

Running head: REDUCING OIL DEPENDENCE THROUGH ALTERNATIVE FUELS

Reducing Oil Dependence through Transportation Fuel Alternatives  
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### Abstract

In an effort to examine ways of reducing the United States' dependence on foreign oil, information about both alternative fuels and alternative vehicles were gathered and evaluated. While there is not one single answer in response to this crisis, several technologies show promise, including hydrogen-powered fuel cells and cellulosic ethanol. While both are clean-burning, domestically produced alternatives, they are currently not readily available, are difficult to obtain, and are too expensive for manufacturers and consumers. However, the U.S. investment in both of these areas will hopefully yield results to make one or both a feasible alternative to our foreign oil dependence.

To feed its consumption of 20.8 million barrels of crude oil per day (World fact book, 2008), the United States, as the world's largest oil importer (Cohen, 2007), imports 13.15 million barrels each day, mostly from Canada, Saudi Arabia, Venezuela, and Mexico respectively (EIA, 2008). Oil imports make up approximately 63.5 percent of U.S. daily consumption and oil consumption represents 40 percent of America's energy needs, primarily for ground and air transportation (Cohen, 2007). The U.S. produces only 7.46 million barrels of oil each day, leaving it largely dependent on foreign oil sources.

Given this high level of dependency on foreign oil, there are several factors to consider when defining and evaluating this problem. The main issues of oil dependency include the perceived threat to our nation's economy and security as well as being a major pollutant that contributes to the problem of greenhouse gas emissions that is believed to cause global warming.

The concern for national security stems from the lack of control over the availability of crude oil, and the regions it comes from. In President Bush's 2006 State of the Union address, he expressed concern over our "addiction" to oil, particularly because it comes from some of the most unstable regions of the world (The White House, 2006). As a result of such a high dependence on foreign oil, the U.S. is vulnerable to trade deficits, supply disruption, and price changes (AFDC, 2008). As Cohen points out, the world is dependent on oil that comes primarily from the unstable regions of the Middle East, Venezuela, and Africa (Cohen, 2007). Both our domestic livelihood and military efforts rely on the availability and affordability of oil from these unstable regions. Cohen suggests, "Recognizing the inherent, systemic, and long-term instability of the global oil markets is the first step in addressing the problem the U.S. is facing." (Cohen, 2007). Our dependence on such a valuable resource from regions that have a history of instability threatens the U.S.'s economic welfare as well as its national security. However, recognizing the

problem is only the first step; the next step is to adopt workable solutions. “By promoting more efficient vehicles, clean fuels, smart growth, and public transportation, governments can put an end to an unhealthy addiction that threatens our citizens’ wallets and our national security, economy, and environment” (Gardiner, 2008).

Crude oil is used to produce many different products (See Figure 1). From one barrel of crude oil, we get 22.6 gallons of gasoline, 6.7 gallons of diesel, and 5.5 gallons of jet fuel, along with several other products (ABC News, 2008).

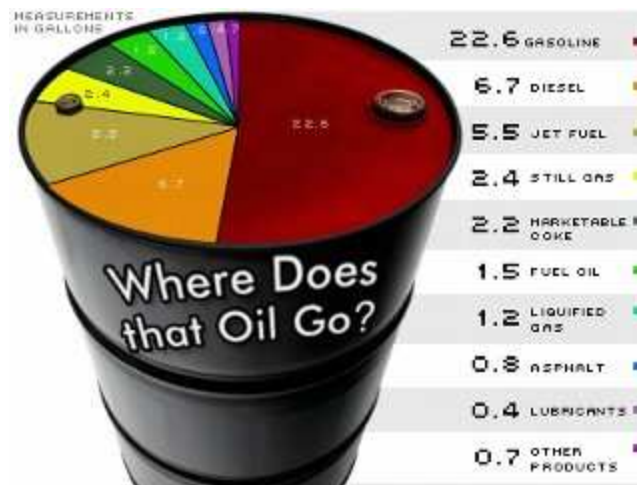


Figure 1: Production of oil products from crude oil (ABC News)

Most of the products from crude oil support methods of transportation. In fact, 40 percent (approximately 9.1 million barrels per day) of oil imported into the U.S. is used to power motor vehicles (Alaska Pipeline, 2006). If we intend to reduce our dependence on foreign oil, it would be reasonable to look at alternatives to fueling cars with something other than gasoline derived from crude oil. Aside from conserving fuel by using less, a more comprehensive solution that includes higher efficiency vehicles and alternative fuel will be needed to make a significant change.

