Sustainable TRANSPORTATION

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

Freight Mobility and SuperTruck

Transportation and Mobility Emerging Trends and Promising Technologies

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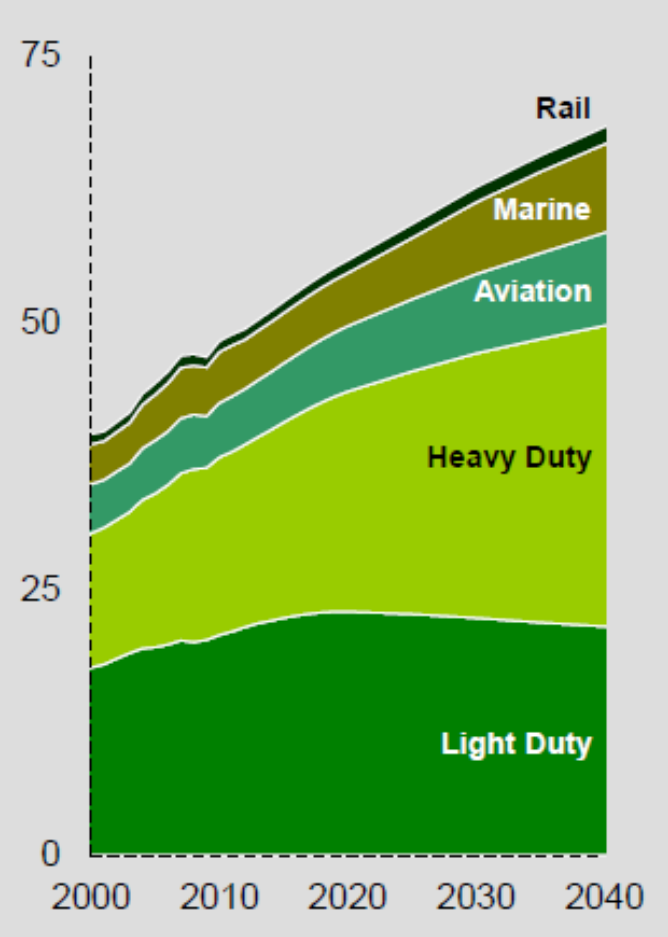
Introduction

- Freight transportation trends
  - Increased freight movement to more places results in more fuel use in the sector (Tracks with economic growth)
  - Class 8 trucks are a major contributor to fuel use and greenhouse gas emissions in the freight transportation sector
- A technology solution
  - SuperTruck I – DOE initiative to make drastic improvements in Class 8 over-the-road truck efficiency – very successful, advances now being commercialized
  - SuperTruck II – DOE initiative to build on SuperTruck I and push Class 8 over-the-road truck efficiency even further, projects just getting underway
- More work to be done
  - Contribution of smart mobility (connected and automated vehicles, electrification)
  - Modeling and planning

