



Central Bucks EMS

ALTERNATIVE FUELS, VEHICLES & TECHNOLOGIES FEASIBILITY REPORT

Prepared by Eastern Pennsylvania Alliance for Clean Transportation (EP-ACT) With Technical Support provided by: Clean Fuels Ohio (CFO); & Pittsburgh Region Clean Cities (PRCC)

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Analysis Background:

Central Bucks Emergency Medical Service (CBEMS) was established in 1959 as a non-profit volunteer ambulance company to provide emergency medical for the communities which they serve. They were originally founded in 1951 as Central Bucks Fire and Rescue Unit to be changed later and officially chartered as Central Bucks Ambulance and Rescue Unit and then to Central Bucks EMS.

CBEMS serves nearly 100 Square miles in the following municipalities: Doylestown Borough, Doylestown Township, Plumstead Township, Buckingham Township, Warwick Township, Solebury Township, New Hope Borough, Wrightstown Township, New Britain Borough, New Britain Township and Upper Makefield township.

There are over 90,000 residents in these surrounding communities. CBEMS has grown with the community and become one of the most active EMS organizations in the region. Central Bucks EMS is one of the largest and busiest squad's in the county, responding to over 5,500 emergency 911 calls annually.

They have three locations that serve the townships and boroughs in their jurisdiction:

Address	Staffed	Vehicles	Fuel Types
455 East Street Doylestown, PA 18901	24 hours per day 365 days per year	2 Advanced Life Support Units 2 Expeditions 2 Ambulances	1 Diesel 5 Gasoline
Sub-station 135 Lingohocken Fire Company 1090 Washington Ave. Wycombe, PA 18980	24 hours per day 365 days per year	1 Advanced Life Support Unit	3 Gasoline
New Hope Volunteer Fire Dept. 46 N Sугan Rd, New Hope, Pennsylvania 18938	Day time	1 Advanced Life Support Unit	Gasoline

Central Bucks EMS has applied to The Commonwealth of Pennsylvania's newly developed Alternative Fuels Technical Assistance Program (AFTA) run by the Department of Environmental Protection seeking alternative fuel and vehicle recommendations for their fleet. This report is a culmination of meetings, information gathering and analysis specific to Central Bucks EMS's, vehicles and fleet usage of those vehicles and best reflects recommended practices and technologies that will best help Central Bucks EMS achieve their desired objectives.

1.0: Introduction – Fleet Feasibility Analysis:

This Alternative Fuel Vehicle (AFV) Fleet Performance Feasibility Study is designed to examine the feasibility and cost-savings potentials of deploying a range of commercially available alternative fuel, advanced vehicle, and efficiency solutions in the Central Bucks EMS fleet. As with many emergency services agencies, the Central Bucks EMS fleet performs a range of essential mobility, health, and emergency transport related services for citizens in their designated geographic region. Providing these services account for large and ever-growing expenses for agency budgets, and the majority of these

expenses come in the form of vehicle acquisition prices, fuel purchases, and equipment maintenance costs. However, a range of advanced vehicles, alternative fuels, and efficiency technologies are currently available and have the potential to significantly reduce both annual and lifecycle fleet operational costs when deployed in the right applications.

2.0: Fleet Management Goals – Scope of Work & Criteria for Analysis:

Eastern Pennsylvania Alliance for Clean Transportation (EP-ACT) and Clean Fuels Ohio (CFO) and Pittsburgh Region Clean Cities (PRCC) are pleased to present the following detailed AFV Options and Feasibility report. This report is designed to provide the following core deliverables: 1) Detail the priority criteria and goals for the fleet in evaluating technologies; 2) Provide a baseline analysis of current fleet operations with Key Performance Indicators (KPIs) on the fleets vehicles and operations; 3) Outline alternative fuel vehicle and efficiency technology options relevant to fleet operations; 4) Assess the operating costs and other investments needed to implement the various technology options; and 5) Provide Return on Investment (ROI) scenarios and recommendations based on the analyses above. We would like to thank Central Bucks EMS for their assistance in gathering data and providing feedback for this report.

Our team has met with key Central Bucks EMS stakeholders who have outlined a set of broad goals and criteria for evaluating new technologies for fleet operations. These criteria are outlined in the table below and used throughout this report to evaluate various technology options for the Central Bucks EMS fleet.