In 1992, Congress passed *The Energy Policy Act (EPAct)*. This act is targeted toward reducing “the nation’s dependence on imported petroleum by requiring certain fleets to acquire alternative fuel vehicles, which are capable of operating on non-petroleum fuels” (EPAct, 2007). According to the U.S. Department of Energy, which regulates the stipulations of the EPAct, there are more than a dozen alternative and advanced fuels in production or use today, but points out that at this is not widespread, but that consumers are “showing a growing interest in them” (AFDC, 2008).

In addition to reducing dependence on foreign oil as a means to improve the U.S.’s economic outlook and national security, reducing the use of oil and oil derivatives is essential to reducing carbon dioxide emissions, which is believed to contribute to global warming. Although some amount of greenhouse gases, including carbon dioxide, are part of the natural regulation of the earth’s climate, according to the National Climatic Data Center, “human activity has been increasing the concentration of greenhouse gases in the atmosphere (mostly carbon dioxide from combustion of coal, oil, and gas” (NCDC, 2008). Energy-related carbon dioxide emissions account for 98 percent of U.S. carbon dioxide emissions, a majority of which come from fossil fuel combustion (EIA, 2008). Since 1990, transportation alone has increased carbon dioxide emissions by 431.8 million metric tons (in 2007). (See Figure 2.) Since 1999, the transportation sector has led all U.S. end-use sectors (i.e., residential, commercial, industrial) in carbon dioxide emissions.

**Table 6. U.S. Energy-Related Carbon Dioxide Emissions by End-Use Sector, 1990, 1995, and 2000-2007**  
(Million Metric Tons Carbon Dioxide)

Sector	1990	1995	2000	2001	2002	2003	2004	2005	2006	P2007
Residential . . . . .	961.7	1,039.2	1,181.6	1,168.3	1,196.3	1,224.6	1,220.7	1,254.9	1,197.9	1,249.5
Commercial . . . . .	787.5	848.4	1,015.2	1,020.1	1,017.9	1,027.1	1,042.3	1,060.2	1,043.0	1,087.4
Industrial . . . . .	1,686.9	1,738.6	1,786.4	1,715.8	1,715.5	1,719.1	1,744.2	1,672.3	1,652.4	1,639.7
Transportation . . . . .	1,582.6	1,682.2	1,872.6	1,850.9	1,890.9	1,897.2	1,958.9	1,988.0	2,013.4	2,014.4
<b>Total . . . . .</b>	<b>5,018.7</b>	<b>5,308.5</b>	<b>5,855.8</b>	<b>5,755.1</b>	<b>5,820.6</b>	<b>5,868.1</b>	<b>5,966.2</b>	<b>5,975.3</b>	<b>5,906.7</b>	<b>5,990.9</b>
Electricity Generation <sup>a</sup> . . . . .	1,820.4	1,955.1	2,300.9	2,261.3	2,271.1	2,299.0	2,331.2	2,397.4	2,364.1	2,433.4

<sup>a</sup>Electric power sector emissions are distributed across the end-use sectors. Emissions allocated to sectors are unadjusted. Adjustments are made to total emissions only.  
P = preliminary data.  
Notes: Data in this table are revised from the data contained in the previous EIA report, *Emissions of Greenhouse Gases in the United States 2006*, DOE/EIA-0573(2006) (Washington, DC, November 2007). Totals may not equal sum of components due to independent rounding.  
Source: EIA estimates.

**Figure 2: CO2 Emissions by End-Use Sector (Energy Information Administration)**

Alternative Fuels, as defined by the Energy Policy Act of 1992 include:

- Biodiesel
- Electricity
- Ethanol
- Hydrogen
- Methanol
- Natural Gas
- Propane

There are other alternative fuels in existence, but for the purposes of this paper, only those defined by EPAct will be explored. In addition to the availability of alternative fuels, auto companies are producing vehicles that are more efficient. These include hybrids, diesel fuel engines, and flex fuel vehicles. The U.S. Government offers Federal tax incentives for the purchase of fuel efficient vehicles, including hybrids, diesels, alternative fuel vehicles (AFVs) and electric vehicles (Fuel economy, 2008).

Certainly, in 2008, although these fuels and motor vehicles are a possibility, and some are available, there are advantages and disadvantages in each, and consumers may not necessarily be sure about what is available or where to invest their money when it comes time to buy a new car. Many consumers may have heard about one type of fuel being better for the environment, or

more fuel-efficient, but it is worthwhile to review each for practicality, viability, and pros and cons.

