Canadian Urban Transit Research & Innovation Consortium (CUTRIC)
Consortium de recherche et d'innovation en transport urbain au Canada (CRITUC)

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CUTRIC Transportation Innovation Pillars

	Descriptions (flexible)
1. Alternative (low- and zero-emissions) propulsion systems & fueling systems	Battery electric propulsion Fuel cell electric propulsion Compressed/Liquefied/Renewable Natural Gas propulsion
2. Light-weight materials and processes	Composites and hybrid structures Light-weight metals Biofibers Processes
3. Autonomous, connected vehicle communications systems	Sensors, signals, control systems Artificial intelligence for networked, 'self-healing' systems
4. Cyber- & critical systems security	Securitization of component parts, critical systems Vehicles-to-X (V2X) communications
5. Big Data & Analytics	Data driven analytic solutions for transportation and transit system optimization and networking Data driven analytic solutions for vehicle-to-grid communications Consumer applications (real-time mobile communications)

Pan-Ontario Electric Bus Demonstration & Integration Trial

Phase I (2017-2020)

Energy delivery, storage, and optimal pricing for electrified heavy-duty vehicle systems

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Project investors & stakeholders

Nova Bus: electric bus solution (Strategy #1)

NOVA BUS

LFS

Time to charge : 5 minutes

1 2 3

POSITIONING
EASY HOOK UP

CHARGING
QUICK SETUP

LEAVING
HAND FREE

- INVERTED PANTOGRAPH
- HIGH GROUND CLEARANCE
- OPEN STANDARD BY

ABB

SIEMENS

- SAFETY / QUALITY / RELIABILITY
- ZERO-EMISSION
- CHARGING EFFICIENCY
- FUEL EFFICIENCY
- COST EFFICIENCY
- TURN-KEY SOLUTION / SERVICE

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New Flyer: electric bus solutions (Strategy #2)

NEW FLYER

- Leader in Heavy duty Transit Manufacturing since 1930
- Innovator since 1993 with Electric trolleys
- Launch of the Xcelsior XE40 Electric Bus in 2014
- Currently operating in Winnipeg and Chicago
- Pending orders for 2016-2017 totalling 31 XE40 buses

ABB Group: charging system solutions

ABB as a pioneer in EV fast charging solutions

ABB DC Charging infrastructure

Active since: 2010

Volume: > 3.000 DC fast chargers installed world wide, biggest installed base of all manufacturers

Regions: Europe, Americas, Africa, Asia, China, Pacific

Standards: CCS-1, CCS-2, GB/T, CHAdeMO, ISO 15118, IEC-61851-23, SAE J1772

Connectivity: Remote management and support, > 99,5% Uptime, global integration with payment systems, RFID, Smartphone, Creditcards and 3rd party IT systems.

Ebus charging experience: Conventry (UK) 2011, Offenback (DE) 2012, Geneva (CH) 2013, Luxembourgh (2016), Namur (2016/2017)

ABB Group: charging system solutions

Objectives: accelerate adoption & enable localization

ABB supports eBus projects/collaboration in Canada

- Demonstration and deployment of a clean energy technology
- Increase awareness and understanding of the implementation & use of eBus “on route” fast chargers at the city, PU & TA levels
- Data gathering, analysis and sharing to develop local engineering expertise in an fast growing emerging market
- Support actual standardization process of “on route” fast charger technology

- Leverage of ABB expertise and footprint in Canada (50 offices, 4300 employees from coast to coast)
- Prepare mass deployment of the technology across Canada to achieve a real environmental & economic impact

Siemens: charging system solutions

SIEMENS

- 11 overhead systems in operation globally, including the first Canadian installation (Montreal).
- 2 additional CSA approved chargers scheduled for completion Dec 2016 as part of the STM Cité Mobilité project.
- First charging system to demonstrate interoperability, charging a Volvo and Solaris bus

(*Hamburg, August 2016*)

HOCHBAHN

Hamburg | Germany
4 x 300 kW HPC

Stockholm | Sweden
2 x 150 kW HPC

Gothenburg | Sweden
3 x 300 kW HPC

Hallerad | Sweden
1 x 300 kW HPC

Wroclaw | Poland
1 x 300 kW HPC

Montreal | Canada
1 x 450 kW HPC

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Siemens: charging system solutions

- Flexible charging solutions; able to provide 150kW, 300kW and 450kW powered chargers
- Fully integrated, CSA approved charging system, adaptable to 600VAC or 480VAC utility feeds.
- Developed for Canadian environment and standards.
- Pioneered the “inverted pantograph” interface and working with the industry to establish charging standards.

