills. LFG is mainly composed of methane (CH_4) and carbon dioxide (CO_2), and its production lasts for several decades until the majority of the organic material is fully degraded (LIFE RE Mida, EU). When capturing LFG to use it to generate RNG, there is an efficiency referring to the percentage of methane collected from a landfill. This percentage varies depending on factors like landfill design, operational practices, and system effectiveness. Efficiencies can reach nearly 90% in closed and engineered landfills (Duan et al, 2022). The part of the LFG that is not captured is emitted to the air, comprising the residual emissions that are difficult to abate.

In the Zero Carbon Scenario, the residual emissions are from industry and energy production (Figure 16). This is because the industrial efficiency and electrification actions do not reduce carbon emissions as completely as in the Net Zero Scenario, which relies on carbon capture and storage. Most of the residual emissions in this scenario result from natural gas combustion (61%) and landfill emissions in the waste sector, which are lower than in the Net Zero Scenario due to the waste generation reduction action.

Figure 16. Remaining emissions (kilotonnes of CO_2e) in the Zero Carbon Scenario, by sector (left) and fuel type (right), by 2050.



Aerial view of London, Ontario. Image adapted from Photo by leonardo/stock.adobe.com

5

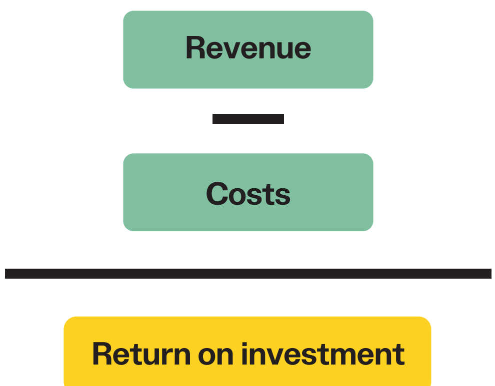
Economics of a Path Forward

GHG reductions are a critical response to the global climate emergency, so their importance goes beyond financial opportunities. However, the direct financial impacts of implementing low-carbon actions provide context for local decision-makers and make the business case for climate action. This chapter summarizes the financial implications of implementing low-carbon actions. Most actions included in the low-carbon scenarios also provide economic and social benefits to the community, such as net job creation and positive health outcomes; however, these are not included in the financial analysis. The benefit of avoided damages from climate change is included and is reflected only as the cost of carbon emitted.[11]

Financial Concepts

The key financial concepts used in this report are described below. Figure 17 illustrates the basic approach used for the financial analysis. Costs (investments and operational) and revenues are subtracted to calculate a net cost (loss) or a net income (profit).

Figure 17. Financial analysis diagram.



A key feature of the financial analysis is that **results are relative to the Business-as-Usual Scenario**, which does not include investments in climate action. This means that projected costs and savings are additional to the BAU Scenario.

Table 5 illustrates the financial estimates from the analysis[12] and their definitions. The two columns on the right include an example of an estimate relative to the BAU.

11 The broader social costs that are avoided from mitigating climate change, defined as the monetary value of the net harm to society associated with adding a small amount of that GHG to the atmosphere in a given year (Interagency Working Group on Social Cost of Greenhouse Gases, USA), are not included in this financial analysis.

12 Administrative costs associated with implementing programs, as well as any energy system infrastructure upgrades that may be required, are excluded. Similarly, the broader social costs that are avoided from mitigating climate change are not included in this financial analysis, such as avoided health costs or avoided damages from climate change.

Table 5. Financial estimates definitions and examples.

Estimate	Definition	Example	How is it Relative to the BAU?
Capital Expenditures[13] (Costs)	Money that is spent buying, building, or upgrading assets[14] (NRCan, 2024).	Purchasing an electric vehicle.	One EV costs $8,000 more than an equivalent gas- and diesel-powered vehicle in 2021.
Operating and Maintenance (O&M) Expenditures (Costs)	Costs incurred when operating and maintaining the capital expenditures.	Maintaining the car.	Maintenance cost savings for switching from a gas-and diesel-powered vehicle to an EV are $500 a year.
Energy Savings (Revenue)	Money that is spent or saved in energy.	Charging the EV.	Fuel savings from switching from gasoline to electricity are $2,000 per year.
Avoided Carbon Taxes[15] (Revenue)	Savings from reducing CO_2 emissions that would otherwise incur taxes.	Avoiding the purchase of fossil fuels because the car runs on electricity.	Saving $80 per tonne of CO_2 avoided.

When showing results of the financial estimates detailed above, we will show the **present or discounted values**. The present value is the current value of an expected expense or savings in the future. This is calculated by using a **discount rate**, which represents the reduced value of future dollars relative to current dollars. A 3% discount rate is applied.[16] The **net present value (NPV)** is the difference between the present value of the capital investment and the present value of the future stream of savings and revenue generated by the investment.

13 Borrowing costs are not included, since we are considering that all investments are made within the evaluation period and to avoid double counting, since financing for climate actions might be similar with financing business-as-usual choices of investments.

14 Costs of stranded assets are not included, since they are a primary responsibility of the owner and in cases these assets might be reconverted or be aided by local governments.

15 Calculations were done before the recent (March 2025) federal decision to drop the consumer carbon price.

16 Environment and Climate Change Canada (2016). Technical update to Environment and Climate Change Canada's social cost of greenhouse gas estimates.

This report also uses the **abatement cost**, which is the estimated cost to reduce one tonne of GHG emissions (measured in CO_2e). This is calculated by dividing the net present value[17] by the total GHG emissions reductions associated with a particular action or project. For example, if a project has a NPV of $1,000 and reduces 10 tCO_2e, its abatement cost is $100 per tCO_2e reduced.

As a convention, costs have a positive sign, while savings have a negative sign. Therefore, since signs are incorporated, the net present value is calculated by adding costs and incomes.

Total Investments and Savings

Investing in climate change actions will bring net benefits to the city of London, which can be referred to as "profitable" (when revenue exceeds expenses).

In the Current Measures Scenario, financial returns (profits) from implementing actions reach $7.9 billion (Table 6). The level of community-wide investment required over 25 years to implement the current measures is $2.5 billion, which, when annualized, is equivalent to 0.4% of London's 2021 GDP. This investment is offset and more than quadrupled by savings in operational and maintenance costs, energy expenditures, and avoided carbon taxes.

The suite of actions in the Current Measures Scenario generate financial returns because investments are low and returns are relatively high, but this scenario does not achieve the City's GHG targets.

Table 6. Summary of financial results for the Current Measures Scenario, $ billions.

Financial Estimate	Present Value in $ Billions for Current Measures, 2025–2050
Capital Expenditures	$2.5
O&M Expenditures	-$1.4
Energy Expenditures	-$7.5
Avoided Carbon Taxes[18]	-$1.6
Net Implementation	**-$7.9**

17 Difference between the present value of the capital investment and the present value of the future stream of savings and revenue generated by the investment.

18 Calculations in this report were done before the recent (March 2025) federal decision to drop the consumer carbon price.

Table 7 shows the financial results for the Net Zero Scenario (third column). These are relative to the Current Measures Scenario, so costs and savings are additional. The Net Zero Scenario by itself nearly offsets costs, with a net implementation cost of $0.7 billion. It also requires an additional investment cost of $9 billion over 25 years, less than 2% of London's 2021 GDP. The last column shows the results of the Net Zero Scenario relative to the Business-as-Usual Scenario ("Current measures + Net Zero"), where $7.2 billion in profits are generated.

Table 7. Summary of financial results for the Net Zero Scenario, $ billions.

	Net Present Value (NPV) in $ Billions, 2025–2050		
Financial Estimate	**Current Measures**	**Net Zero***	**Current Measures + Net Zero**
Capital Expenditures	$2.5	$9.3	$11.8
O&M Expenditures	-$1.4	$0.11	-$1.2
Energy Expenditures	-$7.5	-$5.8	-$13.2
Avoided Carbon Taxes[19]	-$1.6	-$2.9	-$4.5
Net Implementation	**-$7.9**	**$0.7**	**-$7.2**

* Net Zero results are relative to current measures. Therefore, financial estimates of this scenario are additional to the Current Measures Scenario.

The Zero Carbon Scenario generates financial returns of $6.4 billion in addition to the returns from the Current Measures Scenario (Table 8). The average additional investment cost of implementing the Zero Carbon Scenario actions over 25 years is equivalent to 1.3% of London's 2021 GDP. Similar to Table 7, the last column in Table 8 shows the results of the Zero Carbon Scenario relative to the Business-as-Usual Scenario ("Current Measures + Zero Carbon")—a financial return of $14.3 billion. This makes the business case for implementing low-carbon actions beyond current measures.

19 Calculations in this report were done before the recent (March 2025) federal decision to drop the consumer carbon price.

Table 8. Summary of the financial results for the Zero Carbon Scenario, $ billions.

	Net Present Value (NPV) in $ Billions, 2025–2050		
Financial Estimate	**Current Measures**	**Zero Carbon***	**Current Measures + Zero Carbon**
Capital Expenditures	$2.5	$6.5	$9.0
O&M Expenditures	-$1.4	-$0.4	-$1.8
Energy Expenditures	-$7.5	-$9.0	-$16.5
Avoided Carbon Taxes[20]	-$1.6	-$3.5	-$5.1
Net Implementation	**-$7.9**	**-$6.4**	**-$14.3**

* Zero Carbon results are relative to current measures. Therefore, financial estimates of this scenario are additional to the Current Measures Scenario.

In summary, while both low-carbon scenarios manage to decrease a similar amount of emissions, the Zero Carbon Scenario generates the greatest financial returns, while the Net Zero Scenario has a net implementation cost of $0.7 billion. When including current measures, both low-carbon scenarios generate positive financial returns, or are profitable.

20 Calculations in this report were done before the recent (March 2025) federal decision to drop the consumer carbon price.

Breakdown of Financials by Stakeholders

Figure 18 breaks down investments by type of stakeholder. Most investments in the Current Measures Scenario are made by residents and different levels of governments through incentives such as rebate programs, etc. In the Net Zero Scenario, a much higher share of investment is made in the industrial and commercial sectors, mainly driven by the investment costs of CCS. The Zero Carbon Scenario has a more balanced distribution of investment costs because it relies more on electrification, which occurs in both the residential and industrial sectors.

Figure 18. Share of investment costs to finance each scenario by type of stakeholder.

