Alternative FUELS IN TRUCKING

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Lessons Learned from the Biodiesel Fuel Test

Ag Processing, Inc., (AGP) an Omaha, Nebraska-based cooperative, is conducting an alternative fuel test by running part of its tractor fleet on a blend of soybean methyl esters (biodiesel) and petroleum (petro) diesel fuel. Since January 1995, AGP has conducted tests with nine over-the-road trucks stationed in Sheldon, Iowa—three sets of three different chassis and engine groups. In each set, two trucks use biodiesel and the third uses petro diesel. The operators used a blend of 65% petro diesel and 35% biodiesel in these tests. In its first year of testing, AGP learned enough to draw some conclusions about biodiesel's advantages and disadvantages over conventional diesel fuel. Operators also discovered the proper means of storing, using, and blending biodiesel in adverse weather conditions.

Biodiesel's main advantages are that it is domestically produced and is renewable. Laboratory tests have demonstrated that heavy-duty engines running on biodiesel blends have lower hydrocarbon, carbon monoxide, and particulate matter emissions and somewhat elevated oxides of nitrogen emissions. In addition, instead of a diesel odor, biodiesel smells more like vegetable oil. It also makes the engine run more quietly because it lubricates the engine fuel pump and injectors. As fossil fuel supplies continue to be depleted, biodiesel shows great promise as a fuel of the future in the trucking industry. But along with its positive aspects, biodiesel also has some drawbacks, in the areas of both performance and storage.

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Photo courtesy of Ag Processing, Inc./PIX04978

This tractor in AGP's fleet runs on a blend of 65% petroleum diesel and 35% soybean methyl esters (biodiesel).

Biodiesel has a higher gelling temperature than petro diesel, so trucking companies must be careful about its storage. If biodiesel is stored at a temperature below 45°F, it can turn into a gel and clog the fuel filters and lines. Storing biodiesel at a temperature above 45°F can prevent this gelling. According to AGP, the cold filter plugging points (the temperature at which the fuel causes clogging) are:

Soybean oil, 30°F
#2 Diesel fuel, 0°F
#1 Diesel fuel, -40°F.

This tendency to gel in cold weather presented the main problem for the AGP team during the tests. The 1995–1996 winter was particularly harsh. Even in the blended fuel, biodiesel solids formed if the temperature dropped too low, causing the fuel lines to clog. The operators had to raise the temperature of the fuel above 100°F to make the biodiesel solids return to solution. The biodiesel blend had to be tested for gel temperature if the mixture consisted of more than 20% biodiesel. The operators learned that the biodiesel and petro diesel had to be blended as soon as possible, and at a temperature above 45°F. Because the biodiesel was heavier than the petro diesel, they also concluded that the biodiesel should be added on top of the petro diesel to ensure a better mixing of the two fuels.

AGP blended the biodiesel with some #1 petro diesel to lower the gelling temperature, making the fuel easier to handle in colder environments. However, they experienced some problems with this particular blend and have yet to determine the optimum blend of biodiesel and petro diesel in their trucks. They found that if they used too much #1 diesel fuel in the blend, the trucks would show poor performance and lower mileage. But if they used too little #1 diesel fuel, gelling and clogging of the fuel system would result.

AGP tried to keep the fuel warm by installing a submersible heater and a circulation pump into the biodiesel storage tanks. The heater kept the temperature of the fuel at 45°F, and the pump ran 20 minutes a day to keep the mixture from gelling. The below-ground storage tanks kept the fuel at about 56°–58°F without needing a submersible heater.

AGP also used a similar solution in the trucks themselves. In the non-electronic diesel engines, they installed in-tank fuel heaters that used engine coolant to heat the fuel. The return fuel from the injectors to the fuel tanks in the electronic diesel engines heated the fuel in the tank sufficiently to prevent gelling, so these fuel tanks did not need fuel heaters. When the truckers shut down the biodiesel tanks for a longer period of time, they attached a blanket-type electric heater. This heater kept the fuel warm so that the engine would start more easily and the fuel filters would not plug.

Overall, AGP was able to overcome the problems experienced in the first year of tests. By blending the biodiesel fuel with petro diesel, adding anti-gel products, and using heating systems in the above-ground storage tanks and trucks, the company was able to reduce the amount of gelling, and the second winter's operations showed that they had surmounted the problem.

