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Public Acceptance of Fuel Efficient and Economically Sound Automobiles

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Abstract

This project proposes a study into alternative fuel sources and also questions the educational level of the general public concerning hybrid technology. A thorough background investigation was done on the current state of alternative power sources for automobiles with a concentration on hybrid technology. This background information was used to develop a survey to evaluate and educate the public. The results of this survey concluded that people educated about hybrid technology have a greater desire to learn about it.

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1 Introduction

The world has an unhealthy reliance upon fossil fuels. Hundreds of thousands of gallons of crude oil are used yearly to heat our home, fuel our cars, and power our lives. There are several problems with using fossil fuels [21]. Their combustion produces particulate matter, which is blamed for causing a variety of human respiratory disease, and several toxic chemicals including carbon dioxide, nitrous oxides and sulfur oxides, are responsible for global warming and other environmental problems [21]. Global warming occurs when greenhouse gases, such as those released in the burning of fossil fuels, gather in the upper atmosphere and act as a barrier that insulates the earth and causes the global temperatures to gradually rise [13]. As the earth's temperature rises, some ecosystems are unable to adapt and slowly become extinct. If the temperature becomes high enough, the polar icecaps would melt causing the sea level to rise which in turn would cause oceans to move inland, submerging large areas of land. Environmental damage is, however, not the only problem caused by fossil fuel consumption.

Another problem that results from relying on fossil fuels is that there are limited reserves, which will eventually become exhausted [21]. As we continue to use our natural oil reserves, there is a growing need for new technologies that will alleviate our dependency on fossil fuels. Transportation, which consumes approximately 27 percent of the energy used in the United States, is entirely dependent upon oil [21]. Considerable progress has been made in reducing the energy requirements of transportation [11]. Advancements in alternative fuel sources, and alternative and hybrid power technologies could provide a viable means of slowing our oil consumption and possibly even eliminate our need for fossil fuels.

Although there are a number of alternative power technologies that could be used for transportation vehicles, hybrids and diesels are the two most common and readily available [25]. Hybrid technologies incorporate multiple fuel sources to power engines, thus creating a more fuel efficient motor [27]. Recent studies comparing the Honda Civic Hybrid with the Honda Civic show that the incorporation of hybrid technology into

already manufactured cars can reduce gasoline consumption up to 107 gallons annually (based on 12,500 miles driven per year) [2]. Although this technology is relatively new, great advancements in fuel conservation have been made. The United States alone uses approximately 131 billion gallons of gas a year [18]. If all the non-hybrid automobiles were to change to the new, more fuel efficient technology, there would be a savings of 10.7 billion gallons annually [18]. It is proposed that if every car owner in the United States were to switch over to a hybrid alternative, the world's known oil reserves would be extended a minimum of 15 years, based on current world fuel consumption trends [30]. With the rate of current oil usage, the world's known oil supply is estimated to be exhausted by the year 2056 [8]. In addition to the advancement and implementation of hybrid technology, there have also been breakthroughs in the development of more efficient motors and alternative fuels. Another benefit from hybrid technology is that their advanced fuel efficiency leads to fewer and less toxic emissions [11]. Other ways for improving upon the current automotive engines have been examined.

Diesel engines were engineered over one hundred years ago as a fuel efficient alternative to gasoline [25]. While being more fuel efficient, diesel engines produce more pollutants. Some engineers have enhanced standard diesel engines with new components that reduce harmful emissions while maintaining their fuel efficiency [9]. Others have developed cleaner alternative fuel sources, including the development of bio-fuels [7]. Bio-diesel, an alternative to petroleum derived fuel, is produced from organic material and emits forty seven percent fewer pollutants when burned [7]. While there has been significant advancements in diesel technology, there has also been much research into the development of other forms of fuel and ways to increase the efficiency of engines.

1.1 Project Goals

We propose that a study of the public acceptance of fuel efficient and environmentally sound forms of transportation would be a worthwhile endeavor considering that this technology could alleviate or even eliminate our oil dependency. There are multiple applications for hybrid technology; currently, the most important of those is the broad

area of public, personal, and commercial transportation. Presently, automobiles are the largest consumers of fossil fuels considering that they rely on gasoline as a fuel source [11]. Since hybrid engines increase fuel efficiency, the harmful emissions associated with gasoline combustion are minimized as well as the amount of money spent on fuel is reduced [27]. With the known benefits of hybrids cars we pose the following questions: “Why don’t more people own them? Is it a result of inadequate knowledge, apprehension due to cost, hesitation due to the young state of the technology or are there other underlying reasons?” We used general survey tools and education of a sample of the general population to provide us with an insight into the thoughts of consumers.

2 Literature Review

In the past decade, there has been a tendency to buy large vehicles such as Sport Utility Vehicles (SUV) and pickup trucks [31]. These vehicles are less efficient and contribute largely to air pollution [31]. It has reached a point in our nation's history where it is not uncommon to see gas prices over $2.00 per gallon. With the high influx in gas cost, consumers have increased incentive to purchase more efficient alternatives to standard vehicles. Automotive companies have begun to address this demand with the development of alternative fuel sources and hybrid technology [11]. Although, these technologies are cutting edge and still in development, a considerable amount of information is accessible through multiple avenues, including industry and government reports, peer-reviewed publications, and prior student project reports (IQPs) including, "Hybrid Cars: Fuel Economy", "Biodiesel and Alternative Fueling", and "Clean Urban Transport for Europe: A Case Study" to support our findings.

It is estimated that the current rate of fuel consumption will result in the depletion of the world's petroleum reserves by the year 2056 [8]. The majority of automobiles are powered by internal combustion engines [24]. Internal combustion engines use either gasoline or diesel fuel, both derived from petroleum, to power the vehicle. The combustion of these fuels depletes our world's oil reserves as well as releases pollutants into our air and water [12].

2.1 Current Automotive Environmental Impacts

In America there are over 204 million commercially and privately owned automobiles most of which rely upon fossil fuels to power their engines [18]. These vehicles burn fossil derived fuels which release harmful gases into the atmosphere contributing to the already growing ozone problem, the Green House Effect, acid rain and over-all air pollution [13]. Each of these vehicles expels harmful gasses including carbon dioxide, approximately 7,000 pounds of carbon dioxide per year (based on the 12,500 miles driven annually) (Table 1) [2]. This is a global problem that is only escalating with time.

If the current emission levels are not reduced, it will not be long until most of the world experiences smog similar to that which occurs in Los Angeles. With its citizens driving more than half of the world's cars [11], the United States needs to take steps to reduce these harmful emissions.

	Fuel* (estimated per year)	**Vehicle emissions** (estimated, per year in pounds)			
	Consumption	Carbon dioxide	Carbon monoxide	Nitrogen oxides	Hydro-carbons
2003 HONDA CIVIC HYBRID (47.7 mpg, SULEV) 12,500 miles/year	263 gal	5,089 lb	79.9 lb	0.8 lb	0.8 lb
2003 HONDA CIVIC (33.8 mpg, ULEV) 12,500 miles/year	370 gal	7,176 lb	135 lb	7.4 lb	3 lb

Table 1 - Honda Civic - Gas vs. Hybrid [2]

2.2 Internal Combustion Engines

In order to understand how to improve on our current automotive technology it is first necessary to understand how many of the alternative types of automotive engines work. Although the focus of our study is mainly hybrid technology, a description of gasoline, diesel, and rotary engines is provided, along with alternatives to these fundamental types of engines.

2.2.1 Gasoline Engine

The majority of automobiles today are powered by gasoline internal combustion engines. These engines follow a four stroke combustion cycle which converts the energy of fuel combustion into the mechanical energy of motion [24]. The four steps of this cycle are: intake, compression, combustion, and exhaust [24]. The intake stroke moves the piston down to take in air mixed with a small amount of gasoline. This fuel/air mixture is then compressed to create a more powerful explosion. A sparkplug emits a spark to ignite the compressed mixture and drive the piston down. Once the piston reaches the bottom an

exhaust valve opens to release exhaust out the tail pipe. This cycle is repeating and occurs for each cylinder in the engine [24].

2.2.2 Diesel Engine

Diesel Engines are the second most common automotive engine today [25]. They are very similar to gasoline engines, however they do not use a sparkplug to ignite the fuel. Instead, a diesel engine intakes and compresses the air separately [25]. Heat is produced when the air is compressed. A gasoline engine compresses the fuel air mixture at a ratio of 8:1 to 12:1 [4]. This is low enough so the fuel/air mixture will not spontaneously combust and will be ignited by the sparkplug. Since the diesel engine compresses only air, it is able to do so at a ratio of 14:1 to as high as 25:1 [4]. This higher compression causes the fuel to ignite when injected into the cylinder. This higher compression leads to a more efficient burn and creates more power in its combustion [25]. Gasoline engines can have higher compression ratios but in order to prevent spontaneous combustion a high octane fuel must be used.

