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Analysis of Air Force Compliance with Executive Order 13149

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ANALYSIS OF AIR FORCE COMPLIANCE

WITH EXECUTIVE ORDER 13149

THESIS

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AFIT/GLM/ENS/04-09

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Abstract

The Air Force must comply with *Executive Order (E.O.) 13149: Greening the Government Through Federal Fleet and Transportation Efficiency*. This order focuses on the reduction of petroleum consumption in an effort to reduce dependence on foreign oil and preserve the environment. Specifically, it directs federal agencies (such as the Air Force) to reduce fuel use in the vehicle fleet 20 percent between Fiscal Years (FY) 1999 and 2005. This thesis examines the Air Force's current alternative fuel vehicle (AFV) program and its evolution to determine how effective it is and how it should be adjusted to promote compliance with E.O. 13149. The results of this thesis look at steps that the Air Force should consider in an effort to increase the program's impact on petroleum consumption. Analysis shows that the Air Force is working to adopt new technology. However, the availability of such technology in a timely fashion may make it difficult for the Air Force to meet the 2005 goal. Additionally, in instances where the technology is currently available, alternative fuel and the appropriate refueling infrastructure frequently are not. Finding the financial resources to support these improvements would greatly improve the effectiveness of the Air Force's program.

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I. Introduction

General Issue

Over the past 30 years, the United States has steadily increased the percentage of oil consumption that depends on imported oil. In 1973, 34.8 percent of the oil consumed in the U.S. was imported. By 2003, the U.S. was importing 56 percent of the oil that was consumed (Energy Information Administration, 2004). Figure one shows the general upward trend.

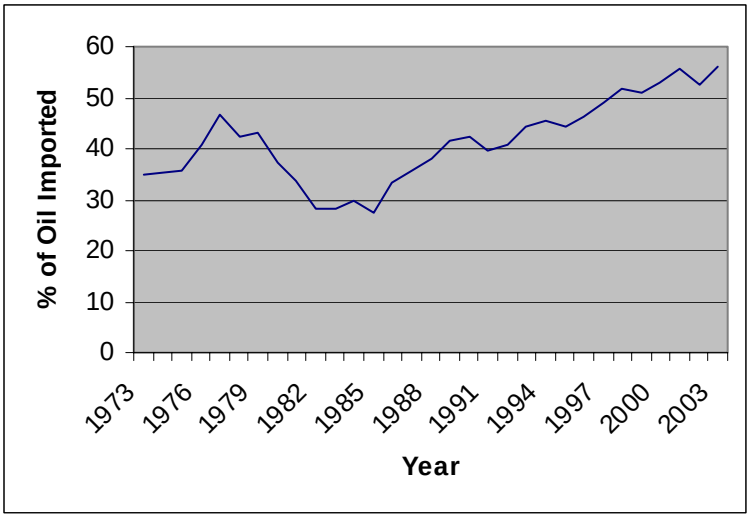

Figure 1. Percentage of U.S. Oil Coming From Imports

Over the same time period, there has been an increase in awareness of the harmful effects on the environment related to oil consumption. In the United States, transportation accounts for two-thirds of the total oil use. Additionally, transportation is almost completely reliant on oil with 95% of the energy used coming from oil (Environmental

Protection Agency, 2003). If the United States intends to reduce dependence on foreign oil sources and preserve the environment, then transportation appears to be the "low hanging fruit" where the biggest improvements can most easily and effectively be made.

The Federal Government has taken the lead and implemented several regulations to direct federal agencies to lower oil consumption within their fleets. The Department of Defense falls under these guidelines and the Air Force needs to respond by being responsible for its fleet. In 2000, President Clinton issued Executive Order 13149, "Greening the Government Through Federal Fleet and Transportation Efficiency." E.O. 13149 was issued "to ensure that the Federal Government exercises leadership in the reduction of petroleum consumption through improvements in fleet fuel efficiency and the use of alternative fuel vehicles (AFVs) and alternative fuels" (White House, 2000). E.O. 13149 does this by mandating that each federal agency operating a fleet of 20 or more vehicles within the U.S. "reduce its entire vehicle fleet's annual petroleum consumption by at least 20 percent by the end of FY 2005, compared with FY 1999 petroleum consumption level" (White House, 2000).

Each agency is required to have a compliance strategy outlining the steps they are going to take to accomplish the 20 percent petroleum reduction. Although there are many possible approaches to bring an agency within compliance, E.O. 13149 identifies two steps that are mandatory components of any strategy. "Each agency shall fulfill the acquisition requirements for AFVs established by section 303 of the Energy Policy Act of 1992." "Agencies shall increase the average EPA fuel economy rating of passenger cars and light trucks acquired by at least 1 mile per gallon (mpg) by the end of FY 2002 and at

least 3 mpg by the end of FY 2005 compared to FY 1999 acquisitions" (White House, 2000).

Section 303 of the Energy Policy Act of 1992 (EPAct) outlines percentage requirements of AFVs for federal vehicle fleet acquisitions. The current requirement (implemented for FY 1999 and beyond) is for new vehicle acquisitions to consist of 75 percent AFVs. In 1992, EPAct identified the following as alternative fuels: methanol, ethanol (E85), and other alcohols; blends of 85% or more of alcohol with gasoline; natural gas and liquid fuels domestically produced from natural gas; liquefied petroleum gas (propane); coal-derived liquid fuels; and hydrogen and electricity. Additionally, P-series was added to the list of EPAct authorized alternative fuels in 1999. Vehicles that are designed to run on these fuels will be considered as an AFV acquisition. E.O. 13149 also took the additional step of identifying biodiesel as an alternative fuel. This allows some AFV acquisition credit to be earned for the consumption of biodiesel. Biodiesel is used in typical diesel powered vehicles which do not count as AFVs. A federal fleet will get credit for acquiring one AFV per every 450 gallons of pure biodiesel that are consumed (Federal Register, 2001). The Air Force uses B20 biodiesel which is 20 percent pure biodiesel and 80 percent regular diesel. This means that one credit is earned for every 2250 gallons of B20 that are consumed. Credits for biodiesel may not be used to satisfy more than 50 percent of a fleet's requirement.

Alternative fuels are intended to reduce oil consumption by simply replacing it with other types of energy. Increasing the average fuel economy of federal fleets is intended to reduce the total energy consumption. The Environmental Protection Agency (EPA) fuel economy rating for vehicles will be used when calculating the average fuel

economy of acquired vehicles. Hybrid vehicles do not count as AFVs, but the DOE highly encourages federal fleets to consider their acquisition due to the high fuel economy they offer (DOE, 2000).

If the Air Force is going to meet the goal of reducing petroleum consumption by 20 percent, the utilization of alternative fuels and the reduction of overall fuel consumption are both very important. Unfortunately, the mandatory acquisition of AFVs does not always effectively promote the utilization of alternative fuels. Many of the AFVs acquired are either "bi-fuel" or "flex-fuel" which can operate on either petroleum based fuels or the intended alternative fuel. Alternative fuel must first be available through the appropriate infrastructure if it is to be utilized to the maximum extent possible. E.O. 13149 requires the use of public alternative refueling infrastructure when possible. Agencies also have the authority to establish non-public infrastructure where public fueling is unavailable. Fueling infrastructure availability and cost greatly impact the "bang for the buck" that the Air Force is getting from its AFVs. As always, funding is scarce and the Air Force needs the greatest capability possible to reduce petroleum consumption 20 percent by 2005.

The historical Air Force strategy has relied heavily on the acquisition of compressed natural gas (CNG) vehicles. That strategy has shifted dramatically toward the use of E85 and B20. The incremental purchase/lease costs of vehicles capable of running on E85 and B20 are dramatically less than the costs associated with CNG (GSA, 2000). Refueling infrastructure upgrades are also dramatically less expensive for E85 and B20 than for CNG. Existing CNG infrastructure and vehicles are being maintained and there is some expansion where it is practical.

The Air Force has had a relatively easy time increasing the average EPA fuel economy rating of acquired vehicles. In 1999 (the baseline year), the AF acquired vehicles with an average EPA fuel economy rating of 17 miles per gallon (mpg). In 2002, the Air Force requirement was an average of 18 mpg. The Air Force exceeded this by acquiring vehicles with an average of 26 mpg. The 2005 requirement is 20 mpg which the Air Force appears very capable of meeting.

Problem Statement

The Air Force must meet the requirements of E.O. 13149 and reduce petroleum consumption 20 percent by FY 2005. Current expectations of success hinge on the effectiveness of new vehicle acquisitions being 75 percent AFVs and actually utilizing the appropriate alternative fuel. This thesis will study the legal, environmental, and financial impacts of previous AFV and infrastructure acquisitions and determine how well the Air Force is complying with E.O. 13149 and how the Air Force should proceed.

Research Question

The objective of this research is to determine if the Air Force's alternative fuel vehicle program is successfully meeting the goals that initiated the signing of E.O. 13149. In this case study, success will be measured primarily by the reduction of petroleum consumption. Additional objectives of this research will be to evaluate the Air Force's progress towards complying with the fuel reduction strategies that are outlined in E.O. 13149.

Investigative Questions

1. How successful is the Air Force at meeting E.O. 13149 guidance?
2. How has Air Force policy evolved with changing legislation and the rapidly changing AFV technology?
3. Does the Air Force have the appropriate infrastructure available to maximize its use of Alternative Fuel Vehicles?

Scope and Limitations of the Research

This thesis will focus on the Air Force's actions towards meeting E.O. 13149 and the effect from those actions. The Air Force has numerous potential strategies towards compliance. It is important that the strategies which are adopted consider the costs and benefits. Costs can be measured in time, money, and loss of capability. Benefits can be measured in reduced pollution, reduced petroleum consumption, and legislative compliance, which is the driving force behind this program.

Whenever compliance is dependent on the use of new technology, there is tremendous uncertainty over whether or not the necessary support will be available. This study will include a focus on whether the resources even exist for the Air Force to fully comply with E.O. 13149.

II. Literature Review

Introduction

This chapter provides a review of the literature that is useful in understanding the Air Force AFV program and analyzing the effectiveness of it. The foundation for the AFV program, E.O. 13149, will be explained. EPAct 92 is an instrumental part of E.O. 13149 and the relevant portions will be explained. Additionally, Air Force and Department of Defense supporting policy will be looked at. Finally, the state of alternative fuel technology will be looked at to help understand what options and decisions the Air Force has at its disposal. Technology that the Air Force is significantly invested in will be emphasized. Technology that is still in development or poorly utilized will be looked at briefly.

Energy Policy Act of 1992

EPAct 92 established goals of having alternative fuels displace at least 10 percent of the petroleum consumed in the U.S. by 2000. By 2010, the goal was for alternative fuels to displace 30 percent of petroleum consumption. In pursuit of this goal, the acquisition of AFVs was required. These acquisition requirements have been adopted in E.O. 13149.

E.O. 13149 states that "each agency shall fulfill the acquisition requirements for AFVs established by section 303 of the Energy Policy Act of 1992" (White House, 2000). Section 303 pertains to minimum federal fleet requirements. EPAct 92 defines a federal fleet as

20 or more light duty motor vehicles, located in a metropolitan statistical area or consolidated metropolitan statistical area, as established by the Bureau of the Census, with a 1980 population of more than 250,000, that are centrally fueled or capable of being centrally fueled and are owned, operated, leased, or otherwise controlled by or assigned to and Federal executive department, military department, Government corporation, independent establishment, or executive agency, the United States Postal Service, the Congress, the courts of the United States, or the Executive Office of the President.

The acquisition requirements outlined are for the Federal Government to acquire at least 5,000 AFVs in FY 1993, 7,500 AFVs in FY 1994, and 10,000 AFVs in FY 1995. Percentage requirements were also identified as such: 25 percent AFVs in FY 1996, 33 percent AFVs in FY 1997, 50 percent AFVs in FY 1998, and 75 percent AFVs in FY 1999 and beyond. The DOD acquires many vehicles every year that EPAct 92 has specifically exempted. Law enforcement, emergency, and military tactical vehicles are not included in the act.

General Accounting Office

The General Accounting Office (GAO) released a report entitled *Energy Policy Act of 1992: Limited Progress in Acquiring Alternative Fuel Vehicles and Reaching Fuel Goals.* This report was released on February 11, 2000, two months before E.O. 13149 was released. The primary function of the report was to address the success and shortcomings of EPAct 92. Many of the GAO's findings were used as the foundation in developing E.O. 13149.