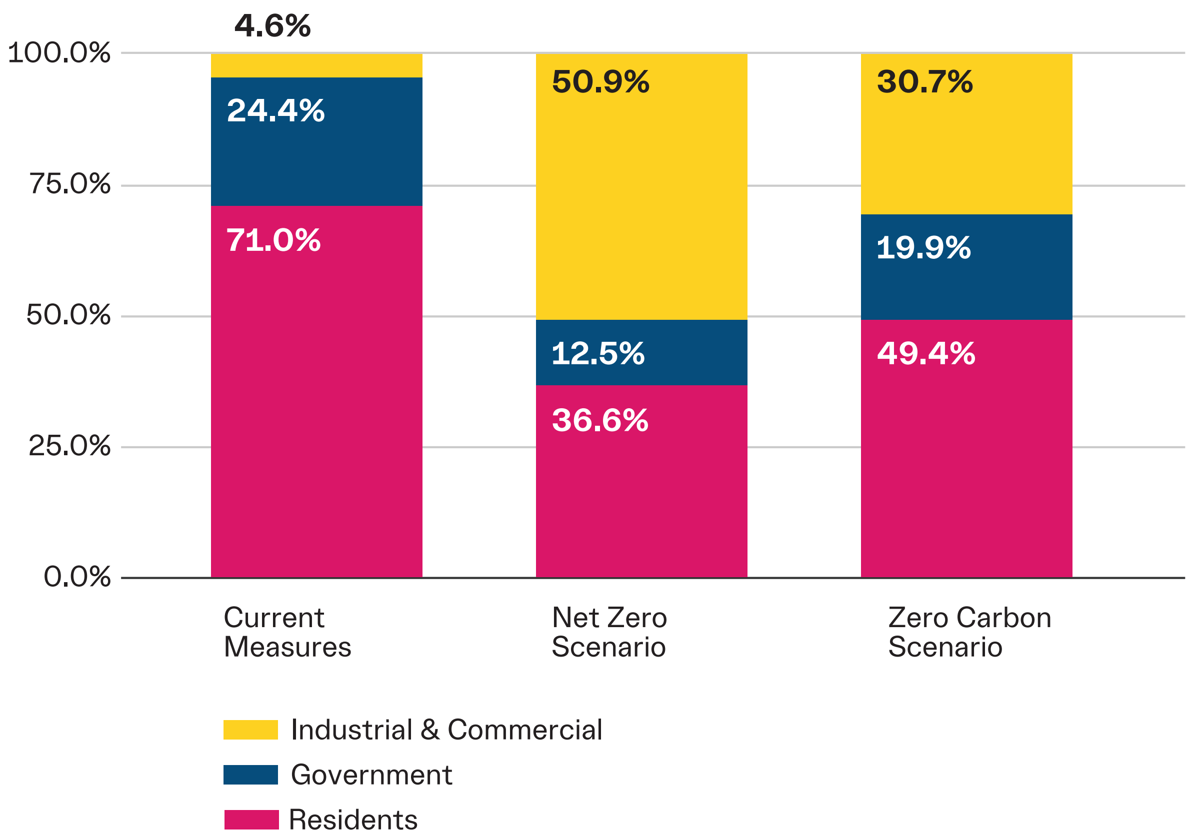
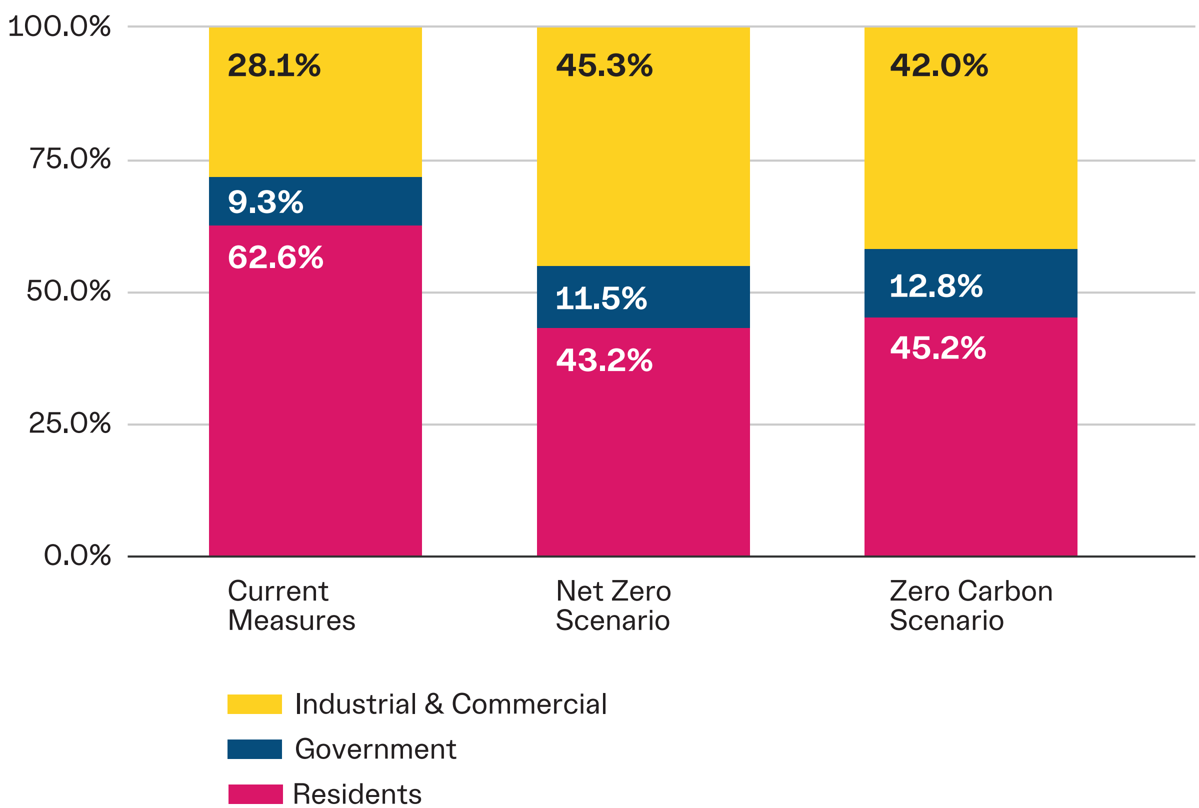


Figure 19 illustrates the operational expenses and revenues by type of stakeholder. Residents receive most of the returns in the Current Measures Scenario. In the Net Zero and Zero Carbon scenarios, a higher share of the returns occur in the industrial and commercial sectors, mainly driven by retrofitting and energy efficiency measures in non-residential buildings. Revenues for citizens in these scenarios come mainly from electrification of vehicles and improving the energy efficiency of new buildings.

Figure 19. Share of the operational expenses and revenues of each scenario by type of stakeholder.



Abatement Costs

Abatement costs indicate whether a climate action or group of actions generate financial returns over its lifetime. They refer to the expenses and savings associated with reducing GHG emissions and are calculated by dividing the net present value of each scenario by the total emission reductions over the whole period (or the area under the curve). A negative abatement cost indicates that financial returns are generated and the scenario is profitable, whereas a positive abatement cost indicates that an action costs money

Table 9 illustrates the GHG emissions reductions for the 2025–2050 period and the abatement costs per tonne of CO_2e for the Current Measures and Net Zero scenarios. As expected from the analysis in the previous section, the Current Measures Scenario generates financial returns over its lifetime, saving $318 per tonne of CO_2. The Net Zero Scenario by itself[21] costs $26 per tonne of CO_2 abated. However, when considering the Net Zero Scenario with current measures (or relative to the BAU) the combined package generates a return of $144 per abated tonne of CO_2.

Table 9. Abatement costs for the Net Zero Scenario (2025–2050).

Estimate	Current Measures	Net Zero	Current Measures + Net Zero
GHG emissions reductions (kilotonnes CO_2e)	24,838	25,502	50,341
Abatement cost (\$/tonneCO_2e)	-$318	$26	-$144

Similarly, Table 10 illustrates the abatement costs for the Current Measures and the Zero Carbon scenarios. Relative to the Current Measures Scenario, the Zero Carbon Scenario generates financial returns, saving $227 for each tonne of CO_2 abated, and reduces more emissions. The Zero Carbon Scenario along with current measures (or relative to the BAU) generates financial returns, saving $270 for each tonne of CO_2 abated.

Table 10. Abatement costs for the Zero Carbon Scenario (2025–2050).

Estimate	Current Measures	Zero Carbon	Current Measures + Zero Carbon
GHG emissions reductions (kilotonnes CO_2e)	24,838	28,217	53,055
Abatement cost (\$/tonneCO_2e)	-$318	-$227	-$270

21 This is the results relative to the Current Measures Scenario.

Marginal Abatement Costs

The marginal abatement cost (MAC) is the incremental cost of reducing one tonne of GHG emissions. The lower the cost, the more affordable the action, and in some cases, the action can be profitable. The MAC is calculated by summing the net present value of capital and operating costs over the lifetime of the investment divided by the tonnes of GHGs reduced. This is a relevant feature when interpreting results because the profitability of the action is influenced by the evaluation period. For instance, low-carbon actions generate financial returns and emissions reductions over the lifetime of the investment, even if the initial investment has been paid off. Therefore, an action that reduces emissions sooner will have a lower marginal abatement cost.

The following figures show the MAC curves (MACC) for modelled scenarios for London. The MACC arranges multiple actions in order from the lowest cost abatement opportunities on the left to the highest cost abatement opportunities on the right. The actions with negative abatement costs generate financial returns over their lifetimes. A positive abatement cost signifies a net cost over the span of the project. This comparison provides one way to view the costs and benefits of implementing emissions-reducing actions but should not be the only metric used to evaluate an action.

Figures 20, 21, and 22 show the MAC curves for the three scenarios. In these curves, axis X represents cumulative emissions reductions (kilotonnes CO_2e) and axis Y represents the marginal abatement cost ($/tonne$CO_2e$). Each action is represented by a bar—the wider this bar, the more it reduces. Similarly, a higher or lower bar indicates higher or lower abatement costs. These bars are coloured according to how each action is grouped, and they include the name of the action, the net cost (million dollars), and the cumulative emissions reductions (kilotonnes CO_2e).

Figure 20 provides the MAC for the Current Measures Scenario. Actions for reducing energy consumption in new residential and non-residential buildings have the lowest marginal cost, generating financial returns (savings) of $630 and $586 for every tonne of GHG reduced, respectively. On the opposite end of the curve, retrofitting residential buildings, together with installing heat pumps, has the highest marginal abatement cost at $317 for every tonne of GHG reduced. This is an interesting example, as it points out the relevance of considering the time lag of impact in emissions reductions with respect to when investments are made. Retrofitting the last house in 2050 will impact the cost of investments, but will not impact savings until after the evaluation period (2021–2050). An option is to implement these actions sooner than later, but there needs to be capacity to invest in the actions earlier. Another consideration is that the buildings actions are codependent, which is not conveyed by the MACC. For instance, installing heat pumps would not be as profitable if buildings were not retrofitted, as the capital cost would increase. To capture this impact, the actions are illustrated as bundles (the results for each action can be found in Appendix 7.4). Regarding transportation measures, vehicle electrification consistently generates savings, including for personal and commercial vehicles (savings of $398/tonne and $378/tonne) and transit (savings of $75/tonne).

In the Net Zero Scenario (Figure 21) the most expensive actions are mixing hydrogen with natural gas ($466/tonne), reducing energy consumption in existing residential buildings ($293/tonne), and implementing carbon capture and storage in industrial operations ($245/tonne). Actions with the lowest marginal abatement cost are implementing solar energy (savings of $1,206/tonne), reducing trips (savings of $918/tonne), and increasing the emission standards of new buildings (savings of $728).

The Zero Carbon Scenario (Figure 22) follows the same logic as the Net Zero Scenario. Mixing hydrogen with natural gas n has the highest marginal abatement cost ($415/tonne). Retrofitting residential buildings, together with installing heat pumps, has the second highest marginal abatement cost at $218 for every tonne of GHG reduced. Sequestering CO_2 by planting trees has the third highest marginal abatement cost at $157 per tonne. The tree planting action illustrates another consideration, as GHG emissions reductions are not always the primary motivator for its implementation. Instead, this action delivers significant benefits (ecology and shade) that are not factored into the calculation as financial benefits.

A comparison of both scenarios indicates that the Zero Carbon Scenario, which accelerates electrification and energy efficiency, has more profitable actions that reduce more GHG emissions and result in greater financial savings.

Figure 20. MAC curve of the Current Measures Scenario.

