

U.S. Department of Energy Vehicle Technologies Program Overview

Annual Merit Review and Peer Evaluation Meeting

Patrick B. Davis
Program Manager

June 7-11, 2010

Vehicle Technologies Program Goals

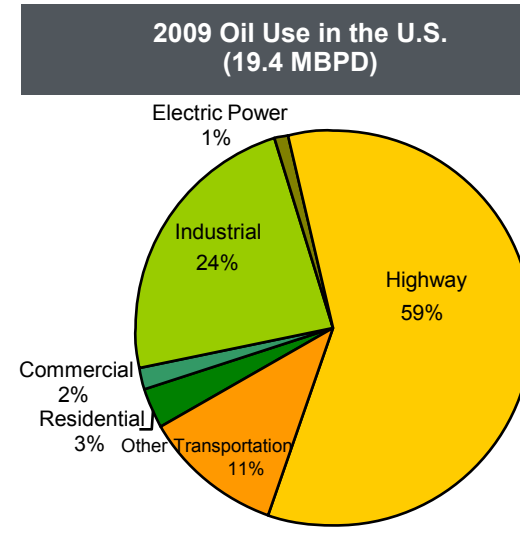
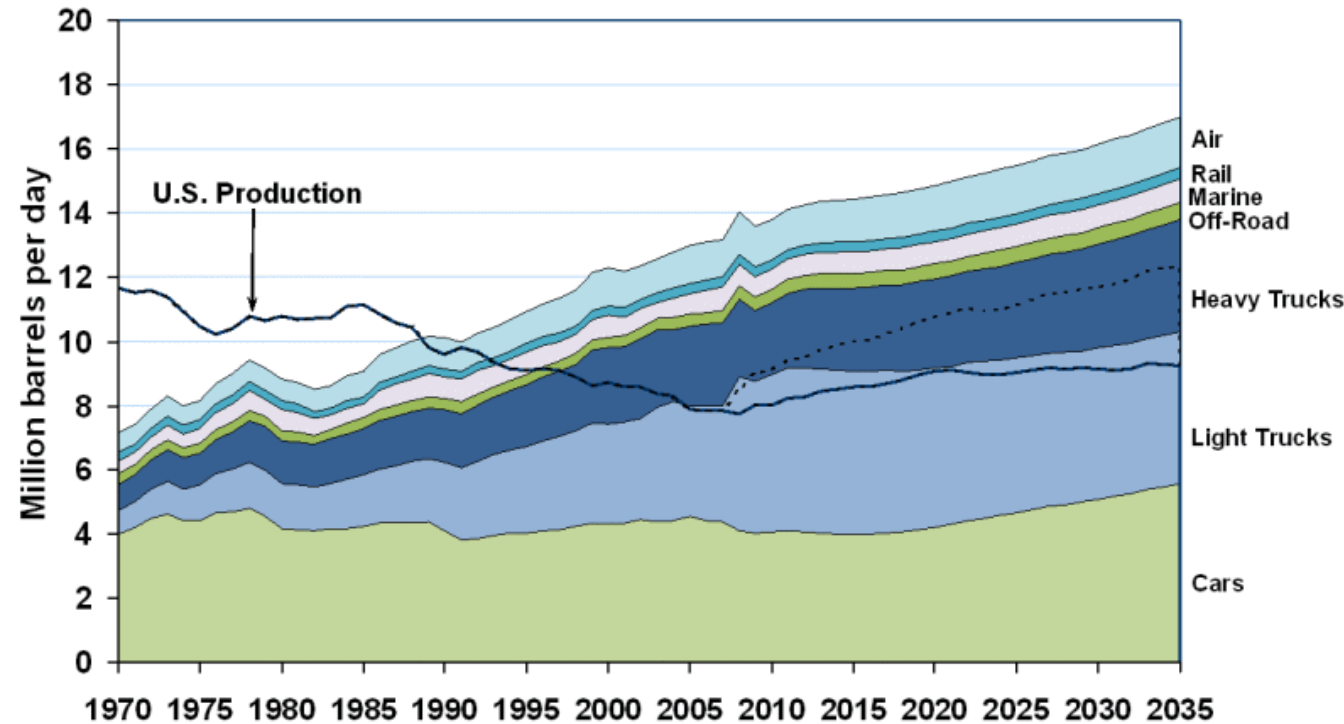
Decrease petroleum dependency