Fleet Forward 2020

Advancing Vehicle Fleet Performance

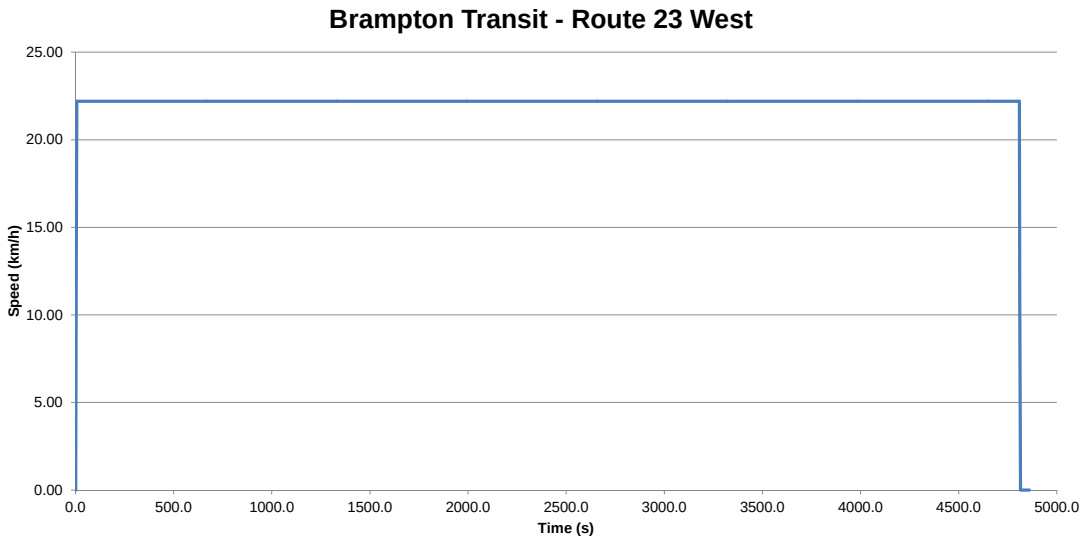
Tyson McWha

Program Technical Leader, FF2020

September 28, 2016

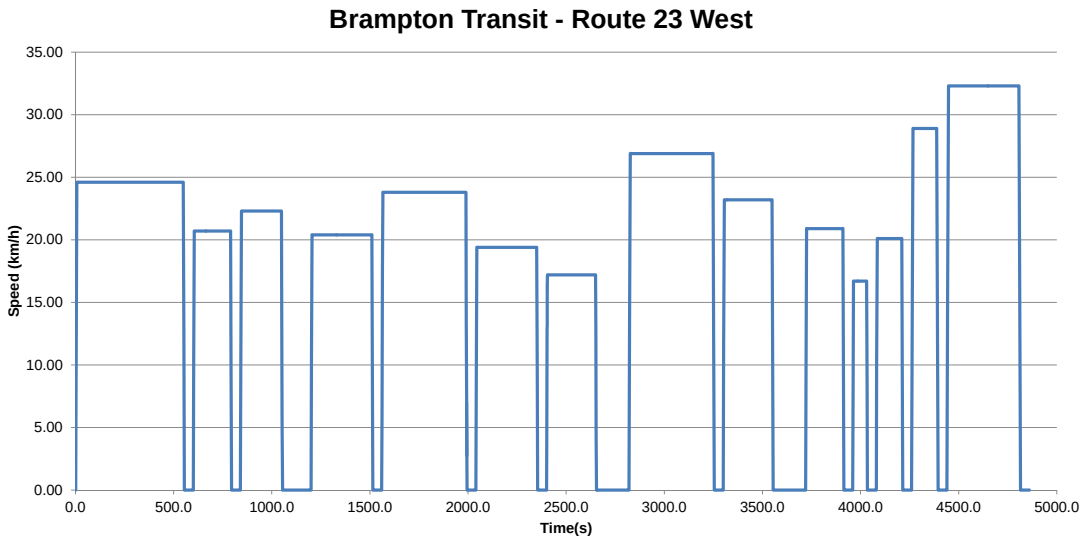
Model Inputs

- Drive cycle – Light-duty



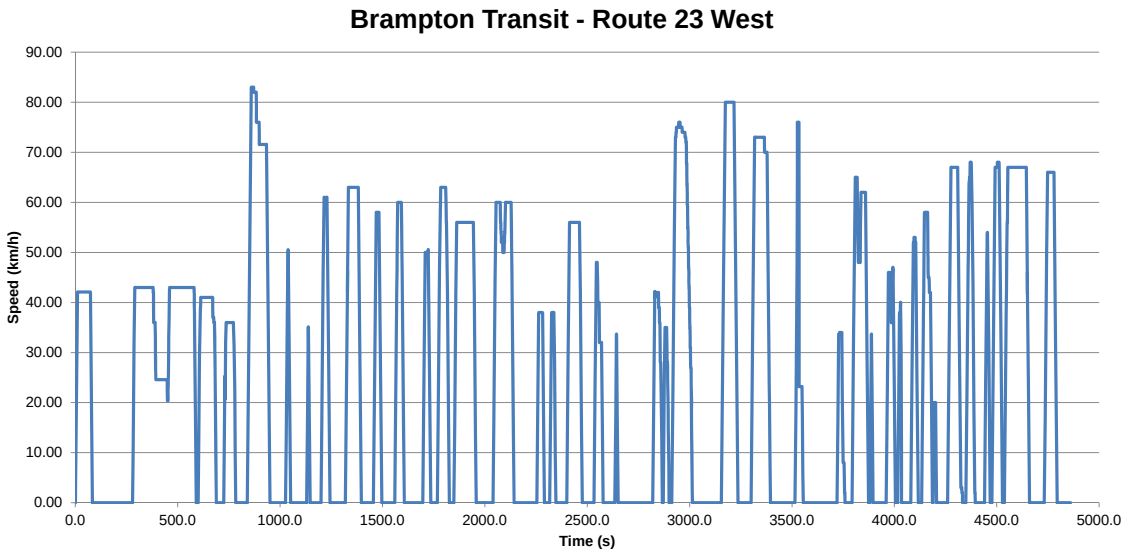
Model Inputs

- Drive cycle – Medium-duty



Model Inputs

- Drive cycle – Heavy-duty



Simulation Results - Usage

Route 23	Eastward Direction			Westward Direction		
	Light-Duty	Medium-Duty	Heavy-Duty	Light-Duty	Medium-Duty	Heavy-Duty
Total kWh used	32.2	36.6	51.8	32.5	36.8	53.3
kWh per kilometer	1.11	1.26	1.78	1.09	1.23	1.78
SOC at route end (200kWh battery)	79.6%	77.4%	70.0%	79.5%	77.4%	69.3%
SOC at route end (80kWh battery)	55.6%	44.7%	31.6%	55.2%	50.0%	28.9%

Simulation Results - Usage

Route 26	Light-Duty	Medium-Duty	Heavy-Duty
Total kWh used	12.5	14.9	27.9
kWh per kilometer	1.06	1.26	2.36
