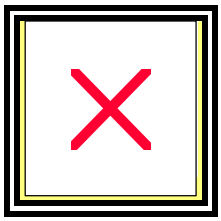

American Society for
Engineering Education

ETHANOL: Start Me Up

THE SUSTAINABLE FUEL FOR AMERICA=S FUTURE

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UNIVERSITY OF NOTRE DAME
DEPARTMENT OF CHEMICAL ENGINEERING

Washington Internships for Students of Engineering

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THIS PAPER IS DEDICATED TO THE CHARACTER, TRADITION, AND SPIRIT THAT IS THE NOTRE DAME FAMILY.

About the Author

Robert Thornburg was born and raised in the community of Titusville, Florida which borders the NASA Kennedy Space Center. He attended Titusville High School where he became the class valedictorian, Secretary of the Student Body, and MVP of the swim team. Presently, Robert is a senior honor student in the Department of Chemical Engineering at the University of Notre Dame. Involved in various positions throughout the University, he is the current Editor-in-Chief of the Technical Review, the Notre Dame Engineering Magazine. He is the former Treasurer of the American Institute of Chemical Engineers, and is now the Secretary of Tau Beta Pi, the National Engineering Honor Society. Robert is also active in other various campus activities. He was the former Chairman of University-Wide Freshman Orientation and is a Resident Assistant. Robert plans to attend law school upon graduation in order to pursue a career in intellectual property rights in petroleum refinement and pharmaceutical development.

The WISE Program

The Washington Internships for Students of Engineering is a ten-week program for outstanding engineering students who have completed their junior year and display evidence of leadership skills and interest in public policy. The students spend the summer in Washington DC, learning how engineers contribute to public policy decisions on complex technological matters. Through frequent meetings and discussions with government officials and other policy-makers, students examine a variety of public policy issues. Each student completes a paper that analyzes specific engineering public policy issues of concern to its sponsoring society. For information about the WISE program, contact WISE, Attn: Anne Hickox, 400 Commonwealth Dr., Warendale, PA 15096-0001.

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EXECUTIVE SUMMARY

It has been ingrained in the American psyche that non- renewable petroleum is the only answer to its energy needs. While this may have been true in the past, several alternative energy sources and technologies have been developed and improved to alleviate our dependence on fossil fuels. Of these, ethanol represents a viable and renewable means of providing liquid fuel that is environmentally friendly and will help the United States in several ways. This paper seeks to reveal the truth on ethanol, to clearly discuss its numerous misconceptions, and display the attributes that make it an important energy alternative for America=s future prosperity.

The major advantage of implementing fuel ethanol are the environmental benefits, in comparison to standard gasoline. While gasoline is comprised of various toxins, hydrocarbons, and sulfur, fuel ethanol is a clean liquid that produces less particulates, carbon monoxide and dioxide, and sulfur dioxide. It is an oxygenate that reduces greenhouse gas emissions, inner-city smog, and the depletion of the ozone layer.

Its use also will alleviate America=s dependence on imported oil and its current trade imbalance. Studies show that it has cost $4 trillion to have a military presence in the Middle East. The US General Accounting Office has shown it costs $36.5 billion per year to protect US interests in the Persian Gulf. These figures are alarming and suggest the development of a more domestic fuel alternative like ethanol.

Research has provided great advances in the ethanol technologies. The Department of Energy=s Hennepin Project helped demonstrate the reliability of fuel ethanol vehicles and their environmental benefits. The Ford Motor Company and Baylor University have both showcased commercial aircraft and automobiles that can run on ethanol. Ethanol is a proven technology ready to be implemented by the American people.

This paper=s findings suggest that ethanol is a sustainable fuel. It finds that Flexible Fuel Vehicles like Ford=s provide the best means of incorporating ethanol into America=s energy infrastructure. While excise taxes initially helped increase ethanol production, lower risk plans like production incentives and income tax deductions should replace older ethanol legislation. Rather, state agencies should help foster ethanol production and use. The result will be balanced trade, less need for military presence in the Middle East, and greater domestic distribution of US wealth.

The implications of making ethanol a major part of America=s future energy usage demonstrates a needed change in our public policy. Only through time and legislation can ethanol become a substantial and effective fuel alternative. By educating the American people of its numerous benefits, ethanol should soon become a standard part of local gas stations, allowing a viable energy choice for America=s future.

ISSUE DEFINITION

The energy needs of the United States is one of the most pressing problems for our nation. A country of consumers, America possesses only 5% of the world population but uses 25% of the world=s natural resources. Because of this, it should become the public policy of this country to embrace the idea of sustainable development and divert its resources into research and development that will reduce America=s dependence on non-renewable fossil fuels.

Ethanol has been shown to be an environmentally friendly and viable energy alternative that suits the energy needs of the United States. Although plagued by both private interests and public misconceptions, ethanol can and should become a significant part of America=s energy usage. This paper seeks to unveil the truth behind ethanol and the factors that make our present use of petroleum problematic. Its findings suggest that ethanol is competitive in various aspects to gas.

The historic struggle of ethanol against petroleum has led to its present position as a fuel alternative. The initial perception of ethanol as a liquor lead Congress to impose unfair taxes, which directly lead to the automotive and chemical industry=s present dependence on oil. With Prohibition, ethanol received its final crushing blow, one that has lasted until this day.

Only when the United States= oil reserves have been questioned has the United States government attempted to impose favorable legislation to aid this industry. During World War II and the oil crises of the late 1970s, Congress implemented programs to raise the amount of ethanol produced. Ethanol soon found use as primary feedstocks in the synthetic chemical industry. However, once the United States regained its ability to purchase cheep fuel, ethanol was once again reduced in stature and use.

In the quest to guarantee United States= ability to purchase cheap petroleum from the Middle East, the American tax payer has indirectly paid for a military presence lasting over the last half century. The hidden and egregious costs of associating with the unstable Arab Nations has led to the Operations Desert Shield and Storm, led to deaths of American Soldiers, and the ultimate fear that the region may use chemical, biological, and nuclear weapons against this nation. Estimates show that America=s presence in the Persian Gulf have totaled $2 trillion- an average of $36.5 billion per year. However, such costs do not include the fear now present in the minds of many Americans. No estimation can put a price on the loss of American lives in the region nor the numerous hijacking and hostages that have resulted from our dependence on fossil fuels.

The American people have also paid for the environmental pollution and health problems resulting from the use of petroleum. Instead of ethanol, the oil industry openly has used toxins and carcinogens as fuel additives. To reduce engine knock, the oil industry opted to use lead over ethanol because it was cheaper. Although knowledge health problems associated with lead were known, the oil industry did nothing until Congress banned its use in 1994. Currently, the oil industry has added benzene, and other known carcinogens as octane enhancers to improve performance. Once again, ethanol was not implemented even though it is a known octane

enhancer. Studies by the Department of Energy have shown that the external costs of a single barrel of oil are around $45, compared to its current selling price of $15. These external costs are composed of the costs the American people must pay for the clean up of oil spills, acid rain damage to lakes and streams, and the numerous respiratory and cardiovascular illnesses caused from its use. These are the real costs the American people pay at the pump.

While these figures cause concern, what is alarming is that they are relatively unknown to the American public. In addition, present ethanol legislation that is suppose to aide ethanol has further lead to public misconceptions and resentment towards this fuel alternative. For the last decade, Congress has allowed an excise tax for ethanol to help make it more affordable and stimulate ethanol production. However, such a tax break has lead to resentment and has been the determent of the ethanol industry. Congress has now realized this and begun to adopt income tax deductions and production incentives as more low-risk options to increase ethanol production.

Another problem that is slowly being reversed is the idea that the consumption of natural resources and growth of industry and infrastructure are the answer to America=s economic problems. Developed in the late 1970s and embraced at the Earth Summit, Sustainable Development is the philosophical and sociological direction that may help educate the American people that petroleum use should be reduced and renewable energy sources like ethanol increased. With the appointment of the President=s Council on Sustainable Development and grassrooted efforts across the country, the American People may begin to understand the serious dilemma that has plagued their lives over the last half century.

The American people have lived under a blanket of protection that has cost them dearly. It is the direct purpose of this paper to allude to the truth about the current ethanol industry and provide a realistic energy alternative that deserves consideration. Ethanol is not the only answer to the energy problems of this country, nor will it solve every problem associated with using a carbon based fuel. However, it is a domestically produced liquid fuel that possesses known environmental benefits. Through outlining the numerous problems associated with petroleum and illustration that ethanol use would reduce such problems, its needed implementation into the energy infrastructure of this country is demonstrated.

BACKGROUND

THE HISTORY OF ETHANOL

Ethanol has been part of America=s energy infrastructure for over 100 years. Before the Civil War, ethanol was considered the nation=s predominant liquid fuel, while gasoline was a dirty oil used for lighting street lamps. Since then, ethanol has suffered under its preception as just an alcohol and suppressed by federal taxes and programs. Only during periods of uncertain petroleum interests has ethanol regained strength and public support.

By the 1850s, the United States had an effective and significant means of producing ethanol from corn. Almost 90 million gallons were produced in the late 1850s with over 3 million from a Cincinnati mill. Soon after, oil was successfully drilled in Titusville, Pennsylvania in 1861. This was the first form of marketable petroleum in the US and was able to enter the market only after help from the federal government. In addition, Congress imposed an incredible $2.08 per gallon tax on liquor, which crippled the ethanol industry. While the tax was meant as a means of financing the Civil War, it allowed fuels like methanol and kerosine to avoid taxation. Only after public pressure from farmers was the federal liquor tax repealed by President Theodore Roosevelt in 1906.

With the rise of Standard Oil Trust and undue taxation, America=s ethanol industry could not compete in the United States= growing energy infrastructure. By 1906, the automobile had been commercialized and gasoline appeared to be the fuel of choice. Ethanol did make a small resurgence after the federal liquor tax was repealed with production raised to 10 million gallons by 1914. However, this capacity was 90% less than production before the Civil War. Ironically, Henry Ford=s Model T was designed to run on both ethanol and gasoline.

The ethanol industry suffered its second devastating setback in the form of Prohibition. This blow allowed the petroleum industry to dominate America=s energy needs and established itself as the basis of industry. Before World War I, Germany led the synthetic chemistry industry. However, after WWI, Congress seized German chemical patents and channeled the royalties to the Chemical Foundation. In order to gain a share of the profits, the petroleum industry began to establish Departments of Chemical Engineering, the first at M.I.T. in 1920. Through the creation of academic endowments, the oil industry oriented fossil fuels as the basis of engineering processes. Congress imposed high tariffs on imported synthetic chemicals, which established fossil fuels as the cornerstone of chemical academic research.

After Prohibition, the petroleum industry had a firm grip on both the chemical and automotive industries and ethanol was regarded as simply an octane enhancer. However, instead of opting for using ethanol to reduce engine knock, the petroleum industry chose to use inexpensive lead. Many scientists and academics pointed to this as a poor decision, one that would directly lead to health problems. It was not until 1994 that federal law banned the use of lead in gasoline. For over 75 years, the petroleum industry poisoned the American people with lead for its own self-interests. Only after numerous deaths and illnesses did our government finally go against the oil industry and require lead-free gasoline.

