City of London
Cycling Master Plan Review

Master Plan Review Working Group

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Authors (alphabetical):

Ben Cowie
Chris DeGroot
Rebecca Henderson
Benjamin Hill
Jamieson Roberts

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1.0 City of London Cycling Master Plan Review Summary

"There is no historical precedent for the scale of the necessary (decarbonization) transitions, in particular in a socially and economically sustainable way."

- UN Special Report on Global Warming of 1.5 °C (SR15)[1]

On September 18, 2019, City of London Staff presented an update to the city's *Cycling Master Plan*[2] (CMP) to the Cycling Advisory Committee (CAC). At this meeting, the CAC passed a motion to strike a Working Group to examine the *Cycling Master Plan* in light of two recently approved City policies:

1) Declaration of Climate Emergency
2) Vision Zero

This report contains the results of the review. During the review, it was necessary to extend our analysis to a preliminary examination of the City of London *Transportation Master Plan* through the lens of the climate emergency to evaluate sources of carbon emissions from various modes of transportation. This summary includes the itemized key findings and recommendations to the City of London Council of the working group and cycling advisory committee on the following pages.

[1] "UN Special Report on Global Warming of 1.5 °C" - Website: https://www.ipcc.ch/sr15/

[2] "London On Bikes - Our Cycling Master Plan" - Website: https://www.london.ca/residents/Environment/EAs/Pages/London-on-Bikes.aspx

1.1 Key Findings

- Successful implementation of the City of London *Transportation Master Plan* will result in London exceeding its 2030 Greenhouse Gas emissions budget by a minimum of 45%. Implementation of Scenario A in the *Transportation Master Plan* will result in a 4% net decrease in carbon emissions, and Scenario B will result in a 10% net increase in carbon emissions by 2030.
- The City of London's Greenhouse Gas emissions budget can only be met by mode shift from automobile to zero-carbon transportation (electric transit, cycling, and walking). The carbon budget **cannot** be met by electrification of automobiles alone.
- The City of London *Cycling Master Plan* explicitly prioritizes other factors above road user safety when considering street design, and does not contain higher order hazard reduction initiatives. Thus, the current *Cycling Master Plan* is inconsistent with Vision Zero objective of zero deaths or serious injuries on our roads.
- The City of London *Cycling Master Plan* is crafted to be exclusionary in its infrastructure design approach: 96% of projects planned for the next four years exclude >90% of the population from using the proposed infrastructure.
- Metrics to assess the current City of London *Cycling Master Plan* are out of sync with both comparable Canadian cities and leading global cycling jurisdictions (e.g. Copenhagen, Vancouver). There are critical gaps in understanding of both current and potential cycling rates, demographics, and behaviour in London.
- The City of London can harvest maximum economic benefit by acting quickly and decisively on climate change mitigation by investing in cycling infrastructure designed for All Ages and Abilities.
- It is virtually certain that examining other climate-relevant City policies, specifically those related to transportation and land use, through a climate lens will yield similar urgent actions to help us decarbonize as rapidly as possible.

1.2 Working Group Recommendations

We RECOMMEND that council:

- request a detailed evaluation of the greenhouse gas emissions implications of the City of London *Transportation Master Plan* in accordance with the City of London's Declaration of Climate Emergency.
- request a detailed evaluation of the greenhouse gas emissions implications of the City of London *Transit Master Plan* in accordance with the City of London's Declaration of Climate Emergency.
- request a detailed evaluation of the greenhouse gas emissions implications of the City of London Official Plan or *The London Plan* in accordance with the City of London's Declaration of Climate Emergency.
- request a detailed evaluation of the greenhouse gas emissions implications of the City of London *Parking Strategy* in accordance with the City of London's Declaration of Climate Emergency.
- request a detailed evaluation of the greenhouse gas emissions implications of the City of London *Accessibility Strategy* in accordance with the City of London's Declaration of Climate Emergency.
- request a detailed evaluation of the City of London *Road Safety Strategy* in accordance with the City of London's Adoption of Vision Zero
- direct staff to undertake major revisions to the City of London's *Cycling Master Plan* infrastructure implementation in accordance with the Declaration of Climate Emergency. The revised plan should be singularly focused on building All-Ages-and-Abilities infrastructure to achieve climate-informed modal split targets, while achieving cost allocation and social equity for basic affordable transportation by 2030.
- direct staff to design and construct an emergency city-wide minimum grid of protected bike lanes designed for All-Ages-and-Abilities to be completed by July 1, 2021.
- enact a moratorium on all currently planned and future road widening. Presently budgeted funds for road widening ($75M/year) should be reallocated to transit and cycling for maximum mitigation of climate disruption.
- fund continued investment in active transportation (including walking, accessibility, and micro mobility) at a rate of $50/person/year, or ~$20M/year, comparable to the scale of investments in major cycling cities.

- decrease speed limits on all residential streets to 30 km/h.

2.0 - Benefits of Urban Cycling

Why is a cycling city a great city?
Why should London encourage everyday cycling?

Averting Climate Disruption - Cycling provides zero carbon transportation for individuals and families[3]. Cycling for logistics and freight movement[4] is a rapidly developing industry.

Safer Streets for All - Car crashes are the leading cause of death for young people in Canada[5]. Nearly 3000 people die in vehicle crashes each year in Canada. Urban streets designed to prioritize walking, cycling, and transit, are more efficient and safer for drivers, too[6]. The happiest drivers in the world are in bike paradise, The Netherlands[7].

Public Health - People who cycle every day are healthier, more productive, and have significantly lower risks of heart disease, cancer, and premature death[8].

Personal Economics - cycling in the city is cost-effective for individuals. Everyday cycling can save individuals and families thousands of dollars per year[9].

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[3] "Want to Fight Climate Change? Swap Out Your Car for a Bike" - Website: https://www.bicycling.com/news/a23707702/climate-change-cycling/

[4] "Cyclelogistics - Opportunities for moving goods by bicycle in Toronto" - PDF: https://www.pembina.org/reports/cyclogistics-final.pdf

[5] "Desjardins Insurance - Safety Awareness" - Website: https://www.desjardinsagents.com/about-us/community/safety-awareness/parachute

[6] "Protected Bike Lanes Are Safer for Drivers, Too" - Website: https://www.citylab.com/transportation/2019/06/protected-bike-lanes-safe-street-design-bicycle-road-safety/590722/

[7] "This is the best country to drive in" - Website: https://fortune.com/2015/09/30/best-country-drive-waze/

[8] "Forget all the other reasons you should be riding a bike. This is the one that matters" - Website: http://shifter.info/forget-all-the-other-reasons-you-should-be-riding-a-bike-this-is-the-one-that-matters/

[9] "Get Rich With… Bikes" - Website: https://www.mrmoneymustache.com/2011/04/18/get-rich-with-bikes/

Public Economics - Full cost accounting of infrastructure investments show that motor vehicles and transit are heavily subsidized, whereas cycling and walking infrastructure provide net benefit[10] to the public purse. With high rates of cycling and healthier population, The Netherlands saves billions of dollars of health-related costs every year[11]. The Dutch government now pays its citizens in cash to cycle[12] because of the enormous benefits to society.

Business Economics - Cities with multiple transportation options attract top talent and corporations[13]. Retail districts with protected bike lanes do better than those without[14].

Air Quality - Replacing motor vehicle trips with cycling decreases air pollution in cities. Air pollution from car traffic impacts the cognitive development of children and teenagers[15].

Noise Pollution - Evidence is building that noise pollution can greatly affect health[16]. Bikes are silent transportation, creating a quieter urban environment[17] than streets dedicated to car travel.

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[10] "What is the full cost of your commute?" - Website: http://spacing.ca/vancouver/2015/04/06/full-cost-commute/

[11] "Dutch Cycling: Quantifying the Health and Related Economic Benefits" - Website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4504332/

[12] "The Netherlands is paying people to cycle to work" - Website: https://www.weforum.org/agenda/2019/02/the-netherlands-is-giving-tax-breaks-to-cycling-commuters-and-they-re-not-the-only-ones/

[13] "Amazon HQ2 RFP" - PDF: https://images-na.ssl-images-amazon.com/images/G/01/Anything/test/images/usa/RFP_3._V516043504_.pdf

[14] "Measuring the Local Economic Impacts of Replacing On-Street Parking With Bike Lanes" - Website: https://doi.org/10.1080/01944363.2019.1638816

[15] "Air pollution in global megacities linked to children's cognitive decline, Alzheimer's and death" - Website: http://theconversation.com/air-pollution-in-global-megacities-linked-to-childrens-cognitive-decline-alzheimers-and-death-105722

[16] "City Noise Might Be Making You Sick" - Website: https://www.theatlantic.com/technology/archive/2018/02/city-noise-might-be-making-you-sick/553385/

[17] "How Groningen invented a cycling template for cities all over the world" - Website: https://www.theguardian.com/cities/2015/jul/29/how-groningen-invented-a-cycling-template-for-cities-all-over-the-world

Space-Efficient Mobility - The conversion of one motor vehicle lane to protected bike lanes can move seven times as many people using the same amount of space[18]. Bicycles are the fastest mode of transport in most dense urban areas.

Equity - Given safe infrastructure, transportation cycling is an attractive option for individuals from 8 to 80 years[19] old, families with young children[20], and persons with disabilities[21].

Children's Development - Children and young adults need to develop independence through mobility in their community. Providing safe infrastructure for cycling to school, part time jobs, activities, and play helps children be happier, healthier, and more independent[22].

Community - Bicycles facilitate interaction among neighbours. When was the last time you stopped to chat on the street with someone you passed while driving your car?

[18] "Efficiency Master – a Comparison of Different Modes of Transportation" - Website: https://www.bikecitizens.net/efficiency-master-for-modes-of-transportation/

[19] "What is an 8 80 city?" - Video: https://www.youtube.com/watch?v=9Ni32qPrGmM

[20] "Travel with your kids in style on one of these cargo bikes" - Website: https://www.theglobeandmail.com/life/health-and-fitness/fitness/travel-with-your-kids-in-style-on-one-of-these-cargo-bikes/article29374076/

[21] "'A rolling walking stick': why do so many disabled people cycle in Cambridge?" - Website: https://www.theguardian.com/cities/2018/jan/02/cambridge-disabled-people-cycling-rolling-walking-stick

[22] "What Makes Dutch Kids the Happiest in the World? Cities That Allow Them to Roam" - Website: http://www.modacitylife.com/blog/dutch-kids-happiest-in-the-world

3.0 - Current State of the *Cycling Master Plan*

The City of London adopted “London ON Bikes” as its *Cycling Master Plan* (CMP) in September 2016. It is intended to serve as a guide for all further planning, design, development, and programming related to cycling. The business case supporting the CMP is based on benefits to six main areas, namely:

- Health
- Environment
- Tourism
- Safety
- Social
- Economic

The CMP acknowledges that each litre of gasoline that is burned emits about 2.3 kg of carbon dioxide and that these emissions are contributing to climate disruption. It acknowledges that the transportation sector accounts for approximately one third of Ontario’s greenhouse gas emissions. While increasing the number of people cycling for transportation is suggested as a means to reduce carbon emissions, the magnitude of the emissions that would be reduced by this shift in mode share is not quantified. In fact, beyond a passing mention in the overview of the business case, emissions reductions are not discussed any further in the CMP. Given the recent Declaration of Climate Emergency by London City Council, the CMP should be re-evaluated to determine the degree to which it helps reach London’s goals for emissions reduction.

