Clean Automotive Technology… Innovation that Works

EPA
Advanced Technologies

China
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World Crude Oil Production

Urgency of Our Combined Effort...
World Crude Oil Production/Consumption

Meeting the Challenge of High Efficiency and Low Emissions

Revolutionary Engines
Revolutionary Drivetrains

Ultra-Clean & Ultra-Efficient Vehicles
Economic Analysis

- We regularly conduct world wide technology assessments
- With that insight and our own analysis we have concluded that certain technologies make more economic sense (see technical report at www.epa.gov/otaq/technology/)

Hydraulic Hybrids and EPA Clean Diesel Combustion Engines look especially attractive with projected consumer paybacks of 1-3 years at $1.50/gallon fuel.

EPA Clean Diesel Combustion - Controlling Diesel Engine-out NOx...

Air Management
- controls peak combustion temperature with boost & EGR (low NOx)

Fuel and Combustion Management
- promotes fast combustion utilizing advanced fuel injection systems for performance, good efficiency, and low smoke/PM

Conventional Aftertreatment
- reduces PM, HC & CO to the level of the standards
EPA Clean Diesel Combustion
(1.9L Multi-Cylinder Evaluation)

More Engine Break-Throughs...

HCCI Combustion
- 4 cylinder engine working, installed in truck
- Virtually "no" NOx or PM emissions
- Diesel like efficiency from gasoline
- Excellent engine for a series hybrid
- Paper in March 2004 SAE Congress

Free-Piston Engine
- Great efficiency - Hydraulic power directly from engine
- Clean 4-stroke cycle or High Power 2-stroke cycle
- Capable of Clean Diesel or HCCI combustion
- High Reliability/Low Cost potential: fewer moving parts

More Emerging Engine Technologies...

HyTEC – Hybrid Thermal Energy Converter
- Recovers energy from engine exhaust heat,
- Yields fuel cell efficiency levels at 1/5th the cost

Ethanol-Value
- Diesel-like efficiency, low GHG
- Payback analysis – low cost fuel (E30) still achieves high FE
- Ready for fleet demonstration

Variable Displacement Engine
- Allows optimum high efficiency use of a small displacement engine while retaining the option for sustained high power when needed

Variable Compression Engine
- Allows low power, very efficient engines to also provide high power performance

Hydraulic Hybrid Configurations
Historic EPA Hydraulic Hybrid Test Chassis

- Full Series Hydraulic Hybrid
- 80+ mpg combined city/highway mpg
- ~8 seconds 0-60 acceleration time
- No need for expensive lightweight materials (test weight 3800 lb)
- Led the way for subsequent demonstration vehicles

Focus for Current EPA Demonstration of Hydraulic Hybrid Vehicles

1. Class 5 Delivery Truck
   - Hydraulic Assist Hybrid
   - Diesel Engine
   - Package suitable for retrofits
2. Class 6 Urban Package Delivery Vehicle
   - Full (series) Hydraulic Hybrid
   - Diesel Engine
3. Sport Utility Vehicle
   - Full (series) Hydraulic Hybrid
   - Diesel Engine

Urban Delivery Truck – Hybrids through Retrofitting

Hybrid Assist Hydraulic Hybrid
- Demonstrates the ease of retrofitting trucks with hydraulic hybrid technology
- Shows ability to get low hanging fruit (20-30% mpg improvement)
- Gold award for mpg improvement and Silver award for performance at the 2003 Michelin Bibendum Challenge

Vehicle Installation

- Control Valve
- Gearbox/Pump-motors
- Driveshafts
- Accumulator
Urban Delivery Vehicle - Full Series Hydraulic Hybrid

- First-ever full integrated hydraulic hybrid delivery vehicle, targets 70% mpg improvement in city driving
- 2-year payback has attracted serious attention from fleets
- Partnership involving EPA, Eaton, fleet, OEM & Army

Showcasing full hydraulic hybrid systems in an Urban Delivery Vehicle.

Full Series Hydraulic Hybrid SUV

- Full integrated hydraulic hybrid, diesel engine, clean packaging, cost effective, targets 85% mpg improvement
- Excellent 1-3 year payback for consumer
- Best configuration to communicate a vision of production potential

Showcasing the full use of hydraulics in a Ford Expedition.

Innovative Integrated Packaging

Hydraulic pump-motor and parking pall integrated with front differential
Hydraulic pump-motor and Two-speed transmission integrated with rear differential

Integrated Design...

Integrated Rear Drive w/ 2-speed Trans
Integrated Front Drive
Engine Pump

View from Rear
Progress Report on Clean and Efficient Automotive Technologies Under Development at EPA - January 2004

For More Information
www.epa.gov/otaq/technology

1) 4 page fact sheet
Worlds First Full Series Hydraulic Hybrid SUV Presented at the 2004 SAE World Congress - March 2004

2) 198 page interim technical report
Progress Report on Clean and Efficient Automotive Technologies Under Development at EPA - January 2004