On-Road Development of the C-Gas Plus Engine in Heavy-Duty Vehicles

PROJECT IMPACT

The natural gas engine technology advanced in part by this project has had an immediate impact. In the first 20 months since Cummins Westport Inc. (CWI) began producing the C8.3G Plus (C-Gas Plus), 1,044 of the engines have been sold or ordered for use in U.S. transit buses. This represents approximately 9.6 million gallons of annual diesel fuel displacement, or 1.5% of the total annual diesel consumption of U.S. transit buses.[1] The engine has also been sold internationally and for use in trucks. Vehicles equipped with the C-Gas Plus engine reduce emissions of particulate matter (PM), oxides of nitrogen (NO_X), and carbon monoxide (CO) compared with conventional diesel counterparts.

- 1,044 C-Gas Plus engines sold or ordered for U.S. transit buses
- 9.6 million gallons of diesel fuel displaced annually
- Reduced emissions of PM, NO_x, and CO

PROJECT GOALS

Natural gas is an abundant domestic fuel. The U.S. Department of Energy (DOE) supports natural gas vehicle (NGV) research and development to help the United States reach its goal of reducing dependence on imported petroleum, as outlined in the Energy Policy Act of 1992. Another benefit of NGVs is that they can reduce emissions of regulated pollutants compared with diesel vehicles.

To advance NGV technology, DOE's National Renewable Energy Laboratory (NREL) supported on-road prototype development of the C-Gas Plus engine, beginning in November 2000. The goal of the project was to advance laboratory-developed technologies, on road and in service, for a natural gas truck and bus engine with significant improvements over the previous C8.3G natural gas engine. This goal was achieved. The C-Gas Plus was launched into production in July 2001 with increased engine ratings, reduced emissions, and lower cost compared with the C8.3G engine.

[1] Using data from the American Public Transit Association, average transit bus diesel consumption was calculated to be 9,200 gal/yr. At this rate, operating 1,044 natural gas buses in place of the same number of diesel buses displaces approximately 9.6 million gal/yr of diesel (about 1.5% of the 635 million gal/yr of diesel consumed by transit buses). Data from American Public Transit Association, *2002 Public Transportation Fact Book*, Washington, DC, 2002.

AVAILABILITY OF THE C-GAS PLUS ENGINE

Various vehicle manufacturers offer the C-Gas Plus engine as an option in refuse truck, transit bus, and shuttle bus applications.

Vehicle Manufacturers

- Crane Carrier Co.
- ElDorado National
- Equipement Labrie
- Freightliner Trucks
- Neoplan USA Corp.
- New Flyer of America
- North American Bus Industries
- Nova Bus Inc.
- Orion Bus Industries
- Volvo Trucks North America

ON-ROAD DEVELOPMENT TEST VEHICLES

Two Class 8 tractor-trailers from Viking Freight were retrofitted with the C-Gas Plus engine for a one-year (January-December 2001) development and data collection project (Figure 1). Two similar tractor-trailers were operated with a Cummins C8.3 diesel engine for comparison purposes. The Viking fleet typically picks up and delivers packaged dry goods. Monthly mileage varied from 500 to 2,000 miles. The natural gas trucks' fuel storage design consisted of nine compressed natural gas cylinders with total capacity of 49.8 DGE for a range of more than 200 miles. This enabled the natural gas trucks to be driven on the same duty cycle as their diesel counterparts.

Figure 1. One of two Viking Freight tractor-trailers powered by a C-Gas Plus natural gas engine for the NREL-funded on-road prototype development project. Inset: C-Gas Plus engine. PIX 05605 Mike Bolin, Viking Freight/PIX 10263

EMISSIONS BENEFITS OF THE C-GAS PLUS ENGINE

West Virginia University and CWI developed a custom drive cycle that represented the driving patterns of the Viking trucks. They performed chassis dynamometer emission testing for this cycle and for the heavy-duty Urban Dynamometer Driving Schedule (UDDS).

On the customized Viking cycle (Figure 2), the natural gas trucks had average NO_X emissions of 5.89 g/mi (45% lower than the diesel trucks), PM emissions of 0.016 g/mi (92% lower), and CO emissions of 0.033 g/mi (93% lower). On the UDDS cycle, the natural gas trucks had average NO_X emissions of 10.3 g/mi (26% lower than the diesel trucks), PM emissions of 0.015 g/mi (94% lower), and CO emissions of 0.044 g/mi (94% lower). Note: the chassis dynamometer emission results were measured in units of grams per mile (g/mi); these measurements cannot be converted to the engine dynamometer units of grams per brake horsepower-hour (g/bhp-h) used in emission certification.

