Sustainable TRANSPORTATION

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

SuperTruck – An Opportunity to Reduce GHG Emissions while Meeting Freight Hauling Demands

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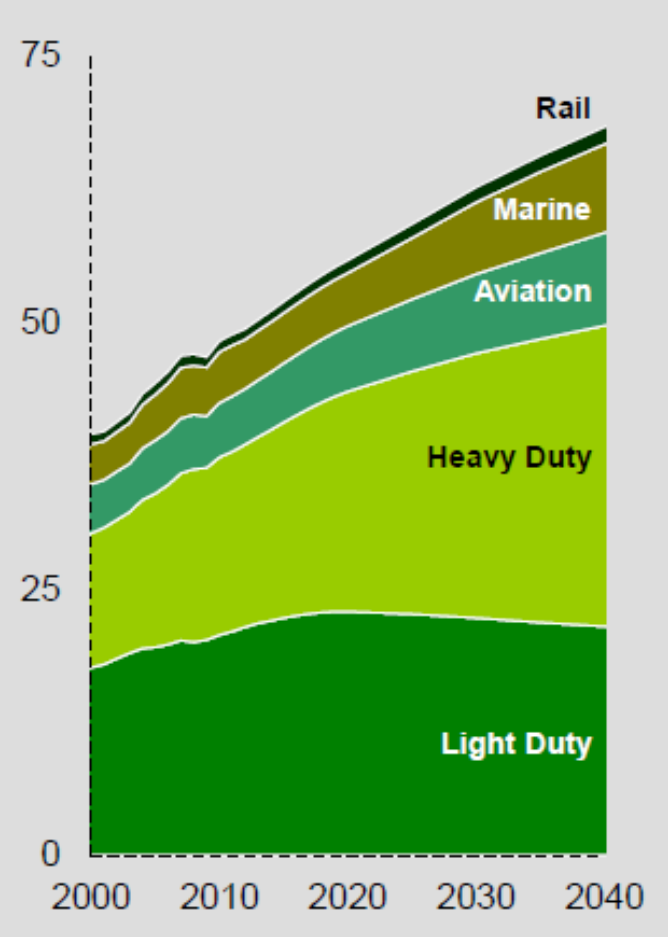
Why Develop Higher Efficiency Commercial Vehicles?

Transportation demand by sector

Millions of oil-equivalent barrels per day



Source: The Outlook for Energy - A View to 2040, ExxonMobil Corporation, 2014

75 percent

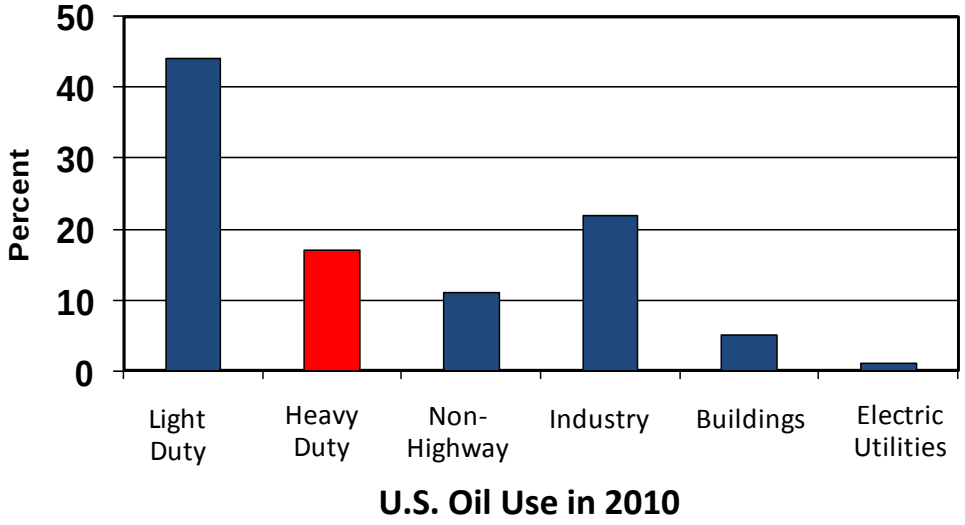
Demand for diesel and jet fuel is expected to increase by 75 percent from 2010 to 2040.

While global energy demand for personal transportation is expected to be relatively flat over the next few decades, demand for energy for commercial transportation — trucks, planes, ships and trains — will continue to grow significantly as economies expand and evolve.

