Alternative FUELS IN TRUCKING

Volume 5, Number 4

The Impact of Federal Highway Taxes on LNG-Powered Trucks

Natural gas costs less to produce than gasoline and diesel fuel. However, it must be delivered to the market area and compressed or liquefied before being put into the vehicle fuel tank, steps that add significant cost. Whether the natural gas at the vehicle fuel tank retains a price advantage over gasoline or diesel fuel depends on many factors. A few of the most important are:

- Distance from the wellhead to the market area
- The gas volumes over which the costs of compression or liquefaction are spread
- The numbers of vehicles being fueled at a given refueling site.

Vehicles using natural gas also cost more than comparable gasoline and diesel vehicles because the fuel tanks are inherently more expensive, whether the gas is compressed (CNG) or liquefied (LNG). At this time, it is not clear whether CNG or LNG will ultimately be the better option; hopes for LNG are high because it has a higher energy density than CNG and because significant further cost reduction in the vehicle tanks is possible.

Despite the higher vehicle cost, the lower fuel cost in some locations and for some uses is already creating opportunities for LNG use. As technology has improved over the past several years, LNG has become increasingly attractive as an economic alternative fuel for heavy-duty trucks.

With the current economics for LNG so close to favorable, the impact of highway fuel taxes has become a critical factor. This factor has been studied to some extent for methanol, CNG, and propane, and was reported in the 1994 study entitled *Impact of Highway Fuel Taxes on Alternative Fuel Vehicle Economics* (CRS Report 94-247, by David E. Gushee, Congressional Research Service, Washington, DC, March 16, 1994, from which this article was taken). The study found that the economics of methanol, natural gas, and propane were so close to attractive that changes in tax policy could have significant impacts on their ability to penetrate the motor fuel market, but LNG was not treated at great length.

In a 1995 setback for LNG, the U.S. Treasury Department ruled that LNG is a "special motor fuel," and imposed a federal highway tax of 18.3 cents per LNG gallon, instead of the rate of about 6 cents per diesel equivalent gallon imposed on CNG used as highway fuel. Because LNG has a significantly lower energy density than the diesel fuel with which it would compete (about 75,000 Btu per liquid gallon—compared to some 130,000 Btu per diesel gallon), this tax rate equates to about 31 cents per diesel equivalent gallon—compared to the tax on diesel of 24.3 cents per gallon. Thus, the ruling has transformed LNG from a fuel with an 18 cent per gallon federal highway tax rate advantage to a fuel with a 7 cent per gallon federal highway tax disadvantage.

Because this change basically wipes out the price advantage necessary for

INSIDE THIS ISSUE

LNG to be competitive with diesel fuel, it eliminates most potential opportunities for LNG to become an economically attractive alternative to diesel fuel. Efforts are under way to seek legislative relief by "normalizing" the federal LNG tax, either by making it equal to the federal tax on CNG, or by making it equal, on a Btu equivalent basis, to its petroleum counterpart.

State taxes on highway fuels also figure into the equation. Most states have historically taxed motor fuels by the liquid gallon, a position that would further increase the tax on LNG at the pump relative to gasoline and diesel fuel. Increasingly, however, states are taking specific actions to favor one or more alternative motor fuels, in some cases taxing by energy equivalence and in other cases taxing at rates lower than those for gasoline and diesel fuel. The state taxes levied in each state can be found on the U.S. Department of Energy's World Wide Web site at *http://www.afdc.doe.gov*

LNG Fuel and Vehicle Economics

Potential Markets

Considerable progress in LNG fuel and vehicle economics over the past several years has resulted in the identification of two on-road truck markets where LNG has potential to be an economically competitive fuel: (1) fixed-route intercity trucks (trucks that travel between or among specific cities on a regular basis on fixed routes), and (2) centrally fueled heavy-duty (Class 8, over 33,000 pounds gross vehicle weight) urban trucks in uses such as trash hauling. Intercity trucks average about 60,000 miles, or 10,000 diesel gallons, per year. Some centrally fueled urban trucks operate on two or three shifts per day and consume up to 4 diesel gallons per hour, some of it consumed in operations other than driving, such as refuse compacting. About 20,000 of the intercity fixed route and 15,000 of the centrally fueled urban vocational vehicles consume sufficient diesel fuel to constitute a conservative target LNG market, which is illustrated in Table 1. Their combined usage would exceed one billion gallons of LNG per year.

