Appendix 8A

Approach to Cost Benefit Analysis

December 2010

METROLINX
An agency of the Government of Ontario

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APPENDIX 8A
APPROACH TO COST BENEFIT ANALYSIS

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1. INTRODUCTION

1.1 Scope of This Technical Note

This technical note presents the methodology employed to undertake the cost benefit analysis of the six preferred options, part of the detailed evaluation.

The key transportation benefits include:

- Existing user journey time savings;
- New user time savings;
- Non-user (highway) time savings;
- Reliability savings; and
- Auto savings.

The key cost elements include:

- Infrastructure Capital Costs;
- Rolling Stock Capital Costs; and
- Rolling Stock Operating and Maintenance Costs.

These benefits will be compared against the costs of electrification over the life-cycle.

1.2 Options Evaluated

The six options being assessed are:

- Option 1 – Electrification of the Air Rail Link (ARL) and Georgetown;
- Option 2 – Partial electrification of Lakeshore (from Bowmanville to Hamilton James);
- Option 3 – Partial electrification of Lakeshore and electrification of ARL and Georgetown;
- Option 11 – Partial electrification of Lakeshore and electrification of ARL, Georgetown and Milton;
- Option 15 – Partial Electrification of Lakeshore and electrification of ARL, Georgetown, Milton and Barrie; and
- Option 18 – Electrification of the entire network.

Chapters 2 to 6 present the costs and benefits which are inputs to the economic appraisal, and the methodology used to estimate them. Chapter 7 presents the appraisal assumptions, describes the process by which appraisal inputs are converted to benefit cost ratios and presents the results of the economic appraisal.

2. TRANSIT JOURNEY TIME SAVINGS, DEMAND & REVENUE

2.1 Introduction

Improving journey times on the GO network by changing rolling stock technology from diesel to electric will yield journey time savings for existing users of the transit network. The reduced journey times will attract new users to the network, resulting in an increase in demand for GO Rail services, and these new users will also accrue journey time savings. This section sets out the methodology employed to calculate the journey time savings for existing users, the incremental demand generated as a result of faster journey times, the journey time savings new users will receive and the incremental revenue accrued from ticket sales to new users of the network.

The sections below summarise the method of calculation for each of these benefits; the calculations as described below were undertaken for each corridor on the GO Network, and then the relevant corridor totals were combined to provide journey time savings, demand and revenue inputs for each option, which were subsequently used in the economic appraisal.

2.2 Existing User Time Savings

The inputs to the existing user journey time calculations were:

- Inbound and outbound journey times by stop for each corridor on the network for both Diesel Locomotive (the technology employed in the Reference Case) and Electric Locomotive (the technology employed in the options) (see Appendix 8A-1). These were taken from the Operating Plan modelled as part of the study, Appendix 5 of the GO Electrification Study Final Report;
- 2021 AM peak inbound boardings by stop for each corridor from the GGHM (Appendix 8A-2);
- Growth in ridership from 2021 to 2031 from the GGHM; and
- The percentage of passengers by stop using local services (services that stop at every station on the corridor) and those using express services (services that do not stop at every station along the corridor), from the GGHM (Appendix 8A-2).

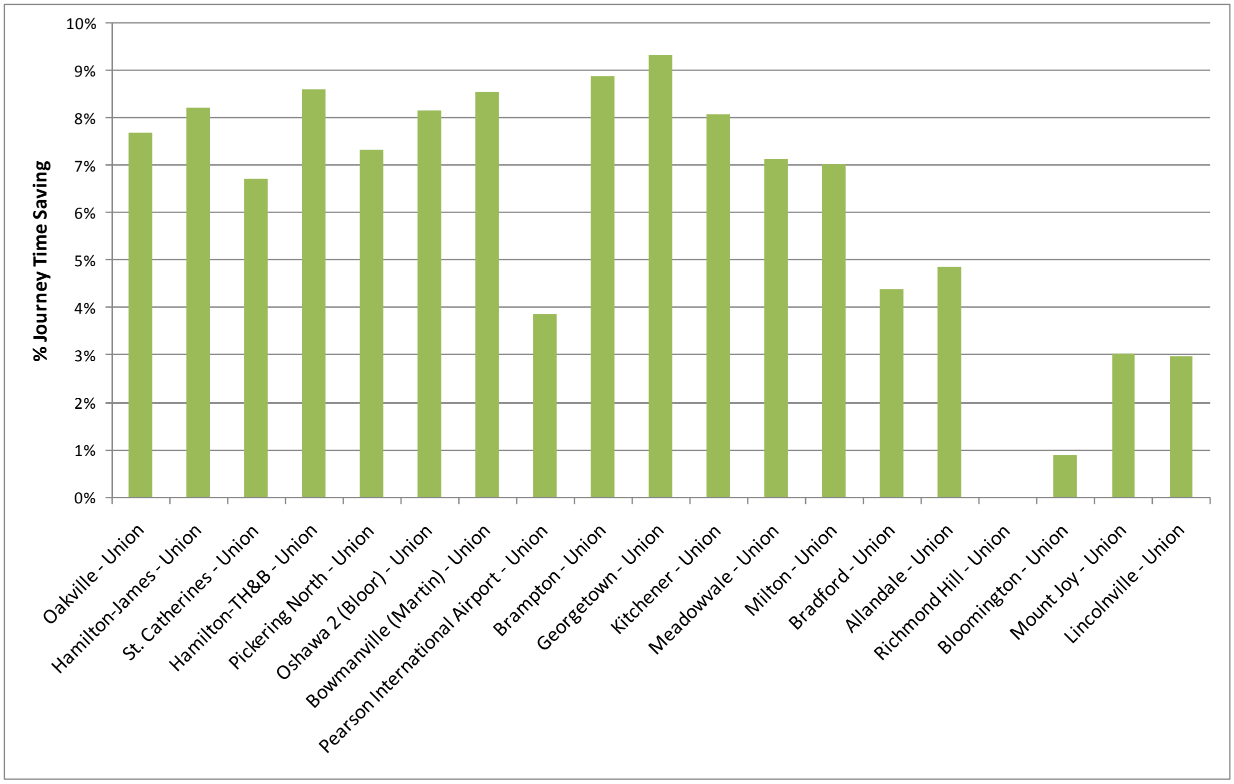
For each corridor, the demand at each stop for local and express services was determined using the boardings and the percentage demand for local/express services.

The number of minutes saved per passenger from each stop to Union Station were calculated for both local and express services using the average of the inbound and outbound journey times provided. Journey time savings from Union Station to a selection of destinations on the network are presented in Table 1, and the percentage end to end journey time savings by corridor are illustrated in Figure 1.

Table 1 Summary of Journey Time Savings per Passenger to Union for a Selection of Journeys

Corridor	Service Section (End-to-End Stations)	Journey Times (minutes) Diesel Locomotive	Journey Times (minutes) Electric Locomotive	Journey Time Saving per Passenger (minutes)
Lakeshore West	Oakville - Union	39	36	3
	Hamilton-James - Union	73	67	6
	St. Catharines - Union	119	111	8
	Hamilton-TH&B - Union	76	69	7
Lakeshore East	Pickering North - Union	41	38	3
	Oshawa 2 - Union	68	62	6
	Bowmanville - Union	82	75	7
Georgetown	Pearson International Airport - Union	26	25	1
	Brampton - Union	45	41	4
	Georgetown - Union	59	54	6
	Kitchener - Union	112	103	9
Milton	Meadowvale - Union	42	39	3
	Milton - Union	57	53	4
Barrie	Bradford - Union	69	66	3
	Allandale - Union	103	98	5
Richmond Hill	Richmond Hill - Union	41	41	0
	Bloomington - Union	56	55	1
Stouffville	Mount Joy - Union	50	48	2
	Lincolnville - Union	67	65	2

Figure 1 Percentage End-to-end Journey Time Savings by Corridor

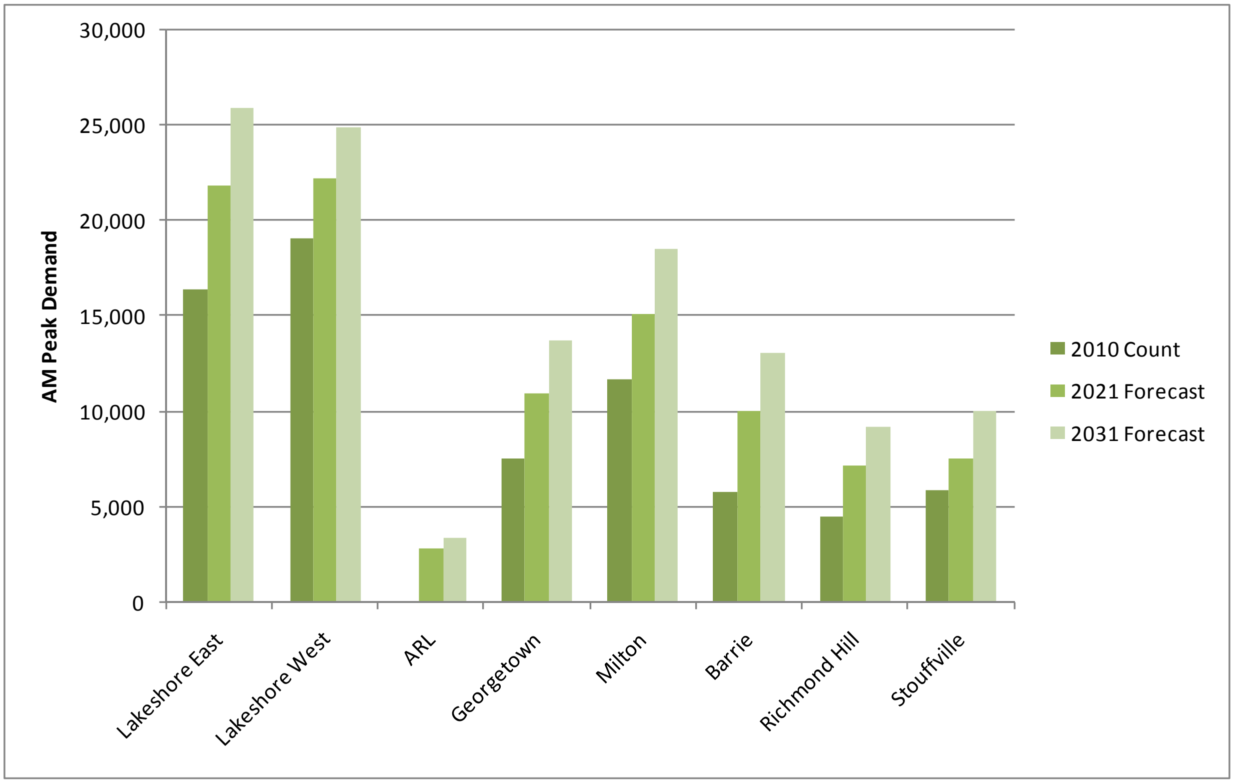


To determine the total user journey time savings on both local and express services for each corridor, the demand at each stop was multiplied by the time savings achieved by employing Electric Locomotives and these time savings were then summed over all stops. The time savings were then factored down to reflect the small proportion of passengers that alight before Union Station. The factors used are based on the demand data by stop from the GGHM. Finally, the time savings were converted from 2021 AM peak period figures to 2021 annual figures using an annualisation factor of 789, based on current Lakeshore demand profiles.

In the case of the Air Rail Link (ARL), the technology assumed in the Reference Case is Diesel Multiple Units (DMU), and the options assume the use of Electric Multiple Units (EMU) technology. The journey time from Union to Pearson International Airport is 26 minutes using DMU and 25 minutes using EMU, calculated based on the Operating Plan (Appendix 5 of the GO Electrification Study Final Report); therefore switching from DMU to EMU technology yields a 1 minute journey time saving. Annual demand forecasts for the ARL were provided by Metrolinx for years 2015 – 2056 (Appendix 8A-3).To estimate the total annual existing user journey time savings for 2021, the one minute journey time saving was multiplied by the 2021 annual demand forecast.

Demand forecasts from the GGHM were provided for two forecast years, 2021 and 2031. These forecasts by corridor are presented in Figure 2 along with 2010 counts for all existing corridors. The growth in ridership from 2021 to 2031 derived from these forecasts was applied to all corridors to give annual estimates for both 2021 and 2031. The existing user journey time savings for each option are presented alongside the new user time savings in section 2.4.

Figure 2 AM Peak Demand Counts and Forecasts by Corridor



2.3 Incremental Demand

In order to estimate the incremental demand generated as a result of improved journey times on the GO network, a demand elasticity with respect to journey time of -0.6 was assumed. This elasticity was provided by Metrolinx and informed by network wide sensitivity tests using the GGHM.

The percentage demand uplift for each stop was calculated using the following formula:

$$\%\, Demand\ Uplift = \left(\frac{Option\ Journey\ Time}{Reference\ Case\ Journey\ Time}\right)^{Journey\ Time\ Elasticity}$$

The incremental demand was then calculated by taking the boardings by stop for both express and local services and multiplying by the percentage demand uplift for each stop. The incremental demand by stop for each service type was then summed over each corridor and the relevant corridors were combined to give the total incremental demand for each option, as presented in Table 2. For the ARL, the percentage demand uplift was calculated and then this was applied to the annual ARL demand in 2021 and 2031 to give the annual incremental demand on the corridor.

Table 2 Annual Incremental Demand in 2021 and 2031

Network Option	Annual Incremental Demand (m passengers)		% Increase in Demand
	2021	2031	
Georgetown	0.57	0.71	25%
Lakeshore	1.53	1.77	16%
Georgetown and Lakeshore	2.10	2.48	18%
Georgetown, Lakeshore and Milton	2.53	3.00	19%
Georgetown, Lakeshore, Milton and Barrie	2.80	3.36	20%
Entire Network	3.18	3.79	19%

The estimated additional demand in the three hour AM peak period is illustrated in Table 3 alongside the Reference Case AM peak demand for 2021 and the percentage increase in demand.

Table 3 AM Peak Demand in 2021 and 2031

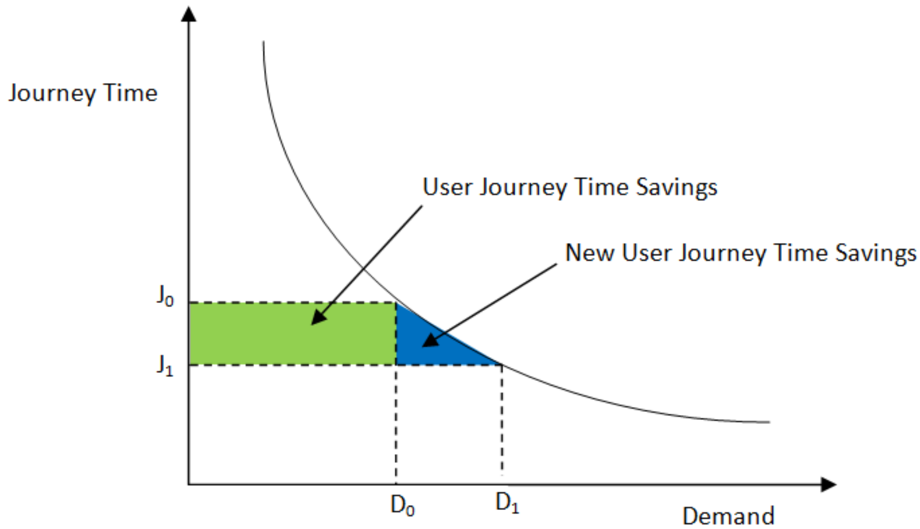
Corridor	2021 Forecast Year			2031 Forecast Year		
	Reference Case AM Peak Demand	Incremental AM Peak Demand	% Demand Increase	Reference Case AM Peak Demand	Incremental AM Peak Demand	% Demand Increase
Lakeshore East	21,870	1,060	5%	25,920	1,260	5%
Lakeshore West	22,200	1,170	5%	24,840	1,310	5%
ARL	2,800	70	3%	3,360	80	2%
Georgetown	10,950	650	6%	13,750	820	6%
Milton	15,110	540	4%	18,510	670	4%
Barrie	10,000	340	3%	13,040	450	3%
Richmond Hill	7,180	10	0%	10,340	10	0%
Stouffville	7,490	180	2%	8,780	210	2%

2.4 New User Time Savings

The time savings accrued by new users attracted to the GO network were calculated using the incremental demand and journey time savings by stop.

