A Feasibility Study of Natural Gas Vehicle Conversion In Wyoming Public School Districts

Presented to:
Governor Matt Mead and the
Wyoming State Legislature

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Executive Summary

The expansion of natural gas vehicle (NGV) usage holds the promise of reducing carbon emissions, lessening dependence on foreign oil, and lowering transportation costs. Viability of natural gas as a transportation fuel has grown partly because the availability of shale gas resources has dramatically expanded and gasoline and diesel prices have spiked. NGVs are also appealing because the high-pressured fuel system is sealed, so little evaporative emission occurs during fueling and use. Currently, compressed natural gas (CNG) is competitively priced with gasoline or diesel. The price of a diesel gallon equivalent (DGE) of CNG has become increasingly lower than the price of a gallon of diesel. Although the market price of natural gas was fairly volatile in the previous decade, it is expected to stabilize at a level highly competitive with diesel. It now appears the price of natural gas has decoupled from the price of oil and has therefore not been as volatile as gasoline and diesel prices.

Despite the favorable attributes of natural gas vehicles, CNG school buses face significant obstacles in capturing a major share of the market segment primarily due to the purchase price premium of about $30,000. Another barrier to the adoption of the NGVs is the lack of available fueling infrastructure. Currently, only five CNG stations in Wyoming allow public access (see Table 2 on page 11). Due to a lack of NGVs currently on the road, businesses are hesitant to actively invest in CNG infrastructure. As of 2012, Federal incentives for purchasing NGVs or constructing CNG stations have expired, and this includes the loss of the federal motor fuel excise tax credit CNG fuel previously received.

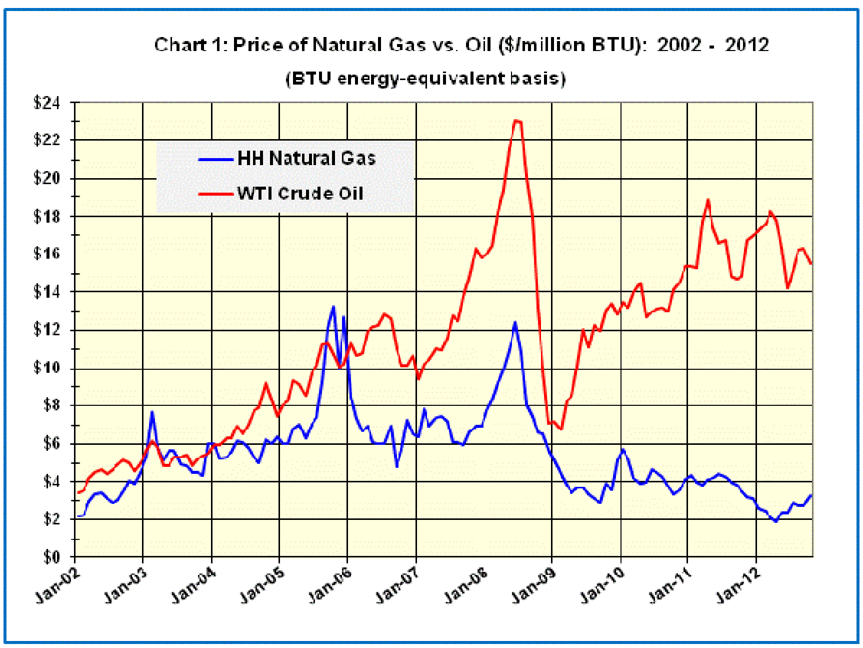
Because natural gas is generally less expensive than diesel (the difference currently is around $2.00 per DGE), the greater the number of miles a vehicle is driven, the more savings a fleet will experience compared to conventional fuels. The assumptions in the payback calculations included different alternatives in the price differential between CNG and diesel and varying average miles traveled scenarios. The results suggest under certain conditions the payback period (the number of years required to pay back the extra incremental cost of CNG powered school buses) is attractive. At the recent price differential of $2.00/DGE, paying back the incremental cost ($30,000) takes six years, assuming a school bus traveled 20,000 per year. In addition, due to the economy of scale, a large school district would be able to recoup the cost of a fueling station in about three years if all conventional and transit diesel-burning buses were replaced with CNG versions.

The option of converting an already owned diesel or gas fueled school bus by repowering (retrofitting) it with a new engine to run on CNG is, however, not feasible due to the high cost. This is particularly the case without tax incentives or grant funding to help absorb the high cost of converting existing school buses to run on CNG.

Introduction

Natural gas vehicles have been a part of global vehicle fleets for decades, with an estimated 15 million[1] on the road worldwide. Currently, the United States is considerably behind many countries in NGV usage. Pakistan, Iran, Argentina, Brazil, and India each have more than 1 million, with Pakistan operating more than 50 percent of its total vehicles on CNG. In the United States, 250 million vehicles are registered; 120,000 or .048 percent of those are NGVs. Across the nation, more than 140 school districts in 17 states are using more than 3,000 natural gas-powered school buses for their students' transportation every day. Some districts have been running CNG school buses for more than 20 years. For example, the Los Angeles School District began operating CNG buses in the late 1980s and currently operates 403 CNG school buses (the largest for a school district in the country), about one-quarter of its total fleet. Tulsa public schools converted 24 buses in 1988 to run on natural gas. In 2009, they repowered 140 school buses (half of their fleet) with CNG engines.

NGVs are clean and quiet, providing emission reduction and related environmental and health benefits, particularly when compared to older diesel buses. They use America's newly abundant supply of domestic natural gas. Natural gas is currently cheaper and more available domestically than petroleum products because of advancements in hydraulic fracturing and horizontal drilling techniques to extract shale gas. With diesel prices consistently above $3.00 per gallon, natural gas looks even more attractive. In addition, advances in natural gas engine and vehicle technology over the past decade have put them on par with gasoline and diesel counterparts in durability, performance, and reliability.



Despite the favorable attributes of NGVs, CNG school buses face significant obstacles to capturing a major share of market segment:

- The primary impediment is the incremental purchase price premium. With weak economic conditions, school district transportation budgets are often underfunded, resulting in deferred equipment replacement and extension of vehicle life. In cost-sensitive environments, extra initial costs are hard to justify unless lower life-cycle operating expenses offset them.

- The lack of refueling infrastructure is a major factor – the "chicken and egg" problem.
- There are also limitations imposed by cruising range and storage space on the buses to accommodate the CNG tanks.

