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DETROIT DIESEL

Increased Engine Efficiency via Advancements in Engine Combustion Systems

September 29, 2010

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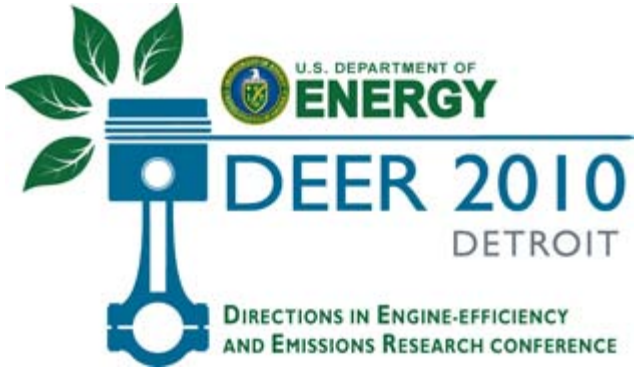
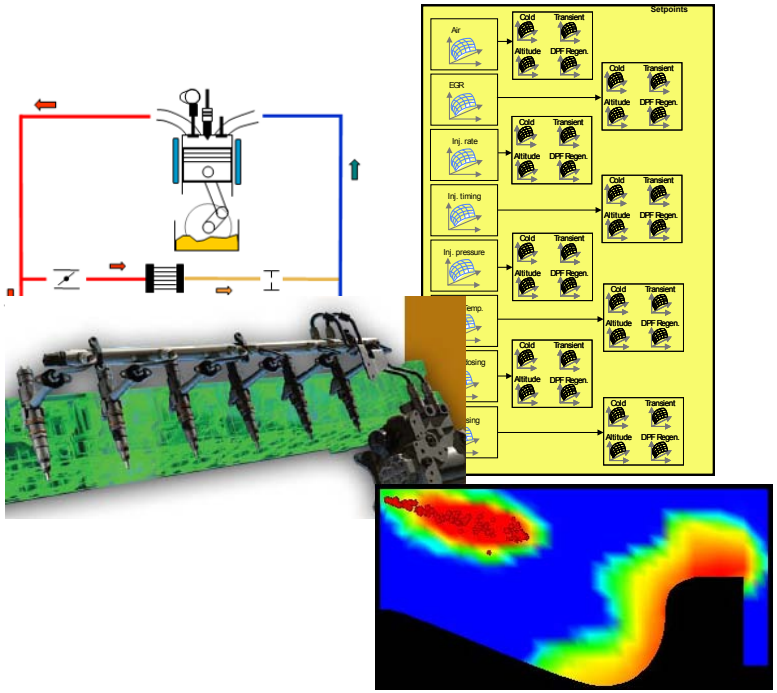


DDC NZ-50 and Super Truck Team

NZ-50 and SuperTruck

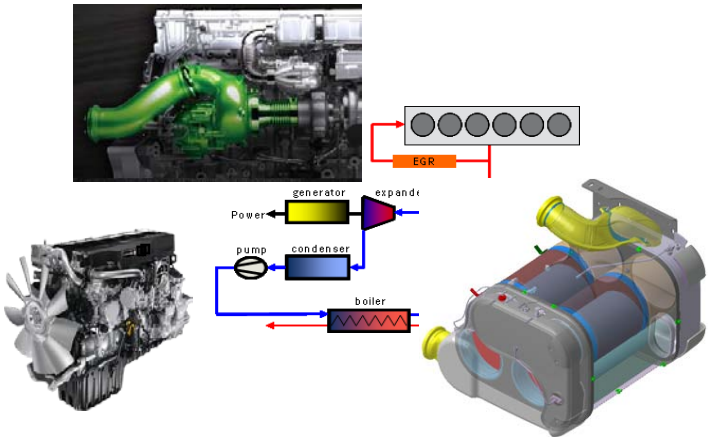
NZ-50 Recent Efforts

- Advanced Combustion System
- Advanced Flexible Fuel Injection
- Air/ EGR Handling System
- Next Generation Controls



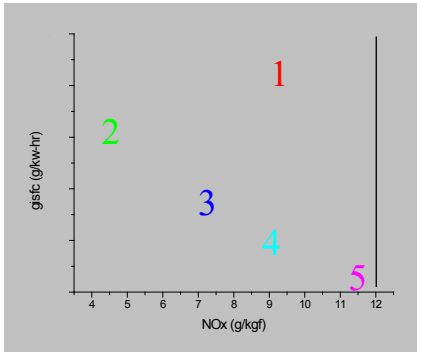
SuperTruck Takes NZ-50 Advancements Plus:

