



Feasibility Study: Asset Electrification

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Content

Executive Summary	4
Bus Garage and Operating Impacts	5
Route Modelling	7
On-Route Charging Assessment.....	8
Bus and Battery Cost Trending	9
Operating and Maintenance Cost Savings.....	11
Infrastructure Review	12
Implementation Planning	14

Executive Summary

York Region Transit (YRT) offers local and rapid transit services in all nine municipalities in the Regional Municipality of York. With a current fleet of 569 vehicles, over 130 routes keep residents connected within York Region, as well as connecting services in the City of Toronto and the Regions of Peel and Durham. In addition, Mobility On-Request conventional and paratransit provides door-to-door, shared-ride, accessible public transit services.

In an effort to reduce greenhouse gas (GHG) emissions, the Region has a goal to fully electrify the YRT fleet to produce zero emissions by 2051.

Vision 2051 and the Energy Conservation and Demand Management Plan (Plan) focus on reducing GHG emissions resulting from Regional service delivery to residents. This goal introduces interesting challenges that will need to be addressed with proper planning and innovative technology solutions.

In 2019, YRT staff conducted an Electric Bus Feasibility Study (Study) that addressed bus garage requirements and the operating impacts required to operate a fully electric bus fleet. The Study used current YRT data to conduct modelling exercises and analysis.

The key objectives of the Plan were to:

- > Review of the current state of the YRT system
- > Overview of the battery-electric bus market in Canada, including case studies of other transit agencies currently operating battery-electric buses
- > Assessment of existing and planned infrastructure
- > Operational goals and scenarios development
- > Impact of battery-electric bus deployments on operations and infrastructure: case studies
- > Operational requirements for YRT
- > Bus route, range and charge modelling
- > Identified utility and infrastructure improvements required to support the conversion
- > Capital and operating cost analysis

Bus Garage and Operating Impacts

Performance Modelling Analysis

A market review of the available electric bus and charging technologies was outlined in the Study and included:

- > An electric bus performance modelling analysis using YRT's current bus schedules
- > Bus trip modelling in winter and summer conditions using new batteries to monitor battery degradation, and the effects of battery degradation on long-term performance and range
- > Calculation of the energy used on each bus per route

Facility Capacity Review

The modelling exercise examined the total energy consumption required at each York Region-owned bus garage when full electrification of the bus fleet occurs, and outlined:

- > The amount of power/Megawatts required on-site at each bus garage to electrify the YRT fleet
- > Alectra and Newmarket Hydro were engaged to determine existing constraints on the power distribution systems and looked at: capacity, reliability and appropriate methods to supply the required load to the bus garages
- > Alectra and Newmarket Hydro provided all requirements to upgrade their distribution systems to meet peak facility loading, and the associated costs to complete the upgrades

Financial Modelling

A financial model was developed to identify the impact of the transition from diesel to electric bus on both the capital and operating budgets.

The model uses 2020 dollars and does not factor in anticipated reductions in electric bus pricing over the 30-year outlook. It also does not include inflation or the introduction of preferred utility rates expected to support mass transit electrification.

- > The capital budget model includes fleet procurements, asset management programs and infrastructure costs, and compares them directly to the 20-year capital plan
- > The modelling identifies a total capital budget impact of approximately \$804 million when compared to the capital budget and projections over the 30-year transition to 2051

As the market continues to mature in Canada, it is expected that the cost of battery electric-buses and infrastructure will gradually decrease. This decrease would bring the incremental increases closer in-line with available budget.

Analysis of Operating Impacts

The Study includes a comprehensive analysis of operating impacts as a result of the transition to an electric fleet. The analysis includes industry available modelling on both battery-electric and diesel buses, and historical maintenance and operating costs directly from the YRT fleet.

- > On average, an electric bus has 60% less moving parts than a diesel bus; this is projected to reduce maintenance and parts costs by approximately 30%
- > A reduction in energy costs is expected to be achieved through electrification.
- > An estimated savings of \$20 million in energy costs is projected over the 30-year period

Financial Savings

A total savings of approximately \$135 million is estimated over the 30-year transition period based on reductions in maintenance and energy costs. As the transition progresses, it is anticipated that:

- > Additional savings will be realized through the implementation of preferred utility rates for mass transit fleets
- > Infrastructure maintenance costs will also continue to decrease as the YRT fleet transitions to fully-electric and diesel fueling systems are decommissioned

