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REVIEW ON ALTERNATIVE FUELS FOR AUTOMOBILES

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Abstract

Steadily escalating gasoline prices, increased environmental concerns, and poor international politics have sparked new interests for alternatively fueled vehicles. There are numerous alternative fuel technologies including gasoline-hybrids, diesels, full electrics, as well as hydrogen and ethanol. These technologies are changing rapidly and consumers are having difficulty trying to decipher which type of vehicle is the most worthy investment. This study provides a simple breakdown of the pros and cons of the alternative fuel technologies as well as a statistical review of the total ownership costs of the vehicle up to 100,000 miles**.**

Keywords: ***Alternative Fuels, Ethanol, Natural Gas, Hydrogen, Hybrid, Fuel Cell, Biodiesel***

1. INTRODUCTION

Increased gas prices as well as greater environmental concerns, have led many Americans to search for better alternatives to the conventional gasoline-powered automobiles. Due to misconception, confusion, and biased public opinion, consumers have been apprehensive towards alternatives such as diesel, gas-electric hybrids, all electric, as well as hydrogen and ethanol. With gasoline prices rising to record highs nation-wide, there has been increased interest in these vehicles. It is evident that clear and unbiased information on this topic is difficult to come by. Through in-depth research including overall life-cycle cost, comparisons, and the analysis of other studies on the matter, the inquiries will be of importance to anyone who owns or is planning to own a passenger or sport utility vehicle. The results will include life costs, cost-to-benefit ratios, vehicle comparisons, and performance statistics. The analysis will be divided into three groups;

20 % city – 80 % highway, and 80% city –20% highway.

1.1. NATURAL GAS

Natural gas is made up primarily of Methane (CH_4) but frequently contains trace amounts of ethane, propane, nitrogen, helium, carbon dioxide, hydrogen sulfide, and water vapor. Natural gas is produced from gas wells or tied in with crude oil production. Currently natural gas is distributed across the United States through a large pipeline but can also be transported via truck, barge, or train. Natural gas can be stored and used as compressed natural gas (CNG) or liquefied natural gas (LNG). There are a number of arguments in favor of the use of natural gas as a motor vehicle fuel. The first set of arguments focuses around the issues of national and economic security. In direct contrast to oil consumption, 87% of the natural gas consumed in the United States is domestically produced.

1.2. Ethanol

Ethanol is a domestically available renewable energy source that is produced from common crops such as corn and sugar cane. It is the same type of alcohol found in alcoholic beverages (ethyl alcohol) and can be used as a biofuel for the transportation sector.Ethanol is a 100% renewable source of energy, but it has being debated that it causes more environmental damage than it does good. The heavy machinery and the processes used to produce ethanol discharge carbon dioxide into the atmosphere. Ethanol can be environmental friendly if the machinery used in the cultivation emits little or no carbon particulates and uses renewable fuel. It is also a fact that the crops absorb carbon dioxide from the atmosphere and during the process of ethanol production the CO2 is released back, having a net carbon dioxide emission of almost zero. All the methods break down the crop or biomass into starches and sugar and then ferment them to produce alcohol. The most commonly used method consists of a process known as dry milling. The starch is converted to sugar, which then is fermented into ethanol. The wet milling ethanol process separates all the fibers, proteins, and germs from crop and the starch is then fermented to produce ethanol. Another method that is currently under research produces cellulosic ethanol. Cellulosic ethanol is the same product as ethanol but uses biomass instead of feedstock. Since biomass is composed of complex sugars, acid hydrolysis or enzymatic hydrolysis is used to break down the complex sugar into simple sugars, and finally fermented into ethanol.

1.3. Ethanol Environmental Impact

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Re-newable fuel. It is also a fact that the crops absorb carbon dioxide from the atmosphere and during the process of ethanol production the CO2 is released back, having a net carbon dioxide emission of almost zero.Studies done by the EPA and other environmental agencies have proven that ethanol-gasoline blends reduce carbon dioxide, ozone pollution, and improve gas mileage46. A major cause of ozone is carbon dioxide.

