CASE STUDY

The Pierce Transit Story

In 1986, the Pierce County Transportation Benefit Area Authority (Pierce Transit), based in Tacoma, Washington, made a commitment to the future of the transportation industry and to the environment by deciding to put buses powered by compressed natural gas (CNG) into everyday service. Eleven years, 72 CNG buses, and countless curious inquiries later, CNG is no longer a novelty – it's business as usual.

"Sometimes we feel like consultants," says Ron Shipley, Director of Maintenance and originator of Pierce Transit's CNG project. "We used to get two or three phone calls a day with questions about our CNG program." The agency's phones are still ringing. But today, Shipley says, "It's not something new anymore. It's the way we do business."

Formed in 1979, Pierce Transit operates in a 450-square-mile area with a population of about 600,000. The agency provides both rural and urban route service, including express lines to Seattle and Olympia. Its 56 fixed routes cover more than 900 miles of road. In 1995, Pierce's vehicles traveled more than 7 million miles and carried more than 10 million riders. The fleet consists of 193 transit buses, 148 of which are in service at any given time. CNG powers 72 of these buses. The agency's facilities include a 35,000-ft^2 administration building, a 76,000-ft^2 maintenance facility, a CNG fast-fill station, 6 transit centers, more than 175 covered bus shelters, and 20 park-and-ride locations.

The Search for a Supplier

Pierce Transit's experience with CNG began in 1986 with the conversion of two General Motors New Look buses to run on a combination of CNG and diesel. Although this experiment was successful, fuel efficiency was a problem. "In hindsight, whenever you are burning two fuels in the engine, whether you are

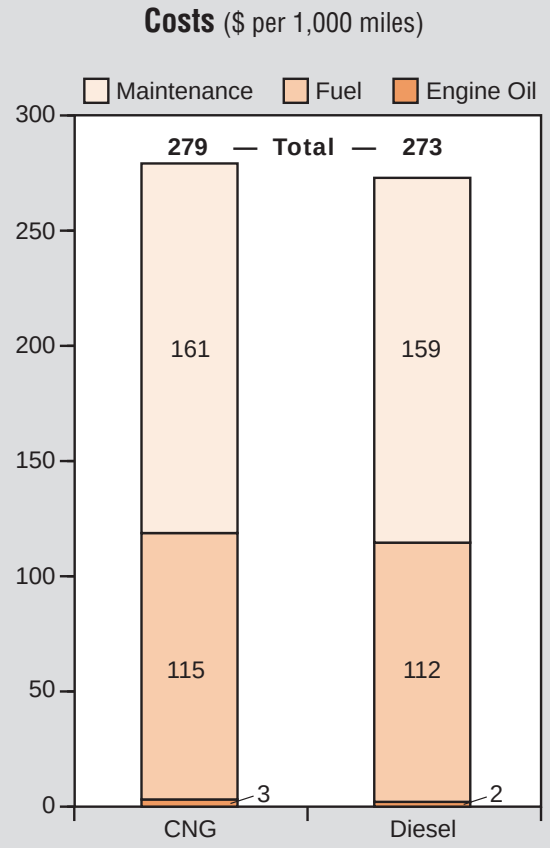
flipping a switch [to change fuels] or [burning] two fuels together, you can't optimize the engine," Shipley says.

The overall success of this initial attempt led to a 1987 decision to purchase dedicated CNG buses. Pierce Transit began searching for an original equipment manufacturer (OEM) that would help develop this type of engine but received no bids.

Remaining committed to CNG, however, Pierce Transit ordered nineteen 28-ft bi-fuel (CNG and gasoline) coaches for rural routes from El Dorado Bus Company in 1988. Challenger Energy Products installed CNG conversion kits in the Ford 460 electronic-fuel-injection gasoline engines at a cost of about $15,000 per bus. In 1991, these conversion kits were replaced with a MOGAS system to solve hard starting, backfiring, and hesitation problems, according to Shipley.

