

U.S. Department of Energy Vehicle Technologies Program Overview

Annual Merit Review and Peer Evaluation Meeting
May 2012

Patrick B. Davis
Program Manager



Oil Dependency is Dominated by On-Road Vehicles

- Transportation is responsible for 2/3 of U.S. petroleum usage
- On-Road vehicles responsible for 80% of transportation petroleum usage
- >240M Vehicles on the road

World Oil Production

2005: 84.58 mbpd
2006: 84.54 mbpd
2007: 84.40 mbpd
2008: 85.37 mbpd
2009: 84.24 mbpd
2010: 87.30 mbpd
2011: 88.40 mbpd

- Economic security, energy security, and environmental stewardship
- Changing energy landscape
 - Natural gas
 - Electrification
 - Fuel Economy Standards

The Cost of Oil is Not Just Monetary



Vehicle Technologies Budget

Activities	FY 2011	FY 2012	FY 2013*
Batteries & Elec. Drive Technology	\$103,163	\$117,740	\$203,594
Vehicle Systems Sim. & Testing	\$42,647	\$47,198	\$56,218
Adv. Combustion Engine R&D	\$55,987	\$58,027	\$55,261
Materials Technology	\$47,748	\$40,830	\$48,475
Fuels Technology	\$10,692	\$17,904	\$11,634
Outreach, Deployment and Analysis	\$32,914	\$39,266	\$33,945
Total	\$293,151	\$320,965	\$409,127

*Old structure, Does not include SBIR/STTR

FY 2012 Budget Highlights

- Lower cost battery and electric drive component
- Vehicle electrification deployment
- Higher efficiency combustion engines and alternative fuels utilization
- Vehicle lightweighting

FY 2013 Budget Highlights

EV Everywhere Grand Challenge:

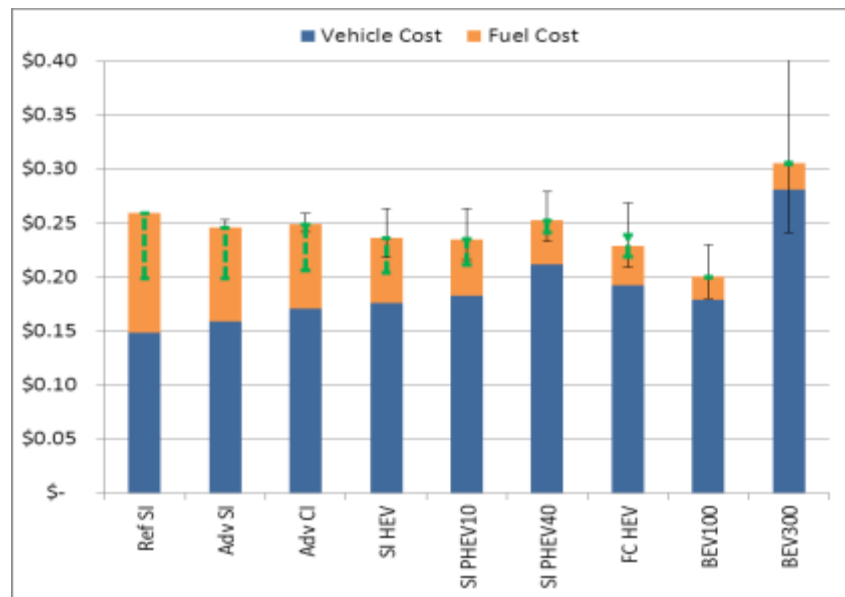
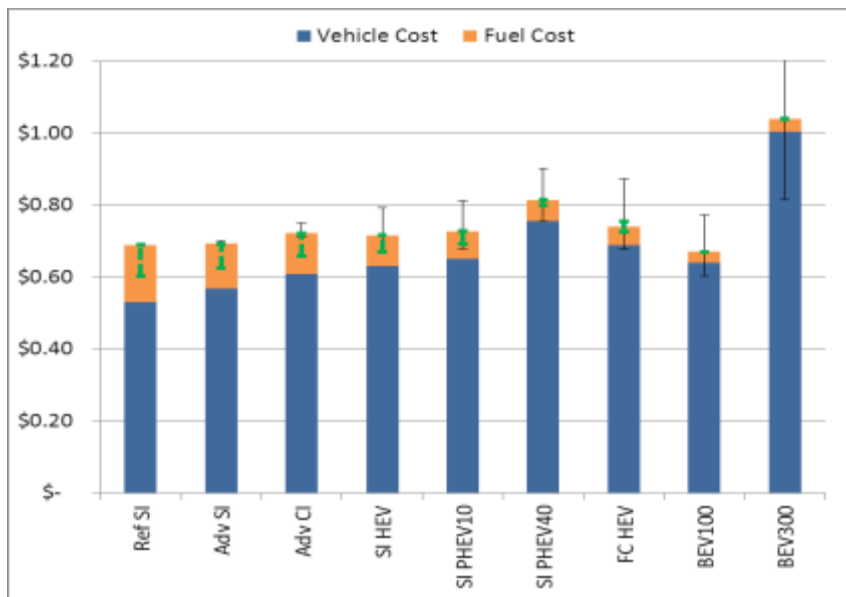
- Accelerate R&D of advanced battery design and manufacturing
- High performance/low cost power electronics
- Improved elec. motor technologies with reduced or no rare earth materials
- Advanced charging and high efficiency HVAC technologies
- Multi-material lightweight vehicle solutions

