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Economic Analysis of Alternative Fuel School Buses

FINAL REPORT

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Introduction

School buses represent a vital link in the transportation of school children in the United States. As such, reliable school bus operation requires a significant number of buses to ensure that all children will be able to get to and from school safely and efficiently. It is possible for alternative fuels to play a role in ensuring the safe and reliable transportation of the nation's school children, especially if global events interrupt petroleum supplies.

This report is intended to give the reader a general idea of the potential economic impacts of choosing alternative fuels for a school bus fleet, with a focus on the three main alternative fuels that are commonly used in school bus fleets today (natural gas, propane, and biodiesel). The intent of this report is not to substitute for a thorough economic analysis specific to a given fleet that might be interested in alternative fuels, but to give general trends in terms of overall costs and benefits.

School Bus Types

School buses are grouped into bus types, depending on the number of passengers carried and the chassis type and size. There are four basic school bus types in use in the United States.

Type A buses: These are small cutaway-van type buses designed to carry 10 or more passengers. These buses retain the driver's door from the cutaway van chassis, and are based on light-duty van chassis.

Type B buses: These are buses based on cutaway-van chassis or stripped chassis. These are similar to Type A buses, but somewhat larger.

Type C buses: These buses use medium-duty flat-back cowl truck chassis, with the engine in front of the windshield and the entrance door behind the front wheels. These are sometimes referred to as "conventional" school buses.

Type D buses: These buses use medium-duty truck chassis with front, mid, or rear engine locations, with the engine behind the windshield and beside the driver's seat (for front-engine buses) or with the engine behind the rear wheels (for rear-engine buses). The entrance door is ahead of the front wheels. These are similar in appearance to transit buses.

Type B school buses are relatively uncommon among school district users, and since they are of the same general size as Type A buses, they are commonly grouped with Type A buses. For this reason, this report will not analyze Type B school buses separately.

Natural Gas Analysis

Natural gas school buses are frequently chosen by school systems wishing to use alternative fuels, as the original equipment manufacturer products in school buses are chiefly natural gas products. In general, natural gas is less expensive on an energy equivalent basis than conventional fuels. Due to the cleaner-burning nature of natural gas relative to conventional petroleum fuels, natural gas vehicles are also likely to have longer oil change intervals. However, due to their low production and specialized fuel tanks, vehicles continue to be more expensive than conventional fuel buses. Specialized fueling infrastructure is also required for natural gas vehicles, which can be an added expense unless the fleet finds opportunities to use existing refueling infrastructure or to share costs of new refueling station construction with other fleets in the area.

An additional consideration is the need for garage facility modifications. Because natural gas is lighter than air, it can rise quickly to the ceiling of a facility in the event of a leak, potentially concentrating into a flammable mixture. For this reason, some facility modifications are needed, including removal of open flame heaters and other ignition sources, installation of methane detectors, and installation of ventilation equipment that can quickly exchange air inside the garage should a release of gas occur. Costs of these modifications will depend on the individual fleet situation.

To give the reader an idea of the potential costs and benefits of natural gas school buses, cost calculations of an average new natural gas bus will be provided below for a range of fuel cost differentials, incremental prices, and average miles traveled per year.

Type A natural gas school buses cost roughly $9,000 more than an equivalent diesel school buses, while Type C and D buses average about $35,000 more than an equivalent diesel bus (based on research performed for MY 2003 alternative fuel buses from OEM sources-Reference 1). For these calculations, the incremental prices in Table 1 will be used: these prices offer a range of incremental costs to show how the payback is affected by initial incremental cost.

Table 1. Estimated Incremental Cost of Natural Gas School Buses

	Low	Mid	High
Type A	$8,000	$9,000	$10,000
Type C	$30,000	$35,000	$40,000
Type D	$30,000	$35,000	$40,000

Based on information from *School Bus Fleet* magazine (Reference 2) and the *Transportation Energy Data Book* (Reference 3), the average school bus travels about 9,000 miles per year. For these calculations, the range of miles traveled will be varied from a low of 8,000 miles to a high of 10,000 miles per year.

Another factor to take into consideration in an economic analysis of natural gas school buses is that natural gas engines (being spark-ignition engines) are somewhat less fuel efficient than compression ignition diesel engines. Based on information available for diesel and natural gas school buses (Reference 4), Type A, C and D natural gas buses will be assumed to have about 75% of the fuel economy of diesel buses. An outline of the assumed fuel economies is illustrated in Table 2 below.

