

ELECTRIFICATION STUDY

Network Option Evaluation Report Draft for Discussion

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EXECUTIVE SUMMARY

CONTEXT

Metrolinx operates a comprehensive transportation system of light rail transit, bus and commuter rail lines in the Greater Toronto and Hamilton Area (GTHA). The system includes the GO rail network, which is an essential part of Metrolinx’s service to the area commuters. GO Transit currently provides commuter rail service on seven corridors in the GTHA, using conventional diesel-electric locomotives and non-powered bi-level coaches in push-pull configuration.

In late 2008, Metrolinx published a Regional Transportation Plan – The Big Move – a multimodal vision for regional transportation to strengthen the economic, social and environmental sustainability of the Greater Toronto and Hamilton Area. The Big Move sets out a fast, frequent and expanded regional rapid transit network as a key element of the plan. The plan includes establishing Express Rail and Regional Rail services at speeds and frequencies that could be enhanced by system electrification.

ELECTRIFICATION STUDY

Metrolinx has initiated a study of the electrification of the entire GO Transit rail system as a future alternative to diesel trains now in service. The electrification study is examining how the future GO rail services will be powered – using electricity, enhanced diesel technology or other means – when these services are implemented in the future. The study is assessing the benefits and costs of a full range of technology options, including enhanced diesel, electric and alternative technologies. The study is considering the existing GO Transit network, the proposed network expansions to St. Catharines, Kitchener/Waterloo, Allandale, Bloomington, Bowmanville, as well as the future Pearson Air Rail Link.

NETWORK OPTION EVALUATION

This *Network Option Evaluation Report* builds on several previous reports prepared as part of the electrification study:

- *High Level Decision-Making Framework* – outlines the overall decision-making process being used to develop findings and conclusions for the study.
- *Baseline Report* – describes the base case being used to compare future technology and network options. This base case is referred to as the “reference case” and incorporates existing attributes and approved/planned enhancements of GO’s rolling stock, rail infrastructure and service levels.
- *Rolling Stock Technology Assessment* – identifies and assesses a broad range of existing and future rolling stock and electrification system technologies that could be used to provide future GO rail services, and recommends a “short list” of technologies for more detailed assessment and analysis.

This report describes the process of identifying and evaluating network options for further consideration as part of the electrification study. These are options for where on the GO Transit network – on one or more of the existing or planned GO rail corridors – “short listed” alternative rolling stock technologies could be deployed in the future.

As outlined in the report, over 16,000 network options are possible based on several key considerations:

- **Alternative technologies** – four “short listed” rolling stock technologies were considered including electric locomotives, electric multiple units, dual-mode locomotives and diesel locomotives (the existing “reference case” technology);
- **Corridor alternatives** – the potential use of a “short listed” rolling stock technology on any specific GO line; and
- **Network options** – an alternative to the “reference case” network, involving the use of a “short listed” rolling stock technology on one or more GO line.

Pre-screening criteria were then applied as part of the evaluation to substantially reduce the 16,000+ potential network options for further evaluation. These criteria include:

- The three “short listed” technologies that require electrification – electric locomotives, electric multiple units, dual-mode locomotives – are considered to be a single “family” of technologies.
- The Lakeshore East and Lakeshore West corridors should operate the same type of rolling stock technology.
- Investment in electrification should be focused on the corridors – Georgetown, Lakeshore East and Lakeshore West – that have the highest demand/service and are likely to deliver the most benefits.

Once the pre-screening criteria were applied, a “long list” of 18 network options was identified for further evaluation. These include network options that range from electrifying one line (Georgetown) to electrifying all corridors to some extent, using either electric locomotives or EMUs, potentially supplemented with dual-mode locomotives.

NEXT STEPS

Next steps in the study involve a mix of quantitative and qualitative assessment to identify a “short list” of 6 network options for more detailed analysis. Section 5 of this report outlines the high level evaluation process that will be used to generate the “short list” of network options. This high level evaluation process will:

- Compare the “short listed” rolling stock technologies taking into account several key evaluation categories – environmental and health, user benefits, financial, economic, deliverability, and social community – specified in the *High Level Decision-Making Framework*.
- Identify specific corridor sections (subsets of the existing and planned GO rail corridors), including which of these are priorities for implementing various “short listed” rolling stock technologies.

Following the high level evaluation, up to 6 network options will be taken forward for detailed evaluation. The “short listed” options will be set out in a later report or revision of this report.

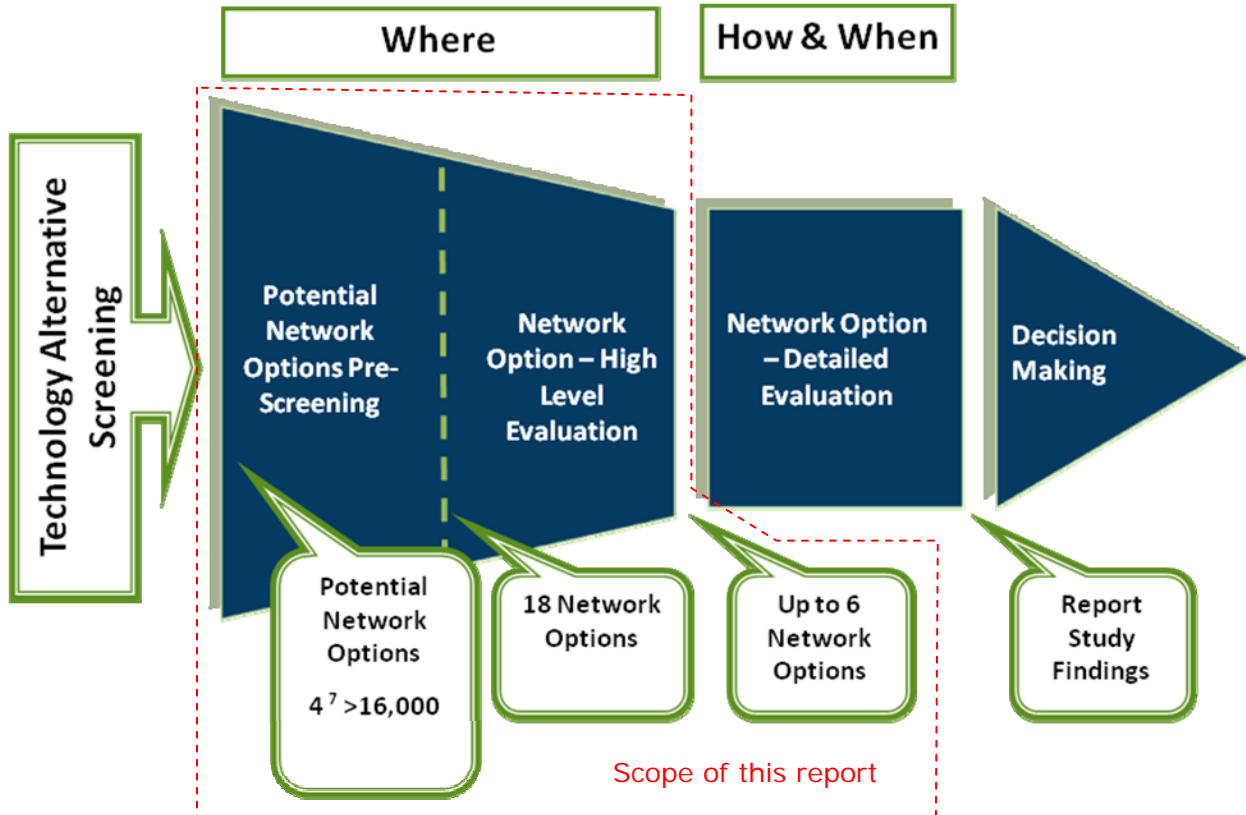
1. INTRODUCTION

This report documents the process of identifying and developing options for detailed consideration.

