An Examination of Compressed Natural Gas For Use In Municipal Fleets: Would CNG Work For Lexington, KY?

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Executive Summary

Compressed Natural Gas (CNG) is an alternative fuel source which could replace diesel as a fuel for municipal fleets. This paper seeks to examine the viability of CNG and its potential to power Lexington-Fayette Urban County Government's fleet of waste removal trucks. This paper takes into account financial and environmental factors in determining CNG's potential, but gives priority to financial considerations. The results of this analysis are mixed—under some future scenarios, compressed natural gas would be a favorable option for the fleet, but given other future scenarios, CNG would not be viable. In terms of environmental benefits, a switch to CNG would represent at most a 0.08% reduction in greenhouse gases, but would net other social benefits such as increased visibility and lower cancer rates.

This analysis takes into account six different scenarios using two different variables. The scenarios are built using three different prices for diesel fuel: high prices, low prices, and the USA Energy Information Association's point estimate for the price diesel fuel, coupled with two different assumptions about the cost of compressed natural gas trucks compared to the cost of diesel trucks. Under the high price of diesel scenarios, there is a possibility that savings associated with adoption of compressed natural gas to fuel Lexington refuse vehicles could fully offset costs of the switch within a 10-year payback period. Under all other scenarios, the estimated savings would not fully offset costs within that payback period.

Introduction

For several decades municipalities have sought sources of fuel other than petroleum to power their various fleets. There exist multiple motivations for doing this, but the chief motivations include future financial savings and improved environmental stewardship. The price of petroleum products represents a major expense for municipalities, as it is a leading factor in transportation costs. Transportation costs are significant factors in all municipal budgets, therefore municipalities want to minimize these costs. The supply of oil depends heavily on many factors outside the control of municipal governments, and forecasts indicate that the price of oil could increase significantly in the future. Because of this, some municipal governments are seeking other sources of fuel (EIA).

In addition to financial arguments, environmental stewardship could motivate municipalities to switch from diesel fuel to alternative fuels. Municipalities provide several services which require the use of heavy duty vehicles—they are used to transport students, pick up garbage and recycling refuse, salt roads, and build public projects. While heavy duty vehicles make up only 4% of the United State vehicle fleet, they account for 25% of the fuel demand (Bryson, Underwood, 2006). Burning fuel emits several chemicals, including significant amounts of carbon dioxide, nitrous oxide, carbon monoxide, and nitric dioxide—all of which have been found by the United States Environmental Protection Agency to be threats to human health. In addition, many municipalities have taken it upon themselves to take part in the Kyoto Protocol, an environmental pact which failed to pass the US Senate (Riley). Cities take part in this treaty by signing the Mayors Climate Protection Agreement, which calls for a 7% reduction in emissions below 1990 levels. The city of Lexington, along with 1,046 other cities has signed on to this agreement.

Municipalities have begun replacing some of their diesel fuel demand with compressed natural gas. Compressed natural gas demand has grown significantly since the mid 2000s—beginning in

California and then spreading to Texas and New York and then to many other locations across the country. How compressed natural gas took hold in each of these locations explains a significant amount about why municipal demand for compressed natural gas has increased in use from the west coast to the east coast since 2004, and gives clues about whether or not compressed natural gas is a viable option for LFUCG.

The Spread of Compressed Natural Gas

In the summer of 2000, the South Coast Air Quality Management District, an air pollution regulatory body in southern California, passed a regulation stating that any fleet—public or private—with more than fifteen vehicles must buy vehicles which use a fuel deemed 'clean' by the SCAQMD whenever it replaced or added to its fleet. Vehicle manufacturers sued the Air Quality Management District, and in 2004, the United States Supreme Court ruled 8-1 that the regulatory agency did not have the authority to regulate private fleets (Engine Manufacturers…, 2004). Shortly after that decision, the South Coast Air Quality Management District amended its ruling such that it only applied to government fleets and—importantly— to fleets which contract directly with the government. Almost overnight, the market for alternatively fueled vehicles grew by the amount of trucks used to complete city contracts. If fleets wanted to keep their contracts with municipal governments, they had to find ways to operate with clean fuels.

At this point, Clean Energy Corporation, a well-funded company with an experienced leader in the energy industry at the helm, was in a prime position to take advantage of this new development. Between 2006 and 2011, Clean Energy built 46 new compressed natural gas stations on the south coast of California. As of February 2011, Clean Energy operated 46 fueling stations within the confines of the South Coast Air Quality Management District (Clean Energy, 2011).

In 2006, a meeting occurred between two people which had a significant impact on the spread of CNG. Joanna Underwood, the President of Energy Vision—a not-for-profit seeking to expand the use of renewable and alternative fuels—met Russell Barnett, the Environmental Director in the town of Smithtown, NY. Ms. Underwood had given a presentation about the use of compressed natural gas in municipal waste fleets which had caught Mr. Barnett's attention. The two of them began a collaboration to facilitate the expansion of CNG use to the East Coast.

Smithtown is a town on Long Island in New York with 118,000 people. Its division of waste management has 22 trucks which use 250,000 diesel gallon equivalents per year. It contracts with 4 different waste removal companies (called carters) to service the town. In 2006, Mr. Barnett devised a plan to utilize CNG in these fleets. Drawing from the example in California, Mr. Barnett worked to pass a law in Smithtown that carters which have a contract with the town must utilize Compressed Natural Gas as their fuel source. The town entered into a contract with Clean Energy Corporation to build a natural gas compressor. Smithtown agreed to provide business to the compressor for a term of 20 years by requiring their carters to buy CNG, and in return, Smithtown negotiated a 7 year fixed price for the compressed natural gas it sells, which it passed on to the carters (Barnett, 2011).

According to Mr. Barnett, the carters that contract with Smithtown favor this contracting policy. In his estimation, fixed pricing allows contractors to more accurately forecast their costs and weigh whether or not contracting with the city is profitable. The costs of contracts between Smithtown and the carters did become more expensive because of the premium which carters had to now pay for compressed natural gas trucks. The employees who collect refuse in Smithtown were originally reticent to accept the new trucks because of perceived deficiencies in the torque and power of the trucks, but according to Mr. Barnett, once they realized that CNG burned odorless and tasteless and that the deficiencies were less than expected, they became some of the biggest supporters of the switch.

Mr. Barnett's figures indicate a $3.34 savings per home against using diesel. He arrives at these figures from a $7.38 per home incremental cost for CNG vehicles (incremental fleet cost) and a $10.72 per home fuel savings. This touted success has caused compressed natural gas to spread to the nearby town of Brookhaven (Underwood, 2011)(DiBrita, 2011).

Brookhaven is the largest of the 14 towns on Long Island. It is more than double the size of Smithtown, with 450,000 people and a fleet of 67 trucks. After hearing about the claimed results of the compressed natural gas program in Smithtown, the city of Brookhaven also opted to implement a law requiring contractors to utilize compressed natural gas. Brookhaven also contracted with Clean Energy to build a compressed natural gas filling station in their town. The second station built by Clean Energy on Long Island is larger than the first, and would allow for expansion to other parts of Long Island (DiBrita, 2011).

While Clean Energy often points to Long Island as a success story, the question remains as to whether or not these cases are comparable to Lexington, KY. There exist significant differences between Lexington, these Long Island towns, and southern California. First and foremost, Lexington owns its own fleet of refuse collection vehicles. Also, Lexington does not have an air quality regulatory body requiring adoption of alternative fuels. Unlike California, a switch to CNG in Lexington would represent a proactive change—meaning the status quo is a viable option in Lexington. Unlike Long Island, Lexington would have fewer points at which to hedge its risk—meaning that any cost increase would be entirely born by the city, not by the city and contractors. While there exist significant and important similarities between Lexington and these areas, a better fix to Lexington might be found elsewhere.

A city with a situation more similar to Lexington's is San Antonio, TX. Like Lexington, San Antonio operates its own fleet of refuse collection trucks. Unlike any of the other cities in question, San

Antonio owns the local natural gas provider, and therefore sells the gas directly to Clean Energy to compress. The contract with Clean Energy is just to compress the natural gas, and therefore leaves the city the most exposed to risk of any of the cities in question. In an interview with David Lopez, the administrative chief of San Antonio's solid waste division, he revealed that San Antonio originally decided to use compressed natural gas for the cost savings it thought it would realize. Lopez stated that the fuel cost savings had been significant, but it was up in the air as to whether or not the savings would pay for the extra cost which the city paid for the trucks. Mr. Lopez indicated that San Antonio was "on the fence" about expanding the use of compressed natural gas.

There exist a multitude of reasons why San Antonio might be less satisfied with its CNG program than Long Island. However, it is interesting to note that the municipality with the situation most closely resembling Lexington is the municipality which is the least enthusiastic about the use of the fuel. Perhaps the same issues which make Lexington comparable to San Antonio also predict a similar less-than-impressive result from adopting CNG. This necessitates additional analysis of the potential for the use of CNG in the city of Lexington.

The Use of Compressed Natural Gas

The two driving factors which led to the spread of compressed natural gas across the country are expected financial savings and the anticipated environmental improvements related to the use of compressed natural gas. Technology is never static, and all fuels burn considerably cleaner than they ever have before. However, compressed natural gas burns quantifiably cleaner than traditional diesel without particulate capturing technologies (Ayala, 2011) (Das, 2000) (Chandler, 2002).

The Environmental Protection Agency states that burning compressed natural gas as opposed to petroleum based fuels reduces the emissions of carbon monoxide by between 90-97%, and reduces the amount of carbon dioxide by 25%. In addition to these reductions in greenhouse gases, there is also "little to no particulate matter" or carcinogens released by burning compressed natural gas as opposed to burning petroleum based fuels (Clean Alternative Fuels, 2002).

However, other studies point to problems with burning compressed natural gas. CNG is mostly methane, and burning methane releases different chemicals than petroleum—particularly formaldehyde, a human carcinogen (Turrio-Baldassarri, 2006) (Kado, 2005). In some studies, especially ones conducted internationally, CNG has been shown to increase the amount of NO_x, nitrous oxide, in the atmosphere (Compressed Natural Gas versus Diesel…, 2005) (Ravindra, 2006). In all studies which cite this phenomenon, it remains scientifically unexplained. However, even in studies citing these problems with CNG, the conclusion has been that compressed natural gas represents an improvement over conventional diesel in terms of greenhouse gas emissions.

Alberto Ayala is the chief of the monitoring and laboratory division of the California Environmental Protection Agency. He has conducted more than 20 studies regarding particulate matter and other emissions, with a significant amount of those studies involving the use of Compressed Natural Gas. In an interview, he said that the question which he finds most intriguing is comparing compressed natural gas to clean diesel. This is relevant, as clean diesel may be another option for reducing emissions for municipalities while retaining the ability to use existing equipment and facilities.

