Quadrennial Technology Review-2015

Chapter 9: Advancing Clean Transportation and Vehicle Systems and Technologies

Public Webinar

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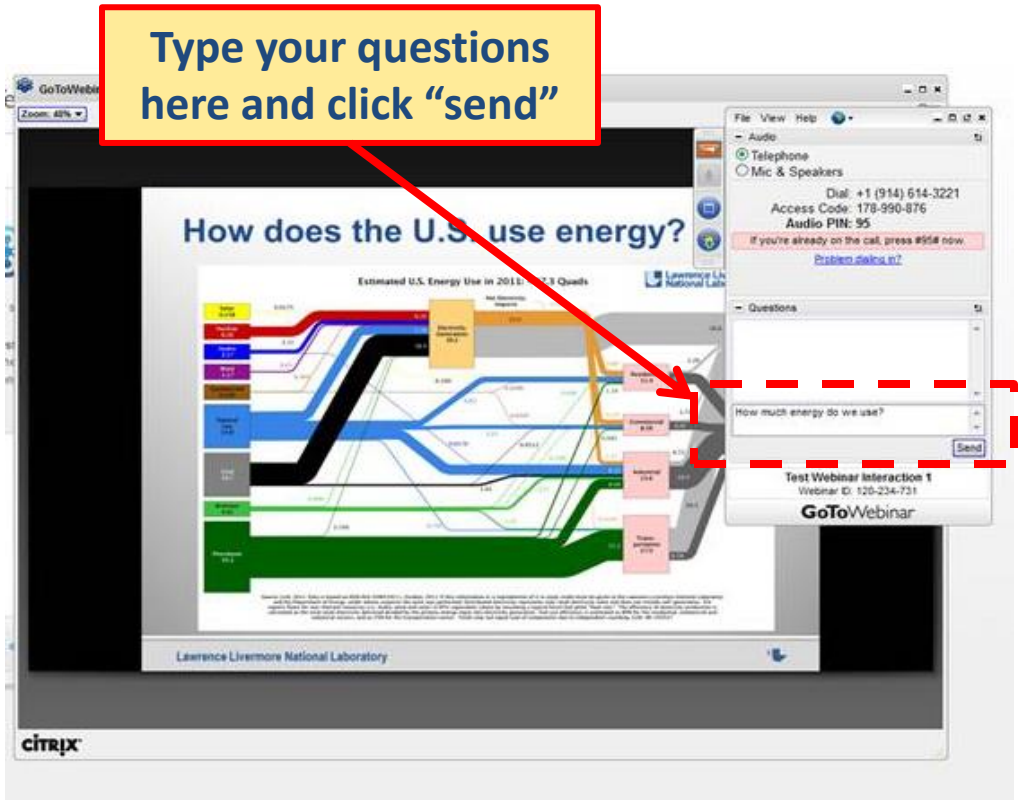
2015-02-18

Webinar Logistics

- Due to the large number of expected participants, the audio and video portions of this webinar will be a “one way” broadcast. Only the organizers and QTR authors will be allowed to speak.

- Submit clarifying questions using the GoToWebinar control panel. Moderators will respond to as many questions as time allows. Substantial input regarding chapter content should be submitted by email to: DOE-QTR2015@hq.doe.gov



QTR 2015 Chapter Outline

Introduction

1. Energy Challenges
2. What has changed since QTR 2011
3. Energy Systems and Strategies

Assessments

4. Advancing Systems and Technologies to Produce Cleaner Fuels
5. Enabling Modernization of Electric Power Systems
6. Advancing Clean Electric Power Technologies
7. Increasing Efficiency of Buildings Systems and Technologies
8. Increasing Efficiency and Effectiveness of Industry and Manufacturing
9. **Advancing Clean Transportation and Vehicle Systems and Technologies**
10. Enabling Capabilities for Science and Energy

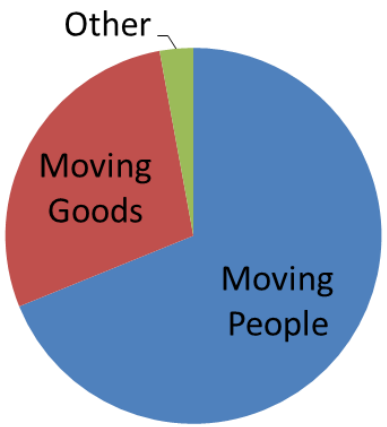
Integrated Analysis

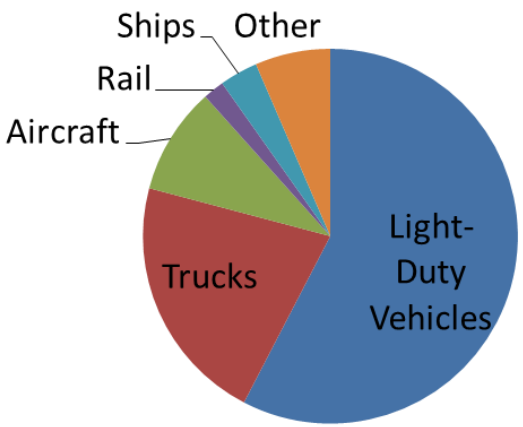
11. U.S. Competitiveness
12. Integrated Analysis
13. Accelerating Science and Energy RDD&D
14. Action Agenda and Conclusions; Web-Appendices

