

Decarbonizing transport through land use and policy change

Full methodology and findings

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Overview

- ✓ This project examined the potential for growth management strategies to mitigate passenger transport emissions in the Greater Toronto and Hamilton Area (GTHA), a rapidly growing metropolitan region.
- ✓ Different patterns of urban densification were evaluated in terms of their effect on greenhouse gas (GHG) emissions and travel behavior under scenarios projecting 1.1 million additional residents by 2031.
- ✓ Growth patterns significantly impact travel behavior and emissions, with daily regional GHG emissions varying by over 10,000 metric tons across scenarios.
- ✓ Existing transit infrastructure is inadequate to support anticipated growth, limiting the effectiveness of compact development strategies.
- ✓ Only scenarios combining aggressive vehicle ownership restrictions with bus fleet electrification achieved meaningful emission reductions.
- ✓ Achieving meaningful transport decarbonization requires coordinated densification, substantial transit investment, and investments in cleaner vehicles.

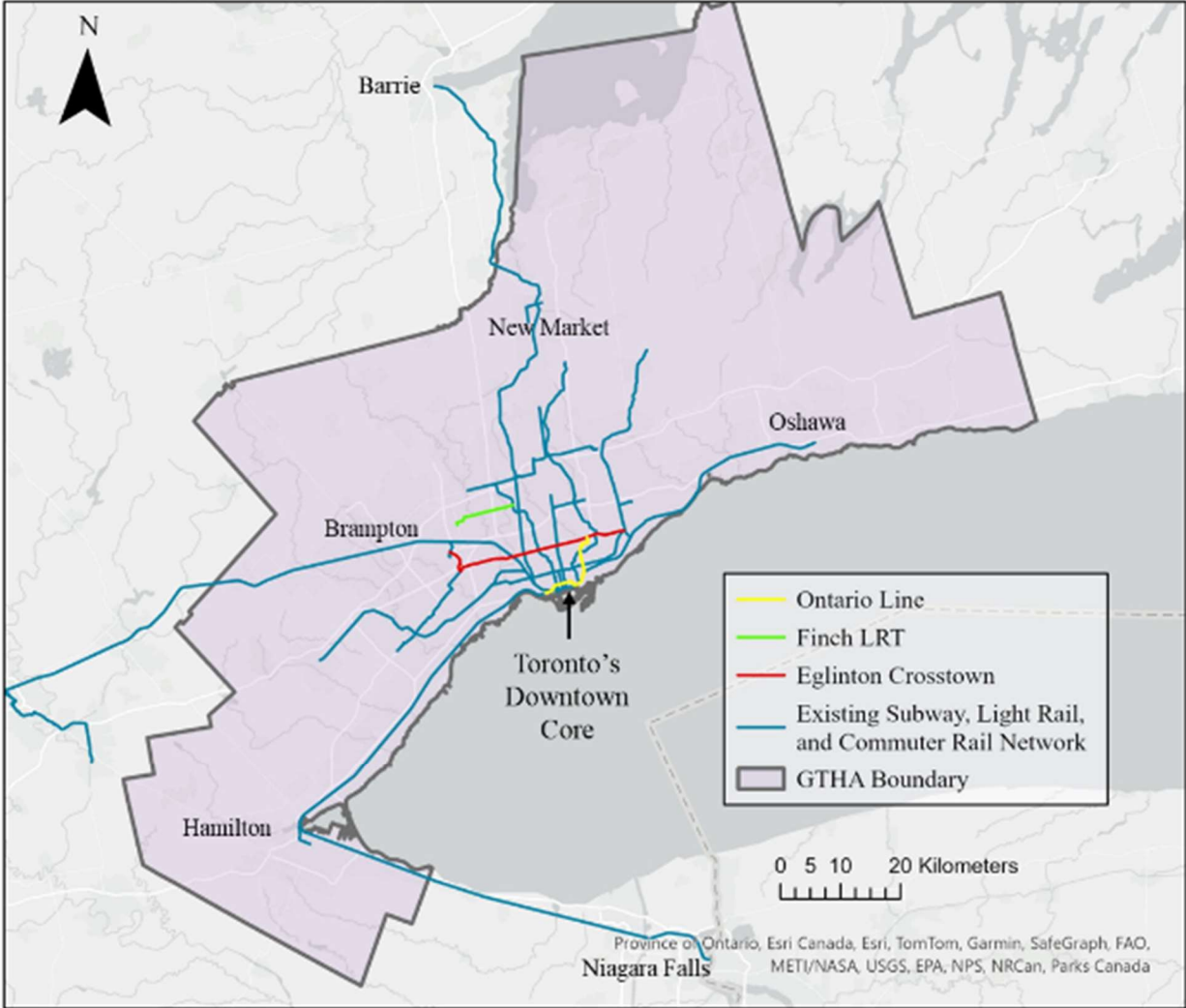
This project aims to understand the extent to which growing cities can mitigate passenger transport emissions using growth management strategies.