Wyoming's Current State Reimbursement for Student Transportation

Wyoming remains the least populated U.S. state and covers a large geographic area. The population density of 5.8 persons per square mile is the second lowest in the nation; only Alaska is lower. Among the state's 48 public school districts, more than half have five schools or fewer. Wyoming Department of Education information shows 37,288 Wyoming students, or 42 percent of enrollment, were transported daily in the 2010-11 school year to 348 public schools. Daily miles driven by all school district fleets totaled nearly 80,000. Distances covered daily range from 120 miles in Platte County School District #1 to more than 10,000 miles in Campbell County School District #1.

School Bus Types

There are 1,731 vehicles for pupil transportation across all school districts. This total includes 177 Type A, 659 Type C, 628 Type D buses, and 269 multi-purpose vehicles (see explanations below for example of vehicle types).

Type A Bus – These small cutaway-van type buses are designed to carry about 20 passengers. They retain the driver's door and are based on a light-duty van chassis.

Type B Bus – These small buses are very similar to Type A, but transport about 30 passengers. Currently, Wyoming school districts do not carry such vehicles.

Type C Bus (Conventional) – These are based on a medium duty flat-back cowl truck chassis with the engine in front of the windshield and the entrance door behind the front wheels.

Type D Bus – This model uses medium-duty truck chassis with front, mid, or rear engine locations. The entrance door is in front of the front wheels.

School districts are eligible for 100 percent reimbursement for replacement costs from the State of Wyoming when bus age reaches 14 years or the mileage exceeds 200,000. The bus fleet nearly always reaches the mileage threshold first, and the replacement normally occurs at around 10 years. Statewide annual route miles for student transportation were 13.4 million miles during 2010-11. The total fleet vehicle miles traveled (VMT), including extracurricular activities and summer school, amount to nearly 20 million miles. The State paid a total transportation amount of $64.3 million in the 2010-11 school year: drivers' and mechanics' salary and benefits ($33.4 million), fuel ($7.8 million), and vehicle replacement, operations and maintenance ($23.0 million).

Manufacturers

Thomas Built Bus and Blue Bird Corp. both offer factory built Type D transit-style U.S. Environmental Protection Agency (EPA) 2010 compliant[2] CNG buses with multiple seating capacities and other options. Both types are equipped with Cummings Westport ISL-G model engines, which have been on the market since 2007. Certain existing diesel or gasoline-powered buses can be converted to run on CNG by repowering the engine. Emission Solutions Inc. (ESI) offers natural gas retrofitting services for Navistar DT400 engines (pre-model year 2009).

Bus Purchase Costs

School bus pricing is affected by a variety of factors such as user specific options, purchase quantities, dealer competition, and order timing. Despite the price increases for 2007- and 2010-compliant diesel engine buses (largely the result of complying with EPA emission guidelines), CNG school buses continued to be more expensive. With limited production and specialized fuel tanks, CNG buses are priced at approximately $150,000, roughly 25 percent more than their diesel counterparts' $120,000. For purposes of this report, the incremental cost of Type-D natural gas school buses is assumed to be $30,000 in calculating the payback period.

Fuel Economy

CNG fuel tanks are heavier than their diesel counterparts, adding about 2,500 pounds for a five-tank bus. Increased vehicle weight reduces fuel efficiency. This is important because fuel efficiency must be considered when comparing fuel costs. A diesel gallon equivalent is the amount of CNG required to equal the energy content – expressed as British Thermal Units or BTUs – of one gallon of diesel fuel. However, there are substantial variances in the manner and efficiency with which the different engines convert fuel energy potential. It is commonly acknowledged that a spark ignition natural gas engine is somewhat less fuel efficient (i.e. lower fuel economy) than a compression ignition diesel engine. Based on multiple publications and citations[3,4,5], this report assumes an average fuel economy of 7.0 miles per gallon (MPG) for diesel buses, and 6.0 miles per DGE for CNG buses. This equates to a 14.3 percent reduction in efficiency.

Diesel and CNG Fuel Costs

After experiencing a spike in the summer of 2008, natural gas prices have fallen and are currently at a 10-year low due to oversupply and lower demand (see Chart 1 on page 3). In contrast, the price of diesel has increased since January 2009. As a result, most areas of the country have experienced a significant price differential between CNG and diesel. CNG ($1.50-$2.00/DGE) is less expensive on a diesel gallon equivalent basis, ranging from 20 percent to 60 percent cheaper than diesel ($2.50-$4.00/gallon) in recent years. Data indicates that CNG price fluctuations are less than that of diesel. CNG prices are less sensitive to the change of natural gas prices than diesel is to changes in oil prices. Oil prices were at their highest in 2008 and diesel was $4.75/gallon. During this same time period, CNG was approximately $2.00/DGE cheaper despite spot prices of natural gas being extremely high, $11.00-$13.00/thousand cubic feet (mcf). Currently, the differential is higher than $2.00/gallon because natural gas prices at Henry Hub are around $3.50/mcf and the CNG price per DGE in some areas of the state is below $1.50.

The recent fuel price gap is expected to remain in the future, chiefly due to greater accessibility and technological advances in exploring shale gas keeping natural gas prices stable at relatively low levels. The price of oil and therefore diesel fuel continue on an upward trend. However, gas industry officials and others expect natural gas prices to stabilize in the $3.00-$5.00/mcf level. That compares to the West Texas Intermediate futures price of more than $85.00 per barrel. Demand for oil from emerging markets continues to increase. So, future costs of natural gas versus diesel as fuels will be prime drivers of market purchase decisions.

Fuel cost considerations go beyond the cost of the fuel itself. How individual school districts purchase their fuel and how they fuel their vehicles may also affect a conversion decision. Final delivered fuel costs will vary based on many factors, including ownership of the fueling facility (contracted versus owned-and-operated), bulk versus individual purchasing agreements, and contract versus market prices. For purposes of this report, only a final fuel cost differential was used in the analysis. The payback calculations assumed four price differential scenarios between CNG and diesel: $1.00, $1.50, $2.00, and $2.50 per gallon.

Operation and Maintenance Costs

Directly and accurately comparing maintenance costs of new school buses operating on diesel and natural gas is difficult because of the short history of CNG vehicles. There are no consistent criteria for measurement. Key factors such as age of the school bus, technician experience, and driver habits vary widely. Based on limited studies and research on comparative operating costs, evidence supports both cost increases and cost decreases[4,5]. Within school districts during initial phases of NGV deployment, maintenance costs could be higher than for diesel fleets. Based on case study research, the cost to maintain fleets that already have years of experience and have optimized their NGV operation practices may be somewhat less. In this analysis, it is assumed operation and maintenance costs are equivalent.

