



@EVSymposium29

#EVS29

Plug-in Hybrid Propulsion Systems for Commercial Vehicles

Electric Vehicle Symposium & Exhibition

June 19-22, 2016 | du 19 au 22 juin 2016

Montréal, Québec, Canada

Gary Parker

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DRIVE ELECTRIC INNOVATION
PROPULSER L'INNOVATION EN MOBILITÉ ÉLECTRIQUE

EVS29.ORG

Making people's lives better by unleashing the **Power of Cummins**

Power of Cummins comes in many forms to meet customer needs

The **Power of Electromobility** is one of them

Electro Mobility is here

Today

- **Founded:** 1919
- **4 complimentary business units:** Engine, Components, Distribution, Power Systems
- **2015 Sales:** \$19.1B
- **Countries:** 190+
- **Global workforce size:** 55,000
- **Continents with development, design, and manufacturing:** 6
- **R&D investment level:** \$750M
- **Engine power range:** 49 – 4,400 HP
- **Globally recognized:**





Heavy-Duty
Truck



Medium-Duty
Truck & Bus



Light-Duty
Automotive & RV



Rail



Mining, Marine, Oil & Gas,
Government



Construction & Agriculture



Stationary Power

Electrification needs are diverse

- Established powertrain player in truck, bus, other automotive and power generation applications
- Hybrid engine supplier for nearly 20 years
- Investing directly in electrification systems, components, and technologies

Examples of early electrification efforts



Power pack for hybrid bus demonstration (1995)



Electric motor and power electronics for hybrid bus demonstrations (2003)