- VTP's levelized-cost analytical framework informs U.S. DRIVE target-setting
- Cradle-to-Grave efforts evaluate lifecycle energy and emissions
- Consumer choice scenario analysis (three versions) offer insights into consumer behavior
- Publications spread VTP information (Transportation Energy Data Book, Market Report, Fact of the Week)

GPRA 14 Preliminary Estimates*

Consumer Perspective (3-year Payback Analysis)

Societal Perspective (15-year Lifecycle Analysis)



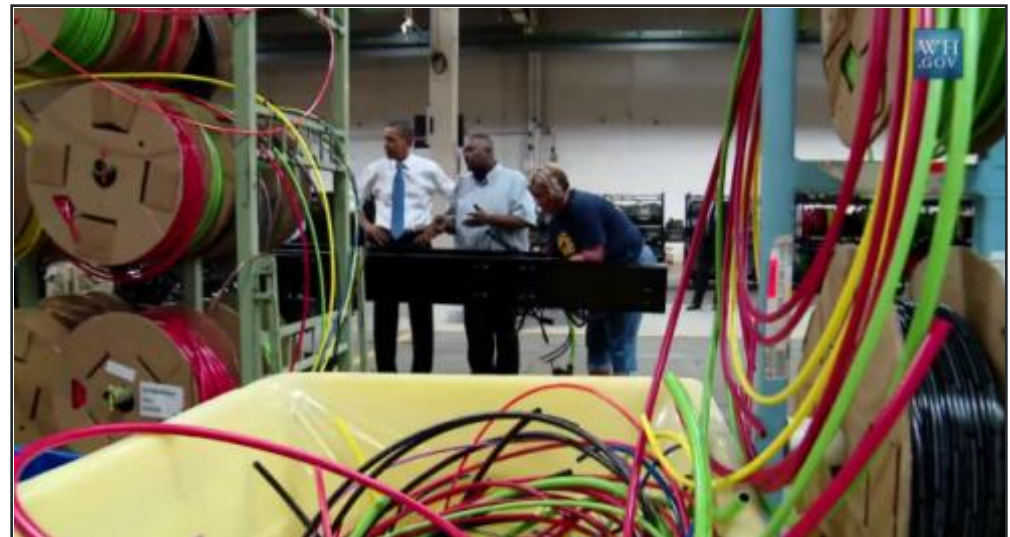
*Example results based on a full suite of assumptions, see analysis presentations

