

**DOCKET**

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**NAVISTAR<sup>®</sup>**

# Electric Drive Vehicles

## California Energy Commission 2010-11 Investment Plan

September 9<sup>th</sup> 2009

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*DEFENSE*



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INTERNATIONAL DIESEL POWER™

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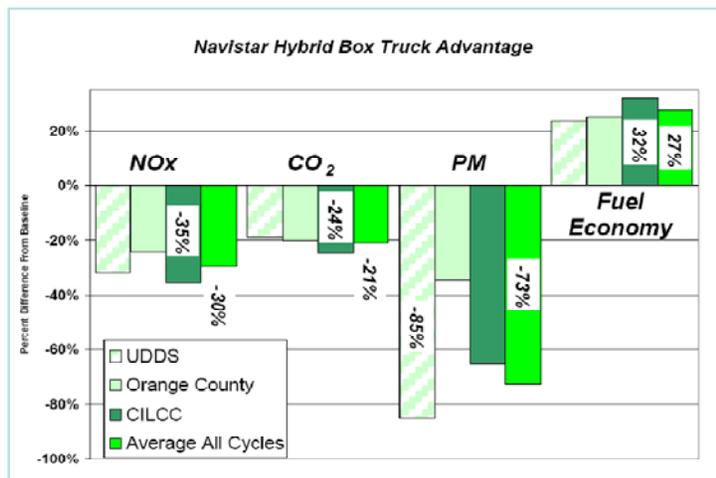
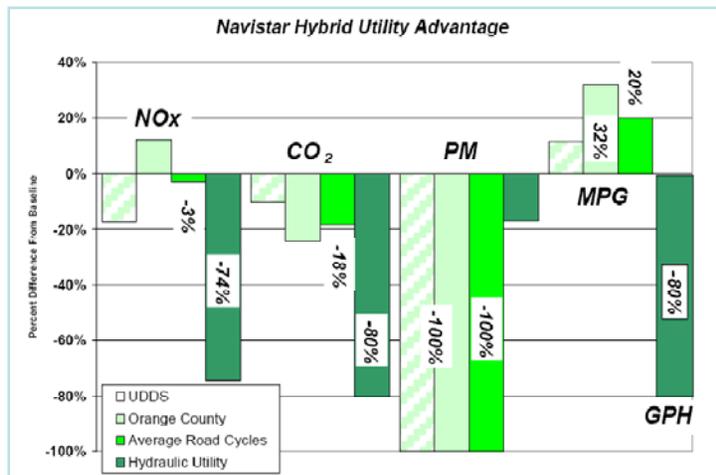
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# Hybrid Electric Trucks