Reduce greenhouse gases

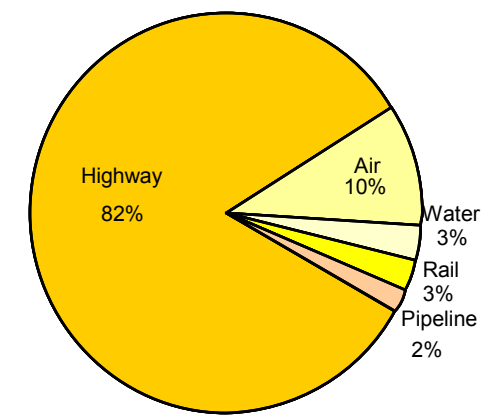
- Develop more energy efficient and environmentally friendly highway transportation technologies that enable America to use less petroleum
- Develop technologies that provide Americans with greater freedom of mobility and energy security, with lower costs and lower impacts on the environment



U.S. Petroleum Production and Consumption, 1970-2035



2007 Trans. CO2 Emissions 32% of Total U.S.



U.S. Vehicle Market

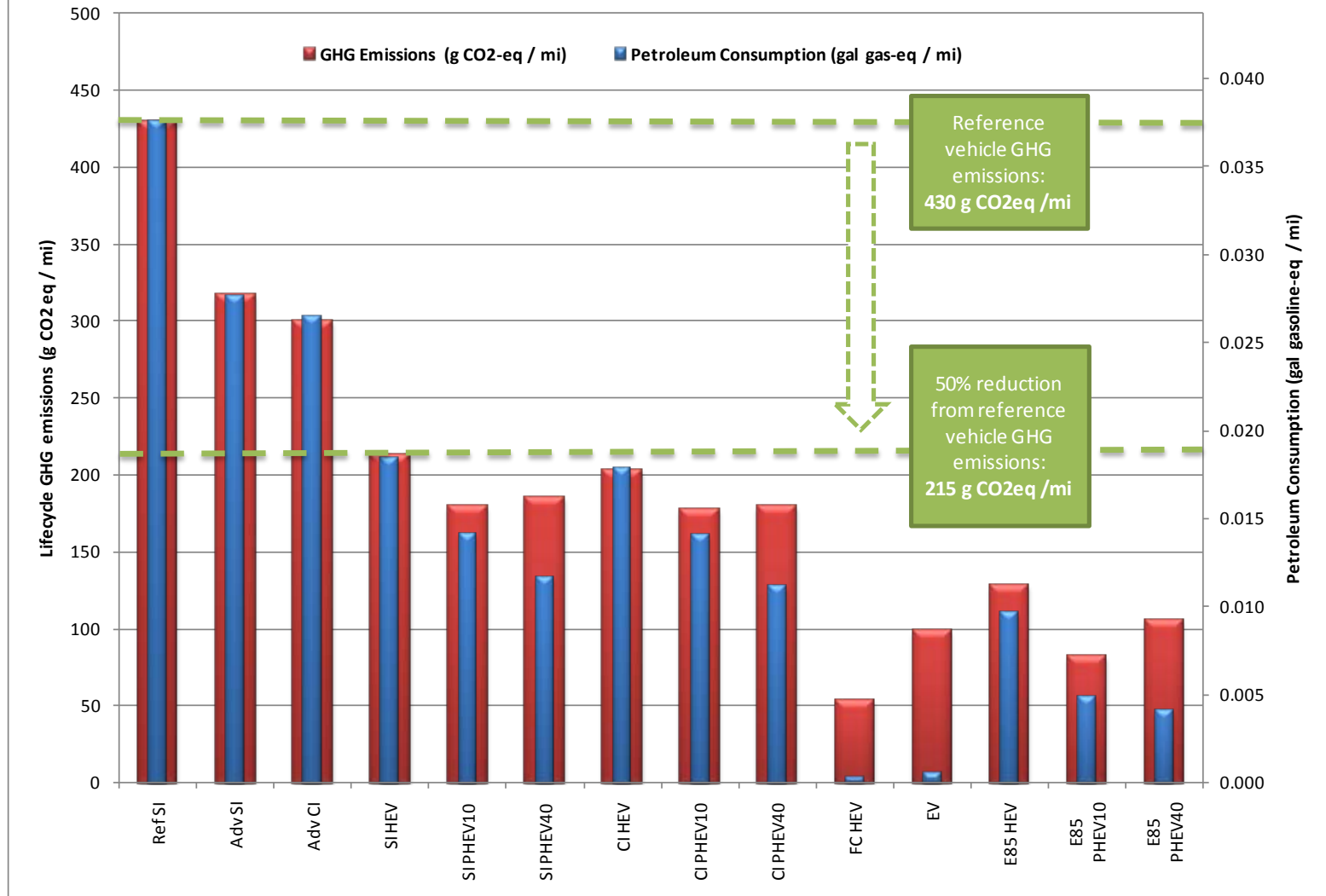
- 240 Million vehicles on the road
- Approximately 9M new cars & light trucks for 2009; average is 15.7 M/yr 2002-2007
- Hybrid vehicles now ~3% of sales
- 13 Million cars and light trucks taken out of use per year
- 11.5 Million barrels of oil per day consumed by on-road

