Appendix 1

High Level Decision Making Framework

December 2010

METROLINX
An agency of the Government of Ontario

APPENDIX 1

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Prepared for:

METROLINX
An agency of the Government of Ontario

20 Bay Street, Suite 901
Toronto ON M5J 2N8

Prepared by:

Delcan JV Arup

In Association with:

steer davies gleave

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1. INTRODUCTION

1.1. Background

The Greater Toronto and Hamilton Area (GTHA) is in the midst of a transportation transformation as a result of a renewed public commitment to invest and grow regional transit. The Big Move - a compelling integrated, multi-modal vision for regional transportation adopted by Metrolinx in 2008, will strengthen the economic, social and environmental sustainability of the Greater Toronto and Hamilton Area and profoundly change how people and goods are transported within the region. GO, a division of Metrolinx and the GTHA's principal inter-regional transit service, will play a decisive part in this transformation. The means by which GO's rail system grows and develops is therefore essential to realizing the ambitious vision of The Big Move and creating a GTHA that is shaped and supported by a world-leading regional transportation network.

1.2. Study Purpose

Metrolinx commissioned this Study to examine how GO can work towards the goals of The Big Move over the next 25 years. The overriding purpose of the Electrification Study is to provide Metrolinx's Board of Directors with the information necessary to make an informed decision on whether to meet future service requirements by using conventional and future diesel powered trains or by utilizing trains powered by electricity or alternate means.

In summary, the key questions to be addressed in this study are:

- Is there a **case** for the electrification of GO Transit network?
- …If so, **how** can this be done?
- …**where** and **when** should it be done?

In order to answer these questions it is important to understand the key attributes of electrification and other options. The trade-offs between different rolling stock technologies, including electric and diesel trains, associated infrastructure and operational considerations will be assessed.

1.3. This Document

This document sets out the high level "Decision Making Framework" (DMF) that will be used to identify trade-offs between alternatives. A key objective of the Study Initiation of Stage 1 is the development of a High Level DMF which permits the team to quickly focus on the key objectives for the Study. This will also be presented to Metrolinx and Stakeholders, with a view to forming a quick 'buy-in' and acceptance before the next work activity. It is intended to supplement the Study Work Plan and is a deliverable of the Project Initiation. This document is structured as follows:

- In Section 2, the **purpose** of the DMF is discussed – why it is required for this study and how the DMF fits in with the overall project cycle;
- In Section 3, the way the DMF was **developed** is discussed – the key considerations and rationale that have led to the design and scope of the DMF;
- In Section 4, the principles of establishing the **Reference Case** is discussed; and

- In Section 5 the **application** of the DMF across the project phases is discussed, including how the DMF is used in screening out options to ensure that appropriate options are taken forward for further detailed assessment in the next stage.

2. PURPOSE OF THE DECISION MAKING FRAMEWORK

2.1. Primary Purpose

In a society where there are finite financial resources available to improve the quality of life, investment decisions are increasingly dependent on the return the investment is likely to make. The justification of a multi-billion dollar investment will require the consideration of its ability to achieve strategic objectives, understanding its impacts, and that the chosen solution offers the best return or value for money.

For the GO Electrification Study, the decision on whether to meet future service requirements by using conventional and future diesel powered trains or by utilizing trains powered by electricity or alternate means will require a great deal of consideration of impacts across a wide range of disciplines. It is important to note that some of these impacts can be quantified or valued in monetary terms, while others will be more qualitative or subjective.

The DMF is intended to be **traceable**, **defensible**, **transparent** and capable of effectively **differentiating** between alternatives based on multi-attribute criteria.

A conventional cost: benefit analysis of monetized impacts of Technology will be used to support the transportation case, however it will only constitute an element of the decision-making process and the DMF will also consider other impacts across various disciplines in a qualitative and quantitative manner. The DMF will provide the "dashboard" of material from which Metrolinx can base their decision in both quantitative (monetized or otherwise) and qualitative terms.

There will be a high degree of stakeholder interest in the outcome of the comparative analysis of alternative technologies. Consequently, it is critical that a robust multi-attribute decision making process is in place to inform Metrolinx the implications of each option to assist their decision making.