GAO stated that EPAct 92 had a nationwide goal for alternative fuels to be 10 percent of all highway fuel used in the year 2000. For 1998, GAO calculated that alternative fuels replaced about 3.6 percent of highway fuel use. EPAct 1992 was deemed unsuccessful and incapable of achieving its goals.

Fundamental shortcomings and economic disadvantages of AFVs and alternative fuels were blamed for the failure of EPAct 92. Gasoline is very affordable, leaving most customers content and unwilling to switch to alternative fuel. Additionally, the AFVs are more expensive and alternative fuel and infrastructure are very scarce.

Although EPAct 92 forced government agencies to purchase AFVs, it failed to force them to use alternative fuels. GAO suggests that the focus be shifted away from acquiring AFVs and towards using alternative fuels. The scope could also broaden to include other methods of conserving petroleum such as using more efficient gasoline vehicles.

Executive Order 13149

Executive Order 13149 was signed by President William J. Clinton on April 21, 2000. It is the driving factor in the current Air Force alternative fuel vehicle program. As mentioned earlier, E.O. 13149 ensures that the Federal Government exercises leadership in the reduction of petroleum consumption. The intention is for this reduction to come through the use of alternative fuel vehicles and vehicles with higher fuel efficiency. The government predicts that this use will help:

- promote markets for more alternative fuel and fuel efficient vehicles
- encourage new technologies

- enhance the United States' energy self-sufficiency and security
- ensure a healthier environment through the reduction of greenhouse gases and other pollutants in the atmosphere.

E.O. 13149 applies to every executive agency as defined by 5 U.S.C. 105. This definition includes executive departments, government corporations, and independent establishments (such as the Post Office and Central Intelligence Agency). The impact is much greater than just the Air Force or Department of Defense; participation by agencies such as the Post Office literally make the effects of E.O. 13149 felt in every town across the United States. Agencies that operate less than 20 vehicles within the U.S do not need to comply, although they are encouraged to do so.

Each agency is required to reduce its entire fleet's annual petroleum consumption by 20 percent. 1999 is the baseline year and the reduction must be made by 2005. Each agency must develop a strategy to accomplish this reduction that will account for unique fleet and mission requirements. E.O. 13149 suggests that strategy plans will need to include such measures as:

- the use of alternative fuels in light, medium, and heavy-duty vehicles
- the acquisition of vehicles with higher fuel economy, including hybrids
- the substitution of cars for light trucks
- an increase in vehicle load factors
- a decrease in vehicle miles traveled
- and a decrease in vehicle fleet size

Additionally, agencies are directed to minimize the costs associated with compliance.

The E.O. also has two mandatory steps that agencies will take to pursue the consumption reduction. Each agency is required to acquire AFVs as established under section 303 of the Energy Policy Act of 1992. The second mandatory step is that each agency must improve the average EPA fuel economy rating of the passenger cars and light trucks that they acquire. Again, 1999 is used as a baseline year. An improvement of one mpg was required by the end of FY 2002. Three mpg need to be gained by the end of FY 2005.

E.O. 13149 gives a significant leadership role to the Office of Management and Budget (OMB), the Department of Energy (DOE), the Environmental Protection Agency (EPA), and the General Services Administration (GSA). Their role is to guide the programs of the other agencies. OMB collects and reviews agency budget submissions. They review budgets to ensure that adequate funds are being directed towards the fulfillment of E.O. 13149 as well as towards agency mission priorities. DOE is responsible for the data collection and reporting system on annual agency performance. DOE produces a "scorecard" of agency and overall Federal compliance. EPA is directed to support DOE and GSA in their efforts to see that the appropriate vehicles are acquired. GSA is tasked with making the acquisition of AFVs as financially and administratively simple as possible. Although AFV frequently have a higher cost than conventional vehicles, GSA is directed to give each agency the option of averaging the extra cost out over the agency's entire fleet. GSA is responsible for interacting with automobile manufacturers to ensure that appropriate AFVs are available to meet agency needs. GSA will then provide agencies with manufacturer production forecasts so that the appropriate acquisition orders can be placed.

E.O. 13149 has several provisions that direct agencies to count acquisition credits and meet directives differently than EPAct 92. The first distinction is between a "federal fleet" in EPAct 92 and an "agency" in E.O. 13149. EPAct 92 exempted fleets that were not in Metropolitan Statistical Areas (MSAs) or had less than 20 vehicles. E.O. 13149 maintains this exemption for the acquisition of AFVs, but these fleets still fall under the agency and will need to be considered when attempting to reduce the agency's fuel consumption by 20 percent. E.O. 13149 has provided several new ways to earn acquisition "bonus credits" for AFVs. Like EPAct 92, one credit is earned for each AFV that is acquired. Agencies also receive one additional credit for each light-duty vehicle that uses exclusively alternative fuels, three additional credits are earned for each medium-duty vehicle that uses exclusively alternative fuel, and four additional credits are earned for each heavy-duty vehicle using exclusively alternative fuel. Although diesel vehicles are not considered alternative fuel vehicles, one credit is earned for every 450 gallons of pure biodiesel that is consumed. Agencies cannot earn more than 50 percent of their credits by using biodiesel. Each Zero Emission Vehicle also earns one additional credit. This currently means electric vehicles.

Alternative Fuel Vehicles will have very little impact if the alternative fuel is not available. E.O. 13149 states that agencies should arrange for fueling at commercial stations that offer fuel to the public. Agencies are also advised to team with State, local, and private entities to develop infrastructure that supports alternative fuels. If public fueling stations are not available, then agencies are authorized to establish nonpublic alternative fuel infrastructure.

Military tactical, law enforcement, and emergency vehicles are exempt from E.O. 13149. This means that they will not count against the requirements for acquiring AFVs or increasing fleet fuel efficiency. Agencies are still encouraged to increase the fuel efficiency of the exempt vehicles. This will help meet the requirements for the 20 percent reduction in petroleum consumption.

Department of Defense Compliance Strategy for Executive Order 13149

Each agency that falls under the requirements of E.O. 13149 is required to prepare an agency strategy for meeting the goals of E.O. 13149. The document sets forth the guidelines and strategy that the DOD will follow in order to comply with E.O. 13149. The Department of Energy is responsible for giving guidance to the agencies on developing this strategy. The current version of the DOD Compliance Strategy was released in Jan 2003.

The DOD Compliance Strategy states that the key objectives are to

(1) meet the alternative fuel vehicle (AFV) acquisition goals of EPAct

(2) to reduce vehicle petroleum consumption by 20 percent through Fiscal Year (FY) 2005 from the FY 1999 baseline

(3) to increase the average fuel economy of acquired light duty vehicles

(4) to meet hybrid light duty vehicle acquisition goals of the National Defense Authorization Act (NDAA) of 2002

The NDAA of 2002 is outside the scope of this thesis and its compliance will not be considered. The document also states that vehicle petroleum consumption will be reduced through the displacement of petroleum products with the use of alternative fuels

and increases in agency fleet miles per gallon (mpg). It is predicted that if all vehicle acquisition and alternative fuel use goals are met, the strategy may reduce petroleum use in the non-tactical fleet by over 30 percent.

DOD recognizes that alternative fuel infrastructure is a current shortcoming that must be improved on. DOD is seeking to work first with partners in the commercial industry to develop privately owned infrastructure. Developing DOD owned infrastructure on DOD installations is an alternate and less preferred approach.

Natural Gas

Natural gas vehicles come in two different configurations: bi-fuel and dedicated. As the name implies, the bi-fuel vehicles are capable of running off of two different types of fuel, such as natural gas and gasoline. Dedicated vehicles are only capable of running on natural gas. The Air Force gets an AFV acquisition credit for the purchase of either bi-fuel or dedicated vehicles. However, if an Air Force acquisition is a dedicated natural gas vehicle, the Air Force gets one additional credit for light-duty vehicles, three additional credits for dedicated medium-duty vehicles, and four additional credits for heavy-duty vehicles.

"'Natural gas vehicles are becoming a lot more common. They are far and away the top alternative fuel fleet vehicle right now,' in terms of fleet sales, said Dave Burch of the California Air Resources Board" (Worley, 2003). "The interest for natural gas as an alternative fuel stems mainly from its clean burning qualities, its domestic resource base, and its commercial availability to end-users (AFDC, 2003). The Air Force (and other agencies under E.O. 13149) do not necessarily evaluate and select AFVs based on the

same criteria as commercial users. Of the three reasons cited by AFDC for interest in natural gas, "commercial availability to end-users" is of particular concern when purchasing an AFV. Commercial users of AFVs often do so in order to capitalize on the tax advantages associated with their use. However, bi-fuel systems also do not usually qualify for most of the tax-incentive plans (Worley, 2002). This forces commercial users to purchase dedicated natural gas vehicles which make it imperative that natural gas refueling stations be available. Regardless of the type of system they purchase, commercial users can benefit by avoiding the taxes associated with gasoline. Natural gas is regulated as a utility and therefore does not have transportation taxes. The Air Force already avoids transportation taxes so this incentive is not a consideration.

The Department of Energy reports that there are 1055 refueling stations in the United States for the most common form of natural gas, compressed natural gas (CNG). This is slightly down from approximately 1200 CNG stations in 2003 and 1300 CNG stations in 2000. AFVs can also use liquefied natural gas (LNG), but the use of LNG is very limited. For comparison, there are 36 LNG refueling stations in the country.

"Refueling can be done easily by trained drivers" (DOE, 2003). The widespread use of natural gas pipelines makes CNG potentially available at many locations. A company called FuelMaker is currently the dominant provider for refueling stations. Fuelmaker was established in 1989 and specializes in the design, manufacture, and installation of natural gas commercial fueling systems. At the World Natural Gas Vehicle show in 2002, Fuelmaker also introduced a refueling station designed for home use. Named "Phill," the refueling station is designed for convenient, overnight use.

The Air Force has acquired some FuelMaker products. The researcher observed the FuelMaker refueling station at Selfridge Air National Guard Base near Detroit, Michigan. FuelMaker currently markets six different refueling stations and claims to have 8,000 refueling stations in service worldwide.

In 2003, Honda announced that it would begin mass selling CNG vehicles to the general public. To ensure the availability of CNG refueling stations, Honda will sell a Phill refueling station with each car. The Air Force Innovative Development through Employee Awareness (IDEA) program recently reviewed this potential opportunity for the Air Force. The IDEA was reviewed at the Air Force Material Command (AFMC). The IDEA was disapproved for several reasons. A primary concern is the use of the Honda Civic. This vehicle is classified as a subcompact sedan. Very few subcompact sedans are authorized in the Air Force. Several of the Major Commands (such as AFMC) have no subcompact authorizations at all. The vehicle is simply too small to perform as required. The Air Force currently has all of the CNG refueling capability that it desires. The Warner Robbins Air Logistics Center reports that the Air Force has not been interested in acquiring CNG infrastructure since 1999. Phill would be a duplication of existing infrastructure. Current emphasis focuses on the acquisition of E85 and biodiesel capabilities.

There is interest in natural gas because of its "domestic resource base." "Most natural gas consumed in the United States is domestically produced" (DOE, 2003). Both the US and Canada have significant natural gas deposits (Auto Alliance, 2003). Natural gas can be collected from gas wells or separated from crude oil and other petroleum

products. Natural gas is also produced as a by-product of landfill operations (Platts, 2003).

There is interest in natural gas because of its "clean burning qualities." Natural gas produces 65-90% less carbon monoxide emissions and virtually no particle emissions (Auto Alliance, 2003). The Triangle Clean Cities Coalition even claimed that carbon monoxide pollution would be reduced 90-97% when compared with gasoline. Additionally, hydrocarbons would be reduced 50-75% and nitrogen oxides would be reduced 35-60%.

Unfortunately, natural gas does have drawbacks that must be addressed before it is widely accepted. As discussed above, the refueling options for natural gas are not as convenient as they currently are for gasoline. The Phill will address some private sector concerns, but the problem still arises when CNG vehicles are used on trips that are longer than their tank range. CNG stations are not as convenient as gasoline refueling stations are. An additional problem stems from the volume (cubic feet) of natural gas. CNG produces 29,000 BTUs per gallon while gasoline produces 111.8 BTUs (Platts, 2003). Consequently, one gge of CNG requires four gallons of tank volume. A CNG vehicle must either sacrifice driving range or cargo capacity. For example, the 2001 CNG Camry has a gge capacity of 11.4 gallons (Auto Alliance, 2003). This means that the tank takes up roughly the same amount of space as a 46-gallon gasoline tank, which is substantially more than the standard gasoline tank. The driving range on a full tank is 270 miles. This is slightly lower than the typical range on gasoline. One possible solution is the bi-fuel system. A bi-fuel system has two tanks and can be switched between CNG and regular gasoline. This prevents the motorist from being stranded when CNG is unavailable. The

additional tank requirements also put more strain on the need for tank space. This option works best in trucks where space is not at such a premium.