Ultra-low sulfur diesel (ULSD) is a cleaner variety of diesel which has been shown to emit considerably less particulate matter and fewer greenhouse gases. It has been in use in most of the United States since 2006. Using this fuel is helpful for reducing emissions. In addition, there are several repairs to vehicles which use diesel that can reduce emissions, including particulate filters and carbon capturers. These physical repairs also significantly reduce the emissions of vehicles which run on diesel (Schubert, 2010) (Study of CNG and Diesel Transit Emissions, 2004) (ARB's Study of Emissions…, 2002).

In Mr. Ayala's estimation, neither compressed natural gas nor complete utilization of these clean diesel technologies produces a better result than the other from an emissions standpoint. In other words, neither technology dominates the other in terms of emissions. However, both of these alternatives have a cost associated with them (Ayala, 2011). As the LFUCG is actively considering CNG, this is the alternative that is evaluated in this report. This analysis will not consider the use of clean diesel, but this alternative ought to also be examined by LFUCG.

How the world will change in the future also represents an important consideration to make when considering a switch to CNG. According to Joanna Underwood of Energy Vision, the goal for heavy duty vehicle fuels should be biomethane—a transportation fuel derived from biological waste such as food or animal waste. Biomethane has the energy potential to deliver the performance needed for larger vehicles, while hybrid and electric vehicle alternatives do not, in her opinion. Biomethane is a gaseous fuel which has the same composition as compressed natural gas. If a vehicle accepts compressed natural gas, it will also accept biomethane. Biomethane is carbon neutral or carbon negative. Also, as long as the human population continues consuming meat at the current rate and continues utilizing its current landfill system, biomethane represents a completely renewable fuel. It is likely worthwhile to take this into account when considering a switch from diesel to compressed natural gas.

Concerns about extraction and the after-use impacts of fuel use also exist when considering compressed natural gas and petroleum. First, the United States owns vast reserves of natural gas. What natural gas the United States does import, it imports from Europe and Canada. If concerns exist about the issue of energy dependence, it would appear that natural gas would provide an amenable alternative to petroleum, which is in part imported from the Middle East and Venezuela (Ayala, 2011) (Underwood, 2011).

However, there are concerns about the production of natural gas. Hydraulic fracking is a method of mining natural gas in which large amounts of water, sand, and chemicals are pumped into a well, freeing natural gas to flow more smoothly. In 2004, the US EPA released a study concluding that there existed no linkage between hydraulic fracking and drinking water contamination, despite hypotheses that this process led to issues surrounding water table contamination and earthquakes (Evaluation of Impacts…, 2004). Other than the EPA study, little scholarly work exists on this issue as of yet, but there has been an Oscar-nominated documentary entitled *Gasland* made about the dangers of fracking. There is a new paper which the journal *Climate Change Letters* will publish in May about the damages of fracking. Media reports about the paper quote that "Compared to coal, the [greenhouse gas] footprint of shale gas is at least 20% greater and perhaps more than twice as great on the 20-year horizon and is comparable when compared over 100 years." The issue of fracking will likely be one debated in academic circles in the coming years, but little solid evidence has been published about it by the time of this analysis. (Fast Company, 2011)

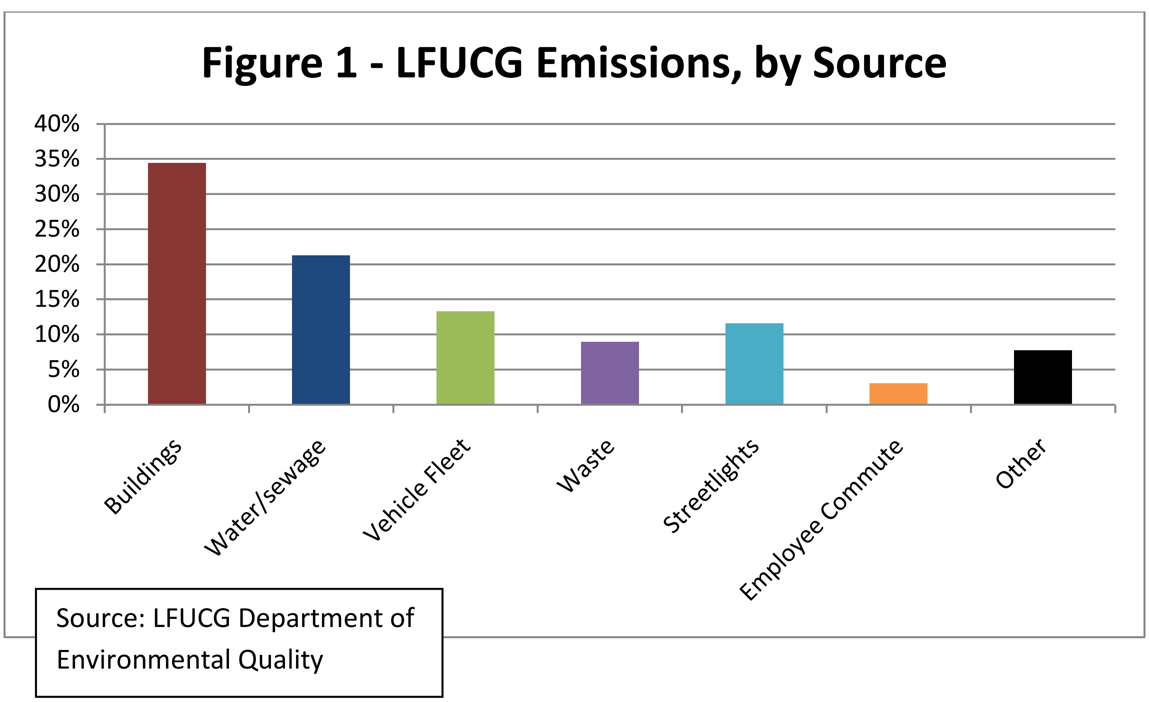
Compressed Natural Gas in Lexington, KY

Lexington, KY is a city of 270,000 which operates its own fleet of 125 refuse collection trucks. Like many other municipalities, Lexington has signed onto the Kyoto Protocol. Clean Energy Corporation approached the municipality recently about investigating the use of compressed natural gas in its refuse collection fleet. The city of Lexington's Division of Waste Management's director, Richard Boone, is currently investigating whether or not this switch would make sense.

The city of Lexington is attracted to the use of CNG because of its potential cost savings and for its reduced environmental impact. In order to determine whether or not it should switch to compressed natural gas, the cost and benefits of doing so must be investigated. First, the benefits in terms of emissions reduction will be quantified. Then, in order to determine if the city will receive any cost savings, a model will be constructed taking into account the expenditures of the city on fuel if it continues to use diesel compared to a potential shift to compressed natural gas.

The benefits to Lexington with which this analysis is concerned include the reduction in greenhouse gas emissions due to a switch from diesel to the use of compressed natural gas. As a signatory of the US Mayor's Climate Protection Agreement, the Lexington Fayette Urban County Government has obligated itself to reduce its emissions to 7% less than 1990 amounts. Furthermore, the city has joined the International Council of Local Environmental Initiatives, which requires its members to complete a "baseline emissions inventory and forecast" in order to adopt an emissions target (Webb, 2011).

Lexington's Department of Environmental Quality recently completed their "baseline emissions inventory and forecast." As a part of that report, the LFUCG learned that their vehicle fleets made up 13% of its total carbon footprint, as can be seen in Figure 1.



Furthermore, research by Energy Vision, the National Energy Policy Institute and the California Department of Energy indicates that switching from diesel to CNG reduces greenhouse gas emissions from between 11% and 29% (Krupnik, 2010)(Stoner, 2007)(Cannon, 2006). A high estimate for the impact of switching from diesel to CNG, therefore, would be reducing 13% of LFUCG's total emissions by 29%. This would have the effect of reducing LFUCG's total emissions by 4%. The corresponding low estimate would yield a 1.5% reduction.

The Mayor's Climate Change Climate Protection Agreement requires that communities reduce their total greenhouse gas output to 7% below 1990 levels. The LFUCG makes up 2% of the total greenhouse gas output of the city of Lexington. Therefore, if the switch were to be made to CNG, it would have the effect of reducing 2% of the city's total by 4%. Therefore, ultimately, if a switch to CNG were to be made, it would reduce LFUCG's emissions by .08%.

The financial model completed in this analysis forecasts savings due to a switch from compressed natural gas for the years of 2011 until 2021. This test period is utilized because according to Mike Riley of Clean Energy, the typical contract period with Clean Energy is ten years. This model includes six different scenarios. The scenarios are a product of the three different diesel price assumptions (high, point estimate, and low prices) and two different assumptions about how much more the government would pay for compressed natural gas vehicles compared to diesel trucks. Compressed natural gas trucks are more expensive than regular diesel trucks. The exact surcharge is impossible to forecast, as each municipality contracts with vehicle manufacturers based on a multitude of different rationales. However, from interviews with professionals in the field of compressed natural gas, it can be reasonably assumed that the exact cost is between $40,000 and $60,000 for each CNG truck (DiBrita, 2011)(Underwood, 2011)(Barnett, 2011)(Lopez, 2011). As a point of reference, Lexington typically pays $250,000 for a new diesel truck. The additional $40,000 and $60,000 are the two surcharges used in this model.

Lexington's expenditures on diesel fuel are a function of the price of diesel and the city's demand for fuel. In order to forecast expenditures, then, assumptions regarding the future values of these factors need to be determined. The United States Energy Information Administration reports on and forecasts the price of different fuels. From the EIA, one can easily determine the price of diesel in any past year. For purposes of this project, EIA estimates for diesel in the region where Lexington exists were used in order to calculate the city government's expenditures for fuel.

However, moving into the future proves a bit more difficult. The price of diesel fuel is a function of several different factors—refining costs, distribution & marketing, taxes, and crude oil all play a part in the cost of diesel fuel. The EIA does provide estimates about the price of diesel going forward, but does not speculate on a range of prices in the future. The EIA does, however, provide a high and low estimate for the price of crude oil in the future. For the purposes of this project, the estimates of high and low prices of diesel were determined in the following manner.

- Determine the mean difference between the high estimate and point estimate for crude oil as projected by the EIA between the years 2011 and 2035. This turned out to be a mean difference of 154%.
- Determine the mean difference between the low estimate and point estimate for crude oil as projected by the EIA between the same period of time. This turned out to be a mean difference of 49%.
- Multiplying the point estimate for diesel prices for the EIA by the mean differences calculated above.

In short, EIA point estimates for diesel were multiplied by 156% and 49% to determine a high and low price for diesel.

At this point it becomes necessary to address the rationale for how the EIA develops its high price and low price projections for crude oil. The data used in this project comes from the EIA document entitled "Annual Energy Outlook 2010 with projections to 2035." Inside this document, the EIA justifies its predictions on both the supply and demand sides. According to this document, the low price of oil depends primarily on the supply side of the market, with OPEC nations opening development to private firms and increasing their supply. The high price depends on both supply and demand—demand in that worldwide growth increases demand for oil and supply in that OPEC remains closed and non-OPEC countries adopt more conservative fiscal policies. Furthermore, under the high price scenario, regulation of products containing petroleum increases.

