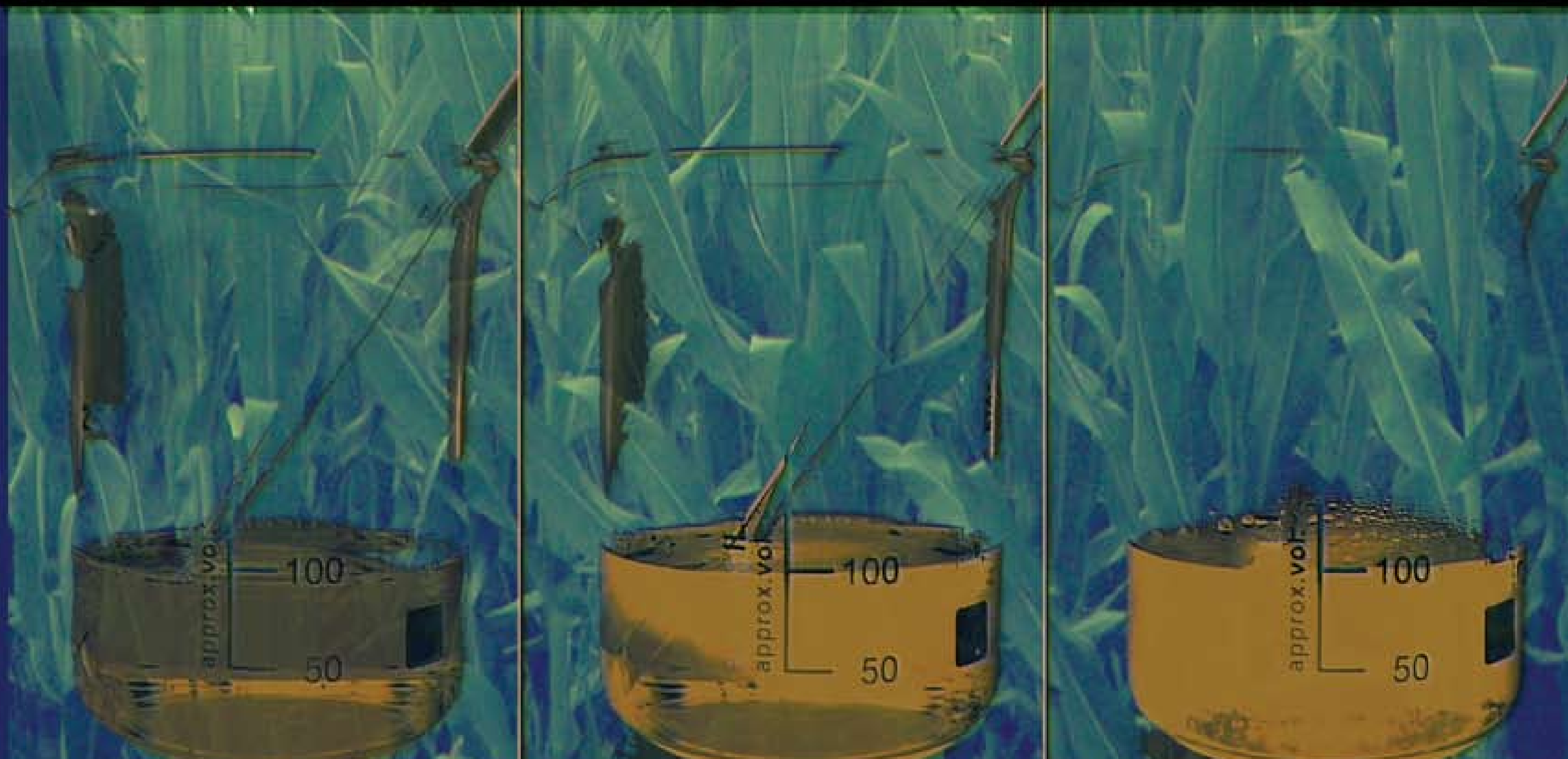
THE RUSH TO ETHANOL:

Not All BioFuels Are Created Equal



Analysis and Recommendations for U.S. Biofuels Policy

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Food & Water Watch and Network for New Energy Choices In collaboration with
Institute for Energy and the Environment at Vermont Law School

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Food & Water Watch is a nonprofit consumer organization that works to ensure clean water and safe food in the United States and around the world. We challenge the corporate control and abuse of our food and water resources by empowering people to take action and by transforming the public consciousness about what we eat and drink.

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For "Ethanol Business: Dollars and Politics on the Farm" chapter.

The Institute distributes scholarly, technical and practical publications; provides forums and conferences for professional education and issue development, and serves as a center for graduate research on energy issues, with an environmental awareness.

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EXECUTIVE SUMMARY

Rising oil prices, energy security, and global warming concerns have all contributed to the current hype over biofuels. With both prices and demand for oil likely to continue to increase, biofuels are being presented as the way to curb greenhouse gas emissions and to develop homegrown energy that reduces our dependency on foreign oil.

In this context, corn-based ethanol has emerged as a leading contender to reduce dependence on fossil fuel–based gasoline. At first glance, corn-based ethanol seems simple, even patriotic: take the sugar from corn that U.S. farmers grow, and ferment it with yeast to distill basically the same stuff found in alcoholic beverages. By products, such as distiller's grain and corn gluten, serve as livestock feed and help offset refining costs. The industry claims that ethanol blends will lower tailpipe emissions, promote energy independence, and revitalize rural America.

Farmers and investors envision a new gold rush. Ethanol production is registering record growth rates, and reached nearly five billion gallons in 2006. Dozens of new ethanol refineries are being constructed, with production capacity forecast to double as early as 2008.[1] President Bush intensified this momentum in his 2007 State of the Union address with a call to produce 35 billion gallons of alternative fuels by 2017 – a fivefold increase from the currently established goals.

However, the leading raw material for ethanol in the United States-corn-is among the least efficient, most polluting, and overall least sustainable biofuel feedstocks.

This report reviews the most up to date scientific evidence and concludes that corn-based ethanol is not the silver bullet everyone is seeking.

Ethanol is not the way to energy independence.

The ability of corn-based ethanol to reduce U.S. dependence on foreign oil is limited. Dedicating the entire U.S. corn crop to ethanol would displace only a small share of gasoline demand.

Ethanol is not the solution to global warming.

Ethanol tailpipe emissions can reduce some greenhouse gases, but can also increase levels of others. Also, large-scale corn production requires farm equipment that runs on fossil fuels, which, in turn, emit more greenhouse gases. Moreover, when fossil fuels are used to power ethanol refineries, it can lead to higher greenhouse gas emissions than the fossil fuel ethanol replaces.

Ethanol is not the solution to revitalizing rural America.

Although the rise in corn prices excites farmers, the ethanol industry's growth could further concentrate agribusiness, which drains the economic health of rural communities.

Corn—now used to produce 95 percent of U.S. ethanol—is the least sustainable biofuel feedstock of all the raw materials commonly used. Intensive corn monoculture (where one crop is continually planted for at least three years in a row[2]) is plagued by serious environmental effects that the ethanol boom exacerbates, among them:

- Intensive harvesting erodes soil;
- Massive use of fertilizers contributes to the eutrophication of rivers and lakes and the reduction of fish and aquatic life habitat;
- Widespread use of pesticides contaminates water and soil; and
- Extensive irrigation for corn monoculture depletes water resources.

Though the corn-based ethanol energy ratio is higher (better) than that of fossil fuel-based gasoline and diesel, it is among the lowest of all the biofuels. In addition, corn-based ethanol could increase the price of food worldwide and pose additional challenges to global food security.

Given the limitations and negative impacts of corn-based ethanol, policy makers, investors, and researchers are focusing now on the second generation of biofuels—cellulosic ethanol, which comes from feedstocks like switchgrass, fast-growing trees, and agricultural residues. These cellulosic "energy crops" are superior to corn-based ethanol because they:

- Offer greater reduction in greenhouse gas emissions;
- Require far fewer inputs (farm equipment, pesticides, herbicides, fertilizer, and water), thereby causing less environmental damage;
- Feature higher energy ratios than corn-based ethanol and soy-based biodiesel;
- Have a wide range and tolerance for degraded soils, enabling them to grow on marginal lands not suitable for agricultural crops, thereby expanding the potential area for growing these plants relative to corn and soy. By extension, cellulosic crops have less potential to affect food supplies or the food economy; and
- Because a variety of raw materials can be used, smaller, specialized refineries will likely be built, which could in turn benefit rural economies.