Clearly, their results show considerable promise for using biodiesel fuels in the trucking industry. In just over 2 years of testing, the AGP trucks have logged nearly 900,000 miles using the biodiesel mixture, and the overall results have been good. The important lessons learned in this project add to the growing body of knowledge about this alternative fuel.

Grocery Chain Puts LNG Tractors on California Roads: Raley's Said to be First in the State with Commercial Use of Alternative Fuel Heavy Trucks

by Jim Beach, Staff Reporter

West Sacramento, California—If you're running a host of food and drug superstores, you know that cleanliness is essential to the success of your business. For Raley's, an 87-store chain of markets in northern California and northwest Nevada, the concept includes running a clean machine as well. That's why Raley's works hard to keep its fleet of tractors and trailers spic and span, inside and out. After all, the equipment on the road, as much as the condition of its stores, can influence a customer's impression of Raley's.

Now Raley's is taking the cleanliness concept to a new level, committing itself not only to clean-looking trucks but also clean-running trucks. It has fielded the first contingent of over-the-road trucks powered by liquefied natural gas (LNG) that California has seen in commercial service. On April 16, the West Sacramento-based company took delivery of eight Kenworth T800s with Cummins LNG engines. It also added two Ottawa yard trucks with Cummins LNG power plants. It is also testing to see if LNG equipment can do the job that diesel power does and if the company can justify the expense of LNG.

Use of LNG will replace some 100,000 gallons of diesel fuel a year. In that span of time, the LNG units will save five tons of nitrous oxides (NO_x) that otherwise would be pumped into the air over Sacramento. The new LNG trucks are different than the rest of Raley's vehicles in more ways than the fuel they burn. While the diesel fleet is painted in company yellow, the new trucks sport a blue background with white clouds and "Clean Air Machine" written on the side.

Photo courtesy of Transport Topics, Inc./PIX04977

Raley's Groceries has fielded the first contingent of over-the-road trucks powered by liquefied natural gas that California has seen in commercial service.

The tractors are powered by Cummins L10Gs, the first natural gas engine certified by the California Air Resources Board. The turbocharged, electronically controlled engines are rated at 300 horsepower and 900 foot-pounds of torque.

The Ottawa LNG yard trucks, supplied by Mid-Pacific Industries, Woodland, California, are also Cummins-equipped. They have B-5.9G engines, which produce 195 horsepower and 420 foot-pounds of torque.

The Sacramento Metropolitan Air Quality Management District (SMAQMD) estimates that an LNG engine produces approximately 60% less pollution than the typical diesel engine. Air quality officials project a reduction of 20 to 40 tons of NO_x during the first 7 years. NO_x is a major precursor to ozone, the pollution that turns the Sacramento area's summertime air gray, they say.

Many experts consider LNG the most logical alternative to diesel fuel. Although LNG is chemically identi-

cal to compressed natural gas (CNG), it packs more energy by volume than CNG, because it stores fuel in a denser fashion. CNG is more widely used in light truck operations, where its bulky tanks are less of a liability.

LNG trucks are limited in their operational area because of range and fueling concerns. The refueling station at Raley's distribution center is the only site in the area. Equipped with two 87-gallon LNG tanks, each of the new units should have a range of about 600 miles. Raley's fueling station also will be open to other LNG users. The city of Sacramento will refuel two LNG-powered municipal garbage trucks there.

The Raley's fleet may help clear new ground for over-the-road freight operations. There is a growing interest in alternative fuel heavy trucks. Another trucking operation, Jack B. Kelley, Inc., also uses Kenworth T800 LNG tractors in its operations in southern Arizona. Kelley put 10 units to work last April and plans to add more.

Although long-haul LNG trucking may or may not loom large in the foreseeable future, some companies, such as Raley's, and with the help of agencies such as the SMAQMD, are prepared to take a risk in local operations.

Using Liquefied Natural Gas as a Vehicle Fuel

by Richard E. Rice, Manager, Fossil Fuel Program
Idaho National Engineering and Environmental Laboratory (INEEL)

Worldwide interest in using alternative fuels instead of conventional gasoline and diesel sources continues to increase. This interest is driven by needs and issues such as compliance with environmental requirements to meet national goals and promote overall energy security, and by economics, where alternative fuels can reduce operating costs. In many parts of the world, government mandates have been imposed on fleet operators to accelerate the process of converting to alternative fuels.