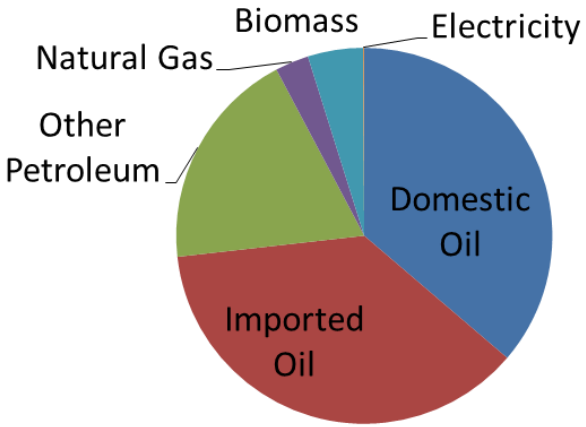
Web Appendices

Chapter Overview

- Transportation is 10% of GDP, and provides essential services for all aspects of the economy and quality of life
- But it is 93% petroleum dependent, represents 70% of all U.S. petroleum use, and produces 27% of U.S. emissions
- Overall, the U.S. uses 21% of the world's oil supply, is 11% of the worlds production, but has just 2% of the world's proven reserves.





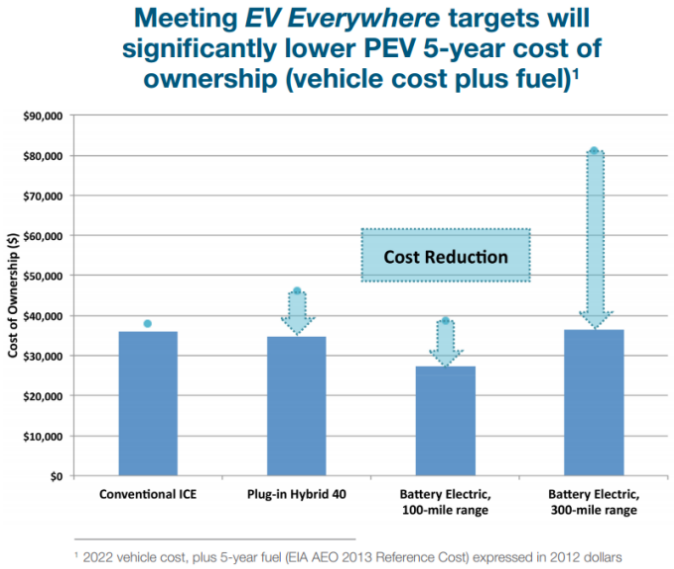


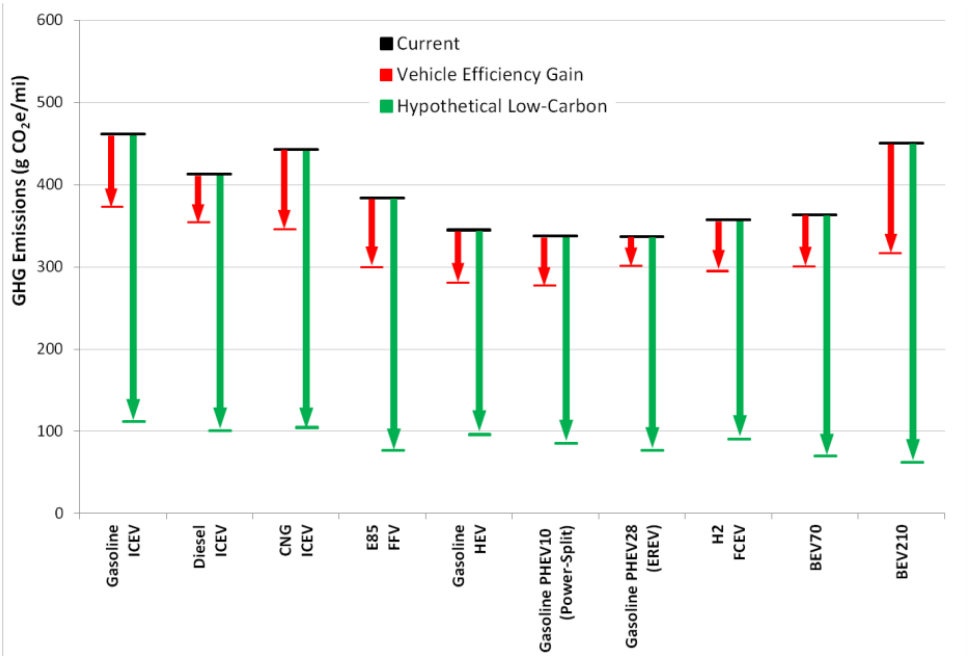
26.8 Quadrillion Btu of transportation energy use