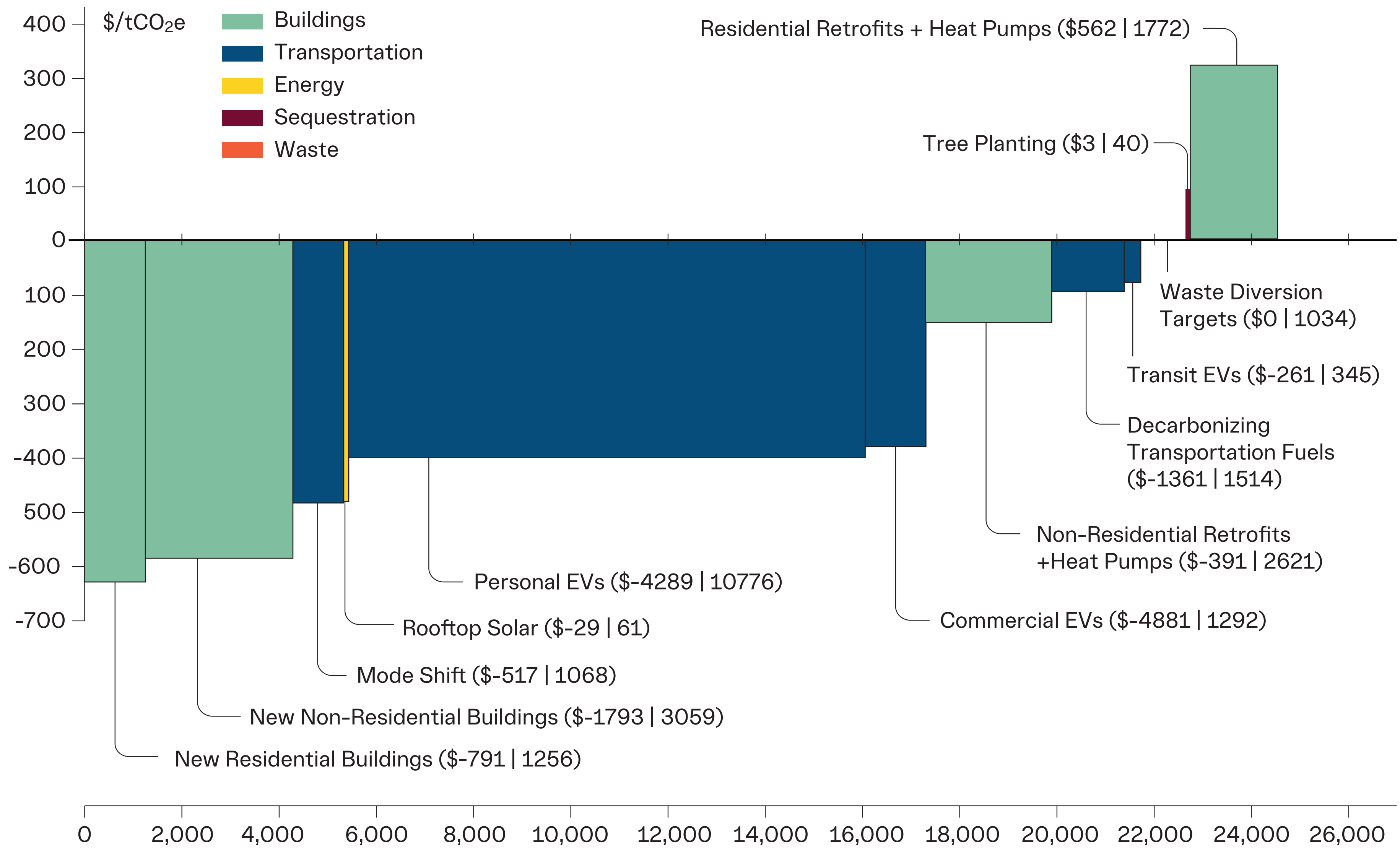


Figure 21. MAC curve of the Net Zero Scenario (relative to the BAU, this includes the Current Measures Scenario).

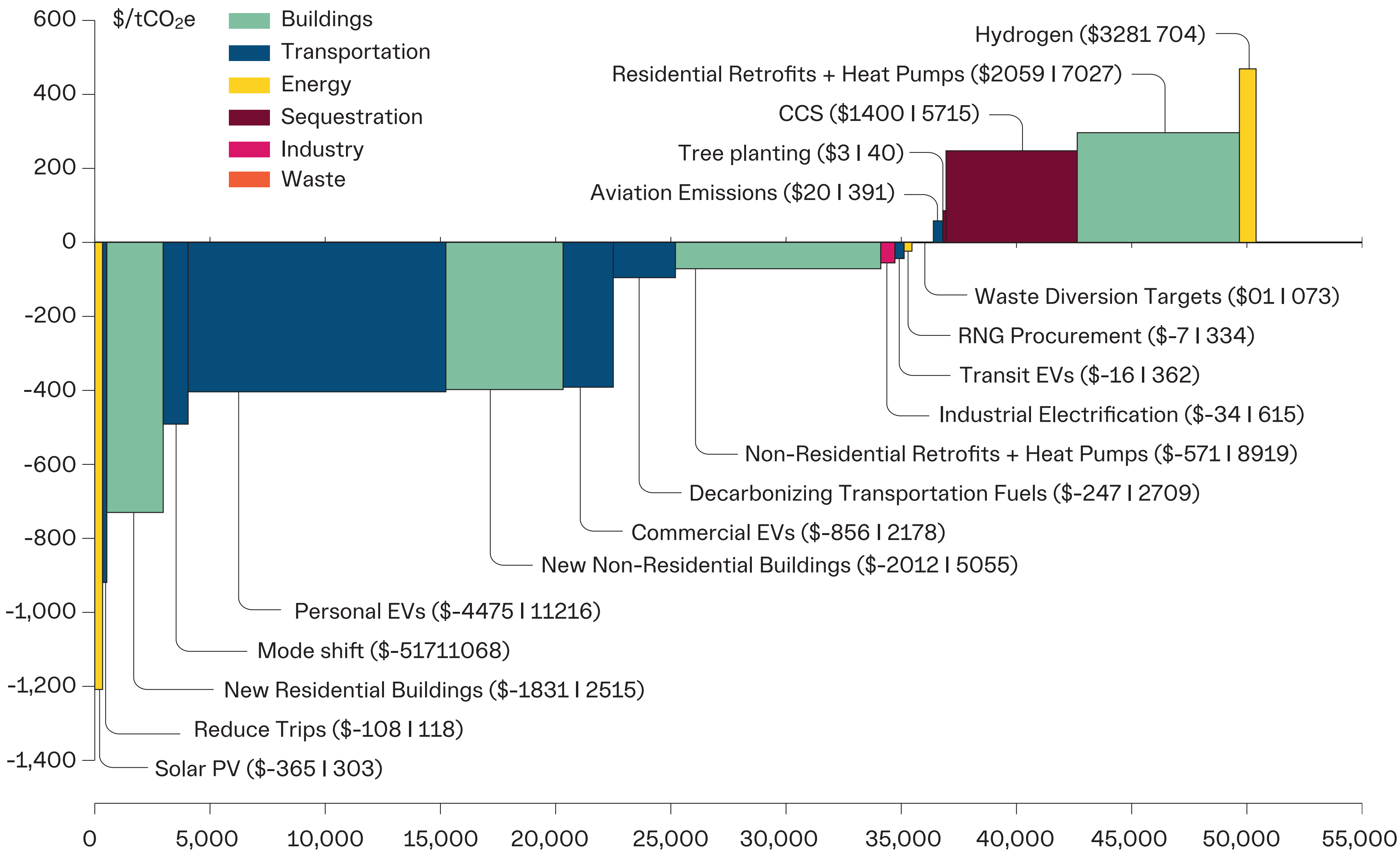
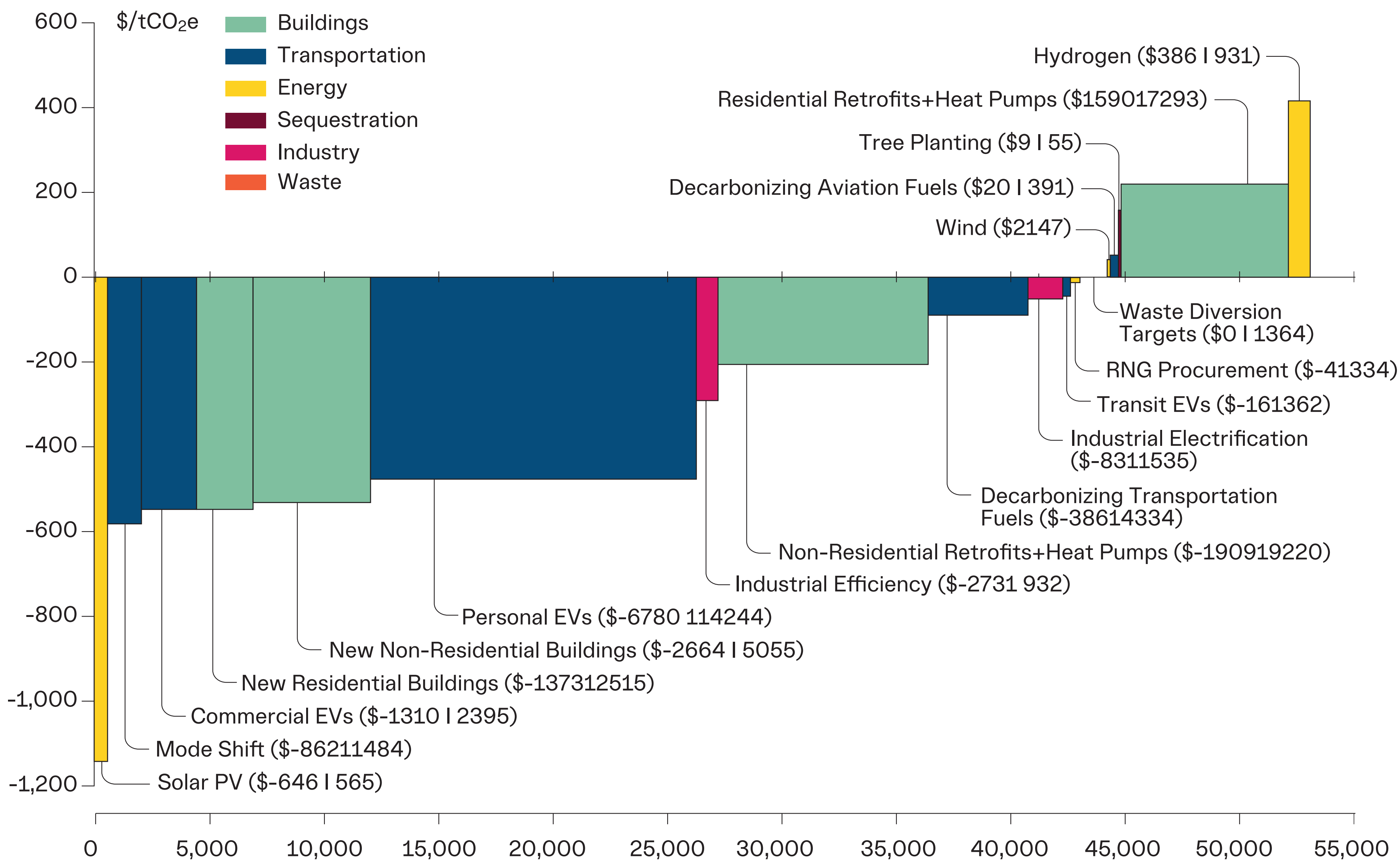


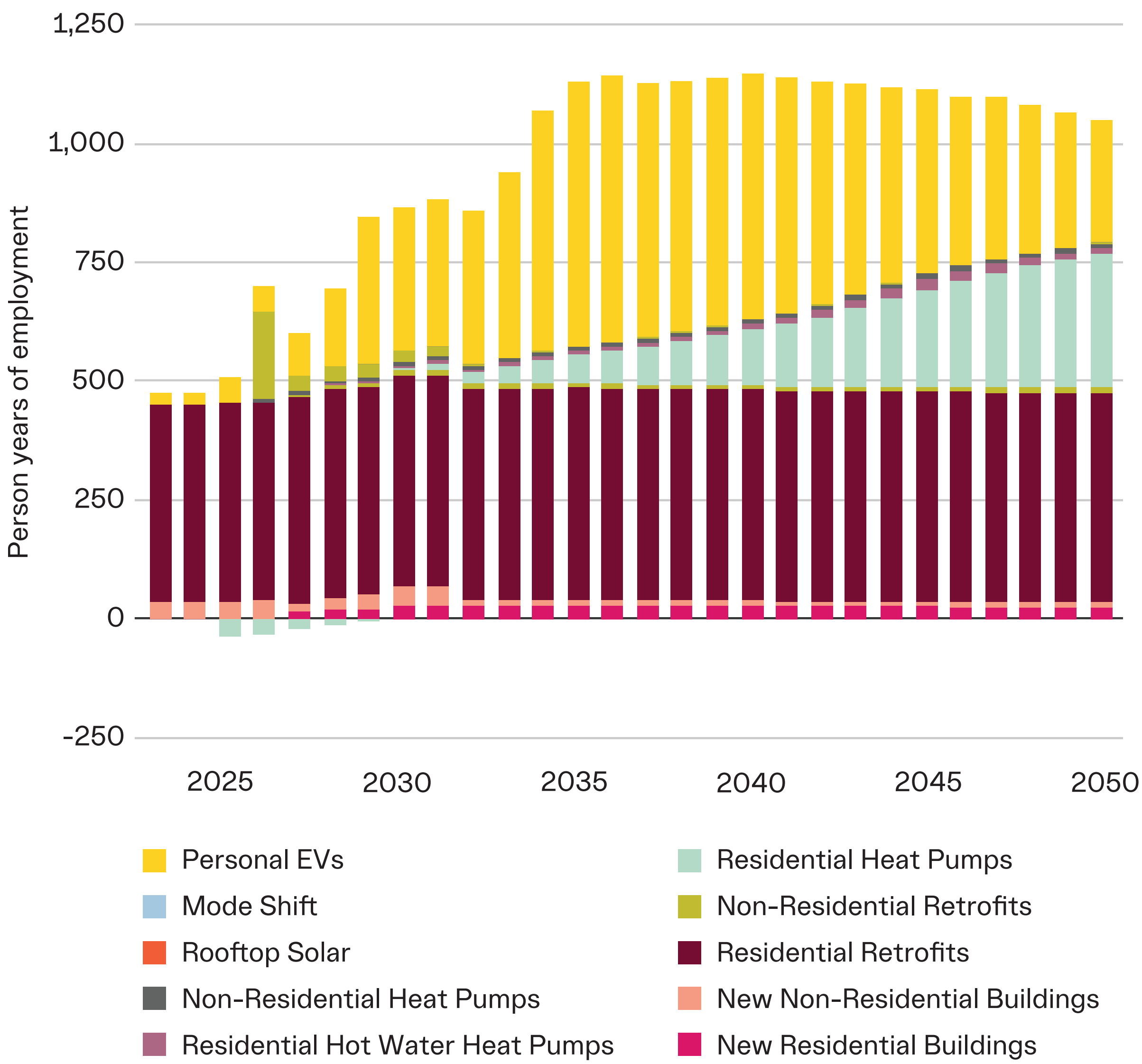
Figure 22. MAC curve in the Zero Carbon Scenario (relative to the BAU, this includes the Current Measures Scenario).



