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Analysis of U.S. School Bus Populations and Alternative Fuel Potential

FINAL REPORT

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U.S. Department of Energy
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Table of Contents

Introduction.....	1
School Bus Types.....	1
School Bus Populations.....	1
School Bus Miles and Fuel Use	2
School Bus Emissions.....	3
Alternative Fuel School Buses	3
Potential for Alternative Fuel School Bus Use through 2010	3
Scenario 1: AFV Products in Type A and D buses	5
Scenario 2: AFV Products in Type A, C and D buses (CNG only)	6
Scenario 3: AFV Products in Type A, C and D buses (CNG and LPG).....	6
Biodiesel Use in School Buses.....	7
Summary	8
References.....	9
APPENDIX A: School Bus Populations By State	10
APPENDIX B: Alternative Fuel School Bus Populations By State.....	12

Introduction

School buses represent a vital link in the transportation of school children in the United States. Reliable school bus operation requires a significant number of buses to ensure that all children will be able to get to and from school properly. Alternative fuels can 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 provide general information concerning the size of the school bus market in the U.S., as well as to provide some quantification of the potential for alternative fuel use in school buses in the U.S., and what that might mean for petroleum displacement and emissions reductions (given reasonable scenarios for implementation of these buses).

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.



Over the past decade, Type A/B bus sales averaged about 20% of total school bus sales, while Type C buses represent about 57% of the sales, and Type D sales were the remaining 23%.

School Bus Populations

A number of sources are available for determining the number of school buses in the United States. One of the most useful is *School Bus Fleet* magazine, a publication dedicated to covering issues of concern to the school bus industry. They offer an annual *School Bus Fleet Fact*

Book, in which they summarize key indicators of the school bus industry, including school bus fleet sales and bus populations.

Illustrated in Table 1 below are the school bus populations as reported by *School Bus Fleet* Magazine (reference 1) for 1995 through 2000. These buses transported almost 23.5 million students per year. Note that the average school bus population has risen about 7 percent between 1995 and 2000.

Table 1. School Bus Populations

	District-Owned ^a	Contractor Owned ^a	Total
95-96	283,823	121,996	428,665
96-97	259,044	114,407	429,086
97-98	246,240	132,395	441,559
98-99	271,118	132,378	448,307
99-00	261,368	123,529	458,229

^a District and Contractor does not add to Total due to breakdowns not being known for some states.

In Table 1, the term “district-owned” refers to buses that are owned by the school district (or the government entity responsible for providing bus transportation). The term “contractor-owned” refers to buses that are owned by a third party who is under contract to provide school bus transportation to the school system for a fee. Districts that own their own buses have historically been more interested in using alternative fuels than contractors, based on the experience of many who have undertaken alternative fuel projects. Note that in Table 1, district-owned buses represent about two-thirds of the total bus population.

Table 1 presents the aggregate information for the U.S. For more information on how bus populations vary by state, Appendix A illustrates the

number of district-owned and contractor-owned school buses by state for the 1999-2000 school year.

School Bus Fleet does not outline the population of school buses by bus type (i.e. Type A, B, C, or D) in its information. However, they do offer school bus sales by bus type for the last decade, which can be used to estimate the population breakdown by type. Based on the total sales over the last ten years, Type A/B buses represent 20% of the population, Type C buses are 57% of the population, and Type D buses are the remaining 23%.

School Bus Miles and Fuel Use

Information on total miles traveled and fuel use for school buses is not as easily available as information on bus populations. Specific information on miles traveled and fuel used for buses by fuel type is unavailable (based on research of the major sources of information on vehicle information of this type.) For this reason, the remainder of this document will estimate miles traveled and fuel used on an aggregate basis for the entire school bus fleet.

The best available information on school bus mileage and fuel use is presented below. Table 2 illustrates the use parameters for these school buses in terms of miles traveled per year and total fuel use. Total bus mileage was obtained from *School Bus Fleet* magazine publications: total fuel use is not explicitly tracked by *School Bus Fleet*, so fuel use information was obtained from the Oak Ridge National Laboratory publication *Transportation Energy Data Book* (reference 2). Note that total mileage traveled per year has not increased significantly between 1996 and

2000, and total fuel use has remained steady as well. Average fuel use over this period is about 550 million gallons, and average miles per year is just under 4 billion. This implies an average fuel economy for the total school bus fleet of about 7 miles per gallon (including all bus types).

