

Should the United States Continue to Move Toward
Ethanol as an Alternative Fuel in Passenger Vehicles?

by

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Abstract

Ethanol as a fuel source has been a topic of interest in the United States in recent years. The purpose of this paper is to provide support for the use of ethanol in the United States as an alternative fuel for passenger vehicles. Ethanol provides positive environmental impact by producing lower greenhouse gas emissions and better air quality, positive social impact by creating jobs and helping improve the United States' infrastructure, and lower costs to Americans by lowering the cost of gasoline. Ethanol is also a renewable fuel source unlike current fossil fuels. All of these points are important when deciding whether or not ethanol is a good choice for fuel in the United States. There are opposing views that believe ethanol is not any better than gasoline and that it is a waste to develop. Some points people who oppose ethanol fuel like to make is that it could negatively affect the environment, its increased production could harm the United States socially, and it is too expensive to be practical. However, the evidence in this paper will prove that ethanol is a superior fuel to gasoline and that this Nation would be taking an important step forward developing ethanol further.

Should the United States Continue to Move Toward Ethanol as an Alternative Fuel in Passenger Vehicles?

On January 23, 2007 President Bush stood up in front of the entire Nation to give the State of the Union Address. In his speech he discussed recent events and what issues the Nation was facing. At one point in his speech the President said “Extending hope and opportunity depends on a stable supply of energy that keeps America's economy running and America’s environment clean.” This is how he introduced the United States’ need for clean, sustainable energy sources. As he continued in his speech he stated “We must continue investing in new methods of producing ethanol...using everything from wood chips to grasses, to agricultural wastes.” Ethanol is the alternative fuel that this paper will discuss.

This is State of the Union Address in which President Bush announced the new fuel standard goal of 35 million gallons of renewable and alternative fuel by the year 2017. One way the United States has been trying to accomplish this goal is through the use of biofuels, particularly ethanol. Biofuels are fuels made from carbon containing feedstocks, such as plants. Ethanol is produced using food crops such as corn and sugarcane, energy crops such as switchgrass and miscanthus, and crop residues such as corn stover. A fermentation process is used to make ethanol, fermenting the sugars found in the plants. There are two types of biofuels ethanol can be classified as. The first type is first generation biofuel. This includes corn ethanol, primarily made in the United States, and sugarcane ethanol, primarily made in Brazil. The other type is second generation biofuel which includes cellulosic ethanol or lignocellulosic ethanol. First generation ethanol primarily uses food crops as the feedstock. The starches and sugars found in the edible part of the plant is the part that is fermented to make ethanol. Cellulosic ethanol is made by breaking down lignocellulosic biomass, which refers to biomass that has the

combination of lignin, cellulose, and hemicellulose in its structure. This lignocellulosic biomass is broken down to an easier to ferment sugar to produce ethanol. Other non-plant sources for future cellulosic ethanol production include paper mill sludge and food waste (Limayem & Ricke).

The United States has seen a jump in ethanol production in recent years. From 2000 to 2011 alone ethanol production has jumped from 17 to 86 billion liters (Yan, et al. 5535) which is approximately a jump from 4.5 to 22.7 billion gallons in ethanol production. Although ethanol has been a topic of interest in recent years the move towards ethanol goes back to the oil embargos of 1973 and 1979. Ethanol was later pushed again because of the Reformulated Gas (RFG) program, which is part of the Clean Air Act Amendments of 1990 (Somma et. al. 374). Ethanol as a fuel source can even be seen in history as far back as 1830 (Carolan 88). Ethanol as a fuel source is not a new idea, but it is gaining momentum.

The current United States administration has also voiced its support for ethanol as a fuel source. On May 5, 2009 President Obama announced the establishment of a Biofuels Interagency Working Group, to help guide the move towards biofuels such as ethanol, as well as other steps to move the United States toward the use of biofuels. During this announcement President Obama said “We must invest in a clean energy economy that will lead to new jobs, new businesses and reduce our dependence on foreign oil,” (Office of the Press Secretary). In his 2013 State of the Union Address President Obama again expressed his support for renewable energy, such as ethanol, by saying “In fact, much of our new-found energy is drawn from lands and waters that we, the public, own together.” Through the years ethanol has gained support from the government and has shown to the American people as the future in fuel.