Employment

The investments made in low-carbon actions result in increased net employment. Employment multipliers for each million dollars of activity were used to calculate person-years of employment resulting from the investments in emissions reductions. For London, implementing the Net Zero or Zero Carbon scenarios is expected to add 112,422 and 80,026 person-years of employment between 2025 and 2050, respectively. These person-years of employment are additional to employment added by current measures, which is estimated to reach 28,718 person-years of employment between 2025 and 2050 (Figure 23).

Figure 23. Annual person-years of employment generated with current measures.



Figures 24 and 25 demonstrate that the buildings sector features prominently for new employment opportunities for retrofits and new energy-efficient buildings, as well as for heat pump installations. Some automotive repair jobs are lost (columns below the horizontal axis) as the requirement for maintenance of vehicles is expected to decline as electric vehicles become the norm.

Figure 24. Annual person-years of employment generated in the Net Zero Scenario.

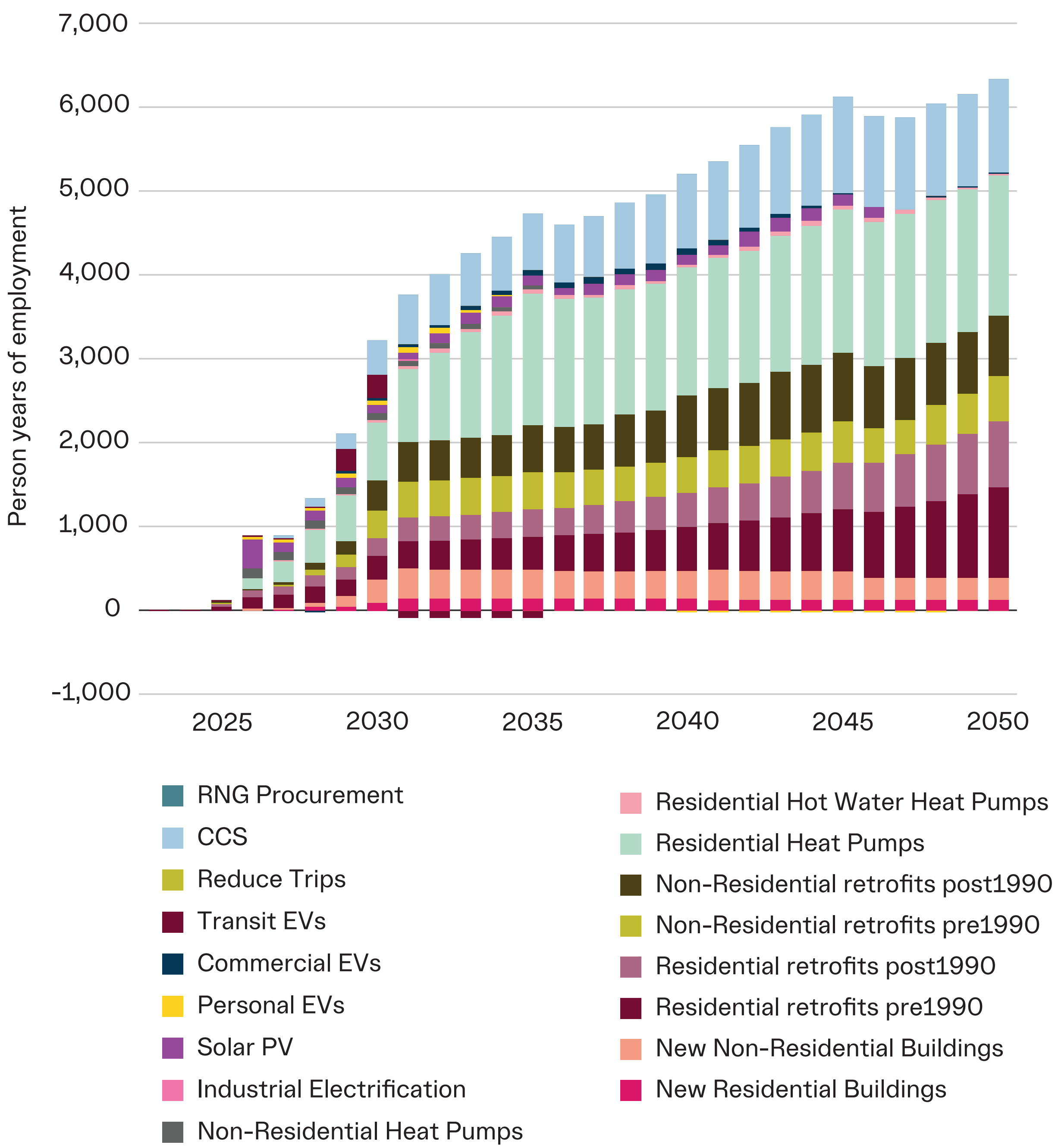
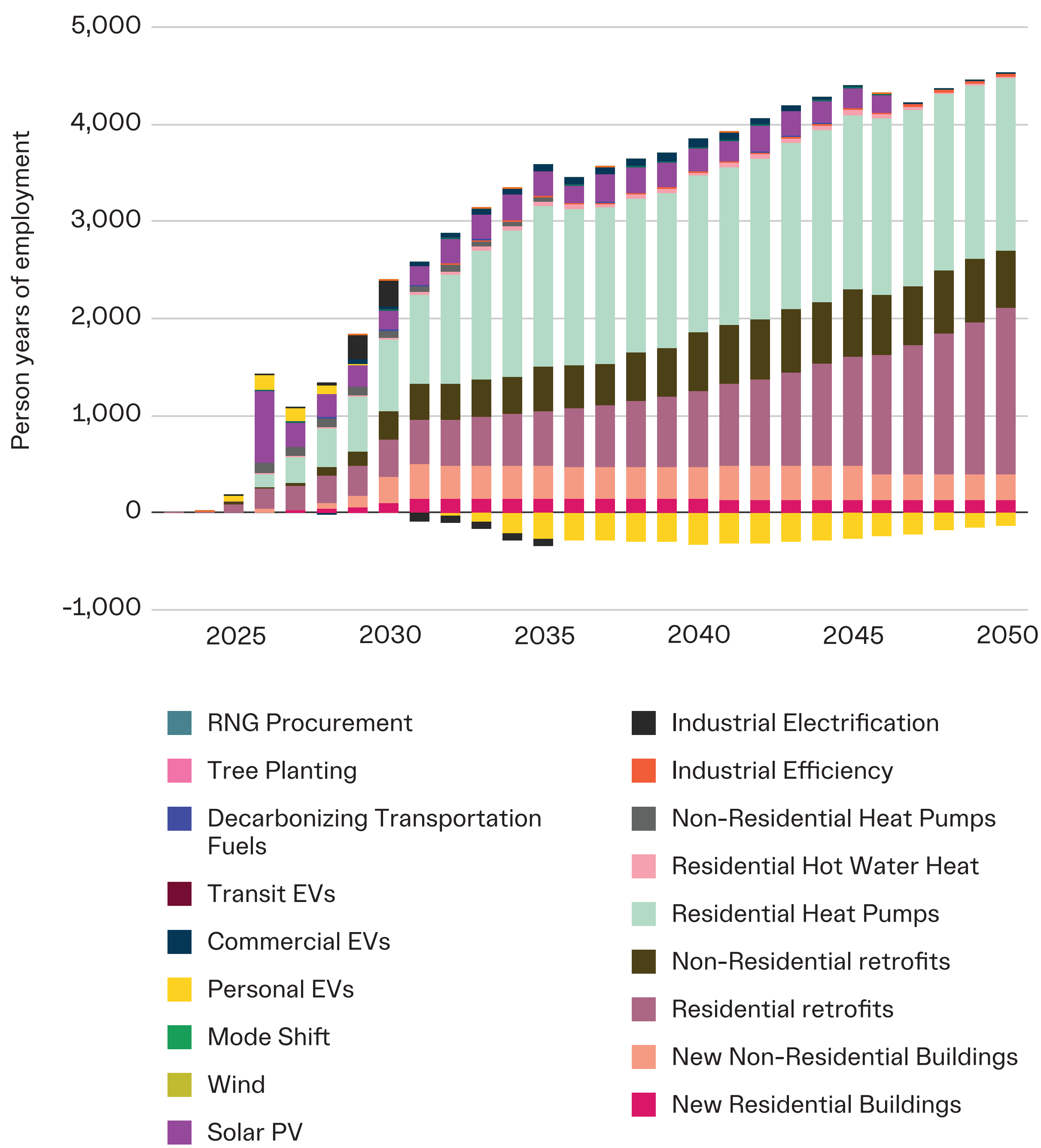


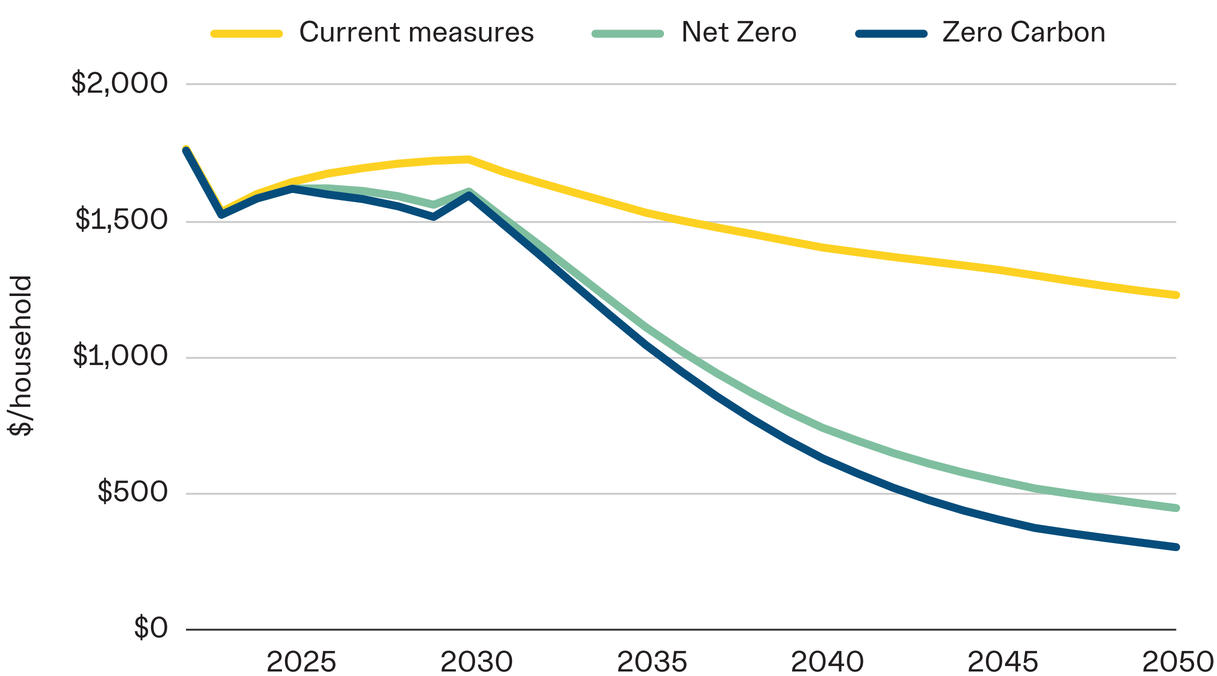
Figure 25. Annual person-years of employment generated in the Zero Carbon Scenario.



