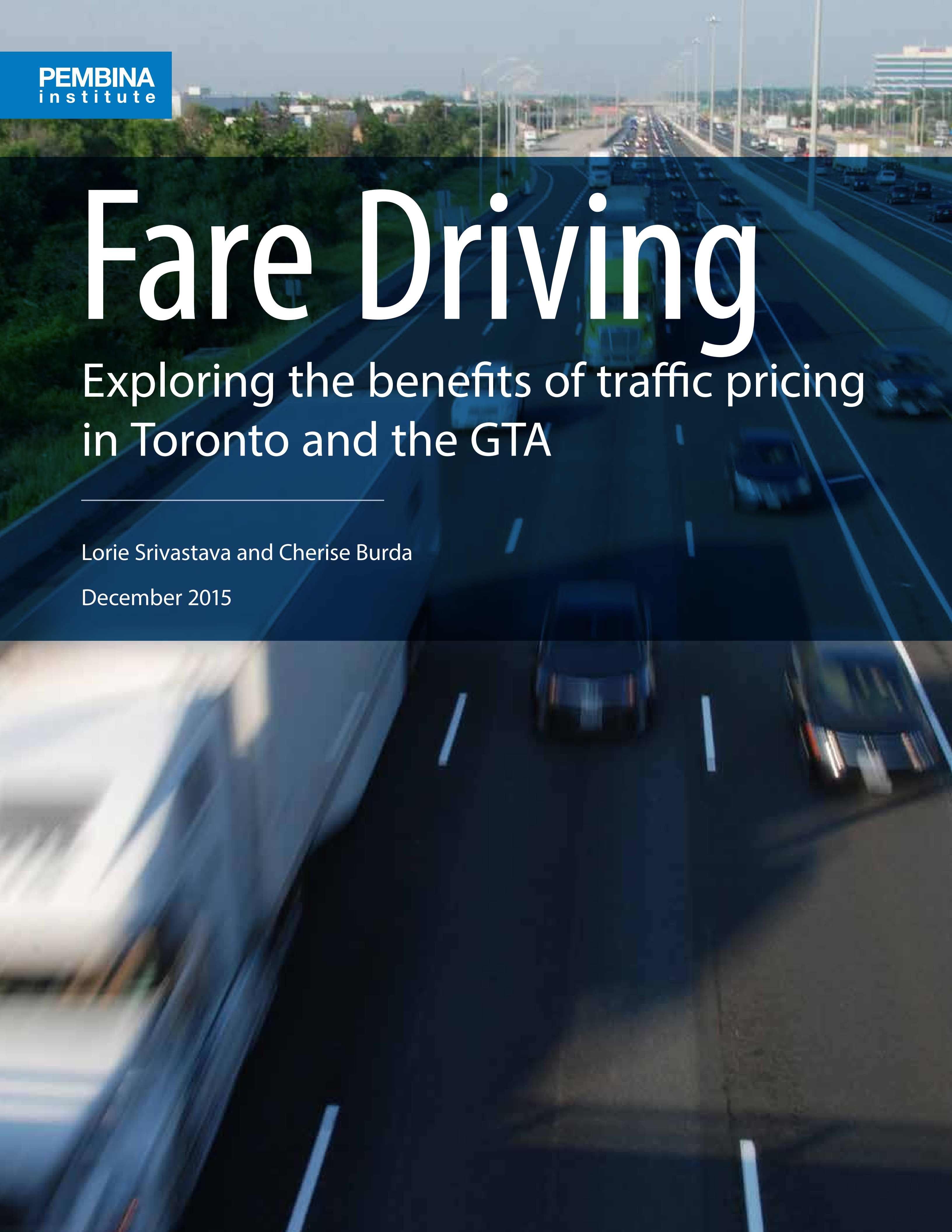


Fare Driving

Exploring the benefits of traffic pricing in Toronto and the GTA

Lorie Srivastava and Cherise Burda

December 2015

By Lorie Srivastava and Cherise Burda
Economic analysis by Lorie Srivastava
Maps and research support by Nithya Vijayakumar

Cover photo: Roberta Franchuk, Pembina Institute

December 2015

This report was prepared by the Pembina Institute for the Pembina Foundation for Environmental Research and Education.

PEMBINA
institute

The Pembina Institute is working to solve today's greatest energy challenges — reducing the harmful impacts of fossil fuels while supporting the transition to an energy system that is clean, safe and sustains a high quality of life. We provide our expertise to industry and government leaders, and we advocate for a strong, science-based approach to policy, regulation, environmental protection and energy development. For more information about the Pembina Institute, visit www.pembina.org.

The Pembina Institute
102, 61 Elm Grove Ave.
Toronto, ON
M6K 2J2 Canada
647-478-9563

PEMBINA
FOUNDATION

The Pembina Foundation is a federally-registered charitable organization. We seek to increase understanding of the way society produces and consumes energy, the impact of these choices on the environment and on communities, and options for the more sustainable use of natural energy resources.

Preamble

The intent of this study is to explore the potential for a congestion charge (or "road pricing") in Toronto and the Greater Toronto Area (GTA). We explore pricing as one tool to address traffic congestion and complement building more rapid transit infrastructure

Like any study, we conducted our analysis using a number of assumptions to determine price point and geographic application. Due to limitations in scope we looked only at kilometre-based pricing. We recognize the need for further studies to test different assumptions and price points, as well as other road pricing applications including high occupancy toll (HOT) lanes that were advanced in the province's 2013-2015 budgets.[1] We hope this study will contribute to the discussion around road pricing policy and the potential for a pilot implementation.

We particularly acknowledge the need for rapid transit alternatives in order to fairly implement road pricing. Part of the reason other countries have found success in their road pricing programs is that drivers also have the option to take frequent and reliable transit. Our study incorporates this consideration into its analysis, including timing and geography of implementation.

Finally, this study does not discuss some important issues and policy measures around road pricing such as implementation costs or technological considerations, revenue recycling options beyond investing in transportation service and infrastructure, or governance and equity issues such as measures to minimize impact on lower-income families. These are important considerations that could not be addressed thoroughly within the limitations of this report, but many of these are examined in other studies, including the recent Ecofiscal Commission report *We Can't Get There from Here: Why Pricing Congestion is Critical to Beating It.*[2]

We quantify a number of benefits resulting from road pricing implementation, including reduction of greenhouse gas emissions, revenue generation, cost savings to drivers and increased health and safety. Moreover, we explore how in other cities, revenues collected from road pricing have been invested successfully in transit and road infrastructure and improved transit service, which is also worth consideration here in the GTA.

This report was peer reviewed by three Canadian economists we wish to thank for their personal time and critical feedback: Mario Iacobacci, Adrian Lightstone and Dale Beugin.

---

[1] Government of Ontario, *Building Ontario Up: Ontario Budget 2015.* http://www.fin.gov.on.ca/en/budget/ontariobudgets/2015/papers_all.pdf

[2] Ecofiscal Commission, *We Can't Get There from Here: Why Pricing Congestion is Critical to Beating It.* http://ecofiscal.ca/reports/traffic/

Table of Contents

Fare Driving – Executive Summary

Putting a price on traffic

Traffic congestion in the Greater Toronto Area (GTA) has long been identified as a top problem for the city and the region. It's considered to be a drain on the economy, a time stress on commuters and a challenge for policy makers.

Investing in transit infrastructure is part of the solution but it will take years to build out our regional transit plan, and even then, fully built transit infrastructure may not be enough to encourage sufficient mode shift. Greater efforts are needed to shift more commuters out of their personal vehicles and onto public transit. One effective option is to put a price on driving to reduce traffic.

The primary goal of *Fare Driving* is to test how road pricing could help reduce traffic on specific highways in Toronto and on provincial highways in the GTA. A secondary goal is to consider additional co-benefits from road pricing, in particular revenue generation to help fund transportation infrastructure in the GTA, and reductions in greenhouse gas (GHG) emissions to help Ontario meet its climate change targets.

Transit options for drivers

Road pricing programs in other countries have been successful in part because drivers have the option to take frequent and reliable transit. Our study incorporates this consideration into its analysis, including timing and geography of implementation.

The study then explores the potential for road pricing throughout the GTA on the Gardiner Expressway, the Don Valley Parkway (DVP) and segments of the 400-series highways coinciding with the implementation of the Big Move's rapid transit projects: SmartTrack, Regional Express Rail (RER) and other planned transit lines, which will provide alternatives to driving.

Pricing Toronto's highways

The primary focus of the study is road pricing for Toronto alone — just the DVP and Gardiner Expressway. This is done for two reasons: to imagine road pricing as a municipally administered policy, where revenue is collected and spent locally; and because these highways represent a near-term opportunity for tolling where there are some current viable rapid transit alternatives, such as all-day two-way GO train service on the Lakeshore line.

A higher price is then administered in 2025 to coincide with the completion of SmartTrack and RER. Additional municipal transit projects being planned include a relief line subway and a Waterfront LRT, which will provide further alternatives to those municipal highways.

The City of Toronto would be able to control the collected toll revenue and adjust the pricing schedule and geography to include non-Toronto residents who use these facilities, letting them contribute to the costs of maintaining and operating these highways that fall within the City's jurisdiction.

Key findings – Toronto highways

Fare Driving sets a modest price of 14 cents per kilometre peak (10 cents off peak) for the DVP and Gardiner Expressway. By comparison, the ETR 407 rate is currently 35 cents per kilometre for peak periods.

- With this modest price applied, peak period traffic is reduced on the DVP and Gardiner by 13% to 16% per day, respectively.
- Savings in travel time per driver during peak times are monetized to over seven dollars per day.

In 2025 the rate for the DVP and Gardiner is increased to 21 cents per kilometre at peak (17 cents per kilometre off peak) in recognition of the greater number of viable transit options.

- This price amounts to a maximum daily peak toll paid for drivers of $4.26 for DVP drivers and $5.11 for Gardiner drivers (assuming driving the entire length of the highway for a two-way trip).
- The total daily savings for these drivers in time, gas and maintenance amount to between $8.87 and $11.58 for peak travel.
- These findings are consistent with the results of road pricing programs in other jurisdictions, where the time and cost savings to drivers are greater than the price of the charge.
- Total revenue to the city would amount to over $1.6 million per day, or almost $513 million per year, in 2015 dollars.

Key findings – 400-series highways

The final section of *Fare Driving* applies road pricing to segments of 400-series highways to correspond with the completion of major transit projects in the Big Move. SmartTrack and RER are expected to be completed between 2025 and 2031, and will provide alternatives to driving on the tolled segments. In 2031, when the full regional transit plan is completed, the daily maximum toll paid ranges from $3.54 to drive both ways along a segment of Highway 400 to $14.63 to drive both ways on a 95 km segment of Highway 401

- Total daily cost and time savings to drivers during peak times range from almost $30 per day on Highway 400 to over $100 per day for Highway 401.
- Total revenues generated from all priced 400-series highway segments are estimated to be around $7.7 million per day, or over $2.5 billion per year, in 2015 dollars.
- Total GHG reductions per year from pricing segments of 400-series highways and Toronto highways in 2031 are almost 3.9 billion kilograms of CO_2.

1. Introduction

Why road pricing?

Traffic congestion in the GTA has long been identified as a top problem for the city and the region, a drain on the economy and commuters and a challenge for policy makers. Both the Ontario premier Kathleen Wynne and Toronto mayor John Tory cited traffic congestion as a key plank in their leadership platforms, along with investing in transportation infrastructure.

Building transportation infrastructure is central to the solution. The Ontario government has committed 10 years of funding to build out its regional transit plan, the *Big Move.* When the plan is fully implemented, commuters in the Greater Toronto and Hamilton Area (GTHA) will experience shorter average commute times compared to baseline (without a regional transit plan in place), but there will not be a reduction in total number of vehicles on the road due to increased population growth,[3] and the GTA is expected to add 3 million residents by 2041.[4]

A growing number of experts[5] are interested in congestion charging or road pricing as a way to achieve traffic levels that cannot be accomplished through transportation infrastructure alone. Simply building the infrastructure itself will not be enough to generate new mode shift beyond population-projection based ridership growth. Greater efforts are required to shift more commuters out of their personal vehicles and onto transit infrastructure — in particular putting a price on traffic congestion.

Road pricing can encourage mode shift locally in the precise location where the problem is. High occupancy toll (HOT) lanes are a good example of this approach, as they are implemented primarily to reduce congestion on a specific highway. They provide drivers with an option to pay to access the high occupancy vehicle (HOV) lanes, which offer a faster option for carpoolers.

This study looks at a broad pricing of the full highway, not just one lane, applying a reasonable price over the full facility to achieve widespread traffic reduction. While we do not test HOT lane scenarios, specific highways might be able to take advantage of existing HOV lane infrastructure and test HOT lanes as a pilot.

Reducing traffic and travel times

The primary goal of this study is to test how road pricing could reduce congestion on specific highways in Toronto and on provincial highways in the GTA. In other jurisdictions that have implemented cordon charging or kilometre-based pricing, reducing congestion has been the primary goal and has resulted in significant results.

---

[3] Cherise Burda, Graham Haines and Alison Bailie, *Driving Down Carbon: Reducing GHG Emissions from the Personal Transportation Sector in Ontario* (Pembina Institute, 2010). http://www.pembina.org/pub/1993

[4] Ontario Ministry of Finance, “Ontario Population Projections: Fall 2014.” http://www.fin.gov.on.ca/en/economy/demographics/projections/

[5] For example, the Manning Foundation supports user-based road pricing as the best way to balance modes in order to reduce congestion (Ben Brunnen, For Whom the Road Tolls: The Prospect of High Occupancy Toll Lanes in Calgary (Manning Foundation, 2014). http://manningfoundation.org/Docs/road-pricing.pdf).

University of Toronto engineering professor Baher Abdulhai states that time-based pricing would encourage transit use or prompt many drivers to modify their route and time of travel (Noor Javed, "Time to pay, one way or another: How congestion pricing could make a difference in your commute," *Toronto Star*, January 30, 2015. http://www.thestar.com/news/gta/transportation/2015/01/30/time-to-pay-one-way-or-another-how-congestion-pricing-could-make-a-difference-in-your-commute.html).

Our study tests a particular kilometre-based pricing scenario for highways in the GTA. With a modest price of $0.14/km on the Gardiner Expressway, for example, traffic is reduced by 16% during peak periods and driver fuel and vehicle maintenance costs and travel time are reduced by $4.09 and 15 minutes, respectively. Even though the maximum a driver would spend for a two-way trip on the Gardiner at peak times is $4.85 per day, they would be saving $11.73 in combined reduced travel time and vehicle costs.

Revenue generation

In 2014, Premier Wynne earmarked $16 billion for rapid transit infrastructure in the GTHA over the next 10 years.[6] This investment is critical to building overdue transit infrastructure, but the price tag for the full next wave of *Big Move* regional transit plan is $34 billion, leaving the region about $18 billion short.[7] That total also does not cover operating and maintenance costs — an amount that could double the full cost of the entire *Big Move* investment.[8]

The City of Toronto also faces the challenge of finding resources to fund necessary transportation infrastructure that is additional and/or complementary to the province's transit plan, including the Relief Line subway, the Waterfront LRT, improved TTC operations and major road and highway projects like replacing the Gardiner East. Former mayor Rob Ford raised city-wide property taxes by 0.5% specifically to fund the balance of the three-stop Scarborough subway, but this tax increase does not extend to transit infrastructure beyond that one project.

Current mayor John Tory also has a funding strategy for a transit project, SmartTrack, which is centred on tax increment financing, a way to recover tax revenue from future developments around rapid transit projects. Tax increment financing may produce sufficient revenue to help fund SmartTrack, but there may not be enough development in Toronto over the next 30 years to collect enough revenue to cover Toronto's full transit needs.[9,10]

In some instances where road pricing is in practice, including the 407 ETR, the primary goal of the toll is to generate revenue. In other jurisdictions, the revenue outcome is being used almost exclusively to build or improve transportation infrastructure and service, mostly transit. While the primary goal of the study is to measure the impact of road pricing on traffic and travel times in the GTA, a secondary goal is to consider the revenue generation potential.

Revenue from road pricing can be localized. For example, the revenue collected from charging the use of City of Toronto owned highways could be returned locally, where it can be used to help fund Toronto infrastructure

---

[6] Government of Ontario, "The Trillium Trust and Moving Ontario Forward," news release, April 16, 2015. http://news.ontario.ca/mof/en/2015/04/the-trillium-trust-and-moving-ontario-forward.html

[7] $34 billion is based on Metrolinx's plans for current and first wave projects as of 2012. These may be updated.

[8] Anne Golden et al., *Making the Move: Choices and Consequences* (Transit Investment Strategy Advisory Panel, 2013), 45. www.toronto.ca/legdocs/mmis/2014/ex/bgrd/backgroundfile-67455.pdf

[9] Andre Sorensen and Paul Hess, *Choices for Scarborough: Transit, Walking and Intensification of Toronto's Inner Suburbs* (University of Toronto, 2015). http://www.utsc.utoronto.ca/home/sites/utsc.utoronto.ca.home/files/docs/Choices%20for%20Scarborough%20Final%20Mar11.pdf

[10] Daniel Dale, "Analysis: John Tory's SmartTrack Funding Proposal is Vague, Massive – and Could Fail," *Toronto Star*, October 12, 2014.

http://www.thestar.com/news/city_hall/toronto2014election/2014/10/12/analysis_john_torys_smarttrack_funding_proposal_is_vague_massive_and_could_fail.html and mode shift. Road pricing could also price users who live outside of the city and are not captured within a city-wide property tax — thus not paying for infrastructure they use. It can also capture greater funds from users who drive the longest distances, thus correlating use with price.

Tolls can also be strategically placed where transit alternatives exist and provide viable options for all incomes, and to avoid areas where no viable transit alternatives currently exist. It is interesting to note that in other jurisdictions, road pricing was better received after it was implemented and once drivers experienced the benefits in real time of an improved commute.

A road price can encourage mode shift right where the problem is, so it is an effective tool to reduce traffic and congestion as its primary goal, with revenue as an outcome. The city can then choose to apply the resulting revenue to improve transportation infrastructure.

