Future of Transportation

Interactive Qualifying Project

This Interactive Qualifying Project was conducted over the course of the 2009-2010 year by an interdisciplinary team of researchers at WPI. Our goal with this project has been to consider the varying aspects of the automobile industry and its future to reduce petroleum usage due to growing concern about pollution and climate change. Our focus lies in alternative fuel cars, specifically in the emergence of hybrid vehicles recently. To do this, we did research on many facets of the auto industry, performed statistical analysis, and conducted interviews and focus groups.

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Executive Summary

This Interactive Qualifying Project was conducted over the course of the 2009-2010 year by an interdisciplinary team of researchers at WPI. The team consists of Tom Jenkins, Brendan Gove, Peter Forte, and Justin Frye. Our goal with this project has been to consider the varying aspects of the automobile industry and its future to reduce petroleum usage due to growing concern about pollution and climate change. Our focus lies in alternative fuel cars, specifically in the emergence of hybrid vehicles recently. To do this, we did research on many facets of the auto industry, performed statistical analysis, and conducted interviews and focus groups. What follows is our report split up into chapters that include the introduction, background research, methodology, data, and results.

In the introduction, we brought up many dimensions of the problem at hand here in the United States with pollution and excessive petroleum usage, especially in the transportation system in the country. It is clear that there needs to be a change in order to alleviate the current unsustainable pattern of consumption and pollution. The push for "green" technology has led to a variety of alternative fuel vehicles that we researched and compared to those of standard internal combustion vehicles. We posed to determine whether or not hybrid vehicles hold potential to be the best auto technology to utilize for main stream society. We sought to analyze the potential success of hybrid technology to alleviate the issues the United States faces. In order to complete this project, we needed a clear idea of the problems at hand and their origins before we look toward a solution.

We then conducted background research on the origins of the automobile as the primary method of transportation in the United States to the current problems we face. It was important for us to understand the decisions and events that went into the creating of the country's highways and auto industry that resulted. We also needed to have insight into our oil tendency, market statistics, and emergence of technology. With this background into the situation, we were able to go into how we would go about this analysis.

The third section of this paper is the methodology for our analysis. In this section, we explained what and how we went about gathering data to come to a consensus. We explained the research we conducted on various technologies and the market. Combined with these secondary sources, we conducted interviews and focus groups to further determine consumer trends and the car buying

process. The purpose of this research was to determine the total impact to both the environment and people as a result of each of these technologies.

The data chapter we presented the data we proposed in the methodology in order to solve the problems discussed. We explained our secondary sources as well as our interviews and focus groups. This allowed us to provide information supporting our proposed solution with specific concentration on hybrid technology.

The previous chapter containing our collected data served to aid our results, which is the final chapter of this project. We went about analyzing the market trends and various technologies. The focus groups and interviews served to give us insight into what people are driving and how they go about buying a vehicle. All of this led us to our conclusion that hybrids are a step in the right direction, however they are not the best possible solution and, in many cases, actually cost more to the environment and the car owner than their potential savings. The hybrid still has a lot of the inherent flaws of a standard internal combustion engine because it includes one. The overall cost for manufacturing, operating, and recycling hybrids is much higher than a standard vehicle, especially because of the batteries. We believe that plug in hybrid technology and all electric vehicles should be where the auto industry is headed. This, as we discovered, requires consumer demand for such technologies, fostered by government incentives, to pressure manufactures to stop dragging their feet in implementing petroleum independent vehicles.

Chapter 1: Introduction

In recent years, the world has become more aware of its growing problems concerning climate change and pollution. As a result, there has been a push from countries around the world to both reduce greenhouse gas emissions as well as the use of natural resources. In the United States, one of the largest contributors to this problem is our use of petroleum products in our transportation infrastructure. The United States houses 4.6% of the world's population, but emits a staggering 19.9 million tons CO2 per capita. In comparison, China holds 21% of the world's population and is responsible for 4.8 million tons of CO2 and the Chinese are eagerly increasing their manufacturing industry which will only increase the amount of worldwide emissions (Rogers, 2009).

These three are the world's biggest polluters, but as stated the United States is head and shoulders above the rest due to their great success in industry and dependency on cars. With regard to transportation, Americans favor the private automobile over the establishment of public transport systems. Car dependency in the United States involves unsustainable social and economic burdens, including the costs of health problems and accidents, heavy government subsidization of roadway construction and maintenance, gas consumption, excessive land consumption, environmental pollution, lost labor and productivity due to traffic jams, net reduction of employment opportunities, and higher costs of living (Newman and Kenworthy, 1999; Kay, 1997).

Not only is this a problem from an environmental standpoint, but also from a political point of view because the US is dependent on importing a majority of oil from other countries. Every year more oil is imported, yet the global production has not increased. Of the 58% of the oil the United States imports, 49% is from countries in the Western Hemisphere such as Canada (18.2%), Mexico (11.4%), and Venezuela (10.1%) as well as 16% from the Persian Gulf (EIA). This has caused a realization that the U.S. has a need for more fuel efficient cars. The car industry has been pressured to introduce new cars that use less; either by improving internal combustion technology or by developing something new.

Hybrid technology has been leading the way in the United States, but still requires the use of a gasoline engine. These cars do, however, get much higher mileage than their regular internal combustion cousins, thus having the potential to alleviate consumption of fossil fuels. Traditional cars utilize a standard internal combustion engine, while hybrids marry the drive train of an internal combustion engine to an electric motor and electronics. This results in power being split between the

engine and the motor, which allows manufacturers to use smaller capacity engines that use less gas. Each manufacturer has unique drive configurations that balance between more efficient and more powerful. The potential for hybrid technology to reduce the use of petroleum is high, but is it the best long term way to do so? Another question one must ask is how do people feel about hybrid technology? Generally speaking, consumer trends in the automotive market have pointed in the direction of large SUV's with powerful engines. This is not exactly pointing in the direction of fuel efficiency. Auto makers such as General Motors have been responding to consumer demand and have invested in the SUV market. This is in large part, the reason for GM's partial bankruptcy and is a huge contribution to the U.S.'s dependency on oil.

It is clear the need to reduce pollution from our transportation methods is better for our health, economy, and ensures a more sustainable future. Hybrid cars have shown a glimmer of hope, but have yet to go widely enough to see a difference in our consumption or their effect. This report will cover an extensive comparison between the internal combustion engine and a select number of hybrid technologies. In order to do so, a look into the United States' past to reveal how the United States arrived at the point, including the political decisions that were made and the historical development of "green technology," is necessary to reveal how the U.S. arrived at this point today. The purpose of this is to analyze where manufacturers have progressed today and the difficulties they have faced when potentially introducing "green" concepts. Additionally, we will analyze whether or not the investment hybrid technology can alleviate the United States' dependency on oil in an economical fashion. Things such as fabrication of hybrid cars, lifespan of hybrid cars, recycling hybrid cars, and an overall comparison between the performances of Hybrid cars to internal combustion vehicles will be made. The goal is to formulate a conclusion as to whether or not hybrid technology is the best mainstream auto technology to utilize and the social aspects associated. Finally, we will pose the question whether or not the success of the hybrid technology advancements has the ability to resurrect and restore the United States economy.

Chapter 2: Literature Review and Background

In this chapter we will start with an analytical survey of the United States history with regards to pertinent events which influenced our country's decision to become an automobile oriented society. Specifically, the in depth analysis will begin in the year 1945 and will continue to the present. The significance of the year 1945 marks the end of World War II, which marks the beginning of a new era in United States history. WWII served as a reality check for most Americans that that their freedoms and privileged lifestyle which they had grown accustomed too were no guarantee. Some of the situations and occurrences in WWII served as a great influence over crucial decisions which our country made. We will then transition into how the automotive industry responded to such an influential move which could highly benefit their industry. Finally, and in depth comparison of how many cars are currently being sold to the price of gasoline will illustrate the changes that our country has made.

2.1: "How it All Began"

First, backing up to the aftermath of WWI starts to set the scene for the U.S. make certain decisions to become an automobile oriented country. WWI brought tremendous devastation and death. The level of devastation was so tremendous that the "Big Three" (America, Britain, France) organized an agreement known as the Treaty of Versailles which, in short, organized the de-militarization of Germanys army and navy in attempt to avoid another world war. However, Germany's Adolf Hitler came to power and after a series of events, raised an army and initiate WWII (Schoenherr, 2004).

For the United States, WWII started with the Japanese military attack on Pearl Harbor Naval head quarters on the morning of Sunday, December 7, 1941. The Japanese intended this attack to cripple the U.S. Pacific Fleet from having any influence on Japans plans to wage war with Southeast Asia against Britain, the Netherlands, and the United States. However, the attack of 353 Japanese aircrafts which sank four U.S. navy battleships, damaged four more battle ships, damaged or sank 3 cruisers, three destroyers, and one minelayer, destroyed 188 U.S. aircrafts, and claimed 2402 lives and left 1,282 wounded did not work out the way Japan had hoped. The fact that this was a surprise attack, not to mention Germany's deceitful actions with the Zimmerman Telegram, did not prevent the U.S. from

engaging in and winning WWII. The implications of this attack on Pearl Harbor causing a ripple effect that would continue long after the end of WWII. (Dept. Of the Navy, 2009)

This attack at Pearl Harbor served as the first large scale inter-continental bloodshed on American soil since, relatively speaking, the American Revolution. Pearl Harbor showed that war is an evident and seemingly un-avoidable part of human nature, and the U.S. had to prepare itself for any future threats against the American way of life. America had to prepare itself against the potential for a surprise attack, against the threat of war, or the potential for war to reach American soil again. This was a serious issue on the minds of Americans during the 1950's. It was an issue that was met with a solution by Dwight D. Eisenhower.

2.2: Dwight D. Eisenhower

Dwight D. Eisenhower was a five-star general in the United States Army and served as a Supreme Commander of the Allied forces in Europe during WWII. During which, he held the responsibility for planning and supervising the successful invasion of France in German in 1944-45. In 1951 Eisenhower accepted the position as the first Supreme Allied commander of NATO. All of this experience gave the 34th President of the United States necessary knowledge and wisdom to make a difficult decision to defend the U.S. against any future attacks.

After WWII, the world realized the decision to de-militarize like after WWI was not possible. Ensuing WWII, an era between the United States and the Soviet Union erupted onto the scene, known as the Cold War. The Cold War was an arms race between the United States and the Soviet Union. WWII brought about technological advances such as the nuclear bomb, so both countries competed to build the most quantity and best quality missiles. They did this as an act of national security. It was thought that whoever had the biggest and most powerful weapon would have power and control, but all the arms race did was increase the potential of a catastrophic nuclear attack. This information is crucial to the development of the United States because the Cold War gave great initiative for the United States to create a system of self defense and a way that the U.S. as a whole could most efficiently respond to an attack. This concept lead to President Eisenhower's final decision to build the National System of Interstate and Defense Highways in the Federal-Aid highway Act of 1956. (The White House Presidents-Dwight D. Eisenhower, 2010)

2.3: Federal-Aid Highway Act

The Federal-Aid Highway Act initiated the construction of nearly 40,000 miles of interstate highway. As of 2006, the value increased to 46,876 miles. The mind set behind building such an infrastructure was that the U.S. could organize quickly and efficiently in case of a foreign invasion by providing a direct route of transportation for military supplies and troop deployments. Contradictory to the belief of many, this was not the first time an idea to build an interstate highway infrastructure came about. The movement started in the 1930's during President Franklin D. Roosevelt's campaign. President Roosevelt pushed the idea of having a network of transcontinental superhighway because of the economic stimulus that it would provide. There would be ample work more millions of people in order to achieve this concept. This was especially popular during Roosevelt's presidency because unemployment was high during the Great Depression. Legislation started to take steps to make this project a reality by passing the Federal-Aid Highway Act of 1938. This act directed the chief of the Bureau of Public Roads to study the feasibility of a six route network which relied on the collection of a toll cost to pass to help pay for the construction. Unfortunately, the verge of WWII brought the construction to a halt. Things picked up again in 1944 with a revised Federal-Aid Highway Act to make improvements and establish new layouts of over 40,000miles of new roadway to be built. The Act was not heavily supported and eventually fell through, only completing around 6,500 miles of highway.

President Eisenhower knew the potential that an interstate highway held not only for defense, but for general mobility from an economical standpoint as well. From a defense standpoint, Eisenhower had seen firsthand from his participation in 1919 on the U.S. Army's first transcontinental motor convoy from Washington, DC, to San Francisco in comparison to his experience as Supreme Commander of the Allied forces where he experienced Germany's autobahn system. The autobahn gave the German's such a great advantage of mobility during the war that Eisenhower actually used the autobahn against them for his own troops mobility when he organized the successful invasion of France and Germany. Eisenhower knew that setting up an interstate highway system was the best option for the United States that during his State of the Union address on January 7, 1954, Eisenhower made it clear that he was ready to turn his attention to the nation's highway problems. Simply stated, he considered it the highest priority to, "protect the vital interest of every citizen in a safe and adequate highway system."

Although Eisenhower knew the potential and benefits of having an interstate highway system, there was a considerable amount of difficulty getting support from Congress between 1954 and 1956.

The main controversy in the superhighway was the balance of funding between the Federal and State government. In 1956, the President made a State of the Union address which stressed the need of this interstate highway system. Shortly after, Congress passed the Federal-Aid Highway Act of 1956 with considerable debate and amendment, agreeing between House and Senate that this infrastructure was crucial to the well being and safety of the country. The act expanded the construction to 41,000 miles with a $25 billion dollar budget between the fiscal years 1957 through 1969. Eisenhower signed the bill to make it law on June 29th, 1956. This day marked the transition which made the United States a fundamentally dependent automobile transportation country. (America's Highways, 1776-1976)

2.4: The Great American Streetcar Scandal

During the 1920's, 1 in 10 Americans owned a car making streetcars and trolleys very popular and necessary for travel (West, 2009). The Great American Streetcar Scandal, also known as the General Motors streetcar conspiracy, occurred throughout the US when streetcar systems were torn up and replaced by buses in the mid-20th century. In the 1920's, GM bought streetcar lines Springfield, Ohio, Kalamazoo, and Saginaw, Michigan. They set up a dummy corporation, put their money into it, bought privately owned streetcar lines, and allowed the transit systems to only buy supplies from the corporations involved in the scandal. Once this system was proven to make profit, General Motors, along with Firestone Rubber, and Standard Oil of California, created a subsidiary corporation, National City Lines. National City Lines was made into a holding company and E. Roy Fitzgerald was placed in power with specific directions to supply exclusive contracts to GM, Firestone, Standard Oil of California, Phillips Petroleum, and the Federal Engineering Corporation and, in return, they invested in City Lines. Fitzgerald was president of a bus system in Minnesota before being named president of National City Lines. He created subsidiary bus lines and soon spread across the US. Between 1936 and 1950, National City Lines, in the East and South, and its subsidiaries Pacific City Lines (1938) in the West and American City Lines (1943) in the Midwest bought interests in 146 electric trolley systems in 45 cities in 16 states and replaced them with GM buses with the money laundered through finance companies that were in on the scandal (Mankoff, 1999). GM, Firestone, and Standard Oil of California sales soared and profits skyrocketed. GM predicted that the unpleasant bus rides would guide people toward buying GM cars.

National City Lines and the corporations involved with it were gaining the wrong kind of publicity before World War II. William C. Dixon, former justice of the Supreme Court, was asked by the US government to investigate the sale statistics of independently owned bus and streetcar lines. The bombing of Pearl Harbor took all attention off the trolley lines and onto WWII. Jay Quimby, a trolley operator, recognized what National City Lines was doing and reapplied the magnifying glass to the scandal. Quimby operated the trolley route between Paterson, New Jersey and Ridgewood, New York after college. He enlisted in the navy during World War II and was stationed in Key West, Florida, where he realized the "conspiracy to eliminate electric-powered mass transit in the name of gasoline-powered profits" (Mankoff, 1999). In January of 1946, Quimby wrote an in depth proposal on the scandal and sent it to every government official, politician, and transportation authority. GM, Firestone, and Standard Oil were indicted under the Sherman Anti-trust Act (Mankoff, 1999). William C. Dixon was again designated chief prosecutor to the case. Dixon stated that one company buying another company and converting its mode of transportation was not illegal. However, acquiring companies and forcing them to only buy from certain corporations exclusively was illegal. The congressional hearings and federal trial were not taken seriously. On March 13, 1949, the corporations were convicted on one count of conspiring to monopolize a part of the trade and commerce of the US. They paid small fines of $5,000 each and key executives were fined only $1 (Mankoff, 1999). Gasoline was 12 cents a gallon so people did not pay much attention. GM maintains that they did not intend to destroy the trolley system.

The scandal paved the way, literally, for a permanent car culture in the US. With a lack of an intercity mass transit network, people were forced to drive. Federal, state, and local authorities poured money into roadway construction. New zoning laws required new businesses to have a certain amount of free parking depending on the size and type of facility and, also, pushed buildings well off the road, only benefitted car use. Shopping centers and suburbs discontinued even constructing sidewalks next to the road, making it difficult and dangerous for pedestrians, so people drove. Even destinations that were within walking distance were driven to because of the unsafe condition, making the US more car-dependent.

2.5: General Motors: Postwar

The General Motors Company was the world's largest automaker from 1931 to 2005. GM played a vital role in the birth of the National Highway of Users Conference, which would become the most powerful lobby in Washington. These lobbyists worked with legislators and influenced them to devise legislation that benefitted the highway system (Motavalli, 1997). GM's advertisements often displayed the slogan, "The American dream of freedom on wheels." In 1953, GM president, Charles Earwin Wilson, was appointed Secretary of Defense by Eisenhower. Wilson worked with Congress to draft the $25 billion Federal Aid Highway Act of 1956. 1953 also saw GM's first sports car, the Corvette, the first plastic bodied car to be mass produced. The postwar industry developed an idea called "planned obsolescence". This strategy used a three year cycle in which a new body shell is developed and marketed. Over the next two years slight styling changes are made to the car so more sales can be made. GM focused each of its automotive divisions on a particular market segment, allowing each to have their own style and technology. When components overlapped between divisions, corporate management created "substantial economies of scale" meaning a buyer could start out with a practical and economical car such as a Chevrolet and, following the path set by the various divisions, move through offers until the buyer eventually bought a top of the line Cadillac (Caulkin, 2009). These divisions were not in competition; rather they passed the consumer from division to division, keeping them buying GM cars and raising profits.

By the mid-1950's, GM was the largest company in the US and the world's largest employer. The introduction of high performance engines in once "entry-level buyer" cars such as Chevrolet and higher trim models like that of the Chevrolet Impala brought prices to be amongst Oldsmobile and Buick cars, making divisions less defined. In 1958, GM showed developments for built in highway guidance systems and Cadillac introduced cruise control. When Pontiac, Oldsmobile, and Buick introduced like styled and priced compact cars in 1961, divisional boundaries were nearly extinct (GM Timeline, 2009).

In the 1960's General Motors developed compact and intermediate cars to compete with the other car manufacturers (About GM, 2009). By 1962 GM had peaked, making 1 million automobiles each year in North America and selling 1 out of every 2 cars and trucks that were sold in the US. Chevrolet Corvair, one of the first of a new compact class, was offered in response to the small, sporty and fuel-efficient automobiles being imported from Europe by Volkswagen and Renault (GM Timeline, 2009). The Corvair stood out with engineering significantly different from other American offerings. It

featured GM's Y-body and had its engine in the rear of the car like the Volkswagen Beetle. Its engine was an aluminum, air cooled, flat-6 engine only produced 80hp. However, it was no match for its Ford rival. The Chevy II and the Chevrolet Camaro/Pontiac Firebird were produced to rival Ford's Falcon and Mustang respectively. The 1960's saw most of GM's vehicles produced by common models and similar body panel stampings.

With more and more imports and their rising market share, the Chevrolet Vega, GM's new subcompact class, was born, but problems with its newly developed aluminum engine led to its discontinuation years later. Following its subcompact trend, GM downsized the Chevrolet Caprice which included a stiffer suspension, higher-grade cloth and vinyl seat and door trim, thicker and higher-grade carpeting, walnut trim on the dashboard and door panels, pull straps on the doors, extra convenience lights, special full wheel covers, and an optional vinyl top. Caprice's also featured cost options such as power steering, automatic transmission, and white sidewall tires which most owners bought.

2.6: GM and the Middle East

In October of 1973, Middle Eastern countries stopped shipments of crude oil to western countries and the US as a consequence of them taking part in ongoing Arab-Israeli conflicts. On October 6th, Arab forces attacked the Israeli military on Yom Kippur, the most sacred Jewish holiday. Since the Arab's were backed by the Soviets, the US took the side of the Israelis. As a result, OPEC ("Organization of Petroleum Exporting Countries") declared a 100% increase in price of Middle Eastern Crude Oil on October 12th. Four days later, the Persian Gulf region OPEC members announced that they would set their own prices. When the Israeli's gained control of the conflict thanks to behind the scenes US efforts, Arab oil authorities declared an oil embargo on the US and increased prices by 70% to Europe. Oil shipments were completely stopped when President Nixon sent military aid to the Israeli army. (The 1970's Energy Crisis, 2009)

The embargo quadrupled gas prices in the US as panicking investors and oil companies became aware of the situation. Gas stations formed lines of cars at their pumps, changing posted prices by the hour. Gas was rationed by using a system of assigning odd and even license plate numbers certain days of the week they could visit the pump. President Nixon even proposed an extension of daylight savings

time and a ban on the sale of gas on Sundays. Gas prices were not the only thing affected by the embargo. Prices of food and manufactured products raised drastically, the workforce suffered greatly, the stock market fell 15% in a month and 45% from before the embargo was set, and US carmakers saw enormous drops in sales (Peak Oil, 2009). Drivers saw the chaos and wanted fuel-efficient cars, but GM was selling 8-cylinder gas guzzlers like the Cadillac Eldorado, Chevrolet Monte Carlo, and Buick LeSabre. Europe and Japan were ahead of the game, already producing smaller cars because of crowded countries and narrow roads that could not fit the larger US cars. Americans began buying Japanese cars to save money. GM was slow in developing smaller, fuel efficient cars that were safer for the environment. In an attempt to stop the surge of imported cars, GM and other carmakers took bigger shares of the market but the Japanese responded by opening plants in Canada and the US (Motoen Misery, 2009). In an attempt to become more environment friendly, GM built catalytic converters into all 1975 car models to reduce emissions and obey federal clean air laws. The first domestic diesel engine was put in several 1978 cars, including the Oldsmobile Delta Eighty Eight, to deal with gasoline shortages (GM Timeline, 2009). President Carter knew the problems and difficulties for the US attributed with oil. He tried to pass a national energy policy by passing tax and rate incentives for developments in hydroelectric energy. President Nixon's Project Independence, which focused on developing synthetic hydrocarbon and alternative fuels. President Carter added a shade of "green" to the White House by installing solar panels connected to the water heater, and a wood stove (Peak Oil, 2009).

2.7: Declining GM Company

The decline of GM continued throughout the 1980s. In the midst of a recession and with car sales declining in 1980, GM posted its first financial lost since the Great Depression. In 1983, GM and Toyota formed a joint venture in California called New United Motor manufacturing. The venture let GM adopt Toyota's lean manufacturing system, which is used in all kinds of manufacturing today. GM also introduced a design for the Saturn, a new small car brand which was forced into sale when an electric car, the Impact debuted. This time teaming up with Suzuki in 1986, GM produced small cars and SUVs in Canada, but closed 11 plants in North America. GM's share of the US automobile market fell from 45% in 1981to 35% in 1989. Tens of thousands of workers were laid off and GM lost $30 million over the decade. American car buyers found the Japanese cars to be more reliable and cheaper

to own than American manufacturers were selling (Motown Misery, 2009). The average American family lost faith in the Big Three and saw their loyalty shift to Japanese carmakers while wealthier families went with European manufacturers such as BMW, Mercedes, and Volvo.

American carmakers dominated one area of the market after the wave of smaller imports, SUVs. The profit margin was so high on these vehicles that GM put much of its effort into the large SUV. The SUV can earn profits of upwards of $10,000 for American manufacturers compared to a few hundred dollars a compact car would earn. SUV sales continued over the 1990s and into the 21st century, but financial losses forced GM to close 21 more plants in the US and Canada.

Although still marketing large gas guzzlers, GM did put effort into alternative fuels. In 1995, GM became the first automaker in modern times to advertise an electric car, the EV1. The project was later scrapped and the cars crushed. GM and Toyota formed a 5-year pact to research and develop alternative vehicle propulsion technologies (GM Timeline, 2009). When gasoline prices again shot up in 2005, SUV sales dropped to one-third of their yearly sales (Motown Misery, 2009). Like in the 70's, consumers want fuel efficient, environment friendly vehicles. Foreign carmakers are taking down GM. Korean and the upstart Chinese carmakers have much better automobile prices, Japanese cars are much cheaper to run and maintain, and European manufacturer's car quality and performance is outstanding.

GM's dominance over the automobile industry is now lower than ever. It relied far too much on selling gas guzzlers and fell behind its foreign competitors in the research and development of hybrid technologies. High labor costs, competition from Asian car manufacturers, high gas prices, freezing of credit, global economic meltdown, and lack of consumers dealt a blow to GM. When workers held protests over the years, their demands were usually met, allowing GM workers to have a higher salary than other car manufacturers ("High Expenses led to GM Downfall"). For example, in 2007, billions of dollars in hourly retiree health care obligations was to the union. The company also faced pension problems with its workers' union when the company stopped putting money into the fund. Instead the money went executive compensation on stock ownership and options. GM gave out $13 billion in multiple repurchases and another $7 billion in dividends, adding to over $20 billion to shareholders (Jacoby, 2009). Basically, the wages and expenses were more than the company was making. On June 1, 2009, GM filed for bankruptcy protection and a cash bailout from the US government, becoming the third largest company to file for bankruptcy and the largest bankruptcy in manufacturing. It is believed that the labor union will get a 20% share through its retiree fund. The government will most likely wipe out the shareholders and keep 70% of the stake in GM. (High expenses led to GM downfall, 2009)

2.8: Understanding the Market

One of the most fundamental concepts of a market economy is the idea of supply and demand. Demand is the amount of a product or a service that buyers are willing to purchase at a given price. Supply is the amount of the product or service available. In terms of simple economics, supply and demand are related in several ways. The price of an item or service is related to both supply and demand. The law of demand states that if all other factors remain the same, if the price of a service or commodity increases, the demand for that product or service will decrease. The law of supply states that as prices increase, the amount of a product or service available will also increase. As demand for oil and gasoline have increased over the past few decades, the price has increased accordingly. As the price of gasoline has increased, the demand has remained relatively stable, even increasing in some areas of the world. To understand this demand stability, one must look both at oil itself and how oil has been used and produced historically. As the world continues to industrialize, the demand for oil and its components is projected to increase. This will impact the world's economy, as well as the supply and demand for oil and its products. Because oil is a finite resource, supply will not be able to keep pace with demand indefinitely. This lack of supply will again impact demand and cost of oil and any oil based products, including gasoline.

2.9: Finding the Oil

Oil, and thus gasoline, is a finite resource. It began forming over five hundred million years ago. The earth at that point was composed of numerous wetland areas that were prone to the accumulation of organic matter in the form of plants and marine organisms. The areas most suited for oil formation were areas with lower movement and exposure to oxygen like river deltas, some lakes, and shallow marine environments. The organic matter ended up accumulating on the shallow sea floors. This organic matter was covered with sediments that eventually turned into sedimentary rock. Thus totally separated from oxygen, the dead plant and animal matter was turned into hydrocarbons by bacteria. Meanwhile, geologic forces including plate movement, further sedimentation, volcanoes and earthquakes buried these organic deposits underneath rock that was not permeable. Eventually the hydrocarbons turned into liquids, which were sometimes washed into reservoirs. Generally oil reservoirs are made of sedimentary rock. Sedimentary rock can be very porous. This provides a place

for oil to accumulate. Once sufficient oil has accumulated, the area can be called an oil field (Selley, 1998). The entire process only occurs under specific circumstance including specific pressure and temperature ranges over prolonged periods of time leaving little possibility of scientists manufacturing duplicate oil.