Biodiesel is a domestically produced, renewable fuel produced from a variety of oil-based resources such as vegetable oils and animal fats (AFDC, 2008). Biodiesel can be used on its own (a.k.a. B100) or as a blend of 20 percent (a.k.a. B20) with other diesel fuel. (B5 is also available, which is 5 percent biodiesel mixed with petroleum diesel.) In the U.S., most biodiesel is B20, which is made from soybean oil and can be produced from leftover restaurant oil or food processing plants (Hybrid cars, 2008).

Biodiesel advantages include the fact that it is domestically produced and is a renewable fuel – all that is required for more is to grow the crop necessary for production. Biodiesel is a clean burning fuel, which reduces emissions of many gases, including carbon dioxide. B100 use reduces carbon dioxide emissions by more than 75 percent and B20 reduces carbon dioxide emissions by 15 percent. Biodiesel is less combustible than petroleum diesel, making it safer to handle, store and transport (AFDC, 2008). Currently, there are 431 fueling stations in the U.S. that offer commercial biodiesel (Hybrid cars, 2008).

Biodiesel, however, is not without its drawbacks. Automakers will not offer warranties on usage of anything over B5 and drivers will experience lower fuel economy using biodiesel. Biodiesel is also not a cheaper alternative, which makes the incentive to purchase, particularly in tough economic times, minimal. Although carbon dioxide emissions are lower, nitrogen oxide emissions (another greenhouse gas) are higher and B100 is not recommended for use in areas that experience lower temperatures. Because B100, which is full biodiesel, is newer in usage, it is unclear what impact it will have on the engine's durability (Fuel Economy, 2008).

Electricity can be used for electric or plug-in hybrid vehicles. There are no emissions, and typically, electricity is stored in the vehicle's battery (although fuel cells are also being tested as an alternative). Having no emissions is certainly an advantage. Additional advantages of electric vehicles include a fast, efficient, quiet ride, but unfortunately, electric-powered vehicles have their disadvantages that make having one as a sole or primary vehicle for consumers a bleak alternative. Because electric cars rely entirely on rechargeable batteries, a single charge only enables a car to travel approximately 100 miles, and when the charge runs out, the only place to recharge it is home. There are not readily available charging stations like there are gas stations. The recharging process could also take up to 7 or 8 hours (Hybrid cars, 2008). There may still be hope for electric cars with new technology and more availability of charging stations, but that remains to be seen.

Ethanol is a domestically produced renewable fuel made from starch, sugar, or cellulosic plant materials. These materials are more generally known as "biomass." About half of all gasoline in the U.S. contains a low-level blend of ethanol, which helps reduce pollution. This blend can be used in gasoline-powered vehicles. E85, a blend of 85 percent ethanol and 15 percent gasoline, is a fuel that can be used in flex-fuel vehicles (AFDC, 2008). Starch-based materials include corn, wheat, and milo. Sugar-based fuels are typically sugar cane and sugar beets. Corn makes up approximately 90 percent of the U.S.'s current ethanol production. Cellulosic ethanol contains cellulose and hemicellulose, which come from plant stalks, leaves, trunks, branches, and husks. They are also in products made from plants such as paper (AFDC, 2008). Unfortunately, cellulose is difficult to break down to sugar and from hemicellulose, it is difficult to ferment the resulting sugar. The U.S. Department of Energy, however, is investing in improving the conversion process to make this a more viable alternative.

There are numerous advantages to ethanol. Ethanol production is increasing jobs in rural areas, and in 2007, the ethanol industry added \$48 billion to the gross domestic product and created more than 230,000 jobs in the U.S. Its environmental advantages include a reduction in greenhouse gas emissions (See Figure 3.), by offsetting the carbon dioxide that is released when ethanol is burned with the carbon dioxide captured when the crops are grown. (AFDC, 2008). This assertion, however, has been criticized as being overly simplistic, as it does not take into consideration all of the other emissions that occur during cultivation and production (Hybrid cars, 2008).

