U.S. Department of Energy
Vehicle Technologies Office Overview

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

Annual Merit Review and Peer Evaluation Meeting

June 2014

Patrick B. Davis

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

(Dollars in Thousands)	FY 2013	FY 2014 Enacted	FY 2015 Request
Batteries and Electric Drive Technology	111,663	108,935	135,531
Vehicle and Systems Simulation & Testing	44,763	43,474	39,500
Advanced Combustion Engine R&D	55,004	49,970	49,000
Materials Technology	40,336	38,137	54,069
Fuels and Lubricant Technologies	16,960	15,990	27,400
Outreach, Deployment and Analysis	34,439	31,231	50,400
NREL Site-Wide Facility Support	-	2,000	3,100
Total, Vehicle Technologies	**303,165**	**289,737**	**359,000**

Analysis: Joint FCTO and VTO Analysis Activity Published

Cradle to Grave Analysis of Energy Use and GHG Emissions Available at:

www.hydrogen.energy.gov/pdfs/14006_cradle_to_grave_analysis.pdf

Included review by industrial stakeholders, energy companies, automobile companies, electric generation organizations, and national laboratories

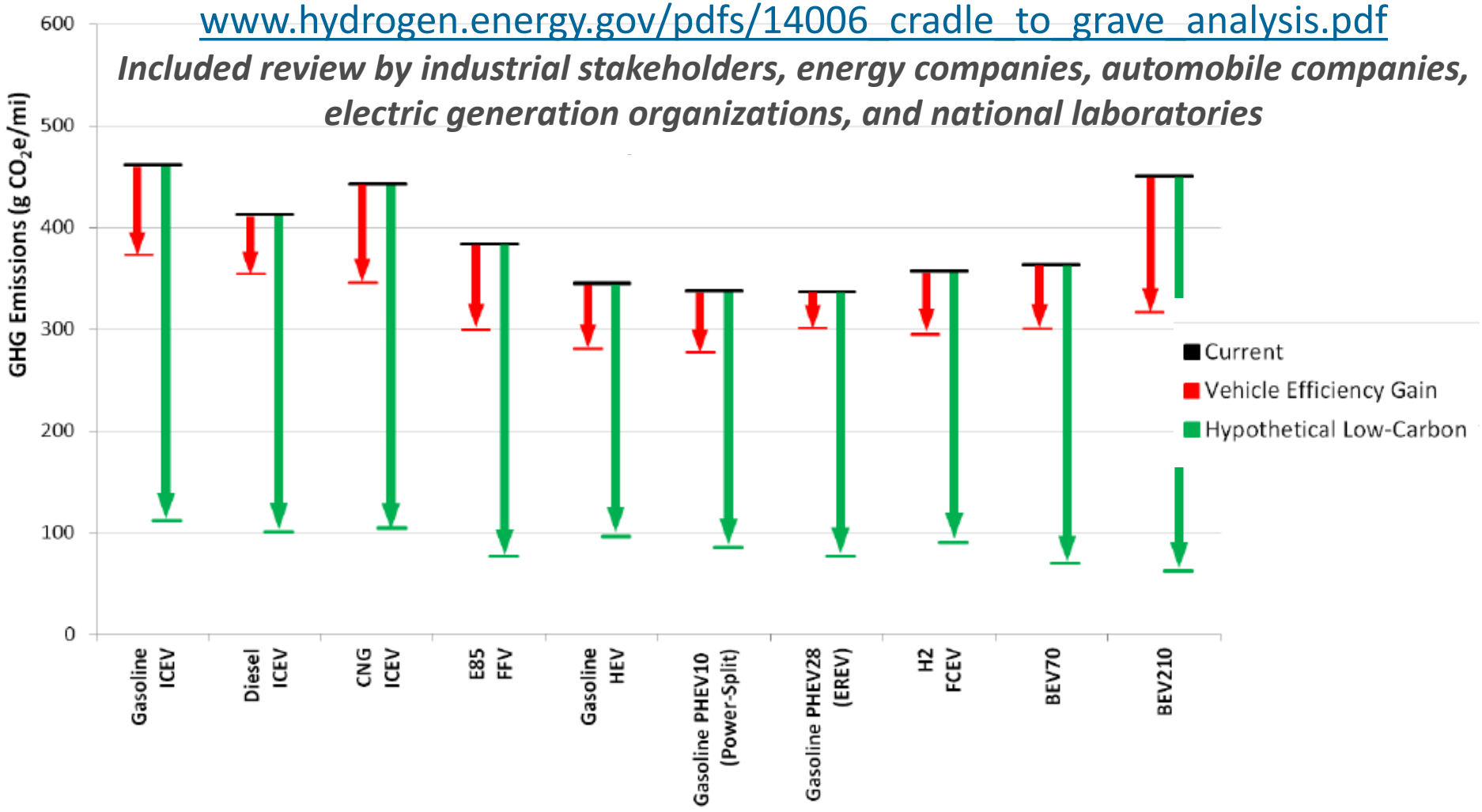
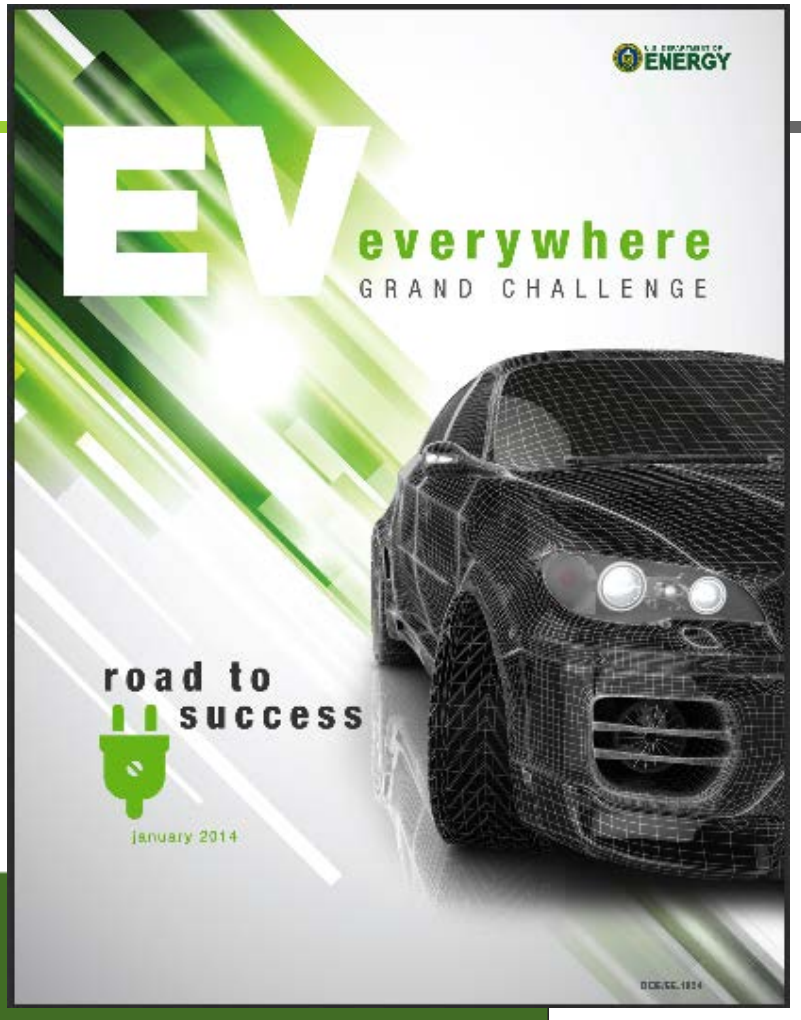


Figure 5. C2G GHG emissions for two bookends ("Current" and "Hypothetical low carbon"*) and the intermediate case ("Vehicle Efficiency Gains"). Contributions of vehicle cycle, fuel production and vehicle operations are shown in the appendix.