Table 2. School Bus Miles and Fuel Use

	Bus Population	Miles Traveled (billions)	Fuel Use (million gallons)
95-96	428,665	4.1	545
96-97	429,086	4.3	545
97-98	441,559	3.2	550
98-99	448,307	3.7	556
99-00	458,229	4.1	556

School Bus Emissions

In 2002, the Union of Concerned Scientists conducted an analysis of the nation’s school bus transportation in terms of its emissions impact. The report, titled *Pollution Report Card*, (reference 3) indicated that the nation’s fleet of school buses releases a total of 95,000 tons of NOx and NMHC, 213,000 tons of CO, 3,100 tons of PM, and 10.7 million tons of GHGs each year. This averages out to about 400 pounds of NOx/NMHCs, 900 pounds of CO, 14 pounds of PM, and 23 tons of GHGs per bus per year. (The PM total seems small by weight due to the very small size and weight of the particulate matter emitted relative to the weight of other pollutants.)

Alternative Fuel School Buses

Estimates of alternative fuel school bus populations vary somewhat from source to source. There are between 2,700 and 3,900 alternative fuel school buses in use

(references 4 and 3 respectively) in over 130 school districts in 21 states around the country, with the lower figure being a DOE number. For the purposes of this report, the alternative fuel bus population figure from DOE will be used.

These alternative fuel buses are displacing 4 to 5 million gallons of petroleum fuel each year. Because of the availability of alternative fuel, the states of Texas and California have the majority of the alternative fuel school buses in use (about two-thirds of the total). Most alternative fuel buses in use currently are either natural gas or propane, although interest in biodiesel is increasing in some areas of the country.

Potential for Alternative Fuel School Bus Use through 2010

Although the number of alternative fuel school buses currently represents about 0.6% of the total school bus population, the U.S. Department of Energy’s Clean Cities Program has placed an emphasis on school buses as an important niche market, and the Clean Cities Program is working with manufacturers to develop new products. DOE is also working with many of the eighty Clean Cities Coalitions across the country to develop more interest in alternative fuel school buses.

In terms of school bus sales for the Type A/B market, General Motors and Ford are the key players supplying these vehicles, and they command most of the market. For Type C buses, International represents 60% of the market, with GM and Thomas/Freightliner representing the remainder. In the Type D market, International products make up 60% of the sales, with Blue Bird and Thomas products making up the remaining 40%.

Some efforts have already been made to estimate the potential alternative fuel school bus sales in the U.S. that might result from increased interest in alternative fuels for energy independence and emissions/health concerns. One analysis provided to the DOE Clean Cities Program (reference 5) examined the potential sales of alternative fuel school buses through 2010. This report looked at two potential scenarios for alternative fuel school bus sales.

In Scenario 1, it was assumed that natural gas vehicles would achieve a market penetration of 25% in both the Type A market and the Type D market. In the Type A market, Ford commands about 40% of the market, and they are currently offering a natural gas product (which was assumed in Reference 5 to continue in production through 2010)¹. Therefore, natural gas buses in the Type A market would be 10% of total sales (25% of 40%)². In the Type D market, Thomas and Blue Bird command about 40% of the market, and both offer natural gas products. Availability of these products was assumed in this scenario to continue through 2010. Therefore, Type D natural gas school bus sales would be 10% of total Type D sales (25% of 40%).

Scenario 2 assumes the same Type A and Type D market penetration for natural gas vehicles as Scenario 1, but also assumes that Type C natural gas vehicle

¹ Reference 5 scenarios were developed prior to Ford's announcement of the discontinuation of their gaseous fuel AFVs, which includes the natural gas school bus chassis. General Motors offers a similar cutaway chassis in a natural gas version, but it has not been certified for school bus use at the time of this writing.

² Although at this writing Ford is not planning on continuing its natural gas Type A bus, for the purposes of this calculation we will assume that sufficient demand would exist so that 10% of the market for Type A buses would still be natural gas powered, to show a general boundary on the potential for alternative fuel buses.

product will be made available starting in 2005, reaching 25% of the portion of the market for these buses not built by International. (As mentioned above, International products are 60% of the total Type C market, resulting in a total Type C market penetration of 10%). Most of the Type C alternative fuel products placed into service to date are conversions, and no Type C natural gas school buses are currently being offered by OEM manufacturers. The Department of Energy is working with some manufacturers to develop Type C buses in natural gas and propane versions: Scenario 2 assumes that these efforts will meet with some success.