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

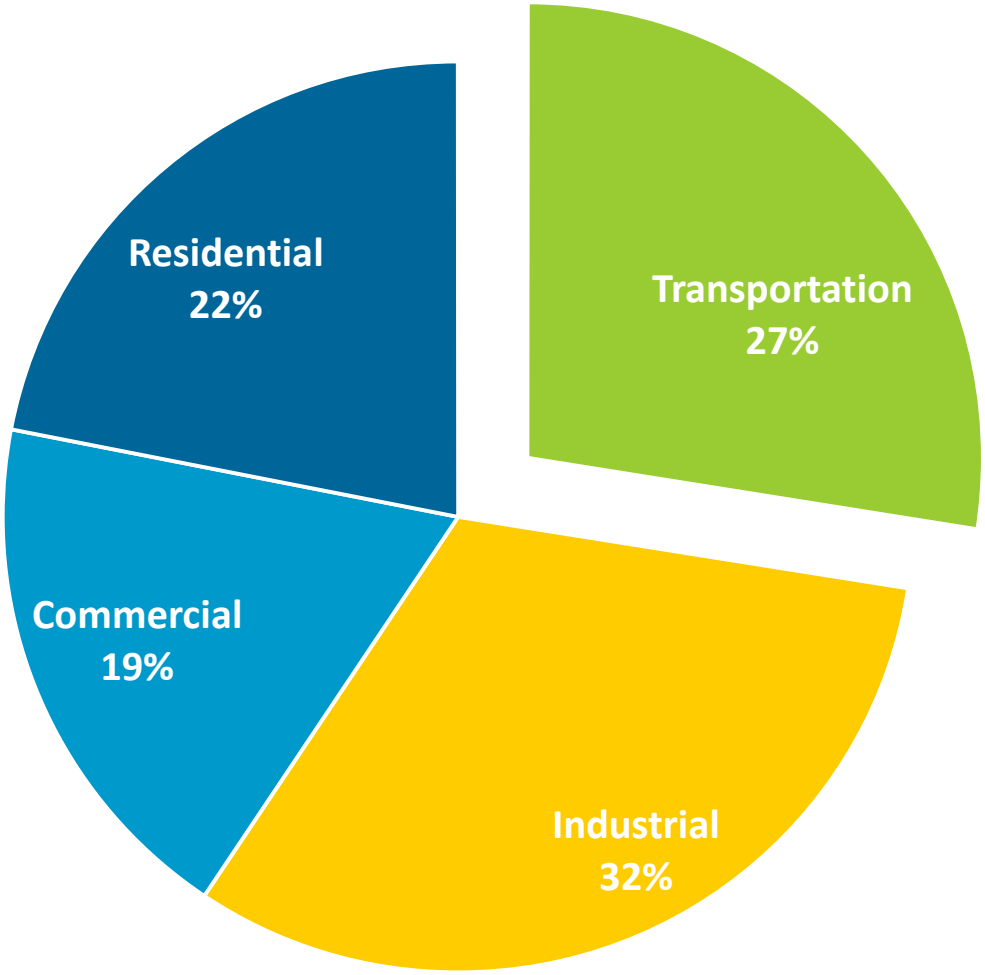
75 percent

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.

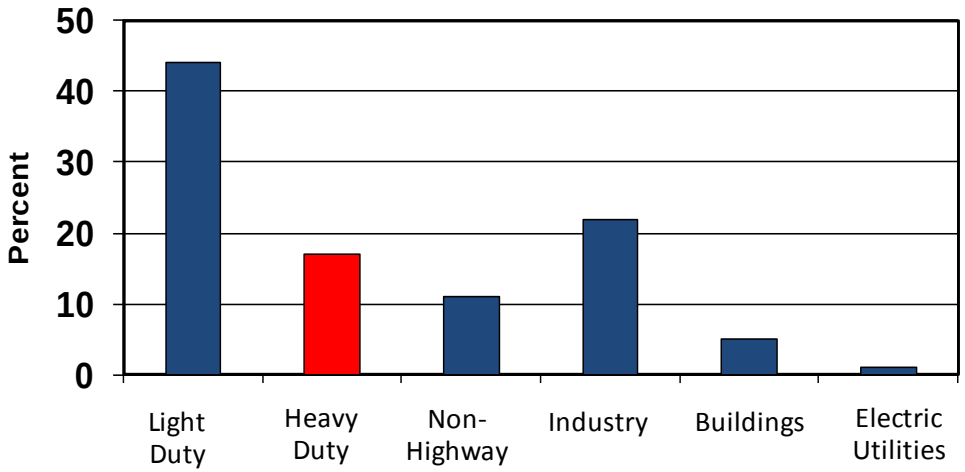
U.S. Energy Consumption by End-Use Sector, 2014

