Cost Impact of Converting a Fleet of Diesel Concrete Mixer Trucks to Compressed Natural Gas

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Abstract

Sustainable practices in the built environment are becoming more and more sought after. With LEED gold and platinum becoming the new standard in commercial construction, contractors in all areas of construction are looking for ways to build more sustainably. When creating a strategy for achieving sustainability, transportation has been identified as an area of the construction industry that can help significantly reduce carbon footprint, especially concrete mixer trucks. One question presents itself: Will the cost impact of converting a fleet of concrete mixer trucks from diesel to compressed natural gas outweigh the environmental benefits? This case study will examine the various costs associated with converting CalPortland's local fleet of mixer trucks from diesel to compressed natural gas. The results of this analysis are comprised in a multi-variable model that includes multiple parameters, government and local policies as well as the cost and availability of compressed natural gas and diesel.

Keywords: sustainable construction, concrete mixer trucks, compressed natural gas, cost analysis, fuel alternatives

Introduction

Rationale for the Research

In the built environment, a constant progression has been established towards more economical building. Transportation is an area of construction that accounts for a large portion of pollution and adds to our country's carbon footprint. Diesel engines produce a significant amount of CO2 emissions, and account for nearly all concrete mixer truck engines in America. One solution to this problem is to choose an alternative fuel source for the mixer trucks. Compressed natural gas is an alternative fuel that is cheaper per gallon, better for the environment, and plentiful across the United States.

Research Goals

With research showing that switching from diesel to compressed natural gas will save a company money in the long term and have a positive impact on the environment, the main goal is to develop a cost analysis on CalPortland's local fleet in San Luis Obispo and surrounding areas. After this model is complete, the objective is to conclude whether it is feasible or not to go through with the conversion.

Outline Methodology of the Research

The methodology used in this research is first an interview with the equipment manager, Jason Schaffer, of CalPortland in San Luis Obispo to know the parameters of the study. Next, a model is developed using Excel that accounts for all variables related to the analysis. For this part of the study, Danny Susdorf, a project engineer for CalPortland in Southern California who led a project of converting 118 concrete mixer trucks from diesel to compressed natural gas, was a main point of contact. This will then provide an estimated total dollar amount for the conversion of a fleet of concrete mixer trucks and the necessary fueling station needed to support it.

Case Study Contents

This case study will start with a literature review referencing previous studies. Next, the research methodology will be examined, followed by an analysis of the results of the study. Lastly, conclusions will be made about the study with a recommendation for further studies.

Literature Review

Critical Review

Natural gas has been gaining much attention in recent years as an alternative fuel source for transportation vehicles. One of the most appealing aspects of natural gas is its abundance. The National Renewable Energy Laboratory (NREL) has been studying the use of CNG in heavy-haul transport vehicles for decades and has built a website to categorize and store all their data relating to CNG (US DOE, 2019). Research conducted by The U.S. Department of Energy (US DOE, 2019) show there are 168 CNG fuel stations in California alone, and 908 stations across the United States. The U.S. Department of Energy also states that "Natural gas is an abundant resource across the United States, and new discoveries and extraction methods have led to a dramatic rise in shale gas development -- making America the world's leading natural gas producer." (US DOE, 2019).

Natural gas is not only abundant, but also non-toxic, non-corrosive, and burns much cleaner than diesel. The U.S. Department of Energy states that, "Currently natural gas fuels 40,000 cars, 70,000 light trucks, and 40,000 heavy trucks in the United States, as well as 15.2 million vehicles worldwide" (US DOE, 2019). Looking at the lifecycles of compressed natural gas engines, CNGV or compressed natural gas vehicles, have the largest losses during combustion at the vehicle propulsion stage compared to fuel cell and electric vehicles (US DOE, 2019).

The use of CNG in transportation vehicles is also a cheaper alternative per gallon of fuel. The current price per gallon of diesel in California is $4.15 per gallon (US DOE, 2019). Comparatively, the cost of compressed natural gas per gasoline gallon equivalent is $2.41 (US DOE, 2019).

Compressed natural gas is supported by the government, and incentives are given at the state and federal level for using CNG as a fuel source. PG&E offers incentives for companies who use compressed natural gas as a source of fuel. "Pacific Gas & Electric (PG&E) administers the Clean Fuel Rebate program, which offers an annual bill credit for CNG account holders that purchase CNG as a transportation fuel from a PG&E station (US DOE, 2019). This program was developed to fight climate change and give companies an incentive to switch to CNG. The system works on a credits basis and is automatically deducted from the companies PG&E compressed natural gas account.

