U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Vehicle Technologies Program

Fuel Technologies: Goals, Strategies, and Top Accomplishments

Introduction

Fuels and lubricants are complex mixtures of thousands of chemical compounds. Because modern engines and emission control equipment are precisely tuned for high performance and low emissions, they are much more sensitive to specific chemical compounds than older engines. In addition, nonconventional fuels often burn differently than conventional fuels, which can impact the performance and longevity of the engine or emission control system. For example, some fuels increase exhaust temperatures, which can damage emission control equipment designed for conventional fuels. Fuels with nonconventional chemical compositions might also cause materials compatibility issues with existing engines, fuel tanks, or fuel dispensing and storage infrastructure.

The Energy Independence and Security Act of 2007 (EISA) established aggressive goals for renewable fuel use that might require significant changes to the nation's fueling infrastructure. Before significant quantities of renewable fuels can be used by U.S. vehicles, it is critical that these fuels be evaluated for compatibility with old and new engines, emission control equipment, and fueling infrastructure.

Fuel Technologies Goals and Strategies

The Fuel Technologies subprogram of the U.S. Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy's Vehicle Technologies Program (VTP) helps the nation move toward cleaner-burning, greener fuels by sponsoring two fundamental activities. First, it funds the development of nonconventional fuels and lubricants that maximize engine efficiency and minimize emissions. Second, it tests the impacts of nonconventional fuels and lubricants on vehicle engines, emission control systems, fueling infrastructure, and human health. This testing ensures that new fuels and lubricants are practical for real-world application, meet DOE's energy-efficiency and petroleum-reduction objectives, and provide vehicle users with high-performance, cost-competitive options.

Goals

By 2010, complete testing to determine if gasoline blended with 15% and 20% ethanol can be used interchangeably with existing fuels in passenger vehicles and small, nonroad engines not specifically designed to run on these blends

By 2014, identify fuel and lubricant components and the interactions between these components and emission control systems that have significant impact on tailpipe and evaporative emissions

By 2014, determine the relative importance of hydrocarbon and nitrogen oxides (NO_x) emissions to the formation of ground-level ozone to inform regulatory decision making

DOE

Chassis dynamometer emission testing

To accomplish its goals, the Fuel Technologies subprogram collaborates with DOE's national laboratories and universities to advance basic fuel and combustion science and with industry partners—including auto and engine manufacturers, ethanol and biodiesel producers, and parts suppliers—to test and validate new technologies. The subprogram also works closely with other DOE programs (e.g., the Biomass Program) to ensure that fuels resulting from their research and development (R&D) are compatible with existing infrastructure. The Fuel Technologies subprogram's key R&D areas and most significant accomplishments are described below.

Evaluating Intermediate Ethanol Blends

The U.S. vehicle fleet consumed almost 10 billion gallons of ethanol in 2008, nearly all in the form of E10 (10% ethanol, 90% gasoline) sold as gasoline at fueling stations. The nation's 7 million flexible fuel vehicles (FFVs) can operate on E85 (85% ethanol, 15% gasoline), but relatively few fueling stations are equipped to dispense E85. Because of E10 and E85's limited ability to absorb increases in U.S. ethanol production, meeting the EISA goal of 36 billion gallons of annual renewable fuel consumption by 2022 likely will require vehicles to use intermediate ethanol blends (i-blends) such as E15 (15% ethanol, 85% gasoline) or E20 (20% ethanol, 80% gasoline).

However, before i-blends can be introduced into the nation's fueling infrastructure, their effects on the performance and emissions of vehicles and small nonroad engines designed to run on gasoline with 0%–10% ethanol must be determined. VTP's i-blends testing activity is examining the impact of i-blends on passenger vehicles, outdoor equipment, and generator sets, with research focusing on regulated and unregulated tailpipe emissions, fuel economy, and emission system durability. Materials compatibility, evaporative emissions, and vehicle driveability are also being investigated.

