Supertruck technologies for 55% thermal efficiency and 68% freight efficiency

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Program Objectives

**Objective 1:**
Demonstrate 50% thermal efficiency improvements in test cell

**Objective 2**

a: Demonstrate a 50% drive cycle freight efficiency improvement

b: Demonstrate 68% freight efficiency improvement on 24hr cycle

**Objective 3:**
Scope & demonstrate improvements for a 55% engine efficiency

Baseline: Peterbilt 386 truck & conventional van trailer with 2009 Cummins ISX
Program Partners

Cummins Inc.
- Cummins Fuel Systems
- Cummins Electronics
- Cummins Turbo Technologies
- Cummins Emissions Solutions
- Cummins Filtration
- Modine
- VanDyne SuperTurbo Inc.
- Oak Ridge National Lab.
- Purdue University

Peterbilt Motors Company
- Eaton
- Delphi
- Modine
- Utility Trailer Manufacturing
- Bridgestone
- U.S. Xpress
- Dana
- Bergstrom
- Logena
- Bendix
- Garmin
- Goodyear
SuperTruck Demonstration Plan

4 Year Program: April 2010 to April 2014

Dec 2011

50% BTE Demonstration

Dec 2012

50% Drive Cycle Freight Efficiency Demonstration

Dec 2013

68% 24hr Cycle Freight Efficiency Demonstration

Apr 2014

55% BTE Scoping & Demonstration
Approach to Technology Improvements

Engine Losses
- Urban: 58-60%
- Interstate: 58-59%

Aerodynamic Losses
- Urban: 4-10%
- Interstate: 15-22%

Inertia / Braking
- Urban: 15-20%
- Interstate: 0-2%

Auxiliary Loads
- Urban: 7-8%
- Interstate: 1-4%

Drivetrain
- Urban: 5-6%
- Interstate: 2-4%

Rolling Resistance
- Urban: 8-12%
- Interstate: 13-16%

Weight Reduction

Note: Analysis of 27 Drive Cycles for Class 8 Vehicles with a Variety of Seasons (Summer, Winter, etc.)
Freight Efficiency Projections

- **Demo #2 Goal**: 80%
- **Demo #1 Goal**: 68%

![Graph showing freight efficiency improvement for different components and demo status vectors.](image)
Component Technology Integration

- Combustion
- Fuel Systems
- Air Handling & EGR
- Aftertreatment (AT)
- Electronic Controls
- Waste Heat Recovery
Enabling technologies for 50% Engine Thermal Efficiency

Gross indicated gains
- Compr ratio increase
- Piston bowl shape
- Injector specification
- Calibration optimization

Gas flow improvements
- Lower dP EGR loop
- Turbocharger match

Parasitic reductions
- Cylinder kit friction
- Cooling pump power

WHR system
- EGR boiler/superheater
- Exhaust boiler
- Recuperator
Progress made to reduce engine friction
- Reductions of 19% measured
- Further reductions are being tested
• Compliance to prevailing emissions 0.2 g/(hp-hr) demonstrated
• FTP requires additional calibration effort with optimized components

- SCR catalyst size optimization
- Improved design of NOx sensing across face of catalyst
- Close loop control
WHR Vehicle Cooling Tests

- Successful Packaging of technologies
- No Increase in Frame Length

- WHR system tested
- Performance as expected
Fan-Off Cooling System Performance

VMT = 48 State Vehicle Miles Travelled

Cruise Power

~400hp

%VMT

18.3%

47.5%

84.9%

99.6%

99.99%

Top Tank Temperature Differential (TTTD) (degF)

Total Heat Rejection (WHR + Rad) (kW)
Improvements to Vehicle Cooling Enable WHR System Performance

- 65% Improved Fan-Off Performance
- Enables Improved WHR Contribution
Freight Efficiency Enabling Technologies

- Idle Management (APU)
- Advanced Aerodynamics
- Transmission/Axle Technology
- Weight Reduction
- Route Performance Management
- Highly Efficient Engine System
- Driver Display with Fuel Economy Tools
- Next Generation LRR Tires
Aerodynamic Progress

- Demo #1: 21.5% Fuel Economy Improvement vs 14% Target
- Demo #2: 23% Fuel Economy Improvement vs 24% Target (48% Aero Cd Reduction)

* Cd's Shown Are Adjusted to SAE J1252 Baseline Using % Average Deltas From 0 and 6 Degree CFD Runs
Vehicle Weight Reduction Projections

~4% Freight Efficiency Improvement With Vehicle Weight Reduction

Weight Additions

Weight Reductions

Freight Efficiency Gains/Losses (%)

WHR/AT system  Aero Devices  Idle Systems  Truck  Trailer  Net Weight
Trailer Development

- Trailer build complete
- Preliminary aerodynamic road tests complete
- End customer input on-going
Hotel Loads

- Baseline Load Assumptions:
  - 1500w Nominal
  - 2500w Peak
- Revised Loads:
  - 1100w Nominal
  - 2900w Peak
- Change Based On:
  - Driver Surveys
  - Fleet Feedback
  - Measured Requirements (by component)
Summary

• Program remains on schedule
• Program roadmaps meet or exceed targets
• Implementing technology for 50% BTE
• WHR on-vehicle performance meets expectations
• Aero trailer preliminary development testing complete
• Completed baseline vehicle testing
• CFD results exceeding truck/trailer aerodynamic goals for Demo #1 (Objective 2a)
• Hotel loading assumptions verified
• Fuel cell APU efficiency quantified
• Vehicle system integration proceeding without any major issues