The following information was given to me by Danny Susdorf, and it explains effects of the Carl Moyer Grant. "SLO APCD has approximately $350,000 annually available on a first come first serve basis. The funding can be secured for either diesel truck replacement to a NZ CNG truck or CNG infrastructure. Funding will be a maximum of $100,000/truck for an HHD replacement as shown below (Danny Susdorf P.E.). The Carl Moyer Grant provides up to $100,000 per truck conversion, however it is on a first-come, first-served basis. Provided this knowledge, we were able to estimate the amount received per truck for the conversion to be $70,000.

Methodology and Procedure of Data Gathering

When conducting the methodology, many variables were analyzed, and an excel spreadsheet was used to gather the data. The problem was going to be tough to tackle and the variables considered were complex and continuously changing. Danny Susdorf graduated from UCSD with a degree in Civil Engineering and he led a CalPortland project in Southern California where they converted 118 concrete mixer trucks from diesel to compressed natural gas.

The goal of this research is to determine whether the conversion in San Luis Obispo will be successful financially. One of the main factors that led to the success in Southern California was that it was a disadvantaged community.

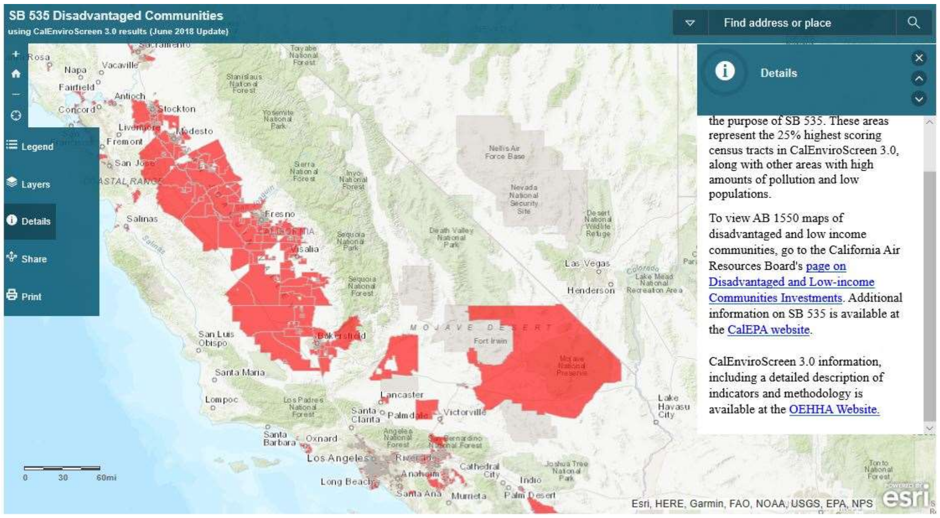

Figure 1A

Figure 1A shows the locations where communities are considered disadvantaged. SLO APCD awards these communities with $615,000 annually (AB 617), and SLO APCD also awards approximately $500,000 in these areas as well (AB 923). These areas have been identified as communities that have the most impact on climate change. For this reason, they are awarded more financial benefit for reducing their emissions of greenhouse gases. San Luis Obispo and its surrounding areas do not represent a disadvantaged community and because of this they do not receive all the benefits that companies in these communities receive. When coming to a conclusion on whether it is feasible to go through with a conversion in SLO, both Danny Susdorf and Jason Schaffer mentioned that the benefits received from being in a disadvantaged community would play a major role in deciding on going through with the project.

When coming up with the excel cost analysis model, Danny Susdorf was able to help identify the main variables that were going to have a cost impact on the company.

Variables

Number of Vehicles in Fleet – this will have the biggest change on the study as adding or subtracting just one truck can change the cost by hundreds of thousands.

Cost of Engine Conversion – This is the amount of money it takes per truck to change the engine from diesel to CNG.

Cost of Fueling Station – This is the total cost of installing a fueling station for CNG vehicles. This includes compressors, dispensers, storage, filling posts, costs of installation and natural gas dryers.

Cost of Fuel Annually – This is based on the current cost of diesel and CNG and multiplied by the average MPG of the trucks, and then multiplied by the average distance covered per year per truck.

Cost of Maintenance – The cost of maintenance was given to me by Jason Schaffer, the equipment manager for CalPortland in SLO. He is the direct manager for the fleet in SLO and surrounding areas and averaged the cost based on 10%-15% of the initial price of the truck annually.

Carl Moyer Grant – A grant given to companies on a first-come, first-served basis. They are available for companies who need engine replacement (diesel to CNG) and complete vehicle replacement.

