Vehicles Technology Program
2012 Annual Merit Review

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

Propulsion Materials

Jerry Gibbs
Technology Development Manager
Propulsion Materials
Vehicle Technologies Program

Propulsion Materials Research Relevant to VT Goals

- Improve efficiency of advanced vehicles through innovative material solutions
- Critical enabler supporting Advanced Combustion, Thermoelectric, and Hybrid-Drive Systems
  - Material compatibility for Alternative Fuels
  - Materials for high efficiency CI/SI Engines
  - Thermoelectric materials
  - Materials for reliable high performance hybrid and EV drive systems
- Vehicle weight reductions and freight efficiency improvements through increased engine power density (hp/liter and hp/kg)

Material Research Role

Propulsion Materials Activities

Materials for Combustion Systems / High Efficiency Engines
Turbocharger, Valve train, Fuel Injection, Structural Components Head/Block, Sensors, Materials/Fuel Compatibility

Materials for Exhaust and Energy Recovery
DPFs, Catalysts, Thermoelectric Materials, Materials for high temperature structures

Materials for Electric and Hybrid Drive Systems
High Temperature Power Electronics Materials, Solder Joints, Materials/Coolant Compatibility, And Materials for Electric Drive Motors

Materials By Design
Materials Synthesis, Characterization, Multi-Scale Computer models, Testing Standards, and Coatings