Savings for Households

Low-carbon actions lower energy expenditures in households (Figure 26). In the Current Measures Scenario, these costs are projected to decline by 30% in 2050, from $1,765 to $1,228. In the Net Zero and Zero Carbon scenarios, savings are much greater, with costs decreasing by 75% and 83%, respectively. Depending on the policies, business model, and financing strategies used in the implementation of the actions, these savings will be partly offset by the incremental capital expenditures required. Investments in building energy retrofits, faster vehicle electrification, increased transit and active trips, high-performance buildings, and renewable energy generation all contribute to significantly reducing average household energy expenditures.

Figure 26. Household annual energy expenditures by scenario, 2022–2050.



Aerial view of London, Ontario. Image adapted from Photo by leonardo/stock.adobe.com

6

Conclusions

London can move forward to implement the climate targets in its Climate Emergency Action Plan; however, additional policies and actions are required beyond what is currently planned at the local, provincial, and federal levels.

In order to evaluate the impacts of a low-carbon future, we modelled two scenarios: Net Zero and Zero Carbon. The primary difference between these scenarios is that the Net Zero Scenario depends on carbon capture technologies, whereas the Zero Carbon Scenario emphasizes electrification.

In terms of GHG reductions, both scenarios reduce emissions more than 80% from 2021 levels. Neither scenario achieves the 2030 targets, which would require a drastic decrease in emissions. Both scenarios achieve the 2035 and 2040 targets; however, by 2050, some residual emissions could remain unabated (15% to 18% of 2021 emissions). Strategies to address these remaining emissions include increasing natural or technological carbon sequestration, purchasing carbon offsets, increasing efforts to electrify industry, and generating additional renewable electricity

The financial analysis indicates that investments are required to implement low-carbon actions but over a long period of time (25 years). The economic effort, additional to current measures, ranges from approximately 0.4% to 2% of London's 2021 GDP. Both scenarios generate financial returns, but the Zero Carbon Scenario is more profitable. This is mainly because energy savings are high in this scenario, so actions yield higher returns. Carbon capture in the Net Zero Scenario significantly reduces GHG emissions, and this action has carbon tax benefits that are monetized; however, this action has no other economic benefits, and as a result, it is a costly mitigation measure.

Other benefits accounted for in this analysis include increased employment from implementing low-carbon actions. Depending on the scenario, more than 100,000 person-years of employment would be added between 2025 and 2050.

Implementing and financing climate action requires a significant effort to coordinate with different levels of government and interested parties. However, although the effort required is significant, the benefits are compelling.

7

Appendices

7.1 Emissions Inventory

Table A1 shows the emissions inventory for London in 2021. These emissions are categorized into three main emission sectors: buildings, transport and waste. Fugitive and energy production emissions are also accounted for.

Table A1. Inventory of GHG emissions year 2022.

Sector	Subsector	Emissions (ktonneCO_2e)
Buildings	Residential	596
	Commercial	551
	Industrial	419
Transportation		1,200
Waste		156
Fugitive		17
Energy Production		77
Total		**3,017**

7.2 Yearly Investments and Returns

Figures A1 and A2 show the year-over-year investments and returns in the Current Measures and Net Zero scenarios, respectively.

In Figure A1 the net annual cost is positive until 2032, and then it is negative, which shows that this scenario is highly profitable. However, Figure A2 shows that the net annual cost is always positive, so on a yearly basis, the Net Zero Scenario does not generate financial returns. This changes when we consider the Net Zero Strategy (Figure A3), which includes current measures, having financial returns from 2037 onwards.

Figure A1. Annual investments and returns in Current Measures Scenario, 2023–2050.

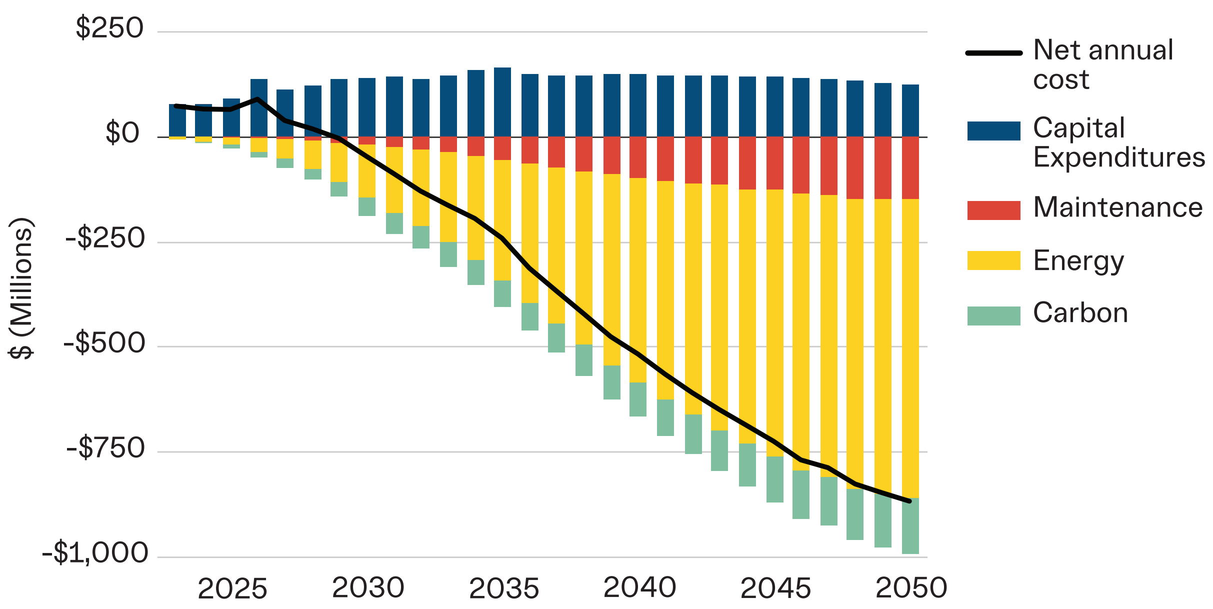


Figure A2. Annual investments in the Net Zero Scenario (relative to current measures), 2023–2050.

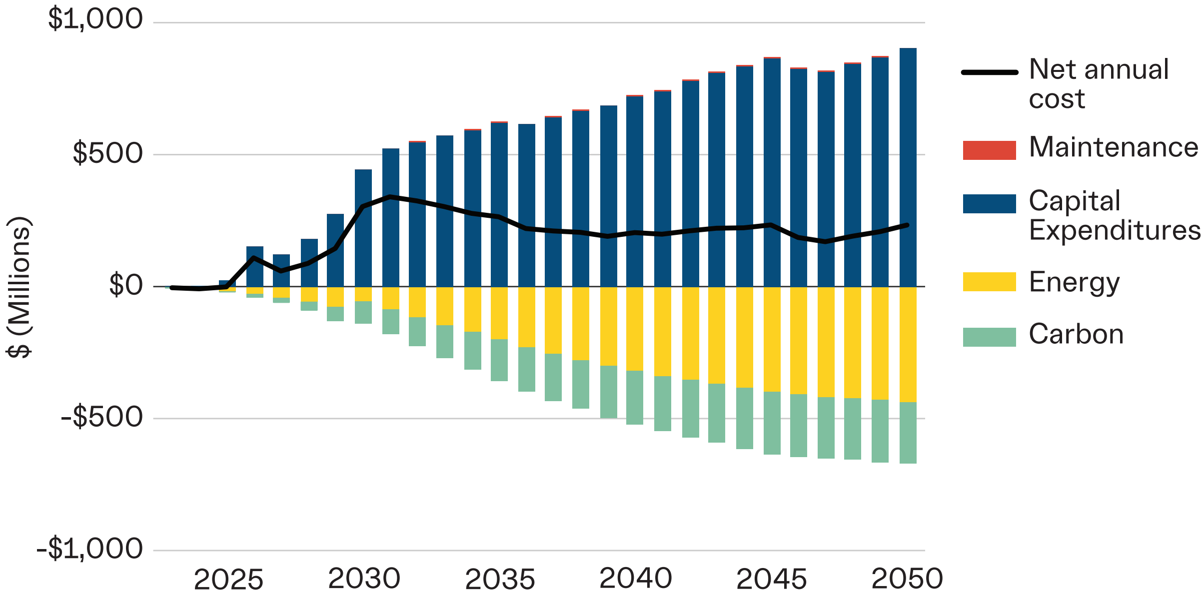


Figure A3. Annual investments in the Net Zero Strategy (including current measures), 2023–2050.

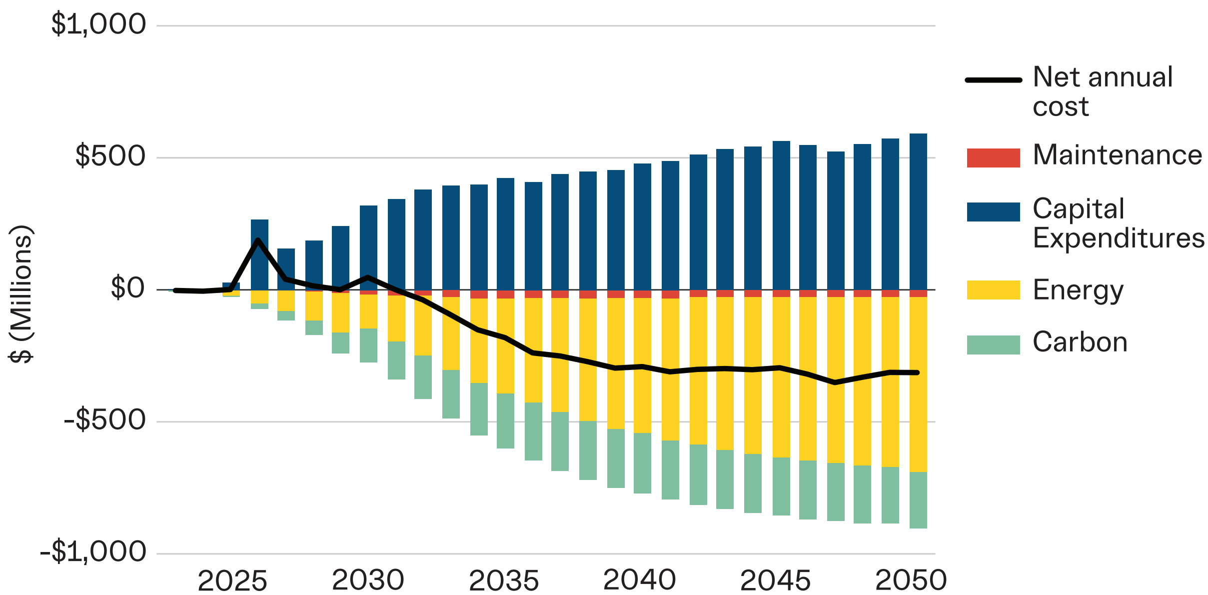


Figure A4 shows the year-over-year investments and returns for the Zero Carbon Scenario, which, on its own, generates financial returns from 2032 onwards. This logic remains the same when considering the Zero Carbon Strategy (Figure A5), but the financial returns are higher.