New users are assumed not to receive 100% of the journey time benefit as a result of the change in rolling stock technology, but rather a proportion of the time savings that existing users will receive. For small changes in journey time, the journey time saving of a new user is on average half of those gained by an existing user – this approximation is known as the rule of a half and is illustrated in Figure 3.

Figure 3 The Rule of a Half



Using this approximation, the journey time savings of new users have been calculated by multiplying the incremental demand ($D_1 - D_0$) by the journey time savings for each stop ($J_1 - J_0$) and then by 0.5 to approximate the blue area illustrated in Figure 3. These new user journey time savings by stop are then summed over each corridor and then the relevant corridors are combined to give the total journey time saving benefit to new transit users for each option. In the same way as for the existing user time savings, the new user time savings were factored down to reflect the small proportion of passengers that alight before Union Station. Finally, the time savings were converted from 2021 AM peak figures to 2021 annual figures using an annualisation factor of 789, taken from the GGHM.

The annual time saving benefits for both new and existing users are presented in Figure 4, and the average journey time savings per passenger by corridor are illustrated in Figure 5.

Figure 4 Existing and New User Time Savings (2021 & 2031)

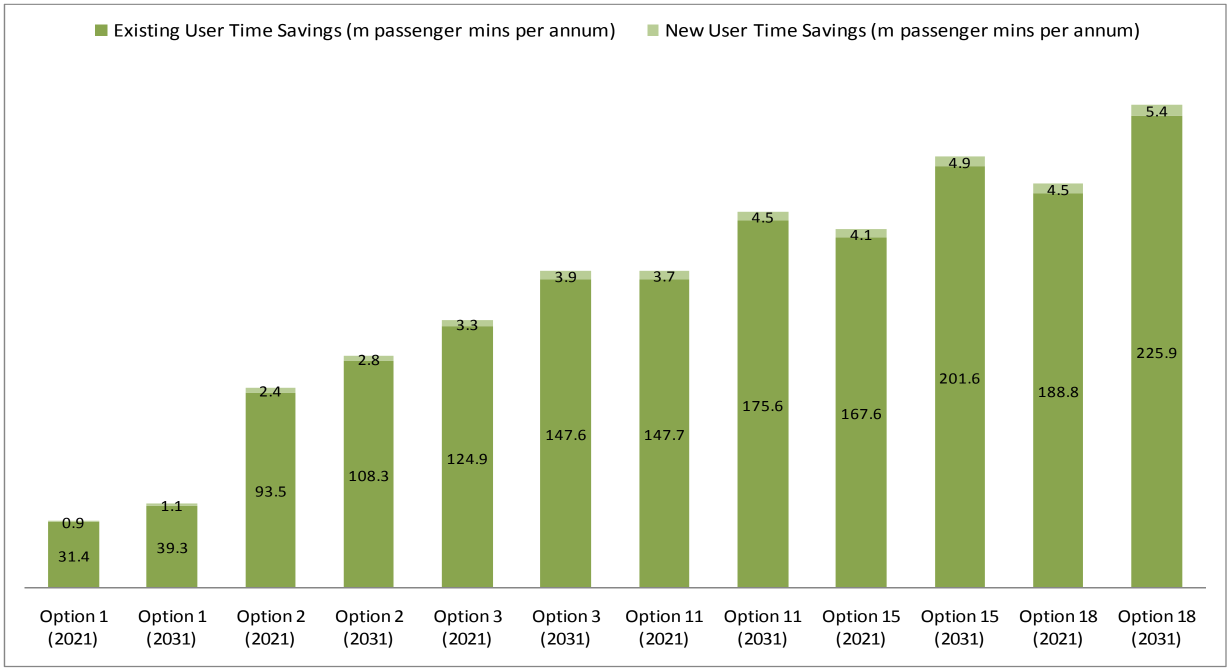
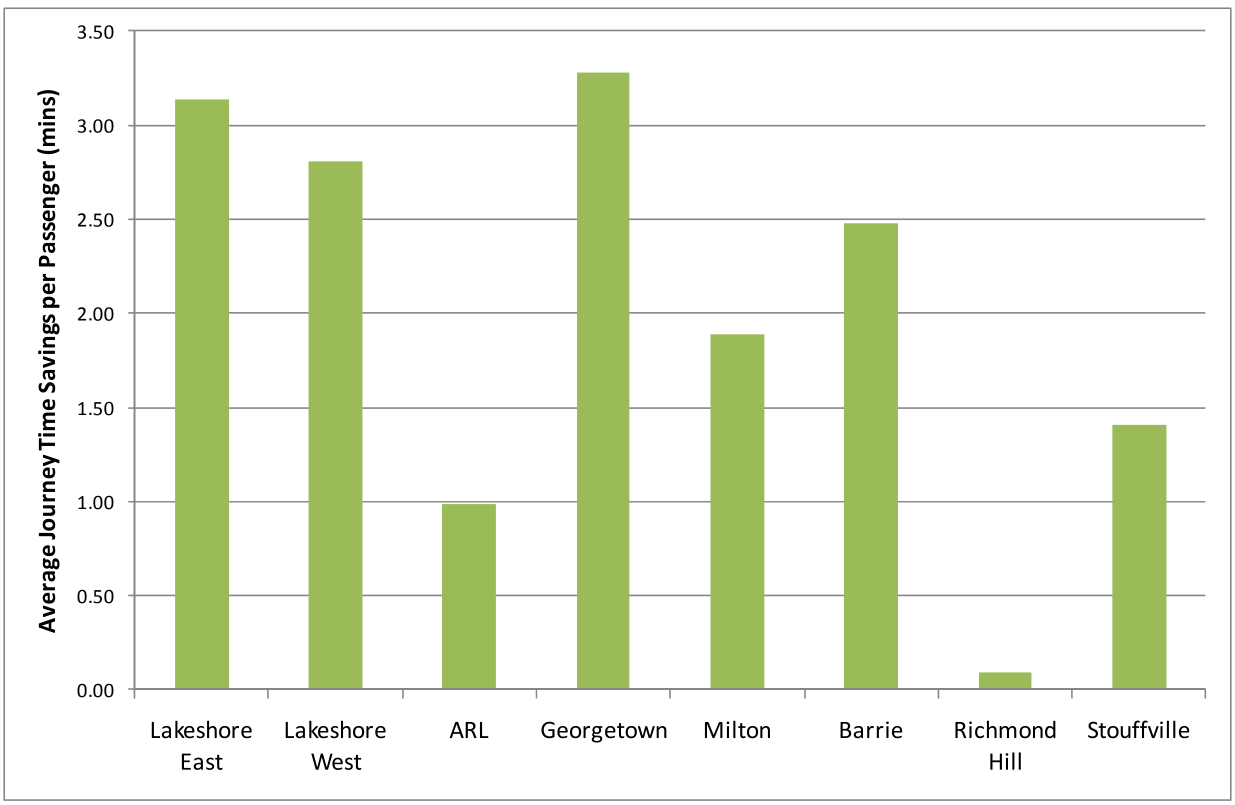


Figure 5 Average Journey Time Savings per Passenger



2.5 Incremental Revenue

As a result of electrification, additional revenue will be generated by ticket sales to new users who are attracted to the network by improved journey times. In order to calculate this incremental revenue, the average fare at each stop was multiplied by the incremental demand by stop to give incremental revenue by stop, and these were summed over all stops on the corridor to give incremental revenue by corridor. It has been assumed that the future fare structure is consistent with the current one and that fares increase in line with inflation. The fare has been multiplied by the 2021 annual incremental demand to give the 2021 annual incremental revenue for the corridor.

The appropriate corridor totals were then combined to provide estimates for each option. The incremental revenue for each option in both 2021 and 2031 is summarised in Figure 6, and the weighted average fare, incremental demand and revenue broken down by corridor are presented in Table 4.

It should be noted that the fare assumptions are not a significantly driver of the benefit cost analysis; this is because revenues do not represent a change in consumer surplus – it is a transfer of fares (negative benefit to the passenger) to GO Rail's revenues (negative cost). The average fare of $20 for the ARL is an enabling assumption and does not necessarily reflect the proposed fare structure of the service in the future.

Figure 6 Incremental Revenue in 2021 and 2031

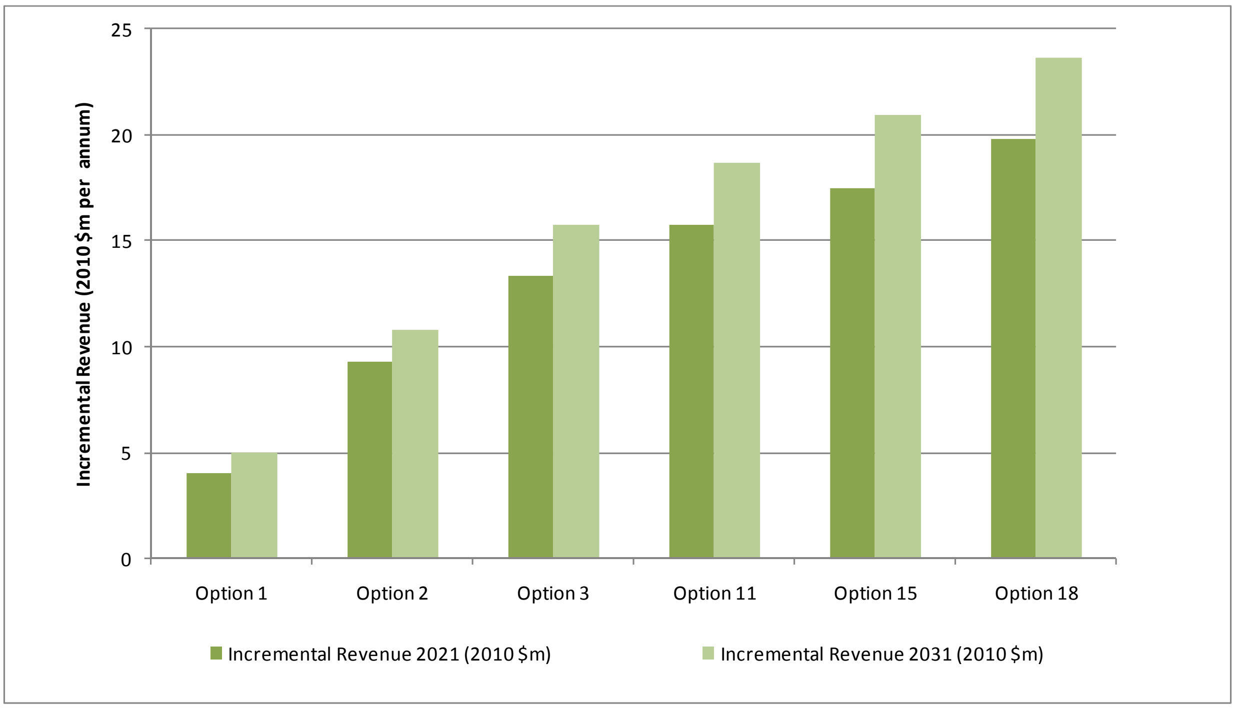


Table 4 Weighted Average Fares, Incremental Demand and Revenue in 2021 and 2031

Corridor	Weighted Average Fare (2010 $)	Incremental Demand (m passengers)		Incremental Revenue (2010 $m)	
		2021	2031	2021	2031
Lakeshore East	6.22	0.84	0.99	5.21	6.18
Lakeshore West	6.11	0.92	1.03	5.63	6.30
ARL	20.00[1]	0.05	0.06	1.05	1.26
Georgetown	5.77	0.51	0.64	2.96	3.72
Milton	5.58	0.43	0.53	2.39	2.93
Barrie	6.37	0.27	0.35	1.73	2.26
Richmond Hill	6.31	0.01	0.01	0.04	0.06
Stouffville	5.44	0.14	0.17	0.78	0.92

Note 1: As per the SNC business case

3. RELIABILITY BENEFITS

The change in rolling stock technology from diesel to electric will yield reliability benefits for transit users in the form of reduced delay time due to rolling stock failure. Both Electric Locomotive units and EMUs on average can travel a longer distance before a failure occurs than Diesel Locomotives and DMUs, and therefore are more reliable. Table 5 below presents the mean distance before failure of each rolling stock technology.

Table 5 Mean Distance Before Failure

Rolling Stock Type	Mean Distance Before Failure (kms)
Diesel Locomotive	150,000
Electric Locomotive	375,000
DMU (ARL)	175,000
EMU (ARL)	350,000

For each option, annual train kilometres by technology were divided by the appropriate mean distance before failure to calculate the annual failures by technology. The same process was undertaken to give the number of annual failures in the Reference Case, and the difference between each option and the Reference Case was calculated to give incremental annual failures by technology for each option. These are presented in Table 6.

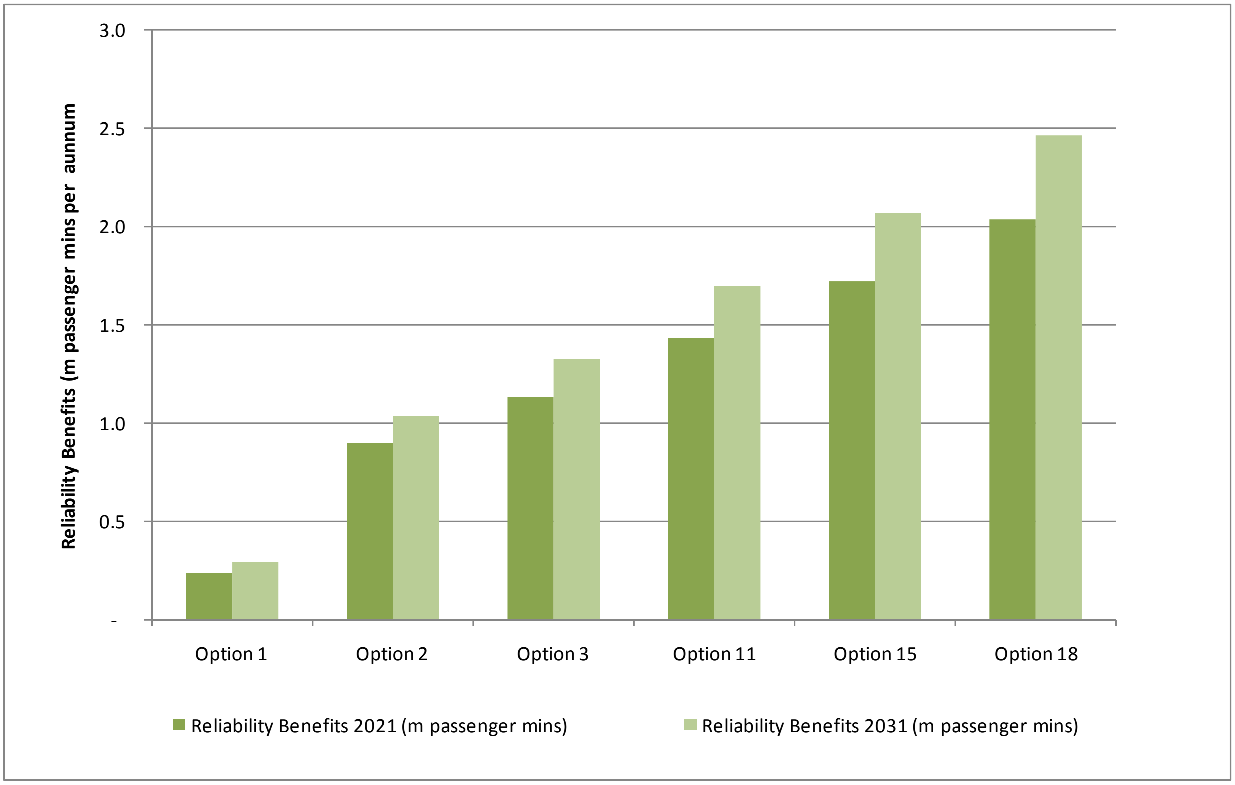
Table 6 Incremental Annual Failures

Rolling Stock Technology	Incremental Annual Failures by Option (to the nearest failure)					
	1	2	3	11	15	18
Diesel Locomotive	-7	-28	-35	-43	-53	-68
Electric Locomotive	3	11	14	17	21	27
DMU (ARL)	-7	0	-7	-7	-7	-7
EMU (ARL)	4	0	4	4	4	4
TOTAL	**-8**	**-17**	**-25**	**-30**	**-36**	**-44**

In order to estimate the number of passengers that would be affected by each train failure, the annual Reference Case demand by corridor taken from the GGHM was divided by the number of trains per day to give forecasts by corridor of the number of passengers per train.