(note: does not include approximately 2.2 quadrillion Btu for offroad equipment)

Metrics

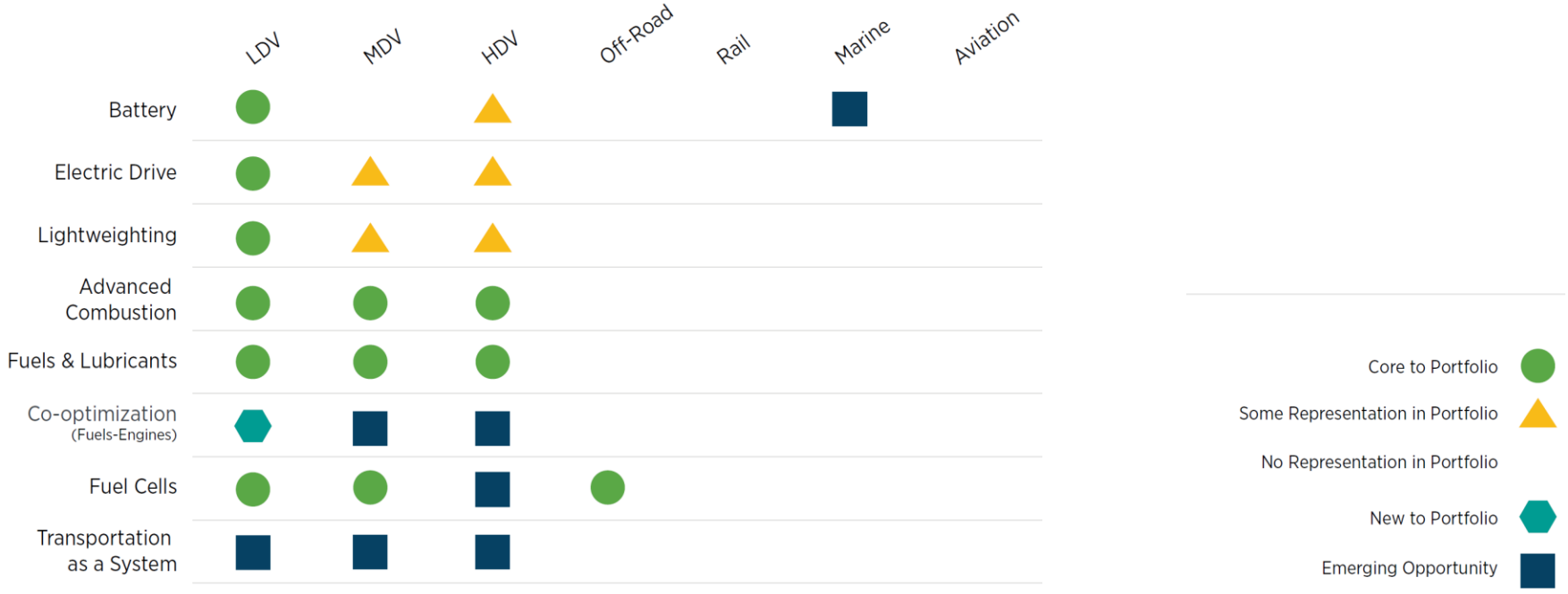
- Metrics differ by technology, but all systems are evaluated based on the potential cost competitiveness as well as impacts on petroleum use and greenhouse gas emissions