- Section 2 sets out the definition of an option in the context of the GO Electrification Study and how options for high level evaluation are developed;
- Section 3 sets out a number of pre-screening criteria to produce up to 18 network options for high level evaluation;
- Section 4 summarizes screening results of the list of network options for high level evaluation;
- Section 5 considers the further evaluation criteria to shorten the list of options to 6 for detailed evaluation; and
- Section 6 summarizes the high level evaluation results.

In summary, the scope of this report, in the context of the overall Study process, is illustrated in Figure 1. The report considers the pre-screening of options (summarized in section 3.3) to derive the 18 network options for high level evaluation. The next stage of the process is to carry out the evaluation of these options to derive the final 6 options which will be set out in a later report or revision of this report.

Figure 1 Option Development Process and Scope of Report



- A **network option** is defined as a network using alternative rolling stock technology on one or more of the seven GO Transit corridors.

The Study initially identifies technology alternatives but the evaluation assessment primarily considers **network options**. Each of the network options would be compared against the Reference Case, which assumes 10-coach Tier 4 MP40 diesel locomotive trains, with 2 car DMUs assumed for the Air Rail Link. In comparing options only the technology will change compared to the Reference Case, except for circumstances where infrastructure changes are required to deliver the technology in question, i.e. catenary for the overhead lines and substations for electrification.

2.2 TECHNOLOGY ALTERNATIVES

An initial rolling stock technology review undertaken as part of this study recommended a total of four technologies (including Tier 4 diesel locomotive) that could potentially be implemented effectively on the GO Transit network. The rolling stock technologies taken forward for more detailed analysis include the following:

- **Diesel Locomotive** trains – where a diesel power locomotive provides self-propulsion for passenger carriages (as existing MP40 and Bombardier bi-level railcars but with conversion to Tier 4 emission standards);
- **Electric Locomotive** trains – where an electrically powered locomotive provides propulsion to haul passenger carriages;
- **Electric Multiple Unit** trains – where no locomotive is required and electrical propulsion is distributed through the passenger carriages; and
- **Dual-Mode Locomotive** (Electric/Diesel) trains – where passenger carriages are hauled by a locomotive which can operate from either electrical power or internal diesel engine.

The detailed rationale for including these technologies and excluding the other alternative technology options is set out in the Rolling Stock Technology Assessment Report.

2.3 CORRIDOR ALTERNATIVES

Having established the alternative technologies potentially viable on the GO Transit network, corridor alternatives can be generated by considering new rolling stock on each of the seven corridors in turn. With three alternative technologies and seven corridors, there are potentially 21 different corridor alternatives to consider (or 28 if existing technology is included). Figure 3 illustrates the potential corridor alternatives. However, it is not appropriate to consider any one corridor in isolation as they are interconnected and therefore it is necessary to consider the network as a whole.

Figure 3 Technology / Corridor Alternatives

Corridor & Technology	Diesel Locomotive	Electric Locomotive	Electric Multiple Unit	Dual-Mode Diesel/Electric Locomotive
Lakeshore West	✓	✓	✓	✓
Lakeshore East	✓	✓	✓	✓
Milton	✓	✓	✓	✓
Georgetown	✓	✓	✓	✓
Barrie	✓	✓	✓	✓
Richmond Hill	✓	✓	✓	✓
Stouffville	✓	✓	✓	✓

2.4 NETWORK OPTIONS

A network option is defined as the **combination of all** GO Transit corridors with a specific technology on a specific corridor. These network options will be assessed against the Reference Case network at the detailed stage. Examples of network options include the GO Transit network having Electric Locomotive trains on the Lakeshore East and West corridors and Diesel Locomotives on the other corridors, or Georgetown having Electric Locomotive trains and diesel on all others.

2.5 EVALUATION PROCESS

The evaluation will be undertaken in three stages with increasing detail as the Study progresses. Further details on the evaluation process is set out in the High Level Decision Making Framework document. The three stages include:

- **Pre-screening** of potential network options to derive 18 network options which only considers the various corridors for electrification using a generic electric train technology;
- **High Level Evaluation** of the 18 network options by undertaking a corridor prioritization process and technology evaluation; and
- **Detailed Evaluation** of 6 network implementation options which would include choosing the optimal technologies, partial implementation and phasing.

3. PRE-SCREENING CRITERIA FOR NETWORK OPTIONS

3.1 PURPOSE OF PRE-SCREENING CRITERIA

Having established the alternative technologies potentially viable on the GO Transit network (Electric Locomotive, Electric Multiple Unit and Dual-Mode Diesel/Electric Locomotive), corridor alternatives can be generated by considering new rolling stock on each of the seven corridors in turn.

There are more than 16,000 potential network options due to the permutations and combinations of technologies and corridors. The number of options can be determined by the following formula:

$$N = T^C$$

Where:

N = Number of potential options (including the Reference Case);

T = Number of rolling stock Technologies considered; and

C = Number of Corridors considered.

Some of these would not be considered practical for implementation, nor is it practical to evaluate all these options. Given that a network option can consist of a large permutation of corridor alternatives, pre-screening criteria have been set up to simplify the assessment to ensure that, at a strategic level, a range of appropriate options are considered.

3.2 PRE-SCREENING CRITERIA

In order to produce a realistic list of 18 network options to be taken forward for high level evaluation, the following 3 pre-screening criteria have been proposed. The rationale for including each of these pre-screening criteria is set out below.

3.2.1 Group Technology Alternatives into a Single “Family” of Electric Trains

Given that all three technology alternatives require electrification on part or all of a corridor and broadly meet the same strategic environmental objectives, the rationale for this pre-screening criteria is to focus the network options on which corridors should be electrified in a network regardless of the rolling stock (Electric Locomotive, EMU or Dual Mode Locomotives).

It is therefore recommended that Electric Locomotive Trains, EMUs and Dual-Mode Locomotive trains are all considered as a single “family” of electric trains at this stage. They will be considered when detailed characteristics of each technology and corridor allows a clear distinction between options to be made at the high level evaluation stage.

3.2.2 Compatibility of Technology on Lakeshore East and West

Currently, counter-peak and off-peak trains that run along the Lakeshore East operate through to the Lakeshore West corridor via Union Station, although the service schedules do not necessarily indicate a through service. In the future, the services are expected to continue to operate as such with the possibility of having a through service advertized in the service schedules.

