VEHICLE TECHNOLOGIES OFFICE

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy




# Annual Merit Review and Peer Evaluation Meeting

June 8, 2015

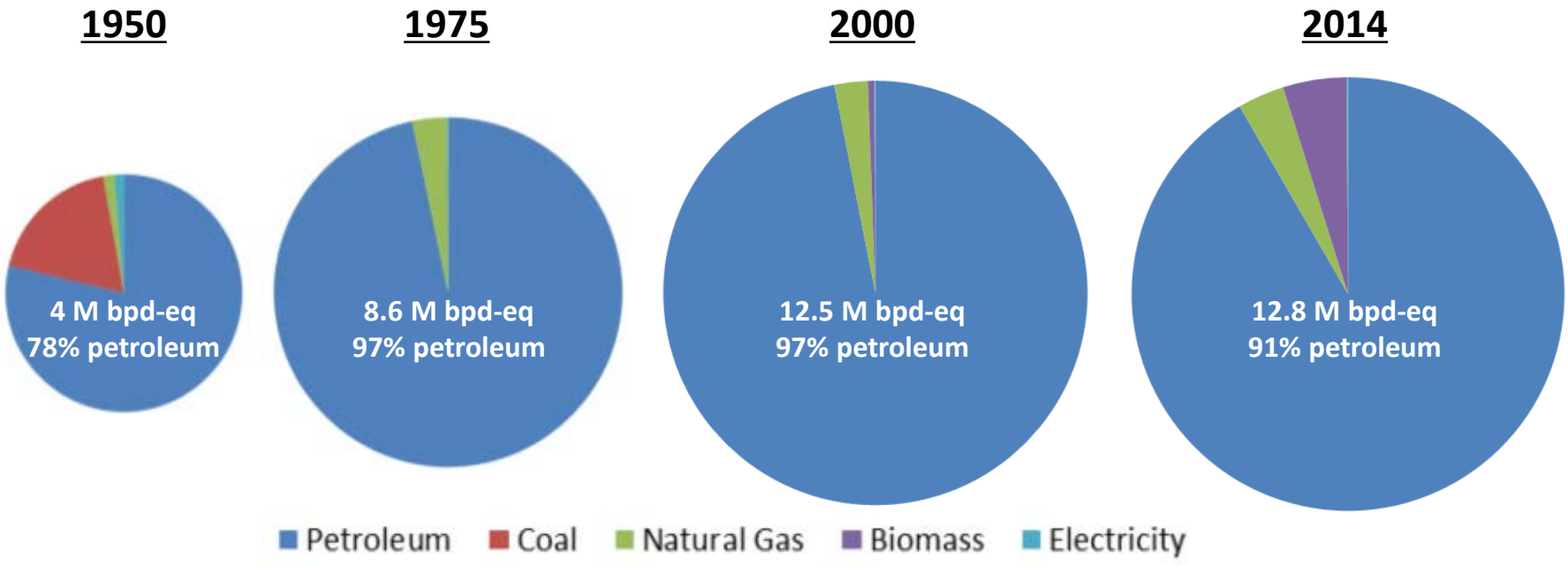
David Howell

Acting Director, Vehicle Technologies Office

# Oil Dependency is Dominated by Vehicles

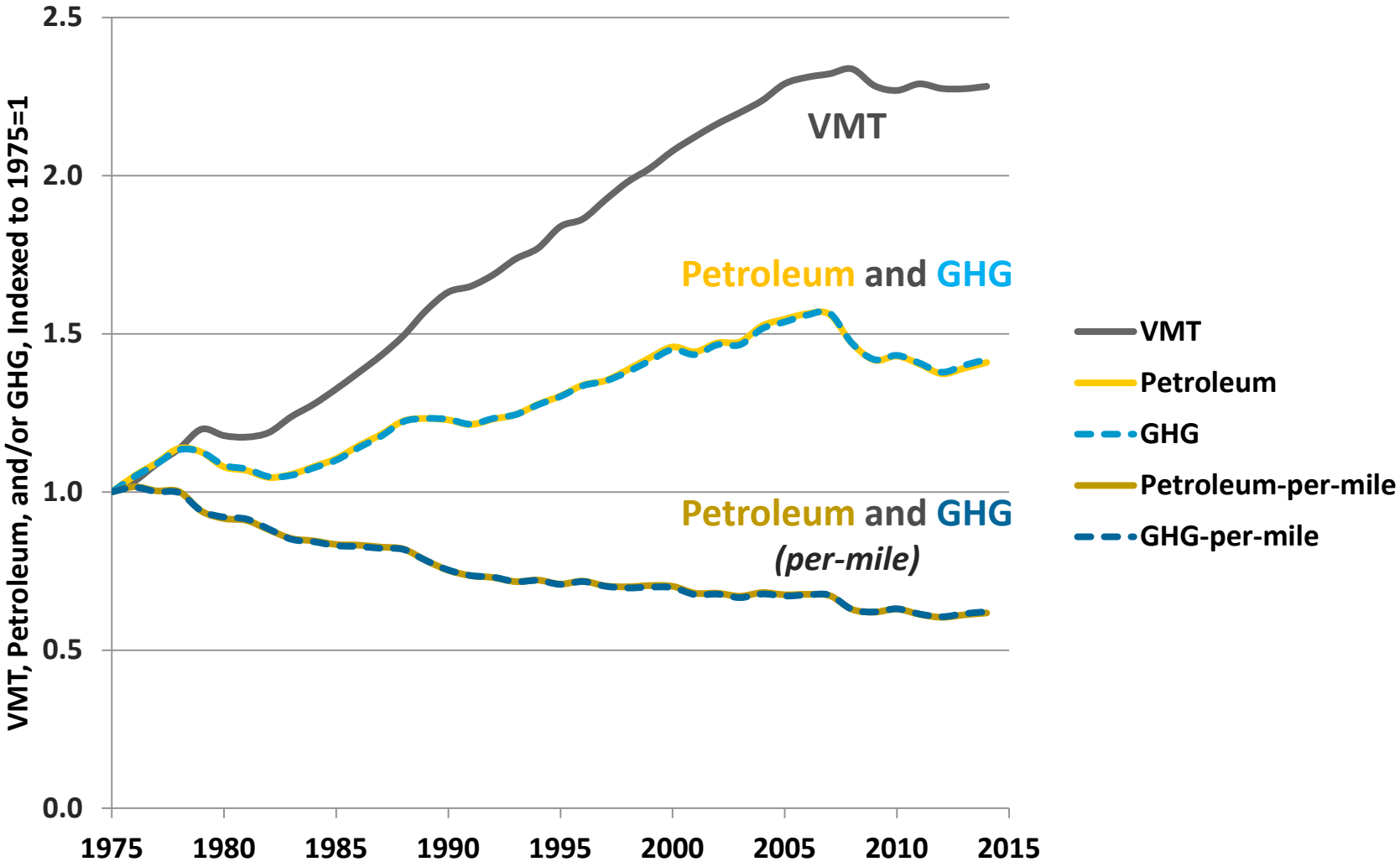
- Transportation is responsible for **69%** of U.S. petroleum usage
- **28%** of GHG emissions