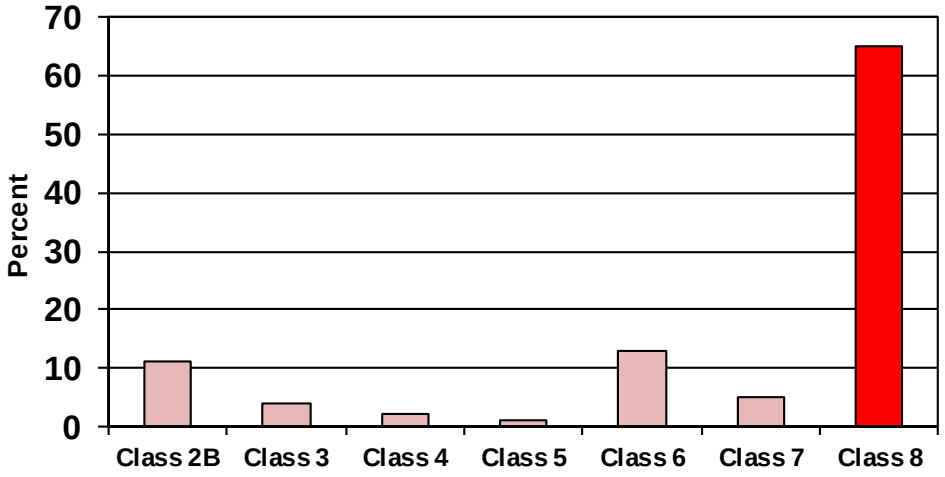


Transportation Energy Data Book 34, Table 2.1, U.S. Department of Energy, 2015

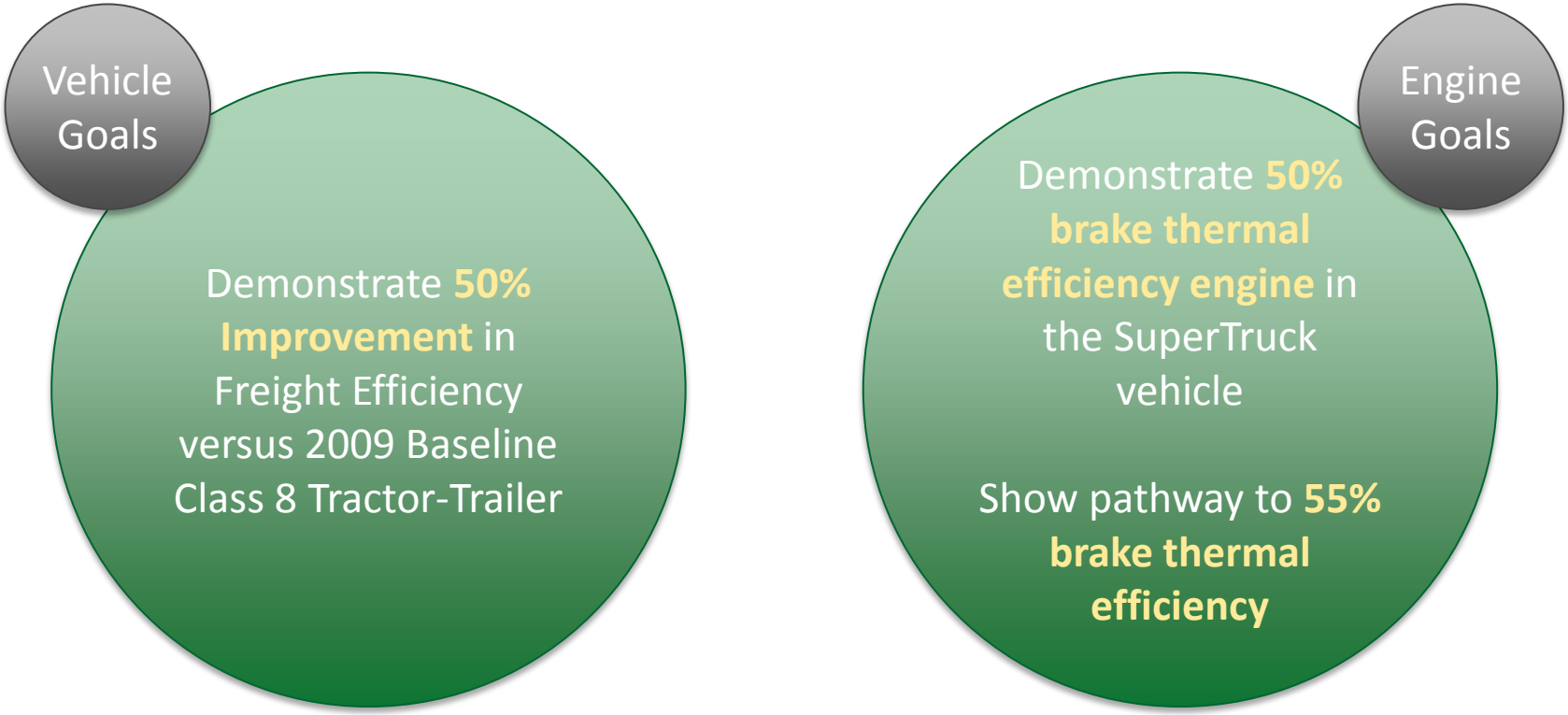
Why Long-Haul Heavy Trucks?