On a positive note, CNG vehicles are readily available today from General Motors, Ford, Daimler Chrysler, Toyota, Honda, and many others. Although prices vary around the country, it is estimated that, CNG will cost about 60 to 80 cents per gge (EV World, 2002). The current initial costs and fuel availability make CNG less desirable though.

Alcohol

The current alcohol fuels that are in use are Ethanol and Methanol. Ethanol is available in two different ratios blended with gasoline. E85 is 85% ethanol and E95 is 95% ethanol. Methanol also comes in two ratios. M85 (85% methanol) is the primary blend that is used. M100 (pure methanol) may be used in the future. Vehicles designed to run on alcohol are usually referred to as "flexible fuel" vehicles. A flexible fuel engine will automatically adjust to the fuel that is in use. E85 is the most commonly used alcohol based fuel with 182 refueling stations across the country. "All of the major automobile manufacturers have models that can operate on E85, gasoline, or any mixture of the two (DOE, 2003).

"Ethanol is produced mainly by a cooking, fermentation, and distillation process using grain crops" (Platts, 2003). Corn is primarily used. Research is currently being done to determine if cellulose, such as wood and agricultural wastes, can be used.

"Methanol is predominantly produced by steam reforming of natural gas to create a synthesis gas, which is then fed into a reactor vessel in the presence of a catalyst to

produce methanol and water vapor" (DOE, 2003). Corn and other feedstocks have been used, but natural gas is the most economical source of methanol.

Ethanol is in widespread use throughout the US. All automobile manufacturers that do business in the US have approved the limited use of ethanol. Consequently, some areas of the country use E-10 as their standard gasoline. This addition of ethanol to the regular gas is intended to boost octane and improve the emissions quality of the gasoline. This is in response to the Clean Air Act Amendments of 1990 that mandate the sale of oxygenated fuels in areas with unhealthy levels of carbon monoxide. Ethanol serves as the oxygenate. E-diesel is a blend with 15% ethanol that is successfully being used without any major engine modifications in diesel engines.

Current problems with alcohols include a price that is higher and an efficiency that is lower than gasoline. GM reports that there will be no noticeable drivability differences when using gasoline or E85. Additionally, low volatility makes alcohol fuels start very poorly and mis-fire during warm-up. This is a serious concern for the northern part of the country.

Alcohols do significantly reduce emissions. When compared to gasoline, alcohols have: 40% less carbon monoxide emissions, 10% less nitrogen oxide emissions, and 20% less particulate emissions (Triangle Clean Cities Coalition, 2003). If technology develops so that alcohols are more affordable, this alternative fuel would be much more widely accepted and utilized. The fact that many vehicles are already flex-fuel capable makes the transition easy.

Biodiesel

Biodiesel is a "cleaner-burning diesel replacement fuel made from natural, renewable sources such as new and used vegetable oils and animal fats" (DOE, 2003). Blends of 20 percent biodiesel with regular diesel (B-20) can be used in nearly all diesel engines. B100 can be used in many engines built since 1994 with little or no modification.

Biodiesel has improved emissions with the best improvements being seen when B100 is used. B100 reduces carbon monoxide by 43%, hydrocarbons by 56%, and particulates by 70%. These are substantial improvements and the best part is that they require not sacrifice in power.

The problem arises because these improvements require a substantial increase in fuel costs. B100 costs about 50% more that regular diesel. DOE is currently trying to increase the supply of biodiesel by developing a way to use the oil from spicy mustard seeds. This could add another 5-10 billion gallons to the supply. The mustard seed is already a high value pesticide that needs to be separated from the oil to be useful. The oil is currently being treated as a waste product. As availability increases, biodiesel is seen as gaining widespread use and acceptance.

Propane

Liquefied petroleum gas (LPG), more commonly known as propane, is probably the most widely used AF. Propane compares very similarly to CNG but is far more accessible. Propane is produced as a by-product of natural gas processing and petroleum refining (AFDC, 2003). "Publicly accessible fueling stations exist in all states; more than

10,000 are documented in the US" (Auto Alliance, 2003). Many of these exist for the refueling of small, recreational type tanks like those on gas grills. There are 350,000 propane-powered vehicles in the US and about 3.5 million worldwide. Propane has been used in vehicles around the world for over 60 years (Auto Alliance, 2003).

There is conflicting evidence as to the cost-effectiveness of propane use. There are numerous sources that cite variations in the range of 20% less than gasoline to similar with gasoline. It is also important to note that both gasoline and propane are measured in gallons. Propane produces 84,000 BTUs per gallon while gasoline produces 112,000 BTUs per gallon (Platts, 2003). With propane, you get significantly less energy for your gallon so the cost should be less (per gallon).

Due to the lower energy content per gallon, driving range on LPG is less than that of gasoline-powered vehicles. The range is much greater than that of CNG vehicles. Power from propane is about the same as that from CNG or gasoline.

From an emissions standpoint, propane is not as advantageous as CNG, but there are substantial improvements when compared against gasoline. Carbon Monoxide is reduced by 30-35%. Hydrocarbons are reduced by 20-40%. Nitrogen Oxides are reduced by 15-20%. Particulates are reduced by 80-95% (Triangle Clean Cities Coalition, 2003).

Ford is currently the main provider of LPG powered automobiles.

Electricity

Electricity is being used (or experimented with) in a wide variety of forms. Two very different designs of vehicles are currently using electricity: Hybrid Electric Vehicles

(HEVs) and Electric Vehicles (EVs). HEVs are vehicles that get their power from a combination of electric motors and internal combustion engines. This combination can be in series, where the internal combustion functions as a generator battery that powers the electric motor that actually powers the car, or in parallel, where the internal combustion engine and electric motor can work individually or simultaneously to power the car. As mentioned earlier, hybrid vehicles are not classified as AFVs because they run on conventional gasoline. EVs get their power solely from electricity (zero *tailpipe* emissions), but even this can be produced in different ways. Battery powered EVs store electric power and need to be charged from a source. EVs can also be powered by fuel cells (such as hydrogen) that actually chemically produce the electricity.

One of the key efficiency advantages of electric vehicles is the regenerative braking capability. Conventional braking converts kinetic motion into heat (via friction), which is then deliberately lost to the air. Regenerative braking converts kinetic energy into electricity, which is then reused to power the vehicle (Auto Alliance, 2003). This regenerative braking allows cars to get better gas mileage in city driving (with frequent starts and stops) than they would in highway driving (Worley, 2002).

In the current sales market, HEVs have eclipsed EVs. There are many easy explanations for this. The first is availability. The General Motors EV1 and the Toyota RAV4-EV were the only two EVs that were actually on the market for mass public use. This research did not consider golf-cart type vehicles such as the Daimler Chrysler GEM or Toyota e-com.

The General Motors EV1-Generation II was available at select Saturn dealerships in California and Arizona. It is a two-seat sedan. The EV1 has a top-speed of 80 MPH

and can accelerate 0-60 in under 9 seconds. These statistics are very comparable to gasoline vehicles, but the range of 130 miles is much less than with gasoline. A 220-volt charger fills the battery in less than 6 hours (Auto Alliance, 2003). The EV1 was only available for lease and the lease is based on an MSRP of $34-44,000. This price range made the EV1 significantly more expensive than comparable gasoline vehicles.

The Toyota RAV4-EV appears to be identical to the gasoline powered RAV4 sport utility vehicle. It has a range of 80-100 miles.

Both the EV1 and the RAV4-EV were cancelled after only a few years of production. General Motors ended their electric vehicle program by recalling the final EV-1s in August of 2003. After an estimated investment of $1.5 billion in the program and the construction of about 1000 EV-1s, General Motors determined that there was not sufficient demand to continue the program.

Toyota attempted to model their RAV4-EV marketing plan after their highly successful Prius hybrid marketing plan. This highly successful plan focused on using the internet to get cars to the consumers who want them, rather than having inventory piling up on dealer's lots in the wrong location. The Prius was launched in 2000 and sold 18,000 vehicles in the first 18 months. After this success, Toyota launched the RAV4-EV in 2001. Although the claimed cost of manufacturing a RAV4-EV was over $100,000, Toyota offered them for a $329 and month leased or $42,000 to purchase before tax incentives. Only 213 RAV4-EVs were sold over the first six months, compared to 3262 Prius' over the same period of time. This low level of demand led Toyota to cancel the program after just six months (Bedard, 2004).

Although the electric vehicles were ultimately considered a failure primarily due to their range capabilities, they did offer energy efficient transportation. On its website, General Motors compares the fuel costs of an EV-1 to those of a vehicle getting 22 miles per gallon at $1.50 per gallon. General Motors used an assumed electricity cost of 10 cents per kilowatt hour and determined that the EV-1 costs 2.6 cents per mile. The above mentioned gasoline vehicle would cost 6.82 cents per mile. Operating costs for electric vehicles are substantially lower.

Although the above-mentioned battery-operated EVs have been discontinued, there is still development being done on electric vehicles that will be powered by fuel cells. Hydrogen powered fuel cells are the most promising. No costs are available at this stage of the development. Fuel cells offer advantages over batteries such as faster "refuel" times. General Motors does have an experimental fuel-cell vehicle. It is called the GM Hy-wire Concept. GM claims that the car has top speed of 100 MPH and an estimated 0-60 time of 16 seconds (Keebler, 2003). Fuel cells are projected to have a driving range of around 280 miles (Auto Alliance, 2003). The fuel-cell in the GM Hy-wire runs on hydrogen and has emissions consisting only of water. Keebler, in his test drive for ***Motor Trend***, spoke very highly of the car's performance.

HEVs solve the range, availability, and cost problems of EVs. Unfortunately, they do so through the use of petroleum powered internal combustion engine. This does not totally eliminate the fossil fuel dependence. Still, when compared against internal combustion engines, HEVs offer substantial improvements. Virtually all of the major car manufacturers have HEVs that are either in, or near production. The Toyota Prius has been sold in the US since 2000 and was the world's first mass-produced HEV. The Prius

has a 1.5 liter gasoline engine and an electric motor. The car operates on electricity at low speeds and switches to gasoline at high speeds. The Honda Insight and Honda Civic are also prominent hybrid vehicles on the market today and have reasonable costs with an MSRP of under $21,000 (www.kbb.com). Numerous other manufacturers and vehicle are scheduled to come on the market in the near future.

Solar energy can also be used to make electricity. Photovoltaic cells collect solar energy and convert it into electricity. Solar energy has many advantages, such as: we get it for free, there's zero pollution, and you can't use it up. Unfortunately, the cost of developing our ability to harness this energy is very high. Photovoltaic cells are expensive to produce. Solar energy is unlikely to be a big player since it does not currently seem likely that a car can be powered by solar energy alone.

III. Research Methodology

Introduction

This chapter describes the research objectives along with the purpose of each investigative question. The case study method of researching was selected and is examined briefly. Data collection, data analysis, and data validity are also discussed.

Research Objectives

The intention of this research is to evaluate how successful the Air Force's Alternative Fuel Vehicle Program is at achieving compliance with Executive Order 13149.

The steps that the Air Force has taken in order to comply and the effects that have resulted are very important to this investigation. Is the Air Force contributing to the government goal of exercising leadership in the "reduction of petroleum consumption through improvements in fleet fuel efficiency and the use of alternative fuel vehicles (AFVs) and alternative fuel" (White House, 2000)?

E.O. 13149 outlines both mandatory and suggested strategies for meeting this goal. E.O. 13149 predicts that meeting this goal will result in enhanced U.S. energy self-sufficiency as well as decreased pollutants in the atmosphere. It is important to determine how and if the Air Force strategy is working towards this end. Taxpayer's money is being spent and it is important to determine if the desired benefit is materializing.

Success on the part of the Air Force will be largely dependent on support from the private commercial industry. Without availability of the appropriate tools, it will be impossible for even the best Air Force efforts to gain compliance.

