Comparative Analysis of Fuel Source Consumption and Economic Costs of Razorback Transit Among Alternative Fuel Sources

Sustainability Capstone Project

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Abstract

Razorback Transit is the public transit system of the University of Arkansas-Fayetteville. This transit system serves the University of Arkansas community (population ca. 25,000) and residents of Fayetteville, AR (population ca. 75,000) with public transportation around the university campus and the city of Fayetteville throughout the year. This case study was a comparative analysis of fuel source consumption and economic costs for the University of Arkansas Razorback Transit System. Presently, Razorback Transit consists of 23 transit buses powered by diesel fuel. The FY 2012 diesel fleet was compared to scenarios replacing the current fleet fuel with B20 biodiesel, B100 biodiesel, Compressed Natural Gas, Liquefied Petroleum Gas, and Diesel-Electric Hybrids. The study had two primary foci: 1) fuel source data and 2) economic evaluation. Analyses of fuel source data included 1) Fuel Consumption, 2) Green House Gas Emissions (GHG), and 3) Fuel Efficiency and GHG Emissions per capita. Current and alternative fuels were compared in diesel gallon equivalency (DGE). Energy and GHG emissions per capita were compared using ridership data obtained from Razorback Transit. The second component of this study was an economic evaluation of the current transit system comparing economy of current fuel to alternative fuel sources. This economic evaluation examined average market prices (in diesel gallon equivalency), fuel cost of Razorback Transit, conversion costs, and cost per capita. Within this part of the study, the conducted analysis compared the current fuel cost to those of the proposed alternatives. Fuel costs were based on annual fuel expenditures relative to fuel source. All data used in the economic evaluation were from FY 2012. The data obtained and presented in this study can be used to evaluate the current diesel transit system and how it compares to alternate fuel sources, serving as a preliminary step in moving the University of Arkansas towards a more resilient and sustainable public transit system.

Introduction

In FY 2012 Razorback Transit provided transportation for 1,980,283 people. 457,025 people (23%) were non U of A students. 128,387.11 gallons of diesel fuel were consumed during the transportation process. This amounted to a substantial $417,761.30 in diesel fuel costs, 375,144.85 miles travelled and 1,296.12 Metric Tons of Carbon Dioxide Equivalent (MTCDE) emitted into the atmosphere during the FY 2012 by Razorback Transit. Razorback Transit is a fare free transit service provided to the public. This study was conducted based on its fleet of 23 fixed route buses.

Transit systems are usually seen as modes of green transportation (Stasko et al). Bus transit systems are unique in that they can provide mobile transportation to a large amount of people in all niches of a city. Alternate fuels have been used within the transit industry as a solution to rising fuel costs and emissions control. Alternate fuels also yield environmental benefits along the lines of reduced tailpipe emissions of air pollutants. These air pollutants include non-methane hydrocarbons (NMHC), nitrogen oxides (NOx) and particulate matter (PM)(AFS: Report to Congress). Some alternate fuels, such as bio-fuels, can be used in current diesel powered buses with no engine or system modifications. Other alternative fuels such as Compressed Natural Gas (CNG) and Liquefied Petroleum Gas (LPG) require bus and depot modifications. Alternate fuels are believed to offer lower emissions and in some cases are seen as greener fuels than conventional gasoline and diesel. This case study was designed to compare the current diesel powered transit system to five alternate fuels. These five alternate fuels are B20 bio-diesel, B100 bio-diesel, diesel – electric hybrids technology, combustible natural gas (CNG), and liquefied petroleum gas (LPG). These alternate fuel scenarios recreate the FY 2012 diesel fuel scenario of Razorback transit to provide in sight for a more sustainable and resilient fuel source.

Methodology

Six separate fuel scenarios were created based on six separate types of fuel sources. The fuel sources chosen were possible, applicable fuels that could be substituted in for the current diesel fuel. The six type of fuel scenarios that were exploited in this case study are diesel, B20 biodiesel, B100 biodiesel, diesel electric hybrids, combustible natural gas, and liquefied petroleum gas. This case study was broken down to two major categories: Fuel Source Data and Economic Evaluation. Fuel source data was focused on the aspects of fuel economies, fuel consumption, and greenhouse gas emissions of each fuel scenario. The category of economic evaluation consisted of fuel prices, total costs, cost per capita and greenhouse gas emission per capita. Razorback Transit provided preliminary data for this report. Results were modeled around their FY 2012 data.

Razorback Transit data was provided from Razorback Transit at the University of Arkansas for the 23 fixed route buses for the FY 2012. This information included fuel costs, fuel consumption, operating times, revenue miles and ridership information.

