



Annual Merit Review and Peer Evaluation Meeting

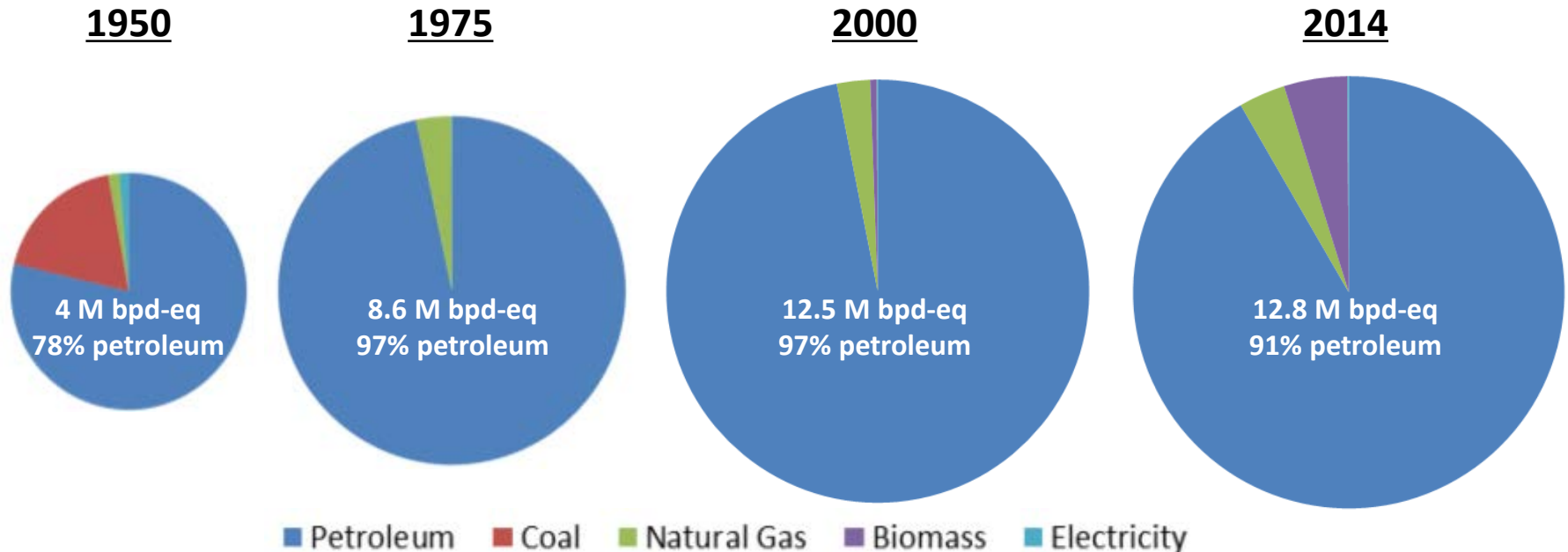
June 8, 2015

David Howell
Acting Director, Vehicle Technologies Office

Oil Dependency is Dominated by Vehicles

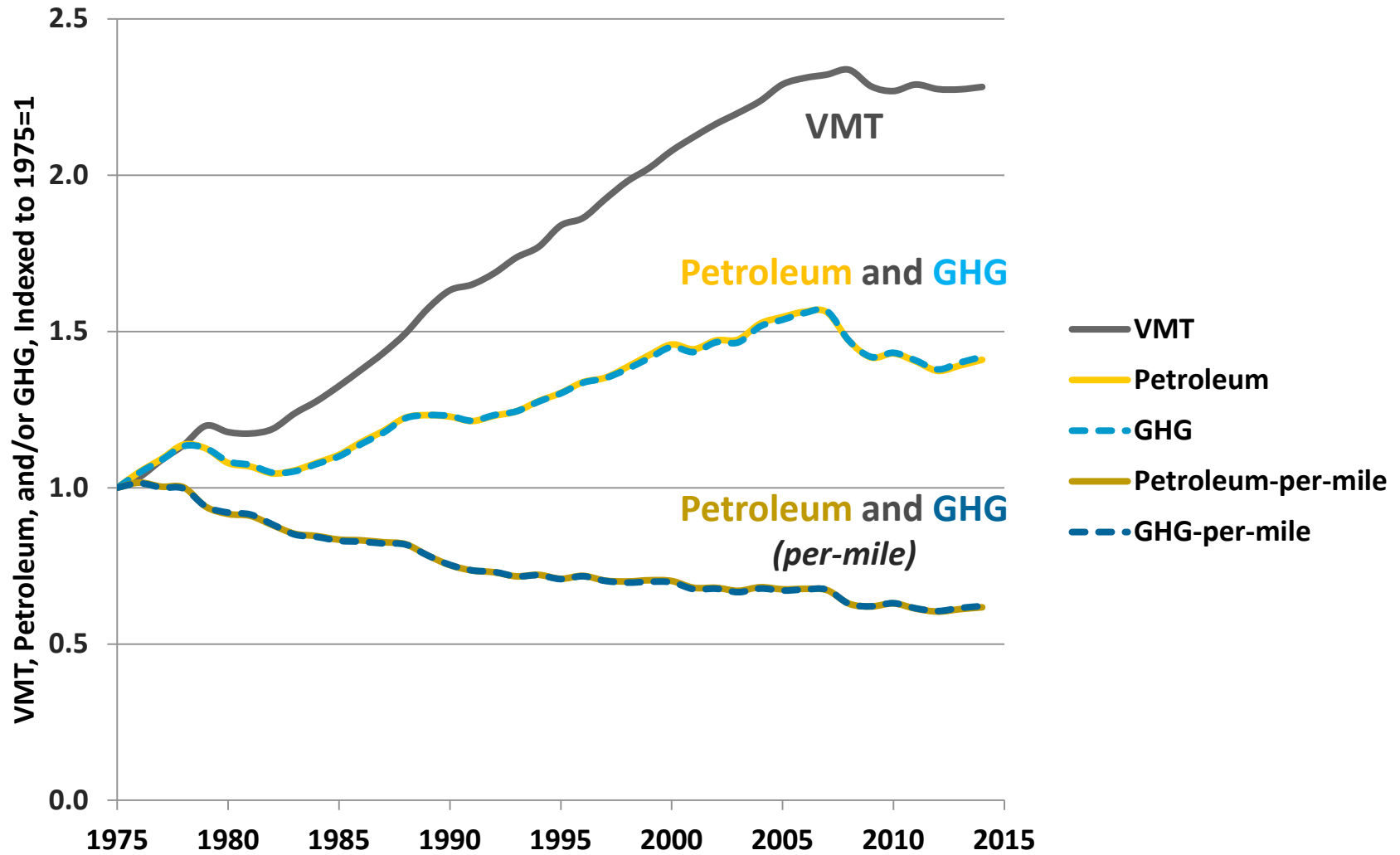
- Transportation is responsible for **69%** of U.S. petroleum usage
- **28%** of GHG emissions
- On-Road vehicles responsible for **85%** of transportation petroleum usage
- **16.4M** LDVs sold in 2014
- **240 million** light-duty vehicles on the road in the U.S.
- **10-15 years** for annual sales penetration
- **10-15 years** to turn over fleet