- Waste Heat Recovery
- Engine Down Sizing
- Parasitic Loss Reduction
- Hybrids

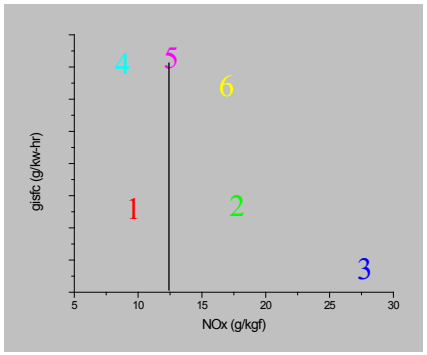


Advanced Combustion – PCCI

Low Speed & Load



High Speed & Load



Simulation Studies

- Evaluated Over a Design Matrix
- At A25; Up to 3%ISFC Improvement
- At B50; ISFC Suffers

Fuel Injector Development

- Dual Mode Injector Functional
- 2nd Generation Hardware Required

Real Time Combustion Feedback

- Evaluated Two Pressure Feedback Devices
- Each Had Unique Challenges
- With Significant Effort, Could Work

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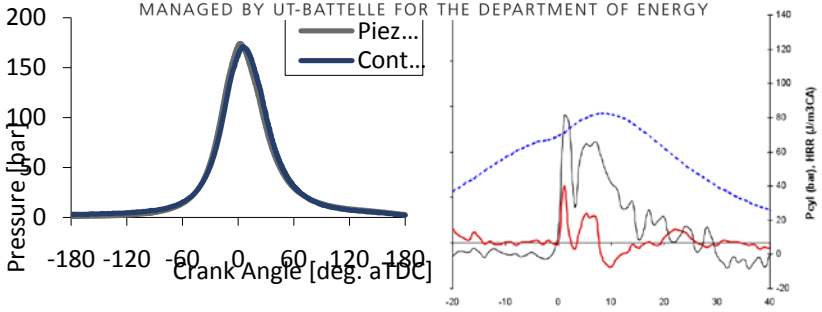