Each fuel was converted into diesel gallon equivalencies. Data was analyzed on a DGE basis. The ratio of British Thermal Units (BTUs) of a gallon of alternative fuel to the BTUs of a gallon of diesel was used to compute the DGE for each alternate fuel. Since combustible natural gas is measured in cubic feet, it was more difficult to compute exact DGE. The "Compressed Natural Gas (CNG) Transit Bus Experience Survey" that took place from April 2009 – April 2010 conducted by R. Adams and D.B. Horne found that CNG lagged diesel in fuel economy by about 20%. This twenty percent was applied when creating the scenario for Razorback Transit running on CNG with units in diesel gallon equivalency. It is very important to understand that all fuel scenarios were analyzed and compared to diesel in diesel gallon equivalency. The following DGE's found and used in this study are shown in Table 1:

Table 1

Fuel Source	British Thermal Units	Alt. Fuel Unit In Diesel Gallon Equivalents
Diesel*	128,500	1
Biodiesel 20**	125,400	0.98
Biodiesel 100*	119,500	0.93
Hybrid***		1.2
CNG***		0.8
LPG*	84,950	0.661

***BTUs were obtained from **Alternative Fuels Data Center – Fuel Properties Comparison**
** BTUs were obtained from the **California Energy Commission**
*****DGE's are based off of comparable fuel economies found in the literature

Each alternate fuel scenario could be carried out after each fuel was properly converted to their respected DGE. All fuel scenarios were dependent on specific data pertaining to fuel consumption, and total miles travelled by Razorback Transit.

Fuel economy was the first component of the study to be compared amongst the six scenarios. Transit buses tend to get very low fuel economies. Drive cycle factors, average speeds, the amount of bus stops, and the route in which a bus operates all affect the fuel economy of an operating bus. Fuel economy for Razorback Transit was first computed. The average fuel economy for the Razorback Transit fleet was computed by taking the total miles travelled in FY 2012 and dividing it by the total diesel fuel consumed (in gallons) in FY 2012:

$$Total\ Miles\ \div Total\ Gallons\ Consumed = mpg$$

$$375{,}144.85 \text{ Miles} \div 128{,}387.11 \text{ gal} = 2.92 \text{ mpg}$$

2.92 mpg was the predicted fuel economy for Razorback Transit fleet during the FY 2012 based on total miles and total fuel consumption. This 2.92 mpg served as the central point of the following fuel calculations. This 2.92 mpg was multiplied by each alternate fuel's DGE factor (shown in Table 1) to find each alternate fuels' respected fuel economy in diesel gallon equivalency. The following fuel economy results are shown in Table 2:

Table 2

Fuel Source	DGE	Fuel Economy
Diesel	1	2.92
B20	0.98	2.86
B100	0.93	2.65
Hybrid	1.2	3.50
CNG	0.8	2.33
LPG	0.661	1.89

Clark et al states that B20 biodiesel shows a 1-2% drop in fuel economy when compared to diesel fuel. B100 biodiesel showed a 7% decline in fuel economy based on BTU ratios between a gallon of B100 and a gallon of diesel fuel (AFDC Fuel Comparison). Diesel Electric Hybrids typically show a 20% - 40% increase in fuel economy (Clark et al). This study based diesel electric hybrid fuel economy on a prediction of 20% increased fuel economy for the overall fleet. Combustible natural gas fuel economy was based on factors taken from Adams et al which stated that fuel efficiency of CNG compared to diesel was approximately 80% for DGE. Liquefied Petroleum Gas showed a 34% decline in fuel economy when compared in DGE. The DGE for LPG was computed used BTU ratios for a gallon of LPG to a gallon of diesel.

Total fuel consumption was then determined for each fuel scenario after the fuel economies for each fuel were calculated from each respected DGE. Fuel consumption was recorded in diesel gallon equivalency. The total fuel consumption is the result of the total miles travelled in FY 2012 divided by each individual fuel economy (in DGE) presented earlier in this paper.

$$Total\ Miles\ Traveled\ \div Miles\ per\ DGE = Total\ DGE\ Consumed$$

Data for diesel fuel remains consistent to data received from Razorback Transit and therefore does not adhere to this equation. The total DGE consumed by each alternate fuel source represents the amount of fuel in DGE that is needed to achieve the same energy output that the current diesel powered system provides. Table 3 shows the relationship between each fuel scenario's fuel economy in DGE, and miles travelled in FY 2012.

Table 3

Fuel Source	Fuel Economy (Miles per DGE)	Miles Traveled	DGE Consumed (DGE)
Diesel	2.92	375144.85	128387.11
Biodiesel 20	2.86	375144.85	131096.19
Biodiesel 100	2.72	375144.85	138144.37
Hybrid	3.50	375144.85	107061.89
CNG	2.34	375144.85	160592.83
LPG	1.93	375144.85	194363.49

The third component of fuel source data was the computation of greenhouse gas emissions for each fuel scenario. Greenhouse gas emission estimations were made on the basis of total fuel consumption in diesel gallon equivalents for each fuel scenario. The three main green house gases focused on in this report were Carbon Dioxide (CO2e), Methane (CH4), and Oxides of Nitrogen (N2O). Table 4 shows the breakdown of the greenhouse gas calculations for grams per mile and Table 5 shows GHG grams per DGE:

Table 4

Fuel Source	Miles Travelled	CO2 (Grams per Mile)	N2O (Grams per Mile)	CH4 (Grams per Mile)
Diesel	375144.85	3453.424658	0.0048	0.0051
B20	375144.85	3530.053117	0.003993519	0.014684487
B100	375144.85	3832.301038	0.000405108	0.056715054
Diesel-Electric Hybrid	375144.85	2877.853881	0.004	0.00425
CNG	375144.85	3383.989726	0.175	1.966
LPG	375144.85	4621.968466	0.175	0.066