*100% biomass derived gasoline, diesel, natural gas, cellulosic ethanol and zero carbon based electricity for hydrogen and plug-in vehicles

EV Everywhere Grand Challenge

President Obama announces EV Everywhere North Carolina, March 2012



EV EVERYWHERE – EARLY SUCCESSES

The top four things you need to know

- DOE research and development has reduced the cost of electric drive vehicle batteries to $325/kWhr, 50% lower than just four years ago.
- In the first year of the Workplace Charging Challenge, more than 50 U.S. employers joined the Challenge and pledged to provide charging access at more than 150 sites.
- DOE investments in *EV Everywhere* technology topped $225 million in the last 12 months, addressing key barriers to achieving the Grand Challenge.
- Consumer acceptance is rapidly growing – 97,000 plug-in electric vehicles were sold in 2013, nearly doubling 2012 sales.

Workplace Charging Challenge Partners

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

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

2013-2014 Accomplishments/Activities:

- ✓ **Convened Executive Steering Group (ESG)** – set high-level priorities and strategic direction (VP level)
- ✓ **Conducted All Tech Team Meeting (ATTM)** – biannual gathering of all 12 teams; cross-cutting interactive discussion of best practices, challenges, and solutions
- ✓ **Published Technical Team Roadmaps** – key public documents that outline team goals and strategy through 2020
- ✓ **Completed Cradle-to-Grave Analysis (Phase I)** – cross-cutting, consensus-based study of full lifecycle petroleum/GHG reduction potential of multiple pathways
- ✓ **Developed "Fuels Proposal"** – set of new, agreed-upon precompetitive activities that expand Partnership scope to include biofuels and natural gas technologies
- ✓ **Published 2013 Accomplishments Report** – highlights key technical progress

USDRIVE

DRIVING RESEARCH AND INNOVATION FOR VEHICLE EFFICIENCY AND ENERGY SUSTAINABILITY

Partners:

USCAR, CHRYSLER, Ford, GM, bp, Chevron, ExxonMobil, PHILLIPS 66, TESLA, DTE Energy, EDISON, EPRI ELECTRIC POWER RESEARCH INSTITUTE

Associate Members at the Technical Level

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

SuperTruck Project On-Track

Team Leads
Cummins, Daimler, Volvo and Navistar

- **Status of 50% engine efficiency:**
  - Cummins and Daimler have achieved the 50% efficiency goal
  - Volvo has demonstrated 48% engine efficiency and is testing 50% BTE technologies in component test rigs

- **Status of 50% freight efficiency improvement:**
  - Cummins has demonstration on-road 76% freight efficiency improvement exceeding the target
  - Daimler exceeded 50% target on A-Sample vehicle through testing on Portland-Canyonville and San Antonio-Dallas routes
  - Volvo has demonstrated 43% freight efficiency improvements and determined pathway to achieve greater than 50%

21st CENTURY TRUCK PARTNERSHIP

SuperTruck Concept

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
- TARDEC hosting of a 21st Century Truck Partnership meeting

➢ Department of Transportation

- Bi-monthly meetings between VTO and DOT on vehicle related topics
- Coordination of activities on safety, lightweighting and connected vehicles
- DOT hosting of a 21st Century Truck Partnership meeting

➢ Environmental Protection Agency

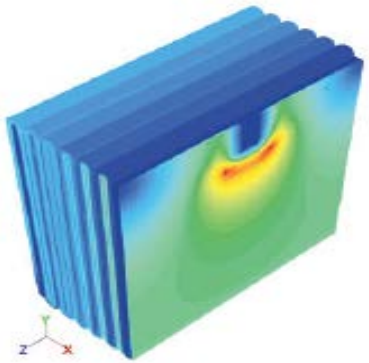
- Continued close collaboration of VTO with EPA across the breadth of vehicle technologies and jointly sponsoring www.fueleconomy.gov and green racing
- Coordination between VTO and EPA's Office of Transportation and Air Quality

Major Technical Areas

Battery R&D

Accomplishments

- **Amprius**: Silicon nanowire anodes for enhanced energy and reduced cost:
  - Provide 260Wh/kg, ~50% more than SOA cells
  - Good cycle life, less than 5-7% fade after 290 cycles
- **GM/Ansys/ESim/NREL**: Creation of a battery design software suite to reduce battery development time and cost:
  - First release in 12/2013
  - Permits thermal response, cycle life modeling, abuse response modeling of battery cells and pack
  - Customers currently using tool for battery design



Future Directions

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

- Develop and demonstrate next generation lithium ion PEV materials and cell technology containing high capacity silicon composite & metal alloy anodes
- Expand focus on beyond-Lithium-ion technology such as lithium metal anodes and solid state electrolytes.
- Develop lower cost material scale up and electrode processing technology.