1.4. Hydrogen

Hydrogen is an abundant source of renewable energy that can be used to power the transportation industry. Hydrogen prototype cars have been around for years and recently highly known car manufacturers such as BMW and Honda are bringing hydrogen vehicles to the market.There exist two types of hydrogen technologies. One technology uses an internal combustion engine (ICE) similar to the gasoline engine. The second type of technology is the hydrogen fuel cell (HFC). It produces electricity to power an electric motor by combining hydrogen and oxygen in a membrane. The advantage of the ICE is that it could work as a dual-fuel, consuming hydrogen and gasoline, such as the BMW 745h sedan. When a hydrogen fueling station is not available, the car is able to run on gasoline. A disadvantage for this type of technology is that it has a lower efficiency than FCV and Nitrous Oxide control is required.52 A disadvantage of the HFC is that great amount energy is wasted as heat. Both technologies share some disadvantages due to the fact that hydrogen is currently very expensive, not because it is rare but because it is difficult to produce, handle and store, requiring massive tanks like those from compressed natural gas or complex insulated tanks if stored as a cryogenic (very cold) liquid like liquefied natural gas.

2. Hydrogen Fuel vs. Gasoline

As the supply of oil decreases and the demand increase, gasoline prices are also increasing. The average price for a regular gas price was $3.13 at the first half of the year 2008 and it even reached at least $4 a gallon. "What we are facing is increasing demand in a supply-constrained market," says Robert Bryce, author of Gusher of Lies: The Dangerous Delusions of 'Energy Independence.' As for hydrogen, the Department of Energy (DOE) has announced that the cost goal of hydrogen fuel delivered and untaxed will be about $2.00-3.00/gge (gasoline gallon equivalent58) for 2010. This is based on hydrogen produced and distributed from natural gas reforming. Hydrogen is not sold by volume but by weight. The strategy that the DOE is implementing is that hydrogen should cost no more than gasoline on an equivalent energy basis. Since most if not all hydrogen sold as fuel for cars is generated from fossil fuel the price of Hydrogen depends on the price of the fossil fuel. Here it is demonstrated the increase of gas price per gallon (taxed) from 1999 to 2008.

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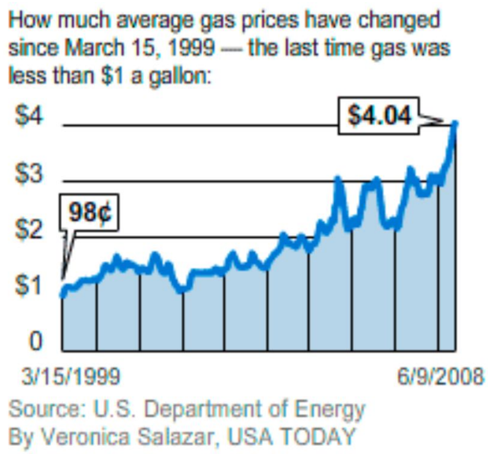

Fig 1: Price of Gas

3. Diesels

Today, diesel is the main alternative fuel to gasoline worldwide. While it is still petroleumbased,the technology for its use is widely available and increasing its use can reduce oilconsumption. Diesel engines can provide 25 percent more fuel efficiency and more torque atlower rpm than gasoline engines. Due to thicker castings and higher quality components neededto withstand the higher pressures and torque of diesel combustion, comparative diesel engines