The CMP provides a categorization of cycling facilities based on the level of separation from motor vehicle traffic:

- **Shared Facilities:** where the cyclist is asked to share the roadway with motorists.
- **Designated Facilities:** where cyclists are provided their own“designated” space delineated by a painted line.
- **Separated Facilities:** where cyclists are provided either physical or spatial separation from motorists and other road users.

Despite the fact that greater separation from traffic clearly corresponds with greater safety and comfort for cyclists, the CMP does not distinguish between these when measuring its progress; it is simply lane kilometres of facilities that is mentioned as a metric of success. In light of the adoption of “Vision Zero” by London City Council, the CMP should be re-evaluated to determine how well it aligns with the principles of Vision Zero.

The cycling mode share in the CMP was estimated at 1%, with a mode share target of 5% by 2030. The CMP does not provide details about how the cycling mode share will be measured and evaluated in the future, nor does it provide any analysis that would indicate that the proposed plan is actually sufficient to attain the stated target.

One of the core objectives of the CMP is to “provide facilities that are considered comfortable for people of all ages and abilities including youth and seniors”. Therefore it is primarily the plans to build **separated facilities** (Figure 3-1 below) that should be used to measure the potential to increase cycling mode share, since most new riders require very safe infrastructure to change their mobility habits.

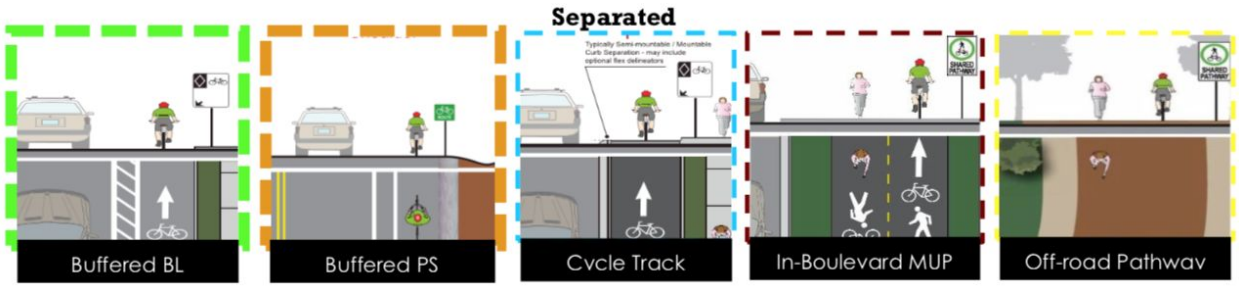

Figure 3-1: Types of cycling facilities described in the CMP. [23]

The CMP includes a number of different types of facilities that are categorized as “separated”, which can be further categorized as those with buffers and those with physical separation. A buffer is defined as a separation between a vehicular lane and a bicycle lane that is denoted using painted lines and hash marks. Physically separated lanes include those with a physical barrier (such as a curb) when a bicycle lane is adjacent to a vehicle lane. Physically separated lanes also include pathways that are separate from roadways. Buffered and physically

[23] “London On Bikes - Our Cycling Master Plan” - Website: https://www.london.ca/residents/Environment/EAs/Pages/London-on-Bikes.aspx

separated lanes provide very different comfort levels for users, warranting a separate assessment of each type of facility. A summary of the existing and proposed facilities, identified as being separated, are summarized below for both buffered and physically separated facilities.

Table 3-1: Summary of the existing and proposed facilities that are separated by a buffer.

	Existing in 2016 (km)	Proposed in CMP (km)	Total (km)
Buffered Bike Lane	0	31.9	**31.9**
Buffered Paved Shoulder	0	10.7	**10.7**
Total	**0**	**42.6**	**42.6**

Table 3-2: Summary of the existing and proposed facilities that are separated by a physical barrier.

	Existing in 2016 (km)	Proposed in CMP (km)	Total (km)
Cycle Track (Protected Bike Lane)	0	7.5	**7.5**
In-Boulevard Multi-use Pathway	42	28.2	**70.2**
Multi-use Pathway	166	78.7	**244.7**
Total	**208**	**114.4**	**322.4**

The CMP states that the cost of building the next 15 years of cycling infrastructure that is planned will cost approximately $53 million ($3.5M/year), including all types of facilities both within the road right of way and outside of it. As of the publishing of the CMP, $34.5 million of the total $53 million was funded; the remainder will require additional considerations to fund. That said, **of the 799 km of cycling facilities that are proposed in the CMP, only 7.5 km (less than 1%) are cycle tracks**. **From the perspective of increasing ridership, cycle tracks (protected bike lanes) are considered to be the most effective since they provide the best physical separation and are typically located along routes that have many destinations.** While the value of multi-use pathways is acknowledged for recreational cycling, this type of infrastructure is less effective for shifting mode share towards bicycles and away from motor

vehicles because they do not directly access key destinations (schools, shops, workplaces, residences).

With regards to safety, the CMP lists a number of strategies including education, enforcement programs, improved signage, and the installation of additional cycling lanes. **However, the only metric of evaluation appears to be the number of lane kilometres of cycling lanes, regardless of their type, or whether anybody rides in them**. When evaluating safety, the quality of the cycling lanes needs to be taken into account, not simply their quantity. Furthermore, continuous connectivity (network effect) needs to be evaluated, since each transition between disconnected lanes represents a serious safety hazard, and a barrier to new ridership.

Notably absent from the CMP is any discussion about providing connections between destinations within the city. For example, major destinations such as downtown, Western University, and Fanshawe College should receive additional consideration for providing safe cycling connections. Cycling lanes have the potential to provide excellent connections between these locations, since the distances between them are within a comfortable cycling distance.

To summarize, the CMP is considers a number of crucial issues such as safety, environment, health, and economy. While it is clear that improving cycling infrastructure can indeed contribute towards all of these goals, it is lacking detail in several key areas. It appears that total lane kilometres is the primary metric by which the success of the CMP is being evaluated, which does not emphasize the need for All-Ages-and-Abilities infrastructure, nor the need to achieve gender equity among urban cyclists. Greater emphasis needs to be placed on measuring the progress in building cycling infrastructure, including improvements in safety, reductions in carbon emissions, demographics of ridership, as well as economic benefits.

This report aims to investigate these aspects of the CMP in greater detail and provide recommendations about how it can be updated to reflect the recent Climate Emergency and Vision Zero declarations, while also implementing better metrics to gauge its successful implementation.

4.0 - Climate Emergency and The Cycling Master Plan

4.1 - Climate Emergency

In 2018, The United Nations released the **Special Report on Global Warming of 1.5 °C (SR15)**[24]. According to the report, with global warming of 1.5 °C there would be increased risks to "health, livelihoods, food security, water supply, human security, and economic growth. "Limiting global warming to 1.5°C, compared with 2°C, could reduce the number of people both exposed to climate-related risks and susceptible to poverty by up to several hundred million by 2050."[22]

The key finding of SR15 is that meeting a 1.5°C (2.7°F) target is possible but would require "deep emissions reductions," and "rapid, far-reaching and unprecedented changes in all aspects of society." Furthermore, the report finds that "limiting global warming to 1.5°C compared with 2°C would reduce challenging impacts on ecosystems, human health and well-being." SR15 also has modelling that shows that, for global warming to be limited to 1.5 °C, **"Global net human-caused emissions of carbon dioxide (CO2) would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050."**[22]

Canada's Changing Climate Report 2019[25] concludes "both past and future warming in Canada is, on average, about double the magnitude of global warming," increasing the urgency by which Canadians need to be concerned about the impacts of climate disruption. The report defines different emission scenarios, which show that the profound effects of the climate emergency are not inevitable, if drastic changes are made. The report shows that limited warming is only possible if **"Canada and the rest of the world reduce carbon emissions to near zero early in the second half of the century and reduce emissions of other greenhouse gases substantially."**[23]

[24] "Special Report on Global Warming of 1.5 °C (SR15)" - Website: https://www.ipcc.ch/sr15/

[25] "Canada's Changing Climate Report" - Website: https://changingclimate.ca/CCCR2019/

These reports are clear that **immediate, substantial action must be taken at the local level to curb emissions to decrease the risks to our civilization from which no citizen of our planet is immune.**

Our understanding of the Climate Emergency is developing so rapidly that keeping up with new information requires one's full attention. The newest UN Report[26] was published during our review of the CMP (Sept 22, 2019), post-dating the City's declaration of Climate Emergency. Highlights of the new report stress the urgency of immediate action:

- Past five years were the warmest five-year period on record
- Continued decrease of sea ice and ice mass
- Sea-level rise is accelerating, sea water is becoming more acidic
- Record greenhouse gas concentrations in the atmosphere

"Only immediate and all-inclusive action encompassing: deep decarbonization complemented by ambitious policy measures, protection and enhancement of carbon sinks and biodiversity, and efforts to remove CO2 from the atmosphere, will enable us to meet the Paris Agreement."