Table 5

Fuel Source	Fuel Economy (Miles per DGE)	Miles Travelled	CO2 (grams/DGE)	N2O (grams/DGE)	CH4 (grams/DGE)
Diesel	2.92	375144.85	10,084	0.014016	0.014892
B20	2.8616	375144.85	10102	0.011427854	0.042021127
B100	2.65428	375144.85	10172	0.001075269	0.150537634
Diesel-Electric Hybrid	3.504	375144.85	10084	0.014016	0.014892
CNG	2.336	375144.85	7905	0.4088	4.592576
LPG	1.89508	375144.85	8759	0.331639	0.12507528

The U.S. Environmental Protection Agency (EPA) provided a greenhouse gas fact sheet that contained the calculations used to estimate tailpipe greenhouse gas emissions. The EPA uses the equation:

$$CO2\ emissions\ per\ mile = \frac{CO2\ per\ gallon}{MPG}$$

This equation gives a result in grams per mile. This equation was also applied to N2O and CH4. Data presented in Table 4 was obtained from different documents and case studies published publicly. Diesel and CNG CO2 grams per DGE were obtained from the "Clean Diesel versus CNG Buses: Cost, Air Quality and Climate Impacts" produced by Strategic Environmental Consulting. This paper also used similar calculations to help verify what was done in this report to calculate greenhouse gas emissions. Greenhouse gas data for B100 biodiesel, CNG and LPG were obtained from the EPA's "Direct Emissions from Mobile Combustion Sources" and their "Emission Factors for Greenhouse Gas Inventories." B20 biodiesel greenhouse gas data was estimated by calculating 20% of the given data for B100 biodiesel and combining it to 80% of the given GHG data for diesel. Calculating NO2 and CH4 grams per DGE and grams per mile followed the same process as calculating CO2 grams per DGE and grams per mile. Metric tons of each GHG were calculated once grams per mile were found for each greenhouse gas. This was simply the result of multiplying the total grams per mile by the total amount of miles travelled that year. Greenhouse gas global warming potentials were multiplied by each correlating greenhouse gas once each individual greenhouse gas was presented in metric tons. Table 6 shows individual metric tons of each GHG and Table 7 shows the global warming potentials provided by the EPA's Greenhouse Gas Factsheet and Table 8 depicts the GHGs in Metric Tons of Carbon Dioxide Equivalency (MTCDE).

Table 6

Fuel Source	Metric Tons of C02	Metric Tons of N2O	Metric Tons of CH4
Diesel	1295.534475	0.001800695	0.001913239
B20	1324.281247	0.001498148	0.00550881
B100	1437.667998	0.000151974	0.021276361
Diesel-Electric Hybrid	1079.612063	0.001500579	0.001594366
CNG	1269.486318	0.065650349	0.737534775
LPG	1733.907667	0.065650349	0.02475956

Table 7

GHG	GWP
CO2	1
CH4	25
N2O	298

*Data taken from the EPA: *Greenhouse Gas Emissions from a Typical Passenger Vehicle* 2011

Table 8

Fuel Source	Metric Tons of C02	Metric Tons of N2O (CO2e)	Metric Tons of CH4 (CO2e)	Metric Tons CO2 Equivalent
Diesel	1295.534475	0.536607193	0.047830968	1296.12
B20	1324.281247	0.446448122	0.137720238	1324.87
B100	1437.667998	0.045288253	0.531909014	1438.25
Diesel-Electric Hybrid	1079.612063			1231.07
CNG	1269.486318	19.56380393	18.43836938	1307.49
LPG	1733.907667	19.56380393	0.618989003	1754.09

It is important to note that data for diesel electric hybrid is based on diesel GHG emissions. The MTCDE correlates with the total fueled consumed in each fuel scenario depicted earlier in this report. Razorback Transit predicted MTCDE based on fuel consumption was then compared to greenhouse gas data obtained through the University of Arkansas' Office for Sustainability. The data that they provided was computed by a third party called Sightlines. Sightlines evaluated MTCDE for the University of Arkansas from 2002 – 2012. Razorback Transit's MTCDE was compared to both the information in the Mobile Combustion Sector and to the overall MTCDE produced by the University for FY 2012. Table 9 depicts this comparison in overall percents for the current diesel fuel scenario:

Table 9

Razorback Transit MTCDE Comparison		
Sector	**MTCDE**	**Percent**
Razorback Transit MTCDE	1296.118913	100.00%
U of A Mobile Combustion MTCDE	4,122.00	31.44%
U of A MTCDE	150,784.00	0.86%

The next aspect of this report was the economic evaluation. This area looked at the total cost of fuel consumed in DGE, per capita cost per total fuel consumed and greenhouse gas emissions per capita. Directly correlated to total fuel consumption in DGE is total fuel cost. Razorback Transit's average price per gallon was evaluated by the following equation:

$$Total\ Fuel\ Cost\ \div Total\ Fuel\ Consumption = Cost\ per\ Gallon$$

$$\$417{,}761.30\ \div 128{,}387.11\ gal = \$3.25\ per\ gal$$

The Clean Cities Alternative Fuel Pricing Report, a quarterly report published by the U.S. Department of Energy, provided price per DGE for each fuel in this study. The average fuel prices were given in dollars per DGE for each fuel scenario stated in this study. An average price was computed from the averages form the four quarterly reports published in 2012. This is depicted in Table 10.