tend to be more expensive to produce and have higher upfront costs for consumers though thelower fuel costs from increased efficiency can usually payback those increased upfront costs in afew years.While diesel engines account for approximately half of the European market, they have not beenpopular in the United States, accounting for less than one percent of light vehicle sales. Some ofthe reasons for this discrepancy have been the U.S. diesel fuel's historically higher sulfur content(compared to Europe), strict U.S. air pollution regulations for nitrous oxides and particulates, andEuropean tax advantages for diesel-fuelled vehicles (making diesel fuel cheaper versus gasolinein Europe). In addition, U.S. consumers have not been interested because they remember thenoisy, smoky, unreliable diesel engines offered in the 1980's; therefore bad associations remainin consumer perceptions regarding diesels, despite significant improvements made in dieseltechnologies over the past 25 years.However, federal rules will require refiners to sell only ultra-low-sulfur diesel fuel in the UnitedStates by December 1, 2014. This change was already substantially met for on-road diesel Combined with improvements in diesel engine technology, it enables diesel enginesto meet tough new emission standards that began for on-road diesels at the beginning of 2007.The Environmental Protection Agency (EPA) estimates that if one-third of U.S. light vehicles

had diesel engines, the United States would save 1.4 million barrels of oil per day, roughly theamount of oil the United States currently imports per day from Saudi Arabia. Unfortunatelythere are several challenges to future diesel sales. These challenges include: the additional costsassociated with developing the technology to comply with strict state and federal emissionstandards; high relative market prices for diesel fuel; overcoming diesels' poor reputation withconsumers; and, marginally by the still developing nationwide availability of ultra-low-sulfurfuel.

4. Biodiesel

Biodiesel has similar properties to petroleum diesel but can be produced from vegetable oils oranimal fats. While similar to petroleum-based diesel fuel, biodiesel is chemically distinct.Because it is chemically different, biodiesel presents problems to the complex emissionsreductions equipment in modern diesel powered vehicles. In addition,vehicle manufacturers arenot as familiar with the long-term effects of biodiesel on the reliability of their engines.

5. Oil and Environmental Concerns

The transportation sector fuels are the fastest growing sources of greenhouse gases. The EPA study, A Wedge Analysis of the U.S. Transportation Sector, states: "The U.S transportation sector represents approximately 10% of all energy-related greenhouse gas emissions worldwide. Over the next 50 years, rising numbers and use of vehicles could swell greenhouse gas emissions from U.S. transportation to 80% above current levels… There are three general approaches for reducing greenhouse gases in the transportation sector: 1) adopting advance vehicle technologies, 2) switching to low greenhouse gas (GHG) fuels, and 3) reducing vehicle miles traveled."A Wedge Analysis of the U.S. Transportation Sector introduces the concept of stabilization wedges and applies it to the U.S. transportation sector to illustrate the potential approaches that are capable to reduce both greenhouse gases and oil consumption. A wedge is an activity that creates 1GtC/y of carbon reduction. To reach about 550 ppm stabilization, the goal for the next 50 years is to achieve 7 wedges by avoiding 175 billion tons of carbon emission.5 Each wedge represents an improvement in technology and/or product efficiency, for example, 2 billion vehicles achieving 60 mpg, improving coal plants efficiency, and installing windmills.

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A global-scale stabilization triangle and the individual wedges (in green). Reproduced from Pacala, Socolow, *Science* (2004), 305, 968 with labels in red added. A business as usual emissions trajectory could result in atmospheric concentration levels 850 ppm CO_2 or greater. Removing the emissions embodied by the stabilization triangle would be analogous to emission pathways stabilizing below 550 ppm.

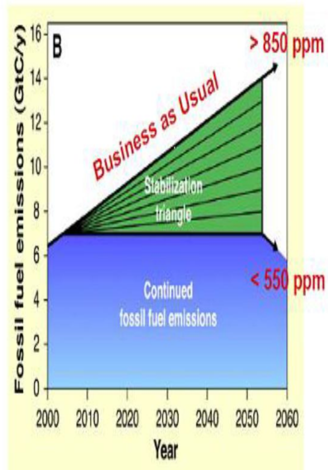

Fig 2: Stabilization Wedges

Another example is, in Figure 6, 1 to 2 wedges or all 7 wedges could represent the nine vehicle technology shown in Figure 7. It could also represent a combination of vehicle technology with a carbon reduction (capture) system.