Reducing greenhouse gas emissions

Road pricing can provide a number of co-benefits at once: reducing traffic gridlock, reducing travel times, generating revenue, reducing GHG emissions and even improving safety.

The Ontario government has prioritized actions to reduce GHG emissions, evidenced by the introduction of the Ministry of Environment and Climate Change in 2014. Transportation represents the largest and fastest growing sector of GHG emissions in Ontario and the most challenging emissions to reduce: Ontario's transportation sector is currently responsible for 34% of the province's carbon pollution. That number is expected to rise to nearly 36% by 2020.[11] Road transportation was responsible for the greatest increase in emissions of all sectors between 1990 and 2011.

A variety of policy options should be explored to reduce GHG emissions from road transportation in Ontario. The *Big Move*, the regional transit plan for the GTHA[12], is the provincial policy that promises the largest cuts to carbon pollution from the transportation sector in Ontario. It's also significant at a national scale, ranking as number six in the list of Canada's 10 most effective climate policies for meeting our 2020 climate targets.[13]

However, even with the *Big Move* built in its entirety, Ontario's transportation emissions will continue to grow. It takes decades to build new rapid transit. To see results by 2020, we need more action, and we need it soon.

Road pricing addresses the dual issues of carbon and congestion and can lead to behavioural change, not simply act as a revenue collection tool. It can also help offset declining revenue from gas taxes as vehicle efficiency improves under federal vehicle emission standards.

A road price in the GTA represents an option worth exploring to address some overlapping challenges: traffic congestion, revenue for transportation infrastructure and operations and Ontario's goals to reduce GHG emissions and air pollution from the transportation sector.

---

[11] Government of Ontario, "Ontario Releases Climate Change Strategy Discussion Paper," media release, February 12, 2015. http://news.ontario.ca/ene/en/2015/02/ontario-releases-climate-change-strategy-discussion-paper.html

[12] Metrolinx, *The Big Move* (2008). http://www.metrolinx.com/en/regionalplanning/bigmove/big_move.aspx

[13] P.J. Partington, "More trouble with 2030," Pembina Institute, January 15, 2014. http://www.pembina.org/blog/776

Approach, scope and methodology

Our methodology interprets practices from other jurisdictions and price-points based on earlier Toronto-based studies and applies these approaches to the current GTA context. The results are intended for study and discussion purposes, to explore the potential benefits of pricing pricing as a tool primarily to reduce traffic and congestion, but we also measure other resulting benefits, including reduced GHGs, reduced travel times and fuel and maintenance costs to drivers, revenue generation and health and safety.

Road pricing programs in other countries have been successful in part because drivers have the option to take frequent and reliable transit. Our study incorporates this consideration into its analysis, including timing and geography of implementation.

The geographic scope for this study occurs in two stages. First a road price is tested for Toronto alone — just the DVP and Gardiner Expressway. This is done for two reasons: to imagine road pricing as a municipally administered policy, where revenue is collected and spent locally; and because these highways represent a near-term opportunity for tolling where there are viable rapid transit alternatives, such as all-day GO train service on the Lakeshore line.

The study then explores the potential for road pricing throughout the GTA on segments of 400-series highways and coinciding with the implementation of *Big Move* rapid transit projects that will provide alternatives to driving. While the *Big Move* is for the GTHA, this study focuses on the GTA only. A detailed methodology section is found in Appendix A.

2. Road pricing schemes in practice

In considering a road price suitable to the Toronto and GTA context, we studied similar programs in practice to understand how price point impacts results and how the goal of the road charge informs the price. We also wanted to learn how the presence of rapid transit alternatives influenced the effectiveness of a pricing charge and what typically happened to the revenues. Four programs were examined: cordon charge programs in London and Stockholm, distance-based pricing on California's SR 91, and the 407 toll highway in Ontario.

Goals and outcomes

Road pricing in practice demonstrates how price and implementation is set according to the goal of the initiative. For example, London implemented a cordon charge with the primary goal of reducing congestion within a specific area of central London. Stockholm's primary goal was to raise revenue to invest in roads and public transit and California's original objective was to reduce congestion on SR 91. The toll on Highway 407 mainly generates profits for a privately operated highway.

The table below presents the main goals of these road pricing schemes and the corresponding prices to achieve these goals, along with the outcomes. Additional details on the four road pricing schemes considered are provided in Appendix B.

In all cases traffic, congestion and private vehicle trips were reduced along with travel times. Air quality and safety improved and GHGs were reduced in jurisdictions that tracked these metrics. In all cases, except for Highway 407, revenues were reinvested in rapid transit and highway improvements to improve traffic flow.

Table 1. Overview of road pricing goals and outcomes

Example	Goal(s)	Current price during peak rush hour	Outcomes
London	**Primary goal** Reduce congestion	$20.92 (flat rate)	Reduced congestion by 27%
	Other goals Improve bus service		Bus service quality rated “best ever” in 2014, ridership increased by 77%, wait times for buses decreased by 45%, bus-dedicated lanes specified within zone
	Improve journey time reliability for car drivers		Journey times initially improved as traffic delays declined by 26%; but are now worsening due to increased population and economic recovery
	Improve goods movement		Goods movement not specifically measured
Stockholm	**Primary goal** Raise revenues for transit and road network	$2.42* (AM peak) $2.69* (PM peak)	$137 million (in 2013)
	Other goals Improve environmental quality		Airborne pollutants declined by 10-14%, NO_x declined by 8.5%, CO_2 decreased by 2-3% across the county
	Relieve congestion		Traffic reduced by 19.7%, private trips declined by 30%, VKTs driven in charge zone decreased by 16%, and congestion has reduced on circumferential roads, reducing queuing times by 30-50%
Ontario Highway 407 ETR	**Primary goals** i) Relieve congestion on 401 ii) Maximize profits and dividends for private owners	$0.3294/km* (AM peak) $0.3353/km* (PM peak for light vehicle in Regular Zone)	i) Average of 380,000 work day trips diverted from 401 (2010) (28% of trips) ii) $887.6 million revenues in 2014, 11% increase over 2013; average revenue per trip increased consistently to $6.96 in 2013; but net income declined from 2013 to 2014 by 10% (from $248.7 million to $222.9 million)
	Other goals No other explicit policy goals, other than to provide users with a safe, fast and reliable trip. No emission reduction objectives		Morning commute is 18% faster, afternoon commute is 21% faster, saving about 26 minutes/day; no safety data published; no emissions data available though estimated to save users about 0.4 litres/100 km of fuel
Southern California SR 91	**Primary goal** Relieve congestion on SR 91	Eastbound: $0.10/km (AM peak) $0.35/km (PM peak)	Saves users 30 minutes per day with increasing trips per week; 144 million trips diverted from non-tolled lanes since 2003

Express Lanes		Westbound: $0.25/km (AM peak) $0.35/km (PM peak)	
	Other goals Provide safe, reliable, predictable commute		No published reports of ongoing monitoring of safety and predictable journey times, though OCTA pays for towing if needed to ensure lanes are clear
	Optimise throughput at free-flow speeds		Lanes remain free flowing through price adjustments, and non-tolled lanes have been widened in past
	Increase average vehicle occupancy		Overall HOV3+ along corridor remains constant, through discounted pricing
	Balance capacity and demand		No clear measurement nor quantification explicitly done
	Generate sufficient revenue to ensure financial viability		$47 million generated in 2013-14, remains financially viable

* These are time-varying charges; an average is calculated for 06:00–09:00, the AM peak period, and 15:00–18:00, PM peak period.

Investing in transit alternatives

A second important lesson learned from other examples of road pricing is the relationship between pricing and public transportation alternatives. Both London and Stockholm actively improved and increased transit services prior to or at the time of implementing their cordon charges. In London, Stockholm and Southern California, the revenues generated from the charge were reinvested in building more rapid transit infrastructure, improving transit service or, in the case of SR 91, improving the expressway.

In Sweden, revenues have gone to expanding the LRT system to suburbs and to new road network investments; Transport for London has been able to invest in the Underground by purchasing new trains and improving maintenance. Road facilities in southern California have benefited from widening and expansion, with new public transit connections further out along the SR 91 corridor.

In London, it is law that revenues collected from the cordon charge must be invested in transport, which has improved public transit services. For example, investments in signals and new trains have reduced the need for night-time maintenance, allowing 24-hour service to be introduced on certain Underground lines in 2015. Additionally, in its 2014 report, Transport for London reported that public transit service quality was at “best ever” levels.[14]

Investment in public transit has been an important component in ensuring that congestion levels remain within Transport for London’s target range. For example, bus patronage has risen by 77% since 1999, partially due to reduced wait times for bus customers. Wait times have declined by 45%, as buses are able to run on time because of the reduced congestion.[15]

California’s main use of revenue was to improve the expressway. However, revenues have been directed to doubling the amount of express bus service now offered along the SR 91 corridor by adding 20 additional express bus trips each day. Moreover, the project is investing in commuter rail service by improving access and reducing congestion near the stations of two commuter rail lines, making the train a more attractive commuting alternative. In addition to expanding integration with regional public transit, the project will also expand integration with a 109-kilometre uninterrupted dedicated bike and pedestrian trail.

In Stockholm, public transit service improved prior to the implementation of the cordon charge to provide a viable alternative option; the improved services included 200 additional buses, 16 new bus lines, and increased frequency of bus, subway and commuter trains. Additionally, the park and ride capacity was increased by 25%.[16]

Revenues from the cordon charge are invested in public transportation service and capacity, including expanding and connecting the LRT system regionally through three suburbs.[17]

---

[14] Transport for London, *Travel in London: Report 7* (2014). https://www.tfl.gov.uk/cdn/static/cms/documents/travel-in-london-report-7.pdf

[15] *Travel in London: Report 7*

[16] Jonas Eliasson, “Lessons from the Stockholm congestion charging trial,” *Transport Policy* 15, (2008), http://www.sciencedirect.com/science/article/pii/S0967070X0800053X

[17] Stockholms läns landsting, *Future-bound on board the new Metro* (2014). http://www.sll.se/Global/Verksamhet/Kollektivtrafik/Aktuella%20projekt/Nya%20tunnelbanan/bilagor-tunnelbana-mot-framtiden-engelska.pdf

Governance plays a role in how these lanes became successful in investing in transit to further encourage mode shift. Since the Orange County Transit Authority bought the facility from a private company[18] it has been investing generated revenue into increasing ridesharing, increasing accessibility to public transit and extending the highway to improve connectivity with public transit buses and commuter trains. Moreover, as a public agency, they are monitoring and reporting on metrics like GHG emissions reductions. In comparison, in Ontario, where the provincial government did not buy back the 407 highway, and the private company maintains a 99-year lease, such benefits are neither quantified nor publicly reported.

In the four programs examined, Highway 407 is the only non-public example, and it lacks the reinvestment in transportation; it is relatively costly to use without the larger public benefits demonstrated by the other programs.

Table 2. Summary of road pricing programs examined – revenue investment

Location	Governance	Type	Opened	Annual revenues (Canadian $)	Revenue purpose
London	Public	Cordon	2003	$427 million (£235 million) 2013-2014	Roads and public transit; $1.8 billion (CAD) spent between 2003-2013
Stockholm	Public	Cordon	2007	$137 million (SEK 850 million) 2013	Roads and public transit
Ontario 407 ETR	Private	Distance	1997	$887.6 million 2014	Profit to owners, maintenance of toll lanes; spent over $1.4 billion on toll lanes since 1999
Southern California SR 91	Public	Distance	1995	$47.1 million ($US 42.6 million) 2013-2014	Maintenance of toll lanes; spent $24.3 million (CAD) from 2003-2014 ($US 22 million)

[18] Marlon Boarnet et al., *Impacts of Road User Pricing on Passenger Vehicle Use and Greenhouse Gas Emissions, Policy Brief* (California Air Resources Board, 2014). http://www.arb.ca.gov/cc/sb375/policies/pricing/road_pricing_brief.pdf

3. Setting the price

It is critical to get the price right in order to be effective at reducing traffic and congestion, while also being fair to drivers, particularly in cases where viable transportation alternatives do not exist.

An appropriate price should:

- Reduce traffic and congestion and GHG emissions in the GTA along key highways.
- Be high enough to reduce traffic and congestion but affordable enough that the net result for drivers is saving time and money, while encouraging optimal speeds for GHG emissions reduction (fuel efficiency degrades at higher speeds, resulting in no reduction in emissions), and also high enough to generate revenues.

Thus, the ideal price will be one that will induce behavioural change and generate positive benefits including:

- Reduced GHG emissions
- Reduced air contaminants
- Reduced negative effects of pollution on cardiovascular and respiratory diseases
- Reduced traffic on tolled roads while also not creating unintended increased traffic and congestion on parallel routes that do not have capacity
- Mode shift
- Fewer traffic collisions
- Revenues that can be used towards various fiscal priorities, especially transit infrastructure
- Some net benefit to drivers in terms of time savings and associated cost savings

Applying a price to Toronto highways

Our study proposes an initial price (2016) of $0.14 on the Gardiner Expressway and DVP at peak times and $0.10 at non-peak. As presented in the remainder of the study these prices change with geographic expansion.

To help determine an appropriate price for Toronto, we considered lessons from two academic studies that modelled road pricing for Toronto, an analysis of potential revenue sources by Metrolinx, and road pricing practices as presented in the previous chapter.

The two Toronto-based academic research studies (Finkleman 2010, Lightstone, 2011) that examined facility-specific vehicle kilometres travelled (VKT) charges recommended charges similar to what we consider in this analysis. One recommended a $0.125/km price on the DVP and the Gardiner Expressway to ease congestion on those corridors and reduce GHG emissions,[19] and the other study concluded that residents in the GTHA are willing to pay $0.20/km to avoid congestion along highways in the context of high-occupancy tolls, where urgency and trip distance are significant determining factors in that choice.[20]

---

[19] Adrian Lightstone, *Congestion Charging in the City of Toronto: Distance Based Road Pricing on the Don Valley Parkway and Gardiner Expressway,* M.Sc. Thesis, Royal Institute of Technology, Stockholm, Sweden (2011).

[20] Jeremy Finkleman, *The HOT Solution: An Examination of the Desirability for High-Occupancy/Toll (HOT) Lanes in the Greater Toronto Area*, Master's Thesis, University of Waterloo (2010). https://uwspace.uwaterloo.ca/bitstream/10012/5151/1/Jeremy_Finkleman_Thesis.pdf

The upper end of the price range, $0.20/km, is approximately equivalent to the amount that commuters pay taking the TTC or GO Transit, but converted to a per-kilometre basis.[21]

Metrolinx examined the effects and benefits of road tolls as low as $0.03/km with an upper limit of $0.10/km along all highways and arterial/local roads in the GTHA.[22] In this case, however, the price is broadly applied to highways, and arterial roads are tolled, so a price at the lower end of the range is warranted to ensure political acceptance and to reduce the financial burden on drivers.

Table 3. Road pricing options for Toronto (and the GTHA)

Source	Toll Rate ($/km)	Time applied	Notes
Academic modelling for DVP and Gardiner	$0.125		Applied to Gardiner and DVP only
Academic quantification of desire for HOT lanes along 401/407 corridor	$0.20		Survey of drivers of their willingness to pay, as a function of congestion severity and trip urgency to use HOT lanes along the 401/407 corridor
Metrolinx Study	$0.03–$0.10		Applied to all highways and arterial roads in GTHA
TTC/GO average transit fare	$0.20		Calculated for Gardiner and DVP
407 ETR	$0.34 - $0.345	Peak periods	In practice in GTA
Scenario price for our study	**$0.14**	**Peak periods**	**Implemented in 2016 along Gardiner and DVP**
	$0.10	**Non-peak periods**	**Implemented in 2016 along Gardiner and DVP**
	$0.21	**Peak periods**	**Implemented 2025 along Gardiner and DVP**
	$0.17	**Non-peak periods**	**Implemented 2025 along Gardiner and DVP**

Pricing to reduce traffic

With the above range, the goal is to reduce traffic sufficiently so that cars travel on average between 50 km/hr to 80 km/hr. Natural Resources Canada estimates that travelling at speeds outside this range results in higher fuel consumption for free-flowing traffic.[23] If traffic on these highways is less stop-and-go, GHG and pollution

[21] This number was calculated by first translating the current cost of a monthly Metropass from the TTC into a per-kilometre rate, using the average distance of the DVP and the Gardiner for the distance; the same was done for the cost of commuting from Hamilton to Toronto using GO Transit. A weighted average was then calculated by taking the average of the share of public transit riders travelling into the downtown core via TTC and Go Transit, as estimated by the Data Management Group in their Transportation Tomorrow Survey. The calculated value is approximately $0.20/km.

[22] Metrolinx, *Big Move Implementation Economics: Revenue Tool Profiles*, prepared by AECOM and KPMG (2013). www.metrolinx.com/en/regionalplanning/funding/IS_Appendix_A_EN.pdf

[23] NRCan, "Fuel-efficient Driving Techniques: Avoid High Speeds." http://www.nrcan.gc.ca/energy/efficiency/transportation/cars-light-trucks/fuel-efficient-driving-techniques/7513

emissions and accidents can be reduced, improving air quality and reducing negative effects on cardiovascular and lung diseases. Moreover, if the toll is integrated with sufficient public transit alternatives, a mode shift away from vehicles will compound the benefits of the toll.

A price set within the range above should be effective in reducing traffic by influencing time of day or week, route, destination, travel mode, trip frequency, etc. and accounting for behavioural change from drivers' price sensitivity to the toll. The toll rate signals a closer approximation of the true cost of driving choices, and offers an incentive to drivers to make choices that can create positive effects by producing lower GHG emissions, less pollution, etc. This is true even if other elements such as infrastructure are not optimal.[24]

Moreover, given that traffic in Toronto and the GTHA is worst at peak commute times, a simple two-rate scheme — peak/non-peak pricing — would be an effective first step. The peak period is defined to be from 06:00 to 09:00, and then again from 15:00 to 18:00 from Monday to Friday; all time outside this range, including weekends, is the non-peak period. In a second phase, a time-varying toll schedule that reflects real-time traffic conditions will most effectively ration the finite road space, thereby ensuring that benefits from reduced traffic and GHG emissions are maximized. Similar types of dynamic pricing have been implemented elsewhere, such as HOT lanes in other jurisdictions[25].