> AIf leaded gasoline kills enough people soon enough to impress the public, we may get from Congress a much-needed law and appropriation for the control of harmful substances, but it seems more likely that conditions will grow worse so gradually for this is the nature of the disease-that leaded gasoline will be in nearly universal use and larger numbers of cars will have been sold that can run only on that fuel before the public and government awaken.@-Dr. Wendell Henderson of Yale University

It was during World War II that ethanol use rose to an unprecedented 600 million gallons per year. With government support and federal subsidies of grain ethanol, ethanol found use as fuel and the basis of the synthetic rubber industry. Ironically, it took uncertain foreign relations and shortages of petroleum for the national government to implement the ethanol industry as a source of renewable hydrocarbon feedstocks. This dependence vanished after the war, with cheap foreign oil and the ability to export American farm products to Europe.

The late 1970s presented the most consolidated era of infrastructure for the ethanol industry. Soon after OPEC began limiting exports of oil to the United States, various coalitions and alliances began to form in order to consolidate the ethanol industry and curve Americaŧs dependence on petroleum. The Midwestern states formed the Governoŧs Ethanol Board, to provide a unified effort to increase the number of ethanol plants in area and educate citizens on the benefits of ethanol. The Nebraska Ethanol Board was formed as the first state agency solely dedicated to developing programs and initiatives to increase production of fuel ethanol in that state. Even though the United States was able to increase its imports of oil, these coalitions remain and serve and the only means of making ethanol a part of Americaŧs energy supply.

ETHANOL TERMINOLOGY

ETHANOL

Ethanol (ethyl alcohol, EtOH) is manufactured by the fermentation of grains such as wheat, barley, corn, wood, and sugar cane. It is clean, colorless liquid with a somewhat sweet flavor. Ethanol melts at -114.10ºC, boils at 78.5ºC, and has a density of 0.789g/ml at 20ºC. Traditionally thought of as a beverage product for use in spirits, beer, and wine, ethanol is an important, viable

energy alternative to unleaded gasoline.

FUEL ETHANOL

Comprised between 85% and 95% of pure ethanol, fuel ethanol is mixed with standard gasoline as a superior performance and environmentally friendly liquid fuel. It is also referred to as E85 (85% ethanol and 15% gas) and E95 (95% ethanol and 5% gas). Fuel ethanol requires specially designed engines for use in automobiles.

GASOHOL

Consisting of 15% ethanol and 85% gasoline, gasohol is an approved fuel for used in all vehicles. It is included in the engine warranties of every US and imported car. Motorboats, snowmobiles, motorcycles, lawn-mowers, and chainsaws can all utilize this cleaner burning fuel. Ethanol as a fuel additive reduces engine ping and allows smoother acceleration. Through blending 15% of ethanol to gasoline, automobiles reduce emission of carbon monoxide up to 25%.

RENEWABLE ENERGY

Unlike gasoline other fossil fuels, renewable energy sources allow for abundant energy without fear of exhausting our energy supply. Mostly produced from agricultural feedstocks and biomass, these energy sources utilize America=s agricultural prowess and lessen dependence on our importation of non-renewable energy.

> ARenewable energy sources typically have fewer environmental impacts than do fossil fuels and have significant domestic and international market potential@ - Sustainable America pg.183

SUSTAINABLE DEVELOPMENT

> AThe challenges ahead are significant, but if we choose the right course, we can together build an America that is not only stronger, more equitable and more prosperous, but truly sustainable@ - Vice-President Al Gore

In June of 1992, at the largest gathering of world leaders in history, the nations of Earth agreed to collectively pursue a new path - a direction to put the world on a more sustainable course. It was at the Earth Summit that the phrase Sustainable Development found use. Later, President Clinton created the President=s Council on Sustainable Development, and asked it toADevelop a National sustainable development action strategy@ While sustainable development is an idea that was first introduced in the late 1970's, it was popularized in 1987 by the World Commission on Environment and Development. Known as the Bruntland Commission, the group defined sustainable development asAdevelopment that meets the needs of the present without compromising the ability of future generations to meet their own needs@

SUSTAINABLE TECHNOLOGY

Sustainable technologies provide the means of achieving sustainable development. In terms of a technology that will reduce the use of non-renewable energy and provide environmental benefits, ethanol is a means of achieving sustainable development.

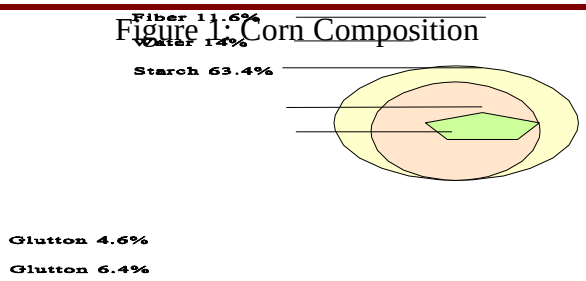
ETHANOL SUSTAINABLE TECHNOLOGY

The processes used to produce ethanol fully utilize the entire corn kernel and produce a variety of other food products. There are two means of producing ethanol: wet and dry milling. In the wet-milling process, water is used in a gentle rubbing action to remove the seed coat while dry-milling crushes the dry kernel. Dry-milling plants are more predominant since they require a smaller initial capitol investment. More lucrative, wet-milling plants produce products like corn glutton, corn syrup and corn oil. An alternative food for cattle producers, corn glutton contains about 17-21% of the protein and 95-100% of the energy in corn. In addition, the carbon dioxide produced during fermentation of corn starch is captured and used by the soft drink industry.

THE ETHANOL PRODUCTION PROCESS

Ethanol can be made from a variety of grains. Corn production in the United States is around 8-10 billion bushels per year which comprises 45% of all grains produced. The availability of corn as a feed stock makes it the choice for production of domestic fuel ethanol.

Figure 1: Corn Composition



A kernel of corn has four major constituents: the germ, pericarp or hull, gluten and starch. The germ and hull are well defined entities while the gluten and starch are intermixed granules in a matrix called endosperm. The endosperm surrounds the germ and is enclosed in the pericarp or hull. Grains other than corn have similar components.

Each of the major constituents of grains have specific uses. The germ is crushed to recover vegetable oil and the remaining solid, also called meal, is used as animal feed along with the hull. Gluten is the protein component of grain used as both human and animal feed. Starch is directly used as food and can be modified for use in the paper industry and other products like high fructose corn sweeteners.

There are two major means of producing ethanol from grains: wet and dry milling. Wet milling isolates the desired starch in a wet slurry while dry milling pulverizes the complete grain to a powder. Both methods use the starch from corn with enzyme and yeast activity to form ethanol.

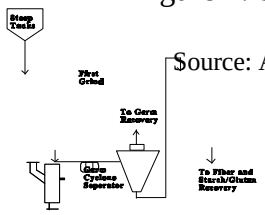
MAJOR ETHANOL PRODUCTION STEPS

(ADAPTED FROM ADM=S PROCESSES) :

Milling

Wet Milling: The Wet Milling Process begins with grain that has been soaked in water for a specific time period. This helps soften the grain which then passes through a series of mills, screens, cyclones and centrifuges that separate and refine the grain constituents for production and sale. The final production used in ethanol is the clean starch slurry.

Figure 2: Steeping and Milling Processes



Source: Arthur Daniels Midland Company

Steeping: The dry cleaned grain is conveyed to specially designed steep (soaking) tanks. The corn is soaked in water and sulfur dioxide for about forty hours. Water returned from the milling area is used to steep the entire grain. This stage loosens the germ and softens the endosperm which aids the mechanical separation steps.

Germ Recovery: Separated from the process slurry, the germ is de-watered by a mechanical press and its moisture is reduced by 50%. The germ is then dried with a rotary drier and sold for its oil content.

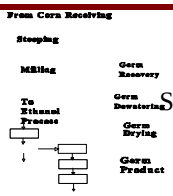


Figure 3: Modified Wet Milling
Source: Arthur Daniels Midland Company

Fiber Separation: A special set of screens separates the starch and gluton from the full. The typical fiber recovery system allows for the separation of the starch/gluten slurry through a series of screens, followed by de-watering with a mechanical press. The dried fiber is palletized and used for animal feed.

Modified Wet Milling:
The oil containing germ has the highest value of the by-products that are separated in the wet milling process. It is desirable to recover this oil but due to the germ=s fragility this can only be performed before further grain processing. Through modifying the original wet milling process by lengthening the soaking step enables the effective amount of germ separation.

Dry Milling: Requiring a set of hammermills to crush the grain into fine powder, dry milling results in a fine meal. The separation of components in this process are much more simple and require a lower capital investment compared to the wet milling process. However, no grain components are separated for use in by-products.

Liquefaction and Saccharification

This initial process first converts starch to fermentable form. The dry milled grain is wetted to form a slurry containing starch. The starch slurry is heated with steam for sterilization and then treated with enzymes. Cookers with a high temperature stage (12 120-150 degrees Celsius) and a lower temperature holding period (95 degrees Celsius) are used. This creates saccharides. The high temperatures reduce bacteria levels in the mash. With further enzyme addition the saccharides are reduced to fermented sugars.

The typical liquefaction system is composed of a premixing vessel, a jet cooker, flash cooler and liquefaction reactor. Liquefaction utilizes continuous cooking which incorporates a steam jet which educts the starch slurry. Steam heats the slurry to open the starch molecule to allow

enzyme attack. This heating step pushes the temperature higher to insure complete sterilization of the feed stream. The slurry is then cooled by flashing in preparation for the addition of alpha amylase enzyme due to its temperature sensitivity. The slurry then passes through a vessel composed of several agitation compartments (Post Liquefaction Reactor) which provides residence time to allow the breakdown of glucose. The stream that leaves liquefaction is less viscous and contains smaller molecules of multiple glucose which is suitable for action by the second enzyme.

The slurry leaving the liquefaction step is then cooled with water. Conditions are adjusted and gluco-amylase enzyme is added to reduce the starch to sugar. The slurry passes through an agitation vessel for the final breakdown process. The resulting product called "substrate" is then cooled. The substrate possesses very little starch and a small amount of glucose.

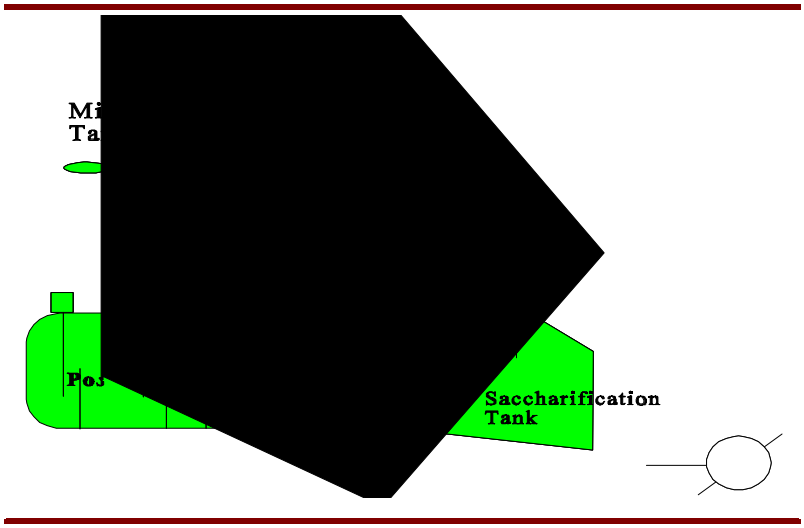
Fermentation

Traditionally, fermentation has been a batch process and is still a prevalent part of fuel ethanol production. However, large scale ethanol production uses continuous fermentation processes.

