APBF-DEC

Quarterly Update♦

**Advanced Petroleum-Based Fuels–
Diesel Emissions Control (APBF-DEC) Program**

#3, Summer 2001

Contracts are being finalized by the APBF-DEC program to launch tests of the selected two emissions control technology systems and the procurement of fuel and lubricants for the projects. The composition of the fuel and lubricants can affect the emissions from advanced engine-emission control systems. The program will evaluate a limited number of light- and heavy-duty platforms to measure the effects of fuel sulfur and lubricant composition (heavy-duty only) on emissions under transient operation. Comprehensive data will be collected on the status of fuel-engine-emission control technologies in reducing criteria emissions. Data on the effects of fuel sulfur and lubricant composition on emissions of unregulated substances will also be collected. Additional information about the APBF-DEC program, including the previous two issues of this publication, is available at http://www.ott.doe.gov/apbf_dec,.

APBF-DEC Participants

Participants include the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA), the Engine Manufacturers Association (EMA), the American Petroleum Institute (API), the Manufacturers of Emission Controls Association (MECA), the American Chemistry Council (ACC), the National Petrochemical and Refiners Association (NPRA), and the California Air Resources Board (CARB)/South Coast Air Quality Management District (AQMD). The program is managed by DOE's National Renewable Energy Laboratory (NREL) and Oak Ridge National Laboratory (ORNL).

Technology Systems

The APBF-DEC program is being conducted in two phases (see Figure 1). Phase I began this year and continues through 2003. Phase II, which is in the planning stages and has not been formally agreed to, would begin in 2004 and continue through 2007. Several projects will span both phases. The schedule for individual projects is also provided (see Figure 2). Current summaries of the APBF-DEC projects follow.

- **SCR/DPF technologies, fuels, engines.** The selective catalytic reduction (SCR) technology is an emissions reduction device that, combined with a diesel particle filter (DPF) and advanced fuel formulations has the potential to reduce regulated, unregulated, and toxic

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♦ **BACKGROUND:** The APBF-DEC is an industry/government program to identify and evaluate (1) the optimal combinations of low-sulfur diesel fuels, lubricants, diesel engines, and emissions control systems to meet projected emission standards for the 2001 to 2010 time period and (2) properties of fuels and vehicle systems that could lead to even lower emissions beyond 2010. Sulfur in the fuel is known to interfere with the functioning of most emissions control technologies and has been implicated as a possible factor in the formation of ultrafine particulate matter (PM). A systems approach is being used, i.e., simultaneously investigating fuels, lubricants, engines, and emissions control systems. A government/industry steering committee and working groups are guiding the APBF-DEC program. Funding for the program is expected to total $36 million, including $22 million in cash ($14 million from the government) and $14 million in in-kind contributions. Information about the APBF-DEC program is posted at: http://www.ott.doe.gov/apbf_dec. APBF-DEC is the successor to the Diesel Emission Control-Sulfur Effects (DECSE) program, whose objective was to determine the impact of fuel sulfur levels on the performance and short-term durability of emissions control systems, which could lower emissions of NO_x and PM from diesel-powered vehicles in the years 2002 to 2004. In June 2001, the final edition of the DECSE Program Summary described DECSE's final results. The program summary and the final DECSE reports are available at: http://www.ott.doe.gov/decse. The DECSE results showed the effects that fuel-borne sulfur has on the performance of emissions control systems. For further information, contact Helen Latham at Battelle, phone 614-424-4062, fax 614-424-5601, e-mail lathamh@battelle.org.

emissions. The SCR will use urea as a reductant. Two types of SCR catalysts are being evaluated in the test, along with two types of DPFs—a catalyzed DPF and a continuously regenerated DPF. The working group for this technology includes representatives of engine, automobile, catalyst, and petroleum companies; national laboratories and research institutes; and government agencies. The objectives of this project are to demonstrate the low emissions attainable using an advanced diesel engine with the SCR/DPF systems; determine the regulated and unregulated emissions with and without emissions controls; assess the durability of emissions controls; and evaluate the sensitivities of emissions controls to fuel variables.

The SCR/DPF project will utilize heavy-duty 12-liter engines. Two different SCR catalyst systems paired with a DPF, and a matrix for three fuels will be optimized. A laboratory durability validation of the two systems will be performed simultaneously over a 6,000 hour, round-the-clock evaluation. Emissions will be evaluated at three intervals—2,000, 4,000, and 6,000 hours.