The fuel used by a Diesel Engine is heavier and oilier than gasoline [4]. Diesel fuel also evaporates slower and has a higher boiling point than water. This fuel requires less refining than gasoline which is why it is usually cheaper. Additionally it has a higher energy density than gasoline. On average, 1 gallon (3.8 L) of diesel fuel contains approximately $155x10^6$ joules (147,000 BTU), while 1 gallon of gasoline contains $132x10^6$ joules (125,000 BTU) [4]. The energy density, combined with the improved efficiency of diesel engines, explains why diesel engines get better mileage than equivalent gasoline engines.

2.2.3 Rotary Engine

A rotary engine is like a piston engine except it uses a rotor which spins in one direction instead of pistons which move up and down, Figure 1. A rotary engine still follows the same four steps as a piston engine:

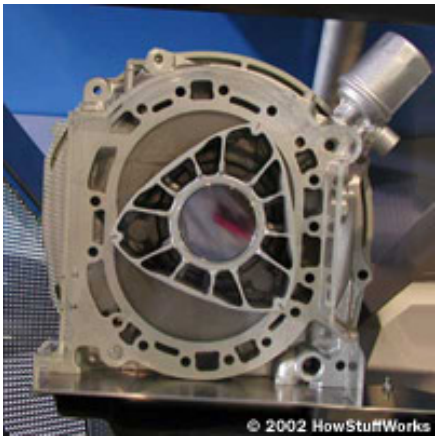

Figure 1 - Rotary Engine [23]

intake, compression, combustion, and exhaust [26]. As the rotor moves through the housing the three chambers created by the rotor change size. This change creates a pumping motion.

Since this engine does not use pistons which switch direction, the concept of a rotary engine continuously spinning could theoretically improve the efficiency of an engine by 50%. This, however, does not occur in the real world. The main reason these are inefficient is because of the low thermodynamic efficiency of the engine caused by the long compression stroke (Figure 2) and the resulting low compression ratio [23].

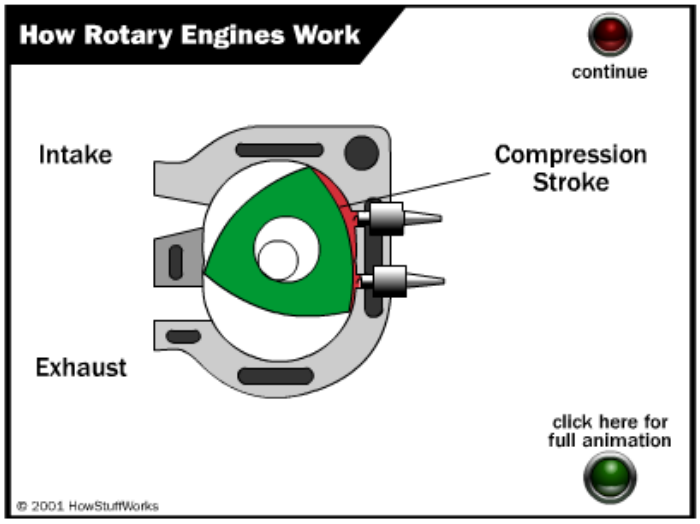

Figure 2 - Rotary Engine Cycle [23]

2.2.4 Improving efficiency in an Internal Combustion Engine

In order to improve the efficiency in an internal combustion engine it is necessary to increase the compression ratio of the engine. Diesel engines achieve this high compression; however, they are a dirtier engine than gasoline engines. This is because they emit high levels of nitrogen oxides (NOx) and particulate matter emissions [24].

Figure 3 - Clean Diesel Engine [9]

Improvements upon this new form of diesel engine have been designed. Clean Diesel Combustion, CDC, encompasses a series of design changes to the diesel engine, which decrease NOx emissions while maintaining or improving engine efficiency (Figure 3) [9]. The key concept of CDC technology is the development of in-cylinder NOx control, where NOx emissions are reduced without decreasing the engine's efficiency [9]. This recent technology may be a way to improve current diesel engines.

2.3 Alternative Energy Options

Even if Clean Diesel technology is able to reduce the emissions created by automobiles as well as increase their fuel efficiency, there is a finite oil reserve and it will eventually run out. This fact has lead to much research into alternative energy sources for powering automobiles.

2.3.1 Electric Engine

Electric engines have been used for powering many devices and can also be used for powering automobiles. Electric cars are composed of an electric motor and a controller [11]. When driven they directly emit zero pollutants. However, electric cars take about 8 hours to charge, can only travel about 50 miles per charge, and have a low top speed [5]. Also, the standard lead-acid batteries used to store the electric energy only last about 3 years and cost about $2000 to replace [5]. Replacing the batteries ends up costing about $0.10 per mile and they cost about $0.02 for recharging per mile. This is much less than the cost of gasoline could ever be. In order to improve their range and top speed, NiMH

(Nickel Metal Hydride) batteries could be used and would last for 10 years, however they cost about ten times as much as lead acid batteries [5].

Despite their drawbacks electric cars seem like a viable option. Although they are only able to travel 50 miles on a charge the average person drives 40 miles or less per day [5]. There are other drawbacks though. When the car runs low on charge it will be necessary for charging stations, similar to gasoline stations, where you can quickly charge your vehicle. This charge would have to be much faster than one from a house hold outlet, but would still take over an hour. The other issue is that, although these cars do not directly cause any pollution, the creation of the electricity to power them does create pollution [21]. For example, 70 percent of the electricity for the United States is created from the combustion of coal, a fossil fuel which will eventually run out [21].

2.3.2 Bio Derived Fuels

Diesel engines are very efficient when it comes to fuel consumption but their emissions leave room for improvement. For this reason many corporations and agencies, including the Environmental Protection Agency (EPA), directed their research efforts towards creating a cleaner fuel for these diesel vehicles. Bio-diesel was first showcased at the 1898 Worlds Fair by Rudolf Diesel, who used peanut oil to fuel a one cylinder flywheel engine [29]. Rudolf showed that it was possible to create a clean burning organic-based fuel that could be used to power engines. The only drawback was that the production of this fuel was quite costly. Today there are many alternative sources of bio-fuels ranging from soybeans, which produce 40 gallons of oil per acre, to algae, which produce 10,000 to 20,000 gallons of oil per acre (Table 2) [29].

Crop	Gal/acre
Soybean	40-50
Mustard	140
Rapeseed	110-145
Palm Oil	650
Algae	10,000 -20, 000

Table 2 - Biofuel Oil per acre [29]

Instead of using an all bio-diesel derived fuel, both civilian and military sectors have experimented with using the high octane bio-diesel as a fuel additive to make regular diesel more efficient [20]. The combustion of bio-diesel emits far fewer pollutants than standard diesel fuel but creating this organically derived bio fuel would require large quantities of plants for its production [20]. An industrial demand for plant based fuels could create a strain on our farmlands and would compete with food-based agriculture.

2.3.3 Hydrogen Fuel Cells

In the search for a readily available and clean running energy source much time has been devoted to hydrogen power. Hydrogen power is derived from a hydrogen power cell that gives off a small electrical charge roughly equivalent to 1.4 volts [6]. This voltage is the result of the hydrogen ion bonding to an oxygen ion. The small electrical charge is far below what would be needed to power an automobile so multiple cells are stacked upon one another in many rows and columns, to supply the power needed. This design minimizes the space need for the hydrogen cells, while at the same time creating a large amount of electrical energy [19]. Hydrogen power is the cleanest form of power for automobiles since its only byproducts are heat and water vapor which are dispersed into the air via the exhaust system [19].

In contrast to using hydrogen's electrical discharge to power automobiles, some major automotive companies have begun testing the likelihood of hydrogen combustion

engines. These engines from Ford are designed to combust hydrogen instead of gasoline [14]. A hydrogen combustion engine emits nearly zero emissions and produces the same power as a comparable gasoline engine because it is equipped with a supercharger and an intercooler. A gasoline engine is about 13 percent efficient while a hydrogen engine can reach, approximately, 38 percent efficiency, a 25 percent increase [14]. This is partly because hydrogen has a very wide combustion range, from 4 to 75 percent. This allows for the engine to use a wider range of fuel to air mixtures than gas engines, and therefore can run in the fuel efficient, lean regime. The engine shown in Figure 4 is based on a current engine used in the Ford Ranger but is modified to combust hydrogen [14].