These two scenarios only considered natural gas school buses, since there are currently no propane OEM school bus products available (with the withdrawal of GM propane chassis from the market). Because of the efforts of DOE and Clean Cities, it is possible that propane OEM school bus products could be reintroduced to the Type C school bus market. If this happens, it is likely that these propane buses would be quite popular with many alternative fuel bus buyers, especially in Texas.

Scenario 3 assumes that Type C natural gas product will be made available in 2005, and Type C propane product will also be made available in 2005. Similar to Scenario 2, these Type C alternative fuel products reach 25% of the portion of the market for these buses not built by International. However, in Scenario 3, half of these alternative fuel buses would be CNG and half would be propane.

Other key assumptions in the analysis include no increase in the total school bus population through 2010. This assumption is made based on current

school system budget constraints and downturns in the economy, which make it likely that many school bus fleets will not be able to expand their fleets in the near future. The analyses also assume that the turnover rate for school buses is about 12 years.

Also note that because information on breakdowns of miles traveled and fuel used by school buses by size type is unavailable, the analyses below will be based on overall average miles traveled and fuel used on a fleet basis. Since school systems are likely to use new buses (like the alternative fuel buses assumed to be purchased) more than older buses, and since Type C and D buses use slightly more fuel per vehicle than the overall fleet average, this assumption will likely understate the total fuel displacement and emissions benefits somewhat.

Emissions benefits are calculated using emissions factors for diesel school buses from the Union of Concerned Scientists report. These factors are combined with information on criteria pollutant emission reductions from EPA emission certification data for typical diesel and natural gas school bus engines and information on greenhouse gas emission reductions from the GREET 1.5a model (reference 6).

Scenario 1: AFV Products in Type A and D buses

As outlined above, Scenario 1 assumes that 10% of the Type A/B market and 10% of the Type D market would be natural gas buses through 2010. The results of the scenario are illustrated in Figure 1 and outlined below.

Alternative Fuel Bus Sales and Population: Approximately 1,900 alternative fuel

school buses would be sold per year by 2010 in this scenario. Given the 12-year turnover rate and the existing alternative fuel bus population (assumed to be about 2,700 vehicles), this means that the population of alternative fuel school buses will rise to about 17,100 vehicles by 2010.

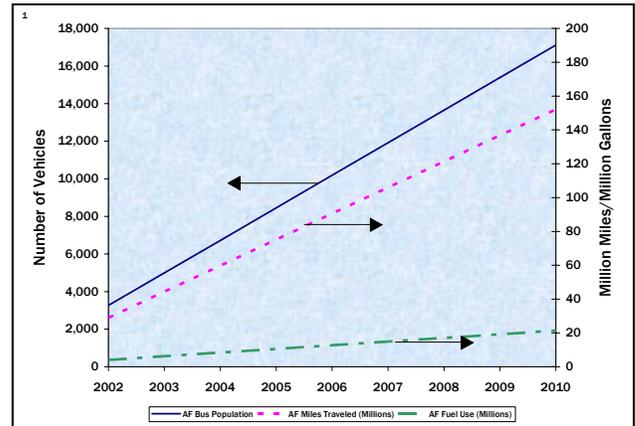


Figure 1. AFV Population and Fuel Use for Scenario 1

Alternative Fuel Vehicle Travel and Fuel Use: These alternative fuel buses would travel about 152 million miles per year and displace about 21 million gallons of petroleum fuel per year by 2010, assuming similar use patterns to conventional buses.

AFVs as Percent of Bus Population: This population represents about 3.6 percent of the total school bus population in 2010, and represents a 3.6 percent displacement of petroleum fuel in school buses by 2010.

AFV Bus Fuel Use Relative to Total Transportation Fuel Use: Given the projected petroleum use in transportation in 2010 of 113 billion gallons per year by the DOE Energy Information Administration (reference 7), this alternative fuel use would represent about a 0.02 percent reduction in total petroleum demand by 2010.

