

# Vector™ EFT Overview

Roger Lackore  
May 2, 2023



# Case for Electric



Zero **Emissions**

Zero **Greenhouse Gas**

**Noise** Pollution Reduction

No **Emissions Exposure** On-Scene

**Quieter** Environment On-Scene



# Greenhouse Gas Reduction

Diesel engines produce 22 lb of CO<sub>2</sub> per gallon.

## Driving

Cummins X-12 averages 6.5 mpg

6500 miles/year

= 22,000 lbs CO<sub>2</sub>/year from driving

Engine	Idle Speed	Fuel Consumption at 35HP (gal/hr)	
		GHG Model	VMS Data
L9	700	1.76	1.68
	800	1.81	1.79
X12	600	1.61	1.73
	800	1.87	1.75
X15	600	1.76	1.95
	800	2.01	2.13

## Idling

Hours Idling per year 747 urban pumper

Fuel consumed 1.7 gal/hr

= 28,000 lbs CO<sub>2</sub>/year from idling

**50,000 lbs CO<sub>2</sub> Saved per Year**  
**425 Tons Saved over 17 Year Life**





# Diesel Exhaust Exposure

**NFPA 1500 - Safety Health and Wellness**

**NFPA 1901 - Automotive Fire Apparatus**

**Prop 65 - California Health Warning**

## CALIFORNIA

### PROPOSITION 65 WARNING

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm

## NFPA® 1500

Standard on  
Fire Department  
Occupational Safety, Health,  
and Wellness Program

2018

**10.1.5\*** The fire department shall prevent exposure to fire fighters and contamination of living and sleeping areas to exhaust emissions.

## NFPA 1901 Standard for Automotive Fire Apparatus 2016 Edition

**12.2.6.2** Exhaust pipe discharge shall be directed away from any operator's position.

## On-Scene

Noise affects health

Electric minimizes noise on scene

## En-Route

Quiet Cab

Headsets Optional



**Driving Fuel Savings**

**Idling Fuel Savings**

**Engine Oil Changes**

**Transmission Oil Flushing**

**DPF Regeneration Diesel Fuel**

**DPF Ash Cleaning and Service**

**Engine Repair**

**No Exhaust Extraction Needed**



**VS**



**VECTOR** 

# Fuel from Idling

EPA: Heavy Trucks - 0.39 and 1.65 gal/hr

Fire Apparatus Higher.

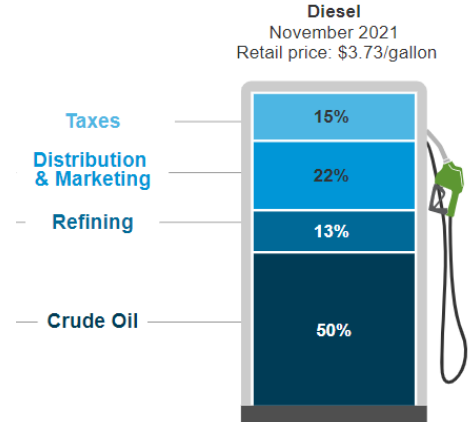
Pumper Idles 747 hr/year.

\$5.25 per gallon of diesel

**\$6471 Diesel Fuel per Year**

Table 7: High, Low, and Average Emissions and Fuel Consumption Rates for 2002 Test Data

	NOx (g/hr)	CO <sub>2</sub> (g/hr)	gal/hr
ARITHMETIC MEAN FOR ALL TESTS			
High Value	329	16,578	1.65
Low Value	55	3,915	0.39
Average Value	144	8,224	0.82
Standard Deviation	72	3571	0.40
Coefficient of Variation	0.5	0.43	0.43
WEIGHTED AVERAGE VALUES (60% High RPM, 40% Low RPM):			
Weighted Average Value:	160	9411	0.94
WEIGHTED AVERAGE VALUES (70% High RPM, 30% Low RPM):			
Weighted Average Value:	167	10012	1.00



## Urban Pumper Hours per Year

Acceleration	80
Deceleration	77
Steady Speed	151
Stopped with Engine Running (Pump Off)	747
Pumping	64
Total	1123



# Fuel from Driving

Heavy Truck 6 mpg

Pumper Drives 6428 miles/yr

1071 gallons of diesel per year.

\$5.25 per gallon.



**\$5623 Diesel Fuel per Year**



# Engine Oil Change Interval

Oil change twice per year

Oil service costs \$450



**\$900 Oil Service per Year**



# Transmission Oil Change



Transmission oil change every 3 years

Transynd fluid \$45 per gallon

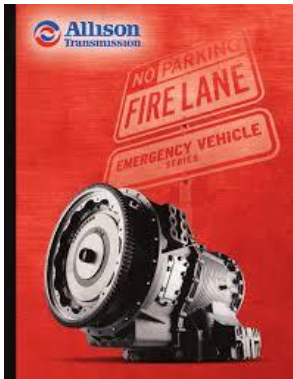
4000 EVS transmission holds 12 gallons of fluid.

Labor        \$240

Fluid        \$600

\$280 per Year

\$840 x 17/4 = \$3,360 Transmission Maintenance Savings



Recommended Fluid/Filter Change For 4000/4500/4700/4800 EVS Transmissions

NOTE: Severe and General Vocations—Local conditions, severity of operation, or duty cycle may require more or less frequent fluid change intervals that differ from the published recommended fluid change intervals of Allison Transmission. Transmission protection and fluid change intervals can be optimized by using fluid analysis. Filters **must** be changed at or before recommended intervals. Change fluid/filter after recommended mileage, months, or hours have elapsed, whichever comes first.

SEVERE VOCATION*				GENERAL VOCATION**			
Fluid	Filters			Fluid	Filters		
	Main	Internal	Lube/Auxiliary		Main	Internal	Lube/Auxiliary
Schedule 1—Non-TranSynd™/Non-TES 295 Fluid							
12,000 Miles (20 000 km)	12,000 Miles (20 000 km)	Overhaul	12,000 Miles (20 000 km)	25,000 Miles (40 000 km)	25,000 Miles (40 000 km)	Overhaul	25,000 Miles (40 000 km)
6 Months	6 Months		6 Months	12 Months	12 Months		12 Months
500 Hours	500 Hours		500 Hours	1000 Hours	1000 Hours		1000 Hours
Schedule 2***—TranSynd™/TES 295 Fluid 4 Inch Control Module (3.5 Inch Approximately)—Requires Filter Kit P/N 29540494							
75,000 Miles (120 000 km)	75,000 Miles (120 000 km)	Overhaul	75,000 Miles (120 000 km)	150,000 Miles (240 000 km)	75,000 Miles (120 000 km)	Overhaul	75,000 Miles (120 000 km)
36 Months	36 Months		36 Months	48 Months	36 Months		36 Months
3000 Hours	3000 Hours		3000 Hours	4000 Hours	3000 Hours		3000 Hours

\* Emergency Vehicle Series with retarders or on/off highway.

\*\* Emergency Vehicle Series Transmissions without retarders and on highway only.

\*\*\* Recommendations in Schedules 2 and 3 are based on the transmission containing 100 percent TranSynd™ fluid and Allison Transmission Gold Series filters.

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# DPF Regeneration

Idling is the bane of the DPF

This leads to more soot in the exhaust

Raw fuel injected during regeneration.

Two ash cleanings over life of apparatus



DPF Ash Cleaning \$850

2 Cleanings Saved

$\$850 \times 2 = \$1,700$

Regen fuel savings

$\$1,200$





# Diesel Engine Apparatus Expense

Idling Fuel	\$110,000
Driving Fuel	\$95,600
Engine Oil Changes	\$15,000
Transmission Oil Service	\$ 4,800
DPF Regeneration Diesel Fuel	\$ 1,200
DPF Ash Cleaning and Service	\$ 1,700
Engine Repair Estimate	\$ 5,000