Route Modelling

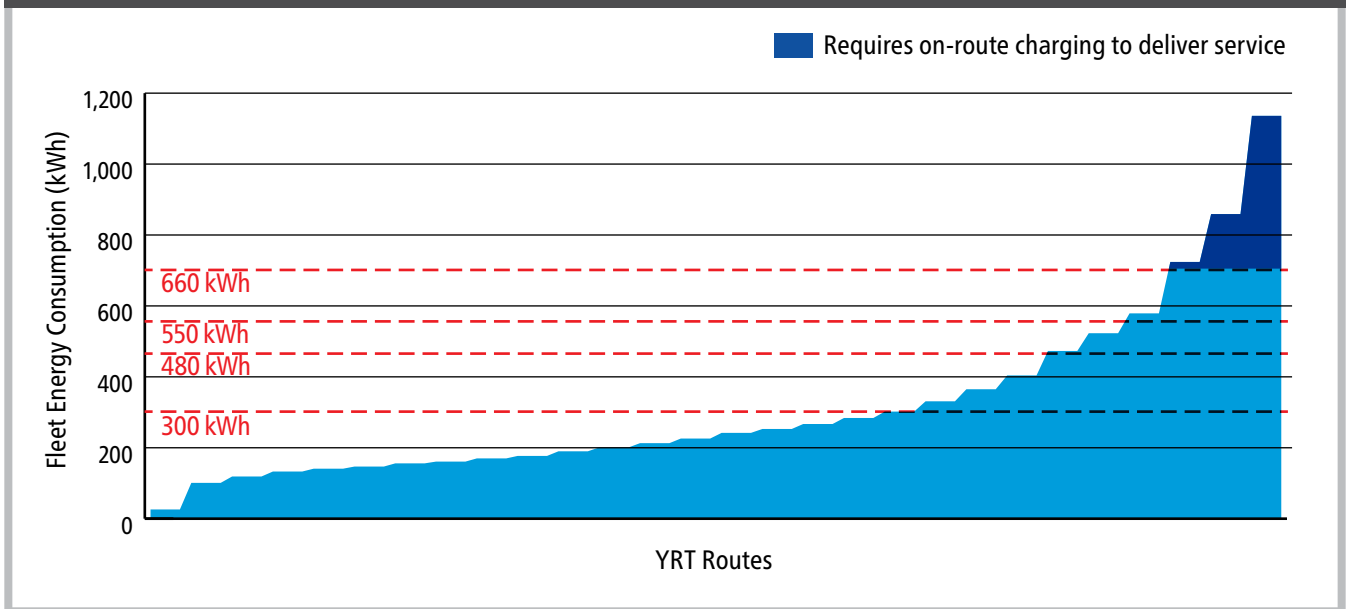
Modelling software was used to evaluate electric bus performance on the entire YRT system. The software simulates operations on a selected transit route or an entire network of routes.

Ridership, bus components/infrastructure, geography and weather conditions were simulated to examine the energy consumption (kWh/km) and the battery state-of-charge (SOC) over time.

Figure 1 identifies the services that make up the entire YRT system and their total energy requirements to deliver service.

- > The red lines identify available electric bus battery options and demonstrate routes that can be electrified based on available technology.
- > Services above the 660 kWh line cannot be electrified based on existing electric bus technology and would also require on-route charging to deliver service.

Figure 1: Block completion for different battery sizes



Graph description: The red lines represent available electric bus battery options. Service blocks above the 660 kWh line would require on-route charging to deliver service.