A number of options must be considered when evaluating opportunities to use alternative fuels in place of gasoline or diesel. In the United States, for example, most alternative fuels are used either in federal fleets or in mass transit situations. So far, there is limited use in heavy-duty applications or by the private sector. In other parts of the world, alternative fuels use has spread from government applications to utilization in a wide part of the private sector.

Additional variations include the choice of fuel, and in some cases, no single choice predominates. Variables affecting what options to choose include required vehicle range, incremental cost of producing or converting vehicles, cost of the fueling infrastructure and of the fuel itself, overall engine performance, and vehicle lifetime. In addition, factors such as public acceptance, overall infrastructure safety, and the vehicle's convenience to the users need to be considered. Because emissions performance of various alternative fuel vehicles is highly variable, it also plays a role in determining whether a given combination of fuels and vehicles would meet emissions-reduction objectives. Finally, overall economics are the ultimate driver, because government mandates can only push the adoption of alternative fuels so far.

With these factors taken into account, most conversions to alternative fuels in the United States have been from gasoline to compressed natural gas (CNG), along with some conversions to propane. Limited amounts of other fuels—ethanol, biodiesel, methanol, and electricity—are being used, primarily in regional or niche areas.

The principal drawbacks of CNG are its limited range and the relatively high cost of tanks, as well as issues of safety and public acceptance. One emerging fuel that can most likely deal with these issues is liquefied natural gas (LNG). Recent studies have shown that LNG is a superior form of natural gas for certain

situations, such as in large, heavy-duty, centrally fueled fleets; in large off-road vehicles; and in marine applications. Traditionally, these vehicles have run on diesel. By focusing on this rather narrow but large usage area, significant environmental benefits can result because the conversion to LNG will reduce the amount of diesel burned.

Because of LNG's relatively high energy density, its use dramatically increases the amount of fuel storage capability over that of CNG. Other advantages include the relative purity of LNG (generally greater than 98% methane) and the ability to transport the liquid commodity from place to place. The environmental benefits are essentially the same as for CNG. The disadvantage primarily centers on the cryogenic nature of LNG and the necessity for storage in unique vessels and limited liquid hold time.

The Idaho National Engineering and Environmental Laboratory's (INEEL) experience with LNG is described in the following paragraphs.

Fueling Infrastructure. INEEL uses a temporary fueling station that provides natural gas as a either liquid cryogenic fuel (LNG) or highly compressed gas (CNG). This fueling station is skid-mounted and can be moved conveniently to various locations. Using this station to service our natural gas vehicles is very valuable in identifying fueling infrastructure issues and problems. This station was built by MVE, Inc., and was provided to us by Amoco LNG. INEEL will soon acquire a new permanent fueling station being built by Drexel Engineering to serve both LNG and CNG fueling needs far into the future.

Heavy-Duty Vehicles. INEEL's transportation fleet includes six LNG buses powered by the 275-horsepower Detroit Diesel Company (DDC) 50G engine, which is a prototype of the closed-loop natural gas engines DDC expects to introduce in large numbers in the medium- and heavy-duty trucking industry. This is a joint project with DDC and tank supplier, CVI, and is receiving significant national attention. Four of these buses went to Atlanta in June 1996, where they were successfully operated throughout the Olympic games.

LNG Research for Heavy-Duty Transportation Applications. INEEL is engaged in a program sponsored by both the U.S. Department of Energy and the Gas Research Institute to pursue research on technologies that will accelerate the deployment of LNG long-haul trucks. Research topics include development of fuel delivery systems, engine controls, tankage, fueling stations, and other hardware-related technologies. Additionally, we are looking at public perception issues and risk assessment, and have completed a system analysis to evaluate dynamic industry response to the introduction of new technologies. These activities are conducted in collaboration with a large number of industry partners. Although initially focused on heavy-duty trucks, most of the research topics are generic and are relevant to other LNG applications in transportation.

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Photo courtesy of Idaho National Engineering and Environmental Laboratory/PIX 05089

These liquefied natural gas buses provided reliable transportation during the 1996 Summer Olympics in Atlanta, Georgia.