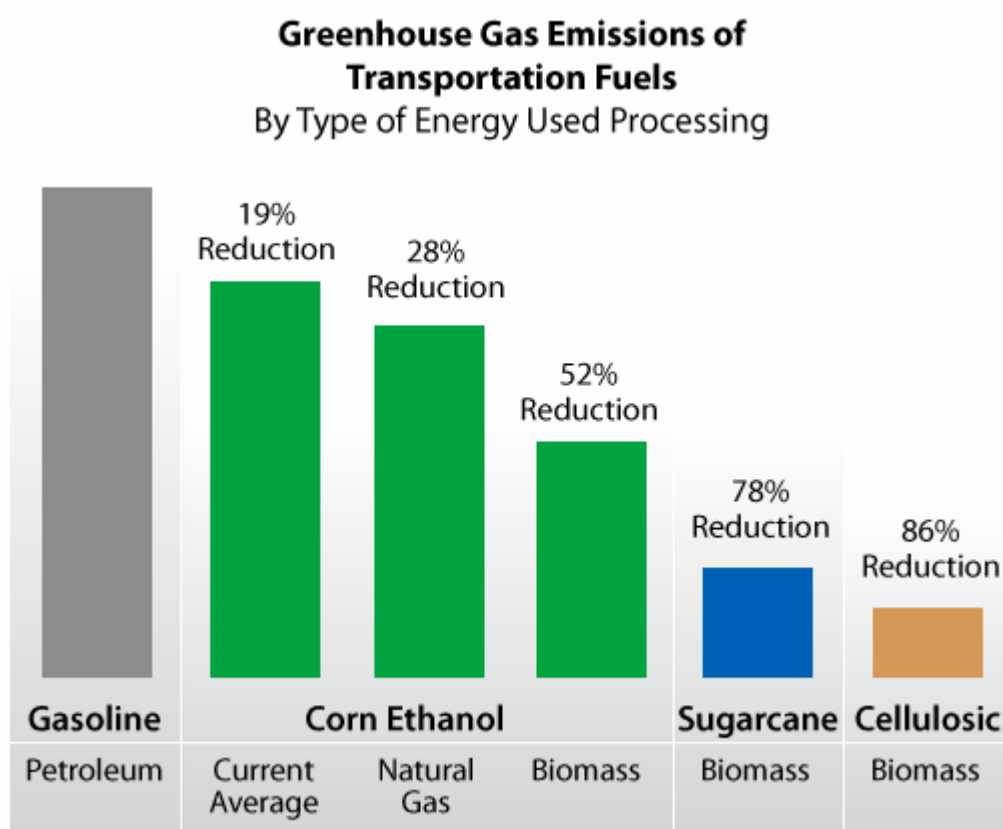


Figure 3: Greenhouse Gas Emissions Comparison (Source: AFDC)

Another criticism of ethanol is that because materials otherwise used in food production is being used to produce fuel (Brown, 2008), it has raised food prices and caused worldwide food

shortages. However, the U.S. Department of Agriculture (USDA) states that although ethanol production has affected food prices somewhat, weather problems and oil prices are primarily to blame (MSNBC, 2007).

Cellulosic ethanol is a more promising alternative to corn-based production because of the more dramatic results in greenhouse gas emissions. Researchers at the University of California at Berkley found that a switch to corn-based ethanol would lead to a 13 percent reduction in greenhouse gases. However, more dramatic reductions in greenhouse gases are possible; as much as 88 percent less, if technological advances that make harvesting cellulosic materials easier (Hybrid cars, 2008).

Right now, ethanol prices vary, depending on which region of the country it is purchased. E85 is about 30 cents cheaper than gasoline in the Midwest, where it is produced, but buying it on the West Coast would be 35 cents more than gasoline. Ethanol also contains less energy than gasoline, so fuel economy actually decreases by as much as 20-30 percent in comparison to gasoline (Hybrid Cars, 2008). It would be difficult to convince consumers to pay more for a fuel that will get them less, despite the lower emissions of air pollutants. Ethanol seems very promising in cellulosic form if processing technology improves.

Hydrogen is another very promising form of energy to fuel vehicles and more. Hydrogen is the simplest and most abundant element in the universe (AFDC, 2008). Hydrogen is most abundant in water and is very rarely found by itself, which is what makes using it so difficult. Hydrogen is commonly viewed as the fuel of the future, because it is clean-burning, can be produced domestically, and can be used to charge fuel cells. It is two to three times more efficient than gasoline. Storage of hydrogen for use in fuel cells is also a drawback to its use. Storing the amount of hydrogen needed would require a very large tank in the car (AFDC, 2008).

The U.S. is investing in improving harvesting and storing hydrogen, as it is projected that global annual demand for fuel cell products would reach \$46 billion by 2011 and more than \$2.5 trillion by 2021 (AFDC, 2008). According the U.S. Department of Energy (DOE), “Developing safe and reliable hydrogen storage technologies that meet performance and cost requirements is critical to achieving a future hydrogen economy.” The DOE has even established a “National Hydrogen Storage Project” that is funding research and development on various technologies (EERE, 2008). However, many critics say that hydrogen will never be practical as a motor fuel and that more practical, near-term solutions should be getting more focus. Given the fact that making a kilogram of hydrogen from water through electrolysis requires 45-70 kWh of electricity, which is equivalent to the amount of energy used to power the average American home for two-three days (Hybrid cars, 2008), it’s imperative that the process of producing and storing hydrogen become more efficient before it is considered a viable alternative.