EV Everywhere Grand Challenge

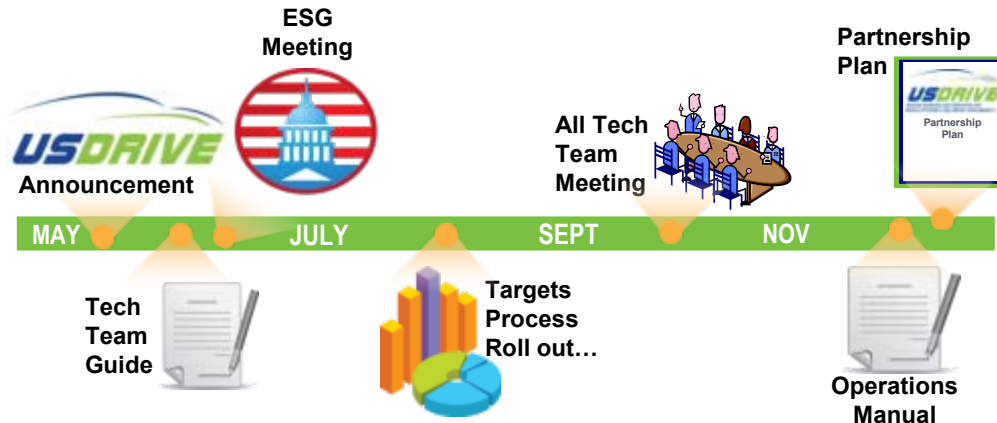
A DOE Clean Energy Grand Challenge with the goal of enabling U.S. companies to produce electric vehicles that are as affordable and convenient for the average American family as today's gas-powered vehicles within the next 10 years (by 2022).

- Midsize sedan, majority of miles driven on electricity,
- < 5 year payback
- Sufficient range and fast charge capability for widespread adoption

- EV-Everywhere Framing Document is under development.
- Stakeholder workshops will be conducted this summer
- Roll Out of Initiative details expected in September 2012



2011: A Busy Year



Current priorities:

- **Complete research targets update** – new analysis-based process provides consistency across teams and vehicle-level view, focus on cost-competitive technologies in 2020 timeframe
- **Update tech team roadmaps**
- **Integrate new associate members**

National Research Council review

The USDRIVE logo is at the top, with the tagline 'DRIVING RESEARCH AND INNOVATION FOR VEHICLE EFFICIENCY AND ENERGY SUSTAINABILITY'. Below it, a section titled 'Partners:' lists various organizations. A central box contains logos for USCAR (United States Council for Automotive Research LLC), Chrysler, Ford, and GM. To the right are logos for BP, Chevron, DTE Energy, ExxonMobil, Edison, and Phillips 66. Below these are logos for Tesla, Shell, and EPRI (Electric Power Research Institute). At the bottom, a dashed box contains the text 'Associate Members at the Technical Level'.

SuperTruck Project Near Halfway Point

Status of 50% engine efficiency:

- Cummins has demonstrated 49%
- Daimler has demonstrated 46%
- Navistar has identified technologies and conducted component test
- Volvo is down selecting technologies

Status of 50% freight efficiency improvement:

- Cummins has built a demonstration tractor, completed aerodynamic design and exceeded interim milestone goal
- Daimler demonstrated 25% vehicle freight efficiency improvement
- Navistar has numerous systems developed, second demonstration vehicle planned for 3Q 2012
- Volvo has completed the baseline and concept vehicle model and finished component level concept selections



SuperTruck Concept

Goals:

- **Demonstrate 50% engine efficiency at 65 mph and a pathway to 55%.**
- **Increase overall freight efficiency by 50% measured in ton-miles per gal.**

Participants: Cummins, Daimler, Navistar and Volvo

Major Interagency Collaborations

- Department of Defense
 - MOU between DOD and DOE signed 7/22/10
 - Advanced Vehicle Power Technology Alliance (AVPTA) Charter Signed 7/18/11; Quarterly meetings between VTP & TARDEC
 - Initial collaboration in four technical areas: Thermoelectrics, Fuel Testing, Battery Modeling, and Combustion Modeling
- Department of Transportation
 - Monthly meetings between VTP and DOT on vehicle related topics
 - VTP consulted NHTSA on battery safety and will participate in the planned workshop on 5/17/12
 - Connected VTP-supported first responder training activities with NHTSA; participated in development of interim guidance
 - Joint funding to NFPA to develop first responder Guidelines
- Environmental Protection Agency
 - VTP continues to collaborate closely with EPA across the breadth of vehicle technologies and jointly sponsoring www.fueleconomy.gov and Green Racing



VTP is positioned at the center of Federal Government's vehicle R&D efforts

EcoCAR2: Plugging into the Future

Provide a new generation of engineers with knowledge and skills in developing and commercializing advanced automotive technologies.