Method

In *Case Study Research: Design and Methods,* Robert K. Yin states that case studies are the "preferred strategy when 'how' or 'why' questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary phenomenon within some real-life context" (1994: 1). The case study approach was used because the research wanted to know how the Air Force is complying (or failing to comply) with E.O. 13149. The investigator did not have control over the data; it was collected and used as it naturally occurred. The Air Force's compliance with E.O. 13149 is a current and ongoing effort, originating with the signing in 2000 and culminating in 2005 when all final deadlines are to be met.

Research Approach

In order to research this topic, data was gathered as available and analyzed to address each of the investigative questions. Each investigative question is restated with the question objective identified. The supporting source of data and documentation is also listed.

Investigative Question One

How successful is the Air Force at meeting E.O. 13149 guidance? The intent of this question is to determine if the Air Force is fully utilizing all of the directives (both mandated and suggested) within E.O. 13149 in order to achieve the required reduction in petroleum consumption. The goal is to identify Air Force steps and strategies that are called for in E.O. 13149. If the Air Force is failing to capitalize on potential strategies that are recommended in E.O. 13149, this will be identified. The determination will be made if the guidance in E.O. 13149 is being fully followed, partially followed, or ignored and if these actions are going to result in a successful 20 percent reduction of petroleum consumption by FY 2005?

The first step was to identify all of the directives that were put forth in E.O. 13149. E.O. 13149 is available on the internet in numerous locations, including the Defense Environmental Network & Information Exchange (DENIX).

The second step was to identify the official Air Force policy and performance in response to E.O. 13149. The *Department of Defense Compliance Strategy for Executive Order 13149: Alternative Fuel/Hybrid Vehicle Requirements* was available on the internet, again from DENIX. Official policy outlined in the DoD Compliance Strategy was complemented and compared with actual Air Force practice when possible. Data on actual Air Force practice was primarily procured from the *U.S. Air Force Fleet Alternative Fuel Vehicle Acquisition Report.* This report was available for fiscal years 2001- 2003 and is based on information that is input into the Federal Automotive Statistical Tool. These reports were either available electronically from DENIX, or in the case of FY 2003, in hard copy from the Air Force Material Command Vehicle

Management Office. Finally, interviews with personnel from the AFMC Vehicle Management Office, Defense Energy Support Center, National Automotive Center, and Warner-Robins Air Logistics Center were utilized to resolve any unanswered issues.

Investigative Question Two

How has Air Force policy evolved with changing legislation and the rapidly changing AFV technology? How has the Air Force and its compliance with E.O. 13149 benefited from this change? The intent of this question is to determine if the present actions and strategies of the Air Force fully exploit the opportunities that have been provided by advancing technology and legislation. The goal is to identify if or how the AFV policy has changed.

The first step is to identify what changes have been made that the Air Force can take advantage of. The relevant portions of EPAct 92 and E.O. 13149 will be identified and compared. EPAct 92 is available on the internet from the Department of Energy. Recent developments in AFV technology will be primarily identified by the Alternative Fuels Data Center, which is run by the Department of Energy.

The AFV fleet was historically based on EPAct 92. Fleet reports from the past three years will be utilized to determine how the Air Force's AFV acquisition and fuel consumption has changed. In order to determine the benefit of any progress to the Air Force; financial, environmental, and mission supportability advances (or lack thereof) will be compared. This data will be based on actual Air Force costs, previous environmental research available from DoE, and interviews with military vehicle managers.

Investigative Question Three

Does the Air Force have the appropriate infrastructure available to maximize its use of Alternative Fuel Vehicles? The intent of the question is to identify Air Force capabilities to procure alternative fuel. The goal is to determine how aggressively the Air Force is pursuing alternative fuel infrastructure and how adequately the commercial sector provides fuel support.

The first step is to identify where alternative fuel is expected to be available and in use. Information on Air Force vehicle fleet placement is available on the Air Force web page. E.O. 13149 emphasizes the placement of AFVs in Metropolitan Statistical Areas (MSAs) and the DoD Compliance Strategy assumes that all AFVs in MSAs have access to alternative fuel. Actual Air Force infrastructure policy will be looked at.

Since E.O. 13149 was signed, the Air Force has developed some of its own alternative fuel infrastructure. The Air Force Petroleum Office (AFPET) is responsible for this and provided a table showing all construction since then and what is scheduled through FY 2005.

Data Collection

In a case study, data can be collected from numerous different sources. Yin identifies six sources that he considers important: documentation, archival records, interviews, direct observations, participant-observation, and physical artifacts (1994: 78). This thesis will rely on documentation, archival records, interviews, and direct observation.

Yin outlines three principles of data collection: "(a) using multiple, not just single, sources of evidence; (b) creating a case study database; (c) maintaining a chain of evidence" (1994: 79). These principles are considered extremely important when doing a high quality case study. This thesis has engaged four of the six identified sources of evidence. The author relied heavily on documentation and archival records, but interviews were frequently utilized to gain clarity or explain inconsistencies. The knowledge and experience provided by vehicle and fuel managers at DESC, NAC, AFMC, and WR-ALC contributed significantly. Yin's second principle of creating a case study database is outside the scope of this study. The Air Force Fleet Reports fit this description though. They are a compilation of data provided by major commands, fuel providers, vehicle providers, and the Department of Energy. Yin's third principle of maintaining a chain of evidence simply connects the questions asked in chapter one, findings given in chapter four, and conclusions explained in chapter five.

Data Analysis

"The analysis of case study evidence is one of the least developed and most difficult aspects of doing case studies" (Yin, 1994: 102). Yin goes on to explain that rigorous thinking and careful consideration of potential interpretations is critical to data analysis. Yin discusses two different general analytic strategies. One of these strategies is to develop a descriptive framework for organizing the case study. This study employs a descriptive analytic approach in its answering of the investigative questions. For example, in the investigative question asking if the Air Force is complying, data will be explained showing exactly what actions the Air Force has taken and how it complies.

Scope and Limitations

As discussed earlier, the Air Force Fleet Reports are the primary source of data for this study. These reports collect data from the Vehicle Information Management System (VIMS) and the Federal Automotive Statistical Tool (FAST). VIMS is the Air Force tool for tracking fuel usage, it is currently limited in its ability to track occasions where a vehicle might use more than one type of fuel. FAST is an accounting and reporting tool. Unlike VIMS, it does not gather information on its own. Data is entered into FAST by hand from the various sources (primarily Major Commands) where it is gathered. FAST is vulnerable to errors that are made when entering data and poor data collection techniques. This study will use the best information that the Air Force has available, and it will be noted when suspected inaccuracies are discovered.

IV. Analysis and Results

Analysis of Compliance With Executive Order 13149

In its *Department of Defense Compliance Strategy for Executive Order 13149 Alternative Fuel/Hybrid Vehicle Requirements*, the DoD states that it will "meet the key objectives of EPAct and E.O. 13149 through the acquisition and use of alternative fueled/hybrid vehicles." The DoD predicts that "this strategy may reduce petroleum fuel use in the non-tactical vehicle fleet by over 30%."

The acquisition and use of alternative fueled/hybrid vehicles are part of an aggressive compliance strategy, but fall far short of being a complete and comprehensive strategy as envisioned by E.O. 13149. Some E.O. 13149 measures that are not specifically mentioned in the DoD Compliance Strategy are: the substitution of cars for light trucks; an increase in vehicle load factors; a decrease in vehicle miles traveled; and a decrease in fleet size. E.O. 13149 predicts that each agency will need to incorporate "most, if not all" of the suggested measures.

In the DoD Compliance Strategy, the key objectives are "(1) meet the alternative fuel vehicle (AFV) acquisition goals of EPAct; (2) to reduce vehicle petroleum consumption by 20 percent through Fiscal Year (FY) 2005 from the FY 1999 baseline; (3) to increase the average fuel economy of acquired light duty vehicles; and, (4) to meet hybrid light duty vehicle acquisition goals of the NDAA." Although the National Defense Authorization Act of 2002 is not specifically within the scope of this thesis, the acquisition of hybrid vehicles will be considered in their relevance towards raising the average fuel economy of acquired vehicles. A very notable exclusion from the key

objectives is the use of "alternative fuels to meet a majority of the fuel requirements of those motor vehicles by the end of FY 2005." It seems that the DoD will have difficulty complying if this requirement is not actively managed.

Reduced Petroleum Fuel Consumption

The primary requirement of E.O. 13149 is to reduce petroleum fuel consumption. "Each agency operating 20 or more motor vehicles with the United States shall reduce its entire vehicle fleet's annual petroleum consumption by at least 20 percent by the end of FY 2005, compared with FY 1999 petroleum consumption levels." The Air Force has had difficulty making significant progress towards this goal. In FY 1999, the Air Force consumed 13,016,001 gallons of petroleum. In 2001 and 2002, the Air Force did show some progress towards reducing the consumption of petroleum. However, in 2003 this trend reversed and there was a 1.7 percent increase from the baseline up to 13,233,385 gallons.

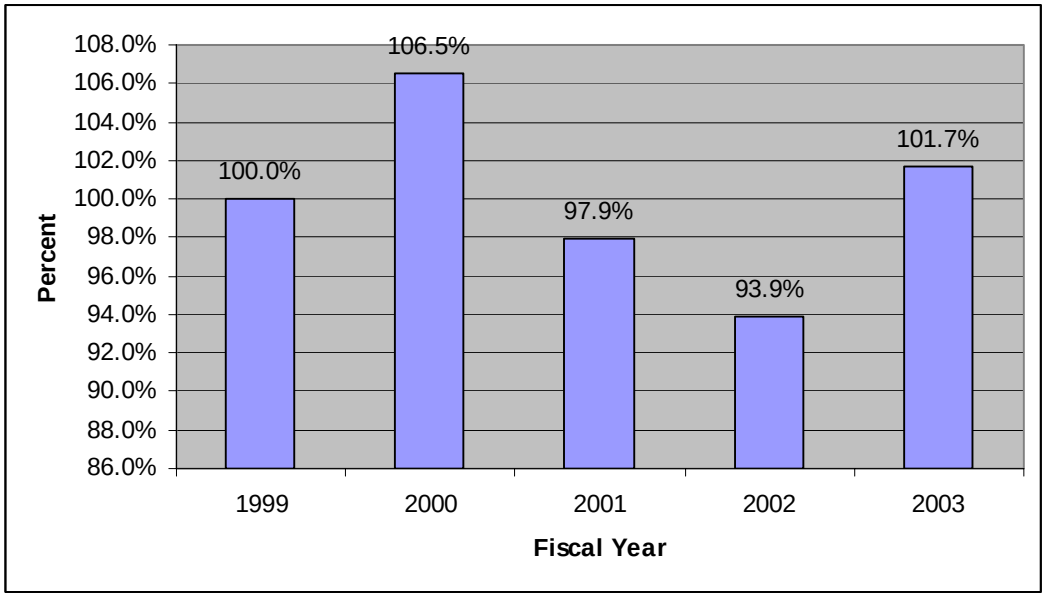

Figure 2. Air Force Petroleum Consumption Compared With FY 1999 Baseline

This trend reversal is concerning and needs to be discussed more. It is very significant to note that 2003 represents the first year of a new method for measuring alternative fuel use. The method used in 2001 and 2002 was potentially overestimating the portion of alternative fuels (and therefore underestimating the portion of petroleum) that was being used in flex-fuel and bi-fuel vehicles. This possible accounting problem and the reflected spike in petroleum consumption is an indicator of the need for improved information technology. This problem will be discussed much more thoroughly under the analysis of alternative fuel usage.

AFV Acquisition and Use of Alternative Fuels

"Each agency shall fulfill the acquisition requirements for AFVs established by section 303 of the Energy Policy Act of 1992." Although E.O. 13149 was signed in 2000, EPAct 1992 percentage requirements began in 1996 and will be considered here. The percentage requirements are 25 percent in FY 1996, 33 percent in FY 1997, 50 percent in FY 1998, and 75 percent in FY 1999 and thereafter. Although the Air Force has been very inconsistent in meeting this requirement, the trend has been up and the requirement was exceeded in 2003. Many factors went into this success which will be discussed in more detail later. The more generous allowances in E.O. 13149 for vehicle reporting credits contributed significantly. The Air Force has directed fleet management personnel to acquire AFVs first on all acquisitions and leases (Air Force, 2003:3). It is DOD's strategy to request and accept all AFVs provided by GSA fleet (DOD, 2003:7). The Air Force is forecasting that AFV acquisitions will be over 200 percent (after bonus credits) in FY 2004 and FY 2005. Figure three shows the acquisition requirements that

were established in EPAct 92 and reaffirmed in E.O. 13149. The Air Force's actual acquisitions are also shown.