There haven't been many recent discoveries of large oil deposits and the deposits that are known to be available for future extraction are generally those that are more difficult to drill due to their location or condition. These untapped deposits are frequently located in polar and deep-water locations or the oil is difficult to extract because it is in the form of a bitumen deposit. One example of heavy bitumen deposits is known as oil sands and located in the Canadian Oil Field in northwestern Canada. This formation contains heavy oil that is mixed with sand and water. It causes challenges when removing and when refining it. In order to harvest oil sands, two different methods are used. If the oil is close to the surface, it is mined using heavy equipment. The sands containing the water are scooped up, transported to the refinery, and mixed with hot water to extract the oil. This mining can only be used to extract the oil close to the earth's surface. When extracting the oil below the surface, the most popular method is steam extraction where steam is injected below the surface to free the bitumen from the sand so it can be pumped to the earth's surface. Both strip mining and steam extraction are more expensive methods of extraction than the traditional oil well (Fiscor, 2009).

Texas, a former major supplier of crude oil, still has over a million barrels of oil waiting to be refined. The oil is located so far beneath the earth's surface that it is currently difficult to drill in a cost effective manner. Oil has also been discovered off the coast of Texas by drilling almost 35,000 feet into the Gulf of Mexico (Julie, 2009). Production from most of these untapped oil deposits are either cost prohibitive or dangerous. As the current oil supply dries up, these new regions will be the locations that will be used for production (Motavalli, 2009). Tapping these resources will be both time and labor intensive, impacting the cost of the oil produced. According to some sources, the amounts of oil produced will soon (if it hasn't already) begin to decline and will continue to decline until the easily extracted oil is gone. This will precipitate the change to the use of oil from alternate sites like deepwater and oil sands.

2.10: A Decreasing Oil Supply

The concept that the supply of gasoline is finite and possibly declining has serious economic and environmental implications. The demand is currently stable in the United States with an annual usage of about 140 billion gallons. Most of this consumption is used for transportation with individual private automobiles accounting for about two thirds of gasoline usage. Gasoline is refined from crude oil and currently about 69% of the cost of a gallon of gas is due to the cost of the crude oil. The remaining 31% of the cost of a gallon of gasoline is due to taxes, refinery costs, profits, and the costs for distribution. This cost for crude oil has recently increased as reflected in the percentage of cost per gallon. Prior to 2008, the cost of crude oil was about 51% of the final gasoline cost with 21% of the cost due to taxes. As crude oil prices increased sharply in 2008, the percentage that was due to taxes, refining costs and profits decreased (Energy Information Association, 2009).

The cost of gasoline is currently about $2.60 per gallon for regular unleaded fuel. The price fluctuates due to a number of factors. The primary factor that influences gasoline prices is the cost of crude oil per barrel. When crude oil prices increase due to OPEC pricing or other factors, the price of gasoline quickly follows. Other factors that influence the price of a gallon of gas are due to seasonal fluctuations and the entire distribution chain. Seasonal fluctuations occur during the summer when prices increase as people travel more and use gasoline for recreational uses. This increase in demand leads to an increase in price. Otherwise the price of gasoline increases or decreases due to location relative to the supply chain. The further from the distribution chain, the more the price will be. This has a lot to do with the ease of delivery. The easier the delivery, the lower the delivery cost. If a refinery in knocked offline like what happened following Hurricane Katrina, local prices can skyrocket. In the case of Hurricane Katrina, the refineries in the New Orleans area were destroyed leaving a gap in the supply chain. Distribution routes were formed but the cost to transport increased and that cost was passed on to the consumer. The prices for the affected region were high for an extended period of time.

2.11: U.S. Long Dependency on Oil

The supply of inexpensive crude oil is currently essential to life in the United States and other counties around the world. Initially the United States consumed much of the oil and gasoline produced

worldwide but that trend has changed. Oil and gasoline are now used the world over. Oil has been used for various purposes including medicinal purposes since before recorded history. Once it was discovered that refining oil could produce products that were useful to man, especially kerosene for lanterns, the demand for oil products increased. The original oil used essentially bubbled from the ground. The first record of oil being extracted from below ground occurred in Pennsylvania in the late 1850s. This oil was shipped to early refineries so that kerosene could be produced. At first the oil was shipped in barrels using the new rail system. The cost of labor to move the oil was prohibitive so the first oil pipeline was built. Then in the 1880s, oil was discovered in Russia and refineries surrounding the oil fields began to flourish. Plentiful oil was discovered in Texas on January 10th, 1901 where eventually over 100,000 barrels a day were pumped and also in California where 4 million barrels of oil were produced in 1900. The East Texas field, the largest oil field discovered in the 48 contiguous states, was discovered in 1938. Then, also in 1938, an oil field was discovered in the Persian Gulf. By the early 1940s, there appeared to be a vast supply of crude oil, which could be easily refined into its component parts, including gasoline (Radkau, 2009).

The numerous crude oil sources that were discovered in many parts of the world were finite sources. Some of these oil fields were immense, containing billions of barrels of oil. This seeming endless supply of oil led to the availability of vast quantities of oil at low cost. The inexpensive price of oil led to an increase in oil consumption primarily in the United States and Western Europe. These countries did not produce the supply of oil that they consumed, leading to a dependence on oil from other locations. The amount of crude oil produced in the United States peaked in the 1980s and has steadily declined since then (Energy Information Administration, 2009). This local peak was in fact predicted by a United States geologist, M. King Hubbert, who in the 1950s stated that oil production in the United States would decline between the 1960s and the 1970s (Haubrich, 2009). He was fairly accurate about the decline of production leading some to call the peak production of oil the Hubbert Peak. This decrease in oil production as the sources dry up also has occurred in other parts of the world including Mexico and Russia. As the supply of readily available oil dwindles, the amount of oil imported increases to meet demand. Additionally, the cost of obtaining domestic oil increases as the difficulty of pumping the oil increases. This increase in cost is not only in dollars; the cost is also in natural resource use. According to Motavalli**,** there is an amount of oil used to procure additional oil that is increasing along with the difficulty of obtaining oil. Back in the 1930's, using a barrel of oil would produce an additional 100 barrels of oil. By the 1970s, a barrel of oil only produced about 30 additional barrels and currently it takes one barrel of oil to extract 11 additional barrels. This cost in natural resources is likely

to increase as oil becomes more difficult to obtain. Either the oil will require increased transportation costs or increased extraction costs.

2.12: How Much Oil is Left?

When supplies of available oil are discussed, the amount of oil available for extraction is called the oil reserve. According to Maugeri, the current worldwide oil reserve is estimated to be between 1.1 and 1.3 trillion barrels. If consumption remained at the level from the mid 2000s, this oil reserve would last somewhere around forty years. There are several problems with this method of estimating reserves. First of all it is an estimated amount and the people doing the estimating are the same people who are supplying the oil. There is currently no verification process. Also, oil reserves estimate the amount of oil that can actually be extracted from the earth. Right now the estimates are that with the current technology, about 35% of the oil in any given well is extracted. The technology used is not standard so some wells bring in a higher percentage while others produce a lower percentage. The oil reserve may in reality vary considerably from the estimates. Much of that oil reserve is located in the Persian Gulf, where information about oil reserves is carefully guarded.

2.13: Where the Oil Supply is Located

The one area where current production of oil is consistently not decreasing is the OPEC nations. The Organization of Petroleum Exporting Countries formed in 1960 in order to achieve some control on oil prices. Formed initially by Iran, Iraq, Kuwait, Saudi Arabia and Venezuela, membership has changed over the years. The OPEC nations continue to be the major exporters of crude oil to the world. Oil production in these nations steadily increased beginning in 1982 and appears to have remained stable over the past several years. These nations supply oil to all parts of the globe. The major oil fields in the OPEC nations are reported to currently produce 40% of the world's oil (World Oil Outlook, 2009). The OPEC nations are expected to continue to maintain current oil exports for the next several years and then production is expected to slowly decrease. The amount of oil available from the OPEC nations remains uncertain. The International Energy Outlook predicts a stable flow of crude oil from the OPEC nations until at least 2030 while many sources citing the Hubbert Model of finite resource depletion predict that peak oil has passed and the world is headed into a period of reduced oil availability (Energy

Information Administration, 2009). The OPEC group itself in the World Oil Outlook predicts that it will continue to produce about the same amount of crude oil daily through 2015 and then expand production and increase overall production to 2030. By 2030, the OPEC nations predict they'll increase production by 38%. Regardless of oil supply, this region is potentially volatile and has placed restrictions on oil exports in the past as evidenced by the 1973 oil embargo. During the 1973 Arab-Israeli War, the United States opted to help supply the Israelis. The OPEC nations announced an embargo that limited the oil supply to the United States and others for about six months. This caused a serious energy shortage. Oil prices increased dramatically. A small portion of the world has a great deal of control over most of the world's oil reserves. This supply of oil can be restricted without notice. Even if the supply of oil from the OPEC nations continues at the current rate, the decrease in supply from other areas is causing a worldwide decrease in production.

2.14: Peak Oil

Because oil is a finite resource that was formed during a short period in the earth's history many years ago, production will eventually be forced to decrease. There has been considerable debate about when that will (or did) happen. A theory called Peak Oil has been around since the late 1940s. When production from new oil wells worldwide cannot offset the lack of production from old wells worldwide, then oil production has peaked. This theory of peak oil has occurred in smaller areas already. The idea of an overall peak oil has been subtly debated for a number of years but hasn't been brought to the attention of the public sector. According to Whipple, there is a consensus developing among many people who study oil production that the peak will actually occur within the next several years and oil production will then begin a long, slow decline. This current peak is at odds with others who state that oil really peaked earlier this decade. Regardless of when the peak occurred or will occur, the results are less debatable. Once the production of oil decreases, the price will inevitably increase. This increase in prices may cause a short-term increase in oil production but eventually production will not be able to keep up with demand.

2.15: Getting the Most Out of the Remaining Supply

As prices for crude oil continue to go up, there eventually will be more oil available for the short term because the oil that is not drillable at the current price of crude oil per barrel will become more lucrative for companies looking to increase profits. Demand and the subsequent profitability will drive businesses to take risks with people and technology to find and retrieve more oil. There are a variety of methods of extracting more oil from the ground. Conventional methods reportedly allow between 20 and 40 percent of the oil to be harvested. Because oil is stored within pores of rocks, different substances can be pumped into the rocks to force the oil upward and outward (Maugeri, 2009). New technology is allowing the insertion of less expensive substances into oil fields and the extraction of a greater percentage of the oil. Additionally, new technology is allowing exploration in areas far beneath the ocean floor. According to Maugeri, three oil strikes have occurred beneath up to 6000 meters of rock and soil and under 3000 meters of water. The ability to extract oil from almost 10,000 feet under the ocean's surface will provide ample opportunities for future development. While some fields cease to produce oil, profitability will drive corporations to produce viable replacements to older oil fields. Technology will aid in this endeavor.

Demand for oil-based products was virtually unheard of prior to the early 1900s. The discovery of oil and the refinery process led to the production of products that were used to improve the quality of human lives. Initially the demand was for kerosene, which people burned in lanterns to replace candles. This use of kerosene allowed people to illuminate larger areas after dark leading to the ability to work later. Then the development of mass produced internal combustion engines increased the demand for gasoline. These engines allowed the growth of the transportation industry, leading to increased manufacturing and crop production. The ability to ship products to locations throughout the world led to further opportunities as people could receive the food and hard goods they needed regardless of the season. People could work and earn a greater incoming, allowing for increased purchases. The demand for gasoline and oil based products increased steadily as a transportation infrastructure was developed. With the addition of the interstate highway system and the increased dependability of automobiles, more people were able to purchase personal automobiles, again increasing the demand for gasoline.

Current demand for gasoline is primarily in the area of transportation and food production. Transportation is critical to the lives and livelihood of people throughout the world. People worldwide depend on transportation to access necessary services including medical care, access people including employment, friends and family, and access to consumer goods including clothing, furniture and food. The food that is consumed by people in the United States is generally grown almost 1500 miles away. Agriculture throughout the world is dependent on gasoline burning technology. The food industry depends on oil products for fertilizers and pest management as well as all aspects of crop production (Motavalli, 2009). Transportation in a timely manner to get food and other products to market is also a key factor in demand for gasoline and oil based products. The freight industry, including cargo ships and trucks, are crucial to transporting food and consumer goods throughout the United States and the world. As globalization has increased, the flow and availability of goods has grown. The demand for petroleum products to fuel that supply has increased as well.

As new countries continue their rise to the manufacturing forefront in the future, the demand for oil will only continue to increase. China's development into a leader in the world is creating a greater demand for petroleum resources even as the supply dwindles. China and India combined used about 10% of the world's oil supply in years past. Now these two countries alone are consuming almost 20% of the world's energy from oil with projections for future increases. Countries that have been small users of oil and gasoline are increasing their consumption as they develop and grow. The annual growth in demand for oil and petroleum based products is about two percent each year (Motavalli, 2009). This translates to enormous growth over time. Average consumption in 2006 was about 85 million barrels a day. By the year 2030, just 24 years later, consumption is predicted to be about 107 billion barrels of oil a day (International Energy Outlook). Up to 80% of this projected growth in demand for petroleum products is projected to be in the transportation industry.

As more countries in Asia are becoming industrialized, the number of people with both access to automobiles and the economic ability to purchase them has increased. Just between the years of 2000 and 2004 the number of passenger cars in China more than doubled (Zhao, 2009). The increase of trucks also increased substantially. As the standard of living in China and other rapidly industrializing nations improves, automobile ownership and the resultant demand for gasoline will increase. This will drive the price of gasoline higher. According to Robert Lenzner, a financial journalist for Forbes, the Chinese government is currently attempting to make deals for resources that are already leased to other

countries. This indicates not only the lack of supply available for export to China but also the potential for increasing prices as supplies are coveted.

Overall, gasoline prices have raised along with other prices since automobiles became commonplace and gas stations proliferated. If one looks only at the dollar per gallon price that was charged for gasoline beginning in 1920, the picture regarding gasoline prices remains unclear. Gasoline was thirty cents per gallon in 1920, which currently seems like a fabulous price when compared to the current cost of $2.60 per gallon. One factor that helps to makes sense of the difference in the dollars is the constant dollar. A constant dollar is a dollar that has been adjusted for inflation. When comparing the cost of gasoline in 1920 to 2006, gas was more expensive in 1920 than in 2006 ($2.91 compared to $2.35). Looking at the cost for a gallon of gasoline over time, some trends emerge. Gas prices in constant dollars slowly decreased between 1920 and 1972 with several increases that coincided with major world conflicts and the Great Depression. This makes sense logically as gas and oil was seemingly available and plentiful. In 1972, gasoline hit an all time low price when adjusted for inflation in constant dollars at $1.69 per gallon.

Then the energy crisis in 1972 interrupted the supply of oil and gas and the gradual increase of gas prices through the 1980s began. The prices declined again in the 1990s with a strong economy and have since risen to their current level. Overall, the price of gasoline has decreased by almost 50% between 1929 and the early 1990s. Since then they have risen to their original level. Even though in real cost it appears that gasoline prices have increased substantially, when prices are adjusted for inflation, the cost for gasoline has remained relatively constant since 1920. According to the International Energy Outlook, the price for crude oil is predicted to increase between now and 2030. In today's dollars, the price per barrel is expected to climb to $110.00 by 2015 and to $130.00 by 2030. Since crude oil price is the largest factor in the price of gasoline, the price of gasoline is projected to continue to increase.

The cost of the gasoline pumped into individual automobiles is just one part of the cost picture. The cost of gasoline per gallon to drive is fairly easily calculated. The other costs of using gas and crude oil are more difficult to calculate. Current estimates are that it takes about 10 calories from a fossil fuel to produce one calorie of the food that is consumed in the United States (Motavalli, 2009). Petroleum is also used to produce many consumer items including computers, plastics, and clothing. As the price point on crude oil rises, it impacts many aspects of people's lives. Consumer goods, food, clothing, transportation, electricity, home heating oil, computers, and durable goods are all affected by the price

of a barrel of crude oil. It permeates almost every aspect of life in the United States and many parts of the Western World. It is beginning to impact the lives of more people around the world as industrialization ensues. This cost of gasoline does not even take into account the environmental costs of burning petroleum products.

Worldwide, the use of automobiles has increased steadily since Henry Ford began assembling automobiles early in the 19th century. The internal combustion engines which powered these automobiles emitted harmful chemicals as a by-product. Automobile exhaust contains: hydrocarbons, nitrogen oxides, carbon monoxide and carbon dioxide. Each of these emissions is minor when one automobile is being considered. Once the sheer number of automobiles in the world is considered, the cost to human health and to the environment is enormous. The release of exhaust is a key factor in air pollution, smog and acid rain. Automobile emissions have also been linked to heart disease and several forms of cancer. The cost of the impact on humans and the environment are difficult to assess. This cost is not factored into the price of gasoline to consumers.

In the world of supply and demand, gasoline elastically depends on the price range. People continue to consume gasoline for transportation and oil for home use (electricity, home heating) regardless of the price. It is difficult for most people to substantially reduce the amount of gasoline that they have to purchase. They can eliminate unnecessary driving and miles but continue to have to purchase gasoline for transportation to work and to other necessary locations.

Because decreasing consumption of gasoline is not easy, many people will have to eliminate other spending from their budgets in order to continue to purchase the oil based products that they need. Because of gasoline's inelasticity, it will most likely take a very large increase in price to decrease demand to the supply level. This shift in supply and demand only makes finding a solution to our current energy crisis that much more important. It is currently difficult to ascertain the impact on the economy that will (and has) occur as prices for gasoline and products made from petroleum rise. The International Energy Outlook uses the events of 2008 to demonstrate oil supply and demand and the impact on prices. Oil prices increased throughout the first part of 2008 just as they had for the previous several years. Even as the prices continued to increase, demand appeared to remain strong, especially in developing countries. This led to additional oil company commitments to produce more oil at greater costs. By the middle of the year it became apparent that the economy was slowing down and the demand for oil was weaker than expected. The supply of oil was greater than the demand and prices fell.

The economic future impact of oil prices is difficult to predict as there are many variables that have to be considered. Demand for oil is projected to continue to rise and supply is projected to either remain constant or to decrease, depending on the source of the projection. This will result in a net increase of oil prices in the foreseeable future. Increases in oil prices generally lead to inflation, reduced demand for other products and fewer investments in countries that import oil (Lim, 2009). Tax revenues for these countries decrease so budget deficits generally increase. Higher oil prices affect overall economic activity, individual and corporate earnings and inflation. Counties that are most dependent on imported oil and spend a greater percent on oil products would suffer the most while oil exporting counties would have the most to gain.

As prices of gasoline and oil based products increase, all consumers have to use a larger percentage of their income to pay for gasoline, leaving less to spend on other goods and services. Because oil products are a vital ingredient in many of the goods produced worldwide, either the cost of the increase in oil to manufacturers would have to be passed on to consumers or production would have to decrease costs in other ways like reduction in workers or shutting down plants. Also, an increase in petroleum products would have an impact on other energy prices. Petroleum products are used to produce electricity so a resultant increase in its price would most likely occur. Prolonged price increases would most likely lead to technological advances to reduce oil consumption in most areas.

Supply and demand are integral parts of the economy of the United States and much of the world. The market is based on free enterprise where value of a commodity is based on the amount of that item available and how much someone is willing to pay for it. Cheap oil has been readily available throughout the world since the OPEC nations began exporting vast quantities of oil. Production of oil has become stagnant over the past few years leading to the prediction of future scarcity. Scarcity causes prices to increase. Gasoline prices are closely tied to crude oil prices that are predicted to continue to rise as peak oil is reached and supplies dwindle. Increased prices traditionally cause people to stop purchasing an item in vast quantities. Gasoline seems to be somewhat immune to these laws. When the price goes up or the supply decreases, people continue to purchase gasoline to fuel their automobiles and oil to heat their homes. They may attempt to cut back a little by combining trips and eliminating unnecessary driving but they continue to purchase gasoline at a fairly steady rate. As the supply of gasoline decreases and the demand increases, some sort of point will be reached where consumers will have to change their purchasing habits. This will most likely begin occurring in the near future as crude oil supplies begin to decrease and prices rise. As supplies diminish, lifestyles will change

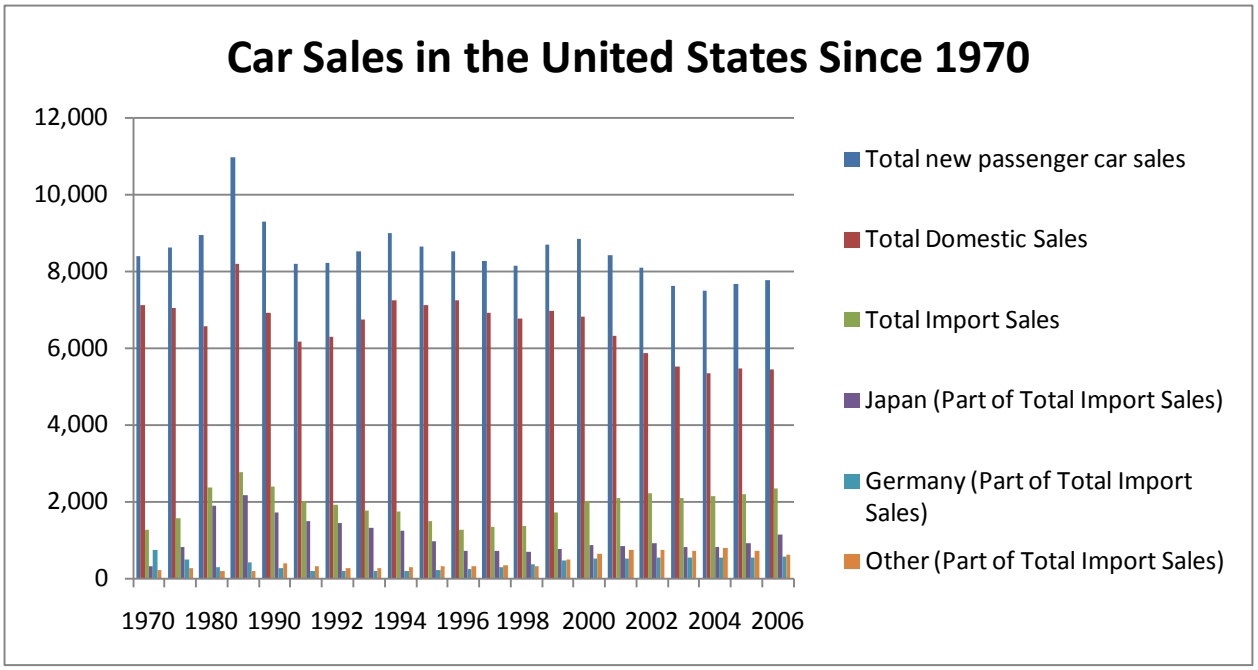
and adaptations will occur. Those people who can adapt early will have an advantage over those who are unable to change.

2.16: Car Sales and Market Research

Since the advent of the automobile, thousands of companies have come and gone from the global market, but only a handful have survived over the long term and grown into major players. The industry is dominated by a few companies who are globalizing their operations to take over the major regional markets. The top overall producers of automobiles currently are as follows: Toyota, General Motors Corporation, Porsche Automobiles Holding, Ford Motor Company, Honda Motor Company, Nissan, and PSA Peugeot Citroën (OCIA, 2009). Japan, geographically speaking, is the smallest country in this comparison, however produces the most cars worldwide. The automobile industry has been shaken up as of late in the United States with the fear about the possibility of the Big 3 going under in 2008, and as a result, the future of those companies has been in limbo. In Europe, the auto industry landscape has not changed as dramatically as that of the United States, however is still very competitive. With the American car companies having to rethink their strategy, some brands have been bought and sold. In addition to that, Porsche has merged with Volkswagen to become the third largest producer of cars. With this, Porsche has become the largest producer of automobiles in Europe with PSA Peugeot Citroën producing the second most in the continent. The real surprise, however, is that by country, China has become a world leader (second to Japan) despite having the international presence that the others at the top of the market do. In this analysis, we will look at the major contenders in the United States, Europe, and Asia and analyze the trends of car sales in each region to get a grasp of the car industry over the years.

The United States', with the adoption of a highway infrastructure, auto industry boomed after the conclusion of World War II when production went from war vehicles to consumer cars. Car sales, as a result, have been a great metric to determine trends in the industry as seen in the graph below (Based on OCIA "Production Statistics")

Figure 2-1 US Car Sales



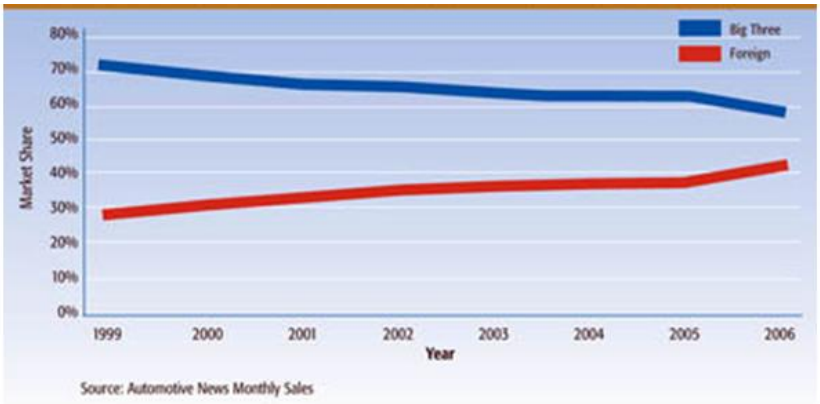
(OCIA,2008)

Analyzing the table, Ford and GM battled for market share by improving manufacturing practices until competition came from overseas. In 1970, 8.4 million cars were sold; 7.1 million of those were American cars. In the 1970's, environmental regulation started to buckle down and the oil embargo meant that new, more fuel efficient cars such as the Honda Civic began to be seen more and more on US roads. In 1980, of the 8.9 million cars sold in the US, 2.3 million were imported. When the 1980's came around, the domestic auto companies in the United States really were losing market share to their Japanese rivals' more fuel efficient and affordable cars. The auto industry peaked at 1985 as sales went over 10.9 million vehicles. The Big 3 were responsible for 8.2 million automobiles. At this time, auto manufacturers started to build vehicles all around the world that led to the mainstream globalization of the car industry. This meant lower costs involved with entering markets.

The Big 3 were trying to regain market share by implementing some of the business practices and philosophy of the Japanese manufactures, but the advent of the internet came a little too quickly for them to hone these practices and the car industry boomed again in the 1990's. The marketing and sales of cars emerged on the web, and as a result, manufactures had the ability to reach further than ever before. The American manufacturers maintained a steady market share in the mid 1990's, but as

the late 90's hit, Americans bought more and more imported automobiles. In 2002, domestic car sales were a scant 5.8 million of the total 8.1 million. That year, imports accounted for 27.5% of vehicles sold. In 2006, the domestic car companies accounted for 70% of sales. However, Japan increased their share to almost 15%. (Bureau of Transportation Statistics, 2009) The trend has continued even more dramatically into 2008 when the financial crisis hit the auto industry hard. The Big 3 had just over 40% market share while the Japanese automakers had almost the same at 38.9% of the market (Wall Street Journal, 2009). The year previous had marked the first time in history the domestic companies had fallen below 50% market share (AutoObserver, 2009). While not necessarily the best of sources, Greg Charleston of Turnaround Management has a nice illustration of the competition in the United States from 1999-2006 that shows the domestic market share slipping and the gap closing.