In 1989, Pierce Transit found its OEM in Cummins Engine Company. Fifteen buses, equipped with Cummins L10-240G CNG engines, were ordered from Orion Bus Industries (formerly Bus Industries of America). Since then, the agency has ordered 15 more L10-240G buses, 27 Orion V buses powered by Cummins L10-260G engines (for the Seattle Express), and 15 Orion buses equipped with Cummins L10-280G engines. Pierce recently placed an order with New Flyer of America for 45 low-floor CNG buses, to be delivered beginning in fall 1998.

Pierce Transit has participated in the U.S. Department of Energy (DOE) Alternative-Fuel Transit Bus Evaluation Program, managed by the National Renewable Energy Laboratory (NREL), since 1993. Data collected for the program support Shipley's evaluation of his alternative-fuel operations: CNG works at Pierce Transit.



Source: Alternative-Fuel Transit Buses, Final Results from the NREL Vehicle Evaluation Program.

Costs

A common argument against using alternative-fuel engines is that capital costs for the engines and the vehicles are too high. The Pierce buses each cost $30,000 to $50,000 more than their diesel counterparts. Most of this additional expense is attributable to the higher cost of CNG engines and natural gas storage cylinders. "That cost will always be there," Shipley says. "As technology improves, however, we'll see that price come down a little."

Shipley predicts that capital costs for CNG and diesel engines will be equal by the end of this decade, but not because CNG engines are getting cheaper. He believes diesel engine prices will continue to rise because of increasingly stringent environmental standards. "Because we have such a high percentage of alternative-fuel vehicles, we're able to meet those standards with less involvement in the EPA's [U.S. Environmental Protection Agency's] certified retrofit/rebuild program for our diesel engines," Shipley says.

Necessary changes to facilities present additional capital costs. Pierce Transit's CNG fueling facility, completed in 1992, cost $847,000. The agency also had to add natural gas detectors to its maintenance facilities and modify its ventilation systems at a cost of more than $500,000.

Maintenance costs for the agency's diesel and CNG fleets are nearly equal. "There are still problems with the ignition system, specifically spark plugs and wires," Shipley says, "but electronics are making the engines more reliable, which translates to lower maintenance costs for us."

The most intriguing cost comparison between Pierce Transit's diesel and CNG fleets comes in the area of fuel. Natural gas prices are more stable than diesel prices, which protects Pierce Transit when the price of petroleum products increases. During the DOE/NREL evaluation program, Pierce Transit paid $0.52 per diesel equivalent gallon for CNG and $0.65 per gallon for diesel. In fall 1996, the agency began buying CNG as a commodity. Pierce Transit is now able to buy a high volume of CNG directly from natural gas suppliers rather than from Washington Natural Gas, a state-regulated utility. This arrangement cuts the cost of CNG from $0.52 to $0.30 per diesel equivalent gallon.

The DOE/NREL data indicate that after 10 years of experience with CNG, Pierce Transit has reached the point where CNG operating costs are almost the same as those for diesel. The evaluation program collected and analyzed operating costs for vehicle maintenance (repairs, inspections, cleaning, and rebuilding), fuels, and lubricants. An additional $0.06 was added to the cost of a diesel equivalent gallon of CNG to account for the cost of maintenance labor and parts for the natural-gas compression station used in fueling