Methanol is wood alcohol and is considered an alternative fuel. It is methane with one hydrogen molecule replaced by a hydroxyl radical (OH) produced using a natural gas process, which produces methanol and water vapor. Despite its low production costs, it has fallen out of favor as it has been found to contaminate ground water (AFDC, 2008).

Natural Gas is also domestically produced and clean-burning. There are two types of natural gas: compressed natural gas (CNG) and liquefied natural gas (LNG). Natural gas has been used for quite some time and makes up about 25 percent of the energy used in the U.S. Only about one-tenth of that natural gas energy is currently used as transportation fuel (AFDC, 2008). Natural Gas is derived from separating the gas from liquids like crude oil, hydrocarbon condensate, water, and entrained solids (AFDC, 2008). Although much of it is domestically produced, the U.S. imports natural gas from Canada as well.

Even T. Boone Pickens, the oil giant who has recently invested in alternative power sources such as wind power, is touting the benefits of natural gas. Of course, aside from the benefits of natural gas, using natural gas for vehicles fits nicely into his wind power plan. His theory is that if we harness wind power for generating the electricity that we currently generate via natural gas, we can then put those natural gas efforts into transportation and use wind for other energy needs (Pickens Plan, 2008). Although it is a self-serving conclusion, it can still be considered a reasonable assertion. This past summer (2008), when gasoline prices soared to over four dollars per gallon, some regions of the country experienced a natural gas vehicle boom. Utah is the first state in the country to experience a broad consumer interest in natural gas to fuel vehicles (Krauss, 2008). Paying 87 cents for natural gas that could fuel a car equivalent to what \$3.95 of gasoline could do, was enticing to Utah consumers. So much so that they were willing to pay money to transform their current vehicle or buy a new natural gas powered car. One of every four of the 800 natural gas powered cars that Honda made in 2008 was sold in Utah. It is estimated that there are approximately 6000 natural gas powered vehicles in Utah (Krauss, 2008). With gasoline prices dropping, it is possible that interest would wane.

Because natural gas has high hydrogen-to-carbon ratio, it is an efficient source of hydrogen that may be paving the way for hydrogen powered fuel cell vehicles. The U.S.'s extensive natural gas infrastructure makes delivery of natural gas to refilling stations more convenient as well. The DOE believes that vehicles fueled with hydrogen-natural gas blends (HCNG) may be a first step in building a demand for a hydrogen infrastructure, while reducing harmful emissions (AFDC, 2008). For now, the U.S. does not have enough filling stations open to the public to encourage widespread use (Hybrid Cars, 2008).

The last in the list of fuel alternatives is propane. Propane is liquefied petroleum gas (LPG) and has been used for decades to fuel light-duty and heavy-duty propane vehicles (AFDC, 2008). When propane is stored under pressure in a tank, it turns into a colorless, odorless liquid. When pressure is released, it vaporizes into a gas used for combustion. It contains a lot of energy with a high octane rating and is non-toxic. Propane is actually a by-product of natural gas processing and crude oil refining, but only accounts for two percent of energy in the U.S and less than two percent of consumption is used for transportation fuel (AFDC, 2008).

Although propane is domestically produced and burns cleaner than gasoline, the auto industry has not produced a new passenger car or truck to run with propane since 2004 and propane is not as available as gasoline and diesel. Although it is less expensive than gasoline on a per gallon basis, it gets fewer miles per gallon (Fuel Economy, 2008). Given the promise and investment in other alternative fuels, propane is not at the forefront of future technology.

Along with the use of alternative fuels, comes the consideration of alternative vehicles that would use these fuels. In some cases, traditional gasoline-powered vehicles can use a blended gas mixture (e.g., E85); in other cases, vehicles can be altered to accept fuel other than gasoline. Other vehicles are produced specifically for alternative fuel use (in whole or in part) such as a hybrid electric vehicle (e.g., Prius).

Currently, the most commonly available alternative to the traditional gasoline-powered vehicle is the Flexible fuel vehicle (FFV). In fact, these are sold by all U.S. vehicle manufacturers and can run on gasoline or E85, which is a blend of 85 percent ethanol and 15 percent gasoline. There are over 6 million FFVs in the U.S. (AFDC, 2008). FFVs offer a single fuel system that is set to accommodate the higher octane of fuels like ethanol and reduce the

greenhouse gas emissions. Unfortunately, fuel economy is lower when these vehicles run on ethanol.

