

Annual Merit Review and Peer Evaluation Meeting

May 2013

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Director, Vehicle Technologies Office

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



- 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 2012*	FY 2013	FY 2014
Batteries & Elec. Drive	\$117,740	\$115,158	\$240,200
Vehicle Systems Sim.	\$47,198	\$45,379	\$70,000
Adv. Combustion	\$58,027	\$56,725	\$59,500
Materials Technology	\$40,830	\$41,599	\$59,500
Fuels Technology	\$17,904	\$17,490	\$17,500
Outreach, Deployment and Analysis	\$39,267	\$34,511	\$126,300
NREL Site-Wide Facility	\$0	\$0	\$2,000
Total	\$320,966	\$310,862	\$575,000

*Does not include SBIR/STTR

FY 2013 Budget Highlights

- Continuing Resolution at FY 12 level minus sequestration
- EV Everywhere Grand Challenge focuses on:
 - 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
- Higher efficiency combustion engines and alternative fuels utilization

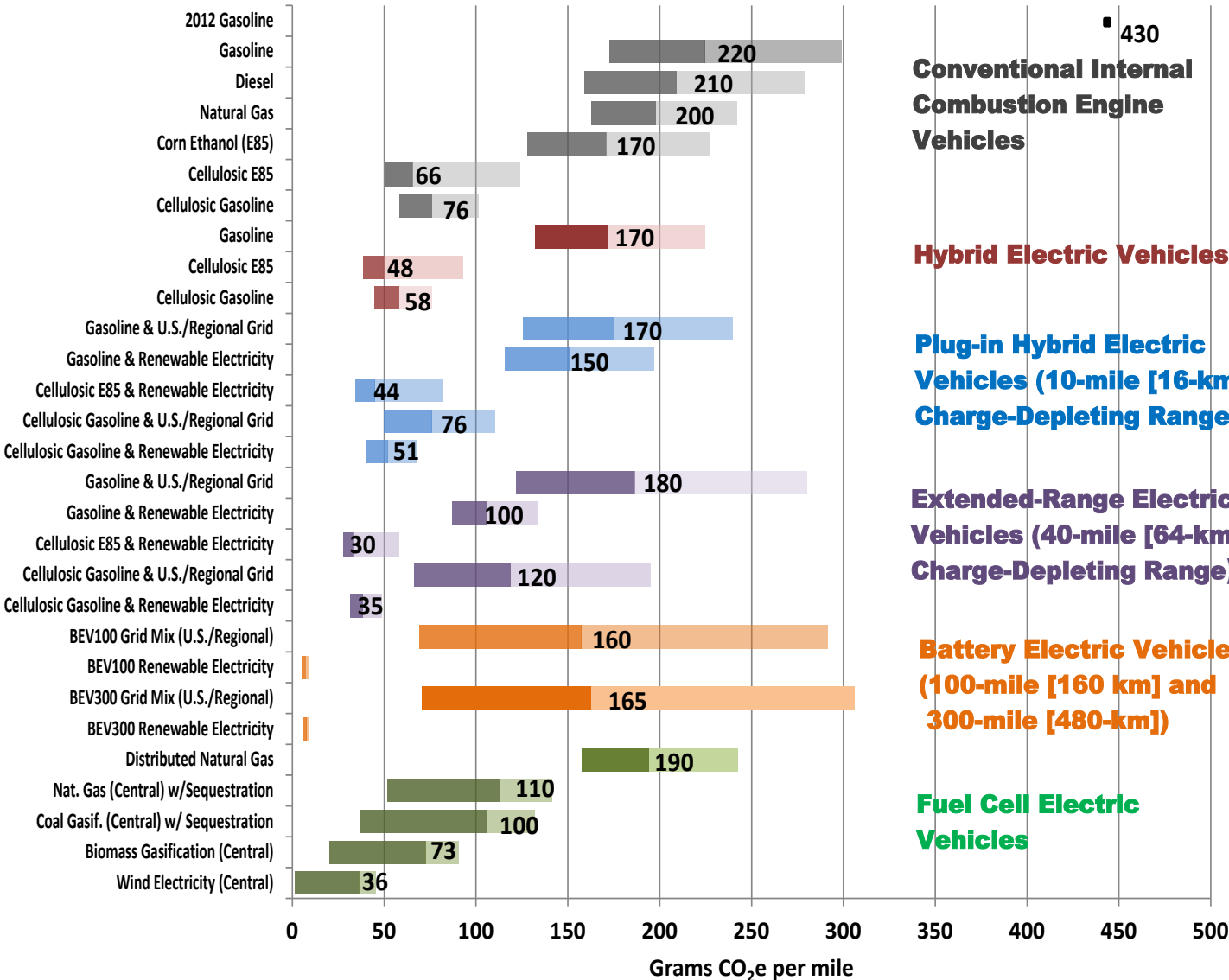
FY 2014 Budget Highlights

- EV Everywhere Grand Challenge
- Alternative Fuel Vehicle Community Partner Projects
- Grid Integration Initiative
- Vehicle Technologies Incubator
- SuperTruck Initiative

Analysis

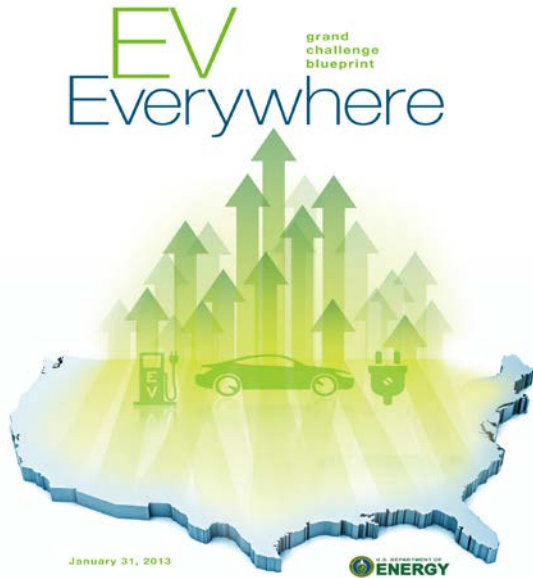
FY13 Well-to-Wheels Emissions Program Record Joint Vehicles-Bioenergy-Fuel Cell Technology Office Effort

Low, Medium & High GHGs/mile for 2035 Technology, Except Where Indicated



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

EV Everywhere



A Clean Energy Grand Challenge

- Enabling plug-in vehicles to be as affordable and convenient for the American family as conventional gasoline-powered vehicles by 2022