Figure 4 - Hydrogen Engine [14]

Although the hydrogen combustion engine appears to solve many of the problems inherent to other alternative engines and fuels, there are still challenges. There are three major problems that need to be solved in order to be able to use hydrogen as a fuel [19]. First of all, hydrogen is the lightest of all elements so even under liquid compression the energy density of hydrogen is less than that of gasoline [1]. Due to this fact, the storage of the hydrogen is an issue because one can achieve far less mileage per tank than that of gasoline. Attempts to solve this problem include possible crystallization of hydrogen to provide adequate power capacity for increasing travel distance [1]. Alternatively, others are looking into a source from which hydrogen can be drawn to allow for a larger fuel supply to be carried onboard.

The second challenge in using hydrogen power is that the fuel cells are still very expensive and are not stable enough to be released for general public use. Hydrogen gas is one of if not the most explosive gases and putting it into vehicles, in which hundreds of accidents occur daily, could be the equivalent of mini Hindenburg catastrophes world-wide [15].

The last problem with using hydrogen as a fuel is that hydrogen is not an energy source. Hydrogen is an energy carrier and hydrogen molecules are generated from other fuel sources [6]. This means that hydrogen is not found in the ground like oil is, it is manufactured. A possible way to create the necessary hydrogen is to use electrolysis to separate the hydrogen from water [19]. Electrolysis can be performed anywhere with a water source and electricity and releases no harmful byproducts. However, it requires electricity to separate the hydrogen from the water. Electricity must come from somewhere and currently 68% of the United Stated electricity comes from coal or natural gas [21]. If electricity was also needed for transportation, the demand for electricity would double; therefore, the amount of electricity produced would also need to double [21].

There are many hurdles that need to be overcome for hydrogen to become a viable option in powering our vehicles. This will most likely be accomplished by the implementation of advanced nuclear power plants as well as taking advantage of solar energy through solar cells [21]. Improved technology in these fields could allow all of our electricity needs to be created through renewable resources and therefore make hydrogen power practical. Hydrogen power is a promising technology but will take many years of research to overcome its challenges.

2.4 Hybrid Technology

After reviewing all possible energy sources it can be seen that each has its drawbacks. Rather than relying on one single energy source, multiple sources can be used to achieve the maximum efficiency.

Hybridization is the use of two or more power sources in one engine [27]. The oldest kind of hybridization was used by railroads, with their locomotives running on diesel-electric systems [30]. Hybrid technology has been recently developed for use in automobiles to reduce our dependency on fossil fuels, and to reduce the amount of pollutants created from gasoline combustion [30]. Currently, there are several different hybrid systems that are under development.

2.4.1 Gasoline Electric

The most common hybrid vehicle is the Gasoline Electric. This vehicle uses a small gasoline engine along with an electric motor. In order for the car to move it must have enough power to overcome air resistance and rolling resistance, as well as power accessories like the alternator. An engine only needs about 20 horsepower to this [22]. However, most automotive engines have hundreds of horsepower to handle acceleration. The rest of the time the motor is carrying around the weight and the friction of the vehicle. These factors are what determine how to best create a hybrid vehicle.

In order to have the most efficient gasoline engine it needs to be made smaller than a standard engine. There are many reasons why small engines are more efficient than big engines. One major reason is the weight to power ratio [23]. A big engine is heavier than the small engine and requires more fuel every time it accelerates. The pistons and other internal components in standard engines are heavier and require more energy each time they complete a cycle. The displacement of the cylinders is also larger, so more fuel is required by each cylinder [23]. Since bigger engines are composed of more cylinders and each of these cylinders requires more fuel, they create far more power but are much less fuel efficient [23]. All of these factors reinforce the decision to use a small gasoline engine in hybrid vehicles.

The traditional hybrid engine is a complete electric engine with a small separate gasoline engine [27]. This gasoline engine is very small, perhaps 10 to 20 horsepower, and is designed to run at just one speed for maximum efficiency. The purpose of this small, engine is to provide enough power for the car at its cruising speed. During times of acceleration, the batteries provide the extra power necessary. When the car is decelerating or standing still, the batteries recharge [27]. This sort of hybrid car is essentially an electric car with a built-in gas powered recharger allowing for longer range. The advantage is that the small, efficient gasoline engine gets great gas mileage. There are other ways to configure these engines, but they all follow this same general idea.

In addition to the efficiency of the motors, hybrid vehicles have many other ways to improve fuel economy. Most hybrids automatically turn off the engine when the vehicle comes to a stop and restart it when the accelerator is pressed [22]. Some models such as the 6 cylinder Honda Accord Hybrid will actually shut off three of its six cylinders during cruising, when the extra power is not needed [16]. All hybrids also incorporate many lightweight materials, such as aluminum hoods, and improve the aerodynamics of the vehicle's body to improve upon gas mileage. Additionally, all hybrid vehicles use regenerative braking to recover the energy usually lost to heat during braking [22]. This energy is then stored in the batteries to be used later by the electric motor. Engineers are continuously looking for ways to improve the gas mileage of these vehicles

2.4.2 Diesel Electric

The technology used for gasoline electric hybrids can also be applied to diesel engines. These diesel electric hybrids can be more efficient than their gasoline counterparts. This is because the high compression of a diesel engine creates a more efficient power source than a gasoline engine. Although a diesel electric engine emits far fewer pollutants than a standard diesel engine, diesel engines still emit more pollutants than gasoline. So far this technology is mainly being incorporated into high power applications such as buses and construction vehicles [22]. New technologies such as "Clean Diesel" may be incorporated into these diesel electric hybrids to further reduce their emission levels.

2.4.3 SHEP

Stored Hydraulic Energy Propulsion, or SHEP, is another form of hybrid technology. This technology can be used for large vehicles such as buses and large trucks. Since large vehicles have a much heavier construction, as well as a substantially larger payload, an extremely large amount of energy is needed to accelerate and stop these vehicles. When one presses on the brakes in their car a brake pad applies force to the axle thus stopping the car. The energy of the moving vehicle is converted from kinetic energy to heat energy given off through the friction applied to the axle. SHEP takes advantage of

this heat energy released from braking. When one applies pressure to the brake, the SHEP system converts the kinetic energy into hydraulic energy and stores it in two tanks located under the vehicle near the drive shaft [28]. These tanks pressurize as the vehicle stops and are released to the drive shaft to accelerate it once the gas pedal is pressed. This boost in propulsion relieves stress from the engine thus saving fuel, up to 40 percent, and engine wear. This concept is much like that of regenerative braking except the heat energy released from braking is turned into hydraulic energy instead of electric energy. This option is best applied to things like city buses where braking and acceleration cycles are frequent. Although it may not be the best option for passenger cars, it is considered the most effective way to recover lost energy during braking [28].

The EPA has worked with companies such as Ford Motor Corporation, who uses SHEP components, to implement this same kind of technology into smaller vehicles. Currently, Ford has retrofitted the Expedition Sport Utility Vehicle (SUV) with this hydraulic technology [10]. They project a 55 percent increase in fuel economy and expect it will increase the cost of a large SUV by an additional $600. It would take less than 3 years to recover the increased cost through fuel savings and less brake wear. This is a much cheaper alternative than a gasoline electric hybrid which increases the cost by two to three thousand dollars [10].

2.5 Current State of Alternative Technology

Hybrid technology is a relatively new field with much yet to be learned and gained. There is a vast variety of alternative fuel sources, many of which could positively affect our future environment. Electric cars are no longer a thing of comic books but have become a reality. It was only 1999 when the first gas electric hybrid reached America, Honda Insight, so these cars are still under five years of running.

Over the past 5 years, Hybrids have slowly started appearing more frequently in public places. Theses cars have even been graced with the honor of being the lead cars in the Boston marathon and have acted as the pace car in NASCAR events. The technology has reached a point where there is a substantial difference between a hybrid and its gasoline

counter part. Car companies, unsure of how long these vehicles would last, originally only guaranteed these vehicles for one or two years. Now, hybrids car are coming with 80,000 mile warranties [16]. The original hybrids had a very distinctive aerodynamic and futuristic look which many consumers found unattractive. However, Honda has taken the best selling Honda Civic and created a hybrid version. Now it is possible to get a reliable, attractive vehicle that is not only better for the environment but also needs to be refueled, under ideal condition, once every 650 miles [16].

Although Hybrids were originally limited to sedans and coupes, the automotive industry has made an effort to accommodate a broader clientele. Major automotive manufacturers such as Chevrolet and Toyota have recently released gas-electric pickup trucks [31]. Not to be out done, Ford has declared that they will release the Escape which will be the first Hybrid SUV to reach US soil. Since pickups and SUV's have become a common means of transportation, making these vehicles hybridized will greatly increase their gas mileage and lower their emissions. The new Ford Escape Hybrid achieves 31 to 36 miles per gallon [31] which is a considerable improvement upon its gasoline precursor which EPA ranks at 22 to 25 miles per gallon [31]. These vehicles which have always been know as "gas guzzlers", can now achieve the same gas mileage as many of the smaller non-hybrid vehicles.