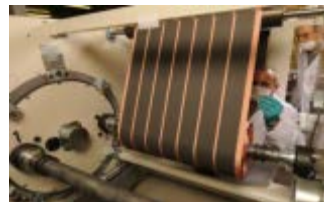
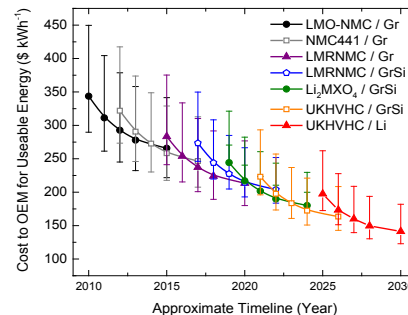
- Challenges students from 15 North American Universities
- 3 year competition following a real-world engineering process (Year 1 – modeling & simulation, Year 2 – subsystem integration, Year 3 – Refinement)
- Joined by Natural Resources Canada, General Motors and over 25 other industry sponsors
- Each team is building its own unique PHEV architecture and renewable fuel such as hydrogen, ethanol or biodiesel



**Year 1 Simulation and Modeling
finals to be held in Los Angeles, CA –
May 18-23, 2012**

Accomplishments

- High Energy Cell Developed (Envia)
 - Scaled-up high capacity cathode material & 20AhEV cells that achieved over 200 Wh/kg.
 - Addition of high capacity silicon-carbon anode w/cell specific energy of >400 Wh/kg (ARPA-E).
- ANL's Lithium-ion Battery Performance and Cost Model (BatPaC) validated.
 - Collaboration of DOE, EPA, DOT
 - Supported CAFE & GHG regs
 - Shows pathway to achieving significant cost reductions
- Established 1.4 Million kWh Battery production Manufacturing capacity



Future Direction

- Emphasize cost reduction, durability, safety, and increased specific energy:
 - Innovative development efforts and manufacturing improvements with potential to reach cost goals.
 - Continue development of high voltage, high capacity cathodes and high voltage electrolytes
 - Develop Silicon Composite & Metal alloy materials and cells
 - Expand focus on beyond-Lithium-ion technology

FY 2015 Goal:

Reduce the cost of a PHEV40 battery to \$300/kWh.

Status:

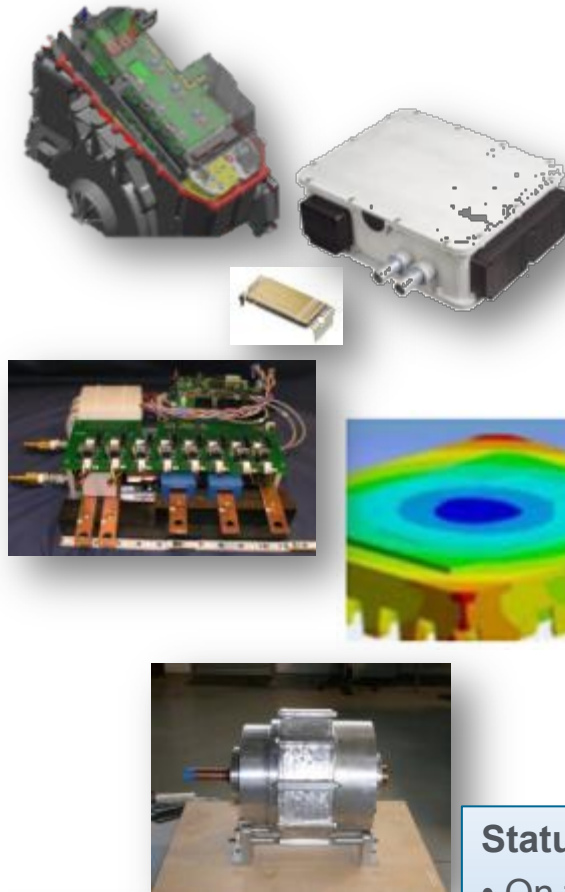
- On track to meet cost target of \$500/kWh in FY12.
- Calendar life up to 10-15 years
- Cycle life between 3,000-5,000 deep discharges

Accomplishments

- Initiated new industry R&D efforts:
 - Motors with reduced/eliminated rare earths (GE and UQM)
 - Scalable, modular inverter (GM)
- Reduced costs:
 - Innovative inverter designs
 - Smaller power module packaging
 - Novel motor designs
 - Enhanced thermal management
- Reduced cost and size while improving reliability:
 - Integrated several functions into one unit (combined inverter, converter, and charger)

FY 2015 Goal:

Reduce cost of technologies for electric traction drive. Demonstrate a cost of \$12/kW through data, simulation, and modeling.