- Near- to mid-term impact will be large
  - Commercial trucks comprise 4% of on-road vehicles but 18% of fuel consumption
  - Heavy trucks move 73% of freight value, 73% of freight tonnage
- 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





SuperTruck I Initiative



freight efficiency = tons of cargo x miles per gallon

$$\textit{Brake thermal efficiency} = \frac{\textit{Net work out of the engine}}{\textit{Fuel energy into the engine}}$$

SuperTruck I Awards

- Awarded 2009-2011
- 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 = $260 Million

Benefits analysis conducted indicated a savings of 6 billion barrels of oil in 2050 (a 500:1 return on investment) for SuperTruck I !!!

Cummins/Peterbilt (SuperTruck I)

1 Project Duration and Funding

Project Complete

- ✓ April 2010 to September 2014
- ✓ DOE $38.8M / Industry $39.6M

2 Important Achievements

- ✓ Demonstrated freight efficiency improvements:
  - **76%** in long-haul drive cycle test
  - **86%** in 24-hr cycle test (includes overnight hotel loads) - lithium ion battery APU
- ✓ Achieved **10.7 mpg** (65 mph cruise)
- ✓ Demonstrated **51%** engine thermal efficiency on dyno, including waste heat recovery
- ✓ Net weight reduction: 1,305 lb
- ✓ 46% reduction in aerodynamic drag coefficient – matched tractor and trailer

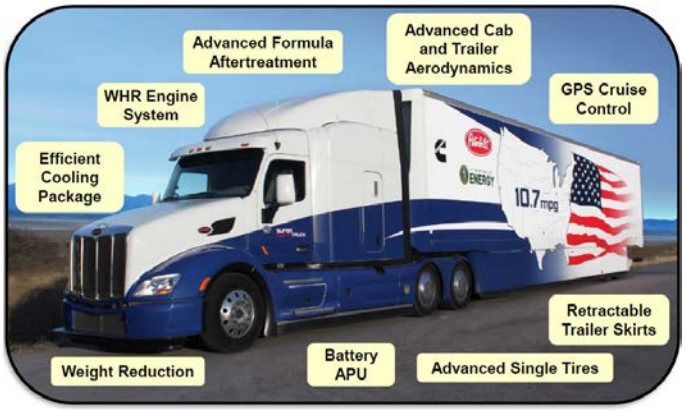


Image source: D. Koberlein, 2015 AMR presentation ACE057.

Daimler Trucks (SuperTruck I)

1 Project Duration and Funding

Project Complete

- ✓ April 2010 to March 2015
- ✓ DOE $35.8M / Industry $38.3M

2 Important Achievements

- ✓ Demonstrated **115%** freight efficiency improvement
- ✓ Achieved **12.2 mpg**
- ✓ Demonstrated **50.2%** thermal efficiency engine with waste heat recovery
- ✓ Net 2,800 lb weight reduction
- ✓ 54% reduction in drag coefficient

Navistar Inc. (SuperTruck I)

1 Project Duration and Funding

Project Complete

- ✓ October 2010 to September 2016
- ✓ DOE $29.3M / Industry $40.4M

2 Important Achievements

- ✓ Demonstrated **104%** freight efficiency improvement
- ✓ Achieved **13 mpg**
- ✓ Demonstrated **50.3%** brake thermal efficiency engine
- ✓ Reduce trailer drag coefficient by more than 30 percent

Volvo Trucks (SuperTruck I)

