Transitioning to a Greener Fleet: A Cost-Benefit Analysis of a Vehicle Fleet Program at the Texas General Land Office in Austin, Texas

By

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Abstract

This study will accomplish three things. First, the study will provide a detailed discussion on cost-benefit analysis and how this type of analysis is used in the decision making process. Second, the study will provide background information on hybrid vehicles and alternative fuels their effect on the environment and the benefit these technologies can have on state and local fleets. Finally, the study will apply the technique of cost-benefit analysis of incorporating hybrid vehicles into the vehicle fleet program at the Texas General Land Office (GLO) in Austin, Texas. A discussion of the scholarly literature defines the costs and benefits associated with a program and offers uses for a cost-benefit analysis. The conceptual framework links the benefits and costs of hybrid vehicles introduced into the vehicle fleet program to the existing literature. The operationalization of the costs and benefit variables are identified, showing how each is measured. Additionally, the decision criteria of present value and net present value are used to determine the viability of the new fleet program. A sound cost-benefit analysis can help decision makers evaluate choices and assure the chosen project will provide the best return on investment. The findings of this study show that the Texas General Land Office can save approximately 100,000 each fiscal year for a three year period by introducing hybrid vehicles into the fleet. Additionally establishing motor pools at each field office with present on-going fuel savings each year.

About the Author

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Chapter One: Introduction

Introduction

The Texas General Land Office (GLO) is not a large state agency. In fact among the many agencies and universities scattered around Texas the GLO is considered a medium to small state agency. The primary mission of the GLO is contributing revenue to the Texas Permanent School Fund. The GLO accomplishes this mission by managing oil leases, selling properties, energy brokering and land leases.

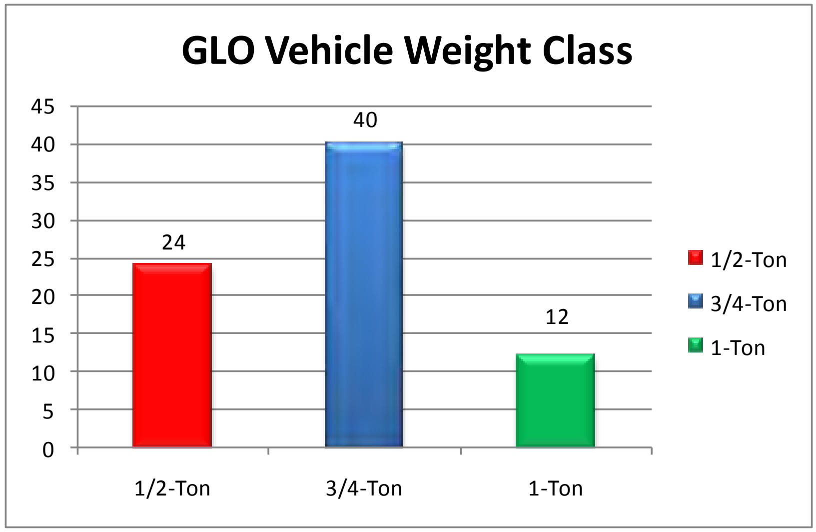
The GLO's fleet is also relatively small with only 76 vehicles used at the Austin headquarters and field offices around Texas. The fleet includes large size vehicles and high fuel usage compared to other state agencies. Little has been done to bring the agency fuel usage into check[1]. A plan to use smaller fuel efficient vehicles as staff transport vehicles is needed.

Field offices have no real fuel efficient vehicles to transport staff to job sites when a heavy vehicle is not needed. In fact all vehicles in the fleet are purchased to complete the most rugged heavy duty task. Large heavy duty 4-wheel drive vehicles are required if the only task is pulling trailers, boats and equipment. However from studying the vehicle use reports such as the one listed in Appendix-B the driving habits and true uses of the vehicle come to life. GLO vehicles spend 55% of the time traveling on roads that don't require 4-wheel drive; they also spend about the same percentage of time traveling without equipment attached.

[1] For projection of the agencies fuel usage see Appendix – C.

The agency mission[2] certainly requires some large vehicles to complete tasks such as pulling boats, trailers, and equipment. However if each region had a vehicle pool that contained some efficient vehicles then fuel savings would be realized. Driving 1-ton vehicles to training, permit offices, and to job sites that only require an inspection wastes resources. These tasks could be completed in a fuel efficient environmentally friendly vehicle that gets three times the fuel economy, emits less air and noise pollution, and presents a better agency image. Out of the 76 vehicles in the GLO's fleet 52 are ¾ and 1 ton vehicles as seen in the graph in figure 1.1.

Figure 1.1: Out of the 76 vehicles in the GLO's fleet 52 are ¾ and 1 ton vehicles. This is approximately 69% of the fleet.



The GLO has recently developed a renewable energy division that promotes initiatives in wind, hydroelectric, and solar energy. The GLO is also a key stakeholder in the Central Texas Clean Cities[3] program that promotes the use of cleaner fuels, hybrid vehicles, and technology that increases vehicle fuel economy. It is only fitting that the GLO upgrade its fleet to more fuel efficient vehicles.

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[2] The GLO's primary mission is to contribute revenue to the Texas Permanent School Fund. Vehicles assist agency personnel complete this mission.

[3] The Central Texas Clean Cities program is coordinated through Stacy Neef and is part of the Austin Energy Climate Protection Program. www.cityofaustin.org/cleancities

The GLO's vehicle fleet program has not undergone an audit or efficiency analysis. The monthly fuel bill is paid along with the repair and maintenance of the vehicles and not much attention is paid to the ever increasing amount. The condition and mileage of the vehicles are also assessed by the financial services section. However the question has not been asked as to whether the agency spends too much on fuel, or is the program really efficient.

Each year the GLO replaces on average 8 to 10 vehicles that have reached their useful life with the agency. Agency fleet policy states that when a vehicle reaches 6 years of age or has accumulated 100,000 miles or more then the vehicle can be replaced (Texas General Land Office Fleet Policy, 2007). Also if a vehicles repair costs outweigh the value of the vehicle then management can make the decision to replace the vehicle.

When discussing vehicle replacement remarks often go back and forth on preference of vehicles. Management and staff often suggest that Ford makes a better looking truck than Dodge or that they would never drive a Chevy. This non rational thinking often leads to purchasing a vehicle more on style than functionality. Purchase of a government fleet vehicle should not be driven by employee preference. Fuel efficiency and its ability to accomplish the task is the only rational approach. Vehicles are not always replaced when they meet the agency criteria. If budget money is not available or if management believes the vehicle is still useful then a decision is made to keep the vehicle longer. This study examines the costs and benefits of replacing these surplus vehicles with fuel efficient hybrid models.

Research Purpose

This study will accomplish three things. First, the study will provide a detailed discussion on cost-benefit analysis and how this type of analysis is used in the decision making process.

Second, the study will provide background information on hybrid vehicles and alternative fuels their effect on the environment and the benefit these technologies can have on state and local fleets. Finally, the study will apply the technique of cost-benefit analysis of incorporating hybrid vehicles into the vehicle fleet program at the Texas General Land Office in Austin, Texas. Specifically this research will consider replacing larger vehicles such as pictured in image 1.1, with gasoline electric hybrid vehicles. A consideration will also be made to set-up vehicle motor pools at field offices so that staff can choose vehicles in the fleet that are the most suitable for the task. Finally a cost-benefit analysis will follow that takes all the dollar figures into account and displays the costs along with the benefits of incorporating hybrid vehicles into the vehicle fleet program at the Texas General Land Office, a state agency in Austin, Texas.

Image 1.1: A group of typical GLO vehicles

The number of current replacement vehicles will be compared to bringing in the same amount of hybrid vehicles toward the middle of the fiscal year. It is the middle of the fiscal year around January and February that divisions have identified money that can be spent on new vehicles. In this comparison the amount of vehicles that is up for replacement in the same fiscal year will be compared to the same amount of hybrid vehicles that can replace this surplused amount. This way no extra vehicles are purchased, they are just replaced with a more fuel efficient vehicle. The Toyota Prius Hybrid vehicle was chosen for this study because the scholarly research identifies this vehicle as the most fuel efficient and well designed vehicle as compared to similar hybrid models. Furthermore the Prius is currently available on state contract, and is used by other Texas agencies and universities. Additionally dealerships offer a great warranty of 8 years or 100,000 miles.

Chapter two reviews the scholarly literature on cost-benefit analysis. The literature defines costs and benefits, discusses the uses of cost-benefit analysis, reviews the appropriate discount rate, and indentifies decision criteria used in performing a cost-benefit analysis. Additionally, this literature review will examine the benefits and costs of hybrid vehicles and how this technology is making its way into the market. Finally this literature review will provide a foundation for conducting a cost-benefit analysis of incorporating hybrid vehicles into the vehicle fleet program at the Texas General Land Office in Austin, Texas.

Chapter three provides background and historical information on the Texas General Land Office and the Office of Vehicle Fleet Management. The divisions and mission of the GLO will be discussed and how its program relates to the states mission for clean technology. Chapter four will describe the methodology used to operationalize the benefits and costs identified in the conceptual framework to determine if the Texas General Land Offices current vehicle fleet program is cost beneficial. This chapter will discuss how each cost and benefit is measured and compared to replacing fiscal year 2010 vehicles with the same amount of hybrid vehicles.

This study is considered an Ex ante cost-benefit analysis because it takes place before the project of concern is implemented. An Ex post study is performed after the fact. This study is also considered a comparison of the status quo which is the current program to an alternative program. A Final section will describe the discount rate and decision criterion used in the cost-benefit analysis for this study. Chapter five will then present the results of the analysis. The results of this study show a great advantage in choosing hybrid vehicles to act as staff transport vehicles.

Chapter six will discuss and support recommendations that the Texas General Land Office and similar agencies replace larger vehicles that are used for staff transport with fuel efficient hybrid vehicles and develop a strategy for motor pooling their vehicles.

Chapter Two: Literature Review

Introduction

The purpose of this chapter is to review and examine the available literature on alternative propulsion vehicles, and the method of cost-benefit analysis. This literature examines the current hybrid vehicle technology giving the costs and benefits of this vehicle type. Further the literature defines costs and benefits, details the history and uses of cost-benefit analysis, reviews the appropriate discount rate, and presents the decision criteria used in performing a cost-benefit analysis. Additionally, this literature review will lay the foundation for conducting a cost-benefit analysis of incorporating hybrid vehicles into the vehicle fleet program at the Texas General Land Office in Austin, Texas.

Choosing a Green Vehicle & Reviewing Alternative Fuels

Green vehicles are those that are environmentally more benign than conventional gasoline or diesel vehicles. Green vehicles have high fuel economy and employ emission reduction technologies. They may also be able to consume non-petroleum-based alternative fuels that tend to reduce air emissions. Greening fleets means increasingly composing them with higher numbers of green vehicles and employing energy efficiency strategies (Rahm and Coggburn 2007, 401). Purchasing a green vehicle can have different meanings in today's market. A green vehicle can use an assortment of new fuels such as: Ethanol, Bio-Diesel, Compressed Natural Gas, and Hydrogen Fuels. Furthermore Green vehicles can receive energy from battery power that drives an electric motor or can use a combination of battery, electric motor and internal combustion engine. Green vehicles currently making their way into the consumer market include: Electric Vehicles, Plug-In Electric Vehicles, and Hybrid Electric Vehicles. In this study one vehicle type will be chosen out of this group to replace current fleet vehicles that are used to transport staff.

Hybrid vehicles come in many different styles and use many different energy sources to propel them forward. In the past 20 years new fuels have been introduced to begin to take the place of fossil fuels like gasoline and diesel. Whether the purchaser wishes to go the route of using a fuel other than diesel or gasoline or chooses a vehicle that runs off energy produced by a battery these all reduce Americas need for fossil fuels.

Flex Fuels

Flex Fuels; include Ethanol, Biodiesel, and Hydrogen fuels (fuel-cell). These flex fuels have entered the market during the last 20 years. Flex fuels were created to reduce Americas dependency on foreign oil and create a source of fuel closer to home. Image 2.1 & 2.2 shows a typical Ethanol fueling station near Austin.

Kromer & Heywood (2007, 20) discuss that currently, there is a renewable fuels standard that calls for 7.5 billion barrels of bio-fuel to be blended into the gasoline supply by 2012; to the

Image 2.1 & 2.2: Ethanol or E85 in its pure form is available at two locations along I-35 near downtown Austin. The HEB on Palmer Lane and the HEB in Buda, TX both locations are approximately 25 miles round trip from GLO headquarters.

extent that these targets are achieved, they will be met primarily by ethanol derived from corn-based feedstock's. These renewable fuel mandates are problematic both in that there may not be enough cropland to support the mandated ethanol supply without affecting food production, and in that corn-based ethanol delivers only marginal Green House Gas (GHG) reduction benefits over petroleum. Longer-term, ethanol derived from cellulosic feedstock's may contribute to the type of integrated solution that is needed, but a viable cellulosic conversion technology may be a decade or more from producing fuel at scale. Similarly Campbell, Lobell, & Field (2009, 1055) agree that the quantity of land available to grow bio-fuel crops without affecting food prices or GHG emissions from land conversion is limited. Therefore, bio-energy should maximize land-use efficiency when addressing transportation and climate change goals.

Image 2.3 & 2.4: Biodiesel in its purest form B100 is sold through small distributers like Eco-Wise hidden off the main roads.

Biodiesel is a form of diesel fuel manufactured from vegetable oils (used or new) or animal fats. Biodiesel can be used in its pure form (B100) or blended with petroleum diesel in various proportions (e.g., B20 is 20 percent biodiesel, 80 percent petroleum diesel) (Environmental Protection Agency 2009, Bio Diesel Emissions Program). Rahm & Coggburn

(2007, 403) point out that “pure biodiesel is nontoxic, biodegradable, and is designated as an alternative fuel by the Department of Energy.” On the downside, higher level blends typically require some modifications of the fuel system. Biodiesel also acts as a solvent and can cause rubber and other components to fail overtime. Image 2.3 & 2.4 shows a biodiesel fueling location at Eco-Wise on 110 W. Elizabeth Street in Austin. The manager at Eco-Wise remarked that” two years ago the 300 gallon tanks were refilled every two weeks. These days we are lucky if we sell 300 gallons in a month.”

Biodiesel is talked about as an alternate fuel, however finding it in local fueling stations or acquiring it from a local vendor in a usable quantity is difficult. According to Sherry Boschert (2006, 3) “Bio-fuels such as biodiesel may offer a homegrown alternative to gasoline, but producing enough biodiesel to power all the cars, trucks, and SUVs in America is impossible today and impractical in the future.”

Hydrogen fueling stations are starting up in small numbers around the United States as Hydrogen Fuel Cell vehicles are produced. A fuel cell operates like a battery. Fuel cells convert chemical energy into electricity by combining oxygen in the air with the hydrogen in the fuel cell (Rahm and Coggburn 2007, 405). As far as hydrogen fuels are concerned, many engineers dispute their readiness in today’s market, but the future hold promise. According to Kromer & Heywood (2007, 91) “an actual hydrogen-based automotive fuel cell transportation system

Image 2.5: This Hydrogen fuel station operated by the University of Texas was difficult to find. UT operates a hydrogen fuel cell bus.

introduces a number of practical constraints to this ideal model. At the stack level, fuel cell performance and durability is limited by the properties of present-day membrane materials, catalyst properties, and system management, and current systems are very expensive with power plant costs for high volume production projected to be a factor of 3 more expensive than a spark-ignition engine. At the vehicle level, storing enough hydrogen (which has low volumetric energy density) to allow for adequate vehicle range is problematic. And at the level of the transportation system, it is not clear *how* to transition to a hydrogen infrastructure; nor will hydrogen deliver the promised near zero well-to-wheel emissions if produced from natural gas without carbon capture." Image 2.5 shows a Hydrogen fueling station operated by the University of Texas.

Image 2.6: Small electric vehicles like this one are used for small tasks around the Capital Complex.

Basic Electric Vehicles (EV)

Basic electric vehicles can be described as a vehicle powered entirely by battery power which powers an electric motor to propel the vehicle forward. A more formal definition of an electric vehicle reads:

- Basic Electric vehicles (BEVs): These are cars, trucks, and sport utility vehicles (SUVs) powered by an electric motor, one or more controllers, and a large bank of batteries. They have no gasoline engine. Electric vehicles plug into a wall socket or other source of electricity to recharge the batteries (Boschert 2006, 30).

The key factor in choosing a BEV is range; this is the distance the vehicle can cover with a full charge from the battery. If the batteries energy is depleted before reaching its destination then the vehicle will need to be charged or towed before it can move. As Boschert (2006, 42,43) suggests "most of the first-generation electric vehicles had a range of 70 – 90 miles, however many of today's vehicles will achieve between 100 and 140 miles before a charge is needed".

Battery technology is becoming more efficient every year and new technologies are being invented, however many problems impede the development of new battery technology. Kromer & Heywood (2007, 38) point out that the primary question surrounding present-day lithium-ion batteries centers around the batteries' tendency to catch fire when overcharged or overheated. Under these conditions, the metal-oxide cathode becomes unstable and releases oxygen, which can ignite the flammable electrolyte or lithium that is deposited on the anode – generating more heat and possibly igniting neighboring cells. Image 2.6 shows an electric vehicle operated by the Texas Facilities Commission in Austin, Texas.

Plug-in Electric Hybrids (PHEV)

Plug-in hybrids (PHEVs) are pure battery-electric vehicles with an electric motor and a small internal combustion engine. They are different from hybrids because they have a larger bank of batteries and an electric plug. They run longer in electric mode, using less gasoline and producing fewer emissions (Boschert 2006, 32). Also, as technologies such as Plug-in Hybrid Vehicles are developed, even higher efficiency ratings will exceed that of internal combustion engines.

Kromer & Heywood (2007, 22) acknowledge that neither plug-in hybrids (PHEVs) nor fuel-cell vehicles have yet been produced for a consumer market. Both are the focus of increasing research and development within both government and industry, and have been deployed in small numbers as test vehicles or as concept cars.

A Plug in Electric Vehicle travels in a charge depleting battery mode until the vehicle eventually needs charging; however, regenerative breaking and a small combustion engine aids in this vehicle achieving a much greater fuel economy. PHEV technology is not without its challenges. Energy storage system cost, volume, and life are major obstacles that must be overcome for these vehicles to succeed. Markel & Simpson (2006, 2) agree that because of different battery sizes the reduction of per-vehicle petroleum consumption in a PHEV results from two factors: Charge depleting (CD)-mode petroleum displacement due to battery energy capacity of the vehicle, and charge-sustaining (CS)-mode fuel-efficiency improvement due to hybridization or battery power capability of the vehicle. Hybrid Electric Vehicles do not have a CD-mode and are only able to realize savings via the CS-mode.

In summary flex fuels such as Ethanol, Biodiesel, and Hydrogen fuels all have their challenges. The most apparent challenge is finding these fuels in the market place. The GLO’s fleet does consist of a portion of Ethanol vehicles and these vehicles help the agency appear green; however vehicle use reports like the one shown in Appendix B show that only gasoline is purchased for these vehicles. Rahm and Coggburn (2007, 413) point out that States can, and do, purchase dual-fuel vehicles to meet their federal requirements; however, then they run these vehicles on gasoline. Flex fuel refueling stations are few and far in-between and GLO drivers often remark that Ethanol is difficult to find in their area. Biodiesel and Hydrogen fuels stations are even more difficult to find and therefore are not acceptable at the current time for the GLO fleet.

Basic Electric Vehicles are not practical at this time for the GLO's fleet because of the great distances between field offices, headquarters, and job sites. If employees forget to fully charge the vehicles, they may become stranded and extra resources will incur bringing the vehicles back to the office. Also current state fleets only use electric vehicles for very small jobs that do not require the vehicle to drive over 25 miles.

Plug in Electric Hybrid vehicles offer a better solution since the battery is partially charged by a small internal combustion engine. However the vehicle does need to be plugged in to recharge the battery fully. In emergency situations the GLO cannot rely on a plug in vehicle to be ready at a moment's notice. Finally a good plug-in infrastructure has not yet been developed to handle large vehicle fleets in the GLOs headquarters and field office areas.

The most reliable vehicle in this study is the Hybrid Electric Vehicle (HEV). The HEV is a combination electric and internal combustion engine vehicle with superior fuel economy. The HEV will be discussed further in this literature review giving the costs and benefits of this type of vehicle alone.

Hybrid Vehicles: Background

Hybrids (HEVs): These are gasoline vehicles with internal combustion engines. Hybrids also have an electric motor and a small bank of batteries that assist the engine, providing boosts of power or extending the range the vehicle can travel. Hybrids can't be plugged in but use the gasoline engine motor plus regenerative braking to recharge the battery (Boschert 2006, 31).

Among the many green vehicle types only standard hybrid vehicles have sold in great numbers and have been accepted by the American vehicle market. According to Kromer & Heywood (2007, 22) Hybrid-electric vehicles (HEV) are in their ascendancy, having established a small but growing niche in the US auto market. In 2006, HEV sales topped 250,000 vehicles and accounted for 1.5% of new vehicle sales.