Emissions Benefits from AFVs: Based on the emission factors established by UCS, this scenario would result in an estimated reduction in emissions from school buses of roughly 850 metric tons per year of NOx and NMHCs, 350 metric tons per year of CO, 25 metric tons per year of PM, and 5,700 metric tons per year of GHGs.

Scenario 2: AFV Products in Type A, C and D buses (CNG only)

As outlined above, Scenario 2 assumes that 10% of the Type A/B market, 10% of the Type C market, and 10% of the Type D market would be natural gas buses through 2010. The results of the second scenario are illustrated in Figure 2 and outlined below.

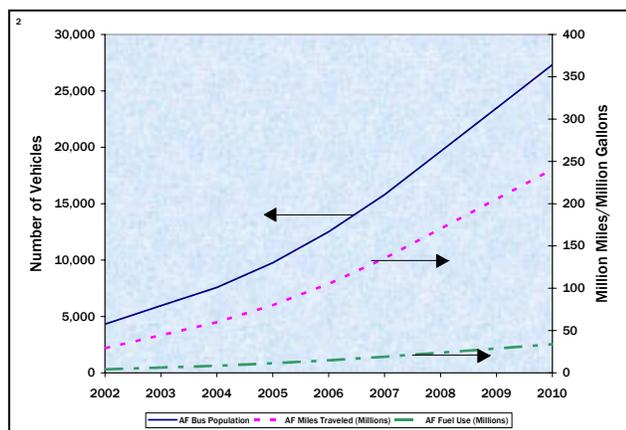


Figure 2. AFV Population and Fuel Use for Scenario 2

Alternative Fuel Bus Sales and Population: Approximately 4,100 alternative fuel school buses would be sold per year by 2010 in this scenario (which adds a total of 2,200 Type C alternative fuel bus sales to the total by 2010). Given the 12-year turnover rate and the existing alternative fuel bus population (assumed to be about 2,700 vehicles), this means that the population of alternative fuel school buses will rise to about 27,300 vehicles by 2010.

Alternative Fuel Vehicle Travel and Fuel Use: These alternative fuel buses would travel about 240 million miles per year and displace about 34 million gallons of petroleum fuel per year by 2010, assuming similar use patterns to conventional buses.

AFVs as Percent of Bus Population: This population represents about 5.7 percent of the total school bus population in 2010, and represents a 5.7 percent displacement of petroleum fuel in school buses by 2010.

AFV Bus Fuel Use Relative to Total Transportation Fuel Use: Given the projected petroleum use in transportation of 113 billion gallons per year by the DOE Energy Information Administration, this alternative fuel use would represent about a 0.03 percent reduction in total petroleum demand by 2010.

Emissions Benefits from AFVs: Based on the emission factors established by UCS, this scenario would result in an estimated reduction in emissions from school buses of roughly 1,400 metric tons per year of NOx and NMHCs, 580 metric tons per year of CO, 43 metric tons per year of PM, and 11,000 metric tons per year of GHGs.

Scenario 3: AFV Products in Type A, C and D buses (CNG and LPG)

As outlined above, Scenario 3 assumes that 10% of the Type A/B market, 5% of the Type C market, and 10% of the Type D market would be natural gas buses through 2010. Also, 5% of the Type C market would be propane buses through 2010. The results of the second scenario are illustrated in Figure 3 and outlined below.

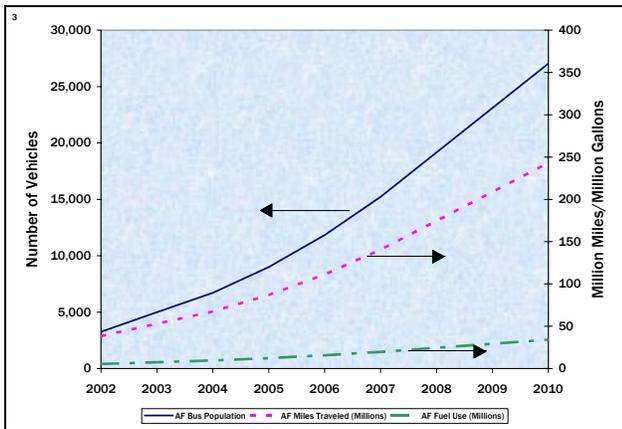


Figure 3. AFV Population and Fuel Use for Scenario 3

Alternative Fuel Bus Sales and Population: Approximately 4,100 alternative fuel school buses would be sold per year by 2010 in this scenario (which adds a total of 1,100 Type C CNG bus sales and 1,100 Type C LPG bus sales by 2010). Given the 12-year turnover rate and the existing alternative fuel bus population (assumed to be about 2,700 vehicles), this means that the population of alternative fuel school buses will rise to about 27,300 vehicles by 2010.