Initially, this study uses $0.14/km as the toll rate for peak periods, and as the optimal price that will reduce traffic and emissions for both the DVP and the Gardiner.[26] This price is firmly within the mid-point of the above range. For non-peak periods, a price of $0.10/km is used to reflect the roughly 20% lower traffic level outside of the peak period.[27] A non-peak price of $0.10/km is comparable to the current price difference between peak and non-peak prices along the 407 ETR during weekdays. The proposed price of $0.14/km at peak is the price used in the 2011 study that was mentioned earlier, but is adjusted for inflation, and is in line with other Toronto studies that were conducted in 2011 prior to the existence of all-day two-way GO train service on the Lakeshore line, so these charge rates are comparatively conservative.

Price in practice

Translated into practice, if applied in 2015, this price point ranges from $1.50 to $2.52, depending on time of day, to drive one way the full length of the DVP or the Gardiner Expressway. This is in line with polling that suggests drivers would be willing to pay at least $3.00 to bypass congestion in 2011 ($3.16 in 2015 dollars).[28] Moreover, it's important to keep in mind that in other jurisdictions that implemented road pricing, public support was low prior to implementation but increased significantly afterwards.[29]

---

[24] Harry Kitchen and Robin Lindsey, *Financing Roads and Public Transit in the Greater Toronto and Hamilton Area*, produced for Residential and Civil Construction Alliance of Ontario (2013)

[25] For example, in Minneapolis: http://www.mnpass.org/about.html, in Virginia: https://www.expresslanes.com/, in Atlanta: http://www.peachpass.com/, and in Seattle: http://www.wsdot.wa.gov/Tolling/SR167HotLanes/

[26] *Congestion Charging in the City of Toronto.*

[27] Since Lightstone did not calculate a differential price between peak and non-peak periods, the above prices are second best, but are still reasonable for the problem at hand.

[28] Some examples include *Drivers Choice*, Pembina Institute, 2012: http://www.pembina.org/pub/2333; CBC Poll 2011: http://www.cbc.ca/news/canada/canadians-willing-to-pay-road-tolls-poll-suggests-1.1118572; Angus Reid poll for Toronto Star: http://www.yorkregion.com/news-story/1443533-road-tolls-may-be-way-of-future/

[29] See Jens Schade, "Acceptability of Mobility Pricing Strategies: Public Opinion, Trust and Risk Aversion," presented at Transport Futures Mobility Pricing Forum, November 2011. http://www.transportfutures.ca/sites/default/files/Transport_Futures_-_Jens_Schade_Keynote.pdf

Our scenario analysis assumes the price is implemented in 2016, and will be a two-way all-day fare, with peak and non-peak pricing as above. SmartTrack is proposed to be finished in 2025 and the electrification of the Lakeshore and Richmond Hill GO lines[30] are projected to be online. Then, a higher rate is applied in 2025 to account for the improved rapid transit options, along with changing economic conditions such as GDP and inflation, as well as a larger forecasted automobile fleet: $0.21/km is used in the 2025 analysis as the peak period rate, and $0.17/km is used as the non-peak period toll rate.

It is also expected that the City of Toronto will be adding significant transit projects additional to SmartTrack and RER, which were included in the *Big Move*. These priority projects include the "relief line" subway, which corresponds with the DVP, and the Gardiner and the Waterfront LRT that corresponds with the Gardiner Expressway. As the relief line is currently listed as a *Big Move* next wave project, we assume it will be online before 2031. The Waterfront LRT has been identified by the City of Toronto as a priority transit project. Although there is no set date for the completion of the Waterfront LRT, we assume it will be completed before 2031, as it is a priority project like the relief line subway. To keep things simple, in this analysis a 2025 date is used to capture SmartTrack and RER and we used the expectation that the relief line and Waterfront LRT will be completed sometime before 2031.

[30] Metrolinx is also considering increasing station frequency on these two lines, which would widen the service catchment of the Lakeshore and Richmond Hill GO lines.

4. Applying a charge in Toronto

When considering implementation in Toronto and the GTA, policy makers may consider whether other routes and mode alternatives exist. In the cases presented from other jurisdictions, either rapid transit already existed as an alternative, or new transit infrastructure and/or improved service came online at the time or subsequent to the road price being implemented.

In terms of a cordon charge vs. per-kilometre approach, analysis by Metrolinx and others suggests that a per-kilometre approach is best suited to the GTA because of how traffic flows in all directions. For the City of Toronto we conducted a per-kilometre analysis on the Gardiner Expressway and the DVP. The city could choose a cordon to capture "out of towners" to pay for Toronto's highways, but a per-kilometre system can also act as a zone-based system that captures more revenue from drivers who drive the furthest, and variable pricing could adjust for reverse commuting by Toronto residents. Ultimately it is up to the city to determine how to apply road pricing to best meet their goals.

Where to apply road pricing in Toronto

Within the municipality of Toronto, road pricing could be applied to the Gardiner Expressway and the DVP. There are several reasons why the City of Toronto should consider these two highways for the first tolled expressways as they work towards achieving their goal of reduced traffic and congestion within Toronto:

- The Gardiner Expressway will have a rapid transit alternative: all-day two-way GO Transit train services on the Lakeshore West line, which is already online.
- The DVP currently has three transit options: The Yonge subway, the Richmond Hill GO line or the Stouffville Go line.
- SmartTrack and RER are projected to be online by 2025, providing additional rapid transit options to the two highways.[31]
- Additional municipal transit projects being planned include a relief line subway and a Waterfront LRT, which will provide further alternatives to those municipal highways.
- The City of Toronto will be able to control the collected toll revenue.
- The City of Toronto can adjust the pricing schedule and geography to include non-Toronto residents who use these facilities, letting them contribute to the costs of maintaining and operating these highways that fall within the City's jurisdiction.

While there are currently a limited number of public transit alternatives along the DVP corridor, commuting options do exist for many commuters, such as the Yonge subway, the Richmond Hill GO train and the Stouffville GO train.

Given the transit alternatives available to commuters, a road price can be applied to the DVP and Gardiner from Highway 427 to Yonge Street. A higher price is applied in 2025 to account for inflation and to correspond with the completion of SmartTrack, which can provide an alternative to the DVP. As well, regional express rail is expected to introduce 15-minute service with the electrification of the GO network.

---

[31] The RER is part of a 10 year provincial investment, which means it should be completed in 10 years. The City of Toronto has stated that they will coordinate SmartTrack implementation with the provincial timelines for RER (Greg Percy, "Regional Express Rail Update," presentation to Metrolinx Board of Directors, March 3, 2015. http://www.metrolinx.com/en/docs/pdf/board_agenda/20150303/20150303_BoardMtg_Regional_Express_Rail_Update_EN.pdf)

5. Pricing Toronto highways — Stage 1

Phasing in pricing along highways where public transit alternatives exist allows more commuters to switch modes and thereby reduces traffic, congestion and GHG emissions. The existence of viable transit options may also allow for a more ready acceptance of road pricing.

We've already recently seen improved transit service. For example, in recent years GO transit has lengthened trains, added express trains and introduced two-way half-hour service all day on the Lakeshore line. In Toronto, the 15-kilometre portion of the Gardiner Expressway from Highway 427 to Yonge Street corresponds with the Lakeshore West GO train route between Long Branch and Union Station. GO services provide commuters a viable transit alternative to driving along the Gardiner.

Pricing the Gardiner and the DVP in 2016 is supported by transit alternatives (Figure 1):

- All day two-way GO service on Lakeshore West
- Yonge subway
- Richmond Hill GO train
- Stouffville GO train

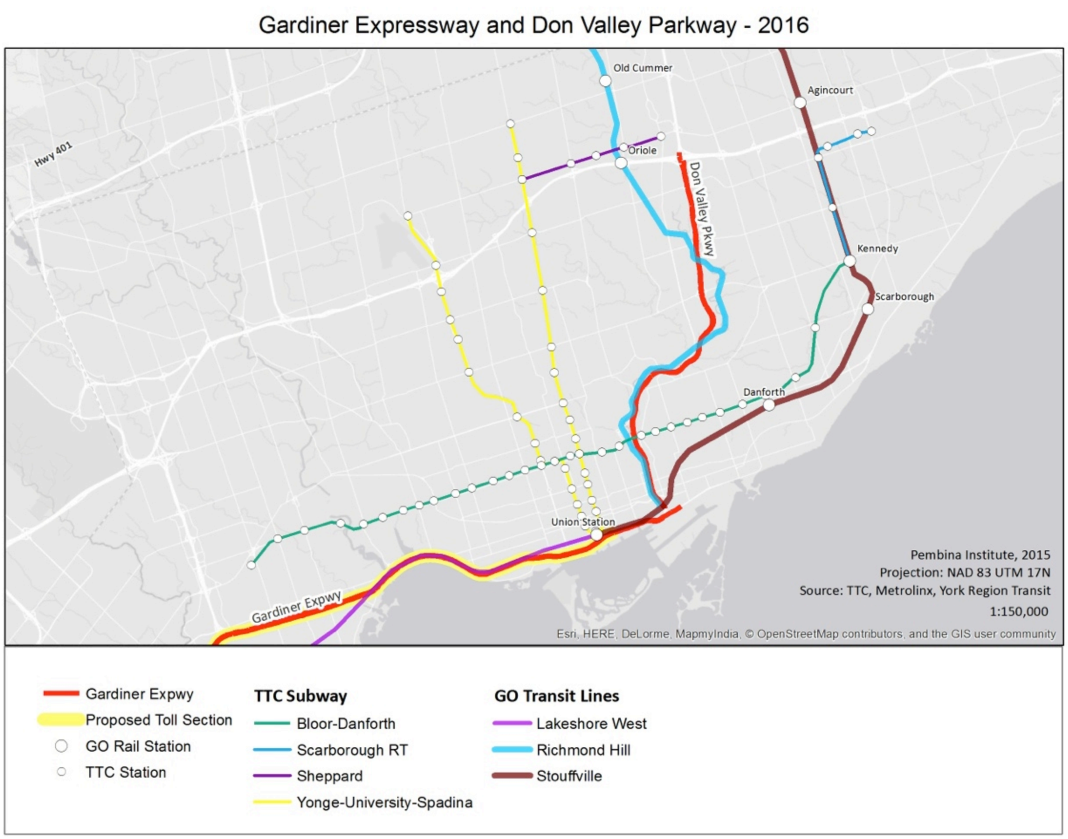


Figure 1. Transit alternatives along the Gardiner and the DVP, 2016

This study examines the potential impacts of applying a road price along the DVP and the Gardiner beginning in 2016. It applies a modest price in 2016 based on limited rapid transit alternatives: all day two-way GO transit on the Lakeshore West line, and the Yonge subway and Richmond Hill and Stouffville GO lines.

Several assumptions have been made to facilitate the analysis, including a 4% real discount rate. Values have been calculated in constant 2015 dollar values. See Appendix A: Methodology for a complete list of assumptions.

Results

The quantified benefits are estimated to accrue by the end of 2016, after commuters have had a chance to adjust their travel behaviour.

Under this scenario, the fee implemented in 2016 along the DVP and the Gardiner is set at $0.14/km during peak periods and $0.10/km during non-peak periods. Traffic will be reduced by 13% and 16% during peak periods along the DVP and Gardiner, respectively. The highest private (out-of-pocket) costs an individual would pay during peak times on the DVP in both directions would be $4.04 per day at peak travel times, or $2.88 at non-peak times. A commuter who drives the full length of the Gardiner during the peak period in both directions would pay a maximum of $4.85, or $3.46 during non-peak hours.

This cost assumes that the individual drives along the entire length of these facilities, hence it is the maximum that they would pay. These costs are offset by the time-savings of 14 to 15 minutes valued at $7.13 and $7.64 during peak periods on these two facilities. Savings will also be realized for travel during non-peak periods on both facilities. Moreover, with reduced traffic and congestion, the fuel and maintenance savings will increase the financial savings for drivers, explained further below. The annual revenue to the city from the two facilities is estimated to be over $487 million.

Similar to other jurisdictions, quantifiable benefits for the City of Toronto from the implementation of road pricing along the Gardiner and the DVP include:

- Reduced traffic and congestion
- Reduced GHG emissions
- Health care savings
- Reduced travel times
- Improved road safety
- Fuel and vehicle maintenance savings
- Revenue to the City

Table 4. Summary of quantified benefits for 2016

	DVP		Gardiner	
	Peak Period	**Non-Peak Period**	**Peak Period**	**Non-Peak Period**
PRICE (per km)	**$0.14**	**$0.10**	**$0.14**	**$0.10**
RESULTS				
Reduced traffic (Per day)	13%	14%	16%	17%
Reduced travel times (Per vehicle/round trip/day)	14 minutes	16 minutes	15 minutes	18 minutes
Travel time savings (Per vehicle/round trip/day)	$7.13	$3.26	$7.64	$3.67
Fuel and vehicle maintenance savings for avoided trips (Per vehicle/round trip/day)	$15.87	$15.87	$19.04	$19.04
Fuel and vehicle maintenance savings for trips (Per vehicle/round trip/day)	$3.41	$3.65	$4.09	$4.38
Safety improvements (Across all vehicles/day)	$22,142	$72,437	$35,727	$99,667
Reduced GHGs (CO_2 reduction across all vehicles/day)	52,964 kg	173,266 kg	85,458 kg	238,406 kg
Health benefits (Across all vehicles/day)	$3,716	$12,157	$5,996	$16,727
Generated revenues (Per day)	$265,819	$462,778	$322,100	$486,615
Maximum charge paid (Per round trip/day)	$4.04	$2.88	$4.85	$3.46
Total private savings to drivers (Travel time savings + fuel and maintenance savings/round trip/day)	$10.54	$6.91	$11.73	$8.05

*Peak Period: Mon–Fri, 06:00–09:00 and 15:00–18:00
Non-peak Period: Mon–Fri, all other times; weekends all day
All monetized values denominated in constant 2015 dollars

Reduced traffic

The decrease in traffic will depend on a number of factors, including the price point used, socio-economic factors such as household income, and driver age. A fundamental factor that embodies these and other variables is the own-price elasticity of demand — or how sensitive the driver is to changes in the price associated with road pricing. Over the years, several empirical studies have reported different own-price elasticity of demand in different jurisdictions; these estimates range from –0.01 to –0.48.[32] This means that a 1% increase in the road price would result in a 0.10 to 0.48% decrease in traffic volume on the tolled segment.

[32] A. Matas and J.L. Raymond, "Demand Elasticity on Tolled Motorways," *Journal of Transportation and Statistics*, 6 (2003); M.W. Burris, "The Toll Price Component of Travel Demand Elasticity," *International Journal of Transport*

Variations within the range of elasticities for toll facilities can be attributed to local conditions that influence their effectiveness. These conditions include the existence of non-tolled alternative routes, availability of alternative travel modes, predominant trip purpose, and traffic and congestion levels.

The analysis shows that along the DVP, traffic will be reduced by 13% during the peak periods.[33] During the non-peak periods[34] traffic is estimated to decline by 14%. For the Gardiner, comparable reductions are predicted to be 16% and 17%. The reduction in traffic is greater for the Gardiner due to the higher level of available alternative public transit options — namely the all-day two-way service via the GO transit Lakeshore East and West lines in 2016 — allowing drivers to mode shift more easily.

With this reduction, traffic along both the DVP and the Gardiner will be able to run at, or close to, free-flow levels during most periods. As expected, traffic reductions are greater during the non-peak period for both the DVP and the Gardiner as these are more likely to be discretionary trips, and drivers are more sensitive to the charge. This reduction in traffic during the non-peak period implies that some of these types of trips will no longer be made via a personal vehicle once the road charge is implemented: either the trip will not be made at all, or those who previously used a personal vehicle will switch modes or routes.

Two concerns have emerged in other jurisdictions prior to the implementation of a road charge: that traffic will be diverted to alternate routes, or that public transit services may be overwhelmed by increased ridership as people shift their mode of travel. In both London and Stockholm, parallel roads or alternate routes did not become congested. Additionally, an earlier study of the DVP and the Gardiner found that when traffic was diverted to other routes — such as regional arterial roads, high capacity regional arterials, HOV lanes, and medium capacity arterial roads — there weren't increased delays because most of the alternative road segments were below capacity; thus any increase in traffic volume can be absorbed without ensuing delays.[35] The second concern, public transit being overwhelmed because of mode shift, is unlikely to be the case here due to the increased service levels that will become available prior to 2016. Traffic reductions would be even greater if GO transit bus service became more frequent or more service routes were to be added by 2016.

Travel time savings

Travel-time savings are a key benefit of introducing road charges and represent the savings in travel time relative to the baseline scenario with no charge applied. Travel times savings are derived using the reduced traffic estimates from the analysis, along with factors from a study by the Conference Board of Canada of travel times savings along the 407 ETR (see Appendix A: Methodology for details). The road charge is expected to save commuters who use the DVP 14 minutes per day per round trip during peak periods, and 16 minutes during non-peak times. Comparable figures for the Gardiner are 15 and 18 minutes, respectively.

Following an earlier modeling study of Toronto[36] and adjusting for inflation, a monetary value of $31.80 per hour is used to value time during the peak periods, and $12.72 per hour is used for the non-peak period. The value of travel time savings is estimated to be $7.13 per day for a round trip along the DVP during peak times, and $3.26 during the non-peak period per day, per round trip. For the Gardiner, the time saved due to less

---

Economics, 30 (2003); California Environmental Protection Agency, Air Resources Board, *Impacts of Road User Pricing on Passenger Vehicle Use and Greenhouse Gas Emissions* (2014).

[33] 06:00–09:00 and 15:00–18:00, Monday–Friday. This is a weighted average of the reductions between the AM and PM periods in the north- and southbound directions.

