

CASE STUDY

Alternative-Fuel Buses Earn High Marks from Antelope Valley Schools



Located about 70 miles northeast of Los Angeles, the Antelope Valley Schools Transportation Agency (AVSTA) operates a fleet of school buses and special-education vans that transport students in four school districts covering 1,700 square miles. As the engines of its aging diesel buses started up each morning, AVSTA accumulated fines of up to \$3,000 per day for violating strict California vehicle emissions regulations. In 1992, Ken McCoy, AVSTA's Chief Executive Officer, found a solution to this problem: alternative fuels.

Grants Cover the Costs of Replacing an Aging Fleet

AVSTA had no funds for replacing its diesel buses, some of which were 30 to 35 years old. As McCoy looked for solutions, he learned of the California Energy Commission's (CEC's) Clean School Bus Efficiency Demonstration Project. If AVSTA was willing to try alternative fuels, the CEC would purchase new buses for them. McCoy replied, "I'll take any kind of alternative fuel you can supply." Not only would the schools get new buses, but AVSTA would also be contributing to better air quality and helping to reduce the nation's dependence on imported oil.

Eventually, McCoy combined grants from CEC, the South Coast Air Quality Management District (AQMD), SoCal Gas, and others to build an alternative-fuel school bus fleet complete with on-site fueling stations. Antelope Valley students now ride compressed natural gas (CNG), methanol, and electric buses that comply with local air pollution laws. This alternative-fuel fleet also supports the City of Lancaster, California, in its efforts as a participant in the U.S. Department of Energy's Clean Cities Program.¹

¹ The Clean Cities Program is a voluntary, locally based government/industry partnership to expand the use of alternative fuels. For information, visit the Clean Cities web site at <http://www.cities.doe.gov>.



A Day in the Life of a School Bus Fleet

About 35,500 students attend the Antelope Valley schools. The three elementary districts hold classes year-round, and 75% of their students are in school at any given time. The high school district follows a traditional schedule. AVSTA's 157-vehicle fleet of 78-passenger school buses and special-education vans transports both elementary and high school students to and from school, sporting events, and field trips. The buses provide about 7,000 rides each day, and the special-education vans about 800 rides. Each school bus travels an average of 100 miles daily in two round trips starting from AVSTA's central depot, for a total of about 15,000 miles per year. The routes are about 60% rural, but the buses also drive on highways and city streets. Buses are assigned according to their operating costs: buses with the highest costs are usually given the shortest routes.

All drivers must be certified to drive school buses. They are also trained and judged on their proficiency in each type of fuel before they can drive the alternative-fuel buses. State-certified instructors provide the training. Drivers bid on the routes, depending on the number of hours they want to work. McCoy states: "Drivers have been really good about accepting the challenges of alternative-fuel buses. Each fuel has

different issues, each type of bus has its own idiosyncrasies, and each bus is unique. But our drivers will take a new alternative-fuel bus in a hot second!"

The buses return to the central depot at the end of the school day for fueling and maintenance. AVSTA has on-site diesel, CNG, and methanol fueling stations and an electric charging station. AVSTA's mechanics have been trained by the bus manufacturers, and they report maintenance and repair information back to those companies each week. McCoy considers in-house mechanics to be more cost-effective than hiring maintenance contractors: "Outside labor rates are \$53 an hour, my in-house mechanics cost me \$25 an hour. We also perform maintenance for outside agencies for additional revenue."

Compressed Natural Gas Buses

The CEC chose CNG as the first fuel to be tested, and AVSTA's first new buses arrived in 1992. These buses had a Tecogen 427 Chevrolet engine on a Blue Bird school bus chassis. Of the 16 buses delivered, four needed engine replacements. According to McCoy, the engines failed because of excessive heat generated by the turbo that provides sufficient horsepower for acceleration and gradability. McCoy claims this tendency to overheating reduces the longevity of the vehicle. He is now trying to replace these engines with 6.8-liter John Deere CNG engines.

The next group of CNG buses was built with a John Deere Power Tech 6081 8.1-liter 250-hp engine in a Blue Bird school bus chassis. This design was developed by Southwest Research Institute, in conjunction with Deere Power Systems Group, Blue Bird Corporation, and the CNG Cylinder Company, with support from the U.S. Department of Energy. According to McCoy, its fuel economy is better than that of the Tecogen engine because it is an electronic engine and specially designed for CNG.

He is pleased with its performance: “This unit represents the future of CNG in school bus transportation. We have operated this unit several thousand miles, and it is unbelievable in its operating economics and viability.”