Status

- On track to meet cost target of $300/kWh.
- Calendar life up to 10-15 years
- Cycle life between 3,000-5,000 deep discharge

FY 2015 Goal

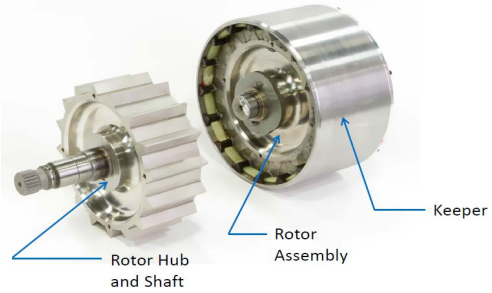
Reduce the cost of a PHEV40 battery to $300/kWh

Advanced Power Electronics and Electric Motors R&D

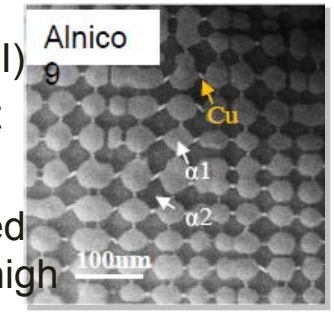
Accomplishments

- New solicitations issued for R&D:
  - VTO BAA- Commercialization of vehicle power electronics using wide bandgap devices
  - Incubator FOA - Impactful, "off-roadmap" technology R&D
- Ongoing industry R&D efforts:
  - Motors to reduce or eliminate rare earth elements (GE and UQM)
  - Scalable, modular inverter (GM)
  - High Temperature Capacitors (ANL, GE, Sigma)
  - Wide Bandgap Inverter (APEI)
- Developed new Alnico magnet alloy design
- Commercialization of integrated charger/converter capable of high temperature operation

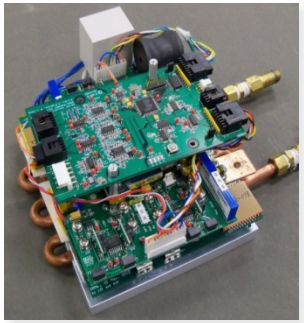
GM Inverter Module



UQM Rotor Design



Ames Magnet Alloy



ORNL Integrated charger dc-dc converter

Status

- On track to meet cost target of $15/kW in FY14
- Met cost target of $16/kW in FY13

Future Directions

- Reduce cost of electric traction drive systems by 4X
- Improve efficiency, performance and reliability
- Utilize WBG devices for high temperature operation
- Reduce or eliminate rare earth elements in electric motors
- Develop advanced materials and packaging to improve heat transfer
- Emphasize scalability and modularity for production
- Accelerate commercialization

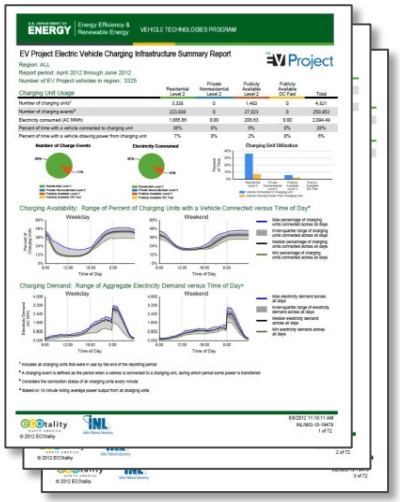
FY 2015 Goal

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

Vehicle & Systems Simulation & Testing

Accomplishments

- Use data and charging profiles analyzed for 11,500 PEVs and 17,000 charging stations.
  - http://avt.inel.gov
- Made laboratory test data publicly available through APRF Downloadable Dyna-mometer Database (D^3)
  - http://www.transportation.anl.gov/D3
- Demonstrated technology for wireless charging of EVs at 10kW and >85% efficiency
- Launched EV/Smart Grid Interoperability Center