**Assumptions:**

**Typical Urban Pumper**

**17 years in service**

**\$ 233,300 Diesel Expense**

# Diesel vs Electric

\$0.1156 per KWh- US Ave Commercial

Idling  $747 \times 10.8 \text{ kw} \times \$0.1156 = \$932$

Driving  $6428 \times 250\text{kwh}/142\text{miles} \times \$0.1156 = \$1308$

Idling Electric	\$16,000
Driving Electric	\$22,000

**\$ 233,300 Diesel Expense**

**\$ 38,000 Electric Expense**

**\$ 195,300 – Conservative Estimate**



**Greater Savings with  
Greater Call Volume**



# Expense Not Required

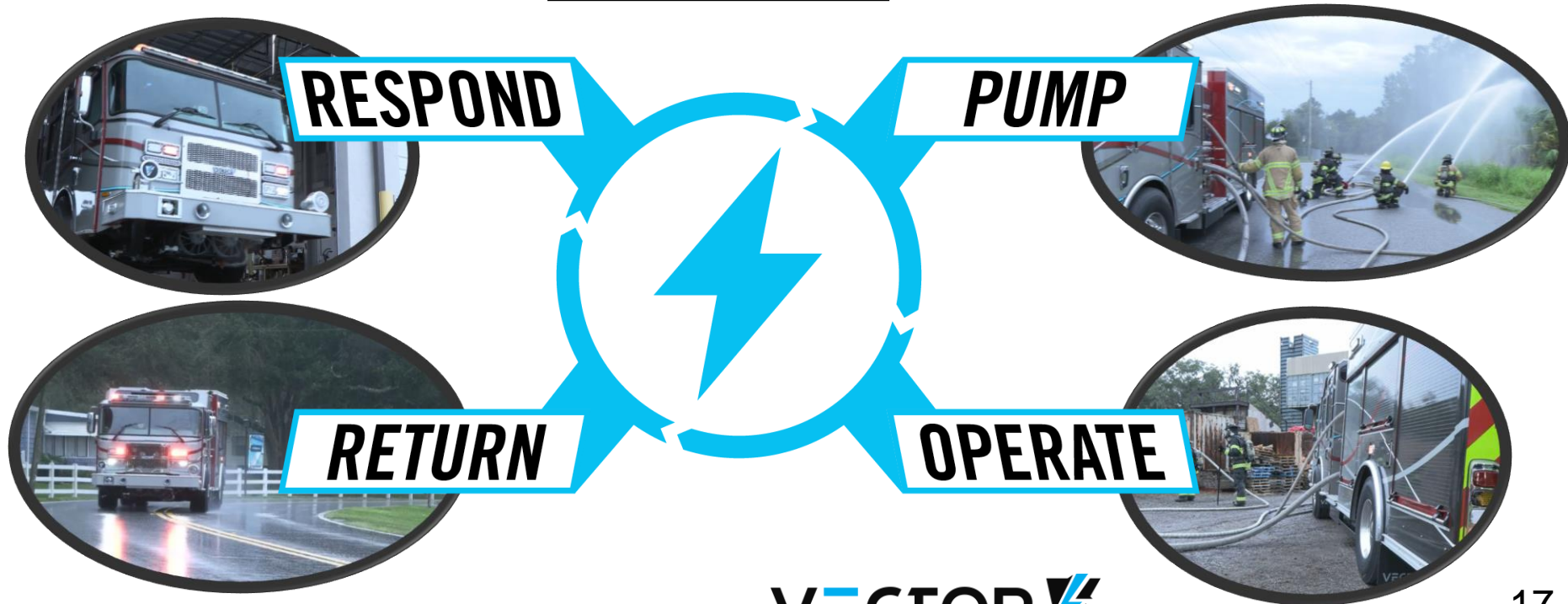


# REV EV Vision





To call a fire truck electric...  
it should do all these on ELECTRIC ONLY.



## All-Electric Fire Truck

### North American Design Configuration

### Optimized Equipment Storage Capability

### Battery placement for Low center of gravity

### Optional Diesel back-up for extended emergency use:

- Pumping beyond 3-4 hours
- Extended operation off the grid (black-outs, earthquakes, hurricanes, etc.)



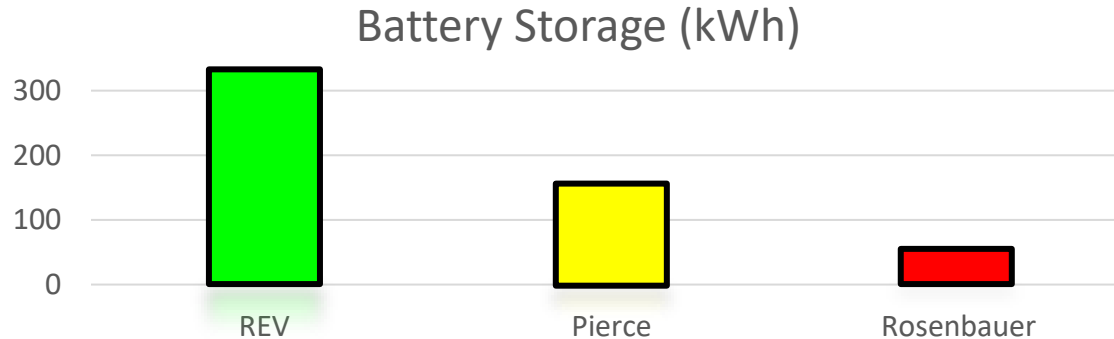
**VECTOR** 

# North American Drive-Train and Fire Suppression



# Product Differentiation

	Vector™	Pierce	Rosenbauer
Approach	All Electric	Hybrid Electric	All Electric
Battery Storage	327 kWh	155 kWh	50 kWh
Battery Location	Low CG	High CG	Low CG
Configuration	North American	North American	European
NFPA/ULC Pump	Electric	Hybrid	Not on Electric





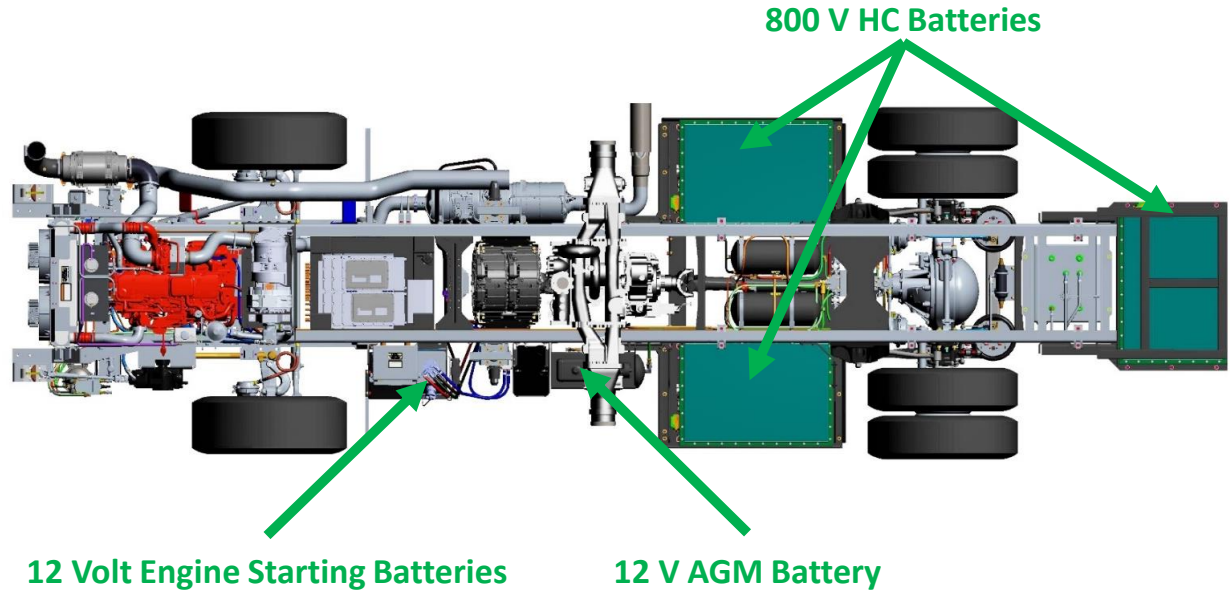
# Technical Features

## High Capacity Batteries:

- 700-800 Volt DC
- Total Capacity 327 KWh
- Usable Capacity 262 KWh

## 12 Volt Batteries

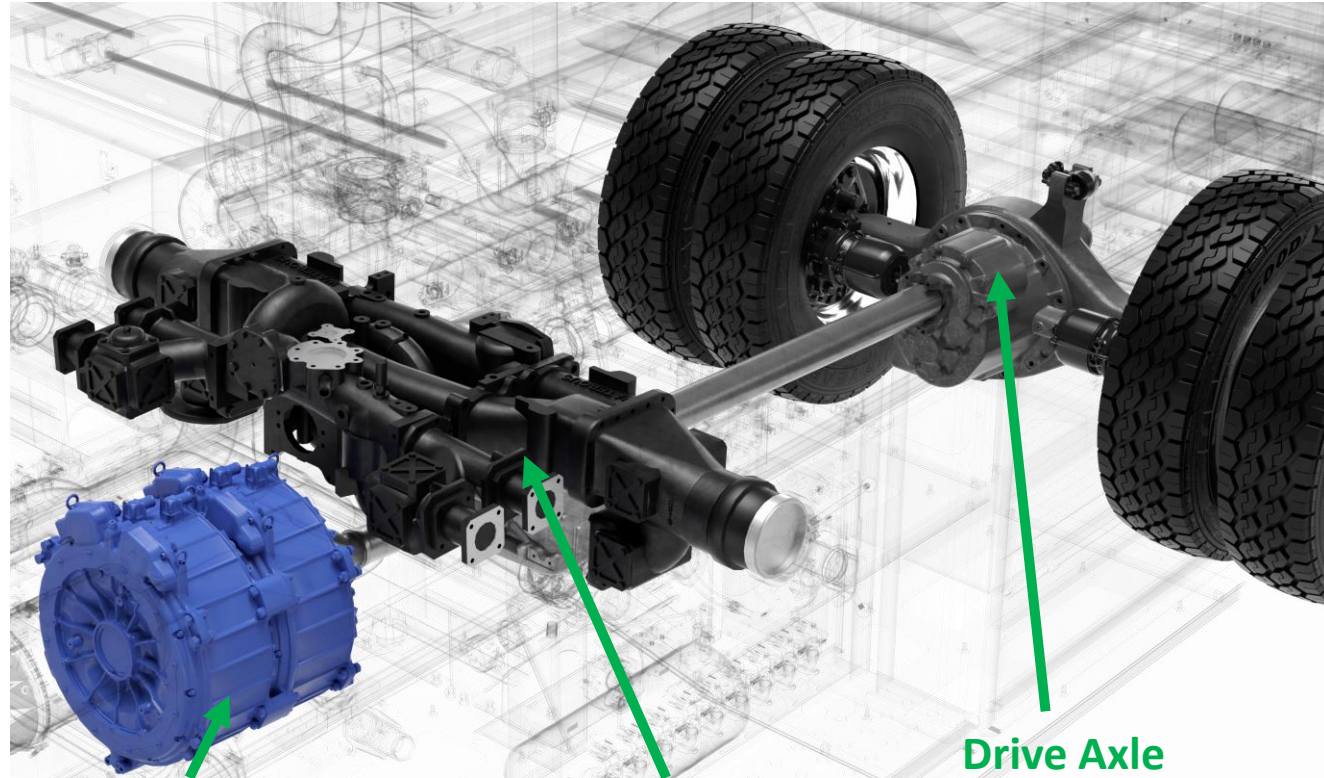
- Lead-Acid for Starting
- AGM for Electronics