On-Route Charging Assessment

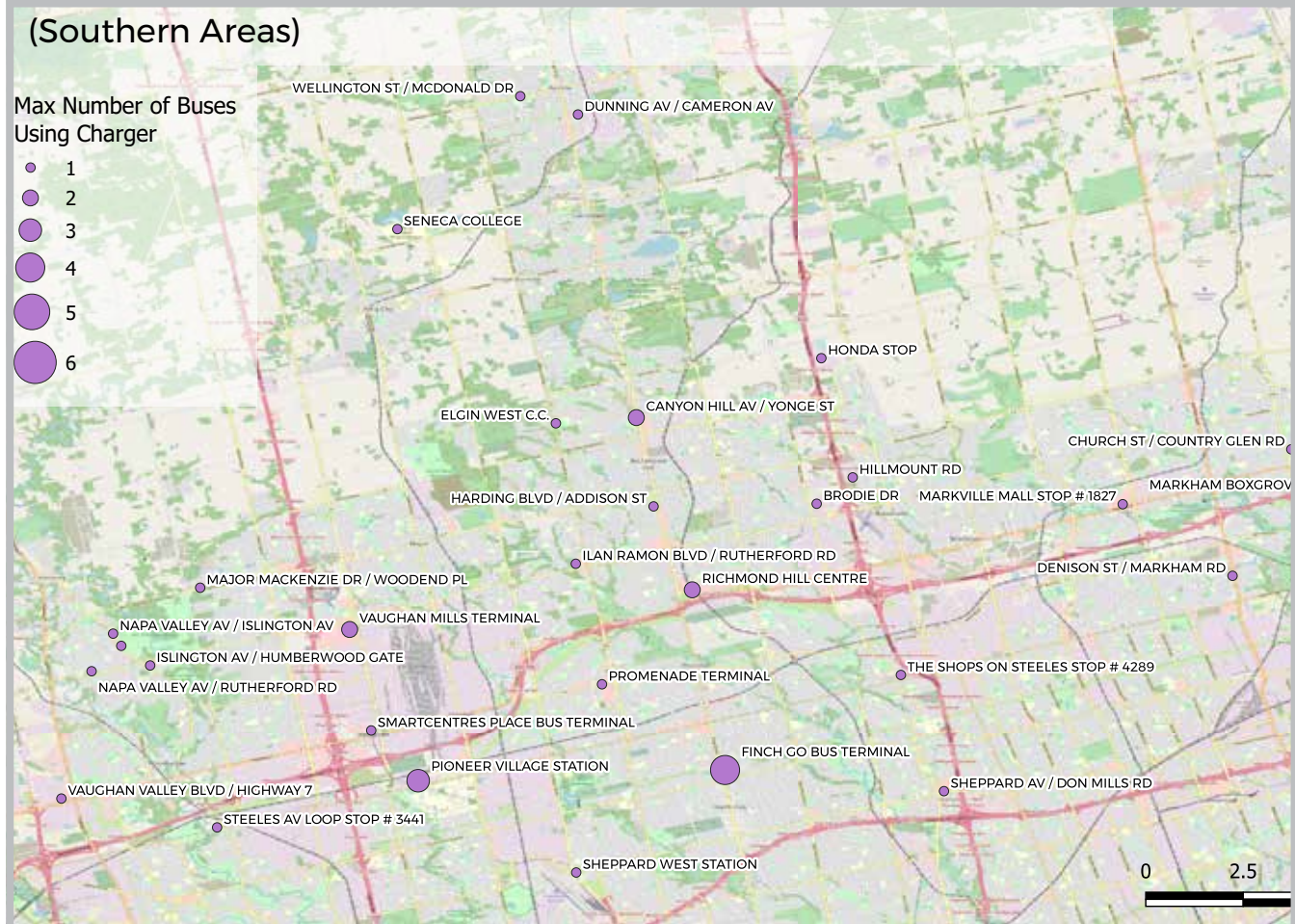
An assessment of on-route fast charging was completed to understand location and quantities of on-route overhead charging units to support a fleet of electric buses.

- > The assessment focuses on existing and future bus terminals and stations wherever possible to

accommodate installations within existing Region-owned facilities or right of way

Figure 2 identifies potential on-route charging locations and quantities which will be further evaluated for suitability.

Figure 2: Potential en-route charging locations



Bus and Battery Cost Trending

Over the 30-year transition period, it is anticipated that the cost of electric buses will decrease through technology advancement and increased demand.

- > The battery cost trend in **Figure 3** shows a decline of 20% per year based on a Bloomberg survey of over 50 companies in the battery manufacturing sector.
- > The cost per kWh for lithium-ion batteries is projected to reach \$100/kWh in 2025. This will put the energy cost and density of battery electric on par with diesel and gasoline for conventional light-duty vehicles.
- > There are many electric bus pilots and fleet procurements ongoing across North America and worldwide. In the USA, the “Low or No Emission Vehicle Program” announced in 2018 includes 52 projects across 41 States which receive a portion of federal funding, totalling \$84 million USD, to expand the adoption of electric buses into public transit fleets. The electric bus market is expected to grow by 18.5% annually until 2024.