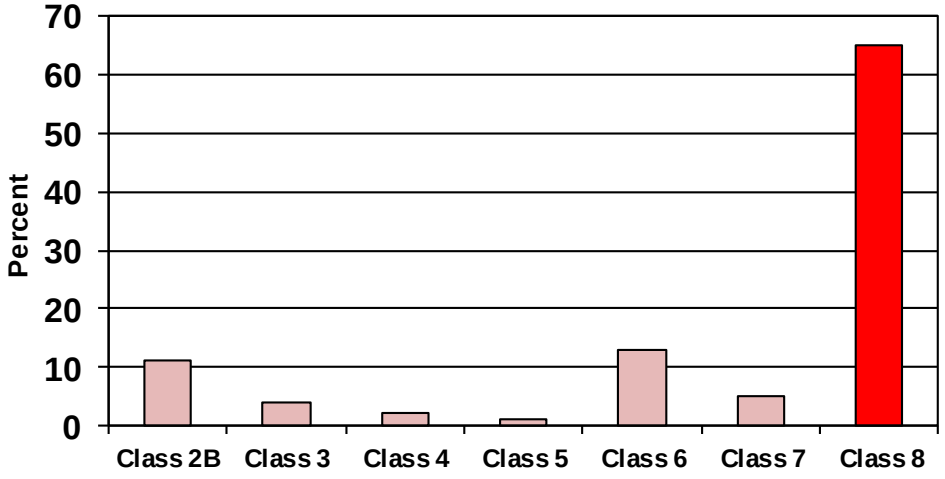
Global demand for energy for commercial transportation is expected to rise by 70 percent from 2010 to 2040, driven by the projected increase in economic activity and the associated increase in movement of goods and freight.

Why Long-Haul Heavy-Duty Trucks?

- Near- to mid-term impact will be large
  - Heavy-duty trucks comprise 4% of on-road vehicles but 18% of fuel consumption
  - Heavy trucks move 73% of freight value, 73% of freight tonnage, and log 49% of ton-mileage
- High return on investment
  - Truck operators and
  - Federal Government
- Industry is ready and willing to adopt new technology
- Growing domestic and international markets
- Saves domestic jobs