Figure 2-2 Market Share



(Charleston, 2007)

As figure 2-2 displays, the foreign competition has grown and taken over, the domestic brands need to regain their market share in order to maintain the dominant stance they have enjoyed before now. With a market this large, the United States has proved to be a very unpredictable market that requires even the established manufactures to innovate faster to keep up with the foreign competition.

In the European market, no company has been more dominant in sales globally than Volkswagen. Germany, after all, is where the United States got the idea to use freeways. Well known for the invention of the automobile, as well as the auto industry's oldest company Daimler-Benz, Germany has risen to become the third highest producing country in the world. The interesting thing

about the European continent is how much more competitive the market seems with fairly steady market share trends over time. In 1990, VW held the top market share of 15.7%, with Fiat holding 13.8%, PSA Peugeot Citroen with 12.5%, and GM and Ford with 12% and 11.5% respectively. Interestingly, Japanese manufactures only account for 11.8% of the total market share. By 1995, the trend continues, but with Ford and GM gaining market share. By 2000, VW continued to control the market with 18.7% share with PSA holding 13.1%. Japan accounted for 11.4% share that year, while Ford and GM accounted for 10.8% share each. The landscape was starting to change a little bit come 2005. VW held majority share still, with PSA in second with 13.7% followed closely by Japan holding 13.5%. With the financial crisis in the United States, the brand landscape shuffled, however VW and PSA continue to hold dominant share. Ford, surprisingly after liquidating a few brands, continues to hold 10.5% share (ACEA, 2009). Even after all of those numbers, it is interesting how little the share changes as compared to other markets. This seems to be due to the closeness of Western Europe economically as well as VW, PSA, and Fiat's dominance of their domestic markets. Regulation has also influenced the industry in Europe with some countries putting a quota on imported vehicles (Ballew, 2009).

The United States and Europe are considered mature markets; however Asia has extreme potential as a growing market. With most of the world's population, but with very little of that population owning an automobile, the industry has taken an interesting turn. China and India are relatively newcomers to the auto industry, but have already shown extreme growth. Shanghai Automotive Industrial Company was founded in China in the early 1960's, but many companies have arisen since then. Just behind Japan for top producing countries, China was responsible for 9.3 million vehicles in 2008 (OCIA, 2009). Japan, unlike China, is export oriented with most of their vehicles ending up in other markets. China has just recently branched out into other markets, even introducing three major brands in Europe in 2008 (ACEA, 2009). China has taken a very aggressive stance in catching up to the rest of the auto industry. From 2001 to 2003, auto sales in China went from 2.3 million to 4.4 million, with more than 80 new types of cars being introduced. China reported their auto exports totaled 4.7 billion in 2004, which was a dramatic 34% increase from the previous year (People's Daily, 2009). Even with all this growth, China is still not at the international level of manufacturing nor is the culture in China as dependent on vehicles as the rest of the world.

The dynamic nature of the car industry is interesting to analyze as manufactures have to either overcome giants, or somehow fit into their own niche in order to succeed. With the evolution of technology, the product has changed, but with it also the way they are assembled. With the shift to

computer controlled manufacturing, the process is more economical and allows manufactures to open plants in more places to effectively operate (Gyllenhammar, 2009). In order to succeed in recent years, it seems as though a company must diversify operations internationally in order to dominate the market. Japan has shown the most progression in this practice, and the results have been unprecedented. Extremely export oriented, Japan had to manufacture vehicles outside their country out of necessity in order to keep up with demand across the world. Nowhere has this been more apparent than in the ever changing American car market. Nissan, Honda and Toyota have plants all over the country. Toyota, out of all of the Japanese car companies, has invested in plants in America very heavily with plants in Indiana, Texas, California, and Kentucky. In 2007, Toyota announced plans for a plant in Mississippi to produce its Highlander SUV- a $1.3 billion project (Freeman, 2007). With evolution of manufacturing going global, the landscape of the United States has changed which in turn has changed the economy of the country as the auto industry is a vital part of the overall economy.

Since the emergence of the auto industry, manufacturing for the Big 3 has been primarily based in the Midwest. More and more jobs were created as the industry boomed, but as time passed, the industry was no longer centralized there. In the 1980's, GM and Toyota formed a joint venture to manufacture cars in California (Charleston, 2007). This is only one example of the now blurred lines of what an American car is. About the same time, many other "import" manufacturers began to find their niche in the market. It became too expensive to keep the suppliers in their home countries in a lot of cases, so companies such as Honda, Nissan, Toyota, and BMW have plants in Canada, Mexico, or the United States. This has influenced the union philosophy of the industry as a lot of these plants are in locations in the United States where laws allow the employees to be in or out of the union. In southern states, labor is generally less than that of more unionized southern plants (Charleston, 2007). Union workers themselves are having a harder and harder time being loyal to so-called domestic companies as they are often working for other manufactures' plants either in the US or abroad. This trend has diminished the brand loyalty Americans had for the Big 3 and opened the door for other manufactures, thus leading to the declining market share seen today.

China and India are considered emerging markets despite accounting for a large percentage of the overall world car production. China, second to Japan for auto production, has taken an interesting approach to production regulation. The focus has been to build the domestic auto base, consolidate manufacturers, and increase research and development. The goal of this structuring is to have 2-3 giant manufactures producing over 2 million vehicles annually with another 4-5 manufactures producing over

1 million cars. Under this plan, the market should be 90% controlled by these 6-8 manufactures. To support this, the market has been projected to increase from the 10 million cars sold in 2009 another 10% each year. (Ping, 2009) To facilitate this, the Chinese government has been planning legislation to encourage auto sales. The last part of the Chinese plan is to eventually become a major player in the electric car field.

Throughout this analysis we have seen the trend toward having a few manufacturing dominating in their home regions. While there are a lot of smaller companies producing cars, what are the advantages or disadvantages of having large corporations controlling the majority of the market? In the United States, we have seen the Big 3 try and shape the evolution of the auto industry in a number of ways, notably by introducing, then destroying electric cars in California in the late 1990's (Jamerson, 2003). The notable advantages to larger corporations producing vehicles are that they usually have more capital to use toward research, production, and the service the end user requires. Smaller companies do not have the same benefits and usually are more focused in their product offerings, but arguably are able to be on the bleeding edge of technology as they are not hampered by corporate red tape. While research by larger manufactures has more funding, they may be hesitant to utilize what they develop for the majority of their products because of the costs involved implementing them across their product lines, and in the case of GM, even try and eradicate it completely from the market. One could easily come to the conclusion that this is a slippery slope for the ethics of the auto industry. Are companies trying to drag their feet when it comes to utilizing new technology? The answer seems to be yes, but worldwide competition is to the point that companies are finding it imperative to evolve along with technology to stay afloat.

2.17: Conclusion

The previous sections are meant to outline the process in which our country, the United States, has arrived at its current dependency on oil. Historically, events in out U.S. history has put the U.S. as a nation this oil predicament. Events such as the World Wars have had serious implications in the U.S. becoming an automobile oriented country. This coupled with Since Federal-Aid Highway Act and companies overwhelming rush to create new automotive technologies and prosper from this governmental decision also provides the main reason for our countries dependency on oil.

Now, we are at a point where our entire society revolves around the use of oil and it is apparent that the fluctuation of oil can have serious implications to the U.S. as a whole and on many different levels. As a country, the U.S. cannot have such a dependency on an imported product that has its main supply located in the Mid-East. It is easy to see that this fact has serious implications of the U.S.'s economical stability, and this cannot be tolerated. The U.S. cannot maintain its position of power in comparison to other countries worldwide with this dependency on oil, so something must be done. The U.S. must decrease its dependency on oil and do so in a way which will re-light the manufacturing and sales industries fire which once was the source of U.S. prosperity. One way this can be done is through the rising "hybrid" automotive technologies.

Chapter 3: Methodology

The remainder of this paper will be focused on a comparison between different hybrid technologies and their overall beneficial impact that could bring to the U.S. economy. This will also include a comparison to the current technology; internal combustion engines. On a more analytical level, things such as the difficulties in introducing new technologies into society and different responses, such as resistance to the new technology, will be analyzed. Most seriously, why would the U.S., being a powerful and intelligent country that it is, ignore the warning signs and caution flags that its dependency on oil would obviously bring?

3.1: Secondary Data

The goal of this research was to analyze different facets of hybrid technology and see how different consumer demands have an effect on the technology's acceptance. Simply put, whether or not alternative fuel driven vehicles are better for the environment than internal combustion engine automobiles. We researched the alternative fuel options and compared them against each other and the internal combustion engine.

These hybrid technologies were compared in the following ways. First, the various technologies' city/highway MPG (miles per gallon) showed which technology uses fuel most efficiently and reduced the amount of fuel use and time wasted refueling. Second, horsepower was compared to show a vehicles' engine size, number of cylinders, and engine efficiency which allowed for towing capacity and ride through rough terrain. MSRP, or Manufacturer's Suggested Retail Price, showed the initial cost of an automobile featuring each technology and how affordable it is for a consumer. Additionally, the cost of upkeep and maintenance of a vehicle throughout its average lifespan was explored in order to assess the true cost of vehicle ownership. Next, information about emissions from vehicles was compared to determine which type of automobile impacts the environment the least.

Then by comparing differing technologies' automobile life, we saw which technology lasts the longest on the road, so the consumer will know the car's reliability. Finally, disposal and recycling of the car plays a major role in the effects each technology has on the environment in years following the vehicle's use. Researching these features provided substantial evidence as to which technology is

"best". "Best" meaning which technology releases the least amount of emissions, gets the most MPG and in turn uses least amount of gasoline, is cheapest to buy, contributes to the longest vehicle life, and is most convenient for everyday use. To accomplish this we used the US Department of Energy's website http://www.eere.energy.gov/, www.hybridcars.com, Car and Driver magazine and website, and several other hybrid technology based articles.

Hybridcars.com was the main source for most of our comparisons on the various alternative fuels. It included a, "…library of articles and online tools explores the environmental and political consequences of driving and oil addiction." With this we were able to provide background information about greener auto alternatives, driving for maximum mpg, and the technology and fuels. The Gas Calculator allowed us to "… compare the fuel economy of any new vehicle to a hybrid gas-electric car. Not just the impact on your pocketbook—which is important—but annual gas consumption, and emissions of greenhouse gases and other tailpipe pollutants." The site offered links based on body types, technologies, and makes. The "Body Type" tag offered the pros and cons of each body type and information on various hybrids available in each body type. A list of vehicles of each body type were listed and their features such as MSRP, MPG, hybrid technology used, etc which allowed us to directly compare different models. Through the "Technology" link we collected information on the science and technology of gas-electric hybrids, Stop-Start hybrids, electric vehicles, hydrogen fuel cell, diesel vehicles, E85 Ethanol, and Plug-in Hybrids. An option to compare up to three vehicles allowed for direct comparisons of alternative fuel vehicles and a similar internal combustion vehicle in terms of MPG, MSRP, Estimated Annual Fuel Cost, Estimated Annual Fuel Usage, etc.

The second problem this IQP covered an investigation into what factors made big companies decide to ignore or not realize that the supply of oil would inevitably come to end. This was done by researching the consumer trends of the automotive industry, using sources such as *The Wall Street Journal,* International Organization of Motor Vehicle Manufacturers, *and Bureau of Transportation Statistics.*

The Wall Street Journal was an ideal source for this research section of the project because it provided us with a wide variety of opinions, data, and secondary research already done. For instance, part of our analysis for this project included survey studies to find out the public opinion of hybrid technology. *The Wall Street Journal* has published numerous articles on this topic which provided a foundation for our analysis that we did in our own private survey. Along the same lines, *The Wall Street Journal's* database had information about the marketing trends and auto sales of the American people.

This benefited our project in the same way, that it provided a depth of information in order to make an accurate analysis of hybrid technology.

The International Organization of Motor Vehicle Manufacturers mainly provided us with information about the production statistics of cars being made internationally. The organization is comprised of all of the major automobile manufacturing countries in the world, therefore had the ability to quantify a lot of data on the production and sales of cars. They are committed to linking and representing the worldwide auto industry by providing research and analysis to align their members' vision and policy to further the advancement of the industry. The majority of our research was done in the production statistics portion of the website. This portal provided statistics year by year for production from all of the member countries on topics of environment, road safety, employment, and various other aspects of the worldwide auto industry.

The *Bureau of Transportation Statistics* provided us with more statistics about the retail and trends of car sales in the U.S. The BTS is a government organization run under the Research and Innovative Technologies Administration department within the U.S. Government. As such, the data collected on car sales trends and other facets of the transportation environment in the United States was reliable data for our analysis. The BTS also provided us with usage statistics for drivers in the United States. Most of the relevant statistics and data we utilized were located under the National Transportation Statistics portion of the website. That portal provided data on safety, physical highway system, economic performance, energy, national security, and the rest of the transportation environment. The statistics are vast and are organized by topic. This assessment of the US transportation system is updated on a quarterly basis, and as such was fairly up to date. The website had statistics for every aspect of transportation, but our analysis focused on the passenger car statistics.

We also used information from the Japan Automobile Manufacturers Association (JAMA), which provided us with information about the Japanese Auto industry. This allowed us to compare the cutting edge technology produced in Japan to the rapidly growing interest of hybrids in the U.S. Much like the International Organization of Motor Vehicle Manufacturers, JAMA provided us with a production and sales statistics, but specifically for Japan. Their data provided our analysis with even more clarity on the Japanese auto industry, which was important for our investigation as Japan's production levels led the world. All of these resources aided our analysis of global car trends, ultimately allowed us to see the industry more clearly.

3.2: Interviews

In order to further the analysis of different vehicle technologies, interviews of strategically chosen personnel were done. In doing so, we revealed the consumer demand which big businesses have been responding to. The people chosen to survey had critical meaning to the analysis because surveying or interviewing a technologically aware person, which one may find at WPI, yielded different outcomes than interviewing someone who may not understand as much about the technology. Because of this fact, interviews of multiple backgrounds of people were conducted.

The first interview planned was of Mike Dabrowski, an affiliate of recent WPI graduate Troy Coverstone. Coverstone and Dabrowski are private innovators of hybrid technology who have successfully implemented hybrid systems to different vehicles which consistently get 99 miles per gallon (Mike Insight MIMA, 2007). Mike agreed to conduct a phone interview in February and agreed to provide information about innovations which he has made and the experience he has had in his effort to sell his innovations to the big automotive industries. Due to personal problems, Mike Dabrowski was not able to go through with the phone interview. He was able to supply information by answering the prepared interview questions via email. This information revealed some interior motives which some members of the automotive industry have in mind for their success and the U.S. economy. For instance, Dabronski reasoned that company's like GM resist technology that he is involved with because it moves away from the manufacturing of large SUV's, a market with a large profit ratio which GM had committed.

In addition, we interviewed some owners of hybrid cars to gain further insight into ownership of such vehicles. The first of such interviews was with Tom Jenkins, a 2005 Toyota Prius owner. Tom agreed to do an interview with us in mid January, 2009. Tom has owned his Prius for quite a few years, so his interview provided us with decisions he made before buying a hybrid as well as various aspects of ownership such as maintenance we would not be able to acquire otherwise. Mr. Jenkins also happens to live in California, a state that has been extremely innovative in the push to be more environmentally friendly. Because of this we gained insight into what, if any, effect the government has had on consumers to adopt cleaner transportation. These interviews gave us a good look into the average hybrid user's thinking as well as their satisfaction with their cars over the years they have owned them.

3.3: Focus Group

We conducted two focus groups. The groups included 8 people who had bought hybrid cars, and 8 people who chose not to buy hybrid technology. The purpose of this focus group was to get a first hand consumer analysis of why people decided to purchase the car they chose to buy, whether it is a hybrid or regular car. This information was crucial to our project because it revealed what components go through the consumer's decision making process when purchasing a car. These are things that the auto manufactures respond to and have great influence over what the auto makers build. We were then able to compare our findings to consumer trends we researched and conclude how companies like GM found themselves in financial disaster.

The questions we asked were both brief and thorough because we stuck to the essential points of our research and only deviated when the need arose. We looked at the thinking involved as people made decisions about the systems used to power their automobiles and quantified the attributes they considered prior to their purchase.

The first focus group was done with people who purchased hybrids. The questions went as follows:

1. How much, on average do you drive a year? What is your daily commute like? City/Highway/Off-road?
2. How much do you spend on gas per week/month/year?
3. How much did the car cost? How much was the last car purchased?
4. How long do you keep your car? How did you go about getting rid of it?
    a. Junk, Sold, Trade-In.

This set of question provided insight into how people used their cars and what factors went into how they purchased a particular vehicle based on their lifestyle and automotive needs.

5. What factors go into making a decision to buy a car, hybrid or not?
    a) What was the comfort factor? How did the interior size/comfort factor affect your decision?
    b) How does output performance (acceleration) affect your decision?
    c) How does your lifestyle/geographic location affect your decision?

i. For instance, do you need a truck for towing purposes, 4WD for winter reasons?

Question 5 is more specific. We were trying to find out if there are specific attributes that people look for in their automobile, whether it is looks, performance, or eco-friendliness

6. Was there anything about hybrid's that may have had a critical influence on you decision making?

The goal of question 6 was to find out exactly why someone chose to buy the hybrid over a different car. This was crucial information for our analysis because it revealed certain attributes about consumer trends first hand.

7. How does the economically unstable foundation of the GM Company affect your decision making?

The goal of question 7 was to reveal product loyalty. We wanted to find out if there is a transition away from certain brands to other brands. For instance, if someone had a product loyalty to an American made car, and then decided to buy an imported car. The reasons why they made this decision would reveal flaws in American automotives and what certain import cars offer that others don't.

The next section included individuals who chose not to buy hybrid. These consumers still bought a car, but not a vehicle with some sort of alternative drive train. Therefore the goal of this section of questions was to assess the consumer attitude and the determinant attributes of their needs. This is much like how we phrased questions in the previous section, but at the group that does not own a hybrid vehicle. We wanted to also assess the consumer's driving lifestyle and how that contributes to their buying decision.

1. What factors go into making a decision to buy a car, hybrid or not?
    a) How did the interior size/comfort factor affect your decision?
    b) How does output performance (acceleration) affect your decision?
    c) How does your lifestyle/geographic location affect your decision?
        i. For instance, do you need a truck for towing purposes, 4WD for winter reasons?
2. How much, on average do you drive a year? What is your daily commute like? City/Highway/Off-road.
3. How much do you spend on gas per week/month/year?

These question focus on the actual car the consumer chose to buy. This was then compared to the previous section responses and analyzed to determine the consumer's thought process.

4. How much did the car cost? How much was the last car purchased?
5. What type of car did you buy? If there is a comparable hybrid on the market, did you consider purchasing it?
6. Was there anything about hybrid's that may have had a critical influence on you decision making?
7. How does the reputation of the car company affect your decision?
    a. How does the economically unstable foundation of the GM Company affect your decision making?
    b. Do you prefer American or foreign/imported cars.
8. How long do you keep your car? How did you go about getting rid of it?
    b. What, if any, environmental aspects factored into your plan?
        i. Junk, Sold, Trade-In.

The last questions applied to the analysis of the consumer's thought process when they buy a car. This is important in assessing the consumer's reasoning and factors associated with his or her decision making. The analysis of our results provided us with insight into the factors that go into buying a vehicle from the viewpoint of those who did not buy a car with a hybrid drive train.

3.4: Conclusion

By using secondary sources, interviews and focus groups, this IQP will attempt to determine the advantages and disadvantages both environmentally and economically that consumers face when they consider purchasing a hybrid automobile. The research includes a look at the differences in vehicles that will be important to both consumers and the environment. For consumers, this IQP focuses on overall cost of ownership, gas mileage, and automobile longevity. As environmental concerns continue to arise and oil supplies dwindle, the mileage and emissions from different vehicle types including hybrids and internal combustion engines were compared to determine the choices that consumers face and the options that are available to them when determining the type of vehicle to purchase. The research shows the type of automobile to purchase when considering both financial and environmental factors.

Additionally, this IQP focuses on the sustainability of any new technology. It looks at the predicted lifespan of some of the fuel cell vehicles and the waste products generated when the fuel cells are drained. The overall impact to both people and environment is the greatest concern in our analysis, determined our final conclusion about hybrid technology.

Chapter 4: Data

In this section, we lay out the data we use to solve the problems discussed in chapter three. We will use this data to draw our conclusions about hybrid technologies in chapter 5.

4.1: Gas Electric Hybrid

Hybrid gas-electric automobiles use a gas engine, an electric motor, and rechargeable batteries. The batteries store electricity made from gasoline that is converted into energy and regenerative braking that is converted into electricity. A smaller, more efficient engine is used because the gas engine receives help from the electric motor during acceleration. The battery is able to provide all power to the automobile at low speeds or idle. An onboard computer switches between gas and electric power when necessary. Hybrid gas-electric automobiles can increase energy efficiency by as much as 50 % compared to an average internal combustion engine car. (Hybridcars.com)

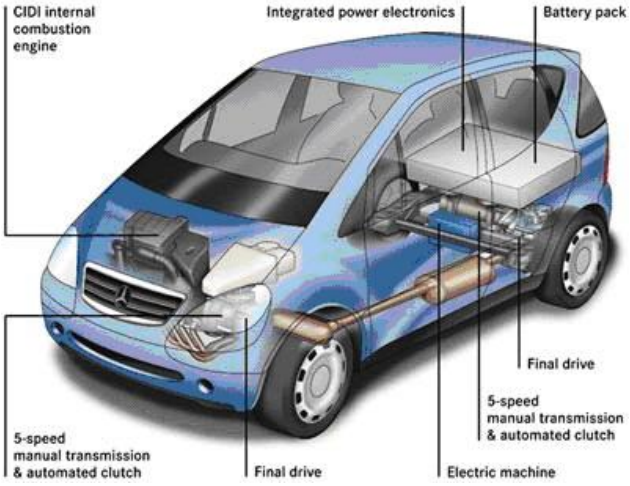


Fig.4.1.1 Gas-Electric Hybrid (Hybridcars.com)

The two motor system has its advantages. The electric motor does not require energy when the car is idling, does not produce exhaust, and uses less energy than gasoline at low speeds, which is near perfect for the stop and go of rush hour traffic. With so many drivers commuting to work in large cities and the millions of automobiles used daily in those cities, the greatest benefit of gas-electric hybrids is the 25-35% decrease in emissions at city speeds compared to the most fuel efficient gas cars. Once the car accelerates to roughly 40 mph, the gas motor takes over and provides the same speed and power of an internal combustion automobile. Another advantage of a gas-electric hybrid is a tax incentive offered in the US. It can reduce the cost up to $3400 depending on the automobile, but this offer only works for the first 60,000 cars sold each year by each carmaker.

The downside to this new technology is the complexity associated with it. Each car comes with the computers and ancillary systems necessary to run the two motor systems, which, in turn, means more initial expense. Money can also be lost on larger repair bills to fix these complicated systems. Hybrids typically get 48-60 mpg, which seems great but is only 20-35% better than a small, fuel efficient gasoline run car. This small mpg difference leads to small differences in annual fuel costs, which alone does not justify the thousands of dollars in average price difference these two motor system vehicles cost unless most driving is done under 40 mph. (Dunn, 2006)

The most popular hybrid on the market is the 2010 Ford Fusion. (Nadaguides.com) Fittingly, the Fusion won North American Car of the Year at the 2010 Detroit auto show. Ford engineers eliminated the "flutter-rumble" that is notorious when the autos switch from gas engine to electric motor. The

Fusion sports a newly developed control logic that allows for better combination of engine operation and power delivery by matching the added power from the electric motor to the engine's varying valve timing, fuel delivery, and spark timing. This advanced teamwork between the Fusion's two power sources delivers a combined 191 horsepower and allows the 2.5 liter engine to shutdown at low speeds. In addition, the regenerative breaking system recaptures up to 94% of breaking energy and stores it in the battery. A new nickel metal hydride battery with 20% more power is actually 30% smaller than previous models. The new battery leaves more space for cargo in the trunk. (Hybridcars.com) The Ford Fusion comes in a sedan and offers 39 MPG for an MSRP of $27,950. (Nadaguides.com)

The most famous line of hybrids, the 2010 Toyota Prius is bigger and more powerful then previous versions. The body is 4 inches longer and an inch wider. A sportier body was unveiled making the automobile taller to charm critics who believed previous models resembled "a corrective appliance on wheels". However, the iconic futuristic shape of the Prius was kept. Its engine increased from 1.5 liters to 1.8 liters providing 134 hp (previously 110hp) and a reduction in 0 to 60 acceleration by a full second. The "beefed up" Prius is the only automobile to offer 50 MPG in combined city/highway driving by keeping its weight down, using superior aerodynamics, and

improving the powertrain design to offer a wider range of electric driving. (Hybridcars.com) The Toyota Prius has an eight-year/100,000-mile warranty on the battery and hybrid systems and a three-year/36,000-mile warranty on the rest of the car. (Dunn, 2006)

Power, Economy, and EV driving modes are offered. Power improves throttle response for better acceleration, Economy reduces throttle response for better gas mileage, and EV allows the car to travel roughly 1 mile at low speeds using only the electric motor. The Prius fits 5 adults comfortably and offers 16 cubic feet of cargo space in the back. The back seats can be folded down for even more cargo room. (Hybridcars.com) This sedan gets a combined 50 MPG and has an MSRP of $22,400. (Nadaguides.com)

The seventh most popular hybrid car, the 2009 Ford Escape SUV offers 29 MPG city and 27 MPG highway. (Nadaguides.com) This most efficient hybrid SUV on the market recently went from a 2.3 liter engine to a 2.5, increasing horsepower from 155 to 177. A redefined braking system provided better traction, more stability, and smoother breaking then prior models. The noise and vibrations associated with the switch from gas engine to all-electric mode was also reduced during the recent redesign. (Hybridcars.com)

It is clear that the Escape is well equipped, but is it worth buying? “Choosing the Escape Hybrid over a gas-only model will likely cost you more money up front than you'll end up saving at the pump, but you can still feel good about using less gas and spewing fewer pollutants…”, says Kelley Blue Book about the Escape Hybrid. However, a tax break of $3,000 and $2,200 for the two wheel and four wheel drive versions is available which might be the incentive needed to purchase this SUV.

4.2: Plug-in Hybrid

An alternate form of the gas-electric hybrid is the plug-in hybrid car. Both use a gasoline powered engine and an electric motor, but the plug-in hybrid features larger battery packs that are recharged by connecting to everyday household electricity at an equivalent cost of less than $1 a gallon.