Figure 3: Battery pack price trend

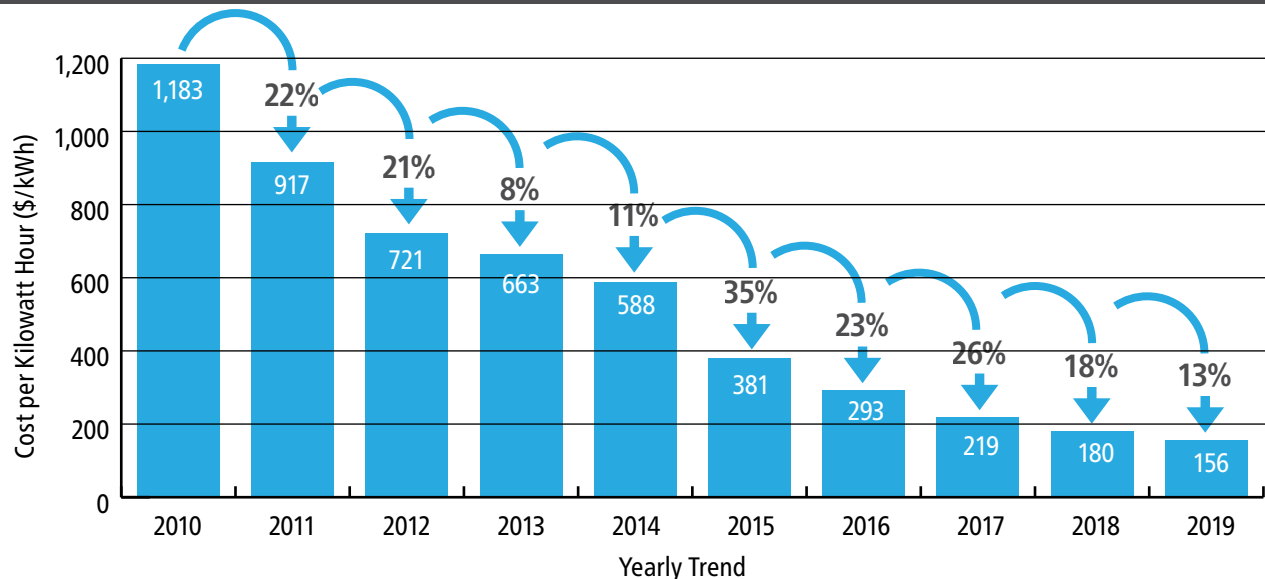


Table 1 provides a summary of electric bus deployments reviewed in the study including location and quantity of buses.

Table 1: Battery Electric Bus Fleet Size		
Transit Agency	Battery Electric Bus Fleet Size	Country
Toronto Transit Commissioner (TTC)	70	Canada
Edmonton Transit Service (ETS)	50	Canada
Societe de transport de Montreal (STM)	46	Canada
TransitLink	4	Canada
Winnipeg Transit	4	Canada
Antelope Valley Transit Authority (AVTA)	141	United States
Foothill Transit	18	United States
Vinyard Transit Authority (VTA)	6	United States
Worcester Regional Transit Authority (WRTA)	6	United States
Pioneer Valley Transit Authority (PVRTA)	3	United States
ABQ Ride	20	United States
Transports Metropolitan de Barcelona (TMB)	123	Spain

Operating and Maintenance Cost Savings

On average, an electric bus has 60% less moving parts than a diesel bus. **Table 2** identifies some projected maintenance reductions associated with an electric bus, as well as new challenges associated with the transition.

The study includes data based on historical maintenance cost from a North American transit agency on their first three years of electric bus operations.

- > On average, the data suggests that electric buses have 30% lower operating and maintenance costs on parts and labour based on four comparative years of work

order records. This is based on sample data from a North American transit agency, operating electric buses in cold conditions comparable to York Region

- > A reduction in energy costs is also expected through electrification. This analysis was completed using current rates for diesel fuel in consultation with Regional utility providers. An estimated savings of \$20 million is projected over the 30-year period included in the analysis

Table 2: Cost benefit analysis of electric bus (relative to diesel)

Advantages	Disadvantages
<ul style="list-style-type: none"> > Annual brake maintenance is expected to be lower for electric buses > Electric buses have regenerative braking, which reduces the use of the brake system and extends the life > Early adopters have seen brake life extended by three to four times of that on diesel buses 	<ul style="list-style-type: none"> > Electric accessories and electric modules/replays/wiring related maintenance costs will be higher for electric buses due to more complex systems
<ul style="list-style-type: none"> > Electric buses have direct drive train through traction motors which negate the need for an internal combustion engine and transmission > This reduces the maintenance cost for these components, which make up a significant portion of the preventative maintenance cost for diesel buses 	<ul style="list-style-type: none"> > Mechanics and maintenance staff need to be trained to work with a greater amount of electrical systems, and training costs will be incurred > There will be familiarization time required before maintenance staff is comfortable with electric bus maintenance and troubleshooting
<ul style="list-style-type: none"> > Bulk fluid such as transmission and engine oil are no longer needed in electric buses > This can reduce the costs and the environmental footprint caused by spills 	<ul style="list-style-type: none"> > Requires the purchase and use of specialized equipment, tools and personal protective equipment for maintenance activities
<ul style="list-style-type: none"> > There are no annual costs related to exhaust system and cranking system maintenance for electric buses 	<ul style="list-style-type: none"> > If the original equipment manufacturer uses an external diesel heater this would result in higher costs related to the HVAC system
<ul style="list-style-type: none"> > No alternator-related charging system maintenance is required on electric buses 	
<ul style="list-style-type: none"> > There is minimal expected hydraulic maintenance and costs related to electric buses, but this will be dependent on specific systems 	
<ul style="list-style-type: none"> > No annual ignition system maintenance or oil changes are required on electric buses 	

Infrastructure Review

A detailed assessment of current and future infrastructure requirements was completed for all Region-owned YRT bus garages to identify required improvements including utility-owned service upgrades.