Advanced Combustion – Conventional Approach

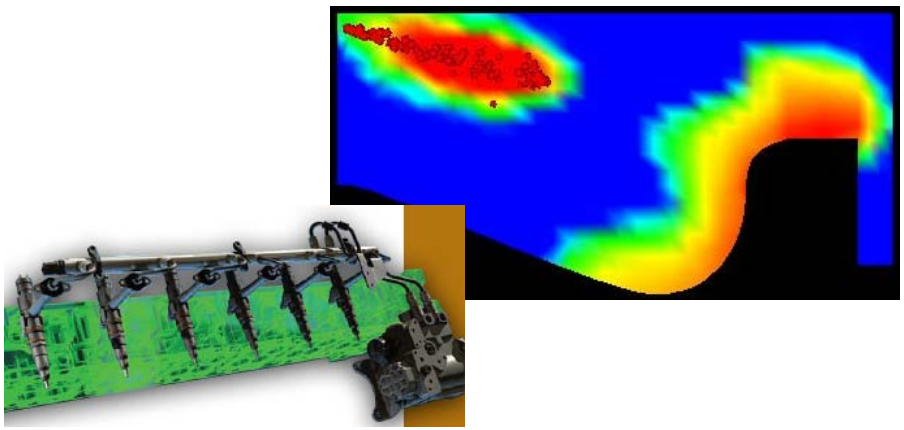
Improvements Being Seen

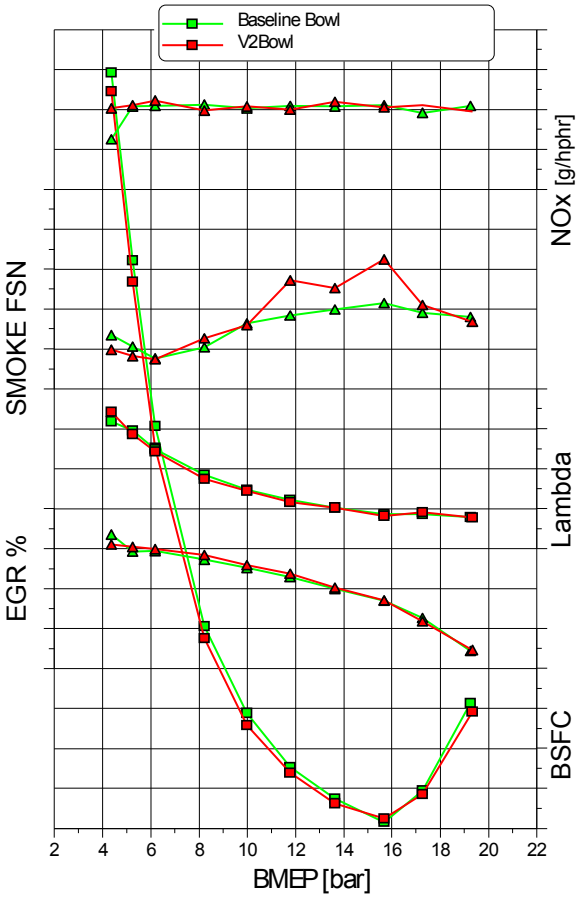
- Expectation is 2%to 3%

Alternative Bowl Shapes

High Pressure Fuel System

Integration with High Efficiency Aftertreatment





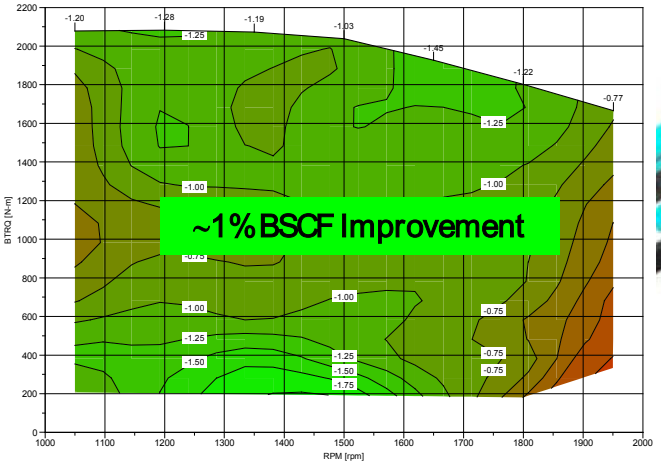
Air/ EGR Advancements

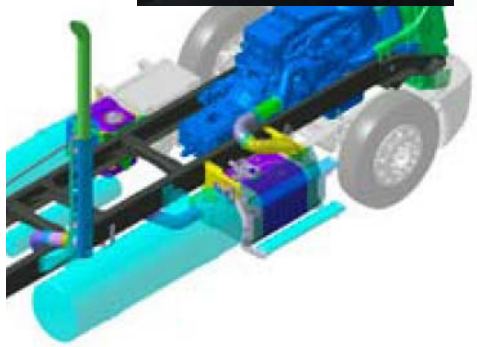
Significant Air System Improvements

- Rematch/ Optimization
- Flow Improvements

Moving Forward

- Interface with Vehicle Aero
- Waste Heat Recovery
- Turbo Compounding
- Aftertreatment





Transition to SuperTruck

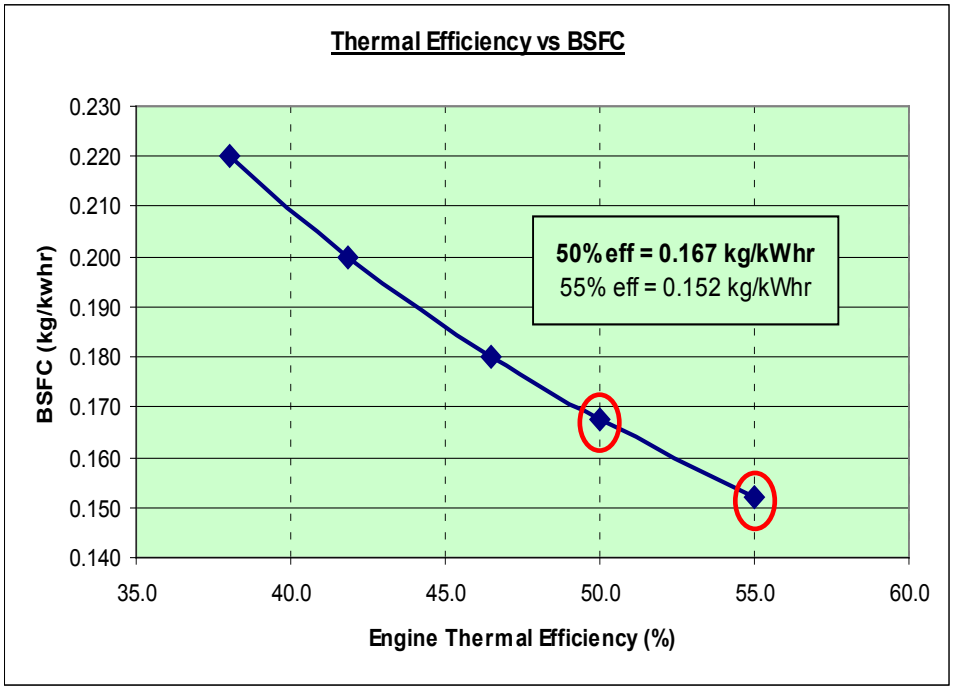
Advance Current State-of-the-Art Engine Technology To Yield 50%Engine Thermal Efficiency On A Dyno