Table 10

	National Average Fuel Price in DGE				
	Term				Average Price
Fuel Source	**Jan-12**	**Apr-12**	**Jul-12**	**Oct-12**	**for 2012 ($/DGE)**
Diesel	$3.86	$4.12	$3.75	$4.13	$3.97
B20	$4.02	$4.26	$3.90	$4.26	$4.11
B100	$4.61	$4.78	$4.64	$4.82	$4.71
Diesel-Electric Hybrid	$3.86	$4.12	$3.75	$4.13	$3.97
CNG	$2.38	$2.32	$2.28	$2.36	$2.34
LPG	$4.75	$4.48	$4.06	$3.94	$4.31

It is important to note that the average 2012 price provided from the Clean Cities Alternative Fuel Pricing Report for diesel and diesel electric hybrids were not used. Instead the price of $3.25 per DGE, computed from data obtained from Razorback Transit, was used. The average prices for each fuel scenario obtained from the Clean Cities Alternative Fuel Pricing Report, reported in dollars per DGE, were then multiplied by the total amount of fuel consumed in each individual fuel scenario. The following equation was used:

$$DGE\ Consumed\ \times Average\ Fuel\ 2012\ Fuel\ Price = Total\ Cost\ \left(\frac{\$}{DGE}\right)$$

Table 11 shows the different cost of the alternate fuels in DGE to achieve the same amount of energy output as the normal diesel powered system to each fuel scenario:

Table 11

Fuel Source	DGE Consumed (DGE)	FY 2012 Average Price Fuel Source (DGE Equivalent)	Total Cost ($/DGE)
Diesel	128387.11	$3.25	$417,761.30
Biodiesel 20	131096.19	$4.11	$538,805.33
Biodiesel 100	138144.37	$4.71	$651,005.34
Hybrid	107061.89	$3.25	$347,951.13
CNG	160592.83	$2.34	$374,984.26
LPG	194363.49	$4.31	$837,220.71

After total fuel prices were estimated, per capita fuel costs were estimated based on ridership data provided from Razorback Transit and predicted fuel cost. Table 12 shows fuel costs on a per capita basis:

Table 12

Per Capita Fuel Source Consumption (DGE)					
Fuel Source	2012 Ridership	Total Fuel Consumption (DGE)	Total Fuel Cost	Fuel Consumption per capita	Total Fuel Cost Per Capita
Diesel	1980283	128387.11	$417,761.30	0.064832708	$0.21
B20	1980283	131096.19	$538,805.33	0.066200734	$0.27
B100	1980283	138144.37	$651,005.34	0.069759913	$0.33
Hybrid	1980283	107061.89	$347,951.13	0.054063932	$0.18
CNG	1980283	160592.83	$374,984.26	0.081095899	$0.19
LPG	1980283	194363.49	$837,220.71	0.098149348	$0.42
* Fuel Price is based on the national average of $/gal of Diesel from the Clean Cities Alternative Fuel Price Report					

Total fuel cost per capita was evaluated by the following equation:

$$Total\ Fuel\ Cost\ \div 2012\ Risdership = Total\ Fuel\ Cost\ per\ Capita$$

After per capita fuel costs were evaluated, greenhouse gas emissions per capita were estimated. Table 13 depicts the greenhouse gas emissions per capita.

Table 13

Per Capita GHG Emisions			
Fuel Source	**2012 Ridership**	**Metric Tons of CO2e for 2012**	**CO2e per Capita***
Diesel	1980283	1296.118913	654.5119628
B20	1980283	1324.865415	669.0283235
B100	1980283	1438.245195	726.2826553
Hybrid	1980283	1231.068945	621.6631384
CNG	1980283	1307.488491	660.2533534
LPG	1980283	1754.09046	885.777669

*Measured in grams of CO2e per person

Per capita GHG emissions were reported in grams of CO2e per person. The following equation represents how CO2e per Capita was found for each fuel scenario:

$$Metric\ Tons\ of\ CO2e\ \div 2012\ Risdership = grams\ of\ CO2e\ per\ Capita$$

Every fuel scenario was represented by units of DGE and appropriate calculations and estimations were made using this baseline.

<u>Results</u>

Transit systems are typically seen as greener modes of transportation (Stasko et al). They have a unique ability to transport a large mass of people quickly and efficiently. Alternate fuels have also been seen or depicted as greener and cleaner fuel sources. This may be the case in some scenarios.

Fuel Source Data:

Fuel economy was reported on a diesel gallon equivalency basis as reported earlier. Figure one shows a graphical representation of each fuel scenarios fuel economy based on data provided by Razorback Transit. Figure 1 provides an easy comparison amongst each fuel scenario.