Systems Approach

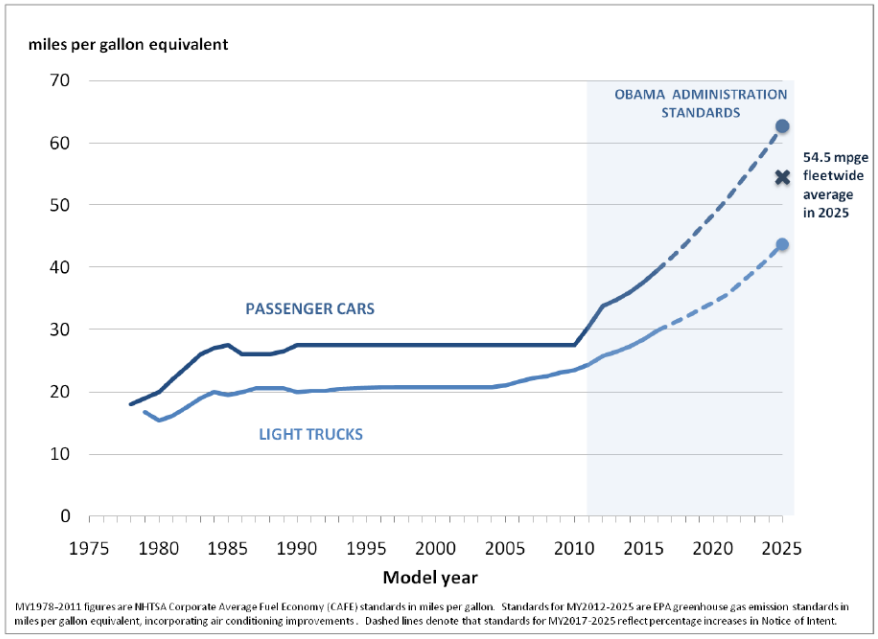
- Historically, most DOE investment has been in technologies for light-duty vehicles (LDVs) due to their large energy use and technology potential
- R&D candidate technologies can affect multiple modes and a systems perspective is necessary to evaluate opportunities



Context

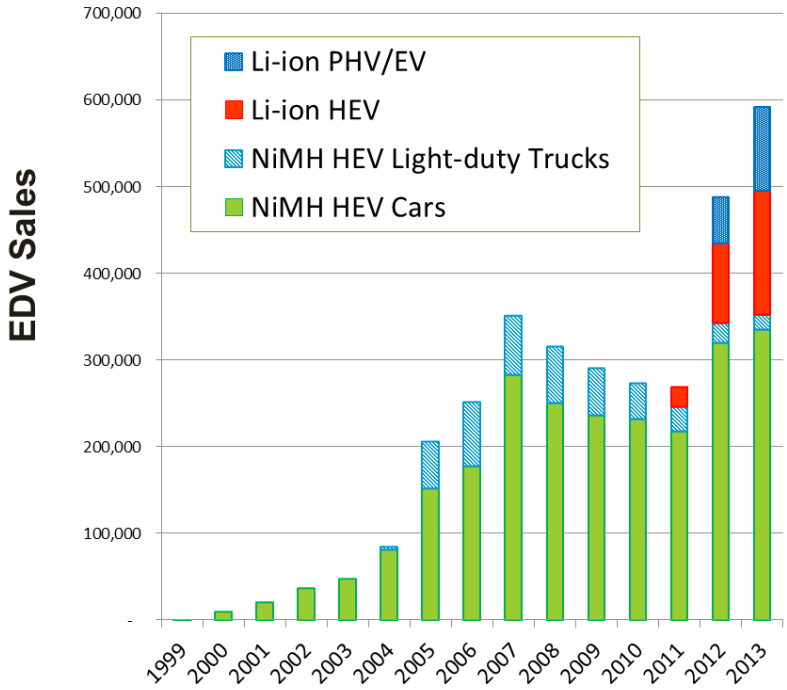
- CAFE is driving increased efficiency for light-duty vehicles and heavy trucks
- Electric drivetrain and alternative fuel vehicles are now widely available
- Available vehicle, fuel, and system options define an 'option space' for improvements in energy efficiency, carbon intensity, and use intensity to meet national goals

CHART 2: LIGHT-DUTY VEHICLE FUEL ECONOMY STANDARDS, 1978-2025



MY1978-2011 figures are NHTSA Corporate Average Fuel Economy (CAFE) standards in miles per gallon. Standards for MY2012-2025 are EPA greenhouse gas emission standards in miles per gallon equivalent, incorporating air conditioning improvements. Dashed lines denote that standards for MY2017-2025 reflect percentage increases in Notice of Intent.

U.S. Electric Drive Vehicle Sales, by Technology (1999-2013)