Fleet Facts

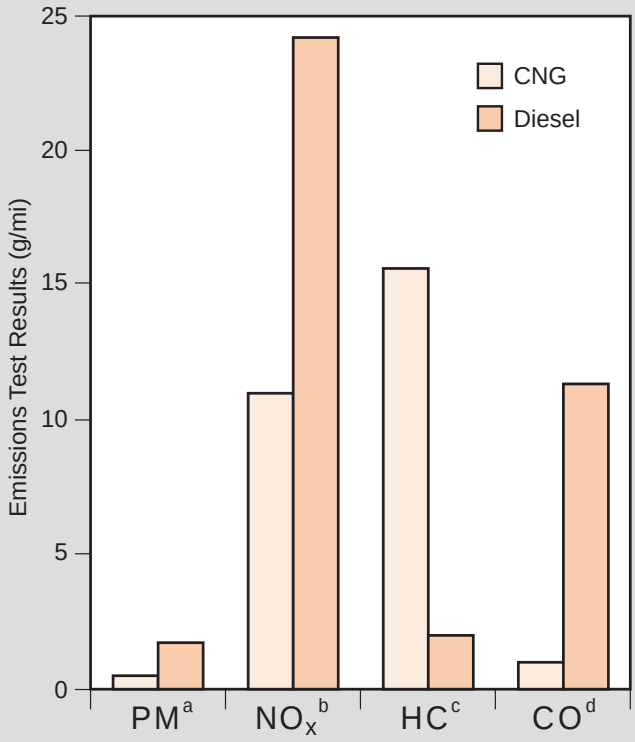
Fleet Type:	Public transit
Fleet Size:	193 buses, of which 72 are alternative fuel
Alternative Fuel:	Compressed natural gas (CNG)
Vehicles:	Bi-fuel and dedicated CNG buses

Road Calls per 1,000 Miles for Diesel and CNG Buses

Total Road Calls	0.21
Engine/Fuel-System-Related Road Calls	0.11

Source: Alternative-Fuel Transit Buses, Final Results from the NREL Vehicle Evaluation Program.

Emissions



[a] Particulate matter.

[b] Nitrogen oxides are the principal pollutants that react with volatile organic compounds to form ozone when exposed to sunlight.

[c] Hydrocarbons are composed of combinations of carbon and hydrogen.

[d] Carbon monoxide is emitted directly into exhaust gases as a result of the incomplete combustion of hydrocarbons.

Source: Alternative-Fuel Transit Buses, Final Results from the NREL Vehicle Evaluation Program.

the buses. During the study, operating costs for the agency's CNG fleet were $0.28 per mile, compared with $0.27 for diesel. With the new lower CNG fuel prices, CNG bus operating costs at Pierce Transit are now significantly lower than those for diesel.

Reliability

On average, the CNG buses travel 4,500 miles per month compared with 5,000 miles per month for the diesel fleet. The average distance between road calls is a measurement of how many times a bus develops a problem while in service. The numbers for Pierce Transit's CNG and diesel fleets are identical, even if only engine- and fuel-system-related road calls – the types of road calls that may be caused by the use of an alternative fuel – are examined.

Fuel Efficiency

Pierce Transit's CNG engines are about 20% less fuel efficient than their diesel counterparts. This disparity can be attributed to the lower compression ratios and throttling losses of the CNG engines, slight differences in duty cycles between the two kinds of buses, and the additional weight of the CNG tanks. The CNG tanks on the Orion buses are made of carbon fiber, a light-weight composite material that reduces the total weight of the tanks and mounting hardware from nearly 3,900 pounds to about 2,500 pounds. This weight reduction, along with new electronic engine controls, should have a positive effect on fuel efficiency.

Emissions

Members of West Virginia University's Department of Mechanical and Aerospace Engineering have measured Pierce Transit's CNG fleet for emissions data by using a chassis dynamometer.

The university tested these vehicles with the standard Central Business District test cycle, which was designed to simulate typical route speeds, loads, and conditions. Results are highly dependent on proper engine tuning and the condition of the engine's catalytic converter, regulators, and mixing valves.