To estimate the impact of train failures on passengers, an average delay per train failure of 30 minutes was assumed. As delays due to train failures are a significant inconvenience to passengers, a weighting of 3 has been applied to the delay time to reflect this. To calculate the incremental reliability benefit, the incremental annual failures on each corridor were multiplied by the passengers per train by corridor, the assumed delay per train failure and the delay time weighting. The total annual incremental reliability benefit for each option (in the forecast years 2021 and 2031) is presented in Figure 7.

Figure 7 Reliability Benefits in 2021 and 2031



4. HIGHWAY BENEFITS

4.1 Introduction

As a result of improved journey times on the GO transit network, there will be a demand shift away from highway and onto the GO network. This transfer of demand away from highway has benefits for those that continue to use highway in the form of:

- Highway user time savings
- Auto vehicle operating cost savings
- Collision cost savings

In order to calculate the value of each of these categories of benefits, the number of car kilometres removed from highway as a result of electrification must first be determined. This section describes the process of determining the car kilometres removed from highway and each category of benefits listed above.

4.2 Car Kilometres Removed From Highway

The first step in determining the number of car kilometres removed from highway is to calculate the number of car trips removed from the road as a result of electrification, using the following formula:

$$Car\ Trips\ Removed = \frac{(Incremental\ Demand\ \times \%\ New\ Users\ from\ Car)}{Car\ Occupancy\ Factor}$$

Based on outputs from the GGHM it has been assumed that 50% of new transit users come from car, therefore a factor of 50% is applied to the incremental demand by stop to determine the number of passenger trips that have transferred from car to rail at each stop. An average car occupancy factor of 1.2 passengers per car has been assumed to convert passenger trips removed from highway to car trips removed from highway. The car trips removed from highway in the AM peak period for the forecast years 2021 and 2031 are illustrated in Figure 8.

The car kilometres removed by stop were then summed to give kilometres removed by corridor, and then the appropriate corridor totals were combined to give car kilometres removed by option.

The car kilometres removed by option were factored down in the same way as the time savings were factored down to reflect the small proportion of passengers that end their journey before Union Station. Finally, the time savings were converted from 2021 AM peak figures to 2021 annual figures using the transit annualisation factor of 789, given that the highway related benefits are expected to be lower in the off-peak period. The annual car kilometres removed by option for both forecast years, 2021 and 2031 are presented in Figure 9.

Figure 8 Car Trips Removed from Highway in the AM Peak Period – 2021 and 2031

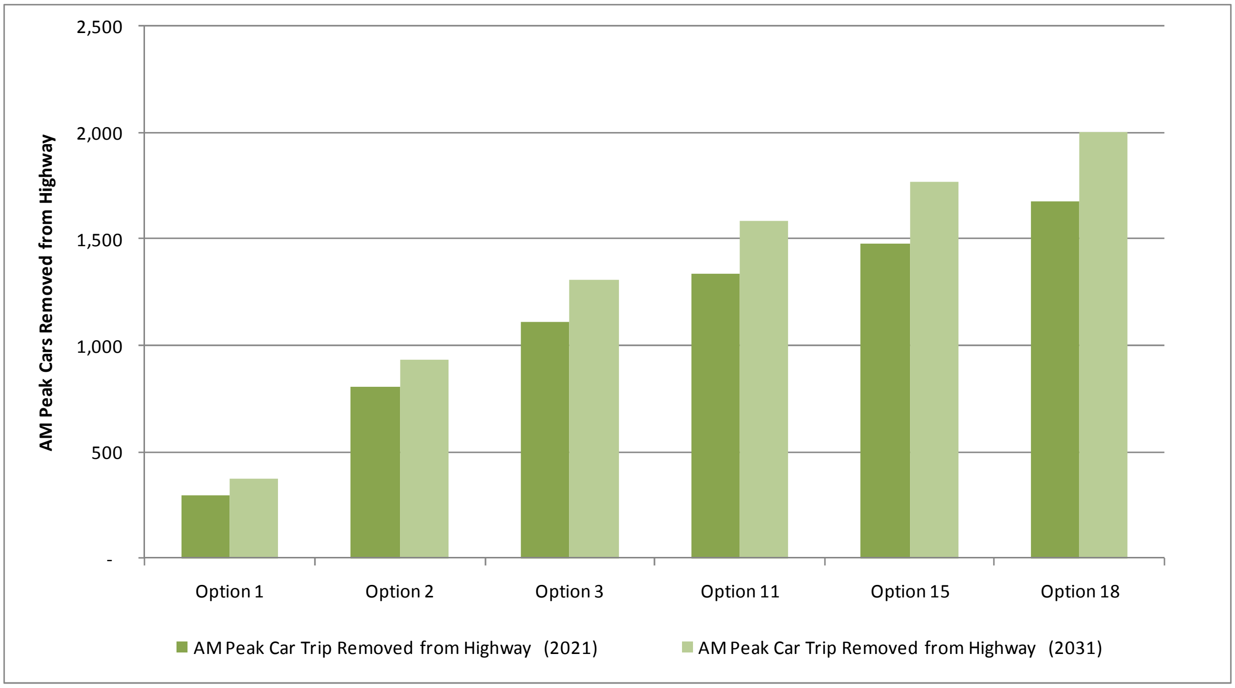
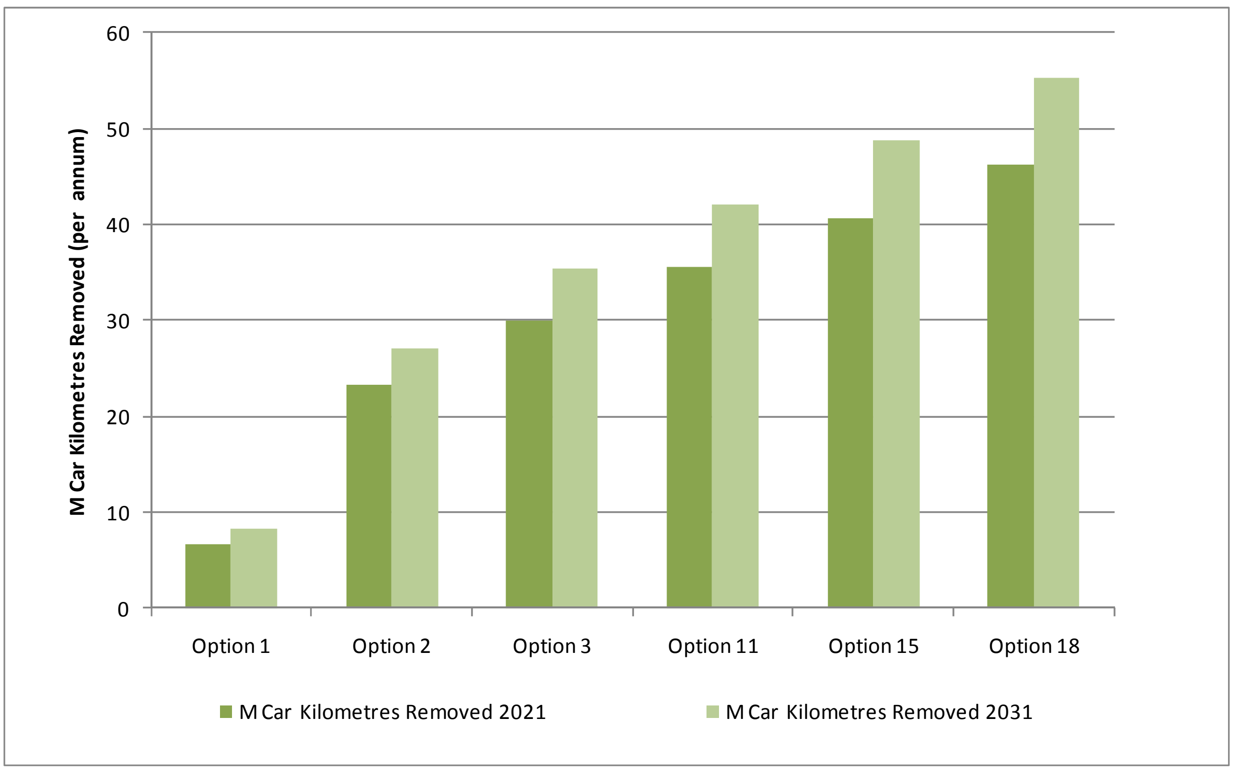


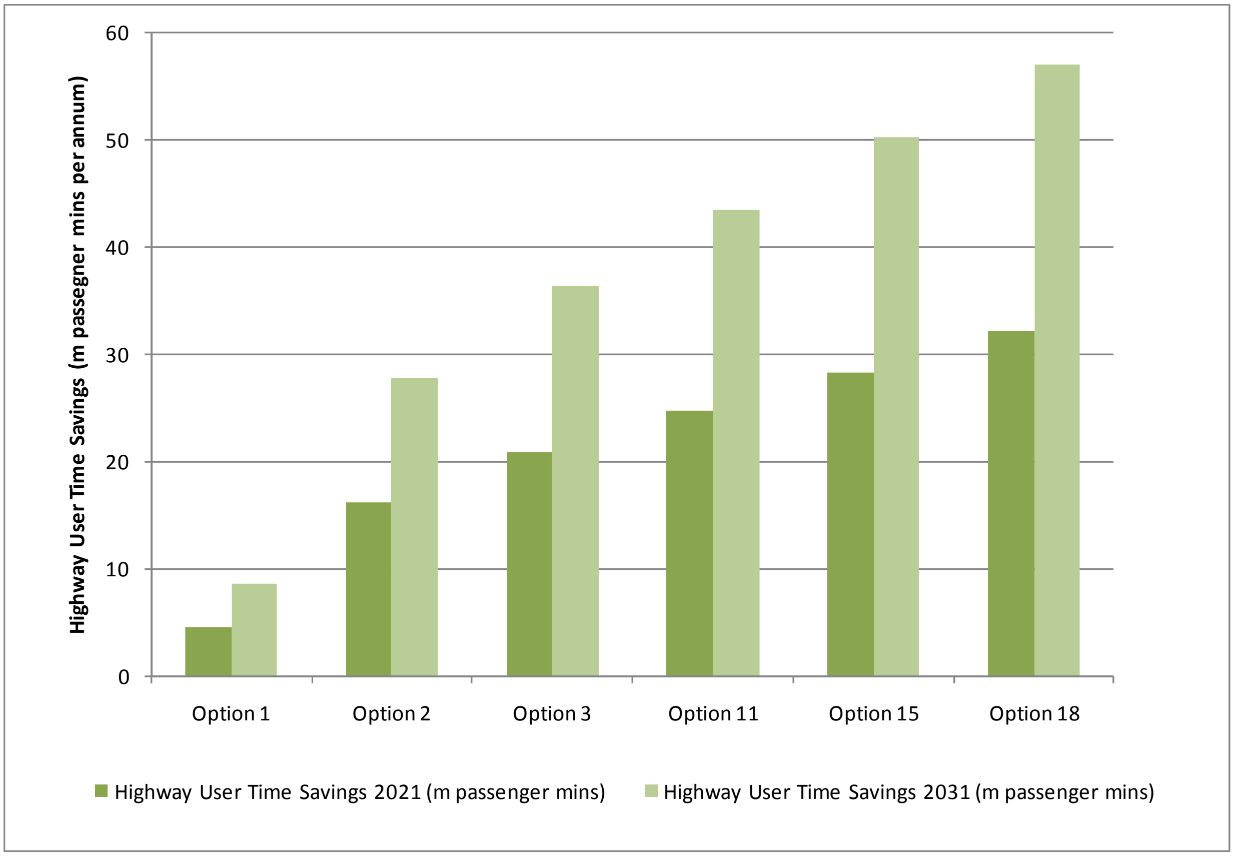
Figure 9 Car Kilometres Removed from Highway in 2021 and 2031



4.3 Highway User Time Savings

As a result of mode shift away from highway and onto the GO network, remaining highway users will benefit from reduced congestion on the highways and will gain journey time savings. These highway user time savings have been calculated using a unit rate per car kilometre removed from the road as a result of electrification: it has been assumed that for every car kilometre removed from highway, remaining highway users will receive a collective benefit of 0.69 minutes in 2021, rising to 1.03 minutes in 2031. These unit rates have been calculated using the outputs of the GGHM for the forecast years of 2021 and 2031 (interpolated between the forecast years, extrapolated prior to the first forecast year and constant beyond 2031). Figure 10 presents annual highway user time savings by option.

Figure 10 Highway User Time Savings in 2021 and 2031



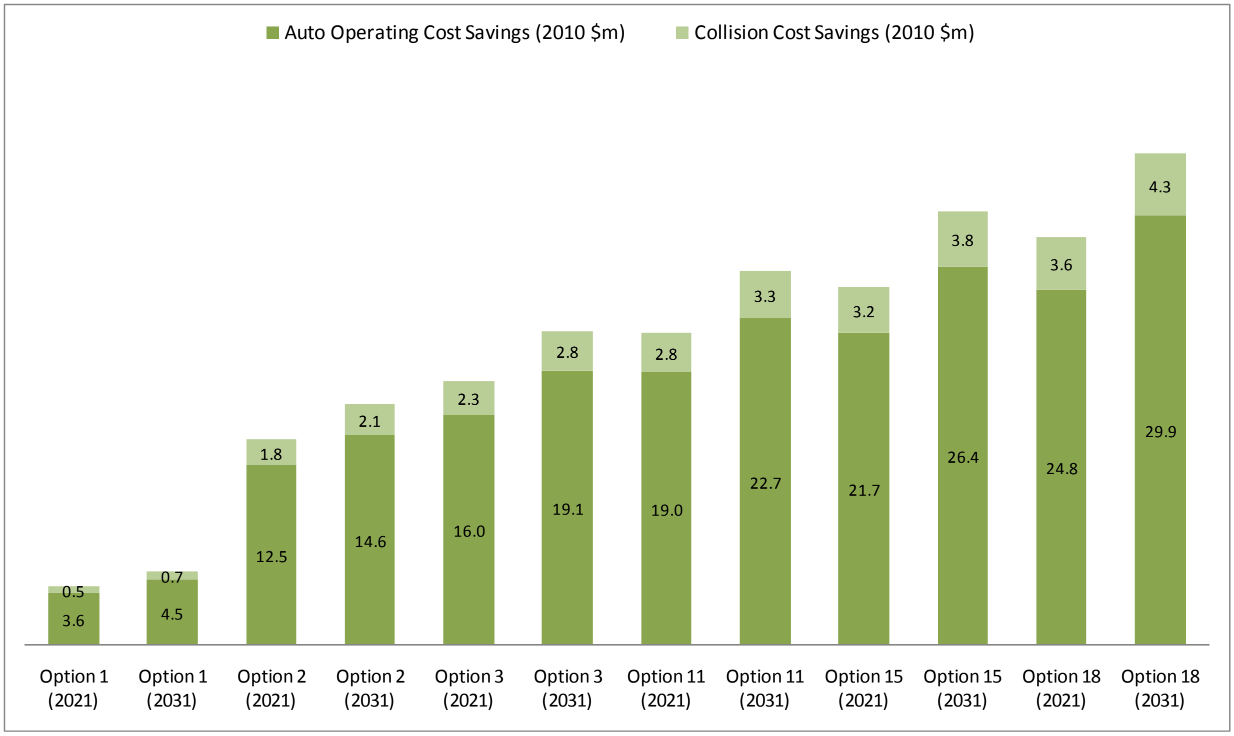
4.4 Auto Vehicle Operating Cost Savings

Those new users that will shift from their cars to the GO Rail network will make savings on their car operating costs due to decreased car usage. A rate per car kilometre removed of $0.53 (2010 $) has been assumed in order to calculate these auto operating cost savings, in line with other Metrolinx Benefits Case Analyses. The auto operating cost savings by option for 2021 and 2031 are summarised in Figure 11.