Batch

Using a single fermentation vessel, batch fermentation holds the substrate for yeast propagation and growth. Nutrients and air are injected during the fermentation cycle for yeast growth. After a specific amount of time, the desired ethanol concentration is achieved in the vessel.

The main advantage to the batch process is that microbial contamination is minimized through regular sterilization cycles. Sterilization is necessary to reduce bacterial entry which reacts with the yeast to produce unwanted by-products and lower yields.



Continuous

Continuous fermentation uses a series of vessels, each with a specific function. The first vessel allows for yeast growth and propagation. Saccharified mash and yeast nutrients are charged continuously to this agitated vessel. In order to remove the heat associated with fermentation, a circulation pump and cooler are used. Oxygen is provided through compressed air pumped through the vessel.

A transfer pump moved the fermented Abeer@ through to the second fermentation vessel.

Addition mash is usually added to the second fermentation vessel without need for areation. This vessel also has a circulation pump and cooler to remove the heat associated with fermentation. A transfer pump moves some of the Abeer@ forward to the third vessel.

Microbial contamination is a major concern for continuous fermentation processes. A low level of infection is allowed but most yeast is not tolerant.

The carbon dioxide produced during fermentation is collected with scrubbers and water and piped to a CO_2 recovery plant for use in commercial sales.

ETHANOL LEGISLATION

There are two major types of legislation that affect ethanol. The first focuses on its environmental benefits while the second type are acts attempting to foster its growth.

The Clean Air Act Amendments of 1990 required the worst polluting areas in the United States to incorporate more oxygenated fuels into their energy infrastructure. The act required that all gasoline sold in carbon monoxide non-attainment areas have at least 2.7% of oxygenated fuel during at least four winter months. The act also specified that if this did not reduce the amount of carbon monoxide into the atmosphere, that the percentage of oxygenate be increased to 3.1%. Ethanol is considered an oxygenated fuel.

The Amendments of 1990 also required gasoline sold in the nine worst non-attainment areas to contain no less than 2.0% oxygen on average. Ethanol is listed as a low polluting fuel that should be used in urban buses and other means of transportation.

In order to achieve this, the Miscellaneous Tax and Budget Reconciliaton Act of 1990 outlined tax credits and incentives to increase ethanol production. The Excise Tax Exemption allowed a tax credit of 5.4 cents per gallon through the year 2001. Usually, gasoline is taxed at a rate of 18.4 cents per gallon - 18.3 cents of which goes to the Highway Trust Fund. This fund helps pay for the upkeep of our national highways. The excise tax reduces the amount of money payed to he Trust Fund and allows ethanol to be more competitive with gasoline. It is also supprose to encourage ethanol production. The act also allows for a Small Ethanol Producers Credit. The credit allows 10 cents per gallon up to 15 million gallons of ethanol per year. In addition, the Blender Tax Credit gave a credit of 54 cents per gallon for the companies that mix ethanol with gasoline for sale to gas stations.

Due to the public opinion and the relative ineffectiveness of the program, the excise taxes on ethanol are slowly being eliminated. With the Building Efficient Surface Transportation Act of 1998, the ethanol excise tax credit has dropped from its current 5.4 cents per gallon to 5.3 cents

in 2001, 5.2 cents in 2003, and 5.1 cents in 2006. Eventually, the tax will be replaced my more prudent and effective legislation.

The following table provides the current budget requested by the Department of Energy. It clearly shows the ethanol production programs are the largest component of the alternatives fuels programs that exist today.

FOR THE FISCAL YEAR BIOFUELS BUDGET, THE DEPARTMENT OF ENERGY HAS REQUESTED

PROGRAM AREA	$ CHANGE FROM FY98	% CHANGE FROM FY98
ETHANOL PRODUCTION	$36,391,000	43%
BIODIESEL PRODUCTION	$1,000,000	33%
FEEDSTOCK PRODUCTION	$6,000,000	140%
REGIONAL BIOMASS ENERGY PROGRAM	$3,500,000	75%
TOTAL:	$46,891,000	53%

INFORMATION OBTAINED BY THE NEBRASKA ETHANOL BOARD

ETHANOL RESEARCH

The Research presently done for ethanol is comprised by research on improved feedstocks, better production processes, and implementation into ethanol vehicles. While most of the research with feedstocks has been performed by the Department of Energy, the majority of ethanol research is performed outside of government. Two of the more interesting research efforts are at Baylor University and the Ford Motor Company. While Baylor is academic and Ford is a corporation, both groups have made important contributions to providing technologies that use ethanol as fuel.

The research at Baylor has shown that ethanol has great environmental benefits in relation to current aviation fuel. They have showcased that an ethanol aircraft engine runs cooler than the current model. Baylor=s research may help begin the production of fuel ethanol aircraft as a safer a more environmentally friendly means of aviation.

Ford Motor Company=s ability to be the first major automobile manufacturer to produce an entire fleet of flexible fuel vehicles that can run on both fuel ethanol and standard gasoline. The fleet also has a similar price and warranty as other Ford vehicles. The new fleet of ethanol cars produced by Ford will finally give the American people the choice of what fuel they wish to use.

Renewable Aviation Fuel Development Center, Baylor University

The Center at Baylor University had modified and flown nine aircraft on ethanol, accumulating over 1,800 hours of flying time. To demonstrate the reliability of the fuel, record flights have been undertaken. The most notable was the first Atlantic crossing flown in an aircraft powered by ethanol. Airshows on ethanol have been performed in the United States, Brazil, France, and Italy.

ΛEthanol produces more power and burns cleaner in an aircraft engine.

ΛThe higher octane of ethanol versus the octane of aviation gasoline allows the use of increased engine compression ratios for improved combustion efficiency.

ΛIn an ethanol powered engine detonation is greatly reduced, resulting in less engine vibration and longer engine life.

As a result of airshows and presentations given in South Dakota, the pilots of the flying team called the AVanguards@ asked the Baylor Team for guidance to convert their aircraft to ethanol. The team is now demonstrating ethanol performance at airshows around the country.

Ethanol meets, and in some aspects exceeds, all the requirements established by the Federal Aviation Administration for Aviation fuels. After severe tests programs, two entire series of Lycoming engines have been certified by the Federal Aviation Administration to operate on ethanol.

FORD MOTOR COMPANY

AFord Motor Company=s continued commitment to the agricultural community, environment and to our domestic economy is evident in their actions today and their plans for more ethanol vehicles in the future@- Ryland Utlaut, President of the National Corn Growers Association

Ford had recently produced the Taurus Flexible Fuel Vehicle (FFV) which can operate on a Fuel ethanol (E85) and gasoline. Here are some of the aspects of Ford=s fleet of ethanol cars:

Flexibility: Ford E85 FFV=s are capable of running on ethanol (E85) alone, unleaded gasoline alone, or any combination of the two fuels on the same tank. As a result, Taurus E85 drivers can refuel with gasoline if fuel ethanol is not available.

Ford Warranty: The Ford FFV is covered by the same warranty as the gasoline powered Taurus and the complete line of Ford Vehicles.

Quality: The Ethanol-powered Ford Taurus can do anything its gasoline powered counter part can do. It has the same agility, response, and quiet and comfortable ride.

Performance: There is a slight improvement in the performance as the percentage of ethanol is increased in the tank. Power, acceleration, payload, and cruising speed are generally comparable to gasoline-powered vehicles.

Fuel-Composition Sensor: A fuel composition sensor monitors the fuel mixture and sends information to the on-board computer, which adjusts the spark timing and fuel flow according to help optimize performance. It=s all automatic and hassle fee for the driver.

KEY CONFLICTS AND CONCERNS

Conflict #1: The Real Cost of Gasoline vs the Real Cost of Ethanol

When looking at the prices of various items at your local gas station, it appears that gasoline is the most affordable commodity. One gallon of gasoline is less expensive than a small bottle of water, even though over 40% of its price is tax. Comparing the current price of gasoline to that of ethanol, their large difference appears to indicate that ethanol is not competitive. Only through looking at the real costs associated with both liquid fuels can a true comparison be achieved.

With the numerous expenses that comprise the petroleum industry, it is amazing how affordable gasoline is. Oil companies recently have invested in satellite technologies and elaborate drilling platforms to explore for petroleum in remote areas. Once the oil is found and drilled, pipelines are built to cross hundreds of miles until it comes to a shipping port. From there it is transported to a refinery on the US coast where it is finally sent by truck to a local gas station. Although large amounts of infrastructure and transportation costs are associated with gasoline, it costs less than one dollar for a gallon of this non-renewable energy source.

In comparison to petroleum=s logistical difficulties, ethanol requires less transportation and a smaller infrastructure. Produced from grains grown in the American Midwest, the ethanol industry is rooted in the center of the nation. Such a local eliminates the need for large pipelines and reduces ground transportation. Also, ethanol plants are usually located in the same areas where their feedstocks are grown and where the fuel is sold. Through having a large number of ethanol plants throughout the nation, this reduces the need for a large energy infrastructure.

Incorporated in the cost of gasoline are the various expenses associated with the clean-up of oil spills and the numerous environmental problems society must pay for using this fuel. As outlines by *Concern #2: The Environmental Costs of Petroleum*, it is estimated that while a barrel of crude oil costs only fifteen dollars, the costs associated with its environmental clean up are around forty-five dollars. Since ethanol is considered a much cleaner burning liquid fuel, such additional costs are not a factor. This makes the affordability of ethanol in comparison to oil very competitive.

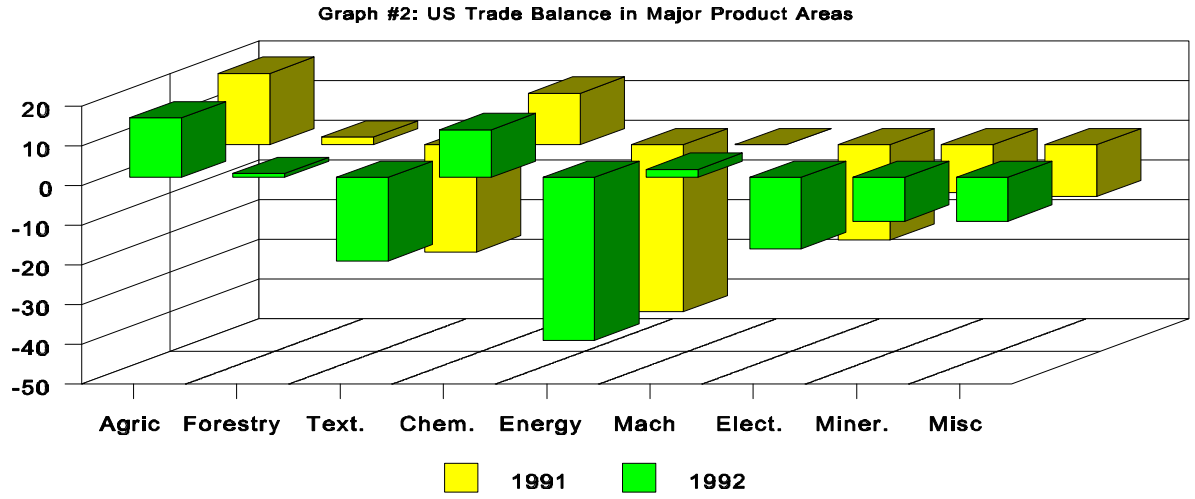
The major realization of this comparison is the fact that ethanol is a competitive fuel and that the American people need a reality check on the real price they pay at the pump. While many consumers will drive out of their way in order to save a few cents per gallon of gasoline, such savings are minuscule in comparison to the damage that using that gasoline will do to society. Every time we use gasoline, we allow more pollution to enter the atmosphere, increase the amount of smog in the atmosphere, and cause more global warming.