VTP Team Collaborations

Advanced Combustion Engine

LD 45%e @ $30/kW
HD 55%e
Biofuels

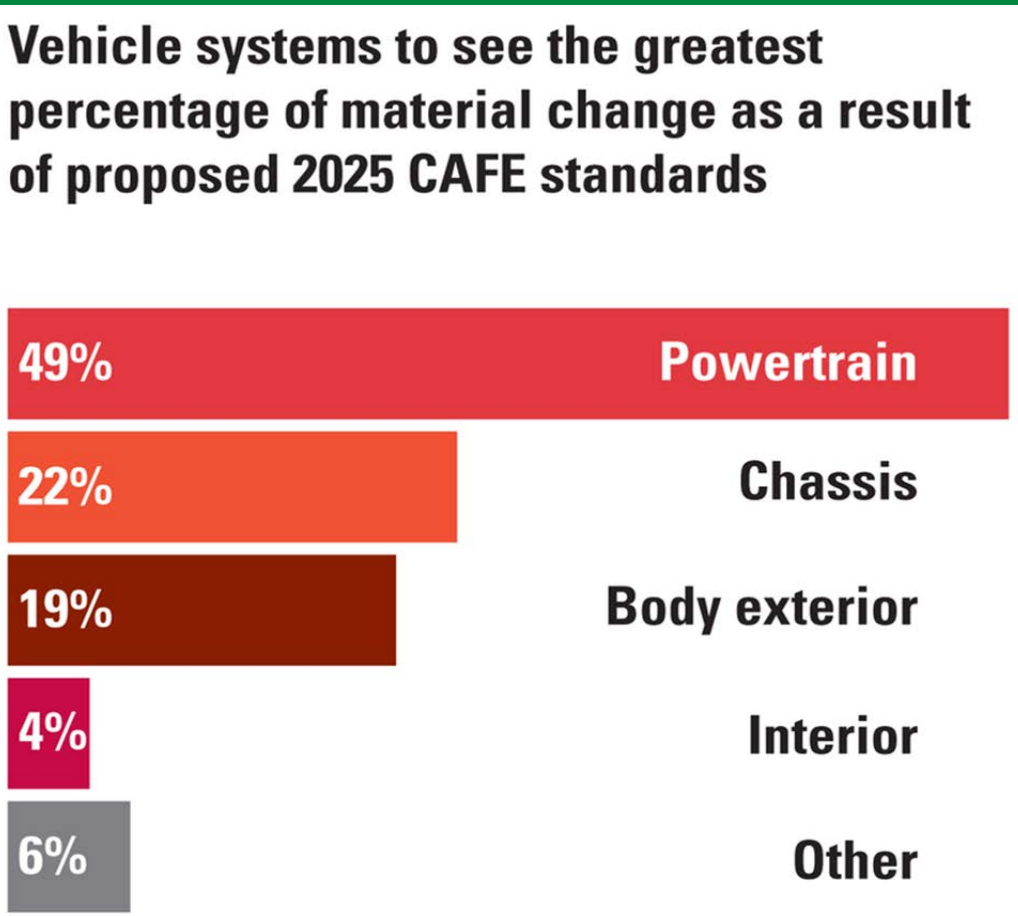
Hybrid Electric Systems

55kW @ $12/kW
300Whr @ $20/Whr

Fuels Technologies

Petroleum Displacement

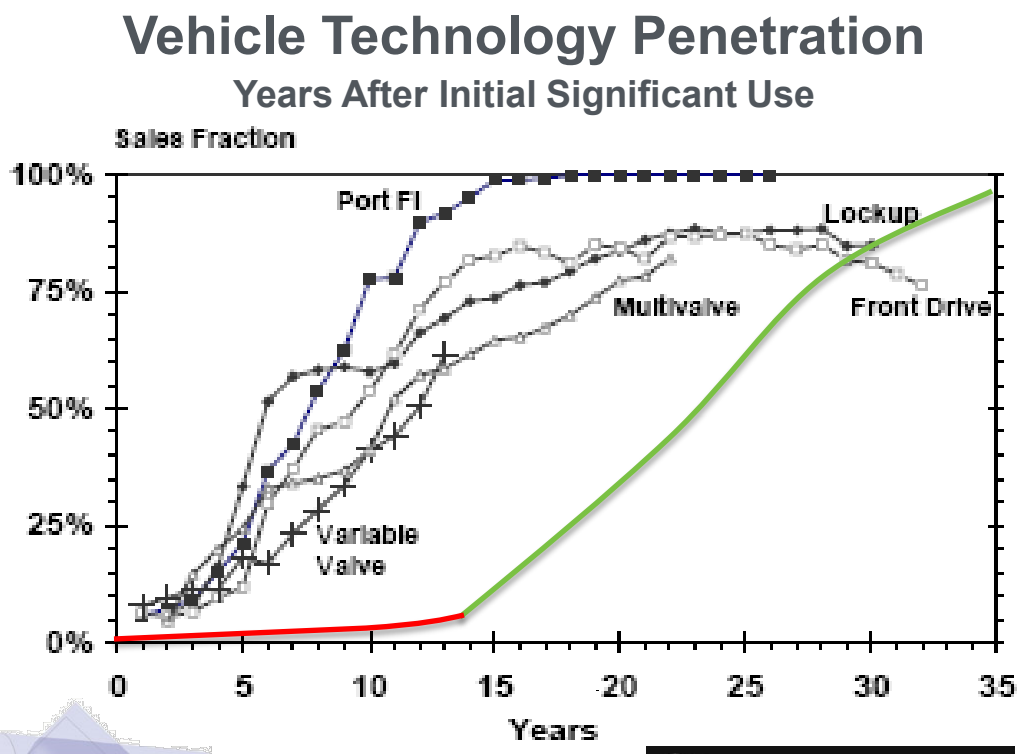
Materials will Be Key Going Forward

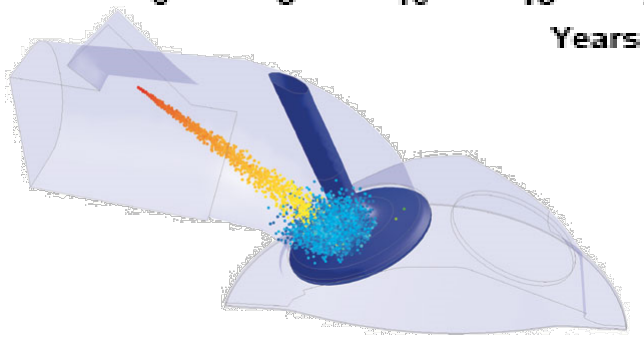


Source: 2011 WardsAuto/DuPont Survey of Auto Industry Challenges, conducted by Paramount Research