An infrastructure upgrade plan was developed for each garage and includes substation and transformer

requirements, charging equipment and systems, backup power and energy storage requirements.

Figures 4 to 6 identify the infrastructure upgrade plans for the YRT bus garages based on fleet requirements in 2051. .

Figure 4: Infrastructure upgrade plan (55 Orlando Avenue)

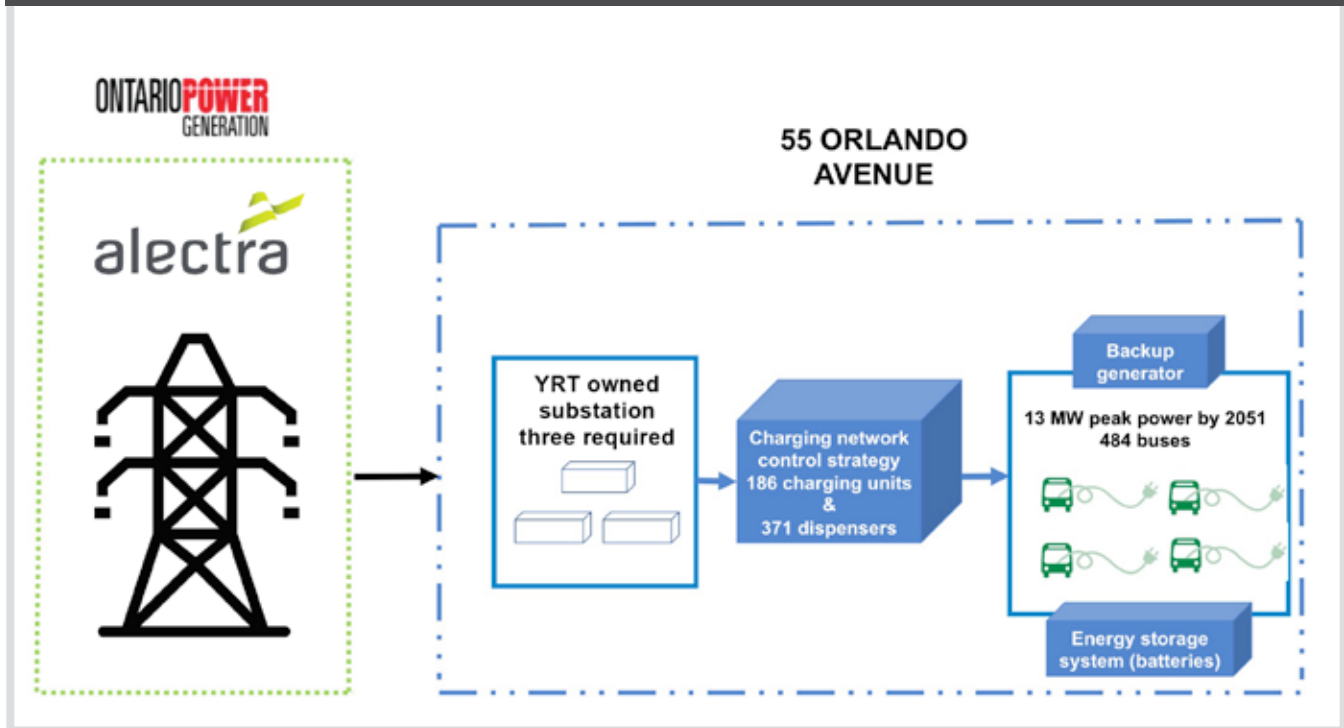


Figure 5: Infrastructure upgrade plan (8300 Keele Street)

