LENZ Modelling Report for the Net Zero Strategy Action Plan (2026-2030)

TORONTO

About the project team

City of Toronto – Project team

- Marvin Quitoras
- Da Huo
- Sourabh Jain

ESMIA Consultants – Consulting team

- Kathleen Vaillancourt
- Elizaveta Kuznetsova
- Romain Chaffanjon
- Nolwen Stéphan
- Antoine Duplantie-Greni

1 Background

The City of Toronto (the City) adopted its TransformTO Net zero Strategy (NZS)[1] in December 2021, aiming for net zero greenhouse gas (GHG) emissions by 2040. The NZS was supported by a technical report[2] analyzing the feasibility of proposed climate actions, using four scenarios developed with the CityInSight[3] simulation model: Business as Usual (BAU), Business as Planned (BAP), Net Zero by 2050 (NZ50), and Net Zero 2040 (NZ40). In 2023, the City began its work to 'in-house' its own model and co-developed with ESMIA, the Local Emissions for Net Zero (LENZ) Modelling Suite[4], an open-source model offering transparency and adaptability for decision-making. LENZ enables the City to test implementation strategies for net zero pathways, refine climate policies, and investigate the operational aspects of the electricity grid, with a focus on cost optimization. Documentation, including manuals and videos, accompanies the model for broader engagement and use.

The LENZ model is now a central component of Environment, Climate and Forestry Division's climate planning toolkit, enabling detailed scenario analysis, cost optimization, and progress tracking toward the City's interim and long-term climate goals. While ESMIA provided technical expertise during the model's development phase, all ongoing scenario design, model updates, and analysis are conducted by City staff. For details, please refer to the LENZ web page.

The current report reflects the latest update and application of the LENZ model. It assesses the impact of federal, provincial, and City-led climate policies through several core scenarios:

- **Business-as-Usual (BAU)**: A reference case that includes policies in place prior to 2016 but assumes no further climate action post-2022.
- **Business-as-Planned (BAP)**: Represents a future where all currently approved, being implemented and potential City policies are implemented, albeit with some uncertainty.
- **Federal and Provincial Policy (FAP)**: Captures the impact of climate policies implemented by higher levels of government, independent of City action.
- **NZS Action Plan Package (NZS APP)**: A combination of the Business-as-Planned (BAP) scenario, which includes most quantifiable City-led actions covered in the Net Zero Strategy Action Plan (2026–2030) and the additional quantifiable actions proposed in the Net Zero Strategy Action Plan (2026–2030).

These scenarios collectively evaluate the impacts of 20+ key actions across Toronto's building, transportation, and waste sectors. Model results inform the City's TransformTO Net Zero Strategy Action Plan (2026–2030), ensuring Toronto remains on a cost-effective and feasible path toward its 2040 net-zero commitment.

---

[1] City of Toronto (2021). TransformTO Net Zero Strategy: A climate action pathway to 2030 and beyond. Available online: https://www.toronto.ca/legdocs/mmis/2021/ie/bgrd/backgroundfile-173758.pdf

[2] City of Toronto (2021). TransformTO Net Zero Strategy: Technical Report (part 1 and 2). Available online: https://www.toronto.ca/wp-content/uploads/2022/04/8f02-TransformTO-Net-Zero-Framework-Technical-Report-Parts-1-2.pdf

[3] SSG - Sustainable Solutions Group (2023). Tools: CityInSight.

[4] City of Toronto (2024). Local Emissions for Net Zero Modelling Suite. Available online: https://www.toronto.ca/services-payments/water-environment/environmentally-friendly-city-initiatives/transformto/local-emissions-for-net-zero-modelling-suite/

2 Methodology

This section provides an overview of the methodology used for the modelling presented in the Net Zero Strategy Action Plan (2026–2030).

TEMOA-TO component of LENZ modelling suite (Figure 1) was used to evaluate the GHG reduction of different policies. LENZ's TEMOA-TO is a long-term energy system linear optimization model that identifies the least-cost mix of resources and technologies that meet a given level of demand of different end-use services for a desired level of GHG emissions.

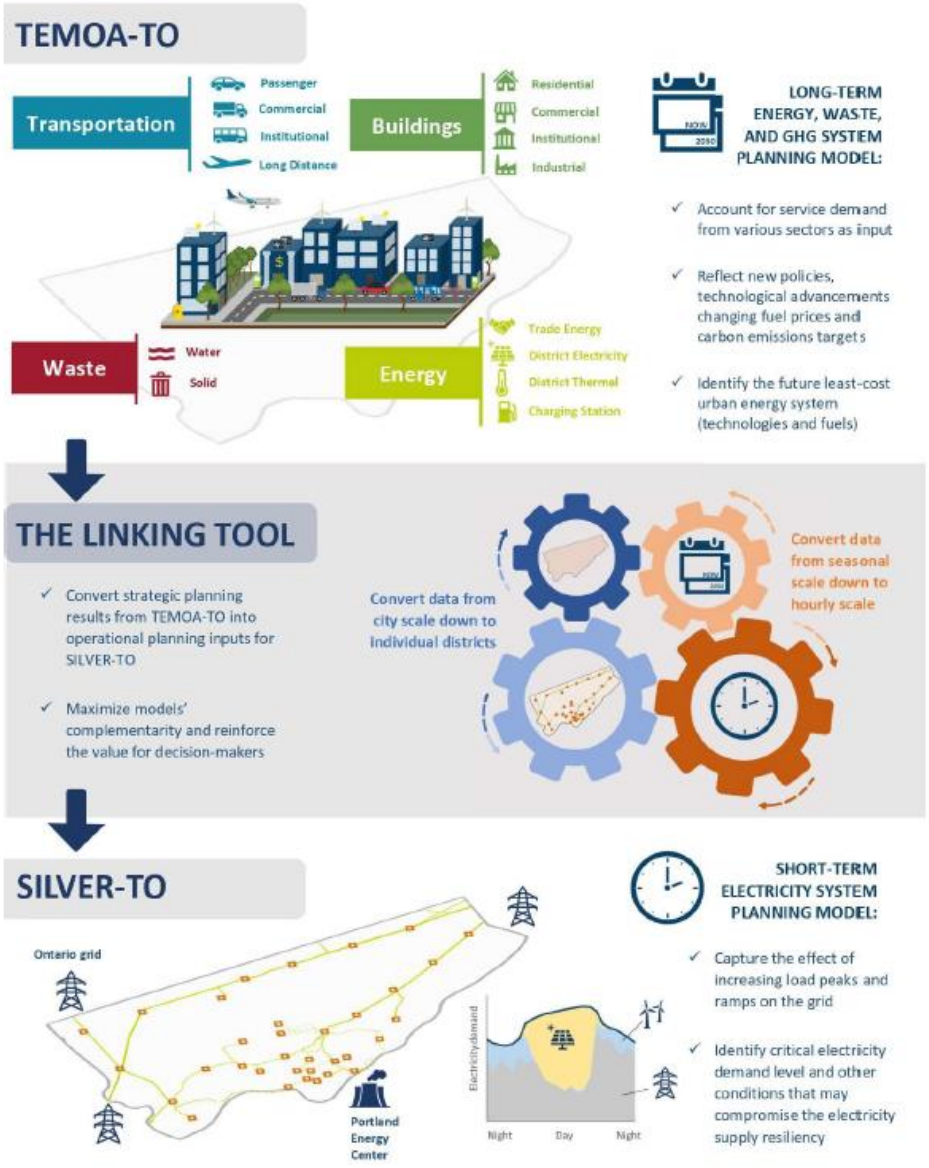

Figure 1. Architecture of the Local Emissions for Net Zero (LENZ) Modelling Suite. The results presented in this report are mainly based on the TEMOA-TO, the long-term energy, and GHG optimization model.