• Vehicle GHG emissions fall into 3 major groups:

- Conventional
- Electric-drive
- Combination electric-drive & biofuel

• Petroleum consumption loosely mirrors GHG emissions

GHG Emissions and Petroleum Consumption by Vehicle Technology



Activity	FY 2009 Approp	FY 2010 Approp ¹	FY 2011 Request ¹
Batteries and Electric Drive Technology	101,572	101,405	120,637
Vehicle and System Simulations & Testing	21,126	44,328	44,328
Advanced Combustion Engine R&D	39,657	57,600	57,600
Materials Technology	38,786	50,723	50,723
Fuels Technology	19,560	24,095	11,000
Outreach, Deployment & Analysis	46,422	33,214	41,014
TOTAL	267,123	311,365	325,302

¹Includes SBIR/STTR Funding -- \$ in thousands

Other FY 2010 DOE-Related Vehicle Activities

- Section 136 Loan Program \$25.0 B
- American Recovery and Reinvestment Act \$2.8 B
- Office of Science, Advanced Research Projects Agency – Energy (ARPA-E), Office of Electricity

Advanced Technologies for High Efficiency Clean Vehicles

Hybrid Electric Systems

- Advanced Batteries
- Power Electronics/Inverters/Controllers & Motors
- Systems Analysis and Testing
- Aerodynamics, Rolling Resistance & Accessory Loads
- Validation



Tech Introduction

- EPA Act/EISA
- Rulemaking
- Deployment
- Student Competitions
- Graduate Automotive Technology Education
- Education
- Safety, Codes, & Standards

Advanced Combustion Engine R&D

- Low Temp. Combustion R&D
- Emission Controls
- Light- & Heavy-Duty Engines
- Solid State Energy Conversion
- Health Impacts

Fuels Technology

- Bio-Based Fuels
- Clean/Efficient Combustion Fuel Characteristics
- Fischer-Tropsch Fuels & Blendstocks
- Advanced Lubricants

Materials Technology

- Lightweight Structures
- Composite Development
- Processing/Recycling/Manufacturing
- Design Data Test Methods
- High Temperature Materials Laboratory