Table 2. Estimated Fuel Economy for CNG and Diesel Buses

	Type A	Type C	Type D
Diesel MPG	13.3	6.6	6.6
CNG MPG	10.0	5.0	5.0

Based on average nationwide diesel prices taken from the December 2002 *Alternative Fuel Price Report* from DOE (Reference 5), a baseline fuel cost for diesel was assumed to be $1.50 per gallon. Natural gas prices were varied to yield savings of between 15 cents and 75 cents per gallon relative to diesel fuel, to illustrate the range of potential cost savings that might be available across the nation (based on the *Alternative Fuel Price Report* information from December 2002). Fuel prices are listed in Table 3.

Table 3. Estimated Fuel Prices for CNG and Diesel

	Case 1	Case 2	Case 3	Case 4	Case 5
Diesel Price	$1.50	$1.50	$1.50	$1.50	$1.50
Cost Difference	$0.15	$0.35	$0.55	$0.65	$0.75
CNG Price	$1.35	$1.15	$0.95	$0.85	$0.75

Some documentation on natural gas vehicles indicates that longer oil change intervals can be adopted for CNG vehicles. As maintenance schedules and procedures vary from fleet to fleet, cost savings for longer oil change intervals will not be considered here, other than to note that it is possible to extend these maintenance intervals.

One gauge of the economics of an alternative fuel program is the so-called "simple payback." Simple payback is calculated by taking the total incremental cost of the vehicle and dividing that cost by the annual fuel cost savings to yield the number of years required to pay back the initial investment. Results of the simple payback analysis using the above listed parameters are illustrated in Table 4 for CNG vehicles excluding any incentives. As this table shows, in these cases a school bus operator would not see cost savings for Type C or Type D vehicles at low fuel cost differentials, due to the difference in efficiency between CNG and diesel vehicles, especially at low average annual mileage. Type A buses and Type C/D buses would offer fuel cost savings at the higher fuel cost differentials, but these savings would be insufficient to repay the incremental cost of the vehicle before it is turned over (remember that the average school bus is kept roughly 12 years).

Table 4. Simple Payback of Natural Gas School Buses Without Other Incentives (Years)

	Case 1	Case 2	Case 3	Case 4	Case 5
Low Incremental Price					
Type A					
Miles: Low	-	-	57.0	36.3	26.6
Miles: Mid	-	-	50.7	32.2	23.6
Miles: High	-	-	45.6	29.0	21.3
Type C					
Miles: Low	-	-	100.6	65.5	48.5
Miles: Mid	-	-	89.4	58.2	43.1
Miles: High	-	-	80.5	52.4	38.8
Type D					
Miles: Low	-	-	100.6	65.5	48.5
Miles: Mid	-	-	89.4	58.2	43.1
Miles: High	-	-	80.5	52.4	38.8
Mid Incremental Price					
Type A					
Miles: Low	-	-	64.1	40.8	29.9
Miles: Mid	-	-	57.0	36.3	26.6
Miles: High	-	-	51.3	32.6	23.9
Type C					
Miles: Low	-	-	117.4	76.4	56.6
Miles: Mid	-	-	104.3	67.9	50.3
Miles: High	-	-	93.9	61.1	45.3
Type D					
Miles: Low	-	-	117.4	76.4	56.6
Miles: Mid	-	-	104.3	67.9	50.3
Miles: High	-	-	93.9	61.1	45.3
High Incremental Price					
Type A					
Miles: Low	-	-	71.3	45.3	33.3
Miles: Mid	-	-	63.3	40.3	29.6
Miles: High	-	-	57.0	36.3	26.6
Type C					
Miles: Low	-	-	134.1	87.3	64.7
Miles: Mid	-	-	119.2	77.6	57.5
Miles: High	-	-	107.3	69.8	51.8
Type D					
Miles: Low	-	-	134.1	87.3	64.7
Miles: Mid	-	-	119.2	77.6	57.5
Miles: High	-	-	107.3	69.8	51.8

However, there are proposals currently being discussed in Congress to provide incentives for alternative fuel vehicles of all types that would include an incentive for 50% of the incremental vehicle cost and a 50 cent per gasoline gallon equivalent of alternative fuels. If these proposals should become law, the results for how the school bus paybacks would be affected are illustrated in Table 5 below.

