Fuels Performance Group

Center for Transportation Technologies and Systems

This flexible-fuel truck was manufactured to run on E85, an ethanol blend, as well as on regular gasoline.

Highlights

To help reduce U.S. petroleum imports and tailpipe emissions, we provide analyses of the performance of advanced petroleum-based and biobased fuels in current and advanced engines and vehicles.

We work with other national laboratories, government agencies, policy makers, and industry to overcome key technical barriers to the use of alternative fuels.

In projects with industry and regulators, we develop fuel specifications and test methods to ensure quality petroleum-replacement fuels for consumers.

We coordinate R&D with industry, the scientific community, environmental agencies, and the research community to address the health impacts of advanced vehicle fuels and blends.

To analyze and test advanced fuels and engines for U.S. vehicles and help reduce petroleum imports, we bring together experts in engineering, chemistry, conventional and alternative fuels, and automotive technologies.

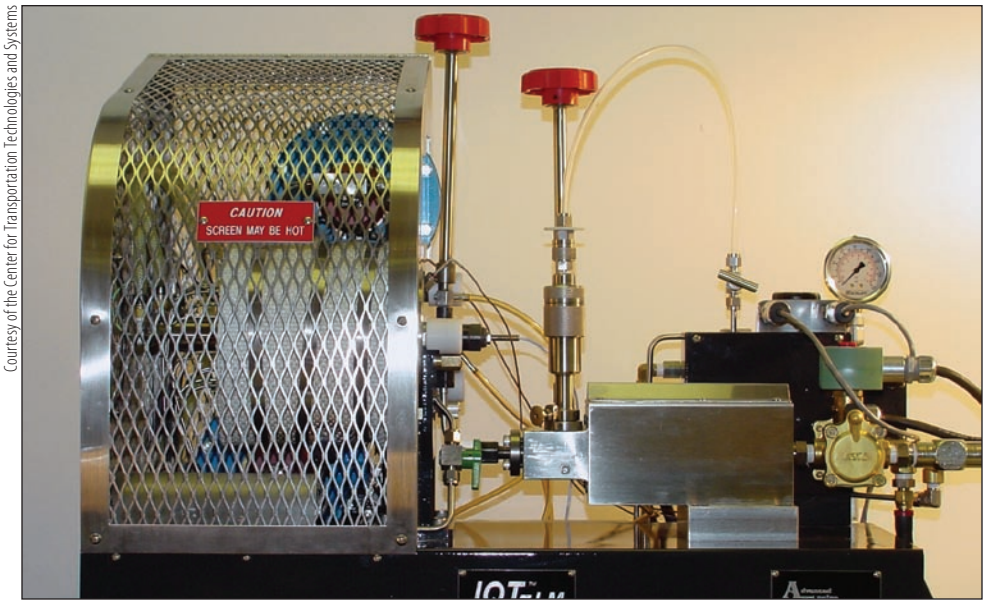
The work of the Fuels Performance Group of the National Renewable Energy Laboratory's (NREL's) Center for Transportation Technologies and Systems is enabling alternative fuels to displace petroleum in the U.S. transportation sector. We provide analyses, consultations, and technical assistance in fuel utilization—especially biobased fuels—to the U.S. Department of Energy (DOE), other government agencies, industry, regulators, and the public. Our expertise covers a broad range of alternative fuels R&D, as well as government/industry partnerships that often include original equipment manufacturers. We also draw on the experience of other experts at NREL and in the private sector. This diversity of experience and skills brings a unique perspective to our projects and allows us to deliver exceptional value.

Our R&D includes designing and conducting experimental programs and providing analyses to address key technical barriers to the use of alternative fuels. We address the compatibility of fuels with current and advanced technology pertaining to vehicles, emission controls, and the transportation fuels infrastructure. We work with regulators and industry to develop specifications and test methods that ensure quality petroleum-replacement fuels for consumers. And we analyze the air quality impacts that can affect human health.

Advanced Petroleum-Based Fuels

In the area of advanced petroleum-based fuels (APBF), we determine the impacts of fuel properties on the efficiency, performance, and emissions of advanced internal combustion engines. Our work ranges from fundamental studies of fuel ignition chemistry to

Courtesy of the Center for Transportation Technologies and Systems



NREL's Ignition Quality Tester™ tests fuels for cetane number by measuring ignition delays.

Courtesy of IMS Photo Operations

An E85-fueled Corvette pace car built for the 2008 Indianapolis 500 demonstrates the high-performance attributes of this alternative fuel.

applied research on emissions from in-use vehicles. Our projects are often carried out with industrial R&D partners and other national laboratories.

The APBF Fuel Chemistry Laboratory. In this laboratory, we use our Ignition Quality Tester (IQT™) to study the impacts of fuel properties on advanced combustion regimes, such as homogeneous charge compression ignition. The IQT is a fully automated apparatus that rapidly tests fuels for cetane number by measuring the ignition delay.