As part of the move towards ethanol fuel there are flexfuel vehicles (FFV) that are made to run on either pure gasoline or ethanol blends. The most common ethanol blend used for flexfuel vehicles is E85, 85% ethanol and 15% gasoline. A blend this high in ethanol will only work in the current FFV, however, the majority of fuel ethanol currently being produced is used as a gasoline additive. The ethanol in the gasoline “boost[s] octane sufficiently to eliminate engine knock (in addition to producing an overall cleaner running engine)” (Carolan 95). Most gasoline sold in the United States has some amount of ethanol in it and although the amounts may vary by region it is usually not over 10% which is normally referred to as E10 (“How Much Ethanol”). All gasoline vehicles have been approved for this low of an ethanol blend to run in their engines. Light duty vehicles from the year 2001 and on can even run on E15. There is still some pure gasoline sold without ethanol but in the approximate 134 billion gallons of gasoline used in the year 2012 about 13 billion gallons of ethanol were blended (“How Much Ethanol”).

There has been some debate as to whether or not the United States should continue to pursue ethanol as an alternative fuel, that is to say making higher blend fuels and even pure ethanol fuels. As there is with any argument there are two sides to be considered. On one side of the argument, ethanol is viewed as the next logical step in the evolution of fuel while on the other side people view ethanol as nothing more than a ploy by environmentalists and that it is no better than regular gasoline if not worse. There are many factors that influence how people view ethanol as an alternative fuel. However, with the issues the United States is currently facing this Nation should continue to develop ethanol as an alternative fuel for passenger vehicles because of positive environmental impacts, positive social impacts, and lower costs than gasoline. Beyond those reasons ethanol is also a renewable fuel.

One of the big arguments against ethanol as an alternative fuel is that its production could damage the environment. The expanding growth of crops for ethanol production has caused some concern as to whether or not the land can support it. The first environmental concern is in regards to the soil. Referencing a 2008 study done by R. Lal, David W. Archer and Jane M. F. Johnson say in their article about the impact of crop residue on the environment, "...crop residues left in the field provide a variety of ecosystem services including nutrient cycling, erosion control, soil carbon sequestration, improvement of soil physical properties, and crop productivity" (700). Traditionally when a farmer harvests a crop, for example corn, they only harvest the grain. There are parts of the plant, such as the cornstalks, which are left in the field. These corn crop residues are also known as corn stover. In this quote Archer and Johnson list the environmental effects of leaving crop residues in the field after a regular harvest. The concern for the soil is that because of cellulosic ethanol, which uses corn stover as a feedstock, there will no longer be any crop residue left to replenish nutrients in the soil as well as accomplish the other tasks that Archer and Johnson mentioned in the above quote.

The concern about water in relation to ethanol production deals with the growing of the feedstocks as well as the processing of the feedstocks. Expanding feedstock growth means an increase in water input for the growing of the feedstocks. According to a study done by Jason M. Evans and Matthew J. Cohen "[e]stimated blue water requirements for sweet sorghum... would increase by almost 25% total freshwater withdrawals for all human uses reported in Florida and Georgia for 2000; corn and sugarcane would require well over twice this water volume" (Evans & Cohen 2267). In this study blue water refers to water demands from irrigation and industrial withdrawal. The other part of this concern is that the process for ethanol production uses large amounts of water. Currently ethanol production plants use approximately 3 gallons of water per

one gallon of ethanol, however, Alya Limayema and Steven C. Ricke state in their research that “...biofuel processing utilizes a significant level of water, [but] it does not consume as much water as biofuel crops” (459). Another concern with water is the possible contamination of the water supply due to increased use of pesticides, insecticides, herbicides, and fertilizers. These chemicals could contaminate the United States’ water supply because of runoff from the feedstock fields. Barbara Esteves Ribeiro sums up the concern about water security when she writes in her research article, “The water security issue...is mostly linked to the diversion of water resources from human needs (water availability) to ethanol feedstock production and the pollution of waterways (water quality) by disposal or runoff of liquid wastes from the fields” (358). Although these seem like legitimate concerns for the Nation’s soil and water, they can be avoided.

