FreedomCAR and 21st Century Truck Partnerships

Hydrogen Production and Northwest Transportation Conference
Seattle, Washington
June 16, 2003

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U.S. Department of Energy

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Advanced Technologies for High-Efficiency Clean Vehicles

Vehicle Systems
- Aerodynamics
- Rolling Resistance
- Accessory Loads
- Systems Analysis and Modeling
- Non-Highway

Combustion and Emissions Control
- Combustion R&D
- Emissions Controls
- Clean Combustion

Fuels
- Advanced Petroleum Based Fuels
- Non-petroleum Fuels – Synthetic & Renewable
- Fischer-Tropsch Fuels & Blendstocks
- Advanced Lubricants

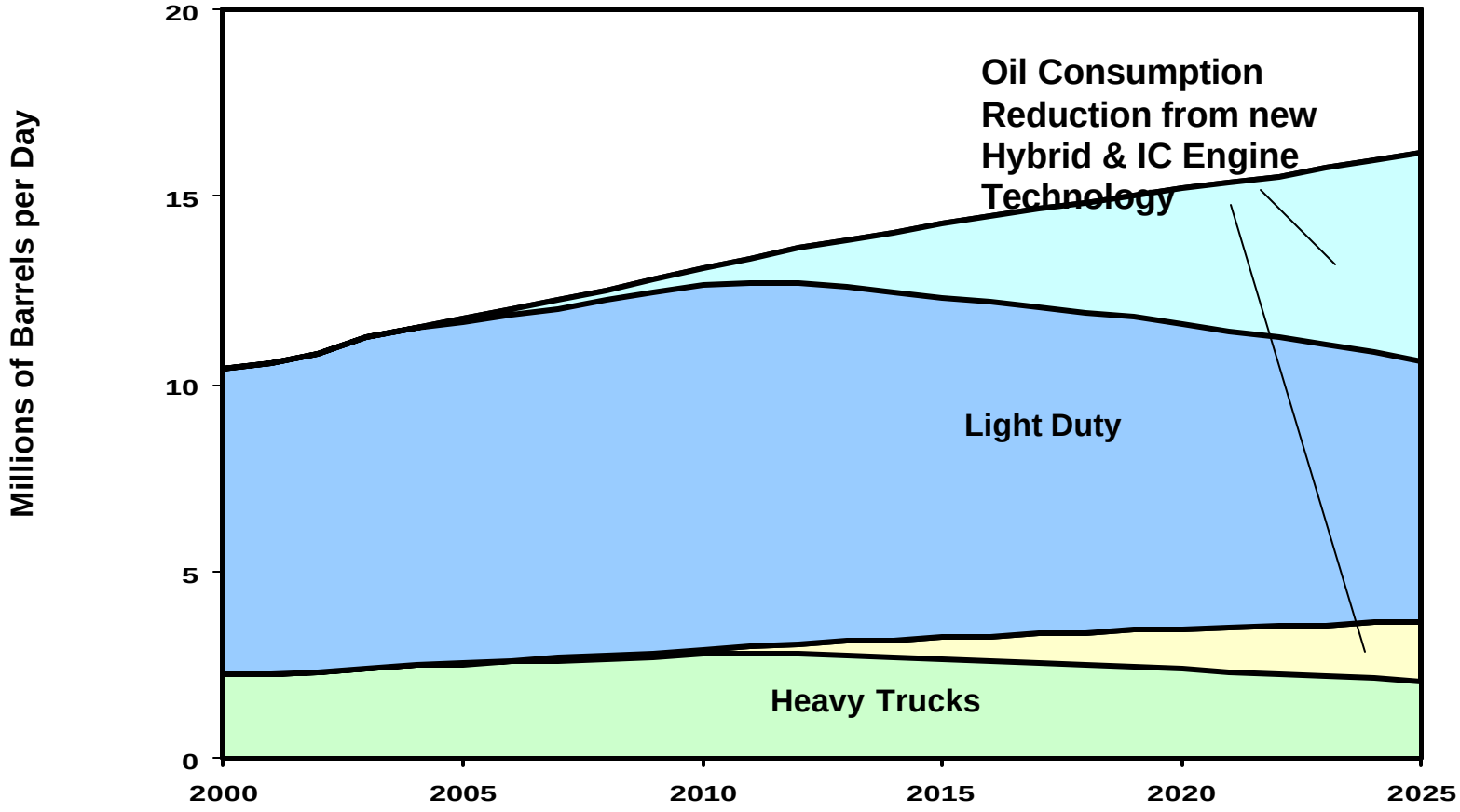
Hybrid Propulsion
- Hybrid Electric Vehicles
- Electric Vehicles
- Power Electronics
- Batteries (NiMH & Lithium)
- Inverters/Controllers
- Motors
- Ultracapacitors