How do patterns of growth impact travel emissions, particularly in the context of a North American city where automobility dominates?

How much can we mitigate passenger transport emissions using TOD?

Case Study: The GTHA

In 2021, the population of the GTHA totaled 7.3 million people and is projected to increase to 10.1 million by 2041, making the GTHA one of the fastest growing urban areas in Canada.



The GTHA and its subway, light and heavy rail lines. The Ontario Line, Finch LRT, and Eglinton Crosstown are light rail lines currently under construction/in delivery.

Methodology

Our analysis explores how different patterns of future housing growth could shape travel behaviour and transportation emissions by 2031.

Using the Ontario Ministry of Finance projection, a 2031 population of 8,774,807, reflecting 20.5% growth from 2021 and an addition of approximately 1.7 million residents compared to our base case for 2016, forms the basis for our analysis.

To do this, we built an integrated modelling framework that links together three components: **population growth**, **travel demand**, and transport-related **GHG** emissions.

We tested “What if?” scenarios for urban densification strategies: from infill to transit-oriented-development (TOD) to high densification compared to business-as-usual (BAU) growth.

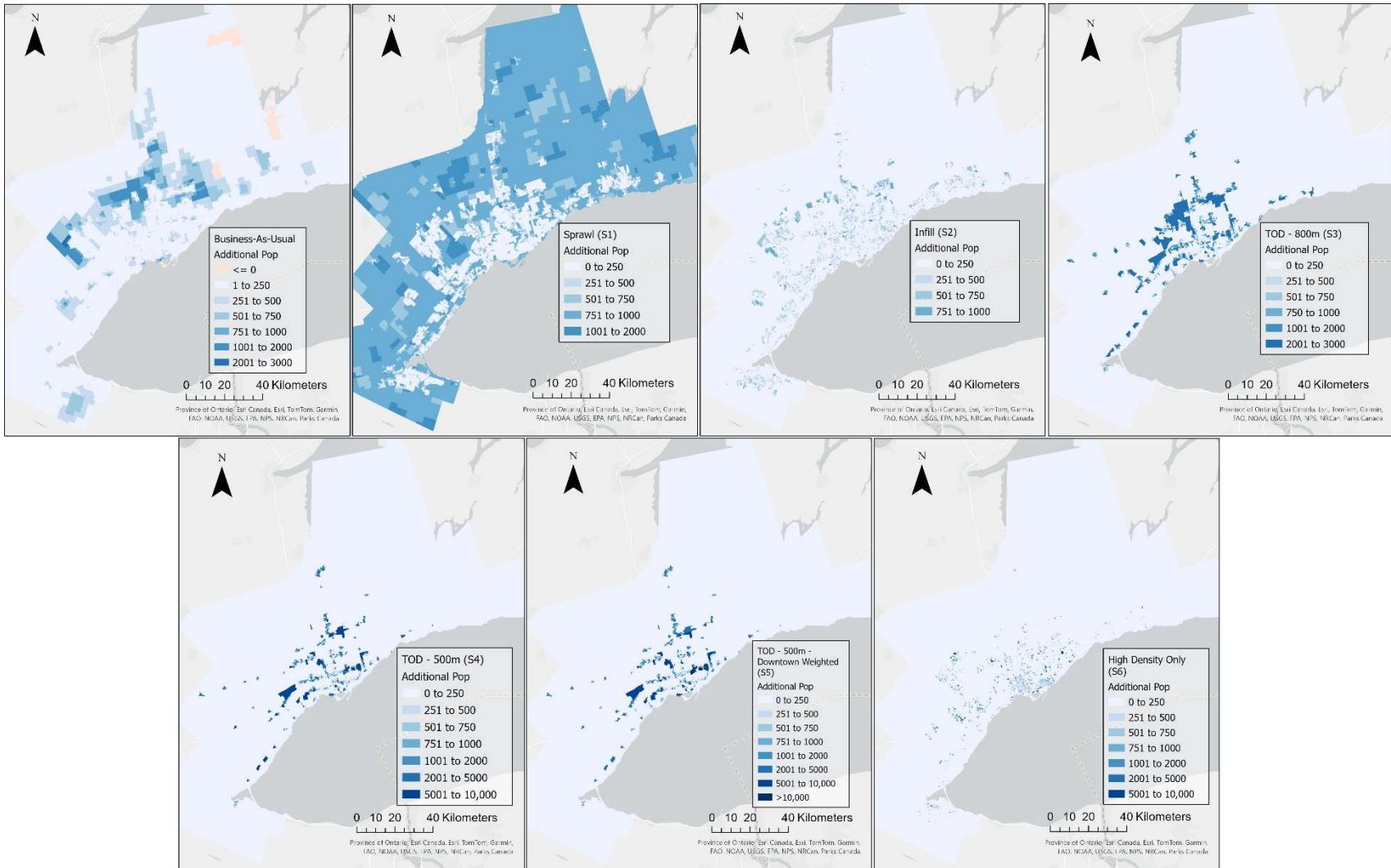
Projecting Where People Will Live

The first step was to understand where new residents are likely to move as the region grows. We developed a Spatiotemporal Autoregressive (STAR) Model that creates a baseline population projection using trends from recent Canadian censuses.

The STAR model is a spatial modelling approach that essentially looks at how neighbourhoods have grown in the past and extends those patterns forward to 2031. This BAU scenario allowed us to estimate how population might continue to distribute itself across the region if there are no interventions.

In addition, we created alternative scenarios that change where new residents are allowed or encouraged to settle. For example, one scenario placed more growth around major transit stations, while another directed growth toward already dense, central neighbourhoods. In each case, the total number of new residents remained the same; only the location of growth changed. The figure below displays maps of where additional population settled within each scenario.

- BAU growth for 2031 (from a base of 2016)
- Sprawl (S1)
- Infill (S2)
- TOD – 800m MTSA radius (S3)
- TOD – 500m MTSA radius (S4)
- TOD – 500m MTSA radius – Downtown Weighted (S5)
- High Density Only – Downtown Weighted (S6)
- S5 – No cars to new population
- S6 – No cars to new population
- S6 – No cars to new population and no new cars to existing population



Spatial Distribution of New Residents by Traffic Analysis Zone (geographic unit in Travel Demand Model)

Modelling Daily Travel Across the Region

Once we had a map of where people would live in each scenario, we estimated how these choices would affect travel. For this, we used the GTAModel, a detailed activity-based travel model developed by the Travel Modelling Group at the University of Toronto. The model simulates daily schedules for every person in the region (school, work, errands, etc.) and converts those activities into trips by car, transit, walking, or cycling.

These trips are then assigned to the region's road and transit networks so we can see how travel speeds and mode change based on where people settle within the region. For future years, we included major transit lines already under construction (such as the Ontario Line) so that the model reflects the network expected to be in place by 2031.