2.1 Why use an optimization model

Modelling is a computational exercise which performs complex calculations that humans are unable to perform. Climate policymaking for cities involves complex energy system calculations and therefore requires the use of models. For example, the community of Toronto, including its people and businesses, has demand for end-use services such as lighting, spacing heating, spacing cooling, electricity, transportation (freight and passenger), and waste management. While meeting the current and future demand for these services, the community must also consider environmental concerns such as GHG emissions (as a part of its Net Zero Strategy) and socioeconomic concerns such as affordability. In short, Toronto's policymakers must simultaneously:

- Meet energy demand for various end-use services
- Reduce GHG emissions
- Identify the lowest cost pathway that achieves the first two objectives

There are millions of combinations (or mixes) of energy resources (e.g., electricity, natural gas, diesel) and technologies (heat pump, electric vehicles) that can fulfill one or more of these objectives, but the key challenge is to find the mix or mixes that meet all three objectives.

As illustrated in Figure 2, each circle represents a mix of energy resources and technologies that use resources to provide end-use services. Only a tiny fraction of all mixes meets one or more of the required objectives, and few (shown with a black dot at the intersection of all three big circles) meet all three objectives. Mathematical models such as the LENZ optimization model can help us find the desirable mix.

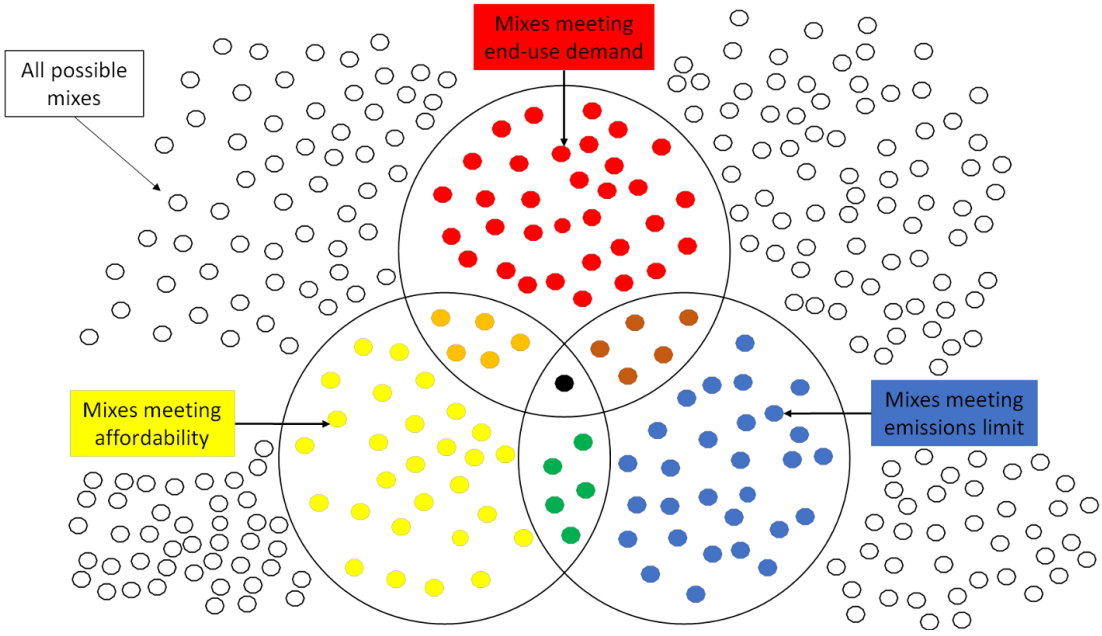

Figure 2. Illustration of LENZ optimization.

2.2 How LENZ optimization works

A linear optimization model has several components:

- **Objective**: The objective describes whether the aim is to minimize the cost or maximize the benefit. In LENZ, the objective can be set to minimize the total system cost. The net present cost is the total cost of meeting all end-use demands every year from 2016 to 2050 and is represented in 2016 dollars after discounting. The total cost has three key components: investment cost, fixed cost, and variable cost. The variable cost includes variable operational and maintenance costs as well as any costs from carbon pricing.
- **Decisions variables**: Decision variables describe what decisions need to be taken. In LENZ, the decisions include the type and quantity of resources to be used each year, as well as the capacities of different technologies to be installed annually.
- **Constraints**: The constraints (e.g., GHG limit, minimum or maximum capacity of a technology) describe what is allowed and not allowed by setting limits on the values that various decision variables can take. Imposing constraints usually increases costs because constraints often restrict cheaper mixes, therefore, orienting the model to select costlier mixes.

LENZ optimization finds the least-cost mix of technologies and energy resources over modelling period, subject to constraints that all end-use service demands are met in each year and that the interim and final GHG emissions targets are achieved. For more details about the LENZ optimization, please visit the LENZ model website.

2.3 Data and sources

Modelling the City's energy system is a data intensive exercise. In this case, the input data included costs of different technologies, technological details (e.g., conversion efficiency), and demand projections of different end use services (e.g., spacing heating, lighting, passenger kilometers). The data were gathered from different City divisions as well as secondary sources such as databases from provincial and Federal government organizations. Another key source of data was the NATEM (North American TIMES Energy Model) database.

2.3.1 Differences between LENZ and CityInSight

A key distinction between LENZ optimization model and a simulation model (e.g. the CityInSight model that the City has been using prior to LENZ) lies in their approach to problem-solving. An optimization model determines a solution to a given problem, whereas a simulation model determines to what degree a chosen solution solves the problem.

An analogy would be preparing a dish (policy goals) using a recipe (policy decisions). A simulation model tests various recipes, one at a time, to see which dish each recipe produces, thereby iteratively experimenting until it identifies the recipe that comes closest to the desired dish. This process offers significant flexibility in developing and adjusting recipes but is manual and time-consuming. In contrast, an optimization model starts by clearly defining the desired dish and systematically determines the exact recipe needed to produce it. This approach is more precise and methodical but offers less flexibility in crafting or modifying recipes.

The table below summarizes the comparison between the two models.