Preliminary test results suggest that cars built to meet the U.S. Environmental Protection Agency's (EPA's) Tier II emission standards (model year 2004 and later) will be able to operate on i-blends without significant issues. However, the preliminary results also show that certain small off-road engines—such as those in lawnmowers, leaf blowers, line trimmers, and small generators—might have problems operating on E15 and E20 because they do not automatically adjust engine operation for ethanol content. Larger off-road and specialty engines—such as those in motorcycles, boats, and snowmobiles—might also be sensitive to increased ethanol content. Additional testing will be conducted to determine which vehicle and engine classes are compatible with i-blends.

Identifying Fuel and Lubricant Components that Affect Emissions

Because fuels and lubricants are composed of many different chemical compounds, it is difficult to determine the effect of a particular component or interaction of multiple components on engine emissions. As emission standards tighten, this sensitivity to fuel and lubricant components will become more significant. VTP is identifying the components that most significantly affect regulated and unregulated emissions. Additional information about the influence of specific fuel and lubricant components on regulated emissions will lead to improvements in current fuels and lubricants. Research on unregulated emissions is also important because combustion of nonconventional fuels could result in toxic compounds not produced by current fuels and not covered under current regulations.

Advanced Engine Technology

Ignition Quality Tester™ used to determine derived cetane number of fuels and quantify other fuel chemistry effects on ignition

Assessing Health and Environmental Impacts

The principal pollutants involved in producing ground-level ozone, a major lung irritant and one of the main measures of air quality, are nitrogen oxides (NO_X) and hydrocarbons. Tightening regulations on vehicular NO_X emissions has been a central strategy in efforts to improve the nation's air quality. However, the mechanism by which the relative

NREL/PIX02228

Ozone pollution in Denver, caused largely by vehicle emissions

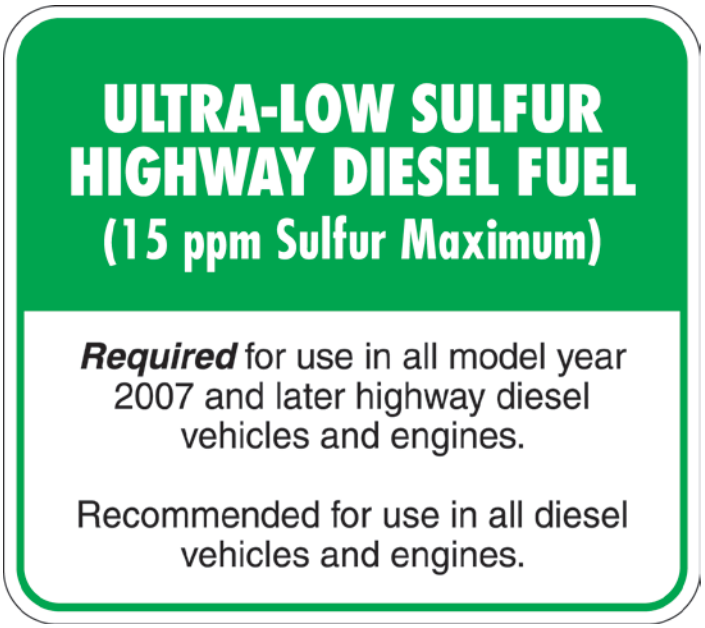
concentrations of NO_X and hydrocarbons influence ozone formation is not well understood. Air-quality modeling and research indicates that decreasing NO_X levels below a certain threshold, without a similar decrease in hydrocarbon levels, results in increased ozone levels in some nonattainment areas. VTP is determining whether further NO_X reductions in vehicle emissions are working as intended to reduce ozone levels.

Top Accomplishments

The Fuel Technologies subprogram has achieved major advances related to ultra-low sulfur diesel, biodiesel quality, FFV performance, and natural gas engine and vehicle R&D. The following are some of the top accomplishments to date.

Performed Research Resulting in Market Shift to Ultra-low Sulfur Diesel

VTP led a government-industry collaboration in demonstrating that the sulfur content of diesel fuel had to be reduced to enable the use of advanced emission control systems. Diesel vehicles need these advanced emission control systems, such as lean-NO_X catalysts, to meet stringent emissions standards. VTP-sponsored research led the EPA to require that all highway diesel fuel contain a maximum