The tactic used to estimate diesel prices in this analysis projects the high and low estimates for the price of diesel only utilizing the price of crude oil. If the other factors involving the price of diesel change at a different rate, or do not change at all, that will not be captured in the estimates. Figure 2 reports the EIA estimates for the makeup of the price of petroleum products. Analysis of Figure 2 shows that taxes represent the factor in the price of petroleum products which varies the most. Municipal governments do not pay taxes on petroleum products. Additionally, the two other factors included in the EIA's assessment depend on the price of crude oil. Therefore, this assumption is believed reasonable. The EIA also reports and forecasts the price of natural gas. This project also utilizes those estimates.

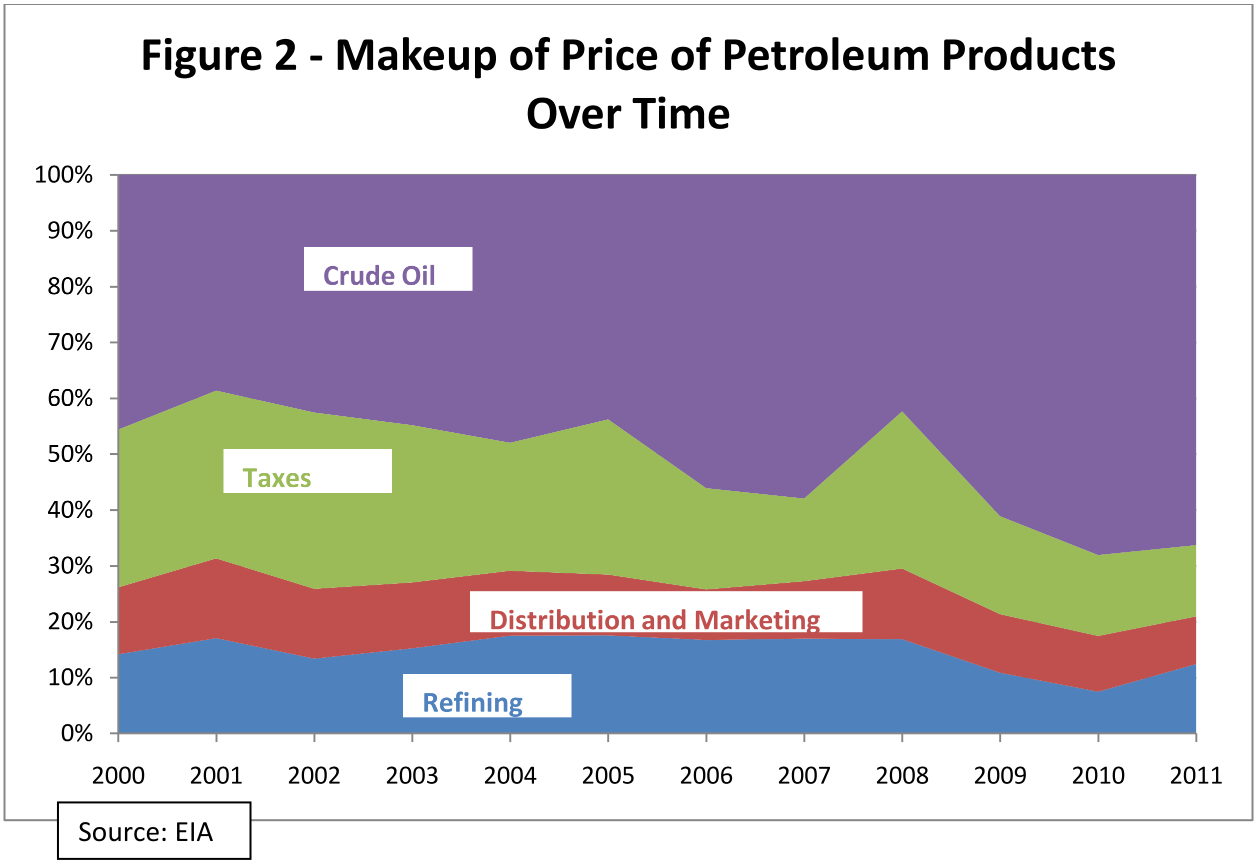


Figure 3 shows the price of fuels using EIA estimates. Solid lines indicate the historic prices as reported by the EIA, while dots indicate forecasted prices. Dashes project the high and low prices of diesel. A high and low price for natural gas was not calculated. Natural gas prices only come into play when calculating profits for the company compressing the natural gas. In this model, Clean Energy would charge a fixed price for natural gas and therefore assumes all the risk associated with varying prices of natural gas. The profits and losses of Clean Energy are of little concern to LFUCG, and therefore natural gas prices are only used for reference in Figure 3.

In order to determine the demand for fuel in Lexington, Richard Boone, a data manager for the waste management division of LFUCG, was contacted. Although a report about the change in demand in Lexington has not been published, after examining the data provided by Tracey Thurman of the LFUCG, Mr. Boone recommended utilizing a 5% annual growth rate. As can be seen in Figure 4, given the six data points previous, this 5% growth rate seems a reasonable assumption. The mean marginal change in fuel usage between the six data points in the LFUCG data is 5.5%.

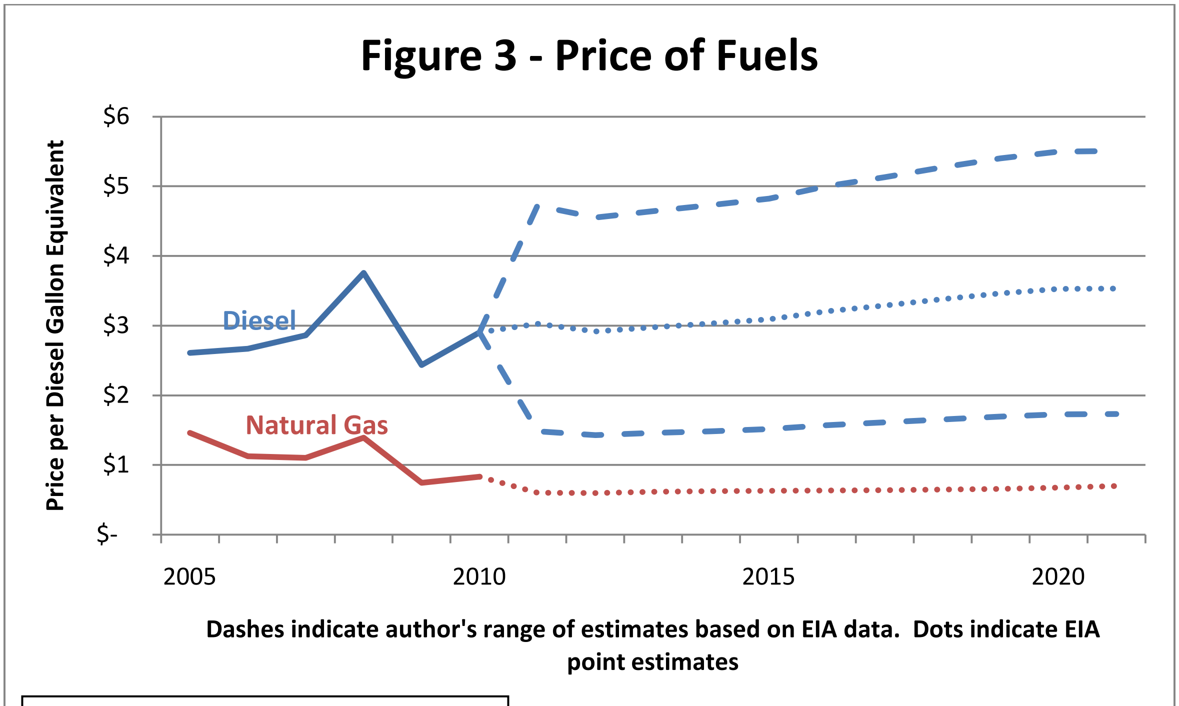


Figure 3 - Price of Fuels

Source: EIA, Author's Projections

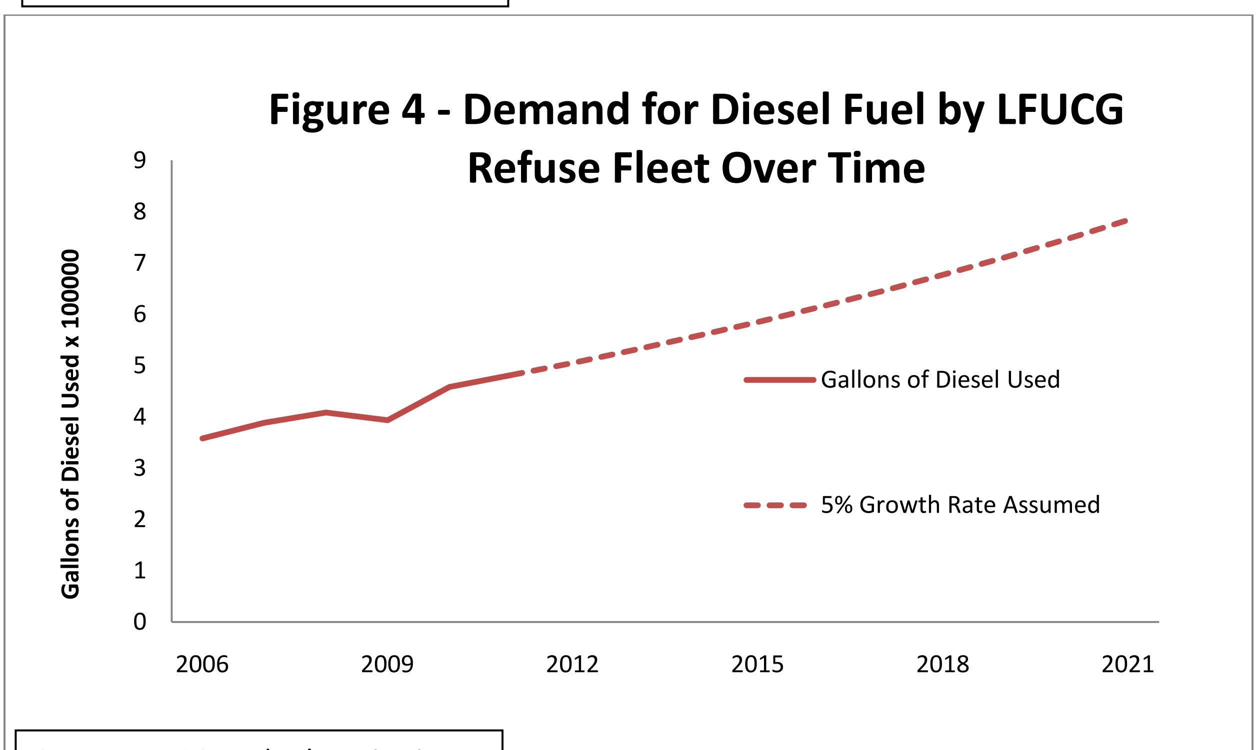
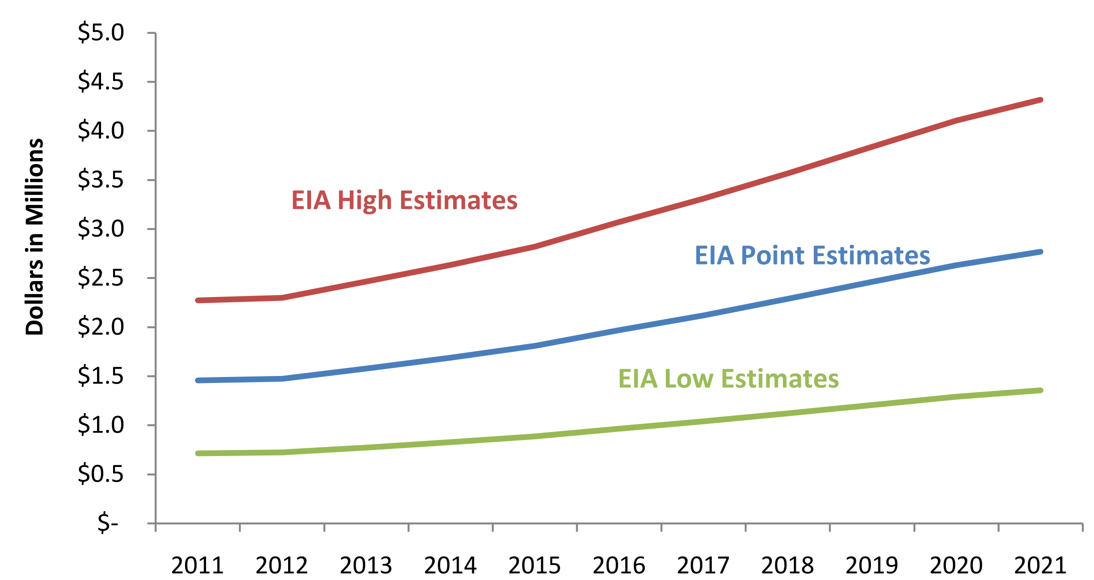