- Bring together America's best and brightest scientists, engineers, and businesses to produce EVs at lower cost, with improved vehicle range and increased fast-charging ability

EV Everywhere Goal

Enable the U.S. to be the first in the world to produce plug-in electric vehicles that are as affordable and convenient as today's gasoline-powered vehicles within the next 10 years

For a copy of the Blueprint, visit electricvehicles.energy.gov



President Obama announced EV Everywhere during a visit to Daimler Trucks in North Carolina, March 2012

Workplace Charging Challenge

Workplace Charging Challenge Goal
 Increase number of U.S. employers offering workplace charging by tenfold in five years.

- **Benefits for the big picture**
 - Fill infrastructure gap
 - Grow the PEV market
 - Increase visibility of PEVs
 - Add electric VMT
- **Benefits for the employer**
 - Employee benefit
 - Corporate sustainability
 - Contribute to LEED certification
 - Keeping up with the Googles

31 Partners

10 Ambassadors

U.S. DRIVE Partnership

U.S. DRIVE enables frequent and detailed interaction to accelerate progress, prevent duplication, and help maintain DOE R&D focus on high-risk barriers to technology commercialization

2012 Accomplishments/Activities:

- ✓ **Updated Partnership Goals and Targets** – new analysis-based process enabled consistency across teams, focus on cost-competitive technologies in 2020 timeframe
- ✓ **Completed National Research Council Review** (www.nap.edu)
- ✓ **Published 2012 Accomplishments Report** – highlights key technical progress
- ✓ **Convened Executive Steering Group** – set high-level priorities and strategic direction
- ✓ **Established Cradle-to-Grave Working Group** – cross-cutting, consensus-based study of full lifecycle petroleum/GHG reduction potential