With increased ethanol research and a commitment to the growing ethanol industry, the price of ethanol should continue to fall. Thus, through looking at all of the internal and external prices of gasoline, ethanol is shown as an affordable and prudent fuel for America=s future.

Conflict #2: A Trade Deficit Analysis of Petroleum and Ethanol

The importation of oil by the United States has directly lead to our trade imbalance. Presently, imported oil accounts for 45% of the trade deficit. Due to the rising demand for oil, the Department of Energy predicts that dependence on foreign oil will continue to rise over the next ten to twenty years. Also, the recent importation of Methyl Tertiary Butyl Ether has further lead to our trade imbalance. Ethanol use is a means of reducing the trade deficit and is an energy source that can be exported.

Ethanol use by the United States positively affects our balance of trade. It replaces the need to import MTBE and other petroleum products. As shown in the graph provided below (Graph #2), energy is by far the largest product the United States must import.



With the United States= larger agricultural base, it can grow enough grain to export ethanol and ethanol products without reducing the necessary amount of food. Corn gluten and corn syrup are already exported in large quantities. Ethanol currently makes a positive contribution of over $1.5 million to balance trade. By increasing ethanol production to 2 billion gallons per year, the USDA predicts an additional $1 billion would be contributed to the US trade balance.

With its inadequate supply of domestic oil and increased energy needs, the United States= trade deficit will continue to increase if an energy alternative is not implemented. Production of domestic oil has decreased in recent years from 8.3 million barrels per day in 1987 to 7.4 million in 1991. The US ranks ninth in the world with regard to proven oil reserves. MTBE imports have increased from 35 million gallons to over 400 million gallons in just three years. Because of the oxygenate requirements of the Clean Air Act, these imports will continue to rise. A domestic alternative to these requirements would be the use of ethanol, a renewable oxygenate.
The various security costs associated with energy importation from the Middle East further

increases the economic costs for the US. Negative impact includes loss of economic output due to higher costs of oil, the damaging impact of periodic oil price shares, and transfer of US wealth to foreign oil producers. An Oak Ridge National Laboratory social cost analysis showed the cost associating with OPEC to be between $100 billion and $400 billion. The study revealed that the total economic costs from 1972 to 1992 ranged in the vicinity of $4 trillion. These figures illustrate the pressing need to find a domestic means of producing an alternative liquid fuel.

In the past, ethanol has provided a positive impact on the US trade balance. According to the Corn Refiners Association, exports of corn glutton exceeded $750 million in 1992. Approximately 323,000 metric tons of corn oil, with a value of about $182 million were exported during 1994. About 125 million gallons of ethanol were exported to Brazil in 1993, with about 10 million gallons of ethanol used to make Ethyl Tertiary Butyl Ether for export. The Renewable Oxygenate Requirement enforced by the US Environmental Protection Agency should increase ethanol production and positively affect the US trade balance. The figure provided below estimates the projected changes due to increased ethanol production and export.

Table 1: Estimated Value of Ethanol-Related Trade Impacts

Commodity	Amount	Value
Displaced MTBE Imports	1 billion gallons	$960 million
Exported Ethanol	135 million gallons	$135 million
Exported Corn Gluten	---	$200 million
Exported Corn Oil	323,000 tons	$ 182 million
		$1,477 million

Note: Describes the value of different ethanol related products that US exports to foreign countries. Note that Corn Gluten and Corn Oil are both types of food that are produced as by-products to fuel ethanol.

Source: Corn Refiners Association, Corn Annual, May 1993

Table 2: Projected Changes to the US Balance of Payments Account Attributed to Increased Ethanol Production (in Millions of Dollars)

	Net Change	Net Change
Subsector	**1995**	**2000**
Crude Oil	$993	$7309
Corn	13	239
Other Crops	-78	-222
Livestock	1	3
Processed Agricultural products	-9	-48
Corn (Ethanol) Co-products	100	364
TOTALS:	**$1,020**	**$7,635**

Note: If ethanol production and use at a level of 2 billion gallons would improve US balance-of-payments by approximately $1 billion.

Source: USDA, Agricultural Economic Report No. 667, p.12

These statistics clearly illustrate the large economic pains caused by oil imports by the United States and show compelling proof that ethanol holds an important key to reducing our trade imbalance. Only time and policy changes will provide the means to reverse the present situation and reinvest our wealth into more domestic forms of liquid fuel.

Concern #1: The National Security Costs of Petroleum

While current gasoline prices are considered affordable and while the amount of known oil deposits in the Middle East are still considered adequate, there are numerous hidden costs that the American people must pay to ensure a reliable source of non-renewable petroleum. The United States government and military have spent egregious amounts of money to ensure stability in the Middle East and provide for our energy needs. The considerable amount of tax dollars allocated for securing the cost of petroleum should be reduced and diverted to establish a viable ethanol industry.

The history of US interests and military involvement in the Middle East has existed since World War II. It escalated following the Shah of Iran=s downfall in January 1979, the hostage crises in Iran, and the Soviet invasion of Afghanistan. President Carter announced the ACarter Doctrine@ in January 1980, by stating that the United States would use military force if necessary to protect its interests in the Persian Gulf. The administration established the Rapid Deployment Force in March 1980, a pool of rapidly deployable US forces to give the ability to respond to contingencies throughout the world, but mostly in Southwest Asia. In January 1983, the Joint Task Force was redesignated the US Central Command (CENTCOM). Throughout the years, these agencies have maintained US interests and objectives of having an uninterrupted flow of Persian Gulf oil, ensuring the security of Israel, and promoting a comprehensive resolution of the Arab-Israeli conflict.

While the US government has effectively enforced its interests in the Persian Gulf, analysis of the costs associated with such protection is amazing. Although the United States Government has effectively channeled funding of such projects through numerous means so that it is difficult to find an accurate account of the money, various organization have performed studies that reveal similar amounts. The center for Defense Information has estimated that of the $2 trillion spent on defense from FY 1982 to FY 1988, approximately $294 billion (15% of the total defense spending) was used to defend the Persian Gulf. Over $49 billion of American tax dollars are spent on defending this small sliver of land just because it posses petroleum.

In August of 1991, the US General Accounting Office published a detailed study of the costs of the activities associated with protecting U.S. interests in the Persian Gulf. The analysis covered the years 1980 through 1990 and concluded that the US had spent over $365 billion to protect the Persian Gulf-an average of $36.5 billion per year. In addition, these estimates do not include the large amount of money used during Operation Desert Shield and Storm. The amount demonstrates how convinced our government and people are that petroleum is so crucial to the economic well-being of our country.

Table 3: Estimated Costs of Ensuring Access to Persian Gulf Oil Supplies (1992)

	Cost Estimate
Generating/Sustaining Military Forces in Peacetime	**$ 60.0 Billion**
Expected Losses from Conventional War	**$ 5.3 Billion**
Expected Losses from Nuclear War	**$ 5.0 Billion**
TOTALS:	**$ 70.6 Billion**

Note: Illustrates the large amount of sustained US military forces present during peacetime around the Middle East. Also shows estimated costs (losses) of both a conventional and nuclear war.
Source: The Governors= Ethanol Board.

Table 4: Costs of US Military/Foreign Aid Programs in Southwest Asia 1980-1990 (Millions of Dollars)

	10 Year Total	Average Cost/ Year
SW Asia-Dedicated Programs	$21,400	$2,140
SW Asia-Oriental Programs	$5,800	$580
Related Contingency/Mobility Programs	$272,600	$27,260
Foreign Military Financing Program	$30,296	$3,030
Military Assistance Program	$472	$47
IMET Program	$78	$8
Bilateral Economic Assistance	$28,285	$2,829
Multilateral Assistance	$6,626	$662
Totals:	**$ 365,557**	**$ 36,556**

Note: Illustrates cost of funding the major military programs in Southwest Asia. The largest are the Mobility Programs begun by President Carter. **Source**: The Governor=s Ethanol Board

Such amounts for National Security could be alleviated through diverting military funding to capitol investment and research in ethanol production. By doing so, we would not only reduce the money spent on the military, but also reduce the risk of going to war again in the Middle East. No study can put a price on the number of future American soldiers that will lose their lives to protect out oil interests. In many ways, the protection of US petroleum interests has been our generation=s Vietnam war. Hopefully, it will not require unpopular public sentiment and unrest

to once again reduce our military involvement overseas and stop allowing private interests to interfere in the policy of our country

Concern #2: The Environmental Cost of Petroleum

The environmental costs of using petroleum far exceed the actual selling price of gasoline. While the current price for a barrel of oil is around $15, the environmental damage resulting from using that barrel is approximately $45. As shown in Tables 6 and 7, the external costs of petroleum include both the Global Warming Emissions and the Regulated Air Pollutants under the Clean Air Act. Table 5 provides the total external cost of oil. Due to the regulations placed by the Act, the National Ambient Air Quality Standards make it necessary to reduce such pollutants; making it a costly venture. Because global warming emissions are not currently regulated by federal legislation, their external costs are smaller.

Table 5: Estimated Environmental Externality Costs of Petroleum (1992)

Externality	Cost Per Barrel
Primary Global Warming Emissions (N_2O, CO_2, CH_4)	$2.29
Regulated Air Pollutants (SO_2, NO_x , CO, PM-10, VOC)	$42.78
TOTAL COSTS:	**$45.07**

Note: Provides a summation of Table 6 and Table 7, both described below. Note the larger costs of Regulated Air Pollutants due to their restrictions by the Clean Air Act. If Global Warming Emissions were also regulated, the external costs of Petroleum could double.

Table 6: External Costs of Global Warming Emissions (1992)

Externality	Tons/year	Cost/year	Gross Value (Million Dollars)	Cost/Barrel
CO_2	546,500,000	$24.70	$13,498,550,000	$2.17
CH_4	158,140	$4,435.20	$701,382,528	$0.11
N_2O	364,000	$246.40	$89,689,600	$0.01
Total:	547,022,140	$4,706.30	$14,289,622,128	$2.29

Note: Estimates the petroleum-related external costs of the three types of global warming emissions. The emission values were derived from the Energy Information Administration estimates for 1991 and adjusted to 1992. Source: Energy Information Administration. September 1993. Emissions from Greenhouse Gasses in the United States 1985-1990. Office of Energy Markets and End Use. United States Department of Energy pp 12,29,32, and 47.

Table 7: External Costs of Regulated Air Pollutants (1992)

Externality	Tons/year	Cost/year	Gross Value (Million Dollars)	Cost/Barrel
SO_x	3,258,000	$1,686	$5.49	$0.88
NO_x	11,943,000	$7,308	$87.28	$14.00
CO	71,024,000	$978	$69.47	$11.25
PM_{10}	915,000	$4,497	$4.11	$0.66
VOC	16,726,000	$5,959	$99.67	$15.99
TOTAL	103,866,000	---	$266.02	$42.79

Note: Provides an estimate of the petroleum-related costs of the preceding air pollutants. Estimates were arrived at through recent air emission data associated with oil and multiplied by updated cost data from the Tellus Institute Report. **Source**: US Environmental Protection Agency, Office of Air Quality Planning and Standards. October 1993.National Air Pollution Emission Trends, 1900-1992, EPA/54/R-93-032

Such figures illustrate that the true price of oil is much larger that what the American public perceives. Through demonstrating the environmental costs of petroleum, further support for the development of alternative renewable fuels like ethanol is shown.