[34] 00:01–05:59, 09:01–14:59, and 18:01–24:00, Monday–Friday,

[35] *Congestion Charging in the City of Toronto.*

[36] *Congestion Charging in the City of Toronto.*

traffic is estimated to be equivalent to $7.64 during peak periods and $3.67 during non-peak periods. For both facilities, these travel time savings exceed the maximum price paid.

Fuel and vehicle maintenance savings

For the purposes of this analysis, $0.55/km is used as the current price to drive a car, without the addition of road pricing (see Appendix A: Methodology for details). This per-kilometre cost of operating and maintaining a vehicle includes fuel, insurance, license and registration, and maintenance costs. Out-of-pocket savings in terms of fuel and maintenance are differentiated between avoided trips and trips that continue to be made; these savings are expressed per vehicle, per round trip on a per day basis. Avoided trips are those trips that are no longer made at the time they previously were, or not made at all. These savings arise due to reduced idle time, and less stop and go driving, which reduces vehicle wear and tear and improves fuel efficiency, all due to fewer vehicles on the road. Vehicle and maintenance savings for avoided trips are estimated to be $15.87 for the DVP during both peak and non-peak periods. The fuel and vehicle maintenance costs savings for trips that are made during peak periods is $3.41, and $3.65 during non-peak periods. For the Gardiner, fuel and vehicle maintenance savings for avoided trips during peak and non-peak periods are $19.04; for trips that are made, the savings are $4.09 and $4.38 during peak and non-peak periods, respectively.

Improved road safety

Introduction of the road charge and ensuing reduction in vehicle kilometres travelled (VKT) is associated with cost savings with respect to traffic collisions. These savings are largely related to human costs through fatalities and injuries, and related infrastructure repairs incurred by the city. The monetary value of this improved road safety is estimated to be $0.10/km (see Appendix A: Methodology for details). The savings are estimated by applying this unit rate to the number of reduced VKT. For the DVP, the total daily benefit in vehicle accident reductions is estimated to be $22,142 during peak periods and $72,437 over non-peak periods. Similarly, savings from reduced traffic on the Gardiner is estimated to be $35,727 during peak periods, and $99,667 during non-peak periods. The difference between these is largely due to the fact that the peak periods cover six hours while the non-peak period covers 18 hours, hence more vehicle kilometres are travelled during the non-peak period.

GHG emissions reductions

An emission factor of 0.23 kg/km is used to estimate the reduction in CO_2, the most prevalent greenhouse gas produced by motor vehicles. Estimates of CO_2 reduction are 52,964 kg per day during peak periods along the DVP, and 173,266 kg per day during the non-peak period. As with safety improvements, the difference between these is due to the fact that more vehicle kilometres are travelled during the non-peak period since it covers a longer time period. For the Gardiner, CO_2 emissions are estimated to decline by 85,458 kg per day during the peak period, and 238,406 kg during the non-peak period.

Health benefits

Health benefits from reducing particulate matter can help to offset the cost of implementing road pricing. Elevated particulate matter levels can lead to mortality, increased respiratory symptoms such as coughing and difficulty breathing, decreased lung function, premature death in people with pre-existing conditions, heart attacks, and aggravated asthma. The estimates are based on the range of $40–$93 (U.S.) per metric ton of carbon dioxide reduction by 2020 (see Appendix A: Methodology for details). After conversion to 2015 Canadian dollars, the health benefit is estimated to be $3,716 per day for the DVP during the peak periods, and

$12,157 during the non-peak periods. For the Gardiner, these figures are $5,996 per day during the peak periods and $16,727 per day during the non-peak periods.

Assuming 250 charge days per year for the peak charge, and 365 days for the non-peak charge, the annual health savings benefit will be almost $13 million. These health savings may help to offset financial expenditures by the province for health care services; additionally, employers will benefit from fewer sick days by employees who are sensitive to air quality changes because of heart conditions or respiratory illnesses, or who have to take care of family members who have these medical conditions.

Collected revenue

The revenue collected from the road price during the peak periods is estimated by multiplying the peak price of $0.14/km by the VKT during the peak periods along the DVP and the Gardiner; similarly, the non-peak price of $0.10/km is multiplied by the VKT during the non-peak periods along both facilities. These estimates are for round trips, and align with the other estimates reported in the tables. The daily revenues from the road price from the DVP are estimated to be $265,819 during peak periods, and $462,778 during non-peak periods. For the Gardiner, the comparable figures are $322,100 and $486,615 per day. Annually, revenue from both peak and non-peak charges from these two facilities is estimated to generate over $487 million for the City of Toronto, which could be used to help finance infrastructure priorities.

GHGs and VKTs

This study has measured GHG emissions reductions based upon a reduction in VKTs; this occurs for different reasons — for example, as travellers switch modes away from personal vehicles, reduce their number of trips or choose an alternate route. But, as traffic conditions improve, those who choose to pay the charge and continue to drive will be able to travel at faster speeds; meaning the amount of time that these travellers spend caught in traffic jams and idling is reduced. This reduction in idling also results in fewer GHG emissions. This study, however, does not account for a decline in GHG emissions from reduced idling. Consequently, the estimates provided above can be considered to be lower bound estimates of GHG emissions reductions.

6. Pricing Toronto highways — Stage 2

By 2025 there will be improved public transit options for commuters and travellers driving during peak and non-peak periods, as presented in chapter four. Therefore, a 2025 road price of $0.21/km during peak periods and $0.17/km during the non-peak periods is analyzed.

SmartTrack is projected to be built by 2025, which will provide alternatives to the DVP as well as central sections of the Gardiner Expressway.[37] In addition, RER is expected to come online by 2025, providing improved express rapid transit alternatives to the DVP and the Gardiner and feeding into SmartTrack[38].

While the timeline for completion is not clear, the City of Toronto has prioritized municipal transit projects including the relief subway line, which is part of the *Big Move's* next wave of transit projects projected to be built by or before 2031,[39] and the Waterfront LRT, which corresponds with the Gardiner Expressway and DVP. Its uncertain when the LRT will be built but it is identified as a top priority for the City and when built, will provide further future transit options.

Increasing the pricing on the Gardiner and the DVP in 2025 is supported by additional transit alternatives including (Figure 2):

- SmartTrack
- Lakeshore east and west GO lines, likely to be electrified as RER
- Kitchener and Stouffville RER connecting to SmartTrack
- Other regular service GO lines, parts of which may be in transition to RER[40]

---

[37] Commuters east of the Don Valley Parkway who travel to downtown Toronto can take more frequent service on SmartTrack to reach downtown instead of using the DVP.

[38] More frequent train service on the Stouffville and Richmond Hill lines can attract drivers away from the DVP and onto transit. Residents from west of Toronto who use Highway 401, Queen Elizabeth Way and the Gardiner Expressway to reach downtown Toronto can now switch to 15-minute service on the Kitchener and Lakeshore West RER lines.

[39] Metrolinx assumes in ridership forecasts that the Downtown Relief Line will be online by 2031. Metrolinx, *The Relief Line*, Regional Transit Project Profile.
http://www.metrolinx.com/en/docs/pdf/nextwave/Fact_Sheet_Relief_Line_EN.pdf

[40] "Regional Express Rail Update."

Gardiner Expressway and Don Valley Parkway - 2025

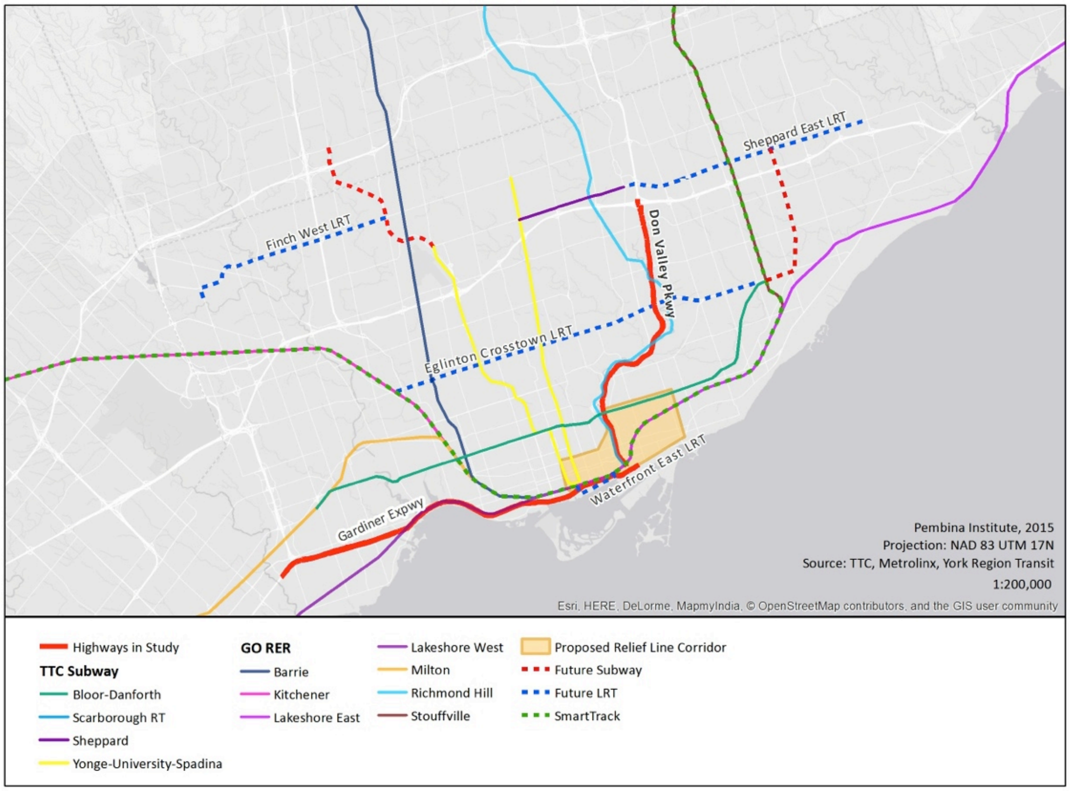


Figure 2. Transit alternatives along the Gardiner and the DVP, 2025

Results

Results are summarized in Table 5 below. All monetized values are in constant 2015 dollars.

Two seemingly opposing factors underlie the outcomes. First, with greater transit options and a higher road price, as expected, traffic levels will be lower. In fact, traffic will be at or below capacity levels along both the DVP and the Gardiner. With such low traffic levels, the revenue generated will be lower than one would expect with higher road prices.

Under this scenario, traffic is reduced by 19% and 24% during peak periods along the DVP and the Gardiner respectively. The maximum total charge a driver will pay along the DVP and the Gardiner during peak periods will be $4.26 and $5.11, assuming they drive the entire length of these roads for a two-way trip. With this charge structure, the travel time savings is 14 to 19 minutes during peak times and the value of these savings is $5.99 and $8.13 during peak periods, along the DVP and the Gardiner respectively.

Yearly revenues to the city are estimated to be over $513 million, in constant 2015 dollars.

Table 5. Summary of quantified benefits for 2025

	DVP		Gardiner	
	Peak Period	**Non-Peak Period**	**Peak Period**	**Non-Peak Period**
PRICE (per km)	**$0.21**	**$0.17**	**$0.21**	**$0.17**
RESULTS				
Reduced traffic (Per day)	19%	24%	24%	28%
Reduced travel times (Per vehicle/round trip/day)	14 minutes	22 minutes	19 minutes	25 minutes
Travel time savings (Per vehicle/round trip/day)	$5.99	$3.76	$8.13	$4.28
Fuel and vehicle maintenance savings for avoided trips (Per vehicle/round trip/day)	$13.38	$13.38	$16.05	$16.05
Fuel and vehicle maintenance savings for trips (Per vehicle/round trip/day)	$2.88	$3.08	$3.45	$3.69
Safety improvements (Across all vehicles/day)	$32,450	$104,088	$54,948	$144,480
Reduced GHGs (CO_2 kg reduction across all vehicles/day)	93,702 kg	314,634 kg	155,896 kg	409,910 kg
Health benefits (Across all vehicles/day)	$5,398	$18,127	$8,917	$23,447
Generated revenues (Per day)	$268,735	$466,953	$332,351	$526,320
Maximum charge paid (Per round trip/day)	$4.26	$3.45	$5.11	$4.13
Total private savings to drivers (Travel time savings+Fuel and maintenance savings/round trip/day)	$8.87	$6.84	$11.58	$7.97

*Peak Period: Mon–Fri, 06:00–09:00 and 15:00–18:00
Non-peak Period: Monday–Friday, all other times; weekends all day
All monetized values denominated in constant 2015 dollars

Reduced traffic

The analysis shows that along the DVP, traffic will be reduced by 19% during the peak periods. This is a weighted average of the reductions between the morning and afternoon peak periods in the north and southbound directions. During the non-peak periods, traffic is estimated to decline by 24%. For the Gardiner, comparable reductions are estimated to be 24% and 28%. These declines are greater than those in 2016 due to the existence of more transit options and a significant amount of time — eight years — during which travellers will have had time to alter their travel behaviour. With this reduction, traffic along both the DVP and the Gardiner will be either at free-flow levels or just slightly above it, at all times.

Similar to chapter five, traffic reductions are greater during the non-peak period for both the DVP and the Gardiner.

Travel time savings

A key measure of effectiveness is whether road pricing is expected to save commuters significant travel time; for the DVP, the analysis indicates that commuters will save 14 minutes per day per round trip during peak periods and 22 minutes during non-peak periods. Comparable figures for the Gardiner are 19 and 25 minutes.

Projecting to 2025, hourly wage rate during peak periods is estimated to be $38.00 per hour, and $15.20 per hour for non-peak periods. Converting the time savings to constant 2015 dollars, the value of time savings travel for each traveller via private vehicle is estimated to be $5.99 per day for a round trip along the DVP during peak times, and $3.76 during the non-peak period per day per round trip. For the Gardiner, the comparable values are $8.13 and $4.28 during non-peak periods. For both facilities, these travel time savings exceed the maximum road price levied for a round trip, which is $4.26 for peak periods and $3.45 for non-peak periods along the DVP; $5.11 and $4.13 for the same periods travelling along the Gardiner.

Fuel and vehicle maintenance savings

By 2025, commuters will continue to benefit from out-of-pocket savings in terms of fuel and maintenance. For avoided trips on the DVP, daily savings are estimated to be $13.38 during both peak and non-peak periods for those vehicles; for round trips that are made, the daily savings are $2.88 and $3.08 during peak and non-peak periods. Along the Gardiner, the savings for each avoided round trip is $16.05, while the savings for each round trip made during the peak period is $3.45 and during the non-peak period is $3.69.

Improved road safety

With reduced traffic and traffic accidents, safety benefits will continue in 2025. The monetary value is forecasted to be $0.12/km by then. For the DVP, the daily benefit from improved road safety is expected to be $32,450 during peak periods and $104,088 during the non-peak period; comparable figures for the Gardiner are $54,948 and $144,480.

GHG reductions

Estimates of CO_2 reduction are 93,702 kg per day during peak periods along the DVP, and 314,634 kg per day during the non-peak period. For the Gardiner, CO_2 emissions are estimated to decline by 155,896 kg per day during the peak period, and 409,910 kg during non-peak periods. These CO_2 reductions are greater than those in 2016 due to the greater number of commuters taking advantage of public transit alternatives, making the trip at a different time, or not at all.

Health benefits

In 2025, health care benefits are projected to be $5,398 per day for the DVP during the peak periods, and $18,127 during the non-peak periods. For the Gardiner, these figures are $8,917 per day and $23,447 per day. These estimates are denominated in constant 2015 dollars; they are greater than those for 2016 due to fewer cars being driven. Assuming 250 charge days per year for the peak charge, and 365 days for the non-peak charge, the annual health savings benefit will be almost $13 million across both facilities in real terms.

Collected revenue

The road price is expected to generate $268,735 during peak periods and $466,953 during non-peak periods along the DVP daily. For the Gardiner, the comparable figures are $332,351 and $526,320 per day. Total revenue to the City of Toronto from these two facilities would amount to over $1.6 million per day, or almost $513 million per year, in 2015 dollars.

7. Applying a road price throughout the GTA — Stage 3

To assess the potential effects of future regional road pricing, this final chapter outlines the results of applying road pricing on select highway segments in the region that align with the completed *Big Move* projects listed in Table 6. This analysis quantifies the outcomes in 2032, one year after the last project is slated to be completed.

Table 6 outlines the timeline of development of the regional transportation network within the GTA, and these transit options are presented in the figures that follow.