However, large-scale development of cellulosic ethanol also portends harmful environmental impacts:

- Removing agricultural residues beyond what is needed to maintain and replenish soil organic matter (SOM) will exacerbate erosion;
- Converting protected lands, such as those enrolled in the Conservation Reserve Program, to energy crops will significantly compromise the ecological benefits of land conservation;
- Planting switchgrass has conservation value relative to corn row cropping, but is not a substitute for (in terms of wildlife protection and soil conservation) diverse, native habitats on protected lands;
- Technical processes for breaking down cellulose for ethanol refining likely would place increasing pressure on water resources, which comes in addition to great uncertainty about requirements for treatment and discharge of processing chemicals; and
- While the amounts of chemicals applied are smaller and the percentage of runoff is reduced with cellulosic crops, they are not nil. These concerns are significant when considering the scale at which cellulosic ethanol production is being proposed.

Ethanol is not the silver bullet that will solve the problems of rising oil prices, dependency on foreign oil, or greenhouse gas emissions. Biofuels, if produced sustainably, should instead be considered in the context of a comprehensive transportation model transformation based on energy efficiency and conservation, and focused on reducing fuel demand.

photo credit: morguefile

INTRODUCTION

As global warming concerns and oil independence considerations focus attention on world energy consumption, the race is on to find alternatives to fossil fuels. Fossil fuel–based transportation methods are responsible for a large portion of the greenhouse gas emissions that cause global warming. While most people agree that we need change, they are unsure about the direction that change should take.

Although biofuels offer significant advantages when compared to petroleum-based fuels, can they be the silver bullet solution? With dozens of new ethanol plants under construction, and farmers and investors embarking on a biofuels gold rush, where will this hype lead? And who will be the winners and losers in the promised ethanol economy?

Almost completely unknown are the economic and food-security repercussions, both national and global, of diverting massive amounts of corn and other agricultural products into gas tanks.

Amidst the current ethanol boom, important questions persist:

Do biofuels have a "positive net energy balance"?

That is, do they provide more energy (in the form of fuel and byproducts such as livestock feed) than the fossil fuels and other energy sources used to produce them? This includes the energy required to make corn and soybean fertilizer, the diesel that fuels tractors, the coal and natural gas that power refineries, and the fuel to transport ethanol to the market. While there is some debate over the numbers, it is clear that corn-based ethanol has one of the least promising energy ratios of all biofuels.

Do biofuels ultimately reduce harmful emissions, particularly factoring in that biofuel refineries themselves emit pollutants that biofuels are designed to reduce?

These include greenhouse gases such as carbon dioxide (CO_2), precursors of ground-level ozone including volatile organic compounds (VOCs), carbon monoxide (CO), and nitrogen oxides (NO_X) as well as toxic chemicals such as the carcinogen benzene. This important point deserves further attention form the scientific community. As of now, research indicates that corn-based ethanol shows the lowest potential for emissions reductions and that using coal to power refineries can actually increase emissions relative to the gasoline fuel replaced.

Can biofuels actually decrease our reliance on gasoline - particularly from foreign sources, which make up two-thirds of the U.S. supply?

Namely, can enough biofuels be produced and sold to measurably reduce consumption of petroleum fuel? And what would be the consequences of producing ethanol on such a large scale? Despite hopeful projections, biofuels will not be able to meaningfully displace soaring fossil fuel demand in the future.

How will the economics of biofuels play out?

Supporters of biofuels often underline that the new biofuel economy will benefit rural America by raising commodity prices, farm incomes, and rural employment. But will family farmers benefit from the ethanol boom, or will ethanol further increase the industrialization and concentration of the agribusiness corporations that control agriculture? If so, we'll see the wealth and well-being of rural America continue to erode. Past experience teaches us that an ethanol boom could exacerbate agricultural consolidation and the imbalance between large and small producers.

Should the $2.5-billion-plus-a-year taxpayer subsidies to the ethanol industry be continued?

Illinois-based agribusiness giant Archer Daniels Midland (ADM), the nation's top ethanol producer, is a lightning rod for critics who claim that such subsidies—over $10 billion from 1980 to 1997—are in fact corporate welfare that do not benefit family farmers.[3] Even pro-ethanol U.S. Energy Secretary Samuel Bodman has said that Congress should consider ending the program when it expires in 2010.

How would large-scale ethanol production affect agriculture and food prices?

Using basically the same inputs as food production—land, seeds, and fertilizers—biofuels will likely affect food production and the price of food in the global markets. As a result of U.S. farm policies, corn prices have fallen below costs of production for much of the past decade, creating incentives for over-production and reaping benefits for multinational corporations. Expansion of ethanol could exacerbate distortions in the global and domestic marketplace. Furthermore, conversion of agricultural lands to energy crop production is already having an impact on food security and environmental protection.

What are the worldwide implications of ethanol expansion on scarce land and water resources?

Seventy percent of the world's fresh water already goes to farming.[4,5] Fragile ecosystems are being decimated by clear cutting and overplanting of monoculture crops. Can the world afford to devote more land to fuel production? Full life-cycle analysis demonstrates that unchecked industrial ethanol expansion would result in unacceptable consequences for human health and the environment.

A deeper look into the answers to these questions will clarify the extent to which biofuels in general, and corn-based ethanol in particular, provide a viable energy alternative and help to build a more sustainable transportation model. On the downside, we already know that the proposed transition to biofuels would require the construction of hundreds of fossil fuel–burning refineries that emit many of the same pollutants biofuels are designed to reduce.

Almost completely unknown are the economic and food-security repercussions, both national and global, of diverting massive amounts of corn and other agricultural products into gas tanks. Moreover, the limited availability of the world's arable land means that biofuel feedstocks may take priority over food crops. In addition, conventionally-grown crops depend heavily on pesticides and petroleum-based fertilizers. Among other problems, fertilizer used to grow corn causes overgrowth of algae in rivers and lakes and destroys habitats of fish and other aquatic life. Expanding industrialized agricultural processes for biofuels would exacerbate this problem.

While some view ethanol as the silver bullet to address both the issues of energy independence and greenhouse gas emissions, others consider it to be only a transition fuel until more sustainable transportation technologies are available, and still others view it as a diversion from existing sustainable options for public and private transportation practices and policies. Therefore, to better stimulate debate on these issues, this report examines the state of technology and issues relevant to the discussion on the future of transportation and the role of ethanol and other biofuels.

PART I: CLIMATE CHANGE, OIL ADDICTION, BIOFUELS, AND THE FUTURE OF TRANSPORTATION

The magnitude of the challenges posed by large-scale, systemic changes to energy production, distribution, and consumption processes are daunting. That the environmental effects of the current global energy system are unsustainable is beyond debate. Indeed, climate change is now understood as a planetary phenomenon of potentially catastrophic consequences. The scientific evidence is overwhelming, as recently confirmed by the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC): human activities, particularly associated with the combustion of fossil fuels, are changing the Earth's climate at an unprecedented scale and pace.[6] There is no doubt that the amount of greenhouse gases in the atmosphere (including CO_2, NO_X, and methane) is rising as a consequence of human activity, and that these anthropogenic emissions are resulting in increased global atmospheric temperatures. The IPCC, an organization of leading climate scientists working under the auspices of the United Nations, has concluded that by the end of the century the planet's average temperature could increase up to 6.4 degrees Celsius (11.5F).[7]

Temperature increases of this magnitude will have irreversible and catastrophic consequences:

- Melting ice sheets will raise sea levels, which in turn will submerge many costal areas, permanently displacing some 200 million people;
- The intensity and frequency of storms, hurricanes, floods, and droughts will increase; and
- Forty percent of all of the world's species will face extinction, infectious disease patterns are likely to change dramatically, and heat-related deaths will increase exponentially.[8]

The economic consequences of global warming are colossal. A report authored by the former chief economist of the World Bank and current senior advisor to the UK government warned that the costs of extreme weather alone could reach 1 percent of the world's annual GDP by the middle of this century.[9]

The need for urgent action is clear. In finding a solution, we must make the best choices possible with the best information available. According to NASA's Head Climate Scientist, James Hansen, the world has a brief 10-year window of opportunity to take decisive action on global warming and avert a weather catastrophe.[10] Swift and determined action to prevent the most severe impacts of global climate change is one of the most pressing challenges facing humanity today, of which addressing emissions from the transportation sector is a key component.

photo credit: morguefile

According to NASA's Head Climate Scientist, the world has a brief 10-year window of opportunity to take decisive action on global warming and avert a weather catastrophe.