Pollution is by far the primary reason for the external costs of petroleum. While current gas prices are nominal, society does not factor the added environmental costs. The production, storage, transportation and use of petroleum-based fuels have adverse affects on the environment, most notably air pollution. The combination of fuel oil and gasoline produce a variety of air pollutants that directly lead to urban smog, acid rain, and global climate change. The public pays for such problems through the purchase of emission controls, destruction of recreation areas, and increased medical treatment of disease. For a number of years, economists, environmental scientists, industry, and policy makers have argued how to identify and quantify the environmental costs associated with petroleum. The majority of these assessments focus on fuel used by utilities and how to incorporate the real price of electricity.

The first approach allows a contingent evaluation through research to determine how much the public would be willing to pay to protect or improve a natural area, like a park or beach. The value of improving an acidified lake would help determine how much the public believed it was worth to restore.

A second means of estimation would be to determine the costs of repairing an existing site

damaged by air pollution. A simple example of this is the clean up of an oil spill. The final approach known as Ashadow pricing@ allows environmental regulations to be analyzed to estimate the costs that society is willing to impose on itself to reduce emission of various air pollutants.

The remediation costs associated with ethanol further show the problems with our use of fossil fuels. The Clean Air Act outlines specific forms of air pollution that are regulated. Among these are the National Ambient Air Quality Standards (NAAQS=) of Sulfur Dioxide, Nitrogen Oxides, Carbon Monoxide, Particulates, and Volatile Organic Compounds. Of such pollutants do not meet these standards, they are labeled as a non-attainment area by the EPA. The most pressing concern with air pollution is its effects on ozone. The major contributions to ozone depletion are Carbon Dioxide and Nitrogen Oxides. Increased levels of carbon monoxide affect individuals suffering from cardiovascular disease due to reduction of oxygen carrying capacity of the blood. Nitrogen Oxides contribute to acid rain and global warming. Particulate matter affects the respiratory system through penetration of the lungs. Such statistics and adverse health problems provide compelling proof that petroleum emissions directly lead to adverse health problems and destruction of nature.

There will never be a means to providing a dollar figure to compensate the American people for the health problems associated with petroleum emissions. No estimate will replace the countless lives affected from the inhalation or consumption of air tainted by petroleum and petroleum based products. The fragile ecosystems of Alaska that have been devastated by oil spills and accidents will never fully recover.

These are the legacies that our government and country must deal with. For we have created a society so ingrained in the need for cheap and abundant energy that we have lost sight of what has made this nation great, our land and the resourcefulness of its people. Now is the time for the American people to become cognizant of the true price we pay for petroleum pollution and demand for the research and implementation of ethanol as an improved means of liquid fuel.

Concern #3: Educating the American People the Truth about Ethanol

If there is one single aspect of American life that we take pride in, it is our ability to make choices. Whether it is our ability to choose Pepsi over Coke, or eat at McDonald's over Burger King, the American individual enjoys the fact that he or she has so many choices to make. These choices are what make us distinct. However, there is no choice for what type of fuel we put into our automobiles. For when the American individual goes to the pump, there is only one choice: non-renewable petroleum based gasoline.

Yet in many ways, our federal government has accepted a role in making gasoline the only fuel that Americans can purchase at the pump. Over 100 years of legislative action has crippled the ethanol industry and allowed the petroleum industry to achieve an almost mind numbing perception that for America to be great, we need to consume greater amounts of non-renewable and environmentally unfriendly fossil fuels. For if the Gulf War is any indication to what extreme measures the United States government will go to ensure cheap and abundant petroleum, it will be some time before public perception can be changed that there are other solutions to our energy needs. The most logical means of reversing this ideology is to simply give the American people the opportunity to choose what fuel they want to purchase. While this seems like an obvious answer to this dilemma, it is not that simple.

The American people need to be educated on the properties and availability of renewable energy so that they can make a prudent choice on which fuel they buy. This will be difficult since energy sources like ethanol have always been perceived as regional and not-cost efficient. Because the feedstocks that are used in the production of ethanol have always been grown in the Mid-West, public perception has been developed to view ethanol as a means of stabilizing corn prices and reducing the corn supply. In reality, the sale of corn to the ethanol industry benefits the federal government and the American people in numerous ways. Sustainable economic conditions allow farmers to reinvest capital into more efficient machinery. In fact, each $1 of up-stream and on-farm economic activity generates $3.20 in down stream economic stimulus attributable to ethanol processing, compared to just $0.31 when corn is exported. In addition, the ethanol industry has created more than 40,000 direct and indirect jobs and has resulted in more than $1.3 billion in increased household income annually, and it has been projected to more than $12.6 billion over the next five years. Such facts make it clear that the ethanol industry is a viable part of the American economy and will continue to bring financial security to the American farmer.

Furthermore, the American public should be educated on the environmental benefits of ethanol. Because ethanol contains oxygen, it helps reduce the amount of toxic carbon monoxide that enters the atmosphere. Just a 10% blend of ethanol in reformulated gasoline reduced carbon monoxide by more than 25%. The result is improved ozone conditions for troubled urban areas and CAA non-attainment areas. Because of the renewable aspect of ethanol, its use also results in the reduction of carbon dioxide emissions. While gasoline simply emits carbon dioxide, the ethanol reduces such emissions because the feedstocks associated with ethanol consume carbon dioxide. Therefore, increased use of such feedstocks would offset carbon dioxide in a cyclic

process that would help curve global warming.

Through knowing such environmental and financial benefits of ethanol, the public could make an educated choice about what type of fuel they want.

Concern #4: Proving the Reliability of Fuel Ethanol Vehicles

Once the American people have been objectively educated on the positive aspects of ethanol and when it has been shown to be an environmentally friendly and cost efficient liquid fuel, the next important step is to prove the reliability of fuel ethanol automobiles.

The first major step will be the development of automobiles that can run efficiently on ethanol. Although our highways do not possess many ethanol driven cars and trucks, there are automobiles that can run on ethanol and the technology has been developed. Both Ford and Chrysler have done extensive research on E85 Vehicles (85% Ethanol and 15% Gasoline). The 1998 Ford Taurus and the some Chrysler Caravans can be equipped to run on E85. The main difference between such fuel ethanol cars and standard gasoline cars are the type of ignition sources for combustion and the fuel lines. Ethanol has been shown to eat through some older cars fuel lines, requiring E85 cars to have a stainless steel fuel line. Also, ethanol runs much cooler than gasoline, reducing the need for anti-freeze and other fuel additives. However, due to initial problems in combustion, glow plugs are used in place of standard spark plugs. Such differences are small and most cars can be retrofitted to run on ethanol for less than $200. Future automobiles will have devices that will register the percentage of ethanol and gasoline in the tank so that cars could run on a variety of different mixtures. This would allow individuals to use fuel ethanol without fear that they will run out of fuel before finding the closest available ethanol station. Since ethanol is a better performance fuel with a higher octane rating than regular gasoline, such cars would allow consumers to use ethanol in the city and then switch to gasoline for rural excursions. The implementation of ethanol in urban areas would improve both air quality and driving performance.

In terms of convincing the American people that fuel ethanol automobiles are as reliable as standard gasoline vehicles, several industry and government funded programs have been performed to showcase fuel ethanol technology. The first and most well known of these was the Hennepin report performed by the DOE=s National Renewable Energy Laboratory. From November 1993 to October 1996, the city of Minneapolis, Minnesota tested two heavy - duty snow plow and road maintenance trucks powered by fuel ethanol. The study assessed the economic, emissions, performance and durability of ethanol in comparison to traditional gasoline based trucks used in Hennepin County, Minnesota. The two trucks used International Paystar models F5070 and were equipped with Detroit Diesel Corporation model 6V-92TA ethanol engines. These trucks were used year-round to maintain the Hennepin country roads. In the winter months, the trucks were run in 8-hour shifts and performed plowing and hauling of snow. While there results did indicate larger maintenance and repair costs due to fuel filter and fuel

pump problems, the E95 trucks emitted far less particulate matter and fewer oxides of nitrogen. Overall, the fuel ethanol trucks operated as well as the standard diesel trucks except for their shorter range and higher operational and fuel costs.

In addition to the Hennepin project, ethanol is now being used in Yellowstone National Park. As a test, the National Park Service used ethanol-blended fuel in all its vehicles in Yellowstone in the winter of 1998 and many towns around the park, like West Yellowstone, have begun to sell ethanol-blended gasoline in order to improve the environment around the country=s most famous national park. In 1994, over 85,000 snowmobiles entered the park which impacts the environment due to their emissions. The Montana Department of Environmental Quality in cooperation with the International Snowmobile Manufactures Association and the US Department of Energy conducted the study. The result shows that the snowmobiles cut emissions of all major types of pollutants, including hydrocarbons (~16%), carbon monoxide (~9%), and particualate matter (~24%). Because of the results, the National Park Service will continue to allow the public to use snowmobiles in the area if they use ethanol-blended fuel in the future.

The results of the Hennepin and Yellowstone Project, along with the availability of consumer vehicles from Ford and Chrysler, show that fuel ethanol automobiles can and should become a reality. While the Hennepin Study revealed minor reliability problems with the fuel filter and fuel pumps, these problems can be reduced with available technology. While gasoline combustion engines have been improved over the span of 100 years, ethanol engines have not had the same amount of time and energy spent for their improvement. With necessary research, these engines and their components will be just as reliable as their gasoline counterparts. In addition, such reports prove the environmentally friendly attributes of ethanol.

Concern #5: Developing an Ethanol Infrastructure to Provide a Choice

After ethanol vehicles have proven reliability and the American people have been educated on the positive aspects of ethanol, the final step will be the development of a viable ethanol infrastructure. There will be two major components for such an infrastructure, the first will be a large enough production capability. The country will need to develop state and federal agencies to help promote and regulate ethanol plants more efficiently, The second step will be requiring gas stations through legislation to have a fuel ethanol pump. Through these steps, the American people can and will be given the choice of what type of fuel they want in their vehicles.

In order to maintain a large enough production capability for ethanol, there must be governmental agencies that are solely dedicated to the regulation of such industry. One such organization is the Nebraska Ethanol Board. The Board was established to help both Nebraska=s ethanol industry as well as raise and stabilize corn prices for area farmers. As of 1996, the results of the Board=s actions have produced many positive effects for the people of Nebraska. Nebraska=s ethanol plants now employ over 800 people with an additional 4,000 jobs generated in industry-related service sectors. Each 100 million bushels of new grain demand created an additional 2,250 rural

job opportunities. Since the first modern commercial sale of ethanol blended gasoline in 1978, Nebraska motorists have purchased nearly 4 billion gallons and driven 70 billion miles on the grain-based fuel. In addition, the State of Nebraska operates 100 flexible fuel vehicles that operate on a E85 (85% ethanol and 15% gasoline) while the Nebraska Department of Roads operates heavy duty trucks fuels with ethanol. Currently, only Nebraska has a dedicated agency for ethanol with Minnesota being the only other state that has state officials working on increasing ethanol usage. If every state had such an agency, similar results achieved by the State of Nebraska could become a reality.