Figure A4. Annual investments in the Zero Carbon Scenario (relative to current measures), 2023–2050.

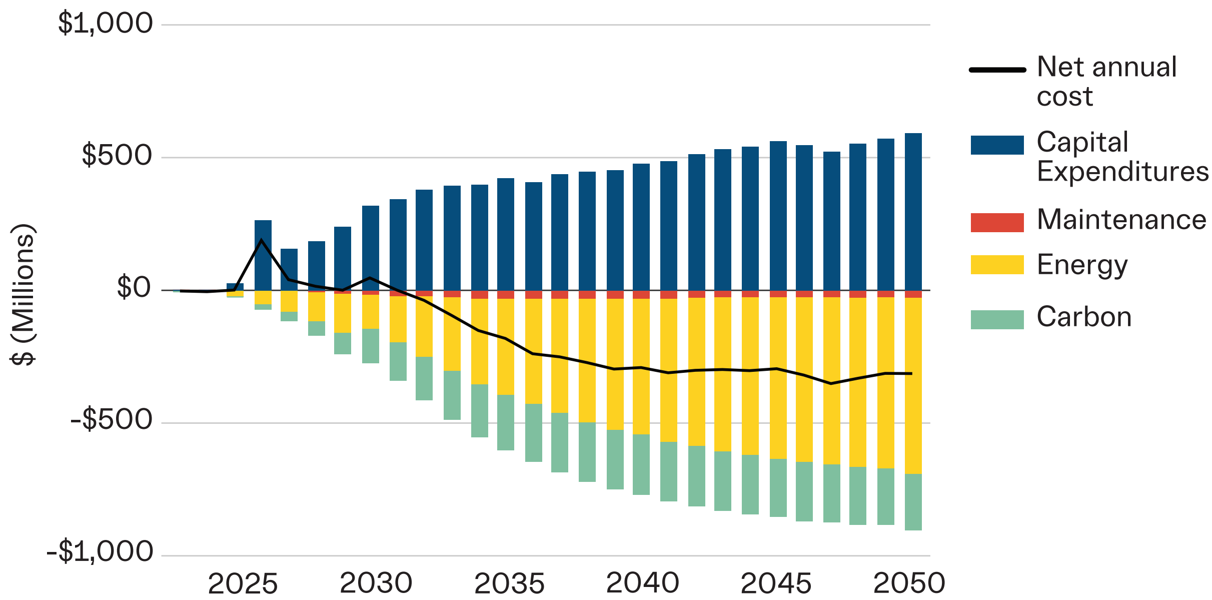
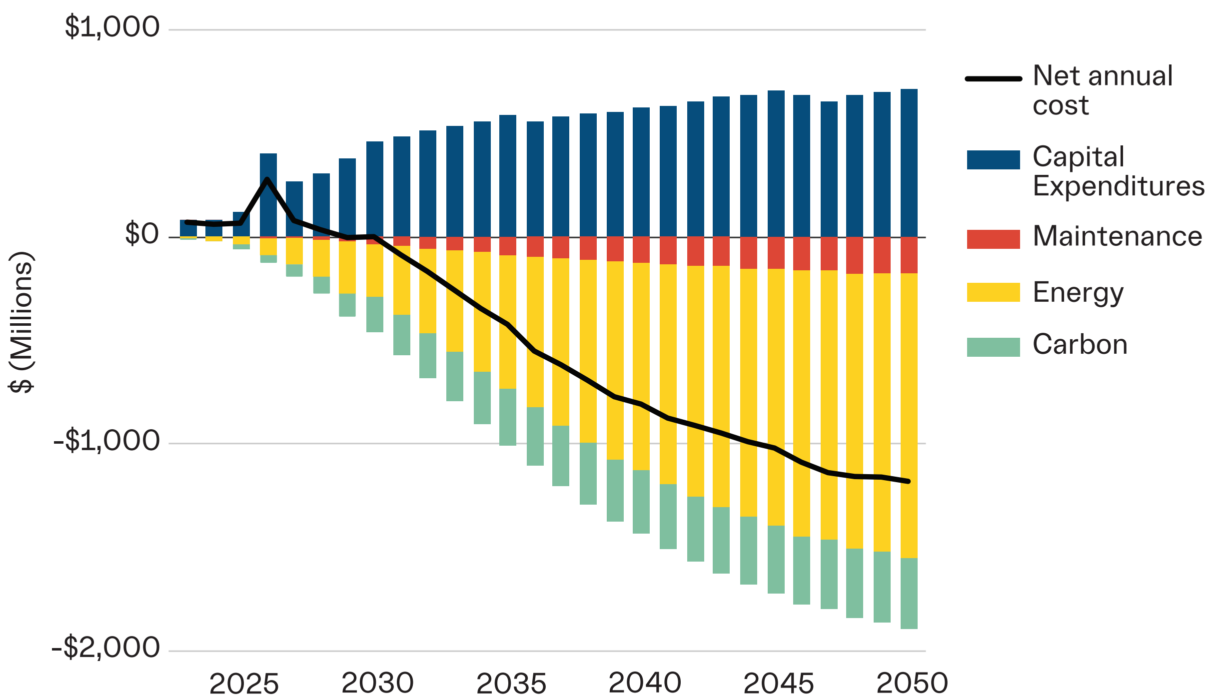


Figure A5. Annual investments in the Zero Carbon Strategy (including current measures), 2023–2050.



7.3 Total Investments by Action Type

Figure A6 shows investments per action in the Current Measures Scenario. Most of the investments are allocated to electrifying vehicles and retrofitting buildings.

Figure A6. Annual investments by action in the Current Measures Scenario, 2023–2050.

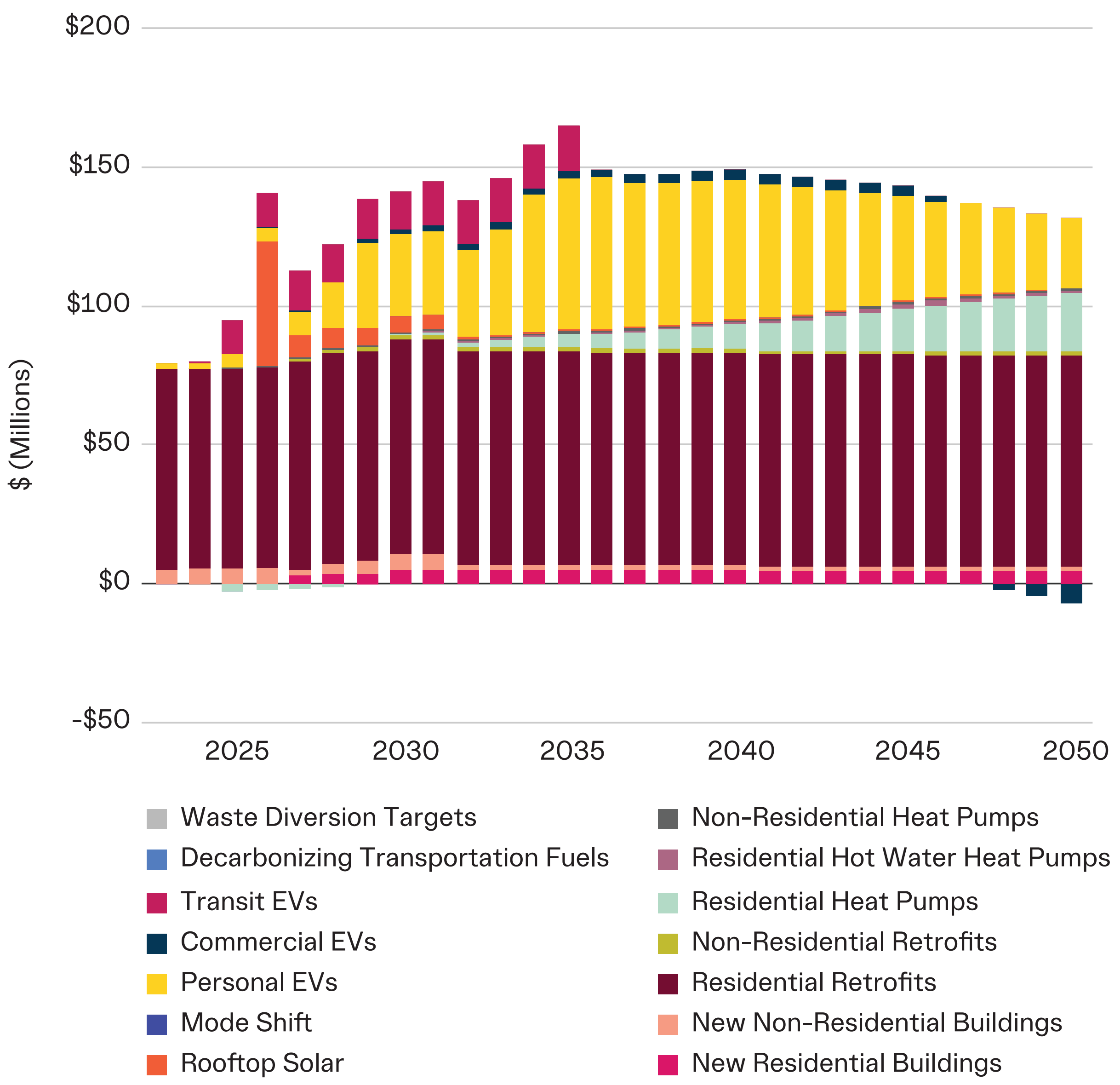


Figure A7 shows investments per action in the Net Zero Scenario. These are additional to the actions in the Current Measures Scenario. Residential building retrofits require the largest investments, followed by non-residential retrofits and carbon capture and storage. Electric vehicle purchases incur additional costs until reaching price parity, as they are typically more expensive than gas or diesel vehicles. Once reaching price parity in 2035, their total cost of ownership becomes a savings (columns below the horizontal axis) as operational and maintenance costs are reduced compared to those of gas vehicles.

Figure A7. Annual investments by action in Net Zero Scenario by action, 2023–2050.