One way to help mitigate the issues with soil and water in regards to ethanol production is through the use of government policies. Aklesso Egbendewe-Mondzozo, Scott M. Swinton, R. César Izaurralde, David H. Manowitz, and Xuesong Zhang conducted a study of possible policies and how they would affect ethanol production’s environmental impact. They tested three different policies: fertilizer tax, which places a tax on fertilizer; no till subsidy, which gives a subsidy to farmers that do not till their field before planting; and carbon price, which places an allowable amount of carbon released for a particular price. The authors’ results show that the fertilizer tax and the no-till subsidy may not have as good of an impact as desired, however “carbon price [was] highly effective at maintaining soil, water and climate quality” (Egbendewe-Mondzozo et al. 528). There are also other ways that these issues can be averted such as the increasing the efficiency of farm irrigation and plant water recycling or improving general water quality (Limayem & Ricke). An example of a biorefinery trying to decrease their impact on

water is POET, the largest ethanol marketer in the United States. POET has implemented a plan called Ingreenuity and the first goal of this initiative is to reduce water use. According to Doug Bervan, Vice President of Corporate Affairs of POET, POET is currently producing a gallon of ethanol with only 2.2 gallons of water. This number is on par with the amount of water it takes to make a gallon of gas, which is 2-2.5 gallons (“Water Use for Ethanol Production”). POET’s initiative set a goal to reduce their water intake to 2.33 gallons for one gallon of ethanol by the year 2014 (POET) and they have passed their goal. That amount is also lower than the water amounts used in other industries. For example, it takes 14 gallons of water to produce 1 pound of sugar and it takes 150 gallons of water to make 1 Sunday newspaper (“Water Use for Ethanol Production”). Compared to these industries the amount of water used to make a gallon of ethanol is relatively low. In addition, the amount of water feedstocks use is not as high as some studies would like to convey. According to Berven these studies add rainfall to the amount of water required to grow crops. This does raise the amount of water used, but it also gives the false impression that this large sum of water is being diverted from human consumption needs. The only crops that divert water from human needs are irrigated crops which according to Berven make up only 3% of ethanol feedstocks in the United States. Ethanol production may seem to use a large quantity of water, but the amount is considerably less than other industries and does not divert water from human needs to as large of an extent as people who oppose ethanol fuel would have Americans believe.

Those who focus on the possible negative impacts ethanol fuel may have neglect to see the positive environmental impact ethanol fuel can have. One of the largest environmental impacts of ethanol fuel is lower greenhouse gas (GHG) emissions particularly compared to gasoline. Greenhouse gas is “any of the gases whose absorption of solar radiation is responsible

for the greenhouse effect, including carbon dioxide, methane, ozone, and the fluorocarbons” (“Greenhouse Gas”). Although the greenhouse effect is a natural effect, human activities have increased the amount of greenhouse gases beyond the natural amount. GHG emissions in most studies are looked at as lifecycle GHG emissions. This means that every part of the lifecycle of ethanol is taken into consideration, from the clearing of the land to the planting and growing of the crop to the harvesting of the crop to the processing and distribution of the final ethanol product. A study done by Juan P. Sesmero shows “that [corn] ethanol plants...can produce energy with considerabl[y] lower (52% lower) GHG intensity than gasoline” (70). He further goes on to say “...these plants have some room for reducing this footprint even more by reallocating inputs and byproducts. Such reallocations would achieve a 6.5% reduction in GHG rendering energy with a GHG intensity 55% lower than gasoline” (Sesmero 70-71). Sesmero’s research shows corn ethanol plants can have significantly lower GHG emissions than gasoline.