The auto industry's current **materials portfolio will need to be augmented** to meet new 2025 fuel economy standards, according to a WardsAuto and DuPont Automotive survey conducted in late July. - Green Car Congress, October 5, 2011

Planning is Critical





Food for Thought

- Design Process is about 4 years,
- For inclusion, new materials must be qualified before designs begin
- New materials typically take 10+ years to develop

Materials Research Must be Focused on the Horizon

March 2011 Materials Workshop

- Objectives: identify technology gaps to be overcome such that advanced materials systems are available for heavy & light duty vehicles
  - Lightweighting and Engine Efficiency Sub-Topic Areas:
    - Identify maximum potential reduction by vehicle class and time
    - Identify material requirements necessary to reach potential
    - Identify technical hurdles and gaps on the critical path
    - Identify time based cost targets

- 135 participants representing light duty vehicles (LDV) and heavy duty vehicles (HDV)
  - OEMs **(36)**
  - Material & Tier 1 suppliers **(43)**
  - U.S. Government experts **(8)**
  - Canadian government **(4)**
  - Trade Organizations **(5)**

Workshop Participating Organizations

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

Workshop Considerations

- Vehicle subsystems include:

- Structural systems:
  - Body structure
  - Chassis structures
  - Suspension and drivetrain systems
  - Engine and transmissions
  - Turbo-machinery
  - Exhaust and cooling systems

- Semi-structural and non-structural systems:
  - Appearance panels
  - Enclosures
  - Bumpers

- Materials considered:
  - Advanced high strength steels
  - Cast iron
  - Aluminum
  - Magnesium
  - Carbon fiber composites
  - Glass fiber composites
  - Unreinforced plastics
  - Advanced materials such as:
    - Titanium
    - MMCs
    - Ni-based alloys

Draft Weight Reduction Goals for LDVs

LDV Component Group	2020	2025	2030	2040	2050
Body	35%	45%	55%	60%	65%
Power-train	10%	20%	30%	35%	40%
Chassis/suspension	25%	35%	45%	50%	55%
Interior	5%	15%	25%	30%	35%
Completed Vehicle	***20%***	***30%***	***40%***	***45%***	***50%***