- On-Road vehicles responsible for **85%** of transportation petroleum usage
- **16.4M** LDVs sold in 2014
- **240 million** light-duty vehicles on the road in the U.S.
- **10-15 years** for annual sales penetration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

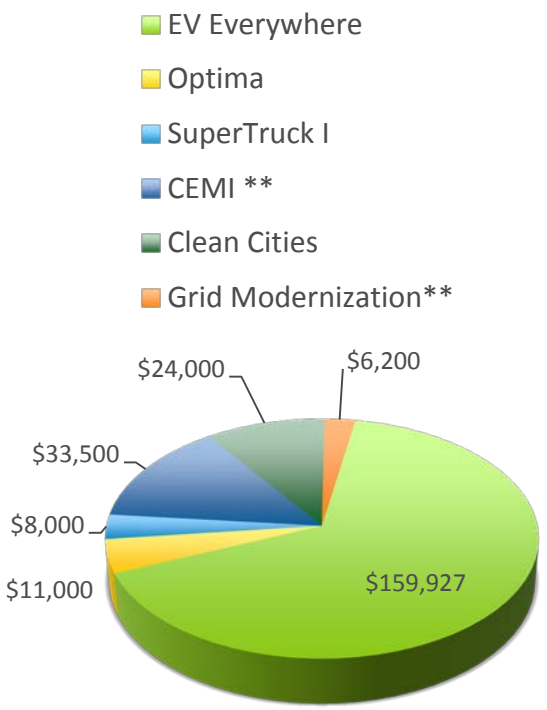



*Sources: Petroleum and GHG from EIA Monthly Energy Review, http://www.eia.gov/totalenergy/data/monthly/; VMT from AFDC, http://www.afdc.energy.gov/data/10315*