As Sherry Boschert (2006, 33) explains, many of the US automakers never really thought that electric vehicles would catch on; they didn't think much of hybrids either. "The US automakers publicly abandoned hybrids and left them to the Japanese automakers, which rode them to popularity and profits, changing the auto industry as they went" (Boschert 2006, 33).

There are other factors that may justify the incremental HEV cost. Examples include tax incentives; reductions in petroleum use, air pollution, and greenhouse emissions; national energy security; reduced maintenance; fewer fill-ups at the gas station; and green image (Markel and Simpson 2006, 7).

Benefit Section for Hybrid Vehicles

Reduction in fuel costs

By far the greatest benefit in hybrid vehicle technology is the reduction in fuel used by the vehicle. Full hybrid sedans can get 40-50 miles per gallon. By using an electric motor in conjunction with a combustion engine higher fuel efficiency ratings can be realized. According to Kromer & Heywood (2007, 18) the US light-duty fleet is dominated by spark-ignited (SI) internal combustion engines (ICE) running on gasoline, which account for about 98% of new vehicle sales; hybrid-electric vehicles (HEVs) and diesels together combine to account for the remaining 2%. Vehicles sold today are fueled almost entirely by petroleum, which accounts for 98% of the on-road transport fuel. A typical US passenger car accelerates from 0-60 in under 10 seconds, can travel about 350 miles between refueling, and gets about 21 miles per gallon (MPG) in terms of on-road fuel economy. It is highly reliable, expected to last more than 15 years and

150,000 miles, and is supported by a widely accessible nationwide fueling infrastructure. Furthermore Matthew Kromer and John Heywood (2007, 19) state that historically, gas prices have been too low to create a significant market pull for fuel efficient vehicles. Rather, vehicles have been marketed primarily on factors such as size, comfort, and perceived safety (each of which correlate with increasing weight), and power. These factors – increasing power and increasing weight – both tend to reduce fuel efficiency. In reaction to this Roger Kemp (2007, 123) suggests that indeed, "as the cost of crude oil reaches new highs, fuel savings may once again become the main reason for purchasing hybrids".

Image 2.7: This is the drivers panel that shows when the vehicle is operating on the combustable engine, the electric motor or operating on battery power alone.

Production hybrid electric vehicles offer the convenience of not having to plug in the vehicle each time it's driven. Markel & Simpson (2006, 2) describe the challenges in the two as: Production HEVs achieve high fuel economy, but they are still designed for petroleum fuels and do not enable fuel substitution or flexibility. Given that HEVs are succeeding in the market they are a good choice for proven technology. Similarly Kromer & Heywood (2007, 124) suggest that "as a technology that has already enjoyed market success and has already penetrated the market in small numbers, the hybrid vehicle faces the least technical risk and the greatest leverage for reducing petroleum and Green House Gas (GHG) emissions in the near-term amongst the technologies under evaluation".

In fact a hybrid vehicle achieves its fuel economy by switching periodically to the electric motor especially during stops or at low speeds. According to Roger Kemp (2007, 122) the electric engine is especially valuable during acceleration from zero to 12 miles per hour, when a diesel engine would otherwise be burning the most fuel and getting the most wear and tear on its components. Furthermore Kemp (2007, 122) points out that the standard hybrid vehicle moves on battery power alone from zero to 20 miles per hour and the batteries recharge when the vehicle is not accelerating.

Reduction in maintenance and repair costs

One of the more amazing technologies to come out of Hybrid Technology development is regenerative braking systems that convert some of the car's kinetic energy into electricity that gets fed back into the batteries when the driver wants to slow down or stop. In conventional cars, that kinetic energy simply becomes heat on the mechanical brakes used to stop the car and is wasted (Boschert 2006, 30). This also means that hybrid brake systems will need to be replaced less because heat is distributed away from the brake pad and shoes therefore extending the life of these parts. Boschert (2006, 30) points out that all hybrid vehicles have regenerative braking systems that convert some of the car's kinetic energy into electricity that gets fed back into the batteries when the driver wants to slow down or stop. Image 2.7 shows the drivers panel in the Toyota Prius. This panel displays when charging from the break system is occurring. This technology is superior to standard vehicle braking systems which need to be replaced more often due to heat and friction submitted to the breaking system. According to Sherry Boschert (2006, 35) since the regenerative braking system helps slow down the car, brakes get used less and need replacing less often.

Electric motors in hybrids can provide as many as 1 million miles (1.6 million km) of service. Kromer & Heywood (2007, 49) agree that projecting into the future, improved regenerative braking and engine optimization offer the primary opportunities for further increasing the hybrid vehicle's fuel economy and maintenance benefit.

According to Markel & Simpson (2006, 7) in the near-term scenario, the hybrid electric vehicle achieves a lower cost-of-ownership than the combustion vehicle (CV). Furthermore the hybrid electric vehicle has a much smaller engine requiring less fluids and maintenance because it is half the size of standard vehicles and approximately half the time the electric motor is doing the work.

Reduced emissions in the environment

Another key benefit to the hybrid electric vehicle is the reduction in direct emissions into the environment. Small & Kazimi (1995, 8) found that vehicle transport accounts for substantial fractions of direct emissions (that is, "inventories") of three primary pollutants: volatile organic compounds (VOC), carbon monoxide (CO) and nitrogen oxides (NOx). VOCs, also known as reactive organic gases (ROG), give car exhaust its characteristic smell. VOCs react with NOx in the atmosphere to form a variety of damaging oxidants such as ozone, and they also produce secondary carbon, a component of particulate matter (PM). Small & Kazimi (1995, 8) stress that motor vehicles, especially those using diesel fuel, emit some particulate matter directly and also emit sulfur oxides (SO_x), primarily sulfur dioxide (SO_2). $S0_2$ is an irritant and contributes to particulate formation and acid rain. Roger Kemp (2007, 122) agrees that "Any vehicle emits the most pollution when it accelerates from a stop or goes up a hill. The hybrid uses electric power from its batteries when it accelerates, eliminating the excessive dark cloud that an accelerating vehicle typically emits."

Emission standards change from state to state. Many states have a standard that exceeds what is recommended by the federal government. The United States' new federal emission standards, to be phased in between 2004 and 2009, require passenger cars, sport-utility vehicles, and light-duty trucks to be 75%-95% cleaner than they are today (Ewing and Sarigollu 2000, 106). Emissions are deadly and cause many health related problems. Small & Kazimi (1995, 18) stress that a single day of high pollution might trigger the deaths of many people weakened by diseases unrelated to air pollution; or at the other extreme, daily deaths might show no correlation with daily pollution levels even though chronic illnesses are caused by long term exposures.

There are many differences between emission levels from country to country. Small & Kazimi (1995, 14) point out that when studies with clear biases are eliminated, the evidence consistently shows that people in nations with high standards of living are willing to pay over one thousand dollars per year to reduce their annual mortality risk by 1 in 1,000: that is, their average "value of life" is more than one million dollars. This means that the cost of a given emission depends on what pollutants are already in the air, and total costs cannot necessarily be allocated among its constituents. Kromer & Heywood (2007, 15) point out that any coherent national or global Green House Gas reduction plan must include a strong focus on reducing emissions from the light-duty vehicle fleet.

The vast amount of literature on vehicle emissions states that internal combustion type engines produce large amounts of air pollution. As the environmental battle over greenhouse gases heats up, reducing vehicle emissions becomes a high priority. Vehicles present a challenging problem because they are not stationary; they spread pollution over large areas. Boschert (2006, 1) points out that "gasoline vehicles produce more than a third of the greenhouse gases that come from the United States and add to global warming. The need for gasoline leaves our economy at the mercy of other oil-producing nations, many of whom don't particularly like us".

Small & Kazimi (1995, 12) offer methods to infer the costs of air emissions; their research states that there are at least three ways to infer the costs of air emissions. The best developed, and the one adopted here, is the direct estimation of damages. In this method, one traces the links between air emissions and adverse consequences, and attempts to place economic values on those consequences. Other methods include hedonic price measurement, in which observed price differentials are related to air quality; and revealed preference of policy-makers, in which pollution costs are inferred from the costs of meeting pollution regulations. In the method of direct damage estimation, several links in the causal chain must be separately measured. The spatial and temporal patterns of ambient concentrations of that pollutant, and perhaps others, are determined by atmospheric conditions, topographical features and the presence of other natural or man-made chemicals in the air. The resulting ambient concentrations then interact with people, buildings, plants and animals in a way that depends on their locations and activity levels. The results may be physical and/or psychological effects: coughing, erosion of stone, retarded plant growth, injury to young, loss of pleasurable views, and so forth. Finally, these effects have an economic value.

Reduced decibel level

Noise pollution is a part of our daily life. However, when the noise reaches critical levels, hearing loss occurs. Examples of sound levels in some common situations are falling leaves, 10 – 20 decibels; vacuum cleaner, 55 – 65 decibels; location close to a main road or highway, 70 – 80 decibels; pop music concerts, 100 – 110 decibels (Passchier-Vermeer & Passchier 2000, 124). According to Passchier-Vermeer & Passchier (2000, 123) exposure to noise constitutes a health risk. There is sufficient scientific evidence that noise exposure can induce hearing impairment, hypertension and ischemic[4] heart disease, annoyance, and sleep disturbance. Additionally Passchier-Vermeer & Passchier (2000, 127) found through analysis of twelve studies on the risk of hypertension among occupational noise-exposed workers, the observation threshold for industrial noise exposure was determined to be at most equal to a value of 85 decibels. Finally Passchier-Vermeer & Passchier (2000, 127) add that epidemiologic studies suggest that the absentee rate of industrial workers increases when they are exposed to equivalent sound levels during working hours of over 75 decibels. Further laboratory experiments conclude that the presence of uncontrollable noise can significantly impair cognitive performance and decrease attention to the task.

Vehicles can contribute greatly to this noise pollution especially at high engine rev. As Small & Kazimi (1995, 7) explain, the costs of air pollution, noise and other environmental damage are not precisely measurable, and even the principles of measurement are not universally accepted. Nevertheless, estimates of noise pollution costs from motor vehicles can help shape the broad outlines of policy toward pollution control. However the Environmental Protection Agency states that outdoor yearly levels on the Ldn (Levels of day & night) scale are sufficient to protect public health and welfare if they do not exceed 55 dB in sensitive areas (residences, schools, and hospitals). Inside buildings, yearly levels on the Ldn scale are sufficient to protect public health and welfare if they do not exceed 45 dB. Maintaining 55 Ldn outdoors should ensure adequate protection for indoor living. To protect against hearing damage, one's 24-hour

[4] Ischemic is a restriction of the blood vessels especially around the cardio vascular system.

noise exposure at the ear should not exceed 70 dB. Passchier-Vermeer & Passchier (2000, 129) argue that the value is slightly higher explaining that a value of 85 decibels has been almost universally adopted as a limit for unprotected occupational noise exposure, with additional requirements for personal hearing protection above this value.

Hybrid vehicles create significantly less noise than standard internal combustion vehicles. In fact, many times they are undetectable at stop signs. According to Sherry Boschert (2006, 35) some people like noisy cars and trucks, though, because we've become used to equating noise with power. Would the Indianapolis 500 or monster-truck rallies be as thrilling without the deafening roar of engines? "Just for laughs, a few electric-car drivers in California carry a CD in their cars that can play the sound of a revving engine in case they need it to mock; I mean, impress someone" (Boschert 2006, 35). One concern that Sherry Boschert (2006, 35) has with the low noise level centers around the ability of pedestrians to hear these vehicles coming. Because pedestrians and bicyclist expect to be able to hear gasoline cars that are backing out of driveways or passing them on the street, the switch to plug-in hybrids and electric cars will require a heightened alertness (Boschert 2006, 35).

Costs Section for Hybrid Vehicles

Payload costs for hybrid vehicles

In private or government fleets the amount of payload a vehicle can carry is critical. Payload also affects the way a vehicle performs. In the case of hybrid vehicles payload capacity is limited in comparison to the current fleet of GLO vehicles. The Toyota Prius Hybrid vehicle has a payload capacity of 863 lbs maximum. A large percentage of the weight a hybrid is carrying consists of its large bank of batteries. According to Moore & Lovins (1995, 4) "The fundamental advantage, again, of hybrids over BEVs is weight reduction in the energy storage unit. Thus HEV performance and efficiency are not impaired by a massive battery pack, nor is their range limited by the electrochemical energy storage technology." Moore & Lovins research suggests that when more payload weight is added to the hybrid vehicle there is reduction in fuel efficiency and emissions are increased. Their research makes the argument that for hybrids to be most efficient weight reduction on the interior and exterior is critical for maximum efficiency. "One noteworthy reason for placing emphasis on this platform[5] design balancing act is that vehicle efficiency gained through reduction in road loads will also necessarily result in lower emissions per vehicle-mile, since it is not how fuel is converted, but how much fuel is converted that will be affected.

Avoidance cost for hybrid vehicles

Not all Americans are excited about changing to new technologies. Drivers love the comfort and performance that the standard combustion engine technology offers. In fact Ewing & Sarigollu (2000, 117) found in their study of 1500 commuters who drive to work regularly that through consumers had a positive disposition toward Clean Fuel Vehicles (CFVs) and perceive environmental impact as important, they were unwilling to trade off the standard vehicle performance levels of range, acceleration, and refueling time. Furthermore Ewing & Sarigollu (2000, 110) point out that their test group labeled unconcerned believe the pollution issue is overrated, and they are not concerned about its effects. Therefore, they do not consider taking action in any way. The unconcerned believe new technologies produce more problems than they solve. They do not perceive themselves to be in control. "We believe that consumers who are

[5] The platform design refers to the entire shell of the vehicle. The researchers are trying to make the point that hybrid vehicles need to be constructed with lighter materials to achieve maximum efficiency.

concerned about the environment and are not intimidated by technology should display a higher preference for CFVs than consumers who are not concerned and are intimidated" (Ewing and Sarigollu 2000, 109). The vehicle avoidance cost is a management issue. If employees are directed by management to use fuel efficient vehicles then they must complete the task at hand and do what is best for the agency. The avoidance costs were presented in this study because there are strong objections to driving hybrid vehicles in the industrial trades.

Cost-Benefit Analysis

Defining Cost-Benefit Analysis

While conducting a cost-benefit analysis does have its limitations, the tool can aid decision makers when approving or disapproving projects. According to Prest & Turvey (1965, 684) "it is always important, and perhaps especially so in economics, to avoid being swept off one's feet by the fashions of the moment. In the case of cost-benefit analysis, one must recognize that it is a method which can be used inappropriately as well as appropriately." Whereas Eva Galambos & Arthur Schreiber (1978, 62) recognize that if optimum use is to be made of these limited revenues, local government must spend them in ways that are socially profitable, generating the most benefits for the community relative to the costs incurred. Projects that involve a major expenditure of local government funds are prime candidates for cost-benefit analysis (Galambos and Schreiber 1978, 74). Prest & Turvey (1965, 685) point out, "cost-benefit analysis as generally understood is only a technique for making decisions within a framework which has to be decided upon in advance and which involves a wide range of considerations, many of them of a political or social character."

In generating the set of cost-benefit studied alternatives the practicing analyst is observed to draw on the methods and concepts of many disciplines. Most commonly these are economics, operations research, management science, physical science, mathematics, statistics, and engineering (Jones 1971, B-744).

History of Cost-Benefit Analysis

Early cost-benefit analyses were mainly used to test the feasibility of different federal water projects. Prest & Turvey (1965, 683) point out that “although the subject of cost-benefit analysis has come into prominence among economists only in recent years, it has quite a long history, especially in France, where Dupuit’s classic paper on the utility of public works, one of the most original path-breaking writings in the whole history of economics, appeared as long ago as 1844.” In the thirties, with the New Deal, the idea of a broader social justification for projects developed. The Flood Control Act of 1936 thus authorized Federal participation in flood-control schemes “if the benefits to whom so-ever they may accrue are in excess of the estimated costs.” The practice of making analyses then spread to the other agencies concerned with water-development projects. The purpose was not only to justify projects but also to help to decide who should pay (Prest and Turvey 1965, 691).

Cost-benefit analysis grew in acceptance during the 50’s and after the 70’s evolved into a tool that was commonly used by the government. According to Kornhauser (2000, 1037) regulation of the environment and of health and safety in the United States often requires that the relevant agency conduct a cost-benefit analysis. On the other hand, although many scholarly commentaries acknowledge its relevance for at least some public decisions, its justificatory foundations remain at best suspect and at worst in ruins. Cost-benefit analysis in principle can also determine how many resources to allocate to risk-reducing or environment-enhancing activities (Kornhauser 2000, 1038).

Identifying Costs and Benefits

"During a cost-benefit analysis, special attention should be given to all costs and benefits, including opportunity costs and social benefits that are often imprecise to measure and difficult to quantify in monetary terms" (Chen, Forsythe, Weikart, & Williams (2009, 77). Cost-benefit analysis involves the following steps to determine whether a project is worthwhile:

1. Identify the costs and the benefits that will result from a course of action (project or program).

2. Measure in dollars these costs and benefits so that both costs and benefits are stated in common denominator units that can be compared with potential alternative uses of local government revenues.

3. Incorporate the time dimension in the evaluation, because costs and benefits must be examined for the entire life of the project or program, not just for the current fiscal year.

4. Decide whether the result of the first three steps yields a large enough social profit (net social benefits) to justify the expenditure of limited funds. (Galambos and Schreiber 1978, 62-63).

The term "cost-benefit analysis" often refers to a family of procedures for policy assessment. However, cost-benefit analysis refers to a narrower class of procedures that evaluate policies in terms of the net benefits the policies provide to individuals (Kornhauser 2000, 1039). Kornhauser (2000, 1039) adds that benefits are then usually defined solely in terms of the change in individual well-being that the policy induces, and costs are generally measured in terms of the monetary costs of resources required to implement the project. Galambos & Schreiber (1978, 64) remind analysts of the need to state all benefits and costs in dollars in order to compare them; otherwise we have "apples and oranges" which cannot be added together.

Project Benefits

The benefits of a project include the increases of gains in goods or services generated during the life of the project. The benefits of hybrid vehicles can reduce the fuel charges to the agency and benefit society by reducing emissions and noise pollution. These benefits can be derived directly or indirectly during the development of the program.

Direct Benefits

According to Kornhauser (2000, 1039) benefits are then usually defined solely in terms of the change in individual well-being that the policy induces. The direct benefits are those directly generated by the life of the project. Direct benefits from an efficient environmentally sound vehicle fleet program might include the reduction in fuel costs, reduced maintenance costs, reduced vehicle emissions, and less noise pollution. Furthermore, a direct benefit of a more efficient vehicle fleet may be the reduction in fleet vehicles if they are unneeded.

Indirect Benefits

For some projects, it will be impossible to convert some costs and benefits into dollar values. These are usually referred to as intangible benefits and costs, which should be included in the presentation of the cost-benefit analysis so that decision makers include them in their deliberations (Galambos and Schreiber 1978, 73). Some costs and benefits (such as the vehicles emissions and noise) cannot be quantified, and others, although they can be quantified, cannot be valued in any market sense (e.g., a reduction in lives lost). Such costs and benefits have been called intangible costs and benefits (Prest and Turvey 1965, 696).

Project Costs

Project costs are those that are directly related to the project's development and maintenance. These costs include initial procurement cost, recurring costs and maintenance costs. Initial costs include research, planning, developing, testing, and training. Recurring costs include education, parts, rental of parking space, miscellaneous safety equipment, parts and maintenance and other costs necessary during the course of a project.

Developing an environmentally friendly fleet of vehicles will involve all of these costs. Initial costs may include working with staff to educate them on the benefits and use of hybrid vehicles. There may be training in new safety equipment required for staff involved in the driving process. Recurring costs may include staff's time charging vehicles and administrative overhead.

Direct Costs

Direct costs are those for activities or services that benefit specific projects, e.g., salaries for project staff and materials required for a particular project. Because these activities are easily traced to projects, their costs are usually charged to projects on an item-by-item basis. According to Mikesell (2007, 269) "direct costs are the capital costs to purchase vehicles for the program along with the costs of maintenance and repairs." Direct costs to an agency to operate its vehicle fleet program include the initial costs to purchase vehicles, materials, supplies, labor, safety equipment, and maintenance for the program. Similarly Mckenna (1980, 134) points out that “other initial costs include research and development, planning, testing and evaluation, vehicles and equipment.”

Indirect Costs

Indirect costs are those for activities or services that benefit more than one project. Their precise benefits to a specific project are often difficult or impossible to trace. For example, it may be difficult to determine precisely how the activities of the director of an organization benefit a specific project. The costs of air pollution, noise and other environmental damage are not precisely measurable, and even the principles of measurement are not universally accepted. Nevertheless, estimates of pollution costs from motor vehicles can help shape the broad outlines of policy toward pollution control (Small and Kazimi 1995, 7). The costs of air pollution, noise and other environmental damage are not precisely measurable, and even the principles of measurement are not universally accepted. Nevertheless, estimates of pollution costs from motor vehicles can help shape the broad outlines of policy toward pollution control (Small and Kazimi 1995, 7).