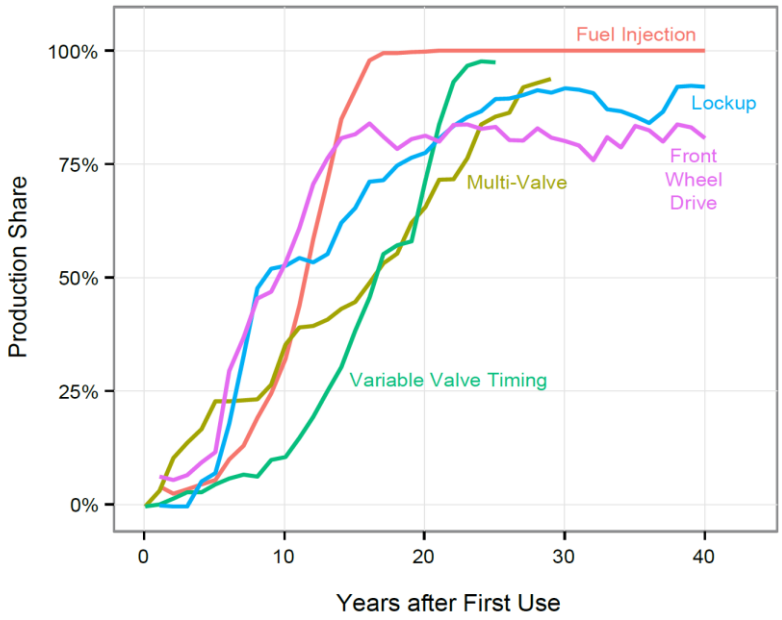


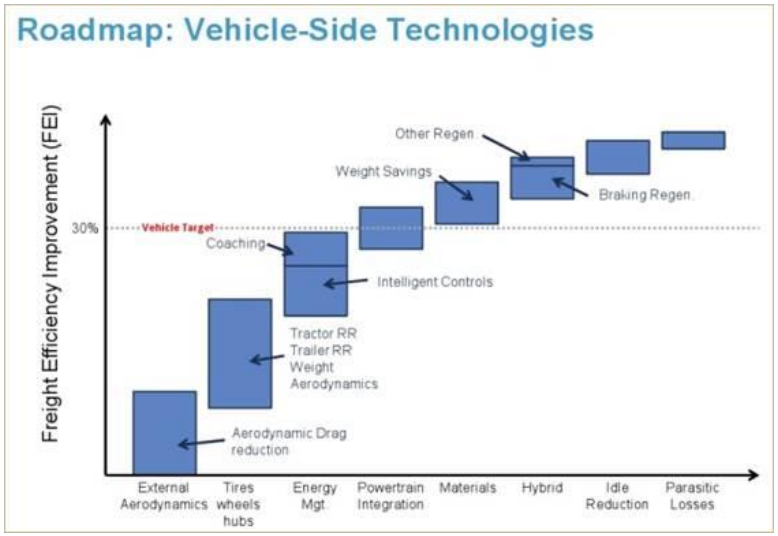
Chapter Outline

1. Transportation Overview
2. Combustion Systems
3. Lightweight Vehicles
4. Plug-in Electric Vehicles
    1. Batteries
    2. Power Electronics and Motors
5. Fuel-Cell Electric Vehicles
    1. Fuel Cells
    2. On-board Hydrogen Storage
6. Other Modes
7. Vehicle Automation
8. Transportation Systems

2.1 Combustion Efficiency

- Significant efficiency opportunities exist for both light and heavy-duty vehicles, including “supertruck”
- These opportunities can be integrated into the vehicles that make up the majority of vehicles on the road today
- Includes combustion engine efficiency, improved emissions controls that reduce parasitic losses from pollution controls, fuel - engine co-development, waste heat recovery, and more