2.6 Reasons for Purchasing a Hybrid

Although Hybrid vehicles cost more than their gasoline counterparts, ranging anywhere from $2,000 to $3,000 [16], there still are many reasons to purchase them. Environmentally friendly hybrids create far less harmful emission and burn less gas per mile. This in turn creates fewer harmful gases which contribute to global warming, acid rain, and ozone destruction. Since hybrid emission are so low, some states require half as many emission inspections and also provide a number of other incentives, ranging from free public parking to the elimination of sales tax on these cars [2]. Some states go as far as providing additional tax breaks for individuals who own hybrids [2]. For example, Vermont eliminates sales tax when purchasing a hybrid vehicle [2]. Although these incentives vary from state to state, there are also federal incentives [2].

Hybrids also serve a social purpose. They not only provide a topic of discussion but also help to inform others who are less educated on hybrids. Although price is major deterrent in purchasing a hybrid, the current hike in gas prices increase the incentive for purchasing a fuel efficient vehicle. Depending upon gas prices, and fuel efficiency of a car it has been calculated to take anywhere from 12-14 years to recover the difference in price (based on the 12,500 miles driven annually) [2]. Purchasing a hybrid may not be a practical means to save money but it does provide many other benefits, such the ability to drive over 600 miles on a single tank of gas [16], and less damage to the environment. Furthermore, the hybrids on board computer provides an instantaneous feedback display of efficiency thereby enabling the driver to learn how to drive most efficiently [22].

2.7 Future of Alternative Energy Technology

Although there are many types of technologies available, there are only a few available to the public, and only a few really viable fuel sources that could alleviate U.S. oil dependency or even eliminate it completely. Since this is an active area of research, it is difficult to predict where it will lead. In dealing with bio-derived fuels there has been a road block due to the fact that the production of the organic oils requires expansive farmlands to grow the required organic material. Clean Diesel is one of the most promising of the alternative power sources discussed thus far. Since Clean Diesel is enhancing the conventional diesel engines it provides a cleaner, more efficient, power source which could be very beneficial once it has been implemented. Stored Hydraulic Energy Propulsion systems (SHEP) seem to be the most worthwhile advancement in the alternative power source field. The only foreseeable draw back to these systems is that they are most beneficial when applied to larger automobiles such as trucks, buses and sport utility vehicles. Although the previously described alternatives seem promising there appears to be two other alternatives that have more advantages than the other options, these being hydrogen power and hybrid electric.

Hybrid technology has reached a state where it is comparable to gasoline powered vehicles and in some cases even surpasses its counterpart. Hybrid electric vehicles, however, only alleviate our oil dependency temporarily. Even though hybrid electric vehicles use less gasoline than normal cars, they still rely upon finite oil reserves that will be exhausted in the future. That is why there is much hope in hydrogen technology. Right now the biggest hurdle facing hydrogen powered vehicles is the storage and production of hydrogen. Although transporting hydrogen has been made safer, it is still not safe enough for use by the general public. Use of hydrogen crystals, a solid hydrogen fuel source, may solve the transportation problem. Production of hydrogen, however, is still a major problem because it requires an initial energy source such as fossil fuels, solar or even, nuclear power. The implementation of hybrid cars, although attractive, actually only increases the development window for production of a practical hydrogen car. In the end, the most fruitful alternative will be hydrogen technology since hydrogen burns cleanly and will ultimately not be fossil fuel reliant.

3 Project Methods

The primary purpose of this project was to develop an educational resource that could be used to educate public perception about on alternative automotive power sources. This information will enable consumers to make better educated automotive purchases. Since these new technologies require less fossil fuel and produce fewer emissions, everyone can benefit. We believe that a more informed public will be apt to purchase these viable alternatives. With the public more educated towards fossil fuel consumption and their repercussions it gives the public the power to decide their future.

3.1 Overview

To accomplish these goals, we pursued various forms of investigation. In our search for information we surveyed the general public, spoke with automotive specialists, and explored published literature. The initial phase of this project consisted of familiarizing ourselves with the workings of all forms of automotive engine technology, including hybrid technology and alternative energy sources, to establish an understanding of the

state-of-the-art. From this information a fact sheet (Figure 5) was constructed with the pertinent information relevant to hybrid automotive technology considered to be important to the average citizen. Two surveys were also constructed to determine the level of public awareness. Once the initial phase of this survey (Figure 6) was completed, the subject was presented with a fact sheet which they were instructed to read. They then completed the second phase of the survey (Figure 7) to determine whether the participants' understanding of hybrid technologies has changed. The two surveys are expected to provide a valuable insight into what consumers consider important when purchasing automobiles, while also providing us with the public's current level of perception of hybrid technology.

Facts

- With our current rate of fuel consumption, the world's known oil supplies will run out within 50 years.
- Transportation accounts for 2/3rds of the US Petroleum use.
- The new Honda Accord Hybrid actually is more powerful than the Honda Accord.
- Hybrids charge themselves while driving so there is no need to plug them in.
- Regular gasoline currently costs an average of $1.99 in New England.
- The Honda Civic Hybrid saves 107 gallons per year over the Honda Civic (based on 12,500 miles driven per year).
- Hybrid cars can travel further than a standard car before refueling.
- Hybrids emit less acid rain and green house causing pollutants, than standard cars.
- There tend to be higher warranties on hybrid automobiles, approximately 80,000 miles.
- An improvement of 7.6 mpg on all American automobiles would eliminate need for foreign oil.
- Many states offer tax deductions for purchasing hybrids, while others provide benefits such as specialized parking or driving privileges for hybrid drivers.
- Hybrids are now available as coupes, sedans, SUVs, and trucks.
- Hybrids cost on average $3000 more then their gasoline power alternatives.
- Some states' public buses and delivery trucks run on hybrid technology.
- Since hybrids use regenerative braking, brakes are changed less frequently.

Figure 5 - Survey fact list

Alternative Energy Automobiles

About You

1. Gender: ☐ Male ☐ Female
2. Age: ☐ 16-20 ☐ 20-30 ☐ 30-40 ☐ 40-50 ☐ 50+
3. Education Level: ☐ Some High School ☐ High School Grad. ☐ Some College ☐ College Grad.
   ☐ Graduate School ☐ Other: _____
4. Do you own a car? ☐ Yes ☐ No (skip 5 and 6)
5. What type of vehicle do you drive? ☐ Sedan/Coupe ☐ Truck/Van ☐ SUV/Minivan
   5a. Is it a hybrid? ☐ Yes ☐ No
6. How many miles do you drive per week? ☐ <100 ☐ 100-200 ☐ 200-300 ☐ 300+
7. How much money do you spend on gas per week?
   ☐ <$20 ☐ $20 - $40 ☐ $40 - $60 ☐ $60+
8. I plan on buying a car within: ☐ 1 year ☐ 1-2 years ☐ 2-3 years ☐ 3-4 years ☐4+years

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Public Knowledge					
I have a general understanding about hybrids.	☐	☐	☐	☐	☐
I would like to know more about hybrids but don't know where to find the information.	☐	☐	☐	☐	☐
Hybrid technology is too much of a risk at this point due to its infancy.	☐	☐	☐	☐	☐
If given the choice, I would choose a hybrid over its gasoline counterpart.	☐	☐	☐	☐	☐
Hybrid cars are better for the environment than regular cars	☐	☐	☐	☐	☐
I am willing to purchase a hybrid car.	☐	☐	☐	☐	☐
As a consumer, my next car will most likely be a hybrid	☐	☐	☐	☐	☐
A hybrid Vehicle is any vehicle which uses multiple sources of energy for power.	☐	☐	☐	☐	☐
Hybrids need to be recharged nightly by plugging them in to an electric power source.	☐	☐	☐	☐	☐
Hybrid cars emit less carbon dioxide, which leads to global warming	☐	☐	☐	☐	☐
Hybrid cars have significantly less horsepower than their gasoline counterparts	☐	☐	☐	☐	☐
Hybrids are less efficient in the city	☐	☐	☐	☐	☐
Hybrid can only go up to 200 miles before refueling	☐	☐	☐	☐	☐

Rate your automobile priorities from 1 to 5, with 1 being most important and 5 least important

Gas Mileage	_____	Cost	_____	Emissions	_____
Towing Capacity	_____	Occupancy	_____	Cargo Room	_____
Safety	_____	4 WD ability	_____	Reliability	_____
Life of Vehicle	_____	Appearance	_____		

Figure 6 - Phase I of survey.