Other Potential Costs

Because natural gas is lighter than air, indoor leaked methane can rise to the ceiling, creating an explosion hazard. Some facility modifications may be needed, including removing open flame heaters and other ignition sources and installing methane detectors and ventilation equipment. Costs of these modifications depend on the individual fleet situation.

While a diesel bus refuels in 5-6 minutes, a CNG bus may require 12 minutes to refuel at a fast-fill facility with good pump compression[3]. Typically, a diesel bus requires fueling once or twice per week, but a CNG bus may require refueling every day due to limited fuel capacity. Over time, the cost of labor associated with refueling may not be cost-neutral if not enough fueling facilities are available to eliminate lengthy transits and queuing.

Although these issues should be considered in any district's final decision process, for the analysis in this report the potential additional costs mentioned above are not included.

Miles per Year and Vehicle Lifetime

The American School Bus Council estimates the average vehicle miles traveled of a school bus is about 12,000 per year and fuel consumption is approximately 1,700 gallons of diesel. Because Wyoming is large and sparsely populated, many school districts cover large areas – some more than 3,000 square miles. Most fleets are considered suburban-route and rural-route fleets, travelling about 20,000 miles a year. For purposes of this analysis, the ranges of miles traveled vary from a low of 10,000 miles per year to a high of 25,000 miles per year.

Because natural gas combusts more cleanly than diesel, less associated engine wear occurs, including less fouling of injectors and valves. Natural gas's low carbon content translates into longer oil change intervals as well. Anecdotal information suggests a CNG engine is expected to have a longer life than a diesel engine, but it is not definitive. Furthermore, the current sole school bus CNG engine maker, Cummins Westport, makes no claims of life span differential. Therefore, no engine life factor is included in this analysis.

Simple Payback Periods

One common measure of the economics of an alternative fuel program is simple payback, which is calculated by dividing the total incremental cost of the vehicle by the annual fuel cost savings to yield the number of years required to pay back the initial investment. All costs and savings presented in this report are in current dollars, so discount rates or other interest rates are not considered here. Also, CNG fuel infrastructure (station) costs are NOT included in these calculations, but they are a major factor to consider in any fuel-switching decision.

Results of the simple payback analysis using the above listed assumptions are shown in Table 1 on page 9. Among the 16 different combinations, 12 have a payback period shorter than current model vehicle lifetime (14 years). If one assumes a district's fleet of daily run buses on a 10-year replacement cycle averaging 16,700 miles per year, the fuel cost differential between diesel fuel and CNG should be at least $1.30 per gallon/DGE to offset the higher cost ($30,000) of the CNG school bus and its lower fuel efficiency. A school bus operator would not see cost savings at low fuel cost differentials, especially at low annual mileage. The high-mileage bus fleet is most likely to generate cost savings, which would justify fuel switching. The more a bus is driven, the greater the cost savings from using natural gas. All other variables held equal, the higher the price differential, the shorter the payback period. Doubling the fuel price differential cuts the payback period by more than half. At the recent price differential of $2.00/gallon, assuming VMT of 20,000 a year, paying back the incremental cost would take six years.

Table 1 illustrates these annual savings and payback periods resulting from various alternatives in fuel price differential and vehicle miles traveled. ***The price of CNG is assumed to be at $1.50/DGE***. The formula for the calculation is as follows:

<u>Annual Savings ($)</u> = VMT/MPG*Price Differential – Additional Cost for a CNG Bus due to lower Fuel Efficiency.

<u>Payback in Years</u> = Incremental Cost/Annual Savings.

As an example, the specific calculation and result in Table 1 for a CNG bus travelling 20,000 miles per year with a fuel ***price differential of $2.00 per diesel gallon equivalent is***:

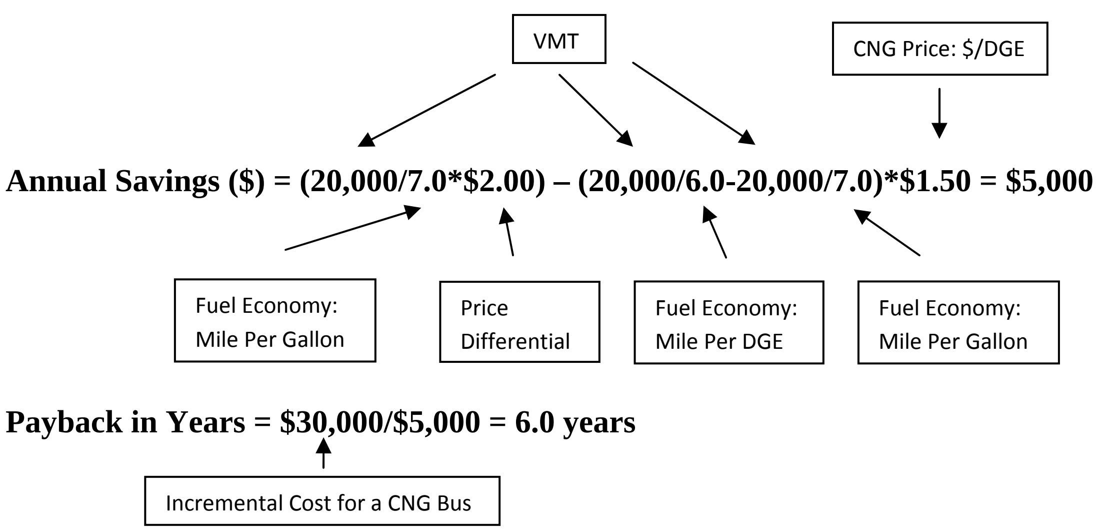


Table 1. Payback Periods for a Type D CNG School Bus with Incremental Cost of $30,000 (at $1.50/DGE of CNG)

Miles Per Year	Price Differential between a DGE of CNG and a Gallon of Diesel							
	$1.00		$1.50		$2.00		$2.50	
	Annual Savings	Payback in Years	Annual Savings	Payback in Years	Annual Savings	Payback in Years	Annual Savings	Payback in Years
10,000	$1,100	27.3	$1,800	16.7	$2,500	12.0	$3,200	9.4
15,000	$1,600	18.8	$2,700	11.1	$3,800	7.9	$4,800	6.3
20,000	$2,100	14.3	$3,600	8.3	$5,000	6.0	$6,400	4.7
25,000	$2,700	11.1	$4,500	6.7	$6,300	4.8	$8,000	3.8

Other Considerations for the Future Dynamics of CNG Vehicles

- New Vehicle Cost. Future new vehicle cost differentials may be lower if demand for NGVs increases, so economies of scale may take effect. In addition, stricter diesel emission standards may further raise prices of diesel buses or diesel fuels. Moreover, natural gas engine technologies are still less mature than diesel and gasoline counterparts. Better CNG engines may be developed.