4.5 Collision Cost Savings

A result of fewer cars using highway is that there will be a reduced occurrence of highway collisions. The cost savings as a result have been calculated using an assumption on collision cost per kilometre removed of $0.08 (2010 $), in line with other Metrolinx Benefits Case Analyses. The collision cost savings for each option for 2021 and 2031 are presented in Figure 11.

Figure 11   Auto Operating Cost and Collision Cost Savings in 2021 and 2031



5. ENVIRONMENTAL BENEFITS

5.1 Greenhouse Gases

Electrification will lead to a reduction in greenhouse gases (GHGs) due to:

- The removal of cars from the highway and their associated emissions; and
- The switch in rolling stock technology from Diesel Locomotives/DMUs (with higher GHG emissions) to Electric Locomotives/EMUs (with comparatively lower GHG emissions).

The reduction in emissions due to mode shift from highway and to GO Rail has been calculated by multiplying the car kilometres removed from the highway by a unit rate of auto GHG emissions per kilometre. Unit rates of emissions were provided for the forecast years: 0.21kg/km in 2021 and 0.20kg/km in 2031 (these were interpolated between the forecast years, extrapolated prior to 2021 and constant after 2031).

The incremental annual kilometres were then multiplied by these rates to give the incremental GHG emissions by technology for each option. The reduction in GHG emissions due to both mode shift from highway and change in rolling stock technology are presented in Figure 12.

Figure 13 illustrates the car kilometres that would have to be removed from the highway in order to achieve the same GHG emission reductions gained from adopting electric rolling stock technology.

Figure 12 Reduction in GHG Emissions

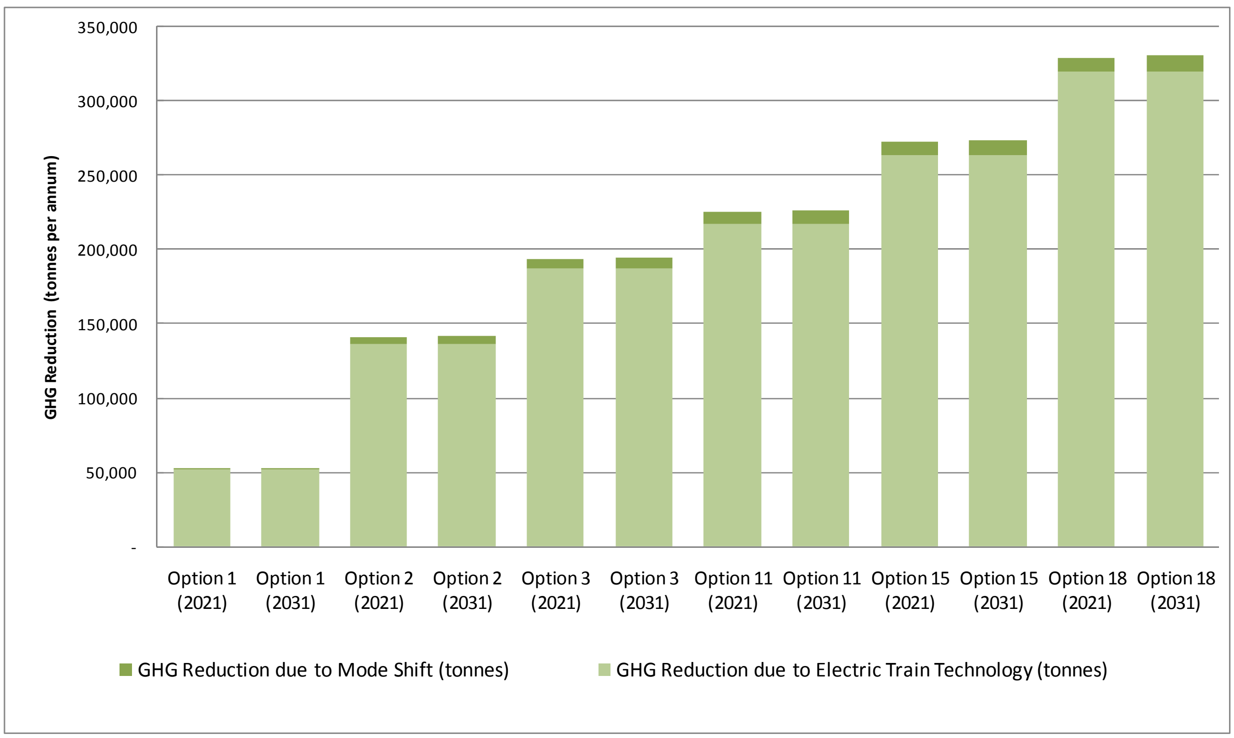
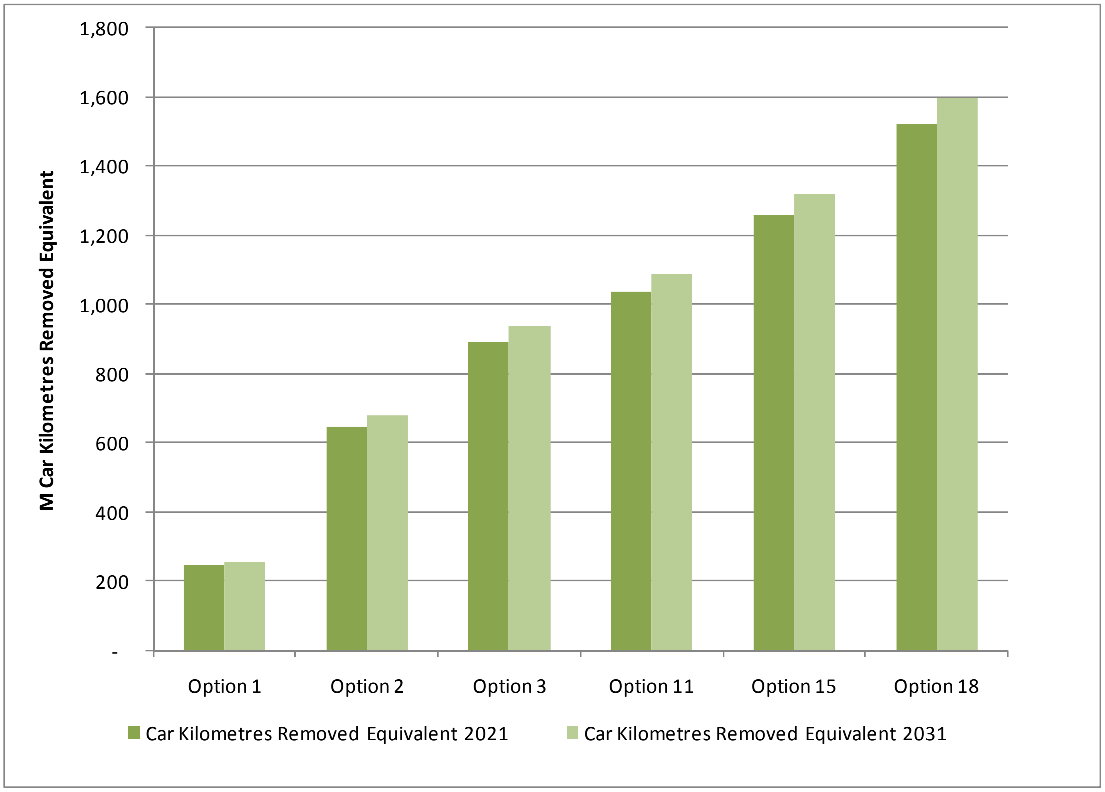


Figure 13 Rolling Stock GHG Reductions in Car Kilometres Removed Equivalent



6. LIFE CYCLE COSTS

6.1 Introduction

There are three types of cost inputs to the appraisal: infrastructure capital costs, rolling stock capital costs and rolling stock operating and maintenance costs. These costs have been estimated by the study team; details of the methodology of the cost estimates are provided in Appendix 8B and 8C of the GO Electrification Study Final Report. This section presents the costs in each category for each of the six options.

6.2 Infrastructure Capital Costs

The base infrastructure capital costs for each option are presented in Table 7 in 2010 prices. These costs include contingency but not future cost escalation.

Table 7 Infrastructure Capital Cost by Option (2010 $m)

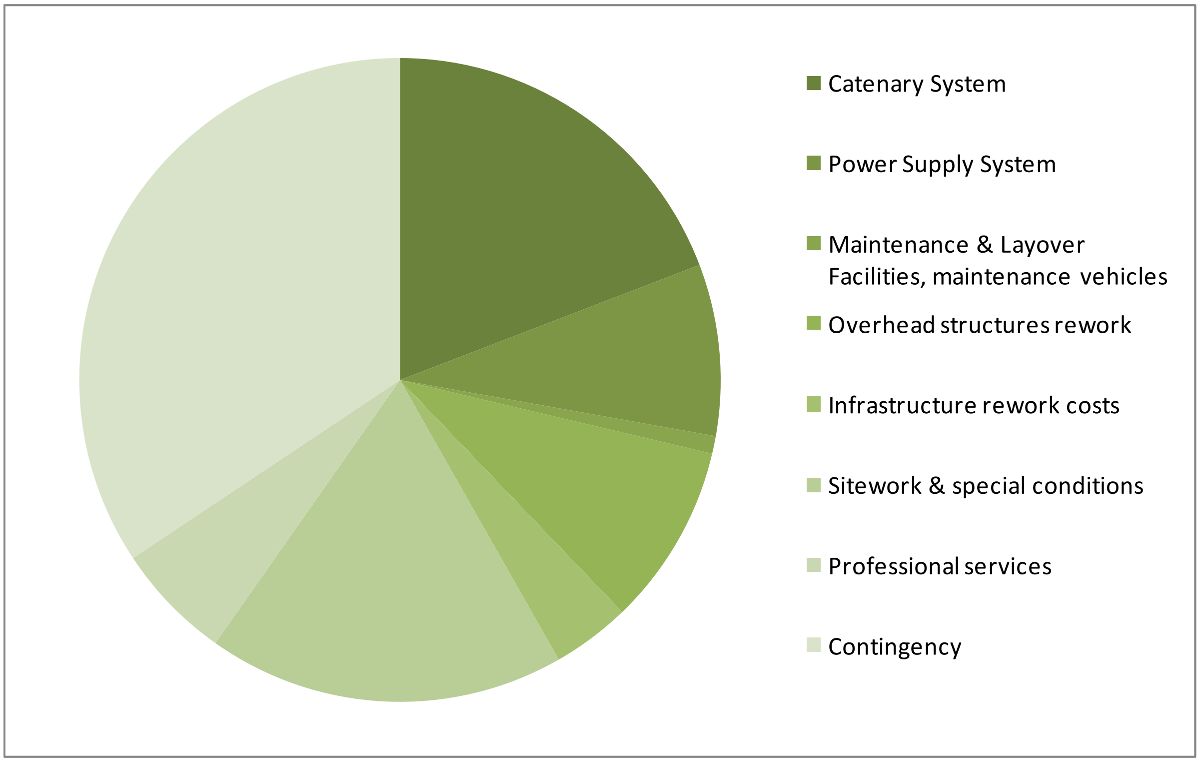
Cost Breakdown (2010 $m)	Option					
	1	2	3	11	15	18
Catenary System	221.2	369.2	511.1	580.8	710.8	861.2
Power Supply System	99.7	166.4	230.4	261.8	320.4	388.2
Maintenance & Layover Facilities	16.3	26.6	28.3	30.8	36.7	39.8
Overhead Structures/Infrastructure Re-work	86.7	96.5	117.4	136.1	183.2	666.1
Sitework & Special Conditions	229.8	309.0	488.7	569.3	743.3	980.0
Professional Services	52.6	67.1	99.9	116.3	152.8	274.6
Total Infrastructure Capital Cost	**706.4**	**1,034.7**	**1,475.9**	**1,695.1**	**2,147.2**	**3,209.9**

A number of cost categories make up the total infrastructure capital cost estimates; these categories and their relative contribution to the total infrastructure capital costs are illustrated in Figure 14 for Option 18. Each category of the infrastructure capital costs takes account of risk by including in the estimate a percentage uplift for contingency; these are presented in Table 8

Table 8 Infrastructure Capital Cost Risk/Contingency

Cost Category	Risk/Contingency
Catenary System	40%
Power Supply System	40%
Maintenance & Layover Facilities, vehicles	40%
Overhead structures rework	60%
Infrastructure rework costs	55%
Sitework & special conditions	70%
Professional services	45%

Figure 14 Option 18 Infrastructure Capital Costs (2010 $)



6.3 Rolling Stock Capital Costs

In order to determine the number of electric locomotives on each option, the number of trains required to operate each corridor as identified in the operating plan was used. The Study also assumes that the 6 ARL train sets (a total of 12 DMU) would be converted to EMUs. Figure 14 illustrates the mix of existing diesel locomotives (that will be converted to Tier 4), future Tier 4 diesel locomotives as part of the reference case and electric locomotives. Where the total number of locomotives exceed the red line, existing locomotives will be surplus to requirements and sold off. Table 9 summarizes this per option.

Figure 15 Number of Locomotives Required/Surplus by Option

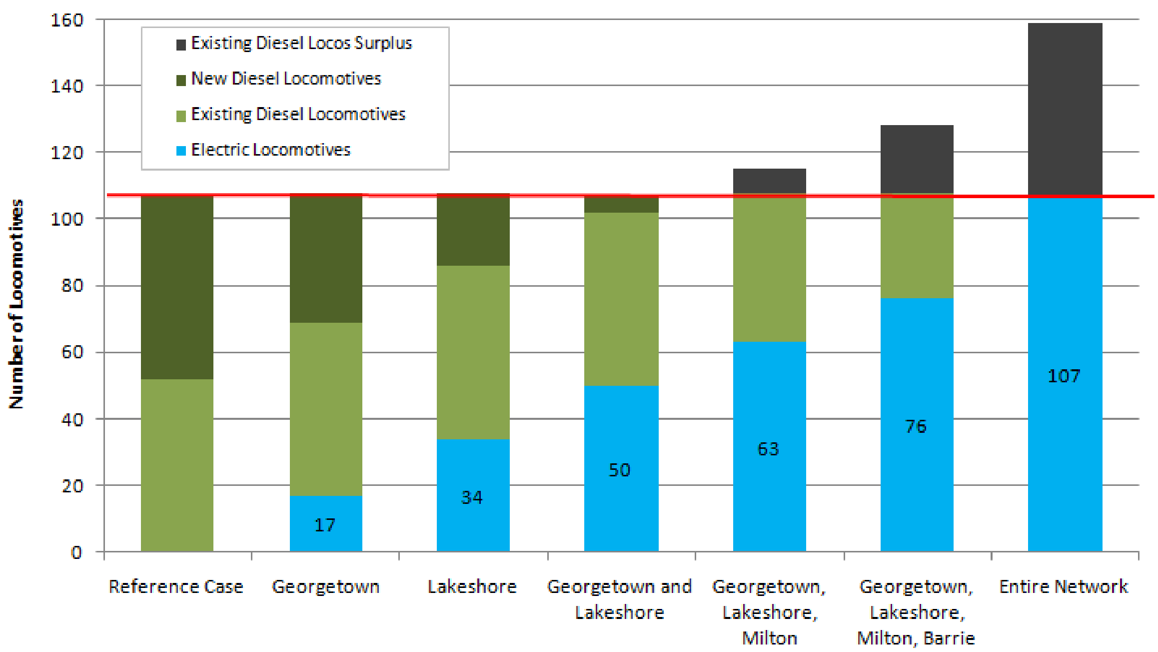


Table 9 Rolling Stock Requirements by Option (Including Spares)

Technology	Option					
	1	2	3	11	15	18
Electric Locomotives	17	34	50	63	76	107
Existing Diesel Locomotives (as part of the Reference Case)	52	52	52	52	52	52
New Tier 4 Diesel Locomotive (as part of the Reference Case)	39	22	5	0	0	0
Existing Diesel Locomotives to be sold off	0	0	0	-7	-20	-52
Total Locomotives	***107***	***108***	***108***	***107***	***108***	***107***
DMU to EMU conversion (ARL)	6	0	6	6	6	6

The unit costs for each type of train set are presented in Table 10. The base capital cost for each vehicle type was adjusted for the following factors:

- Consultant Design and Manufacturing Support;
- Consultant Construction Management/Support;

- Agency Engineering and Management;
- Agency Railroad Flagging;
- Spare Parts;
- Special Tools and Equipment;
- Agency Staff Training;
- Inflation Escalation to 2010;
- Contingency for Vehicle Cost Uncertainty; and
- Currency Conversion to Canadian Dollars.