There has, however, been debate on whether or not ethanol actually has less GHG emissions than gasoline. This is mostly in regards to corn ethanol. Some analyses, such as the study done by Dan Somma, Hope Lobkowicz, and Jonathan P. Deason, suggest that corn ethanol does not have lower GHG emissions when compared to gasoline. The study by Somma, Lobkowicz, and Deason does not give any figures to support their claim, but they do make a good point in their analysis about the possibility of land use change increasing the GHG emissions of ethanol stating, “Any changes from forestland into crop land for fuels will mean a sharp rise in emissions” (378). An example of land use change would be deforestation for crop land. Although this may be a good point Doug Berven states that since 2005 deforestation in the Amazon has decreased while ethanol has increased. This shows that an increase in ethanol production will not increase deforestation. There is some land use change that does increase

greenhouse gas emissions, but these emissions can be decreased by the production and use of cellulosic ethanol.

Research on cellulosic ethanol has shown that it emits less GHG than even corn ethanol. Michael Wang, Jeongwoo Han, Jennifer B Dunn, Hao Cai and Amgad Elgowainy found that “...most analyses of cellulosic ethanol reported significant reductions in life-cycle GHG emissions when compared with those from baseline gasoline. Reductions of 63% to 118% have been reported (Borrion et al 2012, MacLean and Spatari 2009, Monti et al 2012, Mu et al 2010, Scown et al 2012, Wang et al 2011a, Whitaker et al 2010)” (Wang et al. 2). With this being true the next logical step in the use of ethanol as an alternative fuel is from corn ethanol to cellulosic ethanol. This move will continue to lessen GHG emissions which would help bring the amount of GHG to a more natural level.

Along with lower GHG emissions, using ethanol as an alternative fuel can positively impact the environment by improving health conditions. Ethanol is added to gasoline because of its high octane value which prevents engine knock. Instead of ethanol, aromatics have been blended with gasoline to prevent engine knock. Aromatics are known carcinogens (Gray). According to the Clean Fuels Development Coalition Technical Committee of the California Air Resources Board using only ethanol and no aromatics would decrease harmful emissions such as carbon monoxide by 13% and air toxics by 28% (Gray). Aromatics are still used in gasoline today. Even though the 1990 Clean Air Act Amendments issued that gasoline should have “clean ethanol” blended with it gasoline aromatics still make up 20% (Gray). Aromatics are also more expensive than ethanol. Using ethanol is cheaper than using aromatics in gasoline as an octane booster (Berven). Considering the facts of ethanol and aromatics ethanol is the superior choice to promote higher quality health conditions.

For the GHG emissions that ethanol does emit there is a solution. The carbon price discussed earlier would decrease GHG emissions in the United States. Egbendewe-Mondzozo, Swinton, Izaurralde, Manowitz, and Zhang report the findings of their study saying, “[r]elative to the baseline of no biomass production[,]. . . GHG emissions [will] decrease on average by . . . 2.1% . . .” (524-525). This number takes into consideration producers’ behavioral reactions to the carbon price and the changes they will make to help reduce the effect of the carbon price on their businesses.

A second argument proposed by people opposed to use of ethanol as an alternative fuel focuses on the social impacts that may go along with increased ethanol production. These are issues that people in the United States can really understand. In her research article Esteves Ribeiro brings to light hidden issues of ethanol production when she says “. . . processes related to ethanol’s lifecycle can engender . . . processes of social change involving various actors, such as farmers, employees, consumers and members of rural communities” (356). Ethanol production, especially the increase of it, will affect the people of the United States. One such impact would be the loss of jobs for farm workers. Farming methods would need to change to support the growing of ethanol feedstocks. Farms would likely grow to the point of needing to move to mechanization. This would cause farm workers to lose their jobs (Esteves Ribeiro). Another negative impact is caused because ethanol is more corrosive than gasoline and it has a higher susceptibility to water so the current pipeline system for transporting gasoline cannot be used. This means ethanol needs to be transported by truck and train. Because of this traffic will increase and possibly cause problems with traffic flow. The increase in traffic could also put more wear onto roadways and railways (Esteves Ribeiro). These negative impacts can be

detrimental to the United States, but they can be overcome by the positive social impacts of ethanol production.