Figure 4 - Demand for Diesel Fuel by LFUCG Refuse Fleet Over Time

Source: LFUCG, author's projections

The information from Figures 3 and 4 indicate how the city would consume diesel fuel given the status quo. Three scenarios can be shown assuming LFUCG continues to fuel their trucks with diesel by multiplying the demand for fuel by the three different estimates for the price of diesel. We can use these scenarios as a base case, or counterfactual, in order to compare an alternate future which takes into account a policy change. This alternative future takes into account estimates about the price charged for compressed natural gas. Figure five shows the three different expenditures on diesel which LFUCG would make under the different prices shown in figure four.

Figure 5 - Projected Expenditures on Diesel Fuel by LFUCG



Source: EIA, LFUCG, Author's Projections

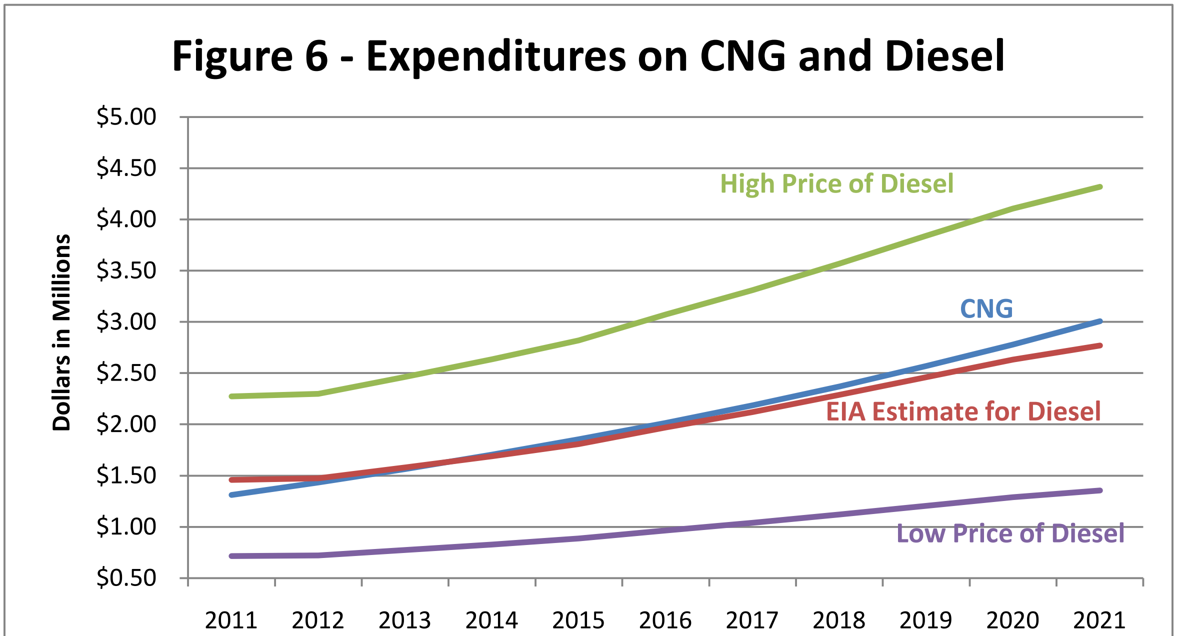
Clean Energy Corporation has contractually agreed to charge towns in Long Island, NY a fixed set for compressed natural gas which is allowed to increase at 11 cents annually between the years of 2008 and 2013, beginning at the price of $2.502/diesel gallon equivalent (DGE) in 2008. For this model, these numbers are utilized. In addition, the 11 cent annual increase is kept throughout the 10 year period. Table 1 shows these prices. It is possible that, if Lexington were to enter into a contractual agreement with Clean Energy, it may negotiate a different price schedule than did the towns on Long Island. However, given that Clean Energy has a large amount of vertical integration as a national corporation with access to natural gas markets all over the country; this means that Clean Energy has a similar ability to supply CNG to most of the United States. Therefore, supply would not be a factor in whether or not Lexington faces a similar price schedule to the one on Long Island. Although it is conceivable that the price schedule which Clean Energy wants to supply to Lexington would differ, there do not seem to be any physical rationale for why the Long Island price schedule would not be possible. Therefore, this report utilizes the Long Island prices. Furthermore, from data obtained from Long Island and the EIA, it appears that Clean Energy bases its price of diesel gallon equivalents of compressed natural gas on the price of diesel rather than the price of natural gas. This point will be discussed in greater detail later in the analysis. Given these factors, this analysis utilizes the prices charged to Long Island towns as the estimated prices for CNG in Lexington.

Table 1 - Price of CNG on Long Island per Diesel Gallon Equivalent

2008	$	2.335
2009	$	2.502
2010	$	2.613
2011	$	2.724
2012	$	2.836
2013	$	2.947
2014	$	3.058
2015	$	3.169
2016	$	3.280
2017	$	3.391
2018	$	3.502
2019	$	3.613
2020	$	3.724
2021	$	3.835

Red Values indicate actual prices on Long Island (source: Russell Barnett, Smithtown, NY), black values indicate author's projections.

Total fuel expenditures for a CNG fleet can be calculated by multiplying the prices in Table 1 by the demand for fuel shown in Figure 4. Figure 6 compares estimated total fuel expenditures for a CNG fleet to the three scenarios of total fuel expenditures of a diesel fleet.



Source: EIA, LFUCG, Smithtown, NY, and Author's Projections

At this point, only the expenditures on fuel have been estimated. In order to complete the analysis, expenditures for equipment and facilities must also be considered as well. In every Clean Energy contract studied for this project, Clean Energy built and maintained a compressed natural gas facility from which municipal governments were contractually obligated to buy. Therefore, the only additional cost faced by the municipal government was the extra cost for each compressed natural gas vehicle purchased. As stated above, the range of extra costs this model utilizes are $40,000 and $60,000 per vehicle.

According to documents obtained from the Department of General Services of Lexington Fayette Urban County Government, Lexington replaces an average of 21 of its fleet of 114 annually. To complete the analysis, the total fuel savings accumulating over the 10-year period from a switch to compressed natural gas is subtracted from the extra cost the government must pay for the number of CNG vehicles purchased. This can be seen graphically in Figure 4. The difference between the various diesel curves and the CNG curve are the fuel savings due to CNG. Since this change occurs gradually the per-truck savings due to a switch to CNG is calculated, and then multiplied by the number of CNG trucks purchased by the government in each year. For instance, there are only 21 CNG trucks in use during a hypothetical 2011, and therefore only the savings accrued to those 21 trucks are considered. In 2012, that number grows to 42. By 2016, the full 113 truck fleet would be compressed natural gas vehicles, and therefore the full fuel savings amount could be realized.

In order to accurately represent the likely savings for LFUCG, two items must be compared. First, the positive fuel savings estimated for the switch from diesel to CNG due to the fact that CNG is cheaper than diesel; and second, the additional costs associated with the higher price of CNG vehicles. The net savings from the two factors was calculated for each year. Then annual net savings were summed from each year to the next to determine whether the accumulated net savings become positive in any year of the 10-year time horizon under analysis. These accumulated savings can be seen in figures seven and eight, and in Tables 2-4.

As an example, for the high price of diesel and the smaller ($40,000) additional cost for CNG trucks, the fuel savings in 2011 from adopting CNG vehicles is $178,785.51. This is the cost of fuel that 21 of the 113 trucks in LFUCG's fleet would use given the demand for fuel found in Figure 4. The 21 CNG vehicles would cost an additional $840,000 over the cost of diesel trucks. (This is 21 multiplied by $40,000.) The difference between these the fuel savings and the additional price of the CNG trucks represents a net annual cost of $(661,214). In 2012, the fuel savings due to using CNG as a fuel could be $322,000, which is the amount of fuel that 42 trucks in LFUCG's fleet would use given the demand found in figure four. The 21 new CNG vehicles bought by LFUCG would again, cost $840,000. The difference between the 2012 figures is $(518,044). This figure, when added to the 2011 figure of $(661,214) is $(1,179,258). This is the figure reported in both table two and figure seven. This process is repeated for each year between 2011 and 2021. The differential between CNG savings and the surcharge becomes positive in 2015, and the accumulated differentials become positive in 2020 for this scenario.

As can be seen from the graphs, in a future where either the EIA point estimate price for diesel or the lower bound estimated price for diesel holds, the fuel cost savings from a change to compressed natural gas will never exceed the additional cost of the CNG trucks. However, if the price of diesel were to approach the upper bound estimate, and the extra cost of a CNG truck is $40,000 rather than $60,000, a switch to CNG would pay for itself within 10 years.