Alternative Fuel Vehicle Travel and Fuel Use: These alternative fuel buses would travel about 240 million miles per year and displace about 34 million gallons of petroleum fuel per year by 2010, assuming similar use patterns to conventional buses.

AFVs as Percent of Bus Population: This population represents about 5.7 percent of the total school bus population in 2010, and represents a 5.7 percent displacement of petroleum fuel in school buses by 2010.

AFV Bus Fuel Use Relative to Total Transportation Fuel Use: Given the projected petroleum use in transportation of 113 billion gallons per year by the DOE Energy Information Administration, this alternative fuel use

would represent about a 0.03 percent reduction in total petroleum demand by 2010.

Emissions Benefits from AFVs: Based on the emission factors established by UCS, this scenario would result in an estimated reduction in emissions from school buses of roughly 1,500 metric tons per year of NOx and NMHCs, 600 metric tons per year of CO, 44 metric tons per year of PM, and 19,000 metric tons per year of GHGs.

Biodiesel Use in School Buses

Biodiesel use is becoming more prevalent in school bus fleets across the U.S., because of its potential for use in existing diesel vehicles with little or no modifications (if used in blends of 20% biodiesel or less) with minimal infrastructure investments. Biodiesel use in school buses could be limited by several factors; relative cost of biodiesel versus conventional diesel; local supply of biodiesel fuel for a given fleet; and overall supply of biodiesel fuel for the entire U.S.

If biodiesel use in U.S. school bus fleets reaches 10% of non-alternative fuel buses (a similar market penetration as natural gas buses are assumed to make in the two scenarios above), and biodiesel is used at blends of 20%, then this could add about 12 million gallons of alternative fuel use to Scenario 1, bringing the total alternative fuel percentage of school bus fuel use to 5.5% (up from 3.6%). Similar biodiesel usage could add about 12 million gallons of alternative fuel use to Scenario 2, bringing the total alternative fuel percentage of school bus fuel use to 7.5% (up from 5.7%). Similar biodiesel usage could add about 12 million gallons of alternative fuel use to Scenario 3,

bringing the total alternative fuel percentage of school bus fuel use to 7.5% (up from 5.7%).

Biodiesel offers some potential for emission reductions as well. Adding the biodiesel component to Scenario 1 would result in total emission reductions (including biodiesel use and natural gas use) of 840 metric tons per year of NOx and NMHCs, 550 metric tons per year of CO, 38 metric tons per year of PM, and 123,000 metric tons per year of GHGs in 2010. This represents an increase in NOx and NMHC emissions of about 10 metric tons per year, but reductions of 200 metric tons of CO, 13 metric tons of PM, and 117,000 tons of GHGs.

Adding the biodiesel component to Scenario 2 would result in total emission reductions of 1,400 metric tons per year of NOx and NMHCs, 800 metric tons per year of CO, 56 metric tons per year of PM, and 125,000 metric tons per year of GHGs in 2010. This represents an increase in NOx and NMHC emissions of about 10 metric tons per year, but reductions of 200 metric tons of CO, 13 metric tons of PM, and 115,000 tons of GHGs.

Adding the biodiesel component to Scenario 3 would result in total emission reductions of 1,500 metric tons per year of NOx and NMHCs, 800 metric tons per year of CO, 57 metric tons per year of PM, and 134,000 metric tons per year of GHGs in 2010. This represents an increase in NOx and NMHC emissions of about 10 metric tons per year, but reductions of 200 metric tons of CO, 13 metric tons of PM, and 115,000 tons of GHGs.

Summary

The school bus population in the U.S. consists of about 460,000 vehicles, carrying 23.5 million students per year, and traveling about 4 billion miles per year and using about 550 million gallons of fuel per year.

There are currently about 2,700 alternative fuel school buses in service in 130 school districts throughout the U.S., using about 4 million gallons of alternative fuel yearly. A summary of the petroleum displacement results of this analysis are illustrated in Table 3 below. Table 4 below illustrates the emissions benefit potential of alternative fuel buses as determined by this analysis. Table 5 illustrates the additional benefits that could be achieved through use of biodiesel in a 20% blend in non-AFV buses.