Coming Soon:

→ *New technical team roadmaps online*

Partners:

Associate Members at the Technical Level

For details and documents, please visit www.vehicles.energy.gov/about/partnerships/usdrive.html

SuperTruck Project On-Track

Participants

Cummins, Daimler, Navistar and Volvo

➤ Status of 50% engine efficiency:

- Cummins has demonstrated 51%
- Daimler, Navistar and Volvo have all demonstrated 48% engine efficiency (Volvo 1-1/2 years ahead of schedule)

➤ Status of 50% freight efficiency improvement:

- Cummins has demonstration on-road 61% efficiency improvement exceeding the target
- Daimler has demonstrated, through modeling and component testing, a 55% improvement
- Navistar has developed a revolutionary rear-engine architecture which supports aerodynamic and weight goals
- Volvo has validated trailer aerodynamic improvements on-road demonstrating an 11% FE impact



SuperTruck Concept



Major Interagency Collaborations

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

➤ Department of Defense

- Advanced Vehicle Powertrain Technology Alliance (AVPTA) – VTO and US Army TARDEC initiative for cooperative technology development
- Collaboration, coordination, and co-funded projects, including three recent joint FOA topics, to do more together than either could do separately



➤ Department of Transportation

- Monthly meetings between VTO and DOT on vehicle related topics
- Exchanged expertise following Superstorm Sandy related incidents
- Coordinated activities on safety/lightweighting interactions
- Organized updates on DOT Intelligent Transportation Systems activities for DOE management
- Planned a DOT-hosted 21st Century Truck Partnership meeting for 6/19/2013



➤ Environmental Protection Agency

- VTO continues to collaborate closely with EPA across the breadth of vehicle technologies and jointly sponsoring www.fueleconomy.gov and green racing



EcoCAR2: Plugging into the Future

EcoCAR2 Goal

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



EcoCAR2 PLUGGING IN TO THE FUTURE YEAR ONE COMPETITION



MAY 18-23, 2012 LOS ANGELES, CA

Year 2 Integration

Yuma, AZ – May 13-19, 2013

San Diego, CA – May 20-24, 2013

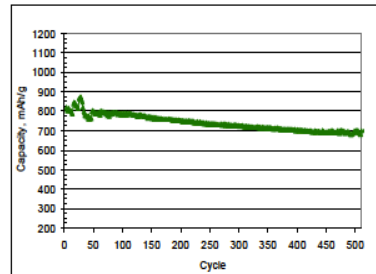
Major Technical Areas



Battery R&D

Accomplishments

- Johnson Controls demonstrated novel cathode slurry processing techniques that reduced N-Methylpyrrolidone (NMP) solvent use by 32%
 - On path to increase cell energy density from 275 Wh/L to 375 Wh/L (36%)
- Nanosys developed a silicon-graphite anode material (SiNANOde™) that demonstrated 850mAh/g of reversible capacity and ~500 cycles
- Established 2.5 million kWh battery manufacturing capacity



Future Direction

Emphasize cost reduction, durability, safety, and increased specific energy:

- Develop and demonstrate next generation lithium ion PEV materials and cell technology
 - Develop of high voltage, high capacity cathodes
 - Develop Silicon Composite & Metal alloy anodes
 - Develop high voltage electrolytes
- Expand focus on beyond-Lithium-ion technology

FY 2015 Goal

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

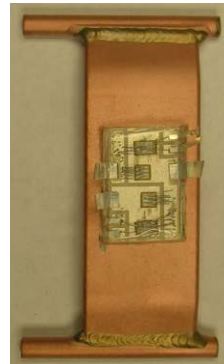
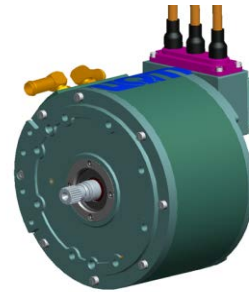
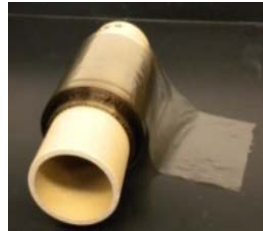
Status