- Efficiency. CNG vehicles are generally less efficient than diesel vehicles when compared on a DGE basis. Depending on the specific engines or vehicles, this drop in efficiency varied widely. An analysis of alternative fuel school buses in 2004 by the U.S. Department of Energy[6] assumed a fuel economy of 6.6 mpg for a diesel bus and 5.0 mpg for a CNG bus. Experiences from two California school districts indicated different fuel economies with higher efficiency for diesel buses in both cases[3,4]. An application engineer on the CNG bus engine ISL-G model believes the difference in fuel efficiency may exist depending on the quality (BTU content) of the natural gas used. The difference is quite small, around 10 percent. However, this drop in efficiency may be reduced somewhat as CNG technology improves and as diesel engines strive to comply with new emission standards.

- Vehicle Life. This analysis sets equal vehicle life between diesel and CNG buses. A change in vehicle life directly influences how much fuel is used, and therefore how much money is saved over the course of service. Extending a bus's life will increase savings as long as CNG enjoys a positive price differential with diesel, and as long as maintenance costs do not outweigh cost benefits of longer replacement periods.

- Staff Costs. This analysis assumes fleets will not encounter additional staff costs when switching to CNG operated buses. This may not be true in every scenario.

- Environmental Benefit. The State of Wyoming has made a significant investment in clean air technology in its school bus fleet. In compliance with EPA's 2007 and 2010 emission standards, modern diesel engine school buses are much cleaner than those built as recently as the 1990s. California Environmental Protection Agency claimed that the Navistar MaxxForce DT diesel engines have lower carbon monoxide and particulate matter (black exhaust soot) than the Cummins ISL-G natural gas powered engine. However, the 2010 compliant CNG buses release less nitrogen oxides (NOx) and less greenhouse gases than the newer diesel engines. In areas with pollution concerns, such as Sublette County, this could be another important consideration (see case study on Sublette County School District #1 at the end of the report).

- Cost of Retrofit. Without tax incentives or grant funding, repowering a diesel or gasoline school bus is probably impractical due to the high cost. Repowering is only for organizations seeking to save money by extending the life of an older existing diesel fleet. However, Wyoming's school buses are eligible to be replaced when their mileage reaches 200,000, and most are replaced within 10 years. Currently, Emission Solutions Inc. offers 2010 EPA compliant natural gas retrofitting options for IC Bus Corporation's Type C bus and Type D buses with Navistar's DT466 engine (pre-model year 2009). However, when Tulsa Public Schools in 2009 began converting more than 100 diesel-powered school buses to CNG, the process took approximately one year to complete and cost $51,500 per vehicle. That was much higher than the average incremental replacement cost of purchasing a new CNG bus at the end of a diesel bus's life.

- Electricity. Electricity to run compressors is the primary operation cost increase for CNG infrastructure. Commercial electricity clients often pay both an energy charge and a capacity charge for electricity. The capacity charge reflects how much electricity the utility needs to be prepared to produce, and it depends on the rate at which the CNG station draws electricity from the grid. This can be a major cost component for large compressor stations, such as CNG fast-fill operations.

- Potential Price Stabilizer. One of the main reasons for the dramatic decline of natural gas prices in the winter of 2011-12 was above-normal temperatures, which reduced demand in an already over-supplied natural gas market. Increased use of NGVs, particularly on a large scale nationwide, will benefit the economy by stimulating demand for domestic natural gas (Wyoming is the third largest natural gas producer in the country). As a result, increasing demand may help mitigate the price fluctuation due to weather. In the past few years, nearly all major truck and bus manufacturers in the United States have begun offering factory-built NGVs. For some of the most fuel-intensive fleets and vehicle applications, NGVs are already an economically viable choice. CNG powered about 40 percent of refuse trucks and 30 percent of transit buses sold in 2011. Certain CNG-powered light duty vehicles such as taxicabs and delivery vehicles also make economic sense. Large-scale NGV production and improved economies of scale could create additional demand for natural gas and balance the seasonality of demand, which is winter-heavy because natural gas is a major heating fuel.

Fueling Stations

As of July 2012, the United States had 1,090 CNG stations, with 510 offering access to the public. Almost every state has at least one station. However, nearly half of the stations are concentrated in just four states – California (237), New York (111), Utah (87), and Oklahoma (86).

As shown in the following table, five of the nine stations operating in Wyoming have public access. Seven stations are operated by Questar Gas Corporation, one by Encana Oil and Gas, and another by Cheyenne Light, Fuel & Power.

Table 2. Wyoming CNG Fueling Stations

Station Name	Street Address	City	Access	Fill Type*
Cheyenne Light, Fuel, & Power	1301 West 24th St.	Cheyenne	Public	Fast-fill
Encana – Pit Stop Travel Center	811 South Federal Blvd.	Riverton	Public	Fast-fill
Questar Gas – Evanston	38 Allegiance Circle	Evanston	Public	Fast-fill
Questar Gas – Rock Springs	1401 New Hampshire St.	Rock Springs	Public	Fast-fill
Questar Gas – Rock Springs	1640 Elk St.	Rock Springs	Public	Fast-fill
Questar Gas – Baggs Station	140 North Penland St.	Baggs	Private	Time-fill
Questar Gas – Hiawatha Station	1401 New Hampshire St.	Rock Springs	Private	Time-fill
Questar Gas – Lyman Station	233 North Main St.	Lyman	Private	Both
Questar Gas – Church Buttes Station	13 miles E of Lyman on I-80	Lyman	Private	Time-fill

*Time-fill and Fast-fill refer to the speed at which a natural gas vehicle is refueled. Fast-fill dispensers can perform a complete fill within several minutes. Time-fill dispensers require several hours, often overnight.

As of the writing of this report, one new station was brought on-line and another is planned.

Sublette County School District #1 (SCSD#1) has completed building a CNG station and purchased two CNG-powered school buses. A more extensive discussion of SCSD #1's experience with the CNG station and buses is found later in the report.

Chapter 27, Section 2, (b), (iii) of the 2012 Session Laws of Wyoming provides the Wyoming Department of Transportation with $1 million "for a compressed natural gas fueling station and conversion of existing vehicles or purchase of new vehicles for the department or the University of Wyoming in Laramie. The construction and operation shall be subject to oversight by the Department of Administration and Information. The station shall be available to the University, the Department of Transportation, school districts, local governments and private payers using credit cards and shall be located to enhance usage by the public and private sectors. No expenditure for a natural gas fueling station shall be made unless authorized by the governor after the Department of Transportation and the University explores the possibility of constructing and operating the station in conjunction with the private sector. After construction, the station may be sold at any time."