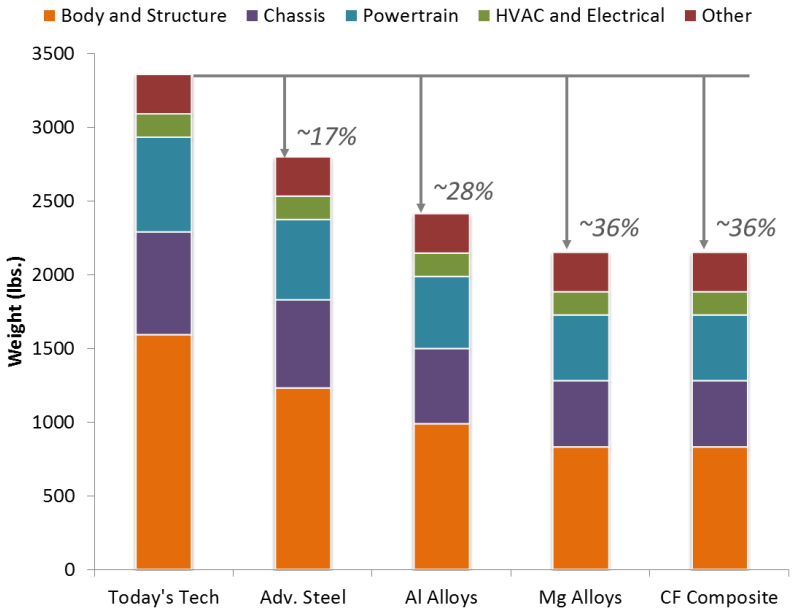


EPA Fuel Economy Trends 2014

Daimler Trucks North America

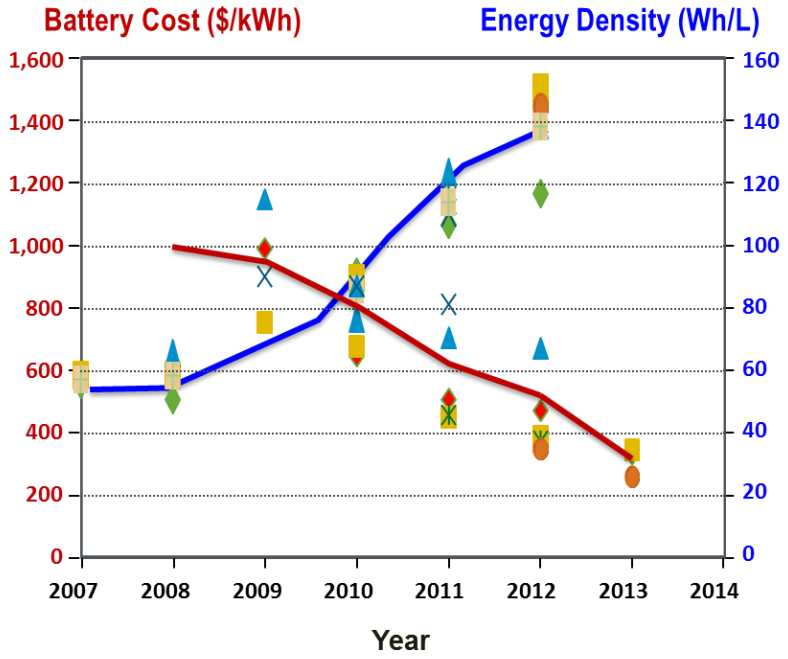
2.2 Lightweighting

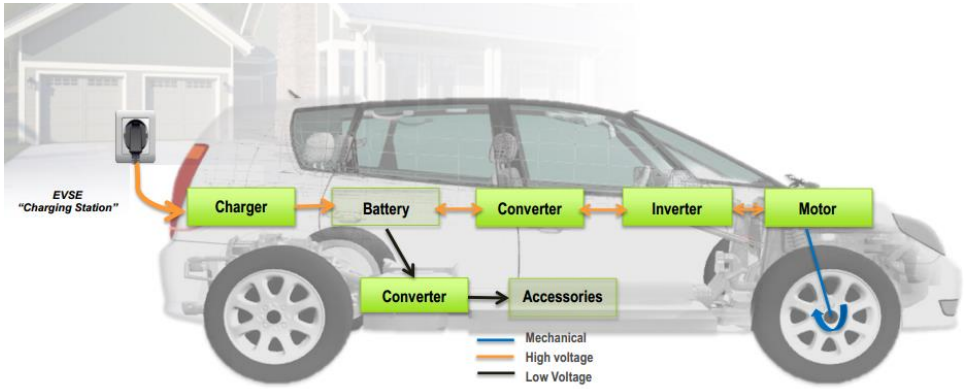
- Reduced vehicle weight improves vehicle efficiency: 10% weight reduction generation translates to 6-8% improved MPG
- Research Includes materials such as aluminum, magnesium alloys, carbon fiber polymer matrix composites
- Benefits all drivetrains and extends range for the same energy storage reservoir
- Advanced materials can also apply to other transportation opportunities, such as H_2 storage and advanced combustion engines