Transportation Energy Use, by Fuel (1950-2014)



Source: 2014 LDV sales from Ward's Auto); other data from Transportation Energy Data Book, ed. 33

VMT, Petroleum, and Emissions (1975-2014)



Sources: Petroleum and GHG from EIA Monthly Energy Review, <http://www.eia.gov/totalenergy/data/monthly/>; VMT from AFDC, <http://www.afdc.energy.gov/data/10315>

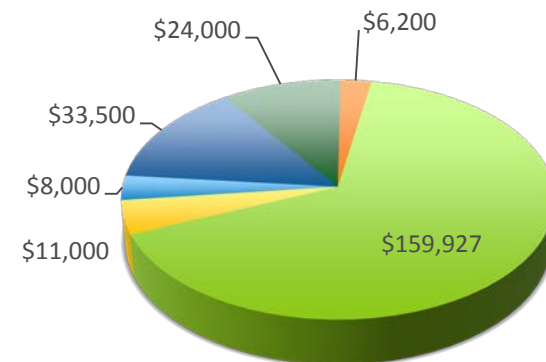
Vehicle Technologies – Budget

(Dollars in Thousands)

	FY 2015 Enacted	FY 2016 Request	High Profile Activities
Total, VTO Funding	\$280,000	\$444,000	
Batteries and Electric Drive Technologies	\$103,701	\$144,400	
<i>Battery Technology R&D</i>	<i>\$82,701</i>	<i>\$105,400</i>	<i>EV Everywhere (QTR), CEMI (QTR)</i>
<i>Electric Drive Technologies R&D</i>	<i>\$21,000</i>	<i>\$39,000</i>	<i>EV Everywhere (QTR)</i>
Vehicle Systems	\$40,393	\$68,100	EV Everywhere (QTR), ST I (QTR), Grid (QTR)
Advanced Combustion Engine R&D	\$49,000	\$64,500	Optima (QTR), ST I (QTR)
Materials Technology	\$35,602	\$70,500	EV Everywhere (QTR), ST I (QTR), CEMI (QTR)
Fuel and Lubricant Technologies	\$20,000	\$37,000	Optima (QTR)
Outreach, Deployment, & Analysis	\$28,304	\$56,500	
<i>Vehicle Technologies Deployment</i>	<i>\$24,000</i>	<i>\$49,000</i>	<i>Clean Cities</i>
<i>Advanced Vehicle Competitions</i>	<i>\$2,500</i>	<i>\$2,500</i>	
<i>Legislative and Rulemaking</i>	<i>\$1,804</i>	<i>\$2,000</i>	
<i>Analysis *</i>	<i>\$0</i>	<i>\$3,000</i>	
NREL Site-Wide	\$3,000	\$3,000	

Funding for High Profile Activities FY 2015 Enacted

- EV Everywhere
- Optima
- SuperTruck I
- CEMI **
- Clean Cities
- Grid Modernization**



* New Key Activity. Analysis was previously funded out of all of the subprograms
 ** Double-counted in EV Everywhere