Intangible costs

For some projects, it will be impossible to convert some costs and benefits into dollar values. These are usually referred to as intangible benefits and costs, which should be included in the presentation of the cost-benefit analysis so that decision makers include them in their deliberations (Galambos and Schreiber 1978, 73). Similarly Prest & Turvey (1965, 696) agree that some costs and benefits (such as the scenic effect of building electricity transmission lines) cannot be quantified, and others, although they can be quantified, cannot be valued in any market sense (e.g., a reduction in lives lost). Such costs and benefits have been called intangible costs and benefits. Intangibles are obviously important in many cases and, equally obviously, have to be presented to the decision-maker in the prose which accompanies the cost-benefit arithmetic, since they cannot be incorporated in the arithmetic itself (Prest and Turvey 1965, 696).

Measuring Costs and Benefits

Measuring costs and benefits can be one of the most challenging steps to the analysis. Quantifying them may be difficult to do, especially for the indirect and intangible costs and benefits. Fuguitt & Wilcox (1999, 173) offer the following three principles when measuring intangible variables:

1. Use monetary units to value as many benefits and costs as possible.
2. Quantify in physical units those that cannot be assigned a monetary value.
3. Identify and qualitatively describe those that elude any type of quantification.

According to Chen, Forsythe, Weikart, & Williams (2009, 77) special attention should be given to all costs and benefits, including opportunity costs and social benefits that are often imprecise to measure and difficult to quantify in monetary terms. This imprecision could be further exacerbated by the narrow perspective of the sponsoring organization that funds the cost-benefit analysis. Professionalism and accuracy play a huge role in measuring the costs and benefits of a project so the decision maker can make the correct choice.

Discount Rate and Time

Given a choice between $100 today and $100 one year from now, most people would choose to have the money now (Galambos and Schreiber 1978, 67). Individuals wish to experience the benefits of today and are concerned that they may not live to experience the benefits of tomorrow. According to Galambos & Schreiber (1978, 74) there is no general agreement on what to use (for example, municipal bond interest rate, corporate bond interest rate, or rate of return on investment in the private sector) as the local government discount rate. Thus, the discount rate chosen for local government cost-benefit analysis will ultimately be decided by local elected officials. Prest & Turvey (1965, 729) stress that the major problem of evaluation is that of choosing an appropriate discount rate. The ideal solutions which have been suggested require knowledge of the as yet unknown answers to questions relating to many aspects of the economy (e.g., the general level of interest rates compatible with the desired growth rate of the economy).

Whatever discount rate is chosen should be consistently applied in evaluation of all projects under consideration at any one time (Galambos and Schreiber 1978, 74). According to the Office of Management and Budget (OMB) (2010, A94) constant-dollar benefit-cost analyses of proposed investments and regulations should report net present value and other outcomes determined using a real discount rate of 7 percent. This rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years. Programs often extend over an extended period of time. Future costs and benefits need to be discounted to obtain their present value before summation and comparison. Although discounting future benefits and costs to derive their present values for policy valuation is a relatively straightforward mechanical process, the selection of an appropriate social discount rate is much more theoretically involved (Chen, Forsythe, Weikart, and Williams 2009, 81). The Government Accountability Office (GAO) uses a more flexible approach; it bases its discount rate on the real rate of interest on federal borrowing (Chen, Forsythe, Weikart, and Williams 2009, 81).

Public v. Private Rates

Research differs on the subject of public v. private rates when discounting for future benefits and costs. David Newbery (1990, 34) points out that Warr and Wright (1981) took this model and demonstrated that, even if the savings rate was suboptimal because of the isolation paradox, the appropriate rate of discount to use in selecting public investment was the private discount rate. After further research Newbery (1990, 34) discovered that public supply of a public good displaces voluntary private supply one for one, and this creates no net increase in the supply of the public good.

Difficulties in Performing Cost-Benefit Analysis

The main goal of a well done cost-benefit analysis is to find the most accurate costs and benefits of a project so that the results can be presented to the decision maker. According to Galambos & Schreiber (1978, 70) the objective of cost-benefit analysis is not to make decisions or choices but to assist elected officials in making them by providing better information on which they can base their decisions. At an early point in a cost-benefit analysis, the staff should point out to elected officials the difficulties and subjective elements that are involved in the analysis (Galambos and Schreiber 1978, 70). Prest & Turvey (1965, 731) agree and state "that in much the same way, insistence on cost-benefit analysis can help in the rejection of inferior projects, which are nevertheless promoted for empire-building or pork-barrel reasons."

The technique of cost-benefit analysis is more useful in the public-utility area than in the social-services area of government (Prest and Turvey 1965, 731). "Complications arise when the analyst seeks to construct a measure of social value from the indices of individual well-being that each-willingness to pay represents" (Kornhauser 2000, 1040).

Decision Criterion: Performing the Benefit-Cost Analysis

Very few decisions that are put forth by leaders are accepted without comment. Citizens want to feel that the benefits they receive are more than just a money decision. Constituents usually want services to stay the same and prices to stay the same. Leaders understand though that services need to change and become more efficient because there are very limited resources. A few of the most common decision methods are discussed in the following.

Fuguitt & Wilcox (1999, 81) have put together three general decision principles that decision makers should keep in mind when considering new projects:

- The decision maker might be considering whether to pursue one (and only one) policy.
- The decision maker might consider several alternative, mutually exclusive policies in order to determine which one, if any, to implement.
- The decision maker might consider several policies that are not mutually exclusive with plans of pursuing a subset.

If decision makers have a set of procedures and criteria that they follow then projects with the most benefit will be created. Following some simple guidelines can make all the difference in making the right decision.

Pareto Criterion

The Pareto Criterion is one method that decision makers choose because of its fairness to take into account all citizens. This method holds "that if at least one person is better off from a policy action and no person is worse off, then the community as a whole is unambiguously better off for the policy" (Mikesell 2007, 16). However if this standard were used for all public projects very few may ever be implemented. "Cost-benefit analysis is concerned with achieving economic efficiency in the use of resources, regardless of who derives the benefits and who bears the costs” (Galambos and Sahreiber 1978, 73). For a project to go forward in an allotted amount of time fairness is not always looked at in the cost-benefit analysis, but may be explored during the decision making process.

Present Value

The present value (PV) helps the analyst predict the value of an investment today in future dollars. Present value is a good decision making formula because it takes into account the time and value of money. The determination of a project’s present value is conducted using the annual capital flow *S*, the annual benefits minus annual expenditures, the discount rate *r*, and the useful life of the project (in number of years *n*) in a specific formula (McKenna 1980, 148-149). The present value annuity formula requires constant annual net flow for multiple years.

Figure 2.1 Present Value Annuity Formula

$$PV = \frac{S}{r}\left[1 - \left(\frac{1}{1+r}\right)^{n}\right]$$

S = Annual Net Flow
r = Discount Rate
n = Number of Years

Along with this formula computing a project’s present value may require the use of other formulas. In some cases, the benefits and costs of a project may fluctuate throughout the life of the project (Fuguitt and Wilcox 1999, 45). In the case of those types of projects that fluctuate in time, the following formula should be used:

Figure 2.2 Present Value of Benefits and Costs Formula

$$PVB = \sum_{i=1}^{T} \frac{B_i}{(1+r)^i}$$

$$PVC = C + \sum_{i=1}^{T} \frac{C_i}{(1+r)^i}$$

B_i= Benefits in year $_i$
C_i= Costs in year $_i$
T= Final year of project
r= Discount rate

After the present value of total benefits along with total costs has been calculated, the net present value of the project can be placed in the formula.

Net Present Value

The net present value (NPV) is measured by the present value of total benefits less the present value of total costs or NPV = PVB – PVC. This measure is indifferent between putting negative social effects on the benefit side with positive effects, and putting them on the cost side with direct costs (McKenna 1980, 149). However NPV alone is insufficient when comparing projects that are dissimilar in size; the benefit-cost ratio formula would work better for that function. Figure 2.2 and 2.3 depict the formulas to calculate NPV.

Figure 2.3 Net Present Value Calculations of Benefits and Costs

$$PVB = \frac{B_0}{(1+r)^0} + \frac{B_1}{(1+r)^1} + \frac{B_2}{(1+r)^2} + \frac{B_3}{(1+r)^3} + \ldots \frac{B_n}{(1+r)^T}$$

$$PVC = \frac{C_0}{(1+r)^0} + \frac{C_1}{(1+r)^1} + \frac{C_2}{(1+r)^2} + \frac{C_3}{(1+r)^3} + \ldots \frac{C_n}{(1+r)^T}$$

B_i= Benefits in year $_i$
C_i= Costs in year $_i$
T= Final year of project
r= Discount rate

Figure 2.4 Net Present Value Calculation

NPV= PVB-PVC

The above listed formulas can be used to calculate the benefit of almost any project. They are very well documented and easy to use with practice. It is very useful to see what future cost and benefits can be calculated with these formulas.

Chapter Summary

In summary, a cost-benefit analysis is an important tool available to public sector officials and elected leaders considering capital improvement projects. Conducting an analysis where indirect and intangible factors of a project are difficult or impossible to convert into monetary terms requires that the analysis find other ways to consider their impact on the final results. Using this tool can ensure that decisions consider all direct and indirect benefits and costs that might affect the use of scarce resources. Finally, hybrid vehicles can make a difference in both reduction of fuel used and environmental protection. Technology is changing all aspects of transportation use. The choices of the fuel used and the types of vehicles will need to change to keep transportation prices reasonable and America less dependent on foreign oil. New ways of reducing waste and increasing economy are being invented every day. However, people's attitudes will need to change from a 20^{th} century view of looking at transportation to a 21^{st} century way. Conducting a benefit-cost analysis on this subject will provide decision makers with a clear picture of the cost savings that hybrid vehicles bring to the table. This research will apply benefit-cost analysis to an actual project to determine its economic viability for a state government.

Chapter Three: Setting

Introduction

The focus of this research now moves to conducting a cost-benefit analysis of the Texas General Land Office vehicle fleet program. All government agencies face difficulties in managing limited resources; the challenge is finding a way to continue services to its citizens while controlling expenditures. In hopes of creating efficiencies in its vehicle fleet program a cost-benefit analysis is being conducted to measure the benefits of replacing current agency surplus vehicles with fuel efficient hybrid vehicles. This chapter provides background information on the Texas General Land Office and its current fleet program. Chapter three also provides background on the Office of Vehicle Fleet Management which is the governing body for fleet management in the state of Texas. Finally a demo hybrid vehicle is tested at the agency.

Background of the Texas General Land Office

History

The Republic of Texas Congress established the General Land Office in 1836 shortly after Texas won its independence from Mexico. The General Land Office was originally responsible for managing the public domain by collecting and keeping records, providing maps and surveys and issuing land titles. Since then the GLO's duties have evolved, but its core mission is still the management of state lands and mineral-right properties totaling 20.3 million acres. Included in that portfolio are the beaches, bays, estuaries and other "submerged" lands out to 10.3 miles in the Gulf of Mexico, institutional acreage, grazing lands in West Texas, timberlands in East Texas, and commercial sites in urban areas throughout the state. In managing that property, the land office now leases drilling rights for oil and gas production on state lands, producing revenue and royalties which are funneled into the state's Permanent School Fund. The dividends and interest from Permanent School Fund investments go into the Available School Fund, and from there money is distributed to school districts on a per-pupil basis, helping to offset local property taxes. Since the Permanent School Fund was established in 1854, the Texas General Land Office has deposited into it more than $6.8 billion, mostly from oil and gas leases and real estate trades and sales (Texas General Land Office Annual Financial Report, 2009).

Structure of the Departments & Duties Performed

The division called Oil Spill Prevention and Response responds to oil spills along the Texas Gulf Coast and inspects boats and facilities for possible leaks and pollution concerns. This division has approximately 36 vehicles used for day-to-day business at their five field offices along the Texas Gulf Coast. The main field offices for Oil Spill reside in: Nederland, La Porte, Corpus Christi, Brownsville, and Port Lavaca Texas. The size of vehicles in the division range from: 7-one ton, 26-¾ ton, and 3-SUVs. All but 3 of the vehicles in this division are 4-wheel drive and use diesel fuel. The average fuel economy rating runs between 11 and 18 miles per gallon. The number of staff at each field office equals the number of vehicles per office. Each staff member has a vehicle to themselves; this is why a motor pool is so critical. When vehicles are checked out from a motor pool random driving is reduced because the vehicle needs to be returned at a certain time. Also there are no fuel efficient vehicles within this division to transport staff or complete light tasks efficiently. Finally a portion of the vehicles are driven home by staff over long distances with in-efficient vehicles.

The next largest holder of vehicles is the Professional Services Division, which includes: survey, appraisals, and asset inspection. The Professional Services Division conducts appraisals of state owned property adjusting the property’s value to today’s rate and appraises new property acquired by the state. The Survey section surveys land throughout Texas finding the boundaries through GPS technology and archived documents. The Asset Inspection section inspects the states owned land, administers land leases, and inspects gulf coast properties. These sections use about 25 vehicles which include: 2-one ton trucks, 2-SUV one-ton Excursions, 3-¾ ton, and 18-½ ton vehicles. All vehicles in this division are 4-wheel drive and run off a combination of diesel, gasoline, and Ethanol fuels. The average fuel economy rating runs between 14 and 18 miles per gallon. This division has made strides to purchase more fuel efficient vehicles and has begun purchasing vehicles that run off Ethanol fuels. This division could still benefit from hybrid vehicles in their fleet because of their total miles driven annually. Since the vehicles are not fueled with Ethanol an alternative fuel benefit is not being achieved. Therefore the miles are driven on standard unleaded fuel at low fuel economy. A hybrid could achieve greater fuel economy and improve emissions.

The last heavy user of vehicles is the Energy Division. This division conducts field appraisals and inspections of state owned and leased oil field equipment. Energy has about 11 vehicles in their division and the sizes range from ¾ to half-ton trucks with an average fuel rating of 14 to 19 miles per gallon. All their vehicles are 4-wheel drive and have the extra cab option, which adds weight to the vehicle. This division could benefit from hybrid vehicles however it is unclear if the Toyota Prius Hybrid vehicle could withstand the rugged conditions in which this division travels.

Introducing hybrid vehicles in the three divisions listed above could make a difference in reducing the agencies fuel budget. Hybrids will not be able to replace every vehicle in these divisions because many are used to pull boats, trailers and equipment or travel along the Texas rugged landscape.

Hybrid vehicles with this type of pulling power have not been introduced in the state's vehicle contract. Therefore hybrid vehicles are only suggested in this study to replace vehicles that are used for staff transport, transporting documents, attending training, visiting the Austin Headquarters, commuting home, and patrols that do not require transporting a heavy load. Image 3.1 reveals a small hybrid vehicle tucked away between the larger GLO fleet vehicles.

Image 3.1: The hybrid vehicle is overshadowed by the larger fleet vehicles.

The final four divisions at the GLO use a combined 7 vehicles. These divisions include: Administration, Asset Management, Coastal Resources, and Veterans Land Board. These particular vehicles see very little travel time compared to the other three divisions and they are mostly for agency staff transport. The vehicles are still quite large for this function and range in size from one 1 ton, 3 ¾ ton, 2 half ton, and 2 fifteen passenger type vans. The average fuel economy for these vehicles is low also with an average of 12 to 14 miles per gallon. Hybrid vehicles have the potential to replace some of the final four division vehicles; however many are specialty vehicles used to transport many employees at once such as 15 passenger vans and handicap vehicles for the Veterans Land Board program.

Purpose of the General Land Office

The Texas General Land Office is unlike many agencies that do one or two particular tasks. The GLO performs many distinct tasks such as: Oil spill prevention and response, survey of land parcels, inspection of coastal lands, appraisal of state lands, and coastal and erosion clean up and inspection. These tasks require GLO staff to travel in rugged areas all around the state of Texas.

Background of the Office of Vehicle Fleet Management

Purpose of the Office of Vehicle Fleet Management

All State agencies and universities report vehicle fleet data to the Office of Vehicle Fleet Management (OVFM), which is a division within the Texas Comptroller's Office. In the past this office was part of the Texas Building and Procurement Commission unit it recently moved to its new agency. Throughout the years this office has been directed by legislation to reduce the states fleet of vehicles and to find those agencies with underutilized vehicles. The legislation included House Bill 3125, 76th Legislature which mandates the OVFM, as directed by the State Council on Competitive Government (CCG), to develop a management plan for the states fleet. This plan was created to provide detailed recommendations for improving administration and operation of the state's vehicle fleet (Texas Building and Procurement Commission, 2007).

The OVFM has been pivotal in encouraging state agencies and universities to create policies and cost savings measures concerning their vehicle fleet programs. In the mid to late 90's the OVFM began looking at alternative fuels such as Liquefied Petroleum Gas or LPG. During this period of time many agencies and universities converted their vehicles to run off LPG or Compressed Natural Gas (CNG). However the conversion kits were very costly and the vehicles engine did not last long on this solvent type fuel. The OVFM also organized better fueling contracts with specific vendors that saved the state even more money. This move allowed agencies and universities to purchase fuel at a discounted rate. The years between 2000 & 2005 experienced a decrease in vehicles using LPG or CNG gas and a gain in Ethanol and Bio-diesel fuels additionally hybrid vehicles starting to hit the market. At this time hybrid vehicles were still vacant from state contracts and because the technology was new they remained expensive. Large purchases of Ethanol vehicles were made from 2006 to 2008 in reaction to the high fuel prices and need to be less dependent for foreign oil. Finally in 2008 and 2009 hybrid vehicles arrived on the state contract for vehicles purchasing. As a benefit to state agencies and universities these vehicles were highly discounted over standard retail prices.

The Office of Vehicle Fleet Management's data states that in subsequent years the office also gained the responsibility of encouraging and facilitating the conversion to, and use of, alternative fuel vehicles. However data released within their state of the fleet report states that: Passenger trucks, including light duty, light/medium duty, and medium duty trucks, are the largest single vehicle class in the state fleet with 15, 427 vehicles. Passenger vehicles are the second largest class, with 4,346 vehicles and the majority runs off gasoline (Texas Building and Procurement Commission, 2007).

Function of the Office of Vehicle Fleet management

The State Vehicle Fleet Management Plan by the OVFM defines fleet management as best practices garnered from public and private sectors. The best practices defined in the Plan are a combination of policies and procedures applicable to fleet management at both the agency and statewide levels to increase state vehicle use and efficiency and reduce maintenance and operation costs of the fleet. The OVFM also manages a vehicle fleet database in which all state agencies and universities can enter vehicle information and run meaningful reports. This database collects data on: mileage, fuel, maintenance, trips, and usage. The data gained from this statewide database is used by the OVFM to create reports used by the Texas Legislature.

Testing a Hybrid Vehicle at the GLO

The GLO was fortunate enough to demo a Toyota Prius Hybrid[6] vehicle during the first two weeks of March 2010. The demo turned into an experiment to determine how much fuel could be saved in two weeks by using this vehicle for every task in the Administration division. It's a true benefit for an agency to have the opportunity to experience using equipment before it's purchased.

The Toyota Prius Hybrid will go through the same two weeks of work that the current administration vehicles go through. This Prius will transport agency mail, surplus equipment to the warehouse (as shown in image 3.3), pick up supplies, transport agency staff to training, transport staff to conduct inventory and other functions as needed. At the end of the two weeks a quick comparison will be conducted between standard administrative vehicles and the Toyota Hybrid to see if a benefit was achieved.

Image 3.2 & 3.3: first photo: the Toyota Prius arrives at the GLO. Second photo: staff transporting goods from the warehouse to headquarters.

[6] Special thanks to Jarrod Reynolds with Philpott Motors in Beaumont Texas for setting up the demo vehicle.

The Toyota Prius Hybrid vehicle arrived on a Friday morning at 7:30 AM. The 2009 Toyota Prius had approximately 1450 miles on the odometer and arrived in new condition. The staff[7] immediately fueled the vehicle to full and recorded the mileage at the start of the test. A vehicle use report was also placed in the vehicle to record: date, mileage, purpose of travel, driver's name, and fuel purchased.

Quick Comparison	Toyota Prius	15- Passenger Chevy Van
Price of Fuel	$2.76	$2.76
Mileage (MPG)	50	17
Distance Traveled (miles)	249	249
Total Fuel Cost	$13.74	$40.43
Total Savings	**$26.69**	

Table 3.1: Quick fuel cost comparison between administration vehicle & hybrid

For two weeks the Toyota Prius performed such tasks as making the agency bank deposit, running supplies to the warehouse, picking-up supplies at the state's central store, delivering agency warrants, and even a long distance trip to the GLO operated Killeen Veterans Cemetery to conduct an inventory of equipment (image 3.4). During the two weeks agency staff drove approximately 249 miles completing these tasks. As shown in Table 3.1 the Toyota Prius achieved a savings of over $26 dollars as compared to the current administration vehicle (Chevrolet15-passenger van). The comparison is between the Toyota Prius and a Chevrolet 15-passenger van driving the exact distance in a two week period.