- Optimized For Speed and Load Representing 65,000 lbs GVW @65 mph

Analytical Roadmap to 55%Engine Thermal Efficiency

Engine Features Identified

Program Moving Forward

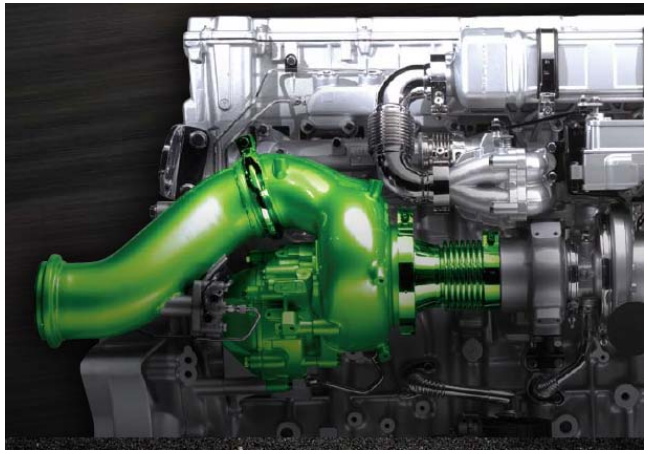


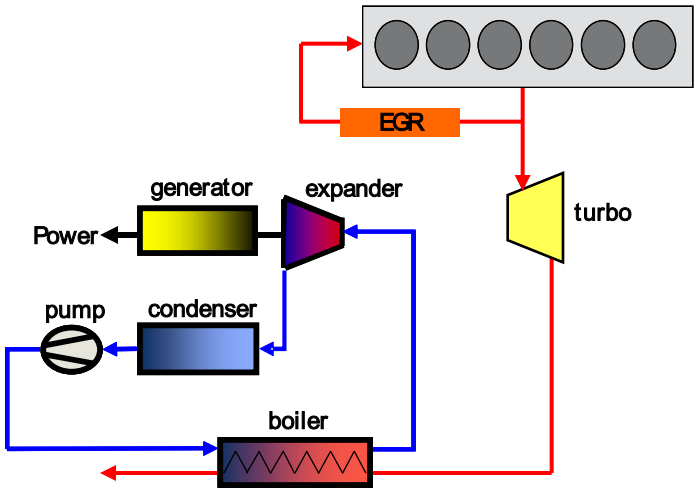
Waste Heat Recovery

Approximately 55%of Fuel Energy is “Waste Heat”

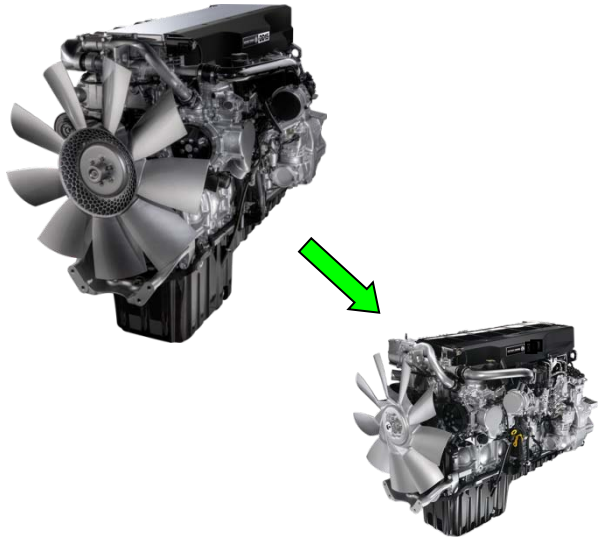
Waste Heat Recovery

- Turbocompound – In Production on DD15
- Rankine Bottoming Cycle – Recover Energy From EGR and/ or Exhaust Gases
  - Works Well With Hybrid System
  - 5%BSFC Improvement Expected
  - Significant Technical Challenges
    - Heat Exchangers, Expander, Compressor, Packaging, Engine Integration, etc