Research into the location and private/public operation and ownership status is ongoing. The timing of the station opening has yet to be determined. Other stations may be built by the private sector if the CNG industry continues to grow and can economically justify expanding refueling infrastructure.

Infrastructure Cost
CNG fueling station prices vary widely depending on location, specific fleet requirements, lot characteristics, and whether the station will be open to the public.

<u>On-site or Offsite:</u>
Existing public access fueling near a school district bus station either operated by a local gas company, a retail fuel provider, or even another public or private fleet makes the conversion decision easier. This option would require that existing equipment be capable of accommodating the additional load. Other factors to consider include the distance from the station to the central bus depot and to the bus routes. The cost of driver time spent traveling to and from an offsite fuel station needs to be analyzed. If using an existing fueling infrastructure is not practical or economical, the other option is building a new station on-site or nearby. If a station has both private and public access, the private section is commonly referred to as "behind-the-fence," and the public portion is referred to as "outside-the-fence."

<u>Fast-Fill versus Time-Fill:</u>
School districts with on-site fueling infrastructure may choose a fast-fill system, a time-fill system or a combination of both. Fast-fill CNG stations provide the convenience of fueling as quickly as with gasoline or diesel. The rate of dispensing and the total amount of available fuel depend on the pressure differential between a storage vessel and the vehicle's onboard storage cylinder, the number of vehicles fueling at one time from the same storage bank, and the control sequencing of the compressor. For school bus fleets that return to a central depot for extended periods (overnight or long mid-day breaks) a time-fill system may suffice. As its name indicates, the slower fueling time-fill system is considered more efficient and economical because it does not require as much compression capacity as a fast-fill system, nor does it require on-site CNG storage or special dispensers. The rate of fuel transfer ranges from one to six diesel gallon equivalent per hour for a time-fill station. The bus driver is not required to be present during fueling because the apparatus automatically shuts off when the fuel tank is full. The cost of a

time-fill station could be as much as 40 percent less than that of a fast-fill station[7]. However, the fast-fill system becomes a necessity if the station allows public access. Large school districts could incorporate the fast-fill system with a time-fill system to save on overall infrastructure cost.

Statewide, six large school districts have more than 50 type C and D buses each and 17 medium districts have between 20 and 50 buses each. The remaining districts have fewer than 20 buses. If it is assumed that each type of CNG station, based on fleet size, costs $1.5 million for a large station in a large school district, $1.0 million for a medium station in a medium district, and $0.5 million for a small station in a small school district, the total refueling infrastructure cost for all 48 school districts would be $36.5 million. This assumes the stations are the fast-fill type. According to the Wyoming Pipeline Authority, 12 small school district locations in the state currently have no natural gas pipeline support. In these districts, propane tanks would be necessary for the CNG station supplies.

Table 3. Cost for CNG Refueling Station

Station Type	**Capacity (SCFM)**	**GGE Equivalent**	**Estimated Cost**
Large Station	>1,000	12.0 GGE/MIN	$1,500,000
Medium Station	200-1,000	7.0 GGE/MIN	$1,000,000
Small Station	<200	3.0 GGE/MIN	$500,000

SCFM = Standard Cubic Feet per Minute GGE = Gasoline Gallon Equivalent

<u>CNG "Station in a Box":</u>

The "CNG in a Box" system is a collaboration between Chesapeake Energy Corporation affiliate Peake Fuel Solutions and GE to produce a high-volume CNG refueling station that offers a simpler self-contained design when compared to traditional CNG stations. The main feature is a "plug and play" fast-fill design that facilitates easier installation at minimal costs and hooks into an existing natural gas line. The estimated cost is around $650,000. The size of the container is 8 ft. x 20 ft. and requires 448 sq. ft. for installation. It includes a dual-hose dispenser and will distribute CNG at a rate of 7.5 gasoline gallon equivalents per minute. It is primarily designed for the retail fuel sales environment. This is a new development in the market and demonstrates interest by private industry in creating new products for the CNG industry.

Payback Periods with Consideration of Infrastructure Cost

Because natural gas is less expensive than diesel, the greater the number of miles a vehicle drives, the more savings a fleet will see compared to a conventional fuel. Because of economies of scale, a large school district with a bigger fleet essentially produces larger accumulated savings annually. For example, if Campbell County School District #1 or Laramie County School #1 switched all of their Type C and Type D diesel buses (more than 100 in each district) to CNG buses, recouping the cost of fueling stations would take about three years. This assumes a CNG station cost of $1.5 million and annual savings from operating a CNG bus of $4,500. In other words, the payback period for both the incremental cost for the buses and a new CNG station could be less than 10 years for a large school district if the current price differential prevails. On the other hand, it would take an additional 20 years to recoup the cost of a CNG station for many small school districts with fewer than 10 buses. Table 4 shows the results of a hypothetical situation where all Type C and D buses in Laramie County School #1 and Fremont County School District #2 were to be converted to run on natural gas. The cost of CNG fuel stations is considered in this example.

Table 4. Comparison of Savings and Payback Periods for a Large and a Small District

Comparison Item	**Laramie County #1**	**Fremont County #2**
Payback for the Incremental Cost of a Bus:		
Fuel Price Differential ($/DGE)	$2.00	$2.00
Incremental Cost for a CNG Bus	$30,000	$30,000
VMT (miles per year)	18,000	10,000
Annual Savings for a Bus	$4,500	$2,500
Payback in Years for a Bus	6.7	12.0
School Bus Life* (miles or year)	200,000	14
Net Fuel Savings After Payback for Incremental Cost	$20,000	$5,000
Total Savings Over Life of a CNG Bus	$50,000	$35,000
Payback for a CNG Station:		
Number of CNG Buses	105	6
Annual Savings for a District	$472,500	$15,000
Cost of a CNG Station	$1,500,000	$500,000
Payback in Years for the CNG Station	3.2	33.3

* School bus is eligible for replacement at 200,000 miles or 14 years.

CNG Bus and Fuel Station Case Study in Sublette County School District #1

Sublette County School District #1 (SCSD #1), located in Pinedale, has begun a CNG-powered school bus pilot project. By the beginning of the 2012-13 school year, the district had completed construction of a CNG fueling station and purchased two CNG-powered school buses, becoming the first Wyoming school district to do so. The station was designed to have both private behind-the-fence and public outside-the-fence access. Currently, the behind the fence portion is operating and refueling the CNG school buses. The district used recapture money to fund this project; that funding is not available to most districts.