Hybrid-Electric Systems




Petroleum Displacement via Fuel Substitution & Improved Efficiency



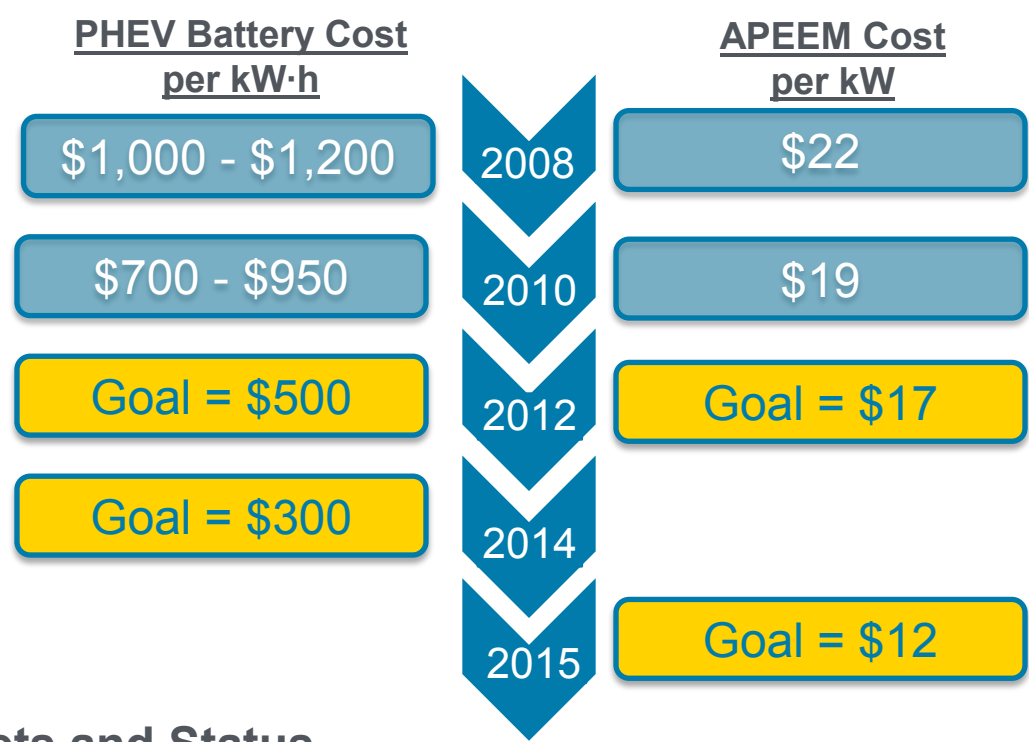
Energy Efficiency & Renewable Energy

Administration Goal: 1 Million PHEVs by 2015

Types of Vehicles and Benefits

HEV	→		Toyota Prius 50 MPG
PHEV	→		Chevy Volt 100 MPGe
EV	→		Nissan Leaf All Electric

System Cost



Targets and Status

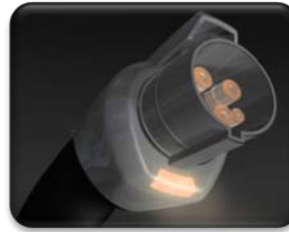
2014 PHEV: Battery that has 40-mile all-electric range and costs \$3,400

2015 PEEM: Cost for electric traction system no greater than \$12/kW peak by 2015

Status: \$8,000-\$11,000 for PHEV 40-mile range battery

Status: Current cost of electric traction system is \$40/kW

Demonstrate market readiness of grid-connected vehicles, create market demand for EVs



Targets and Status

2012 Goal: 62 Million miles of on-road HEV/PHEV/BEV testing. Finalized standards for grid-connected vehicle energy consumption measurement, communication, and safety practices.

2014 Goal: 107 Million miles of on-road HEV/PHEV/BEV testing.

2015 Goal: Accumulate 112 Million miles of on-road HEV/PHEV/BEV testing

Status: Completed total of 15 Million miles of on-road operational performance and cost data on more than 1,600 electric drive vehicles

Accomplishments

- Collected operational performance and cost data on 292 electric drive vehicles over 1.6 Million miles in 2009
- Collected operational performance and cost data on 238 electric drive vehicles over 775,000 miles in 2010
- Modeling and Simulation: Completed initial development of future industry standard modeling tool (Autonomie) in cooperation with General Motors
- Codes and Standards: Completed HEV/PHEV testing standards work and Level 2 charging connector standards in partnership with industry

Increasing engine efficiency is one of the most cost-effective approaches to increasing fuel economy

