

# PLUG-IN HYBRID ELECTRIC MEDIUM DUTY COMMERCIAL FLEET DEMONSTRATION AND EVALUATION

Principle Investigator: Matt Miyasato

Presenter: Jeff Cox

South Coast Air Quality Management District

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ARRAVT068

# Overview

## Timeline

- Start – November 2009
- Finish – August 2013
- 10% Complete

## Budget

Total project funding

- DOE - \$45,443,325
- Contractor - \$45,612,649

## Barriers

- EV mode implementation
- Component reliability
- Sub-system interfaces
- Engine integration
- Emissions system impacts
- System/vehicle validation and certifications
- Wide distribution of demonstration fleet vehicles
- Quick deployment timeline

## Partners

- SCAQMD
- EPRI
- Eaton
- Altec
- SCE
- A123
- Ford

# Objectives

- Nationwide demonstration and evaluation of 378 medium-duty PHEVs
- Develop a production ready PHEV system for class 4 – 5 vehicles
- Develop production ready “smart charging” capability for the vehicle
- Build customer familiarity
- Quantify performance attributes and environmental impact
- Use project results for system development to optimize performance and reduce costs

# Approach – F550 Utility Truck

- Vehicle Design
  - Eaton Hybrid 6 speed Automatic-Manual Transmission
  - Ford 6.7L Diesel Engine
  - High Energy Lithium-Ion Battery (13 to 15 kWh)
  - Blended Regenerative Braking
  - Engine Off at Zero Speed
  - On-board Charger (>3.3 kW)
  - Charging-Level 1 (120 Vac) and Level 2 (240 Vac)
  - Electrified Accessories (Steering, Brakes, and HVAC)
  - Export Power (5 kW, 120 Vac, 60 Hz)
- Performance Specifications:
  - ePTO operation (>5 Hours with Engine-Off)
  - Up to 10 miles pure electric range (30 mph average)
  - Up to 300 miles range between refills
  - Charge time less than 6 hours with Level 2
  - FMVSS compliant



# Approach – E450 Shuttle Bus

- Vehicle Design:

- Azure Hybrid System
- Ford 5.4L Gasoline Engine
- High Energy Lithium-Ion Battery (13 to 15 kWh)
- Blended Regenerative Braking
- Engine Off at Zero Speed
- On-board Charger (3.3 kW)
- Charging-Level 1 (120 Vac) and Level 2 (240 Vac)
- Electrified Accessories (Steering, Brakes, and HVAC)



- Performance Specifications:

- Up to 10 miles pure electric range (~25 mph average)
- Up to 300 miles range between refills
- Charge time less than 6 hours with Level 2
- FMVSS compliant

# Technical Accomplishments

- **Specifications**

- Specification Project Scope –90% complete
- Vehicle Specification –95% complete
- System Specification –90% complete
- Vehicle weight distribution –complete
- Charging sequence strategy –50% complete
- SAE J1772 interface investigation

- **Ford**

- Ford is fully engaged and supportive
- 2 Engineering vehicles were delivered to Eaton (model year 2011 uses a new 6.7L diesel engine)
- Working with Ford on logistics, safety and validation
- First 20 units scheduled at Ford

# Technical Accomplishments

- **Component Development**
  - Component Development Supplier Selection -75% complete
  - Eaton received first battery and motor
  - Body design / PHEV space claim complete
  - Clutch Development -kicked off
  - Flywheel and flywheel housing development -kicked off
  - Motor FEAs complete to investigate transmission housing stress
- **System feasibility study**
  - Structural analysis complete
  - Base vehicle performance testing -complete (MY 2011 vehicle testing)
  - Packaging analysis -complete
  - MP2 vehicle received -will be sent to Altec for upfitting
  - Ran tests on redundant approach for e-accessories

# Collaborations/Partnerships

- SCAQMD – Prime Recipient
- California Energy Commission – Funding Partner
- EPRI – Program Management and Fleet Coordinator
- Eaton – Hybrid System Developer
- Altec – Body Builder & PHEV Integrator
- So Cal Edison – Battery and Vehicle Testing
- A123 Systems – Battery Supplier
- Ford – Chassis Supplier & Integration Support



# Future Work

- Fiscal Year 2010
  - Finalize the specification for the base vehicle with the individual fleet operators
  - Complete clutch and flywheel design
  - Initiate system validation testing
  - Initiate the build of the base vehicles ahead of the delivery of the hybrid drive system
- After 2010
  - Complete system validation testing
  - Install 240V vehicle charging infrastructure
  - Install plug-in hybrid drive systems on the base vehicles
  - Install cellular based data acquisition systems and set-up download servers to acquire in-use performance data
  - Deliver 378 PHEV to fleet operators
  - Evaluate and analyze the vehicle operation in the field
  - Conduct laboratory emissions and fuel economy tests
  - Conduct battery cycle life testing
  - Conduct user surveys

# Project Summary

- The project will:
  - Quantify the attributes of a medium-duty PHEV for shuttle bus and utility truck vocations in terms of:
    - Criteria pollutant emissions
    - Greenhouse gas reductions
    - Fossil fuel displacement
  - Further optimize the efficiency of the system based on data that is collected in the field
  - Create a path to commercialization for a medium-duty PHEV system
- The design specifications are nearly complete to enable an EV capable medium-duty PHEV that can operate accessories electrically at a job site and drive electrically.
- Fleet participants have been engaged to enable a nationwide demonstration program of 378 vehicles
- Major component suppliers have been selected for:
  - Traction motor
  - Traction battery
  - Flywheel and clutch
  - Electric power steering/ brake pump
  - Electric AC compressor