SOC at route end (200kWh battery)	89.1%	88.0%	81.8%
SOC at route end (80kWh battery)	80.4%	77.9%	65.9%

Simulation Results - Charging

Route 23 91% charger efficiency	**Eastward Direction**			**Westward Direction**		
	Light-Duty	**Medium-Duty**	**Heavy-Duty**	**Light-Duty**	**Medium-Duty**	**Heavy-Duty**
Endpoint Charging Time (@ 300 kW)	7.1 min	8.1 min	11.4 min	7.1 min	8.1 min	11.7 min
Endpoint Charging Time (@ 450 kW)	4.7 min	5.4 min	7.6 min	4.8 min	5.4 min	7.8 min
Uptime (@ 300 kVA)	91%	89%	85%	91%	90%	86%
Uptime (@ 450 kVA)	94%	93%	90%	94%	93%	90%

Simulation Results - Charging

Route 26 91% charger efficiency	**Light-Duty**	**Medium-Duty**	**Heavy-Duty**
Endpoint Charging Time (@ 300 kW)	2.8 min	3.2 min	5.1 min
Endpoint Charging Time (@ 450 kW)	1.8 min	2.2 min	4.1 min
Uptime (@ 300 kVA)	88%	86%	78%
Uptime (@ 450 kVA)	92%	90%	82%

Simulation Results - Rate Based Electricity Cost

Assumptions:

- Diesel at $1.00/L
- Cost of electricity – HydroOne Brampton
  - Off-Peak: 8.7 ¢/kWh
  - Mid-Peak: 13.2 ¢/kWh
  - On-Peak: 18.0 ¢/kWh
- Number of charges per week (blocks 2304 and 2601):

	Route 23W	Route 23E	Route 26
Off-Peak	22	32	15
Mid-Peak	15	10	60
On-Peak	10	10	60

Simulation Results - Rate Based Electricity Cost

Route 23 Rate Based	**Light-Duty**	**Medium-Duty**	**Heavy-Duty**
Electricity cost per year	$19,500	$22,100	$31,700
Diesel cost per year	$60,400 (at 39.7 L/100km)	$66,400 (at 43.6 L/100km)	$95,200 (at 62.5 L/100km)
Potential savings per year	**$40,900**	**$44,200**	**$63,600**

Simulation Results - Rate Based Electricity Cost

Route 26 Rate Based	**Light-Duty**	**Medium-Duty**	**Heavy-Duty**
Electricity cost per year	$13,000	$15,500	$29,100
Diesel cost per year	$28,600 (at 34.7 L/100km)	$31,900 (at 38.1 L/100km)	$57,800 (at 69.4 L/100km)
Potential savings per year	**$15,600**	**$16,400**	**$28,700**

Simulation Results - General Service Electricity Cost

Assumptions:

- Diesel at $1.00/L
- Cost of electricity – New Market Hydro
  - Monthly service charge: $136.76
  - Monthly demand charge: 10.1784 $/kW
  - Commodity charge: 0.121 $/kWh
- Number of charges per week:
  - Route 23 westbound (block 2304): 47
  - Route 23 eastbound (block 2304): 52
  - Route 26 (block 2601): 135

Simulation Results - General Service Electricity Cost

Assumptions:

- Monthly demand charge is estimated by:

$$\frac{\$10.1784}{kW} \times \frac{charge\ time}{15\ minutes} \times 300\ \text{kW}$$

$$\frac{\$10.1784}{kW} \times \frac{charge\ time}{15\ minutes} \times 450\ \text{kW}$$

Simulation Results - General Service Electricity Cost

Route 23 General Service	**Light-Duty**	**Medium-Duty**	**Heavy-Duty**
Electricity service charge per year	$1,600	$1,600	$1,600
Electricity demand cost per year	$34,700	$39,400	$56,400
Electricity energy cost per year	$20,100	$22,900	$32,700
Diesel cost per year	$60,400 (at 39.7 L/100km)	$66,400 (at 43.6 L/100km)	$95,200 (at 62.5 L/100km)
Potential savings per year	**$3,900**	**$2,500**	**$4,500**

Simulation Results - General Service Electricity Cost

Route 26 General Service	**Light-Duty**	**Medium-Duty**	**Heavy-Duty**
Electricity service charge per year	$1,600	$1,600	$1,600
Electricity demand cost per year	$6,700	$8,000	$15,000
Electricity energy cost per year	$10,600	$12,700	$23,700
Diesel cost per year	$28,600 (at 34.7 L/100km)	$31,900 (at 38.1 L/100km)	$57,800 (at 69.4 L/100km)
Potential savings per year	**$9,700**	**$9,600**	**$17,500**

Simulation Results - Summary Route 23

Route 23	Rate Based Model			General Service Model		
	Light-Duty	**Medium-Duty**	**Heavy-Duty**	**Light-Duty**	**Medium-Duty**	**Heavy-Duty**
Electricity cost per year	$19,500	$22,100	$31,700	$56,400	$63,900	$90,700
Diesel cost per year	$60,400	$66,400	$95,200	$60,400	$66,400	$95,200
Potential savings	**$40,900**	**$44,200**	**$63,600**	**$3,900**	**$2,500**	**$4,500**

Simulation Results - Summary Route 26

Route 26	Rate Based Model			General Service Model		
	Light-Duty	**Medium-Duty**	**Heavy-Duty**	**Light-Duty**	**Medium-Duty**	**Heavy-Duty**
Electricity cost per year	$13,000	$15,500	$29,100	$18,900	$22,300	$40,300
Diesel cost per year	$28,600	$31,900	$57,800	$28,600	$31,900	$57,800
Potential savings	**$15,600**	**$16,400**	**$28,700**	**$9,700**	**$9,600**	**$17,500**