We study fuels over expanded temperature, pressure, and oxygen concentration ranges to derive parameters such as activation energy and sensitivity to exhaust gas recirculation. And we correlate the results with fuels performance data from advanced engine studies conducted with R&D partners.

The APBF laboratory includes equipment for gas chromatography/mass spectrometry analyses. These provide detailed speciation of exhaust emissions from vehicle exhaust gases—and IQT exhaust—down to parts-per-billion levels.

Non-Petroleum-Based Fuels

The goal of our non-petroleum-based fuels (NPBF) R&D is to identify and eliminate market-entry barriers to renewable fuels that can displace imported petroleum. We work with ethanol and biodiesel producers and with ASTM International to develop improved test methods and specifications. An important part of this work involves studying the impact of ethanol and biodiesel blended fuels on engine performance, durability, and emissions. Our work on second-generation biofuels such as bio-butanol and other renewable diesels will become increasingly important for future fuels.

Performance and Use of Ethanol Fuels. The Energy Independence and Security Act (EISA) of 2007 requires the United States to use 36 billion gallons of renewable fuel by 2022. To reach that goal, we will have to be able to blend ethanol at concentrations well above the 10% found today in most conventional gasoline. Therefore, at NREL we examine the use of intermediate-level ethanol blends in conventional vehicles and small engines and the use of E85 in flexible-fuel (flex-fuel) vehicles.

Evaluating intermediate ethanol blends involves studying their use in a variety of vehicles and engines as well as in marine applications. These evaluations include tailpipe and evaporative emissions, engine and emission control system functionality and durability, and safety and operability. We also conduct materials compatibility evaluations relating to both fuel system and fuel distribution networks.

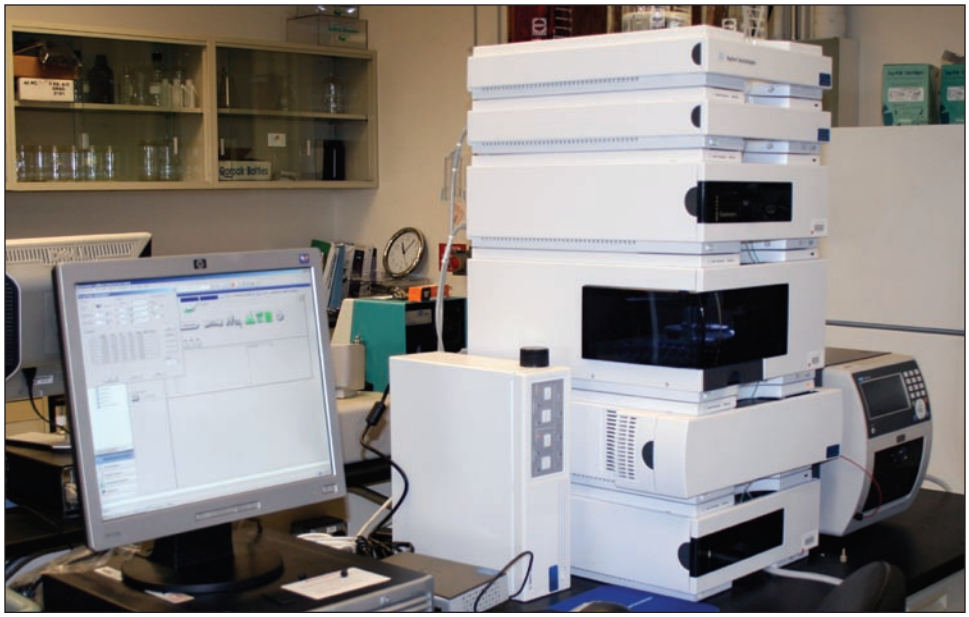
We test both on-road vehicles and small nonroad engines for emissions, safety, and operability at NREL's ReFUEL test facility and through the Colorado Department of Public Health and Environment. We also cosponsor activities with the Coordinating Research Council. These include investigations of evaporative emissions, catalyst durability, vehicle driveability, and fuel system materials compatibility. A major research area involves working with the U.S. Environmental Protection Agency to assess fuel chemistry impacts on late-model vehicle emissions. We also work with Underwriters Laboratories (UL) on fuel infrastructure materials compatibility to facilitate the certification of dispensers, which is necessary to distribute ethanol

and biodiesel blends safely. Our research seeks to understand the air quality impacts of increasing E85 usage in late-model vehicles. Although flex-fuel vehicles are fully compatible with E85 and meet emission standards, their emissions have not been well quantified. Since few flex-fuel vehicles actually operate on E85 today, the effects of usage on long-term performance and durability are not yet well understood.