In summary, the DMF is:

- **A process** which enables us to identify and demonstrate the shortlist of best potential options to be implemented; and

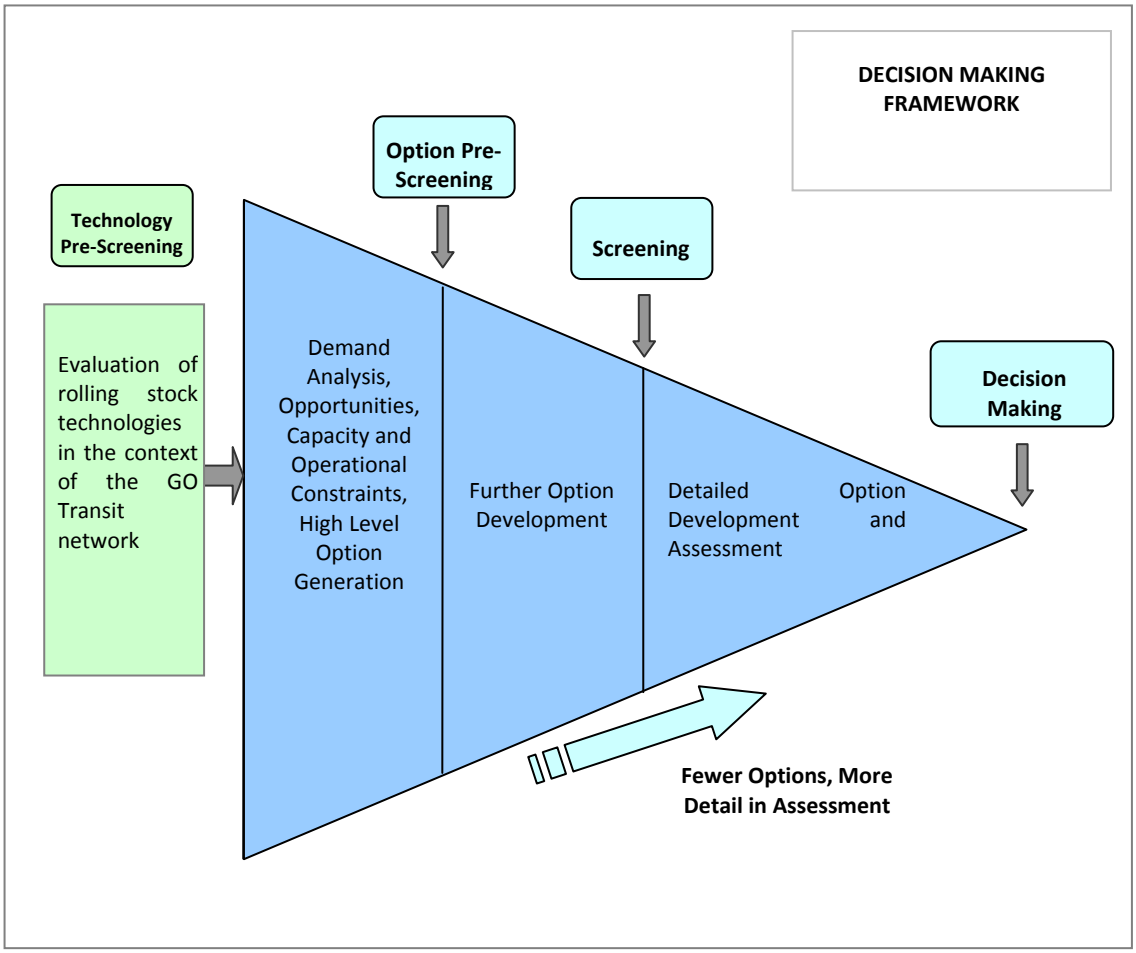
- **An information repository** or "dashboard" that summarizes key impacts of each detailed option under a set of Evaluation Categories from which Metrolinx will base their decision on.

2.2. Principles of Option Screening

With projects of this nature, a large number of options or permutation of options should be considered for assessment. At an initial stage each option will be assessed at a high level but as the study moves towards a shortlist of options, the level of analysis becomes progressively more detailed. Over the project period the DMF therefore facilitates an effective process to screen out options not worth pursuing and concentrate efforts on the options most likely to succeed and meet the GO Electrification Study's objectives. We need to be channelling effort on those options that have a real potential rather than less likely ones. However, the decision to eliminate options must be clearly auditable.

A typical option screening process is illustrated in Figure 1. In the context of this Study, an option is defined as a potential network using alternative rolling stock technology on one or more of the seven GO Transit lines. The application of the DMF at each of these stages will be discussed in more detail in section 4.