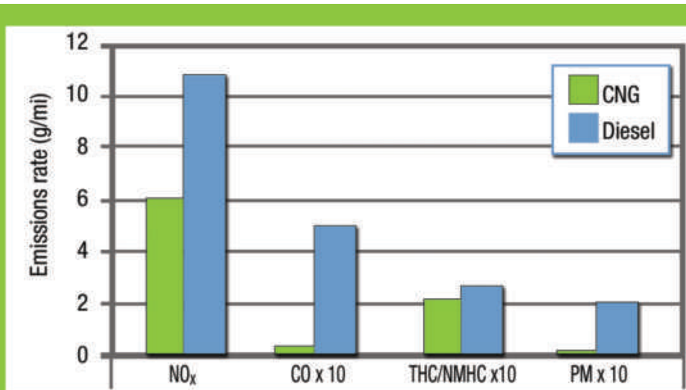

Figure 2. Chassis dynamometer emissions of natural gas and diesel trucks over the Viking drive cycle.

CWI also tested the C-Gas Plus on an engine dynamometer for emission certification protocols, including the supplemental emission test (which is required for meeting the 2004 EPA emission standards). EPA and CARB granted the following emission certifications:

Required standards

Automotive w/catalyst, EPA heavy-duty standards
Urban Bus w/catalyst, EPA heavy-duty standards

Optional low emission standards

EPA Ultra Low Emission Vehicle (ULEV)
CARB low NO_X (2.0 g/bhp-h), Automotive
CARB low NO_X (2.0 g/bhp-h), Urban Bus

FUEL COSTS COLLECTED DURING ON-ROAD DEVELOPMENT

This evaluation showed the potential economic benefits of operating natural gas trucks instead of diesel trucks. Two sets of fuel costs were collected (Figure 3). The first reflects the use of a public natural gas fueling facility 12 miles from Viking Freight; the second an on-site natural gas fueling station. The diesel trucks were fueled at Viking throughout the entire evaluation.

When the natural gas trucks were fueled exclusively off site (January–September), the fuel cost was $0.31/mi versus $0.16/mi for the diesel trucks—94% higher. On-site natural gas fueling became available in October, and the natural gas trucks fueled exclusively on site October–December. During this period, the natural gas trucks had a fuel cost of $0.11/mi versus $0.16/mi for the diesel trucks—31% lower.

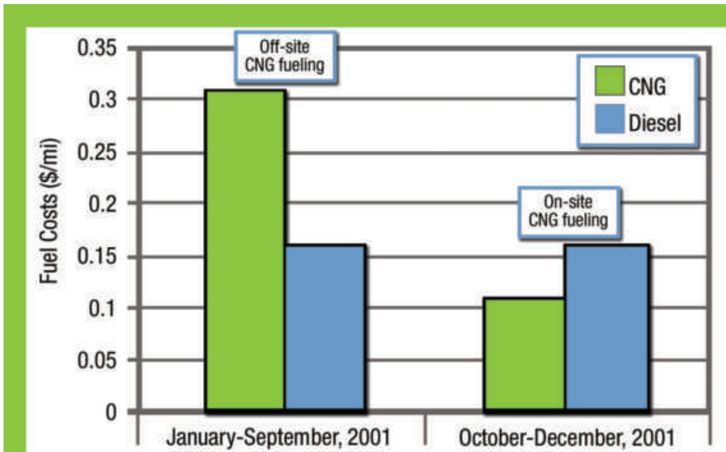

Figure 3. Fuel costs of natural gas and diesel trucks.

RELATED PUBLICATIONS

The following documents are available online from the Alternative Fuels Data Center at *www.afdc.doe.gov.* Hard copies are available from the Alternative Fuels Hotline at 1-800-423-1363 or hotline@afdc.nrel.gov:

An Emission and Performance Comparison of the Natural Gas C-Gas Plus Engine in Heavy-Duty Trucks—Technical report detailing laboratory and on-road development of the C-Gas Plus engine.

Heavy Vehicle and Engine Resource Guide—Availability of the C-Gas Plus engine and other alternative fuel engines and vehicles.

FOR FURTHER INFORMATION, CONTACT

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