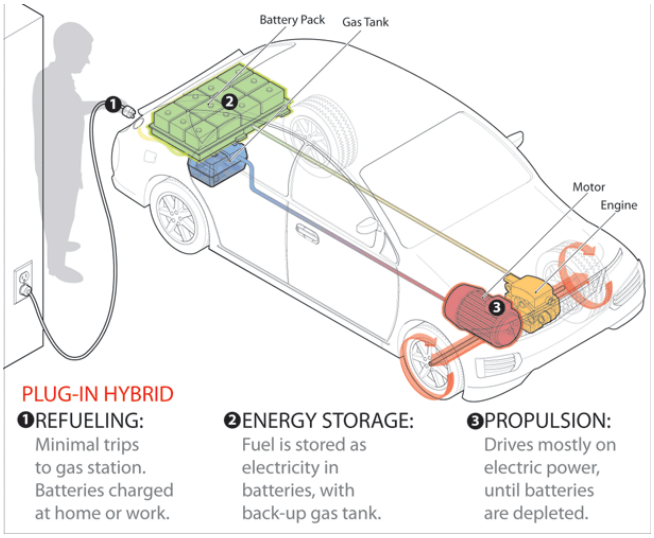


Fig 4.2.1 Plug-in Hybrid (Hybridcars.com)

Plug-in hybrids can be driven much longer than the standard hybrid on electric power alone, up to 40 miles, and are cleaner, cheaper, and quieter to drive. Drivers can use the all electric mode for nearly all of their local travel. When the battery's charge is depleted, a small gas engine is used to recharge the battery during driving or the batteries can be plugged into a power source and recharged. A plug-in hybrid can get double the fuel economy of that of a gas driven car and a standard hybrid car of the same size and capacity. Also, a plug-in hybrid using biofuel can almost run without any use of gasoline. (Hybridcars.com)

The July 2007 EPRI-NRDC (Electric Power Research Institute and the Natural Resource Defense Council) Definitive Study: PHEVs Will Reduce Emissions If Broadly Adopted proves plug-in hybrids are more beneficial for the environment then other fueled vehicles. In addition to plug-ins already being cleaner than gasoline driven vehicles, scientists believe that plug-ins will get cleaner as they get older because the power grid used to recharge them is becoming cleaner. This study shows several scenarios for rates of market penetration of plug-in vehicles and the power grid's characteristics, plug-ins can greatly reduce greenhouse gases for the next 40 years. California, New York, Massachusetts, and other states have had Zero-Emission Vehicle programs since the early 1990s due to the fact that battery electric vehicles in those states run far cleaner than gasoline cars and help reduce urban air pollution and smog. The California Air Resource Board has conducted studies showing that vehicles run on electricity emit at least 67% less greenhouse gases than gasoline driven cars. (calcars.org)

Plug-in hybrid vehicles initially cost more than gas driven cars and standard hybrid vehicles. The cost is about 10-20% more for a compact vehicle, $2,000-$3,000 more for a sedan, and $5,000 more for

a SUV. Incentives, subsidies, and rebates are being considered to bridge the cost gap. However, from a convenience standpoint, plug-ins can: greatly reduce time spent at gas stations, lower maintenance costs, reduce oil imports, and lower pollution. The higher initial cost is mainly due to heavy, expensive batteries. To offset the heavy battery, a smaller gas engine is used and mpg is minimally affected by the added weight anyway. Also, autos with more powerful and cheaper batteries made of nickel metal hydride or lithium ion could be sold by carmakers for only a couple thousand dollars more than standard hybrids. Because recharging is primarily done at night, the electricity used is cheaper during these off-peak hours. With less maintenance fees then those of plug-ins and lower fuel costs, the total lifetime cost of ownership is expected to be less than a gasoline powered car. Because the electric car just recently in production, actual values of savings are not fully known. (Hybridcars.com)

Venture Vehicles in Los Angles, California developed the VentureOne in 2009. It seats two passengers, has three wheels, and gets 100 MPG. The VentureOne combines "the exhilaration of riding a fast motorcycle, the safety and comfort of a commuter car, and the fuel efficiency of advanced automotive technologies". It tops out at about 100 mph and leans to one side when taking turns like a motorcycle. The propulsion system powers the two back wheels that remain on the ground at all times while the front wheel and cabin can tilt up to 45 degrees for the most fuel efficient ride. The automated tilting system uses hydraulic and mechanical technologies to determine the best angle and balance based on the vehicles velocity, acceleration, and road conditions. (Hybridcars.com)

Venture Vehicles states that the VentureOne was designed to surpass the federal safety standards used for traditional vehicles, making it 30 times safer that the average motorcycle. The VentureOne features a driver's airbag, impact protection, restraint systems, and bumpers. It comes in three shades of green and is priced from $18,000 to $23,000 depending on model. The fully electric model has two in-wheel 20 kilowatt electric motors.

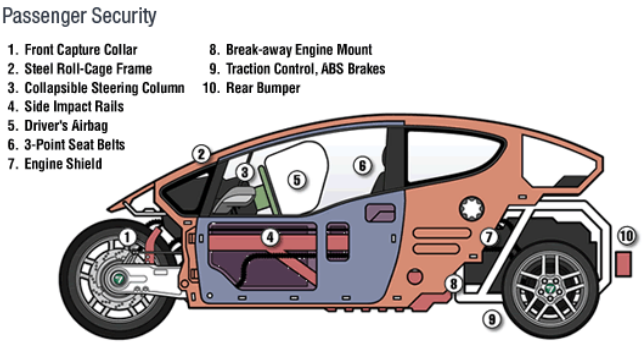


Fig 4.2.2 VentureOne Safety

General Motors displayed final production styling of the Chevrolet Volt in September of 2008. Different than other hybrids, the Volt operates on electricity drawn from a 400 pound lithium battery pack containing 16 kilowatt hours that powers a 150 hp electric motor that powers the front wheels. After a full charge, the Volt will use no gasoline and power itself from the battery pack for its first 40 miles. Once the battery is depleted, a 1.4 liter flex-fuel engine powers a generator that charges the battery for another 300 miles. The Volt will be available in November 2010 at a $40,000 MSRP. A federal consumer tax credit of $7,500 is offered to offset the high price.

The Chevrolet Volt is a "series" hybrid, meaning it is run by only the electric motor and does not switch back and forth from a gas motor to an electric motor. The Volt is equipped with an onboard battery charger compatible with standard 110 volt and 220 volt current. The car can be fully charged in 8 hours with a 110 volt current and only 3 hours using a 220 volt current. Two-thirds of Americans drive under 40 miles a day, so if they recharge their Volt every night they may never use any gasoline. The fundamental set of components, called the "E-flex", powers the Volt. It is based on electrically powering the wheels, but an engine running on gasoline, diesel, biofuels, or a hydrogen fuel cell can add support to the battery and increase the car's range. (Hybridcars.com)

4.3: Electric

The electric car is run only by an electric motor that gets energy from a controller that regulates the amount of power necessary to propel the vehicle to the driver's demands. The driver pushes down on the accelerator, telling the regulator the amount of power to send to the motor. The controller is powered by rechargeable batteries which are recharged by household electricity. No gasoline is used in these vehicles.

Electric cars produce no tailpipe emissions, lower the US dependency on oil, and are overall cheaper to operate. Although the electricity needed to power these vehicles does produce smokestack emissions from the utility plant, this pollution will be just 5-10% of an internal combustion engine's emissions per mile driven even when the electricity source is oil or coal fired plant. Another advantage is

that the small amount of pollution from the power plant will be at a centralized point, reducing smog in large cities. When energy sources such as wind, hydro, and solar are further developed in the future, the production of electricity may not cause any emissions. The mechanical simplicity of the electric car makes it very quiet. There is no need for a transmission in this type of vehicle because electric cars generate maximum torque from 0 rpm. Also, they are three times as energy efficient as a gas driven vehicle because more of the stored energy actually reaches the wheels. These vehicles use regenerative braking, which means the motor can take 20-25% of the energy lost to heat by conventional brakes and use it to recharge the batteries during coasting and braking. The regenerative breaking allows less use of the normal, friction brakes so they last much longer, saving the owner time and money spent on repairs. (Witzenberg, 2008)

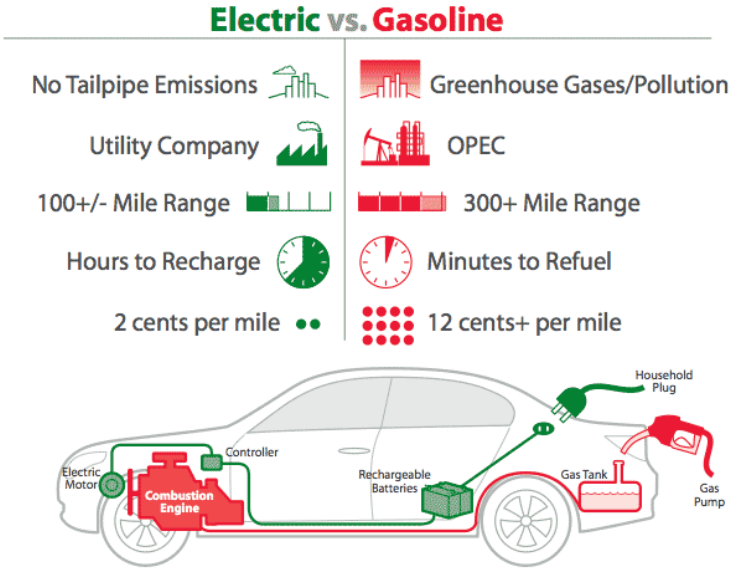


Fig 4.3.1 Electric vs. Gasoline 4.1 (Hybridcars.com)

Electric cars do have their drawbacks, mainly from the energy storage system. Although Lithium Ion chemistry and Nickel Metal Hydride can hold about four and two times the energy per size and weight of lead acid, respectively, batteries large enough to efficiently power an electric car for 100 miles are heavy and expensive. These rechargeable packs can weigh from 800 lbs to 1000 lbs for 30-40 kWh. This is double the Chevrolet Volt's 400 lb, 16 kWh battery pack. The 100 miles of travel they get is roughly one-third the range of the average tank of gas. In addition, the electric car will most likely achieve fewer than 100 miles on a full charge in cold weather, wet weather, and in hilly regions. Drivers would need to plan their travel around the car's range and know the locations of public charging

stations. A car's battery pack takes approximately 14 hours using 110 volt house current to attain a full charge in comparison of minutes to refuel a car with gas. (Witzenberg, 2008) Another disadvantage is the short battery life and replacement cost. However, electric cars are currently being developed and are now hitting the markets.

Set to go on sale in late 2010, the Nissan Leaf was revealed in August of 2009. It is a mid-size, electric hatchback that seats 5 adults and gets 100 miles per full charge. When using a 200 volt outlet, a full charge can be reached in 8 hours. The Leaf uses laminated compact Lithium Ion battery packs that produce an output of more than 90 kW, while its electric motor adds an additional 80 kW. The body is engineered to reduce air resistance. The V-shaped body design with long, slanting LED headlights split and redirect airflow away from the side mirrors, diminishing wind noise drag. An advanced IT system in the Nissan Leaf provides support, information, and entertainment for passengers. A dashboard monitor reveals the battery's remaining power and locations of nearby charging stations. An onboard timer can be set to automatically recharge the battery pack and cell phones can be used to remotely turn on air conditioning and set charging function, even when the car is off. The Nissan Leaf is expected to be priced around $30,000, but this price is not yet official. (Hybridcars.com)

4.4: Diesel

Another form of alternative fuel is diesel. Diesel cars feature an engine that draws air into the cylinder and compresses it. The compression heats the air so much that when fuel is injected it instantly combusts. In a gasoline engine, a mixture of fuel and air enters the cylinder simultaneously. This mixture needs to be ignited by a spark plug. The higher compression ratios and higher temperatures in diesels allow them to operate more efficiently. The higher efficiency and the fact that a gallon of diesel fuel contains 10% more energy results in about 50% better fuel efficiency than gas powered vehicles. (Hybridcars.com)

Diesel has both its advantages and disadvantages when compared to gasoline. Diesel has better fuel efficiency, greater driving range per tank of fuel, larger torque for rapid acceleration and towing,

longer engine life, and diesels are capable of using biofuel. In addition, diesel engines have a higher resale value than gasoline engines. On the other hand, diesel engines are harder to come by, fewer diesel pumps exist, diesel fuel is 20% more expensive then gasoline, diesel vehicles are also generally initially more expensive, and diesel emits more particulate matter and NO.

Biodiesel can be used in most diesel engines without modification. Biodiesel is made from natural oils and fats rather than petroleum. It can be made from many materials including used cooking oil from restaurants. Biodiesel can even be produced at home. Most people who make their own biodiesel use the leftover cooking oils and oils from nearby restaurants. Since restaurants have to pay to dispose of their excess oil, most places will give it away for free. However, additional chemicals, equipment, time, and effort are required to produce biodiesel at home. A great feature of biodiesel is that it is renewable. To get more, simply grow more of the crop needed to produce it. Since the crop needed can be domestically produced, the United States' oil dependency could be greatly reduced with an increase of vehicles using biodiesel. (Hybridcars.com)

The Volkswagen Jetta TDI is available in all 50 states and is right behind the Toyota Prius and Honda Civic Hybrid at the top of fuel efficiency list of cars. This diesel Jetta gets 30 mpg city and 41 mpg highway, an enormous difference compared to the gasoline powered Jetta that gets 21 mpg city and 29 mpg highway. The Jetta TDI has a four cylinder turbocharged, direct injection system producing 140 horsepower and 235 pound feet of torque. In addition, it uses a NO storage catalyst that holds emissions in a reservoir until they can be burned off by the engine and a higher injection pressure due to the piezoelectric fuel injectors that nearly stops emissions and filters the particulate matter. The MSRP of the Jetta TDI is just under $22,000 but does come with a $1,300 federal income tax credit. (Hybridcars.com)

4.5: E85 Ethanol

Ethanol is a renewable source of energy made of ethyl alcohol. The alcohol is made by fermenting things such as starch, sugar, or cellulose and is most commonly made from corn, sugar cane, wheat, grains, cheese whey, and waste from breweries. Similar to gasoline, it contains hydrogen and carbon, but the oxygen in it allows for a more complete combustion process, making for a cleaner burn. The automobiles that run on E85 Ethanol are known as Flexible Fuel Vehicles. They can run on gasoline or E85 ethanol by the use of a microprocessor to distinguish what fuel is in use and adjusts the engine. The driver is not required to do anything to make the switch. FFV's are mainly used in countries that produce large amounts of crops that can be used for ethanol. The large production of sugar cane in Brazil allows over 4 million vehicles to be powered by ethanol. The US has roughly 3 million vehicles running on ethanol. However, fueling stations are almost exclusively found in the Midwest, making E85 ethanol unpopular. (Extraordinaryroadtrip.org)

The advantages of E85 Ethanol are that it's a renewable energy resource and it can be made in the US, improving energy security and reducing the need for foreign oil. It is a high octane fuel, allowing a vehicle to run smoother while giving the same power, acceleration, and cruising speed at gasoline. FFV's can also run on gasoline if the situation arises.

The disadvantages of Ethanol include its corrosive characteristic. Fuel tanks and fuel pumps and hoses must be made of non-corroding materials such as stainless steel. Additional care is necessary to keep tanks and hoses free of sediment that would cause problems in the car. Also, the lower energy content means lower fuel economy and driving range for the vehicle. Finally, there are only about 150 refueling stations in the US, and nearly all are located in the Midwest. (Extraordinaryroadtrip.org)

One such FFV is the Chevrolet Impala. The impala is ethanol compatible at all trim-levels and

engine types including a larger 3.9 liter V6 engine and the 3.5 liter V6. The Impala is known for its powerful, efficient engines and this stays true for E85 Ethanol fuel. Unlike some hybrid vehicles, the Impala did not change its body for the "hybrid look". It continues to fit six passengers and boasts solid crash test scores. The Chevrolet Impala sedan gets 14 mpg city and 22 mpg highway. Its base MSRP is $22,400.

4.6: Costs

Appendix A shows the cost of gas at various gas prices and miles driven for the alternative fuel technologies. An example vehicle for each type of technology was chosen to depict an approximate cost of gas. The gasoline powered Jetta, a small fuel efficient car, gets 25 MPG and would spend roughly $100 per month (1,000 mi) with a gas price of $2.50 per gallon. Comparatively, the Toyota Prius, a gas-electric hybrid, gets 50 MPG and spends only $50 a month under the same conditions. After only 1 month of driving, the hybrid driver saved $50. After a year of driving at $2.50 per gallon, the Jetta paid $1,200 while the Prius paid $600, half the amount for a total of $600 saved. With the additional $2,000-$3,000 cost of a hybrid, the car will pay back this amount in savings in 5 years. Likewise, after 10 years (120,000 mi), a little less than the average life of a car, the Jetta paid a total of $12,000 and the Prius paid $6,000. As a result, the Prius owner saved $6,000 in gas for buying a Prius rather than a gas powered Jetta.

Diesel fuel does get more MPG than an internal combustion engine, but diesel fuel does cost more than gasoline. When comparing the Volkswagon Jetta TDI (diesel) to the Jetta (gasoline), we must compare the $2.50 price of gasoline and the $3.00 price of diesel. After one month, the Jetta TDI spends $83 while the Jetta spends $100, so roughly $17 in savings. After, one year the Jetta TDI will save the owner $200 and after 10 years the savings will grow to $2,000. This is a substantial savings, but less than that of the $3,000 saved by the Prius, after subtracting the additional cost of the hybrid.

The Chevrolet Impala runs on E85 Ethanol and gets only 19 MPG. E85 Ethanol costs, on average, 20 cents more than gasoline. Between the less MPG, the higher cost of fuel, and the scarcity of fueling stations, E85 Ethanol is not cost effective. However, E85 Ethanol does have its environmental advantages.

The two alternative fuel vehicles that are still concepts are the Chevrolet Volt, 230 MPG (unofficially) and the Nissan Leaf, 367 MPG (unofficially). If these MPG's stay true when the vehicles are made available to the public, they will blow away any other vehicle's gas cost. The Chevrolet Volt will spend $11 per month, $130 per year, and $1,300 after ten years, saving the owner $1,070 per year and $10,700 after 10 years in gas. At a base MSRP of $40,000 and a tax incentive of $7,500, the Volt will save you in gas money its additional cost in 15 years, a little more than the average life of a car. If the owner drives more than the average person or if gas prices rise, the payback time will decrease. The Nissan

Leaf will spend only $7 per month in gas, $82 per year in gas, and $817 after 10 years in gas. The Nissan Leaf will save its owner $11,200 after 10 years. At an estimated$30,000 base MSRP, the Leaf has a payback time of 15 years, but with incentives this time will be less.

4.7: Manual Integrated Motor Assistance

One of the claims to fame which have set hybrid cars apart from more traditional cars is the fuel efficiency that hybrid cars achieve. It may be assumed that the more fuel efficient a car could get, the more success it may have. That is not necessarily the case. Investigating the different hybrid technologies revealed several different innovations that are on the market now which have had limited success, regardless of how effective they are with fuel efficiency. One technology is the Manual Integrated Motor assistance (MMIA) developed by Mike Dabrowski, a North Grosvenordale, Connecticut native and affiliate of Troy Coverstone, a WPI alumni.

What sets the MMIA apart from other hybrid technologies out there, like the Toyota Prius, is the overall manual control which the MMIA provides. For instance, the Toyota Prius is controlled by its synergy drive that requires “electric priority,” meaning that the electric motor is used for acceleration and the gas is used for maintaining speed. The assistance acceleration occurs when the electric motor helps push the car, occurring only to create a “regeneration” stage. This regeneration stage allows the combustion engine to basically turn into a generator and charge the HV batteries. This is a highly inefficient system because the regeneration process robs the energy from the drive chain causing the car to slow down as if applying the brakes. This entire process is controlled completely by computers attached to the motors.

The MMIA system lets the driver have control over how much and how often the assistance and regeneration takes place during the drive. This removes the control from an automatic computer control system and allows the driver to determine when to activate the assistance. This is an advantage because it allows the driver to take advantage of geographical terrain which the computer is oblivious to. For example, a driver with the MMIA system may chose to engage the regeneration phase knowing that he/she is coming to a stop. This will in turn decelerate the car and charge the battery at the same time. The computer controlled system only engages when the battery has become critically low and needs to

recharge, or the demand for a high acceleration is needed which obviously is not the most efficient form of crossing these two technologies.

The MMIA also allows access to three added levels of control of electric assistance and recharging availability which greatly enhances the automobiles efficiency and fuel economy. The MMIA system also increases the amount of electronic assist and regeneration available for faster acceleration and more efficient battery management. The first level provides you with basic control of the system, the second allows complete control, and the third allows programmable patterns based on the users driving characteristics. This allows the MMIA system to adapt to many different types of drivers.

Mike Dabrowski's most successful implementation of the MMIA system was on a Honda Insight which he finalized in 2005. Dabrowski's Honda Insight takes the MMIA system a few steps farther and implements a V-Boost battery booster and controller and a highly effective drop down E-Wheel. The V-Boost was designed because of the limited MPG boost that can be achieved by the limited amount of stored electricity a stock hybrid can hold, and also requires a battery recharge from motor power which was discussed earlier. The V-boost and the booster battery pack are charged up with solar energy, or by plugging in to 120volt AC., thereby robbing the drive chain of zero energy. The drop down electrically driven E-wheel, as displayed in figure 1 and 2 below, is the most significant advancement on the Insight automobile. This fifth wheel allows the driver to flip a switch, drop an electrically powered E-wheel and drive for 30 or more miles with pure electric drive. Dabrowski's Insight now gets an average of 75MPG.

It is obvious that 75 MPG is a serious improvement from the Toyota Prius average fuel economy of 42 MPG, but advancements such as have yet to become popular. It seems the fate of this technology has a similar destination as the EV 1.

4.8: Market Trends in the United States

An important part of our analysis of the future of transportation is to look at where the consumer is going to spend his or her money. The United States is, as mentioned earlier, a mature market responsible for a large number of car sales worldwide. As such, it is important to get an idea of what consumers focus on when they are buying a car in order to forecast where companies should, and probably will, be putting their time and energy to increase their market share in the future. To accomplish this, we gathered market data to see where the market was headed.

It is important to understand what kinds of cars consumers are buying, and then move on to the companies dominating those specific segments of the market. The market is divided into trucks and cars, with cars selling slightly more (53% cars vs. 47% trucks). The breakdown of the average car sales from 1997-2007 are represented below, along with the average MPG of each of those segments. Small cars have dominated the car market during this time, with midsize and large cars taking more of the market share recently. There was a temporary surge during this time in the sales of large SUV's, but as of 2010, the cross-overs and midsize SUV's have begun to claim more of the market share in the truck field. An interesting development in this analysis is the quantity of trucks on the road, despite their much lower average MPG. Cars still dominate the market, which account for the highest average MPG, but with almost half of the cars on the road achieving much less efficiency, there is room for improvement, especially if the United States is going to curb its petroleum usage. The average MPG has increased almost every year, mostly due to technological innovation, across the board.

Chart 4-1

Total Car Market (1997-2007 Averages)		
Cars	53.00%	
Trucks	47.00%	
Car Segment	**Market Share (Within Segment)**	**Avg MPG**
Small Cars	44.80%	30.7
Midsize Cars	33.20%	28.2
Large Cars	15.70%	23.3
Truck Segment		
Midsize SUV	26.70%	22
Large Pickup	24.00%	19
Large SUV	18.20%	18.7
Midsize Van	16.20%	23.8
	Data from BTS.gov	

To further the analysis, we must look at the distribution of these specific segments across different companies. As stated earlier, Japan has emerged as the world leader in car production by total volume. The country has been extremely successful in introducing its vehicles into the United States market during the 1970's by taking advantage of the small car market. The United States car market was, and continues to be dominated by General Motors and Ford. Before the influx of Japanese imports, GM, Ford and Chrysler has substantial market share. This has since been whittled down, and as of today, Toyota has become one of the bestselling car companies in the country. The breakdown, however, of the types of cars sold by these companies in the United States is important to analyze and understand the car market and brand loyalty.

The overall leader in market share is General Motors, but not by as much as one would assume. As of February 2010, General Motors held 18.1% of the total car market. Ford is second with 17.6% of the car market, with Toyota behind them with 12.8%. Chrysler has fallen behind the aforementioned three companies with 10.8% of the market share. These facts themselves are not surprising, but the breakdown of what cars these manufacturers produce and sell is. As said in the previous section, the majority of the cars sold in the US are small cars. General Motors, the majority market share holder, sells mostly trucks. Of the 18.1% of their market share, only 7.6% of that consists of cars. The remaining 10.5% is comprised of light duty trucks. This trend also holds true for Ford. Of their 17.6% market share, only 6.8% are cars. Chrysler also falls into this same pattern with their market share consisting of 7.5% trucks and 3.3% cars. Toyota, however, has a more even distribution across their models as far as market share. Their market share consists of 7.6% cars and 5.2% trucks. Honda follows this same trend

with 5.9% cars and 4.4% trucks to account for their 10.3% market share. (WSJ) As shown in the previous section, consumers have been shifting to smaller cars, which consists of a majority of cars sold.

While Ford and General Motors have been on top of the market for a very long time, they have been relying on large vehicles for a majority of their success. Toyota and other Japanese car companies have developed their niche in the market by producing affordable and reliable small cars. Clearly this has been successful, as Toyota especially has seen great success over the last few decades in the United States automobile market. The Big 3 have been utilizing their large vehicles to continue to stay on top of the market, but with consumer buying trends headed toward smaller, more fuel efficient cars, these companies need to be leaning toward that market in order to remain successful. With more and more small cars being sold, these companies will continue to lose market share to progressive companies who have been promoting efficiency. Toyota and Honda have recognized this consumer focus and continue making strides toward producing automobiles that are efficient and reliable, which will continue to garner them success in the marketplace. Adapting to the current and future market trends will lead to success, especially in such a large market as the United States.

4.8.1: Interview at Mill Street Motors

To continue our analysis of the car industry, we went to a local used car dealership to gain insight into this particular facet of the car industry. The used car industry is important to our study of alternative fuels because it gives more of an idea of cars people are buying who maybe cannot afford or do not want to buy a new car. Being in Worcester, Mill Street Motors was a good example of a dealership that caters to people who live in a lower socioeconomic area. We went to interview Ed Proko, owner of Mill Street Motors, to find out more about his company and the consumer trends.

When we asked about the trends of the last few years, Ed explained that gas prices have shown a distinct impact in what cars people are buying. He started by telling us about how SUVs and trucks have always been popular among his customers. During the gas price spike two to three years ago, when gas was over $4 a gallon, there was a shift. He said the “scare” prompted a lot of people to sell back their big SUVs and trucks for very cheap and buy small vehicles instead. Many of these people lost substantial amounts of money on their vehicles as a result, usually over $10,000. This kind of response was due to people being driven by what is happening in the short term. During this time, hybrids and other high mileage vehicles were at a premium everywhere. This trend then shifted back when gas

prices stabilized about a summer and a half ago. People started buying big SUVs and trucks again and no one wanted hybrids or other small cars. He explained that the younger generations are the only people who have continued to buy more fuel efficient cars, speculating that they are more in tune with these new hybrid technologies and the environment.

One of the things we hoped to find out was the depreciation and profit margins of larger vehicles compared to smaller, fuel efficient ones. Ed shared that his dealership stocks mostly SUV's and trucks, specifically the Suburban and 1 ton pickup trucks, because they are most popular and he has a much higher profit margin with them than other vehicles. Hybrids do not seem to show the same levels of depreciation that other vehicles show, but they are also harder for his company to sell. We were surprised to learn that when he does have a hybrid in stock, it sits on the lot for an extended period of time. As a result, he does not buy any hybrids to keep on his lot and has not sold one in over a year.

We learned that a Toyota Highlander hybrid SUV was on his lot for over a year before it was sold. Mr. Proko contributes this to hybrids requiring a person who is actively seeking out such a vehicle. These customers are usually more read in these vehicles and more educated on environmental issues. Ed explained that this does not usually mean all of these people are making an informed decision. In the case of the Highland hybrid, he said that the price difference for the hybrid system does not mean great gas savings, thus does not make sense for the individual trying to save money over the life of the vehicle. He said that most people who buy such hybrids are looking at them as a status symbol over practicality.

Mr. Proko explained that the used car industry sells vehicles in a cyclical pattern. During the summer, smaller cars are more popular. He speculated that when the weather starts getting nicer, more people would rather drive a sports car or convertible than a SUV or big truck. As such, he stocks his lot with a lot of sportier cars, hoping to properly forecast the demand. He speculated that people are apt to respond to gas prices, and as prices generally go up during the summer months, are more inclined to purchase smaller cars. Ed said that this forecasting is very hard to do during any time of year. Most of the time he will get cars people say they are looking for, but he tries to have a good variety of vehicles on his lot at all times. As of late, he has been selling (therefore stocking) more trucks and SUVs even though the weather is getting nicer. Unfortunately due to the tough financial times, he has been losing money on many of the sports cars and convertibles he thought would sell during the warm months, but have not been. As a result he has been more careful as to what he purchases for his inventory. One of the most interesting things we learned was how he goes about acquiring cars for his company.