Biofuels: What Exactly Are They?

Biomass is defined as recently living matter that can be used to produce workable energy as fuel or power production. Biofuels are one type of biomass, and refer to recently living material that has been converted to fuel for uses such as cooking and heating (wood, the simplest and largest biomass energy resource) and for transportation (converted into liquid fuels to be used in cars and trucks).

Biomass can also be used to produce electricity, either by direct combustion (burning of biomass to create heat that generates steam to drive turbines) or by converting it into a gas that will then be used to produce electrical power. As commonly defined, biomass includes organic wastes (animal manure and residues, industrial residues from breweries and paper mills, and forestry wastes), energy crops (corn, sugarcane, soy, and oily plants), and municipal and industrial wastes.[11]

These different types of biomass present varying environmental benefits and limitations. Using waste to generate energy can create more waste and/or divert materials that would otherwise be recycled. Moreover, as will be discussed in detail in this report, using animal manure to produce energy turns a huge liability for factory farms into an asset, thereby promoting unsustainable animal production processes. This definition of biomass excludes coal and petroleum fuels, as they result from geological processes that transformed the remains of plant and animal matter from hundreds of millions of years ago. Such fuels are non-renewable resources—once they are burned, they cannot be replaced. While similar carbon deposits could eventually be accumulated again over millions of years, such a time scale is irrelevant for human needs. Contrary to fossil fuels, biomass can, at least in principle, be replaced in a somewhat brief time period.

Biofuels are used primarily to fuel cars, trucks, and buses. The two most common types of biofuels are ethanol and biodiesel. Ethanol is an alcohol made by fermenting biomass through a process similar to brewing beer. Currently, ethanol is made from starches (such as corn-based ethanol) and sugars (such as sugarcane-based ethanol). Researchers are also looking into making ethanol from cellulose, the fibrous material that makes up the bulk of most plant matter. Ethanol is mostly used as blending agent with gasoline to increase octane and reduce vehicle emissions. Corn constitutes 95 percent of U.S. ethanol feedstocks.[12]

Biodiesel is made by combining alcohol (usually methanol or ethanol) with vegetable oil (mostly soy oil), animal fat, or used cooking grease. Other vegetable oils, including rapeseed, mustard, canola, and sunflower can also be used to produce biodiesel. Like ethanol, biodiesel can be used as an additive to reduce vehicle emissions or in its pure form as an alternative fuel for diesel engines.

Soy, rapeseed and palm oil are some of the most common biodiesel feedstocks.

Biodiesel: Buses, Boats, and Bulldozers

Biodiesel has come a long way even since 2002, when it was twice lampooned on "The West Wing"—once when a soy-diesel pickup truck ran out of fuel in the middle of nowhere in Indiana, and again when the idea of taking a soy-diesel bus to a campaign event in Iowa was nixed. ("There was talk of it," one character said, "but that idea got killed off pretty quick.")

Today, hundreds of vehicle fleets run on biodiesel, including all branches of the U.S. military, NASA, Yellowstone National Park, and many cities, school districts, utility companies, bus systems, and state transportation departments. California's government vehicles run on it. The U.S. Navy—the largest biodiesel consumer in the world—uses it in non-combat vehicles. Camp Lejeune Marine Corps Base in North Carolina uses it in buses, tractors, bulldozers, emergency generators, and other heavy equipment.

Garbage trucks and school buses in Denton, Texas run on biodiesel made from waste cooking oil salvaged from more than 100 Dallas–Fort Worth restaurants. The fuel is made at a refinery powered by methane siphoned from a landfill, where the tractors themselves run on biodiesel.

Gray Line tour buses in British Columbia run on biodiesel, as do Victoria Express passenger ferries that cruise the San Juan Islands off the Washington state coast. North Carolinians can fill up with Willie Nelson's own brand, "BioWillie."

After languishing behind ethanol's curve for years, biodiesel is rapidly making up ground. From 2002 to 2005, U.S. and worldwide production grew five- and seven-fold, respectively. In 2005, Minnesota passed the nation's first biodiesel mandate, requiring a 2 percent blend for all diesel sold in the state. Many other states have approved tax exemptions and infrastructure incentives to promote this fuel. Also in 2005, manufacturers began receiving a federal excise tax credit of one cent per percentage point of plant-based biodiesel added to regular diesel. Other public support includes U.S. Department of Agriculture (USDA) subsidies for purchases of soybean oil and animal fat, which average $0.63 per gallon.

In August 2006, an Iowa company announced plans to build 12 refineries costing a total of $2 billion, marking perhaps the biggest economic expansion in the industry's history. About 65 plants are currently in operation, with another 50 under construction and dozens more being planned. Roughly 75 million gallons were produced in the United States in 2005, representing just 0.2 percent of the 40 billion gallons of diesel consumed (compared to ethanol's 3.5 percent share of the gasoline market). Production is expected to double in 2006 alone.

Biodiesel is now sold at about 850 retail stations nationwide, the first of these offering soy- and palm-derived fuels in the San Francisco area in 2001.

Like ethanol, biodiesel can be made from a variety of raw materials. By far the most common in the United States is soybeans, which provide 90 percent of the nation's current supply, though rapeseed, mustard, palm oil, hemp, waste vegetable oils, and animal fats can also be used. Germany, where rapeseed is the ingredient of choice, is by far the world's largest producer, and France is second, followed by the U.S.

Biodiesel outperforms corn-based ethanol in several categories. It has higher energy ratios and releases less pollution because it needs fewer raw materials and can be converted to fuel more efficiently.[13]

Because of, among other things, the huge amounts of fertilizer and pesticides required to grow soybeans, research is being conducted on types of oil-rich algae believed to be able to produce 250 times more fuel per acre than soybeans.

History of Biofuels: From Peanuts to Switchgrass

The hype surrounding ethanol, biodiesel, and other biofuels has reached a peak of its own. News stories fawn over biofuels as though they were discovered yesterday. But fueling up with ethanol is not new. It was used decades ago to power early automobiles, only to fade when plentiful supplies of cheaper gasoline became readily available.

The history of biofuels is indeed as old as the history of civilization. Humans have been drinking ethyl alcohol for its intoxicating effects since before the written word. This same alcohol was used in pre-war America as a lamp fuel. Ethanol's popularity became its downfall when, during the Civil War, Congress imposed a stiff tax on liquor. The popular lighting fluid, which happened to be drinkable, was taxed out of the energy market to raise funds for the war effort. Ethanol remained in economic exile until the tax's repeal in 1906.

Rudolf Diesel, the inventor of the compression-ignition engine, used peanut oil on his engine at the 1900 World's Fair in Paris. The French government was interested in exploring the possibilities of using peanut oil as fuel because it could be easily cultivated in its African colonies. According to Diesel, peanut oil "is almost as effective as the natural mineral oils."[14]

Henry Ford, thinking far ahead into the future and seeing fossil fuel's obvious drawback of being limited in supply, made his first automobiles with ethanol in mind as the main fuel. In 1916, Ford said, "Gasoline is going—alcohol is coming. And it's coming to stay, too, for it's in unlimited supply. And we might as well get ready for it now."[15] Far before there was a term for it, the Model T was a flex-fuel vehicle, able to run on ethanol, gasoline, or a mix of the two, often called gasahol. Indeed, ethanol powered some of the first internal combustion engines in the 19th century. Ethanol was known as an octane booster that prevented engine knock, and ethanol-gas blends were common in Europe and parts of the United States in the 19th century.

Ethanol's initial setback during the Civil War made the struggle for market share a difficult one. It was hobbled once again by the government in 1919. This time it was not a tax, but Prohibition. Ethanol could not be sold unless it was mixed with gasoline to make it undrinkable. Moreover, ethanol suffered the competition of tetraethyl lead, another component used to remove engine knock. Sadly for public health, tetraethyl lead was slightly cheaper. It was also deadly, but leaded gas ended up pushing out gasahol, which was relegated to the Corn Belt.

Ethanol saw a minor resurgence with World War II, when the military needed to stretch its fuel supply. But it wasn't until the energy crisis of the 1970s that ethanol got a second glance as a viable alternative to fossil fuel. Searching for ways to create an energy economy independent of foreign nations, Congress passed the Energy Tax Act of 1978, providing economic incentives and subsidies for the development of ethanol. Leaded fuel was then banned in 1986, further expanding ethanol's market potential.[16]

While the federal government effectively crippled the ethanol industry at the turn of the century, it has proved quite generous in recent decades. The Clean Air Act Amendments of 1990 and the Energy Policy Act of 1992 mandate the use of alternative fuels in regulated truck and bus fleets. Ethanol became popular once again as a fuel additive, not to prevent knocking, but as an oxygenate, making the fuel burn more efficiently and thus reducing tailpipe emissions. Amendments to the Energy Policy Act in 1998 provided credits for biofuel use, and these laws have been major forces behind the expansion of biofuels.