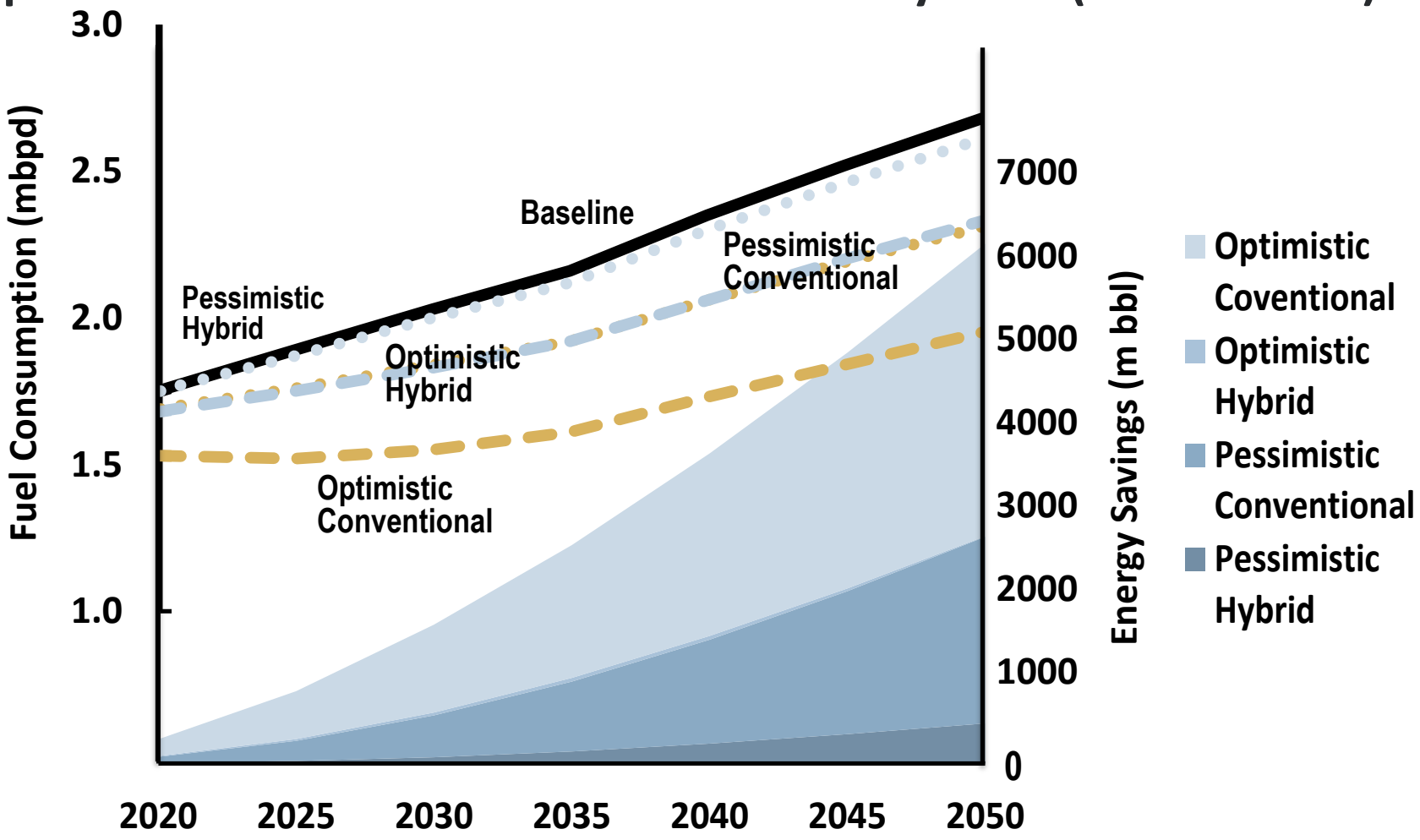
U.S. Oil Use in 2010



Fuel Use by Truck Class

SuperTruck Technology Benefits Analysis

SuperTruck technologies could reduce fuel consumption nearly 30 percent and save 6 billion barrels of oil by 2050 (ROI of 500:1)



Source: *DOE SuperTruck Program Benefits Analysis Final Report (http://www.transportation.anl.gov/pdfs/TA/903.PDF)*

SuperTruck Initiative

- **Goals:** Develop and demonstrate a 50% improvement in overall freight efficiency on a heavy-duty Class 8 tractor-trailer measured in ton-miles per gallon, achieve 50% engine thermal efficiency at 65 mph and show a pathway to 55% engine efficiency.
  - Vehicle target for freight efficiency (ton-miles per gallon) improvement based on 65,000 pound GVW
  - 40% of the total improvement is required from engine technologies (50% thermal efficiency) and the remainder from vehicle system technologies.
- **Cooperative R&D Agreement Awards:**
  - Cummins Inc. with Peterbilt (ARRA Funded)
  - Daimler Trucks North America (ARRA Funded)
  - Volvo Trucks North America
  - Navistar, Inc.
- **Total project funding:**
  - DOE + Industry = $284 Million

Cummins/Peterbilt SuperTruck Team

Cooling Package and Heat Exchangers

MODINE

Power Distribution

COOPER Bussmann

Li Ion Start Batt & APU

corvus energy

Alum Hybrid Driveshaft

DANA

Route Display

Continental

Alum 5th Wheel

SAF Holland

Ceramic Brake Drums

CENTURY, INC

Light Steer Axle and Trailer Tandem

HENDRICKSON
The World Rides On Us

Downspeed-enabling Transmission

EATON
Powering Business Worldwide

Advanced Light Wheels

ALCOA

Magnesium Crossmembers

Meridian

Variable Gage Steel Frame Rails

Metalsa

6x2 Rear Tandem w/ eTrac

DANA

Bendix

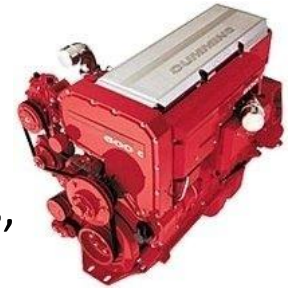
Integrated Air Suspension Bags

Firestone

DOE Share $38.8M
Contractor Share $38.8M

Cummins/Peterbilt *SuperTruck* Status and Highlights

Cummins: Highly efficient and clean diesel engine, advanced waste heat recovery
Peterbilt: Tractor and trailer combination, aerodynamic, lightweighting, battery powered auxiliary unit to reduce engine idling.