Status

- 144 million test miles and data for 6 million charge events accumulated on 11,500 PEVs representing 72 PEV models
- Autonomie Vehicle Modeling & Simulation Software licensed by 750 users at 150 companies worldwide

Future Directions

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

FY 2015 Goal

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

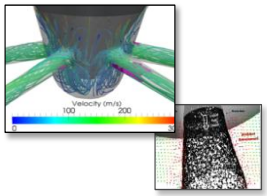
Advanced Combustion Engine R&D

Accomplishments

- Two teams achieved 50 % brake thermal efficiency engine target for *SuperTruck* (Cummins, Daimler)

- Lean-burn gasoline engine demonstrated 25 percent fuel economy improvement in light-duty vehicle (GM)

- Developed detailed simulation of fuel flow showing cavitation in a fuel injector (ANL)
- Non-precious metal catalyst for NO oxidation with improved thermal stability and sulfur tolerance (GM, PNNL)



- Demonstrated on-vehicle PM sensor capable of reducing PM filter regeneration fuel penalty (FST)

Future Directions

- Enable market introduction of high efficiency low-temperature combustion and lean-burn gasoline technology.
- High performance computing to develop detailed simulation models of engine combustion & emission control.
- Develop catalysts capable of 150 deg C conversion for future high-efficiency engines
- Demonstrate 45% efficiency using a turbulent jet ignition system.
- Develop a production prototype PM sensor.

Status

- Cost-shared cooperative awards, to meet 2020 goals for passenger vehicle fuel economy improvements, will be announced in FY 2014.
- Competitive solicitation to meet heavy-duty engine efficiency goals will be released in FY 2015.

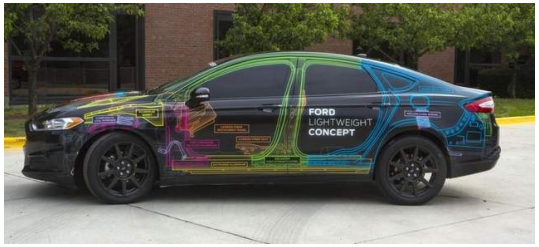
FY 2020 Goals

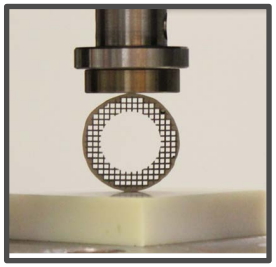
- Improve gasoline and diesel passenger vehicle fuel economy by 35% and 50%, respectively (compared to 2009 gasoline vehicle)
- Improve the heavy-duty diesel engine efficiency to 55% (30% fuel economy improvement over 2009 vehicle).

Materials

Accomplishments

- **MMLV Mach I** – Completed design/CAE and build of a multi-material, lightweight vehicle with >23% weight reduction compared to conventional vehicles (VEHMA, Ford).
- **Low Cost Carbon Fiber -** Validated commercial scale process for manufacturing carbon fiber using precursors with 25% lignin (Zoltek)
- **Propulsion Materials—**Updated performance model for diesel particulate filter enable improved use cycle; lower fuel penalty and efficient cycle conditions





Future Directions

- Develop high-strength, low-cost aluminum sheet alloys and manufacturing processes
- Demonstrate Integrated Computational Materials Engineering techniques for carbon fiber composites
- Develop high-performance, low-temperature catalysts for exhaust aftertreatment

Status

- Multimaterial vehicle Mach I build complete
- Baseline cost model complete
- Cost model for 40% weight reduction complete

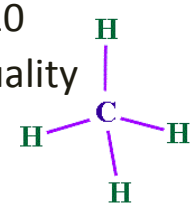
FY 2015 Goal

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

Fuel and Lubricant Technologies

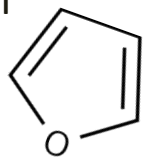
Accomplishments

- Demonstrated 2% fuel economy improvement with advanced additives, relative to Mobil 1 (2015 goal)
- Demonstrated RCCI operating range of 75% of non-idling portions of the city (UDDS) and highway (HWFET) light-duty federal drive cycles
- Full-scale production and strong sales of 11.9L natural gas engine supported under FY 2010 solicitation – "launch quality best to date" (CWI)