Table 6. Timeline of corresponding regional transportation network, The Big Move projects

Project	Completion	Affected Highway(s)	Distance (km)
LRT and subway projects			
York University Spadina Subway Extension	2016	Provides connections to Eglinton, Sheppard and Finch LRTs corresponding with Hwy 401	n/a
Eglinton Crosstown	2020	Hwy 401	20
Sheppard East LRT, Finch West LRT	2021	Hwy 401	36
Yonge Subway Extension	2031	Highway 404 between Hwy 407 and 401	8.5
GO Transit projects and SmartTrack			
Smart Track (Kitchener + Stouffville)	2022	Hwy 400 and Highway 404	20 (Hwy 401) 24 (DVP)
Kitchener electrification and RER	2016 two-way, 2025 electrification, 2031 RER	Highway 401	74
Lakeshore East electrification and RER	2025 electrification, 2031 RER	15 minute frequency. Track west of Burlington may not be electrified in this time as it's owned by CP and CN	23
Lakeshore West electrification and RER	2025 electrification, 2031 RER	QEW	44
Stouffville electrification and RER	2025 electrification, 2031 RER	Hwy 404	25
Barrie electrification and RER	2025 electrification, 2031 RER	Highway 400 and Highway 404	72 (Hwy 400) 33 (Hwy 404)
Richmond Hill electrification and RER		Highway 404	28

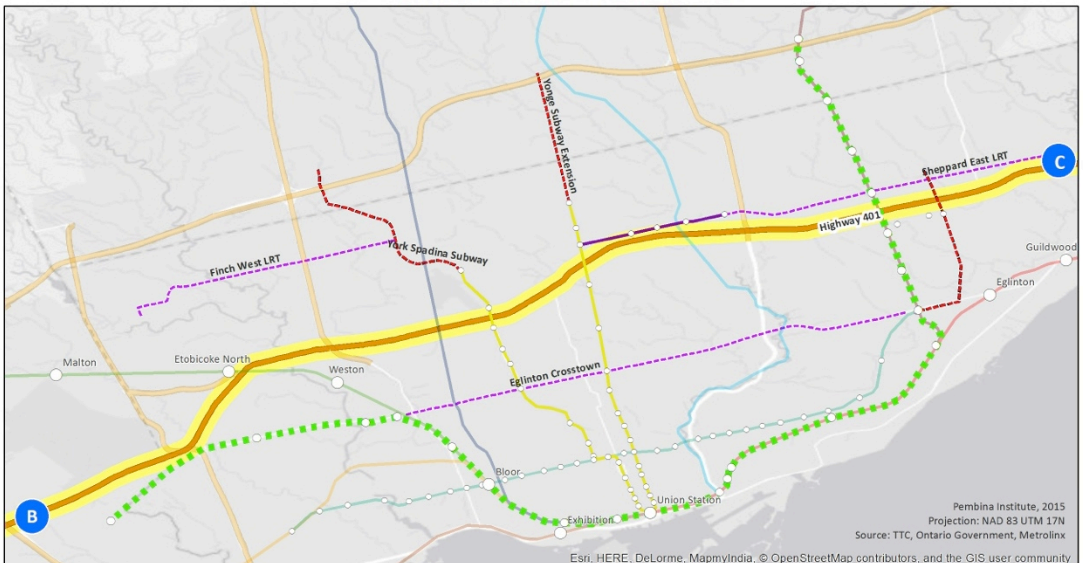
Highway 401

Central segment

Transit alternatives to central segment of Highway 401:

- Eglinton Crosstown and Scarborough transit (currently Scarborough subway)
- Finch LRT feeding into University and Yonge lines
- Sheppard East LRT feeding into Sheppard subway, SmartTrack and Yonge line.
- SmartTrack

Highway 401 (Central Segment) - 2031



The 42 km long segment of Highway 401 from Highway 403 to Meadowvale Rd corresponds with Sheppard Subway, SmartTrack, Finch West LRT, Sheppard East LRT, Eglinton Crosstown LRT, and the Yonge and York-Spadina Subway Extensions. Lakeshore East RER and Kitchener RER offer complementary service for the eastern and western segments of Highway 401, respectively.

Proposed Section for Congestion Charge
GO Stations
SmartTrack Stations

Transit Options
Sheppard Subway
Future LRT
Future Subway
SmartTrack

Other Options / Connections
Bloor-Danforth
Sheppard
Yonge-University-Spadina
Highways

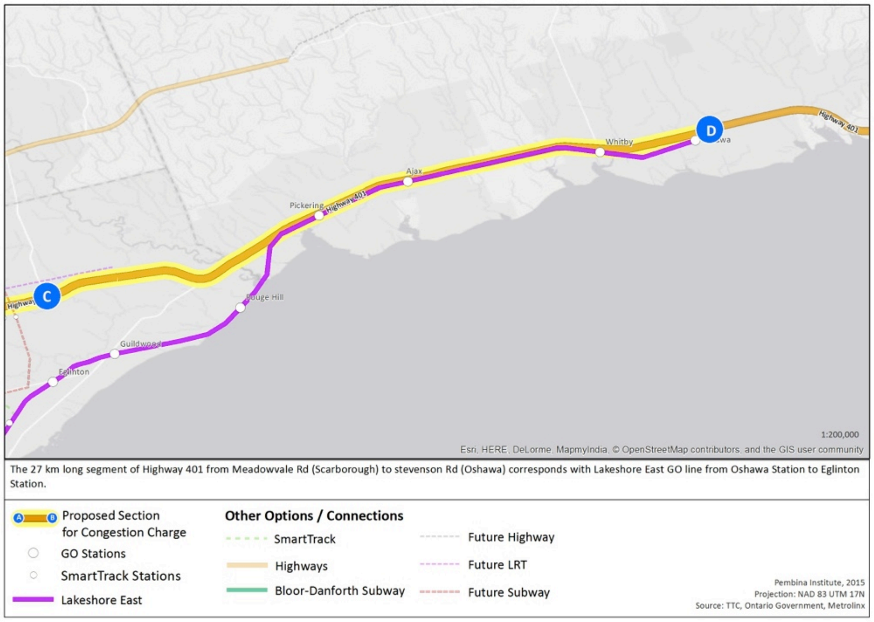
GO RER
Barrie
Kitchener
Lakeshore East
Lakeshore West
Milton
Richmond Hill
Stouffville

Eastern segment

Transit alternatives to eastern segment of Highway 401:

- Lakeshore East (RER)

Highway 401 - 2031



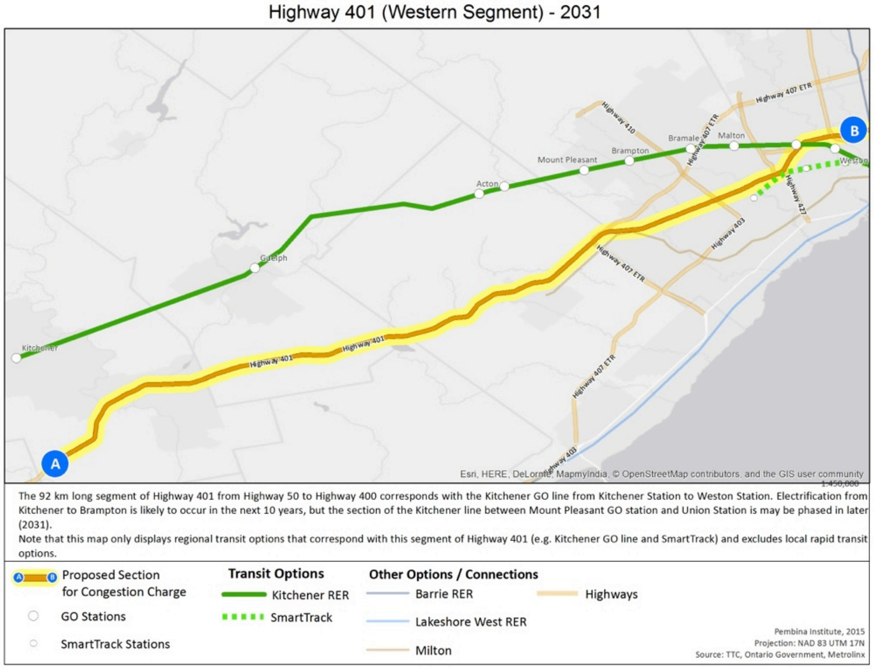
The 27 km long segment of Highway 401 from Meadowvale Rd (Scarborough) to stevenson Rd (Oshawa) corresponds with Lakeshore East GO line from Oshawa Station to Eglinton Station.

Western segment

Transit alternatives to western segment of Highway 401:

- Kitchener line RER

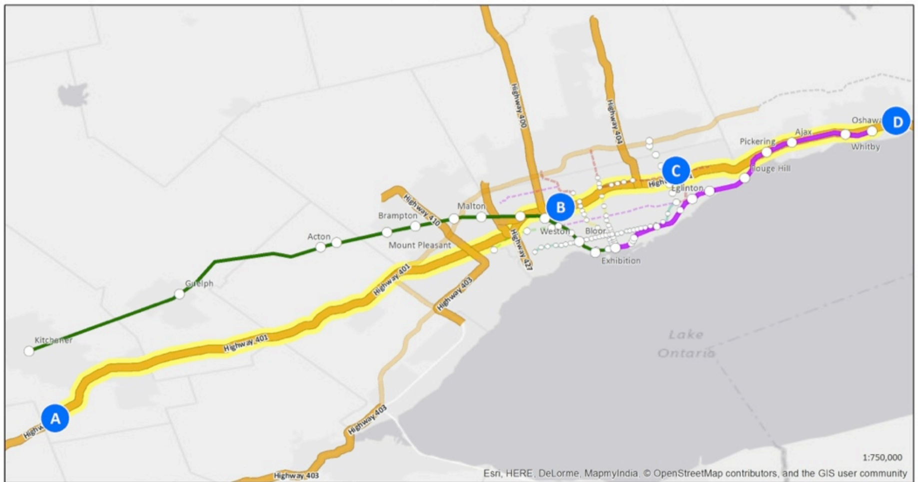
Highway 401 (Western Segment) - 2031



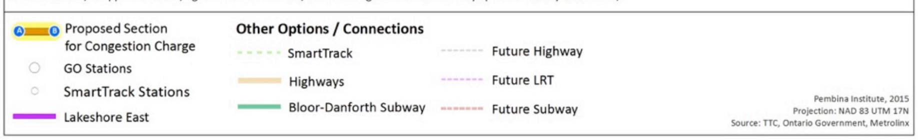
The 92 km long segment of Highway 401 from Highway 50 to Highway 400 corresponds with the Kitchener GO line from Kitchener Station to Weston Station. Electrification from Kitchener to Brampton is likely to occur in the next 10 years, but the section of the Kitchener line between Mount Pleasant GO station and Union Station is may be phased in later (2031).
Note that this map only displays regional transit options that correspond with this segment of Highway 401 (e.g. Kitchener GO line and SmartTrack) and excludes local rapid transit options.

All segments by 2031

Highway 401 - 2031



The 150 km long segment of Highway 401 from Kitchener (Scarborough) to Oshawa corresponds with Kitchener GO line, Lakeshore East GO line, Sheppard Subway, SmartTrack, Finch West LRT, Sheppard East LRT, Eglinton Crosstown LRT, and the Yonge and York University Spadina Subway Extensions,

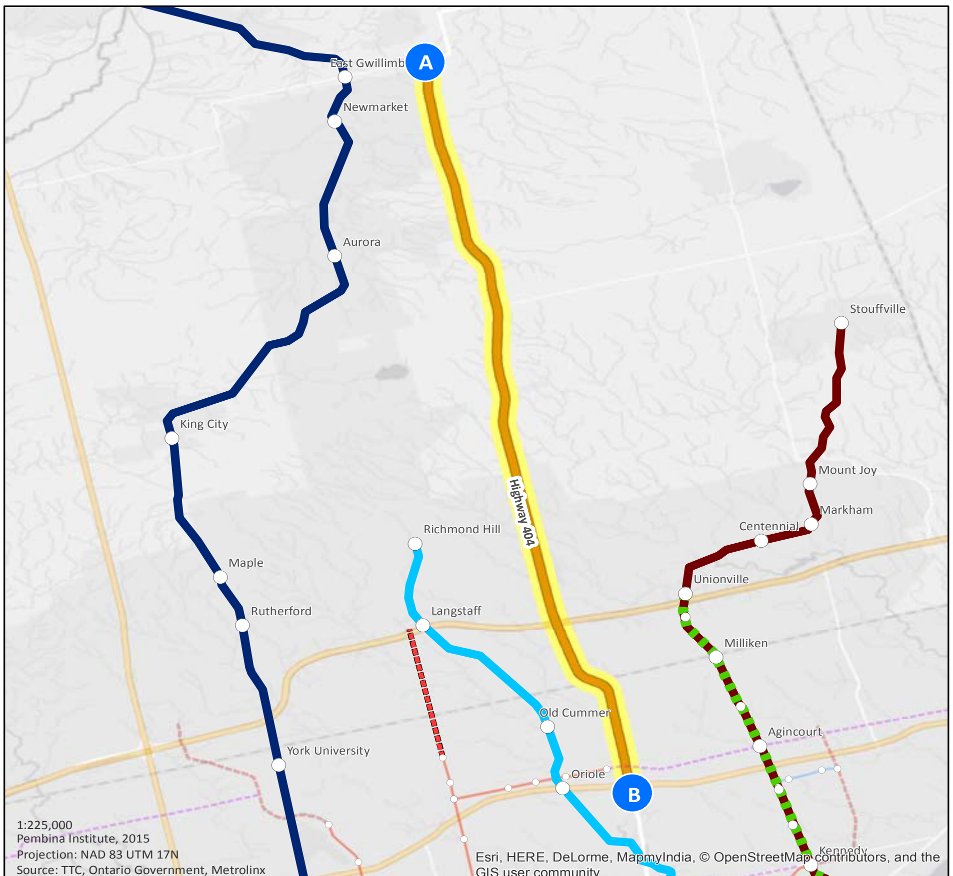


Highway 404

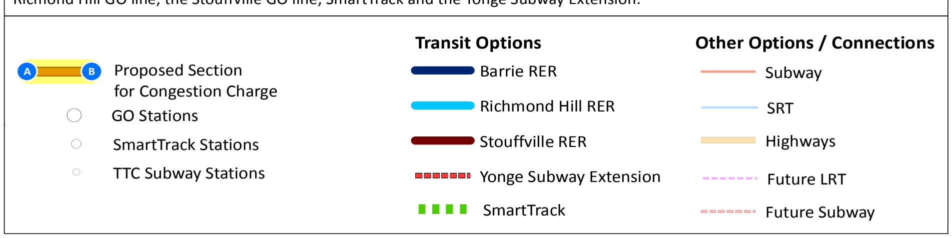
Transit alternatives to Highway 404 segment:

- Barrie RER
- Richmond Hill RER
- Yonge subway extension
- Stouffville RER linked with SmartTrack

Highway 404 2031



The 37 km long segment of Highway 404 from East Gwillimbury to the Don Valley Expwy corresponds with the Barrie GO line, the Ricmond Hill GO line, the Stouffville GO line, SmartTrack and the Yonge Subway Extension.

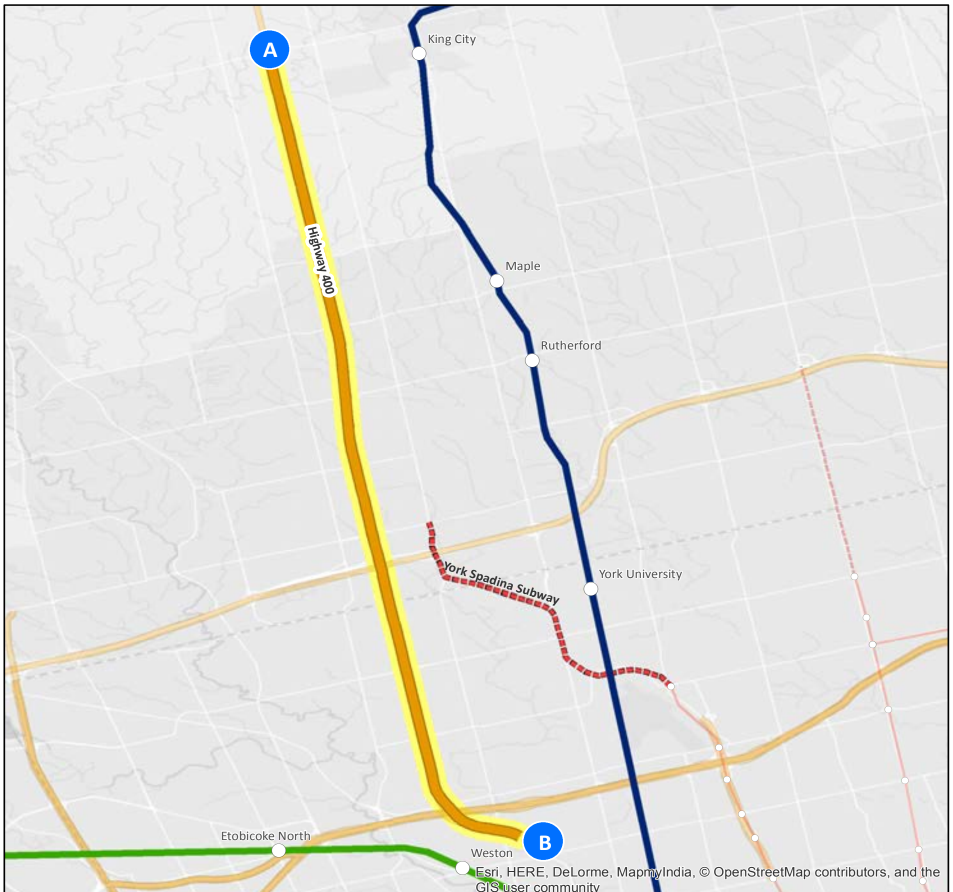


Highway 400

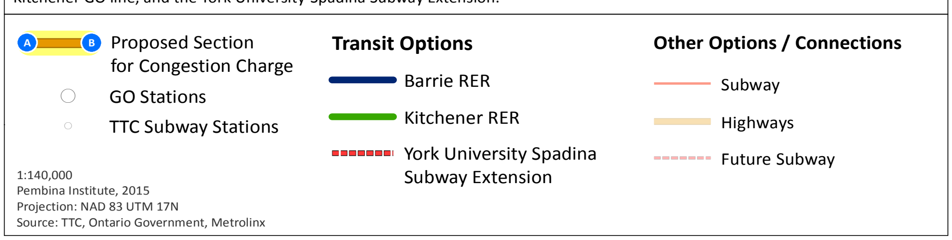
Transit alternatives to Highway 400 segment:

- Barrie RER
- York University Spadina subway extension

Highway 400 - 2031



The 25 km long segment of Highway 400 from King Rd (King City) to Highway 401 (Toronto) corresponds with the Barrie GO line, the Kitchener GO line, and the York University-Spadina Subway Extension.