We were not planning on getting into this facet of the used car market, but it proved to be particularly interesting. There are various local car auctions selling every kind of manufacturers cars. He shared with us the listing for an auction in Connecticut that had mostly Japanese imports (250 Nissans, 200 Honda, etc) at deeply discounted prices. Ed goes to one at least every month, mostly ever 2 weeks, and bids on a variety of cars. He goes with a list of cars his customers come in asking for as well as his own list of what he thinks people will want in the immediate future. One particularly interesting part of these auctions is the price difference between manufactures. Apparently Toyota held the greatest premium at these auctions until recently, probably due to the safety issues across many of their products. He also told us about the hybrid portion of these auctions. He explained that people have been buying hybrids and reselling them to different markets. He gave examples of hybrids being sold in areas where they are very popular (such as California) as well as hybrids being used at taxis in places like New York City.

This interview provided us with a great look at the average consumer trends from both their perspective and the perspective of a company catering to them. We were able to get an idea of the consumer trends of our local area here in Worcester which may be similar to those throughout the country. It is clear that the popularity of SUVs and trucks is still very high and this trend does not seem to be changing any time soon. We also gathered that hybrids are only popular among a select group of people, especially younger generations. It is important to understand where Mr. Proko stands on alternative fuel cars. His bias is directly related to his company's performance, which seems to be removed from the hybrid market. He is responding to the customer requests he gets in a specific area, so this insight into the industry is definitely not universal. Even so, this interview gave us perspective into the car buying environment here in Worcester.

4.8.2: Interview with Hybrid Owner

It was very important for our analysis to interview an actual owner of a hybrid. Tom Jenkins is a 2005 Toyota Prius owner in Southern California. This interview gave us insight into how an educated buyer went about acquiring a hybrid vehicle and the motivations behind the decision.

From our interview, it is clear Mr. Jenkins was looking for his vehicle to help with his commute, both with gas savings and time spent driving. Tom spends a lot of time driving for his job, as shown by

his 70+ miles of commuting a day. Since getting his Prius, he has put over 117,000 miles on it. This seems like it is excessive, but in California, many people commute this much, if not further. In California, there is a carpool (HOV) lane which is separated from the rest of the traffic on the freeway with double yellow lines and only certain spots to get in and out of it. This means the flow of this lane is less interrupted as compared to the other lanes. To get in this carpool lane, you must either have more than 1 person in a vehicle or drive a fuel efficient vehicle with special stickers on it. Mr. Jenkins was looking to have this luxury, therefore only allowing him to look at hybrids that got very high mileage, upwards of 45mpg to qualify. At the time he bought his car, there was a shortage of both cars that would qualify for the HOV lane, the Honda Civic Hybrid and the Toyota Prius. As a result, Tom had to do research on his own and go buy the picture in order to settle on a vehicle. He came to the decision to buy the Prius based on the body style and his ability to get one at the time.

The motivations behind his decision were purely based on his commute. Without having the ability to test drive or look at the car he was going to buy in depth, Mr. Jenkins went ahead and bought a Prius. This interview gave us another outlook on hybrid cars, especially in a progressive area that gives incentives to own a more efficient vehicle. With the high gas mileage and car pool lane accessibility, there are a lot of reasons why one would go with a hybrid vehicle. Without the worry of problems, such as the weather, people in other areas have taken more of a liking to hybrid vehicles for their advantages. This is in stark contrast to those here on the East Coast who have to take weather into account and maybe do not have the government incentives other areas have to take advantage of more fuel efficient technologies.

4.9: Global Market Trends

There are a variety of factors that companies use to develop their products and market these products to consumers. Companies that are selling newer products will generally market them differently than companies offering a product that consumers are familiar with. Automobile makers generally rely on supply and demand to run their industry. Automobiles have historically been expensive to assemble both in terms of labor and parts so manufacturers rely on market trends and current information in order to remain profitable. Automobile manufacturers produce what consumers ask for. If smaller, more fuel-efficient automobiles are in demand, the auto manufacturers will produce more of this model type. When consumers purchase light trucks including SUVs and mini-vans, more of

this type of vehicle is produced (OICA). Overproduction of a vehicle that is not in demand has serious implications to a company's bottom line while production of what consumers are looking for increase profitability for a company. This segment will explore automobile manufacturer's response to the oil industry and how information from the oil industry and from consumers was, and continues to be, used to make manufacturing decisions.

Oil was generally deemed to be in almost endless supply in the early 1940's. In the late 1930s, vast oil fields were discovered both in the Persian Gulf and in Texas. There had been previous oil field discoveries in other parts of the United States and also in Russia. There was a pervasive belief amongst both people and businesses that the supply of fuel was enormous and readily available. There were no indications at that particular time that the supply would ever be depleted. One reaction to this information was to manufacture items including automobiles without regard to any type of fuel economy. There was a proliferation of gasoline pumping stations built. Gasoline was a relatively inexpensive commodity and people did not generally travel many miles yearly so there was little thought of fuel economy by automobile manufacturers or consumers. According to *Popular Mechanics*, the average gas mileage for automobiles in the early 1940s was about 15-20 miles per gallon. There were no concerns about increasing gas mileage at that time by consumers or producers.

The Peak Oil debate began in the 1950s after M. King Hubbert, a geologist with the Shell Oil Company, developed a method to determine when the current oil fields would begin to produce less oil as they passed their peak production. Oil remained plentiful so neither the general public nor automobile manufacturers responded to predictions that oil supplies would eventually begin to dwindle nor eventually the supply of petroleum to manufacture petroleum based products would not meet the demand. Oil and gasoline were readily available. The demand for automobiles increased and the American buyers generally chose automobiles built in Detroit. Detroit catered to the demands of their clientele and continuously produced larger, more luxurious automobiles. Generally people wanting automobiles that were roomier and more comfortable drove the American market. Detroit responded by producing automatics that were easier for people to drive. They also incorporated power steering, power brakes and air conditioning into numerous models. The 1950s was also when the auto manufacturers began producing a station wagon advertised as a family automobile. Between the early 1950s and the late 1950s, the number of station wagons sold increased from one in twenty automobiles sold in the United States to one in six. Much of the reason for the size and luxury demands was because the American consumer had more disposable income available to spend on an automobile as well as

having a generally longer commute over wide highways (Bruegmann 2008). The price of gasoline was also traditionally lower in the United States than in many European countries. Even as consumers, manufacturers and the world began to realize that oil and its byproducts were not in endless supply, the United States auto manufacturers continued to produce automobiles without regard to the mileage they would achieve. They produced a product that the majority of consumers asked for.

As Detroit continued to manufacture relatively large cars for the American public, at least one import began to gain popularity. According to *Consumers Report*, in 1953 less than one percent of all automobiles sold in the United States were imported. The Volkswagen Beetle was the automobile that changed that record, increasing the purchase of imports to about ten percent of the total by the late 1950s (Consumer Reports 2003). The Beetle was touted as a dependable and trouble free automobile that was both inexpensive to purchase and to maintain. It was fuel efficient, averaging about 32 miles per gallon. The Volkswagen Beetle appealed to a group that the American manufacturers had largely ignored, people who needed an economical automobile. As the Beetle and several other imports began to impact the American market, the Detroit manufacturers took notice and began to produce their own smaller, more economical models. By the late 1950s an economical automobile manufactured in the United States that provided good gas mileage was available for customers. Losing a part of the market to an alternate manufacturer forced the American manufacturers to finally produce their own smaller, more fuel-efficient model. Chevrolet, Ford and Plymouth each developed their own small, economical automobile as a response to the increasing demand amongst consumers for this type of automobile. The American public responded favorably by purchasing these automobiles, which in turn led to the decrease in purchases of imports. By 1962, purchase of imports in the United States fell to about five percent of the market (Klier 2009). Once again consumer demand rather than global issues and concern about gas mileage produced the change by American carmakers.

The European purchase of automobiles closely followed the consumption in the United States through the 1950s and 1960s. Many European people purchased automobiles as their lifestyle and finances allowed. Automobiles are associated with wealth. It takes an initial cash amount to purchase an automobile as well as the resources to maintain one. Most of the European countries have access to a variety of models including those manufactured by the Detroit manufacturers. Until recently, they, like the US consumers, were purchasing vehicles with little regard for fuel consumption. One difference in overall fuel usage is due to the geographic anomalies in many European areas. The cities in Europe are significantly older than American cities; therefore they were designed and built prior to the invention of

the automobile. Many of these cities do not have the facilities necessary to serve automobile drivers. The parking areas are extremely limited and roads are narrow and frequently curvy. This is not conducive to driving so public transportation is frequently easier to use (Bruegmann 2008). Even though the population density in European cities has declined and the suburban areas have increased, the amount of driving has remained stable as automobile owners park their cars on the outskirts of cities and use public transportation to get to their jobs. Additionally, the roads in many European locations are older than their US counterparts. Initially built for horses, oxen, and bicycles, they are generally narrow and curvy. This makes owning a large car less desirable and owning a more agile, smaller car more desirable. Additionally, public transportation in Europe, including trains that quickly transport people from country to country, decreases the usage of automobiles. Therefore, even though most European families own at least one automobile, the people tend to use them less, making two to three car trips daily compared to an average four trips in the United States (Schipper 2007). Overall the cars purchased by Europeans, especially prior to oil shortages and higher gasoline prices, were somewhat smaller than those purchased by people in the United States.

Although information clearly disputed the theory that oil was limitless, many consumers didn't respond to this knowledge until the1972 Oil Embargo limited the quantity and increased the cost of gasoline. Once the OPEC nations reduced oil output and caused the cost of a barrel of oil to quadruple, drastically increasing the cost of gasoline to consumers, the demand for smaller, more fuel efficient automobiles increased (Carr-Ruffino, Acheson 2007). This demand stabilized as prices and supply rebounded. Later, after the second oil embargo in the late 1970's, the demand for smaller cars increased again. Consumers were purchasing more economical automobiles. The automobiles available that met the criteria established by the consumers were often imports including the Volkswagen Beetle, the Nissan and the Toyota Corolla. The American automakers did not have the experience in manufacturing smaller, more economical automobiles of the Asian and European manufacturers. Also, the method of manufacture that some of the Asian manufacturers used had the added advantage of being able to adapt quickly to consumer demand (Schipper 2007). This demand once again led to the automakers reaction. When people wanted smaller, more economical automobiles, the automakers responded. The Asian and European manufacturers were able to react more rapidly and manufacture smaller, more gas efficient vehicles to please consumers. The sales of imported autos increased while the sale of larger, family sized auto decreased. By the end of the decade, almost 60% of automobiles sold were smaller, more efficient vehicles. Once the cost of fuel increased, consumers reacted and

increased purchases of automobiles that would go further on a gallon of gasoline. Once again the availability and sales of automobiles was based on consumer choice.

Following this latest increase in the purchase of fuel-efficient automobiles, fuel prices stabilized and consumers again reacted with their vehicle choices. The automakers were asked to provide vehicles that would transport a family. The minivan was developed and sold, primarily in the United States. Consumers asked for vehicles able to deliver larger numbers of people plus cargo and fuel efficiency was once again a minor consideration to many consumers. This was also the beginning of an increase in sales of lightweight trucks, including sport utility vehicles (SUV). Sales of these larger vehicles increased from just over two million in the early 1980s to almost nine and a half million by the middle of the 2000s (Klier 2009). Station wagons, the prior choice of families with numerous people and goods to carry, were practically nonexistent, having been replaced with the newer light trucks. The previous change to more fuel-efficient production was reversed as oil and gas prices decreased and consumers changed their buying habits. Then, with the recent 100 percent increase in the price of gasoline prices, the demand for lightweight trucks and larger vehicles again decreased (Austin 2008).

As American manufacturers focused on larger, more luxurious vehicles, European and Asian producers continued to impact the market. By the end of the 1980s, numerous people were purchasing smaller automobiles. The European and Asian manufacturers were already making smaller, more efficient cars, and could produce a specific type of car on short notice where it took the American car companies months or even years to change production types. Toyota made inroads into the market in the United States, selling about seventy percent of the imported automobiles. Total imports for the first time exceeded 25% of totals. The United States government put some restrictions on imports. The automobile manufacturers reacted to quotas and restrictions by moving manufacturing plants to the United States. European and Asian manufactured automobiles continued to sell well in both Europe and Asia (Schipper 2007). Sales of the larger, family sized American-made automobiles began to decrease.

As the Asian economy grew and developed, the number of automobiles sold in Asian countries, especially China, began to increase (Jimin 2006). Beginning in the 1980s, following China opening its door to imports, sheer numbers of automobiles purchased in China grew rapidly. In 1980 there were less than 2 million vehicles in the country and just fifteen years later, there were almost 12 million vehicles. Some predictions are that by 2020, there will be about fifty million automobiles in China (Campanella 2005). Many of the people in Asia who are buying automobiles have not had the experiences with cars that have occurred in Europe and the United States. They also have begun

purchasing automobiles during an era where oil has traditionally been somewhat scarce. Some people perceive owning an automobile as an indicator of their success, so some consumers will purchase the most opulent automobile available. Others will purchase a model based on the mileage and economy of the vehicle. Volkswagen, General Motors (GM), Toyota, and Nissan are often the models purchased with about eighty percent of automobiles sold in China being one of these brands. China is the fastest growing automobile market in the world. It is now second only to the United States in oil consumption with about 90% of the gasoline in China being used by vehicles (Jimin 2006). Between the late 1990s and 2002, the total gasoline consumption just for vehicles increased by over 90%. The consumers do not have the experience and history of consumers in other sections of the world. Demand is still large and is matched by a variety of supply. This supply and demand continues to be based on a variety of factors and automobiles produced and purchased have not become as stable as it is in other locations.

Currently the world is in the midst of a global decline in the availability of oil. This decline has caused an increase in the cost of gasoline worldwide with a greater percentage increase in the United States and a lesser increase in many European and Asian countries. Because oil is a finite resource, production will eventually decrease. There is considerable debate about when that will happen. When production from new oil wells worldwide cannot offset the lack of production from old wells worldwide, then oil production has peaked. This production decline has occurred in several areas already. The idea of an overall decline in oil availability has been debated for a number of years but only recently brought to the attention of the public. The recent increase in oil prices has brought the idea of oil scarcity to the attention of many consumers. This increase in prices may cause a short-term increase in oil production but eventually production will not be able to keep up with demand. The options are to decrease demand for oil or to decrease consumption of oil. That can occur in a variety of ways including increasing the mileage of automobiles or developing new technology (Carr-Ruffino, Acheson 2007). Many automobile manufacturers have traditionally produced what consumers were purchasing. They have followed the business theory of supply and demand and focused on the bottom line. This practice has served them well in the past, it remains to be seen how things will change in the future as oil becomes scarcer and more cost prohibitive.

4.10: Focus Groups

Two focus groups were assembled to identify the factors affecting hybrid vs. internal combustion engine vehicle purchase. The groups included hybrid buyers and non-hybrid buyers. The

hybrid focus group consisted of 6 Worcester Polytechnic Employees with a wide range of technological knowledge. Through a 50 minute discussion, the group gave their insight into the buying process and what factors they considered. Each participant filled out a survey consisting of background information such as name, newly purchased vehicle, date of purchase, previous vehicle, typical life of their cars, and method of disposal. They were compensated for their time and effort by receiving a $25 gift card.

4.10.1: Hybrid Focus Group

The hybrid buyers had several reasons for purchasing a hybrid vehicle rather than a gas powered vehicle. The first reason is the advancement in technology. Participant #1 had been a committed Toyota Prius driver since it was introduced to the United States around 10 years ago. The first Prius he bought was a 2001 in the year 2000 and the second was a 2004 in 2003. The fact that Participant #1 had made the decision to purchase a hybrid so early in its development and introduction to the market held great value to our analysis of why people buy hybrid automobiles. Simply put, when the participant was asked why he made the decision to seemingly take a risk with a new developing technology, his reasoning relied on the engineering that the car already encompassed. After visiting Toyota as an invited guest to test drive a new Prius before they were introduced, Participant #1 left the visit saying to his wife, “My Gosh that thing was beautiful, from an engineering standpoint…we are getting one as soon as they are available and if they are at a reasonable price.”

Participant #1, as a consumer, relied on his advanced technological background and was sold on the idea that this car was superior to other technologies on the road. . Being the former professor at WPI and co-founder of the electric car and solar car program, Participant #1 had the necessary skills to be able to analyze the Toyota Prius from an engineering standpoint and determine that this car’s design and reliability was worth the extra price. Participant #1 also mentioned that, “the technology was so new that not even the dealers in charge of selling the car could not answer some of the detailed questions I had like; how long the battery would last.” This didn’t stop this participant from buying the car. In conclusion, the sophisticated engineering behind the Prius is what sold this participant and which prompted the purchase of a second Prius as well.

On the other hand, Participant #2 does not have much engineering background, so, she explained, “…did a significant amount of research into the technology as well in weighing the costs and

benefits of purchasing a hybrid in comparison to an internal combustion car." Participant #2 was prompted to do this research after moving to Massachusetts in a location which presented a 20,000 mile per year driving situation. Participant #2 saw this amount of driving as a way to save money on gas, and went into comparing different fuel efficient technologies such as the Honda insight and the Ford escape. Like Participant #1, Participant #2 felt that the engineering of the Prius in comparison to other hybrids and other highly fuel efficient IC's.

Participant #2 admitted that she really didn't know if, from a purely environmental stand point, the Prius was the best car to buy. Participant #2 found advice from ECE graduate students at WPI who supported the fact that the Prius was a good buy, with regards to the battery technology. The students said that although the battery's are made from materials that are at an even more limited supply than petroleum, and that they were not recyclable, that new technology would arise which would fix any battery issue. This decision made by Participant #2 shows that from an engineering standpoint, it is fairly easy for people who may not be as technically literate as Participant #1 to get the necessary information about the technology and make an informed decision.

Another reason hybrid buyers chose to purchase a hybrid was their long commute and the amount of driving they do. Participant #3 has an extensive commute to WPI, accumulating 40,000 miles on her Volkswagen Jetta Diesel in 1 ½ years. For Participant #3, the criteria for buying a new car, whether it was an electric hybrid, regular internal combustion, or other type of hybrid, "came down to sound engineering and highest gas mileage potential." Participant #3's biodiesel Jetta ran at 48mpg on the highway, a number substantially higher than the Prius or any other hybrid available when she purchased the car in 2009. Additionally, Participant #3 took the engineering of the car one step further, "My objective was to, without understanding the tech very well, to make it into a grease car that it, well, because it was so new and well designed that my mechanic who installs grease car conversions refused to put the conversion kit into the new vehicle because it was untested and uncharted terrain." Ultimately, the idea that the Jetta could provide better gas mileage and not have any issues with battery recycling and life span turned participant #3 away from the Prius.

Participant #4, who owns a 2010 Ford Fusion Hybrid, also said that the long weekend trips factored into his choice to buy a hybrid, although he is not completely sure of the economic benefit. Participant #2, who owns a 2007 Toyota Prius, also liked the mileage that the Prius was capable of getting. She said she like the hybrid because she frequently goes on long trips, and other technologies such as a full electric car, does not have the range she needs.

In contrast, Participant #6, who drives a 2004 Toyota Prius, only drives about 8,000 miles a year but still decided to buy a hybrid for its impact on the environment. In fact, all the members of the group felt that the hybrid technologies' positive impact on the environment had a large effect in their decision to buy hybrid. Participant #5 believed that when moving from the west coast, it would be a good idea to use public buses to travel in the city, an assumption that proved to be false. Once participant #5 determined the public transportation was not an option, and that staying a one car family was nearly impossible, participant #5 turned to buying a Prius.

Another reason consumers buy a hybrid is the feeling that they are contributing to a good cause. Participant #5 said about her 2004 Prius, "…symbolically sexy in the academic world." The group felt a sense of pride that they were doing their part in helping the environment and liked the fact that hybrids, such as the Prius, had a distinct look. Although they didn't agree on the Prius as a visually pleasing car, they enjoyed the fact that other people knew they were driving a hybrid. Participant #6 said a hybrid vehicle is a symbol in the academic and technological world. Participant #6 bought a Prius in 2002 while working as teacher at a high class private school in California. Previous to owning the Prius, "school I was driving a broken down SUV and was getting some smerky looks from parents and peers. Then I was able to complete the transaction and purchase the 2002 Prius. I then got different looks, not any less smerky but more towards a lack of understanding about the technology." This input goes to show that from a consumer's standpoint, there is something to be said about the symbolism of owning a hybrid, that it can enhance first impressions and possibly change personal perceptions. This is also a trend that can be characterized with buying other cars, such as an expensive sports car. Participant #6 reasoned that unlike sports cars, hybrids, specifically the Toyota Prius, has "…a brag factor that you want that image of driving a hybrid to attach to you. That it's good for the environment, but you do feel good about driving it and advertising that too."

One of the negatives of a hybrid car is that they usually cost $2,000-$3,000 more than a standard car, but the tax incentives do provide assistance. As a society, we tend to follow the pack in terms of what vehicles we buy. Participant 6 noticed that Americans moved from luxury cars, to SUVs, and are currently moving to hybrids. She believes this shift is caused by changing taxes on automobiles, "You have to look at the tax structures. They had taxed luxury cars so that the people who wanted luxury cars switched to SUVs." With the rebates and tax incentives packaged with the hybrids, it seems that hybrid popularity will continue to increase as long as these incentives continue to help balance the higher price.

None of the members of the hybrid group were turned off by the price discrepancy. Participant #2 was made aware of the money she could save by buying a Prius by several WPI students, and Participant #5 was able to buy a used Prius for under $10,000. What really pushed them toward the hybrid was helping the environment. Even the terrible weather and driving conditions of New England did not stop the members from buying an alternative fuel vehicle. Participant #6 also reasoned that in the decision of buying a Prius, there was a process in recognizing, "…that the earlier models would have certain costs associated with them, but I felt it was important to affiliate myself with a product that had a part of a larger narrative of transformation of the auto industry, toward attempting to deal with these larger issues." This input develops the idea that people that buy fuel efficient electric hybrids are not just doing it for their own financial reasons, but for the public good as well.

Another downside is the lack of power possessed by hybrids compared to an internal combustion engine vehicle. Participant #2 misses the "sports car" feel and the rapid acceleration of a gas engine, "…the power is OK… It's different and I think I drive much more reasonably than I did before. I have changed my driving habits, probably for the safer side, but I still love getting in a friend's car and zipping around in a stick shift every once and a while and its so much fun. "Likewise, Participant #6 said he must be more cautious and aware of his surroundings while driving a Prius, but this doesn't take away from his affection for driving a hybrid, "I like to go downhill with the Prius. The Prius itself taught me how to drive. My driving habits are actually geared to the Prius. Going downhill I put it into engine braking which happens to optimize the amount of energy going back into the battery and I often will go as far as I can with just the electric motor." He went on to say, "I don't think I could drive a regular- I've been driving these too long. I'm tuned into these things." Participant #4 also explained how his Prius has a tough time with hills, but that he knew about the Prius' low power, **"**In terms of the power, I did think about going from four wheel drive to front wheel drive, but it wasn't that big of a part of my decision. But the Prius, the ford fusion- they have as much power as small, midsize or compact cars. It didn't play that much into my decision at all." He said he must plan his travel around his hybrid, but that he doesn't mind doing that.

Because of the small size and weight of most hybrids, buyers are weary to drive them in bad weather. New England winters can be brutal, but the prior knowledge of the Prius' bad weather driving problems did not impact them enough to not buy hybrid. "The Prius is not very good in the snow, at all. I dislike that. Coming from, I lived in upper Wisconsin, and I bought an SUV and I bought it because I needed to be able to get around. It made sense there to have four wheel drive." said Participant #2, but

decided to drive a Prius in Worcester. Participant #5 learned to drive in upstate New York,"… I have probably less fear in driving in snow than I should. I find that you do lose a little bit in the Prius in certain weather conditions." He continued that as long as he takes the weather into consideration when planning a trip, it doesn't affect his plans and he's happy make this adjustment to help the environment. However, Participant #3 chose not to buy a Prius because she deals with a lot of snow and unpaved roads. She found out that her Jetta TDI was not much better under these conditions because of its small size and light frame.

With many different types of alternative fuel technologies already available to the public, and many others still concepts, arguments can be made about which is the best. "It's possible that because- you are saying you get better gas mileage. I mean really when it comes down to it, that's what makes most sense to me, is getting the best gas mileage." said Participant #2. However, other issues play a role. She went on to say that because of her long weekend trips, a fully electric car would not fit her lifestyle, "…probably not going to work for that unless there is high speed plug in stations that they are talking about building. They are not there yet. Maybe someday when they are there, I would consider that, but then I'm relying on the coal infrastructure of our electric system in the United States, so I don't know. There are a lot of decisions to be made."

Most technology is so new that customers are not able to weigh the cost and benefits of each, "The problem with diesel is that, you know, they say that this is a better- these models, this 2009 models, are a better clean burn. And they also say that if you use a biodiesel mix it encapsulates a lot of the particulate matter in a way that you don't get with a regular diesel mix, but I haven't seen the data on it either…" Likewise, Participant #1 is not clear on the advantages of E85 Ethanol because he hears two opposing stories. He first heard, "Everything, you know, I've heard about ethanol vs. fossil fuels, alcohol fuels vs. gasoline. I was negative on those things because I kept hearing that if you turn corn into ethanol and use that somebody is going to lose food or the price of food goes up. And, uh, there were arguments of that, and also that it took more energy, uh, to create ethanol from corn than the energy you finally get from ethanol as a fuel. It didn't seem to make a lot of sense.", but after attending a lecture his opinion changed. The lecture talked about, "…much of the data we have been bombarded with concerning ethanol is incorrect. That these claims are not correct, that in fact ethanol can be made- and he showed data which indicated that, you know, you can increase the amount of food from corn even though you may be using the corn for ethanol. All kinds of things that I thought were true

may not be true. And he was putting on a very strong pitch for us to get off the bandwagon- better than a hybrid could do. Get away from imported oil."

4.10.2: Non-Hybrid Focus Group

Internal combustion engine vehicle buyers had several reasons they chose not to buy a hybrid. The first reason was that most participants believed their commute was not long enough to get the benefits of a hybrid. The average driver puts 12,000 miles per year on their car. In comparison, Participant #1 drives about 10,000 miles per year and spends $50 per week on gas. Participant #2 has only had his car for 2 months but says he doesn't drive to work and drives home only once a week. He only spends $35 per week on gas. Participant #3 drives an estimated 13,000-14,000 miles per year, which is just above national average. He fills his tank once a week and it's about $40-$45. Participant #4 said, "I do a lot of driving but is all city, [my commute] has gone from 5 minutes to one and a half minutes of driving, so I just walk sometimes. But the majority is when I start driving in the summer and that gets me to about 4,000 miles a year." Although driving in the city does use more gas than highway, 4,000 miles per year is well below the national average. He spends $35 every two weeks, much less than the other participants. On the contrary, Participant #5, racked up 35,000 miles in 11 months and spends $40 per week on gas, "…my wife is the primary user and she puts about 20,000 miles just for commuting to work, and bring the kids back and forth to school." He went on to say that most of the commute is highway, but 35,000 miles is nearly 3 times the national yearly average.