Figure 1

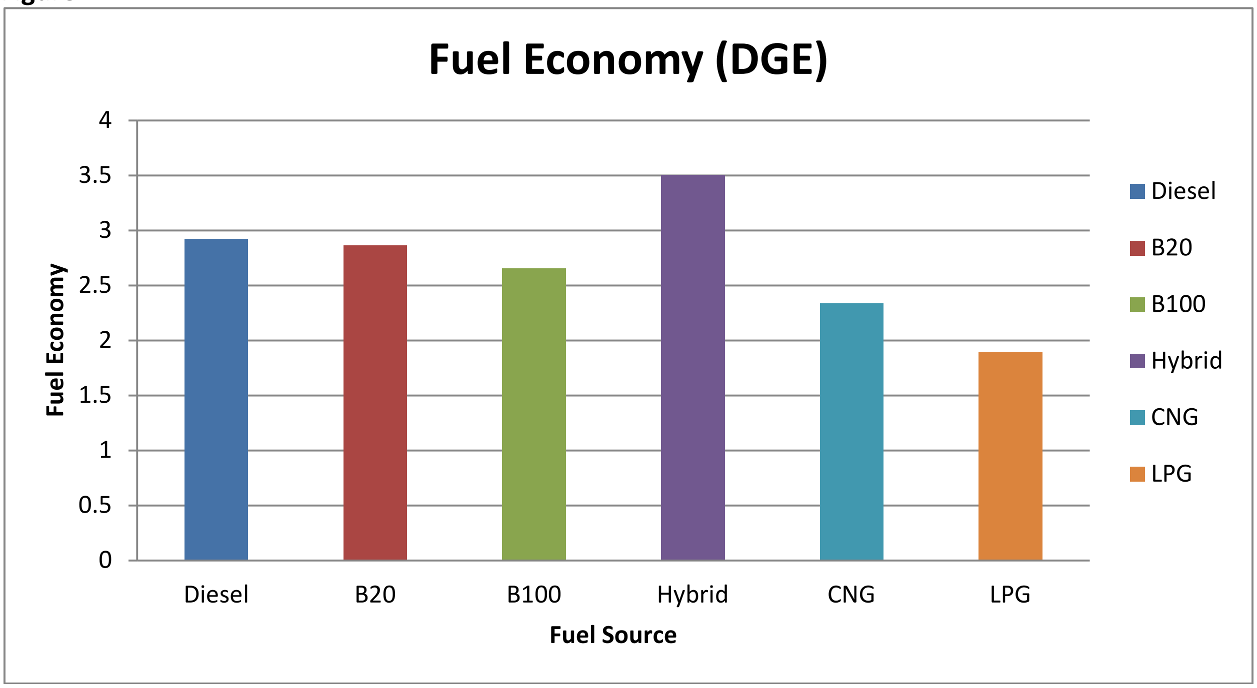
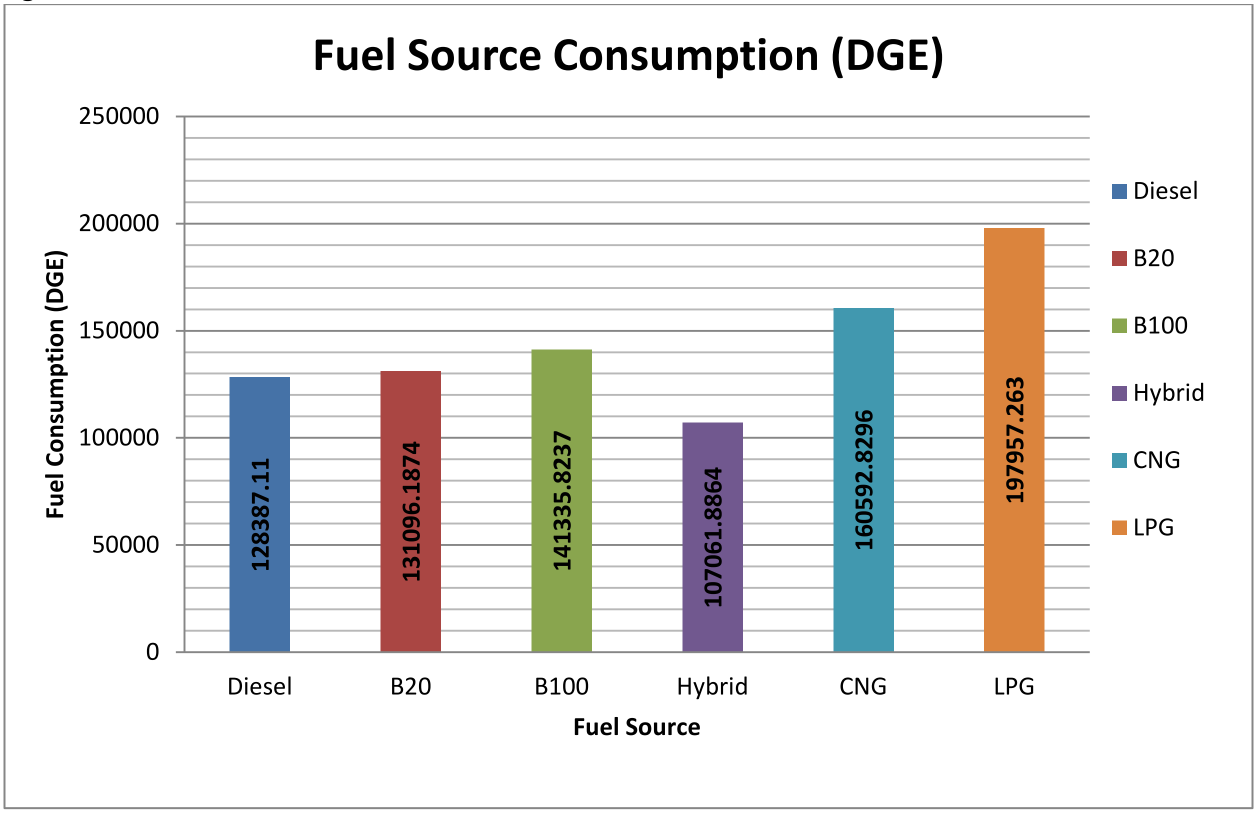


Figure 1 is based off of data provided by Table 2. From this figure we can see that diesel electric hybrids provide the greatest fuel economy. Liquefied Petroleum Gas exhibits the lowest fuel economy. Diesel fuel provides the second best fuel economy. While all diesel based fuel scenarios are close in fuel economies, distinctions start to be seen when calculating the Total Fuel Consumed in DGE.