2.3 Plug-In Electric Vehicles

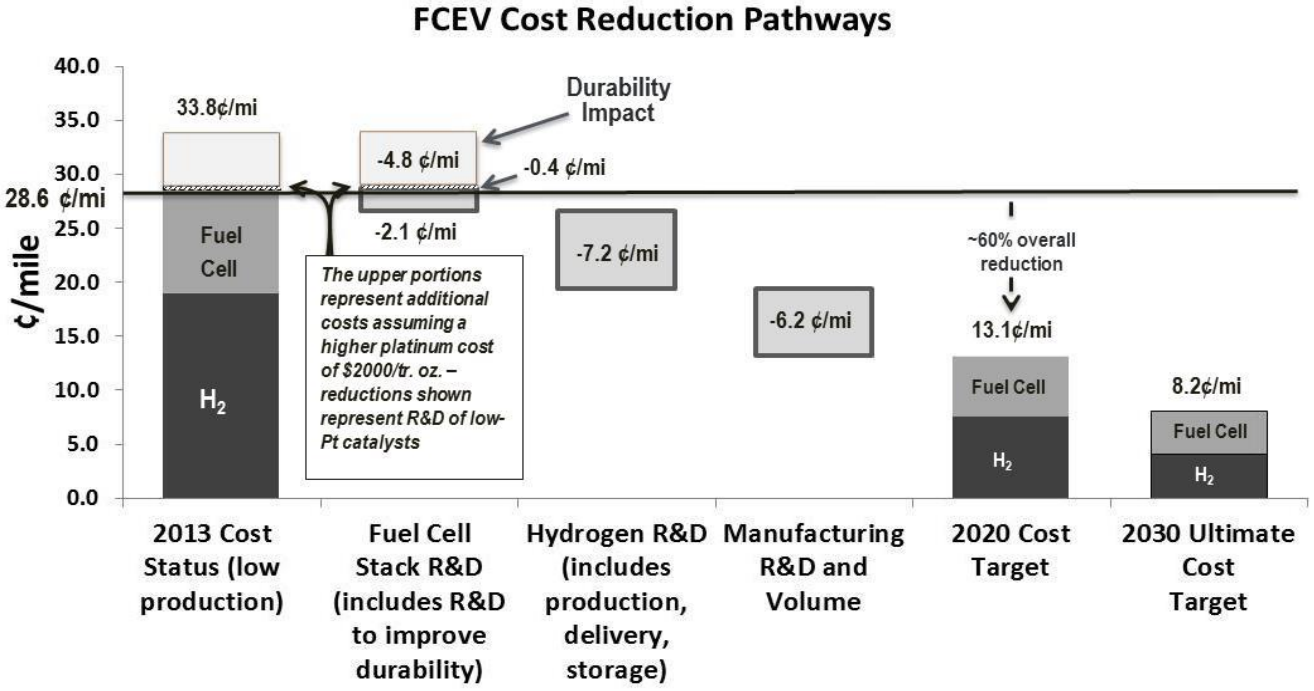
- Plug-in electric vehicles (PEVs) draw their energy partially or entirely from an external electric source by storing the energy in an on-board battery and using that energy to run the vehicle on electric motors.
- Technology opportunities include batteries and energy storage options to reduce cost and improve energy density, power electronics and motors, and system design.





2.4 Fuel-Cell Electric Vehicles

- Fuel cell electric vehicles (FCEVs) derive motive energy from hydrogen through use of a fuel cell, which generates electricity by converting hydrogen and atmospheric oxygen to water.
- FCEVs can be refueled in a few minutes, and used for a wide range of vehicle sizes and performance requirements, and can achieve a driving range of more than 300 miles.
- Research topics include automotive fuel cells, including reduced stack cost and improved reliability, onboard H_2 storage, and system design.



2.5-2.7 Content

- Other Modes
  - DOE has generally invested in LDVs and trucks as the biggest energy opportunities in transportation.
  - Several other modes expect significant activity growth, but have fewer opportunities for electric drivetrains so present a key future challenge. Offroad and international modes are often not included in analysis or goals.
  - Modes examined include aircraft, including fuel design (renewable jet), rail, marine, offroad (including mining, agriculture, construction), pipeline
- Automation and Information Technology
  - Automation is expected to have a variety of energy implications, both benefits and risks
  - Other information technology can improve transportation systems and may substitute for transportation in some cases
  - These are new potential areas for DOE
- Transportation System Effects

Other Key Issues

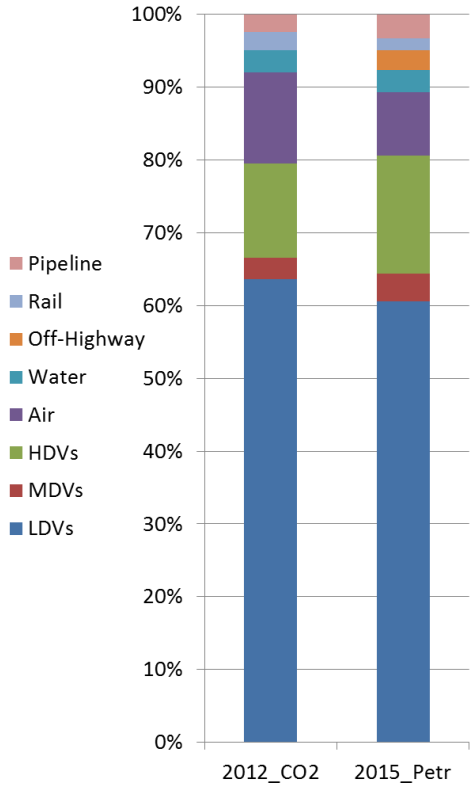
- Vehicle Miles Travelled (VMT) scenarios and futures
  - VMT has decreased since ~2005
  - Trend may continue due to demographic issues, technology, urbanization, etc.
- Fleet and technology turnover issues
  - Vehicle redesign happens over a 4-5 year period
  - Historically, advanced technology takes 10-15 years to fully enter the new vehicle fleet (and 15 more for the fleet to turn over)
  - New manufacturing technologies and more innovative business practices could improve this rate
- IT and advanced vehicles
  - Station locators, parking finding, trip planners may enable advanced vehicles and novel business models
- Refueling / charging strategies
  - Competing charging standards
  - Workplace charging
  - Public station needs