Benefits all Vehicle Classes, HEV and PHEV

Cars
Power Rating: 100-300hp



Trucks
Power Rating: 200-400hp



Class 2b-8
Power Rating: 250-600hp



Light-Duty

Heavy-Duty

**25-40%
Improvement**

**Up to 30%
Improvement**

**Independent study: Over 50 to 1
ROI in heavy-duty diesel R&D**

Accomplishments

- Demonstrated light and heavy duty engine concepts operating on gasoline with ultra-low NOx, no soot and diesel-like efficiencies (ANL and SNL)
- Developed improved models to simulate combustion and emission control processes
- Demonstrated dual-fuel combustion concept with higher than diesel efficiency and near-zero emissions (U of Wisconsin and ORNL)
- Demonstrated 10% improvement in fuel economy with advanced combustion operation (GM)
- Developed Thermoelectric waste energy recovery system for Ford Fusion and BMW X-6 (BSST)

Targets and Status

2015 Passenger Vehicle: Improve gasoline vehicle fuel economy by 25%, diesel vehicle fuel economy by 40%, compared to 2009 baseline

2015 Commercial Engine: Improve commercial engine efficiency by >20% compared to 2009 baseline, 30% by 2018

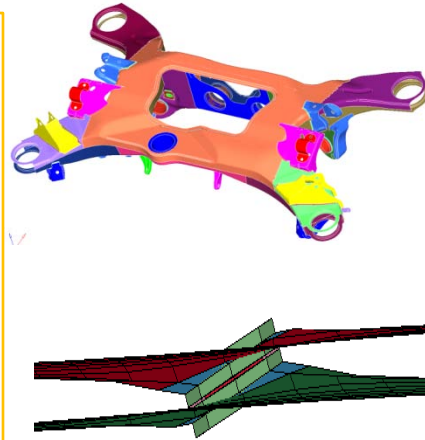
Status: Current fleet average fuel economy of 29.2 mpg; six ATP-LD cooperative awards made to demonstrate goals by 2015

Status: Current commercial engine brake thermal efficiency up to 42%; three SuperTruck awards made to demonstrate 50% BTE in Class 8 trucks by 2015

A 10% reduction in vehicle weight results in a 6-8% improvement in fuel economy

Weight Reduction Demonstrations

- Completed Mg front-end design with 45% weight reduction compared to conventional steel design
- Developed cost-neutral, advanced high strength steel chassis component with 28% weight reduction compared to standard component (pictured)
- Will put metrics in place to measure progress towards 50% weight reduction



Key Technology Advancements

- Demonstrated warm forming of Mg sheet in prototype manufacturing cell at rates compatible with automotive manufacturing
- Released Spot Weld Element model that can be used to predict crash performance of welded light weight assemblies (pictured)

Targets and Status

2010 Target: 50% cost-effective weight reduction of the passenger vehicle body and chassis systems compared to 2002 vehicles.

2015 Target: Commercial introduction of thermoelectric coolers/heaters to replace vehicle A/C systems

2009 Status: Modeling shows that weight reduction of 40% is achievable, *but not at cost parity*

2009 Status: 5% improvement in fuel economy through thermoelectrics that convert engine waste heat directly to electricity

* Hypothetical Distribution

Renewable Fuels Standard 2: 36 Billion gallons per year by 2022

Accomplishments

- Developed and implemented DOE Intermediate Ethanol Blends Test Program – Full Useful Life Emissions System Durability study to be completed this year
- Critical research led to improved biodiesel ASTM standards



Future Directions

- Lubricant research – retrofit solution for vehicles in use
- Evaluate next generation biofuels
- Enable advanced combustion through fuel-effects research

Targets and Status

2015 Fuel Target: Expand operational range of low-temperature combustion to 75% of Federal Test Procedure

2015 Lubricant Target: Demonstrate cost effective lubricant with 2% fuel economy improvement

Status: Intermediate Ethanol Blends Test Program scheduled to complete full-useful life testing of 82 vehicles in 2010

Status: Approximately 10.5 Billion gallons of renewable fuels used – primarily ethanol with some biodiesel

Ethanol “Blend Wall” is approximately 11 Billion gallons per year with E10 / E85

EcoCAR: The NeXt Challenge

Student teams just finished their second year of competition in May at the Desert Proving Grounds in Yuma, AZ.