Deployment
- EPACT Fleets
- Test & Evaluation

Innovative Concepts
GATE

Materials Technology
- Metals
- Composites
- Ceramics
- Propulsion Systems
- High Strength Weight Reduction

Potential Oil Consumption Impact from 50% Improvement in Fuel Efficiency

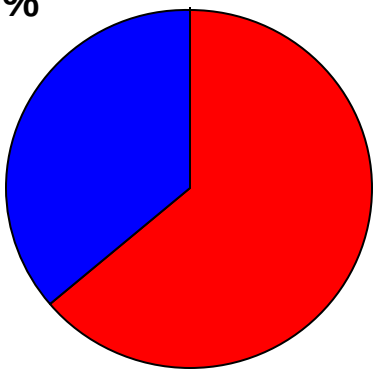


Source: Transportation Energy Data Book: Edition 21, DOE/ORNL-6966, September 2001, and EIA Annual Energy Outlook 2002, DOE/EIA-0383(2002), December 2001

Engine Efficiency Can Be Substantially Improved

Today's Engines

Efficiency
35 - 40%



Losses 56 – 64%

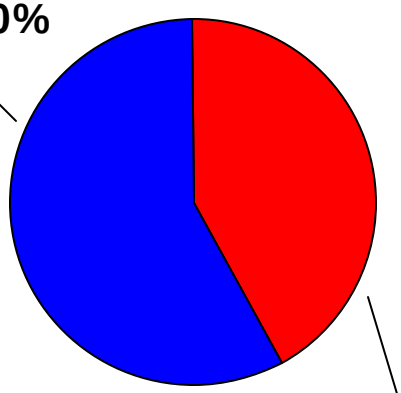
- Emission Controls 3 – 8%
- Exhaust 12%
- Thermodynamic Combustion 16 – 19%
- Heat Transfer 14%
- Mechanical Pumping 6%
- Friction 5%