# Low CG

- Better Cornering
- Safer in Crash

**Electric  
Traction  
Motors  
Provide ALL  
Vehicle Power**



**Electric Drive Motor**

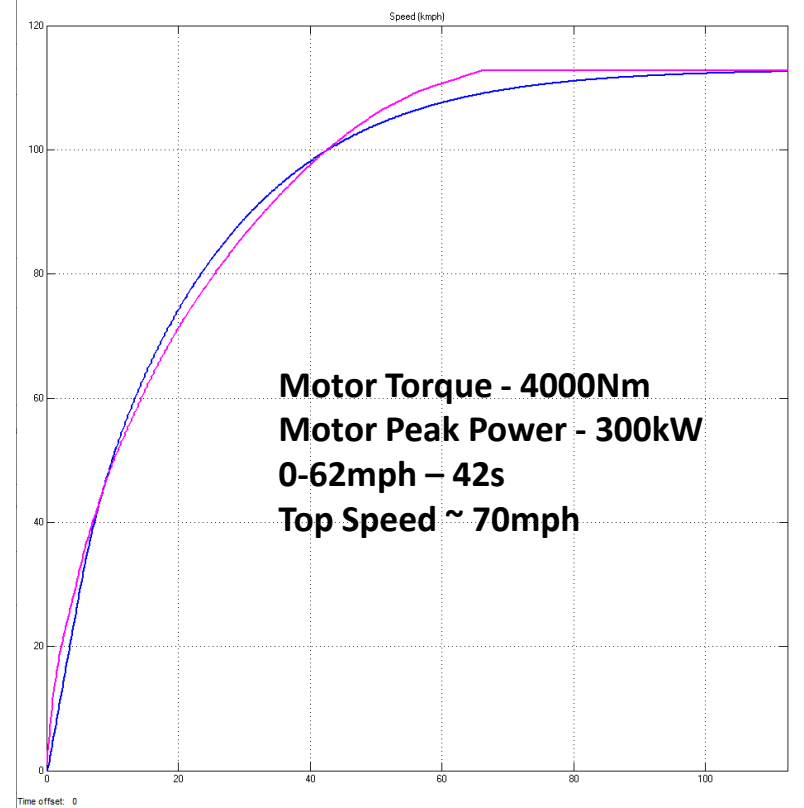
**Fire Pump**

**Drive Axle**

# Full Throttle Acceleration

## Standard performance

- **Matches 500 HP Cummins X12 Diesel**



## Optional Range Extender Engine

Compact Emissions Packaging

Sufficient HP for Charging

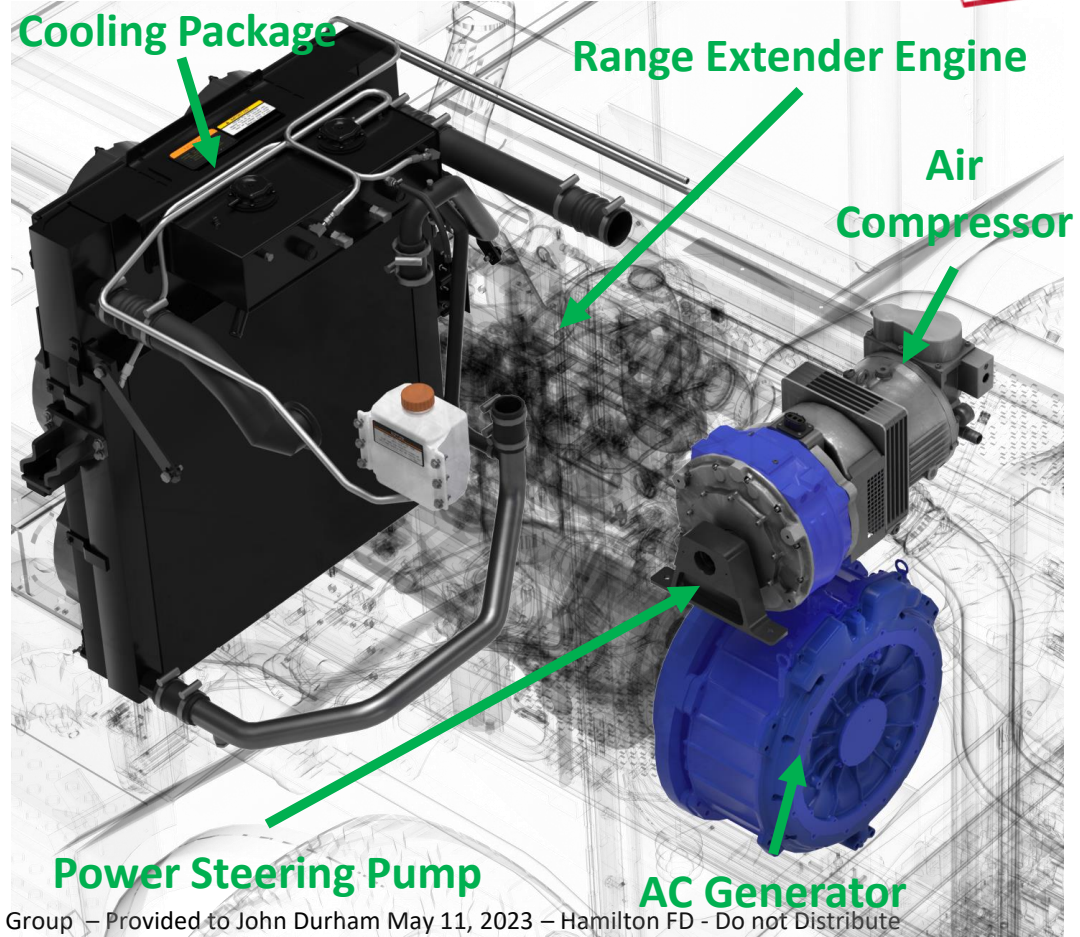
- 120 KW Generator Output

2022 EPA Compliant Industrial Engine

**Range  
Extender Not  
Used for  
Pumping**



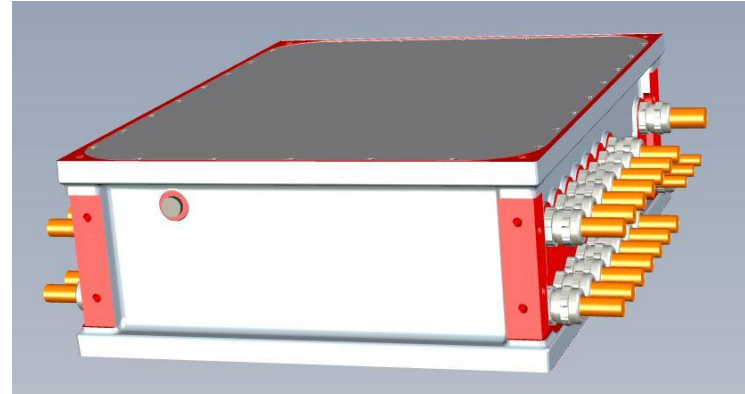




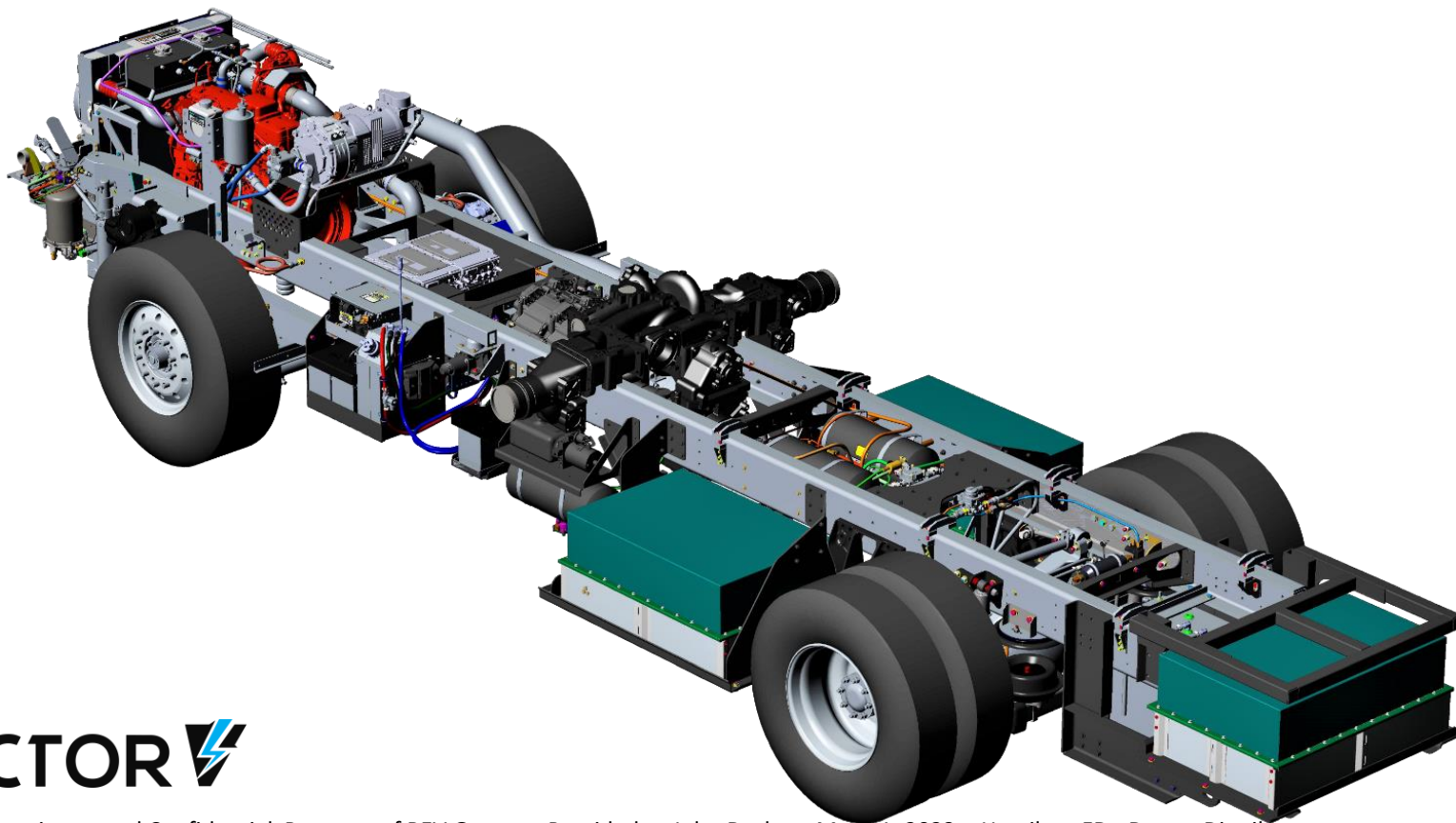


Connections and switching for the following devices:

- Generator
- HC Battery Modules
- Charge Controller Power