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
After hearing these facts...					
I feel that I had many misconceptions regarding hybrid vehicles.	☐	☐	☐	☐	☐
I would like to learn more about hybrid and/or alternative energy vehicles.	☐	☐	☐	☐	☐
I am willing to purchase a hybrid car.	☐	☐	☐	☐	☐
As a consumer, my next car will most likely be a hybrid	☐	☐	☐	☐	☐
Prior to the fact list I found my knowledge about hybrids to be average.	☐	☐	☐	☐	☐
I believe most people are under informed about hybrids.	☐	☐	☐	☐	☐
Consumers would be more apt to purchase a hybrid if they knew more about them.	☐	☐	☐	☐	☐
I found this presentation to be informative as it corrected some misconceptions of mine.	☐	☐	☐	☐	☐

COMMENTS:

_____

_____

_____

_____

_____

Figure 7 - Phase II of survey.

3.1 Targeted Survey Group

The implementation of our survey began with identifying public or privately owned locations with ample and diverse quantities of subjects. We compiled a listing of possible locations that would allow us to survey a total of 50 males and female of diverse age groups, and then attempted to poll each area. Upon visiting our first locations, which were local malls, we requested use of their facilities but were denied due to their no solicitation policies. Next we visited a national department store whose management allowed us to survey outside their establishment. Following this was a grocery store with the same no solicitation policy as the malls. We continued on to a public library that rejected our attempt to poll its occupants. We found that dealing with locations tied to corporations were difficult due to the inability of the local personnel to make decisions independent of the major and distant management. We decided to limit our research to privately owned businesses, public parks, and college campuses. We had much greater success in polling these locations than in our previous trials. After obtaining 47 surveys,

we evaluated each survey for any inadvertent mistakes that could possibly affect our analysis. For example, a few subjects accidentally inverted their rankings for automobile priorities so the results were inverted to obtain accurate results.

3.2 Data Analysis and Statistical Tests

After receiving all the surveys, we first tried to sort them into 10 year age intervals; 16-20, 20-30, 30-40, 40-50, 50+, with each of these groups divided into male and female. Unfortunately, these groups produced too few samples in order to do any statistical tests on them, so we decided to examine the data into two different sets, age and gender. Later, it was decided to also look for significant differences in the data based upon education level. The education set was divided into five different groups: some high school, high school graduate, some college, college graduate, and graduate school.

We decided that only 9 questions were going to be examined. From the pre-educational survey, we choose the following five questions: "I have general understanding about hybrids", "I would like to know about hybrids but don't know where to find the information", "If given the choice, I would choose a hybrid over its gasoline counterpart", "I am willing to purchase a hybrid", and "As a consumer, my next car will most likely be a hybrid". In the post-educational survey the first four questions were chosen in order to determine if the brief education we supplied had any impact upon the perceptions of the subject. The question "I feel that I had many misconceptions regarding hybrid vehicles" was paired up with "I have a general understanding about hybrids" to see if people felt they knew about hybrids but realized that they did not. "I would like to learn more about hybrid technology and/or alternative energy vehicles" and "I would like to know about hybrids but don't know where to find the information" were compared to see if the subject's desire to learn about hybrids increased afterwards. "If given the choice, I would choose a hybrid over its gasoline counterpart" was chosen because people might have felt more inclined to buy hybrids that seem like the more traditional automobile. The two " I am willing to purchase a hybrid" questions were compared to see if people were at least interested in purchasing a hybrid. And lastly, the

two question of “As a consumer, my next car will most likely be a hybrid” were compared to see if people were going to buy a hybrid and if that desire increased after hearing a little bit about hybrid technology and its benefits.

After choosing these questions, we then obtained the mean and standard deviations for all the groupings in the three sets. A t-test was used to compare differences between the means and see if there were any differences both between groups, like males and females and between the 20 year olds and people over 50, as well as to see if the education we provided increased interest in hybrid technology and/or willingness to purchase hybrids. These tests were done at 95% confidence, $p = 0.05$. In order to do the T-tests on the information, a scale was needed to rank the responses in a numerical way. A response of strongly disagree was giving the value 1, disagree a 2, neutral was 3, agree received a 4, and strongly agree was a 5.

4 Study Results

4.1 Study Group Demographics

After receiving the results from the surveys, it was decided to examine the data according to three different demographic groupings: gender, age, and education. The sample population was roughly 68 percent male and 32 percent female. Age groups were roughly equal with slightly more people between 20 and 30 years of age (Figure 8). The education was mostly college level, which was to be expected considering that the population of interest was 16 years of age and older, so the majority of that age bracket is in college or has post graduate education (Figure 9).

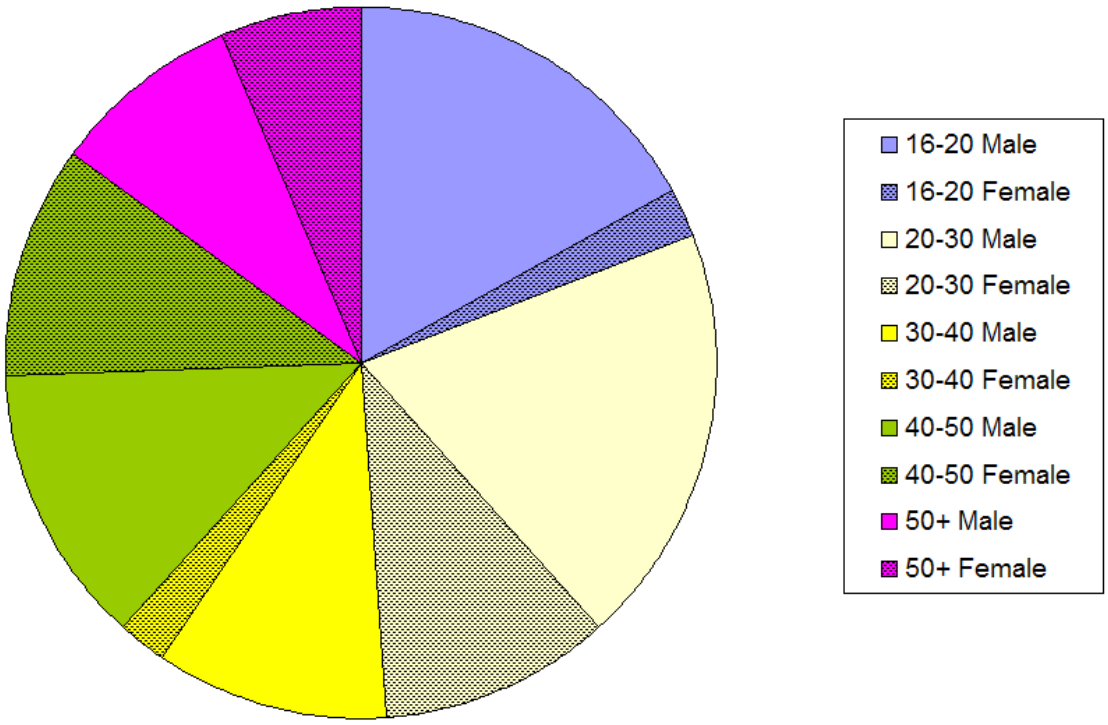

Figure 8: Distribution of age and gender in the respondent sample.

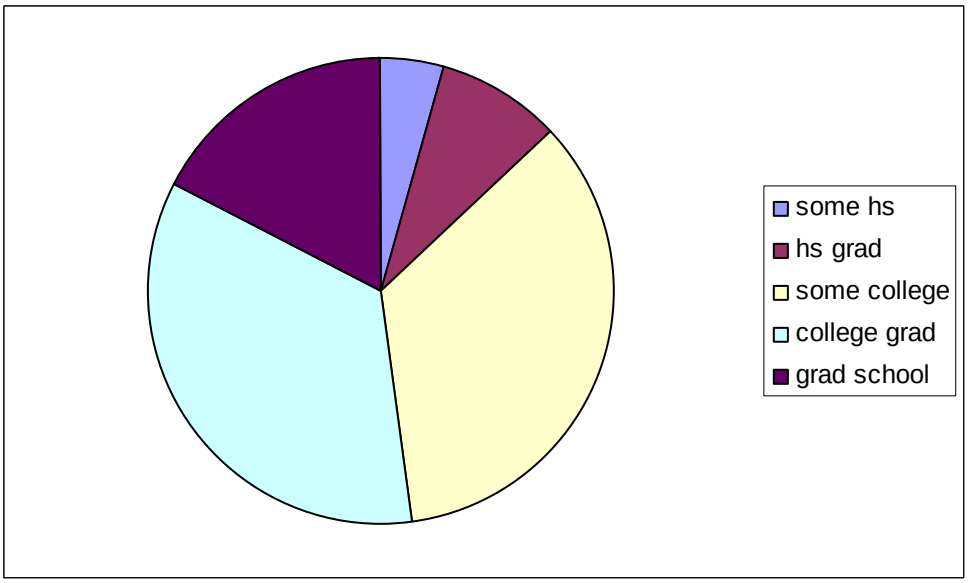

Figure 9: Educational level of respondent sample

4.2 Male vs. Female

Several trends were noticed in our data, when comparing gender (Figure 10). The males seemed to feel more knowledgeable about hybrid technology, although, the females seemed to be more willing to learn about hybrid technology. While these differences were noted they were not statistical significant. In comparison to the differences between male and female, the only difference of significance was between the likelihood of purchasing hybrids after reviewing our survey. Females were significantly higher in their likelihood of purchasing a hybrid car (Figure 10).