# 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** | |
| *Battery Technology R&D* | *$82,701* | *$105,400* | *EV Everywhere (QTR), CEMI (QTR)* |
| *Electric Drive Technologies R&D* | *$21,000* | *$39,000* | *EV Everywhere (QTR)* |
| **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** | |
| *Vehicle Technologies Deployment* | *$24,000* | *$49,000* | *Clean Cities* |
| *Advanced Vehicle Competitions* | *$2,500* | *$2,500* | |
| *Legislative and Rulemaking* | *$1,804* | *$2,000* | |
| *Analysis ** | *$0* | *$3,000* | |
| **NREL Site-Wide** | **$3,000** | **$3,000** | |

**Funding for High Profile Activities FY 2015 Enacted**




*** New Key Activity. Analysis was previously funded out of all of the subprograms**

**** Double-counted in EV Everywhere**

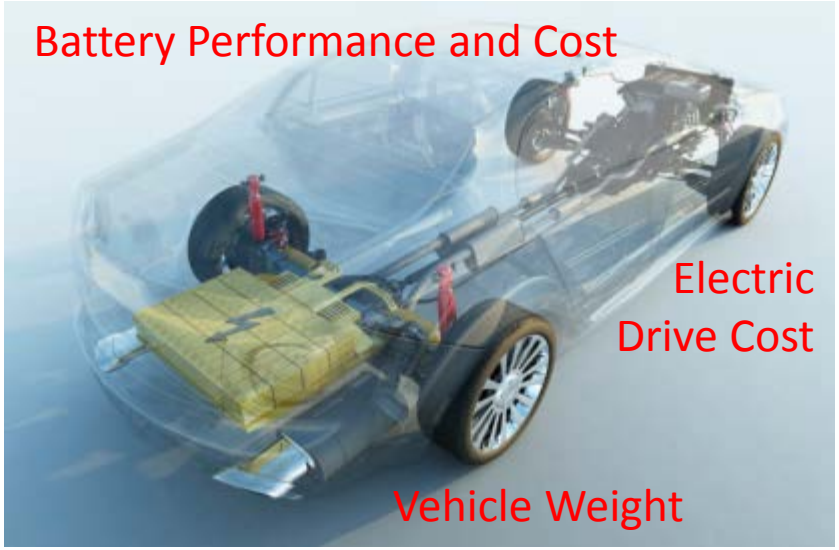