Based on the miles driven per year and the weekly cost of gas each participant encounters, we can compare their yearly gas cost to hybrid vehicles. Participant #1, spends an estimated $2,600 per year on gas, $2,100 more than a Toyota Prius would spend in that time at $2.50 per gallon. Participant #2 spends about $1,820 per year on gas. Using $2.50 per gallon as an example price, the Prius would spend only $600 per year, driving 12,000 miles in that year. Driving about 13,500 miles per year at $45 per week, Participant #3 spends $2,340 per year. This is $1,100 more than the 25 MPG, gas driven Jetta and $1,700 more than the 50 MPG Prius spends on gas per year. Participant #4 drives only 4,000 miles per year, but still spends $910 per year. This is great compared to other gas powered cars, but when compared to the Prius' $600 gas cost every 1,200 miles, it does not look so good. Participant #5 drives much more than the national average 12,000 miles per year, 35,000 miles per year to be exact, but manages to spend only $40 per week on gas. His estimate may be wrong, because he is claiming to spend $2,080 per year while driving 35,000 miles. In comparison, the Prius would spend only slightly less

at $1,800 over 35,000 miles. If his gas cost estimate is true, than is car is very fuel efficient. These are just estimates. Actual costs could be more or less than calculated, but from the results it is clear to see that these vehicles spend more on gas than a Toyota Prius would in a year.

From the estimated yearly gas costs of the participants, it seems that a hybrid vehicle would be a better buy. However, several of the participants wanted better performance and power than a hybrid can offer. Participant #1, recently chose to buy a 2003 Audi S8 over a hybrid vehicle because, "…there was only 300 of them made and I wanted to get one but I did actually look at a Honda Accord Hybrid, which surprisingly has similar performance, but they quit making that as well. But there is no hybrid right now that has the performance that these S8's have." Participant #2, Participant #4, and Participant #5 chose not to buy a hybrid because of the hills they climb on a regular basis. Participant #4 said," I bought a 2009 Honda CR-V. I don't think I really looked at hybrids, the only one I think I might have looked was the Honda Accord. The reason I got it honestly was the place I used to live, you needed a donkey to get up there, it was all hills and I actually need four wheel drive." Similarly, Participant #5 bought a 2009 Toyota Highlander,"… I wanted a hybrid. We needed an SUV because of the terrain and hills that we have to commute."

Participant #6 also needed more power than a hybrid could offer. He owns a pop up tent trailer which requires to be towed from place to place. He decided to buy a 2008 Hyundai for this very reason. The lack of towing capabilities in hybrids is a factor that most people overlook. If hybrids can add the power necessary to tow loads, an entirely new market of contractors, construction workers, and people that own boats or trailers, will open up. The added power will also make hybrids more appealing to people that live in hilly areas or enjoy driving fast.

Another reason an internal combustion engine vehicle was chose over a hybrid was the hybrid's additional cost. Every participant commented that the additional price of a hybrid did not encourage them to buy one. Participant #3 chose to buy a 2010 Mazda CX9 for about $29,000, but did look into the Toyota Highlander Hybrid. He said," …it was just priced out for us, but I would have liked to get one but for our needs there weren't a lot of choices. It was just too highly priced and there weren't that many of them available either." Likewise, Participant #5 originally wanted a hybrid, "… I looked at the Highlander Hybrid but it was about $10,000 more and I looked at what it would take to pay that back, the return on the investment, and it wouldn't work, I would get rid of the car before it paid off." He chose to buy the 2009 Toyota Highlander for $27,000 instead. The higher price for a hybrid also pushed Participant #4 away. When purchasing a new car, he figures out his budget and then finds cars that will fit and the hybrids he researched were not in his price range.

Participant #1 believes that the current technology is not the best solution, but the tax incentives sweeten the deal," certainly there are a lot better options than hybrids, hybrids are just a stop gap so I'm not too excited about them unless they happen to perform well and happen to give the tax incentives to make them pay off before you end up throwing it away." Some consumers see how fast hybrid technology is advancing and choose to wait until more fuel efficient, or purely electric, cars hit the markets at a reasonable price. Participant #2 added about current hybrids," …you realize like they never really pay off in the long run so other than the feel good nature of it…" Participant #3 cares about the environment, but simply can't afford to buy a hybrid,"…for me the environment and the effect on it definitely matters and that if they get to something that I'm thinking about, especially with children and their future, but it's not, and maybe it's selfish of me…I have to feed and clothe and educate my children so I think that if technology is looking where to go and wants to appeal to people, it needs to be at a point where it's cost effective in that the average person who's going to use it can afford it…"

Recyclability is an issue and a hassle with hybrid cars because of the materials used in the battery packs. We asked the participants how they get rid of previous cars they owned. Participant #1 sold his previous car which had 210,000 miles on it. He plans to keep his current car for at least 10 years, but will sell it after. Participant #2 traded in his last two cars, but before that, "Previously I had bought a lot of crappy, used cars, so it was probably under three years…, I just drove them until they died completely and then just gave them away for parts." Participant #4 also keeps a car until it dies, "I kind of used to keep them until they went into the ground. Umm, but it is kind of my idea, I basically, I don't look to upgrade my car, unless I absolutely have to because of the terrain. I am not really in it for status or anything. I just need to move."

Participant #5 chose to trade in his last car because of the government incentives available at the time. He said," When we got the Honda, we intended to be able to go quite a ways, and a year ago the amount of miles we had put on the car and the incentives that they were offering for buying a new car basically we could lower our payment and get a new car that was six years newer. It wasn't a clunker, but we did trade it in. And there wasn't anything wrong with it per say, it was getting up in miles. But it was more driven by the state of the economy and trying to help the economy by making a purchase and it worked for us because as long as we could keep our payment the same we were willing to do it and I think it actually saved us a few dollars."

The participants did not buy into the "status symbol" of driving a hybrid. They believe hybrid buyers want other people to acknowledge that they are doing their part to help the planet by buying a hybrid. Participant #4 agrees that a hybrid is a status symbol, "… it became too much of a status symbol

of hey I'm doing my part, I have a hybrid sticker in the back. Great, you get a parking space, and you get a tax reduction, what about me? I can't afford it. Congratulations. And, I come to find out that they can sit outside with their car running, I turn mine off and I'm doing my part so…" As evidence of how important the "hybrid look" is to consumers, Participant #1 said explained,"…one of the reasons why Honda said why they were unsuccessful and dropped the Accord Hybrid was because it didn't look hybrid enough. It looked just exactly like a regular Honda Accord… yet car and driver would say it's the only hybrid they would ever recommend because it did get remarkable gas at 38 miles per gallon on the highway and 30 miles per gallon in town…" The participants also mentioned the distinctive look of the Prius and how that helps it sell.

These focus groups allowed a look into what factors go into the choice between buying an alternative fuel vehicle and an internal combustion engine car. It's apparent that the new technology plays an important role for the obvious reason of helping the environment. Customers choose to buy hybrids because either they know much about the engineering and technology behind them, or they simply believe that their investment serves a greater purpose. In any case, they chose to buy a fuel efficient car to help the environment, knowing the cost benefit may or may not be present immediately depending on their driving habits. They sacrificed some of the power and acceleration one would get with a gas driven car and ended a safer, more cautious driver. With technology constantly increasing, it is safe to say that alternative fuel vehicles are the way of the future. But which technology will lead the way?

Chapter 5: Results and Conclusion

Throughout this process, we have looked at many facets of the car industry and its future, delving into the history of how automobiles became the standard for transportation all the way to customer buying decisions in today's market. Our focus has been on the emergence of alternative fuel technologies, specifically hybrid technology that marries a standard internal combustion with an electric drive train. In the beginning of this analysis, we were more hopeful for the future of transportation with the appearance of hybrids for the mainstream, but our views have changed as we began to unearth some of the unflattering aspects of such technologies. In the end, it seems that hybrids are a good stepping stone to alleviate problems with petroleum usage, but still have many inherent flaws that prohibit successful widespread use.

Historically, the United States has been dependent on the automobile for transportation. Prior to this, the US relied on locomotives as the main form of mass transportation. However, events such as the Street Car Scandal marked the transition away from this as the preferred method of transportation. This concept was solidified during the 1960's when the US spent millions of dollars building the system of roads under the Federal Highway Act. As a result, the United States set up a highway system as a defense mechanism in case of another world war. Subsequently, cars became the preferred means of transportation. This marked the beginning of the large automotive industry in the country. As time went on, the Big 3 consisting of Chrysler, General Motors, and Ford emerged and dominated market share.

The 1973 Oil Embargo created a crisis in the United States that changed the automobile industry. Smaller, more fuel efficient cars became much more popular as the price of gas dramatically increased. In the 1970's, environmental regulation started to buckle down and the oil embargo meant that new, more fuel efficient cars such as the Honda Civic began to be seen more and more on US roads. When the 1980's came around, the domestic auto companies in the United States really were losing market share to their Japanese rivals' more fuel efficient and affordable cars. Since this point, the Big 3 have been behind their Japanese competitors. They neglected to implement new technologies and remained behind their foreign rivals. The Japanese companies progressed faster in implementing new manufacturing techniques, such as being able to switch production of one model to another one on the same line with almost no down time. This is something that would have taken the US companies

months to accomplish in the plants we have. These advancements also included the use of the Internet and now the emergence of hybrid technology. This then begs questions about the companies themselves.

It has been interesting to see the lag manufactures have when introducing new technology in production. One of the issues we found in the auto industry is that auto manufacturers are maybe not as ethically bound as we would have hoped. They are far more preoccupied with the bottom line performance than trying to solve such an important issue as the current fuel situation. As a result, these manufactures are essentially dragging their feet in rolling out new, far more efficient technology. From GM scrapping and eventually selling their electric car program to the Japanese to the recent Toyota quality issue and recall, auto manufactures have not taken proactive steps toward much larger problems such as reducing emissions, reducing oil dependency, and even safety. They have not tried to exceed any of these areas outside of regulations imposed by the government. It seems these companies only respond to consumer demand and government regulations instead of taking a more ethical approach. While there can be no question that manufacturers have not been as proactive as they could have, whether it is was voluntary or if the market caught up with them is debatable.

Consumer demand has always been the driving force behind what vehicles companies design and build. We have seen that here in the United States, larger vehicles have been exceptionally popular. Because gas has been comparatively cheap to other countries, consumers in the US have been more inclined to drive large trucks and SUVs. As a result, the majority have not felt the need to switch to more fuel efficient vehicles. Although the number of small cars has increased over the last 15 years, trucks still account for almost half of the market. From our analysis of the focus groups and interviews we conducted, it is clear that there is not widespread acceptance of hybrid or alternative fuel vehicles as much as needed in order to alleviate oil dependency.

Part of our analysis led us to interview a local used car dealership owner. The interview with Ed Proko of Mill Street Motors gave us insight into the consumer trends here in the Worcester area. The overall trend for the last few years has been directly related to gas prices according to Proko. Most of the demand he sees is for large trucks and SUVs. Mr. Proko has since stocked his inventory with many of these vehicles, which provides him with the largest profit margin. The few hybrids he has sold have sat on the lot for a very long time before being bought, not bringing in the money that SUVs and trucks can. As a result he has stopped stocking hybrids, and even a lot of small cars, to make room for more

trucks and SUVs. Much like auto manufactures, Mr. Proko follows consumer demands and is bias towards company performance, ultimately profits.

We sampled a variety of educated consumers in order to give us a closer look into the car buying process, specifically factors that push consumers toward hybrids or standard internal combustion vehicles. In our focus groups, we sampled a variety of professors here at WPI. The six participants in the hybrid focus group chose to buy a hybrid because of the advancements in technology, gas savings, and the willingness to be "green". These participants were aware of the tradeoff of performance and bad weather handling for economy, but still went ahead and bought hybrid vehicles. The internal combustion group took the opposite view when it came to buying a car. These participants were concerned with the lack of power, higher prices, and bad weather performance that the hybrids show. In most cases these participants showed need for the added performance in their everyday lives. Most considered buying a hybrid, but the additional price for these models made them shy away from purchasing them.

The issue that arose from the focus groups was the additional cost of hybrid vehicles. This is a result of the added electronics and drive train necessary to marry an electronic system to an internal combustion one. Many consumers buy into the fuel savings associated with hybrids, but do not take into consideration the additional cost of this hardware and the implications that result. The battery systems of the hybrid vehicles, for example, cost thousands of dollars and require a lot of energy to manufacture and eventually recycle. The average hybrid consumer is blinded by the potential gas and environmental savings that are marketed to him or her. The additional cost of the hybrid vehicle does not always mean that the consumer will see dramatic return on investment, especially with the larger SUV hybrids. These SUV hybrids can cost upward of $10,000 more, but do not yield impressive gas mileage. In many cases, the gas savings would not equal the additional cost unless the owner drives far above the average. If the savings cannot be seen by the customer in only that window of the vehicle's life cycle, there is no way it can equate to overall savings if the manufacturing and recycling cost are included. The manufacturing and recycling cost is essentially hidden to the consumer, even though they are important aspects of the vehicle lifecycle and affect the environment as well.

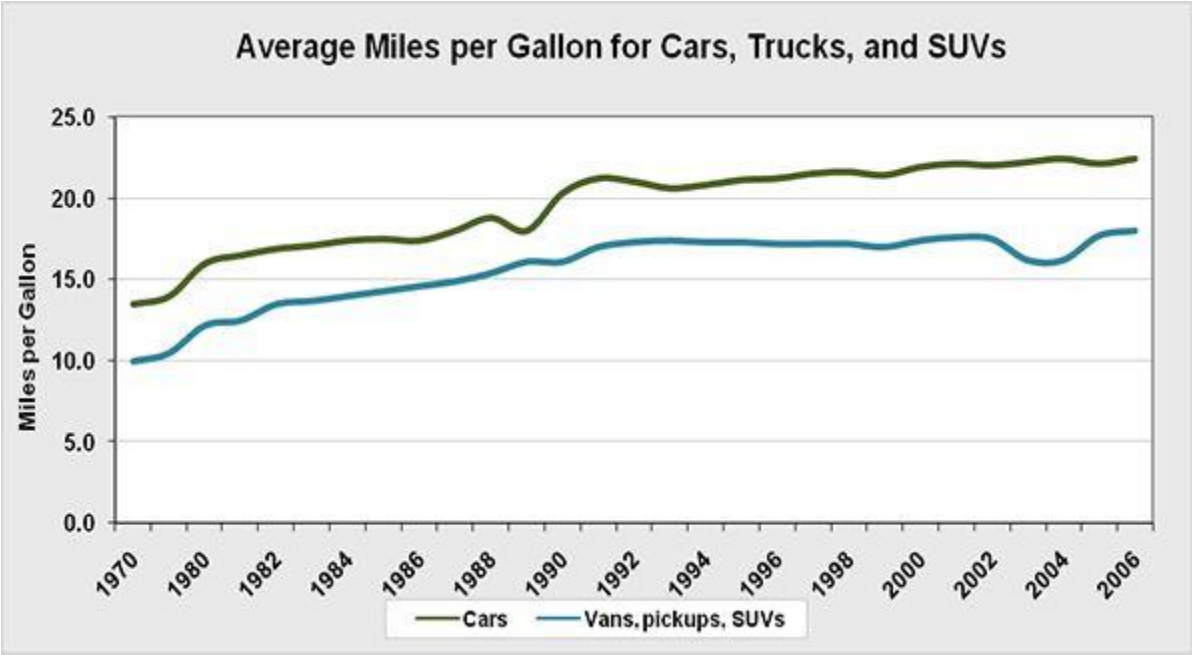
In the end, we feel that current hybrid technology is a good step moving in the right direction to reducing petroleum consumption and environmental harm. It is not the best option available, especially as half the drive train is still based on standard internal combustion technology. In our opinion, this does not adequately alleviate the problems faced by standard internal combustion cars, such as

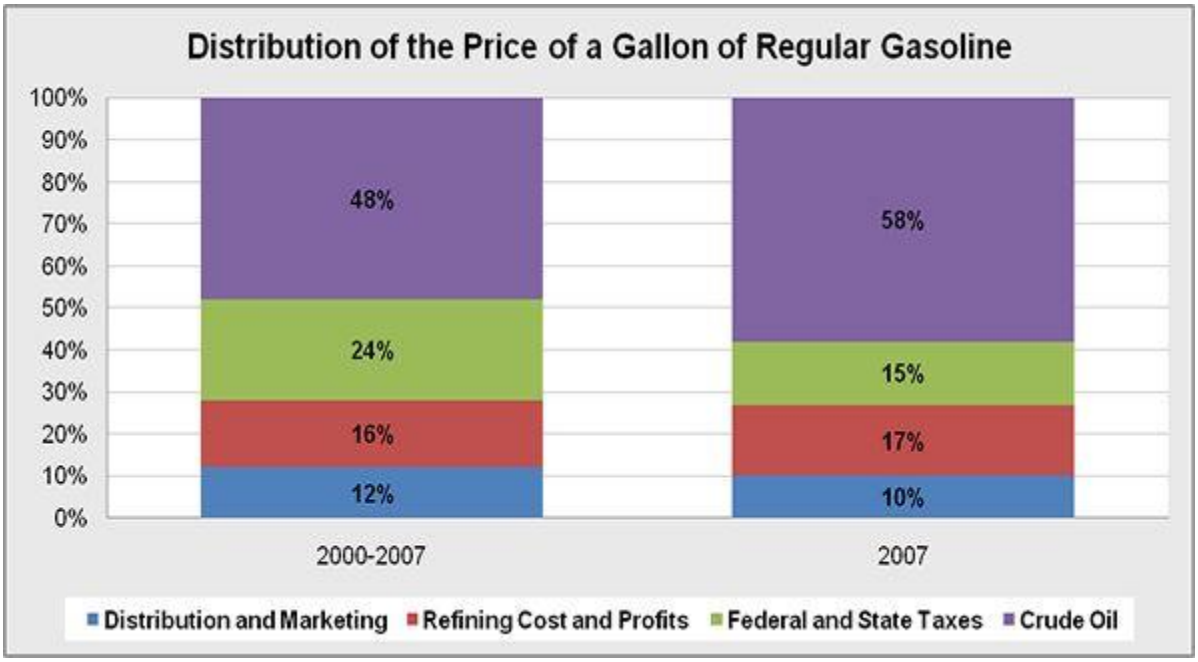
maintenance and pollution, because hybrids are still utilizing such technology. With advancements in plug in and electric vehicle technology, oil dependency could diminish. Technology exists today that allows an all electric car to travel the ranges people need while not emitting any emissions or utilizing petroleum based fuel at all (depending upon the source of electricity). There will be less maintenance required as well as less resources being used with such new vehicles. The technology is becoming better and better, but to make it more widespread auto manufacturers need to be pushed and consumers need to be enticed.

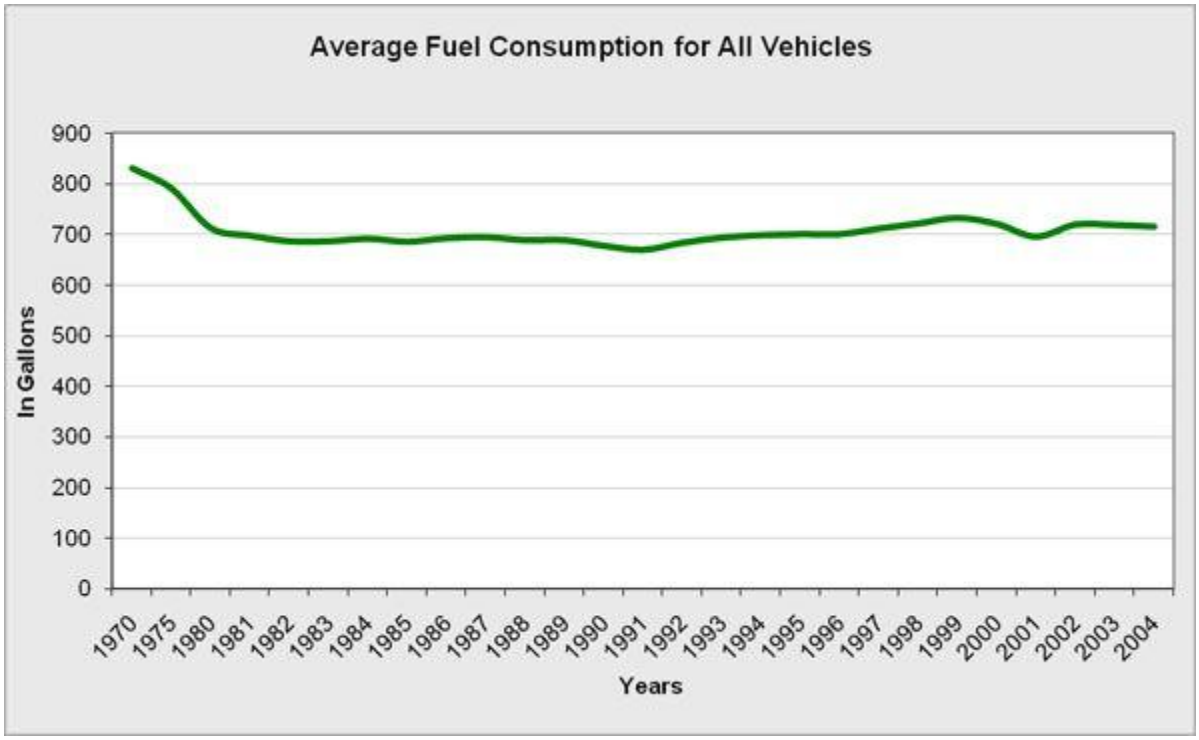
As previously stated, the auto companies are influenced by consumer demand and government regulations for what cars they design, produce, and eventually sell. Consumers need to be motivated to adopt more fuel efficient vehicles. Governments need to give more incentives for people to buy these more economical vehicles, thus stimulating the demand for them. This will then, hopefully, steer car manufactures to produce vehicles that utilize technology straying away from petroleum power. California has been especially progressive with these incentives, for example the use of the HOV lane, which has led to incredible demand for hybrids. There have been times that hybrids were in such demand dealerships were putting a premium on them and there was a waiting list. With more widespread use of such legislation and incentive programs, the United States can steer itself toward independence from petroleum. The real task is to change society's view of transportation. Consumers need to reevaluate how they drive and what they need a car for to move away from these excessively large, inefficient vehicles toward smaller, efficient vehicles that fulfill their needs adequately. The original adaptation of the all electric car was not successful because consumers saw no need for it at the time as the price of gas was so low. Manufactures will need to look at the long term instead of the short term in order to survive in the future. Sure they will be phasing out a technology that has given them great success, but history shows that innovation leads to success. It is clear that the world's petroleum reserves are finite and we need to curb pollution if we as a society are to continue to survive. Manufactures, consumers, and governments need to understand that there is a compelling need to adopt efficient technology in order to be successful in reducing our consumption.

Appendix A: Images

Gregory Charleston, Turnaround Management (2007)






Average Fuel Consumption for All Vehicles
In Gallons
900
800
700
600
500
400
300
200
100
0
1970
1975
1980
1981
1982
1983
1984
1985
1986
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2002
2003
2004
Years

Appendix B: Transcripts

Focus group: Hybrids

Gove: My name is Brendan Gove I am a junior at WPI mechanical engineering major. This focus group point is to support research that we are doing for an economical and environmental analysis on hybrid technology and different impacts that technology can have on our nation and on the world. The goal of this group is to try and inspire you guys to talk to one another and find out what reasons went into you purchase your decision to buy a hybrid vehicle. Starting off on that, what were the major factors that went into purchasing a hybrid vehicle?

Participant #1: My wife and I have been driving hybrids for 10 years. We purchased the first Toyota Prius, a 2001, purchased in 2000, and we did because I went down to a meeting with Toyota with the Mechanical and Electrical engineering professional societies, and all they had was right hand drive Toyota Prius, and I saw the design of this earliest Prius, they were already selling them in Japan, and I came away saying my God that thing is so beautiful, from an engineering standpoint, that on the drive home I told my wife we were getting one of those things as soon as they are available and if they are at a reasonable price. I think we waited at least 2 years until it was introduced, and we bought nearly the first Prius ever sold in Massachusetts, and we still own it. Three years later we purchased a 2004 in 2003 and we have been driving that and typically we keep cars 12-14 years, so we are on the 10th years of our 2001 Prius. I am looking at the possibility of a plug in car. So we have been at this for years. Prior to that, part of my retirement of WPI, I helped create the electric car and solar car program 20-25 years ago. We designed developed and manufactured and raced solar powered race cars. I had the background of helping WPI students create a solar powered racing car that we raced from Florida to Michigan. At times we moved the car at 60mph, but due to energy conservation issues, we often moved slower than that. Then I lead projects with WPI students' immersing students at GM in Warren, Michigan looking at the cars they made. I had students who thought they could do a better design that GM, so we did it, we tried it. That was one reason why we bought the Prius.

Gove: I think the key thing I am going to take form that is you said it was an amazing vehicle, that aspect you are referring to is the advantage of having a dual power system the car provided for you right?

Participant #1: Right that's what the car was, but I was seeing some of the details, but understanding some of the details, the details looked very substantial and very real. So sure, we were there to see the concept, but what I was convinced about was Toyotas ability to design a vehicle with reliability, regardless of the recent happenings that the media is blowing out of proportion. So, they had a design that looked beautiful, almost as if I was a human looking at a painting. For me I was looking at a piece of technical beauty. My wife is not an engineer, but we both agreed that that car was an amazing car. The problem I had was trying to teach salesman how these vehicles worked.

Gove: Because it was so new, right?

Participant #1: Yah, I had to teach these guys what they were all about and how it worked. It was unfortunate because the last guy who sold us the Prius didn't even know how to sell cars. I had to teach him how to sell cars too!

Gove: So any other thoughts? Any one jump right in? Similar thoughts?

Participant #2:I can follow up on that because I did a lot of research looking and comparing the Hybrid Toyotas to fords. I felt the same way, doing the research I knew I wanted to replace my 10-11 yr old SUV I was driving at the time. So I looked at the Honda Insight, and the Ford escape, and the technology of the Prius seemed to be the most advanced, and that's where I felt that splurging and paying the extra expense was worth it. I am still paying off the stupid thing because that's expensive for me. I do not have the ability to pay the sticker price of the Prius.

Gove: Right because that's a huge thing that goes into consumer trends because you pay an extra X amount of dollars so you have to ask yourself if it's worth it.

Participant #2: I didn't know if it was worth it but I realized I could save costs in comparison to the gas guzzler I had before. So I ran some numbers and talked to some ECE students who supported me getting the car. Not only from an environmental standpoint but an economical standpoint, it was funny that these grad students were selling me. And I am still going to be paying for this car for the next 2.5 years.

Participant #1: We came in at 20,000 on both of them. The 2003 was the same as the 2001.

Participant #2: Well I had the upgraded radio system.

Gove: So one of the things that we are finding on our studies is that people are buying these hybrids for what you guys are telling me. Environmentally there are benefits, doing your part, saving gas. In the

same sense, we are finding that the Prius technology is more of a stepping stone because we are still running into problems. This is also a similar type of problem with petroleum shortage. The same thing occurs with the chemical make up of these batteries, being of an even greater shortage than petroleum. Another problem is how do you recycle these batteries, something we do not currently know how to do. So, talk about weighing the benefits of gains in one side but maybe a loss in another side.

Participant #2: The battery recycling was a question for me. I usually keep my car 10 years. I felt that by then that this problem would be solved by then.

Gove: This makes sense because the life span is about 8-10 years.

Participant #3: That was a concern for me too because I was looking for a car because I have an 1.5 hr commute from western Massachusetts, and I needed a car that got better gas mileage than my old Volvo. I was concerned about the battery issue which turned me away from hybrids Prius. I went with the Jetta diesel which at the time was billing as a new clean burn diesel so it didn't have supposedly that same type of particulate emissions as other diesels and it gets 48mpg highway. My objective was to, without understanding the tech very well, to make it into a grease car that it, well, because it was so new and well designed that my mechanic who installs grease car conversions refused to put the conversion kit into the new vehicle because it was untested and uncharted terrain.

