CASE STUDY

Running Refuse Haulers on Compressed Natural Gas

In October 1992, six new refuse haulers appeared on the streets of New York City (NYC). These trucks were different from any the city had seen before. Compared with their conventional brothers, these trucks were much quieter and refrained from the occasional belch of black smoke. The difference? The new trucks ran on compressed natural gas (CNG).

The CNG trucks have accumulated more than 60,000 miles in regular service in the NYC fleet. Overall, their performance has been excellent. "We've really enjoyed running the trucks on natural gas," reports Tim Harte, NYC Department of Sanitation Manager. "Our drivers are satisfied with the horsepower and speed. And the vehicles are quieter and cleaner, there's no diesel knock, and there are no fumes."

The drivers appreciate the significantly lower engine noise levels of the CNG vehicles: they are the only garbage packers in the city in which the driver and assistant can easily talk to each other in the cab. According to Harte, "These vehicles are so quiet, our workers can listen to the radio on routes. With the diesel engines, that's impossible."

The U.S. Department of Energy (DOE) sponsors this project. The Alternative Fuels Data Center (AFDC) at DOE's National Renewable Energy Laboratory (NREL) has been accumulating operating data on these trucks since they went into service.

Fuel Economy and Range

Because the CNG engines are spark-ignited, throttled engines, they should show a slightly lower fuel efficiency than a diesel engine because of pumping losses. Pumping losses are the amount of energy required for the engine to draw in air through the throttle during the intake cycle. Because a diesel engine has no throttle, the pumping losses are much smaller.

The fuel efficiency of the CNG trucks has been 5% to 20% lower than that of the diesel truck. This range is within the expected difference in efficiency between a spark-ignited, throttled engine and a diesel engine.

The diesel trucks carry 50 gallons of diesel fuel, which gives them a range of about 95 miles between fuelings. A diesel equivalent gallon (DGE) is the amount of CNG that has the same energy content as a gallon of diesel fuel. The gas cylinders in the CNG trucks can carry about 36 DGE of natural gas. Therefore, the average range of New York City's CNG trucks is about 61 miles, which has been acceptable for the refuse haulers because their routes are within the city and tend to be short. The Department of Sanitation fuels the trucks about once every other day on the average.

Maintenance and Repair Issues

Because these trucks were the first of their kind, a steady stream of unforeseen problems was expected. Although problems did occur, the trucks have consistently performed above expectations. Harte says the Department of Sanitation has been delighted with them.

The prototypes had a few problems when they first went into service. Early in the project, a piston melted down in one of the engines. The problem was traced to the air/fuel ratio control and corrected for the other trucks. The knowledge gained from this type of experience has helped the engine manufacturers improve their fuel control systems on newer CNG engines.

The maintenance and repair database on the CNG trucks shows that they have been somewhat more expensive to maintain than the diesel trucks. A significant part of this differential cost has been the spark plugs and wires for the CNG trucks. Harte explains: "In terms of regular maintenance…[the CNG trucks] have been right alongside the rest. The spark plugs and wires were the parts that really caught us by surprise." At the beginning of the project, the spark plug wires had to be replaced every 6 to 8 months at a cost of about $125 per wire. With the help of the manufacturer, the wire life has now doubled. In their newer natural gas engines, manufacturers have integrated the design of the spark plug wires and coils. This design change should further increase the wire life and reduce maintenance costs. As Harte puts it: "…if you didn't start somewhere, you wouldn't find that the weak link is your ignition wire and that's part of why we did this."

Cost

On an equivalent energy basis, the retail price of natural gas is lower than that of diesel fuel. During the week of January 8, 1996, the national average station price for diesel fuel was about $1.15 per gallon. The average station price for CNG was about $0.96 per DGE. On an equivalent energy basis, CNG cost about 17% less than diesel.

Some of this advantage is lost because the natural gas trucks have lower fuel efficiency than the diesel trucks. On the basis of the average fuel efficiency of the natural gas and diesel refuse haulers in New York City, and the national average retail fuel prices in January 1996, the fuel cost would be about $0.57 per mile for the natural gas trucks and $0.62 per mile for the diesel trucks. Actual fuel cost at any given site depends on local diesel and CNG prices, which can vary significantly from the national average.

The fuel cost savings must be balanced against the additional cost of a CNG truck. The New York City CNG refuse haulers were the first of their kind, and the costs of these prototypes were considerably higher than those of a comparable diesel truck.

Emissions

Heavy-duty engines are certified for emissions independent of any truck chassis by an engine dynamometer (rather than a chassis dynamometer) and a standardized cycle defined by the U.S. Environmental Protection Agency (EPA). The in-use emissions levels of the truck can be approximated by a chassis dynamometer. The truck is placed on the chassis dynamometer, and a driver follows a specific driving cycle while the emissions from the tailpipe are measured. Unfortunately, no accepted standard driving cycle is available for chassis dynamometer testing of heavy-duty trucks.