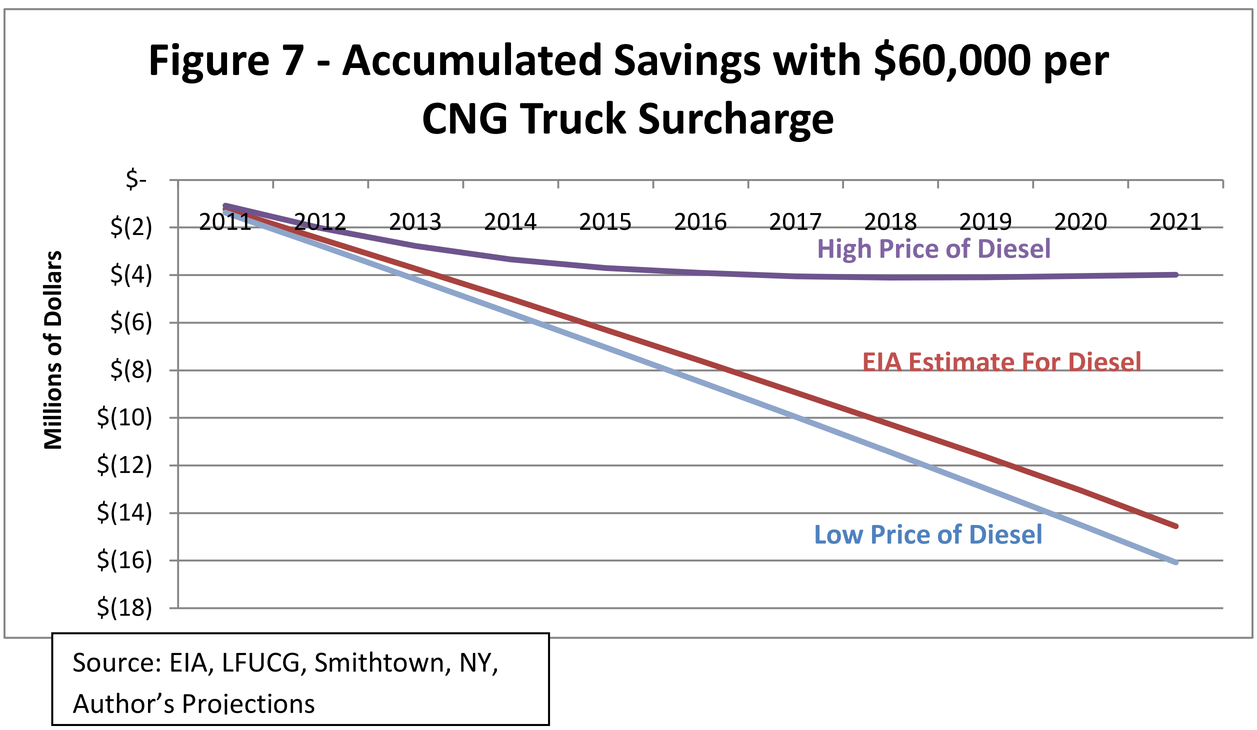
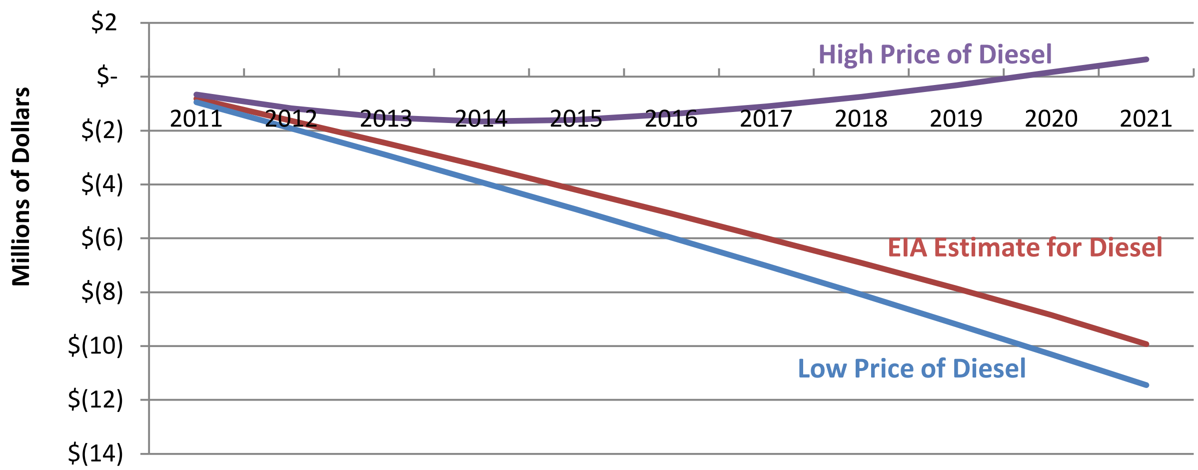


Figure 8 - Accumulated Savings With $40,000 per CNG Truck Surcharge



Source: EIA, LFUCG, Smithtown, NY, Author's Projections

Table 2 - Accumulated Savings for LFUCG Given Upper Bound Price for Diesel

		$40K Surcharge for CNG Vehicles			$60K Surcharge for CNG Vehicles		
	No. of CNG Vehicles	Fuel Savings of CNG Vehicles	Differential	Accumulated Savings	Fuel Savings of CNG Vehicles	Differential	Accumulated Savings
2011	21	$ 178,785.51	$ (661,214.49)	$ (661,214.49)	$ 178,785.51	$ (1,081,214.49)	$ (1,081,214.49)
2012	42	$ 321,955.83	$ (518,044.17)	$ (1,179,258.66)	$ 321,955.83	$ (938,044.17)	$ (2,019,258.66)
2013	63	$ 502,152.13	$ (337,847.87)	$ (1,517,106.53)	$ 502,152.13	$ (757,847.87)	$ (2,777,106.53)
2014	84	$ 693,228.39	$ (146,771.61)	$ (1,663,878.14)	$ 693,228.39	$ (566,771.61)	$ (3,343,878.14)
2015	105	$ 898,604.61	$ 58,604.61	$ (1,605,273.53)	$ 898,604.61	$ (361,395.39)	$ (3,705,273.53)
2016	113	$ 1,057,358.19	$ 217,358.19	$ (1,387,915.34)	$ 1,057,358.19	$ (202,641.81)	$ (3,907,915.34)
2017	113	$ 1,121,922.73	$ 281,922.73	$ (1,105,992.61)	$ 1,121,922.73	$ (138,077.27)	$ (4,045,992.61)
2018	113	$ 1,197,746.02	$ 357,746.02	$ (748,246.59)	$ 1,197,746.02	$ (62,253.98)	$ (4,108,246.59)
2019	113	$ 1,270,257.13	$ 430,257.13	$ (317,989.46)	$ 1,270,257.13	$ 10,257.13	$ (4,097,989.46)
2020	113	$ 1,325,809.35	$ 485,809.35	$ 167,819.89	$ 1,325,809.35	$ 65,809.35	$ (4,032,180.11)
2021	113	$ 1,312,271.47	$ 472,271.47	$ 640,091.37	$ 1,312,271.47	$ 52,271.47	$ (3,979,908.63)

Source: EIA, LFUCG, Smithtown, NY, Author's Projections

Table 3 - Accumulated Savings for LFUCG Given EIA Point Estimate for Price of Diesel

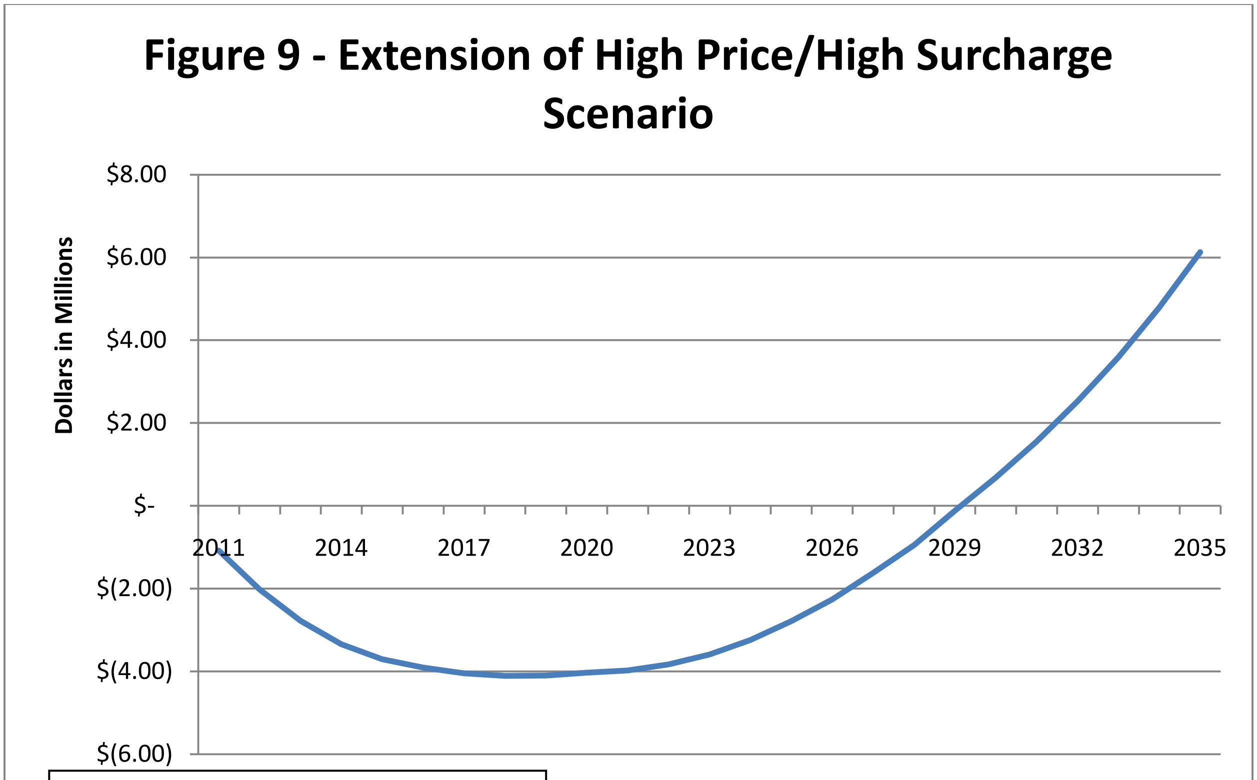
		$40K Surcharge for CNG Vehicles			$60K for CNG Vehicles		
	No. of CNG Vehicles	Fuel Savings of CNG Vehicles	Differential	Accumulated Savings	Fuel Savings of CNG Vehicles	Differential	Accumulated Savings
2011	21	$ 27,160.37	$ (812,839.63)	$ (812,839.63)	$ 27,160.37	$ (1,232,839.63)	$ (1,232,839.63)
2012	42	$ 15,195.55	$ (824,804.45)	$ (1,637,644.08)	$ 15,195.55	$ (1,244,804.45)	$ (2,477,644.08)
2013	63	$ 8,988.14	$ (831,011.86)	$ (2,468,655.94)	$ 8,988.14	$ (1,251,011.86)	$ (3,728,655.94)
2014	84	$ (10,188.71)	$ (850,188.71)	$ (3,318,844.65)	$ (10,188.71)	$ (1,270,188.71)	$ (4,998,844.65)
2015	105	$ (42,245.29)	$ (882,245.29)	$ (4,201,089.94)	$ (42,245.29)	$ (1,302,245.29)	$ (6,301,089.94)
2016	113	$ (45,327.26)	$ (885,327.26)	$ (5,086,417.20)	$ (45,327.26)	$ (1,305,327.26)	$ (7,606,417.20)
2017	113	$ (65,790.82)	$ (905,790.82)	$ (5,992,208.03)	$ (65,790.82)	$ (1,325,790.82)	$ (8,932,208.03)
2018	113	$ (83,414.56)	$ (923,414.56)	$ (6,915,622.58)	$ (83,414.56)	$ (1,343,414.56)	$ (10,275,622.58)
2019	113	$ (107,821.88)	$ (947,821.88)	$ (7,863,444.46)	$ (107,821.88)	$ (1,367,821.88)	$ (11,643,444.46)
2020	113	$ (148,061.17)	$ (988,061.17)	$ (8,851,505.64)	$ (148,061.17)	$ (1,408,061.17)	$ (13,051,505.64)
2021	113	$ (237,868.74)	$ (1,077,868.74)	$ (9,929,374.38)	$ (237,868.74)	$ (1,497,868.74)	$ (14,549,374.38)