- On track to meet cost target of \$400/kWh in FY13.
- Calendar life up to 10-15 years
- Cycle life between 3,000-5,000 deep discharge

Advanced Power Electronics and Electric Motors R&D

Accomplishments

- New solicitation issued for R&D:
 - High temperature capacitors
 - Wide bandgap (WBG) inverter
- Ongoing industry R&D efforts now in Phase II:
 - Motors to reduce or eliminate rare earth elements (GE and UQM)
 - Scalable, modular inverter (GM)
- Developed innovative WBG packaging for power modules:
 - 40% cost reduction
 - 60% power density increase
- First U.S.-based OEM to manufacture electric motors in U.S. (GM/ARRA)
- Inverter production in U.S. based on technology innovations from APEEM R&D (Delphi)



Future Direction

- Reduce cost of electric traction drive systems while improving performance and reliability:
 - WBGs enable increased switching frequency, efficiency, and operating temperatures
 - Motor and magnetic materials research to reduce or eliminate rare earth elements
 - Components designed for scalability and manufacturability
 - Materials and technologies to improve heat transfer and efficiency

FY 2015 Goal

Reduce cost of electric traction drive technologies to \$12/kW



Status

- On track to meet cost target of \$16/kW in FY13
- Met cost target of \$17/kW in FY12

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



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

FY 2015 Goal
Demonstrate large-scale market-readiness of grid-connected electric-drive vehicles

Advanced Combustion Engine R&D

Accomplishments

- Demonstrated 51 percent brake thermal efficiency for *SuperTruck* engine (Cummins)
- Advanced combustion engine shows potential for 50 percent increase in light-duty vehicle fuel economy (Delphi)
- Demonstrated lower-cost emission control system that enables fuel-efficient lean-burn gasoline engines (ORNL)
- Thermoelectric generator (TEG) produced over 600 watts from waste exhaust heat (GenTherm)



Future Direction

- Conduct research to accelerate development of low-temperature combustion, lean-burn gasoline, and clean diesel engines while reducing emissions.
- Develop detailed simulation models using high-performance computing that will reduce design iterations for advanced engines and emission control systems.
- Improve aftertreatment catalyst activity for engines with lower exhaust temperatures.
- Develop high efficiency thermoelectric generators to improve vehicle fuel economy.

FY 2015 Goal

- Improve gasoline and diesel passenger vehicle fuel economies by 25% and 40%, respectively (compared to 2010 gasoline vehicle)
- Improve the heavy-duty diesel engine BTE to 50%.
- Improve light-duty vehicle fuel economy by 5% with thermoelectric generator (TEG) that converts energy in the hot engine exhaust directly to electricity.

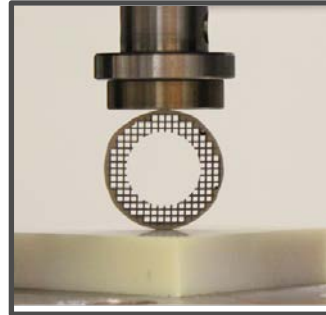
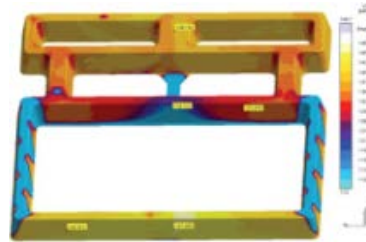
Status

- Six cost-shared cooperative awards with industry on track to demonstrate fuel economy goals with engine-only improvements by 2015.
- Four *SuperTruck* cost-shared awards with industry on track to demonstrate engine efficiency goal for long-haul trucks by 2015.
- Three TEG industry cost-shared awards demonstrating progress towards meeting goal.