Figure 1 A Typical Option Screening Process

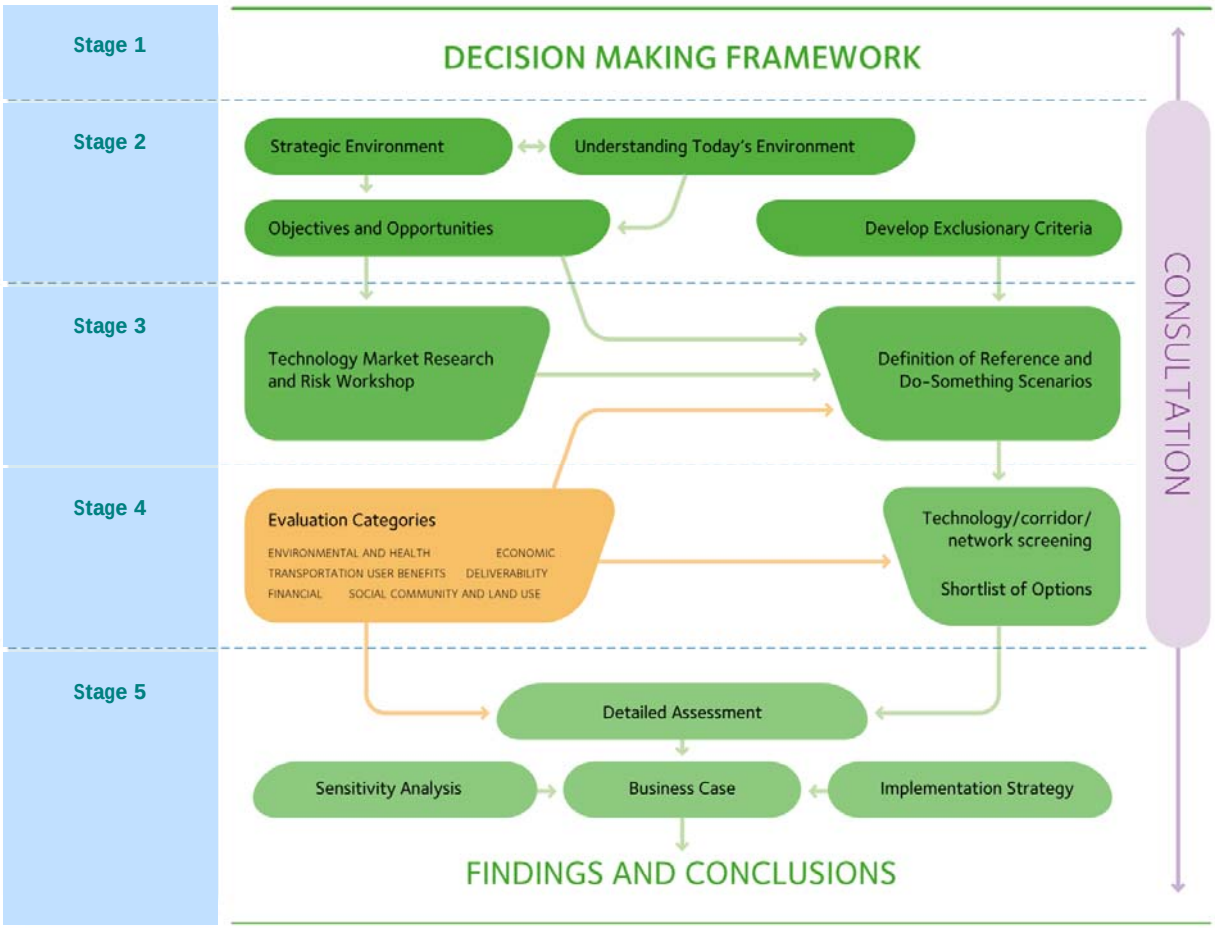


2.3. The GO Electrification Study Option Screening Process

A DMF has been developed and tailored specific to the GO Electrification Study and will vary in its level of detail over the project period. The option screening process sits within the core of the Study, facilitated by the DMF supported by the Evaluation Categories. This is illustrated as a flow chart in Figure 2.

Following the option generation, a pre-screen will reduce a large number of line/technology options down to approximately 18 strategic network options where they are considered in more detail for screening, then up to 6 options would be taken forward for an in-depth assessment so that the most important and relevant information can be summarized before the final decision is made by Metrolinx. Throughout the process, consultation will be made with Metrolinx, various stakeholders to ensure that the principles of the methodology are accepted.

Figure 2 DMF with Study Approach and Phasing

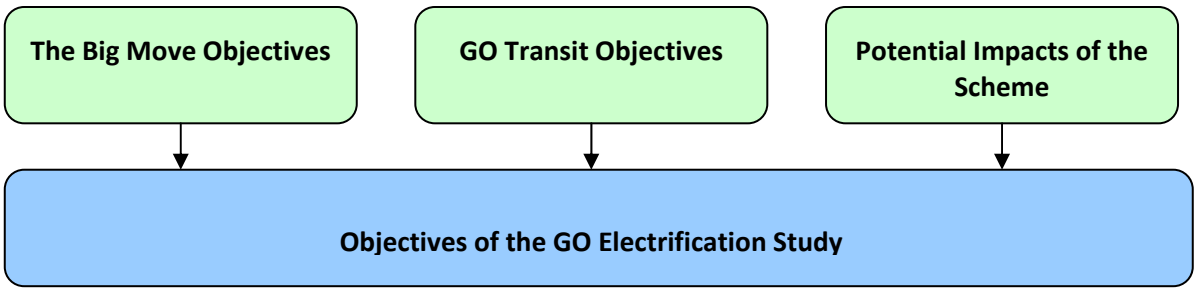


3. DEVELOPMENT OF THE DECISION MAKING FRAMEWORK

3.1. Introduction

It is critical that the DMF is developed in a way that key impacts and considerations can be captured and set out in a transparent manner. The impacts to be assessed (monetized, quantified or evaluated qualitatively) will need to reflect the overall strategic objectives of the region, strategic options of the Study and material impacts that the scheme is likely to have. Figure 3 below summarizes this.