Image 3.4: The Toyota Prius transports staff to complete an inventory of assets at the Killeen Veterans Cemetery.

[7] Special thanks to staff that helped with the project: Chris day, Todd Wesson, and Joseph Russo III.

Staff[8] seemed impressed by the drivability of the Prius and how comfortable the vehicle was for even a few of the larger staff members. In many of the opinions the quietness of the vehicle ranked as high as the comfort when speaking with staff. The staff also enjoyed the ease at which to park the vehicle and get in and out of tight spaces around downtown Austin. Many staff reported an interesting feeling at stop lights or in traffic because of the vehicle turning off and running on battery power. Staff reported that it felt as if you needed to restart the vehicle. Also staff reported that the vehicle did not seem small compared to the many Smart cars around downtown Austin such as the one pictured in image 3.5.

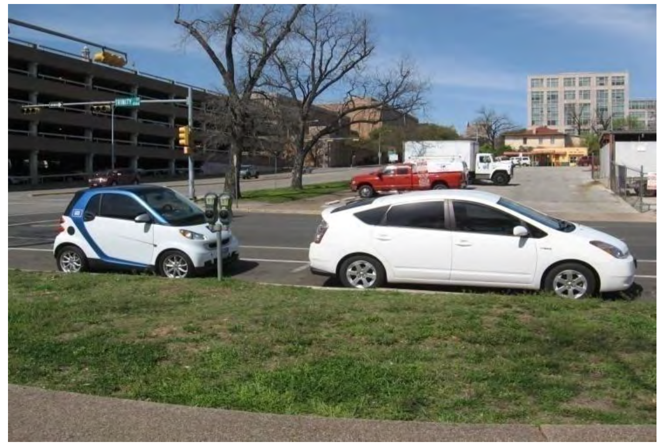

Image 3.5: Most people think of the Toyota Prius as a small car, but it's really not that small compared to the Smart Car pictured alongside. The Smart Car actually gets 13.5 MPG less than the Prius.

Conceptual Framework

The conceptual framework for this applied research project outlines the variables involved in conducting a cost-benefit analysis and links those variables to existing literature. These variables include the direct and indirect costs of the perceived direct and indirect benefits from the project, and the discount rate. This cost-benefit analysis will also measure the social benefits of the program by looking at a few indirect and external benefits and costs. "It should be noted that these frameworks are developed to deal with the complexity of real world problems. Research questions are not answered with a simple yes or no" (Shields & Tajlli 2006, 319). These variables will help quantify an analysis of incorporating hybrids into a vehicle fleet

[8] Staff that drove the vehicle include: Chris day, Todd Wesson, and Joseph Russo III, and Josh Martin.

program at the Texas General Land Office in Austin, Texas. Table 3.2 on page 53 contains the conceptual framework table that will guide this applied research project.

Identifying the costs and benefits for the vehicle fleet program comparison

Direct Benefits

The benefits of a vehicle fleet program with hybrid vehicles have been identified by scholarly research and include the reduction in vehicle purchase price, and reduction in fuel costs. Further benefits include greater payload for current vehicles over hybrids, and the resale value of surplused vehicles at the time they are sold. Direct benefits are those directly associated with the development of the program. The indirect benefits directly associated with this program include: reduced emissions in the environment, and reduced decibel level (noise pollution).

Direct Costs

The direct costs discovered in the scholarly research include: loss of payload costs for the hybrid vehicles. Project costs are those that are directly related to the project's development and maintenance. These costs include initial cost, recurring costs and maintenance costs. Initial costs include research, planning, developing, testing, and training. The following represent the direct costs to the Texas General Land Office with regards to a vehicle fleet program.

The analysis will need to look at all the state contracted vendors to see which dealership has the best price on hybrid vehicles. Vehicle maintenance can be broken down annually with a certain scheduled based on mileage. Certain vehicles will also require more maintenance than others. These figures will be quantified in spreadsheets. Other costs such as: payload will also be broken down into monetary terms. A spreadsheet will be made with all the prices per vehicle from these state contracted prices which are much more reasonable than the standard retail price of a vehicle.

Discount Rate and Time

The discount rate used in this cost-benefit analysis is critical to the results. The outcome of the present value will vary with the use of differing discount rates. Whatever discount rate is chosen should be consistently applied in evaluation of all projects under consideration at any one time (Galambos and Schreiber 1978, 74). According to the Office of Management and Budget (OMB) (2010, A94) constant-dollar benefit-cost analyses of proposed investments and regulations should report net present value and other outcomes determined using a real discount rate of 7 percent. This rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years. Programs often extend over an extended period of time. Future costs and benefits need to be discounted to obtain their present value before summation and comparison. For this project a discount rate of 3, 4, and 7% will be used and a time line of 6 years which represent the surplus life of a GLO vehicle.

Decision Criterion

After the cost and benefit variables have been measured in monetary terms, they can be assessed using the appropriate decision criterion. The primary decision criterion will be the net present value, representing the present value of the project in future values minus its initial cost. If the project is beneficial for the Texas General Land Office and the economic benefits outweigh the costs, the net present value will be positive. Since the present value and net present value calculations take into account both the time and value of money, they are the most appropriate criterion to use when conducting a cost-benefit analysis.

Table 3.2: Conceptual Framework of scholarly research

CONCEPTUAL FRAMEWORK	
Research Purpose: To perform a cost-benefit analysis of incorporating hybrid vehicles into the vehicle fleet management program at the Texas General Land Office in Austin, Texas.	
BENEFITS:	**SCHOLARLY SUPPORT:**
Direct Benefits:	
Reduction in vehicle purchase price (hybrid) Reduction in fuel costs (hybrid) Resale value of surplus vehicles (hybrid) Maintenance and repair costs (hybrid)	Boardman, Greenberg, Vining, and Weimer (2001), Boschert (2006), Brown (2001), Campbell, Lobell, and Field (2009), Carlsson and Johansson-Stenman (2003), Chen, Forsythe, Weikart, and Williams (2009), Environmental Protection Agency (2010), Ewing and Sarigollu (2000), Fuchs and Anderson (1987), Fuguitt and Wilcox (1999), Gonder and Simpson (2006), Jones (1971), Kelly Blue Book (2010), Kemp (2007), Kornhauser (2000), Markel and Simpson (2006), McKenna (1980), Mikesell (2006), Musgrave (1969), Parks and Markel (2007), Passchier-Vermeer and Passchier (2000), Posner (2000), Rahm and Coggburn (2007), Tanous (2007).
Indirect Benefits:	
Reduced emissions in the environment Reduced decibel level	
COSTS:	**SCHOLARLY SUPPORT:**
Direct Costs:	
Loss of capacity (hybrid)	Boschert (2006), Brown (2001), Campbell, Lobell, and Field (2009), Carlsson and Johansson-Stenman (2003), Ewing and Sarigollu (2000), Galambos and Schreiber (1978), Kromer and Heywood (2007), Markel and Simpson (2006), Moore and Lovins (1995), Revesz (1999).
DISCOUNT RATE:	**SCHOLARLY SUPPORT:**
Social 3% Private 7%	Carlsson and Johansson-Stenman (2003), Chen, Forsythe, Weikart, and Williams (2009), David (1979), Jones (1971), Kornhauser (2000), Mikesell (2006), Newbery (1990), Posner (2000).
Time Horizon	6 Years

Chapter Summary

This chapter provided background and historical information pertaining to the Texas General Land Office vehicle fleet program and the Office of Vehicle Fleet Management which regulates state agencies and universities fleet programs. The OVFM regulates legislation that states each agency will develop a management plan for the state fleet. This plan is to provide detailed recommendations for improving administration and operation of the state's vehicle fleet. The chapter also discusses the GLO's use of a demo hybrid vehicle for two weeks and the costs savings and tasks performed in this vehicle. Finally a brief overview of the conceptual framework was presented that outlines the benefits and costs of the project. The following chapter details the methodology used to measure the costs and benefits of incorporating hybrid vehicles into the Texas General Land Offices vehicle fleet program.

Chapter Four: Methodology

Introduction

This chapter will review and describe the methodology used to operationalize[9] the costs and benefits identified in the conceptual framework to determine if adding hybrid vehicles to the Texas General Land Office vehicle fleet program are cost beneficial. This analysis will discuss how each cost and benefit is measured. A final section will describe the discount rate and decision criterion used in the cost-benefit analysis for this study.

Operationalization

The methodology for this research project is a cost-benefit analysis. This type of analysis is a tool used in both the public and private sectors when making decisions involving monetary resources. As Prest & Turvey (1965, 685) point out, "cost-benefit analysis as generally understood is only a technique for making decisions within a framework which has to be decided upon in advance and which involves a wide range of considerations, many of them of a political or social character". According to Chen, Forsythe, Weikart, & Williams (2009, 78) A typical project or program is evaluated in comparison with alternative uses of resources in order to generate meaningful information to support appropriate decisions making. Furthermore there are at least two explicitly expressed and commonly used bases for comparison: the status quo or an alternative program. The results of this research will demonstrate whether the benefits of the GLO's proposed fleet management program outweigh the costs of the status quo.

[9] Conceptual Frameworks like the one in table 3.2 & 4.1 are developed as instruments to organize empirical inquiry (Shields 1998, 218).

The data for this study will be acquired from various sources; however most of the data will come from vehicle fleet reports, GLO financial data, COMDATA which is the fuel card vendor for the agency, the Environmental Protection Agency (EPA), and various field tests conducted to find noise levels and direct testing of vehicles by the student author. The data spreadsheets and graphs will also coincide with GLO fleet policy which states that vehicle surplus or vehicle replacement occurs at 6 years or 100,000 miles (GLO fleet policy, 2007). This analysis considers data from September 1, 2006 through March 1, 2010; which takes into account all the fleet data that has been submitted thus far. The variables in this research will be converted into monetary values to perform the cost-benefit analysis. Since most of the indirect benefits and costs are immeasurable in monetary terms, indirect benefits and costs will be identified and measures in terms of their exposure in the environment such as grams of pollutants and decibels of noise emitted and explained in the final analysis of the program.

According to Chen, Forsythe, Weikart, & Williams (2009, 77) special attention should be given to all costs and benefits, including opportunity costs and social benefits that are often imprecise to measure and difficult to quantify in monetary terms. This imprecision could be further exacerbated by the narrow perspective of the sponsoring organization that funds the cost-benefit analysis. Professionalism and accuracy play a huge role in measuring the costs and benefits of a project so the decision maker can make the correct choice. This study considers what the GLO will spend in the course of replacing surplus vehicles for fiscal year 2010. By no means is it beneficial to the agency to replace all vehicles with hybrid vehicles. The GLO's mission to protect the Gulf Coast and millions of acres of state land requires the use of many heavy duty vehicles to pull trailers, boats, and large equipment. However much of the day to day business requires staff transport vehicles that can be converted into hybrid vehicles.

Table 4.1: Measurement of the Costs and Benefits

OPERATIONALIZATION OF THE CONCEPTUAL FRAMEWORK TABLE	
BENEFITS:	**MEASUREMENT:**
Direct Benefits:	
Reduction in vehicle purchase price (hybrid)	Total contract price of year end replacement vehicles: Program A (status quo) - Program B (hybrid vehicles)
Reduction in fuel costs (hybrid)	Annual fuel costs for different vehicle options. Assumes: (15,000 miles annual / MPG x fuel cost = fuel consumption); Assumes vehicles travel: (45% Highway, 55% City); Calculated fuel economy for Program A & B vehicles @ $2.76, $4.00, and $8.00 a gallon.
Resale value of surplus vehicles (hybrid)	At the end of 6 years or 100,000 miles the vehicle has value if in good or fair condition. Used vehicle resale or trade-in value can be found on kellybluebook.com.
Maintenance and repair costs (hybrid)	Oil changes (O)= 5 per year every 3000 miles. Major tune-up cost (M)all calculated @ year 4 or 60,000 miles. Tires replaced (T), Break Job front & back(B). Battery replaced (BR) + miscellaneous costs (MC). Major tune-up = O+M+T+B+BR+ MC
INDIRECT BENEFITS:	**MEASUREMENT:**
Indirect Benefits:	
Reduced emissions in the environment	Environmental Green Score compaired in spreadsheet data obtained from Environmental Protection Agency web-site and state vehicle contract web-site
Reduced decibel level	Vehicles measured in field by author and staff with sound pressure level decibel meter model: American Recorder Technologies (ART) SPL-8810 Lo setting 30 - 100 db, High setting 60 - 130 db studio quality. Interior measurement @ 2000 RPM; Exterior measurement @ 2000 RPM.
COSTS:	**MEASUREMENT:**
Loss of capacity (hybrid)	Hybrid vehicle holds less passengers than the standard GLO fleet vehicles. The hybrid also holds less cargo per square foot. Cost of procuring rental vehicle (R) will be calculated against the hourly employee wage (W) and time (n). R + W x n. PV@3% & PV@7%

OPERATIONALIZATION OF THE CONCEPTUAL FRAMEWORK: CONTINUED	
DECISION CRITERION:	**MEASUREMENT:**
Present Value of Benefits and Costs	Present value of project today in future dollars. Present value is derived by using the annual capital flow, which is the annual benefits minus annual costs, in a formula with the discount rate and the useful life of the project in years.
Net Present Value	Net present value of project Net present value is derived from the subtraction of the present value of the benefits and the present value of the costs.
Benefit-Cost Ratio	Benefit-cost ratio of project Benefit-cost ratio is derived from dividing the present value of benefits and costs by the initial capital outlay of the project.

Methods of Data Collection

Benefits

Direct Benefits

Conducting document analysis of available data from vehicle fleet reports, GLO financial data, and COMDATA[10] which is the fuel card vendor for the agency provide information for analysis. The program's direct benefits include reduction in vehicle purchase price for hybrids if chosen, reduction in fuel costs, reduction in maintenance and repair costs for hybrids, and the resale value of all vehicles. Data for computing these savings will be provided by vehicle use logs, agency fuel use data, vehicle dealership & repair shop data[11], and Kelly Blue Book[12] used vehicle pricing web-site. Vehicle fleet use logs provide the actual costs for fiscal years 2006 through March 2010 and the estimated costs for fiscal years 2010 and 2015 (see Appendix-C).

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[10] COMDATA is a fuel card vendor who manages the agencies fuel accounts, they provide monthly reports on fuel

[11] Vehicle Dealerships include: Philpott Ford, Leif Johnson Ford & Henna Chevrolet

[12] www.kbb.com

Reduction in vehicle purchase price (hybrid)

To find a reduction in vehicle purchase price requires a simple side by side comparison between program A and B[13]. Program A includes all the current status quo vehicles and their current contract pricing (9 are being replaced this fiscal year). Program B includes the purchase of 9 identical Toyota Prius hybrid vehicles and their current contract pricing. All costs in the vehicle contract cost column are summed up and totaled. Then the total from program A is subtracted from program B to get the total difference. The vehicle contract costs can be found on the Texas Comptrollers financial web-site at www.window.state.tx.us/procurement.

Reduction in fuel costs (hybrid)

One of the major decisions in purchasing a vehicle is its fuel mileage (MPG). The cost of fuel can be a major factor in an agency's budget especially if fuel costs soar out of control. In the past few years the country experienced a major increase in fuel costs when prices reached over $4 dollars per gallon. As with other major studies the current price of fuel is chosen along with prices of $4 dollars and $8 per gallon to see how each increase of price per gallon will affect the overall fuel usage per vehicle. For this study all the program-A status quo vehicles were compared to the program-B hybrid vehicle selected for its superior fuel mileage. All the vehicles were placed in an Excel spreadsheet and the fuel mileage per gallon (MPG) rating was found for each model. For the study an annual mileage traveled was set at 15,000[14] miles per vehicle. The MPG rating for each vehicle was divided by the miles driven (15,000) per year. Then that figure is multiplied by the fuel price (Price per gallon) to get the annual fuel consumption price per vehicle. This calculation was repeated for each fuel price per gallon selected in this study. These

[13] Program A was chosen to represent the status quo vehicles at the Texas General Land Office. Here they represent the 9 vehicles up for replacement. Program B represent new hybrid vehicles.
[14] 15,000 miles annually represent the calculated average mileage of all GLO vehicles.

figures were placed in the spreadsheet to present the total fuel costs at different prices for all vehicles in the study.

Resale value of surplus vehicles

All the vehicles in the study have a resale value. When they have reached the agencies surplus timeline of 6 years or 100,000 miles it is time to dispose of the vehicle. Each vehicle for the study is assumed to be 6 years old and have approximately 100,000 miles. The study vehicles are also assumed to all have the basic standard features of a state agency fleet vehicle which is: air conditioning and heating, power steering, AM/FM radio, and cloth seats other features may have been added to the vehicles without cost. All vehicles were also considered to be in good condition without major mechanical problems or body damage. The Kelly Blue Book web-site was consulted to give the current used vehicle trade-in and resale value for each vehicle. The vehicles were placed in an Excel spreadsheet with all the resale values listed for comparison. Finally the program-A vehicles total is subtracted from the program-B vehicles to get the difference in resale cost between the two.

Reduction in maintenance and repair costs

All agency vehicles require service maintenance and repairs on a regular basis. For this study the parameters match the agency policy for the standard maintenance schedule of three months or 3000 miles. By studying the agency vehicle reports is was discovered that the average distance traveled by agency vehicles is 15,000 miles per year. Three separate dealerships were called as well as consulting the vehicle manuals to find the timeline for scheduled oil changes, maintenance, and full scale tune-ups for vehicles. Dealerships as well as the vehicle manuals recommend a regular oil change every 3000 miles as well as a full scale tune up which includes:

oil, all fluids, plugs, inspection of belts and hoses, filters replaced, transmission inspected, and engine timing inspected every 60,000 miles. Image 4.1 shows the small engine of the Toyota Prius, a smaller engine requires less fluids and less service. Additionally at the beginning of the forth year repairs need to be made on parts that are scheduled to wear out. At this time regular service on the front and back break system needs to be completed as well as replacement of all four tires. The battery will also come to the end of life and will need to be replaced. This same service will need to be performed again when the vehicle reaches 100,000 miles, but by that time the vehicle will be scheduled for replacement. It is the responsibility of the fleet manager and the division's program director to recommend if the vehicle should stay in the fleet for a longer period and receive the 100,000 mile service. Again all prices in the above data were obtained from dealerships and service stations. The costs for all services were averaged out per vehicle size and engine type. A miscellaneous cost of $300 was placed in the figures to take care of any small defect that is not covered by warranty for the vehicle. In this study it was discovered that the Toyota Prius Hybrid vehicle's large bank of batteries is a sealed type scheduled to operate at full capacity for over 100,000 miles without regular service. Furthermore the battery has an 8 year 100,000 mile warranty that takes care of any

Image 4.1: The Toyota Prius Hybrid engine pictured here is much smaller than a standard vehicle therefore less maintenance is required.

manufacturing defects. The cost of this battery was not placed in this study because the vehicle will be replaced after the warranty expires.

Indirect Benefits

Reduced emissions in the environment

Image 4.2: Vehicles like this one pictured exhaust out large amounts of CO_2 gas which then produces particulate material (soot) during start-up and acceleration.

The fuel economy is provided in miles per gallon for both city and highway estimates for each car and truck. The annual driving distance for each is estimated at 15,000 miles driven per year. The Greenhouse score is developed by the EPA and reflects emissions of carbon dioxide (CO_2) and other greenhouse gases. The Greenhouse Gas Score is based on the vehicle's fuel economy. CO_2 is reduced because vehicles with higher fuel economy burn less fuel to travel the same distance. As less fuel is burned, less CO_2 is emitted. Vehicles with higher fuel economy receive a higher Greenhouse Gas Score (EPA, 2009 Green Vehicle Guide).

According to the EPA the score reflects a vehicle's tailpipe greenhouse gas emissions. A vehicle's CO_2 emissions are based on the carbon content of the fuel used and the fuel economy of the engine. In addition to CO_2, the Greenhouse Gas Score also includes methane, and nitrous oxide. The scores range from 0 to 10, where 10 is the best. Also scores vary slightly between fuel types because each fuel has different carbon content per gallon. This means each fuel creates different levels of CO_2 emissions per gallon. Image 4.2 shows a typical GLO vehicle on start-up.