Table 1: Comparison of Simulation versus Optimization Models

	LENZ	**CityInSight**
Purpose	Find an acceptable optimal solution (resource and technology mix) that meets the end-use service demand and emissions targets	Choose a potential solution (resource and technology mix) and checks how closely the solution meets the end-use service demand and emissions targets
Modelling approach	Prescriptive: Determines optimal (lowest cost) mix of technologies for given emissions and demand trajectories	Descriptive: Determines emissions and demand trajectories by simulating a given mix of technologies
Complexity	High	Low
Data requirements	High	High
Accuracy	High	Low to medium

3 Modelled Scenarios, Policies and Implementation Details

3.1 Scenarios Modelled

- **BAU (Business-as-Usual):** Reference pathway reflecting current conditions and policies already in place prior to 2016 and no additional climate actions after 2022; used to benchmark all other pathways and quantify the effect of new measures.

- **BAP (Business-as-Planned):** City-led actions approved or implementable by the City to reduce community-wide emissions. GHG reduction potentials of these actions are reflected in incremental modelling that capture policy interactions while avoiding double counting.

- **NZS APP (Net Zero Strategy Action Plan Package):** Includes the combination of the Business-as-Planned (BAP) scenario, which includes most quantifiable City-led actions covered in the NZS Action Plan (2026-2030) and additional quantifiable actions proposed in the NZS Action Plan (2026-2030). Only two of the additional actions (ZEV for vehicle-for-hire and future versions of TGS) are quantifiable in LENZ. Their contributions are presented as a “Additional Actions in NZS Action Plan Package” wedge in the figures.

- **FAP (Federal and Provincial Policies):** Adding the FAP package substantially improves the community trajectory, as federal carbon pricing and a strong LD ZEV mandate are the top individual drivers, cutting cumulative emissions and shrinking the 2040 gap by roughly one-third compared with City-only action; clean-electricity policy further lowers the grid emission factor, amplifying building and transport electrification benefits.

3.2 Policies Modelled

The descriptions and key assumptions for modelled policies are summarized in Table below. The respective scenarios of each policy are indicated in the parentheses.

Sector/ Action group	Policy Name	Description	Additional Details /Key Assumptions
Buildings			
New Builds	**Toronto Green Standard (TGS) v4 (BAP)**	This set of policies implement the three TGSv4 performance criteria for new buildings (multi-residential and non-residential) as modelling constraints: greenhouse gas intensity (GHGI), total thermal energy demand (TEDI), and total energy use intensity (TEUI).	• All buildings constructed from 2023 are considered new • The policy implementation begins in 2023 • Low-rise residential and industrial buildings excluded from the scope of policy • Only most efficient electrical appliances used due to LENZ modelling limitation to implement TEUI performance limits
New Builds	**Future versions of Toronto Green Standard (TGS v5/v6) (NZS APP)**	Same as TGS v4	• All buildings constructed from 2023 are considered new • TGS v4 implemented from 2023 to 2026 • TGS v5/v6 policy implementation begins in 2027 (v5) and 2031 (v6) • Low-rise residential excluded from the scope of policy • Only most efficient electrical appliances used due to LENZ modelling limitation to implement TEUI performance limits • No longer included in the BAP scenario
Retrofits	**Net-zero Carbon Plan – RNG (BAP)**	The policy repurposes RNG produced from the digestion of solid waste to City Corporate buildings instead of the whole community.	• All available RNG is supplied to City Corporate buildings and substitutes fossil natural gas.
Retrofits	**Eco roof (BAP)**	Cool and green roofs (collectively referred to as eco roofs) lead to a decrease in energy consumption for space cooling and/or space heating energy service demand. The policy provides subsidy on CAPEX for a technology increasing space cooling efficiency.	The maximum space cooling energy gain assumed that 50 per cent of the available roof area in Toronto is covered with Eco-Roofs, since the other 50 per cent can be attributed to solar PV installation.

Transportation			
Electric Mobility	**Light-duty ZEV Mandate (BAP)**	Although the federal government is currently reviewing the Electric Vehicle Availability Standard, it has not renewed incentives for EVs. This policy is implemented by applying constraints on LD ZEV annual sales market share in the passenger transportation sub-sector. Accounting for the capital and operational cost difference of switching the community fleet from conventional vehicles to electric vehicles.	• The City's fleet is excluded as it has been modelled separately in the Sustainable City Fleet policy. • Between targets, ZEV sale growth is assumed to be linear. • Assuming EVs as the current most competitive technology in this demand segment.
Electric Mobility	**TTC Green Bus Program (BAP)**	The TTC Green Bus Program is an initiative aimed at significantly reducing GHG emissions and improving air quality in Toronto by electrifying its bus fleet. The program sets an ambitious target for 20 per cent of the TTC's bus fleet to be zero-emission by 2025-2026, with a goal of achieving 100 per cent zero-emission buses by 2037-2040. This policy is modelled by constraining the electric buses minimum capacity (units of vehicles at each year) for pre-2025 and the minimum share target (per cent of eBus at each year) for post-2025, following the TTC eBus Funded Procurement Plan. For TTC Green Bus Program (pre-2025): 400 units of TTC buses are electrified by 2025. For TTC Green Bus Program (2025-onward): 20 per cent of the fleet are ZEV by 2025, 50 per cent of TTC bus fleet electric by 2030, and retirement of last hybrid bus meaning that 100 per cent of the fleet is electrified by 2037.	• Electric bus penetration rates are interpolated for years in between target years (assuming linear trend). • Assuming single eBus type/technology. 12m and 18m buses, which may have different fuel efficiencies and mileages, are not modelled separately.
Electric Mobility	**Sustainable City Fleets Plan (BAP)**	The Sustainable City Fleet initiative is a critical component of Toronto's strategy to reduce greenhouse gas (GHG) emissions and promote environmental sustainability. As Canada's largest	• Many tech-specific inputs may need updates, e.g., cost, efficiency, lifetime of the ZEVs.