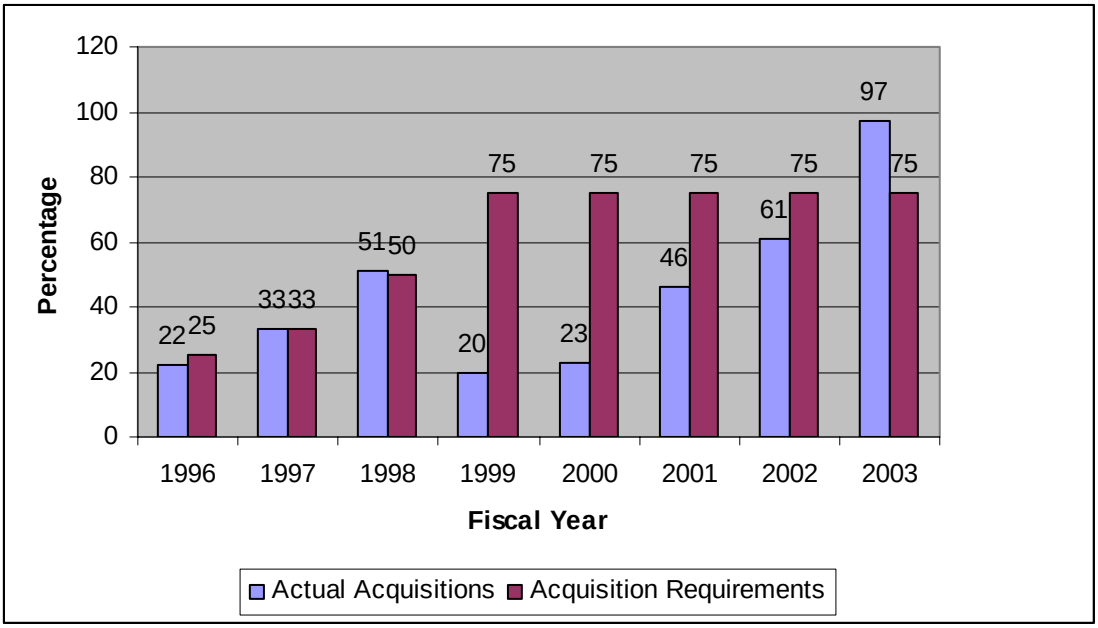

Figure 3. Air Force AFV Acquisition Percentages

In order to gain maximum benefit from AFVs, E.O. 13149 mandates that alternative fuels will be used for the majority of needs in AFVs by the end of FY 2005. Progress in this area has not been monitored and reported as diligently as petroleum consumption, AFV acquisition, and fuel efficiency. There are several reasons for the lack of oversight involving this part of the program. The DoD assumes that certain usage rates of alternative fuel will be met. The following chart outlines the assumptions as given in the DoD Compliance Strategy.

Table 1. Assumed Alternative Fuel Use in AFVs

FY 2001	11%
FY 2002	21%
FY 2003	31%
FY 2004	41%
FY 2005	51%

Unfortunately, progress towards these goals is not being diligently tracked and it appears that the information technology does not currently exist to accurately measure alternative fuel use in AFVs. John Haley, Vehicle Management Specialist for Air Force Material Command, informed me that current fuel tracking tools do not have a way to distinguish between the various types of fuel that might be used in a vehicle. The Air Force vehicle information system (VIMS) will only track a single type of fuel used in a vehicle. Therefore, the various types of fuel used in an AFV must be tracked manually. This is extremely error-prone. The Air Force is planning to modify VIMS by Jun 2004 to account for multiple fuels and replace it entirely by FY 2006. Due to location and alternative fuel availability, the Air Force purchases some alternative fuel at commercial fuel stations off-base. This fuel is paid for by using the General Services Administration SmartPay government charge card. Under this system, GSA is responsible for tracking alternative fuel use. Unfortunately, the commercial sector does not have the ability to provide specific information on the type of fuel purchased. Until unique codes are developed for each type of fuel, electronic monitoring will be impossible. To overcome this problem, GSA estimated alternative fuel consumption in 2001 and 2002. Although this methodology is extremely similar to how the DOD is forecasting alternative fuel use, it is fatally flawed. It was determined to be highly inaccurate when it was realized that some vehicles were being credited with using alternative fuel that wasn't even available in their location. In FY 2003, GSA began crediting alternative fuel use only as it was specifically reported by billing or otherwise. This change in accounting practices has severely negatively affected the perceived accomplishments of the Air Force in 2003 by virtually all fuel usage measurements. The following table shows the "best guess" of

actual Air Force use of alternative fuels in AFVs. Note the dramatic decrease that accompanied the change in accounting procedure between 2002 and 2003.

Table 2. Estimated Alternative Fuel Use in AFVs

2000	2001	2002	2003
1.32%	5.73%	15.26%	3.16%

GSA acknowledges that there are discrepancies when the billing process is used for reporting. It is possible that the 2003 data underestimated the E85 usage. The new method of monitoring fuel resulted in the AF being credited with using less than 29,000 gge of E85 in 2003 compared to nearly 79,000 gge in 2002. Until current monitoring systems are modified by the Air Force and the commercial sector, it will be impossible to confidently report how much alternative fuel is used in an AFV. In the meantime, the preceding table shows a significant underutilization of the alternative fuel capabilities within the Air Force fleet.

The driving force behind the acquisition of AFVs and the usage of alternative fuels is the reduction of petroleum consumption. Considering that the Air Force has acquired a significant number of AFVs and consumed a significant amount of alternative fuel, how much has been contributed towards the goal of reducing petroleum consumption by 20 percent? The following table shows the percentage of FY 1999's petroleum consumption that was displaced by using alternative fuels (including biodiesel) in FY 2000 through FY2003.

Table 3. Petroleum Reduction From FY 1999 Baseline

2000	2001	2002	2003
0.26%	1.88%	1.80%	1.57%

The DOD forecasts that alternative fuels can be used to displace 16 percent of the petroleum consumption in the FY 1999 baseline. The actual usage recorded is substantially short of that goal as well as the 20 percent reduction that is required by E.O. 13149. This chart again reflects the change in accounting practices from 2002 to 2003.

Acquisition of Higher Fuel Economy Vehicles

In the Feb 2000 GAO report, one of the specific criticisms of EPAct 1992 was that it did not implement measures to reduce petroleum consumption such as "mandating the use of vehicles that consume gasoline more efficiently" (GAO, 2000: 5). E.O. 13149 responded by declaring in Section 202 (b) that "agencies shall increase the average EPA fuel economy rating of passenger cars and light trucks acquired by at least 1 mile per gallon (mpg) by the end of FY 2002 and at least 3 mpg by the end of FY 2005. In response, the DoD Compliance Strategy focuses its third objective on increasing the average fuel economy of acquired light duty vehicles. The DoD acquires the majority of light duty vehicles from GSA. The DoD's ability to increase average mpg is directly related to GSA's ability to provide higher economy vehicles from the manufacturers. The Air Force has been very successful in meeting this objective. In FY 2002, the most recent year data is available, the Air Force acquired light duty vehicles averaging 26 miles per gallon. The 1999 baseline of 17 mpg was exceeded by a total of 9 mpg. This accomplishment far surpasses the requirement of 1 mpg for 2002 and 3 mpg for 2005.

Optional Performance Strategies

E.O. 13149 permits each agency to develop a strategy that fits its unique fleet configuration and mission requirements. E.O. 13149 also identifies several optional

measures and suggests that “each agency will need a strategy that includes most, if not all, of these measures.” If an agency is unable to comply, E.O. 13149 states that the agency will be required to show that they made “substantial good faith efforts to comply.” In light of the Air Force’s current state of minimal progress towards compliance, being able to identify “good faith effort” is very important. The Air Force should attempt to utilize the optional performance strategies to the maximum extent possible.

E.O. 13149 mandates the acquisition of alternative fuel vehicles in light vehicle classes, but only recommends the acquisition of AFV in the medium and heavy-duty classes. E.O. 13149 does offer incentives to acquire dedicated AFVs in the medium and heavy-duty class by granting an additional three credits for dedicated medium-duty AFVs and four credits for dedicated heavy duty AFVs. The one credit per 450 gallons of biodiesel (2250 gallons of B20) is also an incentive for medium and heavy duty vehicles since those vehicles are the only ones available with diesel engines. No credits were earned for the acquisition of heavy duty vehicles, but light-duty vehicles, medium-duty vehicles, and biodiesel all contributed significantly. The following figure shows how acquisition credits were earned. For each year, the first three bars show the percentage credits that were earned by each type of acquisition credit. The fourth bar shows the cumulative total percentage credit for that year. Rounding may prevent the three types of acquisition credits from adding up to exactly the total.

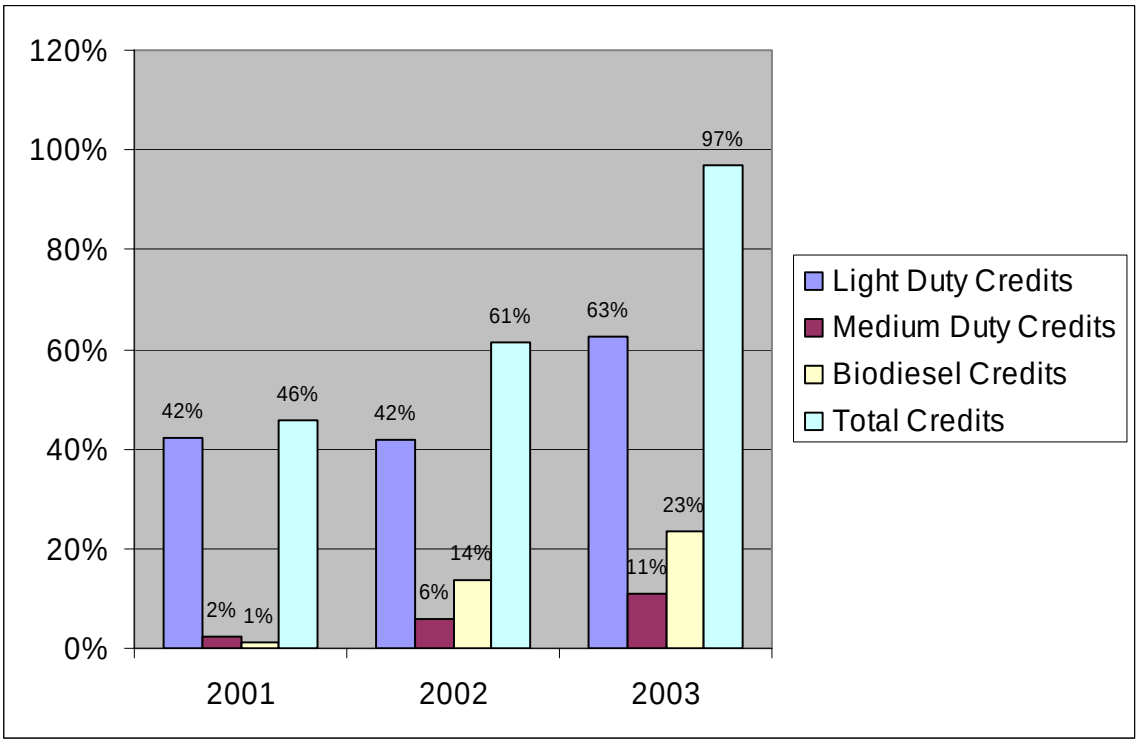

Figure 4. Acquisition Credit by Type

FY 2001 was the first full year that E.O. 13149 authorized credits to be earned by medium duty vehicles, heavy duty vehicles, and biodiesel consumption. Although some progress was in fact made, 42 out of 46 percentage credits were still earned by light duty vehicles. Additionally, 46 percentage credits out of a required 75 was very poor.

In 2002, the Air Force significantly improved acquisition of medium duty AFVs and utilization of biodiesel. Improvements in these two areas single-handedly raised the acquisition credit percentage to 61. The requirement was for 75 percent so the Air Force was still not in compliance. By themselves, light duty vehicles achieved an acquisition rate of 41.6 percent, well below the target of 75 percent.