West Virginia University has tested the New York City trucks on its transportable heavy-duty chassis dynamometer on a driving cycle called the Central Business District (CBD) cycle. The CBD cycle is designed to simulate urban stop-and-go driving.

Specifications for the NYC Department of Sanitation Refuse Haulers

Chassis:	Crane Carrier Corporation Model LT484M, 25-cubic-yard capacity, low-entry cab
Fuel:	Compressed natural gas
Gross Vehicle Weight:	70,000 pounds
Engine:	1992 Cummins L10-240G
Displacement:	10 liters
Power:	240 horsepower
Torque:	750 foot-pounds
Gas Cylinders:	Pressed Steel Tank Company
Capacity:	36 diesel equivalent gallons

Because the NYC trucks were placed into service as prototype demonstration and development vehicles, the engines were not optimized for emissions reductions. The emissions results from these prototype trucks have been highly variable. Emissions of nitrogen oxides and carbon monoxide were sometimes less from the CNG trucks and other times less from the diesel trucks. On the average, however, the diesel trucks emitted less of these types of pollutant.

The total hydrocarbon emissions from the CNG trucks were consistently greater than those from the diesel trucks. However, hydrocarbon emissions from natural gas vehicles are typically 90% to 95% methane. EPA and the California Air Resources Board (CARB) regulations are written in terms of nonmethane hydrocarbons because methane does not contribute to urban ozone (smog). The nonmethane hydrocarbon emissions from the CNG trucks were not measured directly, but NREL expects the values to be similar to, or lower than, those of the diesel trucks.

In particulate emissions, the CNG trucks consistently demonstrated a clear advantage. In 6 of 11 tests, particulate emissions were essentially zero (too low to measure); the particulate emissions from the diesel trucks averaged about 0.7 grams per mile. Reduced emissions are an attractive feature for a refuse hauler because it operates in heavily populated urban areas where particulate emissions from vehicle exhaust are a serious health concern. The truck drivers have also noticed the improvement. Senior drivers get the first choice of trucks, and they consistently choose the CNG trucks.

Where Do We Go from Here?

Experience with these trucks and subsequent demonstration vehicles has convinced major truck manufacturers that there is a place for alternative-fuel heavy-duty trucks. Several manufacturers, including Peterbilt, Kenworth, Mack, Volvo/GM, and Crane Carrier, offer natural gas versions of their refuse haulers. As production volumes increase, manufacturers expect the cost of the natural gas trucks to drop. Natural gas engines are not inherently more expensive to make than advanced diesel engines, but a natural gas fuel system will always be more complex and expensive than a diesel fuel system. However, because the fuel system is a small percentage of the total cost of the truck, the cost of a natural gas option will not greatly boost the overall cost of the truck at high production volumes.

Where Can I Get One of Those!

Because of the experience gleaned from this project and others like it, several truck manufacturers now offer natural gas refuse haulers. Here are some that are available now with natural gas options:

Manufacturer: Crane Carrier Corporation
Chassis Model: Model LT484M
Engine: Cummins L10
Fuel: Compressed natural gas
Contact: Rueben Brown, 918/836-1651

Manufacturer: Volvo/GM Heavy Truck Corporation
Chassis Model: Xpeditor
Engine: Cummins L10
Fuel: Liquefied natural gas
Contact: Your local Volvo/GM heavy truck dealer

Manufacturer: Kenworth
Chassis Model: T800
Engine: Cummins L10
Fuel: Liquefied natural gas
Contact: Evan Campbell, 206/828-5758

Manufacturer: Peterbilt
Chassis Model: 320
Engine: Cummins L10
Fuel: Compressed or liquefied natural gas
Contact: Your local Peterbilt dealer, 800/447-4700

Manufacturer: Mack
Chassis Model: MR Cab-over refuse hauler
Engine: Mack E7
Fuel: Liquefied natural gas
Contact: Kevin Flaherty, 610/709-3816

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Disclaimer

This case study is intended only to illustrate approaches that organizations could use in adopting AFVs in their fleets. The data cited here, although real experience for the fleet discussed in this case study, may not be replicated for other fleets. For more comprehensive information on the performance of AFVs and other related topics, please call (800/423-1363) or e-mail (hotline@afdc.nrel.gov) the National Alternative Fuels Hotline. To learn more about DOE's role in alternative-fuel vehicle research, visit the Alternative Fuels Data Center on the World Wide Web at http://www.afdc.doe.gov.

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