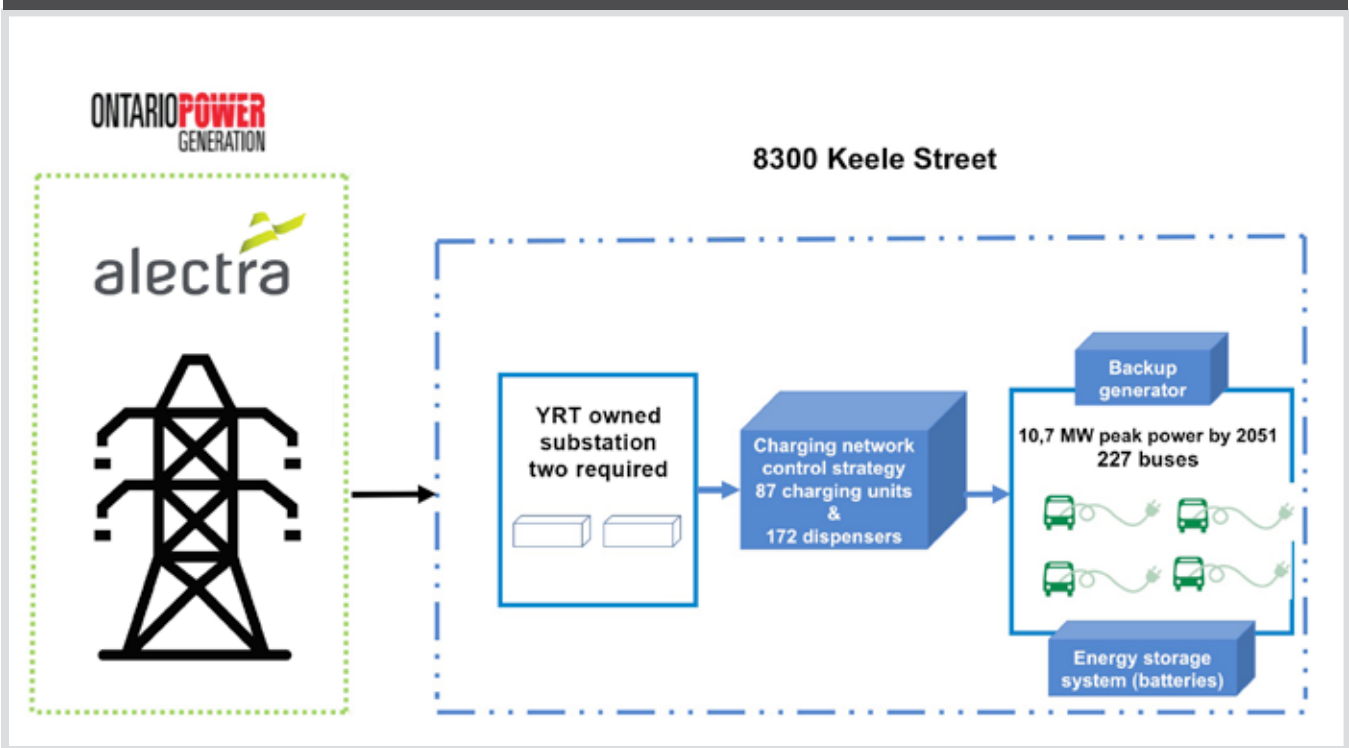
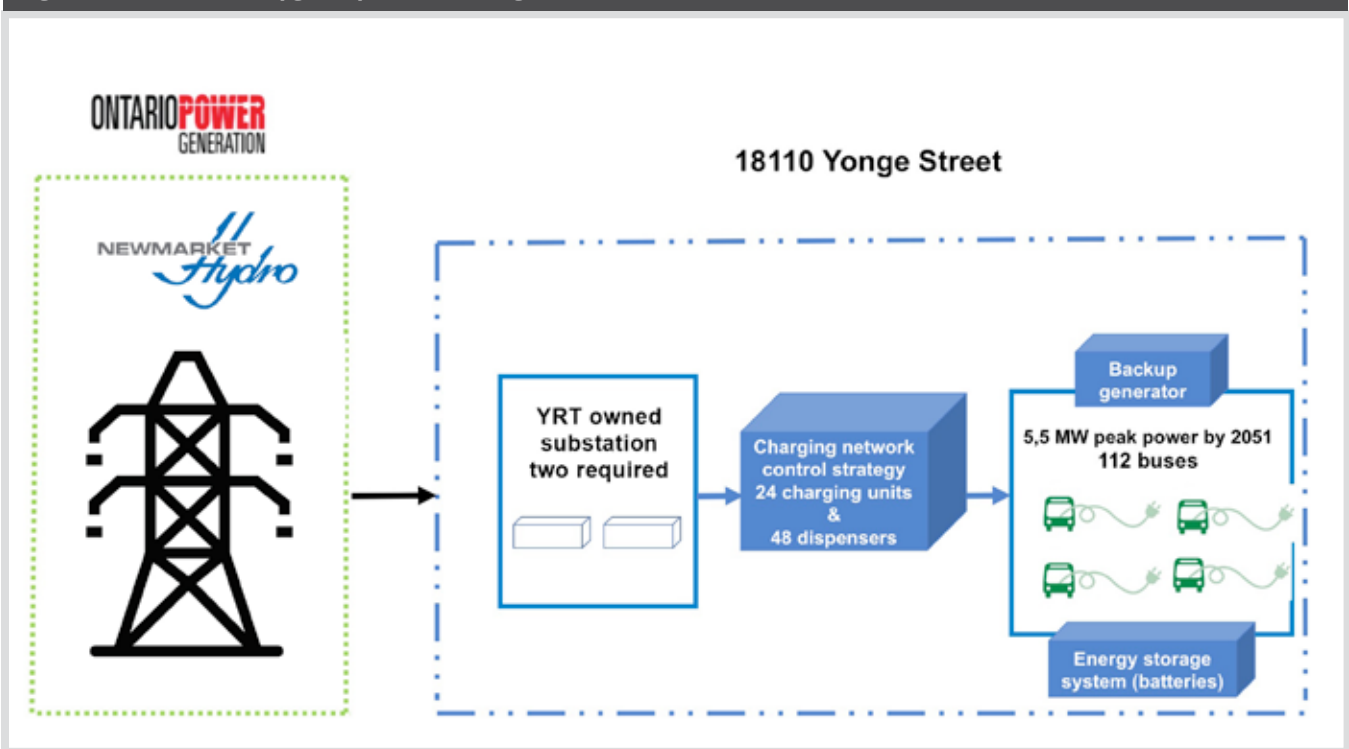