Draft Weight Reduction Goals for HDVs

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

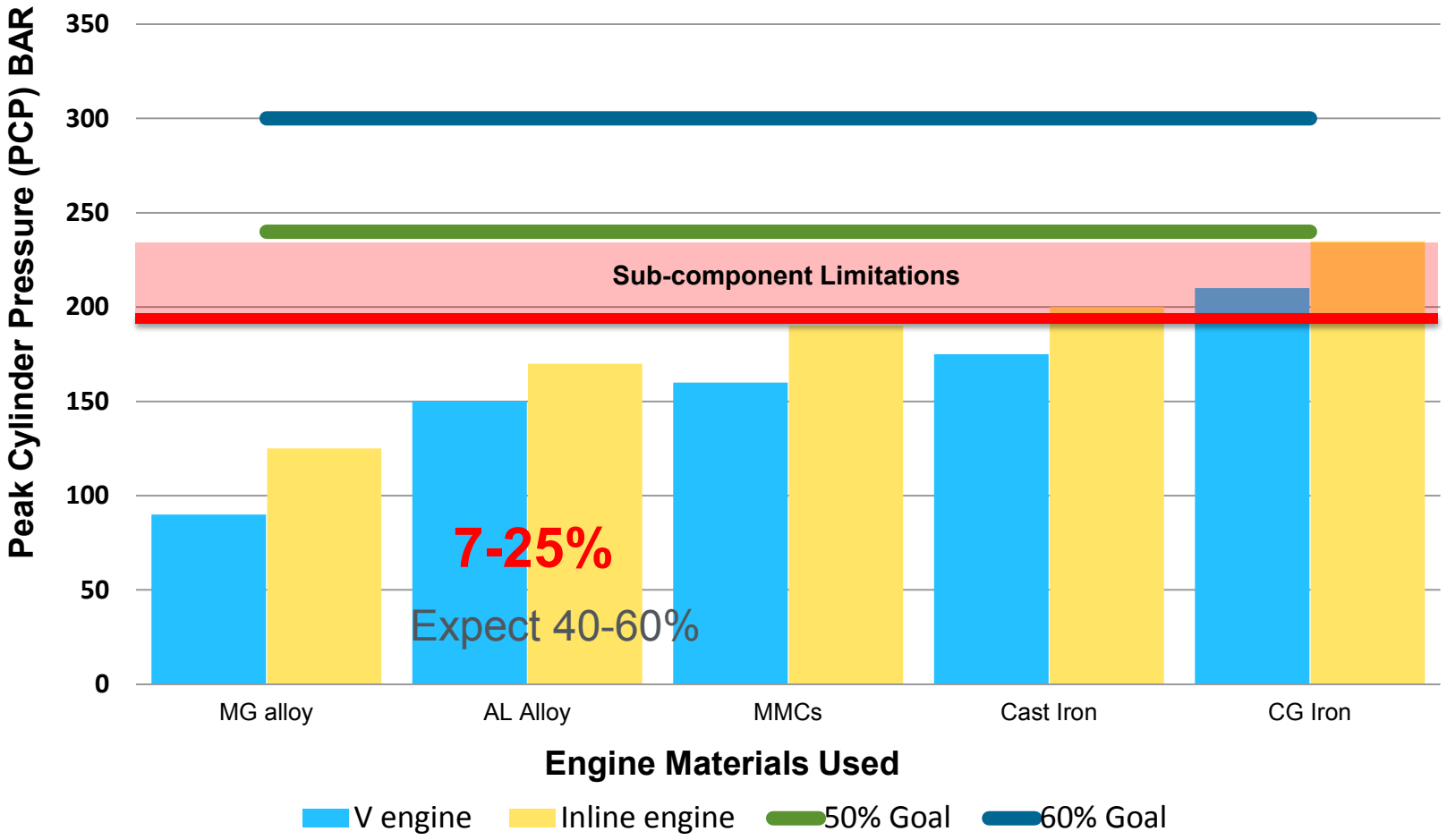
Class 8 Tractor Component Group	2020	2025	2030	2040	2050
Wheels and Tires	10%	20%	20%	25%	25%
Chassis/Frame	0%	10%	10%	20%	20%
Drivetrain & Suspension	0%	5%	10%	15%	20%
Misc. Accessories/Systems	5%	15%	25%	30%	35%
Truck Body Structure	15%	35%	45%	55%	60%
Powertrain	5%	10%	15%	15%	20%
Total Class 8 HDV	***6%***	***16%***	***22%***	***27%***	***31%***
Trailer (53 ft) Component Group					
Wheels and Tires	10%	20%	20%	25%	25%
Chassis/Frame	0%	10%	10%	20%	20%
Suspension	0%	5%	10%	15%	20%
Box/Other	5%	10%	15%	20%	25%
Total Trailer	***3%***	***9%***	***13%***	***19%***	***23%***
Truck and Trailer Combined Totals	**4.8%**	**13.2%**	**18.0%**	**23.6%**	**27.4%**