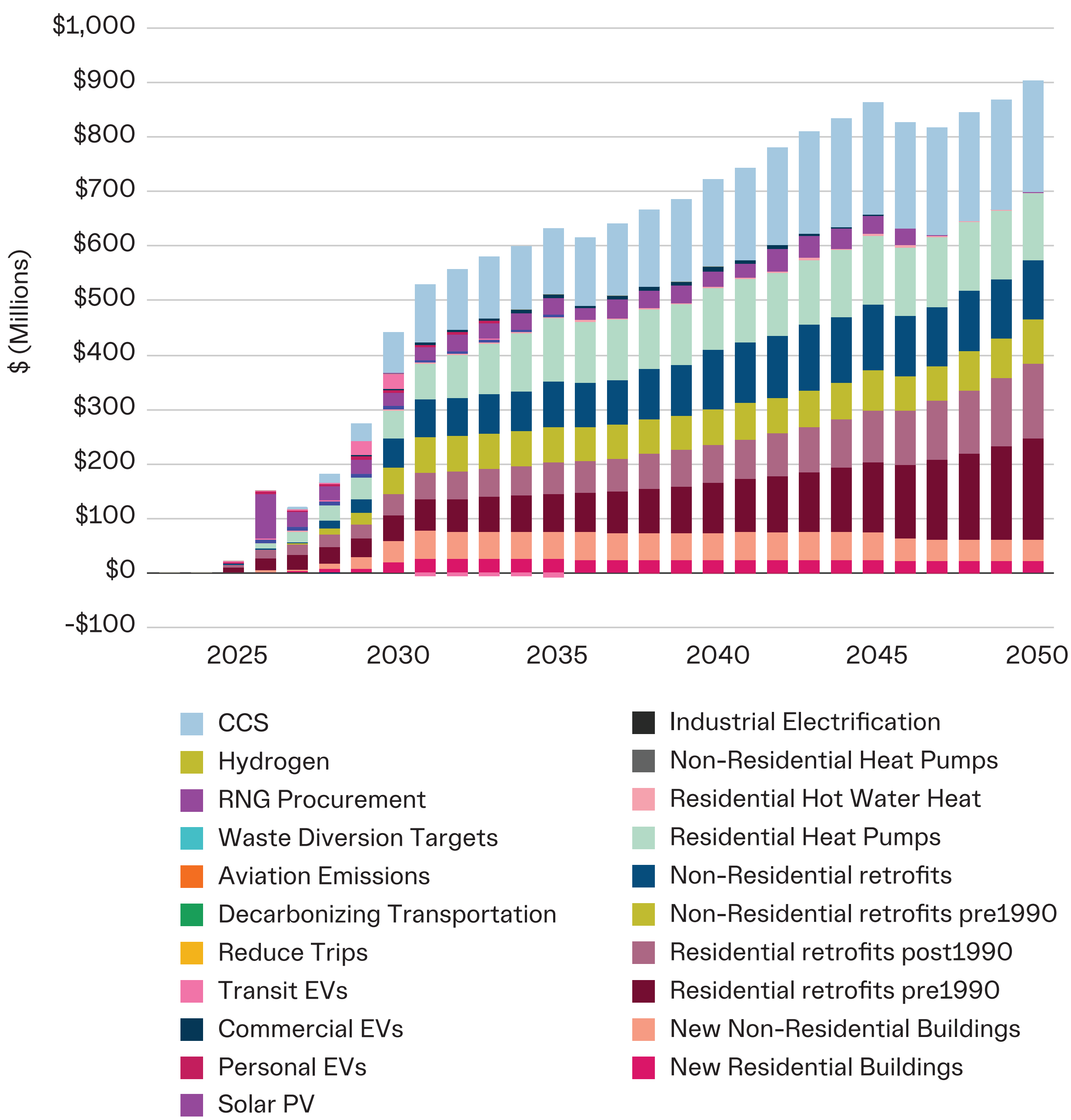
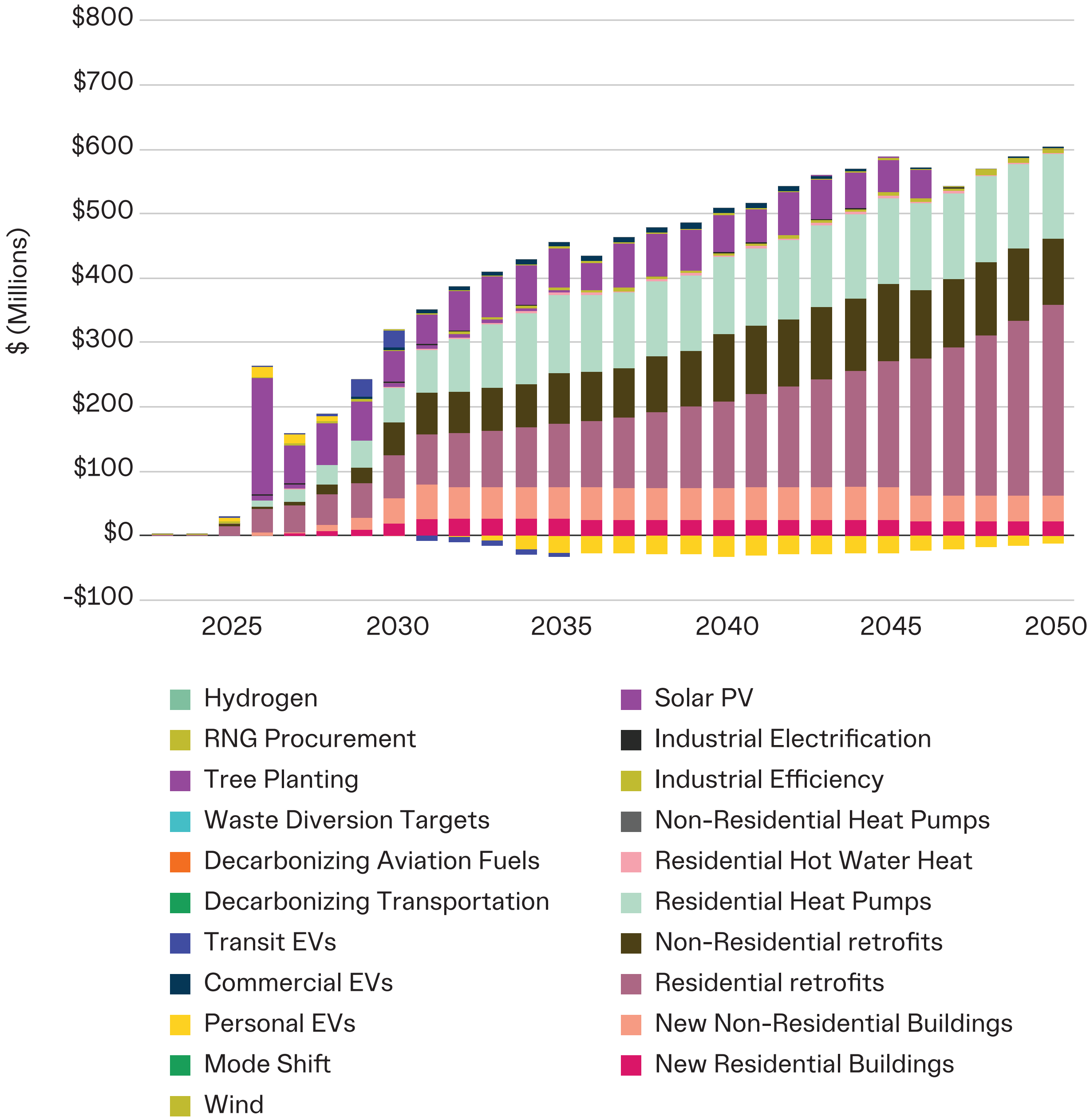


Figure A8 shows investments per action in the Zero Carbon Scenario additional to those in the Current Measures Scenario. Residential building retrofits also require the largest investments, followed by residential heat pumps and non-residential retrofits. Electric vehicle purchases incur additional costs until reaching price parity, as they are typically more expensive than gas or diesel vehicles. In the Zero Carbon Scenario, electric vehicles reach price parity earlier in 2030 than they do in the Net Zero Scenario.

Figure A8. Annual investments by action in Zero Carbon Scenario, 2023–2050.



7.4 Marginal Abatement Costs

This appendix shows marginal abatement costs for each action in each scenario.

Table A2. Marginal abatement costs for the Current Measures Scenario (relative to the BAU).

Action	Cumulative Emissions Reductions (ktonneCO_2e)	Marginal Abatement Cost ($/tonne$CO_2$e)
New Residential Buildings	1,256	-630
New Non-Residential Buildings	3,059	-586
Non-Residential Retrofits	357	-501
Mode Shift	1,068	-484
Rooftop Solar	61	-481
Residential Hot Water Heat Pumps	195	-405
Personal EVs	10,776	-398
Commercial EVs	1,292	-378
Residential Heat Pumps	622	-172
Non-Residential Heat Pumps	2,264	-94
Decarbonizing Transportation Fuels	1,514	-90
Transit EVs	345	-75
Waste Diversion Targets	1,034	0
Tree Planting	40	85
Residential Retrofits	955	783
Total	**24,838**	**-318**

Table A3 shows marginal abatement costs for each action in the Net Zero Scenario, relative to the BAU. This is why total emission reductions are shown at the bottom of the table.

Table A3. Marginal abatement costs for the Net Zero Scenario.

Action	Cumulative Emissions Reductions (ktonneCO_2e)	Marginal Abatement Cost ($/tonne$CO_2$e)
Solar PV	303	-1,206
Reduce Trips	118	-918
New Residential Buildings	2,515	-728
Mode shift	1,068	-484
Personal EVs	11,216	-399
New Non-Residential Buildings	5,055	-398
Commercial EVs	2,178	-393
Residential Hot Water Heat Pumps	1,148	-339
Non-Residential Heat Pumps	6,025	-107
Decarbonizing Transportation Fuels	2,709	-91
Industrial Electrification	615	-56
Transit EVs	362	-44
RNG Procurement	334	-21
Waste Diversion Targets	1,073	0
Non-Residential Retrofits	2,894	24
Aviation Emissions	391	51
Residential Heat Pumps	3,982	77
Tree planting	40	85
CCS	5,715	245
Hydrogen	704	466
Residential Retrofits	1,897	1,131
Total	**50,321**	**-144**

Table A4 shows marginal abatement costs for each action in the Zero Carbon Scenario, relative to the BAU. This is why total emission reductions are shown at the bottom of the table.

Table A4. Marginal abatement costs for the Zero Carbon Scenario.

Action	Cumulative Emissions Reductions (ktonneCO_2e)	Marginal Abatement Cost ($/tonne$CO_2$e)
Solar PV	565	-1,144
Mode Shift	1,484	-581
Commercial EVs	2,395	-547
New Residential Buildings	2,515	-546
New Non-Residential Buildings	5,055	-527
Personal EVs	14,244	-476
Non-Residential retrofits	3,771	-361
Residential Hot Water Heat Pumps	1,149	-339
Industrial Efficiency	932	-293
Non-Residential Heat Pumps	5,449	-102
Decarbonizing Transportation Fuels	4,334	-89
Industrial Electrification	1,535	-54
Transit EVs	362	-44
RNG Procurement	334	-11
Waste Diversion Targets	1,364	0
Wind	47	39
Decarbonizing Aviation Fuels	391	51
Residential Heat Pumps	4,025	98
Tree Planting	55	157
Hydrogen	931	415
Residential Retrofits	2,119	747
Total	**53,055**	**-270**

7.5 ScenaCommunity Model

ScenaCommunity is SSG's energy, emissions, and finance model developed to study complex urban systems. The model tracks how and where electricity and fuels are consumed in a city and how GHG emissions are produced. The fully transparent model addresses all urban sectors (e.g., buildings, transportation, industry, waste, etc.) and systems (e.g., energy, waste). ScenaCommunity is the cutting edge in energy and emissions modelling and has been tested and validated by clients across North America to inform their climate action plans and energy strategies.

Some key characteristics of the ScenaCommunity model include the following:

1. **A Systems Approach:** ScenaCommunity is an integrated energy and emissions systems dynamics model (Figure A9). It simulates multiple dimensions of energy systems over time, incorporating projected population growth, the impact of planned and proposed policies, and feedback between sectors in space, with precisely mapped resolution. For example, Scena can assess GHG emissions from heating buildings by tracking heating equipment (e.g., type and age, size, era, location, use, capital cost, and operating cost). This level of detail enables us to develop realistic, investment-ready climate action strategies that detail costs and savings, and positions the City to align planned capital investments and secure additional implementation funding.
2. **Spatial Resolution:** ScenaCommunity's spatial analysis enables the City to explore future dynamics of transportation and land use in a zone system that aligns with transportation planning, future growth projections, and infrastructure planning.
3. **Integrated Urban Systems:** Most models in this space use spreadsheets with limited dynamics between sectors. They forecast how emissions can be mitigated in industries or buildings. However, emissions reduction actions have cross-sectoral effects. Scena analyzes the dynamics within and between sectors resulting from actions and policies. This analysis ensures that relevant policies in transportation, for example, impact the electricity sector.
4. **Following the Money:** Scena performs a comprehensive financial analysis of energy costs and savings (for the City, households, and businesses). It includes externalities such as the damages caused by climate change (represented by the cost of carbon emitted or the social cost of carbon) and the operating and capital costs and savings of policies, strategies, and actions. It also calculates employment impacts across all sectors and actions. This enables us to design viable climate action pathways that help governments identify financial needs and payback periods for specific projects.
5. **Equity Analyses:** Scena assesses the impact of policies, strategies, and actions from the municipal level right down to the household level. We integrate equity considerations into our plans by assessing the impact of policies and strategies on individual households, neighbourhoods, dwelling types (detached, row, apartments, etc.) and household income levels. This can inform future community engagement activities and measure the impacts of planned climate action on vulnerable populations. Figure A10 shows an example.

Figure A9. SSG's ScenaCommunity Model. The diagram shows the relationships between activities and outputs in our model. The relationships are important to accurately model actions, as any sector's actions can affect energy use and emissions production/reduction in other sectors. As such, modelling these relationships helps determine which actions to take and in what order to take them.