For the farm workers that lose their jobs there would be jobs created by the construction of biorefineries as well as jobs created by the plant when it is running. Some of these jobs would be for skilled workers such as scientists and engineers, but there would be jobs however that unskilled workers such as farm workers could be trained to do. Other jobs would be created by the increased use of pesticides, insecticides, herbicides, and fertilizers. More workers would be needed to keep up production with the increased demand. According to the Renewable Fuels Association (RFA) the ethanol industry created 383,260 jobs in 2012. This includes jobs directly created by the ethanol industry which mostly deals with agriculture, manufacturing, and services. The total count also includes jobs indirectly created, which are jobs created by business to business transactions, as well as jobs induced by the ethanol industry, meaning jobs created by the spending of workers in the directly and indirectly created jobs. The type of jobs included here are agriculture, mining, construction, manufacturing, transportation/public utilities, wholesale/retail trade, services, and government (RFA). Also the economies in rural United States will see a boost due to the increase of crop sales. According to Doug Berven, ethanol production has been one of the biggest boosters of rural economies. This is because ethanol has used up surplus corn crops and in turn has allowed for market pricing of corn. Ethanol production is also helping developing countries by making it more economical for them to grow their own corn. Up until recently it was cheaper for developing countries to buy corn from the United States making them dependent on the United States. However, now that the America does not have the surplus of corn as before these countries grow their own corn crops and are becoming less dependent on the United States and more dependent on themselves (Berven).

Although there are possible negative impacts related to the use of ethanol as an alternative fuel they are outweighed by the many positive social impacts of ethanol production. One very important effect of ethanol as an alternative fuel for passenger vehicles is the improvement of the United States' infrastructure. There are multiple ways that ethanol production can do this. One is by spending less money on imports and more money on domestic needs. The more ethanol the United States uses as an alternative fuel the less the United States will need foreign oil. In 2005 foreign oil dependency was over 60% but in the 7 years since that amount has dropped to 41% partially because of the increase in ethanol use (RFA). This means that less money will be sent to other countries and more money will stay in the United States. Keeping this money in the United States will help boost the economy which is a much needed effect. There is the argument that the United States will buy ethanol from foreign countries such as Brazil which would negate the change. Although this is a valid point there is a difference. If the United States buys ethanol from Brazil rather than oil from countries such as Iran the United States would be dealing with a more stable country and government structure. In a 2010 article C. Boyden Gray discusses one of the lesser known costs of foreign oil saying that because oil is in hostile countries there are costs for the US military to keep oil producing regions safe and shipping lanes safe as well. Ray Mabus, Secretary of the Navy, described the situation as such:

When we did an examination of the vulnerabilities of the Navy and Marine Corps, fuel rose to the top of the list pretty fast. We simply buy too much fossil fuel from actual and potentially volatile places. We would never allow [some] of these countries we buy fuel from to build our ships, our aircraft, our ground vehicles - but because we depend on them for fuel, we give them a say in whether our ships sail, our aircraft fly, our ground vehicles operate. (qtd. in RFA)

The United States risks and spends a lot depending on foreign oil, relying heavily on enemies of war to help fuel our fight as well as way of life. The United States spends between 27 and 137 billion dollars on military operations to transport oil safely from the Persian Gulf. This is the same as adding \$1.17 per gallon to the price of gasoline (RFA). Foreign oil dependency is costing America greatly, but ethanol is helping to lower that cost.

Another way ethanol production can positively impact the United States is that ethanol can help improve the Nation's transportation infrastructure. The increase of traffic and the extra wear will force the United States to work on the transportation infrastructure. The "...implementation of ethanol projects could lead to overall improvement of transportation infrastructure—e.g., repairs of railways (Ng et al., 2011)" (qtd. in Esteves Ribeiro 358). There are roadways and railways that have fallen into disrepair from not being used. We need to utilize those pathways again and give the United States the attention needed. These transportation pathways can be repaired and new ones can also be built. This can also create more jobs for Americans.

A slightly indirect way ethanol fuel production can help the United State infrastructure is through the coproducts and byproducts of the process. Coproducts are made in conjunction with the main product whereas byproducts are an incidental product made with the main product. These coproducts and byproducts can help alleviate some of the stresses of fossil fuel reliance. This is done by replacing petroleum-based products with natural-based products made by the ethanol fuel making process. An example of this is the company POET who sells, in addition to ethanol, other products created from their ethanol production process. One such product is Dakota Gold™ which is an animal feed high in protein. Another product produced by POET is VOILA™ which is a high quality corn oil that can be used in the production of biodiesel. A third

product created by POET is INVIZ™ zein which can be used in a variety of capacities including biodegradable plastic, films, glazes, and adhesives (*POET*). These products produced by POET are all part of a result of the ethanol production process and these products can replace current petroleum-based products which means the United States can spend less money on oil, especially foreign oil.

