CASE STUDY

Sun Metro – 6.2 Million Miles on Natural Gas

Sun Metro, the public transportation authority of El Paso, Texas, operates the world's largest natural-gas-fueled mass transit fleet. Approximately 53% of Sun Metro's fleet of 240 vehicles – buses, paratransit vehicles,[1] and support vehicles – runs on natural gas. A combination of state legislation, federal grant funds, and cost savings motivated Sun Metro to make the move to alternative fuel.

Moving to Alternative Fuel

In 1991, the State of Texas enacted House Bill 734 (Senate Bill 200), which requires all centrally fueled fleets with 15 or more vehicles to begin converting to alternative fuel. Mass transit fleets, the first category required to comply, must use alternative fuels in 90% of their vehicles by September 1998. The law applies to all fleet vehicles, not just new purchases.

The law encourages the use of natural gas, which is produced in Texas. Two types of vehicle fuel are based on natural gas: liquefied natural gas (LNG) and compressed natural gas (CNG). LNG is natural gas that has been condensed to a liquid, typically by cryogenically cooling to about –250°F. CNG is natural gas that has been compressed to a pressure of 2,400-3,600 psi.

In 1992, Gino Chavez was appointed Superintendent of Maintenance at Sun Metro. Chavez had managed a pilot program to operate CNG transit buses in Austin, Texas. He joined Sun Metro with two goals: to use (1) LNG and (2) dedicated vehicles that run on a single fuel rather than bi-fuel vehicles that can run on either natural gas or gasoline. He preferred LNG because it provides a greater driving range than CNG. It is also denser than CNG, and fewer tanks are needed to hold the same amount of fuel, which means less weight. A CNG bus weighs about 1,900 pounds

[1] Paratransit vehicles transport disabled riders. They carry 6-10 passengers and have wheelchair lifts.

more than a similar diesel bus, but an LNG bus weighs only about 600 pounds more. Chavez chose dedicated vehicles because he "felt very strongly that if you wanted to do alternative fuel, do it wholeheartedly."

Obtaining Special Funding

Sun Metro obtained special grant funding from several federal sources to help defray the cost of converting to LNG. Sun Metro also worked with Congressman Ronald Coleman, who represents El Paso, to obtain federal funds earmarked for alternative fuels.

Funds for mass transportation are available under the Section 9 program, which is managed by the U.S. Department of Transportation's Federal Transit Administration (FTA). The program provides grants to urban mass transit programs on the basis of factors such as population, ridership, and service area. These grants may be used for capital expenditures or a limited portion of operating expenses. Grants for vehicle purchases are awarded on an 80/20 basis: federal funds cover 80% of the cost, and local money covers the remaining 20%. In 1992, Sun Metro had Section 9 funds available to purchase buses, but not alternative-fuel buses. Sun Metro worked with the FTA to revise the terms of the grant to allow the purchase of LNG buses.

Funding available through the Congestion Mitigation and Air Quality Improvement (CMAQ) Program, established under the Intermodal Surface Transportation Efficiency Act of 1991, covered 80% of the construction costs of an LNG/CNG fueling facility at Sun Metro's central vehicle depot. The CMAQ Program allocates funds to states to expand or initiate transportation services while producing air quality benefits. CMAQ funds may be used to support alternative-fuel vehicle (AFV) programs.

Building an Alternative-Fuel Mass Transit Fleet

Sun Metro's first two alternative-fuel buses resulted from a unique arrangement. One vendor, Transportation Manufacturing Company (TMC), delayed delivery of a large order for diesel buses, triggering a penalty clause in the purchase contract. Because TMC also manufactures CNG buses and knew of Chavez' interest in alternative fuels, the company offered to pay the penalty in the form of two new CNG buses. Sun Metro accepted the offer and took delivery on the two buses in 1993.

Because of its positive experience with the first two CNG buses, Sun Metro issued a request for proposal (RFP) for CNG paratransit vehicles in 1993. The RFP specified a range of 250 miles. However, the number of CNG fuel tanks needed for this range would push the vehicles over their gross vehicle weight rating, even without passengers. Sun Metro received no responses and was forced to amend its RFP to specify LNG fuel. After receiving several bids, Sun Metro awarded a contract to Supreme Corporation for $75,000 per vehicle (compared with $50,000 each for similarly equipped diesel vehicles). Supreme installs bodies on original equipment manufacturer (OEM) chassis: the first LNG paratransit vehicles were built on Ford E350 chassis, while the second group

of vehicles was built on Chevrolet GP chassis. Sun Metro placed 20 LNG paratransit vehicles into service in 1993.

Sun Metro also awarded contracts for dedicated CNG vehicles. Bus Industries of America supplied 18 40-foot CNG buses at a cost of $244,000 each. The buses, used in general, fixed-route service, began operation in 1994. Sun Metro let a contract for dedicated CNG, rubber-tired trolleys, built to look like old-fashioned trolleys, which serve El Paso's central business district. Chance Corporation delivered seven trolleys in 1996 at a cost of $289,000 each.