Goal C

R&D

Advanced Combustion Engines

Efficiency
50% - 60%



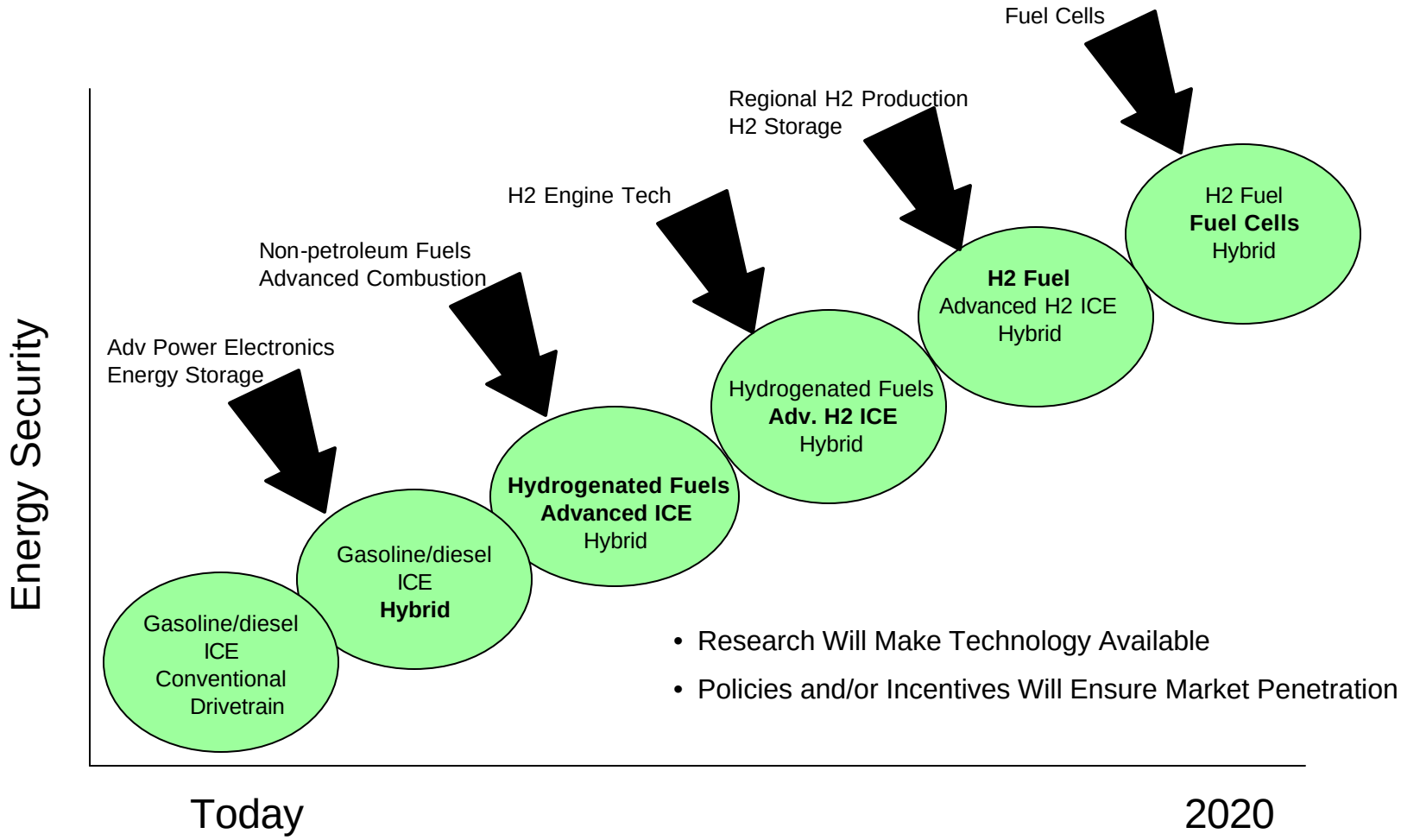
Losses 40 – 45%

- Emission Controls 1 – 3%
- Exhaust 7%
- Thermodynamic Combustion 14% – 17%
- Heat Transfer 10%
- Mechanical Pumping 4%
- Friction 4%

Potential Paths

- Advanced Combustion Regimes
- Camless Valvetrain
- Waste Heat Recovery
- Low Friction Coatings
- Reduced Injection Pressure
- Engine Electrification
- Enabling Fuels