Through the establishment of state ethanol agencies, the ethanol industry could begin to produce large amounts of ethanol to be a major source and reduce our dependence on petroleum based non-renewable energy sources. In addition, such an increase in production would reduce the price of ethanol so that it would become more competitive with gasoline. Such action would reduce the need for federal excise taxes and alleviate negative public perception. Also, the chemical industry could begin to look at ethanol as a viable feedstock in the production of synthetics and pharmaceuticals. Through the implementation of ethanol into the chemical industry, many toxic emission would be reduced, reducing air pollution and Clean Air Act Non-Attainment Areas. Such a switch was seen during World War II when oil was scarce and an alternative feedstock was needed.

After demonstrating the plausible growth of the ethanol industry, it is important to equally assert the need to establish a fuel ethanol pump in every gas station in America. While this would most likely require federal legislation, there are several positive aspects for such a requirement. First, ethanol is a less volatile chemical than gasoline. Thus, storing ethanol under gas stations is less dangerous than gasoline. It has less of a chance to explode if ignited. In addition, it is water soluble, meaning that if ethanol leaked into the ground, it would not cause any environmental problems to area plants and soil (Just a few drunk worms!). Such properties makes the implementation of ethanol gas tanks at stations an act that would only take minimal time and energy. However, there are currently only about 30 stations throughout the country that have E85 gasoline. They are regionally located throughout the West and Midwest. Only through implementing such station nationally can fuel ethanol really become a choice for the American people.

With enough production capability and ethanol stations through the country, fuel ethanol can be given the opportunity for use by the American people. Through giving the public the choice, the United States would reduce the private interests that have crippled ethanol and instead allow the citizens to decide its fate.

POLICY ALTERNATIVES

Alternative #1: Ethanol Vehicles

Gasohol as Preliminary Policy

In any struggle to sway public sentiment, the switch from ethanol to gasoline should begin with the requirement to use reformulated gasoline or gasohol. Gasohol is a combination of standard gasoline (85%) and ethanol (15%), that requires no engine modifications or other changes. With the numerous environmental and performance benefits of using ethanol as a fuel additive, it should be an initial policy for the United States to require gasohol at every gas station in the United States.

Implementing gasohol will provide the American people with a reliable liquid fuel alternative that will require the least amount of infrastructure. Gasohol can be used in the gas tanks of every vehicle in the United States and is also covered in all US automobile warranty. It reduces the clogging of fuel lines and fuel injectors. Conversion of standard fuel to gasohol can be done simply. A tanker supplied with pure ethanol (200 proof) is sent by an ethanol plant to a local mixing site. Mixing the ethanol up to 15% volumetrically allows for its solubility in gasoline so that there is no separation of the two liquids. The mixture of ethanol and gasoline can then be sent to a local gas station. Like premium gasoline, gasohol has a high octane rating and is sold for a comparable price. When given the choice the American people have bought gasohol.

As mentioned above, gasohol's superior performance characteristics would be benefit to vehicles in urban areas or environmentally sensitive areas like National Parks. By adding just 15% ethanol to gasoline, the octane level increases by three. Better performance allows for better handling in stop-and-traffic. Ethanol also burns cooler in car engines, a comforting thought during traffic gridlock in the middle of summer when engines tend to overheat. Because emissions are larger during acceleration, added performance allows environmental benefits.

The key attribute to gasohol are its environmental benefits. A 10% ethanol blend will reduce carbon monoxide better than any other reformulated gasoline - more than 25%. An oxygenate, ethanol contains a large amount of oxygen by volume. When reacted in combustion, oxygenates produce less carbon dioxide than gasoline. Low in reactivity, ethanol reduces the risk of gas line and gas tank explosions. Ethanol is an effective tool to reducing ozone depletion, global warming, and inner-city smog. Current octane enhancers in gasoline have typically been benzene, toluene, and xylene - carcinogens. Use of ethanol as an octane enhancer reduces the emission of cancer causing agents and would reduce petroleum health related problems in the United States. The final environmental aspects of gasohol is that it reduces the need for using anti-freeze agents in vehicles during the winter.

Both the environmental benefits and minimal infrastructure changes needed to implement the use

of gasohol in the United States as the primary reformulated gasoline show that is a viable option in our country=s future energy policy. Through legislation and public sentiment, the goal of having gasohol on every station in America could soon become a reality.

Flexible Fuel Vehicles

Perhaps the most prudent means of implementing fuel ethanol vehicles in the transportation infrastructure of the United States would be the intermediate policy of making flexible fuel vehicles that can be run on a variety of mixtures of standard gasoline and ethanol. Through providing such vehicles, the American people could decide when, if at all, they wanted to used fuel ethanol for their transportation needs. It is the ability to choose which type of liquid fuel that one wishes to use that is important in the ethanol issue. That is, while the American people have a variety of choices they can make in their daily routines, they cannot ever have the decision what type of fuel they want to consume. The reality of flexible fuel vehicles will be the means of allowing that choice, and in doing so determine the degree in which ethanol will be used in the country.

First, it is important to understand exactly what a flexible fuel vehicle is comprised of. The main difference between regular vehicles and flexible fuel vehicles is small device in the fuel line that reads the fuel composition of the ethanol and gasoline mixture. The device then relays back to the engine in order to correct. The engine will then reline such factors as compression ratios and use of glow plug use. The result is a smooth performance vehicle that can run on a variety of different fuel mixtures.

There are numerous advantages to having a fleet of US cars with flexible fuel technology running across America. First, flexible fuel cars allow a larger range than fuel ethanol vehicles because of the reduced need of having to find fuel ethanol stations during trips. With the ability to use any mixture of ethanol and gasoline, the family could start a trip in New York with fuel ethanol, refuel in North Carolina with standard gasoline, and then arrive in Florida only to use gasohol. Any combination of such refuelings would be appropriate and allowable.

Second, the implementation of flexible fuel vehicles would allow the ethanol infrastructure to determine the average supply of fuel ethanol that society would be willing to use. Through allowing the choice of what fuel to buy and use, flexible fuel vehicles would be a means of quantifying exactly how much ethanol would be consumed, how many plants would be needed to be built, and how many bushels of corn have to be grown.

Lastly, flexible fuel vehicles would convince the American people that ethanol vehicles can and should become a reality. Through providing compelling proof of the reliability and performance of ethanol, flexible fuel vehicles would be an intermediate between the idea that ethanol is an excellent fuel additive to the belief that ethanol is a superior fuel. With the transition of public sentiment, the development and implementation of fuel ethanol vehicles that run of E85 would be the next step in the journey to renewable energy and sustainable development.

Fuel Ethanol Vehicles as Final Policy

Once E85 gasoline is available at enough gas stations throughout the country, the manufacture and sale of vehicles that run solely on fuel ethanol can be begin. The culmination of implementing flexible fuel vehicles would have proved the reliability of ethanol technology and a percentage of the American public would begin to want such cars. Since the price of such a car would be comparable to conventional automobiles and if fuel ethanol was readily available, there is little reason why the people would not make the change.

The larger the percentage of ethanol in fuel, the more environmental benefits are achieved. Pure ethanol is water soluble, non-toxic, and biodegradable. If pure ethanol is ingested, there an no harmful side effects. With its reduced volatility, fuel ethanol would reduce the fears of explosions during transportation of the fuel. Storage of ethanol would also be less of a concern. If fuel ethanol were to leak into the ground, it would simply degrade. E85 emissions as discussed before reduces the amount of particulates, carbon dioxide, carbon monoxide, toxins, and sulfur dioxide. E85 provides the best means of reducing global warming emissions, inner-city smog, and depletion of the ozone layer. It would reduce the emission of carcinogens currently used as octane and performance enhancers. The result would be the reduction of lung and respiratory cancer, difficulty breathing in urban areas during hot summer days, and the reverse of global warming.

The technology to make E85 vehicles is proven and reliable. However, retrofitting or converting conventional vehicles to run on E85 is not recommended. Though conversion can be done, there are no air-quality or emission benefits from doing so and converting a vehicle to operate on 85% ethanol will void the manufacturer=s warranty. Flexible fuel vehicles that come with original equipment from the manufacturer have the same warranties as gasoline vehicles and are especially suited to run on ethanol fuel efficiently.

Another question about fuel ethanol cars are the costs for repairing and maintaining the automobile. The costs are roughly the same as regular gasoline cars. Ethanol vehicles do run cleaner than standard cars and thus some maintenance costs may actually be reduced.

One of the most important disadvantages of fuel ethanol vehicles is their smaller range. Ethanol has slightly less energy content than regular gasoline. E85 does have a much higher octane (about 110). As a result of the energy and performance differences, using 85% ethanol will reduce vehicle mileage by 10-20%. This will vary based on temperature and mileage differences.

Alternative #2: Effective Ethanol Programs and Government Projects

Government Ethanol Vehicles

If there is one place that the American people look for the technologies that will govern and shape their future, it is the military and the government. An item that is good enough for G.I. Joe is good enough for John Q. Public. One must look no further than World War II to see some of the most popular items that represent the American pesona-the Jeep Wrangler and the Volkswagon Beetle. On the American front, servicemen enjoyed their experiences traveling throughout Europe in their Jeeps. They like their rugged looks, reliability, and versatility. There had never been a vehicle like it produced for the American people and individuals longed to purchase used Jeeps from the military. For the last 40 years, the look and accessories of the Jeep have changed little, but they still are one of the most popular vehicles sold in America.

While the Americans traveled across Europe in their Jeeps, they saw their German counterparts traveling in their oddly shaped APeople=s Car.@ Ironically, Hitler=s more enduring legacy has been the Volkswagon. The Beetle has come to signify the spirit of the sixties. With its reliability, affordability, and look, the vehicle has recently made its comeback with rave reviews. A simple question must be asked. If the US military produced an efficient and reliable ethanol vehicle that would showcase the positive benefits of such a vehicle, would it spark similar interest in the American people? The United States government should begin to develop and implement such vehicles in both their civilian and military plans.

There have already been demonstrations by the US government to showcase the positive attributed of fuel ethanol. The most known and publicized is the Hennepin Country trial of two multi-purpose trucks. Sponsored by the Department of Energy, the study showed the reliability of fuel ethanol vehicles and how their environmental benefits. Similar studies were conducted at Yellowstone National Park and ADM. While these studies are important in that they provide compelling evidence of ethanol=s reliability, the US government has not yet established a fleet of such vehicles for its own purpose. Such a statement is an inconsistency by the federal government. If the technology is proven, why not develop it for use by the military.

The state of Nebraska has showed its commitment to ethanol through the establishment of a fleet of fuel ethanol vehicles. The state of Nebraska operates 100 flexible fuel vehicles that operate on E85. In addition, the Department of Roads operates heavy duty trucks with fuel ethanol. Such an effort not only showcases the reliability of fuel ethanol vehicles but demonstrates that the state is dedicated to finding energy alternatives to gasoline.

Through implementing programs like Nebraska, the US government could prove to the American people that fuel ethanol vehicles are a viable transportation alternative. Furthermore, their demonstration by the military could lead to popular sentiment and desire for incorporation into our public highways. The possibilities and extent of usage are endless.