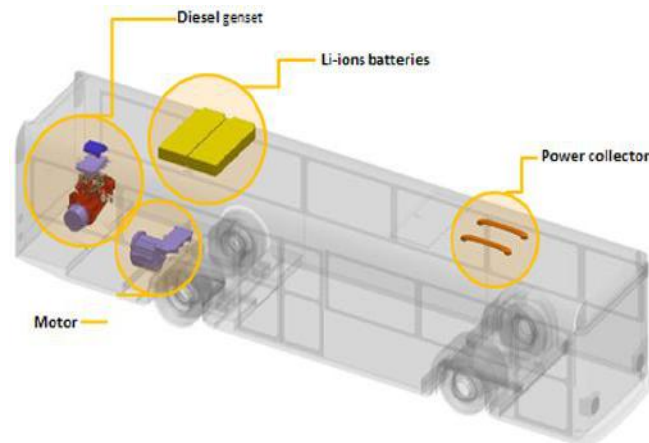
Our **XEV** Systems Projects



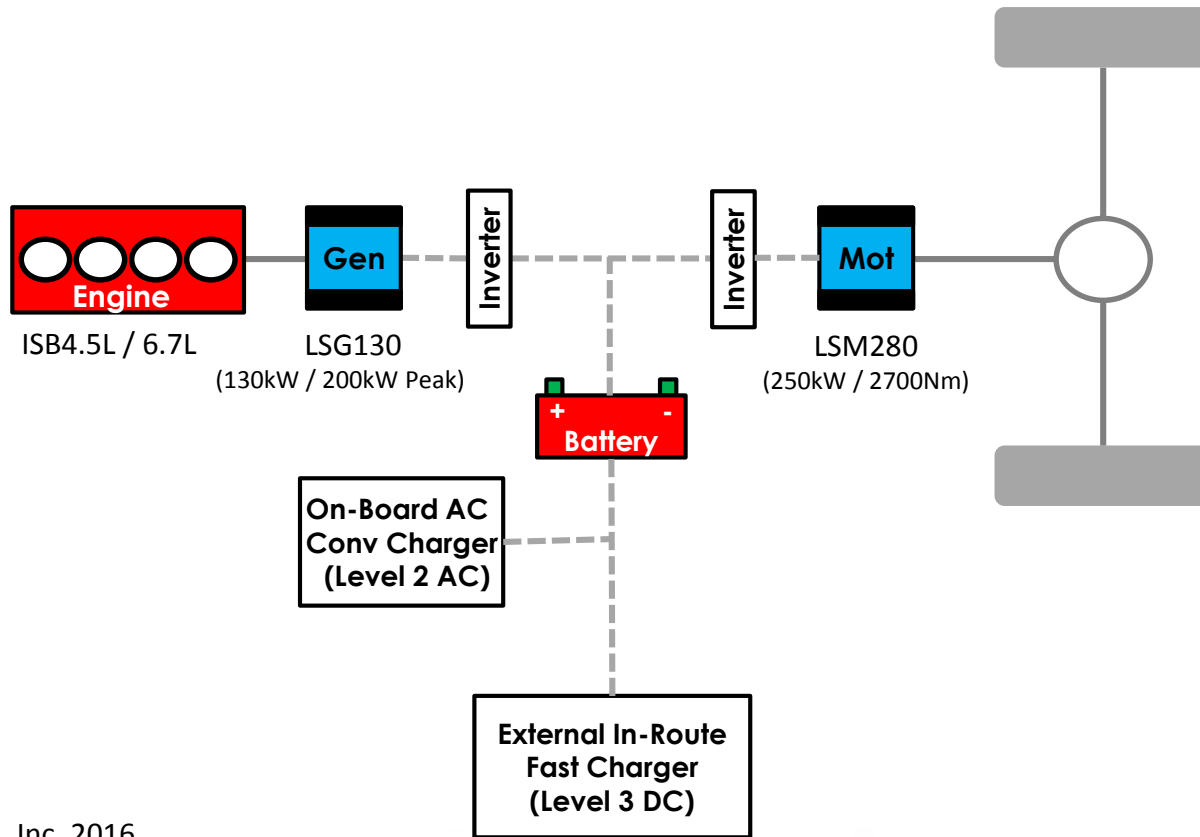
	Purolator BEV Program	Quebec PHEV Program	DOE PHEV Program
Region	NA & EU	NA & EU	NA & EU
Market	Class 4 P&D Truck	Class 7 & 8 Transit Bus	Class 6 P&D Truck
Architecture	XEV (BEV)	XEV (REEV)	XEV (REEV)
Charging	SAE 1772 Level 2	SAE 1772 Level 3	SAE 1772 Level 2
Gen Set	-	ISB 4.5L & 6.7L	ISB 4.5L
ESS Energy	62 kWhr (scalable)	125 kWhr (scalable)	125 kWhr (scalable)
Demos	2016	2017	2018
Program	1 year	3 years	3 years
Partners	TM4 / Purolator	STL / TM4 / IVI	PACCAR / OSU / ANL / NREL

Quebec Transit Bus PHEV initiative underway

- **PHEV:** Plug-In Hybrid Electric Vehicle
- **Market:** Transit Bus
- **Description:** EV powertrain with Genset that extends driving range
- **Key requirement(s):** System will utilize both **off-duty slow charge** and **fast charge on route**
System will **reduce fuel consumption by 50%**
- **4 Member Consortium:** TM4 (lead), Cummins, STL, and IVI
- **Key Deliverable:** 3 year program that delivers 2 PHEV buses in service for STL by Q4 2017