The magnitude of each adjustment factor was customized to each rolling stock type to reflect anticipated costs. For example, a high-volume, previously-built passenger coach needs less general oversight than a lower-volume, new-design locomotive.

The costs presented in Table 10 are for new rolling stock. The total train consists of one locomotive, one cab car and nine locomotives, while the DMU and EMU consists of a "married" pair of multiple units. Options involving more extensive electrification of the network would result in an excess of diesel locomotives and it has been assumed that for these options, they would be sold off at a residual value which is 50% of the new value.

Table 10 Rolling Stock Capital Costs by Technology (2010 $m per unit)

Technology	Locomotive (1)	Coach (9)	Cab (1)	Total Train
Diesel Locomotive	7.8	2.8	2.9	35.8
Electric Locomotive	11.2	2.8	2.0	39.2
DMU	4.0			8.0
DMU converted to EMU	5.6			11.2

Table 11 Incremental Rolling Stock Capital Costs by Option (2010 $m)

Technology	Option					
	1	**2**	**3**	**11**	**15**	**18**
Diesel Locomotive (Reference Case Costs avoided)	-328	-678	-1,014	-1,220	-1,392	-1,764
Electric Locomotives	394	802	1,184	1,489	1,794	2,481
Incremental cost of DMU to EMU conversion (ARL)	19	0	19	19	19	19
Total Rolling Stock Costs	**84**	**123**	**188**	**288**	**421**	**736**

These costs include a contingency of between 5% and 10% depending on the type of unit. These estimates also include allowances for spares to be operated during routine maintenance and in the case of a rolling stock unit failure. Appendix 8B the GO Electrification Study Final Report provides a detailed description of the assumptions used to calculate these estimates.

6.4 Rolling Stock Operating & Maintenance Costs

The operating and maintenance costs by option are presented in Table 12.

Table 12 Annual Incremental Rolling Stock Operating and Maintenance Costs by Option

O&M Cost Category ($m per annum 2010 Prices)	Option					
	1	2	3	11	15	18
Rolling Stock Maintenance	-0.7	-1.1	-2.3	-2.6	-3.1	-4.6
Wayside Maintenance	2.8	4.5	7.2	8.0	9.6	11.2
Energy	-4.7	-18.1	-22.8	-26.9	-31.4	-35.6
Annual Incremental Rolling Stock Operating and Maintenance Costs	**-2.6**	**-14.6**	**-17.9**	**-21.5**	**-24.9**	**-29.0**

As can be seen in Table 12, substantial savings are made on some elements of the operating costs as a result of switching from diesel to electric technology. In particular a large saving is made on the cost of electricity compared with the cost of diesel. This results in overall operating cost savings for the options compared with the Reference Case.

Figure 16 Assumed Diesel and Electricity Real 2010 Costs (Excluding background Inflation)

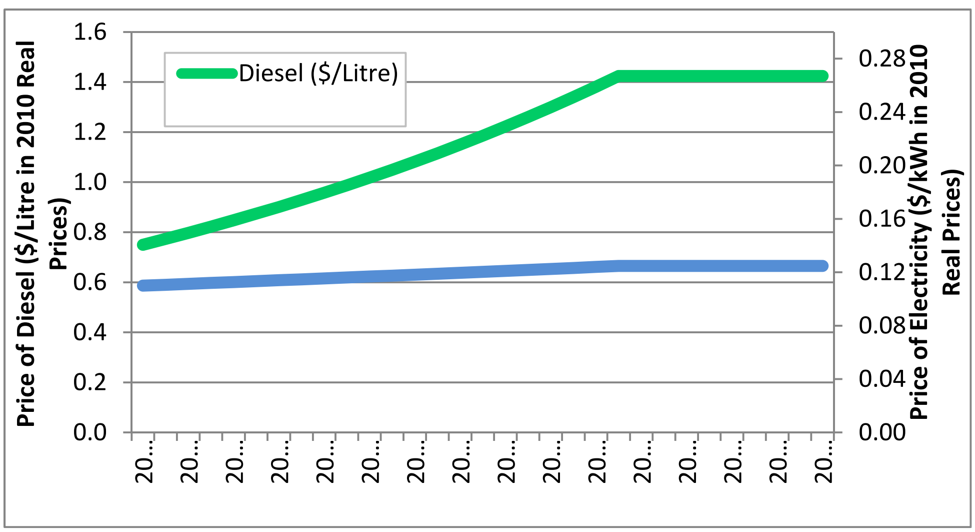


Table 13 below illustrates how the annual O&M cost savings increase over time, primarily due to the relative real inflation of diesel and electricity in the future.

Table 13 Future Incremental Operating and Maintenance Costs ($m per annum 2010 Prices)

O&M Cost Savings ($m per annum 2010 Real Prices)	Option					
	1	2	3	11	15	18
Estimated O&M savings base 2010 values	-3	-15	-18	-22	-25	-29
Estimated O&M savings 2021 with real inflation	-7	-26	-33	-39	-45	-53
Estimated O&M savings 2031 with real inflation	-10	-38	-48	-57	-67	-79

7. ECONOMIC APPRAISAL

7.1 Appraisal Assumptions

The appraisal process takes the single year estimates of costs and benefits, as described in the preceding chapters, and converts these appraisal inputs into a benefit cost ratio for each option using a number of assumptions. The assumptions employed are the same for each of the six options. This section presents the main assumptions used in the analysis. All the detailed evaluation assumptions are documented in Table 14.

Appraisal Period

Metrolinx's major transportation investment has conventionally been evaluated over a 30 year period. It is assumed that the opening year for the scheme will be 2020, and that the construction period will begin in 2017; the appraisal period is defined as being from the time that construction begins in 2017 to 30 years after scheme opening, 2049.

Cost and Benefit Phasing

For appraisal purposes, both the costs and benefits of the scheme are phased over a number of years:

- **Capital Cost Phasing**
  During the construction period, it is assumed that the outlay of capital costs associated with the scheme will be spread over the construction period, with 30% in the initial year of construction, 40% in 2018 and the final 30% in 2019.

- **Revenue and Benefit Phasing**
  It is usually the case that there is a lag following the introduction of improved services and the point when the full benefits of these are realised. This is because people take time to adjust their behaviour in response to reduced journey times and shift from one mode to another. To reflect this phenomenon, a phasing of 80%, 90% 100% in 2020, 2021 and 2022 respectively has been applied to incremental demand, incremental revenue, highway benefits and user time savings. The lag effect in this case is assumed to be relatively small because improvements are being made to existing services rather than new services being created, which would cause a more accentuated lag effect.

Growth of Costs and Benefits

Growth rates are applied to the costs and benefits to convert the inputs, in the form of single year estimates, to real profiled estimates over the entire appraisal period. These growth rates are presented in the table of detailed evaluation assumptions, Table 14.

In most cases, impacts are held constant beyond 2031. This is common practice to ensure that the appraisal of schemes is not unduly skewed by impacts long into the future where the uncertainties are the greatest.

Discounting to Present Values

The discount rate is used to convert costs and benefits that occur in different time periods to 'present values' so that they can be compared. It is based on the principle that, generally, society prefers to receive goods and services now, rather than later, and to defer costs to future generations - this is known as 'social time preference'.

Metrolinx has recently been adopting a discount rate of 5% for Benefits Case Analysis (BCA) of projects. For the purpose of consistency with other BCAs the Electrification Study has adopted a discount rate of 5%.

Inflation

Before applying discounting, costs and benefits are expressed in the unit of account of 'real terms', as opposed to 'nominal terms'. This means that where the effect of expected future inflation (as measured by CPI averages of 1.9% p.a.) has been included in future cash flows, it has been removed by deflating by the relevant deflator.

It is common for particular cost items to increase at a rate higher than background inflation. This typically includes items which are heavily linked to salaries or energy sources. The latter is particularly important in the Electrification Study and the projected cost of diesel and electricity can affect the case for electrification. It should be emphasised that the CPI assumptions do not affect the appraisal results, but any variance from CPI on any specific cost element would change the results.

Price Base

For consistency, all annual costs and benefits are quantified in 2010 values and discounting brings cash flows back to 2010 present values. Values of time and costings exclude HST tax.

Value of Time

The value of time assumption – which converts journey time savings into monetized benefits – is $13.52 per hour in 2010 prices and is based on the GGH model assumptions and reflects the average traveller on GO rail. Value of time, unlike many other assumptions, is assumed to increase through to the end of the evaluation period.

In the case of the ARL, a $18 per hour has been assumed to reflect a higher mix of business travellers given that it will be a premium service to the airport, and journeys of such a nature would typically have a higher value of time.

Table 14 Detailed Evaluation Assumptions

Factor	Description	Proposed Value (Source)	Implications
Opening year	Year of project opening	2020 (Completion of construction program)	Benefit and revenue stream dependent on this opening date.
Project construction	Years of project construction	2017-2020 (Construction program) Capital Cost phasing implemented during each year of construction: 2017 – 30% 2018 – 40% 2019 – 30% 2020 – 0%	The longer the construction period, the longer it will take for benefits and revenues to start accruing. The sooner the construction period, the less capital costs will be discounted.
Evaluation Period	Period for which costs and benefits accounted for.	30 years from opening plus construction period (2017-2049)	Appraisal period should be sufficiently long to reflect the scale of the investment, related to its lifecycle, and hence the 'pay-back' period. There is limited merit in having unduly long appraisal period if it is accompanied by a discount rate that means values are negligible prior to the end of the assessment period.
Price Base	Year in which monetary estimates are based on	Canadian Dollars in 2010 prices, excluding Harmonized Sales Tax (HST) Life cycle impacts discounted and presented as Present Values (PV)	To ensure that all costs and benefits are on a consistent and current price base.
Discount rate	Rate applied to discount all future costs and benefits	5% (real terms) to Present Values	The higher the discount rate the more appropriate it is to have a shorter assessment period.
Value of Time (VoT)	Value applied to convert time into monetary units	Business $35.16 (2008$) Other $10.82 (2008$) Weighted Average $13.02 (2008$) (Source: Transport Canada, Greater Golden Horseshoe Model) ARL VoT $18.00 (2008$)	The higher the VoT, the higher the monetary valuation of the time savings. Generally based on half the average wage rate.
Value of Time growth	Growth factor to apply to VoT	1.6% per annum (Based on GDP per capita increases, GDP/ Population estimates from www.greatertoronto.org)	The higher the VoT growth, the higher the monetary valuation of future time savings.
Consumer Price Index (CPI)	Inflation	1.9% per year (annual CPI increase average 1991-2007 from StatsCan)	The higher the CPI, the higher the nominal fare revenues and lower the real increase in costs

Factor	Description	Proposed Value (Source)	Implications
Benefit and revenue ramp up	Time for passengers to adjust their behaviour to new route choices (if applicable)	Years 1 to 3: 80%, 90%, 100%	The more established the corridor and demand patterns are, the less marked the ramp up will be. Affects benefits incurred in the early years (which are less discounted). However negligible as percentage out of 30 years or so.
Annualization Factor	Conversion of peak period forecasts to annual results	GO Rail - 3 hour AM peak period to annual: 789 (Source: Greater Golden Horseshoe Model, previous GO Rail BCAs)	The higher the value the more benefits assumed. Can have a significant effect on the benefits case but factors applied in models based on observed data.
Demand growth profile	Growth assumptions surrounding forecast model years	Two forecast years: 2021 and 2031. Demand Growth interpolated in between 2021 & 2031 and extrapolated before 2021. Assumes passenger demand and service levels static after 2031. Source: Greater Golden Horseshoe Model	Regular growth in demand up to 2031. After 2031 the growth in demand and service levels are uncertain and a prudent approach has been taken. Demand growth is typically capped at capacity. Growth would generally magnify incremental benefits.
Cost inflation	Construction, operating and maintenance price increases from inflation	Construction: 2010-2030 3% p.a. nominal 2031 onwards 1.9% p.a. nominal Non-fuel operating costs: 2010-2030 1.9% p.a. nominal 2031 onwards 1.9% p.a. nominal Rolling Stock: 2010-2030 3.0% p.a. nominal 2031 onwards 1.9% p.a. nominal Fuel operating costs: (TBC) *Diesel* 2010-2020 5.0% p.a. nominal 2021-2030 5.0% p.a. nominal 2031-2050 1.9% p.a. nominal *Electricity* 2010-2020 2.5% p.a. nominal 2021-2030 2.5% p.a. nominal 2031-2050 1.9% p.a. nominal	The higher the real price cost increases, the higher the project costs and lower BCR. A higher inflation with diesel compared to electricity would enhance the case of electrification.
Auto collision cost	Monetary value of highway collisions	$0.07 per km (2004$) Collision Statistics: 2004 Canadian Motor Vehicle Traffic Collision Statistics, TP3322. Vehicle Kilometers: Statistics Canada, Catalogue No. 53–223–XIE, "Canadian Vehicle Survey"	Estimation based on vehicle kilometres removed. The higher the cost per collision, the higher the collision cost savings.
Auto operating costs	Cost of operating private vehicles	$0.50 per km (2007$) + 2.0% p.a. nominal Data in 2007 based on CAA calculation of average driving costs and includes operating and	Estimation based on vehicle kilometres removed. The higher the auto operating costs, the greater the non-user benefits are.

Factor	Description	Proposed Value (Source)	Implications
		ownership costs (long-term costs). Rate of increase is analysis assumptions.	
Auto decongestion benefits	Time savings for road users as less traffic	2021 0.69 mins/veh-km 2031 1.03 mins/veh-km Based on Greater Golden Horseshoe Model	Unit rates have been calculated by interpolating between the outputs of the forecast years of 2021 and 2031, extrapolating prior to the first forecast year and capping beyond 2021
Transport mode conversion	Percentage of new users converting from car to train	50% Based on Golden Horseshoe Model	50% of new transit users come from car. This factor determines the number of passenger trips that transfer from car to rail at each stop.
Car occupancy factor	Average number of occupants (including driver) per car	1.2 occupants per vehicle	Estimation based on observed data in Greater Toronto
Auto Greenhouse Gas (GHG) emissions	Amount of GHG emitted by road traffic	2006 0.23 kg per km 2021 0.21 kg per km 2031 0.20 kg per km Urban Transportation Emissions Calculator, Transport Canada, Greater Golden Horseshoe Model	Estimation based on vehicle kilometres removed. The higher the emissions per km, the more GHG removed.
Auto Criteria Air Contaminant (CAC) emissions	Amount of CAC emitted by road traffic	Auto only (g/km, values for 2021): CO – 7.1; NH3 –0.062; NOx – 0.28; PM –0.016; PM10 – 0.016; PM2.5 – 0.007; SOx – 0.004; VOC – 0.339 Implementation of BC Tailpipe Emission Standards (equivalent to California Pavley I standards, starting in 2011 through to 2016)	Estimation based on vehicle kilometres removed. The higher the emissions per km, the more CAC removed.
Journey time - Demand elasticity	Demand elasticity with respect to journey time for the incremental demand calculations	-0.6	Provided by Metrolinx and informed by network wide sensitivity tests using the Greater Golden Horseshoe Model. Demand is *relatively inelastic* when the elasticity is less than one (in absolute value): that is, changes in journey time savings have a relatively small effect on demand.

7.2 Calculating Option Benefit Cost Ratios

The Benefit Cost Ratio (BCR) calculation process is performed in a number of stages, as illustrated in Figure 17 and described below.

1. Starting with the time savings, the single year estimates of User, Non-User (or Highway) and Reliability Time Savings (as described in chapters 2, 4 and 3 respectively) are converted to monetary values using a value of time of $13.52 per hour for all corridors except the ARL. This is the weighted average of the 'Business' and 'Other' values of time taken from the Greater Golden Horseshoe Model. In the case of the ARL, a higher percentage of business users has been assumed given that it will be a premium service and therefore the weighted average value of time is larger, at $18.00 per hour.