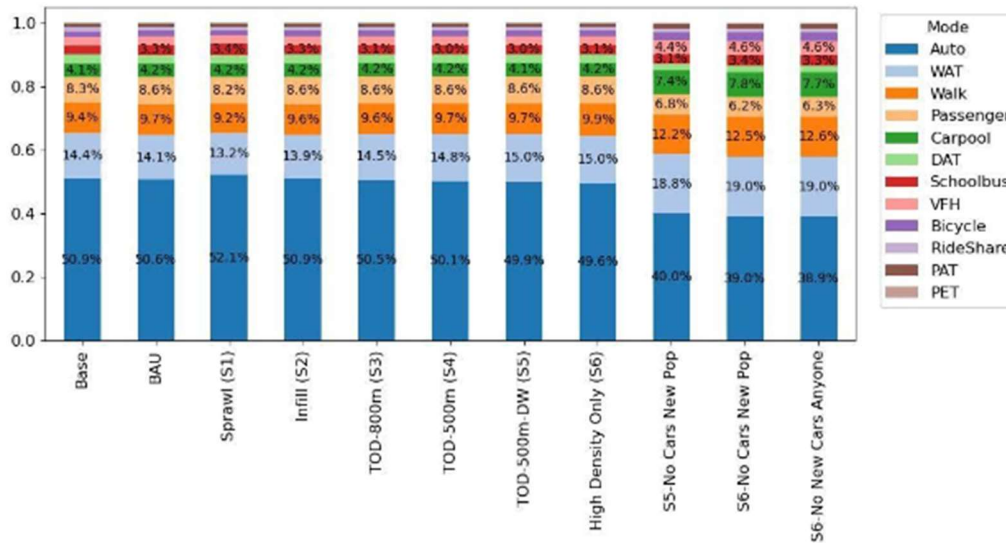
Estimating Transportation Emissions

To understand the GHG implications of our scenarios, we calculated GHG emissions from both passenger vehicles and buses. The travel model provides information on how vehicles travel across the network. We combined this with emissions data from the US EPA MOVES model to estimate how much carbon is emitted on each road segment in each scenario.