Table 5. Simple Payback of Natural Gas School Buses With Fuel and Incremental Cost Incentives (Years)

	Case 1	Case 2	Case 3	Case 4	Case 5
Low Incremental Price					
Type A					
Miles: Low	18.1	10.5	7.4	6.4	5.7
Miles: Mid	16.1	9.3	6.6	5.7	5.1
Miles: High	14.5	8.4	5.9	5.1	4.6
Type C					
Miles: Low	32.7	19.3	13.7	11.9	10.6
Miles: Mid	29.1	17.1	12.1	10.6	9.4
Miles: High	26.2	15.4	10.9	9.5	8.5
Type D					
Miles: Low	32.7	19.3	13.7	11.9	10.6
Miles: Mid	29.1	17.1	12.1	10.6	9.4
Miles: High	26.2	15.4	10.9	9.5	8.5
Mid Incremental Price					
Type A					
Miles: Low	20.4	11.8	8.3	7.2	6.4
Miles: Mid	18.1	10.5	7.4	6.4	5.7
Miles: High	16.3	9.5	6.7	5.8	5.1
Type C					
Miles: Low	38.2	22.5	15.9	13.9	12.3
Miles: Mid	34.0	20.0	14.2	12.4	11.0
Miles: High	30.6	18.0	12.7	11.1	9.9
Type D					
Miles: Low	38.2	22.5	15.9	13.9	12.3
Miles: Mid	34.0	20.0	14.2	12.4	11.0
Miles: High	30.6	18.0	12.7	11.1	9.9
High Incremental Price					
Type A					
Miles: Low	22.7	13.1	9.2	8.0	7.1
Miles: Mid	20.2	11.7	8.2	7.2	6.3
Miles: High	18.1	10.5	7.4	6.4	5.7
Type C					
Miles: Low	43.7	25.7	18.2	15.9	14.1
Miles: Mid	38.8	22.8	16.2	14.1	12.5
Miles: High	34.9	20.6	14.6	12.7	11.3
Type D					
Miles: Low	43.7	25.7	18.2	15.9	14.1
Miles: Mid	38.8	22.8	16.2	14.1	12.5
Miles: High	34.9	20.6	14.6	12.7	11.3

As Table 5 shows, these incentives make a significant difference in the economic case for school bus alternative fuel use: these incentives can produce payback times in some cases of less than 10 years for the largest school buses. Paybacks for the smaller buses can be as little as 4.6 years.

Another alternative for school districts to consider is the use of grants and other funding sources to cover part or all of the incremental cost of the vehicle. The Department of Energy periodically offers grant funding for the incremental cost of alternative fuel vehicles. Additionally, some states offer their own incremental funding for AFVs. If a school system can cover all of the incremental cost of the alternative fuel vehicle through grant funding, then the savings from lowered fuel costs can accrue to the school system immediately. Depending on the fuel cost differential, bus type, and annual mileage, fleets could see annual savings of between $140 and $770 per year (excluding any fuel cost incentives) or $200 and $1700 (with a 50 cent per GGE fuel cost incentive).

These paybacks do not include the cost of construction of new refueling infrastructure, which could cost $250,000 or more per station (depending on the station capabilities and fleet needs). Federal and state grant funding is available to offset much of the cost of constructing new refueling infrastructure. In some cases, sharing of refueling infrastructure can also be considered to reduce the cost of refueling for the fleets. Some school districts have made arrangements to acquire free or very low cost surplus refueling equipment from their local utility to reduce costs even further.

Propane Analysis

Propane school buses are popular in some areas of the country, especially in areas where propane vehicle refueling infrastructure is readily available. There are currently no OEM propane school bus products available, so fleets wanting propane school buses will need to consult conversion companies for these vehicles. As with natural gas, propane can be less expensive on an energy basis than conventional fuels, and oil change intervals for propane vehicles can be lengthened relative to conventional vehicles as well. As with natural gas, propane infrastructure is an additional cost that fleets need to consider, although propane refueling stations typically cost less than natural gas refueling stations.

Because of their less expensive fuel tanks, propane vehicles can be less expensive than natural gas vehicles (Reference 6). Table 6 illustrates the range of representative vehicle incremental costs used in this analysis.