Progressive Automotive X PRIZE:

Inspiring a new generation of super-efficient vehicles that dramatically reduce oil dependence and greenhouse gas emissions.



Green Racing

DOE, EPA and SAE International initiative, adopted by the American Le Mans Series in 2009. Biobutanol, cellulosic ethanol and hybrid powertrains were introduced in the 2009, 2010 seasons.

Improving the speed and scale of market penetration for alternative fuel vehicles and infrastructure

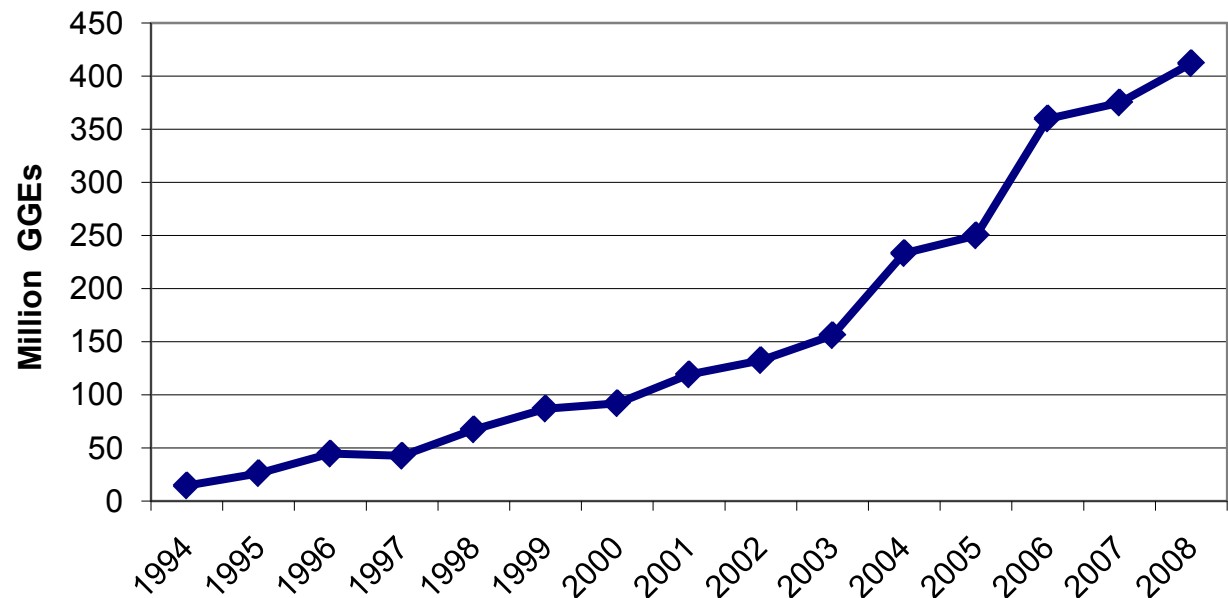
2.4 Billion Gallons of Petroleum Displaced Since 1993



Recovery Act Results

- New Vehicle Distribution: more than 9,000 vehicles, displacing an estimated 38 million gallons of petroleum/year
 - Approximately 5,500 light duty vehicles
 - More than 3,500 medium and heavy duty vehicles
- More than 2,100 new fueling and charging stations

Clean Cities Annual Petroleum Displacement



Worksheet available at www.afdc.energy.gov/afdc/data

Recovery Act :> \$2.8 Billion

More than 98 projects awarded

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

\$1.5 Billion in funding to accelerate the manufacturing and deployment of the next generation of U.S. batteries

\$500 Million in funding for electric-drive components manufacturing

\$400 Million in funding for transportation electrification



Facilities and Equipment Upgrade up to \$105 Million: User Centers, offer expert staff and unique equipment capabilities that no one industrial entity can afford to maintain.