Engine/Transmission Metric Synergies
LDV and HDV – 2025 and 2050

	2010	2025	2050
Weight Reduction	Baseline - LDV Baseline – HDV	25% lighter - LDV 15% lighter - HDV	40% lighter- LDV 20% lighter- HDV
Power density **Fossil Fuel LDV ICE** **Fossil Fuel HDV ICE**	LDV Baseline Midsize Car -2.7L 196 HP (73.4 HP/L) LDT – 5L 308 HP (61 HP/L) 15L 475HP (32 HP/L) - HDV baseline	10% augmented –LDV 2.4L 196 HP (81 HP/L) 1.7L 139 HP (81 HP/L) 15% augmented -LDT – 4.3L 308 HP (71 HP/L) 30% augmented –HDV 11L 475HP (45HP/L)	30% augmented – LDV 1.9L 196 HP (104 HP/L) 0.9L 98 HP (104 HP/L) 30% augmented -LDT – 3.5L 308 HP (78 HP/L) 40% augmented-HDV 9L 475HP (53 HP/L)
Efficiency **Waste heat recovery – LDV** **Thermal - LDV** **Thermal - HDV**	5% recovery – LDV Turbo Machinery LDV Thermal Baseline 30% efficiency 42% efficiency – HDV	20% recovery – LDV Turbo / Thermoelectric(TEs) LDV - 25% improvement (37% e) 50% efficiency- HDV	50% recovery – LDV Turbo/TEs/ Rankine Cycle LDV - 50% Improvement (45% e) 60% efficiency- HDV
Exhaust Temperatures (Exhaust Valve to Turbo Inlet)	870 C - LDV 700 C- HDV	950 C - LDV 800 C - HDV	1000 C - LDV 900 C - HDV
Cylinder Peak Pressures	Baseline – LDV ~ 50 bar 190 bar - HDV	75 bar - LDV gasoline 193 bar - LDV diesel 250 bar - HDV	103 bar - LDV gasoline 206 bar - LDV diesel 300 bar - HDV

Background Graphic Courtesy of Daimler Trucks North America

Current Material Limits



Based on 1999 study

Response to Workshop

- In 2012 three new Propulsion Materials Solicitation topics were released:
- Advanced Light-weight Cast alloy development for LD applications and High-strength Cast Alloys for HD application (two topics). Each topic includes:
  - ICME application and gap analysis
  - Alloy Development
  - OEM technology transfer path
  - Alloy validation
  - Component validation
- SBIR Topic: low-temperature catalysts materials targets:
  - 90% effectiveness at 150C

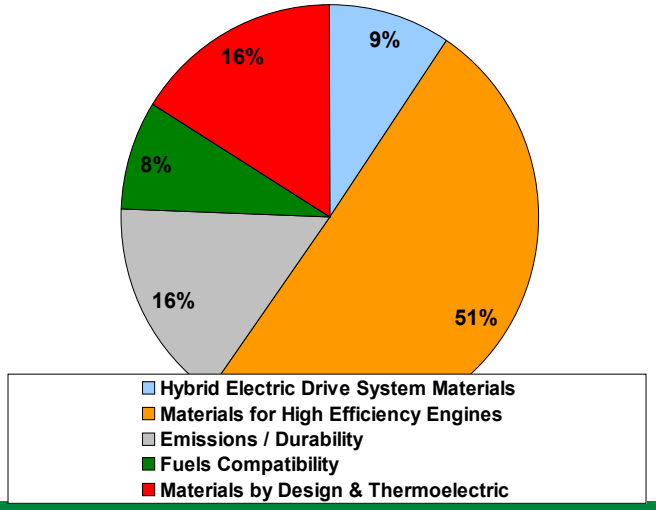
Project/Agreement Management

- Prospective New Agreements in Each Technology Area are Evaluated On:
  - Relevance to Vehicle Technologies Program Objectives
  - Supported Team's Priorities
  - Potential for Co-funding from other VTP Teams
  - Industry Support for Activity
  - Perceived risk/benefit to program
  - Mechanism for Technology Transfer
- Existing activities are evaluated annually
  - Identify activities that should be transitioned to other VTP Teams or Industry
  - Identify activities requiring changes in effort
- Approximately 15% of activities are retired each year
- Goal to migrate over 70% of portfolio to competitively awarded Solicitations by 2014

Funding Direction

Funding	2007	2008	2009	2010	2011	2012	2013 Request
Direct Funding	5.8	8.5	10.6	10.9	11.8	8.1	4.1
Solicitations	0.1	1	0.1	0.1	1.2	4.9	4.9
Total	5.9	9.5	10.7	11	13	13	9

Solicitations %	1.7%	10.5%	0.9%	0.9%	9.2%	37.7%	54.4%



Thank You

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

www.vehicles.energy.gov

Jerry Gibbs
Propulsion Materials
Technology Development Manager
Vehicle Technologies Program
Email: jerry.gibbs@ee.doe.gov