Figure 2 compares fuel consumption amongst each of the fuel scenarios:

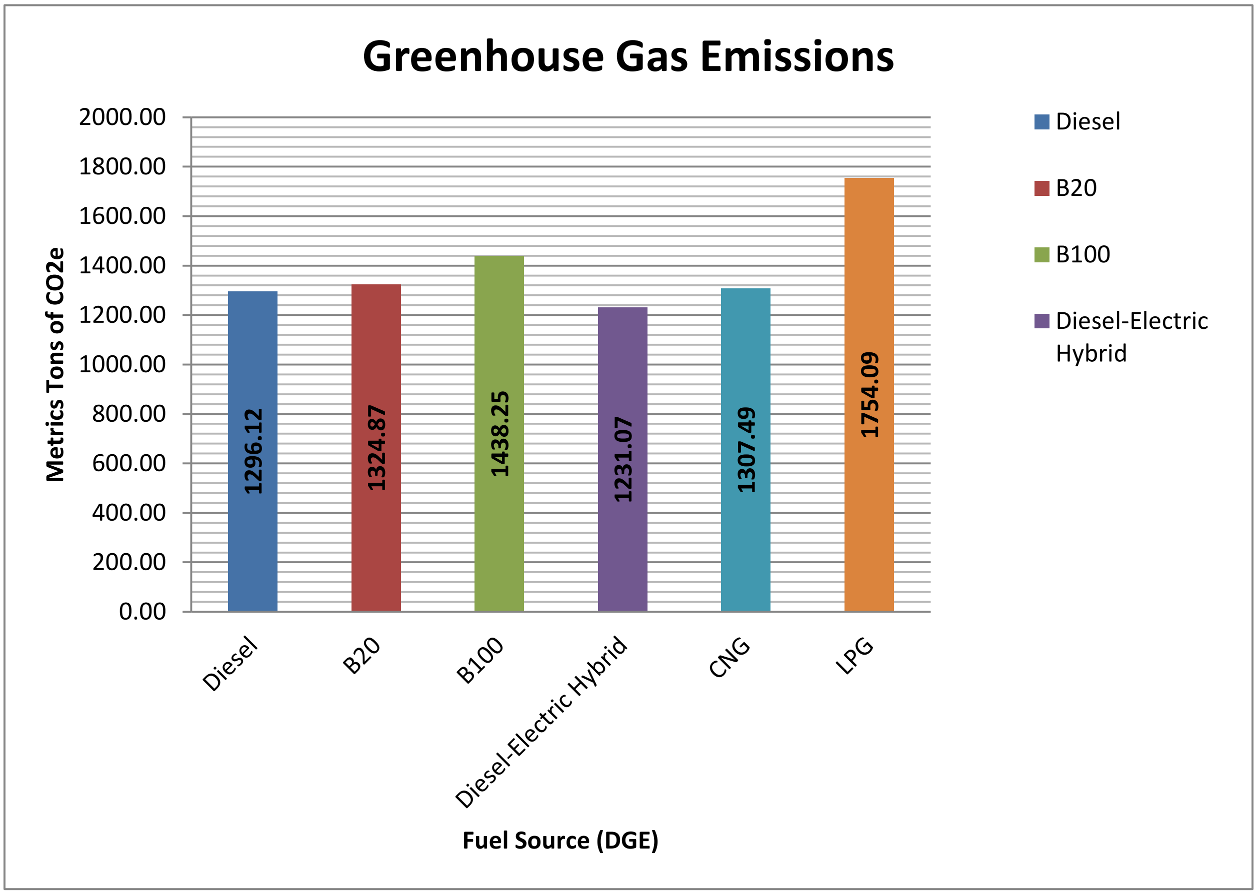
Figure 2



Liquefied Petroleum Gas consumes the most fuel on a DGE basis. It is also seen to have the lowest fuel economy of the six fuel scenarios. Diesel Electric Hybrids consume the least amount of fuel. Conventional diesel shows to consume the second lowest amount of diesel fuel. Fuel consumption is correlated with greenhouse gases emitted on a DGE basis.

Greenhouse gas emissions for each fuel scenario are represented by Figure 3 and based off data from Table 8.