Engine Down Sizing



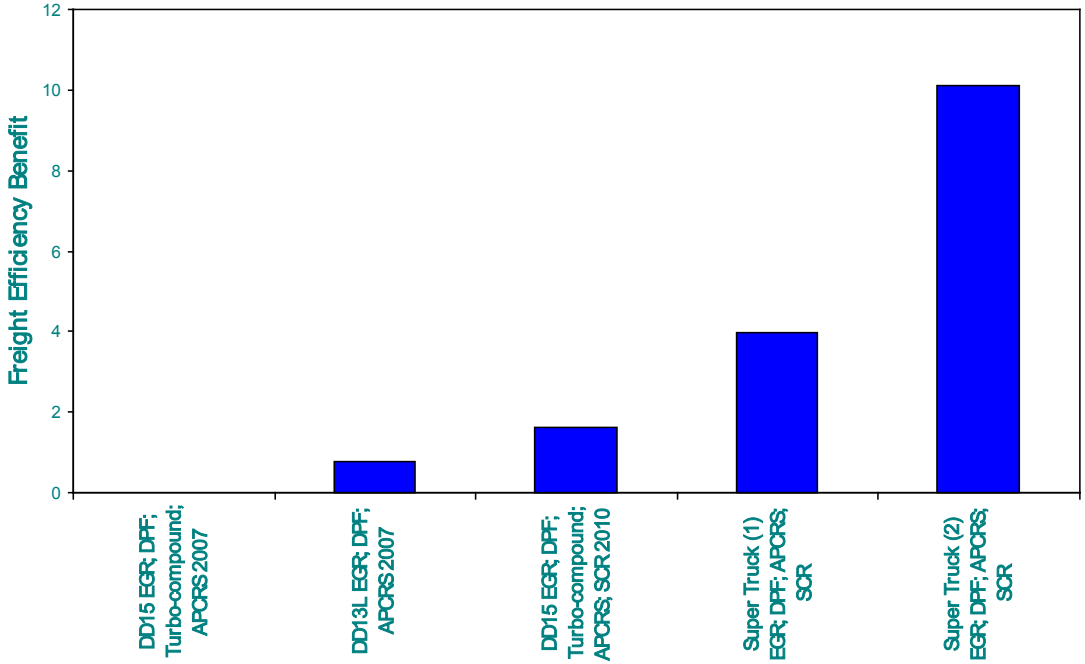
In the Early 1990's, 11-13L Engines Dominated

Today, 13-15L Displacements Dominate

- Power Increase As Well
- Some Reasons Technical, Some User Based

Where is Engine Size Headed?

- Drivability
- CO2/ Fuel Economy
- Weight
- Cost
- Hybrids



Parasitic Reduction – Dual Approach

Reduction Of Baseline Parasitic Losses

Smarter Use Accessories and Pumps

- Increased Flexibility in Component Outputs
- Feedback in Control System to Allow Optimization

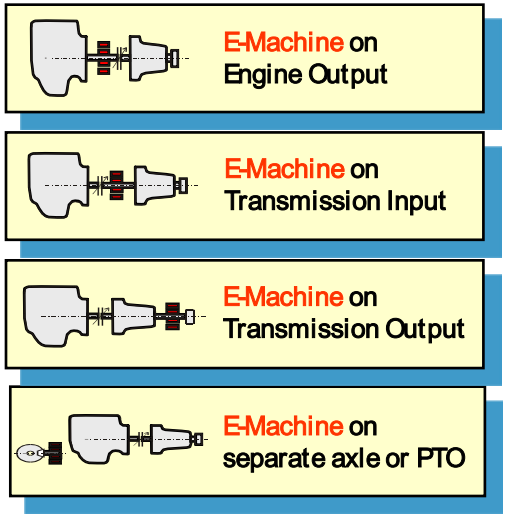
Hybrids for Heavy Duty Trucks

Can Hybrids Improve Engine Performance In Long Haul Application?

- Conventional Wisdom is Hybrid For Urban Cycle Only?
- Recover Braking Losses

Drive Cycle Data Shows Load Varies Significantly

- Hybrid Will Dampen Load Swings
- Potential Benefit For Engine Downsizing



Acknowledgements

- Department of Energy Headquarters
  - Gurpreet Singh
  - Roland Gravel

- National Energy Technology Laboratory
  - Carl Maronde
  - Jeffrey Kooser

This material is based upon work supported by the Department of Energy National Energy Technology Lab under Award Numbers 409000-A-N8, DE-FC26-00-OR22805, and DE-EE-0003348.