FreedomCAR Pathway to Fuel Cell Vehicles and Hydrogen Economy



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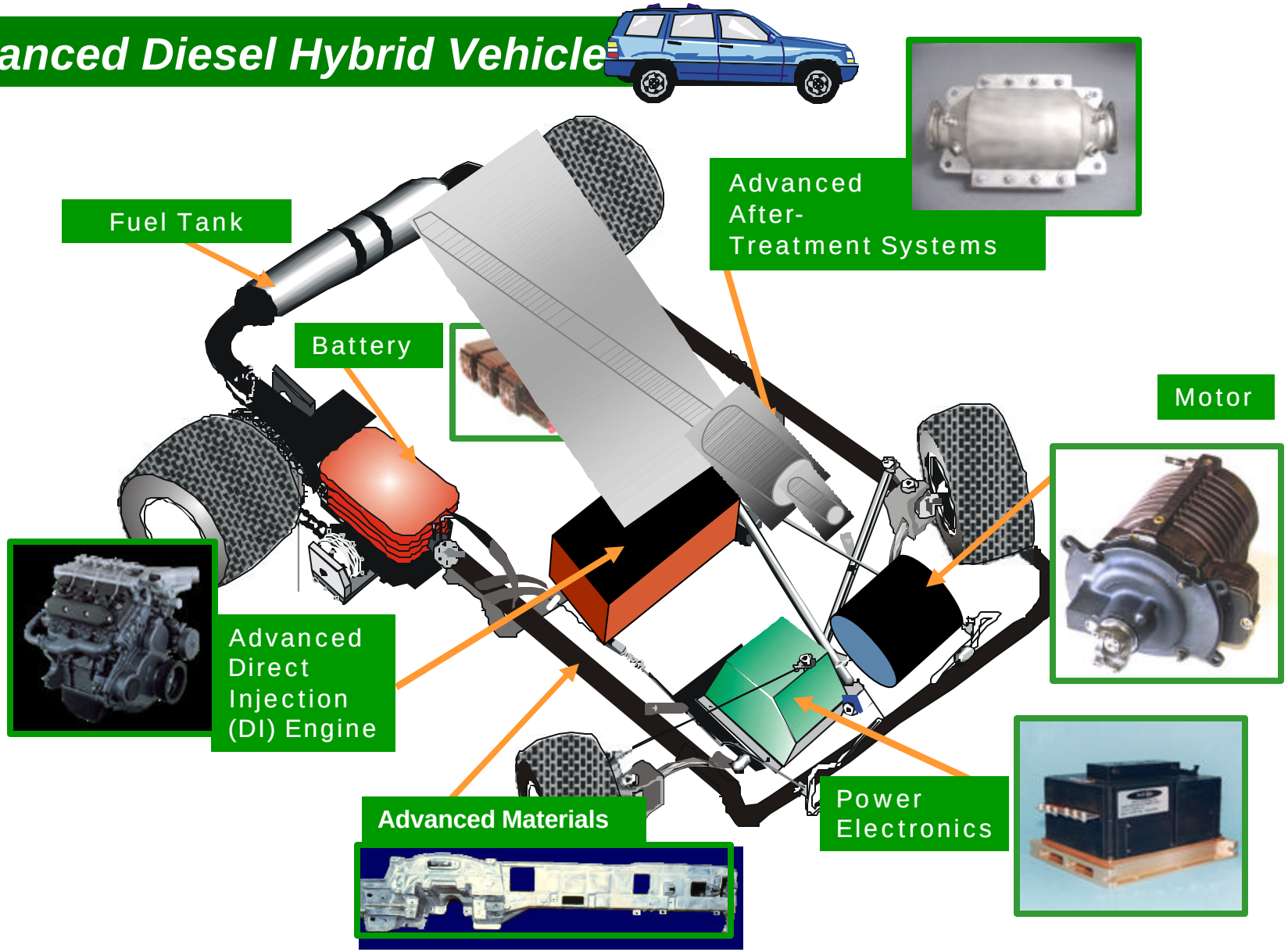
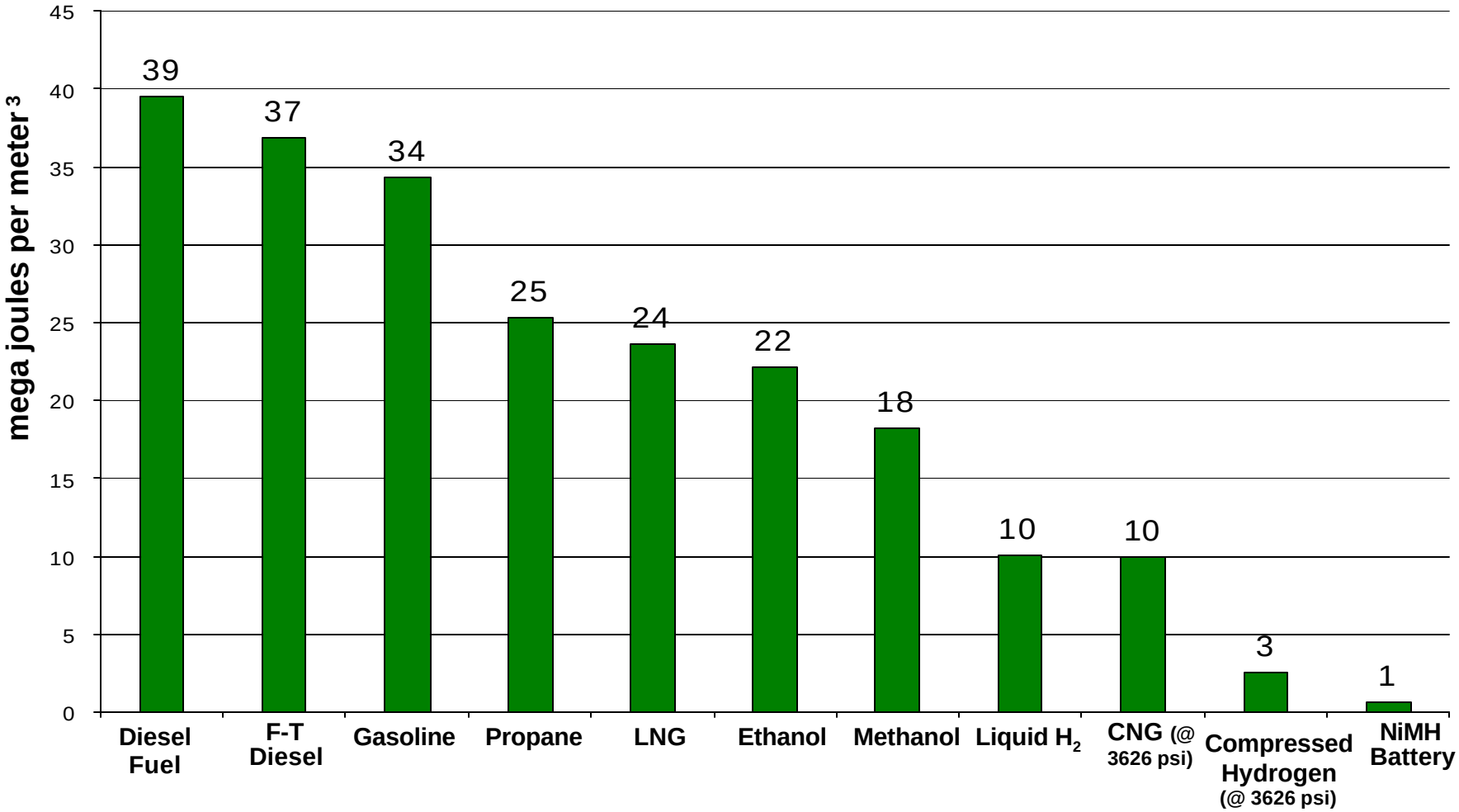
Fuel Cells and Hybrids Share Electric Drivetrain Technology