In 1994, Sun Metro placed orders for 35 full-size buses and 22 paratransit vehicles, all dedicated LNG vehicles. New Flyer supplied the LNG buses at a cost of $256,000 per bus, compared with similar diesel and CNG buses costing $216,000 and $275,000, respectively, per bus. Section 9 funds covered 80% of the cost. Supreme supplied the paratransit vehicles at a cost of $74,000 per vehicle, compared with $62,000 for a similarly equipped diesel-powered paratransit vehicle.

Sun Metro also ordered 21 dedicated support vehicles (vans, minivans, light-duty trucks, sedans) – 2 fueled with LNG and 19 fueled with CNG – which were delivered in 1994 and 1995. The LNG and CNG support vehicles cost an average of $21,000 each, or about $6,000 more than comparable gasoline vehicles. Sun Metro also converted three new off-road vehicles (sweepers, forklift) to CNG, at a cost of about $3,000 each. Chavez' policy is, "If it rolls, hang a natural gas bottle on it!"

Building a Fueling Facility

The local gas utility, Southern Union Gas, had installed a temporary compressor to fuel the CNG buses.

Fleet Facts

Fleet Type:	Public mass transit authority
Fleet Size:	240, of which 128 are alternative-fuel vehicles
Alternative Fuels:	Compressed natural gas and liquefied natural gas
Vehicles:	62 buses, 42 paratransit vehicles, 24 support vehicles

The compressor processes pipeline CNG to a high enough pressure for efficient storage in the fuel tanks. However, when considering the type of fueling facility to build, Sun Metro was concerned about two drawbacks of using pipeline CNG: (1) it is not consistently 98% methane and (2) it can be contaminated by dirty pipeline gas, oil from compressors, and trace gases in the pipeline. LNG supplied in bulk tanks alleviates these drawbacks. Chavez also faced the prospect of fueling both LNG and CNG vehicles. Fortunately, LNG is simply liquefied compressed natural gas, which can be flash-evaporated into CNG.

According to Chavez, Sun Metro has the world's largest LNG/CNG fueling facility. It is served by three cryogenically insulated bulk LNG tanks that each hold 20,000 gallons of LNG at 250°F and 10 psi. The CNG flash-evaporated from LNG creates enough pressure to transfer the low-pressure LNG from the tanks to the vehicles. The facility can fuel six vehicles simultaneously from individual fueling positions. The LNG and CNG are supplied from separate dispensers. It takes 20 minutes to fuel a 40-foot bus with CNG and 4 minutes for small vehicles. In contrast, LNG fueling takes 4-7 minutes.

The CMAQ Program funded 80% of the $3,000,000 construction costs. Because Sun Metro already had a diesel fueling facility at its central vehicle depot, it has not incurred any additional or unusual annual operating costs to support the LNG/CNG fueling facility.

Training Vehicle Drivers

Early training, before the first buses arrived, prepared drivers for the new AFVs. Drivers watched safety films and learned how the driving characteristics of natural gas buses differ from those of diesel buses. Drivers also practiced on the first two CNG buses delivered.

Drivers were also trained to fuel the CNG and LNG vehicles. The fueling process is simple: (1) lock the nozzle into place on the vehicle and (2) push the "on" button. The dispenser automatically stops when the tanks are full.

In-Use Performance

Drivers are generally pleased with the performance of the LNG and CNG vehicles. Drivers of the paratransit vehicles have found little or no difference in performance between natural gas engines and diesel engines. However, drivers of CNG and LNG buses have found that vehicle performance depends on the engine installed.

The 18 CNG buses delivered in 1993 had Cummins L10G natural-gas engines. Drivers had to adjust their driving techniques to the slower acceleration of these buses: when a driver depresses the accelerator, the engine takes 2-3 seconds to build up enough power to pull away. In contrast, the 35 LNG buses supplied in 1995 use the Detroit Diesel Series 50 natural gas engines, which Chavez says, "will run circles around any other bus in the fleet." Chavez explains further, "It [the natural gas engine] has the identical torque curve and horsepower range as its diesel sister. If you bought a 275-horsepower, 890-pound-foot torque diesel, or you bought a gas engine, they would have identical specifications. But, because there's no smoke control on an alternative fuel bus, it will outrun the diesel." To control exhaust smoke, the diesel engine has to reduce fuel flow to the engine during initial takeoff. Natural gas buses do not need to make this type of adjustment and can apply power instantaneously for a faster takeoff.

Typically, about 114 of Sun Metro's 157 buses are on the street during rush hours, and about 44 on-call paratransit vehicles operate during peak demand periods. Buses accumulate about 1,200 miles, paratransit vehicles about 1,000 miles, and support vehicles about 250 miles per week. As of July 1996, Sun Metro's fleet had accumulated 6.2 million miles on natural gas.

It takes about 1.5 gallons of LNG to equal the energy in 1 gallon of diesel fuel. Buses average 3.5 miles per diesel-gallon-equivalent (DGE) of CNG and 3.5 miles per gallon when operating on diesel fuel. Paratransit and support vehicles average 7.5 miles per DGE of CNG.