Vehicle technology categories and their assumed fuel economy and GHG emissions relative to a baseline, conventional gasoline vehicle.

Vehicle Technology	Vehicle Fuel Economy Improvement[26]	Percent Reduction in GHG Emissions (fuel-cycle)[27]
	vs. Conventional Vehicle	
Advanced Gasoline Engine and Advanced Diesel Engine	35-40%	20-26%
Hybrid Electric Vehicle (Gasoline)	40%	29%
Hybrid Electric Vehicle (Diesel)	70%	35%
Optimized E85[28]	-4%	38 to 80%
Advanced Optimized E85[29]	30%	54 to 85%
Plug-In Hybrid Electric[30]	65%	31 to 62%
Electric	390%	31 to 94%
Fuel Cell[31]	270%	21-92%

Fig 3: Vehicle Technology

In Figure 6, it is projected that in 50 years the GHG emissions from the USTS will grow 80% (200,000 MMT added by 2050) above current levels, due to the increase of vehicles and their use.

6. Diesel Background and History

Despite its huge success in Europe, the Diesel engine is largely unaccepted by passenger vehicles buyers in the United States. It makes up for half of the sales in Europe9. Named after Rudolph Diesel in 1893, the diesel engine was revolutionary in comparison to the other options (including steam) at the time. It provided higher thermal efficiencies, thus reducing fuel consumption and increasing

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power output (comparatively). Many false stereotypes on the operation and ownership of a diesel engine however continue to adversely affect its acceptance in America. Most of these stereotypes are from negative past experiences from the early 80's. Through strict emissions controls and advanced engine control units, the diesel engine is rivaling the gasoline engine in terms of performance. The engine cycle is simple. Air is drawn into the cylinder by the reduced pressure created by the downward moving piston, following a compression cycle, fuel is added, combustion occurs, the power stroke is performed and then the products of combustion are exhausted to the atmosphere. Most modern diesels will use an exhaust driven turbocharger to recover thermal energy from the hot combustion products and use it to raise the manifold pressure of the intake. This allows for a greater brake mean effective pressure and increased power output for a given engine displacement. "Adding a turbocharger to a diesel does more than increase the amount of air available for combustion. The turbocharger also improves combustion efficiency by increasing the turbulence in the combustion chamber." Thermal efficiency in such cycles is largely determined by the compression ratio.

$$\eta_{th} = 1 - \frac{1}{r^{\gamma-1}}\left(\frac{\alpha^{\gamma}-1}{\gamma(\alpha-1)}\right)$$

Where η_{th} is thermal efficiency

α is the cut-off ratio $\frac{V_3}{V_2}$ (ratio between the end and start volume for the combustion phase)

r is the compression ratio $\frac{V_1}{V_2}$

γ is ratio of specific heats (Cp/Cv)

Diesels typically operate at a higher compression ratio than gasoline due to the requirement of high cylinder pressures and temperatures to ignite fuel as it is injected. On most gasoline engines, fuel is added either at a throttle body, at the intake manifold, or on modern engines, in the cylinder head (similar to diesel). The reason why gasoline engines can't have as high of a compression ratio is due to pre-ignition by which the air-fuel mixture ignites before the spark plug fires. This is harmful to the engine components and can cause damage. Therefore, the compression ratio as well as the thermal efficiency is lower than that of compression ignition engines.