Figure 3 Key Considerations when Designing the DMF



3.2. Big Move Vision and Objectives

The vision set out in the Big Move, or Regional Transportation Plan (RTP) states that the GHTA will have an integrated transportation system that enhances the quality of life and prosperity of the residents:

- **A high quality of life** – communities will support healthy and active lifestyles, with many options to get around quickly, reliably, conveniently, comfortably and safely;
- **A thriving, sustainable and protected environment** – the transportation system will have a low carbon footprint, conserve resources, and contribute to a legacy of a healthy and clean environment for future generations; and
- A strong, prosperous and competitive economy – the region will be competitive with the world's strongest regions. Businesses will be supported by a transportation system that moves goods and delivers services quickly and efficiently.

These visions and objectives, at a more detailed level, led to a series of aspired ***strategic*** improvements to transportation in the GTHA including more frequent transit services and serving a larger area. These were developed by Metrolinx and the impacts that the Big Move improvements is predicted to have on a range of transportation indicators across all modes is set out in Figure 4.

The GO Electrification Study is relevant to many of the important Big Move deliverables and this is represented at a high level in Figure 4 as ticks against each measure of statistics. These measures can therefore be used alongside the assessment of options in the DMF to illustrate how far the recommendations go in delivering the Big Move aspirations.

Figure 4 Impacts of the Big Move and the relevance to the GO Electrification Study

Key Statistics from the Big Move	% Change with The Big Move	Relevance to GO Electrification Study
Transportation Choice		
Average distance travelled by car each day per person	-25%	✓
Percent of people who live within 2km of rapid transit	+70%	
Time Spent Commuting		
Length of rapid transit service in the region	+330%	
Percent of people who can get to work in 45 minutes or less by transit	+95%	✓
Percent of people who can get to work in 45 minutes or less by car	+30%	✓
Use of Transit		
Average time spent commuting each day per person	-30%	✓
Total number of transit trips taken every year	+60%	✓
Number of transit riders during the morning peak period	+60%	✓
Proportion of morning rush hour trips taken by transit	+60%	✓
Walking and Cycling		
Proportion of morning rush hour trips taken by walking or cycling	+40%	
Approximate percentage of school children who walk or cycle to school	+55%	
Environmental Impact		
Annual greenhouse gas emissions from passenger transportation per person	-25%	✓
Annual energy consumption from passenger transportation per person	-25%	✓
Number of occupants in the average private motor vehicle during the morning rush hour	+10%	

3.3. GO Electrification Study Objectives

The application of the DMF will be guided by a set of GO Electrification Study Objectives. The objectives listed have been developed with input from the Terms of Reference developed by the Community Advisory Committee as approved by the Metrolinx Board of Directors and the Metrolinx Planning documents. The objectives where reviewed at the Stakeholder Workshop #1 and are subject to review and confirmation by Metrolinx. It should be noted that these objectives imply the selection of a single technology, though that is something that will need to be determined through the study process. It is possible that more than one technology might be proposed for the network.

Technology, Capacity and Service

- The implementation of the selected technology should improve transit reliability;
- The selected technology should facilitate faster, more frequent and less crowded transit;
- The selected technology should facilitate improved connections and service within the GTHA and to/from regional, provincial, and international terminals and facilities;
- The implementation of the selected technology should minimize impact on other rail services (e.g. CN/CP/VIA); and
- The selected technology should be proven in a comparable climatic setting.

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; and
- 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; and
- 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); and
- The implementation of the selected technology should provide appropriate land development opportunities.

System Costs, Funding, Financing and Delivery

- The selected technology should provide value associated with all relevant and material hard and soft system capital costs, operating costs, and lifecycle maintenance costs; and
- The selected technology should be implementable with cost-effective financing solutions.