If Lakeshore East and Lakeshore West were to operate two different types of rolling stock (electric and diesel, for example), trains would have to turn back at Union Station and create a significant constraint on the throughput capacity of Union Station. This would have an adverse impact on the number of passengers that could be handled by GO Transit and would not be in line with the Study objectives.

It is therefore recommended that Lakeshore East and Lakeshore West corridors should operate the same type of rolling stock technology.

3.2.3 Prioritizing Highest Service Corridors

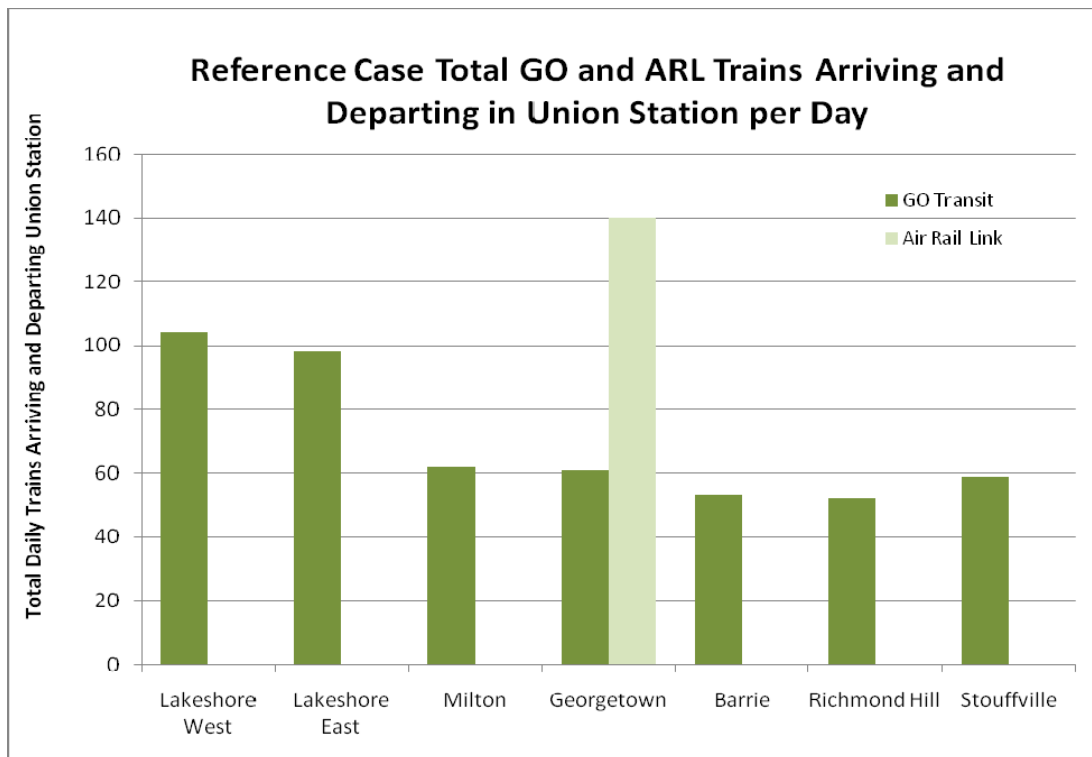
Because it may not be possible to change technology on all corridors simultaneously, investment in electrification should be focused on routes that are most likely to yield the most benefits. Electrification on the corridors with the highest levels of service is also more likely to produce more environmental benefits (emissions, health) per capital investment. Furthermore, should it be possible to run faster or more frequent trains in the future if the new technology allows, the journey time saving would benefit more passengers on those corridors.

Figure 4 sets out the levels of service specified in the Reference Case, measured by the total number of train services operated on each corridor. This measure is most appropriate for assessing the impacts of noise and vibration. The services of the Air Rail Link (ARL) has been set out separately as these will consist of 2-car DMUs unlike the rest of the GO Transit network.

Figure 5 sets out the number of train-cars specified in the Reference Case, measured by the total number of train cars, i.e. the frequency of service multiplied by the number of cars (locomotives + passenger coaches) operated in and out of Union station every day. This measure is most appropriate for assessing the impacts of any change in operating and maintenance costs and energy consumption which leads to CAC and GHG emissions.

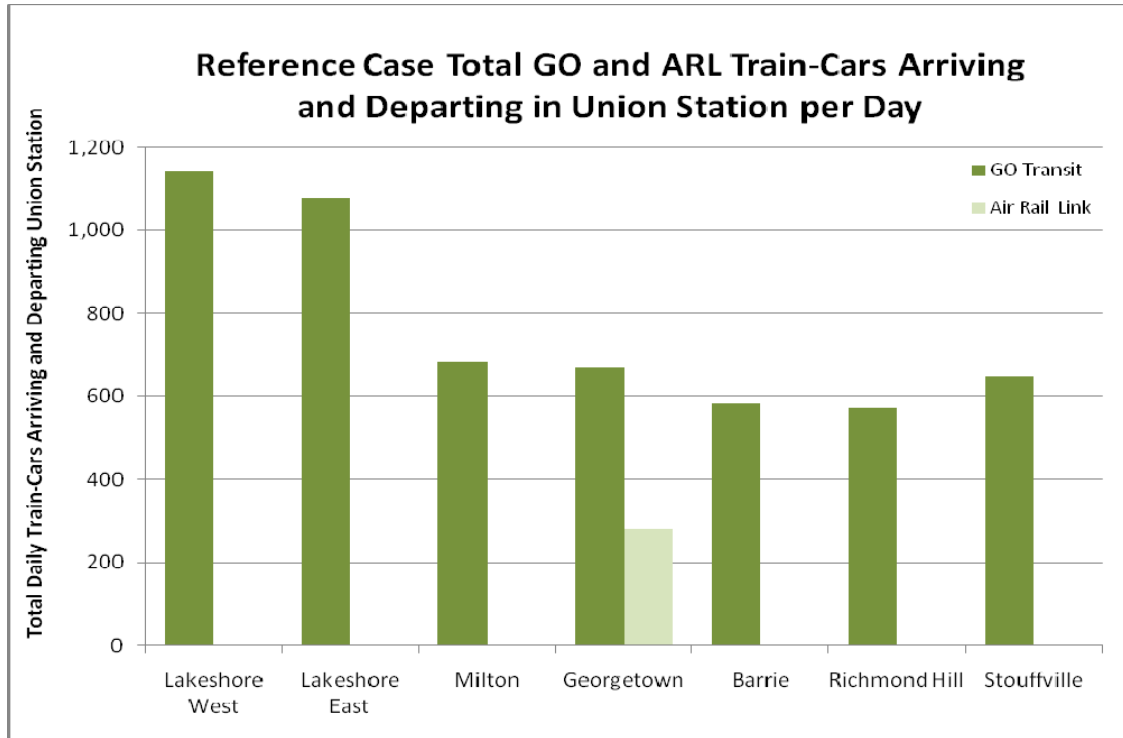
These two figures show that electrifying the Lakeshore East, Lakeshore West and Georgetown corridors are likely to deliver the biggest impact and will be prioritized over other corridors under this screening criteria.