Future Directions

- 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
  - Determine optimum set of fuel properties for low temperature combustion
- Continue fit-for-service evaluations of alternative fuels – with emphasis on candidate "drop-in" biofuels
- Expand work in natural gas



Status

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

FY 2020 Goals

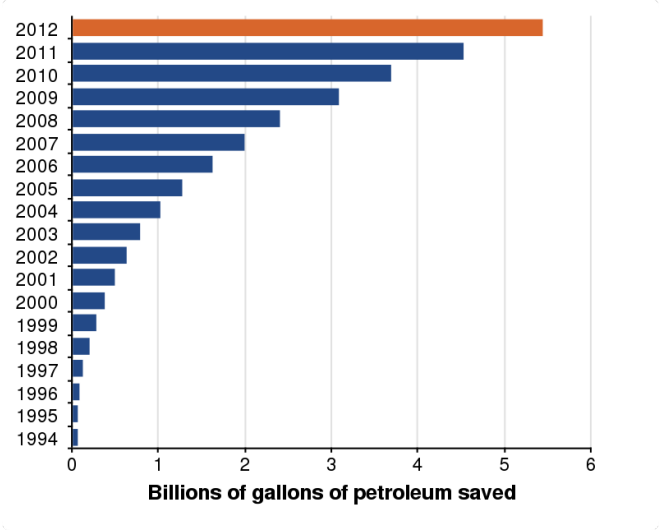
Demonstrate cost effective lubricant with 4% fuel economy improvement relative to Mobil 1

Demonstrate expanded operational range of advanced combustion regimes to >95% of LD Federal Test Procedures

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

Accomplishments

- Saved over 6 billion gallons of petroleum since 1993
- Collaborate with 23 large fleets through National Clean Fleets Partnership and 22 parks through the National Parks Initiative
- 36 community readiness projects expanding alternative fuel markets
- Projects that have deployed nearly 1,500 stations and 9,000 vehicles
- Websites that have reached hundreds of millions of users with fuel economy and alt fuel data



Clean Cities
U. S. Department of Energy

Future Directions

- 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
- Focus on transforming vehicle fleets in key, influential niche markets
- 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

2014 State of the Union

"I'll build on that success by setting new standards for our trucks so we can keep driving down oil imports and what we pay at the pump."

"Congress can help by putting people to work building fueling stations that shift more cars and trucks from foreign oil to American natural gas."

"An autoworker fine-tuned some of the best, most fuel-efficient cars in the world and did his part to help America wean itself off foreign oil."

- President Barack Obama

President Obama Highlights SuperTruck Success

February 2014

SuperTruck at DOE

February 2014

Assistant Secretary Danielson at the NASCAR/Sprint Workplace Charging Challenge Event, February, 2014

U.S. DEPARTMENT OF ENERGY workplace charging challenge

NASCAR

Automotive Media Partners Leverage DOE Information

MotorWeek
Television's Original Automotive Magazine

- > 150 segments produced to date on EVs, alternative fuels, advanced vehicles, fuel economy, EcoCAR, other VTO highlights
- Bi-weekly Clean Cities' success stories
- Programs air on PBS, Discovery, Velocity, and American Forces Network worldwide on allied military bases
- Features available on Clean Cities' websites, FE.gov, YouTube