CARB Certified

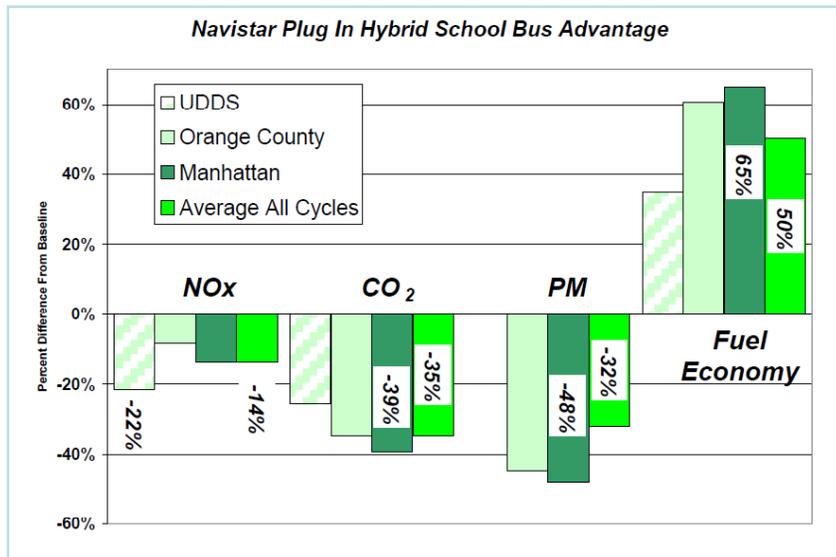


- DuraStar and WorkStar manufactured in Ohio and Texas
- Hybrid System supplied by Eaton, MI
- Manufacturing capacity limited by hybrid system availability from Eaton
- Future plans include
  - Higher GVWR (tandems) applications
  - Electrification of reefers and other body equipment / Export Power
  - Engine Accessory Electrification / HVAC
- Number of hybrid vehicles in California >50
  - Krystal Koach shuttle bus
- No known safety issues
- HEV incremental vehicle costs from \$40k to \$55k
- PHEV plans on hold - incremental cost over HEV likely to be \$15k to \$20k



# Hybrid Electric Buses

CARB Certified



- Two hybrid systems available
  - Charge Depleting (PHEV)
  - Charge Sustaining
- School Bus manufactured in Arkansas
- Hybrid System supplied by Enova Systems, California
- Manufacturing capacity limited by hybrid system availability from Enova
- Number of hybrid vehicles in California – 1 with 1 on order
- No known safety issues
- Incremental vehicle costs from \$45k to \$90k
- Future PHEV 2 plans on hold



# Potential Projects for Collaboration

- Plug-in Hybrid Electric School Bus Generation 3 – (*PHEV 3*)



- SuperTruck



- Workhorse Electric Vehicle



- Thermo-Electric Generators

- Other opportunities (Micro Turbine / Smart Horizon / Intelligent Routing)

# PHEV 3 School Bus – DoE Award

## Program Objectives;

- 30 miles of Engine-Off capability from one charge\*
- 0-45 mph electric mode speed
- Evaluate 4x hybrid architectures (2x parallel and 2x series)
- Project Duration - 4 years
  - Phase 1 – Deliver 8x prototype PHEV school buses (2x system type)
  - Phase 2 – Prototype evaluation, testing (track & chassis dynamometer) and selection
  - Phase 3 – Deliver 30x PHEV production school buses  
(Customers yet to be identified)
  - Phase 4 – Perform field evaluation of PHEV production school buses
- Project Costs \$20M (\$10M DOE grant award with matching funds)
- Build from existing CE School Bus configuration



\* Measured on UDDS drive cycle

# PHEV 3 School Bus – DoE Award

## Engine Off - Performance Requirements

- Electric Power Steering / HVAC & Heating System
- High-Voltage Generator & Distribution Box
- Operator Control and State-Of-Charge (SOC) Display
- Fast 240V On-board Charger



## Target Customers

- Approaches school bus districts' goal of zero emissions
- Reduces exposure of children to emissions / reduces fuel costs / portrays an green image
- Provides school bus districts the opportunity to obtain future government electrification transportation funding

## Current Status

- Contract agreement due 10 Sept. 2009

# SuperTruck

DOE Funding Opportunity Number: DE-FOA-0000079



## Program Objectives;

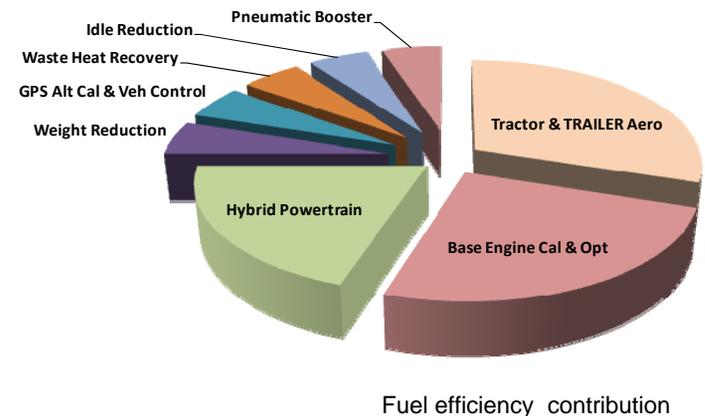
- 50% improvement in overall freight fuel efficiency in ton-miles per gallon
  - 20% is via engine capable of achieving 50% Brake Thermal Efficiency
  - 30% is via tractor & trailer aerodynamic improvements
- One prototype concept ready vehicle  
*(ProStar short sleeper hybrid tractor with matching aero enhanced trailer)*
  - Aerodynamic tractor / trailer drag reduction
  - Vehicle mass reduction
  - Rolling resistance reduction
  - Powertrain hybridization
  - Energy storage / waste heat recovery / brake regeneration
  - Advanced engine fuel and air system hardware & controls
  - FEAD electrification for engine off operation