Performance and Use of Biodiesel Fuels. NREL also analyzes market barriers to increasing the use of biodiesel, focusing on feedstocks, transportation, and utilization. Many biodiesel producers are seeking new feedstocks as well as new markets. A 2004 NREL study estimated that at least 1.7 billion gallons of feedstock for biodiesel are available annually. As production levels increase, it becomes more important to develop new feedstock sources and an oilseed crushing and oil extraction infrastructure. Therefore, we are working on detailed assessments of vegetable oil, animal fat, and waste cooking oil resources along with some unconventional sources, such as algae.

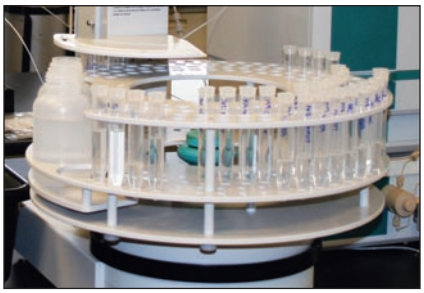
Like ethanol, biodiesel is transported to petroleum terminals primarily by rail and truck. For large biodiesel markets, we need to investigate the potential to transport neat biodiesel (B100) and blends via pipelines. Because biodiesel can potentially contaminate any jet fuel transported in the same pipeline, we are developing analytical methods to detect low levels of biodiesel in this fuel. And because biodiesel is a relatively new fuel, there are still significant barriers to its use. Therefore, a top priority for the automotive and biodiesel industries is to develop ASTM specifications for biodiesel blends. The issues preventing this include oxidation stability, understanding low-temperature operability, and water separation. More accurate quality testing methods are also needed. We are leading the R&D in all these areas.

More recent data are needed on the impact of biodiesel on toxic compound emissions, so we are performing tests using newer engines. We are also working with the National Biodiesel Board and engine manufacturers on several major studies of the performance of biodiesel with new particle filters and NOx reduction catalysts being phased in between 2007 and 2010. These technologies represent a dramatic change in diesel engine technology, so we are investigating both advantages and potential disadvantages. Because data are scarce on the impact of biodiesel blends on long-term engine durability and maintenance costs, we are also conducting several field evaluations of the use of B20.



Dean Armstrong, NREL

This high-pressure liquid chromatograph is used to separate liquid components and help characterize fuels.



Dean Armstrong, NREL

The ion chromatograph is used to determine the glycerin content in biodiesel.

The NPBF Fuel Chemistry Laboratory. This laboratory focuses on analytical and performance tests that go beyond standard test methods. The laboratory is configured with research-quality instruments to advance our understanding of biobased fuels. It is equipped with three gas chromatographs, a high-pressure liquid chromatograph, an ion chromatograph, and a Fourier transform infrared spectrometer. Using these tools, we can characterize trace components in biobased fuels. We also employ various wet chemistry methods to supplement tests conducted using the analytical instrumentation.

Specifications and Standards

Fuels Performance Group members are very active in the Petroleum and Lubricants Committee of ASTM International. We participate in specification committees for ethanol, gasoline,

Southwest Research Institute

Southwest Research Institute

This vehicle emission testing and emission sampling apparatus is used in the Collaborative Lubricating Oil Study on Emissions (CLOSE) Project.

biodiesel, and diesel fuel and their respective blends. NREL's participation has helped to increase industry's acceptance of alternative fuels by providing impartial, high-quality technical data in support of specification limits. Our technical expertise has been key in developing several new standards related to biofuels testing.

One of our most notable collaborations with industry (which are primarily cooperative research and development agreements) is with the National Biodiesel Board, and it serves as a model for work with other groups and individual companies. NREL works with the Board to support the biodiesel industry in producing high-quality fuel and provides data to support improvements in ASTM specifications.

Health Impacts

We conduct studies on environmental science and health effects to identify the atmospheric impacts of operating vehicles using either conventional or alternative transportation fuels and lubricants. We analyze ambient air samples and vehicle emissions data to determine the effects of pollutants on air quality, visibility, and human health. This research ensures that developers of new vehicle technologies will carefully consider the possibility of negative health impacts and not simply comply with existing standards. Early scientific investigations of new potential health hazards and exposures help to avoid unintended consequences, such as those that have resulted from the use of fuel additives like lead and methyl tertiary butyl ether (MTBE).

The Health Impacts project, which is funded by the DOE Vehicle Technologies Program and affects many R&D activities, coordinates research with automobile and heavy-duty engine manufacturers, the petroleum industry, the scientific community, various environmental agencies, and the engine and fuel research community. The most important product of our research is the publication of our results in the peer-reviewed technical literature.

Our Goals

The Fuels Performance Group is committed to creating a transportation sector that is cleaner, more sustainable, and more secure than ever before. Our contributions center around the development of advanced fuels and combustion engines. We disseminate our research results so that the automotive and fuels industries and regulatory bodies will be well informed and able to implement successful future technologies and policies. And we continue to support industry members and decision makers as they work to displace significant amounts of petroleum with clean-burning fuels.

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See our work on the following Web site:
www.nrel.gov/vehiclesandfuels/

Transportation Technologies

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