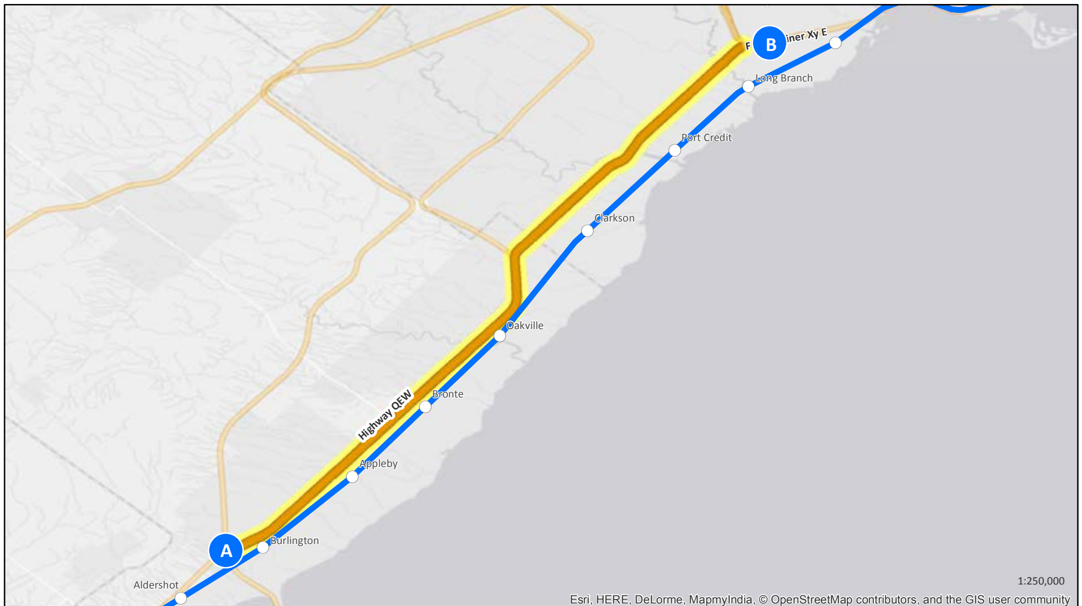


QEW

Transit alternatives to QEW segment:

- Lakeshore west RER

Queen Elizabeth Way - 2031



The 38 km long segment of Highway QEW from Highway 407 the Gardiner Expwy corresponds with the Lakeshore West GO line from Burlington Station to Long Branch Station.

Proposed Section for Congestion Charge

Lakeshore West

GO Stations

Other Options / Connections

Highways

Pembina Institute, 2015
Projection: NAD 83 UTM 17N
Source: TTC, Ontario Government, Metrolinx

Applying a regional price

As these rapid transit projects are built throughout the region, there is an increased opportunity to extend road pricing to the regional highway system. Since governments are investing billions of dollars of public money into rapid transit infrastructure, it is critical to build ridership to make the service cost-effective and ensure that the regional transit system is financially viable. Regional road pricing can assist in increasing ridership at a higher rate than through simple population growth by encouraging travellers to shift their travel mode.

A road price of $0.15/km during peak periods and $0.075/km during non-peak periods is applied across key highways. In its analysis of revenue tools for the Big Move, Metrolinx evaluated a maximum price of $0.10/km; $0.15/km is the inflation-adjusted equivalent in 2032. No non-peak price was evaluated by Metrolinx, so this scenario analysis set the non-peak price to half that of the peak price.

Two things should be noted: first, the (adjusted) higher price examined by Metrolinx is used here, as the main purpose of road pricing is to reduce traffic by having travellers switch modes, travel at different times, or perhaps not make a trip. As such, the higher price will assist in reducing traffic while encouraging residents to take advantage of the new public transit options. Second, these prices in 2032 are lower both in nominal and real terms than those analyzed in chapter five for Toronto-based highways in 2025.

Pricing GTA provincial highways

The highways analyzed are segments of highways 400, 404, and 401, and the QEW that correspond with current rapid transit options, transit projects set to come online by 2025 (e.g. SmartTrack) and *Big Move* projects that are projected to come online by 2031. See the maps above in this section. These highways should see traffic reductions due to mode switching by travellers after public transit service improves both in terms of availability and frequency. Road pricing on 400-series highways, owned by the province, and highways owned by Toronto does bring up governance questions, which are not within the scope of this study.

Results

The summary results are presented in Table 7 below, with all values in constant 2015 dollars. Traffic is predicted to be reduced significantly overall; all the facilities will be either below capacity or only slightly above. Traffic reduction is measured against traffic levels that would have existed without the increased transit options and without road pricing: i.e. against a business-as-usual scenario.

While results differ between highways, the average reduction is 21% during peak periods, and 25% during non-peak periods. The greatest reductions during the peak period occur on Highways 400 and 404 at 26% and 24%, respectively. Traffic will remain below the business-as-usual scenario largely due to greater availability of transit options and a significant amount of time — 15 years — during which those who previously chose to travel by private vehicle will have had time to potentially alter their travel behaviour.

The average that travellers will pay each day for a round trip during peak times is $7.43, which is offset by the average time savings per day of 20 minutes during peak periods, and an associated average daily time value savings of $7.47. During the non-peak period, the comparable cost to travellers is $3.72, while the average daily time saved is 24 minutes per round trip, valued at $3.55. The highest total charge paid is for Highway 401 at $14.63, as it encompasses the greatest distance covered by the road pricing (190 kilometres). The combined value of travel time savings and savings from vehicle fuel and maintenance costs across all relevant segments will exceed the out-of-pocket cost of the road price both during peak and non-peak times. In terms of fuel and maintenance savings, on average, the savings from avoided round trips will be $38.15; for trips that are made, on average, travellers will save $8.20 per round trip each day during peak times, and $8.77 during non-peak times.

On average, with the expected reduction in traffic accidents along these four highways, daily road safety savings are estimated to average $130,401 during the peak period, and $740,413 during the non-peak period, or over $1.2 billion per year.

Similarly, the average per round trip GHG emissions reduction is expected to be 423,346 kg during peak periods per day across all these facilities, and the non-peak period reduction is estimated to be 2,403,750 kg. These values translate to an annual GHG emission reduction of over 3.9 billion kg of CO_2.

Health benefits are estimated to average $23,189 per day across all vehicles along these facilities during the peak periods, and $131,621 during the non-peak periods. These estimates are denominated in constant 2015 dollars; they are greater than those for 2016 due to fewer cars being driven. The annual health benefit will be over $215 million across all vehicles, on these facilities, in real terms.

Generated revenues are estimated to average $561,476 across these highways per day during peak periods, and $1,355,638 during non-peak periods in constant 2015 dollars, with an annual value of over $2.5 billion.

Table 7. Quantified results of broader road pricing in the GTA in 2032

	401		404		400		QEW		AVERAGE
	Peak Period*	Non-Peak Period*	Peak Period*	Non-Peak Period*	Peak Period*	Non-Peak Period*	Peak Period*	Non-Peak Period*	Peak/Non-Peak
Reduced traffic (Per day)	19%	21%	26%	31%	24%	28%	15%	19%	21%/25%
Reduced travel times (Minutes per vehicle/round trip/day)	25	29	18	21	21	26	16	19	20/24
Travel time savings (Per vehicle/round trip/day)	$9.34	$4.33	$6.73	$3.14	$7.84	$3.89	$5.98	$2.84	$7.47/$3.55
Fuel and vehicle maintenance savings for avoided trips (Per vehicle/round trip/day)	$75.11	$75.11	$29.25	$29.25	$18.18	$18.18	$30.04	$30.04	$38.15
Fuel and vehicle maintenance savings for trips (Per vehicle/round trip/day)	$16.15	$17.27	$6.29	$6.73	$3.91	$4.18	$6.46	$6.91	$8.20/$8.77
Safety improvements (Across all vehicles/day)	$356,263	$1,968,848	$122,461	$730,054	$17,654	$102,981	$25,225	$159,767	$130,401/$740,413
Reduced GHGs (CO_2 reduction across all vehicles/day (kg))	1,156,608	6,391,868	397,570	2,370,120	57,312	334,328	81,894	518,684	423,346/2,403,750
Health benefits (Across all vehicles/day)	$63,353	$350,003	$21,793	$129,773	$3,121	$18,288	$4,490	$28,419	$23,189/$131,621
Generated revenues (Per day)	$1,650,905	$4,025,333	$378,850	$883,133	$60,764	$143,917	$155,383	$370,168	$561,476/$1,355,638
Maximum charge paid (Per round trip/day)	$14.63	$7.32	$5.70	$2.85	$3.54	$1.78	$5.85	$2.93	$7.43/$3.72
Total private savings (Travel time savings+fuel and maintenance savings/round trip/day)	$100.59	$96.71	$42.27	$39.12	$29.93	$26.26	$42.48	$39.79	$53.82/$50.47

*Peak Period: Monday–Friday, 06:00–09:00 and 15:00–18:00. Peak period price: $0.15/km

Non-peak Period: Monday–Friday, all other times; weekends all day. Non-peak Period price: $0.075/km

All monetized values denominated in constant 2015 dollars

Appendix A: Methodology

Inputs

1. Price: The initial price of $0.14/km toll for the Gardiner and the DVP is the optimal price estimated in *Congestion Charging in the City of Toronto*, in 2015 prices.[41] At this price, Lightstone concluded that traffic would be relieved along the DVP and the Gardiner, resulting in reduced congestion and attendant benefits such as reduced travel times. The off-peak price of $0.10/km is within the range of off-peak prices used in other jurisdictions, relative to the peak price. The chosen toll for the peak period ($0.21/km) in 2025 is based on the research conducted by Finkleman,[42] where he concluded that respondents were willing to pay $0.20/km to avoid congestion along Highway 401 during peak periods. Again, the off-peak price of $0.17/km is also in line with off-peak prices used in other jurisdictions, relative to the peak price. For 2032, the peak price is based on a report for Metrolinx.[43]. In the report, a regional toll of $0.10/km is used; the $0.15/km rate is approximately equal to $0.10/km, but inflated to 2032. Given that the last analyzed scenario examines a toll on several regional highways, this rate was deemed the most appropriate. The non-peak rate of $0.075/km is half the peak rate.

2. Traffic: Traffic is defined to be the number of vehicles on the facility. The traffic data is from the 2001 Toronto Cordon Count, from the Data Management Group at the University of Toronto. The count data have been updated to current levels using the fact that traffic grew in Toronto by 5% between 2001–2010. Assuming similar growth in population and vehicle numbers, this factor was used to forecast traffic levels for the relevant years.

3. Several empirical studies were reviewed to determine an appropriate price elasticity of demand to employ in this study.[44] The estimates range from –0.01 to –0.48. Given that price elasticity of demand becomes larger in absolute terms over time as well as when the number of substitutes increase, the assumed price elasticity of demand becomes larger in future scenarios. Over time, people adjust their behaviour, thus initially a lower price elasticity of demand is assumed, but larger estimates are used (in absolute terms) as the time horizon increases. The exact price depends on various factors that influence the effectiveness of tolls, such as how sensitive drivers are to the toll price (or the price elasticity of demand with respect to the toll), the existence of non-tolled alternative routes, the availability of alternative travel modes and any behavioural change over time.

---

[41] Adrian Lightstone, *Congestion Charging in the City of Toronto: Distance Based Road Pricing on the Don Valley Parkway and Gardiner Expresswa*y, M.Sc. Thesis, Royal Institute of Technology, Stockholm, Sweden (2011).

[42] Jeremy Finkleman, *The HOT Solution: An Examination of the Desirability for High-Occupancy/Toll (HOT) Lanes in the Greater Toronto Area*, Master's Thesis, University of Waterloo (2010). https://uwspace.uwaterloo.ca/bitstream/10012/5151/1/Jeremy_Finkleman_Thesis.pdf

[43] *Big Move Implementation Economics: Revenue Tool Profiles.*

[44] A. Matas and J.L. Raymond, "Demand Elasticity on Tolled Motorways," *Journal of Transportation and Statistics*, 6 (2003); M.W. Burris, "The Toll Price Component of Travel Demand Elasticity," *International Journal of Transport Economics*, 30 (2003); California Environmental Protection Agency, Air Resources Board, *Impacts of Road User Pricing on Passenger Vehicle Use and Greenhouse Gas Emissions* (2014)

Several assumptions have been made to facilitate the analysis:

1. A 4% real discount rate is used, a value that lies between the recommended value of 3.5% as the appropriate social discount rate to be used in Canada[45] as well as the 5% real discount rate used by Metrolinx for transportation projects,[46] and used by the Ontario provincial government as the social discount rate for public projects.[47] Given that the low interest rates over the last few years are not expected to last, the 4% rate is a reasonable accommodation.
2. The values have been calculated in constant 2015 dollar values.
3. The number of weekdays per year is assumed to be 250.
4. Canadian historical values have been adjusted for inflation using Bank of Canada rates, or in the case of foreign currencies, with the corresponding central bank,
5. For future Canadian dollar values, 2% inflation has been used as it is the target rate for the Bank of Canada,
6. Highway 407 ETR-style electronic charging system,
7. Standard charge regardless of vehicle type or weight,
8. No account nor administration fees for drivers,
9. All capital costs for installation are made in the first year of operation.

Outputs

1. Traffic: The reduction in traffic quantity is estimated by multiplying the price elasticity of demand by the change in price due to the toll.
2. Vehicle kilometres travelled (VKT): This value is given by multiplying the number of vehicles by the distance of the facility under study. In the case of regional highways, the distance used is the number of kilometres of the facility for which there is a public transit alternative route.
3. Time savings: Time savings estimates are derived by estimating the number of drivers who stop driving due to the toll; this number is estimated using price elasticity of demand. The reduced number of vehicles was multiplied by minutes per kilometre factors drawn from the Conference Board of Canada study on time savings on the 407 ETR.[48] A monetary value of $31.80 per hour is used to value time during the peak periods, and $12.72 per hour is used for the non-peak periods, in 2016. The value of time during peak periods has been calculated based on 50% of the average wage rate in the Toronto region, scaled up by a factor of 2.5 to account for the increased cost of travelling in uncertain conditions due to increased traffic during these periods. The non-peak period value is based upon the peak period value of time, scaled down by 2.5; it is equal to 50% of the average hourly wage for the region. The dollar values are forecasted out to the years 2016, 2025 and 2032. These savings have been discounted to constant 2015 dollars.

---

[45] A. E. Boardman, M. A. Moore, and A. R. Vining, “The Social Discount Rate for Canada Based on Future Growth in Consumption.” Canadian Public Policy, 36 (2010).

[46] For example, see *Hamilton King-Main Rapid Transit Benefit Case.*

[47] P.S. Spiro, “The Social Discount Rate for Provincial Government Investment Projects,” in B.F. Burgess & G. Jenkins (Eds.) Discount Rates for the Evaluation of Public Private Partnerships (McGill-Queen’s University Press, 2010).

[48] Vijay Gill, James Knowles, *The Value of Travel Time and Reliability: An Analysis of Commuting on 407 ETR* (Conference Board of Canada, 2013). http://www.conferenceboard.ca/e-library/abstract.aspx?did=5913

4. Fuel and maintenance savings: For the purposes of this analysis, $0.54/km is used as the current price to drive a car in 2015, without the addition of road pricing. This is the per-kilometre operating cost in Ontario for a mid-size personal vehicle, as estimated by the Canadian Automobile Association,[49] forecasted for 2016, 2025 and 2032. This per-kilometre cost of operating and maintaining a vehicle includes fuel, insurance, license and registration, and maintenance costs. These savings have been discounted to constant 2015 dollars.
5. Road safety savings: These savings are largely related to human costs through fatalities and injuries, and related infrastructure repairs incurred by the city. The monetary value of this improved road safety is estimated to be $0.10/km,[50] forecasted to 2016, 2025 and 2032. The savings are estimated by multiplying this unit rate to the number of reduced VKT for the facility being examined. These savings have been discounted to constant 2015 dollars.
6. Reduced GHGs: Following Metrolinx, [51] an emission factor of 0.23 kg/km is used to estimate the reduction in CO_2, the most prevalent greenhouse gas emissions from vehicles. This factor is multiplied by the number of reduced VKT for the facility being examined.
7. Health benefits: The benefits are based on the range of $40–$93 (U.S.) per metric ton of carbon dioxide reduction by 2020.[52] A social discount rate of 3% was used to discount the 2020 value to 2016[53], and the result was converted to Canadian dollars.[54] The mid-point value of the above range is calculated. To derive a comparable figure for 2025 and 2032, the U.S. inflation rate between 2020 and 2025 is assumed to be 3%,[55] and the Canada-U.S. exchange rate is assumed to be $1.079.[56] To estimate the value of annual health care benefits, it is assumed that there are 250 charge days per year for the peak charge, and 365 days for the non-peak charge. These savings have been discounted to constant 2015 dollars.
8. Revenues: Revenue generated by road pricing is estimated by multiplying the peak price by the VKT during the peak periods along the facility being examined; similarly, the non-peak price ($0.10 per kilometre) is multiplied by the VKT during the non-peak periods along the facilities. To arrive at annual estimates, it is assumed that there are 250 charge days per year for the peak charge, and 365 days for the non-peak charge. These savings have been discounted to constant 2015 dollars.

---

[49] For a mid-sized vehicle in Ontario; retrieved from: Canadian Automobile Association, “Drivings Costs Calculator.” http://caa.ca/car_costs/

[50] Based on the 2004 Canadian Motor Vehicle Traffic Collision Statistics. Statistics Canada, “Canadian Motor Vehicle Traffic Collision Statistics: 2004.” T-45/2004. https://www.tc.gc.ca/eng/motorvehiclesafety/tp-tp3322-2004-menu-691.htm

[51] Metrolinx, *Dundas Bus Rapid Transit Benefits Case* (2010).

[52] John M. Balbus, et al., "A wedge-based approach to estimating health co-benefits of climate change mitigation activities in the United States," *Climatic Change* 127 (2014). http://dx.doi.org/10.1007/s10584-014-1262-5

[53] United States Environmental Protection Agency, “Discounting Future Benefits and Costs,” in *Guidelines for Preparing Economic Analyses* (2010). http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-06.pdf/$file/EE-0568-06.pdf

[54] Bank of Canada, January-June 2015 annual average monthly exchange rate, http://www.bankofcanada.ca/rates/exchange/monthly-average-lookup/, US$1 = C$1.23500745

[55] CIBC World Markets, *Interest & Exchange Rate Forecast*. http://research.cibcwm.com/economic_public/download/rates.pdf

[56] Bank of Canada, 10 year monthly average closing rate, 2005-2015. http://www.bankofcanada.ca/rates/exchange/monthly-average-lookup/

Appendix B: Case Studies

London

Goals

In February 2003, London implemented a cordon charge to reduce congestion within a specific area of central London. Although the charge was implemented primarily to reduce traffic and congestion,[57] it was used to meet four transport priorities: reduce congestion, improve bus service, improve journey time reliability for car drivers and improve goods movement.[58]

Price

The fee is applied once the vehicle crosses the border into the cordon zone; however, once inside the zone a vehicle can drive an unlimited distance. The initial fee of £5 has risen over the years and is currently £11.50 ($20.92).[59] It is in effect from Monday to Friday, 07:00 to 18:00, holidays excluded, and can be lowered through discounted methods or be higher if not paid promptly. While this rate has increased by 130%, inflation in the U.K. over this time period was 31%, as measured by the Consumer Price Index.