Table 4.2: Greenhouse Gas Scores for vehicles earlier than 2008, source EPA

Greenhouse Gas Score Criteria MY 2008 & Earlier						
		Minimum Label MPG (combined)				
GHG Score	Grams CO2e per mile	Gasoline	Diesel	E85	LPG	CNG*
10	Less than 302	37	43	23	23	31
9	302 to < 360	31	36	19	19	26
8	361 to < 428	26	30	16	16	22
7	429 to < 493	23	26	14	14	19
6	494 to < 560	20	23	12	12	17
5	561 to < 616	18	21	11	11	15
4	617 to < 693	16	19	10	10	14
3	694 to < 752	15	17	9	9	13
2	753 to < 837	14	16	8	8	12
1	838 to < 852	13	15	7	7	11
0	853 and up	1	1	1	1	1

Table 4.3: Greenhouse Gas Scores for vehicles 2009 & 2010, source EPA

Greenhouse Gas Score Criteria MY 2009 & MY 2010					
		Minimum Label MPG (combined)			
GHG Score	Grams CO2e per mile	Gasoline	Diesel	E85	CNG*
10	Less than 237	38	43	27	31
9	238 to 283	32	36	23	26
8	284 to 329	28	31	20	22
7	330 to 375	24	28	17	20
6	376 to 421	22	25	16	17
5	422 to 467	20	22	14	16
4	468 to 513	18	20	13	14
3	514 to 559	16	19	12	13
2	560 to 605	15	17	11	12
1	606 to 651	14	16	10	11
0	652 and up	1	1	1	1

* CNG's CO2 per gallon estimate assumes a gallon equivalent of 121.5 cubic feet

No LPG light-duty vehicle has been manufactured since 2004

In August 2009, EPA updated the CO2, CH4, and N2O emission factors. As a result, the scores for a small number of 2009 model year vehicles were adjusted. Vehicles that received SmartWay certification for MY 2009 before these adjustments were made will maintain their certification.

To find the Greenhouse score of a vehicle simply find the combined fuel mileage for the vehicle. Then if the vehicle was manufactured before 2009 use the figures in Table: 4.2, if the vehicle was manufactured year 2009 and after use Table: 4.3. Match the fuel mileage up with the correct fuel used in the vehicle and use the figures to the left. This will provide both the amount of grams of CO_2 used per mile and the Greenhouse Gas Score of the vehicle. To calculate the Grams of CO_2 and the Tons of CO_2 per year the following conversions will be useful:

- 1 pound = 453.59 grams
- 1 (U.S.) ton = 2000 pounds

Multiply the grams of CO_2 found in the chart by the annual mileage driven (15,000) to get the total grams of CO_2 released annually. Then divide the total grams of CO_2 released annually by 453.59 which will equal the total pounds of CO_2 released. Take the total pounds of CO_2 and divide that figure by 2000 to get the vehicles tons of CO_2 released into the atmosphere each year. Program A can be compared to program B by adding up the total tonnage of CO_2 released for each vehicle in the programs and comparing their sums.

Reduced decibel level in the fleet

Image 4.3: The author and staff test decibel level on hybrid vehicle.

The testing of vehicles for noise pollution was conducted out in the field over several days. Each vehicles decibel level was tested in the interior and exterior of the vehicle as shown in image 4.3 & 4.4. The field research was carried out by the author and staff volunteers on the vehicles that are ready for replacement in fiscal year 2010 and the Toyota Prius Hybrid test vehicle. Vehicles were measured with a sound pressure level decibel meter manufactured by: American Recorder Technologies (ART) model, SPL-8810 Low setting = 30 - 100 db, High setting = 60 - 130 db studio quality. Testing was carried out on three specific areas of the vehicle. First the Interior of the vehicle was measured at idle with no other noise such as: radio, ventilation fan, or human noise. Second the interior noise was measured at 2000 revolutions per minute (RPM). Finally the exterior decibel level was measured at 2000 RPM standing approximately 5 feet from the vehicle. The interior decibel level was measured to find out how much noise the driver is experiencing at a stop light and driving speed. The exterior decibel level was tested to find out how much noise a person on the sidewalk or outside the vehicle is experiencing. Great care was taken during testing to make sure no other noise source was in the area such as: lawn equipment, heavy equipment or construction. Tests were carried out during normal business hours and standard working conditions. All vehicles were tested in the same location and measured in the same area on the vehicle. Data was entered into an Excel spreadsheet as each measurement was called out.

Image 4.4: Decibel meter reads 40.3 inside the hybrid at idle, a very low reading for a passenger vehicle.

Costs

Loss of payload capacity (hybrid)

Every square foot of the vehicle is usable to an agency. The vehicle can be used for carrying emergency gear, transporting goods and supplies, carrying tools of the trade, and for transporting staff. The interior of the vehicle can be measured cubic feet, for instance the interior cab of a Toyota Prius has approximately 39.6 cu ft of usable space. Vehicles also have maximum payload weight that the vehicle can carry without damaging the vehicle over time. Many vehicles are reinforced to carry a much larger payload over the axles, however exceeding the maximum payload is not advised by the manufacturer. Since the Toyota Prius Hybrid is much smaller than the current status quo vehicles there is a loss of payload capacity. The hybrid simply cannot carry the type of weight of the current fleet.

The Toyota Prius Hybrid Vehicle achieves great fuel economy; however it lacks payload space and capacity. The total maximum payload of the Prius is approximately 863 pounds. This figure is not far off the average capacity of a standard passenger vehicle. Since this vehicle is used to transport staff and some equipment there will be a loss in total capacity. While testing the demo hybrid at the GLO (see settings chapter) it was discovered that only 4 staff members could fit safely and comfortably in the hybrid. The Toyota website states that the Prius can hold up to 5 passengers; however field staff may exceed the safe weight limit of the vehicle if 5 passengers are added. Current GLO vehicles hold on average 6 passengers per vehicle. Because of the difference in passenger payload a rental vehicle may be required periodically to transport staff to inspections or training.

To calculate the total cost to rent a vehicle during times when employees exceed available vehicles, employee wage, vehicle rental costs, and time costs were calculated. To find the average annual employee salary first the job classification was found for field office personnel. Field office employees are classified as Natural Resources Specialist I through IV. In the state salary group Schedule B (see appendix E) the positions fall between pay grades B15 and B18. This places the average salary of field office personnel at approximately $45,000 per year with an average monthly salary of $3,750. To break this down to an hourly salary the monthly salary is divided by the amount of work days in a month, this is 22. The daily wage is then divided by an 8 hour day and equals approximately $21.25 per hour. Salaries at the GLO usually increase by 3.4% each year and this increase will be used to figure the wage estimates.

To calculate the rental vehicle cost the contract rates were found on the Texas Comptrollers web site www.window.state.tx.us . This site gives the current daily and weekly rental rates from two rental venders Avis & Enterprise. Additionally the state of Texas does not pay taxes on rental vehicles. A rental rate of $37.50 was averaged between the two vendors for a full size vehicle. Finally 5% was added to each year because this is the percentage on average that the rental rate increases each year.

To find the average amount of trips per month that a rental vehicle would be needed the vehicle use report trips were calculated to find how many trips required over 4 staff members. Also the amount of inspections and training trips were calculated. The field office personnel make on average: 15 trips for incidents, 20 trips for inspections, and 4 trips for training annually. It was discovered through vehicle use reports (Appendix B) that approximately 3 tips a month would require a rental vehicle because of passenger overages. This equals approximately 36 trips per year requiring rental vehicles. Rental vehicles require fuel, so approximately $30 of fuel was multiplied by the amount of trips to achieve the annual rental fuel cost.

To find the amount of time required to rent a vehicle agency travel records were pulled. Employees claim on average 2 hours to be reimbursed for rental vehicle pick-up. When the amount of trips per month is multiplied by the time to pick up the rental vehicle 6 hours a month or 72 hours a year is the time required to pick-up rental vehicles.

Employee time is added to the cost of rentals per year then calculated at a present value of 3% and 7% for discounting. All the figures will be taken into account and discounted at the proper rate.

Calculating the Life Cycle Costs

With all the data collected from the costs and benefits of program-A and B a Life Cycle Cost (LCC) analysis was conducted. The total life cycle cost in a typical analysis can be simplified and illustrated in the following formula: Life cycle cost = A + O + M + D

Where:

A = Acquisition cost of a project – initial capital expenditure
O = Operating costs – include labor, energy, material and overhead costs
M = Maintenance cost – total maintenance and repair costs
D = Disposal costs – disposal of the asset

In this particular LCC study all vehicles in the study were compared side by side. A spreadsheet was created to include the following information about each vehicle: vehicle purchase price, miles driven annually, gas mileage for each vehicle miles per gallon (MPG), current price per gallon of fuel, average annual maintenance cost, current discount rate, and the residual value of the vehicle. The vehicle purchase price came from the state vehicle contract price. The miles driven were based on the average miles driven per year of 15,000. The gas mileage was based on each vehicles fuel economy rating. The current fuel price was based on the national fuel price average. The average annual maintenance cost was based on 5 oil changes per year. A discount rate of 4 % was used for this study. The residual value for each vehicle was found using the Kelly Blue Book web-site for used vehicles.

To calculate the annual operating and maintenance cost of the vehicles the annual fuel costs were added to the annual maintenance costs. The annual fuel costs were calculated by dividing the total distance traveled annually by the MPG rating for the vehicle. This figure was then multiplied by the price of fuel to get the total annual fuel costs. The maintenance costs was calculated by adding the costs of 5 oil changes (provided by four local dealerships)[15] conducted every 3000 miles. At year 4 or 60,000 miles of the vehicles life a major tune-up occurs which includes: oil, all fluids, plugs, inspection of belts and hoses, filters replaced, transmission inspected, and engine timing inspected. Additionally at the beginning of the forth year repairs need to be made of parts that are scheduled to wear out. At this time regular service on the front and back break system needs to be completed as well as replacement of all four tires. The battery will also come to the end of its life and will need to be replaced. The large bank of batteries in the hybrid vehicle that drive the electric motor are warranted for 100,000 miles and do not need servicing or maintenance, they are a sealed type of battery system.

To conduct the calculation of discounted cash flows of vehicle purchase alternatives all the costs were placed in a spreadsheet for the time period of 6 years[16]. The purchase price of the vehicle was listed and each year of combined fuel and maintenance costs were added. Then at year 6 the resale value of the vehicle was subtracted. The figures were listed in constant dollars for each year and then by using the present value formula each of the values were converted into present value dollars to achieve the life cycle costing. This table provided a good estimate of what each vehicle will cost over its life.

[15] Vehicle Dealerships include: Leif Johnson Ford, Henna Chevrolet, Maxwell Chrysler Dodge, and Champion Toyota.

[16] At year 6 vehicles are listed as surplus and either sold, traded-in or donated.

Cost-benefit analysis and net present value for comparing program-A to program-B

The total program from purchase of the 9 vehicles through the maintenance and fuel cost to keep these vehicles running during a 6 year period (the usable life of a GLO vehicle) is calculated here in comparison to a new program consisting of hybrid vehicles is studied. The financial costs as well as the opportunity costs (if any) are calculated against the benefits gained with each set of vehicles is calculated. The net benefits are converted to present value using a 3% and 7% discount rate for each year to get the present value. Finally all costs are calculated to get the net present value of the program using the net present value formula: NPV=PVB-PVC.

Additionally the Benefit Cost Ration (BCR) is tested at the end of the analysis. The BCR expresses the total benefit and the total cost of a program in a ratio form. A greater BCR indicates efficiency, as more than one dollar is produced in benefit by the program for each dollar of costs. BCR=Benefits / NPV

In this study the full cost of purchasing vehicles that need to be replaced because they reached the end of their agency useful life is calculated. This number is presented as a negative number because even though they are replacement vehicles they agency will need to spend agency funds to replace them. The costs presented in the costs column include: annual fuel costs, annual maintenance costs, the 60,000 mile major tune-up cost completed at year 4 and in program B the costs of renting vehicles when a large capacity vehicle is not available. The benefit column reveals the value of the surplus vehicles toward the end of their useful life according to the Kelly Blue Book used vehicle web-site. Program A is represented as the status quo; this is what the agency will spend if the current vehicles are replaced with the same make, model and style of vehicle that was originally purchased. Program B is represented as the new program this is the cost saving the agency will expect to save if Toyota Prius Hybrid vehicles replace the status quo vehicles in the study.

Conclusion

This chapter explained the methods that will be used to operationalize the costs and benefits for the Texas General Land Office Fleet Program. The decision criteria that will be used in this cost-benefit analysis includes the life cycle cost, present value, net present value and benefit cost ratio in order to evaluate the viability of the program in terms of costs and benefits. If the two compared programs show that the net present value of one of the programs is positive and greater than the other, then the program meets the threshold and is a viable program for the Texas General Land Office. Each cost and benefit variable for the fleet management program has been measured and calculated according to the decision criteria. The indirect benefits were measured, but not placed in monetary terms. The result of each cost and benefit variable is discussed in the following chapter.

Chapter Five: Results

Introduction

This chapter presents the findings of the cost-benefit analysis conducted of the Texas General Land Office vehicle fleet program. The results of this analysis reinforce the importance of identifying relevant variables and appropriate discount rates to determine if the program is economically feasible. The preliminary tables presented before the final life cycle cost and cost-benefit analysis show how the numbers were derived and help the reader understand were the costs and benefits came from. Since the vehicle fleet program contains both public and private funds both the social rate of 3 % and the private rate of 7% were used.

Revenue and expense estimates were provided by the Texas General Land Office vehicle fleet reports, fuel card database[17], vehicle dealerships around the Austin area, and forecasted throughout the life of the vehicles. Since the life of an agency vehicle is 6 years this analysis considers data from FY2004 to FY2010, then fuel cost projections will be made 5 years into the future to 2015[18]. A fiscal year (FY) starts on the 1st of September and ends on August 31st. All vehicles in the study are listed by their current agency inventory numbers or the matching description of the vehicle. They Toyota test vehicle in the study is listed as Toyota Prius or its license plate number. The costs and benefit variables pertinent to the program are in current dollars and then converted to present value.

Results of calculations measuring the costs and benefits of the program were derived from formulas presented in the research found in Figures 2.1 – 2.4. Present value, net present

[17] COMDATA provides fuel credit card activity reports.

[18] See appendix c for these fuel projections

value, and benefit cost ratio were used to determine the programs viability for the Texas General Land Office. The results of the decision criteria are discussed further in the chapter.

Benefits

Direct Benefits

Benefits that are a direct result of the proposed vehicle fleet program include variables such as reduced vehicle purchase price, reduction in fuel costs, maintenance and repair costs, and resale value of surplus vehicles. The direct benefits are those directly generated by the life of the program. The calculated results of each benefit will be discussed after each calculation is made.

Reduced vehicle purchase price: [$9,783.22]

***Table 5.1*: Cost difference between program-A and B.**

Overall agency vehicle cost to replace 9 current surplus vehicles compaired with 9 Hybrid vehicles

	Program A (Status Quo)		**Program B (hybrid vehicles)**	
#	Vehicle Type	Vehicle Contract Cost	Vehicle Type	Vehicle Contract Cost
1	Ford Truck F250 Diesel	$28,412.73	Toyota Prius Hybrid Sedan	$23,347.20
2	Ford Truck F350 Diesel	$30,202.00	Toyota Prius Hybrid Sedan	$23,347.20
3	Ford Truck F250 Diesel	$28,412.73	Toyota Prius Hybrid Sedan	$23,347.20
4	Chevrolet Truck 2500 Gasoline	$20,092.38	Toyota Prius Hybrid Sedan	$23,347.20
5	Ford Truck F350 Diesel 4x4	$30,202.00	Toyota Prius Hybrid Sedan	$23,347.20
6	Dodge Truck Ram 2500 Crew Diesel 4x4	$20,086.00	Toyota Prius Hybrid Sedan	$23,347.20
7	Ford Truck F250 Gasoline 4x4	$22,601.00	Toyota Prius Hybrid Sedan	$23,347.20
8	Dodge Truck Ram 2500 Crew Diesel 4x4	$20,086.00	Toyota Prius Hybrid Sedan	$23,347.20
9	Ford Truck F150 Supercab Gasoline 4x4	$19,813.18	Toyota Prius Hybrid Sedan	$23,347.20
	Total	**$219,908.02**	Total	**$210,124.80**
		Difference	**$9,783.22**	

The state of Texas qualifies for special fleet pricing. Each fiscal year automobile dealerships from all around Texas provide discounted prices on vehicles to get on the state's vehicle contract bid list. The contract is facilitated by the Texas Comptroller's Office and special pricing is available to all state agencies and universities. The contract pricing is a key element in this study because standard retail pricing of hybrid vehicles is much higher in the private sector.

To find a reduction in vehicle purchase price requires a simple side by side comparison between program A and B. Program-A includes all the current status quo vehicles and their current contract pricing. Program-B includes the purchase of 9 identical Toyota Prius hybrid vehicles and their current contract pricing. All costs in the vehicle contract cost column are summed up and totaled. Then the total from program A is subtracted from program B to get the total difference. Table 5.1 shows a total difference of $9,783.22 in purchasing cost for Program-B over A. The GLO would save this amount right from the start by purchasing hybrid vehicles.

Reduction in Fuel Usage & Costs

Table 5.2: Annual fuel cost by gas price: Annual Mileage (15,000) Fuel Cost @ $2.76, $4.00, $8.00 / gallon

License Number	Inventory Number	Description / Model	Fuel Mileage (MPG)	Gas Price		
				$2.76	$4.00	$8.00
799275	21043	Ford Truck F250 Diesel	16	$2,587.50	$3,750.00	$7,500.00
799276	21044	Ford Truck F350 Diesel	13	$3,185.04	$4,616.00	$9,232.00
799277	21046	Ford Truck F250 Diesel	16	$2,587.50	$3,750.00	$7,500.00
824129	26260	Chevrolet Truck 2500 Gasoline	13.3	$3,113.00	$4,512.00	$9,024.00
861250	26940	Ford Truck F350 Diesel 4x4	13	$3,185.04	$4,616.00	$9,232.00
863334	26946	Dodge Truck Ram 2500 Crew Diesel 4x4	12	$3,450.00	$5,000.00	$10,000.00
866949	27103	Ford Truck F250 Gasoline 4x4	12.2	$3,394.80	$4,920.00	$9,840.00
877719	27155	Dodge Truck Ram 2500 Crew Diesel 4x4	12	$3,450.00	$5,000.00	$10,000.00
203002	28104	Ford Truck F150 Supercab Gasoline 4x4	16	$2,587.50	$3,750.00	$7,500.00
91C6417	Test Vehicle	Toyota Prius Hybrid 4-door sedan	50	$828.00	$1,200.00	$2,400.00

Annual (15,000) Fuel Cost $2.76, $4.00, $8.00 / gallon.

Figure 5.2 above shows what the costs of the replacement vehicles and hybrid are at different prices per gallon of fuel. As with other major studies the current national price of fuel is chosen along with prices of $4 dollars and $8 per gallon[19] to see how each increase of price per gallon will affect the overall fuel usage per vehicle. Since the hybrid test vehicle # 91C6417 shows a fuel mileage rating of 50 miles per gallon it is far superior to any other vehicle in the test range. As staff transports vehicles the hybrid will use approximately $1760 dollars less of fuel at $2.76 a gallon than its closest rival vehicle 203002. When fuel prices climb up to $4 dollars a gallon the hybrid vehicle uses $2550 less fuel that its closest rival and finally at a cost of $8

[19] With a volatile oil and gas market and trouble in the Middle East $8.00 fuel is possible in the future.

dollars per gallon of fuel the hybrid uses $5100 dollars less fuel than the highest fuel rated vehicle in the study.