Priority Review Criteria for Analysis:

- 1. Use life cycle cost effectiveness and return on investment projections as the primary tool for evaluating each potential fuel, vehicle technology, and station option.*
- 2. Include data on environmental performance; factor into decision matrix as a secondary evaluation tool.*

We have used these criteria to evaluate alternative fuel and efficiency technologies that are most relevant and effective for the fleet’s operations. In addition to these criteria, our staff have used the real-world fleet data provided by the Central Bucks EMS to create key current vehicle performance profiles. Our staff utilizes these profiles to create alternative fuel vehicle replacement scenarios, charting out similar models of alternative fuel vehicles (including cost differences, mpg differences, maintenance cost differences, etc.).

The core work in this report focuses on comparing the operational costs and return on investment between the current fleet’s vehicle performance and usage profiles and various alternative fuel replacement vehicle scenarios. Finally, we have looked at the Total Cost of Ownership (TCO) and Return on Investment (ROI) based on three fuel price models (a low oil model, status quo or “median” oil model, and a high oil price model). These models come from the U.S. Energy Information Administration (EIA), which collects, analyzes, and disseminates independent and impartial energy information to promote sound policymaking, efficient markets, and public understanding of energy’s interaction with the economy and environment. A summary of the current performance of the fleet is detailed on the following page

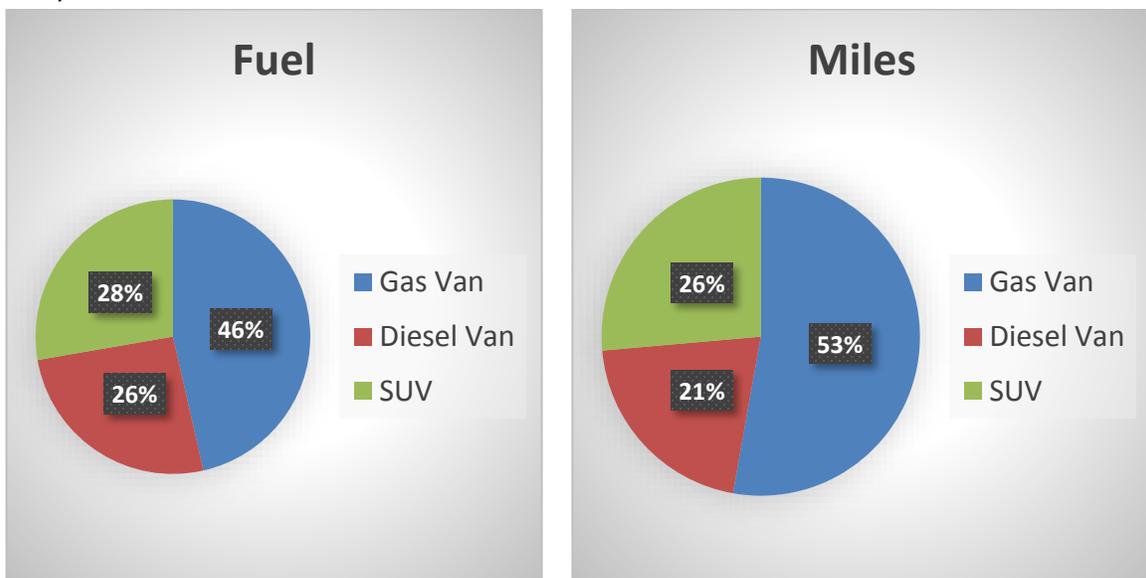
3.0: Key Performance Indicators – Existing Fleet Analysis

We generally recommend replacing vehicles at appropriate intervals to minimize fleet repair costs and maximize performance and efficiency. Therefore, our staff collected data including fleet vehicle inventory data, refueling practices data, and replacement plan data. Based on this data, we have performed a baseline analysis and identified six key indicators that provide a summary of the fleet’s current operating parameters. These Key Performance Indicators (KPIs) are designed to provide a baseline overview of current makeup and operations of the fleet, as well as provide a high-level context for the recommendations outlined in the report that follows.

*The following KPI information has been put together using information stored within the Energy Information Administration.

Central Bucks County EMS							
Vehicle	Units	Fuel	Miles	MPG	\$/Mi	\$/gal ¹	Fuel \$
Gas Van	4	3,450	49,000	14.20	\$0.17	\$2.40	\$8,280.00
Diesel Van	2	1,920	19,300	10.05	\$0.22	\$2.26	\$4,339.20
Expedition	3	2,060	24,500	11.89	\$0.20	\$2.40	\$4,944.00
Total	9	7,430	92,800	12.05	\$0.20	-	\$17,563.20

The vehicles making up this fleet have been sorted into three broad categories of units. These categories are analyzed as follows.