Other Technology Opportunities

- Deployment Opportunities
  - Early markets (forklifts, fleets, etc.)
  - Partnerships (Clean Cities, etc.)
  - Role of learning by doing
- Natural gas use in vehicles
  - Trucks
  - Light-duty vehicles
  - Strategic use discussion

Key Findings

- Significant technology opportunities exist in transportation to reduce petroleum use and greenhouse gas emissions

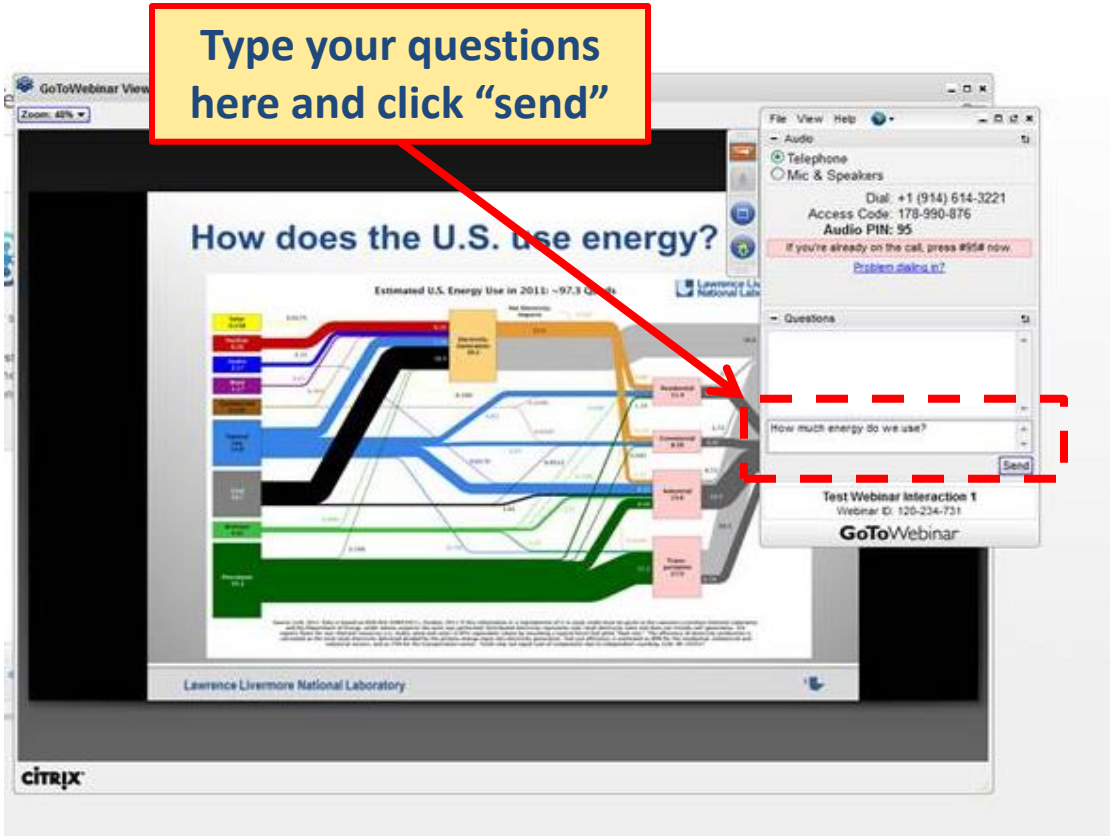


HDV	GHG Benefit	Petrol'm Benefit	Timing
Combustion	→ 25%	→ 25%	Near
Systems	→ 20%	→ 20%	Near

LDV	GHG Benefit	Petrol'm Benefit	Timing
Combustion	→ 25%	→ 25%	Near
LDV Systems	→ 20%	→ 20%	Near
Adv. Matls.	→ 20%	→ 20%	Mid
Electrification	→ 80%	→ 99%	Mid
Fuel Cell	→ 80%	→ 99%	Long

Public Input

- You are encouraged to submit questions using GoToWebinar's "Questions" functionality. The moderators will respond, via audio broadcast, to as many appropriate questions as time allows.



- If you have questions or comments that cannot be addressed during the webinar, email them to DOE-QTR2015@hq.doe.gov

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