The Southwest Research Institute (SwRI) will conduct the test and AD Little will provide the urea infrastructure assessment. In-kind contributions are being provided by Caterpillar (four C12, 12-liter engines); STT of Sweden (low-pressure-loop exhaust gas recirculation [EGR] systems); Bosch (urea injection systems); and MECA (SCR/DPF systems). The baseline fuel will be 8 parts per million (ppm) sulfur. Two additional fuels will be used: 3-ppm and 15- (or 30-) ppm.

The schedule calls for the systems to be set up, optimized, and evaluated by mid-2002 (see Figure 2). The durability studies and evaluation of unregulated emissions will begin in mid-2002 and are expected to be completed in the third quarter of 2003.

- **NO_x Adsorber/DPF technologies, fuels, engines.** The NO_x adsorber catalyst is a flow-through exhaust emissions control device with the potential to significantly reduce NO_x, hydrocarbon (HC), and carbon monoxide (CO) emissions from the diesel engine's exhaust. When combined with a DPF, this catalyst system is also effective in oxidizing the diesel particulate matter and other unregulated diesel emissions. The working group includes representatives from engine, automobile, catalyst, technology, and petroleum companies; trade associations; national laboratories and research institutes; and government agencies.

  The objectives of the NO_x Adsorber/DPF technology projects are (1) to evaluate the viability of meeting future emissions requirements with emissions control systems combining the NO_x adsorber catalysts and DPFs for light-duty passenger, light-duty pickup/SUV, and heavy-duty line-haul diesel engine platforms; and (2) to determine the fuel sulfur level and other fuel properties that will allow the system to meet emissions standards without adversely affecting emissions and engine performance.

  Separate contracts are being awarded for conducting tests of the three platforms. The contract for testing the light-duty automobile platform was awarded to FEV Engine Technology. SwRI will develop and test a pickup truck platform. The remaining contract for the heavy-duty engine is being negotiated. The three projects will be conducted simultaneously.

  The test of the light-duty passenger car platform will use 1.9 liter engines, installed in an Audi A4 vehicle, and continue for 30 months. The test of the light-duty pickup/SUV platform will use a 6.6 liter engine, installed in a full-size pickup truck, and continue for 30 months. The heavy-duty engine platform will use a state-of-the-art 15 liter engine and continue for 24 months. Multiple fuels will be used during the test: 3-ppm (setup and strategy development), 8- and 15-ppm (aging and performance evaluation); and 30-ppm (limited excursion testing). Additional fuels may also be used.

  The schedule for testing the three systems platforms indicates they will be set up and optimized by the middle to late 2002. The performance and aging evaluations are expected to be completed by the middle of 2003.