Materials

Accomplishments

- **Warm Forming of Al**– Demonstrated aluminum door inner design saved 5 pounds (38%) over steel (USAMP)
- **Established Quality Mapping for Ductility in Magnesium Casting** - (PNNL with FORD and U Michigan)
- **Low Cost Carbon Fiber Plasma Oxidation** - Reducing residence time 50% for the oxidation phase utilizing atmospheric pressure plasma technology (ORNL and ReMaxCo)
- **Propulsion Material**—Updated performance model for diesel particulate filter enable improved use cycle; lower fuel penalty and efficient cycle conditions



Future Direction

- Better understanding of Mg kinetics and corrosion
 - Demonstration of multimaterial joining
 - Develop innovative multmaterial joining techniques
- Enable higher performance engines with higher performance, lower cost rotating parts

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 40% weight reduction in process

Fuel & Lubricant Technologies

Accomplishments

- Demonstrated greater-than-50% reduction in boundary friction on bench-top rig using production power cylinder components
- Demonstrated RCCI operating range of 60% of non-idling portions of the city (UDDS) and highway (HWFET) light-duty federal drive cycles
- Limited production of 11.9L natural gas engine supported under FY 2010 solicitation

FY 2015 Goal

Demonstrate cost effective lubricant with 2% fuel economy improvement

FY 2020 Goal

Demonstrate expanded operational range of advanced combustion regimes to 75% of LD Federal Test Procedure

Future Direction

- Maintain lubricant research activities
 - Develop retrofittable low-friction lubes for use as drop-in replacement in existing vehicle engines
 - Expand to include gear oils
- Expand understanding and exploitation of fuel-controlled combustion
 - Investigate potential engine efficiency improvements from increased octane
- Continue fit-for-service evaluations of candidate “drop-in” biofuels

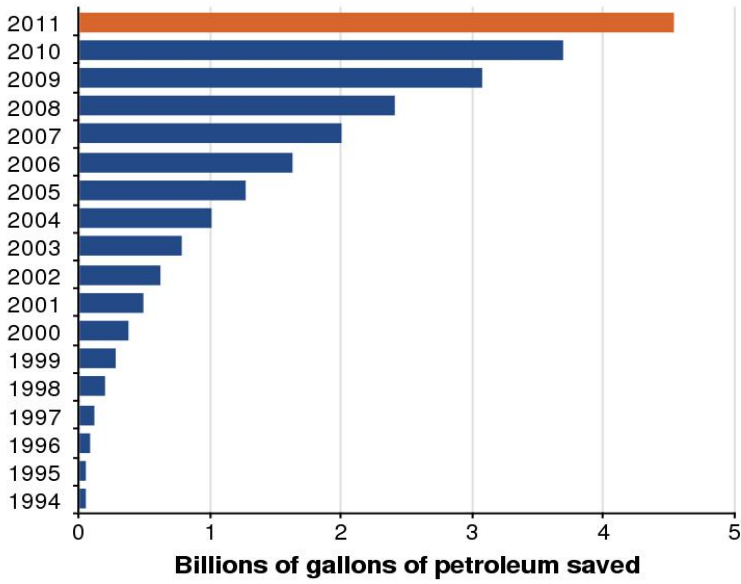
Status

- On-track to meet goals for both fuels and lubricants

VTO Deployment – Clean Cities (leveraging people & resources)

Accomplishments

- Saved over 4.5 billion gallons of petroleum since 1993
- Created the National Clean Fleets Partnership with 22 large fleets and the National Parks Initiative with 19 parks
- 36 community readiness projects expanding alternative fuel markets
- Projects deploying nearly 1,500 stations and more than 8,700 vehicles



Future Direction

- Establish Alternative Fuel Vehicle Community Partner Projects that drastically ramp up vehicles and infrastructure in specific regions
- Facilitate EV deployment that supports the *EV Everywhere Grand Challenge*
- Accelerate deployment of alt-fuel vehicles in support of the President’s “All of the Above” strategy
- Continue improving community readiness and sustainability, developing local policies, 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



2013 State of the Union



“We buy more American cars than we have in five years, and less foreign oil than we have in twenty.”