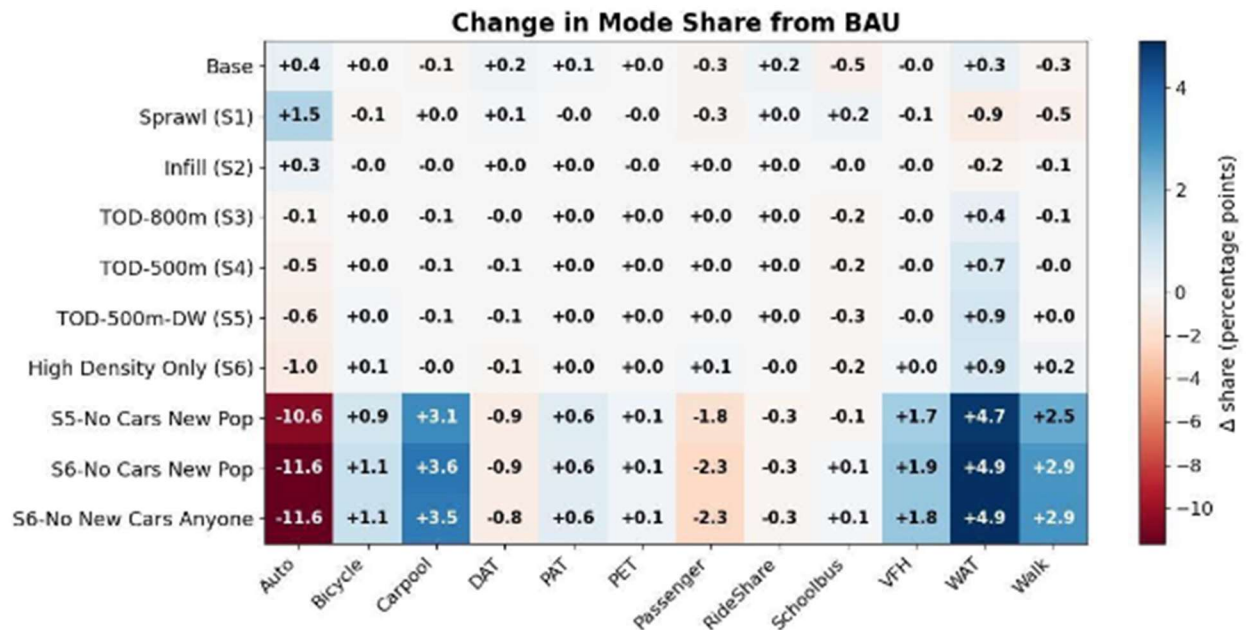
Findings

Patterns of Growth do Matter

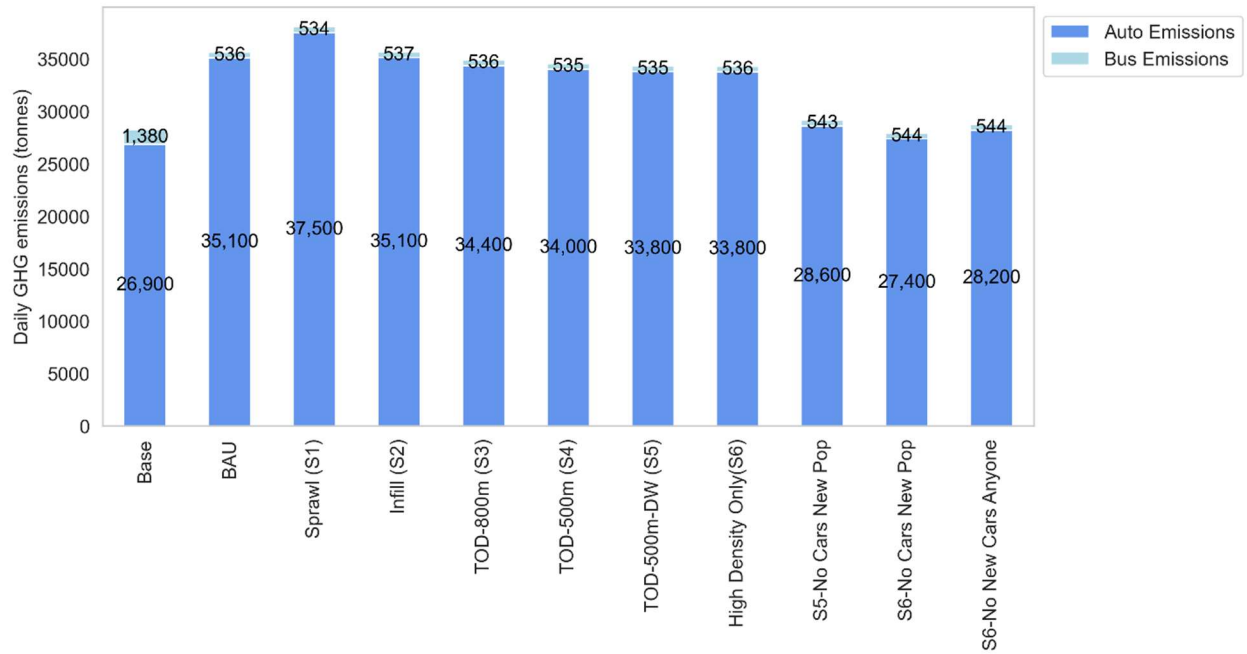
Looking at our comparison of 2016 baseline, business-as-usual growth, and optimized scenarios, we see dramatic variation in outcomes



