Advanced Petroleum-Based Fuels - Diesel Emissions Control (APBF-DEC) Project

Project Summary

Japan Clean Air Program (JCAP) Conference 2002 - Tokyo, Japan
February 2002
DEC Mission

- Identify optimal combinations of fuels, lubricants, diesel engines, and emission control systems to:
  - Meet projected emission standards during the period 2000 to 2010 while maintaining continuous improvement in engine efficiency and durability
  - Maintain customer satisfaction with vehicle performance
  - Provide the basis for economical transport of people and goods
  - Meet additional potential constraints (e.g., emissions of unregulated substances, including ultra-fine particulate matter and greenhouse gases)

- Explore the potential to achieve even lower emissions of criteria and unregulated pollutants beyond 2010
APBF-DEC Products

- Light and heavy-duty platforms for measurement of effects of fuel and lubricant composition on emissions under transient operation
- Comprehensive data on status of fuel-engine-emission control technologies for reducing criteria emissions for U.S. EPA’s biennial technology assessments
- Comprehensive data on effects of fuel & lubricant properties on emissions of unregulated substances
DEC Summary

- Includes vehicles from automobiles to heavy-duty trucks
- Systems approach investigating fuels, lubricants, engines, emission control systems
- Initial timeframe 2000 to 2003 to provide information to industry and government within regulatory environment
- Resource needs of $33 million, including $19.3 million in cash and $14 million in in-kind contributions
- Government planning for $14 million of the $19.3 million cash contribution
- Government/industry Steering Committee and Work Groups guiding the DEC Project
## APBF-DEC Project Schedule

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<thead>
<tr>
<th>CY2001</th>
<th>2002</th>
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## APBF-DEC Phase I Project Schedule

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<td>Lubricant effects on emission control performance and durability</td>
<td>Engine/emission control system confirmatory tests</td>
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# Studies of Fuel Composition Effects

## Phase I (2001-2003)
- **Fuel Effect Studied:** Sulfur

## Phase II (Tentative) (2004-2007)
- **Fuel Effect Studied:** Sulfur, other substances & properties (e.g., aromatics, oxygen, cetane)

## Test Fuels
- **DECSE**
  - 3 ppm sulfur (set-up)
  - 8 & 15 ppm sulfur
  - 30 ppm sulfur
- **Refinery Process Fuels**
  - Fuel B
  - Fuel C
  - Fuel D
- **Fischer-Tropsch Fuels**
  - Fuel E
  - Fuel F

## Emission Measurements
- **NOₓ**
- Particulate matter
  - Soluble organic fraction
  - Sulfate
- Hydrocarbons (HC)
- Carbon monoxide (CO)
- Unregulated substances
  - (limited measurements)
- **NOₓ, HC, CO, N₂O**
- Particulate matter
  - Soluble organic fraction
  - Sulfate
  - PAH, Nitro-PAH
- Speciated non-methane organic gases
  - Formaldehyde
- Other unregulated substances
DEC Participants

- U.S. DOE
- U.S. Environmental Protection Agency
- American Petroleum Institute
- National Petrochemical and Refiners Association
- Engine Manufacturers Association
- Manufacturers of Emission Controls Association
- American Chemistry Council
- California Air Resources Board/South Coast Air Quality Management District
## Participating Companies/Organizations

<table>
<thead>
<tr>
<th>Automobile:</th>
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- **Engines:** EMA, Caterpillar, Detroit Diesel, Cummins, John Deere, Mack Trucks, International Truck & Engine
- **Technology:** Battelle
Integrated Systems Approach

DOE, EPA, additive companies, automobile manufacturers, engine manufacturers, energy companies, emission control mfrs., Calif. agencies

APBF-DEC Steering Committee

- Unregulated emissions
- Experimental design and data analysis
- Fuel and lubricant provision
- Communications

- Fuels, engines, NO\textsubscript{x} adsorbers, and diesel particle filters
- Fuels, engines, selective catalytic reduction and diesel particle filters
- Lubricants
Fuels, Engines, SCR/DPF Technologies

- **Goal** - Demonstrate low emissions performance attainable with SCR and diesel particle filter technologies (SCR/DPF). Evaluate sensitivities to fuel variables.