- UN Climate Action Summit Report Release[24]

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[26] "Landmark 'United in Science' Report Informs Climate Action Summit" - Website: https://unfccc.int/news/landmark-united-in-science-report-informs-climate-action-summit

4.2 - City of London Statement on Climate Emergency

Recognizing the urgency of SR15, on April 23, 2019 the City of London declared a Climate Emergency[27] using the following language:

> *"Whereas climate change is currently contributing to billions of dollars in property and infrastructure damage worldwide, stressing local and international economies; Whereas climate change is currently jeopardizing the health and survival of many species and other natural environments worldwide, stressing local and international eco systems; Whereas climate change is currently harming human populations through rising sea levels and other extraordinary phenomena like intense wildfires worldwide, stressing local and international communities; Whereas recent international research has indicated a need for massive reduction in carbon emissions in the next 11 years to avoid further and devastating economic, ecological, and societal loss; Whereas the climate in Canada is warming at twice the rate of the rest of the world, as per Canada's Changing Climate report;* ***Whereas current initiatives such as the green of the city's fleet and energy reduction initiatives are not sufficient to meet the targets as defined by the IPCC scientists****, Whereas an emergency can be defined as "an often dangerous situation requiring immediate action"; Whereas municipalities such as Kingston, Vancouver and Hamilton have already declared climate emergencies; Therefore, a climate emergency BE DECLARED by the City of London for the purposes of naming, framing, and deepening our commitment to protecting our economy, our eco systems, and our community from climate change."*

> **Essential in this declaration is the recognition by council that many city policies contain insufficient measures to decrease GHG emissions to levels that are scientifically required to avoid catastrophe.**

[27] Council Minutes April 23, 2019 - Website: https://pub-london.escribemeetings.com/Meeting.aspx?Id=03a43442-6a8b-4a0b-88ce-23191066c4ca&Agenda=PostMinutes&lang=English

4.3 - City of London Carbon Budget

Understanding London's present-day carbon budget is essential to planning our GHG reduction strategy. The City of London maintains an up-to-date inventory of energy consumption and greenhouse gas emissions, most recently reported as the 2017 Community Energy and Greenhouse Gas Report[28]. London's total carbon emissions in 2017 was 2870 kilotonnes (kt) CO2 equivalent (CO2e), and in 2010 (SR15 reference year) it was 3500 kt. The decrease from 2010-2017 is due primarily to decarbonization of Ontario's electrical grid, with secondary contributions from improved home energy efficiency, reduced energy use in the business sector, and improvement in the City of London landfill gas collection.

Transportation is by far the sector with the largest emissions of GHG. Our 2017 transport emissions are 1390 kt CO2e (of which ~70% of emissions are from personal vehicles), representing 49% of total emissions today, and has been relatively unchanged since 2007. Residential output (mainly home heating) is 510 kt CO2e. Industrial, commercial, and institutional output was 830 kt CO2e and landfill emissions and sewer incineration output was 140 kt CO2e. Due to the long life-cycles of buildings, businesses, and landfill operations, these values are unlikely to change substantially before 2030.

[28] "2017 Community Energy & Greenhouse Gas Emissions Inventory" - PDF: https://www.london.ca/residents/Environment/Energy/Documents/2017%20Inventory%20Report.pdf

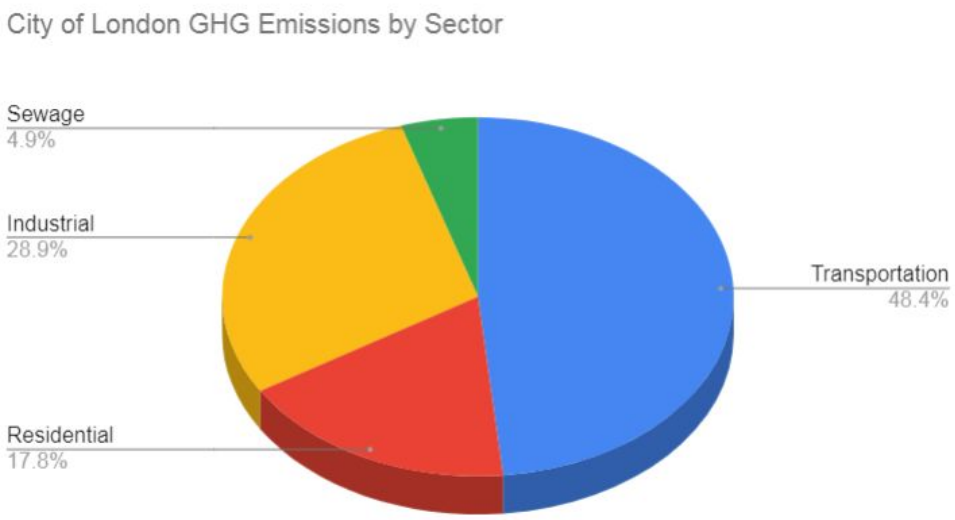

Figure 4-1: Greenhouse Gas Emissions by sector in London, ON. Source: 2017 Community Energy & Greenhouse Gas Emissions Inventory, City of London.[29]

Given the substantial emissions cuts mandated by the scientific requirements of SR15, **London's total carbon budget for 2030 is set at 1925 kt CO2e** (a 45% decrease from 2010: 3500kt CO2e x [1 - 0.45]). The 2030 emissions target corresponds roughly with present-day Sweden, on a per capita basis, and is therefore believed to be reasonable and attainable while maintaining high quality of life.

[29] "2017 Community Energy & Greenhouse Gas Emissions Inventory" - PDF: https://www.london.ca/residents/Environment/Energy/Documents/2017%20Inventory%20Report.pdf

4.4 - Transportation Targets for Climate Action

The City of London Transportation Master Plan[30] (TMP) identifies year 2030 targets for different modes of transportation. Its targets are as follows:

Table 4-1: City of London Transportation Master Plan current mode share and 2030 targets.

Mode	2009 Mode Share	2030 Target
Automobile	76%	60%
Transit	11%	20%
Active Transportation - Cycling - Walking	**9%** ~1% ~8%	**15%** 5% 10%
Other	5%	5%

The TMP considers scenarios with two different growth patterns. Scenario A presents a minimum population growth of 73,800 people to a total population of ~430,000 by 2030. This represents a 21% increase from 355,000 total residents in 2007. Scenario B envisions growth of 140,000 people to 493,000 total residents, a 39% increase from 2007.

We examined the carbon implications of both scenarios in a simple modeling exercise that accounted for variable electrification in the automotive sector, and complete electrification in the transit sector. Using this model, we are able to assess whether the 2030 TMP will achieve the deep emissions reductions required by the scientific consensus to help preserve our civilization. Details of the model's construction including original values are available here: https://docs.google.com/spreadsheets/d/1hEp9AOULDzFEZNXCMTV84jQ6YnRyV9S65x5o-Wnu2Ko

To test various aspects of the City's carbon budget, we made reasonable simplifying assumptions. The modeled results assume zero change in emissions from residential, industrial,

[30] "Smart Moves 2030 Transportation Plan" - Website: https://www.london.ca/residents/Roads-Transportation/Transportation-Planning/Pages/Smart-Moves-2030-Transportation-Plan.aspx

or sewage sources, because the rate of change for new building construction and retrofits will be small on a ten year time scale. While it is essential to decrease emissions from building sources by 2050, (we must begin working on building design and land use immediately) the GHG benefits of building retrofits will likely not be felt for at least a decade because of the long lifespan of buildings, and the sheer number of building retrofits required. Furthermore, most of the electricity emissions gains that can be achieved in other jurisdictions cannot be achieved here, because our electricity supply is already nearly fully decarbonized in Ontario, leaving buildings with less room to decrease in the immediate future.

4.4.1 Modeled Results: Transportation Master Plan, Business As Usual

Table 4-2 illustrates the implications of meeting the TMP targets for transportation mode split by 2030 in terms of carbon emissions. Assuming no changes in trip length, vehicle fuel standards (technology), or human behaviour, attaining the goals set out within the TMP results in a 4% decrease of GHG emissions from transportation by 2030 for Scenario A, and a 10% increase in GHG emissions for Scenario B.

Table 4-2: Modeled carbon emissions implication of adopting TMP targets for mode split by 2030. TMP identifies 60% automobile, 20% transit, 15% active transportation, and 5% other as targets.

	Scenario A (pop 430,000)	Scenario B (pop 493,000)
Change in GHG Emissions (kt CO2e)	-61	+133
% Change in GHG Emissions relative to 2010	-4%	+10%
Total 2030 Carbon Budget kt CO2e	1925	1925
Residential kt CO2e	510	510
Industrial kt CO2e	830	830
Sewage kt CO2e	140	140
Transportation as % of allowable GHG in 2030	68%	78%
Total Emissions (% of 2030 Target)	**145%**	**155%**

> **What these data indicates is that implementing the Transportation Master Plan will not decrease Greenhouse Gas emissions to the scientifically required targets for 2030, if the status quo is maintained for vehicle technology and land use**

4.4.2 - Modeled Results: Transportation Master Plan with Vehicle Electrification

Electric Vehicles (EV's) have been touted as a climate saviour that are "just a few years away from mass deployment." However the current uptake of EV's is slow, even with massive ($5000/vehicle) government incentives. Current EV sales in Canada are ~2% of total sales, which has been estimated by the International Energy Agency[31] to increase to 30% market share of new vehicles by 2030. While EV's are considerably cleaner than internal combustion engine counterparts (especially in Ontario with a low-carbon electricity supply), the overall life cycle emissions from EV's only result in an overall emissions decrease averaging 50% of internal combustion engine (ICE) vehicles[32]. In Ontario, the total emissions of a built-in-Ontario EV could be as low as 30% compared to a similar ICE vehicle, however we use the 50% decrease as a conservative estimate.

There are several major challenges with EV Adoption[33]:

- Long fleet turnover time (~15 years)
- Slow adoption (25% new vehicles by 2030 according to IEA)
- It takes roughly double the energy to construct EV vs internal combustion cars
- Limits, emissions, and ethics of Rare Earth metal mining required for battery construction

The results of the TMP + EV calculations are presented in Table 4-3. It is clear from these results that even with 100% electrification of all vehicles (public and private), the TMP mode split goals are insufficient to reach deep emissions reductions required by the scientific consensus to preserve our civilization.

[31] "Global EV Outlook 2019" - Website: https://www.iea.org/publications/reports/globalevoutlook2019/
[32] "EEA report confirms: electric cars are better for climate and air quality" - Website: https://www.eea.europa.eu/highlights/eea-report-confirms-electric-cars
[33] "The Problem With Switching to Electric Cars" - Website: https://www.citylab.com/transportation/2019/09/electric-vehicle-climate-carbon-emissions-impact-solution/598453/

Table 4-3: Modeled Carbon Emissions from implementing the Transportation Master Plan goals with variable levels of electrification by 2030. Modal split: 60% automobile, 20% transit, 15% active transportation, and 5% other. The rightmost column, 25% adoption, is the most-likely scenario according to International Energy Agency.