3.4. Project Team Approach

The overall Study approach adopted by the team is as follows:

- **Objective** – we will endeavour to ensure that the study will be conducted with a clear and transparent process that can be related to the strategic goals and objectives for transportation in the Greater Toronto and Hamilton Area, such that the outcomes can be readily understood by all parties;
- **Comprehensive** – our approach will consider economic, social, environmental, health, operational and technological considerations in providing a basis upon which Metrolinx decision-makers can assess the relative merits of alternatives;
    - **Inclusive** – we have provided a high-quality and innovative approach to ensuring that stakeholders are engaged and feel part of the study throughout the commission. The overall DMF process must receive buy-in from the stakeholders if defendable decisions are dependent on it; and
    - **Evidence-based** – we recognize the importance of decisions being based upon robust and credible material, and to that effect we will assure that our methodology delivers results that provide that reassurance to Metrolinx.

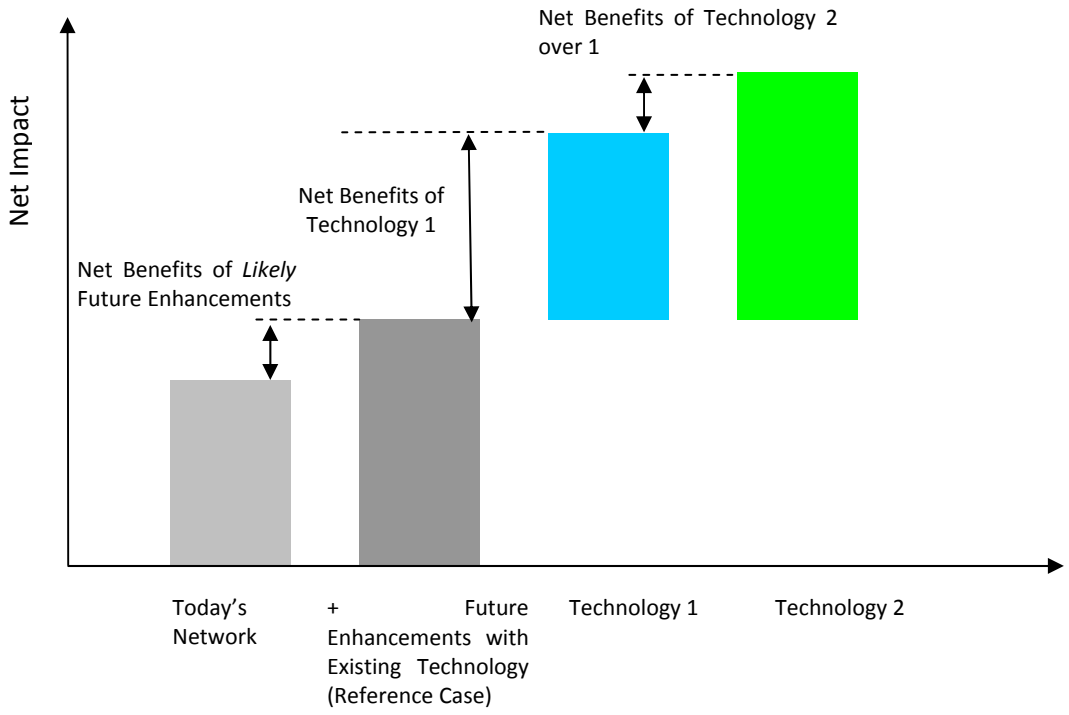
The development of the DMF will endorse these principles whereby comprehensive, multi-disciplinary impacts identified during the course of the Study will be captured within the DMF.

4. ESTABLISHING THE REFERENCE CASE

4.1. Introduction

It is important to be able to distinguish the performance of different technologies against a Reference Case. In order to establish the merits of electrification, various electric and non-electric options will be generated and assessed. Figure 5 illustrates this:

Figure 5 Comparison of Scenarios and Options



Reference Case

At the initial stage of the Study it was agree with Metrolinx what is meant by the Reference Case network. The Reference Case will be the used to compare each option and it has been developed considering the following:

- Current rail service and infrastructure, *plus*
- Committed schemes (infrastructure, rolling stock and services) for which funding identified, *plus*
- Other schemes advised by Metrolinx that might reasonably be expected to be implemented in the medium term.

The Reference Case is documented in detail within the Reference Case Workbook.

5. APPLICATION OF THE DECISION MAKING FRAMEWORK

The Study will consider alternative technologies that may become viable in the short to medium term to inform the Metrolinx Board of Directors' decision with regard to available technology options. The Study is to assess and identify an optimal technology, or combination of technologies, that would be able to attain the system performance goals identified in The Big Move and the objectives of the GO Electrification Study.