The CNG buses undergo a weekly diagnostic check of all systems with a laptop computer, and regular CNG tank inspections are mandated by the state of California. Oil and filters are changed at 25,000-mile intervals on the Deere 8.1-liter-engine CNG buses. In contrast, the diesel buses undergo oil and filter changes every 6,000, 12,000, or 18,000 miles, depending on the type of engine installed.

SoCal Gas built both fast- and slow-fill CNG fueling stations at no charge to AVSTA. The slow-fill facility cost \$300,000 to construct, the fast-fill facility cost \$100,000. Because no other alternative-fuel stations exist within 30 miles, AVSTA’s fast-fill CNG fueling facility is also open to the public. About 25 outside customers take advantage of this opportunity, generating a small revenue for the schools.

Because leaks waste fuel and raise costs, McCoy uses a combustible gas detector that measures methane to ensure that there are no leaks in the in-house fueling equipment between the curb inlet from the pipeline and the bus fill nozzle.

Methanol Buses

AVSTA’s 16 methanol buses were built by Carpenter with Detroit 6V92 methanol-fueled engines. McCoy says: “These units have provided reasonable service, although injector life is limited to 20,000 miles and each injector costs about \$600. The overwhelming disadvantage with methanol is that the average cost per mile for fuel has been around 29-35 cents [over the

Fleet Facts

Fleet Type: Public school transportation

Fleet Size: 157 vehicles, of which 48 are alternative-fuel vehicles

Alternative Fuel: Methanol, compressed natural gas, and electricity

Vehicles: Purpose-built school buses

Mileage: 2,360,721 city, suburban, and rural miles per year

Location: Lancaster, California



last four years].” Performance and maintenance requirements are similar to those for diesel buses.

South Coast AQMD funded the methanol fueling station. Costs were low (\$52,680) because an existing diesel station was converted for methanol use. Pipes and hoses needed upgrading, but the rest of the equipment already met local requirements.

Electric Bus

The nation’s first purpose-built electric school bus went to work for AVSTA on

By the Numbers: Electric School Bus

Capacity:	72 passengers
Purchase Cost:	\$262,000 ^a
Charging Station:	\$15,000 ^a
Cost of Batteries:	\$20,000 per set ^a
Cost of Electricity:	\$0.045/kWh
Fuel Economy:	1.8 kW/h
Operating Cost:	\$2.07/mile ^b
Usage:	53-55 miles/day
Vehicle Range:	about 80 miles per charge

^a Covered by grants

^b Includes cost of regular preventive maintenance as well as cost of experiments with new technology, such as labor to exchange batteries for evaluation, analyze performance of components, and work with manufacturers.

September 6, 1994. Blue Bird Corporation built the 72-passenger vehicle with an electric drive train designed and furnished by Westinghouse.

McCoy needed to know that the prototype electric vehicle would be safe: would the lead-acid batteries endanger the students if the bus were involved in an accident? Representatives of the California Department of Education, the California Highway Patrol, and AVSTA met with Blue Bird and Westinghouse to discuss this concern. In a safety demonstration, an absorb-mat battery held after being cut in half with a chain saw; another battery was shot with a gun and no acid leaked. These tests allayed questions about the safety of the batteries.

Representatives from Westinghouse, Blue Bird, and A-Z Bus Sales, Blue Bird's California distributor, trained AVSTA drivers to operate the new vehicle. The way the driver operates the electric bus affects

its driving range. A major difference between diesel and electric buses is the braking procedure. On an electric bus, the driver must anticipate stops earlier to take full advantage of "regenerative" braking, which charges the battery as the bus coasts to a stop; the power brakes are used only at the very end of the braking cycle. Regenerative braking adds about 15-20% to the driving range of the bus.

An electric bus has no engine, transmission, radiator, or exhaust system to maintain. Checkout time is reduced because there are fewer systems to inspect, and there is no engine oil, oil filter, or antifreeze to replace. The electric motor is quiet, and there are no tailpipe emissions.

The bus holds 112 batteries in four packs. It takes about 6 to 7 hours to charge the batteries, and the bus can drive about 80 miles on one charge. Because of this limited range, the electric bus is assigned to shorter routes.

The bus acts as a test bed for new battery technology. GNB, a battery manufacturer, has supplied four different sets of absorb-mat lead-acid batteries at no cost to AVSTA. The GNB batteries can be charged only about 100 times, however, so they need to be replaced often, at a price of \$20,000 per set. McCoy is now evaluating Ovonic nickel-metal hydride batteries.

AVSTA funded the electric bus, the batteries, and the charging equipment through grants. However, McCoy believes the electric bus is not yet an economical choice for schools. He says: "It was my hope that battery technology would advance rapidly enough to eliminate the need to go through a hybrid stage of development. It seems to me at this point, however, that a hybrid fueled by CNG will be the interim answer. I'm not giving up on electric - what's one more challenge when we have a great future?"