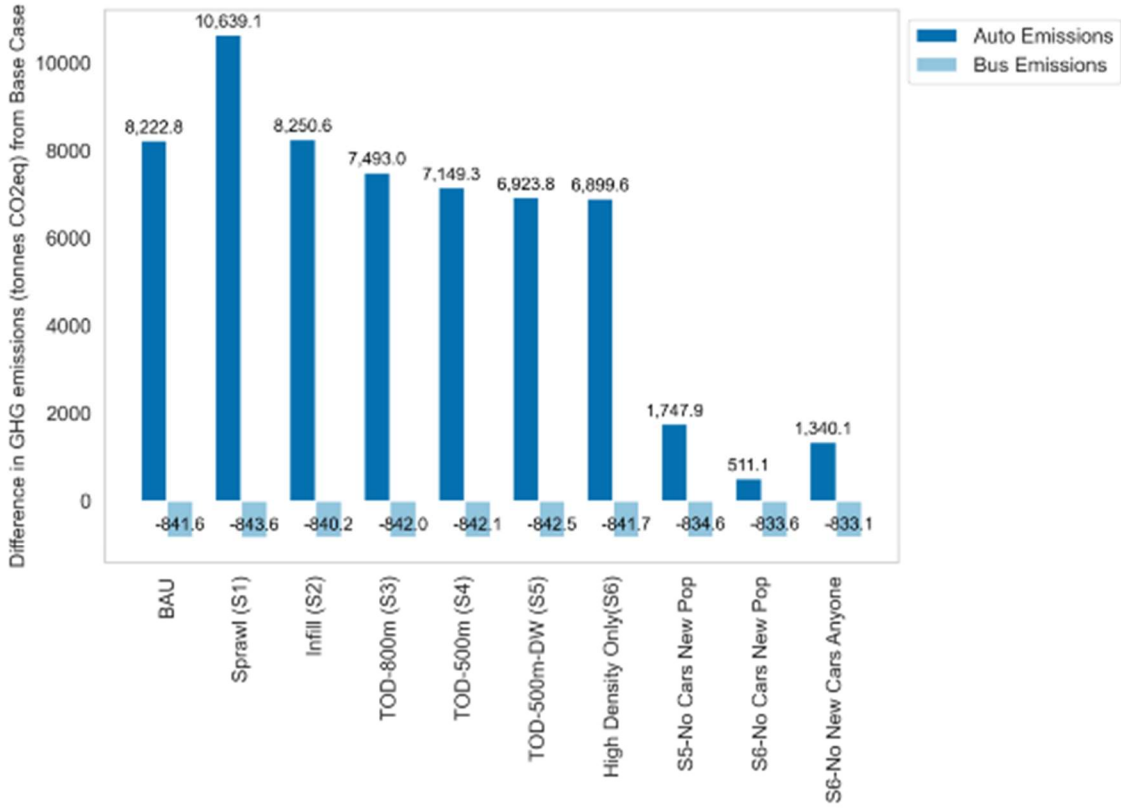
Mode share in the GTHA for each scenario. WAT = Walk-Access-Transit, DAT = Drive-Access-Transit, VFH = Vehicle For Hire, PAT = Passenger Access Transit, and PET = Passenger Egress Transit.