Figure 3

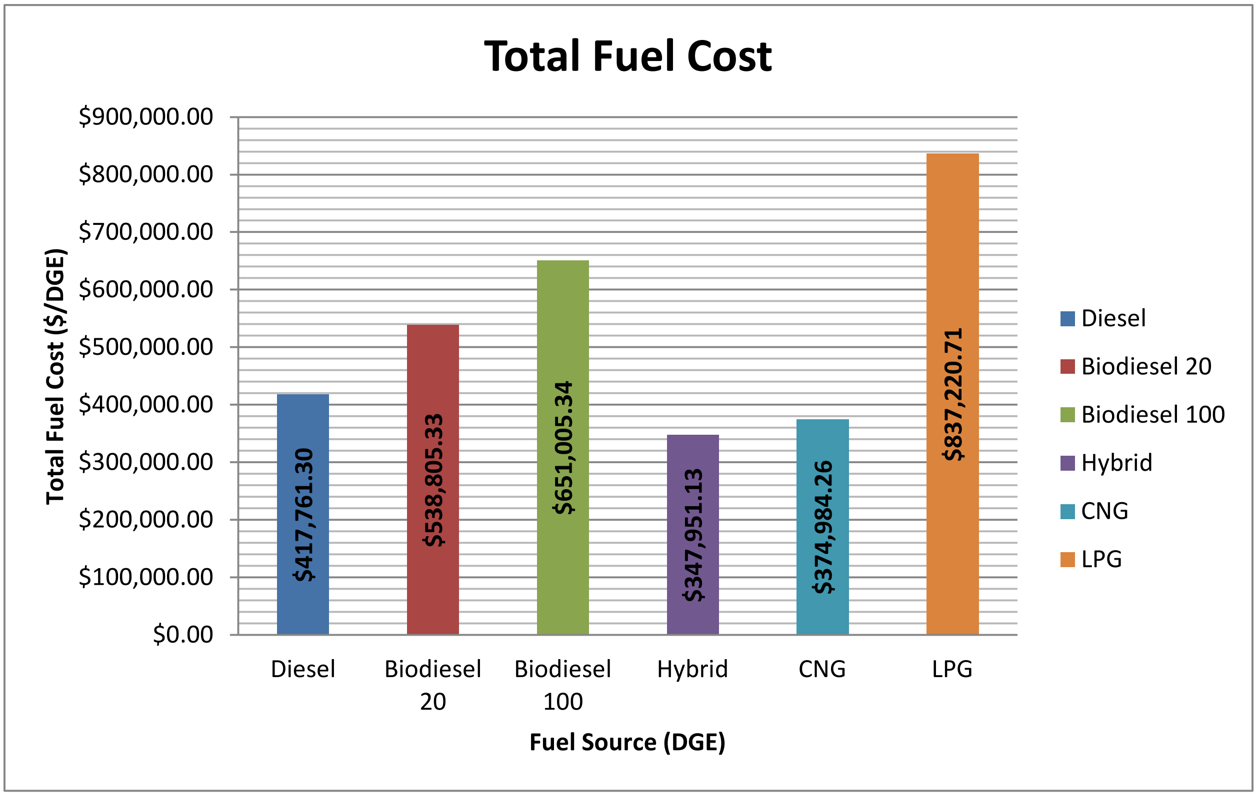


LPG once again shows that it produces the most green house gases on DGE factor. Combustible produces slightly more than diesel on a DGE factor which questions the commonality of it being a cleaner burning fuel. Diesel electric hybrids produce the lowest amount GHG. It is important to note that a large portion of carbon dioxide emitted by B100 biodiesel is actually recycled carbon dioxide from the atmosphere. Approximately 20% of the carbon dioxide emitted from B20 bio-diesel is recycled carbon also. This recycled carbon dioxide already exists in the atmosphere before it is absorbed by plants used to produce biodiesel. It is then returned to the atmosphere as the fuel is burned. It is not adding large amounts of carbon dioxide to the atmosphere but rather cycling existing carbon dioxide between systems.

Economic Evaluation Results

Total fuel cost prices were taken from the Clean Cities Alternative Fuel Pricing Report. Fuel prices for each scenario were listed in Table 10 and were evaluated in Table 11. Figure 4 compares fuel costs for each scenario with respect to diesel gallon equivalency:

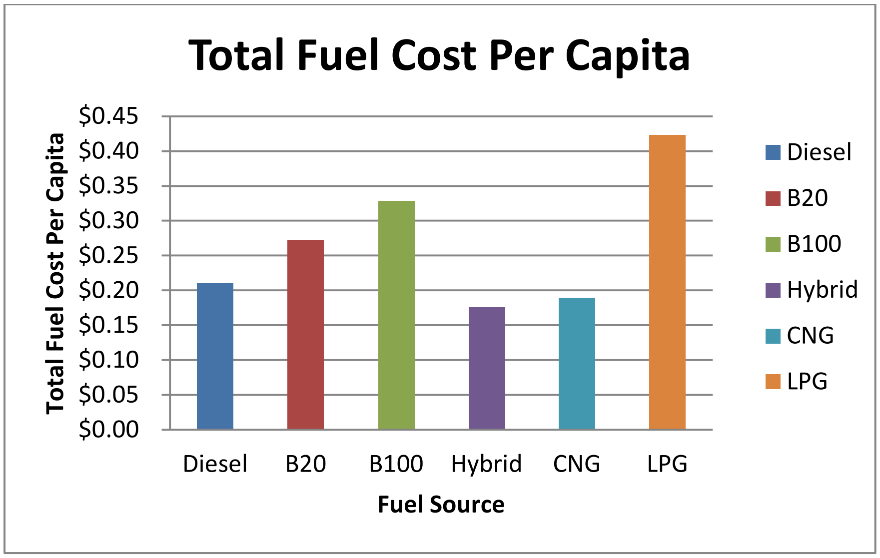
Figure 4



LPG, which consumes the most the most fuel in DGE, is shown to have the highest fuel cost on a DGE basis. B100 biodiesel cost the second highest. Diesel electric hybrids are based on the $3.25 per gallon of diesel fuel that was found for the 2012 fuel price of Razorback Transit.

Per capita costs for each fuel scenario are represented in Figure 5.