1 Project Duration and Funding

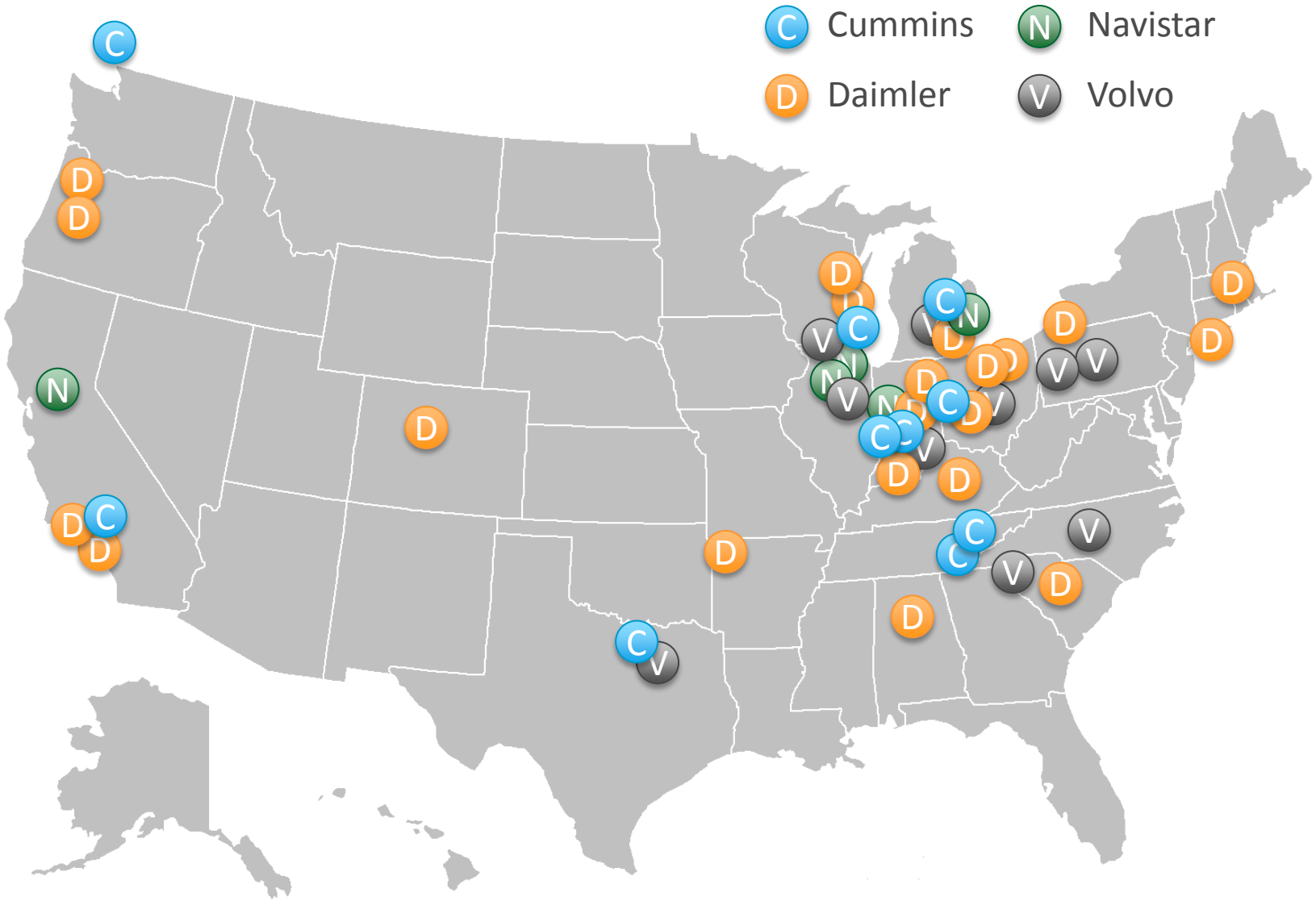
Project Complete

- ✓ June 2011 to June 2016
- ✓ (U.S.) DOE $19M / Industry $19M
- ✓ (Sweden) Gov't $15M / Industry $15M

2 Important Achievements

- ✓ Demonstrated **88%** freight efficiency improvement
- ✓ Achieved **12+ mpg**
- ✓ Demonstrated **50%** thermal efficiency engine with waste heat recovery
- ✓ Completed a simulated 56.2% BTE capable engine analysis

SuperTruck Partners Span the U.S.



(Numerous subcontractors in various parts of the country)

SuperTruck Advances Are Being Commercialized

CUMMINS/PETERBILT

Peterbilt EPIQ Efficiency Package

Cummins X-Series 2017 Engines

DAIMLER

Freightliner Cascadia Evolution Efficiency Package

NAVISTAR

International ProStar ES Efficiency Package

VOLVO

Volvo 2017 Engines

- ✓ Wave piston
- ✓ Turbo compounding
- ✓ Common rail fuel injection system

Industry Statements on SuperTruck and Commercialization

"Many of the engine and drivetrain efficiency improvements and vehicle power demand reductions pioneered in SuperTruck I are headed for production with the latest model year 2017 product offerings by Cummins, Peterbilt and its key product delivery partners."