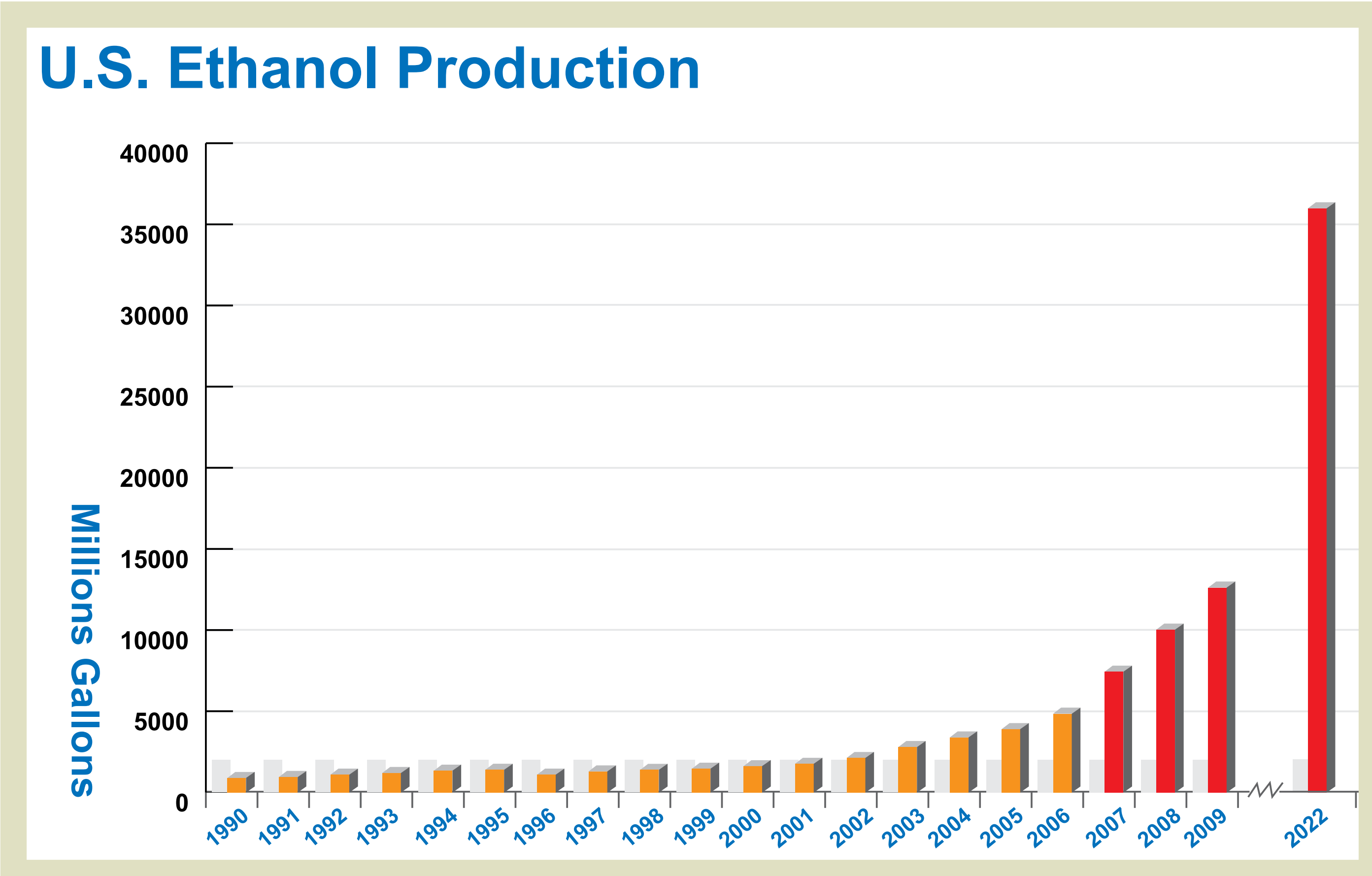


Figure 1: U.S. Ethanol Production

Source: "Industry Statistics: Historic U.S. fuel Ethanol Production." Renewable Fuels Association.
Available at: http://www.ethanolrfa.org/industry/statistics/
Projections for 2006-2009 are based on data from Renewable Fuels Association (current ethanol expansion will add over 6 billion gallons of annual capacity). "Ethanol Biorefinery Locations: U.S. Fuel Ethanol Industry Biorefineries and Production Capacity." Renewable Fuels Association.
Available at: http://www.ethanolrfa.org/industry/locations/
Target production for 2022 (36 billion gallons) according to H.R.6 (passed in the Senate June 21, 2007).

Biofuels Today

Ethanol, as a fuel additive, has two main functions: as a gasoline replacement and an oxygenate, helping gas burn more completely and thereby reducing harmful emissions. To a very small extent, biofuels are already a part of today's American transportation system. Few drivers may realize it, but ethanol has supplanted about 3.5 percent of the U.S. gasoline supply.[17] And the federal government wants to raise biofuel's share of the market to 30 percent by 2030.[18] Biofuels are already being sold in thousands of gas stations throughout the United States, and most of it is corn-based ethanol. In fact, Americans burned more than five billion gallons of it in 2006.[19]

While interest in ethanol was stimulated by the oil crises of 1973 and 1979, and again with the 1990 amendments to the Clean Air Act, two ongoing developments have now brought it to the fore. Groundwater contamination from leaking storage tanks caused a swift crackdown on the oxygenate MTBE (methyl tertiary butyl ether), now banned in 25 states and subject to a multi-billion-dollar nationwide cleanup. Much more significantly, war in the Middle East and elsewhere has stoked intense interest in reducing dependence on foreign oil.

U.S. ethanol consumption more than doubled from 2002 to 2006.[20] Nearly all of the ethanol consumed in the United States is a 90/10 percent gas/ethanol mix, called E10, but higher concentration blends like E85 (a 15/85 percent gas/ethanol mix) are on the rise. Self-imposed government requirements to use alternative fuel vehicles and growing production of flexible-fuel vehicles (FFVs), which can run both on gasoline and on gas-ethanol, are spurring the trend forward.

There are now 119 ethanol refineries operating in the United States, with a total capacity of 6.1 billion gallons.[21] According to the Renewable Fuels Association, there are 77 ethanol refineries under construction (eight of which are expansion projects and the rest are new plants) with a combined annual capacity of over six billion gallons.[22] When construction and expansion are complete, (estimated to occur in 2008–2009), the total capacity will reach over 12 billion gallons per year. Several states have passed laws requiring ethanol's use, including Hawaii, Minnesota, and Montana, with Minnesota setting a 20 percent mandate by 2013.[23] This huge push has already made the United States the world's top ethanol distiller, surpassing Brazil, where abundant sugarcane is the raw material of choice.[24] With such rapid expansion, the U.S. ethanol market is now slated to surpass the current targets under the Renewable Fuels Standard (RFS) which mandated annual biofuel production to reach 7.5 billion gallons by 2012.

Additionally, ethanol is garnering far more public attention than ever before. Cars racing in the Indianapolis 500 in 2007 ran on pure ethanol. However, this enthusiasm has also been tempered by recent skepticism on Wall Street, as investors have expressed a wariness that the ethanol bubble will burst sometime soon. Indeed, the *Wall Street Journal* reported that companies that held public offerings in 2006 "have slumped since their…debuts, and both are still trading below their IPO prices."[25] Despite some revenue and income gains, "investors have raised concerns about challenges facing the industry."[26] The skepticism on Wall Street appears to be reflecting the many challenges facing the expansion of this technology.