Participant #4: What is a grease car?

Participant #3: It is a car that you convert so it can burn vegetable oil; they smell great, like French fries. SO, I obviously didn't convert it to a grease car, but where I live I can buy biodiesel out the part, and the car manual says I can use a certain % of biodiesel, which I do sometimes but it is more expensive.

Gove: So, a 1.5 hr commute is well over 600 miles per week right?

Participant #3: This car is about 1.5 yrs old and has 40,000 miles on it…

Gove: So that's the biggest thing you guys are giving me is that you bought the hybrid because of the large amount of driving you life style brings. People that buy the hybrids are driving a lot of miles.

Participant #2: Yah, I drive 20,000 miles a year.

Participant #3: I would take the train if I could but it's terrible.

Participant #5: I know, I moved from the west coast to Worcester and 3 weeks before we moved our second car hit a deer, so when we came to the east coast we were under the impression that the public transportation was amazing, but it isn't. We tried having a 1 car family for a while, taking the bus. I live near Webster square in Worcester, and we purposely lived in Worcester so I could commute and stay a 1 car family, and it took my 2 hours to take the bus 4.5 miles, using three different bus routes. So, we had to buy a second car which was the Pruis. One of the reasons was that my husband got a job in Westborough for the commute. The other reason was that that I'm an academic and the Prius is symbolically sexy in the academic world. We are a weird group we like that. Part of the purchase reason was also due to the timing that car sales were at an all time low and car prices at this particular dealership was 1/3 the price. So we were able to buy a used Prius for less than 10,000, which was an awesome incentive. I feel very strongly about buying used cars as well, I guess I should throw that out there too. SO yah, it was commuting and I think it's useful to talk about the symbolic reasons that people buy Prius' over other hybrids out there because people see the car and know it's a Prius and know what it stands for.

Gove: Absolutely, we have seen marketing trends that people like their brand name products

Participant #2: I don't know I liked the look of the Honda insight better, I liked the ford escape, but to me it wasn't about the status of having a Prius. Now when I got it people were all, "Oh my gosh you have this car," but I don't feel like I have a symbolic mindset of being proud of this car.

Participant #6: On the subject of status I can tell a very funny back story about my first Prius and now my second Prius. I bought my first Prius in 2002, not quite as much as an early bird as you. But I definitely recognized that the earlier models would have certain costs associated with them, but I felt it was important to affiliate myself with a product that had a part of a larger narrative of transformation of the auto industry, toward attempting to deal with these larger issues. It was the first car I had ever bought just because of my lifestyle. I was teaching at a private school in California. In my early days of teaching at this school I was driving a broken down SUV and was getting some smerky looks from parents and peers. Then I was able to complete the transaction and purchase the 2002 Prius. I then got different looks, not any less smekry but more towards a lack of understanding about the technology. SO I think that the symbolic nature of the Prius definitely has weight in why people get them now however.

Gove: Ok

Participant #6: That car was totaled in 2004 and at that point I was faced with a decision what I do, because at that point, the Prius had become visibly enough so that there was a 6 month waiting list to get a replacement, new Prius. They had just shifted from the first US generation to the second US generation. I decided to wait out those 6 months. It was important enough to me to still have a Prius and to continue on this, sort of, trend toward the newer technology that was moving in an improving direction with regards to ecological concerns that I decided to wait. So I went 6 months in graduate school without a car, and bought a 2004 in, I guess it was, early 2005. That's the car I continue to drive today. I only put, probably, 8000 miles a year on a car. And really try to minimize my use of the car as well.

Gove: So that product reliability, your loyalty to that product, excuses me, which originated from what? That experience you had at that private school?

Participant #6: Well, it's a great car. I'm not an engineer. I'm a human, but just as I'm enthused about looking at paintings I'm also enthused about, you know, engaging with this car because I think it is an important thing. And…also I hate to drive, like I really don't. I would rather my wife drive..And I find the car relatively pleasant to drive on those occasions when I absolutely have to. I do try to avoid driving but I find that the way that it handles means that I'm actually more conscious about the choices I'm making when I am driving it, in terms of laying on the gas, how I break, how I take elevation. All of these things, I notice them much more when I'm driving my own car than when I'm driving my wife's car.

Gove: your wife drives a…?

Participant #6: Drives a Honda Element, much to my chagrin, and will probably upgrade to a mini van when our second baby arrives in the near future. So ya, part of that product loyalty is the, sort of, that way that product turns me from a very ornery driver to a driver that is at least willing to go out on the road when he has to.

Participant #6: My experience is somewhat similar and a little bit different. I enjoy driving and had a driver's car, the Subaru WX Wagon. It was a ton of fun to drive, but it was a little car, 4 wheel drive, and you were lucky to get 24 miles to the gallon. So when that car was old enough that I was going to trade it, I decided I did prefer to get a hybrid for a variety of reasons; long weekend commutes-so a lot of miles, and something that I could feel good about driving. I really felt like, and still feel like, at least for the car I bought, I'm not sure all the economic benefits are there but the more miles you put on, the more you save. So if you're driving long miles anyway, at least you're saving something. Im not sure if

everyone feels this way, but there's an element of you are doing something better for the environment too, by if you're going to drive you're better off owning one of those cars. I got a Ford Fusion Hybrid because I liked how it felt on the road better. But I think another factor that we've heard from a number of other people is the Ford, Prius, I'm not sure who else; the cars are reliable. So the low maintenance, high mileage, car that felt good driving; all those things were important to me. I did think a little about that fact that I wasn't advertising a darn hybrid and that was ok to me. But I do find myself when people say, 'Oh, you got a new car.' And I do say, 'It's a hybrid.' So I do think it's something I'm…

Gove: Conscious of?

Participant #6: Well, not just conscious of. I think there is a brag factor that you want that image of driving a hybrid to attach to you. That it's good for the environment, but you do feel good about driving it and advertising that too.

Gove: Now one of the biggest things that we came across, we were wondering, why is it that companies like, we'll talk specifically about General Motors, why is it that a company in a country, that its claim that they are intelligent above par from other countries, why is it that such a high class company would allow itself to get into the situation it did with regards economically. How is it that they could foreseen in the 1970's when there was a similar gas crisis, an even worse gas crisis, how is it that a company like this could let itself get so far behind in technology such as hybrid technology?

Participant #1: I have an answer for that if you want an answer. I know the whole history of General Motors, why they ended up the way they did. It's very clear. Well it started out with General Motors. The first world solar challenge, a race of solar cars across the outback of Australia from Down Attalaid, took place in 1987. And General Motors put two vehicles in place to take part in that race of solar powered racing cars. They invited me to come along with them to the race in Australia and they won the race 2000 miles handedly. They had really tremendous technology. Much of it came from a skunk works, a small company called Aerovironment in California. They were closely linked. When they had that success with solar powered racing car in Australia they basically tuned to this skunk works and said, 'Hey lets create a vehicle for the public, an automobile, electric automobile, and they took everything they learned in terms of efficiency from that solar powered racing car and put it into this crazy car named, the Impact. Why would you give name to an automobile, the Impact? But that was the name of it, Impact. It was the finest pure electric, not hybrid. It still may have been, today, if I can see other electrics coming along, that GM Impact electric car was the finest electric car I have ever been aware of. It may

still exceed, even now 20 years later. So it turns out they had to take care of the name so they changed the name to EV1. And that had a lead acid battery, and then they went to EV2 with a nickel metal hydride battery. They were in absolutely great shape. The chief executive officer, the CEO and chairman of the board was a WPI alumnus, Bob Stemple, was a good friend of mine, although I don't see much of him. General Motors was absolutely tops, way ahead of Japan, way ahead of everyone. They were bleeding money. There was a serious problem with the company losing money in spite of the good things they were doing. So they actually brought in a new chairman of the board. They didn't replace Bob Stemple, our WPI alumnus. They didn't replace him as CEO but did as chairman of the board. And they replaced him with the CEO of Proctor and Gamble, which puzzled the daylights out of me. But it didn't puzzle me for very long. That new chairman, full time CEO of Proctor and Gamble now brought in, and he's still doing Proctor and Gamble stuff but he's part time chairman of the board at General Motors. He tuned to my friend, Bob Stemple, and said, 'Bob I'm going to have you do two things. First all I'm going to have you fire 40,000 people. And the second thing you're going to do is get rid of this nonsense of electric cars. And General Motors was the tops in the world at that moment. They had a fantastically capable group of 300 people doing their electric car work. Bob Stemple faced the new Chairman of the board and said, 'I will not.' So they fired Bob Stemple and then they proceeded to fire their 40,000 people and immediately got rid of this amazing group of 300 pioneers in electric vehicles. That was not the choice of General Motors. That was the choice of an idiot that they had brought in from Proctor and Gamble, a man who knows all about Ivory soap, pampers, Pringles and a few other things. But apparently he knew nothing about automobiles.

Gove: Right, so his lack of understanding, all he saw was loss of money.

Participant #2: However, with any innovative you have to put a lot of money into research and development in order to be an innovative company.

Participant #1: At any rate, the man from Proctor and Gamble had no vision of the future of any kind, so when we talk about General Motors I like to distinguish General Motors from Proctor and Gamble. Now, there was a mistake made by the board of directors of General Motors to bring this guy in as chairman of the board. That was a serious mistake. It costs; the boards of directors are largely outsiders. So, if I were to blame anybody, I would blame a bunch of outsiders who came in and took command of General Motors and messed it up.

Participant #6: can I actually connect Proctor and Gamble to General Motors, just in terms of my own choices as a consumer because hearing this story, to me, is extremely interesting. It speaks to the notion that once you have a commodity you must continue to monetize it in order to maximize profit, whether it's a diaper or a car. Now as the parents of a 15 month old, we made a decision upfront to purchase cloth diapers. We wash those and that was extremely expensive upfront but it is also a commodity that doesn't continue to be monetized in the same way that disposable pampers would be. And in the same way you pay a certain price upfront for the hybrid car, and then it's not as much as an expense later in the game.

Participant #1: I was the first person who did not work for General Motors who test drove, when it was called the Impact. Eventually, they changed the name to EV1. I was the first guy outside of General Motors to test drive one. It still had potentiometers; it wasn't firmly imbedded with its control panels. You could still jiggle things, and it was the most beautiful car I have ever driven. When they finally came out into the market place, they were very cautious. Now this is before what I just described happened, while they were still trying to make it happen. They decided to have two limited markets; one in Phoenix, the Phoenix area in Arizona, and one in southern California. They were not going to sell them right away. They were going to lease them. So I happened to be visiting one of my sons, my wife and I have a very large family-4 kids, 12 grandkids, 10 great grand kids, and this sort of thing. We were visiting part of our family in Phoenix and he brought me to the particular outlet for the General Motors Impact. They said, 'Hey, get in and drive a real one now that it's all fixed up. You don't have diddling of potentiometers; you just go in and drive it.' And it was marvelous; absolutely beautiful car. Great acceleration, great everything. I had to calm down a little bit because as soon as I got in that car in Phoenix, there was a Phoenix policeman behind me. I wanted to really try this car and see the acceleration and speed, but I was limited by the guy tracking me the whole distance. So I was somewhat limited. But that's sort of the story. With respect to the hybrid car, one of the first questions that people ask me when I bought the first one in the year 2000, first question I'd get was, 'Ya what about the power battery? Isn't there a problem with that?' Now the end result of that is, we still use that 10 year old car. It's our second car. It still has the same power battery. It just goes on. It keeps going and going and going. I had asked that question to the Toyota people in those early days and they said, 'We think it will last the life of the car.' Now, I think a traditional definition of the life of a car is about 12 years. I thought, well, they were being quite honest with me. I was a knowledgeable person and a knowledgeable customer. They said, 'We don't know. We haven't tested it. We think it will last the life of the car.' Well, we have a 10 year old Prius and it still cranks along quite well with its old power battery. During that

time, I happened to be a downhill skier, mostly at Mount Wachusett and I'd have the only Prius, of course, parking at the parking lot of the ski area, Mount Wachusett.

Participant #5: You have to look at the tax structures. They had taxed luxury cars so that the people who wanted luxury cars switched to SUVs. So it's not that gas was cheap, it was that to buy the old symbolic cars became prohibitively expensive. And now there is this new class that gets out of the tax structure that can give you the symbol, right? I think now the tax structure is switching to the hybrids, when really it should be switching to the electric car or the air cars or a billion of the other energy efficient- the biodiesel or whatever because they are better. However, our symbolic imagination is about the hybrids right now because that is very sexy right now. And it is affordable. It's more affordable than a lot of the other options- like I was pricing the Tesla air cars. I was leaping because I really want one those, right? So to divorce it from the cultural aspect I think is dangerous. Also the monetary aspect- the tax structure, it's not just now much does it cost to buy the Prius, but what in the tax structure allows that to succeed and other things to fail, an Because there are massive shifts that are happening all the time.

Participant #4: In terms of the power, um, I did think about going from four wheel drive to front wheel drive, but it wasn't that big of a part of my decision. But the Prius, the ford fusion- they have as much power as small, midsize or compact cars. It didn't play that much into my decision at all. Oh I forgot- my first long ride in a Prius was in the Rocky Mountains. And um, that was with somebody who was looking at the Honda back when it was the civic hybrid or the Prius. And it was a little noisy going up the steep hills, but we got up them and it wasn't a problem. I was quite impressed with every aspect of that vehicle. That probably kind of laid the ground work. So I was thinking, "yeah Im gunna, I could drive a hybrid for sure."

Participant #6: I like to go downhill with the Prius. The Prius itself taught me how to drive. My driving habits are actually geared to the Prius. Going downhill I put it into engine braking which happens to optimize the amount of energy going back into the battery and I often will go as far as I can with just the electric motor. With the original 2001, which we bought in 2000, Prius- it could go with the electric motor alone only 30mph. Beyond that the gasoline engine would turn on. With the 2004 model I could go, for short distance, at 40mph with only the electric motor alone. So it taught me- I don't think I could drive a regular- I've been driving these too long. I'm tuned into these things. Ford, Ford Motor got started with hybrids by being licensed to Toyota. Toyota sold them something like 70 patents, but not

on their newest design. They would only sell Ford the original design so all of Ford's early hybrids were Toyota designs.

Participant #2: Anyway the power is OK. I went from a 6 cylinder which has a lot of power. The Prius is not very good in the snow, at all. I dislike that. Coming from, I lived in upper Wisconsin, and I bought an SUV and I bought it because I needed to be able to get around. It made sense there to have four wheel drive. You know now that I live in the Worcester area I don't really need that, but I have to say when I get into an old stick shift, you know, my friend's mini cooper, I feel like I'm in a sports car. I miss the sort of stick shift and the ability to control a car and really zip around. Its different and I think I drive much more reasonably than I did before. I have changed my driving habits, probably for the safer side, but I still love getting in a friend's car and zipping around in a stick shift every once and a while and it's so much fun.

Participant #1: We drive regularly into New Hampshire, so we are a little accustomed to snow and hills and things. It still works ok.

Participant #2: It works but its not great.

Gove: Do you find your car- how is that in the snow?

Participant #4: I will admit with pure gasoline cars in the past, I would always prefer to drive after the street has been plowed.

Gove: Right, right.

Participant #4: I never enjoyed driving in snow. So that hasn't changed. But with the front wheel drive on the Prius, it is pretty decent.

Gove: Ok

Participant #5: I learned to drive in upstate New York and so I have probably less fear in driving in snow than I should. I find that you do lose a little bit in the Prius in certain weather conditions.

Gove: In terms of handling?

Participant #6: In terms of handling- yeah, you can, especially up hills. You can lose a little bit of handling. But as long as you are aware of that and account for that circumstance, I don't- it very rarely affects where I chose to go. And on the rare occasion I chose to take my wife's car for some specific

purpose in some specific climate situation that's a luxury we have in being a two car family. But in terms of the question of power, that goes right back to what Jennifer was saying about the symbolic issue.

Gove: Its cosmetic.

Participant #6: Im not going to pass a sports car going uphill at 80mph in the Rocky Mountains, nor do I wish to.

Participant #4: Does the turbo diesel, do you feel the lack of power in that?

Participant #3: In the snow? Or just- I mean it has an incredible amount of power on the dry pavement.

Participant #4: It's very torquey, its very torquey.

Participant #3: It's crazy, but its not fantastic in the snow either. Again, it's a small-er car than Im used to driving. It's a lighter car than I'm used to driving. And I did specifically not choose a Prius for that reason because I knew I had to drive through snow and I had heard from friends who live in western Mass who had Prius cars. They said, you know, they take out the Subaru in the winter, you know, because where we live its unpaved roads and deep snow and you can't drive a, they say, that you can't drive a Prius.

Participant #5: I can't get out of my driveway sometimes. If I have 6 inches I have to shovel a path. I mean I have a plow that comes, but he comes at the end of the storm. I have a hundred foot driveway and I can't get out.

Participant #3: I had to be able to get to work.

Participant #2: I used to be able to get out with my SUV, now I gotta get the shovel out.

Gove: Well I guess the point of that is just that having that hybrid, even though you have to deal with the snow, it's worth having the hybrid.

Participant #2: It is, I'm not going to go back to getting, I mean I might consider getting a diesel when biodiesel becomes more available where, you know, where I get my gas and live. Right now that's not as readily available as, you know, Greenfield wherever you are.

Participant #3: Yeah, there is a whole plant out there.

Gove: Really?

Participant #2: It's possible that because- you are saying you get better gas mileage. I mean really when it comes down to it, that's what makes most sense to me is getting the best gas mileage. Electric cars- I drive too much, I drive too far. I'm going to get into my car on Friday and I'm going to drive to Maryland. An electric plug in is probably not going to work for that unless there is high speed plug in stations that they are talking about building. They are not there yet. Maybe someday when they are there, I would consider that, but then I'm relying on the coal infrastructure of our electric system in the United States, so I don't know. There are a lot of decisions to be made.

Participant #3: The problem with diesel is that, you know, they say that this is a better- these models, this 2009 models, are a better clean burn. And they also say that if you use a biodiesel mix it encapsulates a lot of the particulate matter in a way that you don't get with a regular diesel mix, but I haven't seen the data on it either, so I don't know if it's really just spewing particulates, and um, yes getting good mileage but what's the, you know, emission from the vehicle. I'm not sold or sure about that yet, so…

Participant #2: But if there is a hybrid convertible that comes out Id tell you. That's when the sort of culture, what is Jennifer talking about, you know, status. I want a convertible, but there is no hybrid convertible yet.

Gove: From the recent research we have done, you know what Jennifer is talking about, you know, is very real, um, pretty interesting stuff. Any closing arguments, anything…

Participant #1: I think, something that is sort of critical maybe. Everything, you know, I've heard about ethanol vs. fossil fuels, alcohol fuels vs. gasoline. I was negative on those things because I kept hearing that if you turn corn into ethanol and use that somebody is going to lose food or the price of food goes up. And, uh, there were arguments of that, and also that it took more energy, uh, to create ethanol from corn than the energy you finally get from ethanol as a fuel. It didn't seem to make a lot of sense. Id listened to a lecture, I've forgotten the guy's name, I'd listened to a lecture about three weeks ago and I'm beginning to change my mind. He was pointing out that much of the data we have been bombarded with concerning ethanol is incorrect. That these claims are not correct, that in fact ethanol can be made- and he showed data which indicated that, you know, you can increase the amount of food from corn even though you may be using the corn for ethanol. All kinds of things that I thought were true may not be true. And he was putting on a very strong pitch for us to get off the bandwagon- better than a hybrid could do. Get away from imported oil. He was concerned very much for the fact that

China and Saudi Arabia and all these other people are getting our money, and with our money they are slowly buying into us and buying our country through companies and things. They are beginning to gain major components of our own US companies. So he was, he was talking from the point of view of a long range problem. What is, you know, what is it going to do to the freedom of this nation if suddenly we find Saudi Arabia owns 30% of our companies or China owns another 30%. But his argument was that ethanol really is quite good and all he is asking for is that the American companies build all gasoline engines flex engines, so they can use either ethanol, 85% ethanol/ 15% gasoline. We all use 10% ethanol now , 90% gasoline. He was arguing, "Look for the price of creating flex engines, and put 1 pump 1 tank 1 pump at each gas station with 85% ethanol/15% gasoline." And he feels that that will build it. The speaker had very high praise for hybrids, but he pointed out what we know. It costs $3-4-5000 more to buy a hybrid compared to a comparable gasoline car and he's pointing out that to build flex engines will cost only another $2-300. And so he has a strong argument and I am wedded to electric cars of hybrid cars and I was opposed to alcohol fuels thinking that what I was reading was fully correct and apparently it wasn't. So I'm about to do some really deep study to what he was saying and he may be right, and therefore keep in mind that perhaps the future of the company might very well depend on our willingness to pay a couple hundred for a flex engine, try out the 85% ethanol/ 15% gas and see how we like it. And he is pretty certain that if we took that 1 brief step we could break the back of Saudi Arabia and break the back of China with respect to the great, powerful impact they are beginning to have on this country. And, uh, I'm one of the guys who helped win World War II and I'm one of the guys who helped win the Cold War. I provide, I helped to build the minuteman into continental ballistic missile when I was in industry and I'm a patriot and, uh, if you tell me if there is some way to break the back of Saudi Arabia and OPEC and break the back of China- I'm in favor of that. So I'm about to launch into a study into alcohol fuels and flex engines- see if I can understand what they are doing and maybe I have another 15 years, I'm not sure. My father lived to be 100- maybe I've got 15 years, maybe, in which to, uh, still has some impact. But I'm about to move in that direction. So it's just a comment that I think should be said. Look at the idea of flex engines and alcohol as the fuel- 85% ethanol being the fuel. And a couple hundred bucks compared to a few thousand. I love hybrids and I love electric vehicles, but there are some real problems. Every pure electric vehicle is very expensive because of the batteries. Every plug in is very expensive because of the batteries. So if there's a way to think in terms of pulling away from OPEC and pulling away from China and if it happens to use a different technology, I don't care. I'm for it because my concern is for this country.

Gove: Right my head is exact- this weekend I was talking to my grandfather, he's 86- the exact same, you know, conversation. Was that he fought in World War II and he has resentment towards companies, towards other countries who are gaining, uh you know, power. Things he, you know, fought for is relapsing, is what he was saying. So that is a very interesting point. Did you want to say something?

Participant #6: That's a tough act to follow man, I don't know, um. I mean the only point, the very limited point that I wanted to make, but I think an important one. In the same way Jennifer talked about, um, the symbolic power of the hybrid car. When you talk about the American people wanting SUVs. -well where does that come from? In part that is manufactured by advertising appeal to consumers, and so part of the equation here is, you now, what gets advertised, and presented, and marketed, and product placed in TV shows and films to consumers as things to be desired. And I think that is a really important part of the equation that we haven't touched on yet.

Gove: Consumer demand is a reflection of media.

Participant #2: And I guess the other side of it too is how the sort of environmental side, how many people are choosing it for the environmental reason, and I just read, I think in the Boston Globe yesterday, that in 2000-2009 people haven't changed their recycling habits at all in Massachusetts.

Gove: Right, its flat lined.

Participant #2: Its flat lined so are there certain people, and we've reached the threshold of those people who are environmental in buying cloth diapers and hybrid cars. You know where, is there a threshold, or can we convert other people to buy more environmentally friendly products in general. So there's a bigger question I think, it's beyond the car, it's a lifestyle.

Gove: Which is becoming a huge issue with you know, but that's another whole discussion. Ok great, I mean I don't want to hold you guys up. The deal was from 4 to 5.

Focus Group: Non-Hybrids

8. How much, on average do you drive a year? What is your daily commute like? City/Highway/Off-road.

Participant 1 - I drive my car, my primary car was bought, probably only about 10,000 miles a year. My commute is 20 miles round trip, mostly freeway.

Participant 2 - I mostly don't commute to work and I have only had my car for about two months so I don't have any idea of how many miles I commute a year but when I travel home and stuff, which is generally once a week, its mostly back roads.

Participant 3 - I probably put on, it's our main family car, we've had it for three months and have put on about 4,000 miles already so probably about 13,000 to 14,000 a year. I commute to work probably about 30 miles round-trip, about 25 minutes. It's back roads and most of the driving I do is non highway which makes things with fuel a little more difficult. Large trips are all highway but the general use is small roads.

Participant 4 - I think, well I get my oil changed twice a year so, probably around three to four thousand miles. I would say. I do a lot of driving but is all city, [my commute] has gone from 5 minutes to one and a half minutes of driving, so I just walk sometimes. But the majority is when I start driving in the summer and that gets me to about 4,000 miles a year.

Participant 5 - And I went from 1800 feet, when I used to walk to work, to actually the car that we bought, my wife is the primary user and she puts about 20,000 miles just for commuting to work, and bring the kids back and forth to school. We bought the car at the end of March last year and we've got over 35,000 miles on already. But a little more than half of it is the commute, the majority of its highway.

9. How much do you spend on gas per week/month/year?

Participant 1 - about $50 a week for me.

Participant 2 - I think mines about $35 a week.

Participant 3 -I probably fill up once a week and it's about $40-45 a week.

Participant 4 - I fill up every two weeks and it's around $35.

Participant 5 - It's about $40 a week.

10. What type of car did you buy? If there is a comparable hybrid on the market, did you consider purchasing it?

Participant 1 – well I bought a 2003 Audi S8, because you know the was only 300 of them made and I wanted to get one but I did actually look at a Honda Accord Hybrid, which surprisingly has

similar performance, but they quit making that as well. But there is no hybrid right now that has the performance that these S8's have.

Participant 2 - I bought a 2004 RAV4. I looked at some hybrid but I really want four wheel drive and something bigger, slightly bigger car than my Chevy Aveo, which I used to have, so I didn't really look into hybrids that much.

Participant 3 - I bought the 2010 Mazda CX9. I wanted a hybrid originally, but the only one that I really compared it to was the Toyota Highlander Hybrid but it was just priced out for us, but I would have liked to get one but for our needs there weren't a lot of choices. It was just too highly priced and there weren't that many of them available either.

Participant 4 - I bought a 2009 Honda CR-V. I don't think I really looked at hybrids, the only one I think I might have looked was the Honda Accord. The reason I got it honestly was the place I used to live, you needed a donkey to get up there, it was all hills and I actually need four wheel drive. I didn't want an SUV, like I was driving the Mayflower, so I wanted something a little bit smaller.

Participant 5- we got a 2009 Toyota Highlander and I wanted a hybrid. We needed an SUV because of the terrain and hills that we have to commute. I wanted the, I looked at the Highlander Hybrid but it was about $10,000 more and I looked at what it would take to pay that back, the return on the investment, and it wouldn't work, I would get rid of the car before it paid off.

11. How much did the car cost? How much was the last car purchased? When did you purchase it and did you ever consider buying a hybrid then?

Participant 1 - I always buy collectible, used cars. So I paid on ebay 15,700 dollars for this car, but it sold for 82,000, when it was new. And then my car previous to that, sold for 51,000, but I bought it for 11,000. So I always buy them when and I look around for used when they are a few years old.

Participant 2 - I bought my car for 25,500 and my previous car for I think 12,500.

Participant 3 - Oh gosh, I don't even remember. I don't know. I will give you an approximate cause it gets so who remembers what you finalized. I don't remember. I think we bought it for about 29,000. I think that's about what it was. And the previous car we had a Subaru Outback that I loved, but it was too small, was umm I think maybe 24,000. They weren't that different. I needed a third row. Oh yeah. And I looked at the Tribeca, but there third row was a joke.

Participant 4 - So, I bought my 1997 used Saturn for around 8,000 dollars. It was the best investment ever. I love my Saturn. It was a standard. It had a ton of miles on it. It exploded and well I basically drove it to the ground. So the Honda was I think 24,000. I think right on the dot.