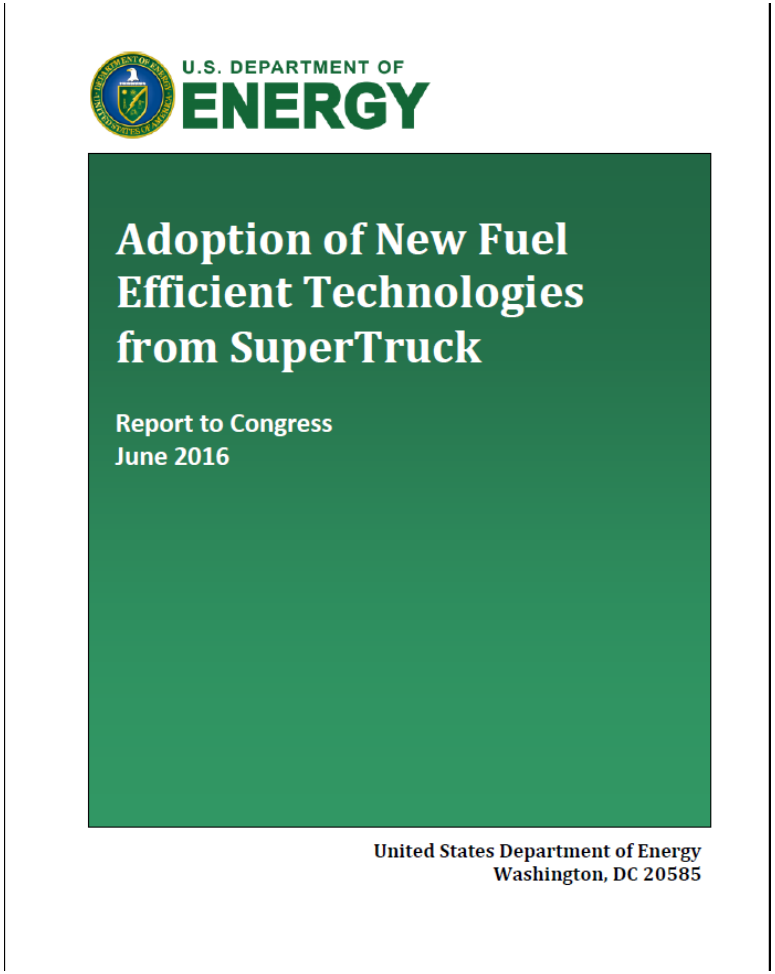
(Cummins press release, 9/1/16)

"The DOE's support, together with the skill of our powertrain engineers working on the SuperTruck program, helped generate significant powertrain innovations."

(Göran Nyberg, President of Volvo Trucks North America)