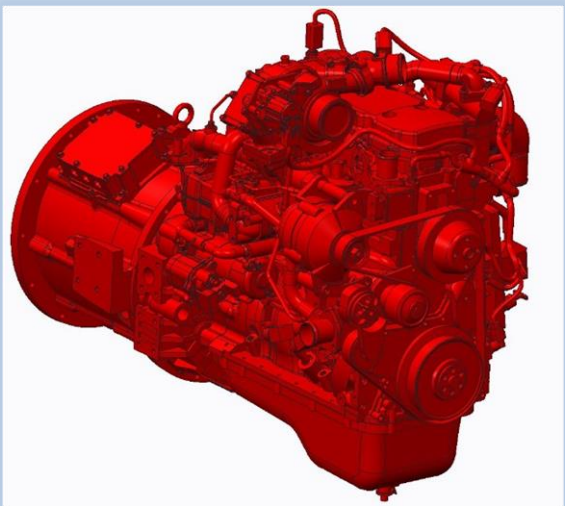


The PHEV Powertrain Architecture

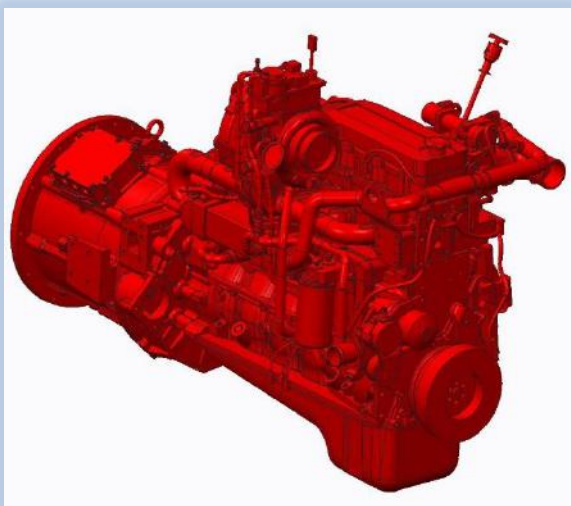


ISB 4.5L & 6.7L Gensets for the Quebec PHEV program

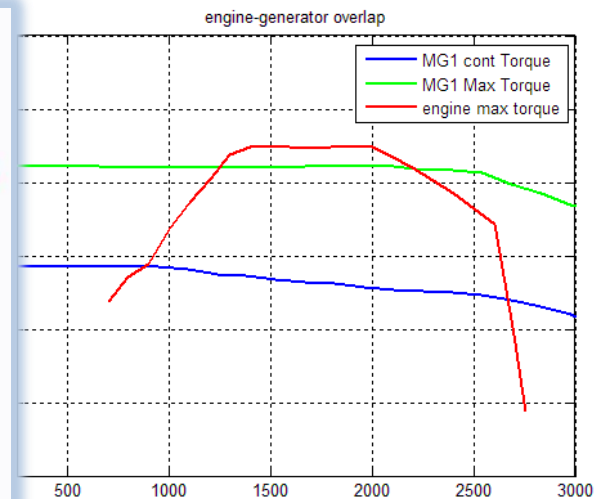
Cummins 4.5L Genset



Cummins 6.7L Genset



Performance Match



Extend Range w/ engine and/or fast charging

Achieve Full Route Coverage

Keep Current Utilization Levels

Maintain Pay Load

Goal: Reduce fuel consumption by > 50%

PHEV Pathway to Saving ½ the Fuel



Fuel Consumption



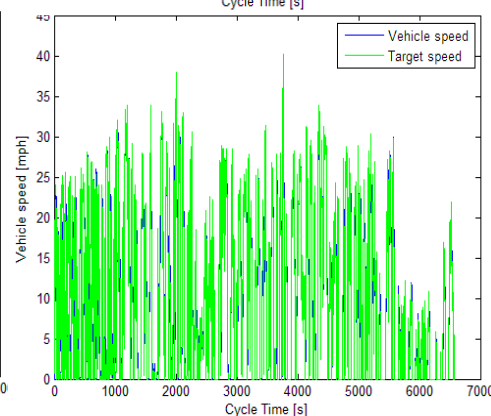
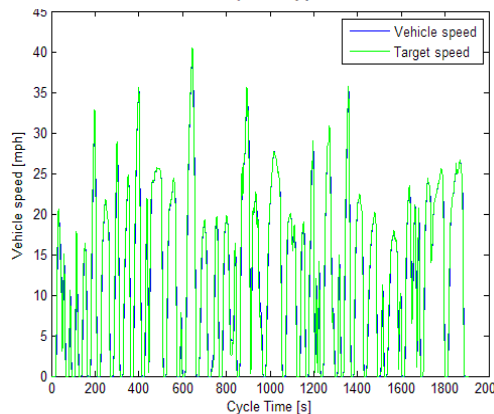
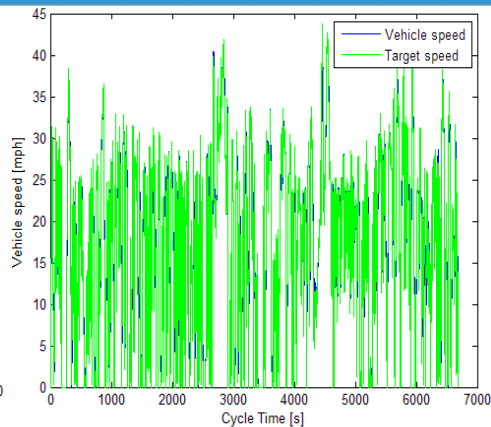
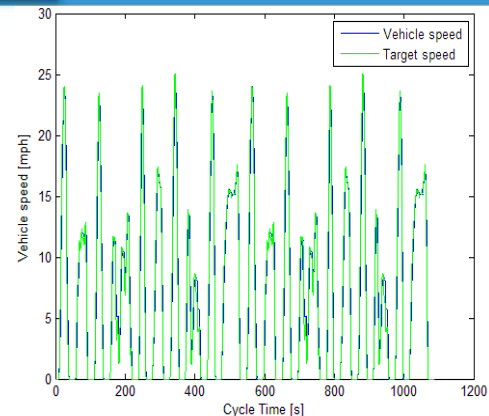
Engine Off Conditions
System Arch / Engine downsize
Accessory Electrification
Off-Duty Charging
Regeneration
Fast Charging Opportunities