2. Of the remaining benefits, Auto Operating Cost Savings and Collision Cost Savings are driven by car kilometres removed from highway, which in turn are driven by incremental demand on the GO network (as described in chapter 4). For this reason, demand growth has been applied to these single year cost savings to convert them into profiled estimates over the appraisal period. Revenue and Time Savings are driven directly by demand, therefore demand growth is also applied to the single year revenue and time saving estimates to produce estimates for each year of the appraisal period. It has been assumed that there is no real growth above inflation of fares, values of time or auto operating and collision cost savings, therefore there are no additional growth rates applied to these benefits. Benefit phasing as described in section 7.1 is applied to each profile of benefits, including revenue.

3. Costs are converted from single year estimates to profiles of costs over the appraisal period by applying real cost inflation. The inflation rate used depends on the type of cost; for example, different inflation assumptions are used for the cost of diesel and the cost of electricity (these are part of the rolling stock operating and maintenance costs). Table 14 documents all the inflation assumptions. Capital cost phasing is applied to spread the Infrastructure and Rolling Stock Capital Costs over the construction period. The Rolling Stock Operating and Maintenance Costs only come into effect from scheme opening in 2020.

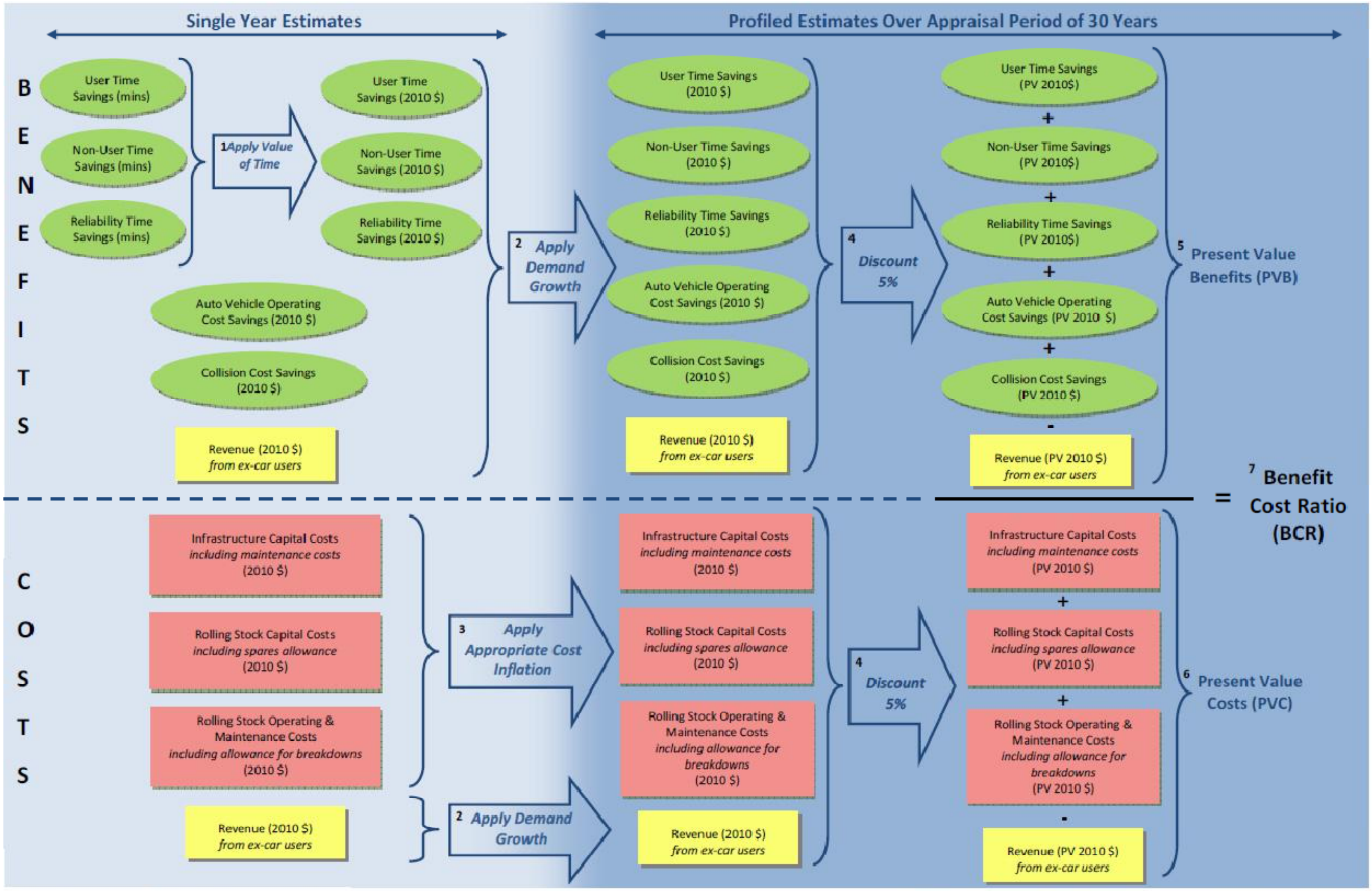
4. All cost and benefit profiles are discounted using a discount rate of 5% to covert them to present values.

5. The Present Value of Benefits (PVB) is calculated by summing the benefits and subtracting the revenue. The revenue generated from ex-car users is subtracted to reflect the fare paid out by passengers, offsetting the package of benefits they will receive. It is assumed that 50% of new GO Rail users come from car, therefore 50% of the incremental revenue is subtracted from the other benefits. New GO Rail users coming from other transit modes already pay fares in the Reference Case and will continue to do so under each of the options, therefore there is no incremental disbenefit for them in terms of expenditure on fares.

6. The Present Value of Costs (PVC) is calculated by summing the costs and subtracting the revenue, which will offset the costs for each option. In the same way as in the PVB calculation, 50% of the revenue is subtracted from the costs to reflect the additional transit revenue gained as a result of new transit users coming from car. New GO Rail users from other transit modes already pay transit fares in the Reference Case, therefore there is no incremental transit revenue gained from these new users under each of the options.

7. The BCR is equal to the ratio of the PVB and PVC.

Figure 17 Benefit Cost Ratio Calculation Process



Note: All costs and benefits are incremental

'PV' indicates costs/benefits have been converted to present values

7.3 Appraisal Results

The appraisal results, including breakdowns of costs and benefits are presented in Table 16; some additional measures based on the appraisal results which are used in the assessment of the options are presented in Table 15.

Table 15 Cost Effective Measures by Option

	Option 1	**Option 2**	**Option 3**	**Option 11**	**Option 15**	**Option 18**
Measure	Georgetown	Lakeshore (excl.TH+B/ St Cat)	Lakeshore* + Georgetown	Lakeshore*, Georgetown , Milton	Lakeshore*, Georgetown , Milton, Barrie	All
Cost per New Rider ($m capex/ new daily passenger in 2031)	0.44	0.26	0.27	0.26	0.30	0.41
Tonnes of GHG saved per annum per $10m capital cost	620	1,120	1,080	1,050	980	770
Present Value Wider Economic Benefits (GDP and wages) per $10m capital cost	3.0	6.6	6.0	5.8	5.3	3.8

The subsequent series of charts (Figure 18 to Figure 23) illustrate the real costs and benefits over the life of the appraisal period for each of the six options.

Table 16 Transportation Economic Appraisal Results by Option

		Option						
		ARL Only	1	2	3	11	15	18
PV Costs	**Infrastructure Capital Costs (PV 2010 $m)**							
	Catenary System	119.3	163.3	272.4	377.2	428.6	524.4	635.5
	Power Supply System	53.8	73.6	122.8	170.0	193.2	236.4	286.4
	Maintenance & Layover Facilities	7.1	12.0	19.6	20.9	22.7	27.1	29.4
	Overhead structures rework	20.2	64.0	71.2	86.6	100.4	135.2	491.5
	Sitework & special conditions	84.4	169.6	228.0	360.6	420.1	548.4	723.1
	Professional services	17.3	38.8	49.5	73.7	85.8	112.8	202.6
	Total Infrastructure Capital Costs (PV 2010 $m)	*302.1*	*521.2*	*763.5*	*1,089.0*	*1,250.7*	*1,584.3*	*2,368.5*
	Rolling Stock Capital Costs (PV 2010 $m)							
	Diesel Locomotive Train		-242.1	-500.6	-748.5	-900.2	-1,027.4	-1,301.4
	DMU Train (ARL)	-35.7	-35.7		-35.7	-35.7	-35.7	-35.7
	Electric Locomotive Train		290.4	591.5	873.6	1,098.9	1,324.1	1,831.0
	EMU Train (ARL)	49.4	49.4		49.4	49.4	49.4	49.4
	Total Rolling Stock Capital Costs (PV 2010 $m)	*13.7*	*62.0*	*90.9*	*138.9*	*212.4*	*310.4*	*543.3*
	Operations & Maintenance Costs (PV 2010 $m)							
	Rolling Stock Maintenance	-3.6	-14.3	-17.6	-30.1	-32.5	-37.6	-52.7
	Wayside Maintenance ($)	15.6	28.1	44.6	71.6	79.2	94.9	111.1
	Diesel	-41.5	-147.1	-488.9	-636.1	-758.9	-904.6	-1,075.7
	Electricity	10.1	45.2	124.9	170.1	206.3	252.6	319.7
	Total Operations & Maintenance Costs (PV 2010 $m)	*-19.5*	*-88.0*	*-337.1*	*-424.5*	*-505.9*	*-594.7*	*-697.5*
	Revenue (PV 2010 $m)	**-5.8**	**-22.6**	**-50.0**	**-72.6**	**-85.9**	**-96.1**	**-108.6**
	TOTAL PV COSTS (2010 $m)	**290.6**	**472.6**	**467.3**	**730.8**	**871.4**	**1,204.0**	**2,105.8**
PV Benefits	**Journey Time Savings (PV 2010 $m)**							
	Exisiting User Time Saving	10.9	118.6	325.8	444.4	527.4	603.0	676.3
	New User Time Savings	0.1	3.2	8.3	11.5	13.2	14.4	16.0
	Highway User Time Savings	1.8	22.7	75.3	98.0	116.5	134.7	152.8
	Total Time Savings (PV 2010 $m)	*12.9*	*144.6*	*409.4*	*554.0*	*657.1*	*752.1*	*845.1*
	Reliability Savings (PV 2010 $m)							
	Diesel Locomotive		1.2	4.9	6.4	8.2	10.0	11.9
	Electric Locomotive		-0.5	-2.1	-2.6	-3.3	-4.0	-4.7
	DMU (ARL)	0.2	0.2		0.2	0.2	0.2	0.2
	EMU (ARL)	-0.1	-0.1		-0.1	-0.1	-0.1	-0.1
	Total Reliability Savings (PV 2010 $m)	*0.1*	*0.8*	*2.8*	*3.9*	*5.0*	*6.1*	*7.2*
	Auto Savings (PV 2010 $m)							
	Auto Vehicle Operating Cost Savings	3.3	40.7	135.5	176.2	209.5	241.9	274.6
	Collision Cost Savings	0.5	5.9	19.7	25.6	30.4	35.1	39.8
	Transit Fare (PV 2010 $m)	-5.8	-22.6	-50.0	-72.6	-85.9	-96.1	-108.6
	Net Auto Cost Savings (PV 2010 $m)	**-2.1**	**23.9**	**105.2**	**129.2**	**153.9**	**181.0**	**205.8**
	TOTAL PV BENEFITS (2010 $m)	**10.9**	**169.4**	**517.5**	**687.1**	**816.0**	**939.2**	**1,058.1**
Economic Efficiency	**Net Present Value (2010 $m)**	**-279.6**	**-303.2**	**50.1**	**-43.8**	**-55.4**	**-264.8**	**-1,047.7**
	Economic Benefit Cost Ratio	**0.0**	**0.4**	**1.1**	**0.9**	**0.9**	**0.8**	**0.5**