A major argument against the use of ethanol as an alternative fuel for passenger vehicles is that the process for making ethanol can be expensive. The basic steps of the process are pretreatment, hydrolysis, fermentation, and distillation. During this process enzymes are added to help break down the feedstock. These enzymes can be expensive, especially in the case of cellulosic ethanol. One such enzyme, cellulase found in the stomach of a termite can "...[cost] roughly 50 cents a gallon--more than 10 times the price of enzymes used in traditional ethanol fermentation." (Biello) Another great expense of ethanol production is the capital it takes to start a plant. Bloomberg New Energy Finance, a part of Bloomberg, "...the world's most trusted source of information for businesses and professionals" ("Cellulosic Ethanol"), did a study on the cost of cellulosic ethanol. According to this study, capital accounted for 41% of the minimum ethanol selling price (Voegelé). The same study noted that the largest expenses besides capital are feedstocks and enzymes ("Cellulosic Ethanol"). Although these prices may seem high, with the advancement of technology these costs are decreasing by the year.

A possible solution to the problem of enzyme expense is gasification. Gasification uses a catalyst that feedstock is passed over to treat it after the feedstock has been turned into a mixture of gases. The gases are then converted to methanol, alcohol, and ethanol liquids and separated. A study in 2007 conducted by Philips et al. of the National Renewable Energy Laboratory predicted that cellulosic ethanol produced using gasification could become competitive with corn

ethanol by the year 2012 (Somma et al. 377). Although this has not been the case that does not mean it will never be true. Cellulosic ethanol currently is more expensive than corn ethanol, but the Bloomberg New Energy Finance predicts cellulosic ethanol may become comparable to corn ethanol by the year 2016 (“Cellulosic Ethanol”). In 2012 corn ethanol was about \$2.54 per gallon of ethanol and cellulosic ethanol was \$3.55 per gallon of ethanol, 40% higher, however, the cost per gallon of cellulosic ethanol should be the same as corn ethanol by 2016 (Voegele). This is due in part to the advancement of technology making enzymes cheaper. The contributing cost of enzymes has reduced by 72% from 2008 to 2012 and it is expected that enzymes will reach as low as 8 cents a litre by 2016 (Voegele). There will be further advancements and breakthroughs for ethanol production that will make production easier and more affordable because technology is an ever changing field that is propelled by the need to be more efficient.

Another possible way ethanol costs are being mitigated is through government subsidies, credits, grants, and loans. According to Biello ethanol has “...been affordable only because of massive federal subsidies.” Ethanol is not the only commodity subsidized. Oil has large subsidies bringing in \$40 billion dollars by direct and indirect subsidies (Gray). Oil companies even receive subsidies that seemingly would belong to ethanol producers. One such subsidy is for blending ethanol into gasoline. According to a report by Phillipott in 2007 the United States spent about \$164.7 billion in agricultural subsidies from 1995 to 2005 which averages out to \$16.5 billion per year (Carlton). This is less than half what the oil companies receive annually. Biello does not support his statement with the types of subsidies ethanol receives and why. He does say that in 2010 corn ethanol only reached commercial availability because of subsidies that reach over \$5.86 billion (Biello). This number on its own seems very large but compared to the amount of subsidies received from 1995 to 2005 it is less than half. It is also dramatically

smaller than the amount oil companies received according to C. Boyden Gray in an article he wrote in 2010.