- Charge Controller Data
- CCS1 Charge Socket DC Power
- DC Convertors
- Motor Invertors



# EV “Skateboard”



**Body can be configured to department requirements.**

- **1250 GPM (4730 LPM) Pump – (NFPA/ULC Certified ALL ELECTRIC)**
- **1500 GPM (5680 LPM) Pump – (NFPA/ULC Certified with Range Extender Operation)**

**Water/Foam Tank Options:**

- **530 Gallons (2000 Liters)**
- **780 Gallons (2950 Liters)**

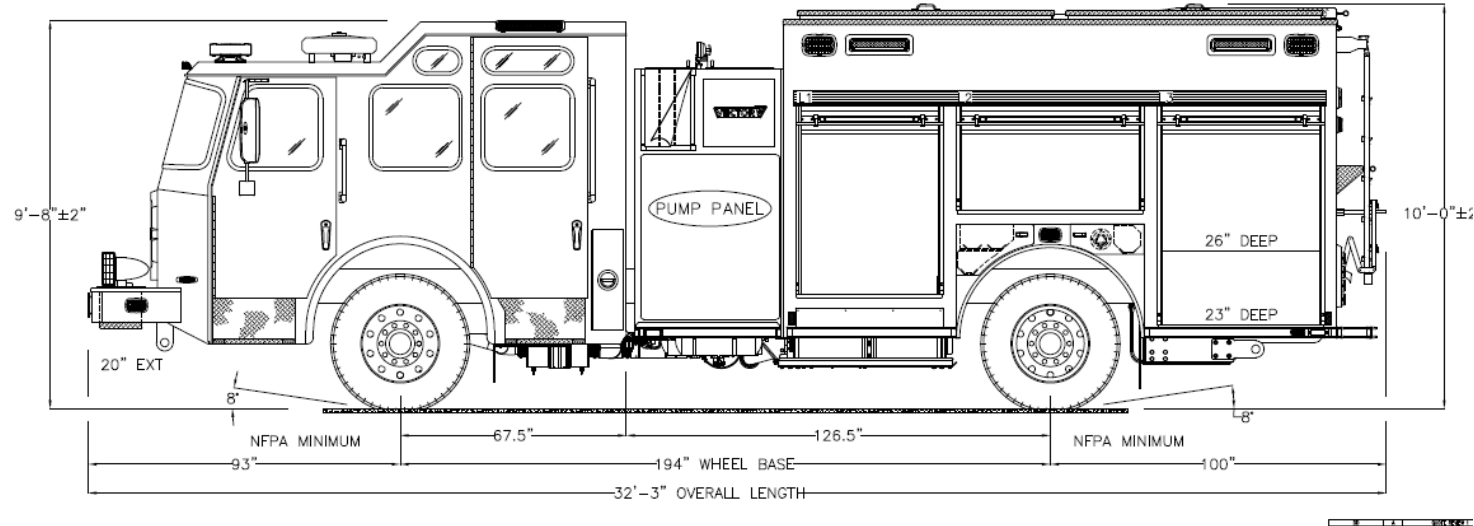


# Pilot Apparatus Basic Dimensions

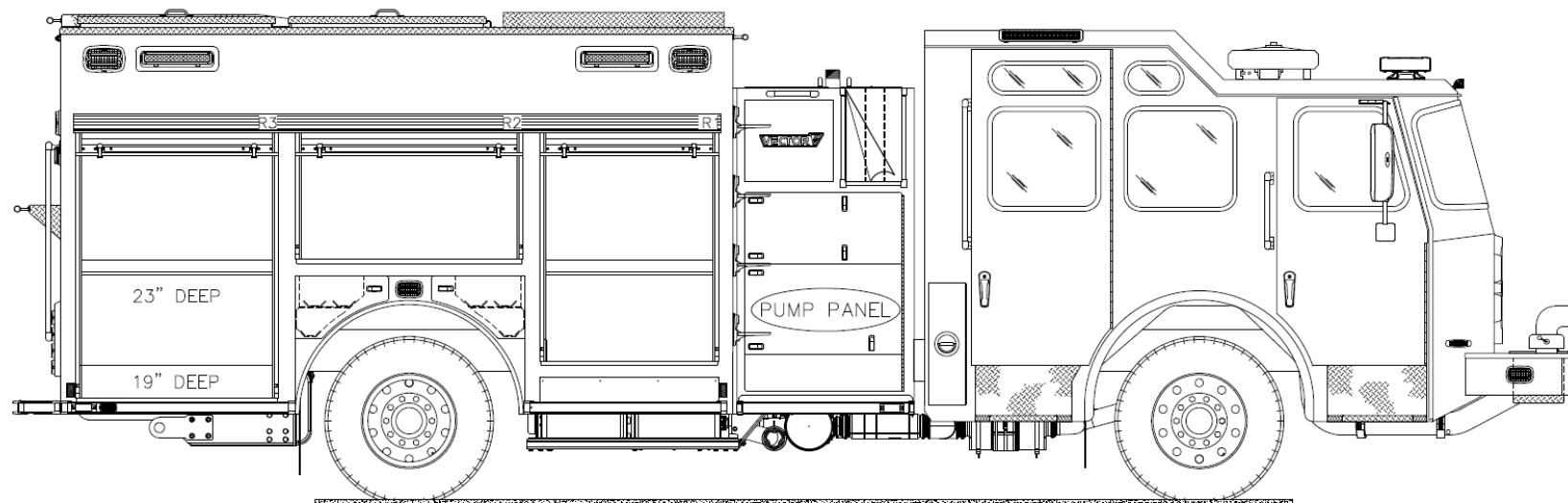
## Customization

- Body
- Pumphouse
- Cab

<b>Wheelbase:</b>	<b>194 in.</b>	<b>(4.9 m)</b>
<b>Length:</b>	<b>33 ft. 2 in.</b>	<b>(9.8 m)</b>
<b>Body Width</b>	<b>98 in.</b>	<b>(2.5 m)</b>
<b>Ground Clearance</b>	<b>10 in.</b>	<b>(0.24 m)</b>