CNG Tax Credit – A financial incentive for fleets of vehicles that use CNG instead of diesel fuel. This credit is applied per gallon and greatly reduces the price of fuel for compressed natural gas per gallon.

After gathering the data that affected the costs for the conversion, they were put in an excel file where based on how many trucks are in the fleet, the data will auto-populate and the costs per year and upfront costs will change based on the number of vehicles. This is useful for future studies because the model is easy to change and will give you a good gauge of costs while only having to change one cell.

Analysis of Results

After the data was inputted into the excel model, the following graphs and tables were put together in order to determine first what the initial upfront cost would be, then to determine approximately how long it would take until the company would begin to profit from the conversion from diesel to CNG. The next step was to multiply the costs associated per vehicle times the number of vehicles. This included $570,000 of upfront costs for the engine conversion from diesel to compressed natural gas (Figure 1). The total initial costs associated with this conversion came out to be $2,118,260 (Figure 1) and that includes everything from engine conversion to the fueling station.

Variables to Consider

Number of Vehicles Purchased	57		Vehicles	Subtotal
Cost of CNG Vehicle Conversion	$ 10,000.00		$/Vehicle	$ 570,000.00
Will you finance your vehicles?	Yes		Yes/No	
Down Payment Amount	0		%	
Annual Interest Rate - Residual	30%		%	
Term of Loan	5		Years	
Life Expectency of Vehicle			Years	
Cost of Maintenance				
Major	40000		$/Vehicle	
Minor	17500		$/Vehicle	
Cost of Fueling Station	1078840		$/total	$ 1,078,840.00
Fueling Station Installation Cost	539420		$/total	$ 539,420.00
Expected Salvage Value of Diesel Vehicle	30000		$/Vehicle	
Additional Incentives??				
Carl Moyer Grant	($350,000)			($70,000)
Finance your Refueling Station	Yes		Yes/No	
Down Payment Amount			%	
Annual Interest Rate			Annual Interest Rate	
Term of Loan			Years	
Expected Hours of Fueling Overnight	8		Hours/Day	
			Total Cost Upfront	$ 2,118,260.00

Figure 2

The next variable we will be looking at is the amount per gas gallon equivalent that the government awards to companies who use compressed natural gas. In order to do this, we must first determine the price per gallon of both diesel and CNG. The current cost for a gallon of diesel is $4.09, and the current cost of a GGE of CNG is $2.41 (US EIA). The next step was to apply the Alternative Fuels Tax Credit to the price per gallon of CNG which reduced the price CalPortland will pay per gallon to $1.99. Shown below in figure 2, we see roughly a $2.10 saving per gallon.

	Diesel	CNG
Total Cost of Diesel Fuel Annually	$ 932,520.00	
Total Cost of CNG Annually		$ 452,580.00
Annual Miles Per Vehicle	$ 14,000.00	$ 14,000.00
Avg. Miles per Gallon of Mixer Truck	$ 3.50	$ 3.50
Price per Gallon or DGE	$ 4.09	$ 2.41
Alternative Fuels Tax Credit		$ (0.43)
Annual Fuel Savings From Switching to CNG	$ -	$ (497,040.00)
CNG Federal Excise Tax Credit per DGE	$ -	$ 0.08
CNG State Road Tax Credit per DGE	$ -	
Price Per Gallon Total	$ 4.09	$ 1.99

Figure 3

This savings has a dramatic impact on the amount of money CalPortland will spend on gas each year. With each truck covering on average 14,000 miles per year, and at a rate of 3.5 mpg, CalPortland will save nearly $480,000 every year on fuel. As shown below in Figure 3, CalPortland is estimated to be able to profit from this conversion in just 5 years.

Costs Incurred Yearly			
	Diesel	CNG Conversion	
Total Cost Upfront	$ -	$ 2,118,260	
Cost of Maintenance			
Major	$ -	$ -	$/Vehicle
Minor	$ 997,500	$ 997,500	$/Vehicle
Total Cost of Fuel Annually	$ 932,520	$ 452,580	$/Year
Fueling Station Interest	$ -		$/Year
Total Costs after 1 Year	$ 1,930,020	$ 3,568,340	
Total Costs after 2 Years	$ 3,860,040	$ 5,018,420	
Total Costs after 3 Years	$ 5,790,060	$ 6,468,500	
Total Costs after 4 Years	$ 7,720,080	$ 7,918,580	
Total Costs after 5 Years	$ 9,650,100	$ 9,368,660	
Total Costs after 6 Years	$ 11,580,120	$ 10,818,740	
Total Costs after 7 Years	$ 13,510,140	$ 12,268,820	
Total Costs after 8 Years	$ 15,440,160	$ 13,718,900	
Total Costs after 9 Years	$ 17,370,180	$ 15,168,980	
Total Costs after 10 Years	$ 19,300,200	$ 16,619,060	