Production Credits as Excise Tax Replacement Policy

The current means of encouraging the use of ethanol by the federal government are through various taxes. There are currently four tax subsidies that are available for the production and use of alcohol transportation fuels. Besides the motor fuel excise tax, these taxes are rarely used. All transportation fuels are taxed under a complicated structure of taxes. Gasoline is taxed at a rate of 18.4 cents per gallon-18.3 cents goes to the Highway Trust Fund, which helps keep up the federal highway system. The excise tax works by reducing the amount of tax charged per gallon. When a mixture of 90% gasoline and 10% ethanol is purchased, a partial exemption of 5.4 cents per gallon is allowed so that it is taxed at 13.0 cents per gallon. Straight or neat alcohol fuels like E85 also qualify for exemptions under the current excise tax program.

It is the opinion of the Congressional Research Service that the current excise tax policy is flawed and should be eliminated. It has been estimated by CRS that the alcohol exemption has resulted in over $8 billion in forgone federal revenues-an annual revenue loss of over $600 million per year. Because of this, HR 2400, passed in May 1998, planned the reduction of the excise taxes until elimination in 2006.

An alternative to the current excise tax program is production credits. Current law provides for an income tax credit of 10 cents per gallon for up to 15 million gallons of annual ethanol production by a small ethanol producer. Enacted as part of the Omnibus Budget Reconciliation Act of 1990, the Small Ethanol Producer Tax Credit is available only to the manufacture who sells the alcohol to another person for blending into a qualified mixture of use as fuel. Off-farm production of ethanol does not qualify for the credit.

The state of Nebraska also has a current production credit system that has been highly effective. The Ethanol Production Credit incentive provides a transferable tax credit of 20 cents per gallon of ethanol produced by a plant located in Nebraska. The first 25 million gallons produced at a plant qualify for the credit. The producer does not begin to receive the credit until the plant produced 2 million gallons annually. The only problem with the program is that it has been so successful that Nebraska is having difficulty in getting the amount of money needed to fund the incentive.

In addition to production credits, income tax deductions for individuals who purchase clean burning fuels are another realistic approach to increasing ethanol useage. The Energy Policy Act of 1992, increased a new federal tax deduction of businesses that purchase ethanol and ethanol vehicles that run on E85. The tax deduction has two components: a tax deduction for the vehicle itself, and a deduction for investments in any equipment needed to dispense alternative fuels.

Both tax deductions and production incentives should be increased and the current excise taxes

should be eliminated.

CONCLUSIONS AND RECOMMENDATIONS

The findings of this policy paper clearly show that ethanol is a prudent and prevalent fuel. The technology and benefits of ethanol all lead to the conclusion that it should be incorporated into the energy infrastructure of this country. With public awareness and education, ethanol should become a viable and important part of our society.

Ethanol is a Proven Sustainable Technology

Ethanol is a proven, environmentally beneficial, liquid fuel that corresponds to the vision and goals of sustainable technology. As set forth by the Earth Summit, the Bruntland Commission, and the President=s Council on Sustainable Technology, Ethanol will be an effective means of a renewable energy source that will meet the energy needs of the present without compromising the energy needs of future generations. The increased use of ethanol will help reduce the depletion of the ozone layer, emission of greenhouse and global warming gasses, and lower the amount of smog in the inner-city. As an performance enhancer, ethanol will eliminate the need for carcinogenic fuel additives. The net affects are less cases of cardiovascular and respiratory illnesses and improved overall health for the American people.

Ethanol Production is an Efficient, Proven Technology

The processes used by Arthur Daniels Midland Company are the most efficient and economic means of producing ethanol and ethanol by-products. In the future, ethanol plant should be wet-milling and allow enough steeping (soaking) to occur to completely separate all grain components. Continuous fermentation processes should be adopted with improved sterilization techniques. Ethanol combustion does produce more energy than is required for the growth of feedstocks and processing.

Ethanol by-products should be apart of the ethanol industry. Corn gluten, corn syrup, and corn oil should find a place on the domestic and import markets. It should be the goal of the ethanol industry to perfect the efficiency of ethanol technology so that the entire corn kernel is utilized.

Ethanol Should Replace US Petroleum Interests in Middle East

The United States Government should concert its efforts away from protecting its oil interests in the Middle East and instead channel taxpayers money towards ethanol and other domestic fuel sources. Although national defense should always be a top priority, the United States has spent an average of 36.5 billion per year on military readiness in the Persian Gulf. By providing an ethanol infrastructure, the government would better serve the American people and help protect the lives of US Servicemen. The protection of US petroleum interests has been our generations Vietnam. Now it the time to defray our association with the Arab Nations and begin investing US wealth domestically in a proved liquid fuel alternative.

Ethanol Use Will Directly Lead to a Balance of Trade

Energy is by far the largest source of America=s current trade imbalance. Ethanol replaces the need to import liquid fuel and provides a valuable fuel alternative that other countries like Brazil import. It is estimated that ethanol currently has a $1,477 million positive impact on the balance of trade. Ethanol is projected to change the balance of trade by $7,635 million by the year 2000. Ethanol should replace the large amounts of imported MTBE and other oxygenates required by the Clean Air Act. Ethanol by-products should also be recognized as valuable exports that will help impact the current trade imbalance.

State Agencies are Best Means of Fostering Ethanol Infrastructure

Because the feedstocks used by ethanol plants are located regionally, the role of regulating and fostering the ethanol industry should fall under the responsibility of individual states. States that produce grains should develop effective State Agencies for the purpose of granting production incentives and aiding capitol investment in ethanol plants. The Nebraska Ethanol Board should be looked at as an effective government agency that has made a positive impact and contribution to the economy and people of their state. Such agencies will help stabilize energy crop prices, set up communal agreements between ethanol plants and farmers, and help increase the use of fuel ethanol across their states.

Flexible Fuel Vehicles as Most Realistic Transportation Solution

Flexible Fuel Vehicles allow the best means of giving the American people the choice of what fuel they want to use. Because there are not enough fuel ethanol stations across America, fuel ethanol vehicles reduce the fear of running out of fuel during long trips. They are covered under the same warranties as regular gasoline fleet vehicles. The 1998 Ford Taurus can be bought with flexible fuel technologies, providing a show case of the reliability of the technology. With the introduction of the Chrysler Flexible Fuel Minivan and 1999 Ford Ranger FFV, the US automakers should continue the trend of providing the option of flexible fuel technology.

Production Tax Incentives and Income Tax Deductions

The current system of excise taxes has been an initial and effective means of supporting the ethanol industry. However, excise taxes are no longer the best means of encouraging growth and should be slowly eliminated as in HR 2400. Production tax incentives have been shown to work in Nebraska and the current legislation should be broadened and expanded. Income tax deductions will encourage more businesses to invest and purchase more ethanol related technologies.

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APPENDIX I:

QUICK FACTS ON ETHANOL

What increased ethanol production means for consumers:

- Ethanol is a proven, high quality octane enhancer that is readily available today
- Ethanol in gasoline can replace lead and therefore remove the health and environmental problems associated with lead
- The use of ethanol enhanced gasoline requires no engine modifications and engines should run cleaner and smoother
- All domestic and foreign automobile manufacturers approve the use of ethanol blended gasoline under their warranties.
- Nearly all ethanol blends sold contain sufficient levels of gasoline detergents to keep port fuel injectors and carburetors clean.

What increased ethanol production means for the agricultural economy:

- The increased demand for corn is helping deplete some of the grain surpluses and consequently, improve the value of the nation=s corn crop.
- A stronger, more stable market for corn will bring more money to the hands of many financially-strapped farmers. Not until market demand balances with production can farmers experience long term security.
- The rural economy surrounding the farmer will be strengthened by the increased purchasing power for the farmer. Every $1 a farmer spends generates an additional $7 in the economy.
- The improved corn market will help to better balance agricultural supply and demand. Consequently, the federal government and the tax payers could save millions of dollars in deficiency payments to farmers, as well as storage fees and loan expenses.

APPENDIX II: TEN IMPORTANT ETHANOL QUESTIONS

QUESTION #1: ***How does ethanol help the environment ?***

- Ethanol has more oxygen by volume than gasoline. It has been established that the higher the percentage of oxygen in gasoline, the greater the reduction in carbon monoxide (CO) emissions from your automobile.

QUESTION #2: ***How will ethanol play an important role as an octane enhancer ?***

- When added to gasoline at a 10 percent quantity, ethanol can raise the fuel's octane level by an average of 3 points. The octant rating is a measure of a fuel's ability to resist knock and ping in gasoline engines. A typical grade of unleaded gasoline has an octane rating of 87 and premium unleaded a rating of 91 to 93.

QUESTION #3: ***Will a vehicle that runs on regular leaded gasoline require any engineering modifications to use ethanol blended gasoline ?***

- NO! Ethanol blended gasoline will actually clean the fuel system, loosening dirt and grime. In some cases, motorists with older cars with rusty and dirty fuel systems may have to have engine filters check more frequent when first switching to ethanol blended gasoline.

QUESTION #4: ***What is the difference between ethanol and methanol ?***

- While ethanol is derived from renewable sources, such as corn or other agricultural products, methanol is produced from non-renewable coal and natural gas.

QUESTION #5: ***How many bushels of corn are needed to make a gallon of ethanol?***

- Each 56 pound bushel of corn yields about 2.5 gallons of ethanol in addition to a variety of valuable co-products.

QUESTION #6: ***What are some of the valuable co-products made in addition to ethanol ?***

- Pure corn oil and carbon dioxide are used by the food processing industry, most noteworthy is Coke and other soft drink manufacturers. Carbon dioxide is produced during fermentation and carefully collected to reduce emissions.

- Gluten feed, produced from the wet-milling process has between 95-100 % of the energy of corn and 17-21% of its protein. It is very popular with cattle feeders and milk producers.

APPENDIX II: TEN IMPORTANT ETHANOL QUESTIONS

QUESTION #7: ***What is the difference between the wet-milling process and dry-milling process?***

- A wet-milling plant will use water and a gentle rubbing action to remove the seed coat, while a dry milling plant simply crushes the dry kernels. The wet milling plant provides the best means of utilizing the entire corn kernel.

QUESTION #8: ***Is it true that the ethanol subsidy costs the federal government more than $500 million each year ?***

- NO ! Several government studies have concluded that because the demand for grain created by ethanol production reduces farm program costs, the government actually saves money as a result of the partial excise tax exemptions for ethanol blends.