Source: EIA, LFUCG, Smithtown, NY, Author's Projections

Table 4 - Accumulated Savings for LFUCG Given Lower Bound Price for Diesel							
		$40K Surcharge for CNG Vehicles			$60K Surcharge for CNG Vehicles		
	No. of CNG Vehicles	Fuel Savings of CNG Vehicles	Differential	Accumulated Savings	Fuel Savings of CNG Vehicles	Differential	Accumulated Savings
2011	21	$ (110,926.81)	$ (950,926.81)	$ (950,926.81)	$ (110,926.81)	$ (1,370,926.81)	$ (1,370,926.81)
2012	42	$ (132,087.71)	$ (972,087.71)	$ (1,923,014.52)	$ (132,087.71)	$ (1,392,087.71)	$ (2,763,014.52)
2013	63	$ (146,714.45)	$ (986,714.45)	$ (2,909,728.97)	$ (146,714.45)	$ (1,406,714.45)	$ (4,169,728.97)
2014	84	$ (162,700.18)	$ (1,002,700.18)	$ (3,912,429.14)	$ (162,700.18)	$ (1,422,700.18)	$ (5,592,429.14)
2015	105	$ (179,818.15)	$ (1,019,818.15)	$ (4,932,247.29)	$ (179,818.15)	$ (1,439,818.15)	$ (7,032,247.29)
2016	113	$ (195,050.72)	$ (1,035,050.72)	$ (5,967,298.02)	$ (195,050.72)	$ (1,455,050.72)	$ (8,487,298.02)
2017	113	$ (213,244.51)	$ (1,053,244.51)	$ (7,020,542.52)	$ (213,244.51)	$ (1,473,244.51)	$ (9,960,542.52)
2018	113	$ (232,335.41)	$ (1,072,335.41)	$ (8,092,877.93)	$ (232,335.41)	$ (1,492,335.41)	$ (11,452,877.93)
2019	113	$ (253,274.52)	$ (1,093,274.52)	$ (9,186,152.45)	$ (253,274.52)	$ (1,513,274.52)	$ (12,966,152.45)
2020	113	$ (276,965.12)	$ (1,116,965.12)	$ (10,303,117.57)	$ (276,965.12)	$ (1,536,965.12)	$ (14,503,117.57)
2021	113	$ (306,563.50)	$ (1,146,563.50)	$ (11,449,681.07)	$ (306,563.50)	$ (1,566,563.50)	$ (16,069,681.07)

Source: EIA, LFUCG, Smithtown, NY, Author's Projections

The case of the high price of diesel merits further investigation. As can be seen from figure eight and table two, it appears that given a high price of diesel, the program could pay back even with a high surcharge for CNG trucks--eventually. The EIA provides estimates of the price of diesel until the year 2035. In its estimates from 2011 until the year 2021, the EIA average increase in their point estimate for diesel is $0.1110 per year, which is the exact annual increase Clean Energy has negotiated with the towns on Long Island for compressed natural gas. However, from the years 2021 until 2031, the average increase in EIA's point estimates for diesel is only $0.0498, and from 2035, the average increase is $0.0167. Therefore, if this model is extended past 2021, it is not rational to assume the average increases in the diesel gallon equivalent stay at $0.1110. It is extremely likely that the city will renegotiate prices with Clean Energy. For the purposes of this model, the annual increase in the price of a diesel gallon equivalent of CNG charged by Clean Energy between the years of 2021 and 2031 has been changed to $0.0498, and from 2031 until 2035, it has been changed to $0.0167. These assumptions are the basis for figure nine, which shows an extension of the high price, high surcharge scenario from figure eight and table two. Under these conditions, the high price of diesel with high surcharge for trucks begins paying back in 2029, which would be under the second hypothetical contract period with Clean Energy Corporation.



Source: EIA, LFUCG, Smithtown, NY, author's projections

Of course, the further into the future the model projects, the less accurate the predictions are likely to be. Assuming a 5% growth rate for the city for such a long period of time may become problematic. Also, it seems odd to base the future price of compressed natural gas on the future price of diesel. However, there does not seem to be any correlation between the diesel gallon equivalent price of natural gas and the price charged by Clean Energy. Therefore, the price of natural gas on which Figure 7 is based is the best guess the author could make. Figure 9 likely represents the least accurate chart in this analysis. It is put forward as an example of how the pattern of longer term savings might be different than the 10-year comparison; however, it is not considered reliable as a basis for current decisions.

Until this point, the analysis has rested on the calculation of dollar amounts over time, without taking into account the time value of money. By taking the time value of money into account, we acknowledge that future expenditures are relatively cheaper than expenditures made in the present. In order to take the time value of money into account, a discount rate must be determined. This discount rate is the rate at which future expenditures are less expensive than current expenditures.

For example, the alternative to the LFUCG spending money on a CNG project would be for the LFUCG to spend money on something else. The return of this “something else” ought to be compared to the return generated by the CNG project, as opposed to the calculation of dollars over time being compared to the CNG project. The difference between the return generated by the proposed policy and the alternative—“something else”—is a way to visualize the discount rate. The discount rate is not just dependent on the direct return of projects, however. The discount rate could vary also based on how the actions of the public sector affect the actions of the private sector. The amount by which public projects decrease private investment is called the “crowding out” effect. According to a circular publication by the federal Office of Management and Budget, the base-case real discount rate applied to public projects ought to be 7%. This takes into account the typical rate of return for public money and the average “crowding out” effect seen by public projects. However, there exist considerable caveats which allow the discount rate to move either direction.

For purposes of this project, the discount rate could be smaller than 7%. There currently exists no compressed natural gas filling station in the city of Lexington. Also, the city currently purchases its own diesel and does not buy from local gas stations. Therefore, there would be relatively less “crowding out” of private investment due to the CNG project in relation to other public projects. However, since this assertion defies empirical proof, a range of discount rates ought to be considered. Tables five, six, and seven describe a range of total savings taking into account the time value of money using a variety of discount rates. It is easily seen that taking the time value of money into account further reduces the legitimacy of the claim that utilizing compressed natural gas will save the government money.

Now it seems that even given the extended scenario of the $60,000 surcharge and the high price of diesel, a CNG program would not pay back, given a 7% discount rate. Even when extending the scenario of high price of diesel with a low surcharge to 2035 (table seven), given a discount rate higher than 8%, the project would not pay back.

Table 5 - Total Savings Taking Into Account the Time Value of Money				
	EIA Estimates			
Discount Rate	High Surcharge	TMV of Savings	Low Surcharge	TMV of Savings
0.04	$ (14,549,374.38)	($11,510,539.91)	$ (9,929,374.38)	($7,831,139.69)
0.05	$ (14,549,374.38)	($10,896,665.41)	$ (9,929,374.38)	($7,407,971.44)
0.06	$ (14,549,374.38)	($10,330,253.31)	$ (9,929,374.38)	($7,017,765.99)
0.07	**$ (14,549,374.38)**	**($9,806,877.18)**	**$ (9,929,374.38)**	**($6,657,433.96)**
0.08	$ (14,549,374.38)	($9,322,579.15)	$ (9,929,374.38)	($6,324,214.16)
0.09	$ (14,549,374.38)	($8,873,815.25)	$ (9,929,374.38)	($6,015,635.22)
0.1	$ (14,549,374.38)	($8,457,407.62)	$ (9,929,374.38)	($5,729,481.99)
	High Price of Diesel			
Discount Rate	High Surcharge	TMV of Savings	Low Surcharge	TMV of Savings
0.04	$ (3,979,908.63)	$ (3,587,094.30)	$ 640,091.37	$ 92,305.92
0.05	$ (3,979,908.63)	$ (3,498,570.64)	$ 640,091.37	$ (9,876.67)
0.06	$ (3,979,908.63)	$ (3,413,553.12)	$ 640,091.37	$ (101,065.79)
0.07	**$ (3,979,908.63)**	**$ (3,331,873.44)**	**$ 640,091.37**	**$ (182,430.22)**
0.08	$ (3,979,908.63)	$ (3,253,371.41)	$ 640,091.37	$ (255,006.42)
0.09	$ (3,979,908.63)	$ (3,177,894.72)	$ 640,091.37	$ (319,714.69)
0.1	$ (3,979,908.63)	$ (3,105,298.66)	$ 640,091.37	$ (377,373.04)
	Low Price of Diesel			
Discount Rate	High Surcharge	TMV of Savings	Low Surcharge	TMV of Savings
0.04	$ (16,069,681.07)	$ (12,734,444.13)	$ (11,449,681.07)	$ (9,055,043.91)
0.05	$ (16,069,681.07)	$ (12,059,906.85)	$ (11,449,681.07)	$ (8,571,212.88)
0.06	$ (16,069,681.07)	$ (11,437,251.58)	$ (11,449,681.07)	$ (8,124,764.26)
0.07	**$ (16,069,681.07)**	**$ (10,861,659.34)**	**$ (11,449,681.07)**	**$ (7,712,216.12)**
0.08	$ (16,069,681.07)	$ (10,328,819.59)	$ (11,449,681.07)	$ (7,330,454.60)
0.09	$ (16,069,681.07)	$ (9,834,871.07)	$ (11,449,681.07)	$ (6,976,691.04)
0.1	$ (16,069,681.07)	$ (9,376,350.07)	$ (11,449,681.07)	$ (6,648,424.44)