The CNG buses achieve a driving range of about 300 miles. In contrast, LNG buses have a driving range of a little less than 400 miles, and diesel buses a little more than 400 miles. LNG paratransit vehicles have a driving range of 250 miles, while the average on-road CNG support vehicle achieves a driving range of 250 miles. On the basis of their respective mileage accumulation and driving ranges, CNG, LNG, and diesel buses fuel once a day, LNG paratransit vehicles twice a day, and the average on-road CNG support vehicle once a day.

Costs

Sun Metro incurred higher capital costs to purchase CNG and LNG vehicles than it would have paid for similarly equipped diesel or gasoline vehicles. However, the large savings in fuel cost, relative to what Sun Metro pays for diesel or gasoline, offsets this initial incremental cost.

Diesel buses cost about $216,000 each, LNG buses about $256,000 each, and CNG buses about $275,000 each. The difference in costs between LNG and CNG buses is due to the need to install 10 additional fuel tanks on a CNG bus to bring its range up to 300 miles. LNG paratransit vehicles cost about $75,000, compared with $50,000 for their diesel counterparts. On average, CNG or LNG versions of the different types of support vehicles cost about $6,000 more than similarly equipped diesel vehicles. Therefore, in acquiring AFVs for its fleet, Sun Metro has spent about $4.2 million more than it would have for comparably equipped diesel vehicles.

Beginning in 1996, Sun Metro let a three-year contract with Mesa Pacific to purchase LNG at $0.37 per gallon, delivered by truck to the central vehicle depot. However, 1.5–1.6 gallons of LNG are required to provide the same amount of energy as 1 gallon of diesel fuel. When comparing LNG with diesel on an energy-equivalent basis, the actual cost of LNG rises to $0.54 per DGE, about 60% less than the price for a gallon of diesel fuel – $1.30. Sun Metro's fleet uses 150,000 gallons of LNG and 24,500 gallons of CNG per month, for a total of 174,500 gallons of LNG per month, compared with 120,000 gallons of diesel fuel. Over the course of a year, Sun Metro saves about $1.6 million by using LNG instead of diesel.

A recent analysis of operating costs showed no significant difference between diesel and alternative-fuel buses. Because the oil in the alternative-fuel buses has been so clean at 6,000-mile oil change intervals, however, Sun Metro intends to double the interval to 12,000 miles. Each of the 62 alternative-fuel buses accumulates 64,000 miles per year and requires 7 gallons of oil per oil change, at a cost of $3.45 per gallon. By changing the interval, Sun Metro will realize a cost saving of about $8,000 per year.

Recommendations

When Chavez arrived in El Paso, he expected ultimately to move Sun Metro's fleet to 100% alternative fuels. The funding helped, as Chavez explains: "The federal people put in 80% of everything we purchased, and we put in the other 20%. We didn't have to come up with that much money locally."

Another factor was the need to replace much of the Sun Metro fleet. Chavez summarizes: "When I got here, I had a fleet that needed to be replaced almost 100%, which worked out to my benefit because then I didn't have to buy any retrofit kits or rehab any buses. I've been able to replace the fleet with new alternative-fuel equipment as it becomes available."

For other transit fleets considering AFVs, Chavez advises: "Do as much research as possible, and I do mean extensive research. Everyone has their own requirements and ideas. There are a lot of fly-by-night companies, so pick and choose the companies you work with very, very carefully. You have to look into every piece of equipment, conversion kits, tanks, everything. You have to work constantly at it. I haven't slept since 1989. It's changing so much daily. There's a lot more better stuff than there used to be, but you still have to pick and choose."

Payback Analysis

Costs

Vehicle Type	Number	Incremental Cost per Vehicle ($)[a]	Total Investment ($)
CNG Buses	27	59,000	1,593,000
LNG Buses	35	40,000	1,400,000
Paratransit Vehicles	42	25,000	1,050,000
Support Vehicles[b]	24	6,000	144,000
Total	128	–	4,187,000

[a]Compared with similarly equipped, diesel vehicles.
[b]Costs are the same for CNG and LNG versions.

Vehicles	$ 4,187,000
LNG/CNG Fueling Facility	$ 3,000,000
Total Cost	***$7,187,000***
80% Matching Grant Funds	$ 5,749,600
Net Cost	***$1,437,400***

Savings

Fuel
(174,500 gallons/month) ($1.30 – $0.54/DGE) (12 months) = $1,591,440/yr

Oil Changes
(64,000 mi/yr) (62 buses) (oil change/12,000 mi) (7 gallons oil/change) ($3.45/gallon of oil) = $7,986/yr

Total Savings ***$1,599,426/yr***

Payback Time

Before Grant Funds
($7,187,000) ÷ ($1,599,426/yr) = 4.49 yr

After Grant Funds
($1,437,000) ÷ ($1,599,426/yr) = 0.90 yr

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PEER REVIEWED

This brochure has been reviewed by representatives of vehicle manufacturers, fuel providers, fleet operators, and federal and state governments.

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