Figure 4 Total Daily Train Services by Corridor*



*The ARL will operate 2-car DMUs compared to GO’s 10-car diesel locomotive trains in the Reference Case

Figure 5 Total Daily Train-Cars Operated By Corridor*



*The ARL will operate 2-car DMUs compared to GO’s 10-car diesel locomotive trains in the Reference Case

3.3 PRE-SCREENING CRITERIA SUMMARY

In summary, the pre-screening criteria to be applied to the potential list of options to generate up to 18 options for high level evaluation is as follows:

1. Consider three alternative technologies as a single “family” of electric trains at this stage;
2. Lakeshore East and West to operate on the same technology; and
3. Prioritizing highest service corridors.

4. PRE-SCREENING OF NETWORK OPTIONS

4.1 PRE-SCREENING OF OPTIONS

The first two of the three pre-screening criteria change the parameters in the equation in paragraph 3.1 to reduce the number of options. For example, considering one type of electric train as opposed to three will reduce T from 4 to 2, so the number of options reduces from 16,384 (4^7) to 128 (2^7). Similarly, assuming that Lakeshore East and West operate the same technology effectively means reducing the number of corridors from 7 to 6, and if applied independently the number of options reduce from 16,384 (4^7) to 4,096 (4^6).

The final criteria of prioritizing highest service corridors was undertaken by inspection following the first pre-screening and details on how the 128 options fared against the other pre-screening criteria is set out in the appendix. In summary, the impact of each pre-screening criteria applied incrementally is shown in Figure 6.

Figure 6 Options Remaining After Each Pre-Screening Criteria Applied Incrementally

Pre-Screening Criteria	Options Remaining
No pre-screening	16,384 (4^7)
1. Consider three technologies as a single family of electric trains at this stage	128 (2^7)
2. Lakeshore East and West to operate on the same technology	64 (2^6)
3. Prioritizing highest service corridors	18 + Reference Case

The 18 network options set out the combination of corridors that merits further consideration for electrification. It should be noted that the electric rolling stock technologies and the case for partial electrification of corridors will be considered separately as part of the detailed evaluation of 6 options. This will be discussed in Section 5.5.

4.2 OPTIONS FOR HIGH LEVEL EVALUATION

Following the application of the 3 pre-screening criteria, the 18 options taken forward for consideration for high level evaluation are set out in Figure 7. Where a tick is entered in a cell for a particular corridor, it indicates that the electric technology is assumed on that corridor, and where the cell is empty it indicates that diesel rolling stock technology remains.

The 18 options cover a range of network sizes, starting from only electrifying one corridor to electrifying all seven corridors. All but one option includes both the Lakeshore East and West corridors, and similarly for the Georgetown corridor, since these were identified as the priority corridors according to specified service levels. The main area of variation between options is the permutation of including Milton, Barrie, Richmond Hill and Stouffville corridors. Each of these corridors appear in 8 options.

Figure 7 Post-Screening Options to 18 + Reference Case for high level evaluation

Lakeshore West	Lakeshore East	Georgetown	Milton	Barrie	Richmond Hill	Stouffville
✓	✓	✓	✓	✓	✓	✓
✓	✓	✓	✓	✓	✓	
✓	✓	✓	✓	✓		✓
✓	✓	✓	✓	✓		
✓	✓	✓	✓		✓	✓
✓	✓	✓	✓		✓	
✓	✓	✓	✓			✓
✓	✓	✓	✓			
✓	✓	✓		✓	✓	✓
✓	✓	✓		✓	✓	
✓	✓	✓		✓		✓
✓	✓	✓		✓		
✓	✓	✓			✓	✓
✓	✓	✓			✓	
✓	✓	✓				✓
✓	✓	✓				
✓	✓					
		✓				

✓ indicates partial or full electrification of corridor
 (Electric xx) provides the cross reference to list of potential options set out in the Appendix