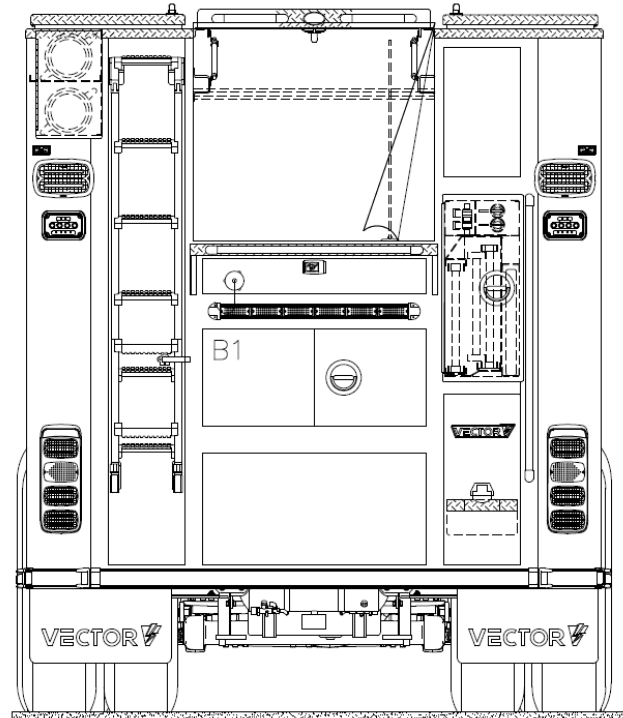
1" = 1' SCALE



Condition	Front Axle (lb)	Rear Axle (lb)	Total (lb)
Gross Vehicle Weight Rating (GVWR)	21000	31000	52000
Empty - Prototype with Body, driver, full fuel.	17480	18820	36320
In-Service – Prototype Loaded, 780 g water, sand-bags, fuel	18200	28040	46360

# 265 Cubic Feet of Compartmentation Possible

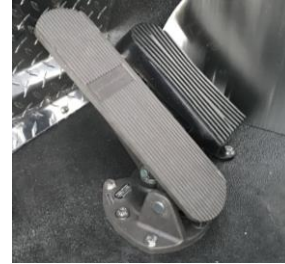
	Width	Height	Depth	Cubic Inch	Cubic Feet
L1	44	47.8	26.0	54626	31.6
	44	38.8	11.8	20034	11.6
L2	56	22.8	26.0	33124	19.2
	56	12.0	11.8	7896	4.6
L3	50	22.0	23.0	25300	14.6
	50	34.8	26.0	45175	26.1
	50	12.0	11.8	7050	4.1
R1	44	21.0	26.0	24024	13.9
	44	38.8	11.8	20034	11.6
R2	56	34.8	11.8	22866	13.2
R3	50	8.0	19.0	7600	4.4
	50	22.0	23.0	25300	14.6
	50	38.8	11.8	22766	13.2
B1	38	19.5	26.0	19266	11.1
Driver Roof	162	18.3	25.3	74652	43.2
Officer Roof	106	18.3	25.3	48846	28.3
					265



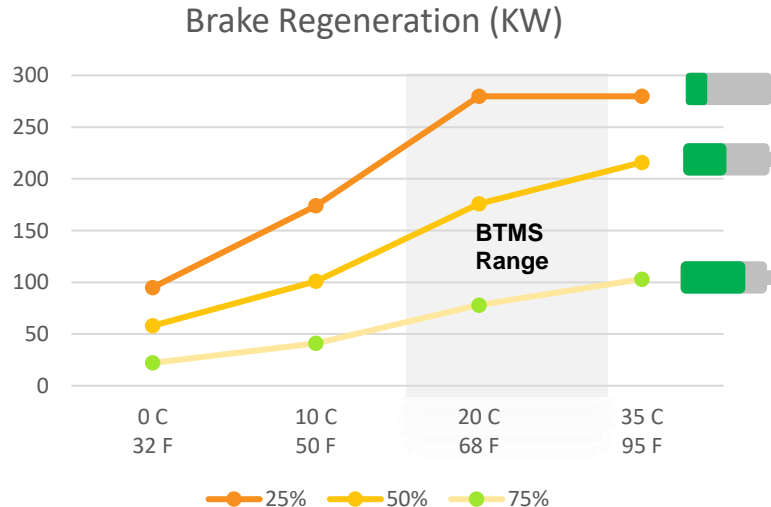


# Regenerative Braking

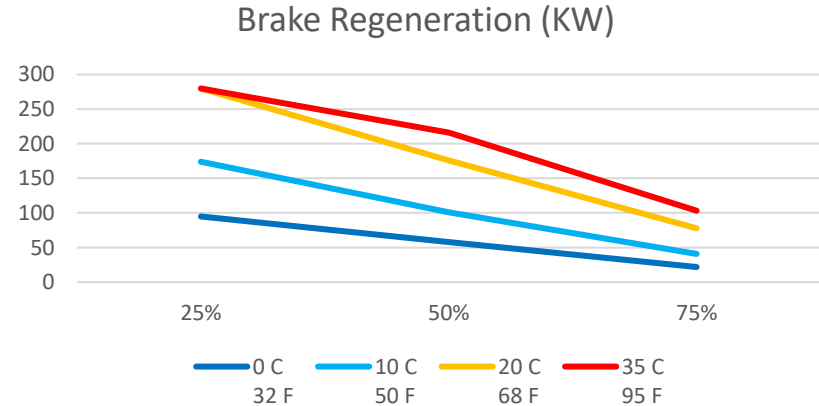
Similar function to auxiliary braking system  
ON with release of Accelerator Pedal



Lower States Of Charge Allow  
Higher Rates Of Charge.



Warmer Batteries Allow Higher  
Rates of Charge.



# Design for Safety

Charge plug locked when Charging.

Truck can't move if plugged in.

EV Batteries shut off in a crash.

System constantly monitors for high voltage leaks

Battery modules pass all ISO 6469 safety criteria

Meets new NFPA 1901 Standards

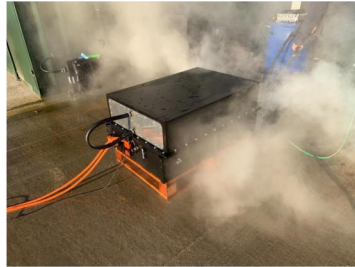


# HC Battery System

- Pouch Style battery cells.
- 700 – 800 Volts DC



**Submersion**



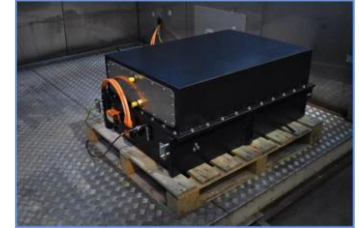
**Jet Wash**



**External Short  
Circuit  
Protection**



**Over Temperature  
Protection**



**Overcharge  
Protection**



**Fire Resistance**



**Vibration**



**Mechanical  
Shock**

# Battery System Mounting

Battery module tray mounting allows removal from out the bottom of the apparatus.

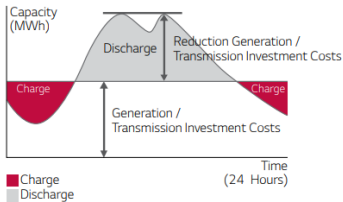
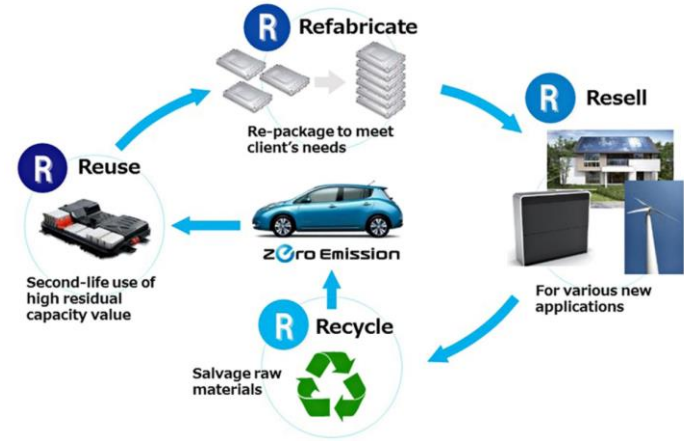
Galvanized structures to resist corrosion



## Used lithium batteries can be re-used in stationary applications

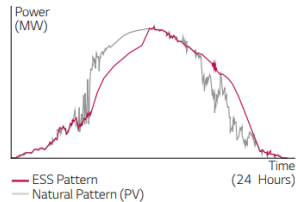


### Scope of 4R Business



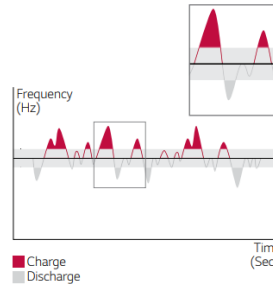
### Peak Shifting

- Charge during off-peak times
- Discharge during peak times



### Renewable Integration

- Stabilize the intermittent renewable power by alternately charging and discharging



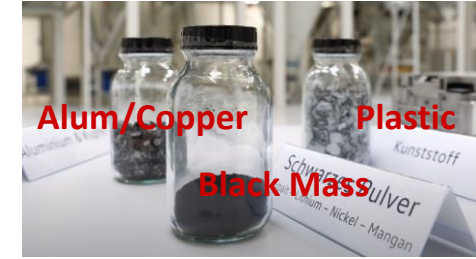
### Frequency Regulation

- Charge when grid frequency increases
- Discharge when grid frequency decreases

**VECTOR**



# Battery Recycling – End-of-Life





## Emergency One Group LTD, UK

- World's First Electric Fire Truck
- Five years of development (beginning in 2017)
- First prototype build in 2019
- Extensive testing and optimization
- Battery Management Technology
- Motor Management
- Pump Governor IP
- Proven Performance