Cost Comparisons

The full purchase cost of AVSTA's alternative-fuel buses was covered by grants. Because these buses are part of an alternative-fuel demonstration project, McCoy keeps close tabs on their operating costs. On the basis of his experience so far, McCoy says: "I'm going to run whatever does the job for me. But if I were choosing fuel, it would be CNG only, based on bottom line."

Community Acceptance

McCoy had no difficulties in introducing his alternative-fuel buses to the community. He has encountered no resistance or concerns regarding the safety of the buses from the school board, parents, or students. He used press releases to build interest in the vehicles before they arrived. Local residents are aware of alternative fuels and air quality issues, and they enthusiastically accepted the new buses. McCoy states: "The electric bus is the most effective in attracting attention to alternative fuels – everyone is wondering why that bus is not making any noise! The others look and sound like any other bus."

The students look forward to riding the alternative-fuel buses, too. McCoy says they appreciate the quieter engines and the reduced emissions. They especially like the electric bus: "If it's not on the route, they want to know why." He opines: "Our future in clean air will be pursued primarily by the generation of children riding on these types of units."

Recommendations

Because he was willing to take a chance on new technologies and by aggressively seeking out funding, Ken McCoy was able to rebuild AVSTA's aging fleet with

Purchase Cost Comparison

Type of Bus	Purchase Cost (\$)
Advanced diesel	89,638
CNG (Deere)	101,100
CNG (Tecogen)	127,226
Electric	260,482
Methanol	151,758

AVSTA's 1996-1997 School Year Vehicle Operating Costs

Type of Vehicle	No. of Vehicles	Fuel Cost per Mile	Maintenance Cost per Mile	Total Cost per Mile
Advanced diesel bus	8	0.16	0.21	0.37
CNG (Tecogen) bus	15	0.29	0.37	0.66
CNG (John Deere) bus	16	0.13	0.13	0.26
Diesel control bus	5	0.14	0.24	0.38
Electric bus	1	0.09	1.98 ^a	2.07
Methanol bus	16	0.29	0.34	0.63
Misc. diesel vehicles	40	0.15	0.32	0.47
Special-ed. diesel van	56	0.16	0.27	0.43

^a Electric bus maintenance costs include cost of regular preventive maintenance as well as cost of experiments with new technology, such as labor to exchange batteries for evaluation, analyze performance of components, and work with manufacturers.

alternative-fuel buses at no cost to the four school districts he serves. Despite difficulties caused by the inherent quirks of prototypes, McCoy is enthusiastic about his new buses: "I love them – I love the challenge! Just show me something that works!" He promotes the use of alternative fuels to anyone who will listen: "I received all this for nothing. My commitment is to tell everyone who wants to know." McCoy offers this advice to those considering alternative-fuel vehicles for their fleets: "Go to a fleet manager who is operating what you're looking at and ask him for his bottom-line numbers. Listen to no vendors until you have talked to their end customers – and talk to many fleet managers."



For further information, contact:

Kenneth R. McCoy
 Chief Executive Officer
 Antelope Valley School
 Transportation Agency
 670 West Avenue, L-8
 Lancaster, CA 93534
 Phone: 805/945-3621
 Fax: 805/949-7393

Antelope Valley Schools Transportation Grant History

Date	Award	Agency	Total Grant (\$)
02/12/93	Methanol Buses	CEC	2,428,100
	CNG Buses	CEC	2,035,600
	Advanced Diesel Buses	CEC	717,100
05/30/93	Methanol Fueling Facility	South Coast AQMD	52,700
06/30/93	CNG Slow-Fill Facility	SoCal Gas	300,000
06/30/94	CNG Fast-Fill Facility	SoCal Gas	100,000
	Methanol/CNG Fuel Grant	CEC	20,000
07/27/94	Electric Bus	South Coast AQMD	260,500
09/01/94	EPTI Pulse Charger	SoCal Edison	20,000
03/29/95	John Deere Conversion	BlueBird/John Deere	55,000
04/21/95	Battery Charger	Enerpro	8,000
05/05/95	CNG Buses	CEC	1,213,200
	Electric Bus	CEC	293,800
06/01/95	Charge Facility	South Coast AQMD/ Lancaster City	30,000
08/01/97	Tecogen to 6.8 Deere Conversion	Southwest Research Institute	30,000
08/01/97	Transit & Spec.-Ed. Buses	Calif. Dept. of Ed.	814,200
Total			\$8,378,200



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

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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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