Conventional

PHEV

Multiple Duty Cycle Simulation Canvas Painting



Attributes

Working Day: 13 – 20 hours

Route cycles: 11 - 66

Fast charge time: 5 mins

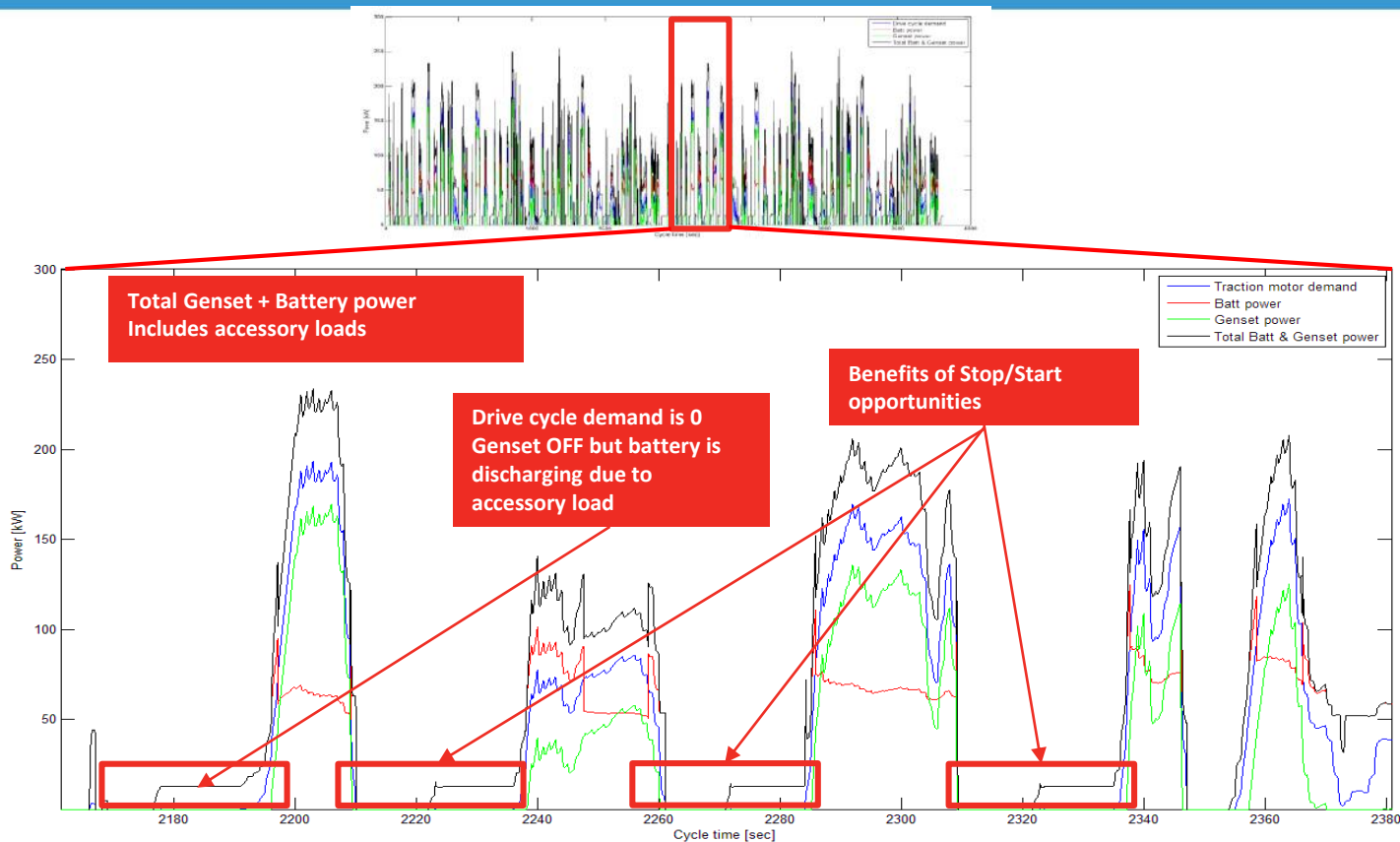
Mileage: 135 – 351 miles

% Idle time: 24% – 60%

Stops: 957 – 1331

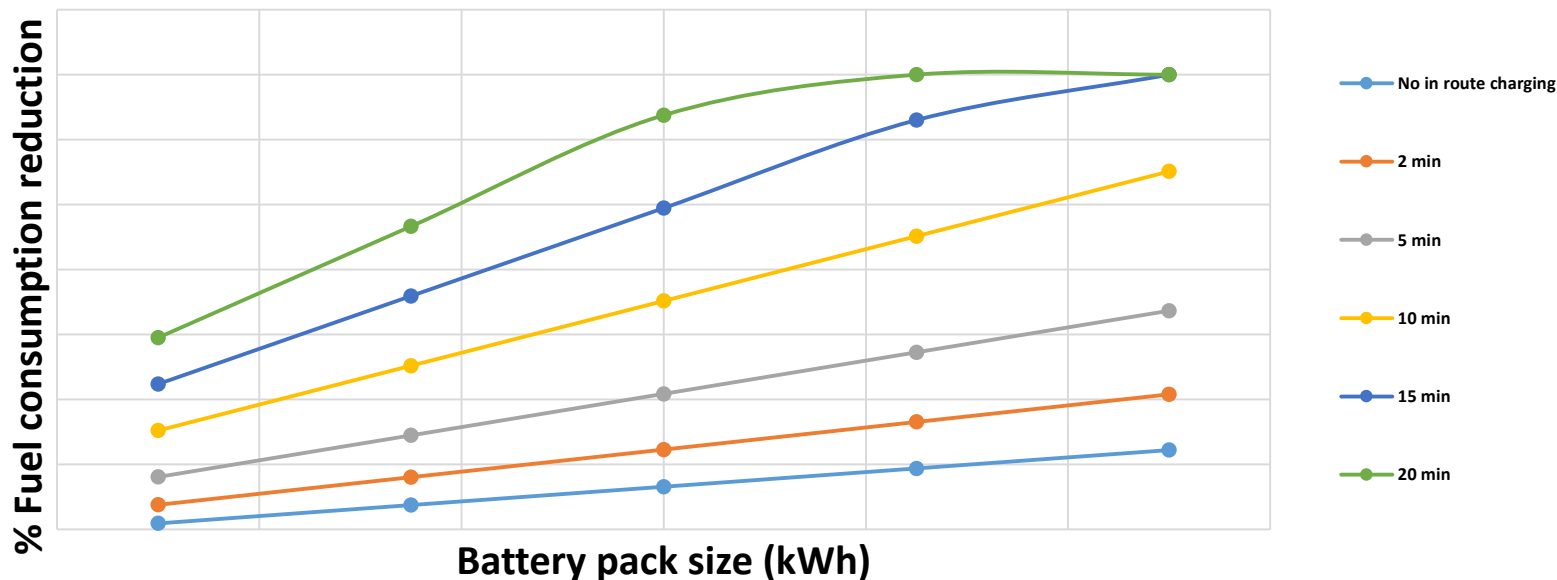
Traction Energy: 580-890 kWhr

The combination of Regen, Grid charging, and Genset power fulfill Driver demand.



Biggest lever will be the in-route charging time

Fuel consumption impact on Battery Size and Charging Time @ 2C every 2 hours



- **PHEV:** Plug-In Hybrid Electric Vehicle
- **Market:** Medium Duty Class 6 Truck
- **Description:** EV powertrain with Genset that extends driving range
- **Key requirement(s):** System drivability, performance, range consistent with conventional
System will **reduce fuel consumption by 50%** over range of duty cycles
- **Team:** Cummins, Argonne, The Ohio State University, PACCAR, NREL
- **Key Deliverable:** 3 year DOE-funded with one year fleet customer test



PACCAR



Kenworth K270



THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

- Quebec is well-positioned in electromobility
- Cummins is well-positioned to take electromobility across our markets
- PHEV will be the transitional robust solution for the Transit Bus market
- The PHEV platform will be extensible to BEV in the transition
- Building the charge infrastructure will be key to further reducing fuel consumption



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