Table 5.3: Total cost of operating vehicle by listed fuel prices (Excluding Maintenance)

Total Cost of Operation Vehicle (Excluding Maintenance Cost, $2.76 per Gallon of Fuel)

Vehicle Cost	$28,412.73	$30,202.00	$28,412.73	$20,092.38	$30,202.00	$20,086.00	$22,601.00	$20,086.00	$19,813.18	$23,347.20
Year	21043	21044	21046	26260	26940	26946	27103	27155	28104	Toyota Prius
1	$31,000.23	$33,387.04	$31,000.23	$23,205.38	$33,387.04	$23,536.00	$25,995.80	$23,536.00	$22,400.68	$24,175.20
2	$33,587.73	$36,572.08	$33,587.73	$26,318.38	$36,572.08	$26,986.00	$29,390.60	$26,986.00	$24,988.18	$25,003.20
3	$36,175.23	$39,757.12	$36,175.23	$29,431.38	$39,757.12	$30,436.00	$32,785.40	$30,436.00	$27,575.68	$25,831.20
4	$38,762.73	$42,942.16	$38,762.73	$32,544.38	$42,942.16	$33,886.00	$36,180.20	$33,886.00	$30,163.18	$26,659.20
5	$41,350.23	$46,127.20	$41,350.23	$35,657.38	$46,127.20	$37,336.00	$39,575.00	$37,336.00	$32,750.68	$27,487.20
6	$43,937.73	$49,312.24	$43,937.73	$38,770.38	$49,312.24	$40,786.00	$42,969.80	$40,786.00	$35,338.18	$28,315.20

Total Cost of Operation Vehicle (Excluding Maintenance Cost, $4.00 per Gallon of Fuel)

Vehicle Cost	$28,412.73	$30,202.00	$28,412.73	$20,092.38	$30,202.00	$20,086.00	$22,601.00	$20,086.00	$19,813.18	$23,347.20
Year	21043	21044	21046	26260	26940	26946	27103	27155	28104	Toyota Prius
1	$32,162.73	$34,818.00	$32,162.73	$24,604.38	$34,818.00	$25,086.00	$27,521.00	$25,086.00	$23,563.18	$24,547.20
2	$35,912.73	$39,434.00	$35,912.73	$29,116.38	$39,434.00	$30,086.00	$32,441.00	$30,086.00	$27,313.18	$25,747.20
3	$39,662.73	$44,050.00	$39,662.73	$33,628.38	$44,050.00	$35,086.00	$37,361.00	$35,086.00	$31,063.18	$26,947.20
4	$43,412.73	$48,666.00	$43,412.73	$38,140.38	$48,666.00	$40,086.00	$42,281.00	$40,086.00	$34,813.18	$28,147.20
5	$47,162.73	$53,282.00	$47,162.73	$42,652.38	$53,282.00	$45,086.00	$47,201.00	$45,086.00	$38,563.18	$29,347.20
6	$50,912.73	$57,898.00	$50,912.73	$47,164.38	$57,898.00	$50,086.00	$52,121.00	$50,086.00	$42,313.18	$30,547.20

Total Cost of Operation Vehicle (Excluding Maintenance Cost, $8.00 per Gallon of Fuel)

Vehicle Cost	$28,412.73	$30,202.00	$28,412.73	$20,092.38	$30,202.00	$20,086.00	$22,601.00	$20,086.00	$19,813.18	$23,347.20
Year	21043	21044	21046	26260	26940	26946	27103	27155	28104	Toyota Prius
1	$35,912.73	$39,434.00	$35,912.73	$29,116.38	$39,434.00	$30,086.00	$32,441.00	$30,086.00	$27,313.18	$25,747.20
2	$43,412.73	$48,666.00	$43,412.73	$38,140.38	$48,666.00	$40,086.00	$42,281.00	$40,086.00	$34,813.18	$28,147.20
3	$50,912.73	$57,898.00	$50,912.73	$47,164.38	$57,898.00	$50,086.00	$52,121.00	$50,086.00	$42,313.18	$30,547.20
4	$58,412.73	$67,130.00	$58,412.73	$56,188.38	$67,130.00	$60,086.00	$61,961.00	$60,086.00	$49,813.18	$32,947.20
5	$65,912.73	$76,362.00	$65,912.73	$65,212.38	$76,362.00	$70,086.00	$71,801.00	$70,086.00	$57,313.18	$35,347.20
6	$73,412.73	$85,594.00	$73,412.73	$74,236.38	$85,594.00	$80,086.00	$81,641.00	$80,086.00	$64,813.18	$37,747.20

Table 5.3 shows what the total cost of operating the vehicles excluding maintenance would be over the agency life of the vehicle. For each vehicle a calculation was made on what the annual fuel cost would be if fuel was $2.76, $4.00, and $8.00 a gallon. Then a comparison was made to show how the variables of time and fuel cost affect how financially sensible each vehicle actually was. For instance even though vehicle 28104 cost approximately $3500 less than the Toyota Prius, the Prius has a lower operating cost because of its high fuel efficiency. At the end of 6 years the Prius costs approximately $7,000 less to operate than vehicle 28104 at a fuel

price of $2.76. If fuel prices reach $4.00 a gallon the Prius costs approximately $11,700 less to operate than vehicle 28104. Finally if fuel prices were to reach $8.00 a gallon the Prius costs approximately $27,000 less to operate than vehicle 28104, which cost less in the beginning to purchase.

Resale Value of Surplus Vehicles (hybrid)

Table 5.4: Resale value comparison between the program vehicles

#	License Number	Inventory Number	Year	Description / Model	Resale Value
1	799275	21043	2001	Ford Truck F250 Diesel	$5,500.00
2	799276	21044	2001	Ford Truck F350 Diesel	$5,500.00
3	799277	21046	2001	Ford Truck F250 Diesel	$5,500.00
4	824129	26260	2002	Chevrolet Truck 2500 Gasoline	$4,350.00
5	861250	26940	2004	Ford Truck F350 Diesel 4x4	$5,500.00
6	863334	26946	2004	Dodge Truck Ram 2500 Crew Diesel 4x4	$5,100.00
7	866949	27103	2004	Ford Truck F250 Gasoline 4x4	$5,300.00
8	877719	27155	2004	Dodge Truck Ram 2500 Crew Diesel 4x4	$5,100.00
9	203002	28104	2005	Ford Truck F150 Supercab Gasoline 4x4	$5,625.00
10	91C6417	Test Vehicle	2009	Toyota Prius Hybrid 4-door sedan	$5,875.00

When vehicles reach the surplus mark of 6-years or 100,000 miles as stated in the GLO's policy handbook they are ready to be surplused. At the time of surplus the vehicles condition is assessed and the ending mileage is presented to the agency fleet manager. The fleet manager then gathers all the information on the vehicle and a final inspection is made of the surplus vehicle. After all the information is compiled a value is established for the vehicle. The fleet manager can input in all the information about the vehicle into the Kelly Blue Book value website at www.kb.com and find the current trade-in value or resale value of the vehicle. The above information in Table 5.4 was found using these steps. In Table 5.4 all the vehicles were assessed using a vehicle year of 2004, listing the vehicle in good condition and posting similar accessories to find the resale value. The Toyota Prius had the highest resale value at $5875.0 and was approximately $250 higher than its closest rival vehicle number 28104. Hypothetically if all vehicles sold today for these price's the current GLO vehicles, program-A would sell for $47,475 and the Toyota Prius hybrid vehicles program-B would sell for $52,875, that's a $5,400 difference in resale value.

Maintenance and Repair Costs (hybrid)

Table 5.5: Maintenance and repair costs for all program vehicles

Information and assumptions	21043	21044	21046	26260	26940
Annual (Oil Changes)	$212.00	$212.00	$212.00	$112.00	$212.00
Tire Cost	$639.20	$790.40	$639.20	$683.20	$790.40
break service front + back	$850.00	$900.00	$850.00	$850.00	$900.00
Battery Costs	$110.00	$110.00	$110.00	$104.00	$110.00
Miscellaneous	$300.00	$300.00	$300.00	$300.00	$300.00
Total Annual Cost (Excluding Fuel)	$2,111.20	$2,312.40	$2,111.20	$2,049.20	$2,312.40

Information and assumptions	26946	27103	27155	28104	Toyota Prius
Annual (Oil Changes)	$212.00	$117.00	$212.00	$112.00	$106.00
Tire Cost	$800.80	$639.20	$800.80	$719.20	$380.80
break service front + back	$700.00	$850.00	$700.00	$550.00	$419.90
Battery Costs	$110.00	$104.00	$110.00	$90.00	$175.00
Miscellaneous	$300.00	$300.00	$300.00	$300.00	$300.00
Total Annual Cost (Excluding Fuel)	$2,122.80	$2,010.20	$2,122.80	$1,771.20	$1,381.70

Table 5.5 indicates when all maintenance and repair costs are taken into account the Toyota Prius has a lower maintenance and repair costs overall. Many studies list the large battery pack as a huge factor in determining repair costs since the cost to replace can range from $5500 to $7000 to replace after 10 years. Since the GLO's vehicles are replaced at year 6 this cost is taken out of the equation. Furthermore the Prius has regenerative breaking systems that take the kinetic energy and converts it into energy. This will allow the Prius to have a longer break life that most vehicles. In Table 5.5 the Prius achieves maintenance and repair cost of $1381.70 which is approximately $400 less than vehicle 28104, its nearest rival. Furthermore the Prius achieves a savings of approximately $700 in savings over the majority of vehicles in the study.

Indirect Benefits

Benefits that are an indirect result of the proposed vehicle fleet program include variables such as reduced emissions in the environment, reduced decibel level in the fleet, and greener image for the agency. For some projects, it will be impossible to convert some costs and benefits into dollar values. These are usually referred to as intangible benefits and costs, which should be included in the presentation of the cost-benefit analysis so that decision makers include them in their deliberations (Galambos and Schreiber 1978, 73). The calculated results of each benefit will be discussed after each calculation is made.

Reduced Emissions in the Environment

Table 5.6: Vehicle fuel economy and Greenhouse Gas Score between the program vehicles

Vehicle Fuel Economy and Greenhouse Gas Score

Company	Vehicle Model	EPA City/Hyway MPG	Greenhouse Gas Score	Grams of CO_2 per mile	Grams of CO_2 per year	Tons of CO_2 per year
Chevrolet	Silverado Truck 2500 Gasoline	14/17	5	616	9,240,000.00	**10**
Dodge	Ram 2500 Truck Diesel	11/14	1	852	12,780,000.00	**14**
Ford	F150 Truck Gasoline	14/19	6	560	8,400,000.00	**9**
Ford	F250SD Truck Gasoline	10/14	1	852	12,780,000.00	**14**
Ford	F250 Truck Diesel	11/15	2	837	12,555,000.00	**13**
Ford	F350 Truck Diesel	11/15	2	837	12,555,000.00	**13**
Toyota	Prius Hybrid Sedan	45/55	9	283	4,245,000.00	**5**

For this study on vehicle emissions and greenhouse gases an emissions meter and testing equipment was simply too expensive to obtain to run field tests. Figures on all vehicles were collected from the Environmental Protection Agency literature. Data concerning vehicle emission and greenhouse gases is also very difficult to quantify into monetary terms. However with the latest data from the EPA it is easy to establish the tonnage of CO_2 emitted into the atmosphere by each test vehicle. CO_2 is a chemical compound composed of two oxygen atoms covalently bonded to a single carbon atom formed by the burning of fossil fuels. Table 5.6 shows that in this study the Toyota Prius achieved a Greenhouse score of 9 and emitted 4 to 5 tons less CO_2 into the atmosphere than even the closest vehicles in the study. If the Prius is judged against the majority of the heaver trucks in the study the Prius emit approximately 8 to 9 tons less pollution into the atmosphere. The Greenhouse Score rates vehicles ability to burn less fuel over a determined distance. The vehicle achieves a good Greenhouse Score because of its high fuel mileage. All vehicles in the study were rated at an annual distance of 15,000 miles.

Reduced Decibel Level in the Fleet

Table 5.7: Decibel levels comparison between the program vehicles

Inventory Number	Year	Description / Model	Vehicle Interior @ Idle	Decible Level Interior @ 2000 RPM	Decible Level Exterior @ 2000 RPM
21043	2001	Ford Truck F250 Diesel	59.5	65.7	81.2
21044	2001	Ford Truck F350 Diesel	63.1	71.0	82.3
21046	2001	Ford Truck F250 Diesel	64.2	76.3	91.2
26260	2002	Chevrolet Truck 2500 Gasoline	52.5	57.3	77.5
26940	2004	Ford Truck F350 Diesel 4x4	65.7	74.2	83.0
26946	2004	Dodge Truck Ram 2500 Crew Diesel 4x4	61.2	75.0	84.5
27103	2004	Ford Truck F250 Gasoline 4x4	58.0	66.0	79.2
27155	2004	Dodge Truck Ram 2500 Crew Diesel 4x4	62.5	73.1	86.4
28104	2005	Ford Truck F150 Supercab Gasoline 4x4	53.9	61.6	78.6
Test Vehicle	2009	Toyota Prius Hybrid 4-door sedan	42.3	55.5	66.9

The testing of vehicles for noise pollution was conducted out in the field over several days. Each vehicles decibel level was tested in the interior and exterior of the vehicle. The field research was carried out by the author and staff volunteers on the vehicles that are ready for replacement in fiscal year 2010 and the Toyota Prius Hybrid test vehicle. Vehicles were measured with a sound pressure level decibel meter manufactured by: American Recorder Technologies (ART) model, SPL-8810 Lo setting 30 - 100 db, High setting 60 - 130 db studio quality. Testing was carried out on three specific areas of the vehicle. First the Interior of the vehicle was measured at idle with no other noise such as: radio, ventilation fan, or human noise. Second the interior noise was measured at 2000 revolutions per minute (RPM). Finally the exterior decibel level was measured at 2000 RPM standing approximately 5 feet from the vehicle. The interior decibel level was measured to find out how much noise the driver is experiencing at a stop light and driving speed. The exterior decibel level was tested to find out how much noise a person on the sidewalk or outside the vehicle is experiencing. Great care was taken during testing to make sure no other noise source was in the area such as: lawn equipment, heavy equipment or construction. Tests were carried out during normal business hours and standard working conditions. All vehicles were tested in the same location and measured in the same area on the vehicle. According to Passchier-Vermeer & Passchier (2000, 123) exposure to noise constitutes a health risk. There is sufficient scientific evidence that noise exposure can induce hearing impairment, hypertension and ischemic heart disease, annoyance, and sleep disturbance. Additionally Passchier-Vermeer & Passchier (2000, 127) found through analysis of twelve studies on the risk of hypertension among occupational noise-exposed workers, the observation threshold for industrial noise exposure was determined to be at most equal to a value of 85 decibels. Finally Passchier-Vermeer & Passchier (2000, 127) add that epidemiologic studies suggest that the absentee rate of industrial workers increases when they are exposed to equivalent sound levels during working hours of over 75 decibels. Further laboratory experiments conclude that the presence of uncontrollable noise can significantly impair cognitive performance and decrease attention to the task. In this study Table 5.7 shows the majority of GLO current vehicles operate at a safe range during vehicle idle between 42 and 65 decibels. However when the engine rev was increased to 2000 RPM in the interior vehicle noise increased to the mid to upper 70's on most vehicles. The surprising portion of the results showed that the noise for the outside world was drastically higher on all but a few vehicles. Table 5.7 shows that measurements taken outside the vehicle at 2000 RPM measured from between 80 to 92.2 on the majority of vehicles. Noise pollution is a serious problem for employees operating these vehicles and for the innocent bystander walking on the sidewalk near these vehicles. The Toyota Prius tested in this study scored a very low decibel noise level. The Prius tested at 42.3 at idle, 55.5

interior at 2000 RPM, and 66.9 on the outside at 2000 RPM. If Prius vehicles were added to the fleet noise pollution would decrease significantly.

Costs

Direct Costs

Costs that are a direct result of the vehicle fleet program include variables such as the loss of payload costs. Payload is a major factor in fleet vehicles because vehicles transport staff, pull equipment, and carry tools. The calculated results of each cost will be discussed in consecutive order.

Loss of capacity (hybrid)

Table 5.8: Payload capacity comparison Program-A and Program-B

Vehicle Type (Program-A)	Gross Vehicle Weight Rating	Maximum Payload	Hybrid Vehicle (Program-B)	Gross Vehicle Weight Rating	Maximum Payload
Ford Truck F250 Diesel	9,600	2,700	Toyota Prius Hybrid Sedan	3,795	863
Ford Truck F350 Diesel	11,100	4,200	Toyota Prius Hybrid Sedan	3,795	863
Ford Truck F250 Diesel	9,600	2,700	Toyota Prius Hybrid Sedan	3,795	863
Chevrolet Truck 2500 Gasoline	9,200	3,200	Toyota Prius Hybrid Sedan	3,795	863
Ford Truck F350 Diesel 4x4	11,100	4,200	Toyota Prius Hybrid Sedan	3,795	863
Dodge Truck Ram 2500 Crew Diesel 4x4	8,800	3,370	Toyota Prius Hybrid Sedan	3,795	863
Ford Truck F250 Gasoline 4x4	9,200	2,800	Toyota Prius Hybrid Sedan	3,795	863
Dodge Truck Ram 2500 Crew Diesel 4x4	8,800	3,370	Toyota Prius Hybrid Sedan	3,795	863
Ford Truck F150 Supercab Gasoline 4x4	7,000	1,550	Toyota Prius Hybrid Sedan	3,795	863
Totals	84,400	28,090	Totals	34,155	7,767

GVWR Difference	50,245
Payload Difference	20,323

Table 5.9: Cost of procuring rental vehicle & hourly wage

n	Estimated Hourly Wage ^ 3.4%	Contract Rental Vehicle Cost ^ 5%	# Rentals Per Year	# Employee Hours Annually	Annual Fuel For Rental
1	$21.25	$37.50	36	72	$1,080.00
2	$21.97	$39.37	36	72	$1,080.00
3	$22.72	$41.34	36	72	$1,080.00
4	$23.49	$43.41	36	72	$1,080.00
5	$24.29	$45.58	36	72	$1,080.00
6	$25.12	$47.86	36	72	$1,080.00

n	Annual Employee Wage Cost	Annual Rental Vehicle Cost + Fuel	Total Wage + Rental	PV @ 3%	PV @ 7%
1	$1,530.00	$2,430.00	$3,960.00	$3,844.66	$3,700.93
2	$1,581.84	$2,497.32	$4,079.16	$3,845.00	$3,562.90
3	$1,635.84	$2,568.24	$4,204.08	$3,847.33	$3,431.78
4	$1,691.28	$2,642.76	$4,334.04	$3,850.74	$3,306.42
5	$1,748.88	$2,720.88	$4,469.76	$3,855.65	$3,186.88
6	$1,808.64	$2,802.96	$4,611.60	$3,862.14	$3,072.90
			Total	**$23,105.52**	**$20,261.81**

Every square foot of the vehicle is usable to an agency. The vehicle can be used for carrying emergency gear, transporting goods and supplies, carrying tools of the trade, and for transporting staff. The interior can of the vehicle can be measured cubic feet or Gross Vehicle Weight Rating (GVWR). In Table 5.8 a comparison is made between the GVWR of the status quo vehicles in program A and the hybrid vehicles in program B. Program A has 50,245 lb greater GVWR than program B the hybrid vehicles. Program A also has a 20,323 lb greater payload capacity than program B. This is a key factor in the amount of passengers and cargo the hybrids will carry.

A solution is considered in Table: 5.9 to overcome the lack of passenger and cargo space for the hybrid vehicles. In Table: 5.9 employee costs along with vehicle rental costs and fuel are calculated to arrive at a cost to rent a vehicle when larger agency vehicles are not available. Table 5.9 shows employee time added to the cost of rentals and fuel costs per year then calculated at a present value of 3% and 7% for discounting. At 3% during the 6 year life of the vehicle until it is surplused the cost is approximately $23,105.52 for renting vehicles. At 7% during the 6 year life of the vehicle until it is surplused the cost is approximately $20,261.81 for renting vehicles.

Calculating the Life Cycle Costs

Table 5.10: Life Cycle Costs (LCC) calculation for all vehicles in the study

Parameters for Agencies Vehicles

Information and assumptions	21043	21044	21046	26260	26940	26946	27103	27155	28104	Toyota Prius
Fuel (price per gallon)	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76	2.76
Distance driven per year (miles)	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000	15,000
Discount rate	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Pruchase price	$28,412.73	$30,202.00	$28,412.73	$20,092.38	$30,202.00	$20,086.00	$22,601.00	$20,086.00	$19,813.18	$23,347.20
Mileage (miles per gallon, MPG)	16	13	16	13.3	13	12	12.2	12	16	50
Maintenance (per year)	$212.00	$212.00	$212.00	$112.00	$212.00	$212.00	$117.00	$212.00	$112.00	$106.00
Major Tune-up 36,000 miles	$1,899.20	$2,100.40	$1,899.20	$1,937.20	$2,100.40	$1,910.80	$1,893.20	$1,910.80	$1,659.20	$1,275.70
Residual value	$5,500.00	$5,500.00	$5,500.00	$4,350.00	$5,500.00	$5,100.00	$5,300.00	$5,100.00	$5,625.00	$5,875.00

Calculation of Annual Operating and Maintenance Costs of Vehicle Purchase Alternatives

Table 5.11: Annual operating and maintenance costs for all vehicles in the study

Annual Costs	21043	21044	21046	26260	26940	26946	27103	27155	28104	Toyota Prius
Fuel	$2,587.50	$3,184.61	$2,587.50	$3,112.78	$3,184.61	$3,450.00	$3,393.44	$3,450.00	$2,587.50	$828.00
Maintenance	$212.00	$212.00	$212.00	$112.00	$212.00	$212.00	$117.00	$212.00	$112.00	$106.00
Total	$2,799.50	$3,396.61	$2,799.50	$3,224.78	$3,396.61	$3,662.00	$3,510.44	$3,662.00	$2,699.50	$934.00

Table 5.12: Present Value of Life Cycle Costs for all vehicles in the study at 4%

		Vehicle # 21043		Vehicle # 21044		Vehicle # 21046		Vehicle # 26260		Vehicle # 26940	
Description	Time	Constant $	PV 4%	Constant $	PV 4%	Constant $	PV 4%	Constant $	PV 4%	Constant $	PV 4%
Purchase Price	0	$28,412.73	$28,412.73	$30,202.00	$30,202.00	$28,412.73	$28,412.73	$20,092.38	$20,092.38	$30,202.00	$30,202.00
Gas and maintenance	1	$2,799.50	$2,692.00	$3,396.61	$3,266.00	$2,799.50	$2,692.00	$3,224.78	$3,101.00	$3,396.61	$3,266.00
Gas and maintenance	2	$2,799.50	$2,588.00	$3,396.61	$3,140.00	$2,799.50	$2,588.00	$3,224.78	$2,981.00	$3,396.61	$3,140.00
Gas and maintenance	3	$2,799.50	$2,489.00	$3,396.61	$3,020.00	$2,799.50	$2,489.00	$3,224.78	$2,867.00	$3,396.61	$3,020.00
Gas and maintenance	4	$4,698.70	$4,016.00	$5,497.01	$4,699.00	$4,698.70	$4,016.00	$5,161.98	$4,412.00	$5,497.01	$4,699.00
Gas and maintenance	5	$2,799.50	$2,301.00	$3,396.61	$2,792.00	$2,799.50	$2,301.00	$3,224.78	$2,651.00	$3,396.61	$2,792.00
Gas and maintenance	6	$2,799.50	$2,212.00	$3,396.61	$2,684.00	$2,799.50	$2,212.00	$3,224.78	$2,549.00	$3,396.61	$2,684.00
Resale or Surplus	6	$5,500.00	$4,347.00	$5,500.00	$4,347.00	$5,500.00	$4,347.00	$4,350.00	$3,438.00	$5,500.00	$4,347.00
LCC			$40,363.73		$45,456.00		$40,363.73		$35,215.38		$45,456.00