Ethanol has actually been saving people in the United States money. A 2009 article written by Xiaodong D. Du and Dermot J. Hayes notes the link between ethanol use and the price of gasoline. In their article they give the amount ethanol has lowered gasoline prices by region. The average of the amounts they give is about \$0.21 per gallon of gasoline. This is an average based on data from a study done in 2009. The Renewable Fuels Association released an article in 2012 noting that in 2011 ethanol lowered gasoline prices by \$1.09 per gallon. According to their study “[r]egular grade gasoline prices averaged \$3.52 per gallon in 2011, but would have been closer to \$4.60 per gallon without the inclusion of more than 13 billion gallons of lower-priced ethanol” (RFA). This is a drastic difference especially considering how much gasoline an average American buys in a week. This means the average American household saved over \$1,200 in 2011, assuming the average American household consumed an average of 1,124 gallons of gasoline (RFA). With the United States economy being in recession many Americans are watching their money and the use of ethanol has unknowingly saved Americans billions of dollars.

A vital reason ethanol production should be continued is because it is a renewable fuel source. According to dictionary.com renewable means something that can be replenished (“Renewable”). Because ethanol uses feedstocks that can be regrown it is said to be a renewable fuel source. This is a fact that has been fueling the move towards ethanol. The United States is currently dependent on fossil fuels, particularly oil, as a source for passenger vehicle fuel. Fossil fuels are derived from once living things, but this not a renewable source because it takes millions of years to form and as humans we cannot replenish the supply. This makes fossil fuels

a relatively finite fuel source. There will come a day when there will no longer be enough fossil fuels to meet the United States' needs. The U.S. needs to start looking forward and preparing for the time when fossil fuels become scarce. If the United States waits to come up with a solution when fossil fuels have already been depleted to an unusable amount it will be too late. With the United State growing in size fossil fuel consumption is increasing. From the year 2000 to 2012 gasoline consumption has increased 84,538 thousand barrels which is approximately 3,550,596,000 gallons ("U.S. Product Supplied"). This is a large amount and as the population of in America increases the amount of oil needed to keep up with demand will increase unless we as a Nation continue to develop ethanol as an alternative fuel.

In conclusion, according to the evidence presented in this paper, the United States should continue to move towards ethanol as an alternative fuel because of positive environmental impacts such as lower greenhouse gas emissions and better air quality, positive social impacts such as lessened foreign oil dependency and improvement of the United States' infrastructure, and lower costs than gasoline. Ethanol is also a renewable fuel source unlike its soon-to-be predecessor fossil fuels. People in opposition of using ethanol as an alternative fuel in passenger vehicles claim ethanol negatively impacts soil and water which negatively impacts the environment. They also believe that ethanol will have a negative social impact because of the job loss to farm workers and the increase of traffic. A third belief that people who oppose ethanol hold is that ethanol is too expensive to be used as a fuel. All of these claims and beliefs may have some legitimate founding, but they are not enough to show ethanol is not a good fuel source. As this paper discussed all of these issues can be overcome and some issues that seem too overwhelming are exaggerated. Doug Berven said that changing the energy complex of the world will not happen without a fight. Even as more studies reveal that ethanol can be, and in

some ways already is, a superior fuel to gasoline there will still be people who will oppose ethanol. It is important to make sure people, especially consumers, understand what it will mean to switch fuel to ethanol and that in spite of the opposition the United States continues to move forward with this important step. More research should be done and made available to the public so they know what the controversy is about and what the truth is.

Although ethanol is superior to gasoline in many regards the United States should use caution when developing ethanol. Ethanol fuels can be very beneficial to the United States, but they could also harm the United States if proper planning is not done. The United States cannot run blindly to ethanol expecting it to solve all the fuel problems. Proper consideration needs to be taken at every step of the move towards ethanol as an alternative fuel. This Nation also needs to be sure not to have tunnel vision when developing ethanol. There are other options for alternative fuels that may show they are better in some regards. The United States needs to diversify the energy supply so the situation that fossil fuel dependency has put us in will not repeat. This Nation should not become so dependent on ethanol that if something were to happen to that industry the United States would not have an energy source to fall back on to. It is important to see all the options and to not shut out other, possibly more viable, solutions. Ethanol may not be an all-encompassing solution. It probably will not solve all the fuel problems the United States faces, but it does offer a step in the right direction to keep the United States moving forward. It can give the people of the United States hope that the energy of the future will not run out and will make the quality of life better.

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