Figure 6: Infrastructure upgrade plan (18110 Yonge Street)



Implementation Planning

A phased approach which supports the implementation of supporting infrastructure and further maturation of technology allows the Region to achieve the goal of an emission free transit fleet by 2051.

Figure 7 outlines the complete transition starting with incremental electric bus procurement and infrastructure

implantation leading up to the purchase of only electric buses being purchased from 2030 onward.

Figure 8 outlines the complete transition starting with accelerated electric bus procurement and infrastructure implantation leading up to the purchase of only electric buses being purchased from 2025 onward.

Figure 7: YRT fleet transition to electric bus (incremental procurement)

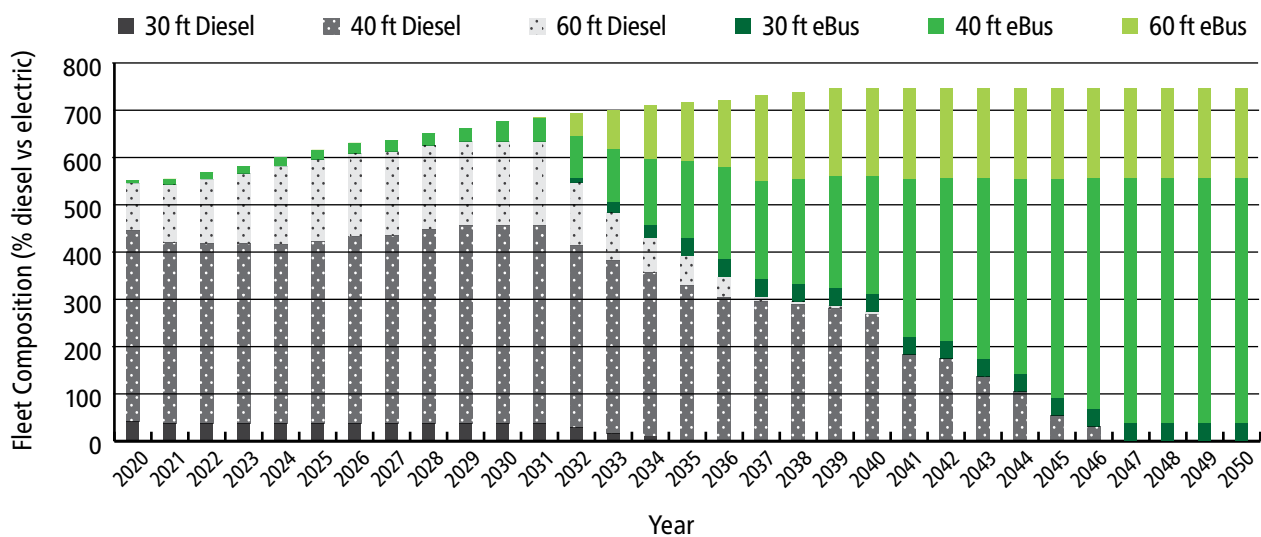
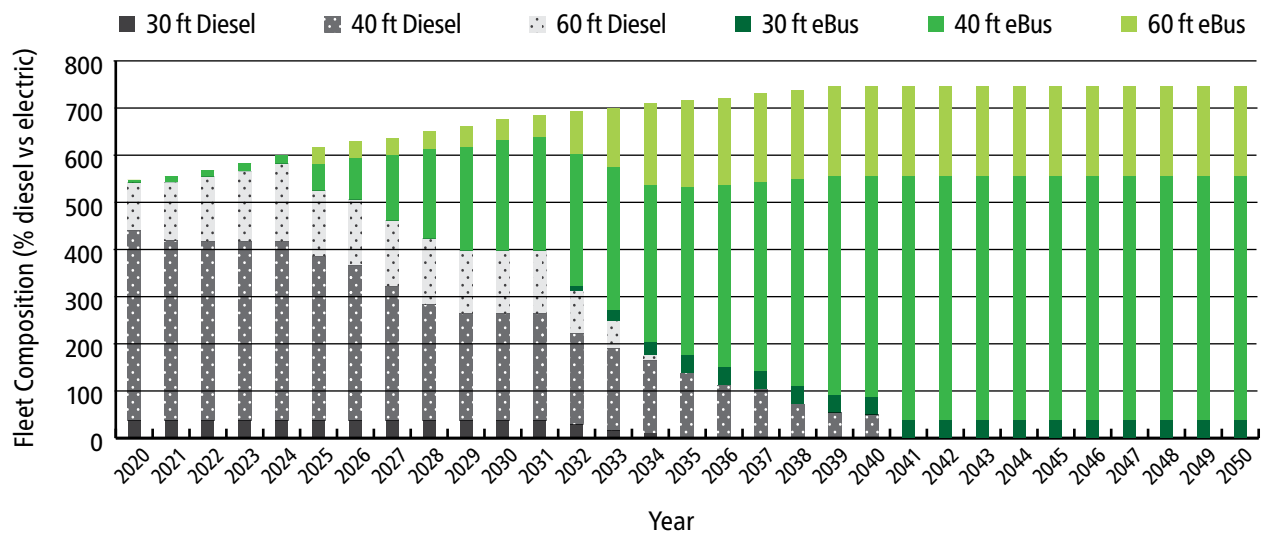