		municipal fleet, the City of Toronto has a unique opportunity to lead the adoption of innovative technologies that enhance vehicle efficiency and safety while minimizing environmental impacts and life-cycle costs. The updated Sustainable City of Toronto Fleets Plan sets ambitious targets, aiming for 20 per cent of the City fleet to be zero-emission by 2025, 50 per cent by 2030, and 100 per cent by 2040. Beginning in 2022, Sustainable City Fleet (pre-2025) is modelled as per the City's Sustainable City Fleets Procurement Plan. Specifically, the Plan is implemented by applying constraints on ZEV minimum capacity deployment in the City fleet. The model also accounts for capital and operational cost differences of conventional vehicles versus electric vehicles. The post-2025 Sustainable City Fleet is modelled as per the Sustainable City Fleets targets.	• Current implementation uses percentage target, however, future Procurement Plan likely to provide specific numbers of ZEV replacement and their tech specs. • Current implementation assumes linear trend between 2030 and 2040, targets (ZEV share) for 2040 to 2050 stay at 2040 level, which may be subject to change.
Electric Mobility	**Vehicle For Hire to EV (NZS APP)**	As per Council direction, the Vehicle-For-Hire (VFH) sector goal is net zero by 2030. This policy is implemented by applying constraints on ZEV annual sales market share for Rideshare vehicles and Taxis in the passenger transportation sub-sector. Capital and operational cost difference of switching the community fleet from conventional vehicles to electric vehicles are accounted for.	• ZEV sales growth is estimated from standard vehicle survival curve. • Assume EVs for VFH are the same (e.g., energy efficiency) as average passenger EVs. • There could be overlapping/overshadowing effects if modelled together with the federal or provincial ZEV incentives.
Electric Mobility	**City public EV charging (BAP)**	The project plans to install City operated off- and on-street EV chargers. Public charging stations are vital not only for private vehicle owners but also for supporting operational fleets, vehicles- for-hire, cargo logistics, and car-sharing services. By ensuring sufficient EV charging is available in residential, commercial, and recreational areas, Toronto can facilitate the widespread adoption of electric vehicles	• Assuming no efficiency gain, but a decrease in cost over time is modelled, from CA$775 (in 2016 CAD) in 2023 to CA$400 (in 2016 CAD) in 2050 for commercial charging stations. • User behaviour is modelled with load curves, but bi-directional chargers are not modelled.

		and promote a shift away from fossil fuel-powered transportation. This policy is implemented by applying constraints on public charging station minimum capacity deployment. Capital and operational cost differences of public versus commercial charging stations are also accounted for. This policy is modelled as per historical and planned deployment of Toronto Parking Authority (TPA) charging stations in TPA's 2024 Budget Submission, assuming the minimum capacity beyond 2050 stays at 2025 level for the pre-2025 time period.	
Public Transit	**Transit expansion + TTC 5-year service plan (BAP)**	The Toronto Transit Commission (TTC) is implementing a comprehensive 5-Year Service Plan designed to enhance public transit efficiency and accessibility across the city. This plan focuses on increasing service levels and introducing priority bus lanes to improve the reliability, speed, and capacity of some of the busiest transit routes. By making transit a more attractive option, the TTC aims to significantly boost transit mode share and reduce greenhouse gas (GHG) emissions associated with transportation. This policy is implemented by changing the travel demand and mode share, which are modelled by the GTAModel and used as inputs to LENZ. The data are also calibrated using CityInSight and Google EIE (Environmental Insights Explorer).	• The travel demand and mode share were modelled in GTAModel. • Note that infrastructure deployment capital costs (e.g., cycling networks, subway expansions, vehicle networks, complete streets, etc.) are not included.
Public Transit	**RapidTO (BAP)**	RapidTO is a transformative initiative designed to enhance public transit efficiency in Toronto by introducing dedicated bus lanes along key corridors. RapidTO is expected to reduce travel times and congestion, encouraging more residents to opt for public transit over single-occupancy vehicles. This	• The travel demand and mode share were modelled in GTAModel. • Note that infrastructure deployment capital costs (e.g., cycling networks, subway expansions, vehicle networks, complete streets, etc.) are not included.

		shift will help reduce the carbon footprint of the city's transportation system. This policy is implemented by changing the travel demand and mode share, which are modelled by the GTAModel and used as inputs to LENZ. The data are also calibrated using CityInSight and Google EIE (Environmental Insights Explorer).	
Active Transportation	**Densification land-use (BAP)**	Densification land-use policies are a crucial component of Toronto's post-net zero city planning strategy, aimed at reducing GHG emissions through urban development. By promoting urban densification, these policies encourage the construction of more compact, multi-unit housing options to maximize the use of existing infrastructure. Densification land-use policies cover city planning policies that encourage residents to adopt alternative transportation methods. By reducing the reliance on cars and promoting public transit, cycling, and walking, these policies contribute to decreased transportation emissions. More densely populated areas can support improved public transit services, making it easier for residents to commute without relying on single-occupancy vehicles. This policy is implemented by changing the travel demand and mode share, which are modelled by the GTAModel and used as inputs to LENZ. The data is also calibrated using CityInSight and Google EIE (Environmental Insights Explorer).	• Assumptions regarding the implementation were derived from the GTAModel's densification scenario. • Note that infrastructure deployment capital costs (e.g., cycling networks, subway expansions, vehicle networks, complete streets, etc.) are not included.
Active Transportation	**BikeShare Toronto (BAP)**	This initiative aims to promote active transportation and low-carbon transit options. By expanding biking and pedestrian infrastructure, including dedicated cycling routes, secure bicycle parking, and accessible bike-share stations near TTC transit hubs, the program aims to enhance connectivity and encourage	• Current implementation assumes that one per cent of less than five kilometre trips will shift to cycling by 2050. The impact on demand and mode share is calculated based on CityInSight trip per distance estimates. Specifically, it is calculated as for biking mode.

		more residents to choose cycling as a mode of transport. Active transportation mode share is improved through the as-planned BikeShare Toronto network expansion, accounting for differences in capital and operation costs of vehicles (i.e., car, bike, train). Infrastructure investment and operation costs (e.g., vehicle lane, cycling lane, train stations) are excluded. This policy is implemented by changing the travel mode share.	
Active Transportation	**Complete Streets (BAP)**	This initiative aims to promoting active transportation and low-carbon transit options. Complete Streets infrastructure projects promote an increase in active transportation mode share. Active transportation mode share is improved through the as-planned Complete Streets infrastructure projects, accounting for differences in capital and operation costs of vehicles (i.e., car, bike, train). Infrastructure deployment capital costs (e.g., Cycling network, subway expansion, vehicle network, complete street, etc.) are excluded. This policy is implemented by changing the travel mode share.	• Current implementation assumes that 25 per cent of less than one kilometre trips will shift to walking by 2050. The impact on demand and mode share is calculated based on CityInSight trip-per-distance estimates.
Waste			
Water Waste	**Island Waste Treatment Plant photovoltaic system (BAP)**	This policy includes the installation of 3.25 MW solar panels (photovoltaic), along with a 6.3 MWh Battery Energy Storage System (BESS) at the Island Waste Treatment and Immobilization Plant. The project is still in design and estimated to be completed in 2028. This policy reduces scope-2 emissions associated with the electricity consumption from the grid. It is implemented by applying a constraint on the minimum	• Current implementation assumes three different potential/efficiency levels for solar PV. However, by 2028, solar panels may have higher potential and efficiency than the best available models today.