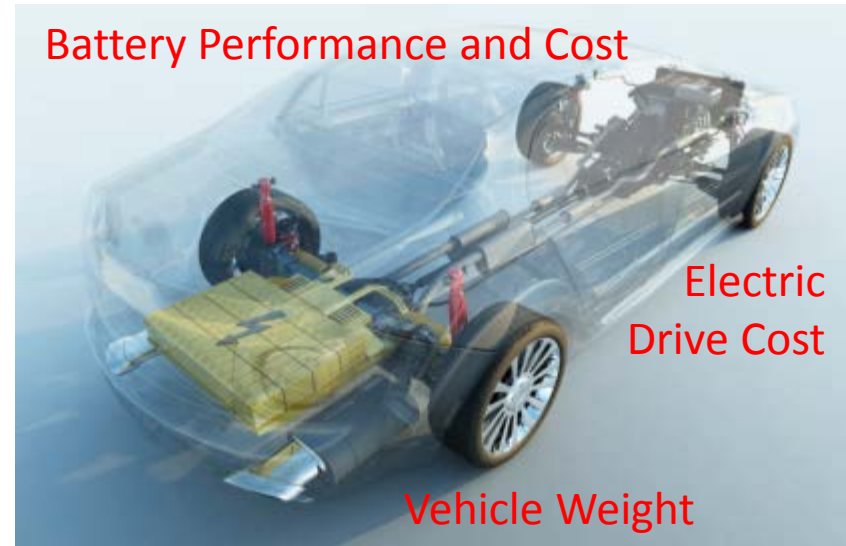
EV Everywhere Grand Challenge



President Obama announces EV Everywhere
North Carolina, March 2012

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

Battery Performance and Cost



➤ **Technology Push (R&D):** Targets focus on reducing PEV costs

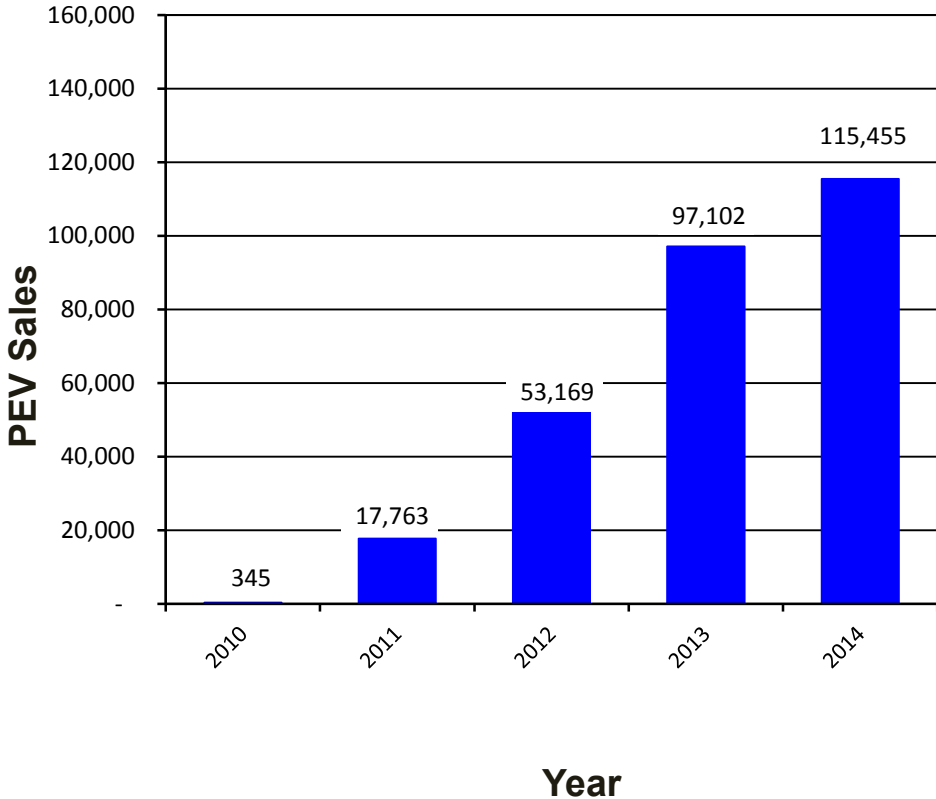
- Advanced batteries
- Electric drive systems
- Lighter weight structures
- Enabling technologies such as advanced climate control

➤ **Charging Infrastructure (Enablers):** Critical issues include codes and standards, siting, grid integration, permitting, and signage

➤ **Market Pull (Consumer Acceptance):** Consumer education and exposure to PEVs, innovative PEV ownership incentives, and leadership by example among public and private fleets

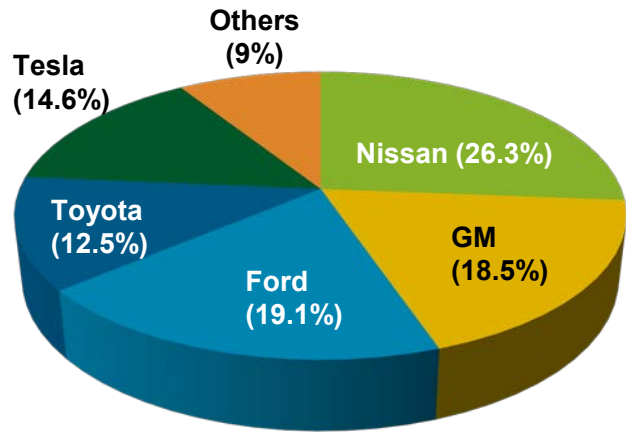
U.S. Plug-in Electric Vehicle Sales

PEV Sales over the years (2010-2014)