Source: LFUCG, Smithtown, NY, EIA, OMB, Author’s Projections

Table 6 - Extention of High Surcharge/High Price Scenario Taking Into Account The Time Value of Money			
Discount Rate	Total Savings		TMV of Savings
0.04	$	6,126,771.24	$998,949.07
0.05	$	6,126,771.24	$295,037.95
0.06	$	6,126,771.24	($265,948.35)
0.07	**$**	**6,126,771.24**	**($712,505.93)**
0.08	$	6,126,771.24	($1,067,238.76)
0.09	$	6,126,771.24	($1,348,128.11)
0.1	$	6,126,771.24	($1,569,517.55)

Table 7 - Extention of Low Surcharge/High Price Scenario Taking Into Account The Time Value Of Money			
Discount Rate	Total Savings		TMV of Savings
0.04	$	16,626,771.24	$7,560,222.65
0.05	$	16,626,771.24	$6,214,494.67
0.06	$	16,626,771.24	$5,103,061.23
0.07	**$**	**16,626,771.24**	**$4,181,999.01**
0.08	$	16,626,771.24	$3,416,167.23
0.09	$	16,626,771.24	$2,777,355.32
0.1	$	16,626,771.24	$2,242,839.25

Source: LFUCG, Smithtown, NY, EIA, OMB, Author's Projections

There exists one other hypothetical which deserves exploration. While LFUCG replaces 21 diesel waste removal trucks annually—meaning that the entire fleet is replaced every 6 years. It may be possible to assume a longer lifecycle with CNG trucks. This may make the program more financially viable—although we cannot take depreciation of these trucks into account in terms of emissions or increased repairs. If we extend the lifespan of CNG trucks to 10 years, that would reflect lifecycles used by San Antonio (Lopez, 2011).

Table 8 - Total Savings Taking Into Account the Time Value of Money & 10 Year Life Cycle							
	EIA Estimates						
Discount Rate	High Surcharge		TMV of Savings	Low Surcharge		TMV of Savings	
0.04	$	(7,529,374.38)	($6,508,405.23)	$	(5,249,374.38)	($4,496,383.24)	
0.05	$	(7,529,374.38)	($6,288,680.42)	$	(5,249,374.38)	($4,335,981.44)	
0.06	$	(7,529,374.38)	($6,081,048.41)	$	(5,249,374.38)	($4,184,962.72)	
0.07	**$**	**(7,529,374.38)**	**($5,884,621.09)**	**$**	**(5,249,374.38)**	**($4,042,596.56)**	
0.08	$	(7,529,374.38)	($5,698,590.43)	$	(5,249,374.38)	($3,908,221.68)	
0.09	$	(7,529,374.38)	($5,522,220.10)	$	(5,249,374.38)	($3,781,238.45)	
0.1	$	(7,529,374.38)	($5,354,838.00)	$	(5,249,374.38)	($3,661,102.25)	
	High Price of Diesel						
Discount Rate	High Surcharge		TMV of Savings	Low Surcharge		TMV of Savings	
0.04	$	3,040,091.37	$ 1,415,040.38	$	5,320,091.37	$	3,427,062.37
0.05	$	3,040,091.37	$ 1,109,414.36	$	5,320,091.37	$	3,062,113.33
0.06	$	3,040,091.37	$ 835,651.79	$	5,320,091.37	$	2,731,737.48
0.07	**$**	**3,040,091.37**	**$ 590,382.66**	**$**	**5,320,091.37**	**$**	**2,432,407.18**
0.08	$	3,040,091.37	$ 370,617.31	$	5,320,091.37	$	2,160,986.06
0.09	$	3,040,091.37	$ 173,700.43	$	5,320,091.37	$	1,914,682.08
0.1	$	3,040,091.37	$ (2,729.05)	$	5,320,091.37	$	1,691,006.70
	Low Price of Diesel						
Discount Rate	High Surcharge		TMV of Savings	Low Surcharge		TMV of Savings	
0.04	$	(9,049,681.07)	$ (7,732,309.46)	$	(6,769,681.07)	$	(5,720,287.46)
0.05	$	(9,049,681.07)	$ (7,451,921.86)	$	(6,769,681.07)	$	(5,499,222.88)
0.06	$	(9,049,681.07)	$ (7,188,046.68)	$	(6,769,681.07)	$	(5,291,960.99)
0.07	**$**	**(9,049,681.07)**	**$ (6,939,403.25)**	**$**	**(6,769,681.07)**	**$**	**(5,097,378.72)**
0.08	$	(9,049,681.07)	$ (6,704,830.87)	$	(6,769,681.07)	$	(4,914,462.12)
0.09	$	(9,049,681.07)	$ (6,483,275.92)	$	(6,769,681.07)	$	(4,742,294.27)
0.1	$	(9,049,681.07)	$ (6,273,780.45)	$	(6,769,681.07)	$	(4,580,044.70)

Source: LFUCG, Smithtown, NY, EIA, OMB, Author's Projections

Table 8 takes into account a situation in which 21 waste removal trucks are replaced annually until LFUCG operates a full fleet of CNG trucks—which is a hypothetical 2017. From 2018 until 2021, no extra costs due to purchasing CNG trucks rather than diesel trucks are subtracted from the fuel cost savings produced by the program. Utilizing a 7% discount rate, this program could show savings if the high price of diesel were to exist within 10 years. However, if the Low or EIA Estimates for diesel were to occur, this plan would not show financial savings within 10 years.

Conclusions

Compressed natural gas use expanded across the country because it was touted as a cleaner and cheaper fuel. However, doubts remain about both of those claims. While CNG is considerably cleaner than using diesel alone, improvements can be made to trucks which would make them run as clean as if they utilized CNG. Also, switching to CNG would at best represent a .08% reduction for Lexington in terms of greenhouse gas emissions. However, moving into the future, if LFUCG would eventually like to use biomethane as a renewable fuel in its trucks, a switch to CNG would represent a "bridge fuel" to that technology. Biomethane is a gas-based fuel, and therefore CNG trucks could utilize it, while diesel trucks, which are equipped for liquid fuels, could not. While there remain environmental concerns about both compressed natural gas and diesel, these amounts are hard to quantify.

For financials, whether or not a switch to CNG would pay for itself depends on what assumption one makes about future diesel prices. If a high price of diesel exists in the future, using compressed natural gas could eventually pay for itself. If the government can purchase CNG trucks for not more than $40,000 above the cost of diesel trucks, the change would pay for itself late in the first contract period. However, taking into account the time value of money, the payback would not occur until later unless the LFUCG were to extend the life of its trucks to ten years. If the government fails to finance a low surcharge, the program would still pay back in the second period. Again, once the time value of money is taken into account, the project would not pay back before 2035 unless the LFUCG extends the life of its trucks to 10 years. In order to make a decision about the financial viability of compressed natural gas in Lexington, decisions makers must decide which diesel price is most likely to exist in the future and which discount rate to believe. Table 5 lists the prices of diesel used to do this analysis. This table is of utmost importance. If decision makers believe the high price is the most likely to occur, then compressed natural gas represents significant cost savings. If not, a switch to CNG would CNG will lose the city money. The amounts listed by the EIA are in 2009 dollars.

Table 5 - Price of Diesel, 2011-2031

	EIA Price	High Price	Low Price
2011	$ 3.028	$ 4.723	$ 1.484
2012	$ 2.917	$ 4.550	$ 1.429
2013	$ 2.977	$ 4.645	$ 1.459
2014	$ 3.033	$ 4.732	$ 1.486
2015	$ 3.091	$ 4.822	$ 1.515
2016	$ 3.206	$ 5.002	$ 1.571
2017	$ 3.289	$ 5.131	$ 1.612
2018	$ 3.379	$ 5.271	$ 1.656
2019	$ 3.461	$ 5.400	$ 1.696
2020	$ 3.526	$ 5.500	$ 1.728
2021	$ 3.532	$ 5.509	$ 1.730
2022	$ 3.586	$ 5.594	$ 1.757
2023	$ 3.639	$ 5.677	$ 1.783
2024	$ 3.690	$ 5.756	$ 1.808
2025	$ 3.736	$ 5.829	$ 1.831
2026	$ 3.763	$ 5.871	$ 1.844
2027	$ 3.808	$ 5.941	$ 1.866
2028	$ 3.809	$ 5.941	$ 1.866
2029	$ 3.865	$ 6.030	$ 1.894
2030	$ 3.834	$ 5.981	$ 1.879
2031	$ 3.851	$ 6.007	$ 1.887

Source: EIA, Author's Projections

It therefore bears reexamining the rationales on which the EIA bases its estimates. If one believes OPEC countries will allow private oil exploration and that regulations will be relaxed to allow further drilling in the Gulf of Mexico and Canada's oil sands, the low estimate makes sense. However, if one believes that world economic growth will continue to increase, resulting in greater demand for oil; and environmental regulations will increase or stay the same, the high estimate becomes more likely. The author believes the actual estimate to be between the high estimate and the EIA point estimate to be the most likely outcome, but the author doubts the price of diesel will be high enough for a switch to CNG to pay for itself in ten years.

Even if switching to CNG does not represent a financial positive, there are also social benefits that could result from the change. Like fireworks displays, parks, and public safety measures, a CNG waste removal fleet may not pay back financially, but might accrue non-market benefits which the city residents may value. A switch to CNG would reduce greenhouse gas emissions by at most 0.08%.. However, there would also be decreases in carcinogenic, but non-greenhouse emissions. In some studies, CNG has been shown to emit 50 times fewer cancer-causing emissions than diesel (Turrio-Baldassarri, 2006). Furthermore, CNG burns odorless, invisible, and tastelessly. This would have non-market benefits towards visibility and general utility.

While these benefits can be quantified, the methods by which this end would be accomplished goes beyond the scope of this project. If the city does determine that these non-market benefits would be worth the estimated costs of this project, it would be a good idea for the city to conduct a more complete benefit-cost analysis of these non-market goods.

In the opinion of the analyst, due to the long payback period required to justify a compressed natural gas program, and the small benefits which would be accrued by the switch, a CNG program does not represent the most efficient expenditure which the city could make in order to reduce its greenhouse gas emissions. However, if high prices for diesel are seen in the future, the subject could be revisited.

Caveats

There exist several caveats for this analysis. For this analysis, a 5% growth rate is assumed throughout. While this estimation is based on the professional recommendation of a LFUCG statistician, moving twenty years into the future using it may present a problem. Secondly, building the high and low estimates from the price of diesel based on EIA estimates solely on the basis of the price of oil may not be a perfect assumption. However, the price of oil dominates the cost of diesel, and it is likely that the price of oil also enters into the equation of the cost of the other factors in the price of diesel. Furthermore, as discussed earlier, basing the price which Clean Energy charges for a diesel gallon equivalent of CNG based on the EIA estimate of the price of diesel seems odd—but it appears that there exists a relationship between these variables.