In order to provide an alternative to private cars, the introduction of the charge coincided with increased public transit services.[60]

Outcomes and benefits

Reduced congestion

In the first year, congestion was reduced by 30% and the number of vehicles travelling in the congestion zone decreased by 15%, without causing excessive congestion elsewhere in the network.[61] This change in traffic occurred due to diverted auto trips, with half switching to public transit, and only about a quarter to alternate road routes.

While congestion and traffic delays declined in the short and medium term due to the introduction of the cordon charge, factors such as population growth, vehicle exemptions and changes in the road network have led to a rebound in congestion levels. Thus, expanding and improving transit service continues to play a critical part in the city's strategy to continue reducing congestion by providing capacity for mode shifting.

---

[57] *Congestion Charge Factsheet.*

[58] *Central London Congestion Charging: Impacts Monitoring: Second Annual Report*

[59] All prices are in Canadian dollars.

[60] BBC News, "First Congestion Fines Go Out," February, 18, 2003. http://news.bbc.co.uk/2/hi/uk_news/england/2774271.stm, and *Central London Congestion Charging: Impacts Monitoring: Second Annual Report*.

[61] Transport for London, *Central London Congestion Charging: Impacts Monitoring: Sixth Annual Report* (2008). https://www.tfl.gov.uk/cdn/static/cms/documents/central-london-congestion-charging-impacts-monitoring-sixth-annual-report.pdf

In the long run, however, the picture is slightly different. Over the past 10 years, traffic has decreased by 10.2%,[62] but journey times for drivers did not improve further after 2007.[63] In fact, by 2008, average speeds had returned to pre-charging levels due to an increase in traffic from vehicles exempt from the charge and the diversion of part of the road network for the exclusive use of buses, pedestrians and cyclists.[64] While journey and reliability times did initially improve — traffic delays initially declined by 26%[65] — they have levelled off and have recently worsened due to growing population and economic recovery.

Nevertheless, traffic entering the charge zone is estimated to be 27% lower than it would have been if no cordon charge had been implemented, translating to 80,000 fewer cars each day.[66]

Mode shift

In Greater London, over the 10-year period from 2003 to 2013, the number of commuter train trips increased by 52%, while subway and light rail trips (the Underground and Docklands Light Rail) rose by 32%; cycle trips (as main mode) increased by 54%. Over the same period, car driver trips decreased by about 13%.

About 50% of the initial increase in bus ridership after the charge came into effect has been attributed to the cordon charge.[67] Additionally, cycling levels in the charge zone have increased by 66% since the introduction of the scheme.[68]

Air quality and safety

Reduced traffic volumes and increased circulation efficiencies due to the cordon charge resulted in approximately a 12% reduction in NO_x and PM_{10} emissions (24-hour annual average).[69]

In order to further improve air quality in London, in 2013 Mayor Boris Johnson announced a proposal to allow only zero and low-emission vehicles in the central charge zone by 2020.[70] The City of London has identified reducing deaths from long-term exposure to air pollution as one of the main motivations behind this strategy.[71]

With respect to safety, the cordon charge resulted in a 40-70% reduction in traffic accidents.

---

[62] Claire Timms, "Has London's congestion charge worked?" *BBC*, February 15, 2013. http://www.bbc.com/news/uk-england-london-21451245

[63] "Has London's congestion charge worked?"

[64] *Central London Congestion Charging: Impacts Monitoring: Sixth Annual Report.*

[65] *Central London Congestion Charging: Impacts Monitoring: Second Annual Report.*

[66] *Congestion Charge Factsheet.*

[67] *Central London Congestion Charging: Impacts Monitoring: Second Annual Report.*

[68] *Congestion Charge Factsheet.*

[69] *Central London Congestion Charging: Impacts Monitoring: Second Annual Report.*

[70] BBC, "Boris Johnson Announces Plans for Ultra Low Emission Zone," February 13, 2013. http://www.bbc.com/news/uk-england-london-21443439

[71] The City reports that in 2008, more than 4,000 deaths in London were due to such exposure. This initiative is part of the Mayor's Air Quality Strategy, which includes several other projects, such as buying lower emission buses for Transport for London, capping the age of the taxi and private hire fleet, and providing incentives to increase the demand for electric and low emission vehicles. London Mayor and Assembly, "Air quality and pollution." http://www.london.gov.uk/priorities/environment/clearing-londons-air

Revenue and transit investment

Revenues from the cordon charge were £235 million ($427 million) in 2013-2014, the last year for which figures are available, up almost 6% from the previous year, and representing almost 5% of Transport for London's total revenues for that period.[72] In the first 10 years of its existence, the charge raised net revenues in excess of £1 billion pounds ($1.8 billion).[73]

By law, revenue generated by the cordon charge must be invested in transport, which has improved public transit services. For example, investments in signals and new trains has reduced the need for night-time maintenance, allowing 24 hour service to be introduced on certain Underground lines in 2015. Additionally, in its 2014 report, Transport for London reported that public transit service quality is at "best ever" levels.[74]

Investment in public transit has been an important component in ensuring congestion levels remain within Transport for London's target range. For example, bus patronage has risen by 77% since 1999, partially due to reduced wait times for bus customers. Wait times have declined by 45%, as buses are able to run on time because of the reduced congestion.[75]

Stockholm

Goals

Stockholm permanently implemented a cordon congestion charge in central Stockholm in August 2007, after a trial period and a referendum. The charge was implemented primarily to raise revenues to invest in roads and public transit, but also to improve the environment and relieve traffic issues in the inner city.[76] It was designed as part of a larger, more comprehensive, partially government-funded transport investment package.

Price

The cordon charge is a time-varying charge that is levied for each crossing in any direction.[77] Officially, the charge is a congestion tax, and is tax deductible.[78]

The congestion charge is in effect Monday–Friday, 06:00–18:30. It is not charged on holidays and days before holidays, or in the month of July. Almost 15% of vehicles, such as buses, are exempt.[79] The fee schedule is given in Table 8. The maximum daily charge is 60 Swedish krona (SEK) ($9.68).[80], [81]

---

[72] Transport for London, *Annual Report,* 2013-2014. http://www.tfl.gov.uk/cdn/static/cms/documents/annual-report-2013-14.pdf

[73] "Has London's congestion charge worked?"

[74] Transport for London, *Travel in London: Report 7* (2014). https://www.tfl.gov.uk/cdn/static/cms/documents/travel-in-london-report-7.pdf

[75] *Travel in London: Report 7*

[76] "Lessons from the Stockholm congestion charging trial,"

[77] Jonas Eliasson, "Cost-Benefit Analysis of the Stockholm Congestion Charging System," *Transportation Research A* 43 (2009) http://www.sciencedirect.com/science/article/pii/S0965856408002140

[78] European Commission, "Milan: Lessons in Congestion Charging." http://ec.europa.eu/environment/ecoap/about-eco-innovation/good-practices/italy/20130708_milan-lessons-in-congestion-charging_en.htm

[79] Jonas Eliasson, *The Stockholm Congestion Charges: An Overview,* CTS Working Paper 2014:7 (Centre for Transport Studies, 2014). www.transportportal.se/swopec/CTS2014-7.pdf

Table 8. Congestion charge schedule for Stockholm

Time	Congestion Charge (SEK)	Congestion Charge ($ Cdn)[82]
06:30–07:00	10	1.61
07:00–07:30	15	2.42
07:30–08:30	20	3.23
08:30–09:00	15	2.42
09:00–15:30	10	1.61
15:30–16:00	15	2.42
16:00–17:30	20	3.23
17:30–18:00	15	2.42
18:00–18:30	10	1.61

Outcomes and benefits

Reduced congestion

Congestion has reduced every year since the introduction of the charge. Relative to the base year, traffic volumes initially decreased by 22% when the trial first began.[83] After the trial period was over, traffic volumes remained 5–10% below the base year of 2005 as some car users persisted in their new travel patterns.

After the charge was permanently re-introduced, traffic was lower by an average of 19.7% each year between 2007 and 2013, compared to the base year of 2005. This is similar to levels that existed in the 1970s. Thus, traffic volumes appear to have been permanently reduced due to the congestion charge, despite economic growth, increasing population and a growing car fleet.[84] In total, the number of private trips declined by 30%, and the number of vehicle kilometres driven in the charge zone decreased by around 16%. In fact, studies confirm indications that the benefits from the congestion charge are increasing over time, resulting in ongoing improved congestion conditions.[85]

Traffic declined most during the peak hours, both morning (07:00–09:00) and afternoon (16:00–18:00) when charges varied between SEK 15 ($2.42) and SEK 20 ($3.23). During the non-peak daytime hours (09:00–15:30), traffic volumes declined by about 22%. This significant reduction is partially explained by the fact that many of these mid-day trips pay a higher charge when leaving the cordon later in the afternoon.

Traffic also declined in the evening, when there is no charge, since there are now fewer incoming vehicles in the morning and day that would leave in the evening. It appears that the decline in the number of trips now

---

[80] In 2014, an agreement has been reached to substantially increase the charge, using the revenues to improve build a metro extension and reduce congestion further.

[81] All prices are in Canadian dollars.

[82] Bank of Canada, 2014 annual average monthly exchange rate, http://www.bankofcanada.ca/rates/exchange/monthly-average-lookup/, C$1 = SEK 6.1972

[83] Börjesson et al., *The Stockholm Congestion Charges — Five Years On: Effects, Stability and Lessons Learnt,* CTS Working Paper 2012:3 (Centre for Transport Studies, 2012) www.vti.se/Global/Swopec test/CTS 2012.3.pdf

[84] *The Stockholm Congestion Charges: An Overview.*

[85] *The Stockholm Congestion Charges — Five Years On.*

being made during the day, with the resulting decrease in outbound evening traffic, has offset any increase in traffic to the evening hours when there is no charge.

Surprisingly, the positive traffic effects have also occurred outside the charge zone. For instance, on the outlying approach roads and streets, traffic volumes have fallen by just over 5%. The expected increase of traffic on circumferential roads at the city's outskirts has not materialized as queuing times have declined by 30 to 50%.

In fact, this reduced congestion has translated into significantly improved travel time and travel time reliability, both within the city and roads close to the inner city. Morning and evening peak delay times on arterial roads declined by one-third and one-half, respectively. Moreover, during the afternoon peak, the top 10 worst travel times on arterial roads fell to a third or less of previous levels.[86]

Mode shift

Car drivers appear to have changed modes and travel times as well as destinations. Some exploratory research indicates that 25% of trips across the cordon no longer occurred after the charge came into effect. Out of these reduced trips, about 10% were commuters who switched to public transit. Another 1% of the 25% took an alternate charge-free bypass route. An additional 6% of these "vanished" trips were discretionary trips where drivers chose another destination or reduced the frequency of their trips[87]; a further 1% of these discretionary trips also chose to take the charge-free bypass. The remaining traffic was commercial traffic — deliveries, trades, etc. — where the businesses re-planned their trips to minimize the number of crossings into the cordon.

Initial studies revealed that all drivers who switched to public transit caused total transit ridership to increase by only 4–5%. Nevertheless, due to fewer cars in the zone, both bus speed and punctuality improved noticeably. Moreover, the added bus capacity along key corridors likely helped to minimize extra crowding on commuter trains.

Air quality and safety

As with London, the reduction in traffic and congestion translated into improved environmental quality from a decline in emissions. In the inner city, airborne pollutants declined by 10–14%. Nitrogen oxides (NO_x) declined by 8.5%, while carbon dioxide decreased by 2–3% across the metropolitan area. An early study estimated that there will be 20 to 25 fewer premature deaths annually due to the improved air quality; this benefit is mainly possible because the reductions are in an area with high population density during the day, resulting in important reductions in average population exposure.[88]

A comprehensive benefit cost analysis estimates the value of improved safety through prevention of personal injury to be SEK 125 million ($20 million).

Revenue and transit investment

In the first few years, annual revenues were just over SEK 800 million ($129 million); but several exemptions were removed, so that by 2013, annual revenues had increased to around SEK 850 million ($137 million).[89]

[86] *The Stockholm Congestion Charges: An Overview*, 11.

[87] *The Stockholm Congestion Charges: An Overview.*

[88] *The Stockholm Congestion Charges: An Overview.*

[89] *The Stockholm Congestion Charges: An Overview.*

Alternative fuel cars were initially exempt to stimulate their introduction to the market; this seemed to be successful, as the share of alternative fuel cars increased from 3% in 2006 to 15% by 2009, when the exemption was removed.[90]

Annual operating costs have steadily declined since the trial, as cost-cutting lessons have been learned and implemented, increasing how much can be spent on improving the road network and public transit.[91]

Public transit service was improved prior to the implementation of the congestion charge to provide an alternative; the improved services included 200 additional buses, 16 new bus lines, and increased frequency of bus, subway and commuter trains. Additionally, the park and ride capacity was increased by 25%.[92]

Revenues from the congestion charge are invested in public transportation service and capacity, including expanding and connecting the LRT system regionally through three suburbs.[93]

Ontario: 407 Express Toll Route

Goals

Residents of the GTHA are familiar with the 407 Express Toll Route (ETR), a 107-kilometre highway that runs east–west, parallel to Highway 401, from Burlington to Pickering. The 407 ETR provides a faster alternative to the non-tolled provincial highways in the GTHA, primarily Highway 401. The highway was originally built by the province in response to congestion on Highway 401 to provide more capacity, and tolls were introduced to pay for its construction. However, the facility was sold to a private operator in 1997.

The objective of the operating company, 407 International — as with any private firm — is to maximize profits while efficiently operating the 407 ETR, providing users with a safe, fast and reliable trip.

When it opened in 1997, the 407 was the world's first all-electronic, barrier-free toll highway; it was completed in 2001. The province chose Canadian Highways International Corporation (CHIC), of Mississauga, as its private partner to design, build, operate and maintain the $1.6 billion facility.[94] Originally, both the provincial government and CHIC earned revenues from the highway. In 1999, the province sold the highway to a consortium[95] for $3.1 billion, plus $900 million for future construction and working capital.[96] The total costs, however, such as buying the required land, has been estimated to be $104 billion.[97]

---

[90] Several studies concluded that the congestion charge exemption played a significant role in this increase. This exemption was removed partially due to the questionable environmental benefits of ethanol vehicles. *The Stockholm Congestion Charges: An Overview.*

[91] Due to operational accounting measures, the operating costs for Stockholm cannot be distinguished from those for Gothburg, another Swedish city where a cordon charge scheme has been implemented. In 2014, the combined costs for both systems was SEK 250 million ($40 million).

[92] "Lessons from the Stockholm congestion charging trial."

[93] Stockholms läns landsting, *Future-bound on board the new Metro* (2014). http://www.sll.se/Global/Verksamhet/Kollektivtrafik/Aktuella%20projekt/Nya%20tunnelbanan/bilagor-tunnelbana-mot-framtiden-engelska.pdf

[94] Jim Trautman, "Did Ontario Taxpayers Get Taken for a Ride on Highway 407?" *Eye Weekly*, May 11, 2000. https://web.archive.org/web/20140809201044/http://contests.eyeweekly.com/eye/issue/issue_05.11.00/news/407.php

[95] Currently, the consortium consists of Cintra, the Canada Pension Plan and SNC-Lavalin. Some analysts speculated that SNC-Lavalin's stake could be worth $3 billion when it announced plans to sell its share in Fall 2014.

The highway is a private facility, so is not part of the provincial highway network, and is operated under a 99-year lease agreement with the provincial government. 407 International is responsible for all maintenance, construction and customer service and also pays the full cost of police enforcement along the highway.

Price

The toll rates and structure have changed since the highway first opened. Currently, the toll rate varies by time of day, distance travelled, day of week, vehicle type and highway zone; it is in effect 24 hours, Monday–Sunday. Discounted holiday rates are in effect for statutory holidays. The highway is divided into two zones, a larger "regular zone" and a smaller "light zone", each with two different rates as shown in Table 9. The rates provided are for light vehicles (5000 kg and under); heavier vehicles pay double or triple these rates. New for 2015, morning and evening rates differ, accounting for different volumes during these times. There are several additional trip charges and fees on top of the per-kilometre rate.