Natural gas vehicles (NGVs) can be a single fuel system that runs only on natural gas or a bi-fuel system that enables it to run on traditional fuel (gasoline or diesel) or natural gas. Due to their optimized engines, single-fuel systems are more efficient and have lower emissions (AFDC, 2008). Unfortunately, according to the DOE, the availability of NGVs have declined in recent years. Certified installers can retrofit a traditional gasoline-powered car to run on natural gas as well (AFDC, 2008).

Propane Vehicles have not been produced since 2004, but these vehicles have been in use for decades and the DOE estimates that there are more than 270,000 of these vehicles on the road in the U.S., but most of them are conversions from traditional gasoline-powered vehicles.

Hybrid electric vehicles (HEVs), like the popular Toyota Prius, combine the internal combustion engine with a battery and electric motor. There are more than one millions HEVs in the U.S. (Hybrid cars, 2008). Unlike plug-in hybrids, HEVs never have to be plugged in to charge the battery. Their batteries are charged by regenerative braking and onboard generators (AFDC, 2008). This can be considered a pro or con. The combustion engine offers low emissions and the convenience of refueling at conventional gas stations. HEVs can get 40-70 miles per gallon of gasoline, making them about 20-35 percent more efficient than traditional gasoline-powered cars. HEVs cost more than traditional, fuel-efficient gasoline vehicles (\$19,000 - \$25,000 for HEV compared to \$14,000 - \$17,000 for gas savers), and over a ten-year period, an HEV owner may save only \$2300 in gasoline (Physorg, 2006). Critics argue that much of the fuel efficiency from HEVs actually comes from improvements in aerodynamics, weight reduction, and a smaller less powerful gas engine. Any car will get substantially better mileage

just by reducing the engine size (Physorg, 2006). Other advantages, like significantly decreased emissions, have helped increase Toyota Prius sales to over one million since it introduced the first model in 1997 (Auto123, 2008).

The plug-in hybrid electric vehicle (PHEVs) (e.g., a Chevy Volt) plug into an electrical grid and can be powered by the stored electricity alone, but can also run on the traditional engine as well. Unfortunately, PHEVs are not commercially available yet, but are projected to get twice the fuel economy as a conventional car of the same size and capacity, and about twice the fuel economy as a conventional hybrid (Hybrid cars, 2008). Some concern that the need for charging these vehicles on a large-scale basis might require new electrical grids has been eased somewhat by the notion that when charged at night, these vehicles would be drawing on power when demand for it from residential and commercial uses is much lower, and would therefore, not require additional grids (Richard, 2008).

Electric vehicles (EVs) are powered by electricity that is stored in a battery. The batteries must be plugged into a power source and charged, either by an onboard device or one located outside the vehicle, but both use power from a power grid and batteries need to be replaced every four years or 20,000 miles (AFDC, 2008). EV motors do not produce any emissions at all, but some criticize that methods of electricity production contribute to air pollution. However, EVs reduce greenhouse gases by 19% overall and nearly eliminate petroleum use. EVs reduce fossil fuel use by 28% even though electricity is generated by fossil fuels (AFDC, 2008). EVs are only available as neighborhood electric vehicles (NEVs) and as scooters and bicycles. NEVs are limited to speeds of 25 miles per hour or less, and may only be useful for short commutes and local transportation at low speeds.

Fuel Cell Vehicles have become the focus of much research and development by the U.S. Department of Energy. A fuel cell vehicle can be two-three times more efficient than conventional vehicles, as it does not “burn” fuel and does not have many moving parts. A chemical reaction in the fuel cell converts chemical energy into electricity, but fuel cells never have to be recharged like batteries. The fuel that powers fuel cells is typically hydrogen (Hybrid cars, 2008). Of course, we are still dealing with the problems of harvesting and storing hydrogen, which is one drawback of fuel cell vehicles. Additionally, the technology is still extremely expensive, and without any commercial fuel cell vehicles available, we do not know what the reliability, durability and performance under different climates and conditions remains to be seen (Hybrid cars, 2008).

Diesel vehicles are highly efficient cars, as diesel fuel contains more energy than gasoline. Diesel engines provide a fast ride and last longer than gasoline-powered engines. Unfortunately, in the U.S. diesel fuel is taxed more heavily than it is in Europe (where diesel engine cars are much more popular and are taxed less heavily than the U.S.). Few models are available in the U.S., and those that are available are more expensive than gasoline-powered vehicles. Environmentally, particulate matter and nitrous oxide emissions are higher in diesel fuel (Hybrid cars, 2008).