		capacity of the Island Waste Treatment and Immobilization Plant's PV panel and battery storage system.	
Water Waste	**Pelletizer facility (BAP)**	The new pelletizer facility will be able to run on digester gas once commissioned and will displace approximately 50 per cent of current natural (fossil) gas consumption. This policy is implemented by constraining the maximum emission activity of the Ashbridges Bay Wastewater Treatment Plant Pelletizer from 2028 to 2050.	• Current implementation assumes that the new pelletizer facility is deployed only at the Ashbridges Bay Wastewater Treatment Plant.
Water Waste	**Fluidized bed incinerator (BAP)**	This policy aims to install fluidized bed incinerator (FBI) at wastewater treatment plants. Moving from existing antiquated multiple hearth furnace technology to new FBI technology will remove a significant amount of GHG emissions. This policy deploys an incinerator technology upgrade to reduce the emission associated with natural (fossil) gas consumption with the existing antiquated multiple hearth furnace. This policy is implemented by constraining the maximum emission activity of the Highland Creek Water Treatment Plant incineration and fluidized bed incinerator from 2028 to 2050.	• Current implementation assumes that the new technology is deployed only at Highland Creek Water Treatment Plant.
Water Waste	**Heat recovery from fluidized bed incinerator and other upgrade (BAP)**	A future project that will include additional heat recovery from the fluidized bed incinerator (FBI), as well as other upgrades to achieve a beneficial use designation for the process. The upgrades reduce the emissions from natural (fossil) gas consumption through energy efficiency improvements (additional heat recovery from FBI). This policy is implemented by constraining the maximum emission activity of the Highland Creek	• Current implementation assumes that the new technology is deployed only at Highland Creek Water Treatment Plant.

		Water Treatment Plant Incineration and Fluidized Bed Incinerator from 2028 to 2050.	
Water Waste	**Service rehab and upgrades (BAP)**	This plan includes multiple maintenance and reliability upgrades to the site, including boilers and building automation system (BAS). As a result, electricity consumption is expected to increase while reducing natural (fossil) gas consumption. This policy is implemented by constraining the maximum emissions activity of the Humber Wastewater Treatment Plant from 2028 to 2050.	• Current implementation assumes that the new technology is deployed only at Humber Wastewater Treatment Plant.
Solid Waste	**Landfill diversion (BAP)**	The policy models the diversion of waste from landfills and increased waste management demand for green bin and recycling waste. It captures a reduction in emissions related to landfill but an increase of emissions from green bin plants.	• The landfill diversion rate is increased to 53.6 per cent from 2023 until 2050, compared to a baseline rate of 52.4 per cent without the policy.
Solid Waste	**Renewable natural gas (RNG) from biogas from Dufferin and Disco organics processing facilities (BAP)**	The policy models the upgrade of the green bin biogas to RNG. It captures a reduction in emissions from using RNG instead of fossil natural gas.	• End-use utilization of RNG: 93.7 per cent for corporate buildings and 6.3 per cent for the corporate fleet (updated annually). • Assumes continued RNG production at these facilities until 2050.

3.3 Community and Corporate Model Run

All policies were implemented in both the “community mode” and the “corporate mode”. The scope of a policy implemented in the community mode covered all activities occurring within the community of Toronto. The same policies were also implemented in the City of Toronto corporate mode, where the scope covered only activities associated with the corporation, a subset of the community of Toronto.

For example, in the community mode, Toronto Green Standard v4 policy was implemented for all buildings (except for residential low-rise) in the community of Toronto. In the corporate mode, the same policy was implemented only for municipal buildings directly owned and/or operated by the City of Toronto. All other assumptions and implementation details remained identical in both modes. Similarly, in the community mode, transportation covered all transportation-related activities, whereas in the corporate mode, transportation only included transportation activities associated with the City Corporate.

4 Key Findings

The LENZ model is used to evaluate the GHG emissions impacts of City-led and higher-order climate actions through incremental model runs. The key findings highlight which policies drive the greatest emissions reductions, where significant gaps remain, and which technically feasible measures may help close those gaps to reach Toronto's 2040 net-zero goal.

4.1 GHG Reductions from Policies Modelled

4.1.1 Community-wide

The results in Figure 3 (a) show that if no climate action is taken, the City's emissions would be 13.4 $MtCO_2e$ (million tonnes of carbon dioxide equivalents) by 2040, around 16 per cent lower than they were in 2016. In this scenario, the residual emissions between the City's 2040 emissions and the net-zero goal would be 12.4 $MtCO_2e$.

BAP actions reduce emissions by 1.0 $MtCO_2e$ (about 8%) over BAU by 2040. The BAP scenario includes the following key policies: Toronto Green Standard Version 4 (TGS V4), TTC Green Bus Program, Renewable Natural Gas (RNG) from Dufferin and Disco organic waste processing facilities, public and active transportation policies, and Sustainable City Fleets Plan.

The NZS Action Plan Package reduces the emissions by an additional 0.1 $MtCO_2e$ over BAP by adding two additional quantifiable actions to the BAP, thus the total emissions reduction from the NZS Action Plan Package is 1.1 $MtCO_2e$ over BAU by 2040.[5]

One of the biggest contributors to emissions reduction in the BAP scenario is TGS V4 policy. Modelling indicates that if TGS V4 continues to be applied to all new multi-unit residential, commercial and institutional buildings, based on projections, it has the potential to achieve a cumulative emissions reduction over 2023-2040 of 5.5 $MtCO_2e$, a 62 per cent reduction compared to the emissions from the new buildings in the BAU scenario. Future versions of TGS could unlock an additional 1 $MtCO_2e$ reduction towards the TransformTO goals. Following changes proposed by the Province through Bill 17, City staff understand the Province is looking at potential legislative or other changes that could impact mandatory TGS requirements. However, there are no changes to the TGS at this time.

Figures 3 (a) and (b) show the impact of layering federal and provincial policies on top of City-led actions. The resulting difference is an additional reduction of 3.5 $MtCO_2e$ emissions from federal and provincial policies. When federal and provincial policies are implemented, residual emissions decline from 11.3 $MtCO_2e$ to 7.8 $MTCO_2e$ in 2040.

[5] These projected emission reductions include reductions anticipated from the Toronto Green Standard version 4 and future versions. As noted in this report, City staff understand the province is looking at potential legislative or other changes that could impact mandatory TGS requirements. However, there are no changes to the TGS at this time.