The outputs of the Study will be:

- A comprehensive and detailed analysis of the trade-offs associated with the implementation of each technology related to its:
  - Capacity and Service Impacts, including reliability of service;
  - Environmental and Health Impacts;
  - Community and Land Use Impacts;
  - Economic Impacts; and
  - System Costs, Funding, Financing and Delivery.
- An implementation strategy for the scenarios considered in further detail;
- An evaluation of the major scenarios in terms of non-monetized metrics that enable a wide range of measures to be assessed and considered alongside the financial outputs;
- An overall cost-benefit analysis on a system-wide and corridor by corridor basis;
- A list of key findings and conclusions, including cost to benefit ratios for the technology and implementation options, within the context of The Big Move; and
- Consideration of stakeholder engagement and consultations.

These outputs will be used to inform the design of the DMF to ensure that the impacts relevant to Metrolinx are documented and presented to the decision maker in a concise manner within the DMF.

5.1. Overall Study Approach

The Study approach is summarized in Figure 6. Figure 2 previously illustrated how the DMF links back to the Study Stages.

Figure 6 Summary of Tasks by Study Stage

Study Stage	Description
Stage 1	Project initiation
Stage 2	• Determine **strategic objectives**, **baseline conditions** and potential **opportunities**; • **Identify the criteria** upon which the pre-screening will be undertaken; and • Obtain values and insight from **stakeholders** and the **communities**, and receive **feedback**.
Stage 3	• Develop alternative technology **options**, identify risks, consult with the public and stakeholders of the possibilities and receive feedback; and • Undertake the **pre-screening** exercise to remove those technologies that do not meet the agreed criteria. It is expected that this will be relatively **high level** in order to filter out those technologies that have very little prospect of being taken forward; we have assumed that we will be left with a maximum of 18 technology/line/scenarios.
Stage 4	We will undertake a more robust application of the **DMF** in which a greater degree of quantification will be applied to the options. The analysis at a network level will include the specification of a **Reference Case** that will enable a series of model runs – we suggest a maximum of 4. The purpose of this stage is to identify up to 6 short listed technology/line scenarios that should be progressed for more detailed assessment, bearing in mind that the partial implementation of an alternative technology by default leaves elements of the existing diesel technology. Consultation with the public and stakeholders and receiving feedback will continue.
Stage 5	• Conduct a **detailed assessment of corridor/technology** scenarios; • Develop **a recommended option**, **phasing** scenario and **business case**; and • **Consult** with the public and stakeholders and receive feedback. Our proposal limits the number of options on which a detailed analysis will be conducted to a maximum of 6 options, recognising the level of complexity required to provide a comprehensive evaluation. In preparing the ridership forecasts that underpin elements of the evaluation, we will specify approximately 6 model runs for Metrolinx to provide.

5.2. Evaluation Categories

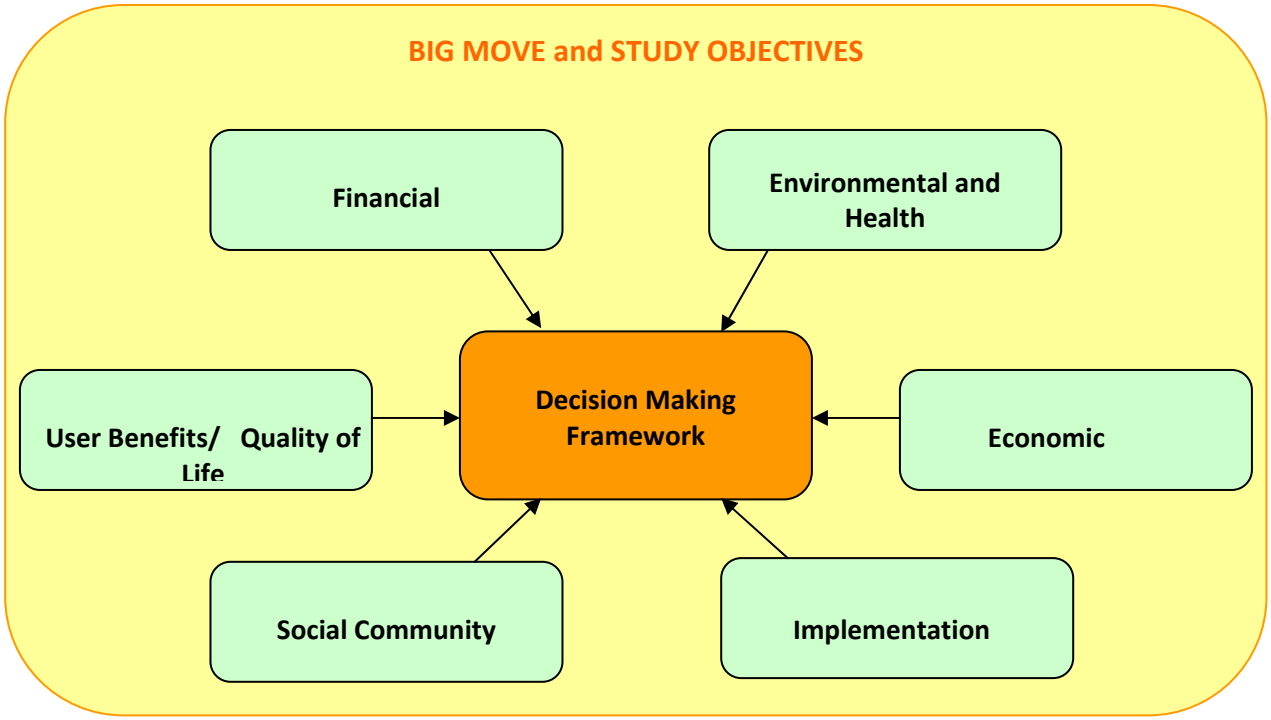
Evaluation Categories will be used to summarize the assessment of various impacts of a particular option, where a category refers to the overall family of specific impacts across similar disciplines and does not necessarily require impacts to be monetized. Impacts can be summarized quantitatively or qualitatively using professional judgement .