	100% EV's (pop 430,000)	**50% EV's (pop 430,000)**	**25% EV's (pop 430,000)**
Change in Transport GHG Emissions (kt CO2e)	-716	-388	-225
% Change in Transport GHG Emissions relative to 2010	-52%	-28%	-16%
Total 2030 Carbon Budget kt CO2e	1925	1925	1925
Residential kt CO2e	510	510	510
Industrial kt CO2e	830	830	830
Sewage kt CO2e	140	140	140
Transportation as % of allowable GHG in 2030	34%	51%	59%
Total Emissions (% of 2030 Target)	111%	128%	136%

> **What these data indicate is that implementing the Transportation Master Plan will not decrease Greenhouse Gas emissions to the scientifically required targets for 2030, even if 100% electrification of vehicles is achieved.**

4.4.3 - Modeled Results: Toward Climate-Informed Transportation Mode Split Targets

Recognizing that the TMP objectives are insufficient to reach our 2030 decarbonization goals, the only remaining lever for GHG reduction in the transportation sector is to change the mode-split targets in the TMP. In this section, we provide estimates on mode-split targets that reach the deep emissions reductions required by the scientific consensus. For simplicity, we only present “Scenario A” which considers population of 430,000, however the results are of similar magnitude and direction for Scenario B (population 493,000).

Table 4-4: Modeled carbon budget considering different mode split targets from the Transportation Master Plan.

Parameter	Mode Split 5	Mode Split 15	Mode Split 30	Mode Split 45	Mode Split 60
Automobile Mode Share (%)	5	15	30	45	60
Transit Mode Share (%)	45	40	30	25	20
Active Transport Mode Share (%)	45	40	30	25	15
Other Transport Mode Share (%)	5	5	10	5	5
Transportation GHG (kt CO2e)	109	327	654	982	1309
GHG Non-Transport (kt CO2e)	1480	1480	1480	1480	1480
GHG-All (kt CO2e)	1589	1807	2134	2462	2462
Change in GHG from 2009	-92%	-76%	-52%	-28%	-4%
2030 Emissions Budget (kt CO2e)	1925	1925	1925	1925	1925
Transport Fraction of 2030 C Target	6%	17%	34%	51%	68%
Total GHG Relative to Target (kt CO2e)	**-336**	**-118**	**209**	**537**	**864**
Total Emissions (% of 2030 Target)	**83%**	**94%**	**111%**	**128%**	**145%**

> **These data indicate that changing mode split targets can decrease Greenhouse Gas emissions to the scientifically required targets for 2030. With 0% vehicle electrification, the automobile mode split required to meet GHG reductions is <20%.**

4.4.4 - Modeled Results: Combining Mode Split with Electrification

“All of the above” approaches create the deepest decreases in emissions. Table 4-5 illustrates the mode split scenarios discussed above, plus a combined electrification and mode-split options for Scenario A. There are diminishing returns on GHG reduction for vehicle electrification as automobile mode share declines. Put differently, electrification has less overall effect with fewer cars on the road.

Table 4-5: Modeled carbon budget considering different mode split targets AND variable electrification for Scenario A (population 430,000)

Parameter	TMP (Mode Split 60)	Mode Split 30 0% EV	Mode Split 30 25% EV	Mode Split 30 100% EV	Mode Split 45 25% EV
Automobile Mode Share (%)	60	30	30	30	45
Transit Mode Share (%)	20	35	35	35	25
Active Transport Mode Share (%)	15	30	30	30	25
Other Transport Mode Share (%)	5	5	5	5	5
Transportation GHG (kt CO2e)	1309	654	573	327	859
GHG Non-Transport (kt CO2e)	1480	1480	1480	1480	1480
GHG-All (kt CO2e)	2462	2134	2053	1807	2339
Change in GHG from 2009	-4%	-52%	-58%	-76%	-37%
2030 Emissions Budget (kt CO2e)	1925	1925	1925	1925	1925
Transport Fraction of 2030 C Target	68%	34%	30%	17%	45%
Total GHG Relative to Target (kt CO2e)	**864**	**209**	**128**	**-118**	**414**
Total Emissions (% of 2030 Target)	**145%**	**111%**	**107%**	**94%**	**121%**

> **These data indicate that changing both mode split targets and adopting electric vehicles can decrease Greenhouse Gas emissions to the scientifically required targets for 2030. While there are multiple solutions**

for decarbonization in this model, a target of ~26% automobile mode split with 25% EV's yields sufficient GHG reductions.

4.4.5 - Modeling Summary

What is made clear by these data is that deep emissions reductions required by the scientific consensus to preserve our civilization require major efforts to cut motor vehicle use compared to the existing TMP, plus considerable electrification of remaining vehicles. **It is clear that we must urgently revise our Transportation Master Plan if we are serious about our commitment to the climate emergency.**

Recommendation: While it is absolutely clear that the existing TMP mode split targets are insufficient, we can rapidly address some of these needs through the Cycling Master Plan. **To achieve GHG reduction goals, the current Cycling Master Plan requires an increase in planned cycling mode split from 5% to ~25% or greater.** This goal can be achieved using well-understood, established infrastructure design principles, but requires a completely different approach than what is laid out in the current CMP. We discuss the key differences in infrastructure requirements to get from 5% from 5% to 25% in Section 6.0.

4.5 - Cost/Benefit of Future Emissions Abatement

The cost of doing nothing is substantial, the benefit of immediate action is large. With a rising price on emitting carbon in Canada, London will benefit economically from acting sooner rather than later on climate emergency. The Parliamentary Budget Officer of Canada[34] recommends a carbon price of $102/tonne by 2030 in order to achieve the necessary emissions cuts. The current price on carbon is $20/tonne, rising by $10/tonne/year until 2022 when the price will reach $50/tonne. Canada's price on carbon is not a tax, but a fee and dividend system, which charges excessive polluters and reward those who cut emissions faster and deeper. This means that as individuals and as a city we can collect dividend payments by lowering our overall carbon footprint. Therefore, if London acts earlier than other cities on decreasing emissions, it will represent a significant wealth injection into the city on the order of tens of millions of dollars per year. While the actual dividend paid out depends on the actions of other cities and industries, it is nearly unthinkable that these financial gains would not be realized in the short- and medium-term future, as the oil and gas industry (Canada's largest polluter[35]) is unlikely to wind down its major operations in the next ten years, and thus will continue to be the main source of carbon dividend funds.

The calculation below(Table 4-6) illustrates the immediate, direct benefit to Londoners from decarbonizing our transportation network. The calculation shows the difference (increase) in carbon dividends paid to Londoners for implementation of a more aggressive plan (Mode Split 30 + 25% EV adoption), versus the existing TMP. The total annual payout in carbon dividend would far exceed the cost of implementing an aggressive transit and cycling expansion, up to an estimated seventy five million dollars per year by 2030 in carbon fee alone (e.g. not counting personal savings to individuals for switching trips from driving to transit and cycling, that have an entirely separate set of economic benefits).

[34] "Closing the gap: carbon pricing for the Paris target (Revised June 20, 2019)" - Website: https://www.pbo-dpb.gc.ca/en/blog/news/closing-gap-carbon-pricing-paris-target

[35] "Greenhouse gas emissions" - Website: https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html

Table 4-6: The immediate, direct financial benefit to Londoners from decarbonizing our transportation network

Price of 1t CO2e emitted in 2022:	$50
Price of 1t CO2e emitted in 2030 (PBO estimate):	$102
Current emissions (tonnes CO2e):	2,870,000
TMP emissions (tonnes CO2e):	2,789,000
Mode Split 30 emissions + 25% EV (tonnes CO2e):	2,053,000
Difference [MS30-ev25 - TMP] (tonnes CO2e):	736,000
2022 [MS30-ev25 - TMP] Difference x Carbon Dividend (annual):	$36,800,000
2030 [MS30-ev25 - TMP] Difference x Carbon Dividend (annual):	$75,072,000

4.6 - Summary of Climate Emergency and City Transportation Policies

At its core, the goals laid out in the Transportation Master Plan are insufficient to reach our international obligations to decrease our carbon emissions, and inadequate to cope with our declaration of a Climate Emergency. Thus we must quickly and decisively change course, with the aim of rapidly decarbonizing our City's transportation system by 2030.

The main findings of this section are as follows:

- The Climate Emergency represents a grave threat to citizens of London and to life on Earth as we know it.
- We must decrease our Greenhouse Gas Emissions by 45% before 2030, and stay within a fixed carbon budget of 1925 kt CO2e.
- Transportation is by far the largest contributor to GHG emissions in London, currently 1378 kt CO2e.
- Buildings, businesses, and sewage contribute the balance of GHG (1480 kt CO2e), however these emissions sources take far longer to decline than transportation.
- Implementing the existing Transportation Master Plan does not achieve required emissions reductions targets even with (nearly impossible) 100% vehicle electrification.
- Only aggressive changes in mode split from automobile to zero carbon transportation (walking, cycling, electric transit) can achieve climate emergency goals. These goals are reasonable, and align with cities in other highly developed countries today (e.g. Sweden, Germany)
- Acting quickly will yield the greatest financial benefits: an **increase** of more than $75M in annual carbon dividend paid to our citizens is possible by 2030 by increasing transit and active transportation mode split in the City.

Climate-Informed Transportation Mode Targets by 2030:

- 100% Electrification of London Transit Vehicles
- 25% Electrification of Private Cars and City Vehicles
- Modal Split:
    - 25% Automobile
    - 35% Transit
    - 35% Active Transportation (walking 10%, cycling 25%)
    - 5% Other

Net GHG Emissions for this outcome: 1957 kt CO2e, ~102% of permitted emissions.

5.0 - Vision Zero and the Cycling Master Plan

"To err is human. To forgive, design.
When humans fail, the transportation system should not.
That's Vision Zero boiled down to its most basic concept."
- Kostelec Planning[36].

5.1 - Vision Zero Principles

Vision Zero is an approach to road safety based on the ethical vision that serious and fatal injuries on our roads are unacceptable and preventable. There can be no compromise between safety of users, and other factors (such as vehicle speed or vehicle throughput). The City of London adopted this policy in May 2017, joining cities across Canada and around the globe. The distinguishing feature focuses on a system design framework that **holds transportation systems designers and policy-makers accountable and responsible for road safety, rather than individual road users**. Whereas traffic collisions disproportionately affects the most vulnerable in our society, including minorities, seniors, and children, the onus must be on the street's designer to ensure the safety of all road users.

The main tenets of Vision Zero are: *traffic deaths are preventable, and the loss of life is not negotiable.* In a 2012 report[37], the Ontario Coroner stated that 100% of 129 cyclist deaths on Ontario's streets from 2004-2010 were preventable.The *London Road Safety Strategy 2014-2019*[38] falls short of a Zero goal, and focuses on *programs* that will reduce injury and death on roads by 10% within five years.