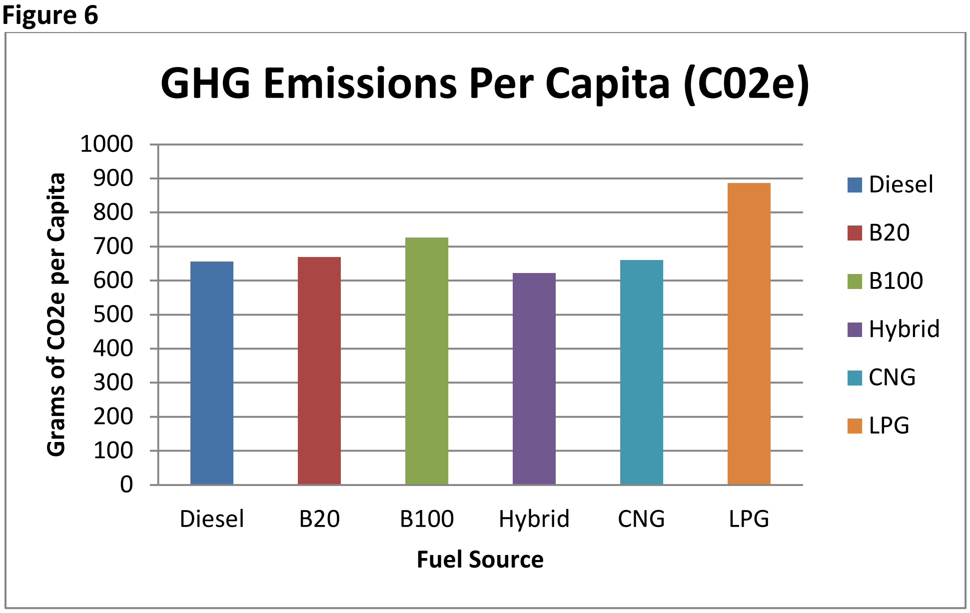
Figure 5



Data depicted in Figure 5 was taken from Table 12. LPG has the highest fuel cost per capita while diesel electric hybrids have the lowest. Diesel fuel per capita cost is estimated to be $0.21.

Figure 6 shows per capita GHG emissions in grams of CO2e.

Figure 6



This graphical representation shows the amount of CO2e emitted per capita during the FY 2012 for each fuel scenario. LPG is yet again the highest emitting fuel source.

Conclusion

After looking at the Tables and Figures presented in both the Methodology and Results sections, we can conclude that on a diesel gallon equivalent basis, alternate fuels are not always the optimum option. When looking at fuel consumption, we can conclude that Liquefied Petroleum Gas exhibited the greatest fuel consumption on a DGE basis and that diesel electric hybrids consumed the least amount of diesel fuel. LPG also produced the most amounts of MTCDE emissions in this study. Diesel electric hybrid and conventional diesel produced the lowest. Diesel electric hybrids and combustible natural gas exhibited the lowest amounts of fuel cost on DGE while LPG exhibited the highest. Fuel Cost per capita directly reflected total fuel cost for each scenario. Greenhouse gas emissions per capita directly reflect GHG emissions for each fuel scenario in MTCDE.

Transit buses consume a large amount of fuel in a single year and throughout their lifetime. Transit routes are fixed pretty tightly and are consistent for long periods of times. This allows transit systems to be prime targets for experimentation with alternate fuels. This case study provided information on six alternate fuel scenarios. It shows that on a diesel gallon equivalent basis that not all alternate fuels such as biodiesel (B100) and liquefied petroleum gas are pliable options. For Razorback Transit diesel electric hybrid buses and CNG buses would be considerable options as alternate fuels. The only problems with these two fuels are bus costs and depot modifications. Stasko et al estimates that a new vehicle purchase of a diesel electric hybrid would be approximately $531, 605 and the vehicle cost for CNG would be approximately $342, 366. However, CNG and some hybrids also require depot modifications and, in the case of CNG, a refueling station (Clark et al, Stasko et al). This cost for hybrids is estimated to be $1,400. The cost for CNG modifications is estimated to be about $2,875,000. Diesel electric hybrids could be potential source for an alternate vehicle. However, with costs this high for a low amount of fuel savings and consumption the purchase may not be pliable. Payback periods would need to be calculated to better understand if these fuel sources would be pliable.

When comparing greenhouse gas emissions of Razorback Transit to the University of Arkansas as was done in Table 9. We can tell that overall Razorback Transit's greenhouse gas emissions are miniscule. They are less than 1% of all the CO2e emissions from the whole university (Table 9). With this being put forth, it can be easily be said that resources and money should be spent elsewhere than on mitigating Razorback Transit's GHG emissions especially with Razorback Transit complying to current EPA regulations.

This case study provided a comparative analysis on six fuel scenarios. It looked at fuel economies, fuel consumption, greenhouse gas emissions, associated fuel costs, fuel costs per capita and GHG emission per capita. It had a goal to search for a sustainable, resilient fuel source to power Razorback Transit. In conclusion one can say with its miniscule costs and GHG emissions for the amount of service that it provides, the current diesel fuel system is the most optimum fuel choice to power Razorback Transit. Diesel-electric hybrid buses could be further sought after. A study on diesel electric hybrids and their performance on hills would have to be done to see if the fuel economy could be compared to the one in this report.

Acknowledgements

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