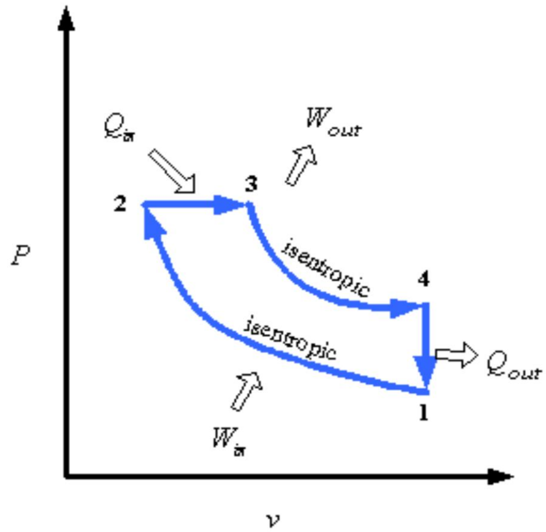

Fig 4: Diesel Cycle P-V Diagram

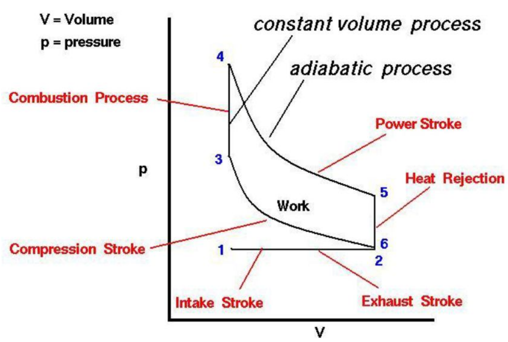

Fig 5: Otto Cycle

7. Hybrid Background and History

The definition of a hybrid vehicle is one that uses two or more separate power sources in its propulsion system. The most common type of hybrid is a hybrid electric vehicle or HEV which includes an internal combustion engine as well as electrical motors. Modern hybrids can come with one of three different types of drivetrains. They include parallel, series, and a combination of both the parallel and series drivetrains. To make matters increasingly more complicated, there are 4 different "levels" a hybrid vehicle can be in: full hybrid, power assist hybrid, mild hybrid, and plug in hybrid. The most commonly created hybrids today use parallel drive trains.. The battery packs in parallel hybrids are smaller than series because most of the work comes from the conventional engine. Some examples of hybrid vehicles with parallel drive trains are the Honda Insight, Civic, and Accord.

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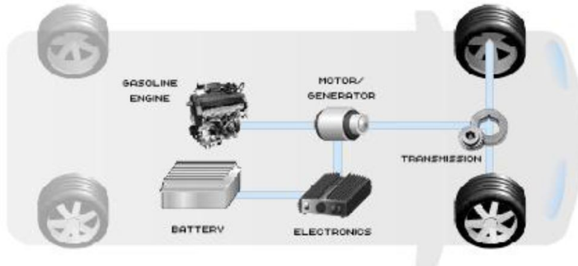

Fig 7: Parallel Drivetrain28

Series drivetrains are the simplest hybrid configuration and are generally the most efficient types of hybrids during city driving.

The most complicated drivetrain is one that is a combination of both series and parallel hybrids. "The engine can both drive the wheels directly (as in the parallel drivetrain) and be effectively disconnected from the wheels so that only the electric motor powers the wheels (as in the series drivetrain).32" At low speeds, the vehicle acts like a series hybrid. To minimize losses at higher speeds, the vehicle acts like a parallel hybrid, allowing the engine to do most of the work. This system is very costly because it needs a generator, a large battery pack, as well as more computing power to deal with the complexity of the dual power system. This type of technology can be seen in the Toyota Prius as well as the Ford Escape Hybrid.