According to the U.S. Environmental Protection Agency, Sublette County is on the Currently Designated Nonattainment Areas for All Criteria Pollutants list[8]. A nonattainment area is a locality where air pollution levels persistently exceed national ambient air quality standards or contributes to ambient air quality in a nearby area that fails to meet standards. Given the environmental concerns in the area, the district considered the air quality benefits of CNG powered vehicles in this decision.

Although the final price has yet to be determined, SCSD #1 estimates the total cost of the CNG station will be between $1.5 million and $1.8 million. The cost for installing the public fueling portion was about $200,000, representing between 11 percent and 13 percent of the total cost. The cost of this particular station was inflated because of the location's unique characteristics and extra features included in its construction, such as a natural gas-fired backup generator costing $300,000, and extra costs of infrastructure associated with providing the public access. The district included the natural gas-fired generator to ensure the station could be used in an electrical outage. Providing public access required infrastructure to be run 125 yards from the compressor to locate dispensers in a reasonably accessible area. Excluding these extra costs, the district estimates a comparable station could be built for less than $1 million. It is important to note the station was intentionally over-built from a capacity standpoint, anticipating increased future usage. Currently, the price charged to the public is expected to be around $1.75/gasoline gallon equivalent, or roughly the district's cost to provide the fuel.

The station has four refueling hoses (from two dispensers) with two outside-the-fence hoses and two behind-the-fence hoses. The station has fast-fill capacity only and the refueling time for the CNG buses is between eight and 10 minutes. This compares to a refueling time with their diesel buses of around six to eight minutes. Because buses are stored inside due to severe winter conditions in the Pinedale area, a time-fill system was not an option because of the prohibitive cost of retrofitting the existing bus garage to accommodate an enclosed time-fill system.

The two CNG buses purchased by the district are Type D Blue Bird vehicles. The incremental cost of the CNG upgrade was approximately $32,000 per bus. One bus runs an in-town route and the other runs an out-of-town route. The district plans to replace two buses per year with CNG buses. The ultimate goal is to have 14 of its 16 Type C and D buses running on CNG. The district wants to keep one or two diesel buses for longer trips when CNG refueling options may not be available. In addition, the district plans to convert and purchase CNG capable passenger, medium and heavy duty, and other non-bus vehicles as funds, replacement cycles, and infrastructure allow.

Although CNG school buses have operated for only about three months, the district provided some preliminary fuel cost data. The in-town bus runs 36 miles per day, or 179 miles per week. Given the CNG to diesel price differential of $2.00, the district estimates the CNG bus is saving around $48.00 per week in fuel costs. The out-of-town route bus travels 128 miles per day, or 638 miles per week. Given the same fuel differential assumptions, the district saves $154.00 per week on this route running CNG compared to diesel. The district estimates it will pay back the extra purchase cost of the buses in five to eight years, given a price differential between CNG and diesel of around $2.00. As the district continues to operate the CNG station and buses, it will track natural gas, utility and incidental costs.

Less quantitatively but perhaps as important from a policy perspective is the nonattainment status in Sublette County. It is important to note this CNG fueling station, the CNG school buses, and other CNG vehicles that will be able to refuel here may help to mitigate that problem. Getting the station built and making it readily available for multiple fleets to use may be a first step in addressing motor vehicle contribution to the nonattainment status.

SCSD #1 is enthusiastic about the prospect of CNG powered vehicles. As circumstances allow, the district plans to run as many vehicles as possible on CNG. The district's experience may provide valuable insight and information for other entities considering a similar conversion to CNG fueled vehicles. Although unique fiscal circumstances allowed the district to build the station, it can still be regarded as a model for other school districts to consider in future CNG fueling and NGV purchase or conversion plans.

REFERENCES

[1] NGV America. Natural Gas Vehicles for America is a national organization dedicated to the development of a growing, profitable, and sustainable market for vehicles powered by natural gas or biomethane. http://www.ngvc.org/about_ngv/index.html.

[2] U.S. Environmental Protection Agency, Emission Standards Reference Guide. http://www.epa.gov/otaq/standards/heavy-duty/hdci-exhaust.htm.

[3] CNG in Escambia School District Buses. April 2, 2012. Escambia County School District.

[4] Business Case for Compressed Natural Gas in Municipal Fleets. June 2010. National Renewable Energy Laboratory.

[5] Will Natural Gas Vehicles Be in Our Future? May 2011. RESOURCES FOR THE FUTURE.

[6] Economic Analysis of Alternative Fuel School Buses. April 2004. U.S. Department of Energy.

[7] Wyoming Natural Gas Vehicle Infrastructure Coalition. WNGVIC advocates incentives for natural gas vehicles in Wyoming.

[8] U.S. Environmental Protection Agency. Currently Designated Nonattainment Areas for All Criteria Pollutants. http://www.epa.gov/oaqps001/greenbk/ancl.html.

Opportunities for, Current Level of Investment in, and Barriers to the Expanded Usage of Natural Gas as a Fuel for Transportation. July 2012. Statement of NGA America.

Natural Gas School Buses - The Right Choice Right Now, and Options for Fueling School Buses & Other CNG Fleet Vehicles. 2010. Advertising Supplement.

An Evaluation of Criteria for Selecting Vehicles Fueled with Diesel or Compressed Natural Gas. 2009. Sustainability: Science, Practice, & Policy.

Economic Impact of Incentives to Facilitate Compressed Natural Gas Vehicles in Florida. August 2012. Florida Natural Gas Vehicle Coalition.

2011-2012 Investment Plan for the Alternative and Renewable Fuel and Vehicle Technology Program. February 2011. California Energy Commission.

Analysis of Vehicle, Fuel Station and Motor Excise Tax Incentives on School Bus Purchases and Operating Costs. May 2006. NGV America.

Alternative Fuels and Advanced Vehicles Data Center. U.S. Department of Energy – Energy Efficiency and Renewable Energy. http://www.afdc.energy.gov/.

Wyoming Department of Education. Fall 2011. Pupil Transportation Office.

Cummings Westport ISL-G Engine. http://www.cumminswestport.com/models/isl-g.