The final item to be discussed is the issue of comparativeness. This analysis compares scenarios of compressed natural gas usages to scenarios of status quo, or diesel usage. Research indicates that the utilization of clean diesel may include emission benefits similar to those of switching to compressed natural gas. Further research ought to be completed about this alternative before completely changing the capital structure of the waste removal fleet of the city of Lexington, which compares the cost of switching to clean diesel instead of using compressed natural gas.

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Appendix A – Notes from Interviews

Interview with Alberto Ayala, Chief of Monitoring and Laboratory Division of California EPA Air Resources Board

Occurred on March 18, 2011

- Burning CNG increases the formaldehyde released, while curbing other emissions. This is not unexpected, as CNG is basically methane. The issue at hand is that CNG is a fossil fuel, and all fossil fuels are going to have emissions.
- It is good I am doing this study rooted in policy because although Science drives policy, lots of other factors drive it too.
- As far as politics go, there are multiple different camps in regards to CNG and its alternatives.
- Technology is never static. People push to make these fuels better and cleaner.
- 10 years ago at the onset of regulatory steps, big push to clean up conventional diesel.
- Industry wanted to retain the benefits of diesel while reducing emissions.
- CA and Sweden→ "When you compare CNG to Clean Diesel, which is better?"
    - Tailpipe is one factor, but there are others.
    - With CNG not as much traditional emissions, but other problems. Newer CNG engines better on emissions.
- The scientists have a good problem on their hand→ the emissions are so low, it is hard to measure them.
- New engines are clean, but will they remain clean after 100K miles? 200K miles? 1 million miles?
- From an emissions standpoint, current technology ultra low sulfur diesel and CNG are about the same.
    - Issue of energy security ought to be taken into account. Natural gas is domestic, petroleum is not.
- The "Fracking" issue represents a shift. It has nothing to do with the tailpipe. People are beginning to holistically examine fuels—what it emits, whether up or downstream.
- Politics: A few years ago, Pickens plan. His ideas made sense (electric→wind, transportation→NG), but they have not really caught on because diesel has become so much cleaner. This is an example of an efficient market.

Notes from conversation with Russell Barnet of Smithtown, NY

February 15, 2011

- Smithtown was the first community outside of California with CNG refuse collection fleet. It came in January 2006 and opened in January 2007.
- Started with one fueling station, which was the largest on the east coast. The second station opened April 2010.

- The Smithtown model is to contract fleet of refuse trucks, but to mandate in contracts with carters than only CNG trucks can be used.
- The Smithtown fueling station has been designed with redundancy to allow for fueling to occur even if part of the station is shut down.
- On Long Island, there are 4 million people in 14 different towns. Mr. Barnett is working to use CNG in all towns.
- The 2nd station is 6 miles from the first station.
- Smithtown financial model is conservative. The government sticks to its core competencies. CNG is used because it is cleaner. They issued an RFP, and Clean Energy won the bid to provide CNG.
- The town to the east (Brookhaven) services 450,000 people, with 67 trucks from 3 manufacturers. They use the new station as well.
- Municipality has the ability to create demand, and can use this as a bargaining chip. Smithtown used this to create a fixed price/gallon. The price has been fixed for a seven year period.
- Contractors love the fixed price per gallon, as it reduces uncertainty in forecasting fuel prices. It led to good contracts for refuse collection. The savings were passed to the government. Risks eliminated for everyone.
- The trucks used straight diesel before switching to CNG.
- The primary reason Smithtown switched to CNG was for cost-savings. The benefits include predictability in fuel costs, domestic supply v. imported supply, cleaner burning fuels and trucks start and stop at every house (quieter).
- Smithtown saves about $3/home. Although there is significant fuel savings, the CNG trucks costs more than diesel trucks.
- Smithtown has a population of about 118,000. It has 22 refuse trucks, operated by 4 carters. The carters use 2 different manufacturers. They use 250,000 diesel gallon equivalents per year in fuel.
- The program is very popular and has won awards. At first there was resistance from operators, but that went away after operators saw how cleanly the fuel burned.
- Lots of different trucks now building in a CNG option.

Notes from conversation with Michelle DiBrita of Brookhaven, NY

Occurred on February 22, 2011

- Brookhaven contracts with outside carters and has 35 different contracts.
- Like Smithtown, all contracts are required to use CNG trucks.
- Clean Energy built a fill station at the landfill, but it is open to the public for use.
- Brookhaven opted for CNG after the success of Smithtown.
- The Town Board decided to opt for CNG. A resolution was passed, and the community received the program well.
- There is an emissions statement, I have it.
- There are some cost savings. They aren't always good, but they often are.

- Ms. DiBrita would not speculate as to why the town board wanted to switch to CNG.
- Service provision has not changed due to the switch in fuel sources, but there are a significantly smaller number of complaint calls. The CNG trucks are quite a bit quieter and cleaner than diesel trucks.
- Clean Energy contracts directly with Smithtown, and then Clean Energy contracts directly with the carters.

Notes from Conversation with David Lopez of San Antonio, TX

Occurred on March 1, 2011

- CNG was used in CA for quite some time before coming to Texas.
- San Antonio owns the local gas utility, and therefore provides fuel to Energy Vision to compress.
- Went for RFP for filling utility and purchased 30 site-load refuse trucks, uses cart collection.
- Clean Energy built facility
- Have been using for about 2 years, it has been an interesting deal. Fuel Costs were original attraction.
- After government grants and rebates, the price was around $1m.
- As it has gone along, trucks have not been quite as powerful and provide less torque. New diesel trucks are just as good on emissions, and San Antonio is on the fence about expanding the use of CNG.
- They provide the market price for CNG.
- Usually replaced 15-16 trucks annually, but replaced 30 trucks at once to start this project.
- Savings on fuel cost are about $1/dge. But savings against amortization are less. Trucks have about $30-$40K bump in cost.

Notes from conversation with Mark Riley, General Manager of Eastern US for Clean Energy Corp

Occurred on February 23, 2011

- Although a flat fuel fee is in place on Long Island, not all municipalities use it.
    - Flat fee as a predetermined number hedges contracts. There is an extended annual cost of fuel which is accounted for in other fees.
    - Long Island compressor built in 2006.
- There are two stations—one in Brookhaven and the other in Smithtown.
- Typically, a station takes 6-8 months to build. The contract with Smithtown is for 20 years, and fixed prices are in place for 7 years.
- Typical base term is 10 years, but it is moving towards 15 years.
    - Contracts require a recovery term
    - Station life is typically 15-20 years
- Typical model→CE invest in the capital for long term fuel contracts and the rights to sell to 3rd parties.
    - San Antonio is a little different.

- Lots of municipalities are privatizing their carting.
    - This issue is regionalized, however.
    - Smithtown model is very good. The city controlled the way refuse was pick up.
- Fleets buy CNG trucks because life cycle costs are cheaper.
- Towns using CNG: Huntington, Montgomery Co, MD. FL: Ft Myers, Polk Co, Ft. Lauderdale. Philadelphia, PA.
- Biodiesel: high cost, less benefit than CNG.
    - CNG: $1 savings/gallon
- Motivations for CNG: Environmental benefits and cost savings.
    - Half as pollutant as diesel trucks. GHG benefits.
    - Many municipalities signed on to Kyoto Protocol.

Notes from Conversation with Joanna Underwood, President of Energy Vision

Occurred on March 6, 2011

- CNG as a fuel was launched in CA, enthusiasm by Boone Pickens.
- Underwood had breakfast with him 12 years ago to speak about a Path to Hydrogen.
- A real addition to the momentum was the South Coast Air Quality District ruling in California that heavy duty fleets in CA with greater than 15 vehicles could not use petroleum based fuels. CNG then became the best option.
- This created a market for CNG in heavy fleets. Systems were introduced in late 80s, cleaner fuel, but issues associated with the fleets and fuels.
- A ruling by the Bush administration stated that only a full, state wide rule could go into an effect, and that the regional rule was out of bounds. This ruling mean that only government fleets were required to use CNG.
- However, the rule was changed again and stated that fleets with contracts with the government can be subject to a “no petro” rule.
- The next place CNG went was San Antonio.
- In 1989, the New York Department of Sanitation utilized CNG, but it was in a different era of the fuel. Although they implemented CNG in parts of the largest fleet in the United States, they gave it up.
- In 2006, Russell Barnett met Ms. Underwood at a conference, where she presented on alternate fuels. He brought CNG to the east coast. Mr. Barnett did a lot of research on CNG, and realized there could be significant economic gains from utilizing CNG. Barnett drew up contracts which mandated private haulers utilize CNG, which was an extraordinary move. Bids had to work for the haulers—which meant they had to pay a premium of $50-$60 K more than diesel trucks. The experience in Smithtown was catalytic. Other folks from other municipalities came to Smithtown to see the project. The program worked well, and Russell Barnett was an effective spokesperson for CNG.

- There was a ripple effect from Smithtown—people with existing fleets saw Smithtown and contacted Clean Energy about the program. Also, the BP oil spill pushed concern about petro-based fuels.
- Energy Vision/Inform's purpose was to inform public about fuel. They studied lots of different fuels, and CNG works. Two levels of importance—it is much cleaner for air pollution and cuts GHGs by 20%, is secure domestic fuel and has greater economic security and less noise.
- However, it also has significant long term benefits. With the adoption of CNG, there will be a refueling system and trucks which accept gas-based fuel, rather than liquid based fuels. Biomethane is the fuel of the future, rather than hydrogen. Biomethane is carbon neutral or carbon negative. Biomethand and CNG are essentially the same fuel from different sources (CH_4).
- Energy Vision helps the DoE with workshops of biomethane and other renewable natural gasses.
- New Jersey is looking into RNGs heavily.
- Biomethane and CNG represent the only choices for heavy duty vehicles to move to a sustainable fuel. Electric and hybrid are not viable options for heavy duty trucks because they require too much power. Don't bet on risky stuff.
- Honda Civic GX is a natural gas vehicle. Bigger in Europe. People buying CNG vehicles typically do it as a second vehicle because of refueling concerns. There is a "home refueling" kit in place for houses that use natural gas for heat. The issue with electric vehicles come from batteries—can they be recycled and can we get a "smart grid" in place? This is a big, long term infrastructure question. Don't count anything out. Heavy Duty vehicles account for 4% of infrastructure and 25% of fuel demand. It's the best place to start.
- Municipalities are the biggest driver by mandating contractors to use CNG. NYC owns its own haulers. Newark, NJ used to but have now privatized.
- If the municipality owns the fleet, it is more challenging. But it can be done—as has been seen in NYC.
- Is CNG just another "fossil fuel."—not in her opinion.
- Put Tracey in touch with Joanna.