As the previous charts detail, the gas vans group of vehicles does the bulk of the work and accounts for most of the fleet mileage and operational costs (~46% of fuel usage). The other two categories seem to

¹ United States. Energy Information Administration. Gasoline and Diesel Fuel Update. http://www.eia.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html. 22 Jun. 2017.
Central Bucks EMS– Fleet Analysis

split usage between them. The recommendations in the report below have been specifically designed to help minimize the costs associated with the fleet’s operations.

4.0: Alternative Fuel Options – Summary Comparisons & Conclusions:

This report is designed to provide a full range alternative fuel and vehicle options analysis for your fleet operations. This section is designed to provide basic foundation information for high level comparison of five commercially available alternative fuel types: Biodiesel (B20), Ethanol (E85), Compressed Natural Gas (CNG), Propane (LPG), and Electric vehicles (EV). The following sections of this report will provide a more detailed explanation and analysis of each fuel type, as well as chart out prospective vehicle and capital cost return on investment scenarios based on each fleet partner’s real-world vehicle and usage data. The following table is designed to provide a high-level summary of each fuel option:

High Level Alternative Fuel Comparisons					
	Biodiesel (B20)	Ethanol (E85)	CNG	Propane	EV
Basics	Biodiesel is a renewable fuel that can be manufactured from organic oils, fats, or recycled grease for use in diesel vehicles.	Ethanol is a widely used renewable fuel made from corn and other plant materials. It is blended with gasoline.	Natural gas is a domestically abundant gaseous fuel that can have significant fuel cost savings over gasoline and diesel fuel.	Propane is a readily available gaseous fuel that has been widely used in vehicles throughout the world for decades.	Electricity can be used to power plug-in electric vehicles, which are increasingly available. Hybrids use electricity to boost efficiency.
Retail Availability	Widely available	Widely available	Purchased through utility pipeline.	Regional / Local distributors.	Widely available but charger required
Retail Cost	Moderate	Moderate	Low	Moderate to low.	Low if charger is available
Pollution-Tailpipe	Low, except for CO2	Low, except for CO2	Low—25 percent lower CO2 than diesel and gas.	Moderate	None
Major Pros	Universal availability and moderate cost. Environmental benefit	Universal availability and moderate cost savings.	Low fuel cost. Low Emissions & Noise. Extensive distribution.	Simpler station than CNG. Fuel savings vs. gasoline likely in fleets.	Limited range and not well suited to heavy vehicles because of range and battery weight.
Major Cons	No major cost savings. Cold flow issues if not properly treated	Lower energy per gallon. Limited environmental benefit	High cost / complexity of stations.	Seasonal price spikes if not under contract. No heavy vehicle options.	A charge take hours and applications are limited based on vehicle drive cycle.
Conclusion	Use biodiesel only when fuel cost is same or lower than diesel fuel.	Do not use ethanol until it’s 20-27% lower \$ than gasoline.	CNG vehicles are not cost-effective especially if including station.	Propane vehicles & station most cost-effective for your fleet type.	EVs cost-effective but no models for priority fleet segment above.

Liquid Propane Gas (LPG) sometimes referred as Propane or even Propane Autogas, when used as a vehicle fuel, is the most cost-effective option for the fleet’s key high use vehicle segments, a full summary of the propane vehicle analysis is provided below.

4.1: Detailed Propane Autogas Options Analysis:

Propane is produced as a by-product of natural gas processing and crude oil refining. It accounts for about 2% of the energy used in the United States. The interest in propane as an alternative transportation fuel stems mainly from its domestic availability, high energy density, and clean-burning qualities. Propane is the world's third most common engine fuel and is considered an alternative fuel under the Energy Policy Act of 1992. Older propane vehicle models injected the fuel as gas vapor for combustion. However, modern propane vehicles now almost entirely operate with Liquid Propane Injection engine systems and offer higher fuel efficiency, performance, and reliability compared to older propane vehicles. Additional information about propane also can be found here:

https://www.afdc.energy.gov/uploads/publication/propane_basics.pdf

Propane Overview: Properties, Characteristics, and Considerations	
Propane Autogas (LPG)	
Basic Properties	Gas (C3H8), stored at low pressure (~120 psi) as color and odorless liquid.
Source/Production	Domestic: By-product of conventional oil & gas exploration; non-renewable.
Distribution	Rail and Truck trailer distribution
Availability	Delivered to station storage tanks
Retail Unit	Gasoline or Diesel gallon energy (BTU) equivalent
Fuel Retail Cost	Regional Avg: ~\$1.47 - \$1.80 gge <i>(*Higher volume contracts result in lower prices)</i>
Vehicle Cost	Lower cost; ~\$5,000-\$10,000 per vehicle
Station Costs	Low cost, similar set up to gasoline except with above ground tanks, limited permitting, and environmental concerns.
Facility Modifications	No major facilities modifications; heavier than air fuel similar properties to gasoline and diesel
Engine Noise Level	Low noise level, ~1/10 decible level
Environmental	No threat to soil, surface water, or groundwater, dissipates in air
Tailpipe Emission	Lower than conventional gas and diesel vehicles

Propane also offers significant emissions benefits as detailed below.

Propane Emissions vs. Typical Diesel Baseline Emissions*					
	PM	NO _x	CO	HC	CO ₂ E/ GHG
Propane (new vehicle)	100%	> 60%	>90%	>80%	19%
Propane (conversion)	80%	0%	20-40%	- 10%	21-24%
* These figures, and new studies on which the figures are based, are posted at the U.S. Department of Energy’s Alternative Fuels Data Center at http://www.afdc.energy.gov/afdc .					

Central Bucks EMS currently operates vehicles that have opportunities to be converted to or replaced with propane powered technologies – particularly the fleet’s Ford E-350 and Transit Vans as well as its SUV Central Bucks EMS– Fleet Analysis

units. Propane engine systems exist for most light and medium duty equipment options (particularly for model years 2005 and newer) and a growing number of heavy duty engine technologies are beginning to enter the market, including school buses, shuttles, and class 6-7 truck chassis. The table below is designed to detail broad guidelines for propane vehicle applications for the major market niches.

Propane Overview: Vehicle Market/Application Relevance	
Propane Autogas (LPG)	
Light Duty: SUVs	LPG is well suited to this light duty market, if these vehicles drive higher miles and return to base.
Light Duty: Vans	LPG is well suited to this light duty market, and many vehicle options exist at relatively low cost, including service trucks and vans, and shuttle chassis.
Med-Heavy Duty: Ambulance	Class 5-7 Propane engines available in a number of makes and models with shuttle/ambulance services providing an excellent application for propane vehicles.

With the incremental cost of light-medium duty propane vehicles ranging from \$5,000-\$12,000, propane vehicles deployed in many fleet operations will easily result in a net lifetime savings if fuel usage meets basic minimum thresholds. Though propane fueling stations are an additional required investment, the total capital costs for a propane station is relatively low for a station needed for Central Bucks County EMS would be approximately (\$18,500), and these costs can be amortized into the per gallon fuel price while continuing to maintain low fuel costs.

The following table provides real world cost details for a medium volume capacity (up to ~8,000 gallons per year as an average budgetary quoted price from local propane suppliers.). The information in the table includes three cost categories (design, equipment, and construction). Though final costs for individual entities will vary, this information is relevant to the size and capacity of a station for your fleet operations. Since propane is delivered by truck, the station capacity is scalable and can be increased at no cost by scheduling more frequent fuel drops as needed or as the number of vehicles increase.

Propane Station Estimate (Station Capacity: 20,000 GGE/Year)	
Total Design Costs	\$500
Total Equipment Costs (500 gal tank + 1 dispenser)	\$15,000
Total Construction Costs	\$3,000
Total Propane Station Costs:	\$18,500

Again, costs for an equivalent station located at your specific location will vary. Cost will vary based on factors such as how much site preparations are needed, i.e. permits, concrete padding, electrical, etc. as well as specific design and construction costs.

Though these costs can be directly incurred by the fleet, propane fuel suppliers are also willing to enter into agreements to front the capital investment for such infrastructure in exchange for a long-term fuel contract with a fleet. In these cases, fuel suppliers amortize the cost of the station into the long-term contract price for the fuel. In a basic demonstration of this, in the case of Central Bucks County EMS, a local supplier who installs, maintains and owns the propane dispensing system, will charge an extra fifteen cents per gallon over the market price for a minimum 3-year contract. What that would approximately

equate to for Central Bucks EMS would be \$ 1.91 per gallon (including taxes). Longer contracts can be secured, and the rate of the fuel cost would decrease, but Central Bucks EMS, would be bound to a longer contract term.