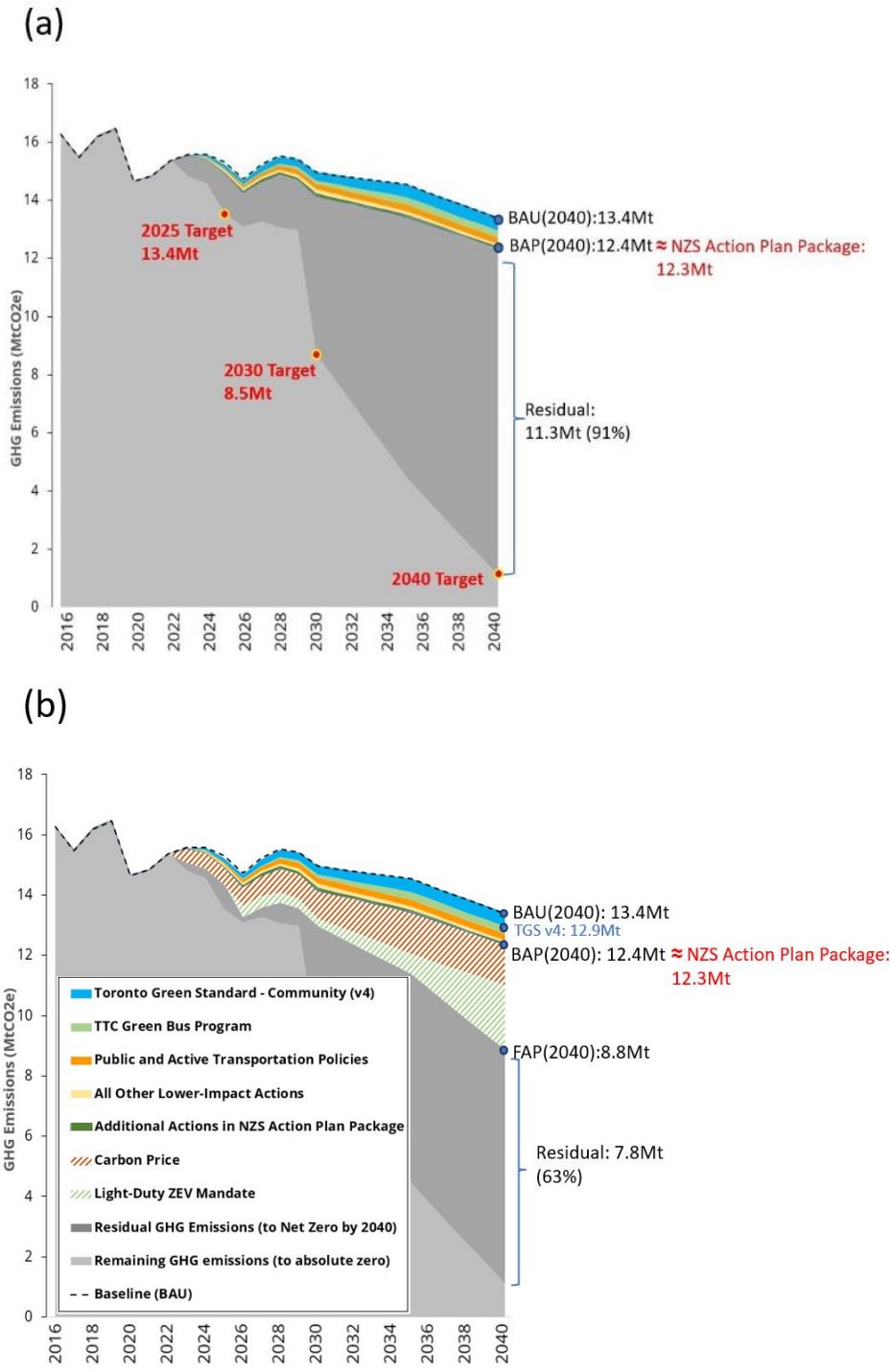

Figure 3. Community-wide wedges diagram illustrates the incremental GHG emissions reductions of modelled policies: (a) without federal & provincial policies. (b) with federal and provincial policies (carbon price and ZEV mandate). Baseline scenario is Business-as-Usual (BAU, dashed line). Some numbers in graph may differ slightly from the numbers mentioned elsewhere due to rounding.

Below are explanations for each legend item found in the Community-wide wedges diagram (Figure 3):

- BAU: The dashed reference path showing what the current trajectory of community emissions would be without any additional actions or policies.
- Toronto Green Standards - Community (TGS V4): Raises energy performance criteria for new buildings by imposing greenhouse gas emissions intensity (GHGI) limits, total thermal energy demand intensity (TEDI), and total energy use intensity (TEUI). Each performance criterion has different performance tiers and is defined for different building archetypes.
- TTC Green Bus Program: Initiative aimed at significantly reducing GHG emissions and improving air quality in Toronto by electrifying the bus fleet. The program sets an ambitious goal of achieving 100 per cent zero-emission buses by 2037-2040.
- Public and Active Transportation Policies: Expands and improves transit service while accelerating walking and cycling infrastructure and programs. This package includes hybrid work for City employees, RapidTO, transit expansion, TTC 5-year service plan, densification of land-use, Bike Share and complete streets programs.
- All Other Lower-Impact Actions: A bundle of smaller corporate measures (e.g., additional efficiency upgrades for buildings and waste treatment plants) that when totaled achieve modest reductions.
- NZS Action Plan Package: BAP plus two quantifiable actions: Vehicles-for-hire[6] (which is modelled as 100 per cent EV adoption for vehicles-for-hire by 2030) and future versions of TGS. Note that the NZS Plan Package includes many actions that reduce GHG emissions or enable reductions, but only quantifiable actions have been modelled. Emission reductions from implementing the Plan are expected to be greater than those modelled.
- Light-Duty ZEV Mandate: Federal initiative aimed at achieving 100 per cent light-duty ZEV sales target by 2035 for all new light-duty vehicles in Canada.
- Carbon Price: Applied the federal consumer carbon price to fuel use, encouraging fuel switching and efficiency.
- Residual GHG emissions (to net zero by 2040): The residual community emissions after all modeled actions, which represent the gap to reach the 2040 target.
- Remaining GHG emissions (to absolute zero): Emissions remaining to reach absolute zero: the remaining emissions between net zero targets and absolute zero in each year, shown for context beyond the net zero 2040.

4.1.2 Corporate-wide

For the City of Toronto's corporate emissions, the residual emissions are significantly smaller than at the community-level (Figure 4). Because the City directly controls its fleets and facilities, City-led policies have a greater proportional effect than at the community scale. The residual emissions wedge shows that, to close this gap, City corporate emissions would need to be lowered by an additional 25 per cent from its 2040 BAU emissions in addition to all BAP and FAP actions.

[6] Vehicles-for-hire include taxis, limousines and private transportation companies.