# SuperTruck

DOE Funding Opportunity Number: DE-FOA-0000079



- Total DOE funds matching program between \$90mil - \$160mil
- Responses expected between \$40mil & \$80mil with cost sharing
- Project duration – 5 years
- Navistar proposal submitted to DoE on 6 Sept. 2009
- Technology deployment to maximize fuel efficiency
- Significant Engine Off operation included in proposal
- Navistar team includes widely known suppliers, customers, National Labs and universities
  - Safeway and Swift are key customer partners



# Workhorse Electric Vehicle

## Program Objective

- Develop and build 400 'all electric' Class 3 (12,000lbs GVW) commercial delivery vehicle
- 100miles on a single, eight-hour charge and 50mph top speed
- Approx. 150 vehicles already in service in Eu

## Project Status

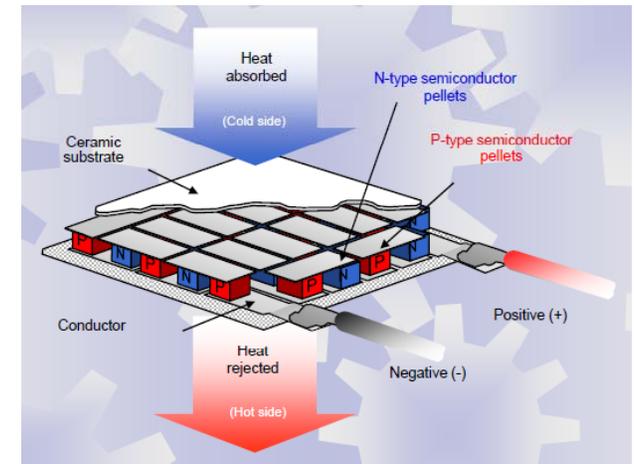
- Successful recipient of \$39mil award from DoE under Transportation Electrification Funding Opportunity DE-FOA-0000028
- Successful recipient of CEC funding award
- Navistar team currently working through DoE and CEC final documentation requirements
- Sacramento selected for initial vehicle demonstration



# Thermo-Electric Generators

## Program Objectives

- Utilize solid-state Thermo-Electric Devices to harvest 6-8kW of waste heat energy from Class 8 truck
- Return recovered energy back to driveline via hybrid powertrain system or to energy storage for later use
- Anticipate ~2.0% fuel economy improvements for 6kW heat recovery\*
- Initial applications focused on passenger car with low energy recovery
- Joint development project with BSST, California
- Build on previously DoE funded development activities
- Proposed project costs - \$3mil



\* Under average Class 8 Tractor operating conditions

# Thermo-Electric Generators

## Program Objectives

- Evaluate heat recovery locations in heavy truck powertrains for application of TE waste heat conversion to electricity
- Develop system architectures and system / subsystem requirements
- Selection architecture and finalization of TEG system requirements.
- Challenge material science to increase energy recovery capability
- Detailed modeling, design, build and test TEG system including, power conditioning electronics, exhaust gas heat exchangers and hybrid system interface.
- Installation and test TEG system in Class 8 truck



Cross Sectional View of Preproduction BSST Waste Heat Recovery TEG

# Summary

- Navistar is an industry leading manufacturer of fuel efficient commercial hybrid electric vehicles and remains the only CARB certified commercial hybrid truck and bus manufacturer
- Navistar continues to set the standard for the development of low emission fuel efficient technologies
- CEC / CARB objective to reduce emissions and improve fuel efficiency compliment those of Navistar
- Navistar would welcome CEC / ARB project participation