Daily GHG Emissions



- 2016 Baseline: ~28,300 metric tons per day
- 2031 BAU: ~35,600 metric tons per day
- 2031 Sprawl (worst case): ~38,000 metric tons per day
- 2031 TOD scenarios: ~34,000-35,000 metric tons per day
- 2031 High density with no car ownership for new residents: ~27,900 metric tons per day



How Other Cities Can Apply This Framework

Our modelling approach offers a replicable template for cities looking to understand the transportation impacts of their growth strategies. While we applied it to the GTHA, the framework is adaptable to any metropolitan region with three key ingredients:

1. **Census or population data** showing historical growth patterns by neighbourhood. This forms the foundation for projecting future population distribution.
2. **A travel demand model** (or access to one) that can simulate how residents move through the city. Many regions already maintain such models for transportation planning. If your city doesn't have one, simpler alternatives exist, though they trade some precision for ease of use.
3. **Policy scenarios** that reflect your city's planning debates. Are you considering growth around light rail stations? Prioritizing urban infill? Our framework allows you to define these scenarios spatially and test them.

Conclusions

Only one scenario achieved lower emissions than 2016, and it required a combination of 1) high-density growth, 2) a lack of car ownership among new residents, and 3) bus fleet electrification. Growth management alone, without complementary policies, couldn't deliver absolute emission reductions in a growing region.

Our analysis reveals a sobering reality: all future growth scenarios led to worse outcomes for transit users compared to the 2016 baseline, with average trip times increasing regardless of where new residents settled. This happened because transit infrastructure saw little expansion under our scenarios – only the addition of the Ontario Line, Eglinton Crosstown, and Finch LRT – while adding approximately 1.1M new residents.

This finding fundamentally shapes everything else. Even when we placed new residents right next to transit stations in walkable neighbourhoods, the overcrowded transit system couldn't deliver competitive travel times compared to driving. As a result, even under TOD growth, some residents still chose to drive, concentrating congestion and emissions in the downtown core.

We found that mode share remained surprisingly stable across most scenarios. Business-as-usual growth and our transit-oriented scenarios showed similar rates of driving, transit use, and walking – typically varying by just 2-3 percentage points.

The only scenarios that achieved substantial mode shift (10%+ reduction in driving) were those in which we artificially prevented new residents from owning cars or went further and prevented the entire population from acquiring additional vehicles. Under these scenarios, people shifted to walking, transit, carpooling, and ride-hailing services.

This tells us something important: proximity to transit matters less than transit quality. When transit is overcrowded and slow, people will drive even if they live next to a subway station.

Policy Implications & Recommendations

1. Transit investment must precede or accompany densification. Increased public transit service quality and quantity must accompany TOD growth.
2. Combine land use planning with demand management. For example, parking maximums, congestion pricing, expanded bike- and car-sharing networks.
3. Limiting car ownership is key. The costs of owning and operating a vehicle in North America are reasonably low which enable many households to remain automobile dependent.