# EV Everywhere Grand Challenge



*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

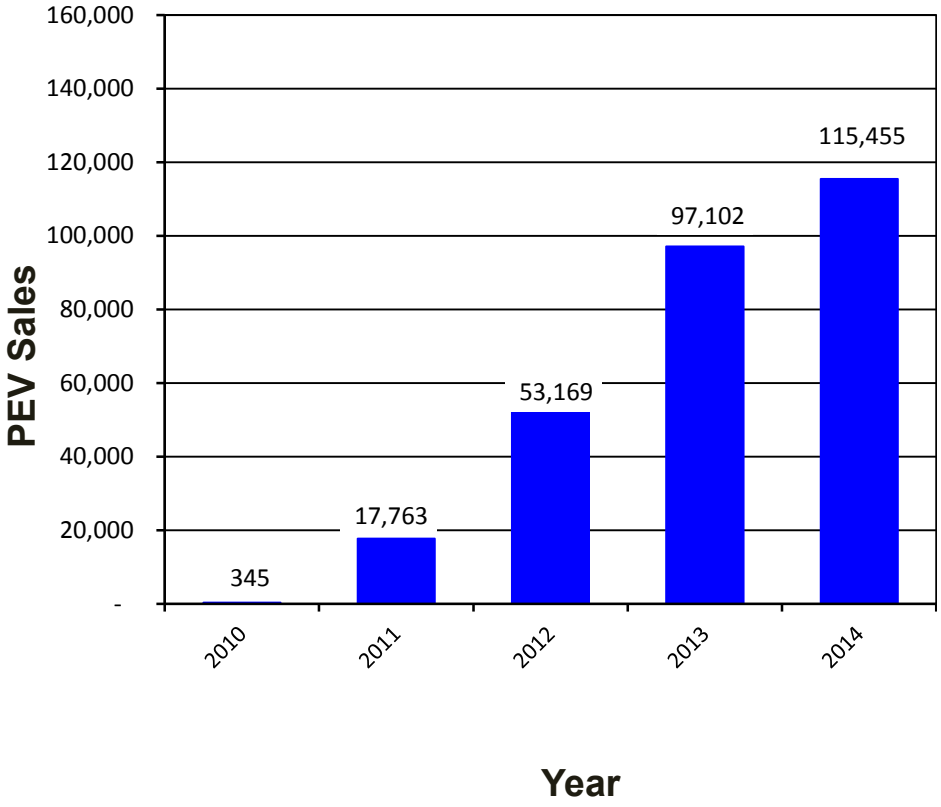
within the next 10 years




- **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

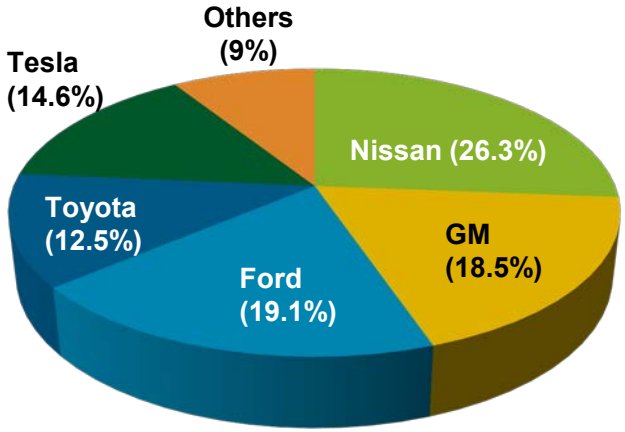
# U.S. Plug-in Electric Vehicle Sales

## PEV Sales over the years (2010-2014)



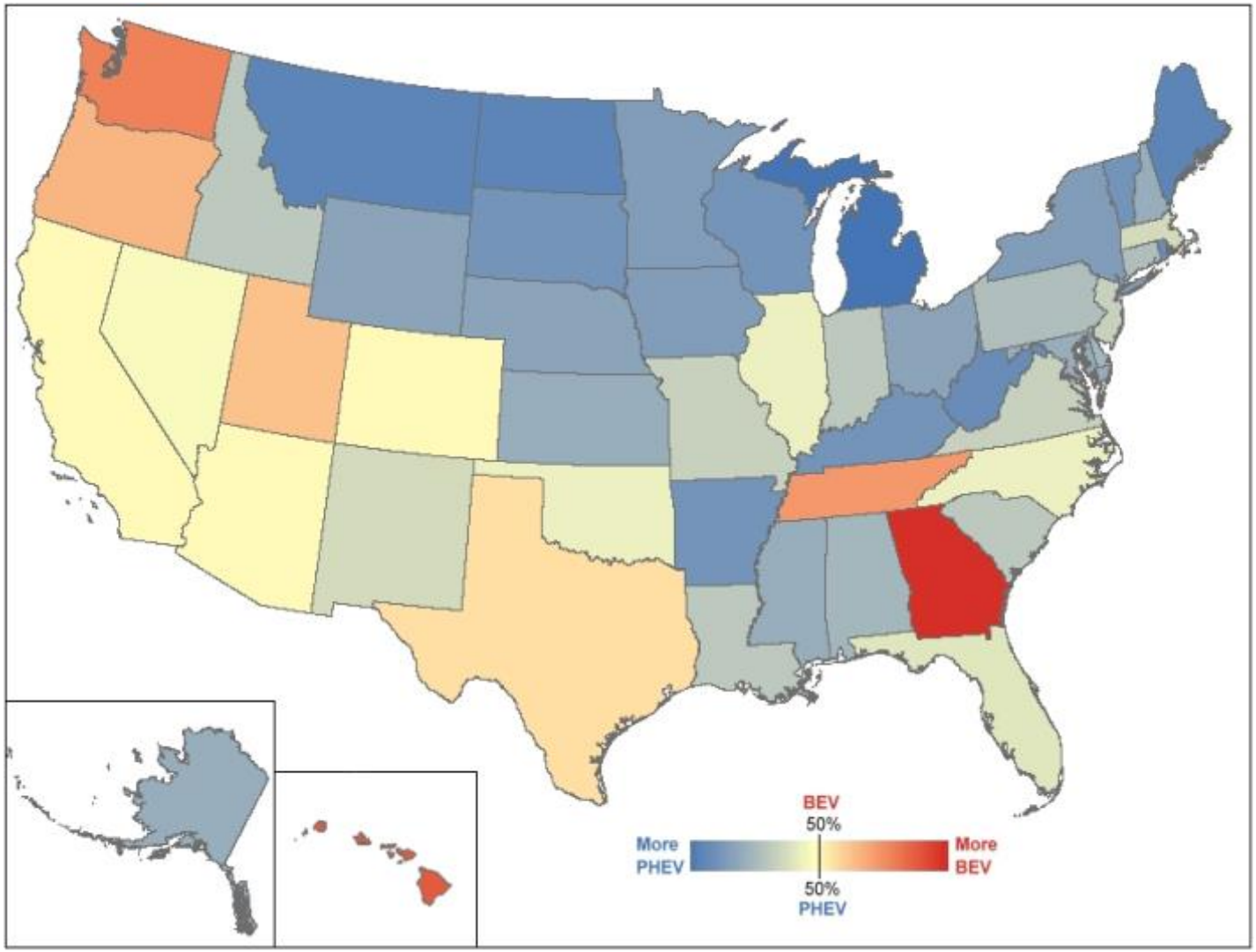

*Source: http://insideevs.com/monthly-plug-in-sales-scorecard/*

## 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




*Source: National Renewable Energy Laboratory (original source: IHS Automotive)*