Biofuels Globally

Worldwide production of ethanol in 2005 (some 12.2 billion gallons) displaced nearly 2 percent of global gasoline demand.[27] After the United States and Brazil, Europe ranks third in ethanol production. In Europe, whose main producers are France, Spain, and Sweden[28], ethanol is mainly produced from wheat, and to a lesser extent, sugar beets. Europe leads the world in biodiesel, accounting for more than 90 percent of world production, with Germany in the forefront, where pure biodiesel (B100) is totally exempt from fuel taxes and is offered at over 1,500 of the country's fuelling stations.[29] Most German biodiesel is produced from rapeseed, and the government plans to greatly expand its production in the next few years. Other main biodiesel producers are France and Italy.[30]

In the European Union (EU), biofuels have doubled their market share in two years, from 0.5 percent in 2003 to 1 percent in 2005.[31] This growth, however, fell short of the EU's 2 percent biofuels target, and was comprised of mainly biodiesel. But expansion is still expected in the European zone, as most member states have introduced tax exemptions for biofuels and some have introduced targets. The EU energy ministers have agreed to increase the share of biofuels used in transport to 10 percent by 2020.[32] This target is likely to be linked to sustainability criteria, a requirement that may rule out U.S. ethanol imports.[33] An EU official stated that the Commission is developing a "certification system to ensure that biofuels that are

Figure 2: World Ethanol Production 2006, Top Five Producing Countries

Country	Ethanol Production All grades millions of gallons	Percentage of World Production
United States	4,855	**36.0**
Brazil	4,491	**33.2**
China	1,017	**7.5**
India	502	**3.7**
France	251	**1.8**
Rest of the World	2,373	**17.5**

Source: "From Niche to Nation: Ethanol Industry Outlook 2006." Renewable Fuels Association. Data quoted from F. O. Licht. Available at: http://www.ethanolrfa.org/objects/pdf/outlook/outlook_2006.pdf imported, or the raw materials, are taken from sustainable production."[34] The Commission has also proposed stricter fuel standards which will require suppliers to reduce the greenhouse gases caused by the production, transport, and use of their fuels by 10 percent between 2011 and 2020 to help ensure that the fuel sector contributes to achieving the EU's emissions reduction goals.[35] Moreover, to compensate for an increase in emissions of polluting vapors that will result from greater use of ethanol, the Commission plans to put forward a proposal for the mandatory introduction of vapor recovery equipment at filling stations.[36]

China is another significant ethanol producer, reaching more than one billion gallons of output in 2005.[37] Chinese ethanol is made mostly from corn, cassava, and sweet potatoes. Mandatory 10 percent blends are in place in eight provinces, and the government plans to increase incentives for biofuels production.[38] In fact, Beijing already subsidizes the production of ethanol at about 1,300 yuan ($167) a ton and has committed to support the development of more biorefineries.[39] Guangxi province, for instance, is set to produce as much as one million tons of cassava ethanol per year, a target that is already raising concerns about the availability of homegrown feedstocks.[40] But the Chinese government has also called for restrictions on developing ethanol due to its effects on food markets. China's Renewable Energy Plan would restrict the country's ethanol industry to producing fuel from non-grain sources (such as grasses, corn stalks or other plant by-products) as a way to reserve crop land for food production.[41]

In India, a nationwide ethanol program is currently being launched which aims to reach 5 percent ethanol in transport fuel throughout the country, attracting the attention of domestic and international investors.[42] There are about 125 ethanol producers in the country, with a total capacity of 1.25 billion liters of ethanol, most of them concentrated in sugarcane states.[43] India is also looking into the development of biodiesel based on Jatropha, an ordinary shrub that is common in the country. Indian Railways, the largest owner of land in India, is growing the shrub on thousands of acres of land along the sides of the railway tracks, and hopes to cut a significant part of its fuel bill by blending Jatropha oil with diesel.[44]

In South America, Colombia is among the countries leading the way with a 10 percent ethanol requirement set for 2009 and some 27 ethanol plants being planned to process sugarcane feedstocks.[45] Colombia also plans to expand biodiesel production to 5 percent of the fuel used in regular diesel engines, and intends to greatly increase the areas planted with palm trees, the feedstock from which their biodiesel is derived. But the expansion of feedstock crops here has tied to deforestation, easing money laundering from drug trafficking, and forcefully removing indigenous and peasant populations from their lands.[46] Other countries considering ethanol programs include Bolivia, Costa Rica, and Guatemala, mainly based on sugarcane feedstocks.

Elsewhere around the globe, the Canadian government has set a 4.5 percent target for ethanol consumption by 2010.[47] In Southeast Asia, Indonesia and Malaysia, major producers of palm oil, are set to use their feedstock source for the production of biodiesel, while Thailand just began to implement a 10 percent ethanol blend based on its sugar and cassava production.[48] Production of biodiesel in these countries has been associated with increased deforestation, as forest lands are cleared for growing feedstocks.

The Ethanol Samba: Is Brazil a Model to Follow?

Brazil is often held up as a model for ethanol production. With an aggressive program that dates back to the 1970s, ethanol has now replaced 40 percent of Brazil's total fuels used by non-diesel powered vehicles. FFVs were introduced in the Brazilian market in 2003, and because of a very positive consumer response, almost all car models are now available in flex-fuel versions, with the number of vehicles that can run on biofuels surpassing conventional gas-only models.[49]

In addition, Brazil is a strong ethanol exporter and hopes to double its exports by 2010 to meet growing demand, largely from Japan and Sweden.[50] This has stirred immense interest around the world and particularly in the United States. As observed by Eduardo Pereira de Carvalho, president of São Paulo's Sugarcane Producers Union: "We receive visiting politicians from the United States, and we get invitations to speak to the Senate Foreign Relations Committee and to leaders of investment funds."[51]

The Brazilian ethanol sector is based on sugarcane, a feedstock which, due to climate conditions and agricultural productivity, presents very different potential than U.S. feedstocks. Sugarcane-based ethanol production in Brazil is much more efficient, and thus yields higher energy ratios than are achievable with corn-based ethanol. (For a detailed explanation of energy ratios see page

18.) Biorefineries in Brazil are generally self-sufficient because bagasse—the fibrous material that is left behind when sucrose is separated from the cane—is used to generate both heat (to boil off the water in the cane juice) and electricity (to power refineries, and is even to be sold to the national power grid). This use of bagasse for cogeneration—the process of producing heat and power concurrently—greatly impacts the net energy balance of sugarcane ethanol, with energy ratios calculated to be as high as 10.[52]

Corn-based ethanol production is much less efficient than sugarcane, with energy ratios around 1.3. Even if cellulosic ethanol becomes a reality in the United States in the near future, its energy balance is still estimated to be much less than that of sugarcane. As mentioned elsewhere, "for net energy yield, ethanol from sugarcane in Brazil is in a class all by itself."[53] Other factors also make the Brazilian experience nonreplicable in the United States. While Brazil's ethanol production of 4.4 billion gallons displaces 40 percent of gasoline consumption, the same 4.8 billion gallons that the United States produced in 2006 displaced a mere 3.5 percent of gasoline use. This disparity can largely be explained by different energy consumption levels per capita. Americans use some 25.4 barrels of oil per capita annually, many times more the average 4.2 per capita consumption in Brazil.[54] Moreover, the average automobile running on Brazilian roads is much smaller, and a large number of vehicles reach as high as 40 miles per gallon.[55] The lesson from this southern neighbor, therefore, seems to be that reducing energy demand is crucial for homegrown fuels to make a dent in oil consumption and imports.

Brazil's ethanol sector, however, is tainted by numerous environmental and human rights violations. Sugarcane is planted in monoculture regimes on huge properties. Among its most serious environmental impacts are deforestation (in order to make space for new plantations), contamination of soil and water (from the use of agrochemicals), and air pollution (from the burning of the fields to facilitate the harvesting of the cane).[56] These *queimadas*—as the burning of the fields is called—are carried out as a way to eliminate straw, debris, and animals that complicate manual harvesting. Annual burnings are responsible for soil depletion and wildlife loss as well as considerable emissions of greenhouse gases. The negative health impacts of the *queimadas* have been extensively documented and include widespread respiratory problems. A study by the São Paulo University, for instance, concluded that hospital admissions for respiratory complications increased by more than 20 percent during the annual cane burning periods.[57]

The expansion of sugarcane production, fueled by the development of ethanol, has been associated with flagrant human rights violations and rural conflict. The sector employs approximately one million people and some 80 percent of the production is manual.[58] Expansion of sugarcane cultivation has resulted in further concentration of land ownership and expulsion of small farmers from their properties, sometimes through the use of violence. The Pastoral Land Commission registered 16 assassinations connected to the sugarcane industry between 1990 and 2002.[59] Only 20 percent of the cane produced in Brazil comes from medium- or small-size properties, and the trend to close down small refineries is on the rise.[60] Moreover, many cane cutters are reduced to slavery through a system of bound work.[61] The Second Conference on Slavery and Work Exploitation held recently in Brazil indicated that more than 16,000 cane field workers had been freed in the last four years but many thousands more continue to be submitted to slavery conditions.[62] In June 2005, for instance, more than a thousand of these workers were freed by inspection teams in the Gameleira refinery, in the state of Mato Grosso.[63]

Therefore, the competitive price of sugarcane ethanol and much of the success of Brazil's ethanol sector is based on a feedstock production with serious environmental impacts, labor exploitation practices, and a record of flagrant human rights abuse—hardly an example to follow.