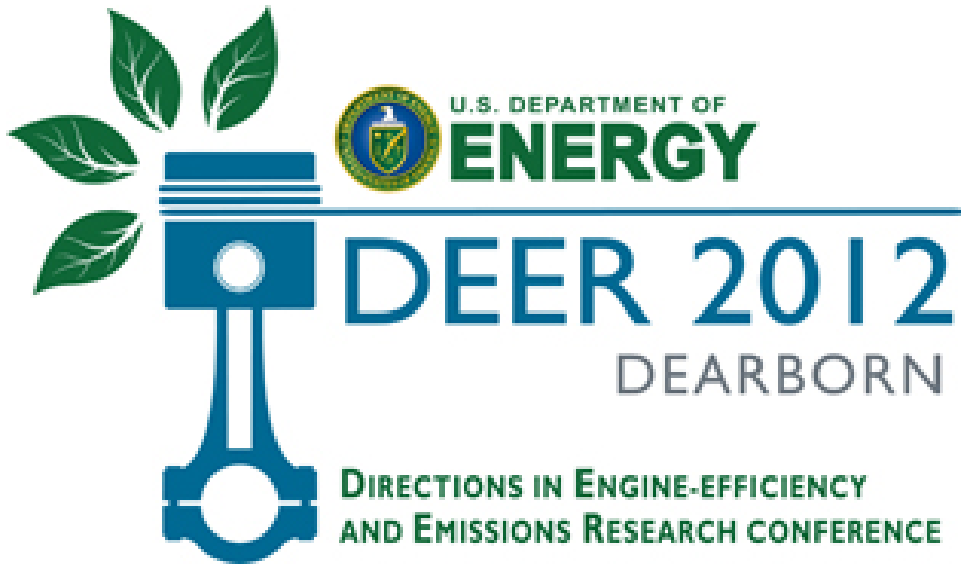
“After years of talking about it, we are finally poised to control our own energy future. We produce more oil at home than we have in 15 years. We have doubled the distance our cars will go on a gallon of gas...”

“Today, our scientists are...devising new materials to make batteries 10 times more powerful.”

- *President Barack Obama,
February 12, 2013*



18th Annual Directions in Engine-Efficiency and Emissions Research Conference, *October 2012*



- 70 Oral Presentations
- 70 Poster Presentations
- 30 exhibits from leading suppliers and OEMs

**Grown from 50 attendees in 1993
to 700 Attendees from over 15
Countries in 2012**

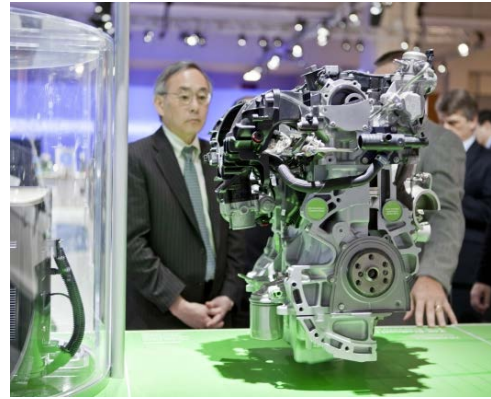


Green Racing – Celebrates 5th Year

ALMS announced merger with Grand-Am Series September, 2012



Secretary Chu Tours the Auto Show, Hosts Workplace Charging Roundtable, Announced Workplace Charging Challenge , *January 31, 2013*



Workplace Charging Challenge Goal

Increase number of U.S. employers offering workplace charging by tenfold in five years



Clean Energy Research Center, *Clean Vehicles*



U.S.-CHINA CLEAN
ENERGY RESEARCH CENTER

中美清洁能源联合研究中心



- **Ann Arbor Annual Meeting**
 - August, 2012
- **Washington, D.C. Summit**
 - January, 2013



Advanced Vehicle Technology Competitions Celebrate 25 Years!



Apps for Vehicles Challenge

- **White House Datapalooza**
 - October, 2012
- **Apps for Vehicles Challenge**
 - February, 2013
- **Vehicle Data Jam**
 - April, 2013



Dash Labs: Judge's Choice



My Carma: Popular Choice

John Fairbanks: 50 Years of Success



**Celebrating Federal
Semisentennial**

- ❖ **Began Federal government career in the Navy in 1962**
- ❖ **Renowned expert on thermoelectric generators**
- ❖ **Made technology applicable to cars, trucks, boats and NASA may use technology on Curiosity rover in Mars**
- ❖ **Currently manages the Solid State Energy Conversion program, Vehicle Technologies Office**
- ❖ **Founder of the DEER Conference**

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