PACCAR - Eaton Hybrid Collaboration

Taking HD Hybrid from Concept to Commercialization

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Heavy Duty Hybrid: Building on MD Success

- 20-60% improvements in fuel cost
- 50% reduction in NOx
- Utility Truck - High Value
- Partnerships are Key!
  - FedEx, UPS
  - DOE, HTUF, Others
Heavy Duty Hybrid: Multiple Paths

Hydraulic Launch Assist:
Start/Stop Assist, generally municipal applications, charges accumulator during deceleration, then releases energy back during acceleration.
Heavy Duty Hybrid: Multiple Paths

**Diesel Electric Hybrid:**
- 2004 Concept vehicle has matured beyond “Show Truck” status with 2009 Production Launch
- Common technology with MD Diesel Electric, with added anti-idle during hotel-mode.
Diesel Electric Product Description:

Hybrid Drive Unit (HDU) and Power Electronics Carrier (PEC)

• Hybrid Drive Unit Assembly
  • 10speed Automated Transmission
  • Clutch Actuation System
  • Electric Traction Motor / Generator
    • (Motor is common to HD and MD Hybrid)

• PEC Assembly
  • Batteries
  • Traction Inverter
  • 12vDC/DC Converter
  • System Controller
  • 120vAC Inverter
HEV System Diagram
Types of Operation:

- **Engine Starting Mode (Start-Stop)**
  - Battery starts/stops engine through Motor inverter auto clutch

- **Diesel Engine Only Mode (Backup)**
  - Diesel Engine Charges Batteries Through Motor Inverter

- **Regenerative Braking Mode**
  - Assist on full stop and/or downhill retardation while capturing power

- **Electric Only Mode**
  - Idle Power for "Hotel Mode" with Engine Off

- **Diesel Engine & Hybrid Motor (Motor Boost)**
  - Uses Battery Power to assist on launch, grades, and acceleration
Eaton’s System: Unique Benefits

• World’s first true production parallel MD Hybrid system
  • Proven customer uptime based on >1,000,000 field test miles
• Based on proven high-volume AMT, Autoclutch and controls components
• Single-Motor/Single-Clutch design vs. Dual-Mode systems
  • Eaton’s Direct Hybrid achieves lowest possible operating cost
• Direct Hybrid architecture provides highest degree of Integrated Functionality
  • APG, ePTO, Anti-Idle, EV mode, etc.
Challenges to Commercialization

- **Battery Technology**
  - Power Density / Life constraints, ie, ability to use all potential energy
  - Battery Weight / Size / Packaging (especially with SCR adds)
  - Sustainability / Recycle / Reuse infrastructure for Batteries

- **Capital Spending Cycle**
  - System incremental cost
  - “Show Me” approach of major fleet purchase decisions
  - Residual Valuation / Payback Cycle
  - ~6-7% fuel savings typically required to develop interest of fleets
  - Clarifying the “Value of Green”

- **Duty Cycle variation and savings demonstration**
Class 8 Hybrid Truck Fuel Economy Improvement Potential

by

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October, 2007
Question of Interest

- Can a significant fuel economy benefit be obtained through hybridization of class 8 over-the-road line-haul tractor trailers?
Fuel Economy (MPG) over City-Suburban Heavy Vehicle Route
(Drive Efficiency = 92.00 %; Avg. Auxiliary Loads = 10.00 kW)

- Only need 20% of braking energy to reduce fuel consumption by 10%
- Need 55% of braking energy to reduce fuel consumption 10%
- Little improvement capturing braking energy

Baseline conventional fuel economy
Better baseline conventional fuel economy
Best baseline conventional fuel economy
Much less regen available for line-haul driving

Regen Energy by Regen Power

- CSHVR Urban
- WVU Interstate
- HHDTC Cruise
Key Enablers to Successful HD Hybrid Commercialization

• Diesel Fuel Price increases and taxation
• Simplification of Tax Credit Regimes nationwide
• Legislation & Regulation
• Taxation / Tolls
• Penalties for Carbon Emissions in city centres (Madrid, Paris, Los Angeles,…)
• Environmental Pressure and increased valuation of “Green” by owners and shareholders of HD Vehicle operators
• Support for technology development to reduce battery cost & packaging
Thank You!
Questions?