Evaluation Categories will be developed that reflect the Electrification objectives. These will be based upon the following:

- Financial;
- Environmental and Health;
- User Benefits/Quality of Life
- Economic;
- Social Community; and
- Implementation.

The Evaluation Categories in the DMF are illustrated in Figure 7, and can be mapped against the key Study objectives set out in 3.3.

Figure 7 Evaluation Categories in the Decision Making Framework



5.3. Application of the Decision Making Framework

The purpose of the DMF is to provide Metrolinx with all the relevant information across the various Evaluation Categories to ultimately make an informed decision. Each of the six Evaluation Categories will contain various impacts to be reported in a quantitative (metrics monetized or non-monetized) or qualitative. The scope of the impacts to be quantified and the metrics to be used will be dependent on the nature and number of options being assessed.

The monetized cost:benefit analysis will be a tool to determine the full value (benefits and costs) of the various technology alternatives where these are transparent to stakeholders, but Metrolinx will also consider various impacts in the other five Evaluation Categories.

In the DMF approach, key impacts not captured financially will be quantified using **metrics** (statistics) and broader **measures**. Where impacts are not quantified, or where they are quantitative (but not monetized) but a qualitative assessment is more helpful than metrics, the evaluation will be undertaken qualitatively by a **"Seven Point Scale" assessment**, such as:

- Strong positive impact;
- Moderate positive impact;
- Slight positive impact;
- Neutral/No impact;

- Slight negative impact;
- Moderate negative impact; and
- Strong negative impact.

Decision Making Frameworks Contents

Figure 8 and 9 sets out, at a strategic level, how the DMF will work and the key considerations. The table considers the information to be included in the DMF and seeks to answer the following questions:

- Option description – what is the option being assessed and what are the key features?
- Strategic Fit Assessment – does the option solve the problems / achieve the Study objectives?
- Comparison against Big Move targets – how does the option help achieve GTHA's aspirations?
- Assessment of the six Evaluation Categories – what are the impacts of the option across a number of disciplines? How do they compare under various metrics and what are the key issues?
- How is the DMF going to assist the option screening and selection?

The assessment will be undertaken at a high-level, enabling a distinction between the different options to help guide further study where appropriate.

An understanding of the potential capacity of each corridor will be made, and an assessment of the operational capability of that corridor in terms of train paths considering the other train movements such as freight operated by CN and passenger services operated by Via Rail. For each technology, there will be a simple assessment of the maximum service on each corridor either with full or partial implementation of a particular technology, and whether there is scope to split the operation between current and an alternative technology.

Where appropriate, network constraints will be identified and high level infrastructure improvements will be suggested to unlock further capacity in order to satisfy passenger demand requirements.

The detail of the assessment will depend on the stage of the Study and the number of options being assessed. This will be developed further throughout the Study following consultation.

Option Progression

Following the initial technology screening down to three alternative technologies plus the existing technology, a long list of corridor/technology options will be generated. Pre-screening criteria on the potential options will be generated to produce a long list of approximately 18 options for further study. At this stage in the process, the focus is on considering implementing alternative technologies the different corridors as network options.

The 18 options taken forward for more detailed assessment would only consider a family of electric trains as the alternative technology and does not consider detailed issues such as partial electrification of a particular corridor – these will be considered once the short list of 6 options has been identified. The process for determining up to 6 options for full assessment will be determined through the application of the DMF coupled with the appropriate engagement and debate with stakeholders.

Decision Making

There are various options that can be used for distinguishing the overall stronger options from weaker options across a variety of assessment criteria. One approach in ranking options might entail a method known as Concordance Analysis, which allows different types of data (qualitative and quantitative) to be integrated in a traceable and mathematically valid manner. It also can be used to undertake sensitivity analysis by applying different weights to the criteria, if desired.