Table 3. Petroleum Displacement in Million Gallons

Scenario	Baseline Petroleum Displacement in 2010	Potential Additional Displacement from B20	Total Petroleum Displacement in 2010
Scenario 1	21	12	33
Scenario 2	34	12	46
Scenario 3	34	12	46

Table 4. Emissions Reductions in Metric Tons (AFVs only)

Scenario	NOx + NMHC	CO	PM	GHGs
Scenario 1	850	350	25	5,700
Scenario 2	1,400	580	43	11,000
Scenario 3	1,500	600	44	19,000

Table 5. Emissions Reductions in Metric Tons (AFVs plus biodiesel)

Scenario	NOx + NMHC	CO	PM	GHGs
Scenario 1	840	550	38	123,000
Scenario 2	1,400	780	56	126,000
Scenario 3	1,500	800	57	134,000

References

1. School Bus Fleet Magazine website, <http://www.schoolbusfleet.com>.
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7. *Annual Energy Outlook 2002*, U.S. Department of Energy Energy Information Administration, Washington, DC, 2001.

APPENDIX A: School Bus Populations By State
 From *School Bus Fleet Magazine 2001 Fact Book*

State	District-Owned Buses	Contractor-Owned Buses	Total Buses Owned
Alabama	7,757	278	8,035
Alaska	135	723	858
Arizona	6,526	270	6,796
Arkansas	6,066	200	6,266
California	15,942	9,375	25,317
Colorado	-	-	5,900
Connecticut	552	5,584	6,136
Delaware	482	1,078	1,560
Florida	18,909	1,383	20,292
Georgia	15,263	80	15,434
Hawaii	7	788	795
Idaho	1,951	658	2,609
Illinois	9,000	9,000	18,000
Indiana	9,280	2,708	11,988
Iowa	-	-	7,109
Kansas	4,363	1,456	5,819
Kentucky	9,268	201	9,469
Louisiana	4,950	3,248	8,198
Maine	2,066	602	2,668
Maryland	3,433	2,961	6,394
Massachusetts	1,681	6,519	8,200
Michigan	14,369	1,416	15,785
Minnesota	4,257	6,351	10,608
Mississippi	5,566	81	5,646
Missouri	6,803	4,387	11,190
Montana	1,222	938	2,168
Nebraska	2,027	435	2,462
Nevada	1,830	0	1,830
New Hampshire	445	1,861	2,306
New Jersey	-	-	19,000
New Mexico	822	2,178	3,000
New York	22,497	23,000	45,497
North Carolina	13,062	42	13,104
North Dakota	1,107	362	1,469
Ohio	16,539	834	17,373
Oklahoma	7,452	110	7,552
Oregon	4,095	2,028	6,123

State	District-Owned Buses	Contractor-Owned Buses	Total Buses Owned
Pennsylvania	5,889	20,286	26,175
Rhode Island	335	1,356	1,691
South Carolina	5,007	35	5,042
South Dakota	1,076	575	1,651
Tennessee	-	-	7,859
Texas	-	-	33,376
Utah	2,008	40	2,048
Vermont	545	630	1,175
Virginia	11,809	-	11,809
Washington	7,529	1,272	8,801
West Virginia	3,691	0	3,691
Wisconsin	2,000	8,200	10,200
Wyoming	1,755	0	1,755
Totals	261,368	123,529	458,229

APPENDIX B: Alternative Fuel School Bus Populations By State

Source: *Pollution Report Card: Grading America's School Bus Fleets*, Union of Concerned Scientists, 2002.

State	Approximate Number of Alternative Fuel Buses	State	Approximate Number of Alternative Fuel Buses
Alaska	2	North Carolina	14
Arizona	223	North Dakota	6
California	624	Oklahoma	240
Colorado	10	Oregon	362
Connecticut	9	Pennsylvania	130
Florida	5	Texas	2,000
Georgia	2	Utah	20
Indiana	141	Washington	8
Massachusetts	4	West Virginia	9
Nevada	7	Wisconsin	63
New York	39	TOTAL	3,918

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- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as vital new "energy carriers."

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Distributed Energy Program

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