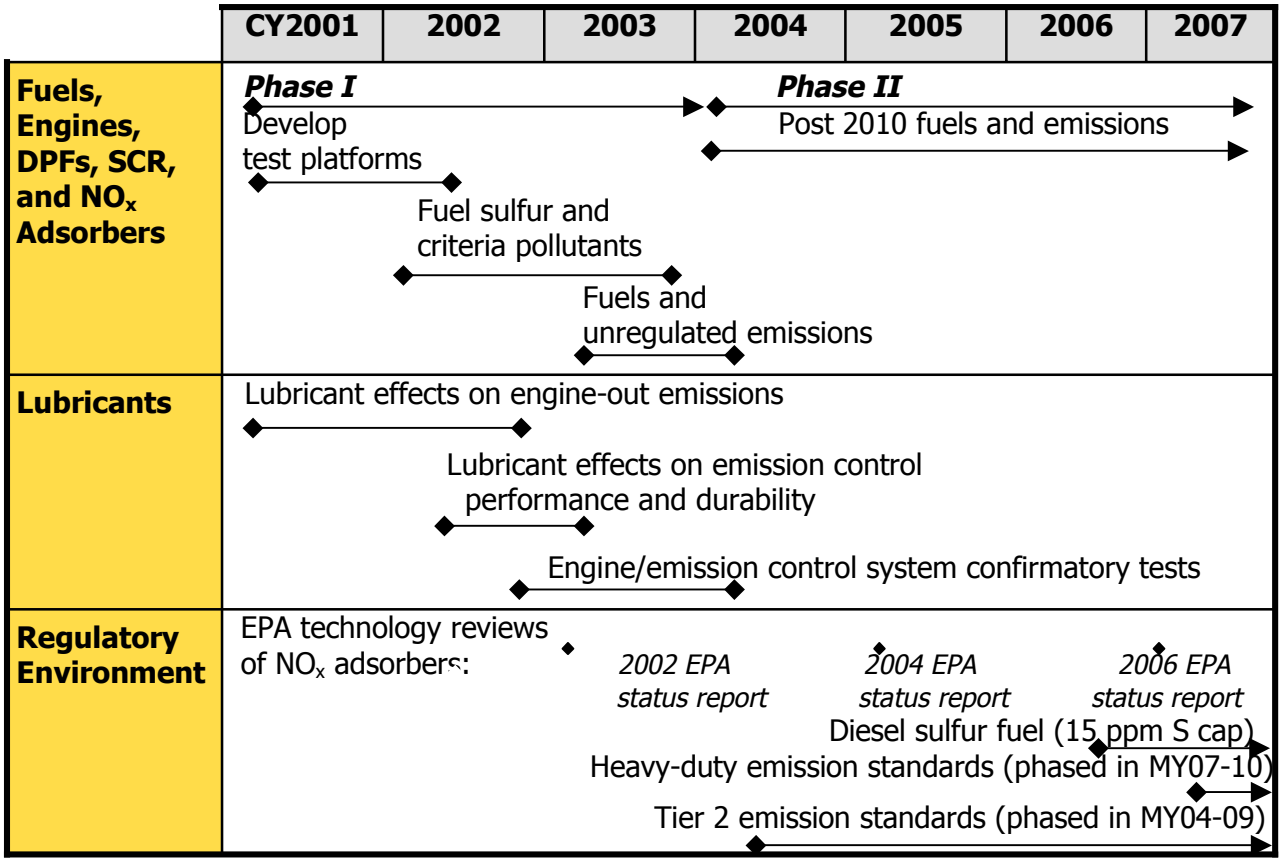

Figure 1. APBF-DEC Program Schedule

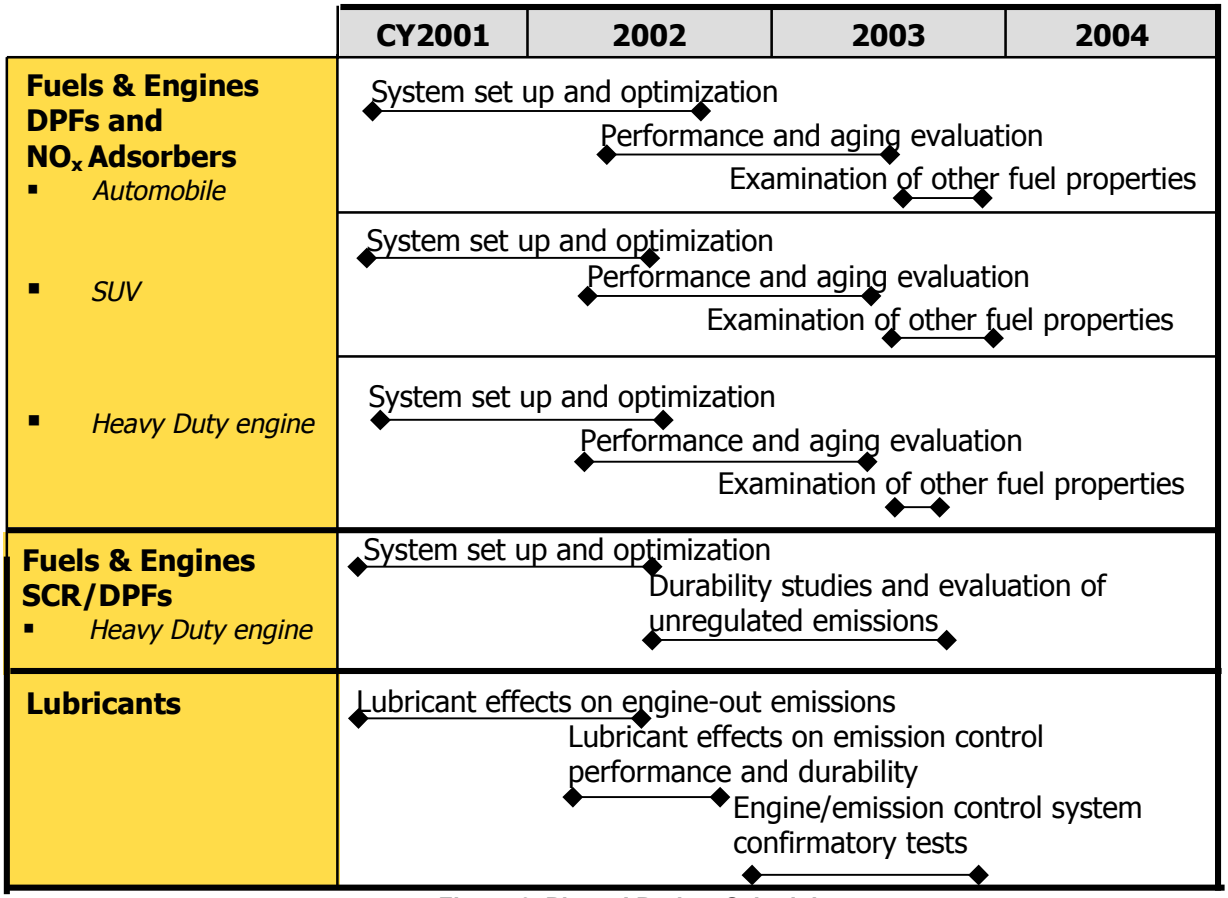

Figure 2. Phase I Project Schedule

Lubricants

Lubricant properties and composition can affect the performance, durability, and aging characteristics of the emissions control systems. Lubricants can contain sulfur and other constituents that become increasingly important as the percentage of sulfur in the fuel is reduced. As the lubricants are burned, they can contribute as much as 7- to 10-ppm of fuel-equivalent sulfur, which can mask the effectiveness of the emissions control system using low-sulfur diesel fuel. The working group includes representatives from engine, automobile, catalyst technology, and petroleum companies; trade associations; national laboratories and research institutes; and government agencies.

The objectives of this project are to determine the effects of lubricant composition on the engine-out/catalyst-in emissions and the effects on the performance and durability of the diesel engine's emissions control systems. The project is expected to determine which, if any, lubricant-derived emissions components are detrimental to systems' performance and durability. Base oil may contain from 0% to 1% sulfur. Lube oil usually has detergent, anti-wear, and other sulfur-containing additives. The results of the project will provide guidelines for the formulation of the lubricant, i.e., basestock selection and additive chemistry and design guidelines for use by engine manufacturers and suppliers of emission control systems.

During Phase I, this project will focus on determining the engine-out effects of the lubricant and evaluating a matrix of additives in combination with four different basestocks. A Navistar T444E, 7.3 liter V8 engine equipped with EGR and closed crankcase ventilation (CCV) equipment will be used. The test will use 3-ppm sulfur fuel. Phase I began this summer and will continue through the middle of 2002. The contract for Phase I was awarded to the Automotive Testing Laboratory in East Liberty, OH. Phase II will begin in early 2002 and focus on lubricant impact analyses and the performance and durability of emissions control systems. Phase 3 will begin in late 2002 and will include confirmatory tests along with the two "systems" projects.