We would ensure that the overall decision making tool is accompanied by a qualitative review in the form of a pair wise comparison to test any quantitative analysis. This would provide Metrolinx with a written decision making trail of the thought process that went into the trade-off process. The quantitative analysis should not be the sole decision making process but an essential part of the body of evidence with which different impacts and trade-offs are considered.

Figure 8 Strategic Function of the Decision Making Framework

MAE Feature	**Technology Option Pre-Screening**	**Corridor Option Pre-Screening**	**Network Option Screening**	**Network Option Detailed Assessment**
Number of Options	From initial list to 4, including Tier 4 diesel technology	From initial list of corridor options to 18 network options	From 18 to 6	Final 6 options
Focus of Stage	Identifying technologies that are proven and viable for the GTHA setting	Identifying appropriate network options	Screen the network options to take forward options that are most likely to succeed in delivering Study objectives	Undertake sufficient analysis to assess all relevant impacts, and summarize this information in a manner that helps the decision maker choose the preferred option
Option Description	Summary description and key characteristics	Summary description and rationale	Summary description and rationale	Summary description and rationale with detailed reporting
Strategic Fit Assessment against Big Move and Study objectives under each Evaluation Category	Not considered in detail.	Not considered in detail.	"**Seven-point**" scale summary assessment with supporting commentary	"**Seven-point**" scale summary assessment with supporting commentary
Compared against Big Move targets *(See Figure 4)*	Not quantified	Not quantified	Not quantified	Impacts quantified and compared against target

Assessment against Evaluation Category: • **Category 1** - Measure 1, - Measure 2… • **Category 2** - Measure 1, - Measure 2… *(See Figure 9)*	Considered at a high level. Primary consideration is deliverability – are those technologies unlikely to appropriate for the characteristics of the GO network or unproven technology to be pre-screened out	Not considered in detail. If known issues significantly reduces the acceptability of the option exists, these will be documented in the DMF.	"**Seven-point**" scale summary assessment with supporting commentary Where appropriate quantify impacts relative to other options to support scaling	Quantify (monetized or non-monetized) key impacts "**Seven-point**" scale summary assessment with supporting commentary for non-quantified impacts
Assessment Methodology	Literature review of technologies and consideration of professional expertise to identify the technically viable technology options	Identification and application of specific decision rules to define the options (technology and associated infrastructure) on each network	Identification and application of exclusionary criteria to eliminate options for further consideration that clearly do not meet the objectives of the GO Electrification Study	Detailed assessment of options under each measure of impact to assess how well the options meet the objectives and comparative criteria.
Decision Making (Screening) to next stage	Primary consideration is deliverability Combine remaining corridor/ technology options into network /technology options	Pre-screen out options considered high risk under deliverability and acceptability Develop pre-screening criteria to produce a long list of up to 18 options	Screen out options considered high risk under deliverability and acceptability Use of Concordance Analysis or similar approach to rank options and take forward the top 6 options which may involve refining the packaging of technology/lines.	Detailed multi-criteria considerations, identifying key strengths and weaknesses All relevant information will be presented in a summary for the decision maker to choose the preferred option. Use of Concordance Analysis or similar approach to rank options

Output	Summary of literature review and findings and the identification of technologies to be considered	Summary of the results of the application of the decision making rules and the identification of technology and associated infrastructure options for each line	Summary description and rationale for the elimination of options	Summary of findings on a criteria group basis (including distinct cost-benefit analysis results) and overall comparative evaluation results

Figure 9 *Indicative Impacts, Measures and Assessments by Evaluation Categories*

Evaluation Categories	Impacts	Potential Measures and Assessments
Environmental and Health	Greenhouse gas Air contaminants Noise Vibration Healthcare	Tonnes of CO2 Concentrations of pollutants Population affected by noise Auto km removed *... etc*
User Benefits/ Quality of Life	Travel time Safety Quality Reliability Accessibility Capacity provision	Average time savings Decongestion Accident savings Auto cost savings Passenger loading index *...etc*
Social Community	Community Environment Health and wellbeing Land Use Planning policy Heritage conservation Landscape	Summary Community Impact Assessment Policy review Land consumption per track km *...etc*
Economic	Value for Money Local and regional economy Job creation Wealth Employment Real estate	Benefit Cost Ratio Employment created Gross Regional Product Wage income Real estate changes *...etc*
Financial	Capital costs Life-cycle costs Farebox revenues Financial sustainability	Outturn capital costs Present value costs Operating and Maintenance costs Operating surplus *...etc*
Implementation	Risks Stakeholder acceptability Affordability Operational Implementation	Feasibility Acceptability Risk register and quantified risk *...etc*

APPENDIX 1-A

Figure 1-1 Reference Case GO Transit Network

The Reference Case network has been developed for the purpose of comparing options only.