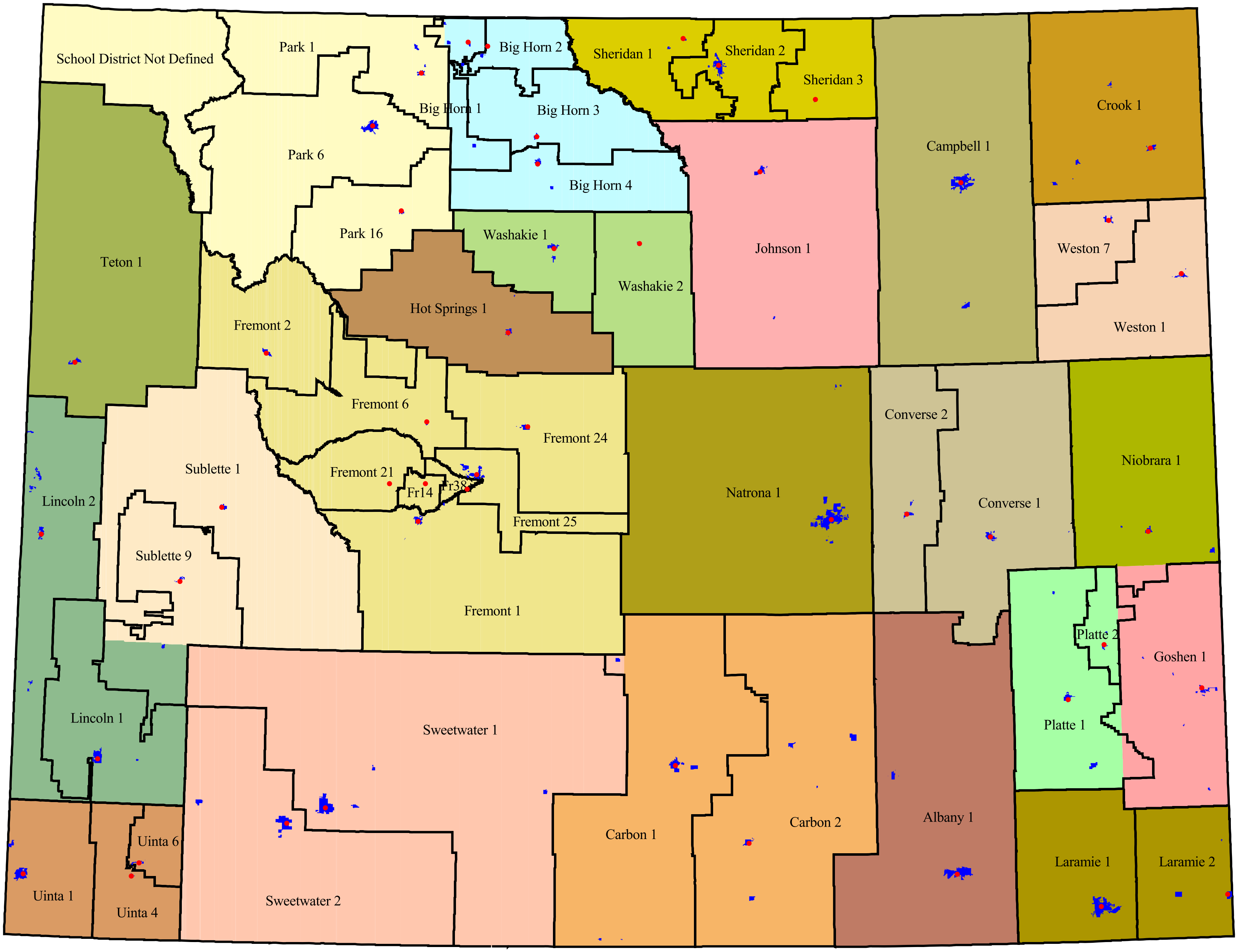
Appendix 1. Population, Enrollment, and Student Transportation

School District	Location	2010 Total Population	Land Area (square mile)	Persons Per Square Mile	Fall 2011 Enrollment	Number of Schools	Daily Miles	Student Transported
Wyoming	**Cheyenne**	**563,626**	**97,093.1**	**5.8**	**89,476**	**348**	**79,845**	**37,288**
Albany #1	Laramie	36,299	4,273.8	8.5	3,673	16	3,272	1,065
Big Horn #1	Cowley	3,085	450.3	6.9	808	6	1,103	231
Big Horn #2	Lovell	3,430	436.6	7.9	710	3	301	163
Big Horn #3	Greybull	3,029	1,160.0	2.6	490	3	553	226
Big Horn #4	Basin	2,244	1,123.0	2.0	322	4	762	171
Campbell #1	Gillette	46,133	4,802.7	9.6	8,337	20	10,113	4,138
Carbon #1	Rawlins	11,195	3,773.4	3.0	1,814	7	977	791
Carbon #2	Saratoga	4,796	4,158.6	1.2	640	7	1,378	217
Converse #1	Douglas	9,557	2,804.1	3.4	1,744	9	1,182	933
Converse #2	Glenrock	4,276	1,450.8	2.9	697	5	521	244
Crook #1	Sundance	7,083	2,854.4	2.5	1,093	6	2,582	643
Fremont #1	Lander	11,330	3,149.5	3.6	1,710	7	2,195	605
Fremont #2	Dubois	1,898	1,493.4	1.3	167	3	201	46
Fremont #6	Pavillion	2,198	1,292.4	1.7	372	3	880	248
Fremont #14	Ethete	2,344	125.6	18.7	568	3	885	399
Fremont #21	Ft. Washakie	2,190	699.8	3.1	494	3	535	311
Fremont #24	Shoshoni	1,545	1,749.2	0.9	332	3	802	229
Fremont #25	Riverton	16,987	590.4	28.8	2,588	6	1,080	800
Fremont #38	Arapahoe	1,631	83.7	19.5	389	2	681	300
Goshen #1	Torrington	13,164	2,068.2	6.4	1,778	11	2,404	635
Hot Springs #1	Thermopolis	4,812	2,004.1	2.4	659	3	543	303
Johnson #1	Buffalo	8,569	4,154.2	2.1	1,284	5	1,047	538
Laramie #1	Cheyenne	86,198	1,587.3	54.3	13,370	34	7,995	3,704
Laramie #2	Pine Bluffs	5,540	1,098.7	5.0	916	6	2,978	448
Lincoln #1	Diamondville	3,894	1,676.9	2.3	612	4	279	308
Lincoln #2	Afton	13,408	1,979.4	6.8	2,601	9	4,374	1,693
Natrona #1	Casper	75,450	5,340.4	14.1	12,075	35	7,430	3,918
Niobrara #1	Lusk	2,520	2,714.6	0.9	803	4	1,385	162
Park #1	Powell	11,915	1,458.9	8.2	1,655	7	1,011	398
Park #6	Cody	15,093	2,549.3	5.9	2,208	7	1,258	583
Park #16	Meeteetse	789	1,161.5	0.7	125	1	412	33
Platte #1	Wheatland	7,251	1,845.1	3.9	1,053	10	1,398	321
Platte #2	Guernsey	1,465	307.7	4.8	189	3	120	16
Sheridan #1	Ranchester	4,623	1,005.6	4.6	902	7	903	504
Sheridan #2	Sheridan	24,064	722.1	33.3	3,202	10	1,954	1,163
Sheridan #3	Clearmont	429	796.3	0.5	90	4	561	55
Sublette #1	Pinedale	6,932	3,690.3	1.9	1,043	4	1,192	349
Sublette #9	Big Piney	4,119	1,616.1	2.5	649	4	687	298
Sweetwater #1	Rock Springs	30,043	6,685.0	4.5	5,296	16	4,493	4,031
Sweetwater #2	Green River	13,657	3,707.2	3.7	2,641	11	1,605	1,163
Teton #1	Jackson	21,294	3,995.4	5.3	2,449	9	1,599	2,587
Uinta #1	Evanston	14,618	1,021.4	14.3	2,863	8	1,299	963
Uinta #4	Mountain View	3,252	729.7	4.5	788	4	525	379
Uinta #6	Lyman	3,248	330.2	9.8	750	3	392	324
Washakie #1	Worland	7,801	949.3	8.2	1,374	5	541	240
Washakie #2	Ten Sleep	732	1,289.2	0.6	104	1	259	58
Weston #1	Newcastle	5,687	1,618.5	3.5	806	4	646	281
Weston #7	Upton	1,521	779.6	2.0	243	3	552	73
District Not Defined	Mammoth	288	1,739.7	0.2	0	0	0	0