Table 6. Estimated Incremental Cost of Propane School Buses

	Low	Mid	High
Type A	$7,000	$8,000	$9,000
Type C	$20,000	$25,000	$30,000
Type D	$20,000	$25,000	$30,000

Although the vehicles tend to be less expensive, the fuel price differentials between diesel and propane tend to be less than for natural gas as well (based on the *Alternative Fuel Price Report*). Table 7 illustrates the range of fuel prices used in this analysis. Table 8 illustrates the estimated fuel economy numbers for propane and diesel buses used in this analysis.

Table 7. Estimated Fuel Prices for Propane and Diesel

	Case 1	Case 2	Case 3	Case 4	Case 5
Diesel Cost	$1.50	$1.50	$1.50	$1.50	$1.50
Cost Difference	$0.15	$0.25	$0.35	$0.45	$0.55
LPG Price	$1.35	$1.25	$1.15	$1.05	$0.95

Table 8. Estimated Fuel Economy for Propane and Diesel Buses

	Type A	Type C	Type D
Diesel MPG	13.3	6.6	6.6
LPG MPG	10.0	5.0	5.0

Results of the simple payback analysis using the above listed parameters are illustrated in Table 9. As this table shows, in the absence of incentives, a school bus operator would not see cost savings for Type A, Type C or Type D vehicles at low fuel cost differences, due to the difference in efficiency between propane and diesel vehicles, especially at low average annual mileage. Type A buses and Type C/D buses would offer fuel cost savings at the higher fuel cost differentials, but these savings would be insufficient to repay the incremental cost of the vehicle before the 12-year turnover period.

Table 9. Simple Payback of Propane School Buses Without Other Incentives (Years)

	Case 1	Case 2	Case 3	Case 4	Case 5
Low Incremental Price					
Type A					
Miles: Low	-	-	-	116.4	49.9
Miles: Mid	-	-	-	103.4	44.3
Miles: High	-	-	-	93.1	39.9
Type C					
Miles: Low	-	-	-	144.7	67.1
Miles: Mid	-	-	-	128.7	59.6
Miles: High	-	-	-	115.8	53.7
Type D					
Miles: Low	-	-	-	144.7	67.1
Miles: Mid	-	-	-	128.7	59.6
Miles: High	-	-	-	115.8	53.7
Mid Incremental Price					
Type A					
Miles: Low	-	-	-	133.0	57.0
Miles: Mid	-	-	-	118.2	50.7
Miles: High	-	-	-	106.4	45.6
Type C					
Miles: Low	-	-	-	180.9	83.8
Miles: Mid	-	-	-	160.8	74.5
Miles: High	-	-	-	144.7	67.1
Type D					
Miles: Low	-	-	-	180.9	83.8
Miles: Mid	-	-	-	160.8	74.5
Miles: High	-	-	-	144.7	67.1
High Incremental Price					
Type A					
Miles: Low	-	-	-	149.6	64.1
Miles: Mid	-	-	-	133.0	57.0
Miles: High	-	-	-	119.7	51.3
Type C					
Miles: Low	-	-	-	217.1	100.6
Miles: Mid	-	-	-	193.0	89.4
Miles: High	-	-	-	173.7	80.5
Type D					
Miles: Low	-	-	-	217.1	100.6
Miles: Mid	-	-	-	193.0	89.4
Miles: High	-	-	-	173.7	80.5

However, the proposals currently being discussed in Congress for alternative fuel incentives would apply to propane as well. If these proposals should become law, the results for school bus paybacks are illustrated in Table 10 below.

Table 10. Simple Payback of Propane School Buses With Fuel and Incremental Cost Incentives (Years)