In 2003, the Air Force achieved 97 percent acquisition credit for AFVs. The Air Force received 23 percent acquisition credit specifically for the use of biodiesel in

medium and heavy duty vehicles. Without the use of biodiesel, the Air Force would have dropped below the 75 percent AFV acquisition target. Medium-duty vehicles, heavy duty vehicles, and biodiesel earned acquisition credits that were critical to the Air Force's compliance in 2003. The Air Force has been effectively utilizing these recommendations and allowances from E.O. 13149.

E.O. 13149 recommends the acquisition of vehicles with higher fuel efficiency, such as hybrids. As discussed earlier, the Air Force acquired vehicles averaging 26 mpg in 2002. This far exceeds the requirement to acquire vehicles averaging 19 mpg by 2005. The Air Force has embraced the higher efficiency vehicles that are being manufactured. The suggestion to acquire hybrid vehicles has been difficult to implement. The Honda Civic, Honda Insight, and Toyota Prius are hybrid vehicles that have been available to civilian consumers for at least one model year, but 2004 is the first year that GSA has offered a hybrid vehicle. The Honda Civic hybrid is offered as a "subcompact" vehicle. This is not ideal because "subcompact" vehicles are not widely authorized or used throughout the Air Force. In the *U.S. Air Force Fleet Alternative Fuel Vehicle Acquisition Report for Fiscal Year 2003* it is stated that the Air Force is anxiously waiting for the arrival of hybrid vehicles in larger vehicle classes. The DoD Compliance Strategy predicts fuel savings in 2005 due to the acquisition of 5 percent hybrid trucks and sedans in that year.

DOE reports that the hybrid vehicles available will increase significantly between 2004 and 2007. The Chevrolet Silverado and GMC Sierra pickup trucks will be offered towards the end of the 2004 model year. These will be the first hybrid pickup trucks offered and should have a significantly positive effect on the Air Force. In 2005 the Ford

Escape, Dodge Ram pickup, Saturn VUE, Lexus RX SUV, and Toyota Highlander will become available. In 2006 the Chevy Equinox and Mercedes S-class will be available. In 2007 the Chevrolet Malibu and numerous GMC SUVs will be available. Although not all of these vehicles are ideally suited towards the Air Force mission, many will provide excellent options for hybrid procurement. Future research and analysis will have to show if the Air Force actually takes advantage of these opportunities.

E.O. 13149 recommends the substitution of cars for light trucks. The DoD Compliance Strategy estimates that that the fuel economy for cars is 6 mpg higher than for trucks. Fuel is being wasted whenever a truck is used to do a job that a car would be suitable for. This problem is typically seen when light duty trucks are used instead of cars for personnel transportation. The following figure shows how the Air Force's fleet of light-duty AFVs has developed over the past three years.

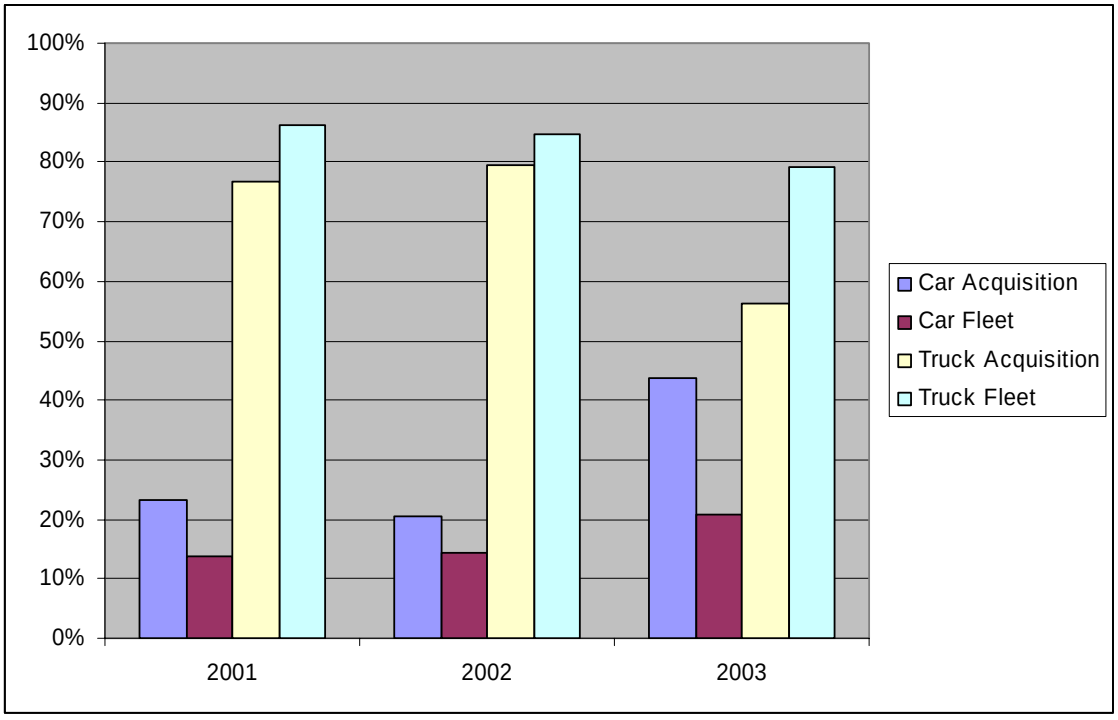

Figure 5. Light Duty AFV Acquisition and Fleet Ratios of Cars to Trucks

In FY 2001, the AF acquired AFVs that were 23 percent cars and 77 percent light trucks. This was the start of a trend that is shifting the fleet of light duty AFVs away from being so heavily truck based. The data shows that in each of the past three years the acquisition of cars gave the cars a more significant percentage of the fleet and the acquisition of trucks allowed that portion of the fleet to dwindle. The most dramatic shift is in FY 2003 when the Air Force acquired light duty AFVs that were nearly 44 percent cars and 56 percent trucks. A large portion of this jump can be attributed to the increase of E-85 flexible fuel compact vehicles purchased. In FY 2002, three such vehicles were acquired. In FY 2003, when the E-85 Dodge Stratus became available, 293 such vehicles were acquired. The Air Force AFV fleet is successfully transitioning towards having a higher percentage of cars.

E.O. 13149 recommends increasing vehicle load factors. The Air Force does not currently have any method of tracking the "people per mile" that its vehicles transport. Furthermore, there is no mention of any such plans or development in the future. Carpooling when possible should be an automatic response for all service members.

E.O. 13149 recommends a decrease in vehicle miles traveled. The Air Force reports that vehicle miles did decrease in 2003. Surprisingly, petroleum use increased over the same time period. The Air Force hypothesizes that petroleum use for FY 2002 was calculated at an inaccurately low level due to overestimation of E-85 use. Additionally, significant E-85 and CNG infrastructure was unusable during the year due to mechanical problems. This forced the use of petroleum in vehicles that might have normally used an alternative fuel (Air Force, 2003).

E.O. 13149 recommends that vehicle fleet sizes be decreased in order to save fuel. From FY 2001 through FY 2003, the Air Force's fleet decreased substantially in size. The Air Force has used this recommendation aggressively. However, it is important to realize that possession of excess vehicles does not necessarily translate into excess fuel usage. In the case of the Air Force, there appears to be little correlation between fleet size and fuel use. This suggests that the excess vehicles were not being used, or perhaps the reduced fleet of vehicles is being utilized at a much higher rate.

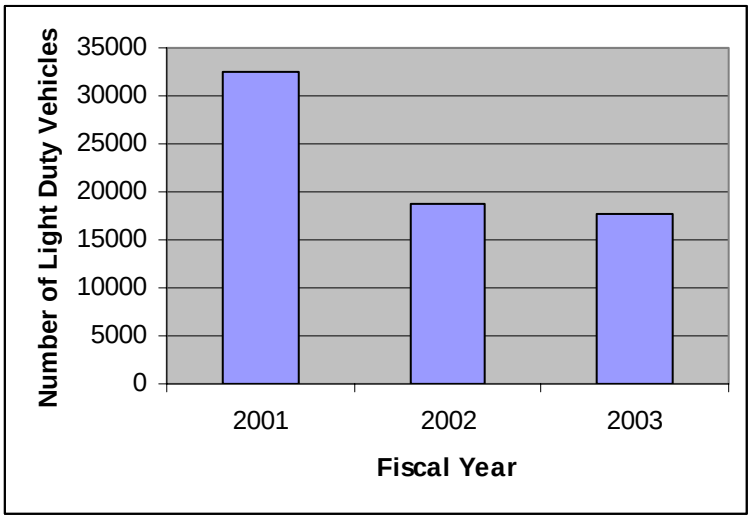

Figure 6. Air Force Light Duty Fleet Size by Fiscal Year

Compliance with Executive Order 13149 revolves around the requirement to reduce petroleum consumption. Given that alternative fuel is seen as the primary solution, it is of the utmost importance to look at the actual alternative fuel use and see how much petroleum is being saved. As mentioned data integrity is a tremendous concern in this area. GSA has acknowledged that estimations of alternative fuel use were most likely excessively high before 2003. However, even this cannot be confirmed absolutely when looked at across the entire fleet. There is no way of knowing if AFVs

with access to alternative fuels used more than the estimation. Although current reporting attempts to be more accurate, the vulnerability of under calculating alternative fuel use does exist if its use goes unreported. Vehicles that are filled on base are subject to the same reporting difficulties. When vehicles are filled with gasoline part of the time and then CNG or E-85 at other times, the different fuels are not distinguished in the records of fuel use for that vehicle. The only solution at this time is to monitor the use of separate fuels in a particular vehicle by hand. At some Air Force bases, CNG usage will only be measured on the same meter that measures CNG used for heating or cooking. The chance for human error is dramatically higher in this case. During FY 2002, there was one instance where a unit reported CNG usage that was off by two decimal places. Future analysis in this area depends on the availability of accurate data. Until the Air Force Vehicle Information Management system is updated to monitor multiple fuels in a single vehicle, it will be very difficult to measure alternative fuel usage with absolute accuracy. Additionally, GSA and the commercial sector need to establish a method of tracking different types of fuel use. Compliance with E.O. 13149 will be determined with much greater accuracy after these advances are made.

Analysis of Current Technology Utilization

This thesis builds on a 2001 thesis that was done by 1st Lt. Janette D. Ketchum. Her thesis focused on an Air Force AFV policy that was centered on the acquisition and use of compressed natural gas vehicles. MSgt Brian Lafleur at Warner-Robins Air Logistics Center states that CNG is no longer at the center of the Air Force AFV program. He reports that 1999 is the last year that the Air Force was significantly

interested in CNG. Analysis of the current Air Force AFV fleet shows that the current fleet consists of primarily CNG and E85 capable vehicles. Is the Air Force transitioning and evolving in-line with developments in the commercial sector? The first item that will be looked at is the Air Force's fleet of E85 and CNG vehicles. The following figure shows the number of acquisitions and the size of the fleet according to fuel type over the past three years.