# Battery R&D

## FY 2022 Goal

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

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

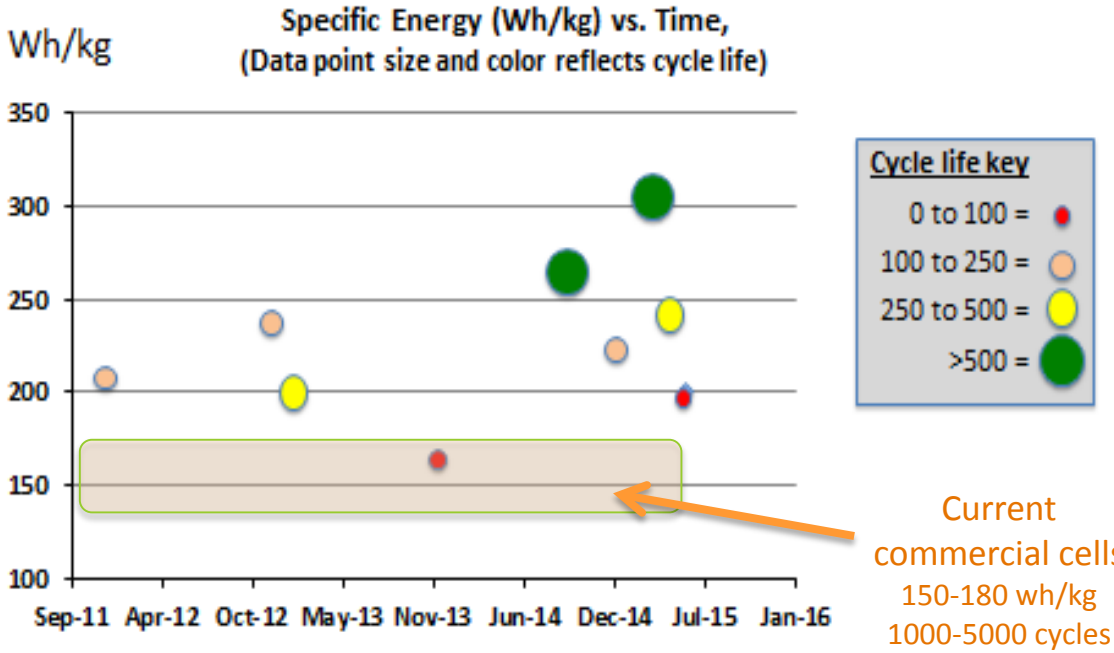
**PAY OFF:** Intermetallic active anode materials can increase the negative electrode capacity from 2X to 4X and higher than graphite-based cells; this puts EDV 2022 energy density and cell cost goals within striking range

### 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*



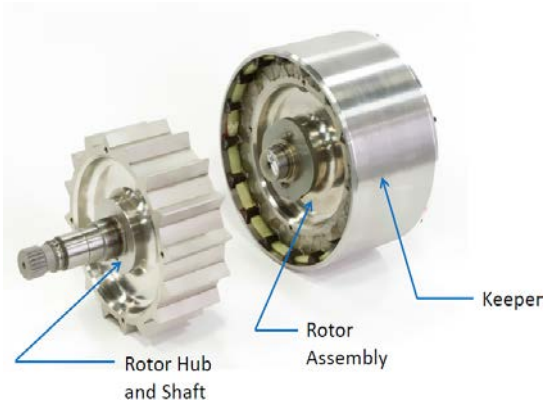
# Advanced Electric Drive Technologies

**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



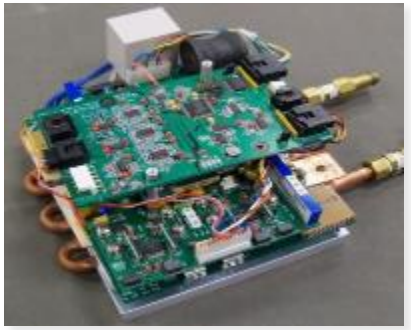

UQM Motor Design

- Delphi inverter advancements incorporated in new 2016 Volt, uses less silicon for lower cost