Advanced Diesel Hybrid Vehicle



Energy Density of Fuels



Our public-private partnership seeks significant advances in truck and bus technology by 2012

- The case for trucks and buses
- The Partnership and its strategy
- Recently announced technology goals
- The potential impacts of Partnership efforts

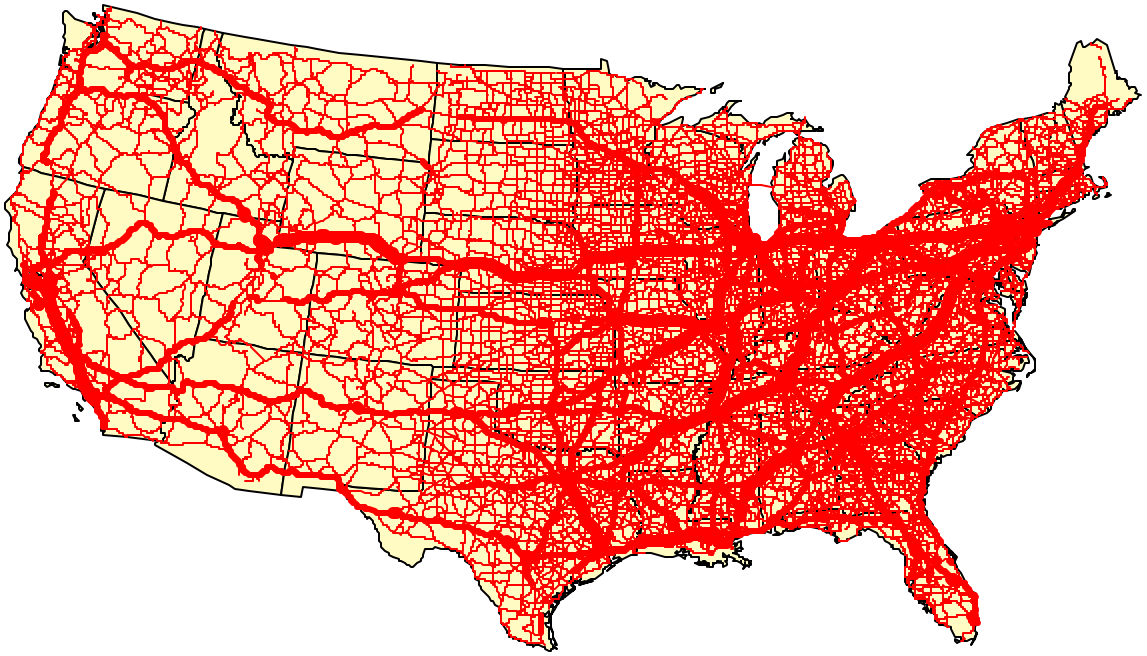
21ST CENTURY TRUCK
PARTNERSHIP

Trucks and buses are vital to the U.S. economy

- Trucks account for nearly 70% of all freight tonnage delivered.
- By dollar value, nearly 72% of all goods are truck-shipped.
- The military's logistics burden is dominated (70%) by fuel shipment, principally for trucks.
- Americans take 5.6 billion bus rides annually to work, to recreate and to shop.

Washington and Oregon carry about 6% of the U.S. highway freight

Top commodities moved by truck are wood products, agricultural products, and minerals.



Truck Freight Flows of all Commodities and truck types (highway freight density in tons)

The Pacific Northwest has historically been a major center for heavy duty truck development

- Kenworth (Seattle, 1923) - First American diesel powered truck (1933)
- Freightliner (Portland, 1930's) – Aluminum structure increases payload capability (1942)
- Peterbilt (Tacoma, 1938) – Purpose-built specialty trucks versus mass production (post-WWII)
- PACCAR (Seattle, 1972) – Major consolidation of several truck and heavy equipment manufacturers
- Freightliner Corporation is nation's sales leader for Class 8 trucks, making one in every three Class 8 trucks sold (2001)