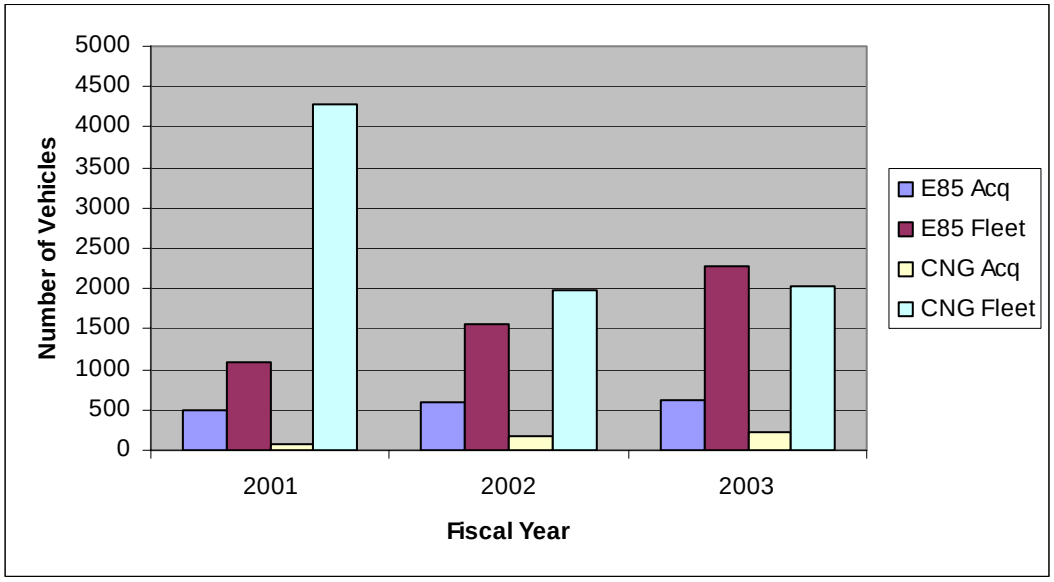

Figure 7. E85 and CNG Acquisitions and Fleet

In the above figure, the first two bars for each year show the number of E85 AFV acquisitions and the size of the E85 fleet. Analysis shows that there has been steady support in the form of acquisitions and the E85 fleet has grown significantly with each year. The second two bars for each year show the number of CNG AFV acquisitions and the size of the CNG fleet. CNG acquisitions have been minimal for each year; far less than the number of E85 acquisitions for each year. The CNG fleet has responded to this lack of support by shrinking substantially over the three years observed. The CNG fleet

was once the dominant portion of the Air Force's AFV fleet, but the E85 fleet is now larger. In comparison to the Air Force's changes, it is important to look at what changes have been made in the commercial industry. Data from the DOE was used to determine how many different vehicles of each alternative fuel type were available over the past three years. The figure below shows how the commercial sector has developed. Appendix A shows the specific vehicle models and the availability that was used to make this figure.

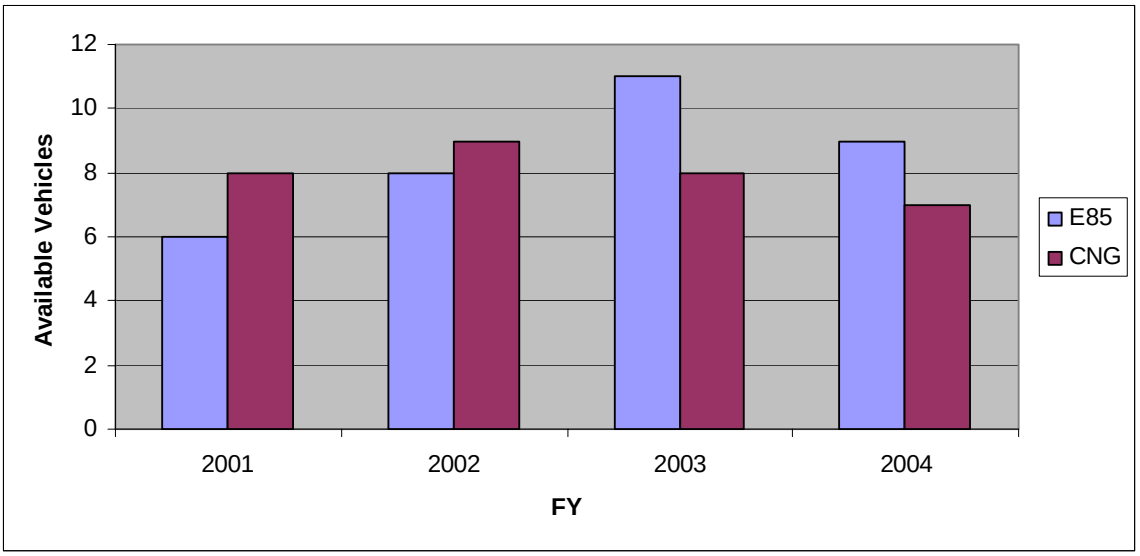

Figure 8. Commercially Available E85 and CNG Vehicles

Comparison of the commercial sector with the Air Force fleet shows that they are closely related. In 2001, the majority of AFVs that were available were CNG. By 2003 the number of available E85 vehicles had dramatically increased and exceeded the number of available CNG vehicles. In 2004 there are still more E85 vehicles available than there are CNG vehicles available. The number of both types available decreased in 2004. For CNG, 2004 marks fewer vehicles available than in any of the previous three

years. Although the 2004 reduction in available CNG vehicles was expected, the reduction in available E85 vehicles was not. It is possible that the highly anticipated introduction of numerous hybrid vehicles within the next several years is causing the commercial sector to shy away from the previously celebrated E85 technology. One notable E85 vehicle that was discontinued for 2004 is the Dodge minivan. This vehicle played a very important part in the Air Force's AFV program. In 2003 the Air Force acquired 83 of these vehicles out of a total of 845 AFVs acquired. Over 18 percent of the Air Force's AFV fleet was Dodge Minivans (818 out of 4351). The Air Force was projected to acquire another 166 E85 Dodge Minivans in 2004. The loss of these AFVs reduces the Air Force's projected acquisition credit percentage from 229 down to 213. This is still far above the required 75 percent; the Air Force is projected to make significant sedan acquisitions in 2004 which lessens the impact of losing the minivans.

The utilization of alternative fuels is critical to compliance with E.O. 13149. The previous analysis clearly shows that the Air Force fleet of AFVs is transitioning; it is important to determine if fuel usage is also making the same transition. The use of biodiesel is not driven by the acquisition of AFVs, but its utilization is very important to Air Force compliance. The following figure shows how the Air Force utilization of the three primary types of alternative fuels has developed since 2000.

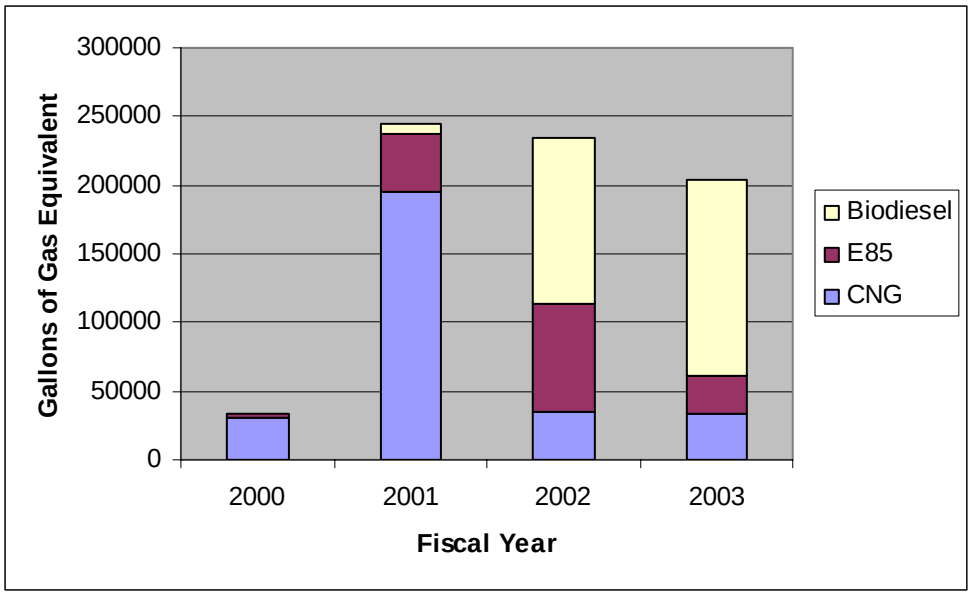

Figure 9. Air Force Use of Biodiesel, E85, and CNG

The Air Force use of alternative fuels is reflective of the AFV fleet. The above figure shows the strong decline in CNG use. This decline is most noticeable between 2001 and 2002 when the Air Force CNG fleet decreased sharply in size. The use of E85 decreased sharply between 2002 and 2003. This is consistent with the change in accounting practices by GSA. The high estimates that were used in 2002 were replaced by the actual reports that were used in 2003. This is considered to be much more accurate but certainly looks bad as reported. The significant increase in the utilization of biodiesel is readily apparent in this figure. Its use has steadily increased over the past three years to the point where it is the dominant alternative fuel of the Air Force. This is consistent with the Air Force policy to make biodiesel the primary diesel fuel of all CONUS fleets when practical (Air Force, 2003).

When comparing and selecting between the various types of different fuels, there are numerous factors to consider. Financial impacts, environmental benefits, and mission

supportability are a few that quickly come to mind. This Air Force is motivated almost exclusively by legislative requirements. E.O. 13149 does instruct agencies to "attempt to minimize costs" and the Air Force is forced to work within a budget. Mission supportability is also an extremely big concern to the Air Force.

When considering the costs associated with adopting a given type of fuel, the vehicle, refueling infrastructure, and fuel itself each have potential costs associated with them. The vehicle costs of an AFV are determined by GSA. Each class of vehicle has a base price. This base price is for the least expensive vehicle in that class. For vehicles other than the least expensive car in each class there is an incremental cost. The incremental cost of a vehicle is the additional cost that is required to add options or "move up" to a different vehicle. The 2004 GSA schedule was used to determine what the incremental cost was for each CNG or E85 AFV that is offered by GSA. The average incremental cost for a CNG vehicle was $5530. The average incremental cost for an E85 vehicle was $1165. For E85 vehicles, GSA frequently noted that the upgrade to E85 required that the car be upgraded from a four cylinder engine to a six cylinder engine. This was the driving factor of the incremental cost, not the actual E85 capability. If a six cylinder engine was to be specified from some other reason, then the E85 capability could be perceived as having no additional expense. Biodiesel capability is considered to be no additional cost because these vehicles would have diesel engines regardless of whether or not an alternative fuel is scheduled to be utilized.

Refueling infrastructure varies widely in price. Biodiesel and E85 are stored and pumped with the exact same type of equipment that conventional diesel or gasoline uses. Assuming that this type of equipment would be constructed or otherwise available

regardless, biodiesel and E85 have no additional costs associated with infrastructure. If infrastructure must be procured, this is the least expensive. In some instances, excess diesel or gasoline infrastructure is converted to biodiesel or E85 infrastructure. If the existing infrastructure is clean, there is no cost of this conversion. In some instances, built-up sludge or grime must be cleaned from the tanks and lines before the new types of fuel can be stored. CNG refueling infrastructure is much more complicated and expensive. Pressurizing CNG to 3600 PSI is a significant task. As discussed in the literature review, FuelMaker offers pumps that can fill one vehicle overnight for as low as $1000. This is woefully inadequate for the volume and demands of the Air Force. John Haley reports that commercial grade infrastructure can cost as much as $200,000. This is obviously a tremendous expense for the Air Force and greatly discourages the use of CNG. Some Air Force installations have creatively found ways to fund such infrastructure. In some instances the local CNG provider has been willing to install CNG infrastructure in exchange for a contract promising to purchase a certain quantity of CNG. This has proven very troublesome for the Air Force as the CNG fleet has declined. Some contracts have the Air Force locked into purchasing quantities of CNG that the installation is not even capable of using.

Fuel prices can vary dramatically depending on the season and geographic location that it is being purchased in. The DOE lists national average prices for each type of fuel. The figure below reflects prices at the end of Dec 2003.

Table 4. Fuel Costs by Type

CNG	Gas	Diesel	E85	B20
$1.35	$1.48	$1.48	$1.70	$1.75

These prices are the average costs that the civilian consumer would pay after taxes. It is significant to note that the civilian gains a price advantage with CNG by avoiding transportation taxes. The Air Force already does not pay the full after-tax price on the other types of fuel so the low cost of CNG is not such an advantage.

Many customers focus on the environment advantages often associated with alternative fuels. CNG and E85 are typically considered as an alternative to gasoline. CNG is substantially more environmentally friendly than gasoline. A vehicle using CNG only produces about 20 percent of the pollution that the same vehicle would produce if it were consuming gasoline. E85 is not as clean as CNG but it still only produces about 75 percent of the pollution that gasoline produces. B20 biodiesel is a replacement for diesel and produces less than 90 percent of the pollution that diesel produces.