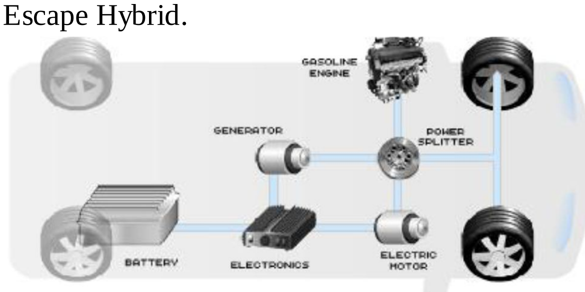

Fig 6: Combination Drive train

The computer splits the mechanical and electrical energy according to the power needs. For example, if the battery is in need of power, some of the electrical energy will be routed to the battery. The battery may also be charged ifthe engine or motor are working independently and has enough power to both sustain proper driving capability while directing power towards the battery. This is known as battery charge mode. The next regime is the power boost mode. When the driver is requesting a lot of power, whether for heavy acceleration or other large loads that neither a single power source can handle alone, it joins both boosting the overall power output. The final mode is the negative split mode where the vehicle is in cruise mode but the battery is fully charged. The battery applies power to both the motor and the engine. The reason for this is to use as much of the energy the system produces in order to be fully fuel efficient.

Conclusion

The future effectiveness of fuel economy programs is difficult to gauge, given that thebaseline fuel economy (in the absence of policy) is sensitive to oil prices, technology costs, andother factors. In addition, the cost-effectiveness of the standards remains contentious, particularlydue to uncertainty about how consumers value fuel-saving benefits. At first glance, fuel economyregulations seem difficult to justify on welfare grounds, given that
fuel taxes—even in the UnitedStates—exceed most estimates for per-gallon climate damages. In contrast, our stylized modelsuggests that high levels of fuel taxation can be defended—up to a point—on economicefficiencygrounds because they reduce congestion and other externalities that vary with milesdriven and are relatively large in magnitude. Even in the presence of a large, misperceptionbasedmarket failure, and even if the social costs of global warming or oil dependence are high,fuel economy regulations may not be needed if fuel taxes can be adjusted.On the other hand, by revealed preference, standards seem to be more practicable thanhigh fuel taxes for the United States. Regulations may also help create a more stable environmentfor the development of clean technology by removing some of the downside risks to innovatorsin a world of uncertain fuel prices. It is not well understood, however, whether fuel economyregulations are better or worse than other instruments (e.g., technology prizes, fuel taxes, andfuel price floors) along this dimension.Each of the alternatives presented has advantages and disadvantages. However, it is also important to note that most of the alternatives only address a few of the problems associated with the automobile, namely pollution and foreign oil dependence. With 189 counties or municipalities listed as serious to severe in terms of pollution, addressing these issues with alternative fuels will no doubt have the potential for positive outcomes. Quality of life in many urban areas will be greatly improved. There are other issues to consider, for instance the social, environmental, and public health ramifications of an auto-dependant society.

References

[1] Alternative Fuels for Automobiles, Alessandro Chiumiento, Brian Beach, Jose Molina,December 17, 2008, Professor Kenneth Stafford, Major Advisor

[2] Brown, Daniel, C. Moving toward alternative fuel vehicles. *Public works*, v. 135,Nov.2004:34-37. TD1.P8

[3] Coles, Gerald. An alternative in motion. *Chemistry and industry*, no. 9, May 2, 2005: 23-24.TP1.S6332

[4] Fleming, Jesse S., Shiva Habibi, and Heather L. MacLean. Investigating the sustainability of lignocellulose-derived fuels for light-duty vehicles. *Transportation research, part D, transport and environment,* 11D, Mar. 2006:146-159.HE192.5.T684

[5] Janssen, Arthur, and others. Model aided policy development for the market penetration of natural gas vehicles in Switzerland. *Transportation research, part A, policy and practice,* v. 40A, May 2006:316-333.
HE192.5.T682

[6] Kaneko, Makoto, and others. A study on homogeneous charge compression ignition gasoline engines. *JSME international journal, series B, fluids and thermal engineering,* v. 46, no.1,2003:31-36. TJ1.J752

[7] Lipman, Timothy E., and Mark A. Delucchi. A retail and lifecycle cost analysis of hybrid electric vehicles.*Transportation research, part D, transport and environment,* 11D,Mar.2006:115-132. HE192.5.T684