5. OPTION PROGRESSION

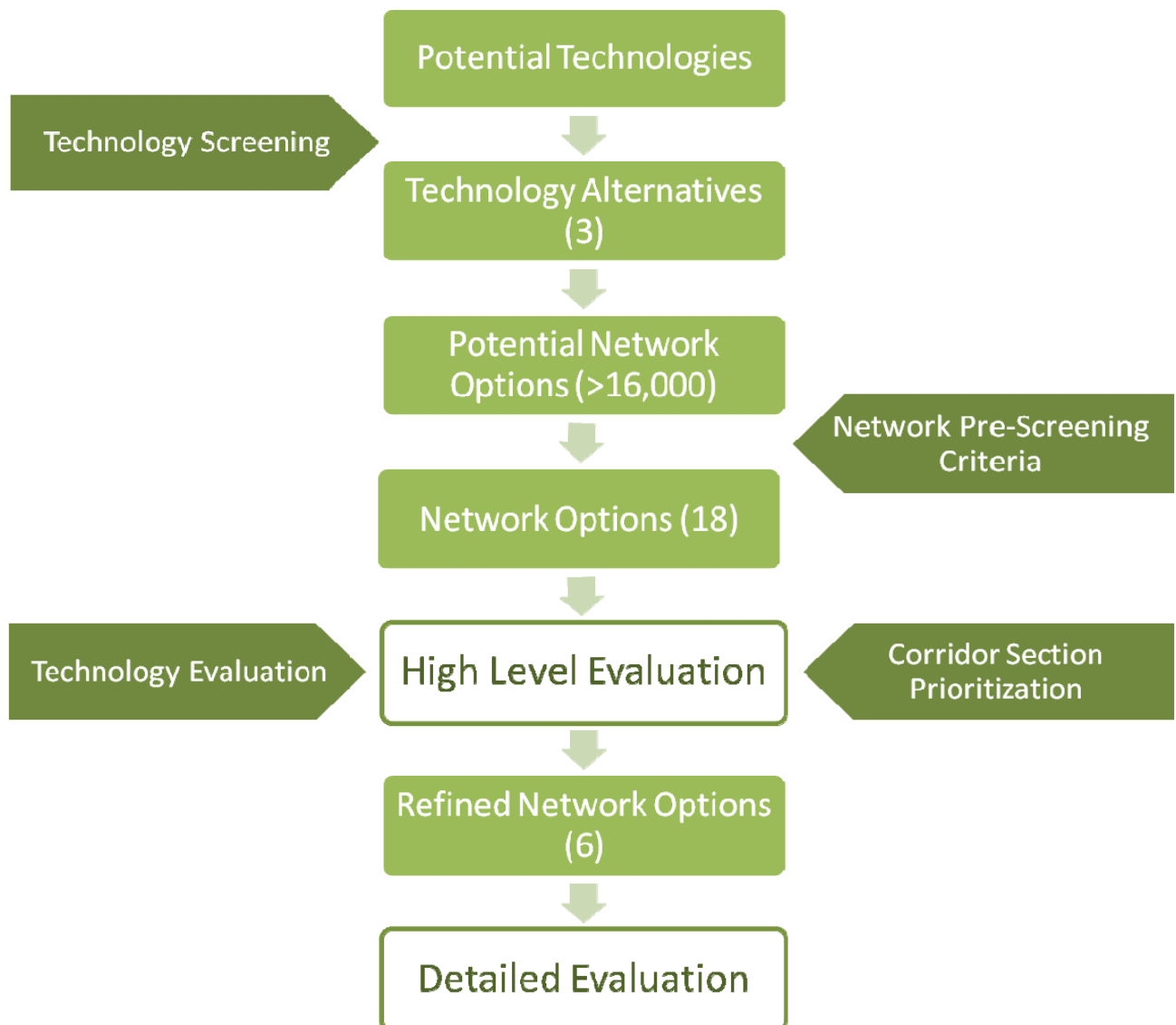
5.1 OPTION EVALUATION PROCESS

The previous section described how the list of 18 options for high level evaluation was identified. The way in which these options are evaluated can be undertaken following three key activities:

- Technology evaluation;
- Corridor section prioritization (ranking); and
- Implementation Option identification.

Once the corridor prioritization has taken place it will be possible to determine the order in which the corridor sections should be implemented if the maximum benefits are to be delivered first. The following figure illustrates the overall process.

Figure 8 Option Evaluation and Progression



5.2 HIGH LEVEL EVALUATION FRAMEWORK

This section expands on the Decision Making Framework (DMF) and sets out the short listing process from 18 options to 6 options for detailed assessment. At this stage the emphasis is on ensuring that options taken forward are deliverable and broadly meet the Study Objectives (which are set out in the DMF and reproduced in the appendix). Figure 9 sets out the following information:

- The Evaluation Categories (as indicated in the DMF);
- The sub-categories that are reviewed at this Evaluation Stage;
- The high-level quantitative measures of assessment under the sub-categories;
- The data input required to conduct the quantitative analysis.

The quantitative analysis will inform the qualitative evaluation options under each sub-category which will be used for the prioritization to produce up to 6 network options for detailed assessment. The evaluation assumptions have been made consistent with previous Metrolinx studies where applicable. Information on Tier-4 MP40, 10-passenger car trains will also be provided alongside equivalent alternative technologies so that differences can be established. Further detailed work has commenced to accurately provide the inputs to the high level evaluation process.

Quantitative measures will be used to inform a qualitative assessment, depending on the magnitude of change, based on the following seven-point scale:

- Strong positive impact;
- Moderate positive impact;
- Slight positive impact;
- Neutral/No impact;
- Slight negative impact;
- Moderate negative impact; and
- Strong negative impact.

Figure 9 High Level Option Evaluation Framework

Evaluation Category	Sub-Category	Measure	Data Required for Quantitative Analysis
Environmental & Health	Emissions	Improvement in air quality (NO _x , CO, HC, PM, SO ₂ , and ozone)	Emissions per train kilometre by technology; Estimated population residing within 200m of corridor
	Sustainability	Not considered at this stage	Not considered at this stage
	Visual	Density of overhead catenary system	Length and width of catenary system
	Noise & Vibration	Population affected by noise	Decibel of noise by technology per train; Estimated population residing within 200m of corridor
User Benefits	Journey Time & Comfort	Capacity, Speed	Passenger capacity per train by technology; acceleration/ deceleration capabilities
	Reliability	% train km operated reliably	Mean train kilometres operated before failure by technology
	Disruption during Construction	% passengers affected	Passenger demand by corridor
Financial	Financing	Not considered at this stage	Not considered at this stage
Economic	Economic Efficiency	Incremental Present Value Capital; Operating/Maintenance and Net Cost over 30 years @ 5% discount rate	Capital cost per kilometre electrification by corridor segment; capital cost per train by technology; operating and maintenance cost per train kilometre operated; number of trains required to operate each corridor
	Wider Economic Benefits	Not considered at this stage	Not considered at this stage
Deliverability	Technology	Assumes technology options are proven at this stage and/or is reflected in costing	Qualitative assessment on known issues
	Operational	Assumes options are operable at this stage	Qualitative assessment on known issues
	Affordability	Capital Cost	Capital cost per kilometre electrification by corridor segment; capital cost per train by technology; number of trains required to operate each corridor
	Acceptability	Stakeholder support	Feedback from Stakeholder Workshop
Social Community	Community & Land Use	Not considered at this stage	Not considered at this stage

5.3 TECHNOLOGY EVALUATION

At this stage of the study, the four rolling stock technologies will be evaluated at a high level to determine the relative differences in technologies. The key differences are expected to be on capital and operating costs, environmental impacts (emission reductions) and potentially passenger time saving benefits. The technology evaluation will be based on the high level evaluation framework.

To determine the performance of each electric train technology, we will make the comparison against Tier 4 diesel trains using the full network Reference Case. The technology evaluation will primarily consider the relative performances of Electric Locomotive and EMU trains compared to Diesel Locomotive trains. The Dual Mode trains become a potential alternative where corridors are partially electrified so that environmental benefits of electrification can be delivered for services which traverse both the electrified and non-electrified sections.

Information from the technology evaluation would then be used to inform the appropriate technologies to be deployed on each service in the 6 implementation options taken forward for detailed evaluation.

5.4 CORRIDOR SECTION PRIORITIZATION

A key component of the Study evaluation would be to consider the relative performance of operating electric trains on the various corridors against diesel trains. The case for electrification can vary along the corridor – it may only be worthwhile electrifying a particular part of a corridor. As such it was decided that the analysis should be undertaken at a corridor section level.

Corridor Sections

Within a corridor there are sections with large changes in service levels (which can be an indication for cost changes and environmental benefits), it is appropriate to consider corridor sections rather than entire corridors, meaning that partial electrification (with running the optimal electric train technology) on the corridors will be considered.

Figure 10 illustrates the frequency of GO services along each section of route under the Reference Case, where the thicker the line the more services are operated, noting that the trains operated on the Air Rail Link are 2-car DMUs compared to 10-car Diesel Locomotive trains on the other corridors. Figure 11 illustrates the proposed way of dividing corridors into sections based on the levels of service along the route and proposed stabling facilities.

In some cases the boundaries have been moved following consultation with Metrolinx so that if inner sections were electrified, the trains would still be able to access the stabling facilities on the corridor. Two instances of this include extending the extent of MT1 from Streetsville to Meadowvale and extending GT1 from Bramalea to Brampton (and subsequently moving GT2 from Mount Pleasant to Georgetown for strategic purposes). This means that the sections do not exactly match the destination of services which do not operate to the end of the line.

In addition, for the purpose of developing costing and for the avoidance of overlapping costs when a number of lines are considered for electrification together, Union Station and the corridors in the downtown area have been broken down into detailed Union Station sections as shown in Figure 12. However, these sections have not been considered for electrification in isolation.