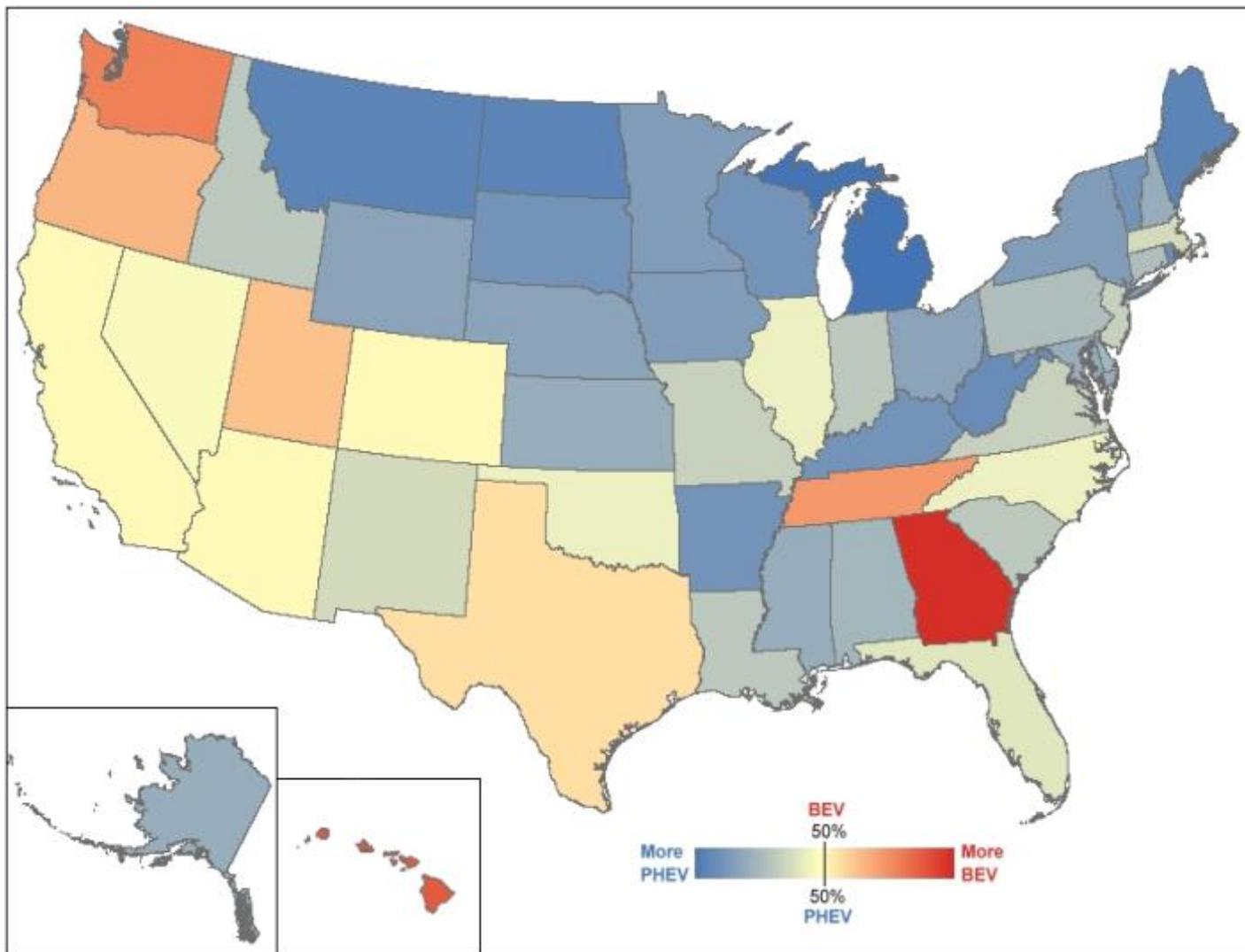
Source: <http://insideevs.com/monthly-plug-in-sales-scorecard/>

2014 PEV Sales (by manufacturer)



- ❑ The top five manufacturers accounted for 91% of the market in 2014 (individually between 15% - 26% each)
- ❑ The 2014 PEV sales leaders represented 83% of sales
 - Nissan Leaf (30,200)
 - Chevrolet Volt (18,805)
 - Tesla Model S (16,750)
 - Toyota Prius (13,264)
 - Ford Fusion Energi (11,550)
 - Ford C-Max Energi (8,433)

BEV-to-PHEV Proportion, By State



Battery R&D

FY 2022 Goal

Reduce the Plug in Electric Vehicle battery cost to \$125/kWh

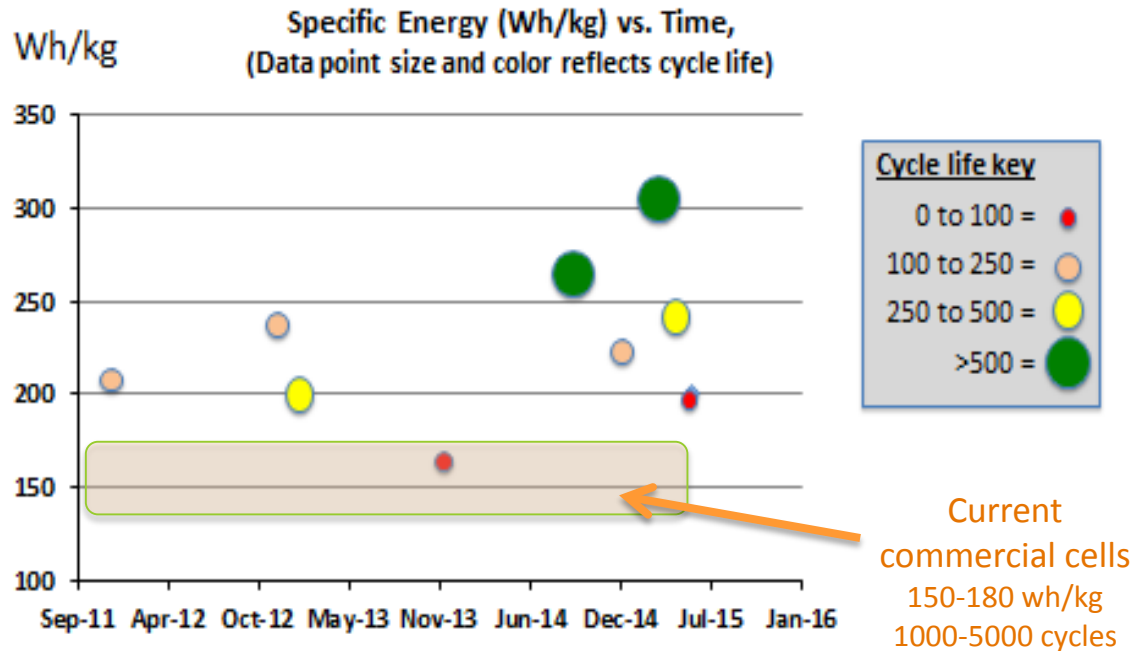
Current emphasis: Generation of high-capacity reversible Silicon composite anodes, with good rate capability and cycle life