Appendix 2. Vehicle Type and Miles Traveled: 2011

School District	Type A Bus	Type C Bus	Type D Bus	MPV	Total	Route Miles	Activity Miles	Other Miles	Total Fleet Miles	Annual Miles Per Vehicle
Wyoming	**177**	**659**	**628**	**267**	**1,731**	**13,448,493**	**3,788,924**	**2,259,865**	**19,497,282**	**11,264**
Albany #1	0	40	12	0	52	605,320	112,411	107,504	825,235	15,870
Big Horn #1	3	18	4	4	29	167,530	84,443	15,813	267,786	9,234
Big Horn #2	1	9	3	2	15	46,031	47,306	13,905	107,242	7,149
Big Horn #3	5	0	8	2	15	95,874	41,217	10,251	147,342	9,823
Big Horn #4	3	5	5	6	19	96,307	25,685	11,219	133,211	7,011
Campbell #1	22	58	54	26	160	1,769,775	244,544	207,387	2,221,706	13,886
Carbon #1	8	3	19	9	39	173,906	97,073	38,814	309,793	7,943
Carbon #2	0	20	3	14	37	184,165	113,353	31,980	329,498	8,905
Converse #1	3	20	6	8	37	184,699	94,150	50,465	329,314	8,900
Converse #2	1	12	4	6	23	82,339	48,108	9,354	139,801	6,078
Crook #1	9	29	6	12	56	389,991	114,214	62,059	566,264	10,112
Fremont #1	0	0	30	2	32	349,491	112,230	29,348	491,069	15,346
Fremont #2	0	0	6	1	7	34,048	29,024	2,214	65,286	9,327
Fremont #6	2	12	2	6	22	136,227	21,540	28,739	186,506	8,478
Fremont #14	1	2	17	9	29	132,835	17,658	11,770	162,263	5,595
Fremont #21	1	2	10	3	16	79,121	4,972	31,583	115,676	7,230
Fremont #24	1	6	5	2	14	125,921	28,694	14,228	168,843	12,060
Fremont #25	4	0	27	6	37	187,414	130,064	56,839	374,317	10,117
Fremont #38	2	12	1	3	18	104,144	18,405	13,633	136,182	7,566
Goshen #1	17	44	13	4	78	423,540	95,041	54,459	573,040	7,347
Hot Springs #1	0	3	14	7	24	87,130	40,208	41,747	169,085	7,045
Johnson #1	7	11	14	4	36	184,944	113,242	27,280	325,466	9,041
Laramie #1	1	83	24	14	122	1,455,277	298,795	190,961	1,945,033	15,943
Laramie #2	0	36	4	8	48	519,514	50,187	75,045	644,746	13,432
Lincoln #1	0	10	3	4	17	56,238	41,606	18,207	116,051	6,827
Lincoln #2	12	0	45	0	57	707,211	152,296	67,676	927,183	16,266
Natrona #1	20	27	48	9	104	1,329,815	288,725	179,636	1,798,176	17,290
Niobrara #1	3	3	5	5	16	136,629	35,487	9,272	181,388	11,337
Park #1	0	19	5	6	30	182,211	88,402	39,714	310,327	10,344
Park #6	0	0	36	0	36	220,583	82,883	34,007	337,473	9,374
Park #16	0	6	1	6	13	72,840	21,044	889	94,773	7,290
Platte #1	0	35	12	1	48	228,373	68,644	53,178	350,195	7,296
Platte #2	1	3	2	3	9	19,077	18,627	8,084	45,788	5,088
Sheridan #1	1	9	10	4	24	133,644	58,964	58,829	251,437	10,477
Sheridan #2	3	30	10	2	45	336,735	110,927	66,304	513,966	11,421
Sheridan #3	1	2	2	10	15	84,596	14,186	11,910	110,692	7,379
Sublette #1	1	8	8	4	21	139,160	71,601	33,553	244,314	11,634
Sublette #9	0	13	2	5	20	117,553	34,779	24,480	176,812	8,841
Sweetwater #1	15	39	22	3	79	763,819	116,679	202,169	1,082,667	13,705
Sweetwater #2	14	1	27	10	52	280,875	116,852	68,447	466,174	8,965
Teton #1	3	1	26	3	33	296,812	100,178	30,219	427,209	12,946
Uinta #1	1	0	33	7	41	257,771	105,964	106,480	470,215	11,469
Uinta #4	0	3	13	4	20	74,142	29,497	10,688	114,327	5,716
Uinta #6	2	5	6	2	15	60,896	70,077	30,887	161,860	10,791
Washakie #1	0	14	4	1	19	95,757	55,069	29,028	179,854	9,466
Washakie #2	1	4	0	2	7	39,815	15,184	2,413	57,412	8,202
Weston #1	4	0	15	10	29	127,699	72,792	20,429	220,920	7,618
Weston #7	4	2	2	8	16	70,699	35,897	16,769	123,365	7,710
District Not Defined	0	0	0	0	0	0	0	0	0	NA

Appendix 3. Wyoming School District Map



Source: U.S. Census Bureau

Prepared by Wyoming Economic Analysis Division