■ Support Groups

- **Procurement of Fuels, Lubricants.** The Fuels and Lubricants Procurement Group established criteria for the fuel: has a low sulfur content (about 15-ppm), meets other current industry-average (D975) parameters; is a blend of petroleum-based streams, from a reliable, repeatable source. The group chose the 3-ppm fuel used for the DECSE program as the APBF-DEC's base fuel, which will be "doped" to 8-, 15- and 30-ppm. After receiving recommendations from U.S. EPA and input from other members of the APBF-DEC working groups, the Fuels and Lubricants Procurement Group agreed the set-up of the tests should be conducted using the 3-ppm sulfur base fuel. The majority of testing and aging should be conducted with 8-ppm and 15-ppm sulfur fuel. Some limited testing with 30-ppm sulfur fuel will be conducted. The group estimated that 260,000 gallons will be needed for the APBF-DEC tests. The base fuel will be purchased from and distributed by Chevron Phillips. The group also recommended that a common lubricant oil be used, i.e., an oil that is commercially available, low in sulfur content, and has a 15W-40 viscosity grade. Approximately 15 drums will be required. Results from a study of possible lubricant formulations may lead to specifying a more "catalyst compatible" lubricant for the durability tests. In addition, the group is identifying another low-sulfur fuel produced by a process that might be used to produce diesel fuel in 2006. This fuel will also be tested in Phase I of APBF-DEC.

- **SCR Infrastructure.** NREL has contracted with AD Little/Acurex to prepare a report analyzing urea's pathway from production (e.g., manufacturers and distributors) to the buyers; estimating the future need for SCR-grade urea by diesel fleets; identifying capital requirements and retail costs; and projecting environmental impact of spills and life-cycle greenhouse gas emissions. Urea is a concentrated aqueous solution which also contains additives to improve its properties, e.g., lubricity, antifreeze. The analysis is an outgrowth of the use of urea in the SCR/DPF testing.