Biofuels and Transportation

The Role of Transportation

Today's world economy is heavily dependent on fossil fuels. Oil is now consumed at a rate of 80 million barrels a day (Mbd), compared to just eight Mbd in the middle of the twentieth century, an amazing tenfold increase in just five decades.[64] The top consumer of oil in the world is the United States; with only 5 percent of the world's population, it consumes 25 percent of global oil. The U.S. fleet of approximately 210 million automobiles and light trucks (vans, pick-ups, SUVs) accounts for about two-thirds of the country's oil use, roughly 14 Mbd.[65]

Figure 3: Oil Consumption per Capita, Top 10 Oil Consuming Countries

	Country	Barrels per Year
1	United States	25.4
2	Canada	25.3
3	South Korea	16.1
4	Japan	15.3
5	Germany	11.7
6	France	11.5
7	Russia	6.4
8	Brazil	4.2
9	China	1.8
10	India	08

Source: "The World Factbook 2007." January 23, 2007. Central Intelligence Agency. Available at: https://www.cia.gov/cia/publications/factbook/index.html

Almost all transportation vehicles in the world run on oil. Worldwide, vehicles burn more than 40 million barrels of oil every day.[66] Growth in passenger travel, mainly by car and plane, has been the biggest contributor to increases in oil demand.[67] Currently, transportation is responsible for 14 percent of greenhouse gas emissions worldwide, making fossil fuel–based transportation a significant contributor to climate change.[68,69] The United States is also the largest emitter of greenhouse gases, contributing almost 40 percent of the world's anthropogenic greenhouse gas emissions.[70] Transportation is responsible for 27 percent of U.S. greenhouse gas emissions.[71]

Not only is transportation one of the most polluting sectors, its technology is based on substantial inefficiencies. This means that in addition to emitting high quantities of greenhouse gases in order to move goods and people around the world, a lot of energy is wasted doing it. Current internal combustion engines are highly inefficient—most of the energy content in the gas fuel is lost in noise, heat, useless vibration, and wasted braking energy. Only 1 percent of the fuel energy is actually used to move the driver.[72] Indeed, the United States has the lowest standards in fleet average fuel efficiency rating and also the most permissible standards for greenhouse gas emissions compared to the European Union, Japan, China, Australia, and Canada.[73]

Furthermore, fuel efficiency and conservation considerations have been largely absent from urban planning and public transportation models, dimensions of public policy that can greatly affect fuel consumption. Comparatively low oil prices in the United States contribute to this situation. The oil shocks of the 1970s and 80s were followed by great reductions in oil consumption and fuel efficiency improvements, but these gains were diluted as oil prices fell. More cars per family and new suburbs engulfing open space and farm land have also factored into the U.S. oil consumption and waste model. Indeed, traffic congestion is responsible for tremendous fuel waste. In 2003, U.S. drivers in the 85 most congested urban areas of the country experienced 3.7 billion hours of travel delay and wasted 2.3 billion gallons of fuel, with a total cost of $63 billion.[74]

A heavily subsidized sector, oil is estimated to have been the recipient of some $149 billion in taxpayer money from 1968 to 2000.[75] Now a century-old industry, oil was nevertheless granted subsidies in the range of $6 billion in the Energy Policy Act of 2005 (EPACT 2005), plus royalty waivers totaling $7 billion to companies extracting oil from public lands.[76] The industry has posted record profits as fuel prices have risen without absorbing any costs associated with the environmental and health impacts of oil production and consumption,.[77]

Transportation is one sector that clearly needs to change and it is indisputable that the heyday of the gasoline-fueled automobile is over. Drivers can no longer fill up with impunity, and every gallon pumped contributes to the worldwide effects of fossil fuel dependency . This dependency is also a source of instability because oil, as any other finite, nonrenewable resource, is limited and will reach a level of maximum output (the point of "peak oil" which means not that we have run out of oil, but that we have run out of "cheap oil"). Indeed, experts agree that oil will become more difficult and expensive to extract, which will result in increasingly higher prices. Therefore, for a world economy totally dependent on increasing amounts of cheap oil, the consequences of this pending crisis could be disastrous. A study commissioned by the Department of Energy (DOE) points out that "peaking will result in dramatically higher oil prices, which will cause protracted economic hardship in the United States and the world." The Hirsch Report, as it is commonly known, also indicates that "as peaking is approached, liquid fuel prices and price volatility will increase dramatically, and, without timely mitigation, the economic, social, and political costs will be unprecedented."[78]

Figure 4: United States Greenhouse Gas Emissions by Sector - 2005

Sector	Emissions Million Metric Tons of Carbon Dioxide Equivalent	Percentage of Total Emissions
Residential	1,284.0	**17.9**
Commercial	1,301.0	**18.2**
Industrial	2,561.8	**35.8**
Transportation	2,000.3	**27.9**
Total	7,147	**100**

Source: "Emissions of Greenhouse Gases in the United States 2005." Energy Information Administration. Available at: http://www.eia.doe.gov/oiaf/1605/ggrpt/pdf/ghgeuse_table.pdf

Figure 5: Top Greenhouse Gas Emitting Countries - 2000

Country	Emissions Million Metric Tons of Carbon Dioxide Equivalent	Percentage of World Greenhouse Gases
United States	6,928	**20.6**
China	4,938	**14.7**
European Union-25	4,725	**14**
Russia	1,915	**5.7**
India	1,884	**5.6**
Japan	1,317	**3.9**
Germany	1,009	**3.0**
Brazil	851	**2.5**
Canada	680	**2.0**
United Kingdom	654	**1.9**

Source: "Navigating the Numbers: Greenhouse Gas Data and International Climate Policy." World Resources Institute. Available at: http://pdf.wri.org/navigating_numbers_tables.pdf

But instead of moving away from a fossil fuel–based structure, the global economy is expected to demand an estimated 118 million barrels a day in 2030 (driven in part by strong economic growth in China and India).[79] Projected increases in transportation are key factors driving up oil demand, with use in this sector estimated to account for half of total use.[80]

In addition to the dangers posed by global warming, the continuing reliance upon foreign oil is arguably one of the greatest threats to U.S. national security, making the country highly vulnerable to a breakdown on oil supplies. The United States imports almost 60 percent of the 20 million barrels of oil it consumes daily, and these numbers are projected to go up to 70 percent by 2025.[81] In 2005, the United States spent some $250 billion on oil imports—about $25 million per hour![82] Besides the economic cost of this reliance on foreign oil, the situation also results in critical foreign policy constraints. According to former CIA director, James Woolsey, and Senator Richard Lugar, Chairman of the Foreign Relations Committee, U.S. dependency on foreign oil keeps its military forces tied to the Middle East and forces foreign policy compromises, preventing U.S. diplomacy in the region from being "guided more by a respect for democracy than by a need to protect oil supplies and accommodate oil-producing regimes."[83] Reducing oil dependency will certainly result in an overall rethinking of U.S. foreign policies.

Therefore, the urgenct need to address climate change coupled with rising oil prices, as well as concerns over energy independence, have accelerated the need to find alternative fuels for transportation. With a renewed vigor in the race to find a substitute for gasoline, biofuels have emerged from decades of marginalization to become the darling of elected officials, academics, the media, family and corporate farmers, and even some mainstream environmental groups.

The Future of Transportation Infrastructure and the Need for Large Scale Change

Some of the big questions facing transportation experts are to what extent biofuels can provide an alternative to our fossil fuel–based transportation sector, and where we should be investing today's dollars to help create an environmentally sound transportation system for the future. In addition to cropland, an ethanol boom will necessitate significant national infrastructure investments. As alternative technologies compete for public and private funding, there are opportunity costs associated with any policy choice regarding the future of transportation, and the issues should be examined with the best information available.