QUESTION #9: ***What is the excise tax and how does it work ?***

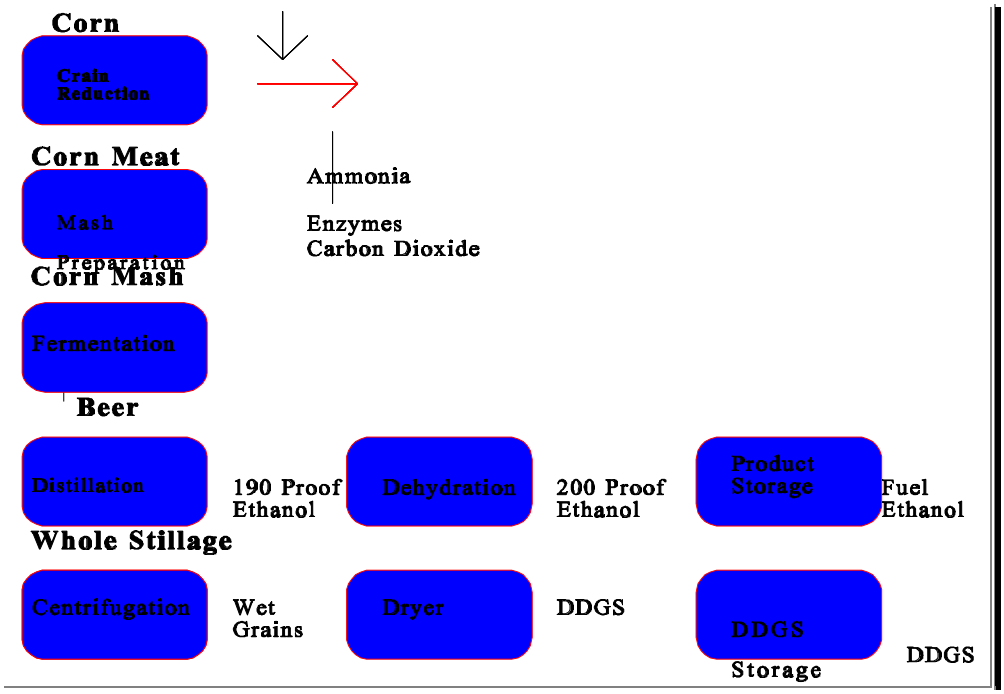
- Every time you buy a gallon of gasoline, approximately 18 cents goes to the Highway Trust Fund (HTF). The trust collects approximately $20 billion annually and operates with a surplus of approximately $9 billion. If the gasoline contains at least 10 % ethanol (gasohol), the local fuel blender is given approximately 5.4 cents. Therefore, the money goes indirectly into the local ethanol plant. However, statistics show that no state receives fewer federal highway dollars as a result of ethanol use.

QUESTION #10: ***Is it true that it takes more energy to produce a gallon of gasoline than the energy contained in a gallon of ethanol ?***

- While this was true 15 years ago, industry has grown and ethanol has become the most energy efficient of all the energy producing industries. A modern ethanol production plant requires 32,000 Btus to process grain into fuel grade ethanol. A bushel of corn requires approximately 60,000 Btus to produce. In addition, 24,000 Btus can be attributed to the production, harvest, and transportation of ethanol feedstocks. A gallon of ethanol contains 76,000 Btus. Thus, the energy balance is positive by approximately 20,000 Btus.

APPENDIX III:

BASIC MEANS OF ETHANOL PRODUCTION



1) ***Milling:*** The feedstock (corn, barley, wheat, or sawgrass) is first passed through a hammer mill which grinds it into a fine powder that is called meal.

2) ***Liquefaction*****:** The meal will then be mixed with water and alpha-amylase, and will pas through cookers where the starch is liquefied. Heat will be applied at this stage to enable liquefaction. Cookers with a high temperature stage (120-150 degrees Celsius) and a lower temperature holding period (95 degrees Celsius) will be used. These high temperatures reduce bacteria levels in the mash.

3) ***Saccharification:*** The mash from the cookers will then be cooled and the secondary enzyme (gluco-amylase) will be added to convert the liquefied starch to ferment sugars (dextrose).

4) ***Fermentation:*** Yeast will then be added to the mash to ferment the sugars to ethanol and carbon dioxide. Using a continuous process, the fermenting mash will be allowed to flow, or cascade, through several fermenters until the mash is fully fermented and then leaves the final tank. In a batch fermentation process, the mash stays in one fermenter for about 48 hours before the distillation process is started.

5) ***Distillation:*** The fermented mash, now called Abeer@, will contain about 10 % alcohol, as well as all the non-fermentable solids from the corn and the yeast cells. The mash will then be pumped to the continuous flow, multi-column distillation system where the alcohol will be removed from the solids and the water. The alcohol will leave the top of the final column at about 96% strength, and the residue mash, called stillage, will be transferred from the base of the column to the co-product processing area.

6) ***Dehydration:*** The alcohol from the top of the column will then pass through a dehydration system where the remaining water will be removed. Most ethanol plants use a molecular sieve to capture the last bit of water in the ethanol. The alcohol product at this state is called anhydrous (pure, without water) ethanol and is approximately 200 proof.

7) ***Denaturing:*** Ethanol that will be used for fuel is then denatured with a small amount (2-5%) of some product, like gasoline, to make it unfit for human consumption.

8) ***Co-Products:*** There are two main co-products created in the production of ethanol: carbon dioxide and distillers grains. Carbon dioxide is given off in great quantities during fermentation and many ethanol plants collect that carbon dioxide, clean it of any residual alcohol, compress it and sell it for use to carbonate beverages or in the flash freezing of meat. Distillers grains, wet and dried, are high in protein and other nutrients an are highly valued live stock feed ingredient. Some ethanol plants also create a Asyrup@ containing some of the solids that can be separate production sold in addition to the distillers grain, or combined with it. Ethanol production is a no-waste process that adds value to the corn by converting it into more valuable products.

Disclaimer : The aforementioned information of ethanol production is made possible from information obtained by the American Coalition for Ethanol

APPENDIX IV: BRIEF DESCRIPTION OF ETHANOL LEGISLATION

THE CLEAN AIR ACT AMENDMENTS OF 1990

Reformulated Gasoline: Beginning in 1/1/95, gasoline sold in the nine worst ozone non-attainment areas must contain no less than 2.0% (wt.) Oxygen on average. Other cities with a less serious ozone problem may choose to opt-in to the requirement after 1/1/95

Oxygenated Fuels: Beginning not later that 11/1/92 all gasoline sold in all carbon monoxide (CO) non-attainment areas (38 cities currently) will be required to contain no less than 2.7%(wt.) average for no less than four winter months. If an area fails to attain the CO standard, it would be required to meet a 3.1%(wt.) average oxygen requirement. Even after an area achieves the standard, the Environmental Protection Agency (EPA) shall require continuation of the requirement to maintain compliance with the standard.

Low Polluting Fuels: Ethanol is included in the definition of fuels for use in urban buses subject to stricter emissions standards effective in model year 1994. It is listed along with methanol, propane, natural gas, or Aany comparably low-polluting fuel@

THE MISCELLANEOUS TAX AND BUDGET RECONCILIATION ACT OF 1990

Small Ethanol Producer Credit: On 1/1/91, producers of qualified ethanol shall be eligible for a 10 cents per gallon tax credit up to 15 million gallons per year of ethanol at one or more facilities controlled by one person having an aggregate capacity not in excess of 30 million gallons per year. Dehydration of ethanol does not qualify.

Excise Tax Exemption: Effective 12/1/90, the excise tax exemption for gasoline blended with 10% ethanol blends shall be 5.4 cents per gallon through 12/31/2000

Blender Tax Credit: Effective 1/1/91, the Section 40 blender tax credit for eligible ethanol or ethyl tertiary butyl ether (ETBE) blenders shall be 54 cents per gallon through 12/31/2000.

1990 FARM BILL

Low-Cost Grains: The Commodity Credit Corporation is required to make 15 million bushels of out-of-condition corn available to ethanol plants at a discounted price in the states of Nebraska, Iowa, and Louisiana.

BUILDING EFFICIENT SURFACE TRANSPORTATION ACT OF 1998

Ethanol Tax Credit: The extension of the ethanol incentive that trims the amount of the incentive slightly over five years - dropping from the current 5.4 cents per gallon to 5.3 cents in 2001, 5.2 cents in 2003, and 5.1 cents in 2005.

APPENDIX V: Benefits of Ethanol for America

CONSUMER BENEFITS:

- U.S. consumers use more than 10.5 billion gallons of high performance, cleaner ethanol-blended gasoline each year
- Ethanol and ETBE increase oxygenate supplies, reducing the need for MTBE imports and helping to reduce consumer costs
- Ethanol is a high octant blending components used by many independent gasoline marketers--helping to keep this important class of trade available and creating competition for the major oil companies
- ETBE is a low volatility oxygenate with provides refiners a cost-effective means to meet CAA standards

TAXPAYER BENEFITS:

- The partial excise tax exemption for ethanol and ETBE blend available to gasoline marketers actually saves money.
- A GAO study has shown that reduced farm program costs and increased income tax revenues offset the cost of the incentive
- According to the USDA, if ethanol use does not continue to grow, Adeficiency payment for corn and other program crops will increase by $580 million for crop year 198 and $740 million by the year 2000" C more tan the cost of the tax incentive.
- The economic activity attribute to the ethanol industry will generate $3.5 billion in additional income tax revenue over the next five years C $1 billion more than the cost of the exemption
- The U.S. ethanol industry will create a net gain to the taxpayers of almost $4 billion over the next five years

APPENDIX V: Benefits of Ethanol for America

ECONOMIC BENEFITS:

- More than $3 billion has been invested in 43 ethanol production facilities operating in 20 different states across the country
- The ethanol industry is responsible for more than 40,000 direct and indirect jobs, creating more than $1.3 billion in increased household income annually, and more than %12.6 billion over the next five years.
- The demand foe grain created by ethanol production increases net farm income more than $1.2 billion annually
- As the economic activity created by the ethanol industry ropples throughout the economy, it will generate $30 billion in the final demand between 1996 and 2000
- Increases in ethanol production over enormous potential for economic growth in small rural communities. USDA has estimated that a 100 million gallon ethanol plant could create 2,250 jobs.

AGRICULTURAL BENEFITS:

- The ethanol industry is the third largest user of corn, trailing only feed and exports, and is the largest value-added industrial use
- Each $1 of up-steam and on-farm economic activity generates $3.20 in down stream economic stimulus attributable to ethanol processing, compared to just $0.31 when corn is exported
- Ethanol production consumed 535 bushels of corn in 1994
- The demand for corn created by the ethanol industry increases crop values--accounting for approximately $0.14 of the value of every bushel of corn sold last year
- If the market for ethanol did not exist, corn stocks would rise and net income to American corn farmers would be reduce by $6 billion over the next five years.

APPENDIX V: Benefits of Ethanol for America

ENERGY/TRADE BENEFITS:

- Domestic ethanol and ETBE production reduces demand for imported MTBE which drain our economyC oil and MTBE imports now represent almost 80 % of the US trade deficit bill
- Currently, imported oil accounts for 53 % of consumption, and imported MTBE is at a record 31% of domestic production
- Today, ethanol reduces the demand for gasoline and MTBE imports by 98,000 barrels per day. A 98,000 barrel/day replacement of imported MTBE would represent $1.1 billion reduction to out annual trade deficit
- Ethanol production also generates exports of feed co-products, such as corn gluten, further enhancing our balance of trade. Corn gluten exports exceeded $800 billion last year, the single largest US export
- Ethanol production is extremely energy efficient, with a positive energy balance of 125 % compared to 85 % gasoline
- Ethanol production is by far the most efficient method of producing liquid transportation fuels

ENVIRONMENTAL BENEFITS:

- 10 % ethanol blends reduce carbon monoxide better than any other reformulated gasoline blend C more tan 25 %
- Ethanol is low in reactivity and high in oxygen content, making it an effective tool in reducing ozone pollution
- ethanol is a safe replacement for toxic octane enhancers in gasoline such as benzene, toluene, and xylene
- Because it is produced from renewable agricultural feedstocks, ethanol reduces greenhouse gas emissions