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[36] "To err is human; to forgive, design" - Website: https://www.kostelecplanning.com/to-err-is-human-to-forgive-design/
[37] "Office of the Chief Coroner for Ontario - Cycling Death Review" - PDF: http://www.mcscs.jus.gov.on.ca/sites/default/files/content/mcscs/docs/ec159773.pdf
[38] "City London Road Safety Strategy 2014-2019" - PDF: https://www.london.ca/residents/Roads-Transportation/Road-Safety/Documents/city-of-london-road-safety-web.pdf

This goal accepts,

1) More than 1000 injuries and deaths on our roads are inevitable,
2) Programs (i.e. not safe systems) will reduce injury and death.

Neither premise is compliant with the Vision Zero approach.

Vision Zero requires focus on **system failure.** Safe system design focuses on building better roads, improving vehicle safety technologies, and managing kinetic energy (speed reduction) to reduce the physical forces on humans when motor vehicle crashes inevitably occur. The Safe System approach strives to create road system designs that anticipate human error, and that are forgiving when errors are made.

5.2 - City of London Statement on Vision Zero

On May 16, 2017, Municipal Council adopted the following principles as its Vision Zero declaration[39]:

- No loss of life is acceptable
- Traffic fatalities and serious injuries are preventable
- We all make mistakes
- We are all physically vulnerable when involved in motor vehicle collisions
- Eliminating fatalities and serious injuries is a shared responsibility between road users and those who design and maintain our roadways

Safe System Components

1) **Safe Road Users -** Reduce unsafe behaviours including: drinking and driving, drug use and driving, distracted driving, speeding, and failing to use occupant restraints; targeting high-risk drivers and chronic offenders; and protecting vulnerable road users such as pedestrians and cyclists.
2) **Safe Vehicles** - Requires working with partners, identifying safety technologies and monitoring safety concerns.

[39] "Vision Zero" - Website: https://www.london.ca/residents/Roads-Transportation/Road-Safety/Pages/London-Road-Safety-Strategy.aspx

3) **Safe Roadways -** Focuses on the role of road project development, and on land use and neighbourhood planning. This **component encourages the explicit consideration of safety for innovations in road design**. Areas for work include identification and improvement of high-risk locations, and better road designs that benefit vulnerable road users.
4) **Safe Speeds -** Promotes setting safe speed limits, greater compliance with speed limits, vehicle-speed management technologies, and educating road users. Beyond certain speeds, safe road users, safe vehicles and safe roadways will fail. **Vision Zero recommends 30km/h in residential neighbourhoods where people mix with automobiles**.

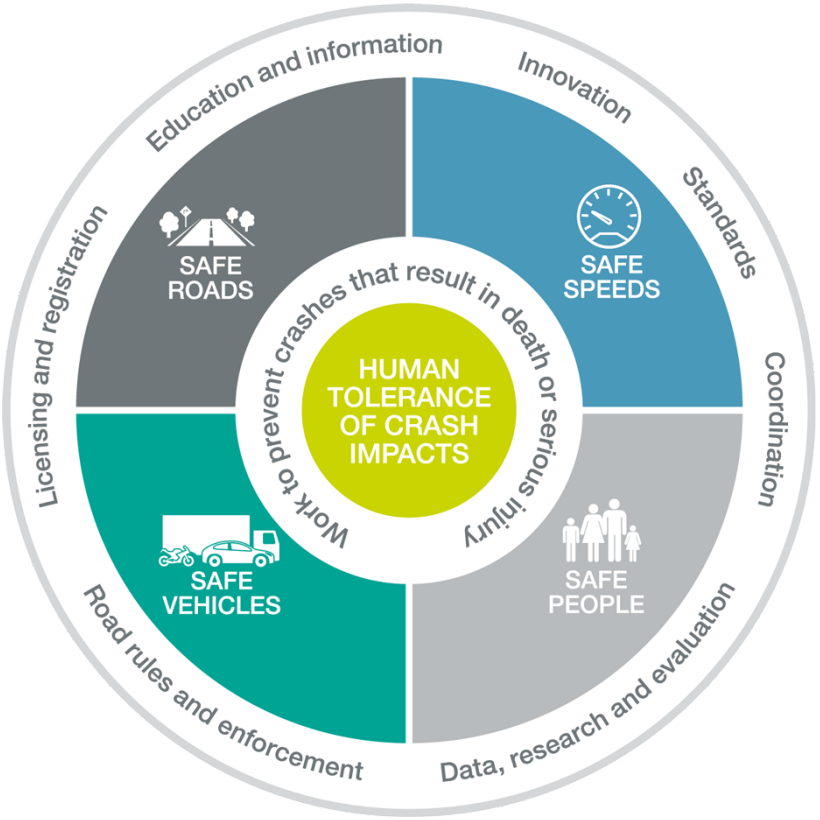

Figure 5-1: Safe system diagram, Safer Roads, Safer Queensland: Queensland's Road Safety Strategy 2015–21[40].

[40] "Safer Roads, Safer Queensland: Queensland's Road Safety Strategy 2015-21" - Website: https://www.tmr.qld.gov.au/Safety/Road-safety/Strategy-and-action-plans.aspx

5.2 - Representative Examples of Non-Compliant Street Design

"When cyclists mix with traffic at 60km/h or more, the risk of a collision causing catastrophic injury or death in London is 27% - or 1 in 4"

- Rebecca Henderson - Report at the Civic Works Committee meeting[41]

Moving toward Vision Zero requires innovative efforts that go beyond the traditional road safety approach. Recently introduced road designs from within the CMP that have not been proven to reduce the risk of crashes, fatalities, and serious injuries include, but are certainly not limited to, the following examples:

Figure 5-2: Painted and bollard bike lanes on Highbury Ave between Killarney Rd and Edgevalley Rd. installed in 2018. Posted speed limit 70km/h, 4 traffic lanes. When cyclists mix with traffic at 60km/h or more, the risk of a collision causing catastrophic injury or death in London is 27% - or 1 in 4[38]. Left plate shows broken bollards from collisions with vehicles. The bollards are completely removed in the winter when the bike lane is used for snow storage. Middle plate shows cyclists share the road with large trucks and buses at high speeds. Right plate shows planned bus stop in

[41] "The 8th Meeting of the Cycling Advisory Committee August 21, 2019 at 4:00 PM" - Website: https://pub-london.escribemeetings.com/Meeting.aspx?Id=7c329f6d-0d9d-48c6-af75-f9e041180d69&Agenda=Agenda&lang=English

bike lanes. A high-risk but important route for roughly 900 Montcalm Secondary School students and staff, and commercial district at Huron St and Fanshawe Park Rd.

Figure 5-3: Windermere Road is an important connector from Northeast London to Western University for its 30,000 students and more than 4,000 staff. Additionally, University Hospital employs more than 13,000 staff, students and volunteers. Discontinuous painted bike lanes were implemented on Windermere Road (60 km/h speed limit) between Adelaide Street and Richmond Street. Painted lanes start and end abruptly to prioritize left turning motor vehicle traffic. This is perhaps the clearest example of what is NOT Vision Zero in the city. Motor vehicle speed and throughput has been explicitly prioritized ahead of the safety of vulnerable road users. Safe systems design would separate cyclists from high speed vehicles with concrete planters, curbs, or bollards, and the cycling infrastructure would be continuous from end-to-end of the street.

5.3 - Hierarchy of Hazard Controls

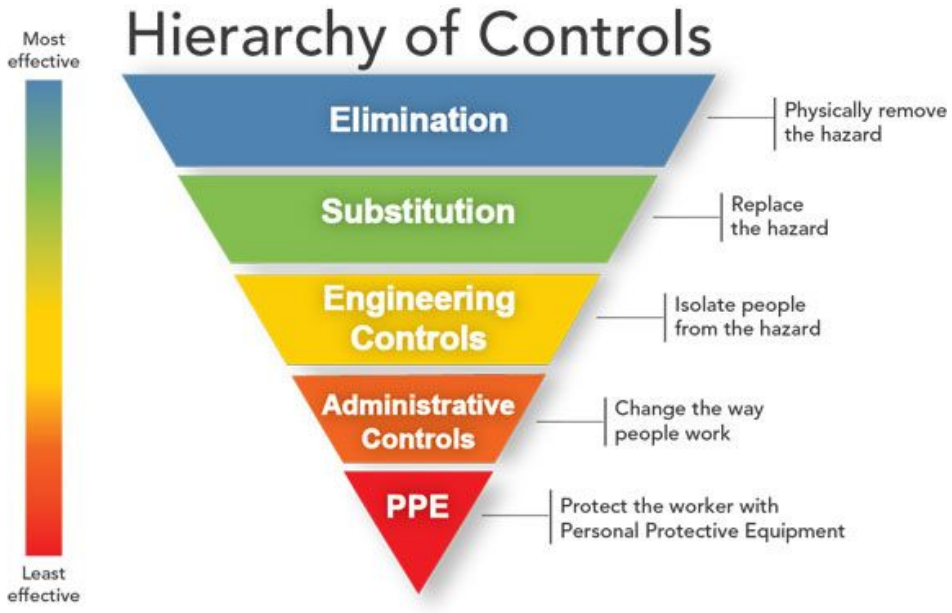

Figure 5-4: Hierarchy of Controls illustrating the effectiveness of various hazard avoidance efforts [42].

A fundamental concept in safe systems research is the Hierarchy of Controls[39]. On our streets, the hazard that causes 99% of deaths and serious injuries are high speed motor vehicles. Thus steps must be taken to control the risk the drivers of these cars impose on other users. The hierarchy of controls places in rank order of most effective to least effective methods of decreasing risk. Vision Zero focuses on the higher order controls: elimination, substitution, and engineering.

5.3.1 - Elimination (most effective control)

Elimination of hazards means the removal of dangerous automobiles from public space. Ten years ago this would have been unthinkable, yet today many cities are choosing to go car-free in their city centers and beyond. There are no deaths due to motor vehicles where they are eliminated. Expanding car-free areas is the most effective way of improving safety for cyclists (and pedestrians). Restricting cars from a 1 km radius around schools would help get more children walking and cycling to school.

[42] "Hierarchy of Controls" - Website: https://www.cdc.gov/niosh/topics/hierarchy/default.html

5.3.2 - Substitution

More use of walking, cycling and public transport substitutes for car use. By making these modes more attractive than driving a car, risk to vulnerable road users is decreased.

5.3.3 - Engineering

Engineering approaches that create safe streets include separation by concrete curbs, bollards, or planters. Bicycle bridges, underpasses, or overpasses that allow users to avoid interaction with motor vehicles are also included in this category. Most Engineering controls can be considered “infrastructure” in nature.

5.3.4 - Administrative

Painted lines and sharrows, all rules such as the 1m passing law, and signage to “share the road”.

5.3.5 - Behaviour

Advertising and education campaigns.

5.3.6 - Personal Protective Equipment (least effective control)

Helmets.