At this point, ethanol is dominating public discourse, even though other possibilities for transportation reform and emissions reductions exist. Because of ethanol's hydrophilic properties (its tendency to attract water), a large-scale transition to biofuels would require significant changes to our fuel transport infrastructure. Because ethanol can't be transported through the pipeline distribution system that is currently in place for gas, this infrastructure change would require huge investments in dedicated pipelines. Indeed, the ethanol industry has called for government incentives to build a pipeline from the Midwest, where most refineries

are located, to the east and west coasts, and legislative initiatives are now underway to study the feasibility of a dedicated ethanol pipeline.[84]

Additionally, railways and roads would be needed to move corn from fields to refinery sites and ethanol to fueling stations. Rail capacity is already at a critical stage simply keeping up with the demand to move corn from the Midwest to both coasts. Moreover, higher blends of ethanol may have corrosive qualities that can affect the metal and plastic parts of the pumps at gasoline stations. Underwriters Laboratories, the private product-safety testing company that certifies the safety of products and components, raised the issue when E85 blends were found to be corroding pumps that were built to dispense E10 only.[85]

These infrastructure requirements are important to understand because they may lead to a long-term commitment to a technology when better solutions may be available. In fact, it has already been noted that "with that existing infrastructure in place and U.S. energy needs so great, it's a safe bet that any new fuels (such as cellulosic) would supplement corn-based ethanol, rather than replace it anytime soon."[86] Thus, once this structure is in place, it will be very hard to displace it as investments in ethanol production, distribution, and commercialization grow. We are now living within the constraints of an oil-based transportation system, and would be wise to envision larger systemic changes beyond simply looking to substitute the type of fuel. The opportunity costs associated with any given strategy must be assessed against all available alternatives.

Regardless of what emerges as the solution—biofuels, electric cars, hydrogen and fuel cells, improved mass transit, higher fuel efficiency, better car designs, smart urban planning, or a combination of these and other technologies and policies—moving away from a fossil fuel–based economy is urgent. It requires, first and foremost, the development of a more sustainable transportation system and smaller quantities of fuel used for personal travel and moving goods around.

Infrastructure requirements may lead to a long-term commitment to ethanol technology when better solutions exist.

PART II: CORN-BASED ETHANOL – AMERICA'S ENERGY PANACEA?

Limitations of Corn-Based Ethanol

Energy Ratios

How do we measure whether or not biofuels provide more energy than the fossil fuel energy consumed to produce them? To do this, researchers consider the entire fuel cycle, factoring in energy content of all inputs for production and processing. The total energy produced by the biofuel is then divided by the nonrenewable energy needed to produce it. The result is a net energy balance ratio. If the ratio is higher than one, the balance is *positive*, meaning that more usable energy is yielded than was put into producing the fuel; if it's less than one, the balance is *negative*, and the fuel took more energy to produce than it will yield.

Energy Content

Ethanol's energy content is about one-third less than that of gasoline. For E10 fuel, this lowers miles-per-gallon efficiency by 2-3 percent, so more fuel is needed to go the same distance. This also affects price competitiveness of ethanol relative to gas, as a gallon of pure ethanol contains only 70 percent of the energy contained in a gallon of oil-based fuel. For consumers in Brazil, for instance, where pure ethanol is commonly available, this means that ethanol is preferable to gas as long as the price of the biofuel is as least 30 percent less than that of gasoline. This has sharpened the math skills of Brazilian drivers who learned to do quick calculations at the pump to determine what the best buy is. Pure ethanol is usually cheaper—53 cents per liter (approximately $2 per gallon), compared with 99 cents per liter of gasoline (about $3.74 per gallon) in Sao Paulo the summer of 2006.[87]

There have been conflicting studies and much rhetoric surrounding the debate about ethanol's energy content. In an effort to harmonize the parameters and results reached by different researchers, several comparative studies have been advanced. The most comprehensive analysis to date was conducted in 2006 by the Institute for Lifecycle Environmental Assessment (ILEA), which compared 10 recent net energy balance studies—six for corn-based ethanol and four for cellulosic.[88] For corn-based ethanol, energy inputs included the fuel needed to manufacture fertilizer, run farm machinery, transport and distill corn, and distribute ethanol.

The ILEA report's findings speak to the difficulty in coming up with objective, consistent assessments of ethanol's energy and environmental benefits. There are many factors that determine net energy balance ratios, and there are not standardized criteria for calculating relevant values. The main reason for disparities between the teams' ratio calculations was that the input sets they considered were not uniform across studies. For example, how much energy "credit" should be attributed to byproducts of ethanol processing, such as animal feed. The energy "saved" by producing these byproducts would be subtracted from energy inputs to determine net energy input.

Of the six corn-based ethanol studies ILEA examined, five showed positive ratios. The only exception was the research team of Pimentel and Patzek. However, ILEA attributed the Pimentel and Patzek negative ratio to their relatively high estimates of energy needed to manufacture nitrogen fertilizer and operate farm equipment, as well as the study's consideration of two inputs not considered by any other team—personal energy consumption of farm laborers and the energy costs of manufacturing capital equipment. These same researchers were also the only team to calculate a negative energy ratio for cellulosic ethanol, estimating that switchgrass ethanol takes 45 percent more fossil energy than the fuel yielded. In this case, their model included fossil fuel to power refineries instead of lignin, a component of woody plants that is envisioned as a plentiful energy source for these facilities.[89]

However, political bias may serve as an explanation for these anomalous conclusions from Pimentel and Patzek.

Energy ratios of ethanol production have been improving steadily over the last two decades, as farmers and refiners have become more efficient. Nonetheless, it is clear that corn-based ethanol has one of the lowest net energy balances of all biofuels.

While the USDA and American Corn Growers Association found positive energy ratios for corn-based ethanol, Patzek's negative energy ratios are seen as a reflection of his pro-oil sympathies. He is a cofounder of the University of California Oil Consortium, an industry-supported organization that provides laboratory and training services to oil and gas companies, including drilling and exploration technologies. Participants over the years have included BP, Chevron, Mobil, Phillips, Shell, and Unocal, all of which have an obvious interest in suppressing ethanol. Despite the fact that their findings were out of sync with the majority of researchers, Pimental and Patzek have garnered disproportionately more media coverage than other teams in recent years, and the oil industry often relies on their findings to dismiss ethanol.

Following up on the ILEA assessment, a team of researchers at UC Berkeley reviewed six studies on ethanol energy ratios, including some of those previously analyzed by ILEA.[90] This assessment involved reanalyzing each study, correcting for errors, inconsistencies, and outdated information. After applying corrections, the Berkeley team concluded that all estimates pointed to positive energy ratios. Like the ILEA assessment, their analysis showed that only the Pimentel and Patzek studies reported negative net energy values. The Berkeley team concluded that the reason for this disparity was that Pimentel and Patzek ignored byproducts of ethanol production and used some obsolete data.[91]

Moreover, energy ratios of ethanol production have been improving steadily over the last two decades, as farmers and refiners have become more efficient. Increased yields per acre of corn production and the transition away from energy intensive wet mills to dry mills have been the main factors affecting this positive trajectory of ethanol's energy balance.[92]

A study out of the University of Minnesota has concluded that corn-based ethanol yields 25 percent more energy than the energy invested in its production (net energy ratio of 1.25).[93] However, this positive energy balance is almost entirely attributable to the distiller's dry grain (DDG) which is a byproduct of refining and can be used as animal feed, rather than to efficiency gains in the ethanol itself. This study also estimates the energy ratio of soybean biodiesel, calculating that this fuel contains 93 percent more energy than is required for its production (net energy ratio of 1.93). In this analysis, biodiesel's advantage stems from the lower agricultural inputs and more efficient conversion of feedstock to fuel. These conclusions are consistent with ILEA's findings.

Numerous other studies have also focused on the ratios of different biofuels. Tropical plants such as palm and sugarcane have by far the most favorable energy balances, with ratios of about nine and eight, respectively.[94] These favorable ratios result from the fact that they are grown in climates more suitable for enhanced plant growth and require less fertilizers and pesticides.

Despite the varying estimates, it is clear that corn-based ethanol has one of the lowest net energy balances of all biofuels. Overall, researchers believe cellulosic ethanol has the potential to achieve the highest positive net energy balance of non-tropical feedstocks. Researchers also believe that ratios for cellulosic ethanol can be improved, particularly because its production is currently undergoing major technological advances, and because cellulosic feedstocks farming is not as advanced as corn farming, suggesting more room for improvement.