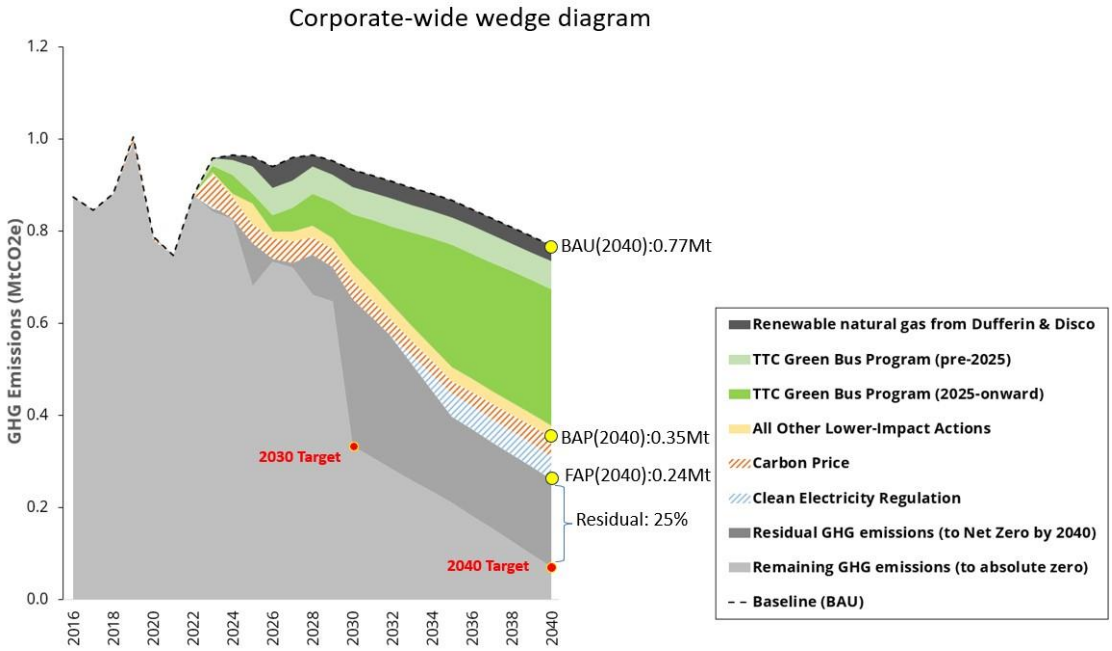

Figure 4. Corporate-wide wedges diagram illustrates the incremental impacts of modelled policies on City corporate GHG emissions.

Below are explanations for each legend item in the corporate-wide wedge diagram (Figure 4):

- BAU: The dashed reference path showing what the current trajectory of corporate emissions would be without any additional actions or policies.
- Renewable natural gas from Dufferin & Disco: Captures biogas from the Dufferin and Disco organics processing facilities, upgrades it to RNG, and uses it in City facilities/fleets, cutting methane and displacing fossil (natural) gas. Note that to avoid double-counting and confusion between RNG generation and RNG use, this wedge also includes the contribution from Net Zero Carbon Plan – RNG, which substitutes RNG for a portion of the City's fossil natural gas consumption across corporate buildings to lower direct combustion emissions.
- TTC Green Bus Program: Initiative aimed at significantly reducing GHG emissions and improving air quality in Toronto by electrifying the bus fleet. The program sets an ambitious goal of achieving 100 per cent zero-emission buses by 2037-2040.
- All Other Lower-Impact Actions: A bundle of smaller corporate measures (e.g., efficiency upgrades for corporate buildings and waste treatment plants, active transportation promotion) that together amount to modest reductions.
- Carbon Price: Applied the federal carbon price to corporate fuel and electricity use, encouraging fuel switching and efficiency.
- Clean Electricity Regulation: Federal and Provincial policy pathways that lower the grid emission factor by driving cleaner Ontario electricity (e.g., nuclear, hydro, and other low-carbon generation), reducing emissions from corporate electricity use.

- Residual GHG emissions (to net zero by 2040): The residual corporate emissions after all modeled actions, which represent the gap to reach the 2040 target.
- Remaining GHG emissions (to absolute zero): Emissions remaining to reach absolute zero: the remaining emissions between net zero targets and absolute zero in each year, shown for context beyond the net zero 2040

4.1.3 Community-wide Residual GHG Emissions

The sectors contributing most to the residual emissions are represented in Figure 5. The primary sources of residual emissions are residential buildings, commercial buildings, and passenger transportation. Although no specific actions are being proposed in the NZS report to address these residual emissions, they outline where new or enhanced actions must be taken by stakeholders such as City Divisions, TTC, utilities, the provincial and federal government, private sector, and residents to reach the 2040 target.

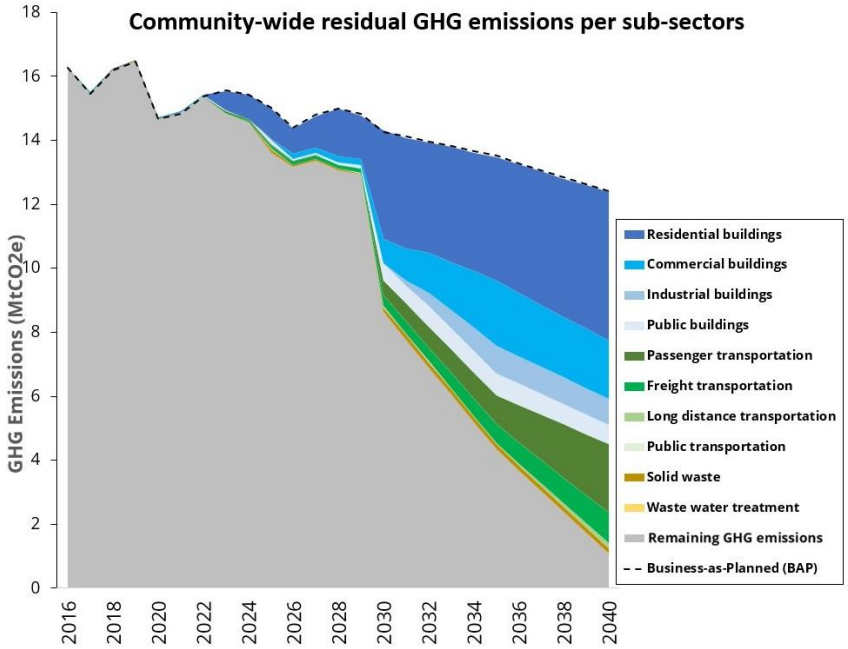

Figure 5. Community-wide wedges diagram for residual GHG emissions. This diagram provides details on the darker grey wedge found in Figure 3a), divided into sub-sectors. Primary sources of residual emissions are residential buildings, commercial buildings, and passenger transportation.

4.2 Most and Least Impactful Actions

The following actions are the most impactful in reducing cumulative GHG reductions from 2023 to 2040.

- Carbon Tax, although recently cancelled at the federal level, could have contributed to significant emissions reductions (11.7 $MtCO_2e$ cumulatively). This indicates that with the carbon pricing we would have been much further ahead.

- Light-Duty Zero Emission Vehicle (LD ZEV) Mandate, another federal-level policy that is recently paused as the government conducts a 60-day review, is the most impactful policy, reducing over 18.1 $MtCO_2e$ of cumulative emissions. This is due to the high emissions share of light-duty vehicles and the mandate's structure as a strict constraint.

- Toronto Green Standard – Community (TGS v4) can reduce cumulative emissions by 5.5 $MtCO_2e$, which is one of the most important building policies that can be applied to new construction.

- TTC Green Bus Program can achieve cumulative reduction of 3.9 $MtCO_2e$, accounting for about 20 per cent of total City-led reductions and is one of the most effective transportation and corporate actions.