5.4 - Research on the Relationship between Safety and Infrastructure

Foundational research by Kay Tesckhe[43] published in 2012 illustrated the relationship between cyclist preference and cyclist safety on various types of street designs. Separating people riding bicycles from both automobiles and pedestrians (Engineering controls) yielded the safest results short of eliminating cars altogether. Protected Bike Lanes (cycle tracks), dedicated bike paths (separated from pedestrians), and quiet local streets neighbourhood streets were identified as both comfortable for the user, and were statistically safer options. **Protected bike lanes are not only much safer, they are strongly preferred by users, which make them ideal infrastructure for a Vision Zero approach.**

[43] “Route Infrastructure and the Risk of Injuries to Bicyclists: A Case-Crossover Study” - Website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3519333/

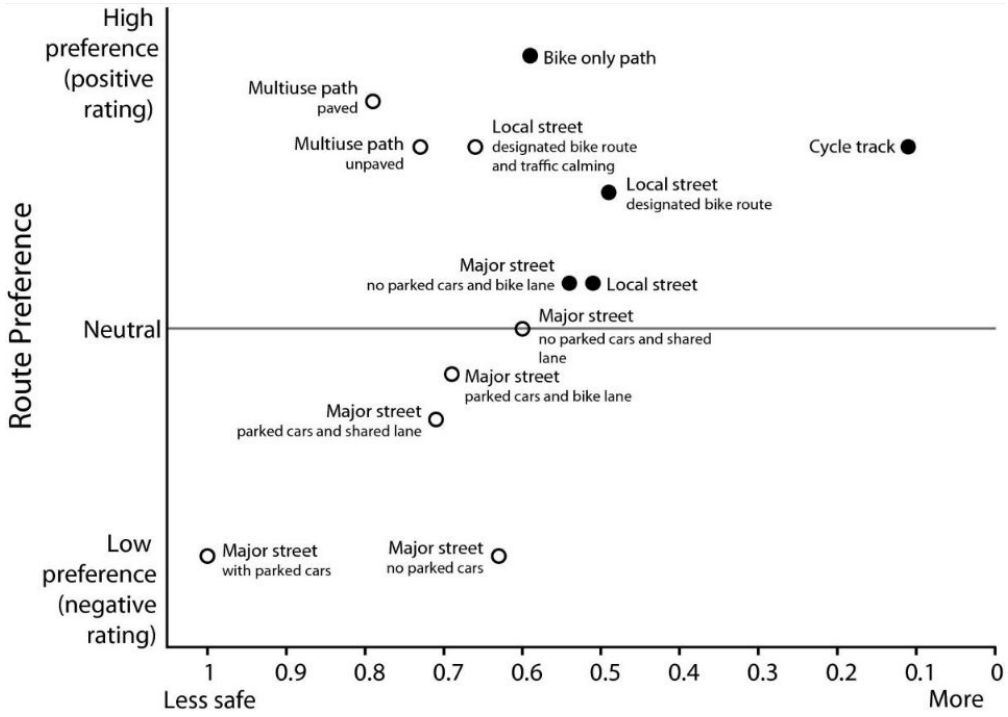

Figure 5-4: Safety vs route preference for cyclists in Vancouver and Toronto (Teschke, 2012). Closed circles represent route types with positive preference rating and adjusted injury Odds Ratio < 0.6 (safest route types). Open circles represent route types with negative or neutral preference rating or adjusted injury Odds Ratio ≥ 0.6. Odds Ratios for injury risk are plotted in reverse order. Note: cycle track = protected bike lane.[44]

5.4 - Cycling Master Plan Compliance with Vision Zero

Compliance of the CMP with Vision Zero safe design principles is effectively nil. Of the major initiatives in the CMP, the majority of planned initiatives are considered to be Administrative or Behavioural Controls. Less than 1% of planned interventions (protected bike lanes, 7.5 km out of 799 km of "facilities") could be considered Engineering controls, and 0% of the CMP could be considered Substitution or Elimination. Substitution could be achieved by making cycling more appealing to Interested But Concerned group, whereas Elimination would require elimination of motor vehicles from congested areas of the City such as the City of Oslo, Norway has done with their Downtown.

[44] "Route Infrastructure and the Risk of Injuries to Bicyclists: A Case-Crossover Study" - Website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3519333/

The assessment metrics found in the 2016 CMP do not set targets to eliminate (or even to decrease) collisions, deaths, and serious injuries to cyclists. Without measurements, targets or goals, how does the City anticipate reaching Vision Zero objectives?

Prioritizing convenience of motorists ahead of the safety of vulnerable road users including cyclists is not a trade-off that the City of London can choose under a Vision Zero framework. Implementation of the current Cycling Master Plan will not make substantial progress toward Vision Zero goals of eliminating deaths and serious injuries on our roads.

6.0 - Transportation Cycling Infrastructure Assessment

Achieving the required Greenhouse Gas reductions, and achieving Vision Zero through improved design of our transportation system does not require the impossible. Other cities of similar size have *already* achieved greater than the required GHG reduction without sacrificing quality of life, or economic prosperity. However, changing mode split requires more, faster, and higher-quality infrastructure development than is currently planned in London today. In the following section we discuss the scale, quality, and design characteristics of required infrastructure to attain the required **cycling** mode share.

6.1 - A Nod to Great Transit

"Public Transit is most effective for moderate- and long-distance trips on busy corridors, while cycling is effective for shorter-distance trips with multiple stops. Combining transit and cycling can provide a high level of mobility comparable to automobile travel."

- Victoria Transport Policy Institute.

While fundamentally an essential support to the cycling network, improvements in transit required to reach 35% mode share is beyond the scope of this committee. It is essential to consider both transit AND cycling, however, as both offer distinct benefits stated above.

6.2 - Better Land Use Serves Transit and Cycling

"The best transportation plan is a great land-use plan."

- Brent Toderian, and others.

Also outside the scope of this committee is a review of land use through a climate lens. It is essential to reconsider:

1) parking requirements (eliminate)
2) sprawl (virtually all growth must occur in existing developed areas)
3) easing zoning restrictions on infill density, among other factors.

All of these changes create a better environment for the requisite change in modal split. The London Plan must be inspected through the lens of Climate Emergency to assess whether it goes far enough to achieve essential climate targets.

6.3 - Cycling Infrastructure for a High Cycling Mode Share City

Using the modeled carbon emissions presented earlier, we selected a likely mode-split solution that reaches the GHG goals, and reaps large carbon dividends for Londoners.

Climate-Informed Transportation Mode Targets by 2030:

- 100% Electrification of London Transit Vehicles
- 25% Electrification of Private Cars and City Vehicles
- Modal Split:
    - 25% Automobile
    - 35% Transit
    - 35% Active Transportation (walking 10%, cycling 25%)
    - 5% Other

It is instructive to examine other cities that have achieved these mode split targets. Bremen, Germany, is not usually heralded as a "great cycling city" yet it maintains very high transit and active transportation mode share, with a population slightly greater than London's, and a comparable land area. Bremen's winters are not nearly as snowy as London's, but the wind and rain from the North Sea are fierce and nearly as inhospitable to cycling as a Great Lakes squall. Why does Bremen have such outstanding mode splits? It has an extensive network of protected bike lanes, and reliable, effective transit that meets targets for frequency and convenience. Copenhagen has approximately half as many snowy days as London, and a **winter mode share for cycling above 40%** because they efficiently and predictably clear snow from their ubiquitous protected bike lanes. **What every single one of the cities with high bike mode split has in common is a network of protected bike lanes throughout the city.**

It is essential to recognize that zero North American cities have achieved European levels of cycling because of an historical lack of cycling infrastructure investment. However, cities like Vancouver are approaching their European counterparts due to key cycling infrastructure investments such as the Burrard Bridge bike lane, and its All-Ages-and-Abilities protected bike lane network. Virtually all of Calgary's inner city neighbourhoods boast >5% bike mode share[45] following their implementation of their downtown protected bike lane network in 2014, with bike mode share growing every year. Montreal has been North America's premiere bike city since the 1980s when they eschewed Vehicular Cycling and built a network of protected bike lanes instead. Infrastructure investment dictates mode share, everywhere. How infrastructure is built in the next five years will dictate mode share in London too.

Examining data from other cities in Table 6-1, it is clear that:

1) attaining high modal splits for cycling and transit is possible in winter cities,
2) attaining high modal split in relatively lower density cities is also possible (Bremen, Munster), and
3) High transit usage and high cycling mode share are not necessarily coincident (e.g. Boston/Munster) - both require different infrastructure investments that are complementary when done well.

[45] "Mode Split to Work - Bicycle - Calgary" - PDF: https://www.calgary.ca/_layouts/cocis/DirectDownload.aspx?target=http%3a%2f%2fwww.calgary.ca%2fTransportation%2fTP%2fDocuments%2fdata%2fmode-split%2fmodesplit-bike-2016.pdf

Table 6-1: Mode Share Trip Distribution of Major Winter Cities (estimates from 2009 - 2019). Note that walking is not included in these metrics, and would contribute to required Active Transportation mode share targets. Data compiled from various sources including cityclock.org, and wikipedia[46]

City	Population	Area (km^2)	Bike Share (%)	Transit Share (%)
London, CAN	***355,000***	***232 sub/urban 402 incl. south rural***	***~1%***	***11%***
Montreal, CAN	1,780,000	431	3%	19%
Toronto, CAN	2,930,000	630	1%	24%
Vancouver, CAN	675,000	115	12%	17%
Greater Victoria, CAN	85,000	20	7%	11%
Boston, USA	685,000	232	2%	36%
Copenhagen, DEN	602,000	88	62%	27%
Utrecht, NL	1,285,000	99	33%	28%
Uppsala, SWE	168,000	49	28%	20%
Munster, GER	**310,000**	**302**	**39%**	**11%**
Freiburg, GER	227,000	153	13%	12%
Bremen, GER	**557,000**	**326**	**25%**	**24%**

[46] "Modal Share" - Website: https://en.wikipedia.org/wiki/Modal_share

6.4 - It's Not About Culture, It's About Infrastructure.

When people from The Netherlands visit London, they usually don't choose to cycle, whereas they cycle daily at home. Why not?

To a Dutch person, cycling on London's streets looks just as dangerous as it appears to the average Londoner. Sharing the road with high speed cars and trucks is a non-starter for the Dutch, and it must be the same if we expect large numbers of people to choose cycling for transportation every day. **We must change our approach to public street infrastructure if we are to achieve mode split on a scale required to decrease our carbon emissions.**

The Portland Bike Survey[47] (first published in 2005) was the first to characterize the "type" of person willing to cycle on a given street, given its design principles. Surveying people in the fifty largest metros in the United States, Roger Geller found that people choose to cycle based on the **quality** of infrastructure on the street. Some people will cycle without infrastructure, most people need a connected network that is completely separated from cars in order to choose their bike regularly.