LE-55 Natural Gas Engine Project Targets 55% Efficiency and Low Emissions

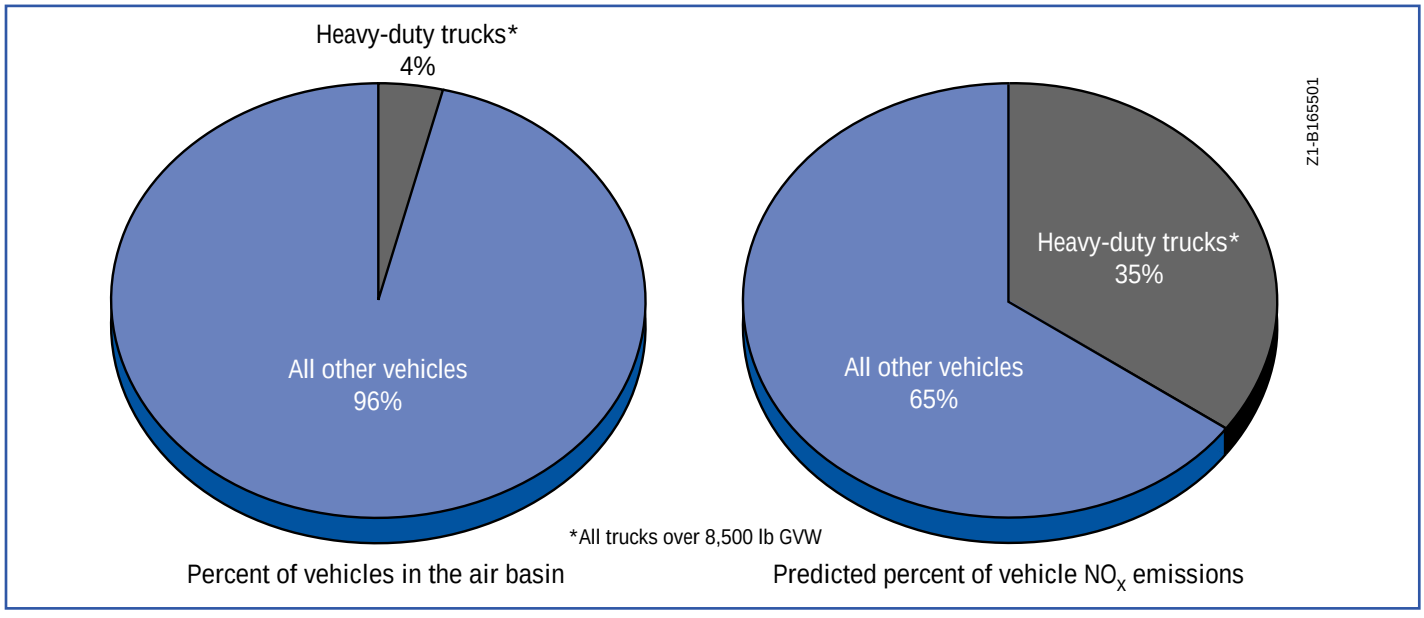
The U.S. Department of Energy (DOE), California's South Coast Air Quality Management District (SCAQMD), the Gas Research Institute (GRI), and the American Trucking Association's Trucking Research Institute (TRI) are joining forces in a 5-year-plus program directed at engine original equipment manufacturers (OEMs). The program is designed to enhance natural gas engine efficiency and emissions performance, which will require substantial research investment on the part of the OEMs. The goal of the program is to build natural gas engines with 55% thermal efficiency and low emission levels, code-named LE-55. The program's total cost is $1.2 million.

Breakdown of Cost-Sharing by LE-55 Sponsors

Sponsor	Funding Amount
U.S. Department of Energy	$400K
Gas Research Institute	$400K
South Coast Air Quality Management District	$400K
Trucking Research Institute	In-kind
Total:	**$1.2 million**

In explaining its funding decision, the SCAQMD board said that although heavy-duty trucks represent less than 10% of the total vehicle population registered in the basin, they contribute 13% of the carbon monoxide (CO), 40% of the oxides of nitrogen (NO_x), and 87% of the area's particulate matter (PM) emissions inventory. Recognizing the contribution of heavy-duty truck emissions to the inventory, and that out-of-state trucks are significant contributors to the emissions inventory, the California Air Resources Board (CARB) and the U.S. Environmental Protection Agency (EPA) entered into an agreement with the major heavy-duty engine manufacturers to set a NO_x plus hydrocarbon standard of 2.5 g/bhp-hr in 2002. The California state implementation plan (SIP) seeks to reduce these levels further to 1.0 g/bhp-hr of NO_x.