PAY OFF: Intermetallic active anode materials can increase the negative electrode capacity from 2X to 4X and higher than graphite-based cells; this puts EDV 2022 energy density and cell cost goals within striking range

Challenges:

- Large first-cycle irreversible loss
- Low cycle life/ High capacity fade
- Poor coulombic efficiency
- Inferior power capability

Wh/kg and Cycle Life of Si-based Cell Deliverables from 7 DOE Funded Developers
Improvements in Energy and Cycle Life Continue



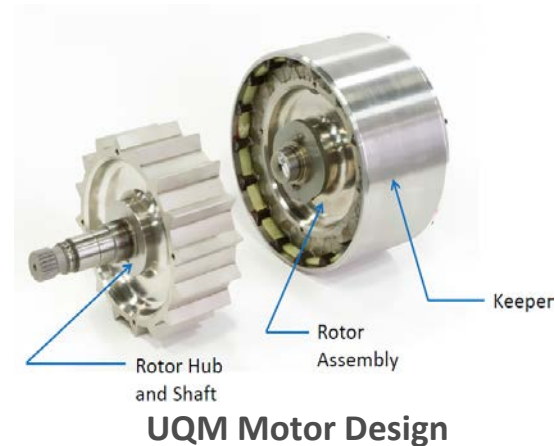
Advanced Electric Drive Technologies

FY 2015 Goal

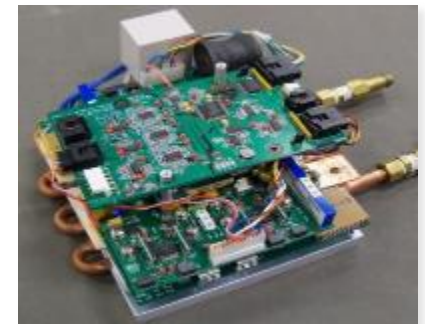
Reduce cost of electric traction drive technologies to \$12/kW

Accomplishments

- Unique Mobility (UQM) patented a novel motor design that does not use expensive rare earth magnets
- Delphi inverter advancements incorporated in new 2016 Volt, uses less silicon for lower cost
- Development of integrated charger/converter capable of high temperature operation



Delphi Inverter



ORNL Integrated Charger
DC-DC Converter

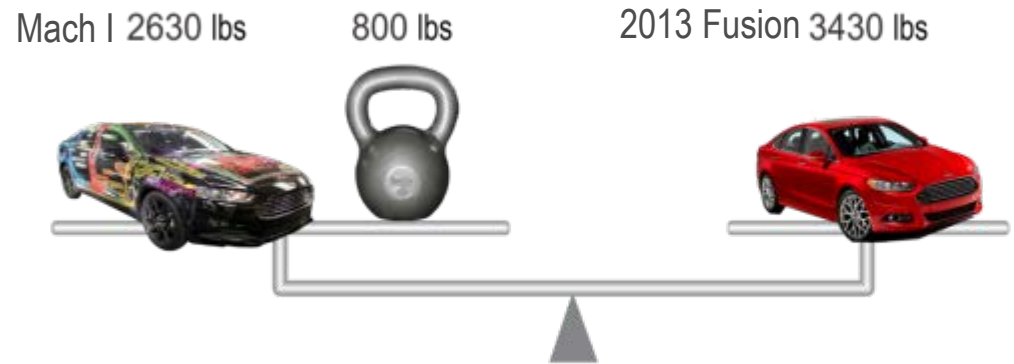
Materials

FY 2015 Goal

Validate the cost-effective reduction of the weight of passenger vehicle body and chassis systems by 50% with recyclability comparable to 2009 vehicles

Accomplishments

- **MMLV Mach I** – Completed design/CAE and build of a multi-material, lightweight vehicle with >23% weight reduction and realizing 16% reduction in life cycle GHG and primary energy vs. 2013 Fusion (VEHMA, Ford)
- **Lightweight Materials** – Developed and deployed Al friction stir welded tailor welded blank process technology with weight reduction potential of up to 60% versus conventional techniques



The Materials Genome Initiative

Presidential Initiative to develop and deploy materials twice as fast and at half the cost as compared to traditional methods:

Shifting materials R&D culture towards sharing and Integration

Integrating computation, experiment, and theory

Making digital materials data easily accessible and useable

Training the next-generation materials workforce

VTO Role and Activities

- **Integrated Computational Materials Engineering Projects**
 - Ongoing programs in sheet steel, cast Al, cast steel, Mg, and carbon fiber composites
- **Materials Data for Accelerated Development**
 - Partnering with NIST to make materials data in Mg alloys, advanced steels, and carbon fiber composites readily searchable and useable by the entire R&D community