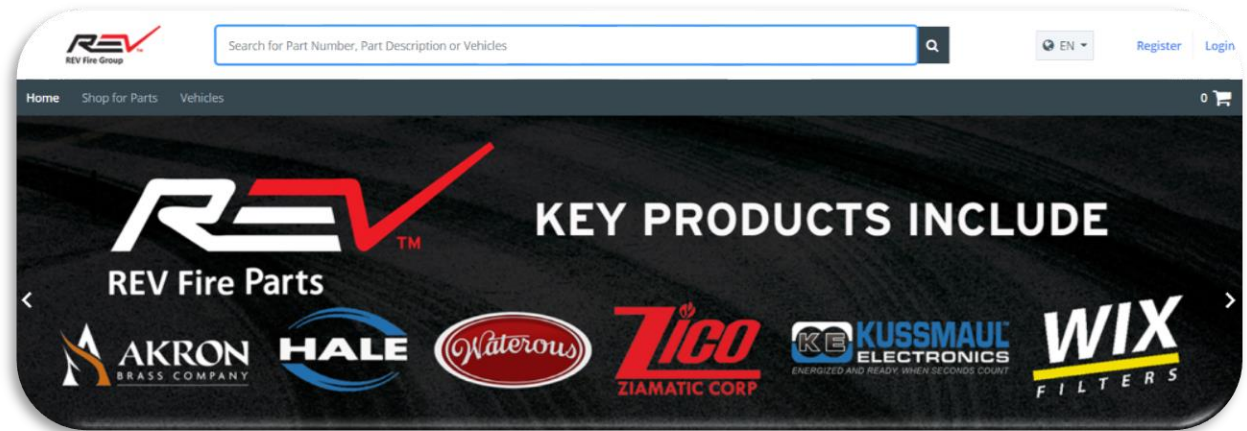
**Partner Experienced with  
Pumping on All-Electric**



Critical EV parts will be stocked by REV Parts including:

- Motors
- Generator
- Control Modules

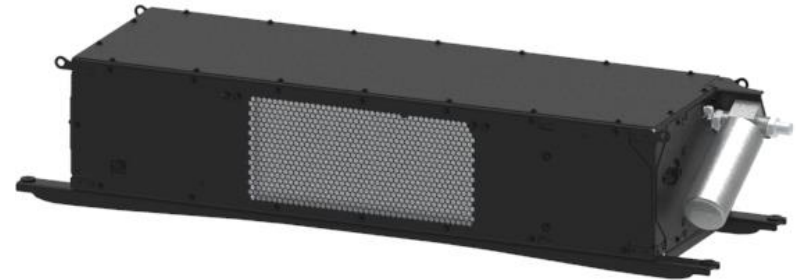
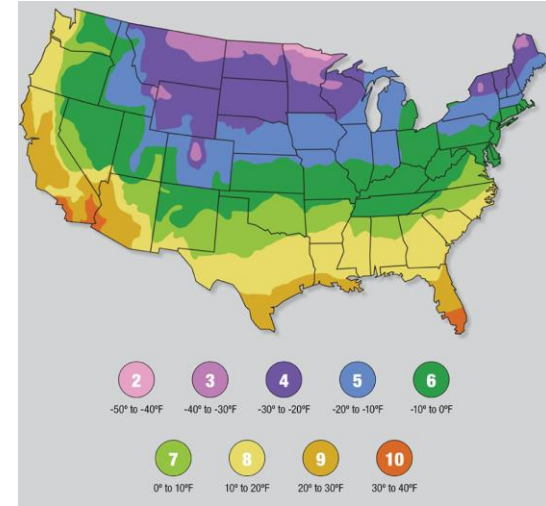
Batteries will be stocked in North America.



## Battery Thermal Management (BTMS)

- Winter mode pre-conditions batteries for cold climate
- Summer mode pre-conditions batteries for hot climate

Batteries maintained within their optimal performance temperature range



# Cab Dash Display

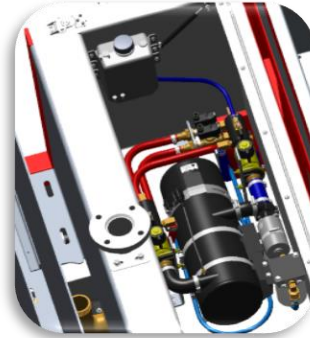
## Driver View





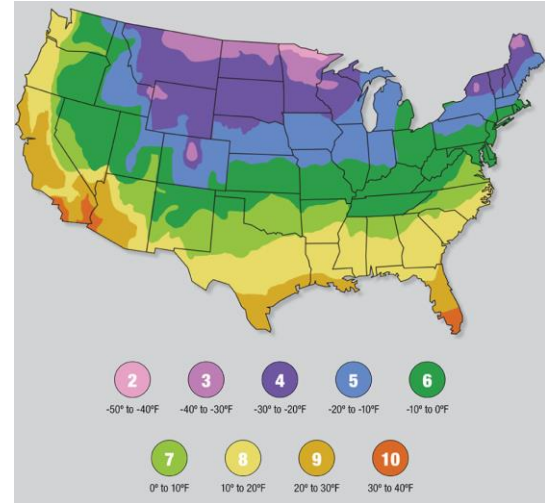
## Cold Climate

- US growing zones 2 through 6 and all of Canada.
- Fuel-fired heater that provides cab heat and defrost.
- Fuel for the heater comes from the range extender diesel tank.



## Hot Climate

- US growing zones 7 through 10.
- Electric heater to provide cab heat and defrost.





# Cab Air Conditioning

**Standard E-ONE System**

**Same BTU Output**

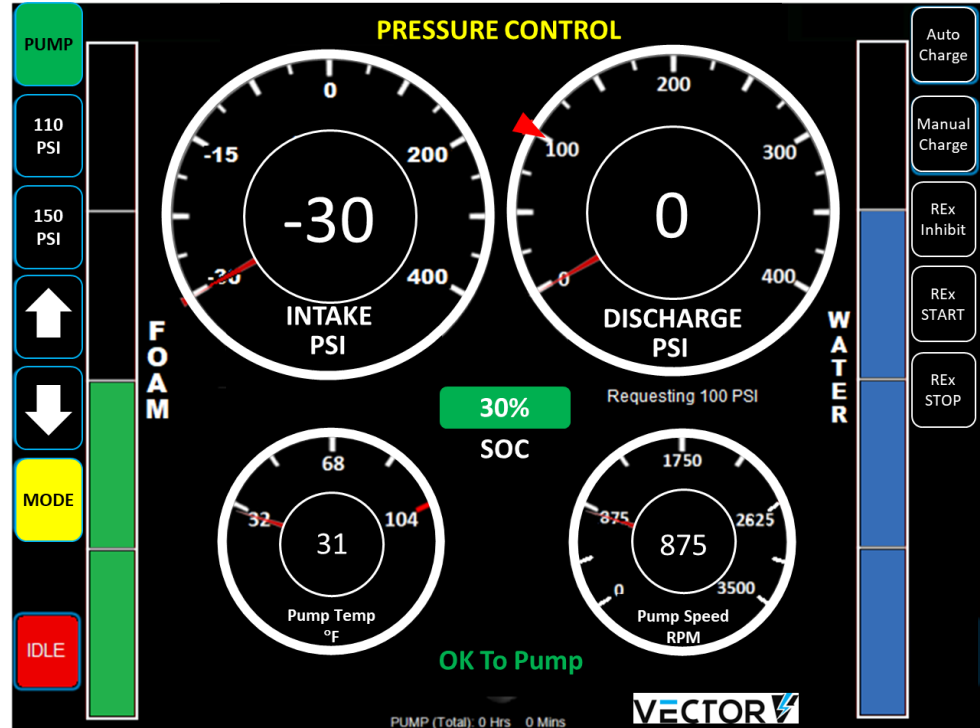
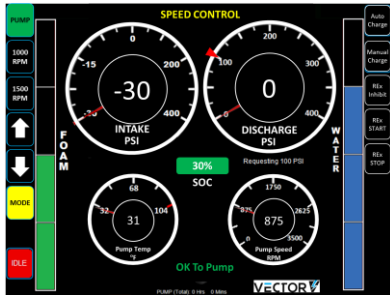
**800 V DC Driven Compressor**



**VECTOR** 

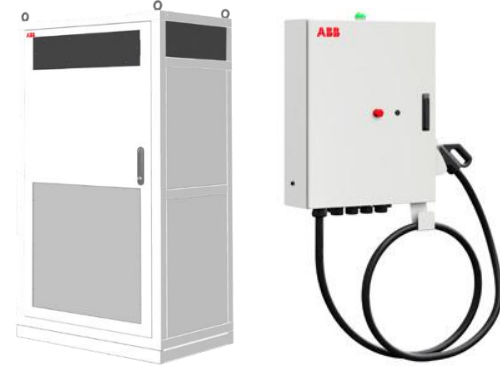
## Custom Pressure Governor

- 12 in. Display
- IP67
- Sunlight Readable
- Pressure and Speed Modes



**CCS1 – DC Fast Charging 120 KW**

**ZERO to FULL in 2 hrs. 30 min.**



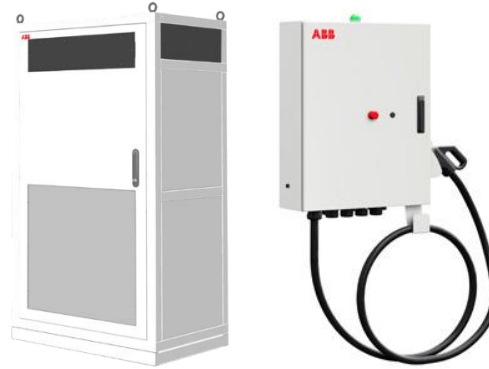
# Charge Plug Safety

## Locked when Charging



## REV Fire Turnkey Consultant

- Site Evaluation
- Utility Upgrades if Needed
- Charger Installation
- Charger Maintenance Plan



Is your facility ready to meet demand for EV charging?