The SCAQMD and others have been supportive of developing and demonstrating natural gas heavy-duty engine technology. Over the past decade, major U.S. engine manufacturers have developed heavy-duty natural gas engines for use in transit buses and heavy-duty commercial



South Coast Air Basin. Number of vehicles and predicted emissions in 1997. (Source: South Coast Air Quality Management District)

trucking. These current-generation natural gas technology engines can achieve NO_x emissions well below 2.0 g/bhp-hr; however, there is a significant performance penalty to achieve those levels. Conversely, if performance is optimized, emissions suffer. These technology barriers currently inhibit the widespread use of natural gas in intra- or interstate trucking operations. Thermal efficiency improvements while retaining emissions of 2.5 g NO_x or lower are necessary if natural gas engines are to successfully compete with diesel engines and achieve full commercialization.

The SCAQMD board believes that participation in this engine development project is in its best interests for a couple of reasons. First, the agency will be an active participant in determining the direction of this national program and will be able to ensure that the developments focus on the NO_x and PM emissions reductions from heavy-duty trucks required in the basin. Second, the district will be able to participate in review and selection of the proposals. Because interstate trucks are significant contributors to emissions in the basin, it is advantageous for the SCAQMD to participate in this national program to support natural gas engine technology developments that could ultimately lead to the increased and widespread use of clean-burning fuels.

The program started with meetings with heavy-duty engine OEMs to determine the requirements for (1) near-term (2 years or less) prototype engine development, and (2) long-term goals for advanced natural gas heavy-duty engines. From the meetings, a Statement of Work was generated, forming the basis for bids from major engine manufacturers.

The OEMs performed the necessary research and planning to prepare bid packages. The packages contained the OEMs' technical approach for building the prototype and illustrated how this will lead to their ultimate high-efficiency design. OEM proposals are being evaluated by an advisory committee made up of representatives of DOE, GRI, SCAQMD, the California Trucking Association, and others. Proposals for the advanced natural gas engine development have been submitted to TRI, which is a charitable trust research and educational organization that supports the U.S. commercial trucking industry through research activities. DOE selected TRI to initiate and coordinate the LE-55 research effort. As the research arm of the American Trucking Association, TRI has direct access to ATA member companies, which include all major OEM chassis and engine manufacturers. ATA's Engineering Department, which directly supports TRI's engine and vehicle-related research, maintains relationships with every industry involved in the manufacture of commercial trucks and components. Ongoing research programs include topics such as advancement of alternative fuels, intelligent transportation systems for commercial vehicle operations, and driver fatigue and alertness.

TRI will provide technical and administrative management of the selected development projects, and provide cosponsors with quarterly reports. At the completion of the near-term engine development program, the project sponsors will assess the feasibility of proceeding with longer term development.

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The aim of **Alternative Fuels in Trucking** is to inform fleet owners and operators, equipment suppliers, government officials, and other interested parties about important developments in the use of alternative fuels in heavy-duty trucks. Suggestions and comments are welcome and may be directed to the National Alternative Fuels Hotline at 800-423-1DOE. Views expressed by guest authors are their own, and not those of ATAF, DOE, or NREL.

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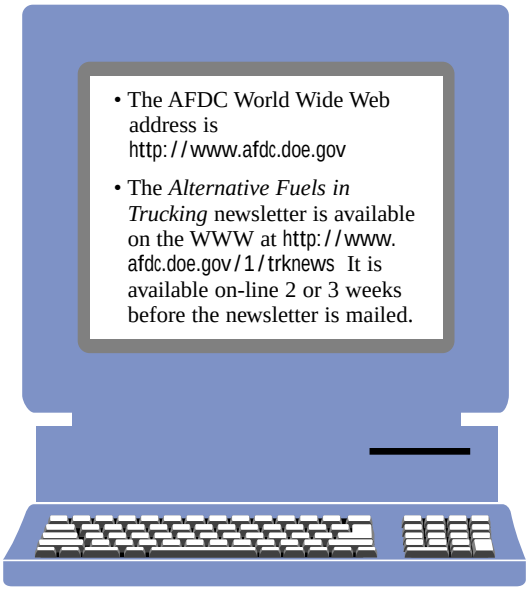
How to Reach Us

To speak to a human being, call the National Alternative Fuels Hotline at 800-423-1DOE.



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