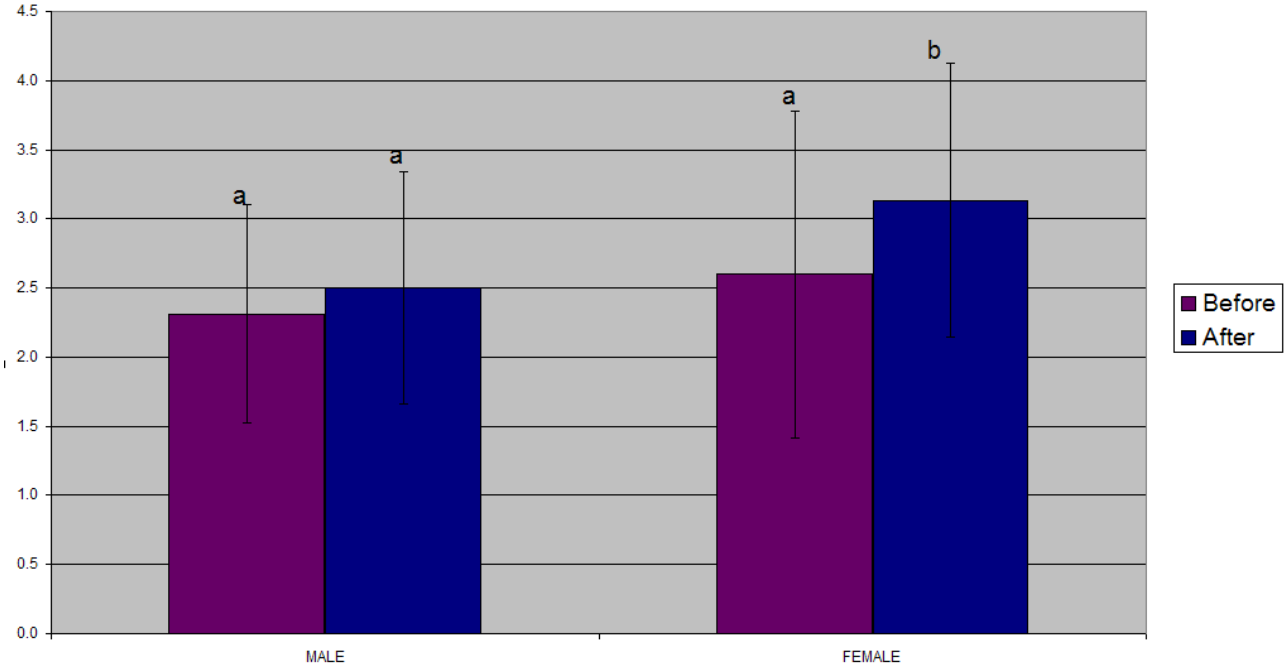

Figure 10 - Gender differences in the likelihood of purchasing a hybrid car before and after education.

This graph shows the typical likelihood of males and females purchasing a hybrid automobile before and after reading the facts sheet. A score of 3 would mean the individual felt neutral about purchasing a hybrid. Greater then 3 means a greater chance of purchasing a hybrid; numbers less than 3 represents a lower chance of purchasing a hybrid. The letters indicate statistical difference (p=0.05). Bars with the same letter mean no difference between them.

It was also found that the change in the desire of both genders to learn about hybrid technology significantly increased after learning about more about hybrid technology (Figure 11).

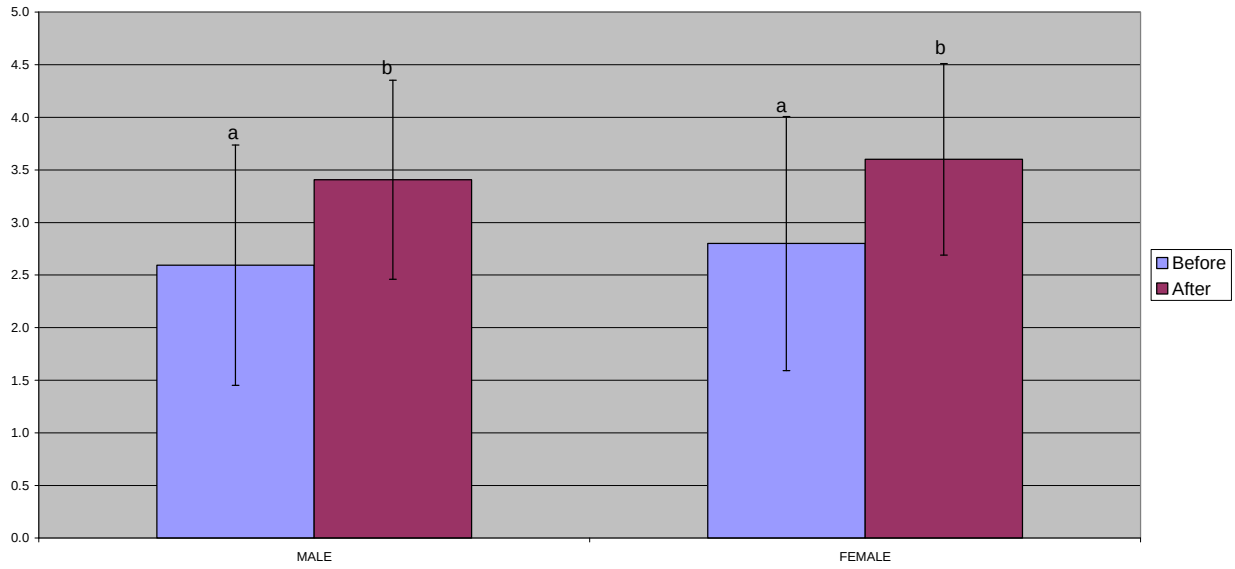

Figure 11 - Gender differences in the desire to learn about hybrid technology before and after education.

This graph shows the desire of males and females to learn about hybrid automobiles before and after reading the facts sheet. A score of 3 would mean the individual felt neutral in this desire to learn. Greater then 3 means a greater desire to learn, numbers less than 3 represents a lower desire to learn. The letters indicate statistical difference (p=0.05). Bars with the same letter mean no difference between them.

4.3 Age Differences

When different age groups were compared, the only significant result occurred with people's interest in hybrid technology. Although, most people were interested in hybrid technology, those older than 50 years of age had significantly more interest in learning about hybrids than people younger then 30. It was also observed that the 20-30 year old group and the 40-50 year old group showed a significant increase in their desire to learn about hybrid technology after reading the fact sheet (Figure 12). Although, other age categories showed increased interest in hybrid technology after our short educational program, the difference was not significant.