EV charging stations can provide a new revenue stream for your facility, improve sustainability metrics, and deliver a key differentiator for tenants and customers. To navigate the intersection of evolving technology, power infrastructure, and operations that impact a successful EV charger installation, turn to ABM. Our teams self-perform installation, supporting power distribution upgrades, and cost-effective preventive maintenance. With our extensive experience in parking management and energy-saving solutions, ABM is also uniquely positioned to help clients design and implement custom, innovative EV charging projects. Our teams fit EV charger installations to your operations and can include solar power and high-capacity power storage options for even more energy independence and sustainability.

To learn more call our EV Charging specialist at  
866-448-4979



## Preferred System

- 124 KW DC Fast Charger
- 480 V – 3-Phase



# Performance



**142 miles (228 km) - CITY**

**100 miles (161 km) - HWY**



**VECTOR** 

# Rated Pump Duration on Full Charge

## Rated GPM Pumping from Draft

Durations Assume Full  
Electric Operation

Battery Capacity (KWh)	252
---------------------------	-----

Flow (gpm)	Hydrant Pressure (psi)	Pump Pressure (psi)	Discharge Pressure (psi)	Waterous Pump Model	Power (KW)	House Load (KW)	Power Consumed (KW)	Duration (hrs)
500	0	150	150	CG	51	12	63	4.0
750	0	150	150	CS	71	12	83	3.0
1000	0	150	150	CS	86	12	98	2.6
1250	0	150	150	CS	107	12	119	2.1
1500	0	150	150	CSU	132	12	144	1.8

# Rated Pump Duration on Full Charge

## Rated GPM Pumping from Hydrant

Durations Assume Full  
Electric Operation

Battery Capacity (KWh)	252
---------------------------	-----

Flow (gpm)	Hydrant Pressure (psi)	Pump Pressure (psi)	Discharge Pressure (psi)	Waterous Pump Model	Power (KW)	House Load (KW)	Power Consumed (KW)	Duration (hrs)
500	50	100	150	CS	45	12	57	4.4
750	50	100	150	CS	52	12	64	3.9
1000	50	100	150	CS	60	12	72	3.5
1250	50	100	150	CS	82	12	94	2.7
1500	50	100	150	CS	104	12	116	2.2

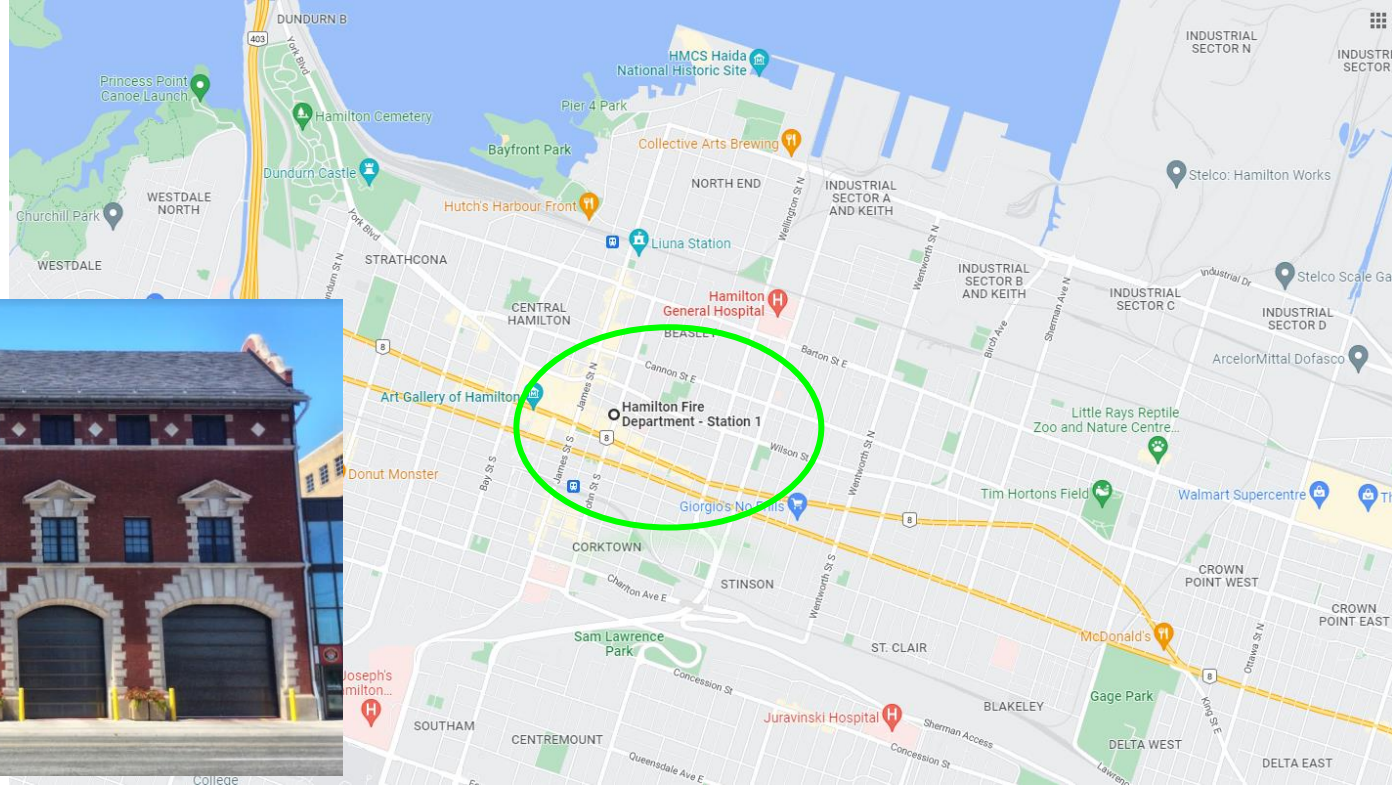
# Pumping Range on Electric

Flow (gpm)	Condition	Time (hours)
1500	DRAFT	1.8
1250	DRAFT	2.1
1250	HYDRANT	2.7
750	HYDRANT	3.9
500	HYDRANT	4.4