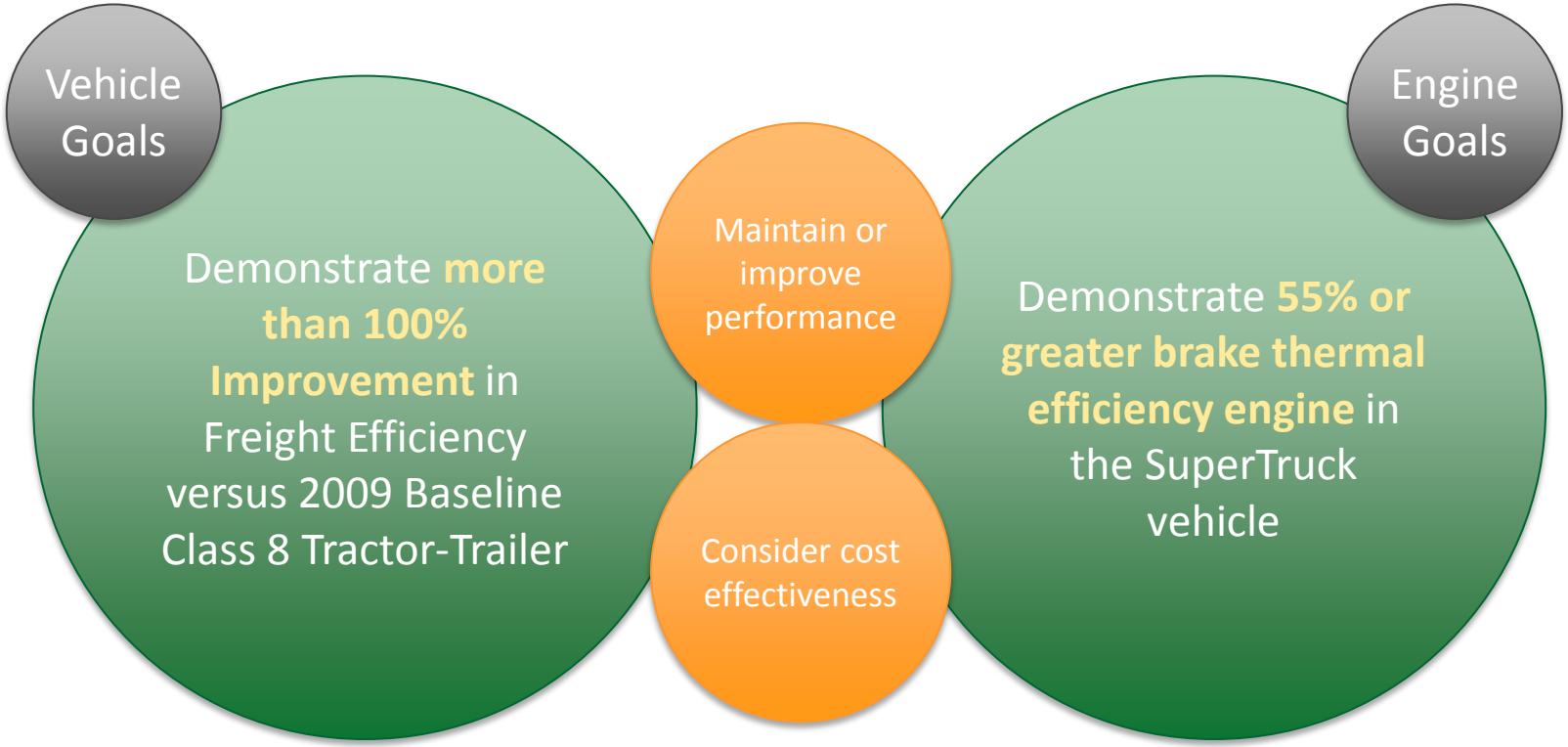
SuperTruck Report to Congress

- Report to Congress completed June 2016
- Overall conclusions
  - SuperTruck teams very successful in meeting or exceeding the goals of SuperTruck
  - SuperTruck teams using suites of technologies with potential of market success
  - Many technologies already making inroads into commercial markets
  - Some technologies require additional research to show positive business case



http://energy.gov/eere/vehicles/downloads/vehicle-technologies-office-report-adoption-new-fuel-efficient-technologies

SuperTruck II Initiative



SuperTruck I was 50% freight efficiency improvement

SuperTruck I was 50% brake thermal efficiency demonstration

SuperTruck II Awards and Technical Highlights

Awards made in 2016

Cummins/Peterbilt

- Goal of 125% freight efficiency improvement
- *Smaller, purpose-built engine & advanced drivetrain features*
- *Hybridization*
- *Advanced materials and lightweighting*

Daimler

- Goal of 115% freight efficiency improvement
- *Active aerodynamics*
- *Engine cylinder deactivation*
- *Hybridization/electric accessories*
- *Lightweighting*
- *Vehicle system operation improvements*

Navistar

- Goal of 140% freight efficiency improvement
- *Electrified engine components*
- *More aerodynamic cab design*
- *Weight reduction*
- *Engine efficiency improvements*

Volvo

- Goal of 120% freight efficiency improvement
- *Reimagined lightweight cab*
- *Alternative engine designs*
- *Electrified powertrains*
- *Lightweighting*

SMART Mobility in the Commercial Truck Sector

- Connected and automated vehicle technologies are being considered for this sector
  - Truck platooning systems (Peloton, Otto) being developed to provide semi-autonomous operation (throttle and braking, but not steering)
  - Freightliner Inspiration Truck (first licensed autonomous commercial truck) already being demonstrated
- Current autonomous vehicle work in the commercial truck space is focused on safety and crash avoidance – fuel savings are an additional benefit

Conclusions

- SuperTruck II represents an opportunity to build on the success and technology foundation of SuperTruck I
  - Goals that reach beyond those of SuperTruck I (freight efficiency and engine efficiency)
  - Teams identified areas for further efficiency gains
  - Additional focus on cost effectiveness is likely to bring technologies into SuperTruck II that are closer to commercial viability
- SuperTruck II team selection process was rigorous
  - Open funding opportunity with clear goals and objectives
  - Careful technical and programmatic review of proposals by qualified technical review panel
  - Most credible proposals were from SuperTruck I teams, as they cover 99% of the Class 8 truck market
- Class 8 commercial trucks represent an important opportunity for addressing greenhouse gas emissions
  - Class 8 trucks represent upwards of 60 percent of total truck fuel use and associated GHG emissions