- Transportation mode shift actions, including RapidTO, TTC transit expansion, hybrid work, densification of land-use, Complete Streets and BikeShare Toronto, together reduce cumulative GHG emissions by 3.0 $MtCO_2e$.

- Renewable natural gas (RNG) policies, including RNG from Dufferin & Disco biogas and Net Zero Carbon Plan RNG, provide moderate reductions (0.5 $MtCO_2e$ cumulatively), and are among the few actions that are cost-optimal and emissions-reducing. To avoid double-counting and confusion between RNG generation and RNG use, the RNG wedge in Figure 4 includes both RNG generation from Dufferin & Disco and RNG use in the Net Zero Carbon Plan, which substitutes RNG for a portion of the City's fossil natural gas consumption in corporate buildings to lower direct combustion emissions.

- Eco-Roof incentives and certain wastewater treatment plant upgrades are limited in scale or cost-effectiveness to drive significant changes in emissions reduction. While they show minimal or no impact on carbon emissions reduction, their importance on reducing air and water pollution and addressing resilience objectives such as stormwater retention and reducing urban heat island, advance many other City objectives including objectives related to climate resilience.

- Policies like the Medium- and Heavy-Duty ZEV Mandate show limited emissions impact due to their incentive-based design and the smaller, slower-changing vehicle stock.

4.3 Community-wide insights

Under the modelled Business-as-Planned (BAP) scenario, Toronto's community-wide emissions falls short of its 2040 net-zero target. The main sources of community-wide residual emissions, ranked in order, are residential buildings, passenger transportation, commercial buildings, and freight transportation (Figure 5).

- In 2030, the gap between BAP and the Net Zero 2040 scenario is about 5.6 $MtCO_2e$, with over 80 per cent of this gap coming from the buildings sector (especially residential heating using natural gas). Residential buildings alone account for 3.1 $MtCO_2e$, while passenger transportation contributes 0.5 $MtCO_2e$.

- In 2040, the emissions gap grows to about 11.3 $MtCO_2e$, again dominated by the buildings sector (7.9 $MtCO_2e$). The transportation sector accounts for around 27 per cent of the gap, with passenger transportation contributing 2.1 $MtCO_2e$.

4.4 Corporate-wide insights

For the City of Toronto corporate emissions, the path to Net Zero by 2040 looks promising (Figure 4). City-led policies have a higher proportional impact than at the community scale because the City directly controls its vehicle fleets and facilities.

- The TTC Green Bus Program is the single largest contributor, accounting for about 70 per cent of all corporate reductions. Other impactful actions include RNG projects, the Sustainable City Fleets Plan, and waste and wastewater treatment facility upgrades.

- The largest residual at the corporate level is in public buildings (CREM + TCHC). This makes building-focused policies, especially the TGS compliance for new builds, crucial for closing the remaining corporate gap alongside green fleet initiatives.

- At the corporate level, federal and provincial support still plays a meaningful role. When a durable carbon price and Clean Electricity Ontario are added to the BAP corporate package, they could reduce the remaining 2040 emissions gap by about 14 per cent. This reduction mainly comes from cleaner grid electricity for City facilities and carbon-price signals that encourage fuel switching and operational efficiency in CREM and TCHC buildings. While this incremental gain is smaller than the community-wide impact of FAP policies, it still accelerates progress in City operations and lessens the burden on City-led measures needed to close the residual gap.

4.5 Potential Actions to Close the Gap

In the absence of supportive federal/provincial policies, LENZ identifies some key areas that local actions need to focus on to bridge the gap:

Buildings Sector:

- Aggressive electrification and RNG use for space and water heating.
- Deep retrofits of older residential buildings for energy efficiency improvements.
- Fuel switching for industrial processes and auxiliary services in public buildings.

Transportation Sector:

- Promote electric/renewable energy-powered passenger vehicles and MD/HD trucks.
- Continued investments in improved facilities to promote EV charging, public transit, and active transportation.

Waste Sector:

- Improve overall energy efficiency of waste treatment facilities.
- Expand the generation of end user adoption of renewable natural gas (RNG) from solid waste.

5 Key Takeaways

The LENZ modelling results provide critical insights into the progress and challenges of achieving Toronto's net-zero by 2040 target.

Under the Business-as-Planned (BAP) and the Net Zero Strategy (2026-2030) actions, which includes all current and potential City-led actions, Toronto's annual GHG emissions are projected to decline by approximately 8 per cent compared to the Business-as-Usual (BAU) scenario by 2040. This is equivalent to an annual emissions reduction of 1.1 $MtCO_2e$. However, a significant gap of 11.3 $MtCO_2e$ remains between the BAP emissions trajectory and the level required to reach the City's 2040 net-zero target. This underscores the urgency for additional measures and systemic shifts, especially in the buildings and transportation sectors, which dominate both the city's emissions profile and the residual emissions in the net-zero scenario.

Modelling results indicate that emissions gap is concentrated primarily in the buildings sector, which contributes approximately 70 per cent of the shortfall. Within the buildings sector, residential and commercial buildings remain major sources of natural gas combustion for space heating, water heating, and auxiliary systems. The transportation sector accounts for another approximately 30 per cent of the 2040 gap, primarily due to continued use of gasoline and diesel in passenger and freight vehicles. Without decarbonization of the provincial electricity grid or national fuel standards, Toronto must rely on aggressive solutions to close this emissions gap.

The modelling confirms that net-zero by 2040 is not realistically achievable without coordinated support from higher levels of government, particularly through carbon pricing, ZEV mandate, and electricity grid decarbonization. The Net-Zero by 2040 scenario, which models aggressive emissions reductions shows that reaching net-zero will be challenging. The absence of electricity grid decarbonization forces the model to replace electricity-based decarbonization strategies with alternatives across both buildings and transportation, creating "unrealistic" system-wide energy transitions. On the other hand, federal policies including carbon pricing and ZEV mandate could significantly shrink the gap and pull the community emissions trajectory toward the target. A durable, economy-wide carbon price would have driven earlier fuel switching and efficiency across buildings and transport, prevented rebounds in fossil use when conventional energy prices fall. Likewise, the federal light-duty ZEV mandate has the potential to be the single most impactful policy in terms of GHG reduction by 2040.

From a City of Toronto corporate perspective, the path to Net-Zero by 2040 is more optimistic. Policy, dedicated budget, and operational commitments made prior to and during the 2021 to 2025 period make corporate emissions targets more achievable. Key City policies like the TTC Green Bus programs will play a decisive role in achieving net-zero at corporate level.

In conclusion, the LENZ model provides robust, transparent analysis to support evidence-based decision-making for climate policy. **It highlights that while the City of Toronto has made significant progress through its existing TransformTO strategy, local policies alone will not be enough. Deeper retrofits, full fuel switching, grid transformation, and support from higher government levels are essential to close the emissions gap**.