A market penetration of this magnitude would be an important contribution to the goal of Title V of the Energy Policy Act of 1992 (EPAct), which promotes the displacement of petroleum-based motor fuels with nonpetroleum-derived alternatives, preferably domestically produced.

These two markets have the one characteristic essential to LNG's potential: very high fuel consumption. High fuel consumption is necessary if a potential fuel cost advantage is to make up for the added cost of the alternative fuel vehicle.

Table 1. Potential LNG Vehicle Markets

	Intercity Trucks	Centrally Fueled Urban Trucks
Estimated Number of Trucks with Sufficient Fuel Use	20,000	15,000
Required Annual Fuel Consumption (diesel per capita)	25,000 gallons	15,000 gallons
Estimated Diesel Fuel Use / Year	500,000,000 gallons	225,000,000 gallons
Estimated LNG Fuel Use / Year	867,000,000 gallons	390,000,000 gallons

Total LNG Cost in the Vehicle Fuel Tank

The "average" cost of LNG delivered to the vehicle fuel tank is about 71 cents per diesel equivalent gallon, before taxes of any kind. The elements of this price are tabulated in Table 2, although 71 cents is not the "average" of the best and worst case prices.

Table 2. Delivered Cost of LNG to Vehicle

	Cost Element Cost / DEG*	Cost / mcf
Natural Gas at Wellhead	$1.75	$0.25
Transportation to City Gate	$0–$1.25	$0–$0.15
Liquefaction		
Capital Recovery		$0.02–$0.14
Operating Cost		$0.10
Delivery to Refueling Site (range)		$0–$0.02
Retail Markup (range)		$0.05–$0.14
Total		
Best Case		$0.42
Worst Case		$0.80
Pretax Cost of Diesel Fuel (range)		$0.65–$0.85

Source: EA Science, Engineering, and Technology, 1996, *Impact of Federal Highway Tax on Potential for LNG in Heavy Duty Trucks*, prepared for the U.S. Department of Energy Office of Transportation Technologies.

*DEG = Diesel equivalent gallon (on Btu basis), defined as the quantity of natural gas that contains the same energy as a gallon of conventional diesel fuel

An Innovative Emissions Testing Facility

West Virginia University, working with the U.S. Department of Energy's Office of Transportation Technologies, designed, constructed, and is operating two Transportable Vehicle Emissions Testing Laboratories. The labs are used to monitor engine performance and to test the emissions from heavy-duty vehicles operating on conventional and alternative fuels. Because the laboratories can be moved easily from site to site, vehicles can be tested where they are housed, minimizing their downtime.

Simple but Thorough Testing

The transportable laboratory can

- Perform transient and steady-state chassis dynamometer emissions tests on vehicles in the field, at or near their home base or maintenance shop
- Simulate a range of driving cycles to provide performance data for medium- and heavy-duty vehicles
- Provide emissions data for carbon monoxide, carbon dioxide, oxides of nitrogen, methane, methanol, formaldehyde, particulate matter, and other emissions constituents
- Simulate road load, wind drag, and vehicle inertia
- Incorporate effects of gear shifting by providing the driver with visual prompts via a computer monitor in the cab
- Provide a complete computer database and a hard-copy log of time-varying speed, torque, and emissions.