Estimated Cost Per Year for Diesel Fleet	$ **1,930,020**
Estimated Cost Per Year for CNG Fleet	$ **1,450,080**

Figure 3

Lastly are the variables associated with the fueling station. On the project in Southern California, the team installed 4 compressors capable of supporting 118 trucks. An equation was formed to factor the necessary compressors needed for the project in San Luis Obispo (Figure 4). The fueling station is a slow fill station that simply fuels the trucks for 8 hours overnight in order to load the most compressed natural gas into the tanks as possible. This method, as opposed to a fast-fill fueling station, is cheaper and fills the trucks to their maximum capacity. The only drawback is the time required to fill the tanks completely.

	Large Fueling Station $1.2-$1.8m	1500-2000 gge/day	
Quantity	Equipment	Total	Units
2	300-400 scfm Compressors (143-190 gge/hr)	$ 296,280.00	$/compressor
1	200 HP Ariel Compressor	$ 185,175.00	$/compressor
1	125 HP Ariel Compressor	$ 111,105.00	$/compressor
1	Dispenser	$ 45,000.00	$/unit
1	ASME Storage Sphere	$ 70,000.00	$/unit
15	Dual-hose time-fill post	$ 5,000.00	
1	Mechanical Desiccant Natural Gas Dryer	$ 10,000.00	$/unit
		$ 1,078,840.00	Total
		Installation Costs	50% of Equipment Costs

Figure 4

After conducting the study, a few conclusions were made. First, the many variables at play are subject to change both annually and day to day. Prices of diesel and compressed natural gas fluctuate every day and on a year to year average basis. It is very important to note this because with a truck that gets only 3.5 mpg and drives over 14,000 miles per year, a $0.10 change in the price of fuel can equate to hundreds of thousands of dollars for an entire fleet. Secondly, if these prices remain somewhat constant year to year, the conversion from diesel to CNG can be quite profitable, but with the volatility in gas prices and insecurity in acquiring tax credits, it is hard to predict whether the switch will profit in the long run. In SLO and surrounding areas, location of the fueling stations is also very important as they are quite expensive. Mixer trucks only have the ability to travel 45 min-1 hour before the concrete is no longer useable.

Conclusion

While many of these variables are subject to vary year to year, the fleet conversion should be able to profit in anywhere from 5-8 years, and savings continuing thereafter. It is recommended that CalPortland make the conversion, because switching from diesel to CNG can not only save money, but also have many environmental impacts that help reduce carbon footprint and pollution. CalPortland completed a conversion of 118 concrete mixer trucks in Southern California and after conducting my study, they will be able to use my information to decide if they would like to switch their fleet in San Luis Obispo and surrounding areas. The main reason this has not already been done is because San Luis Obispo is not considered a disadvantaged community. Being in a disadvantaged community, the Southern California project was able to profit more because of the benefits provided to disadvantaged communities from SLO APCD. Going forward, any company should be able to apply the research done in this study and apply it to a cost analysis of their own fleet of concrete mixer trucks. With sustainability at the front line of all areas of construction, having your company make the switch to CNG can be both economical and profitable.

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References

(n.d.). Retrieved from https://oehha.ca.gov/calenviroscreen/sb535

(n.d.). Retrieved from https://www.eia.gov/dnav/pet/pet_pri_gnd_dcus_sca_w.htm

Alternative Fueling Station Counts by State. (n.d.). Retrieved from https://afdc.energy.gov/stations/states

Alternative Fueling Station Counts by State. (n.d.). Retrieved from https://afdc.energy.gov/stations/states

CNGPrices. (n.d.). Retrieved from http://www.cngprices.com/stations/CNG/California/Santa-Barbara/

Compressed Natural Gas (CNG). (n.d.). Retrieved from https://www.arielcorp.com/cng/

EERE: Alternative Fuels Data Center Home Page. (n.d.). Retrieved from https://afdc.energy.gov/

Incentive Funding. (n.d.). Retrieved from http://www.ampamericas.com/resources/incentive-funding

National Renewable Energy Laboratory (NREL) Home Page. (n.d.). Retrieved from https://www.nrel.gov/

Solutions for Sustainability. (n.d.). Retrieved from http://www.cleanfuture.us/

State Laws and Incentives. (n.d.). Retrieved from https://afdc.energy.gov/laws/state