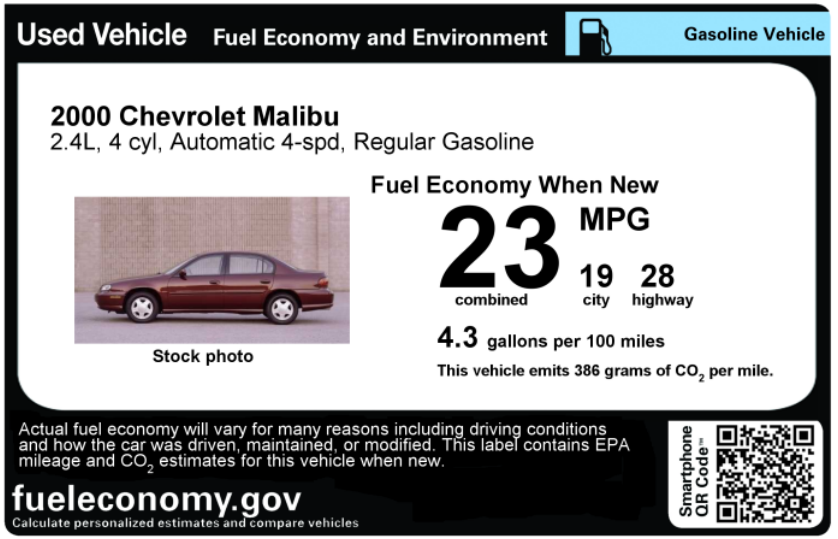
23

Clean Cities highlights over past 12 months

- Celebrated 20th Anniversary as a national deployment program
- FuelEconomy.gov 30 years of vehicle data and has surpassed 300M users; introduced Used Car label
- National Clean Fleet Partners has grown to 23 members:
  - **Enterprise Holdings** – 21 of their car rental locations now offer PEVs and 80% of their 500 airport shuttle buses are powered by alternative-fuel
  - **AT&T** – Deployed their 8000th CNG vehicle as part of their plan to place 15,000 AFVs in service by 2018
  - **United Parcel Service** – Announced plans to deploy 1000 propane delivery trucks and build 50 propane fueling stations
- EV Scorecard tool released for rollout to thousands of communities along with PEV Readiness Guide and Lesson Learned

Clean Cities

U. S. Department of Energy



Secretary Moniz Tours the Washington Auto Show, Announces Vehicles Program Wide Solicitation, January, 2014

THE WASHINGTON AUTO SHOW
The Public Policy Show

Secretary Moniz Announces Nearly $50 Million to Advance High-Tech, Fuel Efficient American Autos

" The new research and development funding announced today will help support our domestic automakers' continued growth and make sure that the next generation of advanced technology vehicles are built right here in America,"
- *Secretary Moniz*

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

EcoCAR2: Plugging into the Future

EcoCAR 2 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 built its own unique PHEV architecture and renewable fuel

Launch of EcoCAR3: Secretary Moniz Unveils the Vehicle Platform

April, 2014

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

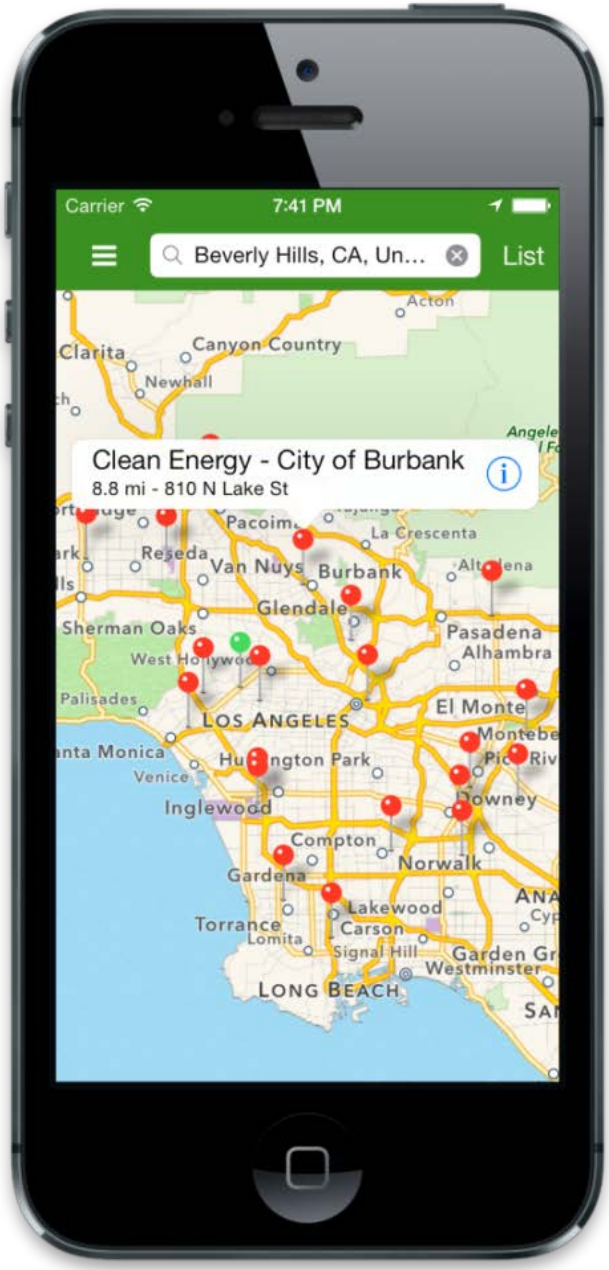
Mobile Station Locator App Available on iTunes – It's Free!