Delphi Inverter

- Development of integrated charger/converter capable of high temperature operation



**ORNL Integrated Charger DC-DC Converter**

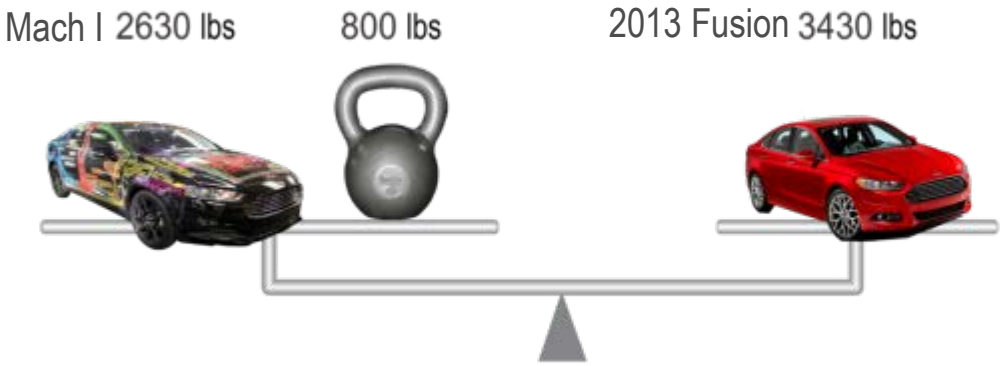
# Materials

**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



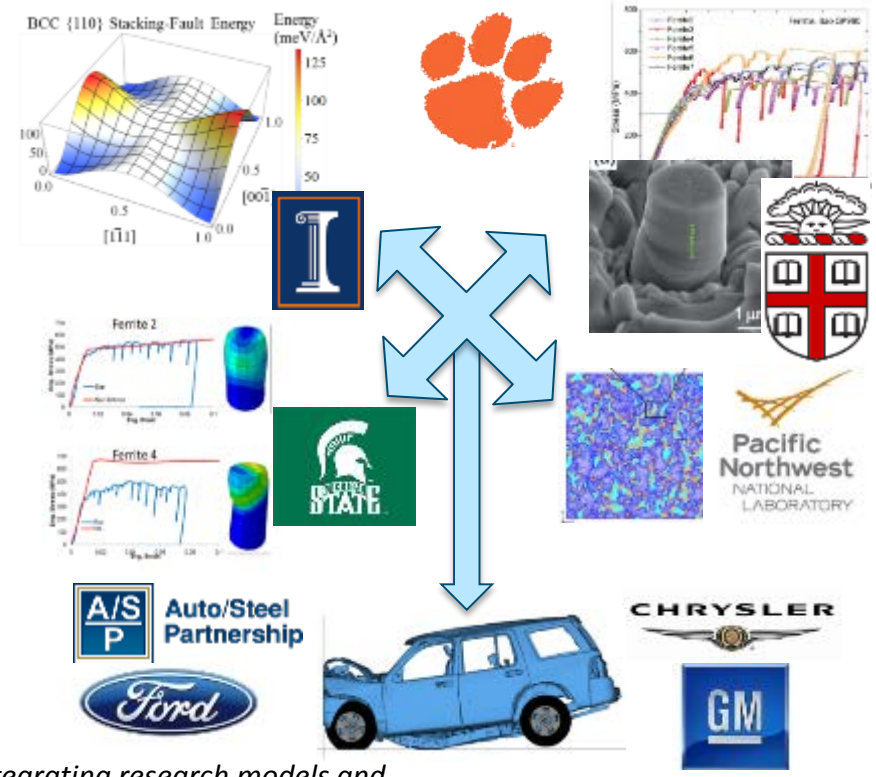
# The Materials Genome Initiative

*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*

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# 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



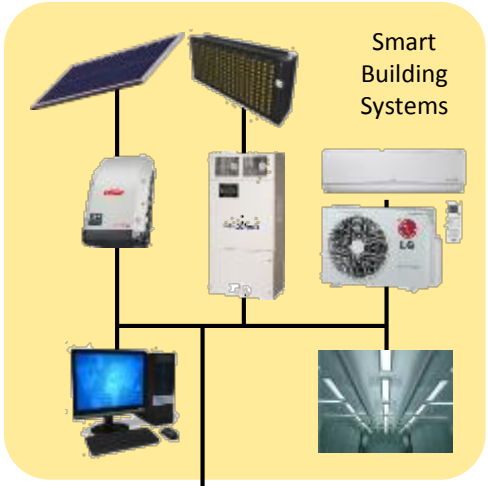
- Launched EV/Smart Grid Interoperability Center