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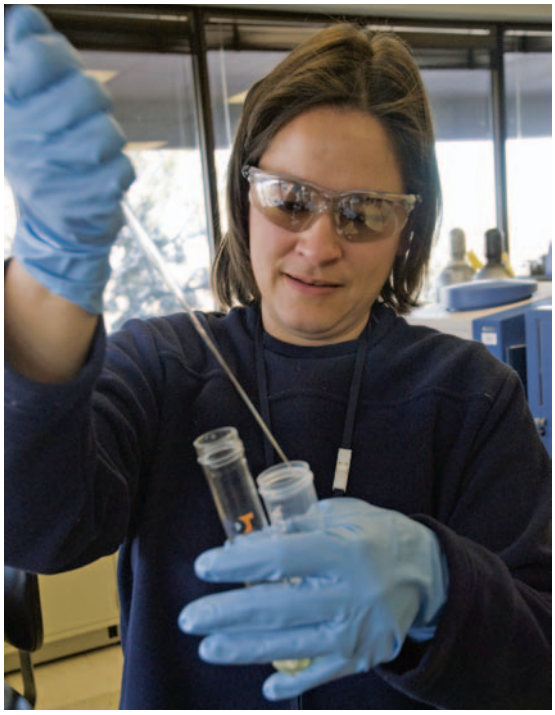
Ultra-low sulfur diesel fueling pump label



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Preparing a biodiesel sample for analysis

of 15-ppm sulfur. Before this ruling went into effect in 2006, diesel fuel for on-road use contained an average of 350-ppm sulfur, with a legal maximum of 500 ppm.

Instilled Confidence in Biodiesel Fuel Quality

During the fall of 2005, a large fraction of the biodiesel sold in Minnesota did not meet fuel-quality specifications and caused serious filter-clogging problems in many trucks. As a result of this incident and similar problems with the quality of U.S. biodiesel, VTP partnered with the National Biodiesel Board to improve ASTM (an international standards organization) biodiesel fuel specifications and ensure that suppliers adhere to the specifications.

Surveys of marketed biodiesel conducted by VTP in 2005 and 2007 showed a large improvement in compliance with the ASTM standard over this period, including more consistent biodiesel concentration and reduced levels of impurities. The fuel-quality improvement resulted in increased willingness among engine manufacturers to endorse biodiesel use in their engines.

Optimized Engines for Ethanol Use

Engines in current FFVs are primarily designed to be fueled with gasoline and to tolerate E85. VTP is sponsoring the development of engines for the next generation of FFVs designed specifically to exploit the desirable fuel properties of E85, such as its high octane, which will increase the fuel economy of vehicles running on E85. Advanced controls and combustion systems should enable these next-generation engines to operate at high efficiency regardless of ethanol concentration.

Championed Natural Gas Engine and Vehicle R&D

From 1992 to 2005, VTP advanced the state of the art for natural gas engines and vehicles. VTP-sponsored activities covered a range of technology development steps, from proof of concept to near-term engine/vehicle development and the commercialization of products by industry partners. All heavy-duty natural gas engines sold in the United States today were developed in partnerships between VTP and industry. This includes the 8.9-L Cummins-Westport ISL G, which met EPA 2010 emission standards years in advance of the requirement. Natural gas has found particular success in the transit bus market: about 20% of U.S. transit buses are fueled with natural gas.

NREL/PIX12534

Phoenix/Valley Metro liquefied natural gas bus

Fueling the Future

VTP's Fuel Technologies subprogram has made significant strides toward reducing dependence on foreign petroleum and reducing emissions by developing alternative fuels based on U.S. energy sources. It is focusing on evaluating ethanol i-blends, identifying fuel and lubricant components that affect emissions, and assessing the health and environmental impacts of NO_x emissions. Through these activities, and by strengthening collaborations with industry, universities, and national laboratories, the Fuel Technologies subprogram will continue to leverage R&D investments to achieve even greater petroleum displacement and health benefits.

More Information

For more information about VTP's Fuel Technologies subprogram, contact Kevin Stork at *kevin.stork@ee.doe.gov*.

Cover photos (clockwise from upper left): chassis dynamometer emission testing/DOE, fuel dispenser/DOE, beaker with ethanol/DOE, X-ray phase-contrast image of biodiesel injection taken at Argonne National Laboratory's Advanced Photon Source/Argonne National Laboratory, triple biofuels dispenser/NREL/PIX13531.

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