Clean Cities: Petroleum Displacement through Alternative Fuel Vehicles and Expanded Alternative Fuel Infrastructure

SuperTruck and Advanced Combustion R&D
\$104.4 Million Solicitation:

Heavy-duty trucks are emphasized because they rapidly adopt new technologies and account for 20% of the fuel consumed in the United States.



Energy Storage Recovery Act Funding

\$1.5 Billion for Advanced Battery Manufacturing for Electric Drive Vehicles “Commercial Ready Technologies”

Awards

- 9 Battery Pack or Cell Manufacturing Awards
- 10 Material Production Awards
- 1 Recycling Award

Timeline

- **December 2011** – Battery Manufacturing Capacity of 50,000 PHEV Batteries (10 Kilowatt-hours)
- **2015** – Battery Manufacturing Capacity of 500,000 PHEV Batteries (10 Kilowatt-hours)



Demonstrate a 50% improvement in freight efficiency by 2015, allowing market introduction this decade

Trailer skirts

Gap reduction

Tractor/trailer integration (major redesign)

AERODYNAMICS

Highway 21%
Urban 5%

Combustion improvements
Turbocompounding
Waste heat recovery

ENGINE

Highway 59%
Urban 58%

AUXILIARIES

Highway 2%
Urban 7%

Electric accessories

ROLLING RESISTANCE

Highway 16%
Urban 9%

INERTIA/BRAKING

Highway 0%
Urban 16%

DRIVETRAIN

Highway 2%
Urban 5%

New generation wide base single tires

Tire rubber compound

Central tire inflation

Hybridization

Reduced drivetrain friction

Automated manual transmissions

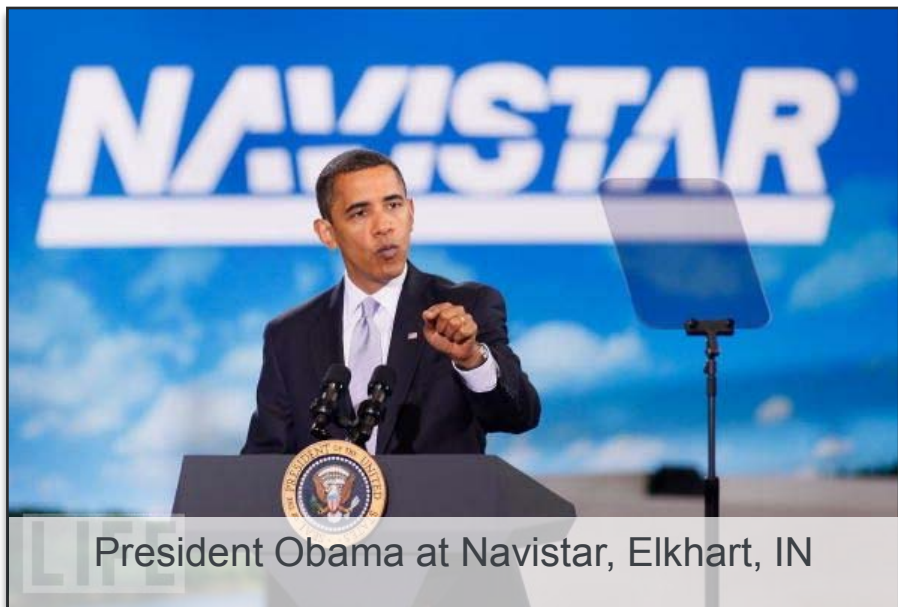
Approach Emphasis:

- Cummins/Peterbilt: Engine Efficiency
- Daimler: Hybridization
- Navistar: Aerodynamics

Heavy-duty trucks use 20% of the fuel consumed in the United States.

Fuel economy improvements in these trucks directly and quickly reduces petroleum consumption.

Recovery Act Events



Recovery Act Events, continued

Saft America Lithium-ion battery plant in FL



Assistant Secretary Cathy Zoi at
SBE, Inc., Barre, VT



Governor Granholm at Toda,
Battle Creek, MI



Secretary Steven Chu marks the production
of the first Chevy Volt battery off the line

Contact Information

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy

www.vehicles.energy.gov



Patrick Davis, Program Manager

202-586-8061

patrick.davis@ee.doe.gov