- **Deliverables:**
  - Optimized SCR/DPF systems for testing heavy-duty engines
  - SCR/DPF emissions performance
  - Effects of fuel variables including sulfur and aromatics
  - Durability data, emissions performance with aging
  - Assessment of urea infrastructure barriers

- **Contractors:**
  - Southwest Research Institute - testing
  - A.D. Little - urea infrastructure assessment
Fuels, Engines, SCR/DPF Technologies

- **Scope:**
  - Two heavy-duty engines (Caterpillar C12, 12-liter, ~MY2000)
  - SCR catalysts (two of the following: vanadium, zeolite, base metal) with DPFs
  - Fuels matrix - DECSE fuels (3, 8, 15, 30 ppm sulfur), Fischer-Tropsch, variable aromatics
  - Durability data out to 6,000 hours
  - Emissions - regulated, PM fractions (soluble organic fraction, sulfate), $N_2O$, $NH_3$, $C_6H_6$, HCHO, $CH_3CHO$, 1,3-butadiene

- **Schedule:** April 2001 - September 2003

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<th>CY2001</th>
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SCR Test Cell at SwRI
Fuels, Engines, NO\textsubscript{x} Adsorber, DPF Technologies

- **Goal** - Demonstrate low diesel emissions performance with system of engine, controls, fuel, NO\textsubscript{x} adsorber, diesel particle filter, thermal management technologies

- **Deliverables:**
  - Optimized NO\textsubscript{x} adsorber/DPF systems for testing heavy- and light-duty engines utilizing late-cycle injection
  - NO\textsubscript{x} adsorber/DPF emissions performance
  - System durability

- **Contractors:**
  - FEV Engine Technology - passenger car
  - Southwest Research Institute – pick-up truck/SUV
  - Ricardo - heavy-duty engine
Fuels, Engines, $\text{NO}_x$
Adsorber, DPF Technologies

**Scope:**
- One heavy-duty engine (15-liter Cummins ISX) and one light-duty engine (1.9-liter TDI in Audi A4 passenger car) and one medium-duty engine (6.6-liter GM Duramax in a pickup)
- Two emission control systems in each project, including $\text{NO}_x$ adsorbers and DPFs, and thermal management technologies
- Initial demonstration on DECSE fuel - other fuel properties examined after demonstrating ultra-low emissions
**Fuels, Engines, NO\(_x\) Adsorber, DPF Technologies**

- **Schedule** - May 2001 - October 2003

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FEV Light-Duty Passenger Car Project
Vehicle: Audi A4 Avant 1.9 L TDI
FEV Light-Duty Passenger Car Project
1.9 L Diesel Future II HSDI Common Rail Engine
SwRI SUV/Pick-Up Project
Vehicle: 2002 Chevrolet Silverado, 2500 Series
SwRI SUV/Pick-Up Project
6600 V8 Duramax/ ZF 6-speed Manual

- Center-mounted turbocharger
- Charge Air Cooled
- Bosch Common rail fuel injection
- Noise optimized FI rate
- OH 4-V
- 2002 CA calibration with EGR
- Weight: 835 lbs.
SwRI SUV/Pick-Up Project
Test Cell Set up

6.6L Duramax CIDI Engine

Dual Leg Exhaust
HD NOx Adsorber/DPF
Ricardo

- Cummins ISX engine
  - 15L, DOHC
  - Integrated EGR w/ VGT
  - Secondary fuel injection system for NOx adsorber regeneration (to be developed by Ricardo)

- ECS architecture
  - Single leg (system ‘A’)
  - Twin-bed (system ‘B’)

APBF-DEC
Lubricants

- **Goal** - To determine which (if any) lube-derived emission components are detrimental to performance/durability of emission control systems

- **Deliverables:**
  - Documentation of effects of lubricant composition on emissions and performance of advanced emission control technologies
  - Guidelines for formulation of lubricants
    - Basestock selection
    - Additive development

- **Contractor** - Automotive Testing Laboratories
Lubricants

- **Scope:**
  - Engine and accelerated aging tests will determine the impact of lubricant formulation on the performance and durability of diesel emission control devices.
  - International T444E (7.3-liter, V8) engine equipped with CCV and cooled exhaust gas recirculation

- **Schedule** - April 2001 - December 2003

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Planned Phased Approach

Phase 1

Phase 2

Phase 3

Engine-out → Emission Control Device → Catalyst-out