Mission supportability is an important issue to the Air Force and must be considered carefully when making vehicle acquisition decisions. CNG is the most problematic when mission supportability is considered. The availability of the fuel is a primary concern. CNG needs to be supplied by a pipeline. This makes refilling impossible if the vehicle is not used in an area with a pipeline nearby. Even if the pipeline is available, the rare and expensive CNG refueling infrastructure may not be. If the refueling infrastructure breaks, repairs or a replacement may be very difficult to procure. Dedicated CNG vehicles face a very high risk of going to a location where it is impossible to get the needed fuel. Bi-fuel CNG vehicles are considered to be much safer because gasoline can be used if CNG is unavailable. Once on-board the vehicle, there are limitations and compromises that CNG forces. Even at 3600 PSI, CNG is not a very dense form of energy. This means that a very large tank must be used and it still does not

store as much energy as a conventional gas tank does. The on-board space consumed by the CNG tank takes away from the vehicles ability to transport its intended cargo. The lower quantity of energy stored in the CNG tank means that the range of the vehicle is negatively affected. Mission supportability is compromised when biodiesel is utilized in extremely cold environments. Many of the northern CONUS bases report that biodiesel does not work in some of the cold conditions that they face. These bases need to have conventional diesel available, at least during the winter. E85 is very limited in where it is geographically available. Since it is primarily a corn-based fuel, it is most readily available in mid-west states like Illinois. Costs are likely to be very high in other areas of the country, if it is available at all. The Air Force mission is not compromised since these vehicles can easily use gasoline, but the Air Force's ability to comply with E.O. 13149 is compromised.

Analysis of Current and Projected Infrastructure

The Air Force is currently working with DESC to provide the capability to issue both biodiesel and E85 at all CONUS bases. To meet this goal, the Air Force has submitted 276 projects for tankage to DESC. Funding for these projects is very difficult to find and it is doubtful that the projects will be completed before the FY 2005 deadline for the 20 percent fuel reduction. At the end of Jan 2004, only 34 bases had B20 infrastructure and only 17 more were on the schedule to get infrastructure. E85 infrastructure is even worse. At the end of Jan 2004, on 6 bases had E85 infrastructure and 19 were identified as either scheduled to get infrastructure or not planning on getting infrastructure. Considering that there are about 60 major bases in the CONUS, there are

many bases that are still developing a plan to obtain B20 and E85 infrastructure. Appendix B contains the complete list of bases provided by DESC that have infrastructure or are projected to get infrastructure.

The Air Force cites DoDD 4140.25, *DoD Management Policy for Energy Commodities and Related Services* as mandating the DLA and DESC to plan, program, and budget for construction of new permanent fuel storage and distribution facilities (Air Force, 2003:1). Interviews with Ronald Catchings at DESC indicate that DESC considers itself to be in the maintenance but not construction business. DESC sees their responsibility as being the maintenance that is paid for with the Defense Working Capital Fund. Alternative fuels and alternative fuel infrastructure has not been included in the Defense Working Capital Fund. DLA even went as far as to say that the alternative fuel program is an experiment that belongs under the Department of Energy.

Until it is clearly determined where infrastructure should come from, it will be very difficult for the Air Force to meet these requirements. Although some projects are being generously funded by wing commanders, major commands, or creative deals with suppliers; this will not be enough for the Air Force to comply with E.O. 13149. As long as alternative fuels are not available due to infrastructure shortages, it will be physically impossible for the Air Force to affectively reduce petroleum consumption through alternative fuels displacement.

V. Conclusion

Alternative Fuel Vehicle Acquisition

The Air Force has developed a program that excels at AFV acquisition. The Air Force is acquiring AFVs to the maximum extent that the manufacturers and GSA are offering them. The Air Force will continue to improve as more alternative fuel vehicles are offered. The utilization of B20 will continue to drive major improvements as more bases gain B20 infrastructure.

Fuel Efficient Vehicle Acquisition

The Air Force's acquisition of fuel efficient vehicles has risen dramatically. This is primarily due to the great strides that have been made within the automotive industry. If an improved product is made available for purchase, then the Air Force can take advantage of it. There appears to be opportunities for vast improvement as the first hybrids become available in vehicles classes that suit the needs of the Air Force.

Alternative Fuel Vehicle Infrastructure

The alternative fuel infrastructure is desperately lacking within the Air Force. The Air Force has submitted 276 tankage projects to DESC which shows tremendous potential for accomplishment. The Air Force needs to hold DESC accountable for its responsibilities or find other funding for these essential projects.

Alternative Fuel Tracking

The alternative fuel tracking system is a major weakness. The Air Force needs to successfully update VIMS in the summer of 2004 so that multiple fuels can be tracked in a single vehicle. It will not matter how successfully the Air Force is reducing petroleum consumption if the tools are not available to measure it. The problems that GSA is encountering with commercial venders are beyond the control of the Air Force. The Department of Energy is given the responsibility to collect data by Executive Order 13149. It may be their responsibility to align commercial venders and ensure that common codes identify usage of alternative fuels.

Alternative Fuel Utilization

Alternative fuel utilization appears to severely lacking. However, this is impossible to accurately determine without the appropriate tracking tools. The Air Force needs to gain visibility over exactly how much alternative fuel it is using. Then the issue of improving alternative fuel utilization can be seriously taken up. The availability of alternative fuel and alternative fuel infrastructure will be instrumental to realizing a significant improvement in alternative fuel utilization.

20 Percent Petroleum Reduction

The chief goal of complying with E.O. 13149 and reducing petroleum consumption by 20 percent is still very far off. The Air Force has made significant gains in acquiring AFVs but needs to fully utilized them if progress is to be made towards the reduction of petroleum consumption.

Future Research

Future research on this topic is needed to ensure that the Air Force successfully follows-up on the introduction of hybrid vehicles. Hybrid vehicles offer tremendous potential to use less gasoline. They require no additional infrastructure or compromises. They deliver all the capabilities of conventional gas vehicles.

Hydrogen vehicles also represent cutting edge technology that the Air Force may find itself utilizing in the near future. The Air Force needs to continue to be involved in taking advantage of the best technology available rather than continuing to invest time and money into technology that is obsolete or inadequate.

Particular attention needs to be paid to the acquisition of alternative fuel infrastructure and its availability. As infrastructure becomes available, and information technology is improved, the Air Force needs to be closely watched to ensure that the maximum utility is being gained from these capabilities. Research might include analysis of each base's fleet of AFVs and the fuel that they use.

Conclusion

The Air Force has the answers to E.O. 13149 compliance. Aggressive pursuit and implementation of these answers will make the Air Force successful. Issues such as construction of alternative fuel infrastructure need to be rapidly resolved so that progress can be made.

Appendix A. Listing of E85 and CNG Vehicles

E85 Vehicles Available

	2001	2002	2003	2004
Chrysler Sebring			x	x
Dodge Stratus			x	x
Dodge Minivan	x	x	x	
Dodge Pickup				x
Ford Taurus	x	x	x	x
Ford Explorer	x	x	x	x
Ford Ranger	x	x	x	
Mazda B3000	x	x	x	
Chevrolet S10	x	x		
Chevrolet Tahoe		x	x	x
Chevrolet Suburban		x	x	x
Chevrolet Pickup			x	x
Mercedes C320			x	x
Total	6	8	11	9

CNG Vehicles Available

	2001	2002	2003	2004
Honda Civic	x	x	x	x
Dodge Van	x	x	x	
Ford Van	x	x	x	x
Ford Pickup	x	x	x	x
Ford Crown Victoria	x	x	x	x
Chevrolet Van	x	x	x	x
Chevrolet Cavalier	x	x	x	x
Chevrolet Pickup		x	x	x
Toyota Camry	x	x		
Total	8	9	8	7

Appendix B. Listing of E85 and B20 Infrastructure

B20 (34) bases	Date B20 Base On Line
Scott AFB, IL	Jun-01
Peterson AFB, CO	Oct-01
Vandenberg AFB, CA	Dec-01
Tinker AFB	May-02
Malmstrom AFB, MT	May-02
Patrick AFB, FL	Jun-02
Cheyenne Mountain AFB	Aug-02
F.E. Warren AFB, WY	Aug-02
Eglin AFB	Oct-02
Langley AFB, VA	Nov-02
McChord AFB, WA	Nov-02
Andrews AFB, MD	Feb-03
Travis AFB, CA	Apr-03
Hurlburt Field, FL	Apr-03
Wright Patterson AFB	Jun-03
Fairchild AFB, WA	Jun-03
SHAW	Jun-03
Kirtland AFB	Jun-03
Dover AFB, DE	Jul-03
McConnell AFB, KS	Jul-03
Hill	Jul-03
DAVIS MONTHON	Jul-03
DYESS	Jul-03
HOLLOMAN	Jul-03
Schriever, AFB, CO.	Jul-03
Hanscom AFB	Aug-03
Robins AFB	Aug-03
ELLSWORTH	Aug-03
Grand Forks AFB	Nov-03
Bolling AFB	Dec-03
Seymour Johnson	Dec-03
Charleston AFB, SC	Dec-03
Barksdale AFB	Jan-04
MOUNTAIN HOME	Jan-04
CANNON	Feb-04
Holloman AFB	Feb-04
MacDill AFB, FL	Aug-04
Pope AFB, NC	CY 2004
OFFUTT	CY 2004
Whiteman AFB	CY 2004
MINOT	Pending
Little Rock AFB	Pending
Keesler AFB	Dec-05
Lackland AFB	Dec-05
Columbus AFB	Dec-05
Luke AFB	Dec-05
Altus AFB	Dec-05
Maxwell AFB	Dec-05
Laughlin AFB	Dec-05
Goodfellow AFB	Dec-05
Sheppard AFB	Dec-05
Vance AFB	Dec-05

E85 (6) bases	Date E85 Base On Line
Peterson AFB, CO	Oct-01
Scott AFB, IL	Jun-02
McChord AFB, WA	Aug-02
Malmstrom AFB, MT	24-Nov-03
Hulman Field ANG	Nov-03
Vandenberg AFB, CA	9-Dec-03
Patrick AFB, FL	DOE grant ETIC 1st Q CY 04
Andrews AFB, MD	Feb-04
Wright Patterson AFB	Feb-04
Bolling AFB	Feb-04
Hurlburt Field. FL	Feb-04
McConnell AFB, KS	Apr-04
MacDill AFB, FL	Aug-04
Hill	CY 04
Little Rock AFB	CY 04
Kirtland AFB	CY 04
Niagara Falls ARS	CY 04
Charleston	TBD
McGuire	TBD
Tinker AFB	Plans Require approval by DLA
Pope AFB, NC	Plans require approval by DLA
F.E. Warren AFB, WY	Out of cycle FY 04 conversion submitted
Eglin AFB	No project submitted
Schriever, AFB, CO.	No Plans
Cheyenne Mountain AFB	No Plans

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Vita

First Lieutenant John Calvin Kirkwood was born on 1 May 1978 in Syracuse, New York. He grew up in the suburbs of Syracuse where he attended Onondaga Central Jr/Sr High School. He graduated in 1996 and immediately entered the United States Air Force Academy in Colorado Springs. He spent his first two years at the Academy as a member of the Loose Hawgs of Cadet Squadron 34. He was a member of Raging Bull Six his last two years. John earned a Bachelor of Science in Management and graduated in 2000.

Upon graduation, John was commissioned as a Second Lieutenant and was assigned to Nellis Air Force Base in Las Vegas, Nevada where he worked in the 99th Supply Squadron. He graduated from the Supply Officer's Course in March 2001 and the Air and Space Basic Course in May 2002. During the summer of 2001 he was sent TDY to the Maple Flag Exercise where he functioned as the Vehicle Fleet Manager in Edmonton, Alberta, Canada.

He PCSed in August 2002 to enter the Graduate Logistics Management program at the Air Force Institute of Technology. At AFIT, John specialized in Transportation Management and Acquisitions Management. Upon graduation, he will be assigned to the Air Force Logistics Management Agency in Montgomery, Alabama.

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14. ABSTRACT
The Air Force must comply with *Executive Order (E.O.) 13149: Greening the Government Through Federal Fleet and Transportation Efficiency*. This order focuses on the reduction of petroleum consumption in an effort to reduce dependence on foreign oil and preserve the environment. Specifically, it directs federal agencies (such as the Air Force) to reduce fuel use in the vehicle fleet 20 percent between Fiscal Years (FY) 1999 and 2005. This thesis examines the Air Force's current alternative fuel vehicle (AFV) program and its evolution to determine how effective it is and how it should be adjusted to promote compliance with E.O. 13149. The results of this thesis will look at steps that the Air Force should consider in an effort to increase the program's impact on petroleum consumption. Analysis shows that the Air Force is working to adopt new technology. However, the availability of such technology in a timely fashion may make it difficult for the Air Force to meet the 2005 goal. Additionally, in instances where the technology is currently available, alternative fuel and the appropriate refueling infrastructure frequently are not. Finding the financial resources to support these improvements would greatly improve the effectiveness of the Air Force's program.

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