The corridor sections would help identify where it may be desirable to partially electrify corridors because of one or more of the following reasons:

- There is relatively low service levels at the ends of a corridor. For example, in the Reference Case on the Lakeshore West corridor, the 64km section between Union and Hamilton will have between 96 and 104 trains per day operated along it (as shown in Figure 13, but the 50km section between Hamilton and St Catherine’s will have only 8 trains per day, a significant difference in service levels;
- Capital budgeting could require a phased implementation of electrification;
- If the route passes through an area where the construction of an overhead catenary system may be deemed unacceptable to the local community; and
- Parts of route with higher population along the route who could benefit from improved air quality and noise may be prioritized first.

Figure 10 Reference Case Frequency Diagram



Figure 11 Definition of Corridor Sections



Figure 12 Detailed Union Station Sections

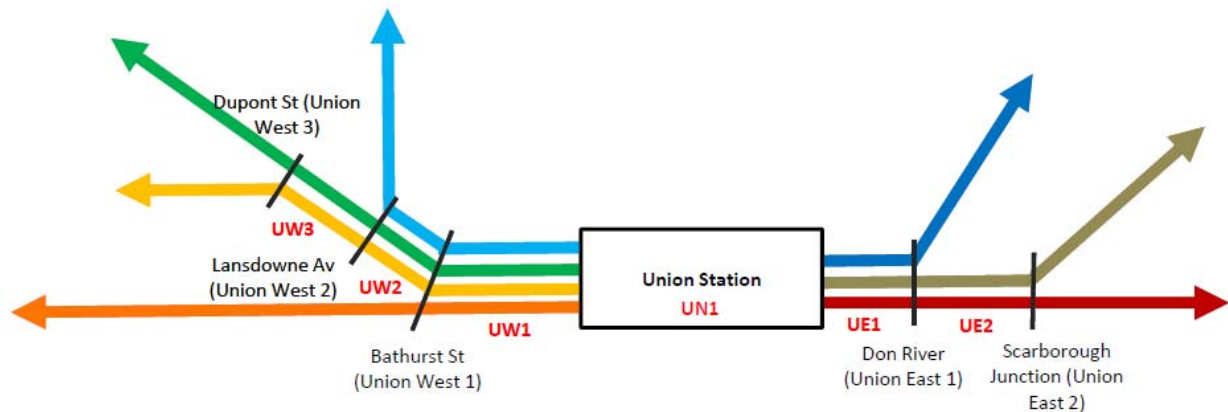
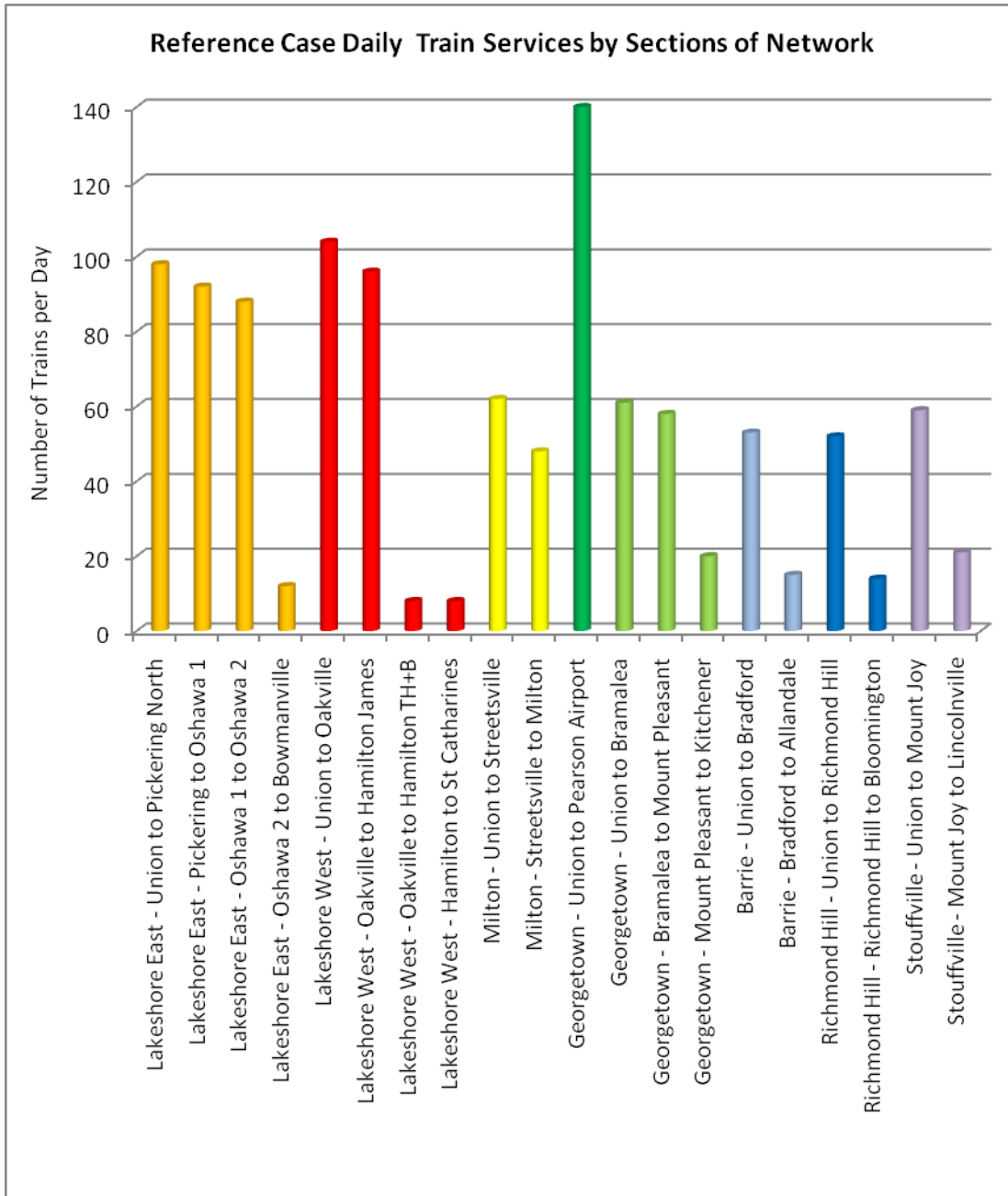


Figure 13 Variation of Number of Daily Trains by Corridor in the Reference Case



Prioritizing Corridor Sections

As part of the high level evaluation criteria there will be corridor section information across various categories and it would be possible to rank in order the corridors in terms of value, measured by a unit cost of investment to deliver the scheme objectives, such as air quality improvements.

Based on the ranking, corridors sections will be put in order of priority which will then dictate the order of implementation, which by implication would consider partial electrification.

5.5 SCREENING OPTIONS FOR DETAILED EVALUATION

Following a technology review of corridor sections, the optimal sections of each corridor is identified and remaining sections are also considered. The 18 network options are then ranked in order of performance based on transportation and environmental cost effectiveness measures. The highest performing network options are then taken forward to detailed evaluation.