Figure 8: YRT fleet transition to electric bus (accelerated procurement)



Emission Profiles

Figure 9 shows the projected emissions costs for the business as usual diesel bus fleet. It also identifies the projected emission cost profile for electrification scenarios 1 and 2.

Figure 9: Projected emissions costs for diesel bus fleet

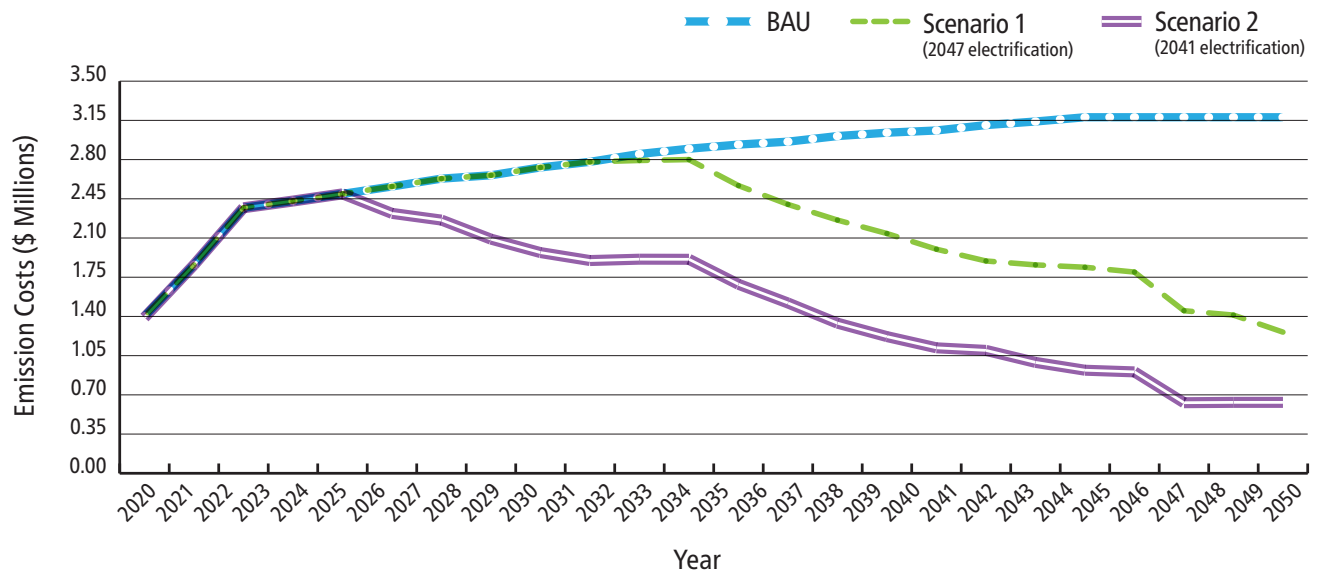


Table 3 outlines the total capital budget impact for each scenario and compares it to what is included in the approved 2020 10-Year Capital Plan.

Table 3: 10-Year Capital Budget Impact 2020-2029			
Description	BAU* (\$M)	Scenario 1 (\$M)	Scenario 2 (\$M)
Fleet Procurement	437	449	563
Fleet Midlife/Overhaul	71	71	75
Infrastructure Upgrade	-	25	25
Charging Stations	-	3	52
Total Capital Expenditures	508	548	714
Capital Budget Impact vs BAU*		40	206

* Business as usual

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