Dynamometer test results for Pierce Transit's CNG buses show that particulate matter was below detectable limits of the instrumentation, which indicates a significant advantage for CNG. Average emissions of nitrogen oxides from the CNG buses with Cummins L10-260G engines were 54% lower than those from comparable diesel buses with L10 engines. Average carbon monoxide emissions were 94% lower. Hydrocarbon (HC) levels from the CNG buses were significantly higher than those for diesel. However, 90% to 95% of the total HC count may be attributable to methane, which is considered nonreactive in the formation of atmospheric ozone and, therefore, is not used by the EPA as a basis for emissions regulations.

Future Trends

In 1986, Pierce Transit took a big leap into the future of the transportation industry. According to Shipley, it did so for a very good reason: "For those that get into natural gas, it has to be more than a purely economic decision. If petroleum products get rationed, as has happened in the past, then I can't provide service, and I need to be there for our customers."

Environmental concerns should also play a role in the decision to turn to alternative fuels. "They are cleaning up diesel engines, but we know that natural gas is a very clean fuel, and we know what it can do," Shipley says. "If you're only concerned about the bottom line, diesel is still cheap by world standards.

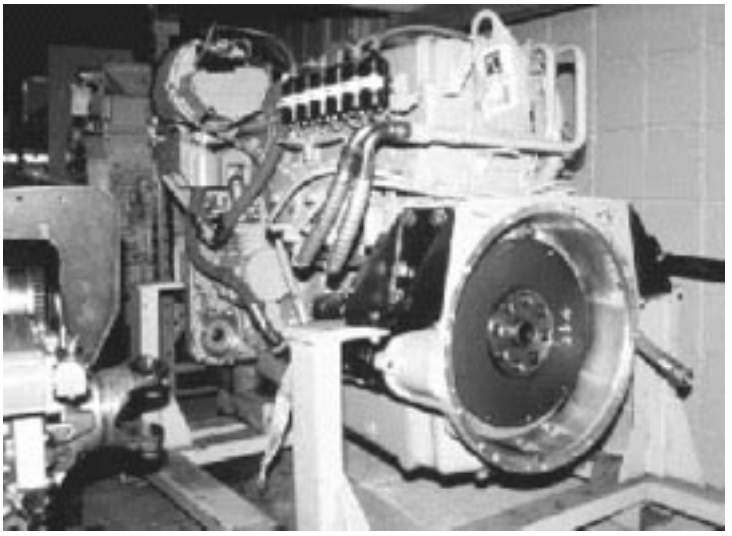
Natural Gas Engines for the Transit Market

Cummins Engine Company

- Cummins B5.9G
- Cummins C8.3G
- Cummins L10-280G/300G

Detroit Diesel Corporation

- DDC Series 30G
- DDC Series 50G



My gut feeling is that the day of reckoning is in the not-so-distant future. If you think you're going to be in business 10 years from now, you should be looking at some other way to do business that provides fuel price stability and availability as well as environmental improvements."

Shipley expects that by 2003, if the agency's replacement schedule continues at its current pace, all of Pierce Transit's buses will be powered by CNG engines.

Lessons Learned from Pierce Transit's Experience

According to Ron Shipley, you need to make the commitment if you want alternative fuels to make a difference.

- **Commit resources if you want to see benefits.** Your fleet must include a significant number of alternative-fuel vehicles to benefit from the economies of scale experienced at Pierce Transit. This also requires committed management and strong individual leadership.
- **Keep your employees informed about the fuel and the technology.** Training for vehicle operators, maintenance teams, and fueling crews will promote the transition and lessen anxiety about new technology.
- **Work with the experts to solve your problems.** Cummins Engine Company, Orion Bus Industries, the Gas Research Institute, and the Natural Gas Vehicle Coalition provided invaluable service to Pierce Transit. Demonstrating the effectiveness of the fuel, the engines, and buses was a team effort.
- **Base your decision on all aspects of the financial evidence.** The initial investment in alternative-fuel vehicles requires a substantial financial commitment. However, the long-range view indicates that operations, fuel, and maintenance costs are not substantially higher. Data also indicate that a natural gas engine does not require modifications to meet current and future environmental regulations.

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