Future Direction

- Emphasize cost reduction of electric traction drive systems:
 - Non-rare earth motors
 - Wide bandgap based designs to increase switching frequency, efficiency, and operating temperature
 - Manufacturability
 - Thermal management
 - Reliability

Status:

- On track to meet cost target of \$17/kW in FY12
- Met cost target of \$18/kW in FY11
- Achieved FY10 traction drive system cost goal - GM traction drive system development

Vehicle & Systems Simulation & Testing

Accomplishments

- Use data on thousands of vehicles and EVSEs:
 - 113,000 PHEV/EV test miles and 4,430 charging events documented each day
 - <http://avt.inel.gov/evproject.shtml>
- Deployed commercialized version of Autonomie vehicle modeling & simulation platform
 - Developed through CRADA between Argonne National Lab and GM
 - Distributed through LMS

FY 2015 Goal:

Demonstrate large-scale market-readiness of grid-connected electric-drive vehicles



Future Direction

- Support electric-drive vehicle (EDV) market transformation:
 - Wireless Charging RD&D
 - Auxiliary load reduction / Advanced HVAC RD&D
 - Expand EDV evaluations through AVTA as market evolves
 - Expand EDV codes & standards support

Status:

- 35.1 million test miles accumulated on nearly 8,000 light-duty vehicles representing 91 different PHEV/EV models
- Autonomie released through commercialization partner in April 2012

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

Accomplishments

- Demonstrated pathway to combustion that could improve passenger vehicle fuel economy by up to 75%. (SNL, UW)
- Demonstrated diesel-like efficiencies and low emissions running on gasoline. (ANL)
- Ford's 2011 Super Duty diesel pickup truck utilizes DOE supported emission control technology.
- Heavy-duty multi-cylinder engine w/bottoming cycle at 49% brake thermal efficiency.
- 1st generation thermoelectric generators produced over 500 Watts on vehicle tests. (BSST)

FY 2015 Target:

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 diesel engine efficiency by >20% compared to 2009 baseline, 30% by 2020.

Future Direction

- High-efficiency low temperature combustion technologies and lean-burn gasoline.
- Simulation codes that reduce design iterations and engineering design tools for validation of simulation models.
- Increase efficiency of NO_x, PM and HC emission control systems focusing on low-cost base metal catalysts.
- High efficiency thermoelectric generators to improve vehicle fuel economy.

Status:

- Six cost-shared cooperative awards with industry to demonstrate fuel economy goals with engine-only improvements by 2015
- Four SuperTruck awards to demonstrate engine efficiency goal for long-haul trucks by 2015

Significant Accomplishments Support Technical Targets for Materials

Accomplishments

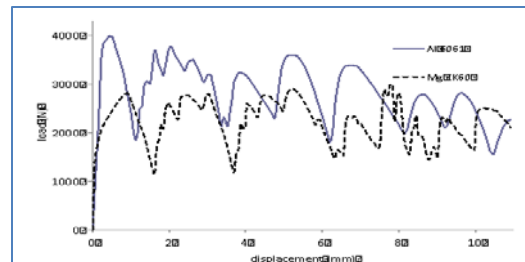
- **Multimaterial joining** – For Mg, demonstrate laser-assisted self piercing rivet and friction stir weld (USAMP)
- **Room temperatures processing of Al alloys lowers cost** -Pulse pressure forming enables **2.5x to 6x** increase in safe strains (PNNL)
- **Non-Rare Earth Mg alloy provides good properties using domestically available materials** - Significantly improve crash energy absorption (PNNL)
- **Propulsion Material**- SS alloy provides greater strength at higher temperatures (>750C), and lower cost by 33% - turbocharger housings and turbine-wheel/shaft assemblies (ORNL/Honeywell)



Joining demonstration: laser assisted (left)
self piercing rivet and FSW (right)



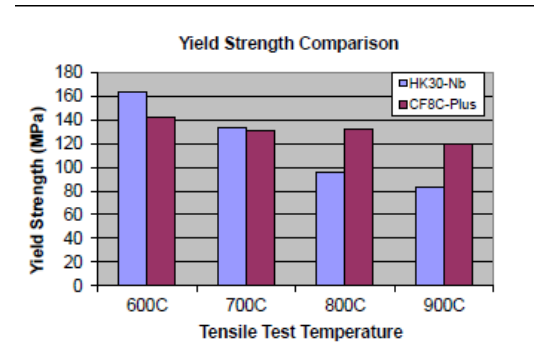
Al RT Pulse Pressure Forming



Mg alloy with comparable crash energy
to Al with 20% weight savings

Future Direction (FOA)

- Predictive modeling of carbon fiber composites
- Predictive modeling of advanced steels
- Advanced alloy development for automotive and heavy-duty engines



FY 2015 Goal:

Validate (to within 10% uncertainty) the cost-effective reduction of the weight of passenger vehicle body and chassis systems by 50% with recyclability comparable to 2002 vehicles.