From Alta Planning in Portland, Oregon[48]:

> *Originally developed by Roger Geller at the City of Portland, OR, the "Four Types of Bicyclists" are meant to guide efforts in assessing — in broad terms — what certain segments of a population require or want in a bikeway facility. Geller suggested that Portland's population could be categorized into the following four groups:*

[47] "Portal Bike Survey - Four Types of Cyclists" - PDF: https://www.portlandoregon.gov/transportation/article/264746
[48] "Understanding the "Four Types of Cyclists" - Website: https://blog.altaplanning.com/understanding-the-four-types-of-cyclists-112e1d2e9a1b

1) Strong and Fearless: People willing to bicycle with limited or no bicycle-specific infrastructure

2) Enthused and Confident: People willing to bicycle if some bicycle-specific infrastructure is in place

3) Interested but Concerned: People willing to bicycle if high-quality bicycle infrastructure is in place

4) No Way, No How: People unwilling to bicycle even if high-quality bicycle infrastructure is in place

Figure 6-1: Portland Bike Survey: Four Types of Cyclists as hypothesized by the creator of the survey, and as surveyed in Portland, OR and the average of Fifty (50) American Cities. It is unlikely that the population of London, ON deviates from the Survey of Largest Metros by more than 10% in any single category. [49]

[49] "Understanding the "Four Types of Cyclists" - Website: https://blog.altaplanning.com/understanding-the-four-types-of-cyclists-112e1d2e9a1b

One of the greatest challenges with the current Cycling Master Plan is the assumption on which it is founded. The City of London TMP did not adopt Geller's approach to assess cycling potential, and as a result, has grossly mischaracterized its population's willingness to cycle. The Conclusion from the Transportation Master Plan 1-15 (sample size 353 people)[50]:

"The market for commuter based cycling infrastructure is approximately 9% of the overall population."

- City of London Transportation Master Plan.

The above statement contains large and erroneous assumptions regarding the type of infrastructure presented to citizens who claim they are willing to cycle. The 9% value reported is suspiciously similar to the "*Strong and Fearless"* and "*Enthused and Confident"* groups above, suggesting London has not offered "*Interested but Concerned"* types any confidence that they could choose cycling for transportation. Because it has been demonstrated time and again, in city after city, that given safe, connected infrastructure, up to 70% of people will choose to cycle at least some of the time for transportation, **it is with virtually certainty that we conclude that London's potential cycling market-share is not a measly 9%, but given proper infrastructure, greater than 60% of the total population would choose cycling for many trips. The climate emergency mitigation implications that stem from this error are enormous.**

6.5 - Infrastructure Requirement for All Ages and Abilities (AAA)

To achieve high mode share of cycling (>10% mode share, engaging Interested But Concerned riders), high-quality, connected, maintained infrastructure must be in place **throughout the city**. There are only three major factors that create comfortable conditions for everyday cycling:

[50] "Smart Moves 2030 Transportation Plan" - Website: https://www.london.ca/residents/Roads-Transportation/Transportation-Planning/Pages/Smart-Moves-2030-Transportation-Plan.aspx

1) Slow vehicle speeds to 30 km/h or less in residential areas. Use filtered permeability to prevent through traffic in neighbourhoods, which has the positive side-effect of decreasing neighbourhood traffic volumes.
2) Build protected bike lanes and protected intersections[51] (protected intersections are not mentioned once in the 2016 CMP) on high-speed (greater than 30 km/h design speed) and high-traffic (generally busy) roads. Provide high-priority winter maintenance on these routes.
3) Provide secure bike parking facilities throughout the city to protect personal property.

The City of Vancouver is the Canadian leader in retrofitting a North American city for citizen cycling. To achieve their goal of having two thirds of all trips by walking, cycling, and transit, Vanvcouver created comprehensive rules for designing suitable AAA infrastructure[52]. We recommend that the City of London copy Vancouver's approach verbatim. What is evident from Vancouver's guidelines is that **only 4% of London's planned bike routes over the next four years meet AAA quality standards**. Stated differently, London's approach builds 96% of its cycling infrastructure to serve existing cyclists (Strong and Fearless, Enthused and Confident) marginally better, rather than planning streets for a wider rider-ship demographic, which represents more than 90% of the population. This approach is exclusionary, as only a small group of cyclists with high risk tolerance will share street space with high speed cars separated by a strip of paint. While some of these ideas about user types and protected infrastructure are discussed in technical appendices of the CMP, the planned build-out of the plan does not reflect the needs of the vast majority of users.

In the next four years, 96% of new bike lane kilometers built in the City of London are systematically designed to exclude 90% of our population.

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[51] "Protected Intersections for Bicyclists" - Website: http://www.protectedintersection.com

[52] "Transportation Design Guidelines: All Ages and Abilities Cycling Routes" - PDF: https://vancouver.ca/files/cov/design-guidelines-for-all-ages-and-abilities-cycling-routes.pdf

Re-allocating City resources to projects that are designed to serve All Ages and Abilities would have a far greater outcome in terms of ridership, equity, and cost-benefit to the City. By building exclusively All-Ages-and-Abilities facilities, we maintain our commitment to equity in transportation, decrease our carbon footprint, and help meet our Vision Zero objectives.

Figure 6-2: City of Vancouver guidelines for All Ages and Abilities Cycling Network Design. Off-street pathways must be brightly lit, and maintained through four seasons to be considered effective.[53]

6.6 - Secure Bike Parking: An Under-Appreciated Barrier to Cycling

Facilities that provide protection of personal bikes from theft and exposure to the elements is an essential part of a AAA cycling network. The City has considerable land holdings that could provide secure public storage facilities at minimal cost. The detailed design of such facilities are context specific, and well beyond the scope of this report.

[53] "Transportation Design Guidelines: All Ages and Abilities Cycling Routes" - PDF: https://vancouver.ca/files/cov/design-guidelines-for-all-ages-and-abilities-cycling-routes.pdf

Recommendations:

- Provide secure, covered bike parking at major City of London properties (parks, arenas, libraries, City Hall, parking lots)
- Develop guidelines for secure bike parking for new buildings and incorporate through zoning.
- Provide incentives for secure bike parking on existing private property to accelerate adoption (e.g. Town of Canmore will pay for ~80% of cost of new publicly accessible bike parking on private land that meets Town guidelines).

6.7 - Comparison of CMP to Requirements for High Bike Modal Share

The CMP calls for 7.5 km of protected bike lanes by 2030, or <1% of the arterial road network. Simply put, there is zero probability that 1% street conversion to All-Ages-and-Abilities facilities would achieve the 5% modal share required by TMP, let alone 25% that is required by the Climate-Informed Transportation Mode Split Targets. By comparison, Vancouver has constructed more than 125 km of All-Ages-and-Abilities facilities[54], which has achieved a doubling of their bike mode share from 6% in 2013 to 12% in 2019. To attain significant bike modal share, there must be safe, comfortable access to every area of the city, with quality connections to important destinations (schools, commerce, workplaces) for citizens.

Continuing with the TMP-based 5% modal share goal, the City may be able to optimize the built environment for “Fearless” and “Enthused and Confident” groups. However, it will never be able to grow mode share beyond 5-10% by primarily deploying painted bike lanes on high speed roads. For example, brand new bike lanes on Commissioners Rd, Oxford St W, and Southdale Rd, all “share the road” with a 60 km/h speed limit, and design speeds of 70 km/h, separated by nothing more than a stripe of paint. Each of these lanes are a complete waste of money with ridership approaching nil, as only people who are *already* riding confidently would use these facilities, and most people who are already riding would choose to avoid these high speed roads whenever possible.The demographics of those using the currently planned infrastructure will be similar to today: white, male, adults will be vastly overrepresented, whereas women, children, seniors, and non-white cyclists will be underrepresented compared to the overall population.

[54] “Vancouver Builds a Better Bike Lane” - Website: https://usa.streetsblog.org/2019/06/10/vancouver-builds-a-better-bike-lane/

We must recognize that in a climate emergency, we must do what is necessary, not what is politically convenient or popular. We need to provide zero carbon options for transportation and we need to provide them as soon as humanly possible. Most people don't consider cycling as an option for their family because they have never seen, let alone used, quality AAA bike infrastructure. Once people see it, and try it, and they (finally) feel comfortable on our streets, they will choose a bike for many trips. Until that point, citizens will never ask for it, because they don't know that it is even possible. **Building a City-Wide Network of All Ages and Abilities bike facilities is a necessary part of achieving our GHG reduction targets. We cannot achieve our GHG targets without this investment, and stand to greatly benefit as a city by building the network as soon as possible.**

6.8 - Funding for Bicycle Infrastructure

A conservatively high cost estimate for building quality protected bike lanes is $1M / km (both sides of a street, costs consistent among
municipalities across Canada). This cost of bike infrastructure is miniscule compared to transportation projects designed exclusively for cars (compare with Wonderland Road widening "early estimate" of $55M for 8 km = $7M/km if on-budget). To complete a minimum grid across the City, London needs approximately 150 km of protected bike lanes (<5% of total lane km conversion) on primary/secondary streets. Simple math shows the capital cost of this network to be no greater than $150M in total.

London currently has a budget of **$75M per year** allocated to miscellaneous road widening projects from 2020-2025. Because there is no Climate-Informed Transportation Mode Split solution that results in an increased number of driving trips, there is no justification to continue spending money widening roads for automobile trips that can *never increase*. Widening roads has been clearly demonstrated to increase vehicle trips, total kilometers driven, congestion, and greenhouse gas emissions by the Fundamental Law of Road Congestion[55]. Put simply, we should take Vancouver's lead, and never widen another road ever again (they haven't built a

[55] "Fundamental law of road congestion: Evidence from U.S. cities" - Website: https://journalistsresource.org/studies/environment/transportation/fundamental-law-road-congestion-evidence-u-s-cities/

new road, or widened an existing road since the 1970s). Re-allocating half of the road widening budget would fund the entire city-wide cycling network's capital cost by 2025, and leave the other half of the money to improve transit, insulate buildings, or do *literally anything else that would not exacerbate the climate emergency.*

"Building great cities isn't always about what you do, it's what you stop doing."