		Vehicle # 26946		Vehicle # 27103		Vehicle # 27155		Vehicle # 28104		Toyota Prius	
Description	Time	Constant $	PV 4%	Constant $	PV 4%	Constant $	PV 4%	Constant $	PV 4%	Constant $	PV 4%
Purchase Price	0	$20,086.00	$20,086.00	$22,601.00	$22,601.00	$20,086.00	$20,086.00	$19,813.18	$19,813.18	$23,347.20	$23,347.20
Gas and maintenance	1	$3,662.00	$3,521.00	$3,510.44	$3,375.00	$3,662.00	$3,521.00	$2,699.50	$2,596.00	$934.00	$898.00
Gas and maintenance	2	$3,662.00	$3,386.00	$3,510.44	$3,246.00	$3,662.00	$3,386.00	$2,699.50	$2,496.00	$934.00	$864.00
Gas and maintenance	3	$3,662.00	$3,256.00	$3,510.44	$3,121.00	$3,662.00	$3,256.00	$2,699.50	$2,400.00	$934.00	$830.00
Gas and maintenance	4	$5,572.80	$4,763.65	$5,403.64	$4,619.00	$5,572.80	$4,764.00	$4,358.70	$3,726.00	$2,209.70	$1,889.00
Gas and maintenance	5	$3,662.00	$3,010.00	$3,510.44	$2,885.00	$3,662.00	$3,010.00	$2,699.50	$2,219.00	$934.00	$768.00
Gas and maintenance	6	$3,662.00	$2,894.00	$3,510.44	$2,774.00	$3,662.00	$2,894.00	$2,699.50	$2,133.00	$934.00	$738.00
Resale or Surplus	6	$5,100.00	$4,031.00	$5,300.00	$4,189.00	$5,100.00	$4,031.00	$5,625.00	$4,446.00	$5,875.00	$4,643.00
LCC			$36,885.65		$38,432.00		$36,886.00		$30,937.18		$24,691.20

When fuel costs are combined with scheduled maintenance and purchase price it is easy to see that a few select vehicles come out better than others. A life cycle cost (LLC) was assessed for the vehicles in this study to determine the total cost of ownership over the lifetime of the asset. According to Chen, Forsythe, Weikart, & Williams (2009, 68) the total cost – the life cycle cost – is the sum of all monies attributed to the asset or project from its conception to its disposal. Table 5.10 shows the parameters that were selected in the LLC study. Table 5.11 shows the annual operating and maintenance costs for all vehicles in the study. Table 5.12 shows the actual LLC study with data selected from the previous tables. A present value of 4% was chosen because it relates more closely to what state agencies are achieving on average. The LLC test is interesting because it takes all costs into account and discounts them over time. A good test of LLC can benefit the purchaser of any vehicle in comparison to another because the vehicle with the smallest life cycle cost is most economical and therefore should be recommended. This test of LLC shows that the present value of the Toyota Prius is $24, 691.20 over the life cycle of the vehicle. The Prius is approximately $6200 less expensive to own and operate than its closest rival vehicle 28104 a Ford F150 ½ ton truck that cost approximately $3500 less to purchase. When the Prius is compared to the vehicle with the greatest cost of ownership vehicle 21044 a Ford F350 1 ton diesel the Prius costs $20,764.80 less to own and operate over 6 years.

In the next section a cost-benefit analysis is performed taking into account all the costs and benefits of incorporating hybrid vehicles into the fleet. A great deal is learned for the LLC comparison and now all data is compared at a discount rate of 3 and 7%.

Cost-benefit analysis and net present value for comparing program-A to program-B

Table 5.13: Cost-benefit analysis & Benefit Cost Ration of all vehicles in program at 3 & 7%

Cost-Benefit Analysis and Net present Value for Compairing GLO's Vehicle Program
To adding Hybrid Vehicles

Program A. (Status Quo)

	Costs		Benefits			
Year	Financial	Opportunity	Extra Earnings	Net benefits	Present Value @ 3%	Present Value @ 7%
0	$219,908.02			$219,908.02	$219,908.02	$219,908.02
1	$29,150.94			$29,150.94	$28,301.88	$27,243.87
2	$29,150.94			$29,150.94	$27,477.56	$25,461.56
3	$29,150.94			$29,150.94	$26,677.24	$23,795.85
4	$46,461.34			$46,461.34	$41,280.30	$35,445.13
5	$29,150.94			$29,150.94	$25,145.86	$20,784.22
6	$29,150.94		$47,475.00	$18,324.06	$15,346.11	$12,210.09
Net Present Value					$353,444.74	$340,428.56

Program B. (Hybrid Vehicles Added)	Costs		Benefits			
Year	Financial	Opportunity	Extra Earnings	Net benefits	Present Value @ 3%	Present Value @ 7%
0	$210,124.80			$210,124.80	$210,124.80	$210,124.80
1	$12,366.00			$12,366.00	$12,005.83	$11,557.01
2	$12,485.16			$12,485.16	$11,768.46	$10,905.02
3	$12,610.08			$12,610.08	$11,540.01	$10,293.58
4	$24,221.34			$24,221.34	$21,520.35	$18,478.34
5	$12,875.76			$12,875.76	$11,106.74	$9,180.24
6	$13,017.60		$52,875.00	$39,857.40	$33,379.95	$26,558.67
Net Present Value					$244,686.24	$243,980.33

GLO's Vehicle Fleet Program	Costs	Benefits	Benefit-Cost Ratio	NPV @ 3%
Program A	$412,124.06	$47,475.00	0.12	$353,444.74
Program B	$297,700.74	$52,875.00	0.18	$224,686.24

The total program from purchase of the 9 vehicles through the maintenance and fuel cost to keep the vehicles running during a 6 year period is calculated here in comparison to a new program consisting of hybrid vehicles is studied. The financial costs as well as the opportunity costs (if any) are calculated against the benefits gained with each set of vehicles. The net benefits are converted to present value using a 3% and 7% discount rate for each year to get the present value at different rates. Finally all costs are calculated to get the net present value of the program using the net present value formula: NPV=PVB-PVC. Additionally the Benefit Cost Ration (BCR) is tested at the end of the analysis. “The program with the highest BCR should be considered for adoption first, before programs of lower ranks. The information from the BCR criterion can be insufficient under certain circumstances, however. It may require the supplement of NPV to inform decision making" (Chen, Forsythe, Weikart, and Williams 2009, 86). Table 5.13 shows the results of the cost-benefit analysis taking into account all figures presented in the previous tables. At a net present value of 3% program-B costs approximately $108,758.50 less than Program-A. At a NPV of 7% program-B costs approximately $96,448.23 less than Program-A to undertake. The BCR ratio toward the bottom of Table 5.13 shows that Program-B has a higher ratio than Program-A. The program with the highest BCR should be considered for adoption first, before programs of lower ranks, however the BCR test may not be sufficient to make recommendations alone.

Conclusion

This chapter reviewed and discussed the results of the present value and net present value calculation for the costs and benefits of the Texas General Land Offices vehicle fleet program compared to a new program that would introduce hybrid vehicles. The social and private discount rates used in the analysis provided slightly different net present values and benefit-cost rations. With either discount rate, program-B has a much higher net present value result than program-A. Even though both final numbers appear as negative the Texas General Land Office will spend less on initial purchase price and over the life of the vehicles if program-B is chosen. This cost-benefit analysis was intended to show the cost savings between the two compared programs and program-B is the most economically viable.

GLO Employees may be slow to accept hybrid vehicles at first in the field offices. However the economic advantage they bring to the agency is great. If management implements this plan and educates employees about the cost savings then change is easier to accept. Before the demo Toyota Prius Hybrid vehicle arrived staff was hesitant to try it out. At the end of the two week demonstration it was difficult to keep them out of the Prius. In social terms the indirect benefits are great. It's difficult to place in monetary terms the benefit of cleaner air or less noise pollution, but these two factors add up over time when large inefficient vehicles are taken off the road. Fuel efficiency is a key factor when choosing fleet vehicles. Agencies should look at vehicles the same as buildings or other capital assets and choose the most efficient asset that will cost less over its lifetime. The following chapter will discuss the conclusions of the project.

Chapter Six: Conclusion

Introduction

This chapter provides a summary of the cost-benefit analysis performed on the Texas General Land Office vehicle fleet program. This chapter also recommends that the Texas General Land Office add hybrid vehicles to its fleet to use as staff transport vehicles as well as develop a motor pool system for its field offices. Finally a recommendation is made to perform a Life Cycle Cost analysis when new vehicles are purchased.

Summary

This research project began by discussing all the benefits and costs associated with hybrid vehicles. Additionally the history of and processes for conducting a cost-benefit analysis was discussed. Chapter two of the research contained the Literature Review and discussed the theories and opinions of scholars regarding hybrid technology, Flex fuels, vehicle emissions, and noise pollution. Chapter two also contained scholarly research regarding the utility of cost-benefit analysis and where such is appropriate. Cost-benefit analysis is a decision making tool used by public and private decision makers to determine the viability of funding and in developing capital improvement projects. The literature review chapter detailed the steps for properly conducting a cost-benefit analysis along with the proper way to identify the costs and benefits of a project.

Chapter two also reviewed similar vehicle fleet programs along with other cost benefit analysis on specific vehicle comparisons. The Literature Review determined that hybrid vehicles use less fuel because at idle and in stop and go traffic they are running off battery power alone so no fuel is burned and no emissions are exhausted. This makes a big difference when total fuel consumption is calculated. The Literature Review also revealed that the hybrids use of regenerative breaking allows the vehicle to use the kinetic energy off the breaks to produce electricity that gets fed back into the batteries as the driver slows down to a stop. Regenerative breaking is a magnificent technological advance that conserves the breaks while capturing energy. Finally Literature Review chapter paved the way for comparisons to be made in emission ratings and noise pollution studies.

Chapter three, the Setting chapter, explored the background of the Texas General Land Office and the Office of Vehicle Fleet Management at the Texas Comptroller's Office. Additionally costs and benefits were identified that helped move the project forward. The conceptual framework of the analysis outlined the benefits, costs, discount rate, and decision criterion used in the research.

Chapter four, the Methodology Chapter, reviewed how each benefit and cost would be measured. Benefits and cost measurements included the direct and indirect factors for the benefits and were converted into monetary terms where possible. Most of the indirect benefits of the project could not be placed in monetary terms but were still considered in the final results of the analysis. The discount rates of 3%, 4%, and 7% were used throughout the present value analysis of each measurable variable to show the difference that each discount factor can have on each variable. The useful life of a vehicle according to the GLO fleet policy is 6 years and corresponds to the time period of measurement.

The cost-benefit analysis used Net Present Value and Benefit Cost Ratio to determine the viability of introducing hybrid vehicles into the fleet program. This research also used a Life Cycle Cost assessment to analyze the total vehicles cost over its lifetime in order to determine which vehicles are cost effective. The purpose of this research and the analysis is to determine if replacing current large vehicles that are inefficient for staff transport with smaller hybrid vehicles is cost effective. The net present value derived in the analysis found that program-B is cost effective and can save the agency approximately $108,000 each vehicle replacement period. With the current inventory level of vehicles in the GLO's fleet two more fiscal years could see replacement of large vehicles with hybrid vehicles to be used as staff transport vehicles. If replacement occurs in three fiscal years the GLO's could potentially save over $325,000 as well as the recurring costs savings associated with a staff transport fleet achieving over 50 MPG.

Chapter five, the Results Chapter demonstrates how the discount rate plays a role in the analysis. By evaluating a project using more than one discount rate, decision makers can clearly see the impact of the rates on projects. The results also demonstrate how much a vehicle with low fuel mileage can cost over its lifetime along with the impact each vehicle has on the environment.

Recommendations

The results of this cost-benefit analysis are essential in accurately forecasting the future costs of vehicle ownership. By following the steps outlined in this research, the Texas General Land Office and other agencies can duplicate this process to determine the viability of future vehicle fleet programs.

By introducing hybrid vehicles into the fleet to be used as staff transport vehicles the field offices will have a choice on which vehicles to drive. The following recommendation is made to create a motor pool in each of the five GLO field offices. Based on current inventory levels of vehicles at the field offices the following hybrid vehicles are recommended in the field office. Table 6.1 shows how the vehicles are distributed among the 5 field offices.

Table 6.1: Suggested number of hybrid vehicles per field office

Regional Office #	Field Office Location	Divisions at this Location	Current Inventory of Vehicles	Current Staff that Use Vehicles	Suggested # of hybrid staff Transport Vehicles
1	Nederland, Texas	Oil Spill	6	7	2
2	La Porte, Texas	Oil Spill + Pro Services	16	21	6
3	Corpus Christi, Texas	Oil Spill + Pro Services	13	16	5
4	Brownsville, Texas	Oil Spill	5	5	1
5	Port Lavaca, Texas	Oil Spill	5	5	1
		Totals	45	Totals	15

A vehicle pool is defined as a group of vehicles that reside at a particular office and can be checked out by any staff member needing to complete a business related task. The vehicles are maintained and tracked at the field office by an assistant fleet manager designated by the main agency fleet manager to be a custodian of that particular set of vehicles. A vehicle use log will be kept in the vehicle and vehicles will be distributed by the type of task that needs to be completed. Vehicle pools can save agencies money because tasks are based on fuel mileage and the size of vehicle. A recommendation is also made that agency personnel who are required to take vehicles home use hybrid vehicles.

By reviewing both quantitative and qualitative data, cost-benefit analysis provides substantial evidence and support for a projects success or failure prior to completion. Government entities can use a cost-benefit analysis or other suitable analysis types to properly plan projects to ensure economic viability.

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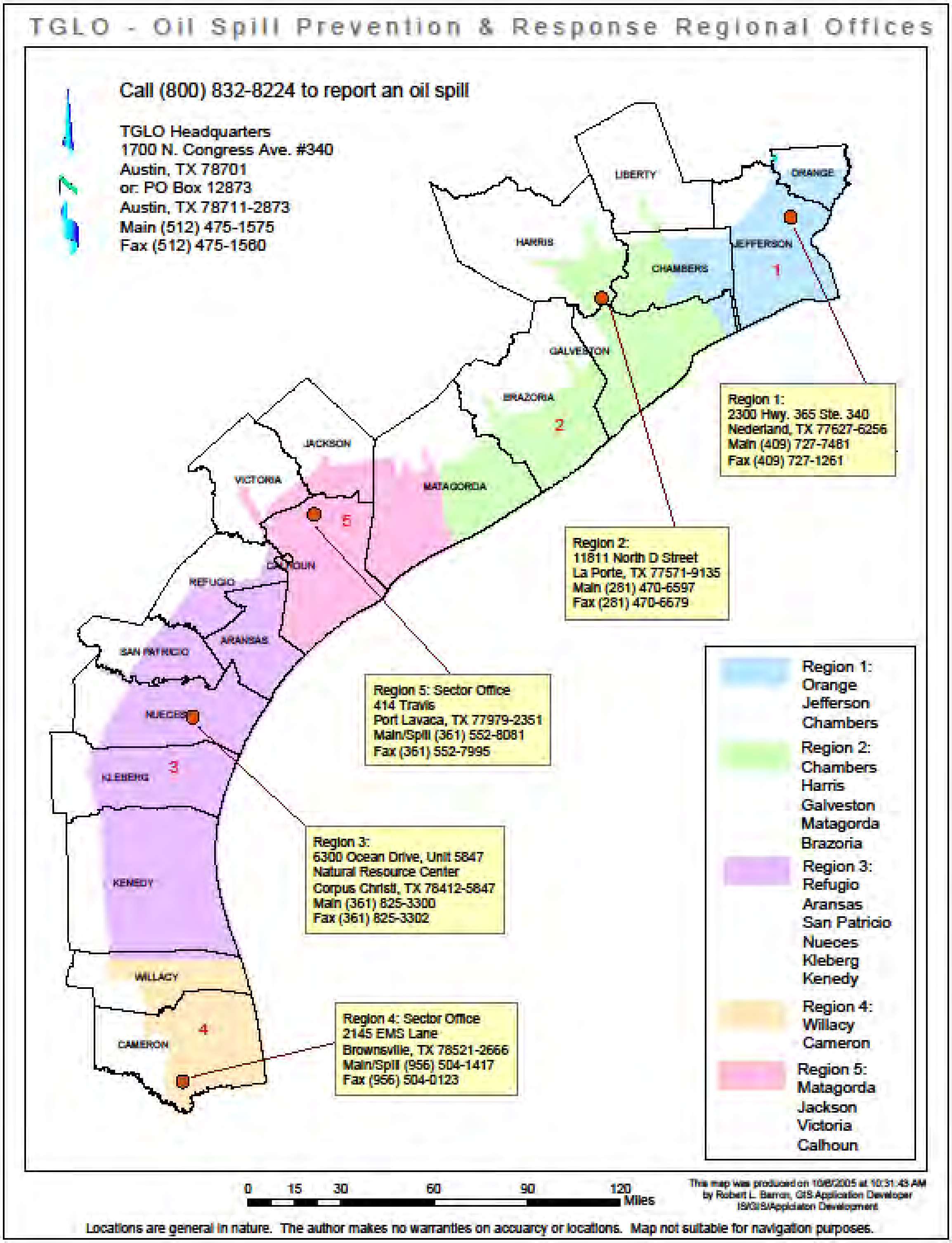
Appendix A


TGLO - Oil Spill Prevention & Response Regional Offices
Call (800) 832-8224 to report an oil spill
TGLO Headquarters
1700 N. Congress Ave. #340
Austin, TX 78701
or: PO Box 12873
Austin, TX 78711-2873
Main (512) 475-1575
Fax (512) 475-1560
LIBERTY
ORANGE
HARRIS
JEFFERSON
CHAMBERS
GALVESTON
BRAZORIA
JACKSON
VICTORIA
MATAGORDA
CALHOUN
REFUGIO
ARANSAS
SAN PATRICIO
NUECES
KLEBERG
KENEDY
WILLACY
CAMERON
1
2
3
4
5
Region 1:
2300 Hwy. 365 Ste. 340
Nederland, TX 77627-6256
Main (409) 727-7481
Fax (409) 727-1261
Region 2:
11811 North D Street
La Porte, TX 77571-9135
Main (281) 470-6597
Fax (281) 470-6679
Region 5: Sector Office
414 Travis
Port Lavaca, TX 77979-2351
Main/Spill (361) 552-8081
Fax (361) 552-7995
Region 3:
6300 Ocean Drive, Unit 5847
Natural Resource Center
Corpus Christi, TX 78412-5847
Main (361) 825-3300
Fax (361) 825-3302
Region 4: Sector Office
2145 EMS Lane
Brownsville, TX 78521-2666
Main/Spill (956) 504-1417
Fax (956) 504-0123
Region 1: Orange Jefferson Chambers
Region 2: Chambers Harris Galveston Matagorda Brazoria
Region 3: Refugio Aransas San Patricio Nueces Kleberg Kenedy
Region 4: Willacy Cameron
Region 5: Matagorda Jackson Victoria Calhoun
0 15 30 60 90 120 Miles
Locations are general in nature. The author makes no warranties on accuarcy or locations. Map not suitable for navigation purposes.

