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In the fall of 1994, the UPS fleet in Landover, Maryland, began operating 20 vehicles on CNG. UPS selected CNG because natural gas is an abundant domestic resource that is available in almost every city in the United States, and it also generally costs less than other fuels.

On average, natural gas is 82% to 98% methane with smaller percentages of ethane, propane, and butane. The relatively simple molecular structure gives natural gas the potential to emit very low levels of exhaust pollutants. Plus, it has a high octane rating (120-130), which allows it to be used at higher compression ratios (relative to gasoline) without damaging the engine.

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Twenty-five vehicles were used in the development project: 20 CNG vehicles and 5 gasoline control vehicles. The GMC chassis had a gross vehicle weight rating of 20,000 pounds. They ranged in age from the 1987 model year to the 1990 model year. The special purpose bodies are built for package delivery and UPS calls them “package vehicles.” Five vehicles were type
the gasoline engines on a gge basis. A gge is the operating at a higher compression ratio, the natural gas has a significantly higher octane rating, the natural gas desired air-fuel mixture. However, because natural gas exhaust indicates whether the engine is operating on stoichiometric conditions. An oxygen sensor in the both the natural gas and gasoline (control) engines accumulated 554,575 miles during the demonstration.

Fuel Economy and Range
Both the natural gas and gasoline (control) engines feature closed-loop air-fuel ratio systems and operate at stoichiometric conditions. An oxygen sensor in the exhaust indicates whether the engine is operating on the rich or lean side of stoichiometric, and also provides a signal for adjusting the fuel system to achieve the desired air-fuel mixture. However, because natural gas has a significantly higher octane rating, the natural gas engine can operate at a higher compression ratio than the gasoline version (12:1 compared to 9.3:1). Operating at a higher compression ratio, the natural gas engines were able to achieve better fuel efficiency than the gasoline engines on a gge basis. A gge is the amount of CNG that has the same energy content as a gallon of gasoline. On average, the P80C achieved 9% better fuel economy than the P100 gasoline vehicle, and the P100C achieved 15% better fuel economy than the P100 gasoline vehicle. The graph on the following page compares the average fuel economy of the package trucks.

Maintenance and Repair Issues
Although the UPS development project proved the viability of using CNG in a pick-up and delivery fleet, some operational issues are inevitable with any new technology. This project was no exception. The natural gas pressure regulators, the fuel injectors, and the spark plug and spark plug wires presented most of the maintenance and repair issues.

Fuel pressure regulators failed without warning, stranding vehicles by the roadside. Because these are relatively low volume components, replacements can be in short supply, and the price is high at $425 each. When several regulators were needed at once, UPS experienced delays of up to 14 days. This problem recurred throughout the project.

Although several concerns about the fuel injectors surfaced during the project, the main problem was that the injectors would stick shut, keeping fuel from flowing to the engine. Initially it was thought that the fuel station compressor was passing oil to the fuel. However, further inspection revealed that the oil was a residue from the manufacturing process.

The CNG vehicles also experienced problems with the durability of the spark plugs and the spark plug wires. These components required replacement at twice the rate of those on the gasoline-powered vehicles. Because the natural gas requires more energy to ignite than gasoline, the natural gas ignition system uses higher voltage, which wears out the components twice as fast.

A comprehensive comparison of maintenance costs is unavailable because many of the components replaced during the project were covered under warranty. The UPS maintenance and repair tracking system did not capture warranty repairs.

Lessons Learned
Fueling Frequency and Vehicle Range
At the beginning of the project, the CNG vehicles’ shorter range, along with coarse fuel gauge accuracy, led to the vehicles running out of fuel. Training drivers to do a pre-trip inspection of both the dash fuel gauge and the system pressure gauge before leaving the building resolved the problem.

Fuel System Freezing
During cold weather (below 25°F), moisture in the fuel would occasionally cause the CNG fuel systems to freeze. The freezing would typically occur in the regulator or the pressure-relief devices. After a thorough review of various solutions, the option to drain coalescing filters more often during cold weather was the most viable alternative. This process was implemented with positive results. Infrastructure changes could also alleviate this problem; the refueling site could be equipped with dryers to eliminate the moisture from the natural gas before it gets into the vehicle tanks.

Natural Gas Parts Availability
CNG vehicle downtime during the project was exacerbated by the limited availability of replacement parts. Where it was practical, UPS inventoried its own components. UPS also worked with local suppliers who agreed to stock specific problematic components.
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### Emissions

The Tecogen Tecdive 4300s were production engines and were emissions-certified to the federal ULEV standard. The category on the following page shows the CFFP’s federal standards. The test procedure for the CFFP standards is the EPA Federal Test Procedure.

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