Integrating research models and experimentation to predict steel performance

Vehicle Systems

FY 2015 Goal

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

Accomplishments

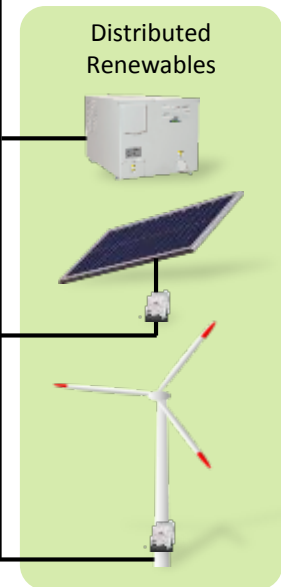
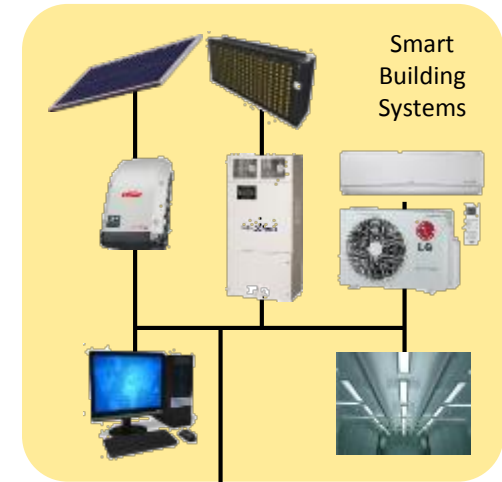
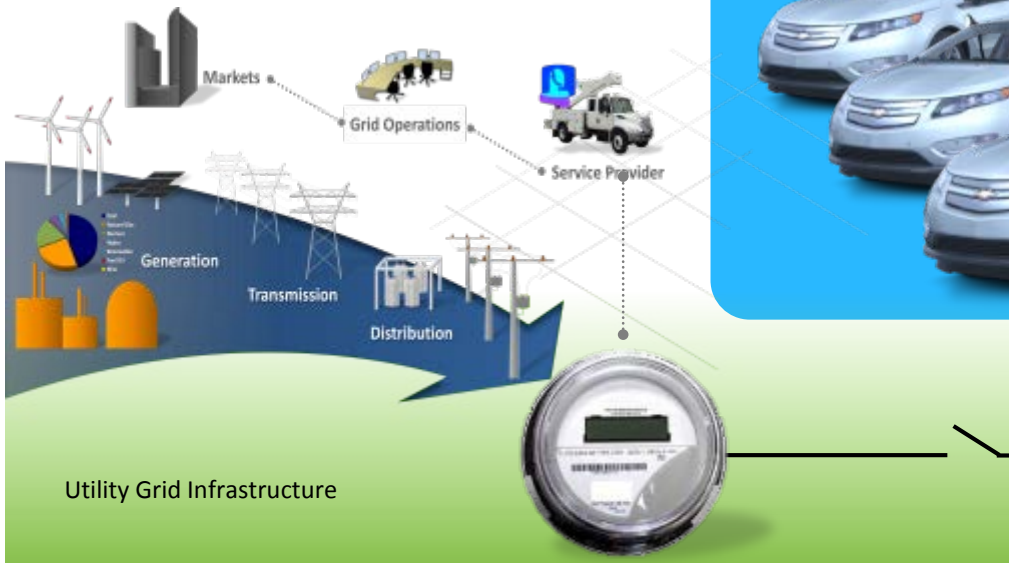
- Use data and charging profiles analyzed for 11,500 PEVs and 17,000 charging stations
- Demonstrated technology for wireless charging of EVs at 10kW and >85% efficiency
- Launched EV/Smart Grid Interoperability Center



Plug-in Electric Vehicles/Grid Modernization

Vehicles & the Grid Modernization Lab Consortium

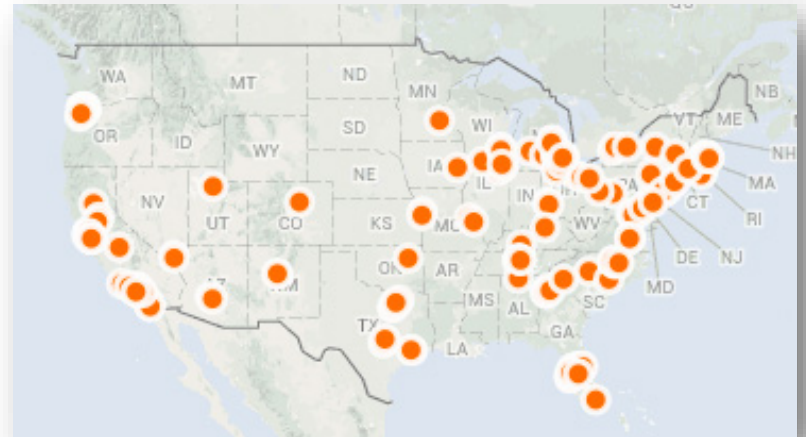
- **Sensing & Measurement** devices to communicate electric vehicle charging demand
- Demonstrate **Integrated Systems** of interoperable electric vehicles and local grid
- **Power Flow** control technologies to optimize operation of electric vehicle charging and other grid assets
- Enhance **Security & Resilience** of the grid through cyber and physical interface with plug-in electric vehicles



Workplace Charging Challenge

Goal

Increase the number of employers offering charging by 10x by 2018



- 200** Partner employers committing to provide EVSE for employees
- 3,500+** EVSE installed or planned
- 18** Ambassadors + numerous Clean Cities coalitions promoting and supporting workplace charging

Snapshot of 195+ Workplace Charging Challenge Partners

Employees who have access to WPC are 20x more likely to drive electric than those who don't



SuperTruck Initiative On-Track

Team Leads

Cummins, Daimler, Volvo, and Navistar

- **Status with respect to 50% freight efficiency improvement goal:**
 - Cummins has demonstrated 76% improvement through on-road testing
 - Daimler has demonstrated a 115% improvement through on-road testing
 - Volvo has demonstrated 43% freight efficiency improvement and has pathway to achieve greater than 50%
 - Navistar is on track to meeting efficiency goals
- **Status with respect to 50% engine efficiency goal:**
 - Cummins and Daimler have demonstrated over 50% engine efficiency
 - Navistar and Volvo have demonstrated over 48% engine efficiency; on track to achieve the 50% goal



Advanced Combustion Engine R&D

FY 2020 Goals

Improve gasoline and diesel passenger vehicle fuel economy by 35% and 50%, respectively (compared to 2009 gasoline vehicle)

Improve heavy-duty diesel engine efficiency to 55% (30% fuel economy improvement over 2009 vehicle)

Accomplishments

- Achieved 60% fuel economy improvement with 4-cylinder diesel over comparable gasoline V-8 powered light-duty pickup truck (Cummins) baseline (GM)