One thing that should be considered when evaluating the costs of any of these alternative vehicle types is that the state and federal government does provide tax incentives and rebates for purchase and use of these vehicles and fuels. The Alternative Fuels & Advanced Vehicles Data Center (AFDC) provides a database of all federal and state regulations that consumers can use to look up what their cost incentives might be. For example, in New Jersey, the Alternative Fuel

Vehicle (AFV) and Hybrid Electric Vehicle (HEV) Rebate would provide between a \$2000 - \$12,000 rebate for the conversion of a vehicle to this alternative or the purchase of a vehicle.

<b>GVWR (in pounds)</b>	<b>Rebate Amount (dedicated or hybrid)</b>	<b>Rebate Amount (bi-fuel)</b>
Light-duty (<8,500)	Up to \$4,000	Up to \$2,000
Medium-duty (8,500-14,000)	Up to \$7,000	Up to \$4,000
Heavy-duty (>14,000)	Up to \$12,000	Up to \$6,000

**Figure 4: NJ Incentives and Laws (Source: AFDC)**

These incentives and rebates should be considered along with any possible higher vehicle cost and/or battery replacement costs. For example, if an HEV costs \$7000 more than a conventional vehicle of the same size and capacity, the rebate might cancel that cost out, leaving the consumer to look forward still to a savings in gasoline and lower greenhouse gas emissions. This may be worth it to consumers to purchase that type of vehicle should they be in the market for a new vehicle.

What is clear after evaluating a variety of alternative fuels and vehicles is that there is no perfect solution. If our goal is reducing our dependence on foreign oil, from that perspective alone, there are many choices, and all alternatives achieve that goal. But that is not the only criteria we need to use when putting these solutions into practice. In marketing ideas and technology to consumers, the technology not only has to work, it also needs to be fiscally sound and convenient. The hybrid electric vehicles have seen some steady growth given government tax incentives and rebates, making the decision to buy one more palatable. Filling up a gas tank that will be utilized, but will get you more miles per gallon, is also enticing, particularly if you drive enough to make the payoff worth it. Given that the HEVs are said to get much of their efficiency from the aerodynamic design and smaller engine, I do not think they will be able to produce a variety of vehicle styles that will satisfy most consumers. Consumers like vehicle

purchases that not only make sense, but also fit their style. For example, many people do not find the Prius, which is the best-selling HEV on the market today, very appealing and are not compelled to buy it, despite its fuel efficiency and reduced emissions. The pressure to design other models of HEV will reveal that it is not simply the electric motor/battery combination that makes it efficient. The HEVs will not see long-term (15-20 year) success. However, after reviewing many of the articles and information about the various options, hybrid electric vehicles seem to be the best alternative now, but not where the U.S. is investing its money and efforts. Hybrid Electric cars particularly saw a sales boost during the recent gas price increase the U.S. experienced when consumers reacted to the possibility of continuing high gas prices.

Both hydrogen fuel cell vehicles and cellulosic ethanol fuel seem to have the most promise – seeing two to three times the fuel efficiency with a clean burning fuel that is domestically produced would reduce our dependence on foreign oil while improving our carbon footprint in hopes of reducing our impact on global warming. Unfortunately, these alternatives are too expensive and impractical for the consumer right now. I hope that the investment the U.S. Department of Energy is making in both of these technologies will lead us to the next steps in reducing our foreign oil dependence.

Once the issues of hydrogen separation and storage of hydrogen are resolved, I believe that the option of hydrogen-powered fuel cells is the long-range solution to reducing our dependence on foreign oil. It is an appealing alternative because hydrogen is so abundant, and the fuel cells it would power are extremely efficient, without sacrificing speed or comfort in driving. In addition, the fact that it only emits water, rather than harmful exhaust, is a combination that is attractive to manufacturers and consumers. If resolving these issues were insurmountable, I do not think that the U.S. Government would proactively invest in its future.

Even though the hydrogen-powered fuel cells may be the long-term solution, what about the interim? Even if the fuel cell becomes a reality and ready for production, it is unrealistic to think that consumers would purchase a new vehicle simply because it is available. This solution probably also would not come to fruition for another 10-15 years, possibly. This means that there is an opportunity for an interim solution to enter the marketplace that enables consumers to use the vehicles they have, with a possible fuel alternative like cellulosic ethanol. Currently, all cars manufactured now are built as flexible fuel vehicles. These vehicles can accept ethanol fuel to power the car. Right now, these are a mix of sugar or starch based ethanol. This ethanol does not reduce harmful emissions to the degree that cellulosic ethanol would, and cellulosic ethanol can be made of materials that do not compete with the world food supply. This could start our path to reducing our dependence on foreign oil and be the first step toward a standard fleet of vehicles in the U.S. that is not powered by gasoline at all.