- Developed and demonstrated 51 percent brake thermal efficiency for an engine on a dynamometer:
  - Demonstrated waste heat recovery system improvements, including system simplification.
  - Compression ratio and peak cylinder pressure increased.
  - Engine system optimized and calibrated.
- Demonstrated 76% freight efficiency surpassing 50% freight efficiency goal:
  - Demonstrated 25% improvement in aerodynamics
  - Advanced Automated Manual Transmission (AMT)
  - The driver communication interface has been interlaced within the vehicle network and truck display systems. Cruise control in place.
  - Demo 2 truck – completed.

Cummins/Peterbilt *SuperTruck*

Daimler SuperTruck Team

Energy Management

NREL

DELPHI

OSU Oregon State University

Telogis

Hybrid

FUSO

MBtech Mercedes-Benz technology

A123 SYSTEMS

EATON

MiaSolé

itk ENGINEERING

Mercedes-Benz

US Hybrid

Aero/Cooling

ARC AUTO RESEARCH CENTER

CD-adapco

TITANX

MEKRA LANG

FREIGHT WING

MODINE

Lightweighting

OSU Oregon State University

TORAY

STRICK Trailer

INMAGUSA

Powertrain/Parasitics

DETROIT Engine Transmission

CONMET Pointing the Way

MICHELIN

ACCURIDE

Parker

Bendix

ASHLAND

Fleet

SCHNEIDER NATIONAL

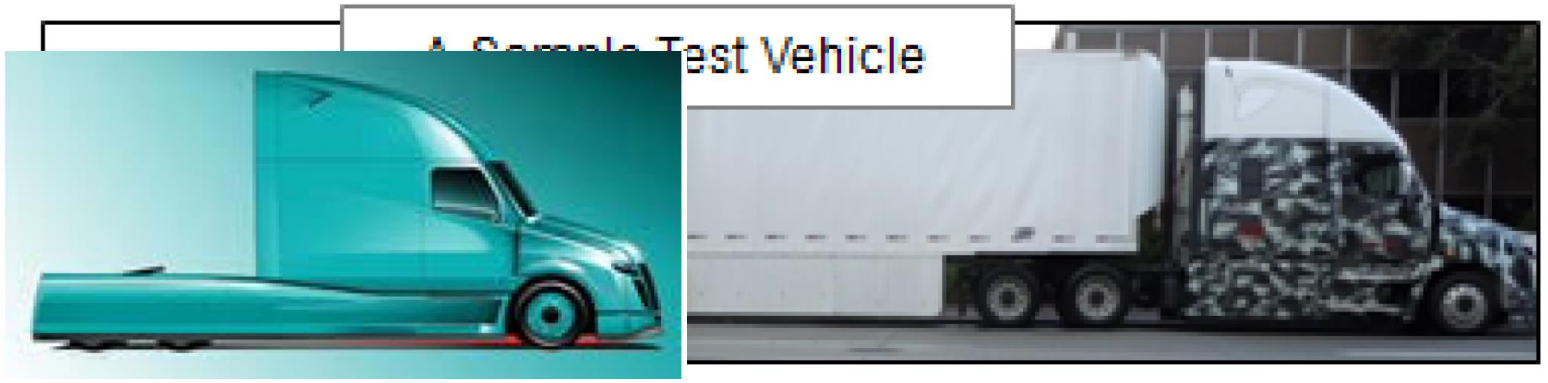
Walmart Save money. Live better.

DOE: $39,559,861

Daimler: $39,559,898

Daimler *SuperTruck* Status and Highlights

- **Achieved 115%** freight efficiency improvement significantly exceeding the 50% goal!
  - **ENGINE/POWERTRAIN:**
    - 50% Brake Thermal Efficiency target exceeded on engine dynamometer. Included; combustion improvements, turbocharging improvements, waste heat recovery, engine downsizing, controllable/electrified auxiliary systems, hybridization
  - **FREIGHT EFFICIENCY:**
    - Included: aerodynamic improvement (skirts, gap reduction, boat tail, active grill, tractor and cab redesign), 6X2 axles, single wide tires, solar roof on trailer, 1500 lb weight reduction and eCoast.