# Vector Located in Hamilton Station #1

## Starting Location

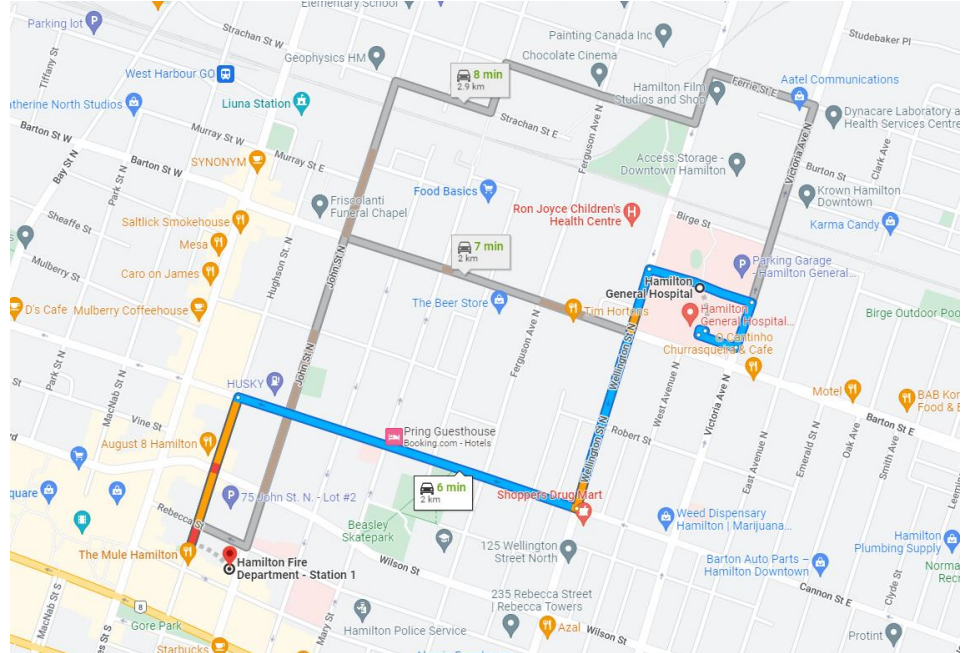


# Hamilton General Hospital

**2.0 KM (1.3 miles)**

**6 Minutes**

**48 Minutes on-Scene**



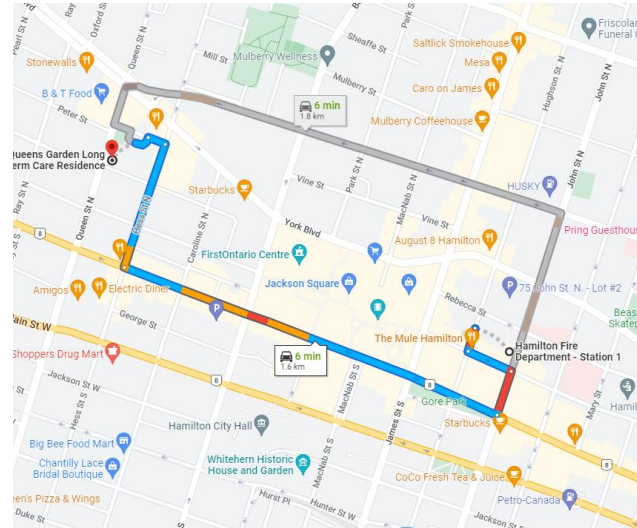


# Queen's Garden Long Term Care

**1.6 KM (1.0 Miles)**

**6 Minutes**

**48 Minutes on-Scene**

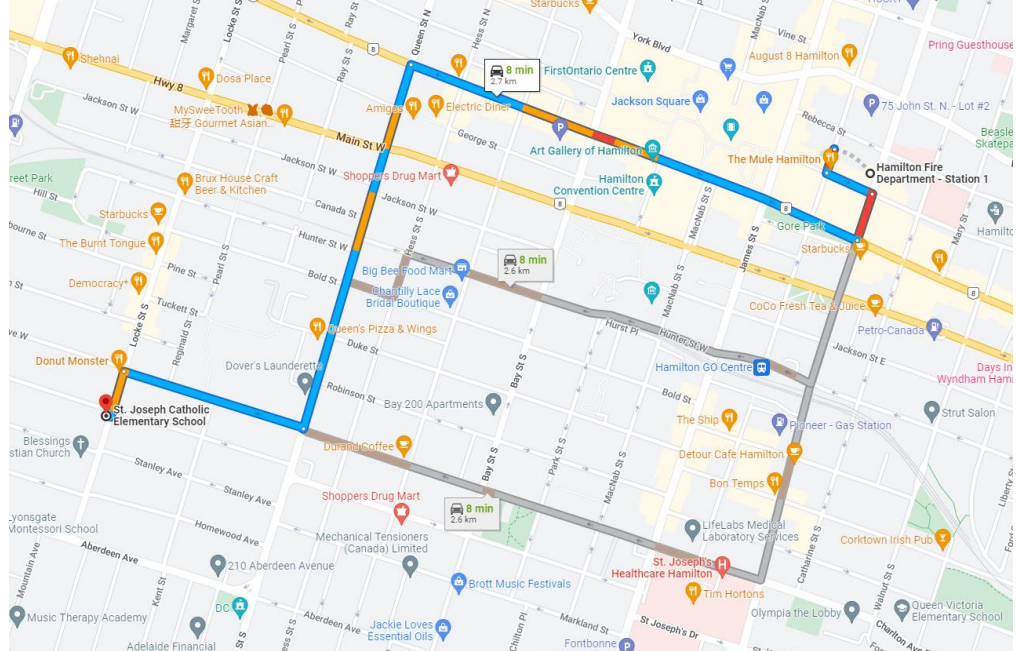


# St. Joseph Catholic Elementary School

**2.7 KM (1.7 Miles)**

**8 Minutes**

**44 Minutes on-Scene**

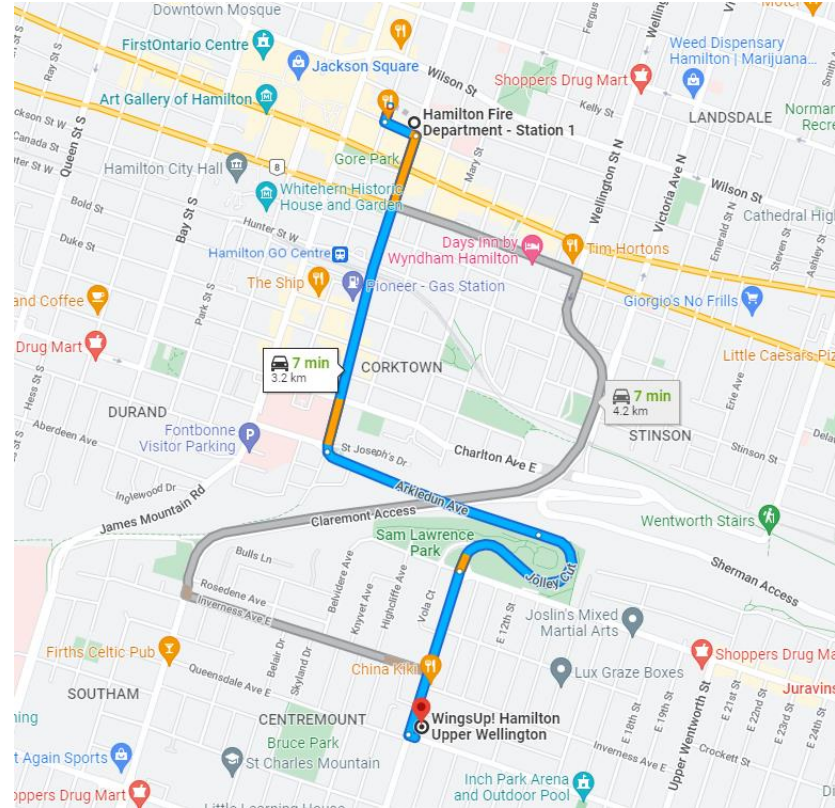


# Wings Up! Hamilton Upper Wellington

**3.2 KM (2.0 Miles)**

**7 Minutes**

**46 Minutes on-Scene**



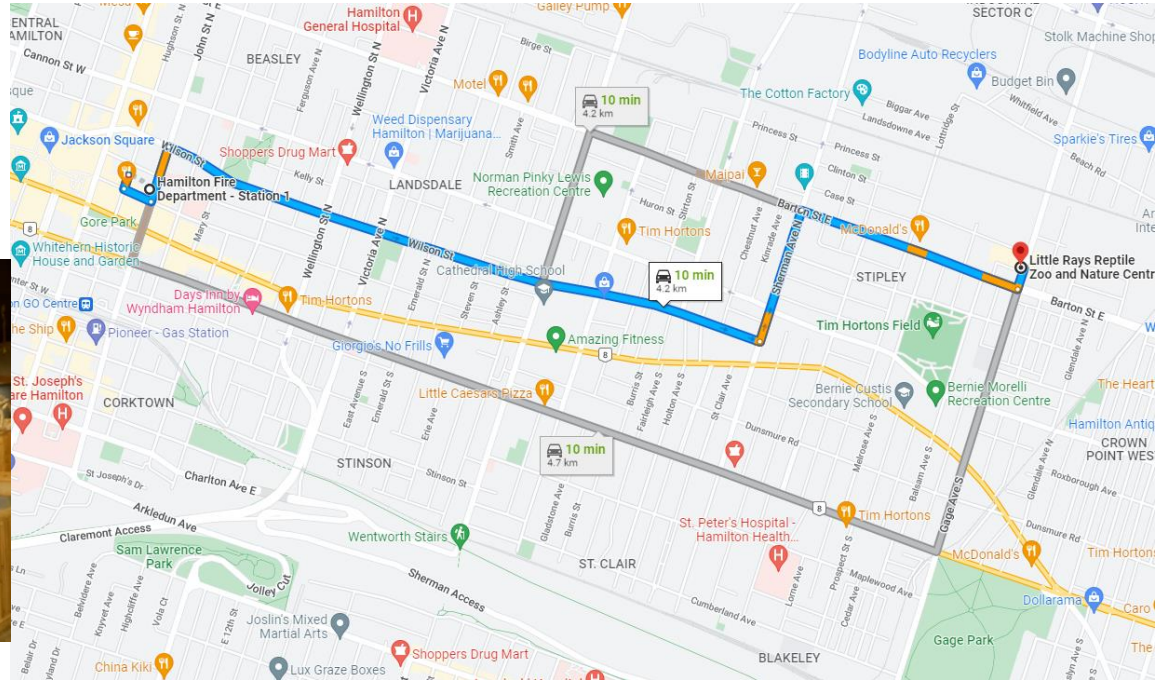


# Little Ray's Reptile Zoo

**4.2 KM (2.6 Miles)**

**10 Minutes**

**40 Minutes on-Scene**



# Example Simulation Results

- 12 1-hour EMS runs without charging
- 20 minutes between runs maintains 100% SOC
- 3 hours pumping at 750 GPM (2800 LPM) on hydrant, and 2 EMS calls with no charging
- 2 hours pumping at 1250 GPM (4700 LPM) on hydrant, with no charging











# Pumping

**Captain Josh Westbrooks**  
**Charlotte NC FD**







STOP





All-Electric Fire Truck  
North American Design  
Highest EV Battery Capacity  
Respond on Electric  
Pump on Electric  
Operate on Electric  
Return on Electric



**Real North American Fire Truck**

**Fully Electric Vehicle with Large Battery Storage Capacity**

**DC Fast Charge Allows Around the Clock - Fully Electric Operation**

**Proven Technology**

**Operational Benefits**

**Environmental Benefits**







**OEM Technical Information:**

**REV Fire Group**

**Roger Lackore**

**[roger.lackore@revgroup.com](mailto:roger.lackore@revgroup.com)**

**920 840 4996**

**VECTOR** 