The following table demonstrates the lifetime cost savings or propane vehicles vs. conventional fuels, using US EIA price data. *Propane has a lower energy per volumetric unit than gasoline and diesel fuel. Therefore, the assumed fuel consumption amount is higher for the propane vehicle.

Gas/Propane Vehicle Comparisons: E 350			
Current Vehicle		Propane Replacement	
Base Cost	\$30,945	Incremental Cost	\$11,615
Avg. Fuel/Year	863	Avg. Fuel/Year	1,191
Annual Mileage	12,250	Annual Mileage	12,250
Maintenance Costs/Mile	\$0.03	Maintenance Costs/Mile	\$0.015

Gas vs. Propane Operating Costs: E 350						
	Low Oil Price		Median Oil Price		High Oil Price	
	Gas	Propane	Gas	Propane	Gas	Propane
O&M	\$3,675	\$1,837	\$3,675	\$1,837	\$3,675	\$1,837
Total	\$18,265	\$17,435	\$26,404	\$20,645	\$43,007	\$28,089
Total Savings	\$829		\$5,759		\$14,918	
Net Savings	\$10,785		\$5,855		\$3,303	

Gas/Propane Vehicle Comparisons: Expedition			
Current Vehicle		Propane Replacement	
Base Cost	\$47,125	Incremental Cost	\$7,500
Avg. Fuel/Year	687	Avg. Fuel/Year	948
Annual Mileage	8,167	Annual Mileage	8,167
Maintenance Costs/Mile	\$0.03	Maintenance Costs/Mile	\$0.015

Gas vs. Propane Operating Costs: Expedition						
	Low Oil Price		Median Oil Price		High Oil Price	
	Gas	Propane	Gas	Propane	Gas	Propane
O&M	\$2,450	\$1,225	\$2,450	\$1,225	\$2,450	\$1,225
Total	\$14,064	\$13,641	\$20,544	\$16,197	\$33,761	\$22,123
Total Savings	\$422		\$4,347		\$11,638	
Net Savings	\$7,077		\$3,152		\$4,138	

Diesel/Propane Vehicle Comparisons: E 350			
Current Vehicle		Propane Replacement	
Base Cost	\$30,945	Incremental Cost	\$11,615
Avg. Fuel/Year	973	Avg. Fuel/Year	1,498
Annual Mileage	7,781	Annual Mileage	7,781
Maintenance Costs/Mile	\$0.03	Maintenance Costs/Mile	\$0.015

Diesel vs. Propane Operating Costs: E 350						
	Low Oil Price		Median Oil Price		High Oil Price	
	Diesel	Propane	Diesel	Propane	Diesel	Propane
O&M	\$2,334	\$1,167	\$2,334	\$1,167	\$2,334	\$1,167
Total	\$20,765	\$20,792	\$32,786	\$24,830	\$54,889	\$34,197
Total Savings	\$26		\$7,955		\$20,692	
Net Savings	\$11,641		\$3,659		\$9,077	

Maximize Incentives – Pursue Federal, State, and Local Subsidies:

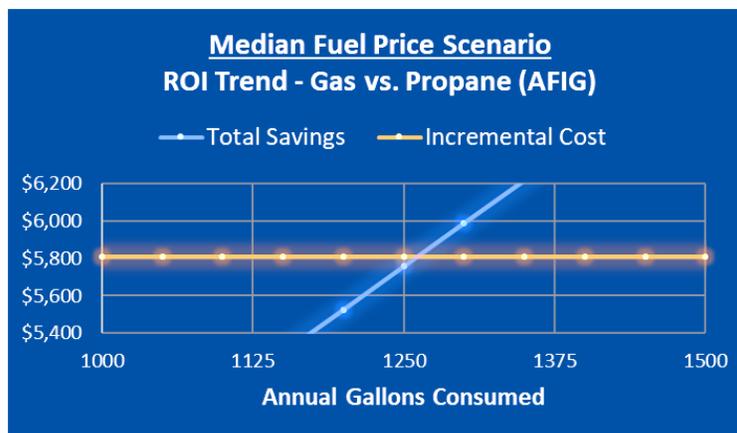
Securing funding is often critical to the success of efforts to reduce petroleum use and vehicle emissions in fleet operations. The Pennsylvania Department of Environmental Protection (DEP) has and will continue to offer grant funding for clean, alternative fuel projects in Pennsylvania and investment in Pennsylvania’s energy sector through the Alternative Fuels Incentive Grant Program (AFIG). The AFIG program is designed to reimburse up to 50% of the incremental cost to purchase alternative fuel fleet vehicles or convert vehicles to utilize alternative fuels up to a maximum of \$20,000 for each vehicle and \$300,000 per application. Station Cost can be applied for in a separate application provided you have 10 or more vehicles in your fleet that are less than 26,000lbs. Gross Vehicle Weight (GVW). The Alternative Fuel Incentive Grant , is currently open, the program, details of the program, and the RFP can be found here: <http://www.dep.pa.gov/citizens/grantsloansrebates/alternative-fuels-incentive-grant/pages/default.aspx>