Table 9. Current 407 ETR toll rates for light vehicles

	Toll rate (cents per km)
Regular Zone Rate	
Peak period (AM) Mon-Fri: 06:00–07:00, 09:00–10:00	30.56
Peak hours (AM) Mon-Fri: 07:00–09:00	34.13
Peak period (PM) Mon-Fri: 15:00–16:00, 18:00–19:00	31.13
Peak hours (PM) Mon-Fri: 16:00–18:00	34.73
Light Zone Rate	
Peak period (AM) Mon-Fri: 06:00–07:00, 09:00–10:00	29.05
Peak hours (AM) Mon-Fri: 07:00–09:00	32.43
Peak period (PM) Mon-Fri: 15:00–16:00, 18:00–19:00	29.59
Peak hours (PM) Mon-Fri: 16:00–18:00	33.01
Midday rate (entire highway) Weekdays 10:00–15:00	25.75
Midday rate (entire highway) Weekends & Holidays 11:00–19:00	23.59
Non-peak rate (entire highway) Weekdays 19:00–06:00, Weekends & Holidays 19:00–11:00	19.74

The toll rates and structure have changed since the highway first opened. Initially, rates varied by time of day, distance travelled and vehicle type. The initial toll rates for light vehicles was $0.10/km during peak periods, $0.07/km for non-peak and $0.04/km during late night and early morning. The peak toll rate has increased in

Vanessa Lu, "SNC-Lavalin says time is right to sell Highway 407," Toronto Star, August 8, 2014. http://www.thestar.com/business/2014/08/08/snclavalin_suffers_revenue_drop_still_makes_profit.html

[96] www.roadtraffic-technology.com, "407 Express Toll Route (ETR), Ontario, Canada." http://www.roadtraffic-technology.com/projects/407/

[97] Ontario Legislature, October 21, 1998 (E.J. Douglas Rollins). http://hansardindex.ontla.on.ca/hansardeissue/36-2/l047.htm

nominal terms by 224% during the morning peak period, and 230% during the afternoon peak period.[98] The inflation rate for Ontario over that period was 36%, as measured by CPI.[99]

Outcomes and benefits

Reduced congestion

The 407 ETR alleviates traffic primarily on Highway 401 and the Queen Elizabeth Way (QEW). In 2010, the last year for which comparable figures are available, there were an average of 380,000 workday trips;[100] in terms of VKT, this is about 28% of traffic on the 401.[101]

The highway lease with the province requires the 407 ETR to attract and maintain certain levels of traffic. If these levels are not met, a congestion payment is due to the provincial government. To date, one payment has been made, in 2003, for almost $29 million.[102]

Savings

While no emissions or mode shift estimates have been published, fuel savings were estimated to be a minor 0.4 L/100 km, or about 5%; fuel efficiencies were greater in the afternoon than morning. This finding is consistent with the fact that afternoon trips on un-tolled routes are less reliable and have more congestion than morning trips. Driving in less-congested conditions reduces vehicle operating costs. Using the 407 ETR for the average morning commute saves the vehicle owner about $5.10 per 1000 kilometres, and using the 407 ETR in the evening saves the driver $7.80 per 1000 kilometres in wear and tear on the vehicle.

With respect to travel speed, the average morning commute speed on the 407 ETR is estimated to be 72 km/hr, while the alternative un-tolled speed is 61 km/hr, a difference of 18%. The evening speed improvement is higher at 21%, with average speeds on the 407 ETR being 72 km/hr also, while the un-tolled alternative was 57 km/hr. [103] The Conference Board of Canada estimates that using the 407 ETR saves users about 26 minutes per day, for a value of travel time savings to be $25/hr. Travel times are slightly higher in the afternoon than morning.

Safety data in terms of reduced accidents are not published by 407 International, Inc., the owner of the 407 ETR.

---

[98] An average of the peak period and peak hour charges was used for the period 06:00–09:00 ($0.3235/km), and 15:00–18:00 ($0.3293/km) to be comparable with other jurisdictions.

[99] Statistics Canada, Consumer Price Index (CPI) statistics, monthly, Table 176-003. http://www5.statcan.gc.ca/cansim/a26?lang=eng&retrLang=eng&id=1760003&paSer=&pattern=&stByVal=1&p1=1&p2=-1&tabMode=dataTable&csid=

[100] 407 International, "Facts & Stats." http://www.407etr.com/about/background-information2.html

[101] Vijay Gill, James Knowles, *The Value of Travel Time and Reliability: An Analysis of Commuting on 407 ETR* (Conference Board of Canada, 2013). http://www.conferenceboard.ca/e-library/abstract.aspx?did=5913

[102] 407 ETR, "The World's First All-Electronic Open-Access Toll Highway," presentation at 12th Annual BMO Infrastructure & Utilities Conference, February 5, 2015, 14. http://www.407etr.com/Documents/407%20International%20BMO%20Infrastructure%20and%20Utilities%20Conference%20Feb%205%202015.pdf

[103] *The Value of Travel Time and Reliability*

Revenue and transit investment

407 International, the operating company, reports that the average revenue per trip it earns has consistently risen: $5.44 in 2010, $5.89 in 20111, $6.39 in 2012 and $6.96 in 2013.[104] These values are reflected in the latest revenues reported by the consortium. In 2014, 407 International reported revenues of $887.6 million, compared to $801.2 million for 2013, an increase of almost 11%. Net income, however, has declined, from $248.7 million in 2013 to $222.9 million in 2014, a 10% decrease.[105]

Due to the private nature of the consortium, no revenues are allocated to public transit. The consortium has, however, invested in expansion and upgrades over the years. Since 1999, the consortium has invested over $1.4 billion in the facility. For example, new lanes were opened in both 2012 and 2014.

The Province of Ontario has initiated extensions eastward with the Highway 407 East phase one and two projects. The province will receive toll revenue and set toll rates.[106] Phase one will be completed in 2015 at a cost of $1.2 billion.[107] The construction cost of phase two has yet to be determined. At the time of writing, neither a toll policy nor toll rates have been announced.

Southern California: State Route 91 Express Lanes

Goal

California's State Route 91 Express Lanes tolls are the first example of peak/non-peak congestion pricing in the U.S,[108] implemented in 1995. The toll lanes are in the median of the existing highway; the 16 km stretch parallels the most heavily congested portion of the approximately 48 km corridor from the fast growing suburbs of Riverside County to job centres in Orange County.[109]

Although the express toll lanes were originally constructed and operated by a private company through a 35-year lease granted by the state, the facility was bought by the Orange County Transit Authority (OCTA) — a public agency — in 2003, less than a decade after the lanes opened. OCTA shifted the goals for the lanes somewhat away from purely generating profits for the private firm, to also increase ridesharing. The goal of these lanes is to reduce congestion along this route; they provide drivers the option of paying a fee to drive in the tolled lanes to bypass the congestion.

---

[104] "The World's First All-Electronic Open-Access Toll Highway," 15.

[105] 407 International, "407 International Reports 2014 Results," news release, February 12, 2015. http://www.407etr.com/about/news-release/news-release2015-02-12.html

[106] Highway 407 East, "Design." http://www.highway407east.com/project-info/project-facts/design/

[107] 407 East, "Project Overview." http://www.407eastphase1.ca/project-overview/

[108] Marlon G. Boarnet and Joseph F. Dimento, *The Private Sector's Role in Highway Finance: Lessons From SR 91* (University of California Transportation Center, 2004). http://www.escholarship.org/uc/item/9q69608s.pdf

[109] Conceptually, Ontario's proposed HOT lanes are different than tolled lanes on SR 91. HOT lanes convert a previously untolled lane into a user pay lane if the HOV requirements are not met. With the SR 91, all lanes are tolled but HOV3+ users receive a subsidy; the value of the subsidy is the full price of the toll (they drive for free), except peak PM hours, going east, when they pay 50%.

With that as the primary objective, time-varying tolls were implemented on the express lanes to ensure that traffic remained free flowing.[110] The current toll policy explicitly states five goals:

- provide customers a safe, reliable, predictable commute
- optimize throughput at free-flow speeds
- increase average vehicle occupancy
- balance capacity and demand, thereby serving both full-pay customers and car poolers with three or more people who are offered discounted tolls
- generate sufficient revenue to sustain the financial viability of the 91 Express Lanes.

Price

The toll facility has two lanes in each direction, separated from four adjacent general purpose lanes. It is an express facility with no intermediate exits or entrances. Heavy vehicles and vehicles towing trailers are prohibited, though motor homes and buses are permitted.

The toll rate varies by time as well as direction, and is in effect 24 hours, Monday to Sunday. A holiday toll schedule is in effect for statutory holidays as well as certain traffic-heavy days such as Mother's Day; these schedules are priced to reflect holiday traffic conditions.[111] In 2003, the toll policy was amended to allow ridesharing with three or more persons (HOV3+), zero emission vehicles, motorcycles, vehicles with disabled plates and disabled veterans to use the lanes free of charge, except Monday to Friday, 16:00–18:00 in the eastbound direction, when they pay 50% of the published toll.[112]

Also in 2003, OCTA based its toll policy on the concept of congestion management pricing, which is designed to optimize 91 Express Lanes traffic flow at free-flow speeds. To accomplish this, OCTA monitors hourly traffic volumes. Tolls are adjusted when traffic volumes consistently reach a trigger point where traffic flow may become too congested. These are known as "super peak" hours. Given the capacity constraints during these hours, pricing is used to ration the facility to meet demand. Once an hourly toll is adjusted, it is frozen for six months. Other (non-super peak) toll prices are adjusted annually by inflation.[113]

As of July 2014, the lowest hourly rate is US$1.45 ($1.60[114], or $0.10/km)[115] at midnight in either direction, and the highest is US$9.85 ($10.88) at 15:00, eastbound, or approximately US$0.99 per mile ($1.75/km).[116] Over this 19-year period, the lowest rate has increased 480%, while the highest rate increased by 294%. The inflation rate for the state of California over this same period was 60%, as measured by the CPI.

---

[110] Edward Sullivan and Mark Burris, "Benefit-Cost Analysis of Variable Pricing Projects: SR-91 Express Lanes," *Journal of Transportation Engineering*, 132 (2006). http://ascelibrary.org/doi/abs/10.1061/%28ASCE%290733-947X%282006%29132%3A3%28191%29?journalCode=jtpedi

[111] 91 Express Lanes, "Toll Schedules." http://www.91expresslanes.com/schedules.asp

[112] OCTA, *91 Express Lanes Toll Policy*, July 14, 2003. http://www.octa.net//pdf/RevFinalTollPolicy7-30-03_v7.pdf

[113] 91 Express Lanes, "Toll Policies." http://www.91expresslanes.com/policies.asp

[114] Unless noted otherwise, all prices are in Canadian dollars.

[115] Bank of Canada, 2014 annual average monthly exchange rate, http://www.bankofcanada.ca/rates/exchange/monthly-average-lookup/, US$1.00 = C$1.10483917

[116] Various discounts are available, for example through frequent user programmes. 91 Express Lanes, "Toll Schedules."

Outcomes and benefits

Reduced congestion

In the short run, the toll lanes resulted in dramatic reductions in peak-period travel times. Typical peak-period delays before the lanes were built were 30 to 45 minutes, but fell to five to 10 minutes per trip after the toll lanes opened. Travel time for the eastbound afternoon peak trip on an 18-mile (29 km) portion of SR 91 that included the toll lane corridor dropped from 70 minutes in June 1995 to just under 30 minutes in June 1996. Average peak-period travel speeds on the eastbound free lanes more than doubled as traffic diverted to the toll lanes.[117]

Subsequently, however, delays increased such that during the first half of 1999, travel time delays returned to about 30 minutes in the afternoon peak and slightly less in the morning peak. Travel times improved again when toll rates were raised as part of variable pricing, diverting some traffic to the publicly operated Eastern Toll Road. The latter facility opened in October 1998, and operates in direct competition with the SR 91 Express Lanes for traffic between Riverside County and the major employment centres southwest of SR 91.[118] Additionally, after OCTA purchased the facility, it widened the non-tolled adjacent lanes and added two additional non-tolled lanes to the corridor.[119]

Despite growing population, and year over year increases in customers and revenues, OCTA reports that traffic still moves well, resulting in high levels of customer satisfaction — 91% in 2014.[120] Unlike the cordon charge in London and Stockholm, the number of drivers and trips continues to increase along the SR 91, meeting the requirements that OCTA attract enough users to generate revenues to service financing.[121] So, the agency is torn — on the one hand it needs more users to collect more revenue, but on the other hand, it also wants more people in each car, and more people to use transit, both of which decrease its revenue stream. For example, the average number of trips rose in 2014 from 2.7 to 3.9 per week, alleviating congestion on the non-tolled lanes on SR 91. Since 2003, when OCTA bought the facility, 144 million trips have been diverted from the non-tolled lanes.

Mode shift

Since the facility runs between counties, and each county has its own transit system, no specific county or city bus runs along it — there are no public bus alternatives for mode shifting on the lanes. With respect to ridesharing, OCTA had originally planned to build high occupancy vehicle lanes (carpool or HOV) in the median of the existing highway — not a tolled expressway. But, due to limited state budgets, the lanes were constructed and operated by a private company.

---

[117] *The Private Sector's Role in Highway Finance.*

[118] "Benefit-Cost Analysis of Variable Pricing Projects."

[119] Peter Samuel, "CEO 91 Express operator writes to Washington Times on benefits of tolls," *Toll Roads News*, December 10, 2011. http://tollroadsnews.com/news/ceo-91-express-operator-writes-to-washington-times-on-benefits-of-tolls

[120] This satisfaction is reflected in an increase in both commute and discretionary trips. Currently, about 60% of customers use the facility to commute to work; but in terms of trip type, 67% of users used the facilities to visit family or friends, and 63% for shopping or recreation. The average number of trips rose in 2014 from 2.7 to 3.9 per week. 91 Express Lanes, *2014 91 Express Lanes Annual Report*, 7. Available at http://issuu.com/octamarketing/docs/2014_annual_report_all_pages

[121] OCTA requires revenues to help pay the bonds and pay for maintenance and expansion.

Overall the number of HOV3+ vehicles travelling along the corridor has remained constant.[122] Recent studies on the effect of these express toll lanes on transit use are unavailable; total public transit ridership in the corridor amounted to less than 1% of the highway traffic, and therefore was not considered in the 2006 benefit-cost study.

Air quality and safety

It's estimated that emissions have worsened due to the faster speeds that traffic travels at; estimates for eastbound afternoon peak traffic along the 14-kilometre stretch where congestion levels are the highest, were 4.95 metric tonnes of carbon monoxide and 0.72 metric tonnes of NO_x per day. The comparable values without the express toll lanes were estimated to be 3.48 (CO) and 0.57 (NO_x).

Despite limited quantification of environmental benefits, OCTA has committed to reducing GHG emissions as it expands the facility, simply because it has no choice. The SR 91 currently carries more than 280,000 vehicles daily. Traffic volume is forecast to reach 420,000 vehicles daily by 2035, far exceeding the capacity of the highway's original 1960s design.[123] Consequently, OCTA has joined efforts with other county transportation authorities to extend the express toll lanes along with public transit services via the 91 Project, explained in more detail below.

Collision trends were initially monitored but no significant differences were noted between the free lanes and the express lanes, so potential safety benefits have not been quantified. What is known, however, is that collision rates on eastbound 91 are higher than the state-wide average, with rear-end collisions being most common. The 91 Project is expected to reduce traffic congestion and stop-and-go conditions that lead to these types of collisions.

Savings

Despite congestion growing on the SR 91, a detailed benefit-cost study[124] showed that benefits from the express toll lanes grew to $34.9 million by 2005, with an overall estimate of the net present value in terms of vehicle travel time saved to be $171.3 million between 1996 and 2005.[125] The cost of eastbound daily delays during the afternoon peak period was estimated to be $216,000 in 2005 travelling along the corridor if the toll lanes had not been built, while the same delay cost was estimated to be $82,000 travelling on the toll lanes. Thus, in 2005 the toll lanes provided a travel time benefit of $134,000 per day.

---

[122] The number of 'carpool' vehicles with three ore more passengers in the toll lanes appears to have declined relative to the years when HOV3+ vehicles were initially not charged a toll. When the SR 91 toll lanes initially opened, the number of peak period vehicles with three or more passengers increased by 40%. This figure declined after the 50% rate was implemented; nevertheless, it appears that the vehicles began to use the adjacent free lanes instead, so that the overall number remains constant.

[123] 91 Project, *Metrolink & the 91 Project: Your Commuting Connection*.
http://www.sr91project.info/media/upload/oheycmp2cc.pdf

[124] "Benefit-Cost Analysis of Variable Pricing Projects."

[125] Edward Sullivan, *Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes*, produced for California Department of Transportation, 2000.
http://www.ops.fhwa.dot.gov/congestionpricing/value_pricing/pubs_reports/projectreports/pdfs/sr91_expresslanes.pdf

Revenue and transit investment

The effect of the toll policy has been to increase customer usage along with sufficient revenue to pay all expenses and also to provide seed funding for general freeway improvements. Revenues generated by the toll lanes are invested in the SR 91 corridor.[126]

In 2013-2104, revenues increased by 8% over the previous year, to US$42,610,000 ($47,077,000), while operating costs were US$18,541,000 ($20,484,000).[127] Between 2003 and 2014, OCTA has spent US$22 million ($24.3 million) in SR 91 toll revenues on road improvements and extensions.[128] Additionally, in 2014, OCTA joined efforts with the Riverside County Transportation Commission to extend the express toll lanes almost 13 km eastward to Riverside County, in an ambitious US$1.3 billion project called the 91 Project. Toll revenue bonds, augmented by federal, state and local sources, fund this project.[129]

The 91 Project investment is expected to reduce air pollution emissions caused by vehicles stuck in traffic by improving travel operations with new lanes, ramp metering, auxiliary lanes, interchange reconstruction, traffic signal coordination and promotion of ridesharing. Better air quality is also expected to result from increased access to public transit systems and improved traffic flow.

The project will nearly double the amount of express bus service now offered along the SR 91 corridor by adding 20 additional express bus trips each day. Moreover, the project is investing in commuter rail service by improving access and reducing congestion near the stations of two commuter rail lines, making the train a more attractive commuting alternative. In addition to expanding integration with regional public transit, the project will also expand integration with a 109 kilometre uninterrupted dedicated bike and pedestrian trail.

Governance plays an important role in how these lanes became successful in investing in transit to further encourage mode shift. Since the Orange County Transit Authority bought the facility[130] it has since been investing revenue in increasing ridesharing, increasing accessibility to public transit, and extending the highway to improve connectivity with public transit buses and commuter trains. And, as a public agency, they are monitoring and reporting on metrics like GHG emissions. By comparison, in Ontario, the province did not buy back the 407 highway, and the private company maintains a 99-year lease.

---

[126] 91 Express Lanes, "Toll Policies."

[127] *2014 91 Express Lanes Annual Report*.

[128] *2014 91 Express Lanes Annual Report*.

[129] 91 Project, *Fast Facts* (2014). http://www.sr91project.info/media/upload/obs0s1m1k6.pdf

[130] Marlon Boarnet et al., *Impacts of Road User Pricing on Passenger Vehicle Use and Greenhouse Gas Emissions, Policy Brief* (California Air Resources Board, 2014).
http://www.arb.ca.gov/cc/sb375/policies/pricing/road_pricing_brief.pdf

PEMBINA institute

pembina.org

pembina.org/subscription
email updates

twitter.com/pembina

www.facebook.com/pembina.institute