21st Century Truck Partnership

Industry Members

Allison Transmission

BAE SYSTEMS Controls

Caterpillar

Cummins

DaimlerChrysler

Detroit Diesel

Eaton Corporation

Freightliner

Honeywell

International Truck and Engine

Mack Trucks

NovaBUS

Oshkosh Truck

PACCAR

Volvo Trucks North America

Department of Energy

DOE/EE/OFCVT Heavy Vehicle Technologies R&D

Department of Defense

Army/TACOM NAC Military Vehicle R&D

Department of Transportation

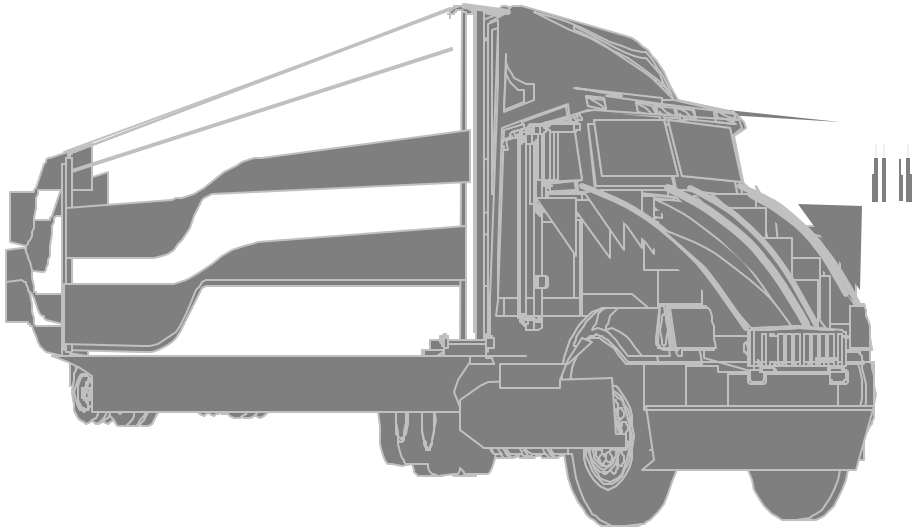
Intelligent Vehicle and Highway Safety R&D

Environmental Protection Agency

Vehicle Emissions Regulations

Our desired technology goals focus on five key areas

- Engine Systems
- Heavy-Duty Hybrids
- Parasitic Losses
- Idle Reduction
- Safety



Support Research, Development and Demonstration

Improve efficiency of Engine Systems

- Improve Class 7- 8 brake thermal efficiency to 50% by 2010
- Research and develop technology to achieve 55% efficient prototype by 2012
- Explore new diesel fuel specs using renewables and non-petroleum-based fuels to displace 5% of petroleum by 2010

Co-development of advanced fuels, aftertreatment and new combustion regimes can attain high efficiencies and near-zero emissions

Reduce Heavy Hybrid component costs to promote market penetration

- Develop drive units under $50/kW
- Develop energy storage systems under $25/kW
- Demonstrate emissions-compliant heavy hybrids with 60% fuel economy improvement on an urban driving cycle

Improving integration and reliability will lead to longer lifetime and market acceptance

Reduce Parasitic Losses to regain horsepower in Class 8 trucks

- Lower tractor-trailer aerodynamic drag by 20%
- Drop essential power loads by 50%
- Pursue 15-20% weight reduction through materials optimization

Existing losses can account for 40% of fuel energy consumed

Reduce Idling fuel use and pollution by 85%

- Demonstrate clean, quiet 5 kW auxiliary power units (APUs) for under $200/kW by 2007
- Develop 30 kW fuel cell APUs that use multiple fuels for under $400/kW by 2012
- Pioneer new codes and standards for electrification of trucks and truck stops

Unnecessary pollution and wasted diesel fuel can be virtually eliminated

Contribute to reducing truck-related fatalities by 50% through safer trucks

- Improve crashworthiness at highway speeds through better materials and vehicle design
- Improve crash avoidance for trucks through better braking, rollover stability and visibility

Safer heavy vehicles also mean fewer injuries, less property loss, lower operating costs and higher efficiency

Tech Transfer to Industry

? **New Rapid Infrared Curing Process:** Ford and NREL jointly developed a rapid infrared curing process which enables the use of a one-component epoxy material to produce a high-quality finish.