Participant 5 - I loved my Saturn. I had two of them. I loved them. Umm I believe we paid about 27,000 and the last one we had a Honda Odyssey that I think was 23,000.

12. How long do you keep your car? How did you go about getting rid of it? Was it junk, did you sell it, did you trade it in when you got a new car?

Participant 1 - I still have the first car I ever bought new, I bought a new 1973. It is still in my garage. So it has 300,000 miles on it. So I don't normally get rid of cars. The car I got previously to this one, I sold it with 210,000 miles. I had it for about ten years. I bought it used. And I will keep this one for at least ten years. Uh normally if it is a German car I will go for at least 200,000 miles before I sell them. And I do sell them, at that point. But my Fiat I will keep forever. It won't be sold.

Participant 2 - Um previously I had bought a lot of crappy, used cars, so it was probably under three years, but I did trade in my car with this purchase and when I bought my Chevy Aveo I also traded in the car I had. And previous to that, I just drove them until they died completely and then just gave them away for parts.

Participant 3 - I would say I keep cars for average five to seven years. We've sold, we had prior to, you know we've sold a car on our own, we have traded in, we have done kind of everything. But um this last one, the Subaru, we traded in for the Mazda.

Participant 4 - I kind of used to keep them until they went into the ground. Umm, but it is kind of my idea, I basically, I don't look to upgrade my car, unless I absolutely have to because of the terrain. I am not really in it for status or anything. I just need to move.

Participant 5 - We used to have a, it's an American made, vans that I didn't want to go over 100,000, so it, we wanted them longer, but we had been burned on it once, so we avoided that. When we got the Honda, we intended to be able to go quite a ways, and a year ago the amount of miles we had put on the car and the incentives that they were offering for buying a new car

basically we could lower our payment and get a new car that was six years newer. It wasn't a clunker, but we did trade it in. And there wasn't anything wrong with it per say, it was getting up in miles. But it was more driven by the state of the economy and trying to help the economy by making a purchase and it worked for us because as long as we could keep our payment the same we were willing to do it and I think it actually saved us a few dollars.

Participant 3 - I don't know if you are going to ask this, but I would say to, it is a hard question circumstantially why we have kept our cars. I would have kept, we have moved every car because we had one kid and then we had two kids. So safety became a factor, space became a factor, so I think it is just circumstances. You know? The idea with this new one according to my husband is that we are staying in it for a long time. So, but I think, as our lives have changed, I also used to live and work residentially, so I never needed a car. And then I got a new job where I had to commute. So it has always been circumstantial for us, getting a new or changing a car.

13. What factors go into making a decision to buy a car, hybrid or not?
    d) How did the interior size/comfort factor affect your decision?
    e) How does output performance (acceleration) affect your decision?
    f) How does your lifestyle/geographic location affect your decision?
        ii. For instance, do you need a truck for towing purposes, 4WD for winter reasons?

Participant 3 - The number one for us is safety, since this was the car that I was going to be driving with both of our children. So safety was number one, without question, size and ability to transport strollers and pack and plays and the amount of stuff that two children under four require. We needed trunk space. So for this one with two car seats and I have parents that are local so we are often traveling with them. That is why finding a third row was also …we wouldn't have bought a new car without a third row. So we wanted to be able to have the car seats and other people come in the car, have me get in the back seat with the kids…so it was all about functionality with being a parent with children…so safety, functionality, and then from there probably went price, to style, and what factors in for me honestly was the people at the car place. I won't buy a car from someone who I think is a jerk. There were some places that I ruled out because I didn't like their attitude. I was like I don't need to give you my money, and I left. That is way down on the list because there is always a million dealers and dealerships if you don't like the people. That is what I would say for me.

Participant 1 - When it came down to our….the reasons why we bought another car is because my 220,000 mile previous Audi…it was time to sell it. 220,000 miles is my limit – not 100,000. Although seriously now we have four cars. The lowest mileage one of any of them is 110,000. That is what my S8 has. I have with 300 and one with 200, and one with 120, and my wife's Audi has 120,000. But at any rate, when it came down to my purchase, it was between three cars and I am very, very particular about what I get. You know I'm an engineer, an automotive engineer, and I gotta have the right stuff and so it was either gonna be an exotic, affordable car which is the Audi S8, which is incredibly exotic. It was appealing to me because there are only 100 of them made that were that color….300 altogether and it had the performance that I was looking for, but I was also intrigued by small comedic cars so I came close to some others. The second car in consideration was the super charged cooper…the little mini cooper because I had one of those…the real one when I was in college, and the third again was the four year Accord v6 hybrid, and they were all about the same price and the used price range that I am doing it. The answer came down to….my wife said you're not buying the mini because we needed a full size car and we cannot have two small cars, and so ultimately I said oh yeah because I wanted to buy the S8. And so I think that the performance and exotic nature of a car really appeal to me and but one of the trips for my wife was that we wanted something that would be comfortable for people to travel and obviously you can't in her two–seater or my 300,000 Fiat, our Toyota appliance that we keep.

Participant 2 - Previous to this car, I just bought cars to get me from one place to another and…but I spent most of my life living at the bottom of a hill so I could not drive up it in the snow, so I wanted a four wheel drive car. I mostly bought this one because my brother did all of the research. He told me that that's the care to buy…and I did actually leave a dealership because they were a jerk and drove all of the way to Wellesley and paid $2000.00 and they were the nicest people that I ever met….and so I could afford it finally for the first time in my life.

Participant 4 - I think the factors to be honest I look right at the price, to start off with, because I know my budget, so I eliminate more cars then I try to research. Living in Worcester and New England I've come to the rationalization that I'm just tired of being the best maneuver of a two wheel drive car in the snow and hills. So I do need that flexibility. And then I prefer to drive a standard. Only because it just feels like I am actually driving, and it saves gas. but unfortunately my ex wife at the time couldn't…I was like a valet parker I would move it because she didn't

know how to drive it so one of my motivations was to get an automatic so whoever had the car that I was behind could just take it and leave and go to work. But that's what it comes down to. And I am not one of those people that goes into a dealership and is looking to barter I want to go in and out within 2 hours and leave.

Participant 5 - Again hill wise we needed a four wheel drive, that was essential. Size wise I would have preferred something smaller but I had a small Saturn that I used for commuting so we couldn't get a second small car we needed something larger to be able to haul the kids and their friends and all that around and then be able to fill it up to get kids moved to college…try to do it in one trip. And then the price and also spent a lot of time with consumer reports…going through checking the repair histories and the reliability and all that…the different models.

14. Was there anything about hybrid's that may have had a critical influence on you decision making? If you were at one point looking at a hybrid was there anything that critically influenced your decision to not get one?

Participant 1 - I have a problem theoretically with hybrids and that the research shows of course it's just a stop gap measure. The real reason for buying them would be the tax incentives and a few things like this because when it gets right down to it the technology is not the way we should be encouraging people right now actually. On the other hand the tax advantages make it significant…and so I would much rather buy something which is a longer term look at fuel economy…certainly there are a lot better options than hybrids, hybrids are just a stop gap so I'm not too excited about them unless they happen to perform well and happen to give the tax incentives to make them pay off before you end up throwing it away.

Participant 2 - I did a project in a grad class where I always thought great things about hybrids and then you realize like they never really pay off I the long run so other than the feel good nature of it…which in that case I would just move closer and drive it less, which has a similar thing. And then when I want to and need to drive in the snow I get…I can get where ever I want…so…

Participant 3 - Yeah as I said I originally wanted the Toyota highlander hybrid that was my initial thought but um A.) It ended up being too small in the middle row, I couldn't fit myself and two car seats and then really it just came down to price. And that there wasn't really another option

in a hybrid that fit our needs and the cost was really the main thing, we were just…it was just too priced out for us and as we talked about it, it would have taken us too long to make that difference back.

Participant 4 - Um, I never really looked at them. I guess to be kind of vain I thought they looked like golf carts. Not that I care that much about it. But I got to admit…it looked flimsy, I'll put it that way, it didn't look safe I guess you could say. But the other thing is, is that I'm all pro environment but to me it kind of felt like I could just get a car that does well on gas and I'm helping the environment…then having to use something else…so spending less…driving less…conserving gas…is kind of the same and like she just said it was out of my price range…beyond that…

Participant 5 - Pretty much price range. We would have been prepared to buy the hybrid highlander but just…we knew we wanted the highlander…we couldn't afford the hybrid.

Participant 1 - If you look at the highlander especially the Lexus SUV hybrid all the studies show that is a 200,000 mile break point for cost. In fact I think on the Lexus…the 478…you never come out ahead on it…so there's a little hype.

Alyssa- And my last question is does the reputation of the car's manufacturing company affect your decision? Like if it's foreign or American?

Participant 1 – I definitely don't mind. The ad that most automotive makers will spout on is you buy American if you want the biggest and best value, you buy Japanese if you want something which is the automobile appliance, you go there, you push a button and it goes, push a button it stops. Then you buy German cars if you're an engineer because the German cars have a certain engineering exotic nature that appeals to me and so I'll almost buy a car in spite of the fact that it's important and it doesn't rate well because I don't see eye to eye on some of the features that are important so I think I do base reputation quite a bit about cars and if you can afford something which meets your standards then I guess I would say I influenced it…

Alyssa – I bought a Toyota because I heard they last a long time and I did buy iton the day they stopped selling roud fours as well so, mine was made in Japan, it's all good. I had a Volkswagon before which lasted forever and then I owned a Chevy which was only 3 years old and it sucked. I put more money into it then I ever paid… I definitely have a bad view of American cars after driving them.

Participant 3 – We looked at, um, we narrowed it down as the Mazda CX9 and the Chevy Traverse and the GMC Arcadia, that's what we narrowed it down to, and we were definitely influenced by the fact that Mazda, we were happy with that company and we heard good things. The problems that the companies were having like looking at GMC and looking at Chevy, it definitely gave us some pause and with all things made equal it may not have mattered but there were a bunch of little factors and that definitely swayed us a little bit. We had heard good things. My father is a Mazda guy. We're a Mazda family so we've had good luck with them, we've all enjoyed them and we've heard some things going into a GMC or going into a Chevy. When you mention it to some people they give you a (insert negative sound) but when you go to a Mazda people go "oh I love my Mazda we've heard good things and are happy with the company" and so…

Participant 5 – My father was a Dodge and Chryster guy all the way through, and so was I. I guess I tried to live the, support American car but I've come to find out the Honda engine is made in Kentucky so… I really wasn't too influenced too much but I guess it was just by word of mouth, the people that I saw that owned Hondas had them for a very long time and seemed to have no problems with them so…

Participant 1- The last Chrystler product that we had which was the minivan was made in Canada and had a Japanese engine, so it's a very good car.

Participant 4 – We had a Honda and would have preferred to have gone with the Honda SUV but it didn't have 4 wheel drive and prior to that all our vans had been American, and our previous new cars had been American. We just had a used Honda Accord several years back, but this was our first Toyota and between its ratings and all that we felt comfortable. I don't know how I feel about Toyota now but…

Participant 1- You shouldn't worry about that. They'll be right on top again.

Alyssa- Hi, I'm Alyssa.

Participant 6- I'm (Says name) sorry I'm late.

Alyssa- would you like to tell us about your car?

Participant 6- Yeah. In January I bought a Hyundai 2008. It came off of a lease. My wife and I have a pop up tent trailer and I would have loved to get a hybrid but you can't get a hybrid that will tow a

trailer, and this trailer is not a heavy trailer, it's about 1500 pounds without any load in it. I could have gotten a Subaru I think it's an outback with a 6 cylinder engine but it takes premium gas. I booked on consumer reports, I looked on Edmunds, I also read comments on people who bought Hyundais and I found out that they were built in Alabama and that made me feel better about it. We had a Ford station wagon for 8 years and had about 137000 miles on it and it was starting to, every other month I was going into the garage with it but up until 100,000 miles on it had been a great car and I was very interested in the Ford Fusion but again, 4 cylinder so… this car is 6 cylinder and it also gets very good gas mileage, not so much in the city. It gets about 18 miles to the gallon, but on the highway I actually get over 30 miles to the gallon. The quality from that from what I've read is that they're right up there with, I wanna hesitate to say Toyota but, Toyota and Honda and some other cars. The market hasn't quite recognized it yet but the price on them is a little bit lower but I think now that with the problems that Toyota are having people are actually looking at these Hyundeis because their quality is very good and I've been satisfied with them. Again I would love to be able to buy a hybrid car if we were going to buy another car that we weren't going to tow I probably would have gotten a 4 cylinder and a hybrid. Note the one question I haven't thought of is what to tow with a Toyota Prius, if you buy it used, what the life cycle going to like. The battery that you have there. And I think in the next couple of years, that technology is gonna change quite a bit. I was hoping I could wait another couple of years to buy a car but, it's just this car was not gonna hold out for me.

Alyssa- Do you do a lot of driving?

Participant 6- Not really a lot, but enough that, you know I drive back and forth from work, it's about 8 to 10 miles or so but I'm driving around the state or down to Connecticut to visit relatives and then when we go on vacation we usually drive so…

Mike- How much to you put on for mileage per year?

Participant 6- about 15000 or so.

Alyssa- Did you trade in your last car to get this car?

Participant 6- No I gave it to my son.

Mike - That brought up an interesting thing. What do your cars take for gas? I know that my WRX takes premium. I have to add 91-93 in it, for octane.

Participant 1- 93

Alyssa - Regular. Whatever, I'm cheep.

Participant 5 - Regular

Participant 2 - Regular

Participant 4 - Regular

Mike - You and I take the hit.

Participant 1 - I don't drive much.

Mike - I think that's all we have. Anything else interesting facts or figures about hybrids that anyone has? Concerns or issues?

Participant 1: I think that the whole, once we go to plug in hybrids the equation does change a bit. Because when we don't have to put gasoline to charge the battery through the inefficient reciprocating engine and through inefficient generators and inefficient transmissions when you're actually able to use the central grid to charge your batteries then it becomes much more attractive. But again hybrids by their nature, are never going to be as efficient as a purely direct motivator whether it be a high tech diesel or pure batteries, so I just… it bothers me when I personally people promoting hybrids as if they were the last bit when it's just a stop gate technology. Stop gap technology.

Alyssa - I would agree with what Participant 1 said that I think there's a lot of hype, and everyone's feeling this need and this pressure to do something but when you really look into it, it doesn't seem to have the results that I think you were expecting. Like you think, well I'm gonna get a hybrid, like that was my initial thought and then I looked into it and I did the research and looked at everything… well it's not quite there yet, I agree. So…

Participant 1- It's funny, one of the reasons why Honda said why they were unsuccessful and dropped the Accord Hybrid was because it didn't look hybrid enough. It looked just exactly like a regular Honda Accord, in fact even the industry panel just had one additional extra gauge. And yet car and driver would say it's the only hybrid they would ever recommend because it did get remarkable gas at 38 miles per gallon on the highway and 30 miles per gallon in town, and yet it's the fastest Honda

ever sold, faster than the S2000 because it had a 240 horse power V6 plus about another 130 horse power hybrid and so it was faster than my S8, 0-60mph.

Alyssa - But then were they just not selling?

Participant 1 - Nope. They dropped after 2… 3 years.

Alyssa - Cause I didn't even know they made one.

Participant 1- It was also the worst looking Honda accord for a long time. It didn't improve by doing that. And it's funny because a lot people buy hybrids because they look like golf carts. It is proven that there is a certain niche that likes to buy something that looks the part and then there's these other people that say "ahh make it look like a normal car and maybe I'll buy it" but those people aren't buying them. Because the Toyota camery looks like a regular car and most of the Lexus hybrids look just like regular cars and they're not selling like hot cakes.

Participant 6- But the prius…

Participant 1 - The prius and the new Honda insight…

Participant 6 - The prius has a definite look…

Participant 1 - Right.

Participant 6 - … And people can recognize it from way off… in the distance…

Participant 4 - My last two cents it became too much of a status symbol of hey I'm doing my part, I have a hybrid sticker in the back. Great, you get a parking space, and you get a tax reduction, what about me? I can't afford it. Congratulations. And, I come to find out that they can sit outside with their car running, I turn mine off and I'm doing my part so…

Participant 1 - The new Subaru has got a partially zero emission vehicle which is a hybrid. They simply have a bigger battery and a bigger starter and they shut off the engine every time you come to start so therefore it qualifies for the partial zero emissions as electric backup for the air conditioner, all this kind of stuff, but it's not a hybrid and so there's lots of ways you know and the problem with, as we all know the problem with throttled engines, gas engines is that they're just woefully inefficient at partial throttle, and that's the reason why hybrids are so much better in town cause they shut the engine off. But a diesel is remarkably efficient idly. Remarkably. The high performance 8 series

Audi's with the diesel 310 horse power turbo diesels get 40 miles per gallon in a car that does 170 180 miles per hour. But they're not legal to sell in America yet. That particular diesel engine.

Participant 6 - I had a Volkswagen diesel during 1980 I think it was, and I had it for… I bought it brand new and I had it for 110,000 miles, but in the winter, if it was really cold you had to plug it in… did they solve that kind of problem or…

Participant 1 - No, but you should understand that it's a battery, in themselves are way down in production in the cold by the tube. You asked our associate who has a prius what gas mileage he gets in the winter time and it's not any better than a Toyota corola's. Yeah it's like 38 miles per gallon. That's what it gets in the winter time. And 38 maybe 40 is good because battery capacity goes down as a factor of temperature as well and then of course you have to heat up the fluids for the heater and keep the engine running almost all the time anyway, and so hybrids get much less gas mileage in winter time then they do during summer time.

Participant 3 - See I don't think the average person would ever know that.

Participant 1 - Yeah.

Participant 3 - That's why they come to WPI and talk to people here. But like I would never know that except for you just said that, I would never have thought of that…

Participant 1 - But all of our gas mileage goes down during winter time too cause they reconfigure the fuel, and most people and regular cars get 5-10% less gas mileage too cause they put the ethanol and stuff in there. Which is, you know, reconfigures the fuel to the point where you don't get the same…

Participant 3 - And now what would you say to me that for my IQP that for me the environment and the effect on it definitely matters and that if they get to something that I'm thinking about, especially with children and their future, but it's not, and maybe it's selfish of me, not affordable yet because at the same time I have to feed and clothe and educate my children so I think that if technology is looking where to go and wants to appeal to people, it needs to be at a point where it's cost effective in that the average person who's gonna use it can afford it and that it's worth it and that I think it does make a difference that I do want to you know help the environment whenever I can you know as long as it makes some sense and I don't think it's quite there yet given all the other factors. Hopefully someday.

Participant 1 - Yeah. I mean with all things being equal, you would take a car that was more environmentally friendly, that's the economic decision for a lot of folks which is what it is, and you mentioned safety as well which is interesting as well because the 8 series Audi was the first car in America to sell with 5 star protection in all quadrants, but it was very, very unaffordable, and so I can tell myself about this car that it was very safe. That's why I bought it.

Participant 5 - I was discouraged, because I really wanted a hybrid but… the numbers wouldn't work, the upfront cost and the payback… and I really wanted it but it's just…

Participant 1 - And if you think carefully on it from the engineering details it's got to be more expensive, you know in fact the argument was that Toyota was losing money on Prius' for quite some time. And even though they were priced above and so if you look at the technology, there's a lot of technology in it to get what they got and it is expensive technology, and so if they were to sell it for the same prices then someone's a cost error here cause there's no reason why they should sell it for the same price. You have an entirely nother system in there. And the engine itself is a much more expensive engine to build than a regular internal combustion engine. It's not even running on auto cycle it's running on a miller cycle. It's a different cycle and it requires different valve manipulation and lots of things so it's expensive and engine, let alone batteries, chargers and electronic controllers .

Mike - And the materials that go into them allow the hybrid to pull out more aluminum and copper and stuff which is way more expensive to get from raw material and to produce than you know steel and most other ice's and stuff…

Participant 1 - And odd thing is if you were to take a car, if you were to take a prius shell , use a prius low rolling resistance tires, use a prius high efficiency electric power steering and all the other stuff, and you put in the ergonomics of a prius, and then you put in an internal combusting engine which gives you the same performance as the people in hybrids are willing to take, it will exceed the gas mileage of the hybrid, but no one is willing to take a 12 second 0-60 time. No one is willing to have a car you can't pull a trailer with. No one's willing to do that unless they have this feel good thing about it being a hybrid. If you were to sell a car with a prius performance to the American public and it wasn't a hybrid, you couldn't sell it. Why would I want something that couldn't get out of its own way? And the hybrids that do perform well like again the Toyota cruiser and these… the Lexus, the payback doesn't work out, because they need to have a big enough engine to provide the performance you want. And then you're hauling all the extra weight in batteries and all this other

stuff so it doesn't make sense. The number 1 factor ever to predict the fuel economy of a vehicle is its weight. Not its driveline, not whether it's a 4,6 or 8 cylinder or even if it's a hybrid, you look at its weight that's the number 1 predictor for fuel economy. And when you start putting in 500 pound batteries, you gotta go with aluminum chassis, you gotta go with super light weight wheels, you gotta go with all these sorts of things.

Mike - And then it'll cost more to make and manufacture and get the raw materials…

Participant 1 - Aluminum is, we talked about the carbon footprint for making aluminum, aluminum is really expensive to make, luckily it's recyclable. Aluminum is really easy to recycle but man, aluminum plants is what eat up all the power. Of course, my car is totally aluminum.

Miike - It's almost three times as much as steel manufacturing …

Participant 1 - But you can recycle it with very little cost, and that's the good thing about it…

Participant 6 - Are you gonna share your results with us?

Alyssa - I think so.

Mike - I think after we finish.

Participant 3 - What's your IQP, like you're just looking at the difference between why one group chose to buy one vs. the other?

Mike - Well it's more of, are they up to the hype.

Participant 3 - Oh.

Mike - So we're doing analyzing how they're made and the processes from start to finish. Getting rid of the Nycad batteries vs. other batteries and how much goes into manufacturing and then also the consumer side. What causes people to buy them. If they're just looking to get one for the hype or for this reason or that. So that was the purpose for this area of study.

Participant 6 - Just to reiterate what some people have said is, I try to buy cars that are coming off of a lease, I don't like buying a brand new car. And there definitely is a cost factor in terms of looking at these hybrids vs. you know, another car. I got a lot more money in terms of another car that I got vs. what I could have gotten in a hybrid. Like this gentleman was saying I think that the hybrid is kind of like,

you know, what it's going to be 2 years from now, that technology is gonna be very different and I'm just not willing to pay an extra 5 to 7000 dollars for a hybrid.

Alyssa - Thank you guys very much for participating…

Tom Jenkins Interview

Tommy Jenkins: This is the interview with Tom Jenkins for the Future of Transportation IQP on January 17, 2010. So Tom, what kind of car do you drive?

Tom Jenkins: A 2005 Toyota Prius

Tommy Jenkins: How many miles do you have on that so far?

Tom Jenkins: 117500.

Tommy Jenkins: Oh, so you do quite a bit of driving. What is your average drive like every day?

Tom Jenkins: At a minimum it's 35 miles each way to work and back. A lot of days I travel to job sites so I'll travel all over the Southern California area.

Tommy Jenkins: Mostly highway then?

Tom Jenkins: Uh no, it's a combination of both highway and side streets.

Tommy Jenkins: Ok, cool. How much did the car cost?

Tom Jenkins: $29,000

Tommy Jenkins: What was the last car you had?

Tom Jenkins: Before that I had a Ford pickup truck. I believe it was a 2003.

Tommy Jenkins: Ok, cool. And how much did you spend on gas with that compared to how much you spend on gas with the Prius?

Tom Jenkins: Well, the Prius uses about a third of the gas that I was using with the pickup truck.

Tommy Jenkins: Cool. What factors go into your decision making for the car, hybrid or not?

Tom Jenkins: Well my main this was that in California we have a carpool lane and to get into the carpool lane you have to be driving a hybrid car with 45mpg or more. And that was my goal- to be driving in the carpool lane by myself.

Tommy Jenkins: Alright, was comfort a factor? Interior size? Any of these things? Or was it mostly just about the mileage and the carpool lane?

Tom Jenkins: Uh, it was mileage and carpool lane. Comfort is really important because I'm on the road so much, but because the cars were so hard to get that I really never really test drove the car before I bought it.

Tommy Jenkins: Um, so obviously performance was not decision- wasn't a factor in your decision making. How has your lifestyle affected your decision?

Tom Jenkins: Well it saves me at least an hour a day in traffic- maybe an hour and a half per day on average in traffic. Initially when I first got it I realized that I have a lot more time. It was funny, I didn't anticipate having more time, but as it turned out I had more time every day.

Tommy Jenkins: Cool, what about the brand? I mean there were other options for hybrids, why did you choose a Prius?

Tom Jenkins: Well there was only two options- Honda Civic Hybrid and Toyota Prius. Honda Insight was another but they weren't making any and you could not get those. The Honda Civic Hybrid- I didn't really like the body style and it too was very hard to get. I couldn't test drive it and I just basically went by pictures. I looked at the Toyota Prius and I had seen a few of them on the road and thought this looks like it will work for me.

Tommy Jenkins: Cool, well thank you for your time.

Appendix C

Gas Cost Comparison

Gas Price	Technology	MPG	1,000 mi (month)	5,000 mi	12,000 mi (year)	60,000 mi (5 years)	120,000 mi (10 years)
	Jetta (gas engine)	25					
$1.00			$40.00	$200	$480	$2,400	$4,800
$2.50			$100	$500	$1,200	$6,000	$12,000
$3.00			$120	$600	$1,440	$7,200	$14,400
$3.50			$140	$700	$1,680	$8,400	$16,800
$4.00			$160	$800	$1,920	$9,600	$19,200
	Toyota Prius (hybrid)	50					
$1.00			$20	$100	$240	$1,200	$2,400
$2.50			$50	$250	$600	$3,000	$6,000
$3.00			$60	$300	$720	$3,600	$7,200
$3.50			$70	$350	$840	$4,200	$8,400
$4.00			$80	$400	$960	$4,800	$9,600
	Chevrolet Volt (plug-in)	230 (unofficial)					
$1.00			$4.35	$21.74	$52.17	$260.87	$521.74
$2.50			$10.88	$54.35	$130.43	$652.18	$1,304.75
$3.00			$13.05	$65.22	$158.10	$782.61	$1,565.22
$3.50			$15.23	$76.09	$182.60	$913.05	$1,826.09
$4.00			$17.40	$86.96	$208.68	$1,043.48	$2,086.96
	Nissan Leaf (electric)	367 (unofficial)					
$1.00			$2.72	$13.62	$32.70	$163.49	$326.98
$2.50			$6.80	$34.05	$81.75	$408.73	$817.45
$3.00			$8.16	$40.86	$98.10	$490.47	$980.94
$3.50			$9.52	$47.67	$114.45	$572.22	$1,143.43
$4.00			$10.88	$54.48	$130.80	$653.96	$1,307.92
	Volkswagen Jetta TDI (diesel)	36					
$1.00			$27.78	$138.90	$333.36	$1,666.80	$3,333.60
$2.50			$69.44	$347.20	$833.28	$4,166.40	$8,332.80
$3.00			$83.34	$416.70	$1,000.08	$5,000.40	$10,000.80
$3.50			$97.24	$486.20	$1,166.88	$5,834.40	$11,668.80
$4.00			$111.12	$555.60	$1,333.44	$6,667.20	$13,334.40
	Chevrolet Impala (Ethanol)	19					
$1.00			$52.63	$263.16	$631.58	$3,157.89	$6,315.79
$2.50			$131.58	$657.90	$1,578.95	$7,894.74	$15,789.50
$3.00			$394.74	$789.47	$4,736.84	$23,684.20	$47,368.40

$3.50		$1,381.58	$921.05	$16,578.90	$82,894.70	$165,789.00
$4.00		$5,526.32	$1,052.63	$66,315.80	$94,736.80	$663,158.00

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