U.S. Department of Energy
Vehicle Technologies Program Overview

Annual Merit Review and Peer Evaluation Meeting

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Program Manager

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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. 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 vehicles

2009 Oil Use in the U.S.
(19.4 MBPD)

2007 Trans. CO2 Emissions
32% of Total U.S.
Analysis Informs Strategy

- 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**

- Reference vehicle GHG emissions: 430 g CO2eq /mi
- 50% reduction from reference vehicle GHG emissions: 215 g CO2eq /mi
<table>
<thead>
<tr>
<th>Activity</th>
<th>FY 2009 Approp</th>
<th>FY 2010 Approp$</th>
<th>FY 2011 Request$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batteries and Electric Drive Technology</td>
<td>101,572</td>
<td>101,405</td>
<td>120,637</td>
</tr>
<tr>
<td>Vehicle and System Simulations &amp; Testing</td>
<td>21,126</td>
<td>44,328</td>
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<tr>
<td>Advanced Combustion Engine R&amp;D</td>
<td>39,657</td>
<td>57,600</td>
<td>57,600</td>
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<tr>
<td>Materials Technology</td>
<td>38,786</td>
<td>50,723</td>
<td>50,723</td>
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<tr>
<td>Fuels Technology</td>
<td>19,560</td>
<td>24,095</td>
<td>11,000</td>
</tr>
<tr>
<td>Outreach, Deployment &amp; Analysis</td>
<td>46,422</td>
<td>33,214</td>
<td>41,014</td>
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<tr>
<td>TOTAL</td>
<td>267,123</td>
<td>311,365</td>
<td>325,302</td>
</tr>
</tbody>
</table>

$Includes 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
### Administration Goal: 1 Million PHEVs by 2015

#### Types of Vehicles and Benefits

<table>
<thead>
<tr>
<th>HEV</th>
<th>Toyota Prius</th>
<th>50 MPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHEV</td>
<td>Chevy Volt</td>
<td>100 MPGe</td>
</tr>
<tr>
<td>EV</td>
<td>Nissan Leaf</td>
<td>All Electric</td>
</tr>
</tbody>
</table>

#### System Cost

<table>
<thead>
<tr>
<th>Year</th>
<th>PHEV Battery Cost per kWh</th>
<th>APEEM Cost per kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>$1,000 - $1,200</td>
<td>$22</td>
</tr>
<tr>
<td>2010</td>
<td>$700 - $950</td>
<td>$19</td>
</tr>
<tr>
<td>2012</td>
<td>Goal = $500</td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>Goal = $300</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>Goal = $12</td>
<td></td>
</tr>
</tbody>
</table>

#### Targets and Status

- **2014 PHEV**: Battery that has 40-mile all-electric range and costs $3,400
- **Status**: $8,000-$11,000 for PHEV 40-mile range battery

- **2015 PEEM**: Cost for electric traction system no greater than $12/kW peak by 2015
- **Status**: Current cost of electric traction system is $40/kW
Demonstrate market readiness of grid-connected vehicles, create market demand for EVs

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

**Light-Duty**
- **Cars**
  - Power Rating: 100-300hp
  - 25-40% Improvement
- **Trucks**
  - Power Rating: 200-400hp
  - 25-40% Improvement

**Heavy-Duty**
- **Class 2b-8**
  - Power Rating: 250-600hp
  - 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
- 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 lightweight 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
Fuels & Lubricants

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

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

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

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

Targets and Status

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

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

$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.

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.

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

Combustion improvements
- Turbocompounding
- Waste heat recovery

AERODYNAMICS
- Highway 21%
- Urban 5%

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

President Obama at Navistar, Elkhart, IN

Vice President Biden and MI Governor Granholm at Next Energy in Detroit, MI

Vice President Biden at UQM in Frederick, CO

President Obama at Celgard plant, Charlotte, NC
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

www.vehicles.energy.gov

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