The chassis dynamometer incorporates:

- Fast-response, computer-controlled eddy current power absorbers
- Direct mechanical coupling between drive axle and the dynamometer power train using wheel hub adapters. This coupling method eliminates problems associated with tire slippage and overheating, which are common for systems with tire to roller coupling
- Flywheels that can be adjusted to simulate inertia of a vehicle in

range from 20,000 to 60,000 pounds

- On-line continuous torque and speed measurement
- A full exhaust dilution tunnel and a secondary dilution tunnel for particulate sampling
- The same emissions analysis instrumentation and calibration gases required for measuring emissions in accordance with the Federal Test Procedure (FTP) for certification of heavy-duty engines.

The laboratory facility arrives on the test site pulled on two trailers: a box trailer containing equipment for emissions measurement, data acquisition, and control; and a flatbed that carries the power absorber unit. Once on the site, the flatbed is lowered to the ground with hydraulic jacks.

The test vehicle is driven onto the flatbed and positioned so that the drive axle of the vehicle is over the center section of the test bed and is perpendicular to the test bed's length. The wheels of the vehicle are positioned on free-standing rollers. The outer wheels of the dual wheel set on each side of the vehicle are removed and special hub adapters are mounted to the drive axle. These adapters connect the drive axle to the drive shaft of the dynamometer units located on each side of the vehicle. Each dynamometer unit consists of a power absorber and flywheel. The flywheels connected to the drive shafts consist of a series of selectable discs to allow simulation of the inertia load of the vehicle.

During the test cycle, torque cells and speed transducers in the power absorber drivetrain measure the actual vehicle load and speed. The vehicle can be driven through a wide range of possible test cycles to simulate both dynamic and steady-state vehicle driving conditions. A computer system contains a program description of the driving cycles and sends a signal to a video display screen mounted next to the driver's compartment. The display screen shows the driver's desired and actual vehicle speed during the preselected pattern of transient speed and load conditions.

The full exhaust from the tailpipe of the test vehicle is ducted to the dilution tunnel on top of the second trailer. The exhaust is mixed with air and the quantity of diluted exhaust is precisely measured. The air flow in the dilution tunnel is maintained using a blower, and the amount of air flow is measured using critical orifices. Sampling probes send diluted exhaust to a number of different gas analysis instruments.

Calibrations of dynamometer components and emissions measurement equipment are made before and after each test. Test results are accurate, repeatable, and traceable, and emissions measurement equipment and procedures correspond to FTP requirements. All data are sent to the National Renewable Energy Laboratory's Alternative Fuels Data Center for analysis. These data can be accessed on the World Wide Web at *http://www.afdc.doe.gov*

Local Company Fuels Up with Latest Technology: The Chambers-USA Waste Project

by Michael Bradwell

A local Washington company will soon begin operating a first-of-its-kind liquid natural gas fueling station that could eventually set the standard for the way many of the country's heavy-duty trucks are fueled.

The storage tank was to be placed into the ground in January, but the burial was postponed because of frozen water in the ditch meant to hold the tank.

In the spring of 1997, the fueling station will be operational, providing LNG fuel for a fleet that will grow to seven trucks built especially for the project. The trucks will be used on Martin's regular hauling schedule, and will be quieter and have fewer emissions than the standard diesel trucks.

If the pilot project is successful, it could represent the future for Martin's hauling operations. Ben Woods, Martin's Washington district manager, said the Washington office employs 87 drivers and 43 helpers who operate 88 refuse trucks on routes in Washington, Allegheny, Greene, Beaver, and Fayette counties.

Woods said Chambers became interested in the LNG project because of the fuel's economics and its ability to reduce noise and harmful emissions. Jack Bonn, Vice President for Product Development for CVI, the Columbus, Ohio, firm that designed and is building the fueling station, said the design greatly reduces the complexity of LNG fueling, lowering both initial and operating costs while enhancing safety and environmental advantages.

"This station is the cutting edge of a new technology for LNG infrastructure," Bonn said. "It will lead the way to commercializing LNG as an available, domestically produced and inexpensive fuel for vehicles." Bonn added that Martin's station is the first to incorporate an underground storage tank in the design.

Stephen Petty, Manager of Columbia Gas Distribution Companies, said the station is the result of five years of planning by a number of companies and several government agencies.