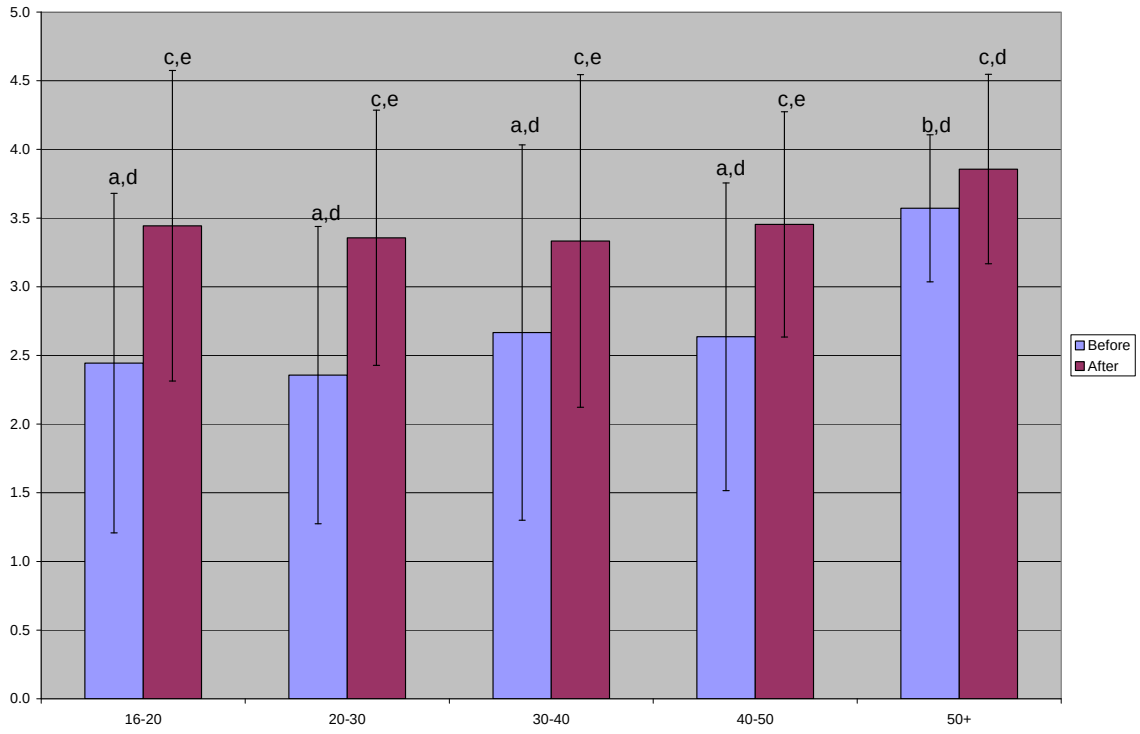

Figure 12 - Effect of respondents age on the change in desire to learn before and after reviewing the facts sheet about hybrids.

This graph shows the desire based upon age to learn about hybrid automobiles before and after looking over the facts sheet. A score of 3 would mean the individual felt neutral in this desire to learn. Greater then 3 means a greater desire to learn; numbers less than 3 represents a lower desire to learn. The letters indicate statistical difference(p=0.05). Bars with the same letter mean no difference between them. a,b = changes between "before" groups; c = no changes in "After" groups; d,e = change between "Before" and "After" groups at each age interval.

4.4 Education

When we examined the differences between a person's interest in hybrid technology based upon their educational level we found that the initial interest of college students and graduates was significantly higher than that of the high school students. Although, all of the samples showed an increase in their desire to learn about hybrids only those who were either in college or college graduates had a significant increase (Figure 13).

Unfortunately, the data from this series of analyses are not really complete. For the two groups who had some high school education or graduated from high school, the sample size was not large enough with only 4 and 2 responses, respectively. The group who had

graduate degrees was also a little small, containing only 8 individuals. This made statistical analysis challenging.

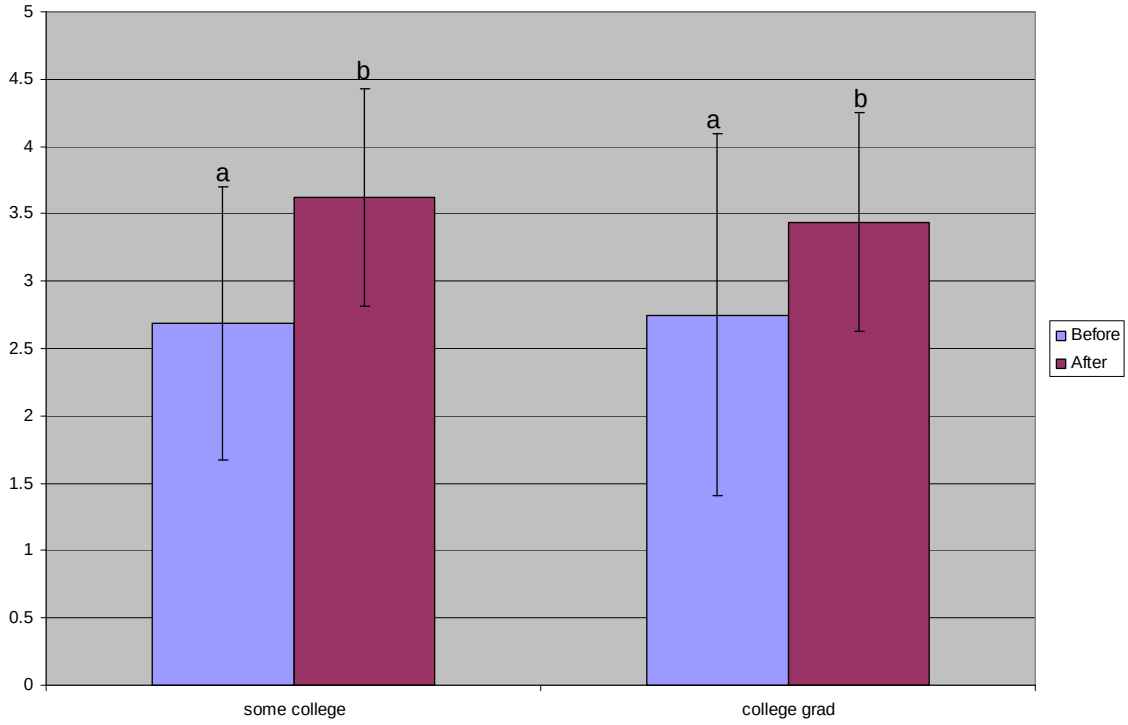

Figure 13 - Effect of educational level on desire to learn about hybrids before and after reviewing fact sheet.

This graph shows the desire of person based upon educational level, in college or graduated from a 4 year school, to learn about hybrid automobiles before and after looking over the facts sheet. A score of 3 would mean the individual felt neutral in this desire to learn. Greater then 3 means a greater desire to learn, numbers less than 3 represents a lower desire to learn. The letters indicate statistical difference(p=0.05). Bars with the same letter mean no difference between them.

5 Conclusions

Our study found that people educated about hybrid technology have a desire to learn more about it. JD Power and Associates did a similar study which showed that people knew about the existence of hybrid and clean diesel technology [17]. The combination of their study with ours suggests that most people know about the existence of hybrid technology and that educating them about hybrids increases their desire to learn more about this novel technology [17]. This suggests that increased accessibility to information about hybrids would increase public acceptance. Once public acceptance of hybrid technology increases, fears and apprehensions regarding hybrids will diminish and consumers will be more apt to purchase them.

6 Recommendations for Increasing Hybrid Awareness

Although most of the information we found came from a variety of sources, we believe that if automotive companies were to make the information more available to consumers, hybrid sales would increase as more people would learn about the environmental benefits of hybrids and how they work. In speaking with our survey subjects we found that many of them did not know where to find information about hybrids. We propose that a three pronged approach should be used to educate the public.

First, car manufacturers could develop a national tour that could stop by malls, fairs, car dealerships, beaches, and nearly any place where the public gathers. For example, Honda Motor Company sponsored a music tour using concerts to target youth groups about the Honda Civic in 1998 [33]. During these national tours the audiences could become acquainted with this new technology. Informational presentations would take place in which participants could earn prizes such as t-shirts or toy hybrid cars. These prizes would advertise the cause and provide a means of disseminating a hybrid informational webpage address. Upon the conclusion of each presentation, pamphlets would be made available for those interested in learning more. The second approach would consist of developing an infomercial / documentary in which viewers can see how hybrid technology arose, where it is going, and the current implementation of hybrid technology in automobiles. This could be done for public television and could play at tour stops along the way. As the public becomes more accustomed with hybrid technology fewer misconceptions will arise and their interest will increase. Last, a webpage should be designed summarizing the advancements in hybrid technology and all of its benefits.

Other suggestions would be:

1. Hybrid Giveaway – During the hybrid awareness tour, visitors have the option of filling out a contest entry form in which they would be entered to win a hybrid car, donated by a manufacturer. The winner(s) of the contest would be announced during a movie sponsored by the manufacturer, aired during

primetime. This movie would be family oriented and hybrid technology would be advertised during its commercials.

2. Soft drink and fast food companies could be paid to advertise hybrids on their product as well as include a chance to win various hybrid oriented prizes upon purchasing one of their products
3. Hybrid appearances in the media – Hybrid manufactures could donate their vehicles for use in movies, television shows, sporting events, as well as in games.

The incorporation of these types of advertising would raise public awareness and educations level concerning hybrid technology, thus increasing the overall sales and broader use of hybrids.