Figure 18 Undiscounted Option 1 Costs and Benefits over Appraisal Period

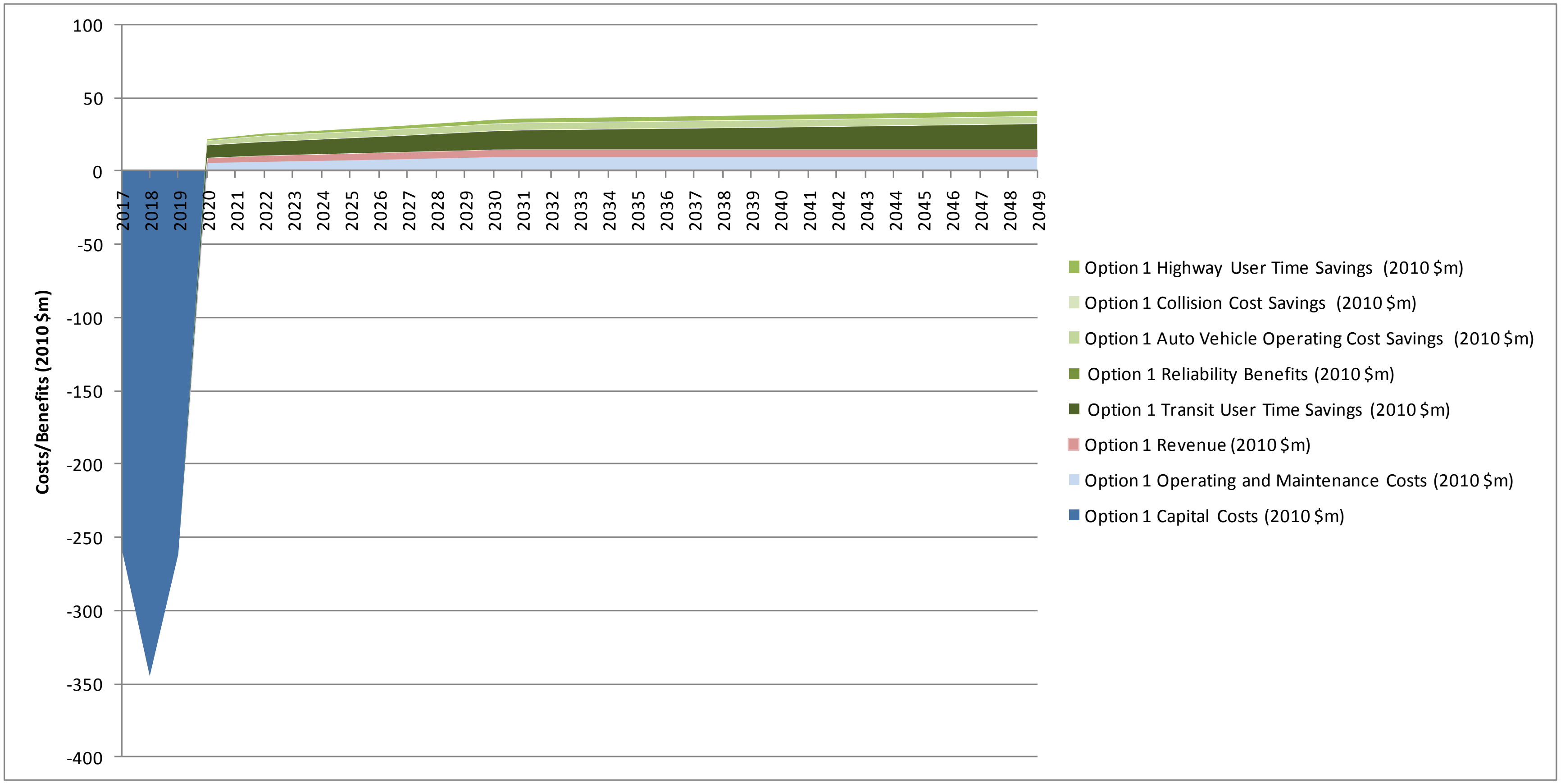


Figure 19 Undiscounted Option 2 Costs and Benefits over Appraisal Period

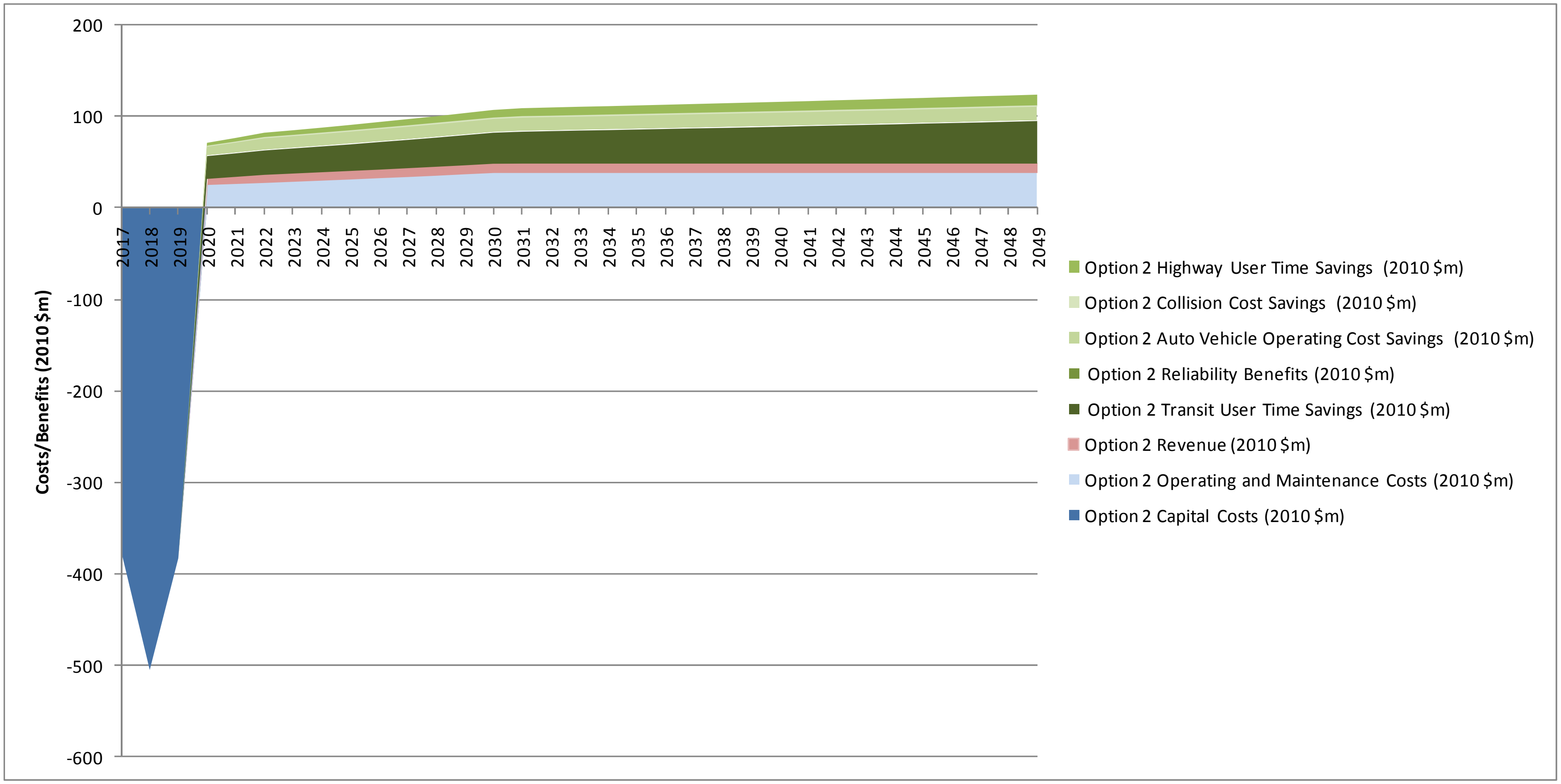


Figure 20 Undiscounted Option 3 Costs and Benefits over Appraisal Period

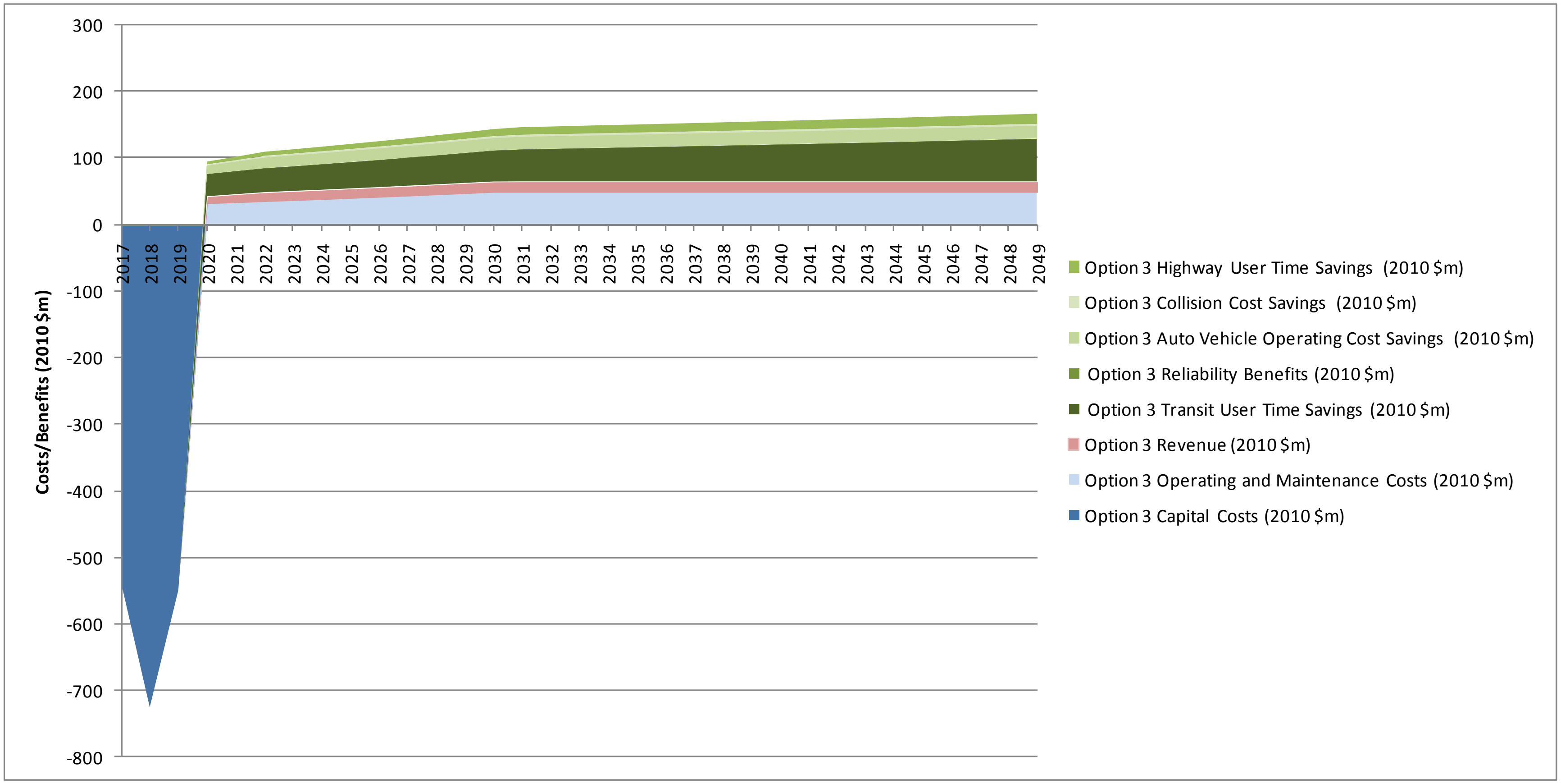


Figure 21 Undiscounted Option 11 Costs and Benefits over Appraisal Period

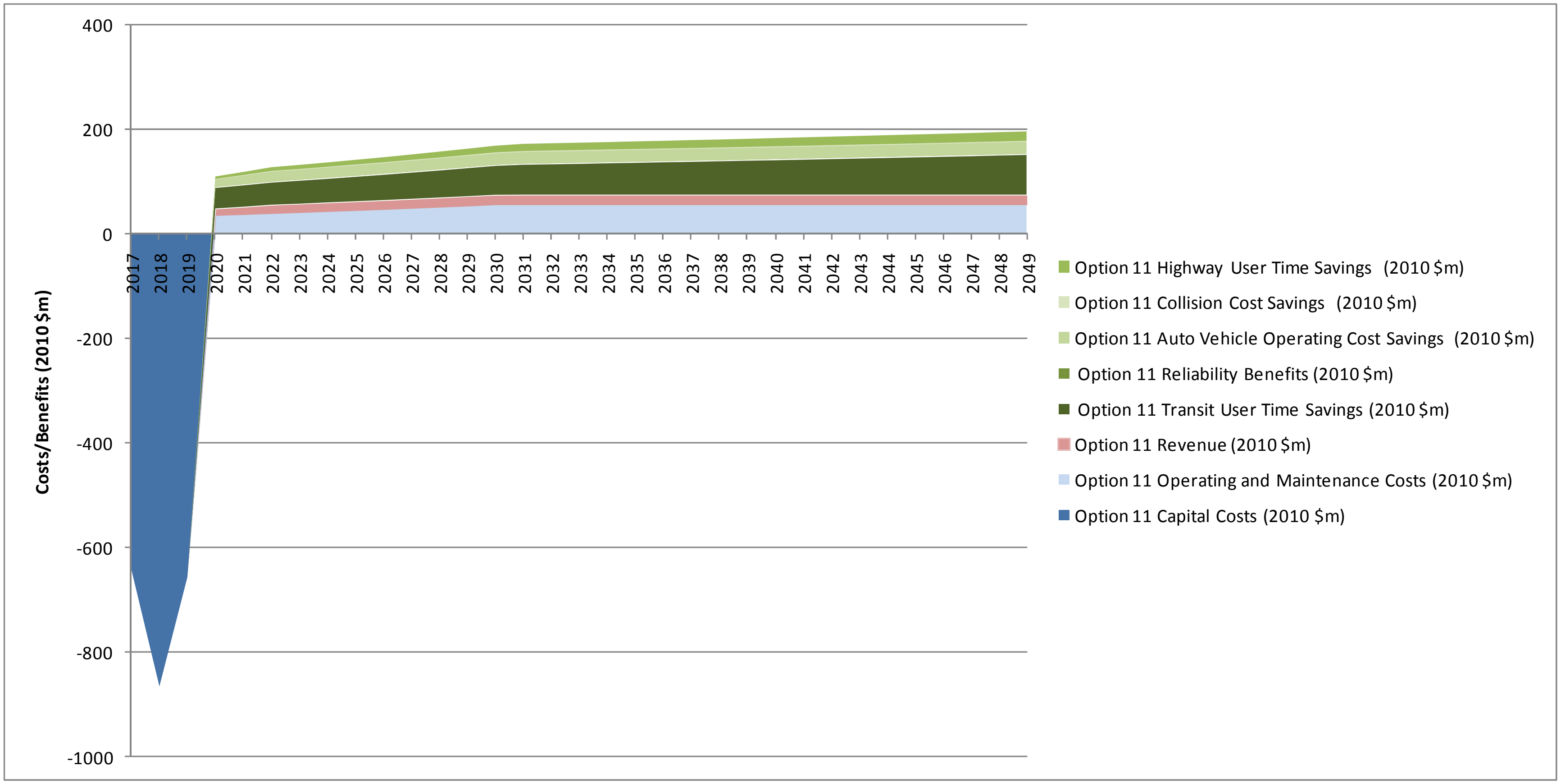


Figure 22 Undiscounted Option 15 Costs and Benefits over Appraisal Period

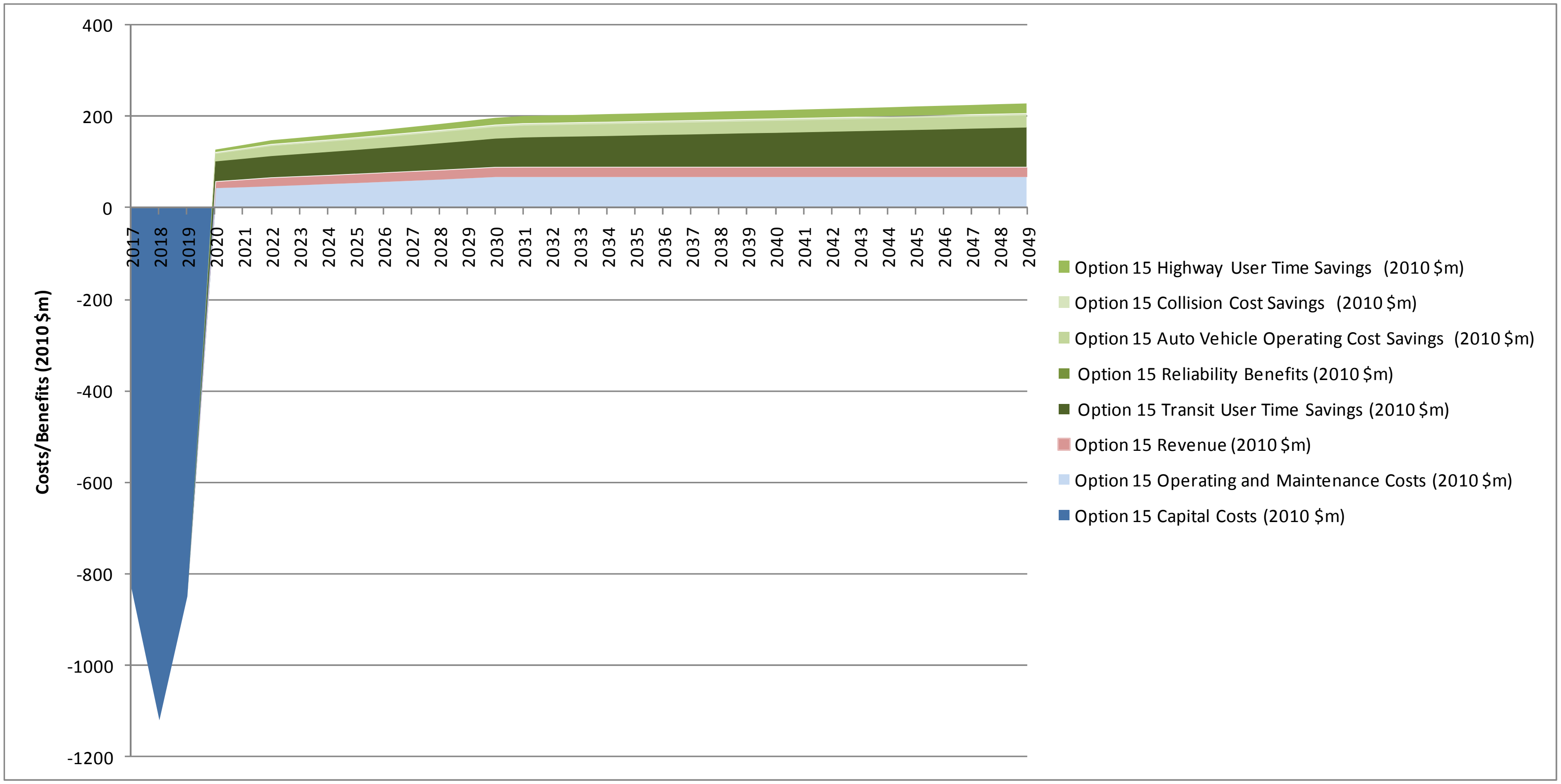
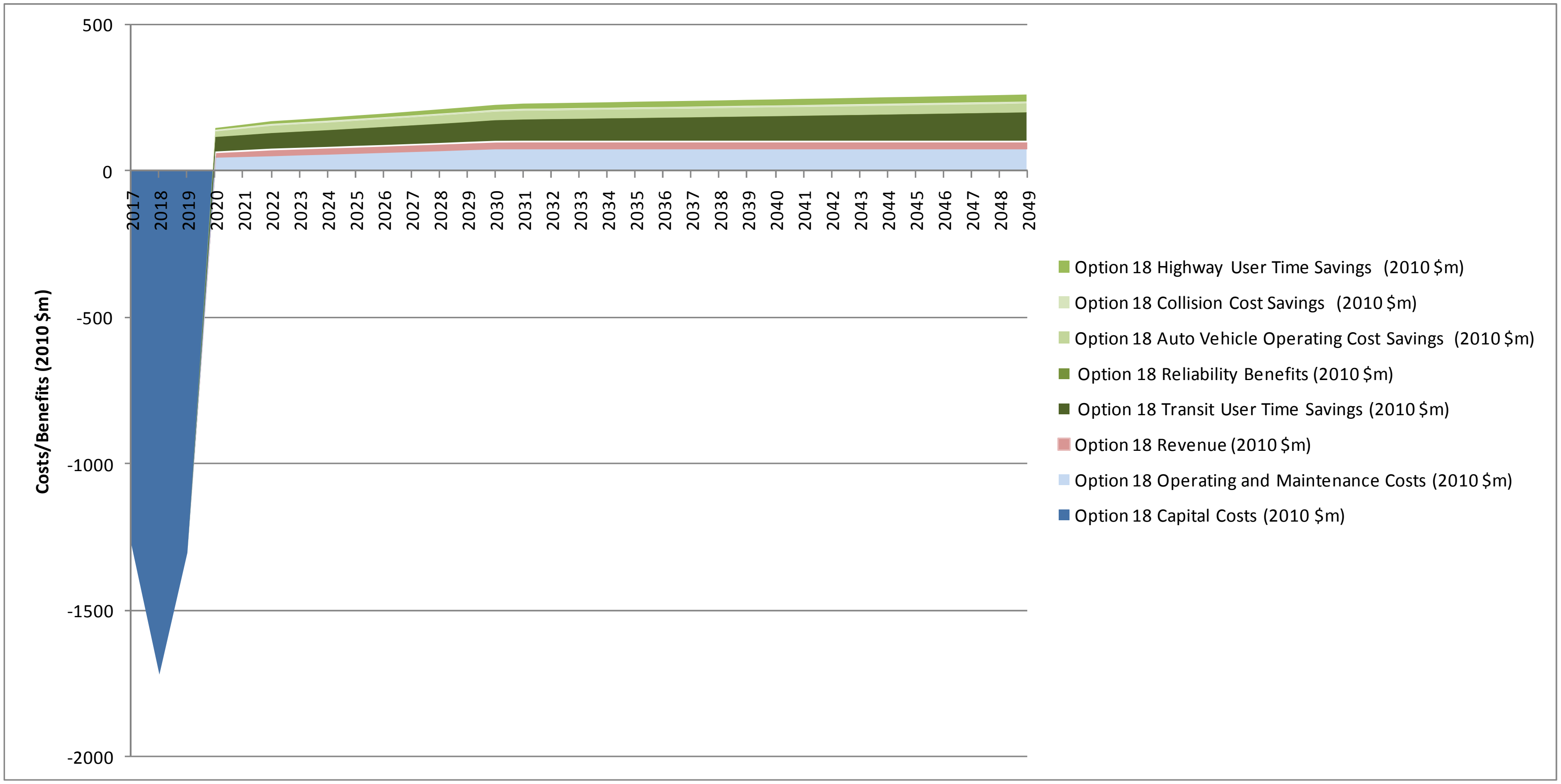