# Plug-in Electric Vehicles/Grid Modernization

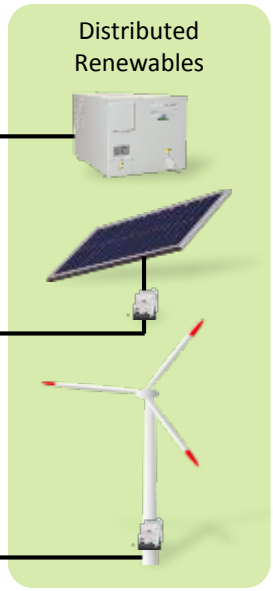
## *Vehicles & the Grid Modernization Lab Consortium*

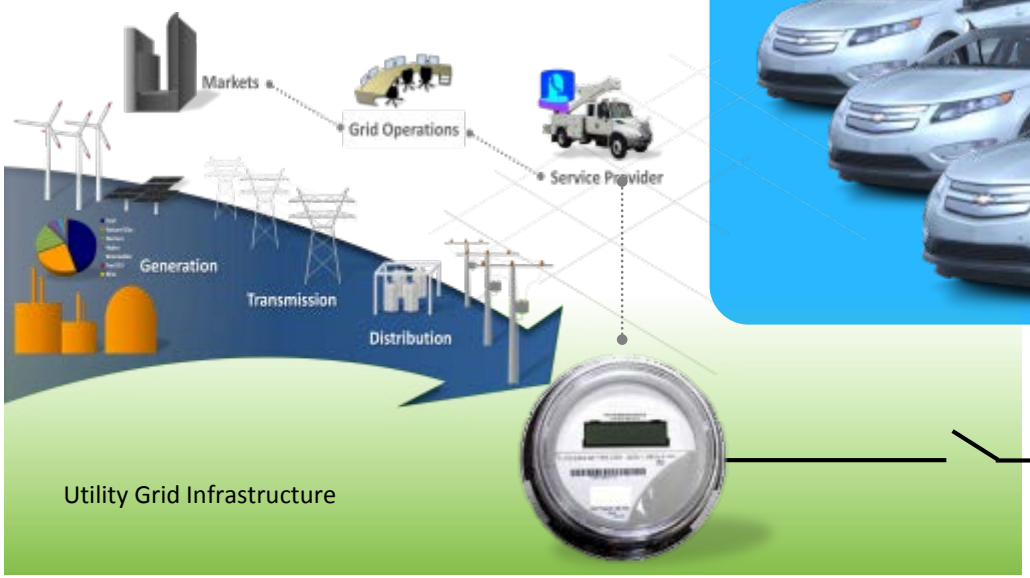
- **Sensing & Measurement** devices to communicate electric vehicle charging demand
- Demonstrate **Integrated Systems** of interoperable electric vehicles and local grid
- **Power Flow** control technologies to optimize operation of electric vehicle charging and other grid assets
- Enhance **Security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









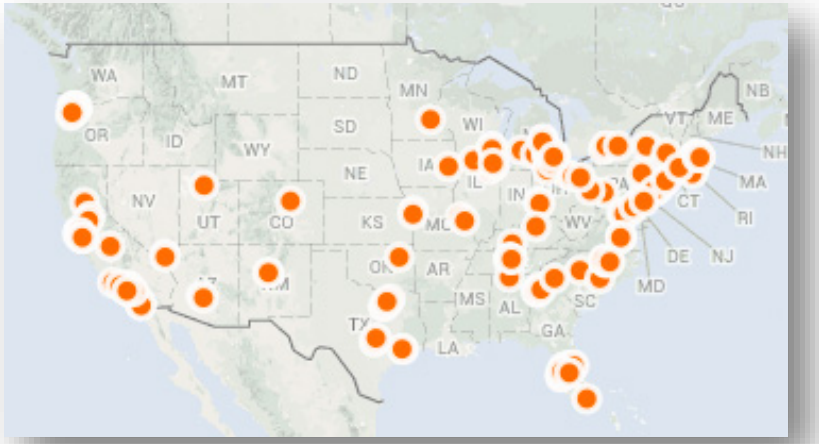



# Workplace Charging Challenge

**Goal**

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

Workplace Charging Challenge
U.S. DEPARTMENT OF ENERGY




| | |
|---|---|
| **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







12 mpg



Daimler Trucks North America VOLVO NAVISTAR U.S. DEPARTMENT OF ENERGY Energy Efficiency & Renewable Energy