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9 Appendix

9.1 Raw data organized in spread sheet format.

	16-20 M	16-20 F	20-30 M	20-30	30-40 M	30-40 F	40-50 M	40-50 F	50+ M	50+ F
number	8	1	9	5	5	1	6	5	4	3
PK 1	34	4	34	21	18	5	22	19	15	7
PK 2	19	3	22	11	11	5	17	12	14	11
PK 4	28	4	25	18	10	4	17	15	13	8
PK 6	27	3	31	18	15	4	20	17	13	8
PK 7	19	2	22	16	8	3	15	12	10	6
AF1	15	3	27	11	12	4	18	15	14	12
AF2	28	3	29	18	16	4	21	17	15	12
AF3	28	3	29	19	16	4	21	18	13	10
AF4	22	2	22	17	11	3	16	16	9	9
AVG										
PK1	4.250	4.000	3.778	4.200	3.600	5.000	3.667	3.800	3.750	2.333
PK2	2.375	3.000	2.444	2.200	2.200	5.000	2.833	2.400	3.500	3.667
PK4	3.500	4.000	2.778	3.600	2.000	4.000	2.833	3.000	3.250	2.667
PK6	3.375	3.000	3.444	3.600	3.000	4.000	3.333	3.400	3.250	2.667
PK7	2.375	2.000	2.444	3.200	1.600	3.000	2.500	2.400	2.500	2.000
AF1	1.875	3.000	3.000	2.200	2.400	4.000	3.000	3.000	3.500	4.000
AF2	3.500	3.000	3.222	3.600	3.200	4.000	3.500	3.400	3.750	4.000
AF3	3.500	3.000	3.222	3.800	3.200	4.000	3.500	3.600	3.250	3.333
AF4	2.750	2.000	2.444	3.400	2.200	3.000	2.667	3.200	2.250	3.000

	Overall	Male	Female	16-20	20-30	30-40	40-50	50+
number	47	32	15	9	14	6	11	7
PK 1	179	123	56	38	55	23	41	22
PK 2	125	83	42	22	33	16	29	25
PK 4	142	93	49	32	43	14	32	21
PK 6	156	106	50	30	49	19	37	21

PK 7	113	74	39	21	38	11	27	16			
AF1	131	86	45	18	38	16	33	26			
AF2	163	109	54	31	47	20	38	27			
AF3	161	107	54	31	48	20	39	23			
AF4	127	80	47	24	39	14	32	18			
AVG		**MALE**	**FEMALE**	**16-20**	**20-30**	**30-40**	**40-50**	**50+**			
PK1	3.809	3.844	3.733	4.222	3.929	3.833	3.727	3.143	Pre 1		
PK2	2.660	2.594	2.800	2.444	2.357	2.667	2.636	3.571	Pre 2		
PK4	3.021	2.906	3.267	3.556	3.071	2.333	2.909	3.000	Pre 5		
PK6	3.319	3.313	3.333	3.333	3.500	3.167	3.364	3.000	Pre 3		
PK7	2.404	2.313	2.600	2.333	2.714	1.833	2.455	2.286	Pre 4		
AF1	2.787	2.688	3.000	2.000	2.714	2.667	3.000	3.714	Post 1		
AF2	3.468	3.406	3.600	3.444	3.357	3.333	3.455	3.857	Post 2		
AF3	3.426	3.344	3.600	3.444	3.429	3.333	3.545	3.286	Post 3		
AF4	2.702	2.500	3.133	2.667	2.786	2.333	2.909	2.571	Post 4		
STD		**MALE**	**FEMALE**	**16-20**	**20-30**	**30-40**	**40-50**	**50+**			
PK 1		0.954	1.032	0.667	0.829	1.472	0.786	1.215			
PK2		1.143	1.207	1.236	1.082	1.366	1.120	0.535			
PK4		1.313	1.223	1.667	1.329	1.032	1.045	1.155			
PK6		1.030	1.113	1.414	1.092	0.753	0.809	1.155		*	
PK7		0.792	1.183	1.000	1.016	0.753	1.036	0.756			
AF1		1.203	1.195	1.000	1.069	1.211	1.183	1.254			
AF2		0.946	0.910	1.130	0.929	1.211	0.820	0.690			
AF3		1.004	1.121	1.236	1.158	1.211	0.820	0.951			
AF4		0.842	0.990	1.118	1.051	0.816	0.816	0.787			

df	**M/F**	**Sig**	**Ages**	**DF**	**SIG**	**ages**	**df**	**sig**	**ages**	**df**	**sig**
PK 1	25	no	20-+	8	yes=96.6						
PK2	26	no	30-+	18	yes=98%	20-+	11	yes=97.8%	50-+	15	yes
PK4	29	no	20-40	12	yes=95%						

PK6	25	no	30-+	11	no	
PK7	20	no	30-40	12	yes	
AF1	27	no	20-+	11	yes=99.4%	
AF2	28	no	40-+	7	no	***
AF3	24	no	50-+	12	no	
AF4	23	yes=97.7%	40-50	10	no	

b/a pk2af2	**MALE**	**FEMALE**	**16-20**	**20-30**	**30-40**	**40-50**	**50+**
df	59	26	4	25	9	18	11
t	3.1	2	1.8	2.6	0.9	2	0.9
sig	yes	yes	no	yes	no	yes	no

sum	**some HS**	**HS grad**	**S. College**	**College G.**	**grad school**
number	2	4	16	16	8
PK 1	9	17	63	57	29
PK 2	2	10	43	44	25
PK 4	6	8	58	43	23
PK 6	7	11	58	49	28
PK 7	4	8	41	37	17
AF1	3	7	41	52	24
AF2	7	11	58	55	28
AF3	8	11	58	54	27
AF4	4	9	47	43	22

avg	**some hs**	**hs grad**	**S. College**	**College G.**	**grad school**
PK 1	4.5	4.25	3.976	3.563	3.625
PK 2	1	2.5	2.688	2.75	3.125
PK 4	3	2	3.625	2.688	2.875
PK 6	3.5	2.75	3.625	3.063	3.5
PK 7	2	2	2.563	2.313	2.125

AF1	1.5	1.75	2.563	3.25	3
AF2	3.5	2.75	3.625	3.438	3.5
AF3	4	2.75	3.625	3.375	3.375
AF4	2	2.25	2.938	2.688	2.75

std	**some hs**	**hs grad**	**s. college**	**college g.**	**grad school**
PK 1	0.707	0.5	0.772	1.263	0.916
PK 2	0	1.732	1.014	1.342	1.126
PK 4	2.828	0.816	1.204	1.195	1.126
PK 6	2.121	1.258	0.957	1.063	0.926
PK 7	1.414	0.816	0.727	1.25	0.641
AF1	0.707	0.957	1.031	1.065	1.511
AF2	0.707	1.5	0.806	0.814	1.195
AF3	0	1.258	0.885	1.147	1.188
AF4	1.414	0.957	0.68	1.078	1.035

s2/n	**some hs**	**hs grad**	**s. college**	**college g.**	**grad school**
PK 1	0.2499245	0.0625	0.037249	0.0996981	0.104882
PK 2	0	0.749956	0.0642623	0.1125603	0.1584845
PK 4	3.998792	0.166464	0.090601	0.0892516	0.1584845
PK 6	2.2493205	0.395641	0.0572406	0.0706231	0.1071845
PK 7	0.999698	0.166464	0.0330331	0.0976563	0.051360125
AF1	0.2499245	0.22896225	0.0664351	0.0708891	0.285390125
AF2	0.2499245	0.5625	0.0406023	0.0414123	0.178503125
AF3	0	0.395641	0.0489516	0.0822256	0.176418
AF4	0.999698	0.22896225	0.0289	0.0726303	0.133903125

		df	**sig**		**df**	**sig**
pk 2	1--5	7	yes	1--3	2	yes
PK 6	2--3	3	no			

AF2	2--3	3	no

	2	4	16	16	8					
b/a	**Some HS**	**HS Grad**	**S. College**	**College G.**	**Grad School**	**some HS**	**HS grad**	**S. College**	**College G.**	**Grad School**
info	1	9	28	24	13	no	no	yes	yes	no
willing	1	10	29	29	13	no	no	no	no	no
will	2	5	29	29	11	no	no	no	no	no

avg	**some hs**	**hs grad**	**s. college**	**college g.**	**grad school**
PK 1	4.5	4.25	3.976	3.563	3.625
PK 2	1	2.5	2.688	2.75	3.125
PK 4	3	2	3.625	2.688	2.875
PK 6	3.5	2.75	3.625	3.063	3.5
PK 7	2	2	2.563	2.313	2.125
AF1	1.5	1.75	2.563	3.25	3
AF2	3.5	2.75	3.625	3.438	3.5
AF3	4	2.75	3.625	3.375	3.375
AF4	2	2.25	2.938	2.688	2.75

9.2 Raw data sheets (Prof. Weathers copy only)