Figure 23 Undiscounted Option 18 Costs and Benefits over Appraisal Period


500
0
-500
-1000
-1500
-2000
Costs/Benefits (2010 $m)
2017 2018 2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043 2044 2045 2046 2047 2048 2049
Option 18 Highway User Time Savings (2010 $m)
Option 18 Collision Cost Savings (2010 $m)
Option 18 Auto Vehicle Operating Cost Savings (2010 $m)
Option 18 Reliability Benefits (2010 $m)
Option 18 Transit User Time Savings (2010 $m)
Option 18 Revenue (2010 $m)
Option 18 Operating and Maintenance Costs (2010 $m)
Option 18 Capital Costs (2010 $m)

APPENDIX 8A: Journey Times and Demand data

APPENDIX 8A-1: Journey Times by Technology, Direction of Travel and stopping Pattern

APPENDIX 8A-2: 2021 Boardings & Percentage Demand Local vs. Express by Stop

APPENDIX 8A-3: ARL User Demand Forecasts

APPENDIX 8A-1: Journey Times by Technology, Direction of Travel and stopping Pattern

Lakeshore West & St. Catharines – Outbound															
Journey Times from Union Station (minutes)	Union Station	Exhibition	Mimico	Long Branch	Port Credit	Clarkson	Oakville	Bronte	Appleby	Burlington	Aldershot	Hamilton-James	Stoney Creek	Grimsby	St. Catharines
Diesel Locomotive – Local	0	5	12	18	24	30	37	43	49	55	61	71	84	97	119
Electric Locomotive – Local	0	5	12	17	22	28	34	39	44	50	55	65	78	90	111
Diesel Locomotive – Express	0	0	0	0	0	0	21	27	33	39	45	55	68	81	102
Electric Locomotive– Express	0	0	0	0	0	0	20	25	30	36	41	50	63	75	95

Lakeshore West & St. Catharines - Inbound															
Journey Times from Union Station (minutes)	St. Catharines	Grimsby	Stoney Creek	Hamilton-James	Aldershot	Burlington	Appleby	Bronte	Oakville	Clarkson	Port Credit	Long Branch	Mimico	Exhibition	Union Station
Diesel Locomotive – Local	0	18	31	44	54	60	66	72	78	85	91	97	103	110	119
Electric Locomotive – Local	0	17	29	42	52	57	63	68	73	80	86	91	96	102	111
Diesel Locomotive – Express	0	18	31	44	54	60	66	72	78	0	0	0	0	0	102
Electric Locomotive– Express	0	17	29	42	51	56	62	67	72	0	0	0	0	0	95

Lakeshore West & Hamilton TH&B - Outbound												
Journey Times from Union Station (minutes)	Union Station	Exhibition	Mimico	Long Branch	Port Credit	Clarkson	Oakville	Bronte	Appleby	Burlington	Aldershot	Hamilton-TH&B
Diesel Locomotive – Local	0	5	12	18	24	30	37	43	49	55	61	75
Electric Locomotive – Local	0	5	12	17	22	28	34	39	44	50	55	69
Diesel Locomotive – Express	0	0	0	0	0	0	22	28	34	40	46	59
Electric Locomotive– Express	0	0	0	0	0	0	20	25	30	36	41	54

Lakeshore West & Hamilton TH&B - Inbound												
Journey Times from Union Station (minutes)	**Hamilton-TH&B**	**Aldershot**	**Burlington**	**Appleby**	**Bronte**	**Oakville**	**Clarkson**	**Port Credit**	**Long Branch**	**Mimico**	**Exhibition**	**Union Station**
Diesel Locomotive – Local	0	12	18	24	30	36	43	49	55	61	68	76
Electric Locomotive – Local	0	12	17	23	28	33	40	46	51	56	62	69
Diesel Locomotive – Express	0	12	17	23	29	35	0	0	0	0	0	58
Electric Locomotive– Express	0	12	17	23	28	33	0	0	0	0	0	54

Lakeshore West & Aldershot - Outbound											
Journey Times from Union Station (minutes)	**Union Station**	**Exhibition**	**Mimico**	**Long Branch**	**Port Credit**	**Clarkson**	**Oakville**	**Bronte**	**Appleby**	**Burlington**	**Aldershot**
Diesel Locomotive – Express Service	0	0	0	0	0	0	21	27	33	39	46
Electric Locomotive– Express Service	0	0	0	0	0	0	20	25	30	36	42

Lakeshore West & Aldershot – Inbound											
Journey Times from Union Station (minutes)	**Aldershot**	**Burlington**	**Appleby**	**Bronte**	**Oakville**	**Clarkson**	**Port Credit**	**Long Branch**	**Mimico**	**Exhibition**	**Union Station**
Diesel Locomotive – Express Service	0	6	12	18	24	0	0	0	0	0	45
Electric Locomotive– Express Service	0	5	11	16	21	0	0	0	0	0	41

Richmond Hill – Outbound							
Journey Times from Union Station (minutes)	Union Station	Oriole	Old Cummer	Langstaff	Richmond Hill	Stouffville	Bloomington
Diesel Locomotive – Local Service	0	23	27	34	40	49	56
Electric Locomotive – Local Service	0	23	27	34	40	48	55

Richmond Hill - Inbound							
Journey Times from Union Station (minutes)	Bloomington	Stouffville	Richmond Hill	Langstaff	Old Cummer	Oriole	Union Station
Diesel Locomotive – Local Service	0	5	13	18	25	30	55
Electric Locomotive – Local Service	0	5	13	18	25	30	55

Barrie – Outbound												
Journey Times from Union Station (minutes)	Union Station	Downsview (York)	Rutherford	Maple	King City	Aurora	Newmarket	East Gwillimbury	Bradford	Innisfil	Barrie South	Allandale
Diesel Locomotive – Local	0	16	25	29	37	47	54	58	67	80	91	104
Electric Locomotive – Local	0	15	23	27	34	44	51	55	64	76	86	98

Barrie – Inbound												
Journey Times from Union Station (minutes)	Allandale	Barrie South	Innisfil	Bradford	East Gwillimbury	Newmarket	Aurora	King City	Maple	Rutherford	Downsview (York)	Union Station
Diesel Locomotive – Local	0	9	20	32	41	45	52	63	71	75	84	102
Electric Locomotive – Local	0	9	20	31	40	44	51	61	68	72	80	98

Lakeshore East – Outbound													
Journey Times from Union Station (minutes)	**Union Station**	**Danforth**	**Scarborough**	**Eglinton**	**Guildwood**	**Rouge Hill**	**Pickering North**	**Ajax**	**Whitby**	**Oshawa 1**	**Oshawa 2 (Bloor)**	**Courtice Road**	**Bowmanville (Martin)**
Diesel Locomotive – Local	0	10	16	21	26	32	40	45	53	62	67	73	83
Electric Locomotive – Local	0	9	15	19	24	30	37	42	49	57	61	66	75
Diesel Locomotive – Express	0	0	0	0	0	0	24	29	37	46	51	57	66
Electric Locomotive– Express	0	0	0	0	0	0	22	27	34	42	46	51	59

Lakeshore East – Inbound													
Journey Times from Union Station (minutes)	**Bowmanville (Martin)**	**Courtice Road**	**Oshawa 2 (Bloor)**	**Oshawa 1**	**Whitby**	**Ajax**	**Pickering North**	**Rouge Hill**	**Guildwood**	**Eglinton**	**Scarborough**	**Danforth**	**Union Station**
Diesel Locomotive – Local	0	7	13	18	26	34	39	46	53	58	63	69	81
Electric Locomotive – Local	0	7	12	16	24	31	36	43	49	54	58	64	75
Diesel Locomotive – Express	0	7	13	18	27	35	40	0	0	0	0	0	65
Electric Locomotive– Express	0	7	12	16	24	31	36	0	0	0	0	0	59

Milton – Outbound									
Journey Times from Union Station (minutes)	**Union Station**	**Kipling**	**Dixie**	**Cooksville**	**Erindale**	**Streetsville**	**Meadowvale**	**Lisgar**	**Milton**
Diesel Locomotive – Local Service	0	15	20	25	31	36	42	47	57
Electric Locomotive – Local Service	0	14	19	24	29	34	39	44	53

Milton – Inbound									
Journey Times from Union Station (minutes)	**Milton**	**Lisgar**	**Meadowvale**	**Streetsville**	**Erindale**	**Cooksville**	**Dixie**	**Kipling**	**Union Station**
Diesel Locomotive – Local Service	0	8	13	19	24	30	35	40	57
Electric Locomotive – Local Service	0	8	13	18	23	28	33	38	54

Georgetown – Outbound

Journey Times from Union Station (minutes)	Union Station	Bloor	Weston	Etobicoke N.	Malton	Bramalea	Brampton	Mount Pleasant	Georgetown	Acton	Guelph	Breslau	Kitchener
Diesel Locomotive – Local	0	8	16	22	31	36	43	49	57	68	83	102	114
Electric Locomotive – Local	0	8	16	21	29	34	40	45	52	61	75	93	103

Georgetown – Inbound													
Journey Times from Union Station (minutes)	Kitchener	Breslau	Guelph	Acton	Georgetown	Mount Pleasant	Brampton	Bramalea	Malton	Etobicoke N.	Weston	Bloor	Union Station
Diesel Locomotive – Local	0	7	24	39	48	56	62	69	74	82	87	95	109
Electric Locomotive – Local	0	7	23	38	47	55	60	66	71	79	84	92	102
Diesel Locomotive – Express	0	7	24	39	48	56	62	69	0	0	0	0	98
Electric Locomotive– Express	0	7	23	38	47	55	60	66	0	0	0	0	94

Stouffville – Outbound										
Journey Times from Union Station (minutes)	Union Station	Kennedy	Agincourt	Milliken	Unionville	Centennial	Markham	Mount Joy	Stouffville	Lincolnville
Diesel Locomotive – Local	0	15	23	29	35	41	45	49	59	68
Electric Locomotive – Local	0	14	22	27	32	38	43	47	56	65

Stouffville – Inbound										
Journey Times from Union Station (minutes)	Lincolnville	Stouffville	Mount Joy	Markham	Centennial	Unionville	Milliken	Agincourt	Kennedy	Union Station
Diesel Locomotive – Local	0	7	16	20	25	31	37	42	50	66
Electric Locomotive – Local	0	7	16	20	25	31	36	41	49	65

APPENDIX 8A-2: 2021 Boardings & Percentage Demand Local vs. Express by Stop

Lakeshore East													
	Union Station	Danforth	Scarborough	Eglinton	Guildwood	Rouge Hill	Pickering North	Ajax	Whitby	Oshawa 1	Oshawa 2	Courtice Road	Bowmanville
Boardings	0	25	345	535	735	2245	3070	4375	4575	3935	760	325	940
Local (%)	0%	100%	100%	100%	100%	100%	70%	65%	65%	60%	60%	10%	10%
Express (%)	100%	0%	0%	0%	0%	0%	30%	35%	35%	40%	40%	90%	90%

Lakeshore West														
	Union Station	Exhibition	Mimico	Long Branch	Port Credit	Clarkson	Oakville	Bronte	Appleby	Burlington	Aldershot	Hamilton-James	St. Catherines/Grimsby	Hamilton (TH&B)
Boardings	0	0	710	1040	2195	3195	5185	2460	2580	2970	495	1095	150	120
Local (%)	0%	100%	100%	100%	100%	100%	65%	60%	60%	60%	60%	75%	35%	35%
Express (%)	100%	0%	0%	0%	0%	0%	35%	40%	40%	40%	40%	25%	65%	65%

Georgetown													
	Union Station	Bloor	Weston	Etoblcoke N.	Malton	Bramalea	Brampton	Mount Pleasant	Georgetown	Acton	Guelph	Breslau	Kitchener
Boardings	0	515	340	475	580	2700	2945	2625	235	145	55	0	335
Local (%)	0%	100%	100%	100%	100%	90%	90%	90%	90%	70%	70%	70%	70%
Express (%)	100%	0%	0%	0%	0%	10%	10%	10%	10%	30%	30%	30%	30%

Milton									
	Union Station	Kipling	Dixie	Cooksville	Erindale	Streetsville	Meadowvale	Lisgar	Milton
Boardings	0	550	2265	3245	2300	2545	1150	435	2620
Local (%)	0%	100%	100%	100%	100%	100%	100%	100%	100%

Barrie											
	Union Station	Downsview (York)	Rutherford	Maple	King City	Aurora	Newmarket	East Gwillimbury	Bradford	Barrie South	Allandale
Boardings	0	0	1390	780	295	2630	1960	990	680	355	915
Local (%)	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Richmond Hill							
	Union Station	Oriole	Old Cummer	Langstaff	Richmond Hill	Stouffville	Bloomington
Boardings	0	485	1,420	1070	2825	680	695
Local (%)	0%	100%	100%	100%	100%	100%	100%

Stouffville										
	Union Station	Kennedy	Agincourt	Milliken	Unionville	Centennial	Markham	Mount Joy	Stouffville	Lincolnville
Boardings	0	540	560	815	1765	835	900	975	655	440
Local (%)	0%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Appendix 8A-3: ARL User Demand Forecasts

Forecast Year	Annual ARL Demand (m passengers)[1]
2021	2.21
2026	2.45
2031	2.65

Note 1: As per the SNC business case