- Paraphrasing Brent Toderian, from Place Matters Conference in London, Ontario September 2019

The Netherlands has developed its extensive system of bikeways by investing $50/year/person in cycling infrastructure. This dollar value is of the same magnitude as the value of the carbon dividend discussed in Section 4. However the return on investment of this spending far exceeds the cost. Recent estimates show that The Netherlands investment in cycling has generated annual health benefits on the order of 3% of GDP[56] (for London, 3% of GDP is $630 million dollars per year). The enormous return on investment should be sufficient to convince any fiscally responsible government to invest in transportation cycling in their city or town. Building AAA cycling infrastructure is an investment in the city's long term budget, population health[57], childrens independence and social development[58], transportation equity / mobility for all ages and abilities[59], personal wealth[60], street safety[61], and preventing climate disruption[62]. **There may**

[56] "Dutch Cycling: Quantifying the Health and Related Economic Benefits" - Website: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4504332/

[57] "What is the full cost of your commute?" - Website: http://spacing.ca/vancouver/2015/04/06/full-cost-commute/

[58] "What Makes Dutch Kids the Happiest in the World? Cities That Allow Them to Roam" - Website: http://www.modacitylife.com/blog/dutch-kids-happiest-in-the-world

[59] "Cycling and Mobility: The Great Equalizer" - Website: http://www.modacitylife.com/blog/2014/8/20/cycling-and-mobility-the-great-equalizer

[60] "Get Rich With… Bikes" - Website: https://www.mrmoneymustache.com/2011/04/18/get-rich-with-bikes/

[61] "Protected Bike Lanes Are Safer for Drivers, Too" - Website: https://www.citylab.com/transportation/2019/06/protected-bike-lanes-safe-street-design-bicycle-road-safety/590722/

[62] "For cities, bike networks are a free-wheeling climate solution" - Website: https://www.climatesolutions.org/article/1557871842-cities-bike-networks-are-free-wheeling-climate-solution

be no other single investment that both combats the climate catastrophe while simultaneously provides enormous financial, health, and social benefits to our citizens.

7.0 - Inter-City Comparison

London's Cycling Master Plan[63] (CMP) was compared with the plans from similar cities around Canada: Halifax (2014)[64], Waterloo Region (2014)[65], Ottawa (2013)[66], Waterloo (2011)[67], Victoria Capital Regional District (2011)[68], and Kitchener (2010)[69]. London's 2016 CMP is missing crucial elements that the others contain, which is impacting the effectiveness of London's approach and the organization of its actions. These missing elements affect the alignment of London's actions with its vision and goals for its cycling plan and largely stem from a lack of clarity and vision regarding the Evaluation of London's cycling policies and actions.

7.1 - Addressing "Interested but Concerned" Cyclists

Each of the other cities recognize that focus and the key constituent of cycling infrastructure projects are the 60% of the population who are "interested but concerned." The concerns of this 60% of the community regard their personal safety while riding among traffic on urban streets. "What people fundamentally want when they talk about active transportation safety is to feel that they are not taking undue risks by choosing to walk or bike,"[34] Every other city identifies the

[63] "London On Bikes" - PDF: https://www.london.ca/residents/Environment/EAs/Documents/London%20ON%20Bikes%20-%20Full%20Report%20-%20Final%20September%202016.pdf

[64] "Making Connections: 2014-19 Halifax Active Transportation Priorities Plan" - PDF: https://www.halifax.ca/sites/default/files/documents/transportation/transportation-projects/AT_Plan_Final_July222014_000.pdf

[65] "Walk Cycle Waterloo Region February 2014" - PDF: https://www.regionofwaterloo.ca/en/regional-government/resources/Reports-Plans--Data/Moving-Forward/Active-Transportation-Master-Plan.pdf

[66] "Ottawa Cycling Plan" - PDF: https://documents.ottawa.ca/sites/documents/files/documents/ocp2013_report_en.pdf

[67] "The City of Waterloo Transportation Master Plan" - PDF: https://www.waterloo.ca/en/government/resources/Documents/Cityadministration/TransportationMasterPlan/Transportation-Master-Plan---PDF-Version.pdf

[68] "Capital Regional District Regional Pedestrian & Cycling Masterplan" - PDF: https://www.crd.bc.ca/docs/default-source/regional-planning-pdf/pedestrian-amp-cycling-master-plan.pdf?sfvrsn=2028fc9_0

[69] "City of Kitchener - Cycling Master Plan for the 21st Century" - PDF: https://www.kitchener.ca/en/resourcesGeneral/Documents/DSD_TRANSPORT_CyclingMasterPlan.pdf

need to address and substantially assuage the concerns of that large group as the key to significantly improving the cycling mode share and making cycling a mainstream and widespread transportation option. According to data presented in these other CMPs, approximately 50% of the daily trips are within an easy cycling distance of 5 km, which means that assuaging the concerns of the "interested but concerned" demographic could result in an increase of cycling mode share by 30% or more.

7.2 - Identifying Goals and Expected Outcomes

Each of the other cities have clear statements regarding multiple goals and expected outcomes for their cycling policies and actions. In all cases, a user-based metric (rather than a geographic-based metric) is the primary goal or outcome. **Every city other than London identifies significantly increasing the cycling mode share and reducing cycling collisions as a metric for evaluating the cycling policies and actions.** Most are aiming to double or triple their cycling mode share with some heading toward a cycling mode share >12%, especially in city cores and key destination areas such as around universities, colleges, and neighborhood destinations. Furthermore, some cities include as additional outcomes increasing the budget share dedicated to cycling projects and reducing GHG emissions. Each of these goals provides different means for measuring and determining the success of the policies and actions. London's CMP is the only one to focus exclusively on increasing the kilometers of cycling routes and pathways as the principal outcome of their policies and actions.

7.3 - Criteria for Evaluating the Success of Projects

With increasing cycling mode share percentages as a goal and expected outcome, the better CMP's consider methods for evaluating the success and gauging the potential for routes and infrastructure project to increase mode share by assuaging the fears of the "interested but concerned" 60% of potential riders. Notable here is Ottawa's Level of Travel Stress methodology (Appendix A)[70]. Ottawa has developed a criteria based on automobile traffic volume, flow, and speed, space for bikes, and frequency of cycle lane blockage to rank the stress cyclists feel while riding along routes and through intersections (1 least stressful, >4 most stressful). It utilizes the "weakest link principle" in establishing a ranking, meaning that the

[70] "Ottawa Cycling Plan" - PDF: https://documents.ottawa.ca/sites/documents/files/documents/ocp2013_report_en.pdf

ranking is determined by the most stressful feature or segment within the whole route. It can be used to guide the type of cycling infrastructure required for a given project as well as for evaluating the success of the project in mitigating the fears of the “interested but concerned” 60%.

7.4 - Data and Demographics Collection

Each of these elements connect and determine the type of data the cities require in order to properly evaluate their cycling policies and actions. Passive counts of bikes crossing a single location and single day usage counts are small parts of the data city planners and evaluators need. Unlike London’s CMP, the other cities’ CMPs address the need for and the means for collecting the data that their planning and evaluative processes require in order to facilitate data-driven decision-making.

7.5 - Conclusion

London's CMP states its vision of "providing infrastructure which is considered comfortable, safe, and convenient...for all Londoners,". **Kilometers of routes and pathways by themselves do not provide that. Only routes and pathways that service the needs of their users in the right way align with, and further, that vision.** By neglecting to develop measures and means for evaluating how their efforts to grow and improve their cycling network, London's CMP has, in comparison to other cities', fallen short.

Table 7-1: Comparison of London's CMP to other municipalities

	Cycling Mode Share Target	**Cycling Collisions Rate**
London 2016	not specified	138 (annual average)
Halifax 2014	double by 2026	32 including scooters & skateboards (Jan-Jul 2019)
Waterloo Region 2014	3% by 2031	98 (2017)
Ottawa 2013	12% inner area by 2031 8% within greenbelt by 2031	263 (2018) 225 injuries (2018) 1 fatality (2018)
Victoria 2011	25% in densely populated areas by 2038 15% across the region	63 (2016)

8.0 - Recommendations

Based on our assessment of new policies London ON Bikes **does not** meet City of London policy goals of:

1. Declaration of Climate Emergency
2. Vision Zero

Additionally, the Cycling Master Plan falls short in many areas compared to other cities in terms of its infrastructure design, and evaluation metrics. We therefore make the following recommendations:

1. We recommend that council request that staff conduct a detailed assessment of climate emergency implications of the Transportation Master Plan, and The London Plan. Transportation and Land Use are the two largest contributing factors to climate emergency within the city, and examining these through the lens of Climate Emergency may reveal essential changes in outcome. We believe this report is the first assessment of ANY City of London policy through this lens, and given our findings, believe it prudent to examine all relevant documents from a climate perspective.
2. We recommend that council direct staff to overhaul the existing London ON Bikes plan, with major revisions to meet climate informed modal splits by 2030. The new plan should aim for transportation equity by only using modern Vision-Zero compliant design approaches and by building exclusively All Ages and Abilities infrastructure.
3. We recommend funding the creation of an Active Transportation Strategy at a funding rate of $50/person/year, or ~$20M annually. This is consistent with funding in high mode-share cities throughout the world.
4. We recommend that council direct construction of a temporary city-wide bike grid to be constructed by July 1, 2021. This emergency network should rapidly deploy inexpensive materials, while retaining All Ages and Abilities design principles. Full implementation of permanent AAA infrastructure should be completed during regular life cycle renewal of these streets to minimize ongoing costs.
5. We request that staff initiate consultation with Vision Zero Canada for a frank assessment of our Vision Zero progress. We request Vision Zero Canada’s continued

involvement in our trajectory toward zero deaths or serious injuries on our road system for cyclists, pedestrians, and motorists alike.

6. We recommend a moratorium on all planned and future road widening, unless required for transit and/or cycling infrastructure improvements, due to there being no climate informed transportation mode split scenario that permits for anything less than 50% decrease in total driving. Funding currently allocated to road widening ($75M per year) should be used to fund transit and cycling infrastructure for maximum climate emergency mitigation effect.
7. We recommend that the City of London decrease all residential speed limits to 30 km/h commensurate with safe practices as defined by NACTO. This will immediately facilitate safe cycling in all neighbourhoods, including school routes, city-wide. While we acknowledge that design, not speed limit, is the essential factor in decreasing speeds on roads, neighbourhood streets should be re-designed for 30 km/h design speeds during life cycle renewal.

"We have presented governments with pretty hard choices. We have pointed out the enormous benefits of keeping to 1.5C, and also the unprecedented shift in energy systems and transport that would be needed to achieve that. We show it can be done within laws of physics and chemistry. Then the final tick box is political will. We cannot answer that. Only our audience can – and that is the governments that receive it."

- Jim Skea, Professor of Sustainable Energy at Imperial College London, co-chair of the United Nations Intergovernmental Panel on Climate Change working group on mitigation.