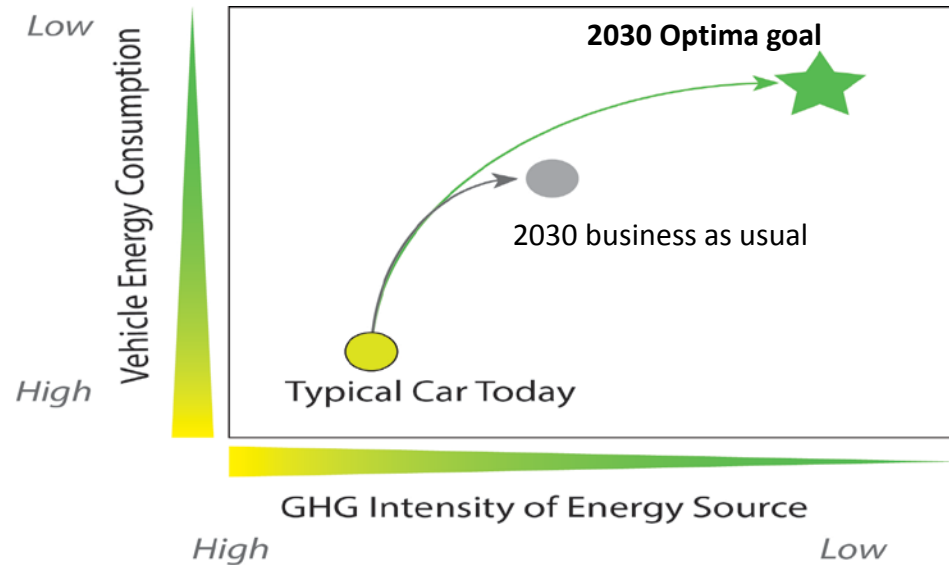
Fuels/Engines Optima

Rationale

- Increasing ICE efficiency is very promising and cost effective approach to improving fuel economy of the fleet
- Current fuels constrain engine design and efficiency potential

Objectives

- Through co-optimization of fuels and engines, reduce per-vehicle petroleum consumption 30% vs. 2030 business-as-usual
- Through a coordinated DOE and national lab effort, maximize value to widest range of stakeholders



- Presented to Secretary Moniz and DOE National Laboratory leadership as lead transportation idea at the 2015 DOE Big Ideas Summit
- FY 2016 budget request includes \$27M to support the Optima activity in FY 2016
- Joint funding from Bioenergy Technologies Office and the Vehicle Technologies Office
- Multi national laboratory R&D plan under development
- Significant stakeholder engagement underway

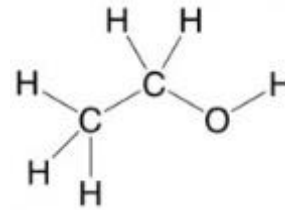
Fuel and Lubricant Technologies

FY 2020 Goals

Demonstrate cost-effective lubricant system with 4% fuel economy improvement relative to 2013 base fluids, and expanded operational range of advanced combustion regimes to >95% of LD Federal Test Procedure

Accomplishments

- Demonstrated 2% fuel economy improvement with advanced additives, relative to SOA synthetic SAE 5W-20 (2015 goal)
- Demonstrated fuel-property enabled RCCI operating range expansion to 75% of non-idling portions of the city (UDDS) and highway (HWFET) light-duty federal drive cycles



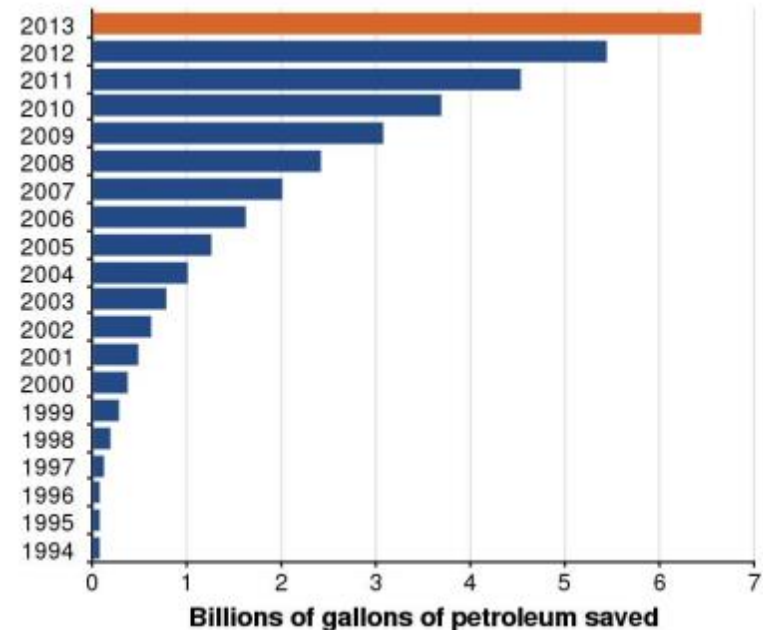
VTO Deployment – Clean Cities *(leveraging people & resources)*

FY 2020 Goal

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

Accomplishments

- Support deployment of nearly 600,000 alt-fuel vehicles
- Saved 7 billion+ gallons of petroleum since 1993 (2014 est.)
- In total, 500+ projects deployed thousands of vehicles and stations
- 11 projects in 2015 focusing on consumer experience, training, and emergency response



U.S. Department of Energy

Clean Cities: Partnerships Lead to Success

- Nearly 100 local Clean Cities coalitions with 14,000 stakeholders
 - 389 M+ GGEs/ reduced/year
- 30 projects with National Parks, reaching 80 million visitors/year
- 26 major National Clean Fleets Partners
 - Waste Management
 - Frito-Lay
 - United Parcel Service