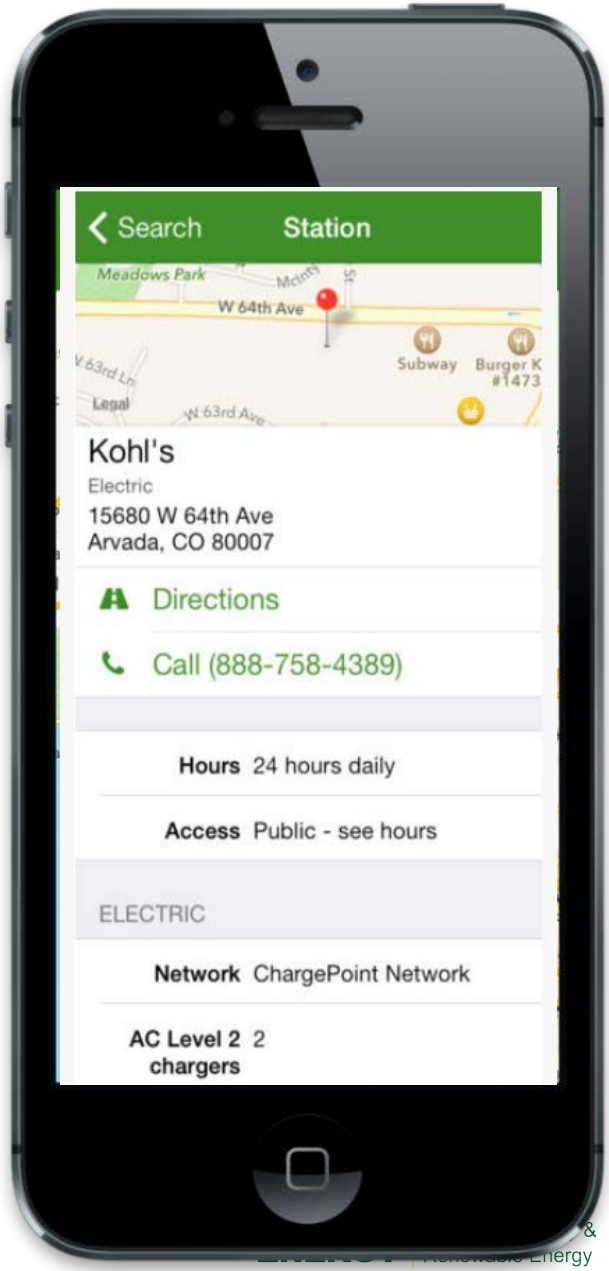
View In iTunes

Free

Category: Navigation
Released: Nov 04, 2013
Version: 1.0
Size: 2.4 MB
Language: English
Seller: National Renewable Energy Laboratory
© National Renewable Energy Laboratory
Rated 4+

Compatibility: Requires iOS 6.1 or later. Compatible with iPhone, iPad, and iPod touch. This app is optimized for iPhone 5.





Contact Information

Patrick Davis
Program Manager
patrick.davis@ee.doe.gov

www.vehicles.energy.gov