The network options may become “refined” network options as they could include partial electrification rather than full electrification on a corridor as assumed in the option generation stage. The refinement will be based on the relative merits of the inner corridor sections compared to the outer corridor sections as identified in the corridor section prioritization/ranking developed.

Up to 6 network options will be taken forward for detailed evaluation. The evaluation will compare the impacts of the optimal electric rolling stock technology (Electric Locomotive or EMU) compared to Tier 4 diesel on services which operate entirely through the electrified sections, while Dual-Mode locomotives will be compared to Tier 4 diesel on services which only partially operate through the electrified sections.

For example, if the optimal section on Lakeshore West was identified as electrifying from Union Station to Hamilton James but not to Hamilton TH+B or St Catharines, then all trains which terminate at or before Hamilton James would be electric trains in the option being evaluated. Services which operate to Hamilton TH+B and St Catharines cannot be electric trains because parts of the route is not electrified – they could be either Diesel Locomotive trains or Dual-Mode Locomotive trains which run in electric mode between Union and Hamilton James but in diesel mode to Hamilton TH+B and St Catharines. The high level evaluation would identify the relative merits in deploying Dual-Mode trains in these circumstances.

6. APPENDIX

- **Electrification Study Objectives – refer to Figure 14.**
- **Pre-screening of 128 options – refer to Figure 15.**

This table sets out how the 128 network options were comprehensively generated, with 1 indicating electrification under each corridor and 0 indicating that no change will be made and diesel trains will continue to operate. This reflects the simplification made in the first pre-screening criteria (Electric Locomotive trains and EMUs considered as a single family of electric trains).

The final 3 columns represent the second and third pre-screening criteria (Lakeshore East and West to operate the same technology and prioritize Lakeshore East, West and Georgetown over the other corridors). In these columns a 1 indicates the criteria has been satisfied and a 0 if it has not been satisfied. The final column requires both criteria to be satisfied, and a total of 18 options satisfy both criteria.

- **Schematics of 18 options for high level evaluation – Refer to pages 22-31.**

Figure 14 **Electrification Study Objectives**

Evaluation Category	Objective
User Benefits	The selected technology should facilitate faster, more frequent and less crowded transit
	The implementation of the selected technology should improve transit reliability
	The selected technology should facilitate improved connections and service within the GTHA and to/from regional, provincial, and international terminals and facilities
Environment and Health	The selected options should result in a net improvement to human health in adjacent communities
	The selected technology should contribute to improved air quality
	The implementation of the selected technology should make a significant contribution to the achievement of the transportation related GHG reduction targets of GO Green: Ontario's Action Plan for Climate Change
	The selected technology should be implemented in a manner that will minimize negative impacts on agricultural and natural systems
	The selected technology should decrease the use of non-renewable resources
	The selected technology should encourage environmentally sustainable operations (e.g. through the use of green technologies).
Community and Land Use	The selected technology should be capable of being implemented in a manner that would encourage transit-supportive densities, visionary community developments and enhanced community facilities (e.g. bike paths)
	The selected technology implementation should minimize the need to acquire property to accommodate associated infrastructure
	The selected technology should be implemented in a manner that will minimize adverse community/social impacts including aesthetic impacts and impacts from noise and vibration
	The selected technology should be implemented in a manner that will minimize adverse heritage and archaeological impacts
Economic	The implementation of the selected technology should optimize opportunities to provide positive economic benefits to the local, regional and national economies (e.g. domestic manufacturing capacity, foreign direct investment, demand for skilled labour)
	The implementation of the selected technology should provide appropriate land development opportunities
Financial	The selected technology should be implementable with cost-effective financing solutions
	The selected technology should provide value associated with all relevant and material hard and soft system capital costs, operating costs, and lifecycle maintenance costs
Deliverability	The selected technology should be proven in a comparable climatic setting.
	The implementation of the selected technology should minimize impact on other rail services (e.g. CN/CP/VIA)

Figure 15 Pre-Screening on 128 Options

Option	Options								63	22	18	
	Lakeshore West	Lakeshore East	Milton	George town	Barrie	Richmond Hill	Stouffville	Total	Criteria 2	Criteria 3	Criteria 2 & 3	
	Route km	6726	5642	2851	3547	4035	1919	2480	27200	LSE=LSW	Prioritize LSE/W & GT	
RC	Reference Case	0	0	0	0	0	0	0	0			
Electric Options	Electric 1	0	0	0	0	0	0	1	1	1	0	0
	Electric 2	0	0	0	0	0	0	1	0	1	0	0
	Electric 3	0	0	0	0	0	0	1	1	2	0	0
	Electric 4	0	0	0	0	1	0	0	0	1	0	0
	Electric 5	0	0	0	0	1	0	0	1	2	0	0
	Electric 6	0	0	0	0	1	1	0	2	1	0	0
	Electric 7	0	0	0	0	1	1	1	3	1	0	0
	Electric 8	0	0	0	1	0	0	0	1	1	1	1
	Electric 9	0	0	0	1	0	0	0	1	2	0	0
	Electric 10	0	0	0	1	0	1	0	2	1	0	0
	Electric 11	0	0	0	1	0	1	1	3	1	0	0
	Electric 12	0	0	0	1	1	0	0	2	1	0	0
	Electric 13	0	0	0	1	1	0	0	1	3	0	0
	Electric 14	0	0	0	1	1	1	0	3	1	0	0
	Electric 15	0	0	0	1	1	1	1	4	1	0	0
	Electric 16	0	0	1	0	0	0	0	1	1	0	0
	Electric 17	0	0	1	0	0	0	0	1	2	0	0
	Electric 18	0	0	1	0	0	1	0	2	1	0	0
	Electric 19	0	0	1	0	0	1	1	3	1	0	0
	Electric 20	0	0	1	0	1	0	0	2	1	0	0
	Electric 21	0	0	1	0	1	0	0	1	3	0	0
	Electric 22	0	0	1	0	1	1	0	3	1	0	0
	Electric 23	0	0	1	0	1	1	1	4	1	0	0
	Electric 24	0	0	1	1	0	0	0	2	1	0	0
	Electric 25	0	0	1	1	0	0	1	3	1	0	0
	Electric 26	0	0	1	1	0	1	0	3	1	0	0
	Electric 27	0	0	1	1	0	1	1	4	1	0	0
	Electric 28	0	0	1	1	1	0	0	3	1	0	0
	Electric 29	0	0	1	1	1	0	1	4	1	0	0
	Electric 30	0	0	1	1	1	1	0	4	1	0	0
	Electric 31	0	0	1	1	1	1	1	5	1	0	0
	Electric 32	0	1	0	0	0	0	0	1	0	1	0
	Electric 33	0	1	0	0	0	0	1	2	0	0	0
	Electric 34	0	1	0	0	0	1	0	2	0	0	0
	Electric 35	0	1	0	0	0	1	1	3	0	0	0
	Electric 36	0	1	0	0	1	0	0	2	0	0	0
	Electric 37	0	1	0	0	1	0	1	3	0	0	0
	Electric 38	0	1	0	0	1	1	0	3	0	0	0
	Electric 39	0	1	0	0	1	1	1	4	0	0	0
	Electric 40	0	1	0	1	0	0	0	2	0	1	0
	Electric 41	0	1	0	1	0	0	1	3	0	0	0
	Electric 42	0	1	0	1	0	1	0	3	0	0	0
	Electric 43	0	1	0	1	0	1	1	4	0	0	0
	Electric 44	0	1	0	1	1	0	0	3	0	0	0
	Electric 45	0	1	0	1	1	0	1	4	0	0	0
	Electric 46	0	1	0	1	1	1	0	4	0	0	0
	Electric 47	0	1	0	1	1	1	1	5	0	0	0
	Electric 48	0	1	1	0	0	0	0	2	0	0	0
	Electric 49	0	1	1	0	0	0	1	3	0	0	0
	Electric 50	0	1	1	0	0	1	0	3	0	0	0
	Electric 51	0	1	1	0	0	1	1	4	0	0	0
	Electric 52	0	1	1	0	1	0	0	3	0	0	0
	Electric 53	0	1	1	0	1	0	1	4	0	0	0
	Electric 54	0	1	1	0	1	1	0	4	0	0	0
	Electric 55	0	1	1	0	1	1	1	5	0	0	0
	Electric 56	0	1	1	1	0	0	0	3	0	0	0
	Electric 57	0	1	1	1	0	0	1	4	0	0	0
	Electric 58	0	1	1	1	0	1	0	4	0	0	0
	Electric 59	0	1	1	1	0	1	1	5	0	0	0
	Electric 60	0	1	1	1	1	0	0	4	0	0	0
	Electric 61	0	1	1	1	1	0	1	5	0	0	0
	Electric 62	0	1	1	1	1	1	0	5	0	0	0
	Electric 63	0	1	1	1	1	1	1	6	0	0	0
	Electric 64	1	0	0	0	0	0	0	1	0	1	0
	Electric 65	1	0	0	0	0	0	1	2	0	0	0
	Electric 66	1	0	0	0	0	1	0	2	0	0	0
	Electric 67	1	0	0	0	0	1	1	3	0	0	0
	Electric 68	1	0	0	0	1	0	0	2	0	0	0
	Electric 69	1	0	0	0	1	0	1	3	0	0	0
	Electric 70	1	0	0	0	1	1	0	3	0	0	0