## References

- The Alaska pipeline*. (2006, April 4). Retrieved December 13, 2008, from  
[http://www.pbs.org/wgbh/amex/pipeline/peopleevents/e\\_consumption.html](http://www.pbs.org/wgbh/amex/pipeline/peopleevents/e_consumption.html)
- Alternative fuels & advanced fuels (AFDC)*. (2008, November 11). Retrieved December 13, 2008, from U.S. Department of Energy Web site: <http://www.afdc.energy.gov/afdc/fuels/>
- Brown, L. (2008, March 2). *Why ethanol production will drive food prices even higher in 2008*. Retrieved December 14, 2008, from  
[http://www.treehugger.com/files/2008/02/why\\_ethanol\\_pro.php](http://www.treehugger.com/files/2008/02/why_ethanol_pro.php)
- Bush, G. W. (2006, January 31). *State of the union*. Address presented at US Capitol.
- Cohen, A., Ph.D. (2007, March 22). *The national security consequences of oil dependency*. Retrieved December 13, 2008, from The Heritage Foundation Web site:  
<http://www.heritage.org/research/nationalsecurity/hl1021.cfm>
- Crude oil and total petroleum imports*. (2008, November 26). Retrieved December 13, 2008, from Energy Information Association Web site:  
[http://www.eia.doe.gov/pub/oil\\_gas/petroleum/data\\_publications/company\\_level\\_imports/current/import.html](http://www.eia.doe.gov/pub/oil_gas/petroleum/data_publications/company_level_imports/current/import.html)
- Emissions of greenhouse gases in the United States 2007*. (2008, December). Retrieved December 9, 2008, from Energy Information Administration (EIA) Web site:  
<ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/ggrpt/057307.pdf>
- Energy efficiency and renewable energy (EERE)*. (2008, October 30). Retrieved December 14, 2008, from U.S. Department of Energy Web site: <http://www.1eere.energy.gov>
- Energy policy act (EPAct)*. (2007, October 25). Retrieved December 13, 2008, from U.S. Department of Energy Web site: <http://www1.eere.energy.gov/vehiclesandfuels/epact>

*Fuel efficient vehicle tax incentives information center.* (n.d.). Retrieved December 9, 2008, from

<http://www.fueleconomy.gov/Feg/taxcenter.shtml>

Gardener & Associates, D. (2008, July). *Fighting oil addiction.* Retrieved from National

Resources Defense Council Web site: <http://www.nrdc.org/energy/states/states.pdf>

*Global warming frequently asked questions.* (2008, May 8). Retrieved December 13, 2008, from

National Climatic Data Center (NCDC) Web site:

<http://www.ncdc.noaa.gov/oa/climate/globalwarming.html>

Hybrid car - pros and cons. (2006, January 19). *Physorg.* Retrieved December 14, 2008, from

<http://www.physorg.com/news10031.html>

*Hybrid cars.* (2006, September). Retrieved December 13, 2008, from <http://www.hybridcars.com>

Krauss, C. (2008, August 30). Surge in natural gas has Utah driving cheaply. *The New York*

*Times.* Retrieved from

<http://www.nytimes.com/2008/08/30/business/30gascars.html?pagewanted=print>

Oil, not ethanol, driving food prices official says. (2007, October 2). *MSNBC.* Retrieved

December 14, 2008, from Associate Press Web site:

<http://www.nsnbc.msn.com/id/21105859>

*Pain at the pump.* (2008, February 27). Retrieved December 13, 2008, from ABC News Web

site: <http://abcnews.go.com/Business/PainAtThePump/story?id=4353789&page=1>

*Pickens plan.* (2008). Retrieved December 14, 2008, from <http://www.pickensplan.com>

Richard, M. G. (2008, March 13). Plug-in hybrids might not need new power plants. In

*Treehugger.* Retrieved December 14, 2008, from

<http://www.treehugger.com/files/2008/03/plug-in-hybrids-no-new-power-plants.php>

The Toyota Prius, the world's most successful gasoline-electric hybrid vehicle. (2008, May 18).

*Auto123*. Retrieved December 14, 2008, from <http://www.auto123.com/en/news/green-wheels/the-toyota-prius-the-worlds-most-successful-gasoline-electric-hybrid-vehicle?model=prius&make=Toyota&carid=1086101800&artid=97513>

*World fact book*. (2008, December 4). Retrieved December 13, 2008, from

<https://www.cia.gov/library/publications/the-world-factbook/print/us.html>