Status:

- **Multimaterial vehicle demonstration in process**
- **Baseline cost model complete**
- **Cost model for 25% weight reduction in process**

FY 2011 Accomplishments

- Initiated new industry and university R&D efforts:
 - Longer lifted-flame combustion
 - Expansion of RCCI engine operations
 - Reduced-friction, advanced base engine oils
 - Supplementary alcohol injection for improved combustion efficiency
- Completed 4-year testing program on intermediate ethanol-gasoline blends.
- Co-funded, with California state agencies, development of 3 medium-duty CNG engines.

FY 2015 Goal:

Demonstrate cost effective lubricant with 2% fuel economy improvement

Future Direction

- Increase emphasis on lubricant research:
 - Develop retrofittable low-friction lubes for use as drop-in replacement in existing vehicle engines
- Expand understanding and exploitation of fuel-controlled combustion
 - Example: RCCI
- Continue fit-for-service evaluations of candidate “drop-in” biofuels

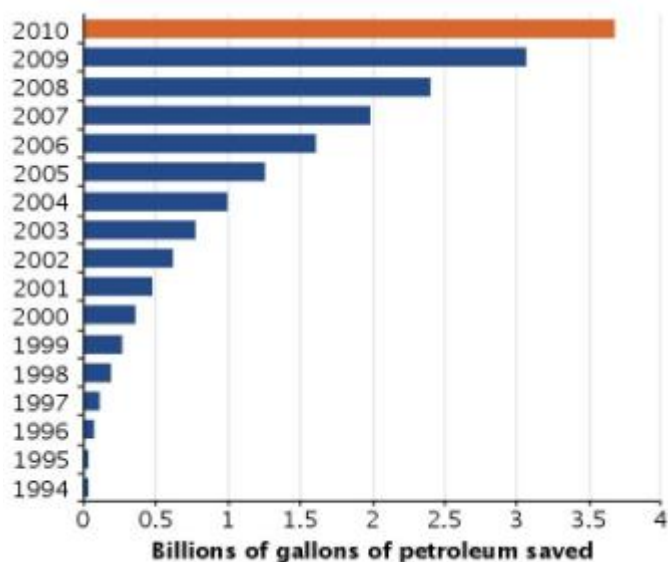
Status:

Demonstrated greater-than-50% reduction in boundary friction in bench-top tests

VTP Deployment – Clean Cities (leveraging people & resources)

Accomplishments

- Saved nearly 4 billion gallons of petroleum (GGE) since 1993
- Created the National Clean Fleets Partnership with 20 large fleets
- Recent awards helped deploy over 1,500 stations and 8,500 vehicles



U. S. Department of Energy

Future Direction

- Facilitate EV deployment that supports “1M EVs on the road by 2015” Presidential goal.
- Remove barriers and accelerate deployment of alt-fuel vehicles in support of the President’s “All of the Above” transportation energy strategy.
- Focus on community readiness and sustainability, policy development, and removing market barriers

FY 2020 Goal:

Facilitate 2.5B gal/yr. (GGE) of petroleum reduction with alt-fuels and other VT-Deployment initiatives.

Highlights 2012



President Obama Visits Ohio State EcoCAR Team, March 2012



President Visits Daimler Truck, March 2012



Green Truck Summit/Work Truck Show, March 2012



President Obama in Las Vegas, Highlight Clean Fleets, January 2012

Highlights 2012

U.S. DEPARTMENT OF
ENERGY

Energy Efficiency &
Renewable Energy



Secretary Chu at the North American Auto Show, January 2012



Clean Cities Summit in Indianapolis, IN, June 2011





Recovery Act Grand Openings

GM White Marsh
Celgard
Johnson Controls
Saft
Toda America
Pyrotek
Delphi
Magna E-Car



Patrick Davis
Program Manager

202-586-8061

patrick.davis@ee.doe.gov

www.vehicles.energy.gov