In addition to participation by Chambers and Columbia Gas, the $3.8 million project has the support of the U.S. Department of Energy and its National Renewable Energy Laboratory, the Commonwealth of Pennsylvania's Department of Environmental Protection, Pacific Gas and Electric Company, Mack Trucks, the Gas Research Institute, and the American Trucking Association's Foundation.

Petty said Pennsylvania's award of $350,000 to the project was the largest single grant given to any program in the commonwealth in 1996. This grant was particularly beneficial because it provided major funding for the infrastructure—the station itself.

Martin's fueling station will provide data that will be used to determine LNG fuel's marketability for Class 8 trucks (vehicles that weigh more than 33,000 pounds). There are about 1.8 million Class 8 trucks in use, and nearly all are equipped with diesel engines. These large, heavy-duty trucks represent the most practical market for LNG, because a great number are used in situations where the vehicles are returned to a home site for refueling each day.

As a result of its work on the Martin project, Mack Trucks now produces an LNG heavy-duty truck on its assembly lines. Although there is little difference in weight between LNG and diesel fuel, LNG engines are quieter and burn fuel with far fewer emissions than diesels. The other major advantage is that LNG fuel is produced domestically, which should ensure availability and reduce dependence on foreign oil.

Steve Petty of Columbia Gas noted that LNG fuel also has advantages over compressed natural gas, which is used in many smaller vehicles but requires much larger on-board fuel tanks that add extra weight to each vehicle. With LNG, Petty said, "You can get more fuel on a (large) truck for a lot less weight" than a truck equipped for compressed natural gas.

Note: This is an edited version of an article that appeared in the Washington, PA, Observer Reporter on January 22, 1997. It describes the arrival of a 13,000-gallon LNG fuel storage tank on the site of the William H. Martin Company, a local refuse hauler in Washington. The Martin Company, formerly part of Chambers Development Company, is now a subsidiary of USA Waste, which purchased Chambers last year. The LNG fueling station at the Martin company site features underground storage, the first such configuration in the country. Actual burial of the tank was to have occurred on its delivery, but, as the article states, weather precluded that from happening. The tank has since been buried, and the station is expected to be completed in the near future. Individuals who were present at the site to witness the arrival of the tank represented companies and organizations that have been instrumental in developing the project.

Alternative FUELS IN TRUCKING

Volume 5, Number 4
René Texeira, Editor
Jim Miller, Graphic Designer

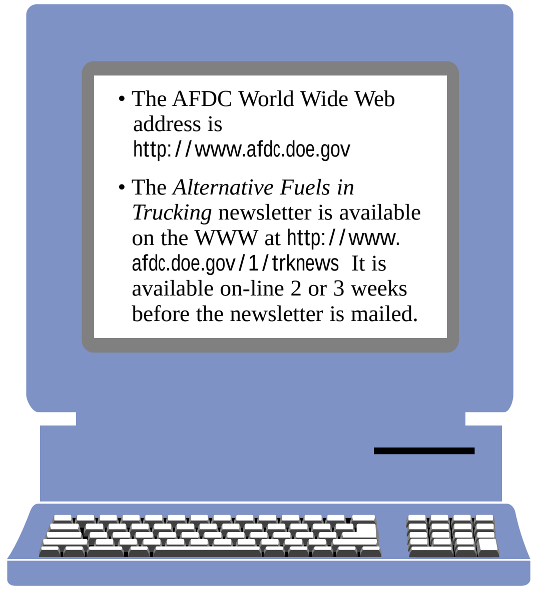
Alternative Fuels in Trucking is published quarterly by the National Renewable Energy Laboratory (NREL), a U.S. Department of Energy (DOE) national laboratory. The newsletter is written by the American Trucking Association Foundation's (ATAF's) Trucking Research Institute.

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.

NREL/BR-540-22663
June 1997

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 20% postconsumer waste

How to Reach Us



U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Office of Transportation Technologies