	Case 1	Case 2	Case 3	Case 4	Case 5
Low Incremental Price					
Type A					
Miles: Low	15.9	11.6	9.2	7.6	6.5
Miles: Mid	14.1	10.3	8.2	6.7	5.7
Miles: High	12.7	9.3	7.4	6.1	5.2
Type C					
Miles: Low	21.8	16.2	12.9	10.7	9.1
Miles: Mid	19.4	14.4	11.4	9.5	8.1
Miles: High	17.5	12.9	10.3	8.5	7.3
Type D					
Miles: Low	21.8	16.2	12.9	10.7	9.1
Miles: Mid	19.4	14.4	11.4	9.5	8.1
Miles: High	17.5	12.9	10.3	8.5	7.3
Mid Incremental Price					
Type A					
Miles: Low	18.1	13.3	10.5	8.7	7.4
Miles: Mid	16.1	11.8	9.3	7.7	6.6
Miles: High	14.5	10.6	8.4	6.9	5.9
Type C					
Miles: Low	27.3	20.2	16.1	13.3	11.4
Miles: Mid	24.3	18.0	14.3	11.8	10.1
Miles: High	21.8	16.2	12.9	10.7	9.1
Type D					
Miles: Low	27.3	20.2	16.1	13.3	11.4
Miles: Mid	24.3	18.0	14.3	11.8	10.1
Miles: High	21.8	16.2	12.9	10.7	9.1
High Incremental Price					
Type A					
Miles: Low	20.4	15.0	11.8	9.8	8.3
Miles: Mid	18.1	13.3	10.5	8.7	7.4
Miles: High	16.3	12.0	9.5	7.8	6.7
Type C					
Miles: Low	32.7	24.3	19.3	16.0	13.7
Miles: Mid	29.1	21.6	17.1	14.2	12.1
Miles: High	26.2	19.4	15.4	12.8	10.9
Type D					
Miles: Low	32.7	24.3	19.3	16.0	13.7
Miles: Mid	29.1	21.6	17.1	14.2	12.1
Miles: High	26.2	19.4	15.4	12.8	10.9

As Table 10 shows, these incentives make a significant difference in the economic case for school bus alternative fuel use: these incentives can produce payback times of less than 10 years for the largest school buses. Paybacks for smaller buses can be as low as 5.2 years.

Grant funding can apply to propane vehicles as well. If a school system can cover all of the incremental cost of the alternative fuel vehicle with grant funding, then the savings from fuel cost differentials can immediately accrue to the school system. Depending on the fuel cost differential, bus type, and annual mileage, fleets could see annual savings of between $60 and $370 per year (excluding any fuel cost incentives) or $200 and $1300 (with a 50 cent per GGE fuel cost incentive).

Biodiesel Analysis

Biodiesel is becoming a more attractive option for many fleets to introduce alternative fuels into their operations with lower cost impacts than other alternative fuels. Biodiesel is typically used in a blend of 20% biodiesel with 80% conventional diesel fuel. Biodiesel is typically more expensive than conventional diesel fuel per gallon. However, no vehicle modifications or specialized refueling stations are required for dispensing biodiesel (although due to its solvent properties, some additional maintenance on filters and dispensers will be needed as the biodiesel clears any sediments from tanks). Biodiesel does not require any garage modifications for safety compliance.

On average, biodiesel in a 20% blend with regular diesel costs about 20 cents more than regular diesel fuel (Reference 7). For a Type D bus traveling 9,000 miles per year at 6.6 miles per gallon (using a total of 1,364 gallons of fuel per year), a year's worth of biodiesel use will have an additional cost of $270 per year. This will be the only significant incremental cost for biodiesel use in the average biodiesel program. In some states, incentives and/or grants for biodiesel fuel are available to reduce this incremental cost.

Summary

Natural gas and propane offer fuel cost savings relative to conventional fuels, but also include incremental vehicle costs. In some cases (depending on vehicle type, vehicle and fuel cost incentives and average annual fleet mileage), the cost of natural gas school buses can be repaid in as little as 4.6 years (for natural gas) or 5.2 years (for propane) for small buses. For larger buses, simple payback for natural gas and propane buses is about 9-10 years, depending on incentives available. If grant funding is obtained to cover all of the incremental cost of the alternative fuel vehicles, cost savings accrue to the fleets immediately.

Biodiesel fuel is more expensive than conventional diesel (and thus offers no fuel cost savings), but requires no incremental vehicle investments and little or no infrastructure investment. This makes this option attractive for many school bus fleets that are seeking to enter the alternative fuel market.

In some cases, decreased frequency of oil changes can increase the cost savings of the alternative fuel vehicle relative to conventional vehicles. These savings will depend on the maintenance schedules of the individual fleet and preferences of the fleet maintenance manager.

For natural gas and propane, arrangements for refueling will need to be made. These additional costs can be reduced by arranging for shared infrastructure or through arranging for lower-cost refueling infrastructure through a local utility or other source. To take advantage of infrastructure grants to defray part of the modifications or installation costs, fleets must apply for these monies through the appropriate channels.

Remember that, because individual conditions can vary so significantly from fleet to fleet, infrastructure and garage facility modifications have not been included as part of the vehicle cost savings scenarios.

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