Final Demonstrator Vehicle

Volvo SuperTruck Team

Organization	Key Contribution
Volvo Technology of America	Project lead & concept simulations
Volvo Group Truck Technology	Complete vehicle integration & vehicle testing
Volvo Group Powertrain Engineering	Efficient complete powertrain solutions
Ridge/Freight Wing	Advanced aerodynamic devices for trailers
Grote	Advanced lighting systems
Penn State University	Advanced combustion modeling & simulation
Hendrickson	Lightweight trailer axle & suspension components
ExxonMobil	Advanced fuels & lubricants
Alcoa Wheels	Lightweight wheels
Michelin	Advanced low-friction tires
Metalsa	Ultra-Light Frame Assembly

VOLVO FREIGHT WING Grote PENNSTATE

Funding: Volvo (U.S.) - $19,066,700
DOE - $18,929,194
Sweden - $15M
Volvo (Sweden) - $15M

Volvo *SuperTruck* Status and Highlights

Priority: truck/engine efficiency integration; engine efficiency, truck-trailer aerodynamics, waste heat recovery, idle reduction, and reduced rolling resistance tires.

ENGINE:

- Demonstrated 48% brake thermal efficiency of integrated powertrain system in vehicle 1.5 years ahead of schedule
- Improvements include: turbocompounding, Rankine WHR, higher pressure fuel injection system, down-sped engine, advanced aftertreatment, next generation axles, dual clutch transmission, etc.

FREIGHT EFFICIENCY:

- Demonstrated on-road 43% freight efficiency improvement and determined pathway to achieve greater than 50%

Demonstrator Truck

Concept *SuperTruck*

Navistar SuperTruck Team

Priority: aerodynamics truck-trailer aerodynamics, combustion efficiency, waste heat recovery, idle reduction, and reduced rolling resistance tires.

- **Navistar** - Principal Investigator, Vehicle Systems Integrator Controls Systems, Engine & Vehicle Testing
- Alcoa - Lightweight Frame & Wheel Materials
- AT Dynamics - Trailer Aerodynamic Devices
- Behr America - Cooling Systems
- Michelin - Low Rolling Resistance Tires
- TPI - Composite Material Structures
- Wabash National - Trailer Technologies
- Argonne National Lab - Simulation and Controls
- Lawrence Livermore National Lab - Aerodynamic modeling

Project Funding: DOE $37,328,933
Navistar $45,000,000

Navistar SuperTruck Status and Highlights

ENGINE:

- Demonstrating 48.3% Brake Thermal Efficiency without Waste Heat Recovery.
- Procuring the hardware needed to meet the 50% BTE and demonstrate a pathway to 55% BTE
- Waste heat recovery system assessment is underway to down select the optimal system

FREIGHT EFFICIENCY

- Vehicle technologies improvements include; advanced aero, light-weighting and drive train optimization as well as system integration
- Vehicle level hardware is in the procurement phase
- Current wind tunnel results are showing positive results and demonstrating the proper trends
- Combined vehicle light-weighting efforts showing a weight reduction of greater than 2,000 pounds over the baseline

SuperTruck Initiative On-Track

Industry Team Leads
Cummins, Daimler, Volvo, and Navistar

UPI Photo

- **Status of 50% engine efficiency:**
  - Cummins and Daimler have achieved the 50% efficiency goal
  - Volvo and Navistar 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
  - Daimler has demonstrated 115% freight efficiency improvement
  - Volvo has demonstrated 43% freight efficiency improvements and determined a pathway to achieve greater than 50%
  - Navistar is on track to meeting efficiency goal.

Technologies developed under SuperTruck will begin to enter the market over the next decade.

Daimler Trucks North America VOLVO NAVISTAR

Commercialization Potential

Will not be able to buy a SuperTruck anytime soon at a dealership near you!

- *Focus is on R & D and moving state-of-the-art forward, exploring new possibilities… consider SuperTruck beyond the regulations*

PROMISING TECHNOLOGIES

SHORT TERM: downspeeding, downsizing, better match of engine size to vehicle, improved aftertreatment, intelligent torque, parasitic loss reduction, increased AMT usage… prerequisite to; downspeeding – torque management, predict cruise control. Trailer skirts, gap improvement, boat tail, light weight drive shafts and frame rails, single wide tires (auto inflate, lower energy), predictive cruise control

Commercialization Potential

MID-LONG TERM: Dual clutch transmissions, controllable or electrified auxiliaries, mild hybridization, waste heat recovery, 55% efficient engine, increased peak cylinder pressure

Cab forward designs, further weight reduction (aluminum, carbon fiber), novel tire compounds, solar energy harvesting etc…

Contact Information

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http://energy.gov/eere/vehicles/vehicle-technologies-office