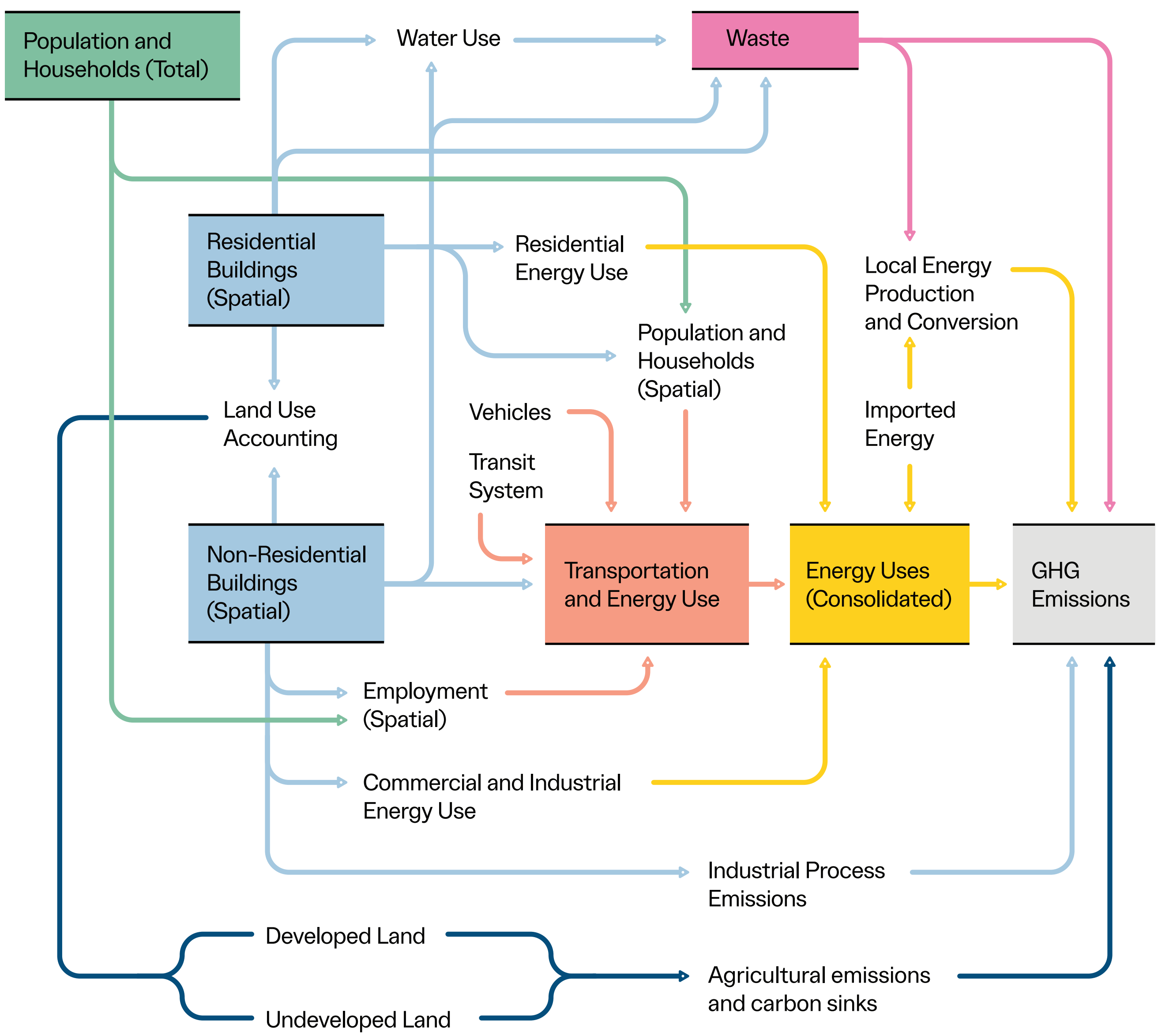
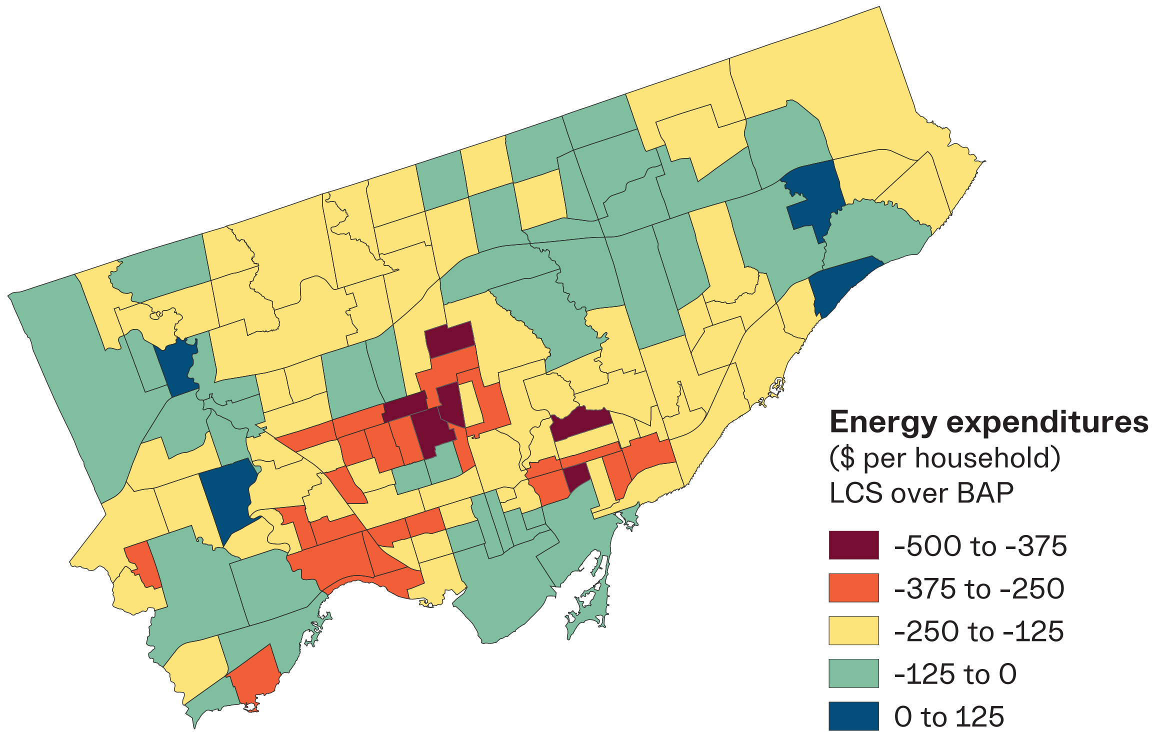


Figure A10. Household energy expenditures in a Low-Carbon Scenario (LCS) versus the Business-As-Planned (BAP) Scenario in the year 2050. Created by SSG for the City of Toronto.



7.6 SSG's Team

Carla Gallardo, Consultant, BSc.| P. Eng | MSc Industrial Ecology

Role: Project Lead

Carla (she/her) has worked in the private sector and in government at Chile's Ministry of Environment. She has a background as an analyst and project and team lead, with experience providing technical and economic insight and feedback based on modelling for public policies on local pollution problems and environmental quality standards. She has also assessed the cost of environmental damage remediation and explored environmental justice issues. At SSG, Carla works as project lead on initiatives that assess greenhouse gas emissions and the costs and benefits of mitigation measures. She is leading climate plans for Newmarket, ON; recently completed climate action plans for 11 municipalities in the Los Rios Region of Chile; and led an award-winning project for the Global Methane Hub. Carla is passionate about creating better policies for an environmentally just society.

Yuill Herbert, SSG Principal, BA | MA

Role: Project Advisor

Yuill (he/him) has been working in the climate change mitigation and adaptation field for nearly 20 years. He has leading expertise on climate change mitigation and adaptation, urban planning, and systems modelling that incorporate energy, GHG emissions, and co-benefits. Yuill has developed corporate and community energy plans with evidence-based targets and has modelling experience with district energy systems, transportation systems, and land-use planning, allowing for analysis and recommendations that are holistic and precise. He has worked on more than 40 community plans across Canada, including high-profile projects like HalifACT 2050 for the Halifax Regional Municipality, the City of Toronto's TransformTO, the Town of Bridgewater's Community Energy Investment Plan, the City of Ottawa's Energy Transition, and the City of Edmonton's Energy Transition Plan Update. Yuill has worked on multiple projects in the Maritimes, including for Colchester County, the Union of Municipalities of New Brunswick, and Nova Scotia's Western Region Enterprise Network (South and French Shores). Yuill was a fellow of Project Drawdown, an ambitious initiative to model 100 global solutions to climate change. He also developed the first spatial energy and emissions model for municipalities in Canada and co-developed ScenaCommunity (formerly CityInSight).

Marcus Williams, SSG Principal, BA | MA

Role: Lead Modeller

Marcus (he/him) is a Principal and Senior Modeller with more than 15 years experience in integrated systems modelling and analysis encompassing energy, emissions, land use, transportation, buildings, and demographics. Marcus has been instrumental in the development of CityInSight (Community Edition)—a state-of-the-art energy, emissions, and finance model for cities—since its launch at COP 21 in Paris in 2015.

He led the development of CityInSight (Corporate Edition), oriented toward organizations planning low-carbon transitions for their building portfolios, thermal networks, vehicle fleets, employee commuting, and travel. Marcus used and adapted this model to support development of low-carbon pathways for Canada's federal government operations in the National Capital Region with more than 2,000 fixed assets and one of Canada's largest thermal networks.

Most recently, Marcus led a first-of-its-kind effort to provide free, open-source GHG inventories for every single one of Canada's more than 5000 municipalities. The Municipal Energy and Emissions Database (MEED, meed.info) is a bottom-up activity-based community GHG inventory calculator and a top-down national and provincial downscaling framework.

Marcus is a member of the Energy Modelling Hub's Platform Committee. He keenly follows the exploding open-source data ecosystem—for data processing, geoprocessing, and data visualization—for urban and regional low-carbon analysis.

Chris Strashok, Principal Consultant, BSc Eng | MA

Role: Modeller

Chris (he/him) has more than 20 years of experience modelling and working with complex, dynamic processes. He has evaluated sustainability initiatives in energy, water, infrastructure, transportation, and social capital. Chris has led the analysis and modelling of energy and emissions related to transportation, industry, and land use for clients across North America. In Canada, he led the technical analysis for climate actions plans for Edmonton, Vancouver, Banff, Sudbury, Guelph, North Cowichan, Hamilton, Caledon, Burlington, etc. In the U.S., Chris has led projects for municipalities and state government organizations, ranging from the City of Tacoma and Clackamas County, to the State of Washington and State of Oregon. Previously, Chris taught a graduate-level Systems Methods for Environmental Managers course in which he used a custom systems dynamics model to evaluate future scenarios against a range of social, environmental, and economic indicators.

Deryn Crockett, Principal Consultant, BSE | MSE

Role: Modeller

Deryn Crockett (she/her) has an exceptionally strong background in the systems engineering approach to problem-solving with an emphasis on system design and analysis. As a model analyst at SSG, she has designed and implemented several models that track energy use and emissions within different sectors. Early in her career, she applied mathematical models and discrete event simulation to assess the end-to-end viability and performance characteristics of satellite and terrestrial communications systems. More recently, she has led the modelling and analysis process for multiple municipalities across Canada and the U.S., including the municipalities in the Western Regional Enterprise Network; the cities of Ottawa, Saskatoon, Moncton, and Toronto; and the city of Tacoma, Washington. Deryn has also designed and supported custom solutions for clients using software product suites in the fields of military simulation and training, energy management, and emissions planning.

Amber Nicol, Senior Modeller, BSc | Eng

Role: Modeller

Amber (she/her) is a model analyst and has contributed to the energy use and emission modelling process for the creation of climate action plans for the city of St. John's, the city of Thunder Bay, the city of Richmond Hill, the town of Caledon, the region of York, the district of North Cowichan, and several communities in Nova Scotia, including Colchester county. She is currently leading SSG's knowledge management initiative. Prior to joining SSG, Amber worked in the process design industry, helping to create, develop, and support a variety of simulation software. Early in her career, she focused on reactor behaviour and general reactor modelling, helping to design and implement reactor models for a group of simulation products used in chemical, oil and gas, and polymer industries. She later moved into a technical support role, where she trained and supported clients in the use of those products.

London
CANADA