Option		Lakeshore West	Lakeshore East	Milton	George town	Barrie	Richmond Hill	Stouffville	Total	Criteria 2	Criteria 3	Criteria 2 & 3
	Route km	114	69	50	100	101	46	49	529	LSE=LSW	Prioritize LSE/W & GT	
	Service km/day	6726	5642	2851	3547	4035	1919	2480	27200			
	Demand Rank	3	1	6	2	4	7	5				
Electric 71	1	0	0	0	1	1	1	4	0	0	0	
Electric 72	1	0	0	1	0	0	0	2	0	1	0	
Electric 73	1	0	0	1	0	0	1	3	0	0	0	
Electric 74	1	0	0	1	0	1	0	3	0	0	0	
Electric 75	1	0	0	1	0	1	1	4	0	0	0	
Electric 76	1	0	0	1	1	0	0	3	0	0	0	
Electric 77	1	0	0	1	1	0	1	4	0	0	0	
Electric 78	1	0	0	1	1	1	0	4	0	0	0	
Electric 79	1	0	0	1	1	1	1	5	0	0	0	
Electric 80	1	0	1	0	0	0	0	2	0	0	0	
Electric 81	1	0	1	0	0	0	1	3	0	0	0	
Electric 82	1	0	1	0	0	1	0	3	0	0	0	
Electric 83	1	0	1	0	0	1	1	4	0	0	0	
Electric 84	1	0	1	0	1	0	0	3	0	0	0	
Electric 85	1	0	1	0	1	0	1	4	0	0	0	
Electric 86	1	0	1	0	1	1	0	4	0	0	0	
Electric 87	1	0	1	0	1	1	1	5	0	0	0	
Electric 88	1	0	1	1	0	0	0	3	0	0	0	
Electric 89	1	0	1	1	0	0	1	4	0	0	0	
Electric 90	1	0	1	1	0	1	0	4	0	0	0	
Electric 91	1	0	1	1	0	1	1	5	0	0	0	
Electric 92	1	0	1	1	1	0	0	4	0	0	0	
Electric 93	1	0	1	1	1	0	1	5	0	0	0	
Electric 94	1	0	1	1	1	1	0	5	0	0	0	
Electric 95	1	0	1	1	1	1	1	6	0	0	0	
Electric 96	1	1	0	0	0	0	0	2	1	1	1	
Electric 97	1	1	0	0	0	0	1	3	1	0	0	
Electric 98	1	1	0	0	0	1	0	3	1	0	0	
Electric 99	1	1	0	0	0	1	1	4	1	0	0	
Electric 100	1	1	0	0	1	0	0	3	1	0	0	
Electric 101	1	1	0	0	1	0	1	4	1	0	0	
Electric 102	1	1	0	0	1	1	0	4	1	0	0	
Electric 103	1	1	0	0	1	1	1	5	1	0	0	
Electric 104	1	1	0	1	0	0	0	3	1	1	1	
Electric 105	1	1	0	1	0	0	1	4	1	1	1	
Electric 106	1	1	0	1	0	1	0	4	1	1	1	
Electric 107	1	1	0	1	0	1	1	5	1	1	1	
Electric 108	1	1	0	1	1	0	0	4	1	1	1	
Electric 109	1	1	0	1	1	0	1	5	1	1	1	
Electric 110	1	1	0	1	1	1	0	5	1	1	1	
Electric 111	1	1	0	1	1	1	1	6	1	1	1	
Electric 112	1	1	1	0	0	0	0	3	1	0	0	
Electric 113	1	1	1	0	0	0	1	4	1	0	0	
Electric 114	1	1	1	0	0	1	0	4	1	0	0	
Electric 115	1	1	1	0	0	1	1	5	1	0	0	
Electric 116	1	1	1	0	1	0	0	4	1	0	0	
Electric 117	1	1	1	0	1	0	1	5	1	0	0	
Electric 118	1	1	1	0	1	1	0	5	1	0	0	
Electric 119	1	1	1	0	1	1	1	6	1	0	0	
Electric 120	1	1	1	1	0	0	0	4	1	1	1	
Electric 121	1	1	1	1	0	0	1	5	1	1	1	
Electric 122	1	1	1	1	0	1	0	5	1	1	1	
Electric 123	1	1	1	1	0	1	1	6	1	1	1	
Electric 124	1	1	1	1	1	0	0	5	1	1	1	
Electric 125	1	1	1	1	1	0	1	6	1	1	1	
Electric 126	1	1	1	1	1	1	0	6	1	1	1	
Electric 127	1	1	1	1	1	1	1	7	1	1	1	