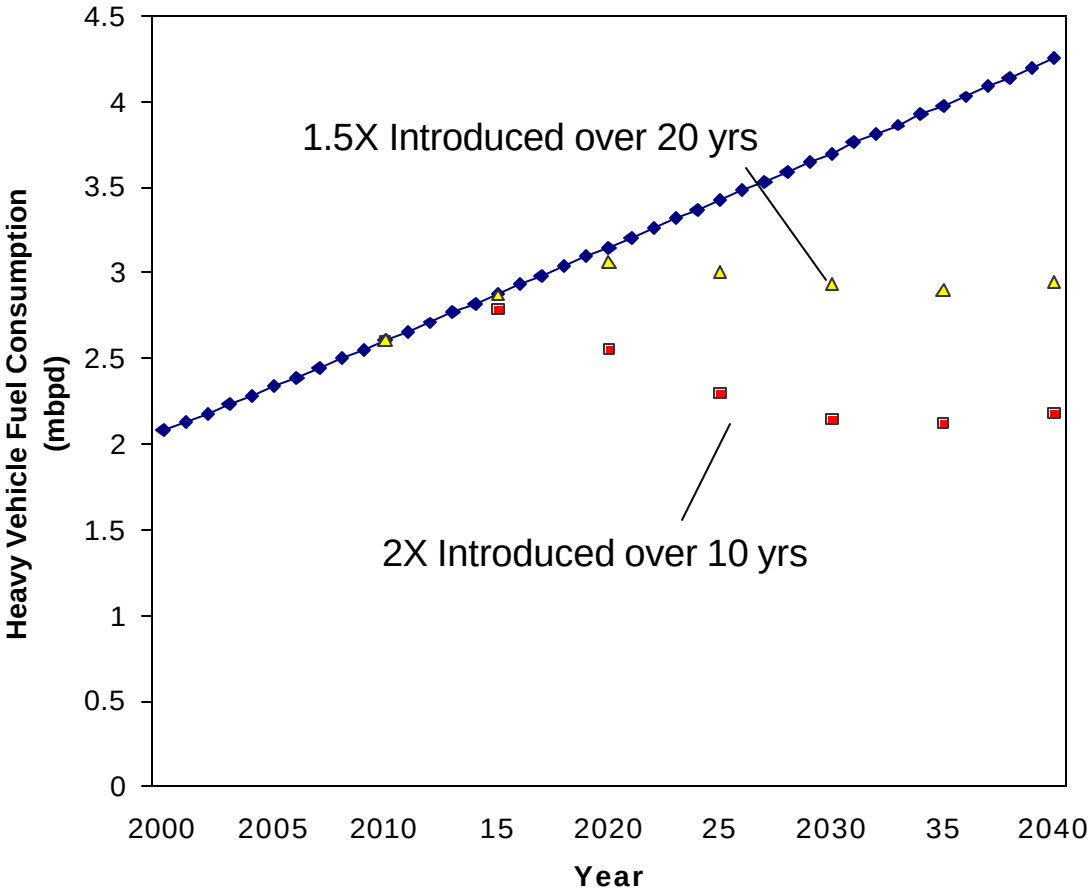
? **Self-Cleaning Diesel Particulate Filter:** The Microwave-Cleaned Ceramic Filter, now being prepared for marketing by Industrial Ceramic Solutions, has been demonstrated on stationary diesel engines at Ford, ORNL, and the University of Tennessee, where test data have demonstrated a particulate removal efficiency greater than 95% across a spectrum of normal engine operating conditions

? **Superplastic Forming of Aluminum Sheet Metal for Automotive Applications:** An advance blow forming process called Quick Plastic Forming is now being used successfully to produce aluminum closure components.

? **Wirebondless Technology for Power Electronic Building Blocks:** The new wirebondless "ThinPak" power semiconductor is being marketed by Silicon Power Corporation (SPCO). Rockwell Automation is poised to be one of the first major industrial users of the ThinPak technology.

? **Fiber Optic Microsensors for Automotive Power Electronics**: ORNL is teaming with Luna Innovations to commercialize this technology. (2002)

Potential Heavy Duty Vehicle Fleet Energy Savings - A Million Barrels per Day by 2030



Base consumption based on EIA projections through 2025 (AEO 2003, p.130)

21CT Partnership's Vision was recast November 2002 to focus on "safe and cost-effective movement of larger volumes of freight and greater numbers of passengers while emitting little or no pollution and dramatically reducing our dependence on foreign oil."

– *Secretary of Energy Spencer Abraham*