# 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)





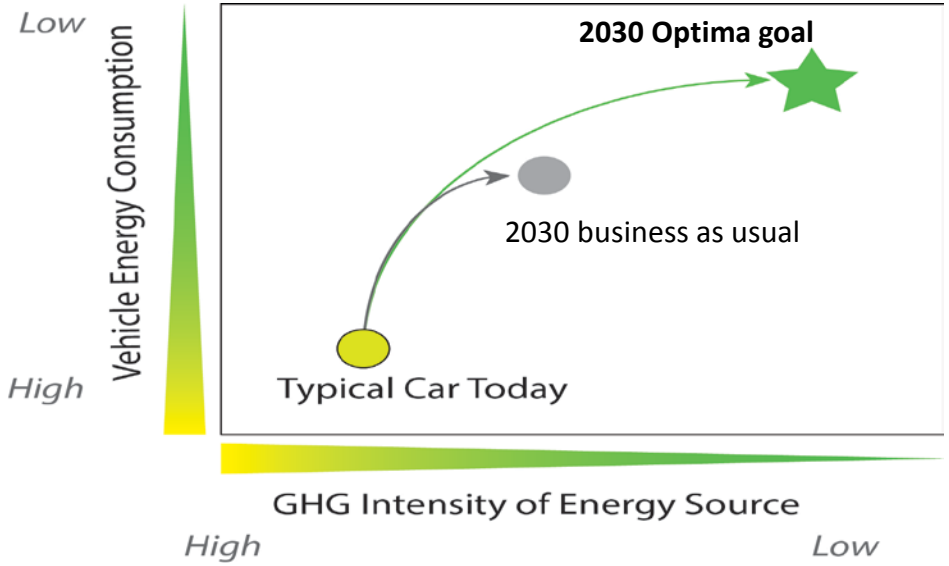
# Fuels/Engines Optima

## 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

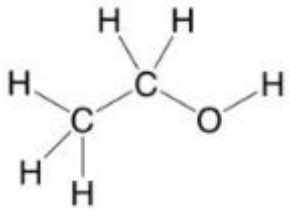
# Fuel and Lubricant Technologies

## 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





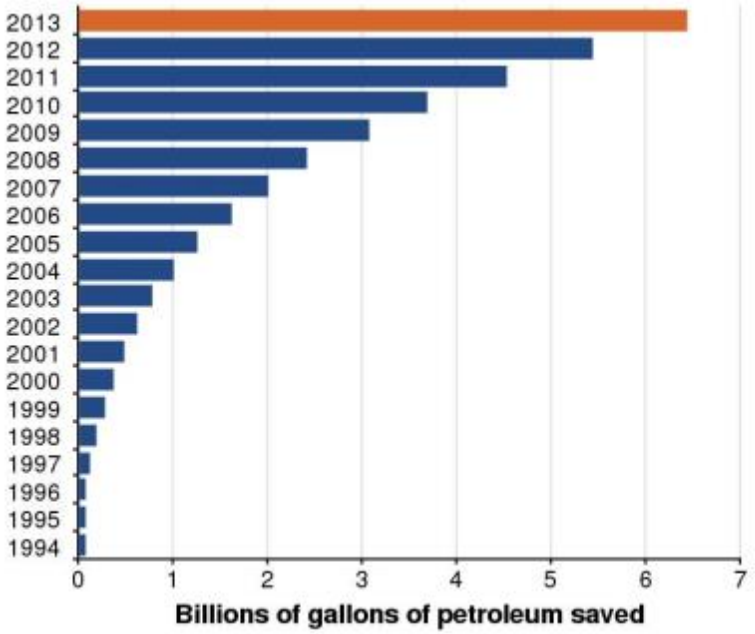

# VTO Deployment – Clean Cities *(leveraging people & resources)*

**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




Clean Cities
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






# 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



Clean Cities
U. S. Department of Energy

# 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)

USDRIVE
DRIVING RESEARCH AND INNOVATION FOR VEHICLE EFFICIENCY AND ENERGY SUSTAINABILITY

*Partners:*

USCAR, FCA, Ford, GM, bp, Chevron, ExxonMobil, DTE Energy, Edison, Phillips 66, EPRI, Tesla, Shell

*Associate Members at the Technical Level*

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

# 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

21st CENTURY TRUCK PARTNERSHIP



# 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**

TUDOR UNITED SPORTSCAR CHAMPIONSHIP

***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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**www.vehicles.energy.gov**