Based on the Central Bucks EMS fleet’s vehicle utilization and commercially available, cost-effective propane vehicles and infrastructure, significant cost savings are not likely to result under circumstances outlined in the low and median fuel price scenarios when transitioning to propane autogas. However, there are opportunities with the AFIG program to save 50% on incremental costs of alternative fuel replacement vehicles. With that cost reduction, more savings opportunities present themselves, and projections change accordingly. The following table is designed to detail projected numbers assuming replacement of all vehicles from each category, as well as an extra \$0.15/gal fee involved with an infrastructure agreement:

As described above, there is a possibility of contracting a station under a partnership with a local Propane Autogas supplier and eliminating station costs based on securing a long-term contract for fuel supply. This would further change projection scenarios. The following table is designed to detail projected numbers assuming replacement of all vehicles from each category, with AFIG funds, and no investment in infrastructure based on partnership and long-term contracting with a local fuel supplier.

10 Year Total Investment ROI Scenarios (w/AFIG Incentives)				
Vehicle Types	AFIG \$/Vehicle	Low Oil Price	Median Oil Price	High Oil Price
(4) Gasoline E 350	\$5,807	\$27,055	\$7,335	\$29,299
(3) Gasoline Expedition	\$3,750	\$13,498	\$1,724	\$20,148
(2) Diesel E 350	\$5,807	\$16,161	\$198	\$25,275
Ten Year ROI	-	\$56,714	\$9,256	\$74,722

The long-term contracting with a local fuel supplier strongly influences the 10-year ROI scenarios. Below is a chart demonstrating a vehicle threshold profile for a gas E 350. It shows how many average annual gallons of gasoline such a vehicle would have to consume, assuming prices used in the median fuel price scenario and additional cost factored in from long-term contracting with a local supplier, to generate a positive ROI over 10 years.



This threshold mark was generated using a fleet average MPG of 14.2 for gas E 350s. For such a vehicle to show a positive ROI over 10 years when converted to a propane alternative fuel vehicle, it would have to annually consume 1,261 gallons of gasoline and travel 17,910 miles. The Central Bucks County EMS fleet does not currently have any vehicles that match this profile.

5.0: Key Recommended Actions – Conclusion

The following recommendations for further action are based on our review and assessment of data supplied and current fleet Key Performance Indicators. These summary recommended actions are designed to provide a framework for achieving fleet goals. The Table below summarizes each of the overall recommendations in this report, based on a detailed analysis leading to the specific recommended action. Through current market conditions, price of fuel, cost to convert or purchase new propane powered vehicles we suggest that you wait until the price of fuel moves to \$2.86 begin the conversion of your fleet utilizing the table below as a guide to help attain suggested fleet objectives.

Key Recommended Actions:

Fuel Options Assessment:

1. ***Deploy propane vehicle replacements and/or conversion for E-350s and SUVs when the price of fuel rises to \$2.86/ gallon, and partner with a local propane supplier for long-term contract resulting in no upfront cost for station.***
 2. *The vehicles that would have an immediate impact on your fleet metrics at that time would be to replace: the 2009 diesel E350; the 2012 diesel F350; convert the 2013 E350's as soon as possible or replace the 2013 E-350's fleet with propane vehicles after end of useful life occurs.*
1. *Pursue state and federal incentives, subsidies, grant programs, and other incentives to help reduce the implementation costs of strategies and technologies outlined in this report.*
 - a. *Apply for PA Alternative Fuel Incentive Grant helping to offset incremental cost of propane fuel system.*

More information describing the methodology and full analysis results for each of the alternative fuel options scenarios is available upon request. This report has researched many possible scenarios based on the current fleet profile, as Central Bucks EMS shifts its fleet structure to utilizing different types of vehicles and other scenarios not examined here, the recommendations made herein might change as well.