Clean Cities: Data-Driven Online Tools for Decision-Making

- **FuelEconomy.gov:** Find-a-Car tool has 30+ years of vehicle data; 300M users
- **AFDC:** 20,000+ entries in Station Locator; 17 other interactive tools; nearly 200 case studies
- Data available through APIs, widgets and data downloads

The screenshot shows the homepage of FuelEconomy.gov. At the top, it features the U.S. Department of Energy logo and the text "Energy Efficiency & Renewable Energy". Below this is the website's name "www.fueleconomy.gov" and the tagline "the official U.S. government source for fuel economy information". A navigation bar includes links for "Find a Car", "Save Money & Fuel", "Benefits", "My MPG", "Advanced Cars & Fuels", "About EPA Ratings", and "More...". The main content area has a large banner with the text "Want to know more about hybrid and electric car options? We can help." Below the banner are four columns of featured tools: "Find & Compare Cars", "My MPG", "Save Money", and "Hybrids & Electrics". Each column contains a small image and a list of specific tools or services available.

The screenshot shows the homepage of the Alternative Fuels Data Center. At the top, it features the U.S. Department of Energy logo and the text "Energy Efficiency & Renewable Energy". Below this is the website's name "Alternative Fuels Data Center" and a search bar. A navigation bar includes links for "FUELS & VEHICLES", "CONSUME FUEL", "LOCATE STATIONS", "LOANS & INCENTIVES", "Maps & Data", "Case Studies", "Publications", "Tools", "About", and "Home". The main content area has a section titled "Fuels & Vehicles" with a row of icons for Biodiesel, Electricity, Ethanol, Hydrogen, Natural Gas, and Propane. Below this is a section titled "10 ways to get started" with the text "Cut fuel costs, reduce emissions, and bolster U.S. energy security." To the right, there are sections for "Maps & Data" and "Tools". The "Maps & Data" section includes a "Fuel Prices" widget with a line graph and a "Station Locator" widget with a map of the United States. The "Tools" section includes a list of tools such as "Laws & Incentives", "Vehicle Cost Calculator", "Light Duty Vehicle Search", "Heavy-Duty Vehicle Search", and "TransitBBS".

Clean Cities Funding Opportunity Announcement

- Up to \$2M to develop aggregate purchasing models
- Design system for an organization to coordinate and maximize customers' buying power
- Covers plug-in electric and other alt fuel and advanced technology vehicles, subsystems and components
- Decrease uncertainty around demand and lower up-front costs
- Will not pay for components or vehicles
- Application deadlines
 - June 29, 2015: Concept paper
 - August 21, 2015: Full application



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

2014-2015 Accomplishments/Activities:

- ✓ **Established New Fuels Working Group (FWG)** – evaluate potential properties of lower carbon fuels for future high-efficiency engines and combustion regimes
- ✓ **Completed Cradle-to-Grave Analysis (Phase II)** – cross-cutting, consensus-based study of full lifecycle petroleum/GHG reduction potential of multiple pathways
- ✓ **Convened Executive Steering Group (ESG)** – set high-level priorities and strategic direction (VP level)
- ✓ **Published 2014 Accomplishments Report** – highlights key technical progress

Look Ahead:

- New 2025 Partnership research targets
- Next National Research Council (NRC) Review (starting Fall 2015)
- 2015 All Tech Team Meeting (October 2015)

For details, see <http://energy.gov/eere/vehicles/vehicle-technologies-office-us-drive>

Partners:

- U.S. DEPARTMENT OF ENERGY
- USCAR (UNITED STATES COUNCIL FOR AUTOMOTIVE RESEARCH LLC)
- FCA (FIAT CHRYSLER AUTOMOBILES)
- Ford
- GM
- bp
- Chevron
- ExxonMobil
- PHILLIPS 66
- Shell
- DTE Energy
- EDISON
- EPRRI (ELECTRIC POWER RESEARCH INSTITUTE)
- TESLA

Associate Members at the Technical Level

21st Century Truck Partnership

- **Mission:** Accelerate introduction of truck and bus technologies to reduce fuel use, increase fuel diversity, and meet future emissions standards, while maintaining cost effectiveness, safety and reliability
- **Research partnership between government and industry**
 - Major truck, engine, and hybrid/powertrain manufacturers, and key federal agencies involved in commercial truck transportation
- **Regulatory environment informs R&D needs/gaps/barriers**
- **21CTP goals are longer range/higher risk, and complement nearer-term regulatory goals**



Major Interagency Collaborations

➤ 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 joint FOA topics, to do more together than either could do separately



➤ Department of Transportation

- Bi-monthly meetings between VTO and DOT on vehicle related topics
- Coordination of activities on safety, lightweighting and connected vehicles



➤ Environmental Protection Agency

- Continued close collaboration of VTO with EPA across the breadth of vehicle technologies and jointly sponsoring www.fueleconomy.gov and green racing
- Coordination between VTO and EPA's Office of Transportation and Air Quality



Green Racing – 6th Year

Launch of the United SportsCAR Championship



EERE Principal Deputy Assistant Secretary
Mike Carr at the 24 Hours of Daytona



New series launched January 2014



EcoCAR3 Year 1



**Over 16,000 Students
have participated in the
DOE Advanced Vehicle Technology
Competition Series!!**

EcoCAR 3 is challenging 16 North American university teams to redesign a Chevrolet Camaro to reduce its environmental impact, while maintaining the muscle and performance expected from this iconic American car.

Year 1 Focus: Project initiation, and development of Mechanical & electrical designs and control strategies.

Year 1 Competition Results

- #1 The Ohio state University
- #2 Virginia tech
- #3 University of Waterloo



Contact Information



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