Appendix B

Vehicle Monthly Use Report

Vehicle Custodian: William H. Foster | Vehicle Make: Ford | Type: 3/4 Ton Truck | Year: 2004

Report Month [redacted] | License #: 866-949 | Agency Code: 305 | Fuel Type

Previous Month Odometer: 1 1 3 1 7 9

DATE	Trip/Daily Ending Odometer	Purpose	Destination	Driver Last Name	Number of Passengers (per trip)	Fuel Type [illegible]	Gallons	Cost
1		Not in use						
2		Not in use						
3		Not in use						
4		Not in use						
5		Not in use						
6		Not in use						
7		Not in use						
8		Not in use						
9	1 1 3 3 2 8	Lease Inspections	Jasper, TX	Foster	0	G	19.3	46.90
9	1 1 3 5 9 8	Lease Inspections	Longview, TX	Foster	0	G		
10	1 1 3 5 9 8	Lease Inspections	Karnack, TX	Foster	0	G	22.7	53.50
10	1 1 3 9 8 6	Return to GLO	Nederland, TX	Foster	0	G		
11	1 1 3 9 8 8	Fuel Truck	Nederland, TX	Foster	0	G	25.6	59.05
11	1 1 3 9 9 0	Return to GLO	Nederland, TX	Foster	0	G		
12		Not in use						
13		Not in use						
14		Not in use						
15		Not in use						
16		Not in use						
17		Not in use						
18		Not in use						
19		Not in use						
20		Not in use						
21		Not in use						
22		Not in use						
23	1 1 4 2 9 2	Lease Inspections	Caddo/Marshall	Foster	0	G	24.6	54.65
23	1 1 4 3 2 3	Lodging	Longview, TX	Foster	0	G		
24	1 1 4 4 6 6	Lease Inspections	Lindale, TX	Foster	0	G		
24	1 1 4 6 3 8	Lease Inspections	Henderson, TX	Foster	0	G		
25	1 1 4 5 4 0	Lease Inspections	Darco/Tatum	Foster	0	G	23.1	51.35
25	1 1 4 7 8 9	Return to GLO	Nederland, TX	Foster	0	G		
26		Not in use						
27		Not in use						
28		Not in use						
29		Not in use						

Month End Odometer: 1 1 4 7 8 9

Total Trips: 12 | Total Fuel: 115.3 | 255.45

Total Miles: 1,610

Use additional pages as necessary

Use totals from final page for Data Entry purposes

Total Passengers/Mo.: 0

Fuel data entry must be per transaction

Incidental Lubricants / Fluids

Date	Type	Qty.	Cost/each	Total Cost

Lubricant/Fluid Types

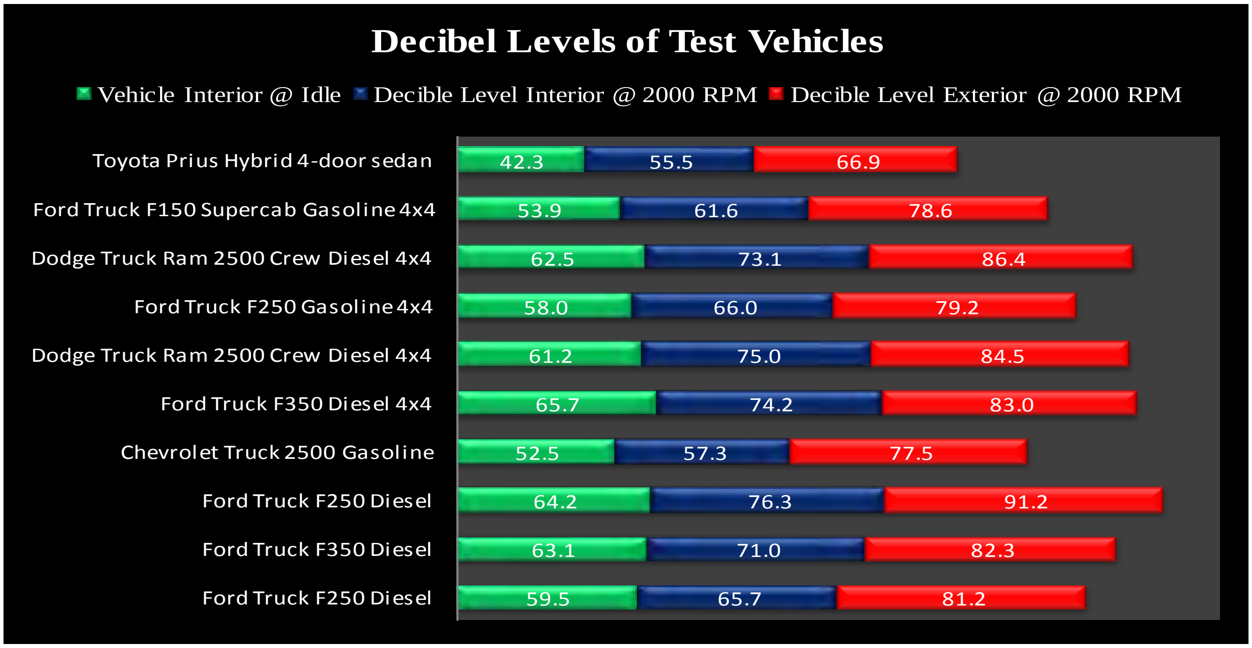
Type	Level	
Engine Coolant	Full	
Motor Oil	5w20	CASTROL
Gear Oil	Full	
Transmission Fluid	Full	
Brake Fluid	Full	
Hydraulic Fluid	N/A	

I certify that I have read the provisions of law quoted in the accompanying documents, that the foregoing report is correct, and that the operation and maintenance of this vehicle have been in accordance with lawful orders.

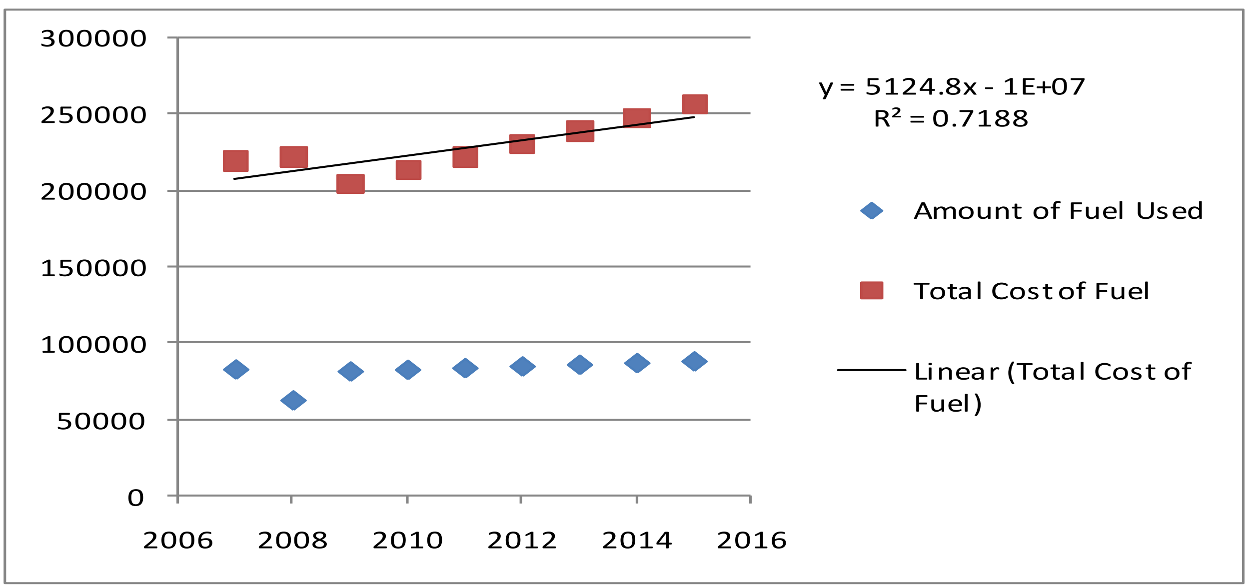
Signature of Custodian: [signature] 09/30/2009

Appendix C

APPENDIX – C: Decibel levels of test vehicles, field research completed March, 2010

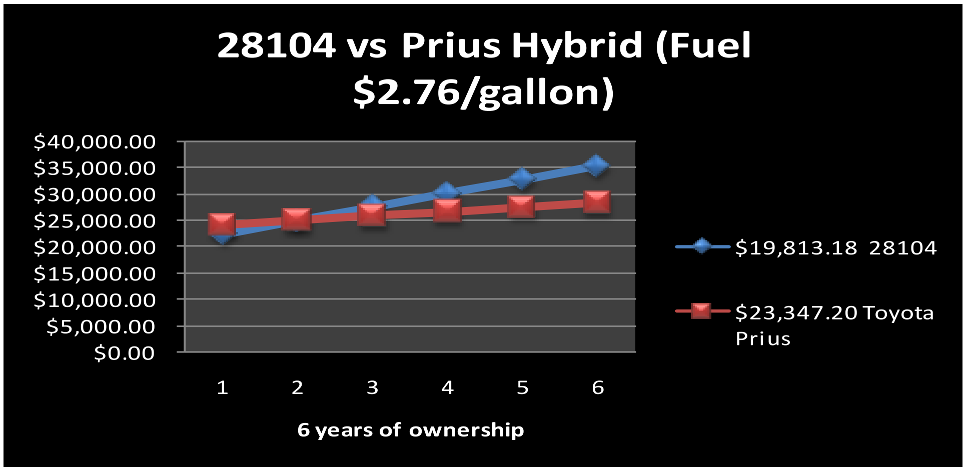


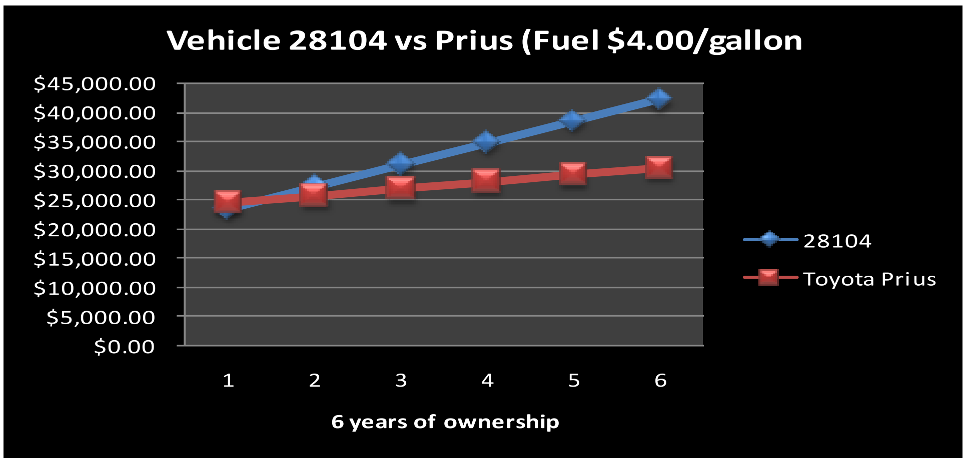
APPENDIX – C: Total fuel usage projection from 2006 to 2015. 2010 through 2015 projected

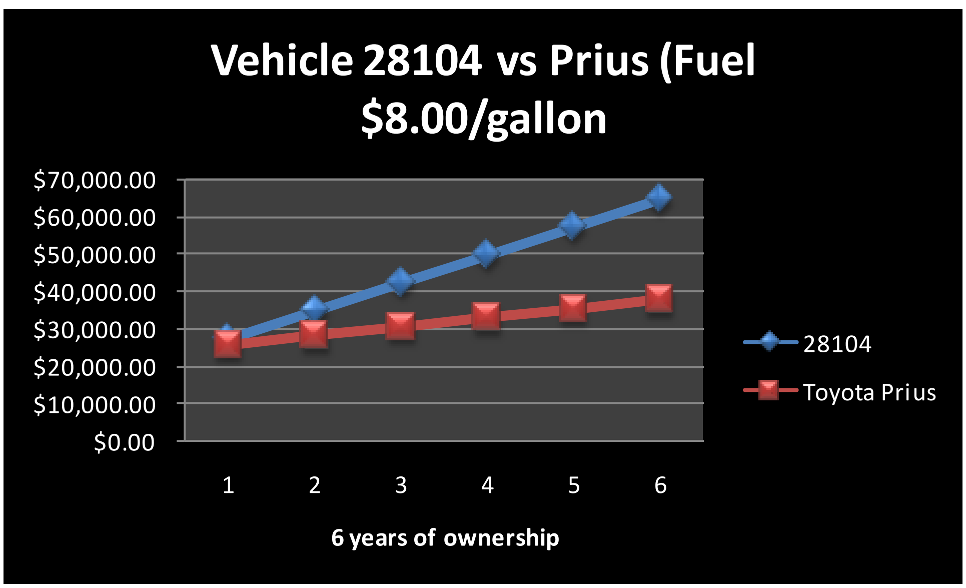


Appendix D

APPENDIX – D: Toyota Prius hybrid v. Ford Truck F150 Gasoline # 28104 @ $2.76, $4.00 & $8.00 Fuel Price







Appendix E

Schedule B

FY2010

SALARY GROUP		1	2	3	4	5	6	7	8	9
B10	Year	$23,710.00	$25,043.63	$26,377.25	$27,710.88	$29,044.50	$30,378.13	$31,711.75	$33,045.38	$34,379.00
Inspector I - 1320	Month	$1,975.84	$2,086.96	$2,198.10	$2,309.23	$2,420.37	$2,531.51	$2,642.64	$2,753.78	$2,864.91
B11	Year	$25,132.00	$26,859.88	$28,587.75	$30,315.63	$32,043.50	$33,771.38	$35,499.25	$37,227.13	$38,955.00
	Month	$2,094.34	$2,238.32	$2,382.31	$2,526.30	$2,670.29	$2,814.28	$2,958.27	$3,102.26	$3,246.25
B12	Year	$26,640.00	$28,471.50	$30,303.00	$32,134.50	$33,966.00	$35,797.50	$37,629.00	$39,460.50	$41,292.00
	Month	$2,220.00	$2,372.62	$2,525.25	$2,677.87	$2,830.50	$2,983.12	$3,135.75	$3,288.37	$3,441.00
B13	Year	$28,239.00	$30,180.38	$32,121.75	$34,063.13	$36,004.50	$37,945.88	$39,887.25	$41,828.63	$43,770.00
	Month	$2,353.25	$2,515.03	$2,676.81	$2,838.59	$3,000.37	$3,162.15	$3,323.93	$3,485.71	$3,647.50
B14	Year	$29,933.00	$31,990.88	$34,048.75	$36,106.63	$38,164.50	$40,222.38	$42,280.25	$44,338.13	$46,396.00
	Month	$2,494.42	$2,665.90	$2,837.39	$3,008.88	$3,180.37	$3,351.86	$3,523.35	$3,694.84	$3,866.33
B15	Year	$31,729.00	$33,910.38	$36,091.75	$38,273.13	$40,454.50	$42,635.88	$44,817.25	$46,998.63	$49,180.00
Auditor I - 1042	Month	$2,644.09	$2,825.86	$3,007.64	$3,189.42	$3,371.20	$3,552.98	$3,734.77	$3,916.55	$4,098.33
B16	Year	$33,633.00	$35,945.13	$38,257.25	$40,569.38	$42,881.50	$45,193.63	$47,505.75	$49,817.88	$52,130.00
	Month	$2,802.75	$2,995.42	$3,188.10	$3,380.78	$3,573.45	$3,766.13	$3,958.81	$4,151.48	$4,344.16
B17	Year	$35,651.00	$38,101.88	$40,552.75	$43,003.63	$45,454.50	$47,905.38	$50,356.25	$52,807.13	$55,258.00
Auditor II - 1044	Month	$2,970.92	$3,175.15	$3,379.39	$3,583.63	$3,787.87	$3,992.11	$4,196.35	$4,400.59	$4,604.83
B18	Year	$38,146.00	$41,007.00	$43,868.00	$46,729.00	$49,590.00	$52,451.00	$55,312.00	$58,173.00	$61,034.00
	Month	$3,178.84	$3,417.25	$3,655.66	$3,894.08	$4,132.50	$4,370.91	$4,609.33	$4,847.75	$5,086.16
B19	Year	$40,816.00	$43,877.25	$46,938.50	$49,999.75	$53,061.00	$56,122.25	$59,183.50	$62,244.75	$65,306.00
Auditor III - 1046	Month	$3,401.34	$3,656.43	$3,911.54	$4,166.64	$4,421.75	$4,676.85	$4,931.95	$5,187.06	$5,442.16
B20	Year	$43,673.00	$46,948.63	$50,224.25	$53,499.88	$56,775.50	$60,051.13	$63,326.75	$66,602.38	$69,878.00
	Month	$3,639.42	$3,912.38	$4,185.35	$4,458.32	$4,731.29	$5,004.26	$5,277.22	$5,550.19	$5,823.16
B21	Year	$46,731.00	$50,235.75	$53,740.50	$57,245.25	$60,750.00	$64,254.75	$67,759.50	$71,264.25	$74,769.00
Attorney II - 3502	Month	$3,894.25	$4,186.31	$4,478.37	$4,770.43	$5,062.50	$5,354.56	$5,646.62	$5,938.68	$6,230.75
B22	Year	$50,002.00	$53,752.13	$57,502.25	$61,252.38	$65,002.50	$68,752.63	$72,502.75	$76,252.88	$80,003.00
Manager I - 1600	Month	$4,166.84	$4,479.34	$4,791.85	$5,104.36	$5,416.87	$5,729.38	$6,041.89	$6,354.40	$6,666.91
B23	Year	$53,502.00	$57,514.63	$61,527.25	$65,539.88	$69,552.50	$73,565.13	$77,577.75	$81,590.38	$85,603.00
Attorney III - 3503	Month	$4,458.50	$4,792.88	$5,127.27	$5,461.65	$5,796.04	$6,130.42	$6,464.81	$6,799.19	$7,133.58
B24	Year	$57,247.00	$61,540.50	$65,834.00	$70,127.50	$74,421.00	$78,714.50	$83,008.00	$87,301.50	$91,595.00
Manager III - 1602	Month	$4,770.59	$5,128.37	$5,486.16	$5,843.95	$6,201.75	$6,559.54	$6,917.33	$7,275.12	$7,632.91
B25	Year	$61,254.00	$65,848.13	$70,442.25	$75,036.38	$79,630.50	$84,224.63	$88,818.75	$93,412.88	$98,007.00
Auditor VI - 1052	Month	$5,104.50	$5,487.34	$5,870.18	$6,253.03	$6,635.87	$7,018.71	$7,401.56	$7,784.40	$8,167.25
B26	Year	$67,380.00	$72,854.50	$78,329.00	$83,803.50	$89,278.00	$94,752.50	$100,227.00	$105,701.50	$111,176.00
Director I - 1620	Month	$5,615.00	$6,071.20	$6,527.41	$6,983.62	$7,439.83	$7,896.04	$8,352.25	$8,808.45	$9,264.66
B27	Year	$74,118.00	$80,140.00	$86,162.00	$92,184.00	$98,206.00	$104,228.00	$110,250.00	$116,272.00	$122,294.00
Attorney V - 3505	Month	$6,176.50	$6,678.33	$7,180.16	$7,682.00	$8,183.83	$8,685.66	$9,187.50	$9,689.33	$10,191.16
B28	Year	$81,529.00	$88,153.38	$94,777.75	$101,402.13	$108,026.50	$114,650.88	$121,275.25	$127,899.63	$134,524.00
Director III - 1622	Month	$6,794.09	$7,346.11	$7,898.14	$8,450.17	$9,002.20	$9,554.23	$10,106.27	$10,658.30	$11,210.33
B29	Year	$89,682.00	$96,968.75	$104,255.50	$111,542.25	$118,829.00	$126,115.75	$133,402.50	$140,689.25	$147,976.00
Attorney VI - 3506 Director IV - 1623	Month	$7,473.50	$8,080.72	$8,687.95	$9,295.18	$9,902.41	$10,509.64	$11,116.87	$11,724.10	$12,331.33
B30	Year	$98,651.00	$106,666.25	$114,681.50	$122,696.75	$130,712.00	$138,727.25	$146,742.50	$154,757.75	$162,773.00
	Month	$8,220.92	$8,888.85	$9,556.79	$10,224.72	$10,892.66	$11,560.60	$12,228.54	$12,896.47	$13,564.41
B31	Year	$108,516.00	$117,332.88	$126,149.75	$134,966.63	$143,783.50	$152,600.38	$161,417.25	$170,234.13	$179,051.00
General Counsel V - 3524 Director V - 1624	Month	$9,043.00	$9,777.73	$10,512.47	$11,247.21	$11,981.95	$12,716.69	$13,451.43	$14,186.17	$14,920.91
B32	Year	$119,367.00	$129,065.63	$138,764.25	$148,462.88	$158,161.50	$167,860.13	$177,558.75	$187,257.38	$196,956.00
	Month	$9,947.25	$10,755.46	$11,563.68	$12,371.90	$13,180.12	$13,988.34	$14,796.56	$15,604.78	$16,413.00
B33	Year	$131,304.00	$141,972.50	$152,641.00	$163,309.50	$173,978.00	$184,646.50	$195,315.00	$205,983.50	$216,652.00
Deputy Director - 1630 Chief Investment Officer - 1165	Month	$10,942.00	$11,831.04	$12,720.08	$13,609.12	$14,498.16	$15,387.20	$16,276.25	$17,165.29	$18,054.33
B34	Year	$144,434.00	$156,169.38	$167,904.75	$179,640.13	$191,375.50	$203,110.88	$214,846.25	$226,581.63	$238,317.00
No Job Classification in FY10	Month	$12,036.17	$13,014.11	$13,992.06	$14,970.01	$15,947.95	$16,925.90	$17,903.85	$18,881.80	$19,859.75
B35	Year	$158,878.00	$171,786.75	$184,695.50	$197,604.25	$210,513.00	$223,421.75	$236,330.50	$249,239.25	$262,148.00
No Job Classification in FY10	Month	$13,239.84	$14,315.56	$15,391.29	$16,467.02	$17,542.75	$18,618.47	$19,694.20	$20,769.93	$21,845.66

[illegible] Schedule A & B [illegible]