This debate on the energy ratios of ethanol is, however, a largely academic discussion that has been decontextualized from its actual significance. It is important to keep in mind that energy is not lost or created, but transformed into forms in which it can be more or less useful. In this context, it is also important to remember that gasoline has a negative energy ratio, as more fossil-fuel energy is needed to produce a gallon of gasoline than the energy content of that gallon yields.[95] Therefore, the ethanol energy ratio debate should be put into perspective, as it represents an improvement over oil.

The overall conclusion regarding the energy ratios of biofuels makes clear three main points:

- The net energy balance of biofuels has improved over time as efficiencies in both feedstock and fuel production have increased.
- Biofuels represent a clear gain when compared to fossil fuel–based gasoline and diesel.
- Corn-based ethanol has one of the lowest energy ratios of all biofuels.

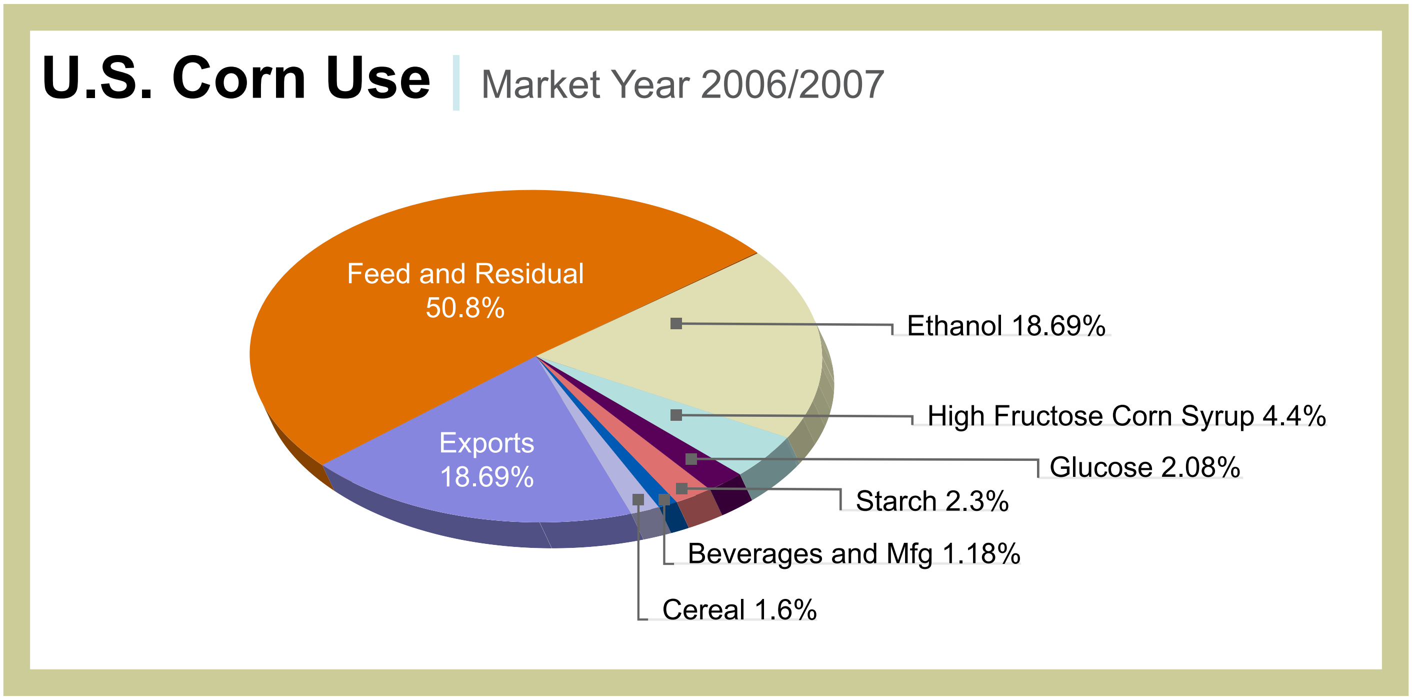


Figure 6 U.S. Corn Use

Source: "Feed Outlook." Economic Research Service, USDA. June 13, 2007. Baker, Allen and Edward Allen. Available at: http://usda.mannlib.cornell.edu/usda/ers/FDS//2000s/2007/FDS-06-13-2007.pdf

> **"The idea of U.S. energy independence is now a myth, but could become a reality if U.S. lawmakers find ways to expand demand for fuels blended from homegrown sources like corn and give automakers incentives to make cars that burn on them."**
>
> *Monte Shaw, president of the Iowa Renewable Fuels Association[96]*

Potential to Displace Fossil Fuels

Proponents of biofuels claim to have the answer to energy independence and U.S. addiction to foreign oil. Corn growers and ethanol producers talk enthusiastically about replacing the oil fields of the Middle East with the corn fields of the Midwest. In a report prepared for the German government, the Worldwatch Institute concluded that "The recent pace of advancement in technology, policy, and investment suggest [that] these fuels have the potential to displace a significant share of the oil now consumed in many countries."[97] The Natural Resources Defense Council (NRDC) estimates that a highly aggressive research, development, demonstration, and deployment program could result in biofuels contributing 25 percent of projected U.S. transportation-related oil consumption by the middle of the century.[98]

A report commissioned by the DOE and the USDA found that land resources in the United States are capable of growing a supply of 1.3 billion dry tons per year of biomass by 2030, and that one billion tons of biomass would be sufficient to displace 30 percent or more of the country's petroleum consumption at 2004 levels.[99] This estimate assumes that 25 percent of this potential supply (368 million dry tons of biomass) could be gleaned from forestlands, including fuel wood harvested from forests, residues from wood and paper mills, urban wood residues, and logging and site clearing residues. As for the potential from agricultural lands, the report estimates that the remaining 75 percent of biomass potential (some 998 million dry tons) would consist of crop residues, perennial crops, grains used for biofuels, and animal manure.

However, the promising figures in the NRDC and government reports are based on massive changes and complex and uncertain developments. For example, the NRDC's projection that biofuels could supplant 25 percent of petroleum for the transportation sector assumes that, among other modifications, vehicle fuel efficiency will reach 50 miles per gallon, switchgrass yields will increase by 50 percent, 10 to 15 million acres will be removed from conservation lands, and smart growth policies will be enacted to reduce fuel demand.[100] Similarly, the estimates in the DOE assessment would require large-scale development of perennial crops as an energy source, modifications in agricultural crop management systems, crop yield increases of 50 percent, and considerably lower production costs. Moreover, the DOE report does not include any considerations regarding the impacts of producing of such quantities of biomass on the agriculture (food and feed production) or forestry sectors of the economy. Nor does it evaluate the environmental impacts of producing these billions of tons of biomass.

In consideration of the possible side-effects of such an aggressive approach, experts from various fields have raised concerns. Some point to the impact of harvesting feedstocks from farmland now set aside under the Conservation Reserve Program.[101] Also, removing such massive amounts of biomass from forest land may have unintended ecological consequences, as it would drastically reduce the total amount of nutrients present in the forest. Donald Waller, an environmental studies professor at the University of Wisconsin-Madison, warns, "You can't take it all away without seriously diminishing the ecosystem functions and the plant and animals that live there."[102] (For further discussion on this topic refer to chapter *Cellulosic Ethanol: How Much Better?* on page 56)

Other estimates regarding the potential of ethanol to displace the demand for fossil fuel are less favorable. For one, researchers at the University of Minnesota found that converting every corn and soybean field in the United States to biofuel production, a highly unlikely scenario, would reduce gasoline demand by just 18 percent.[103] Furthermore, due to the huge energy inputs that would be required, overall energy consumption would be reduced by only 5.3 percent.[104]

In a similar vein, the Congressional Research Service (CRS) has estimated that even if the entire U.S. corn crop was dedicated to ethanol, it would displace less than 15 percent of national gasoline use.[105] Replacing 30 percent of total U.S. oil consumption would require nearly 140 million acres of land for corn production and would require that the entire crop be dedicated to ethanol production. Yet, only 78.4 million acres of corn were planted in 2006, and in 2007 corn acreage is expected to reach 93 mllion.[106] Therefore, the CRS concludes that "barring a drastic realignment of U.S. field crop production patterns, corn-based ethanol's potential as a petroleum import substitute appears to be limited by a crop area constraint."[107]

Therefore, the potential of ethanol to displace fossil fuels, and thus to reduce imports of foreign oil, is limited. The most favorable estimates point out that fuel made from biomass can replace between a fourth and a third of transport-related oil demand. As demand for oil in the transport sector is projected to increase from the current 14 Mbd to 20 Mbd by 2030, even the most aggressive projections for biofuel production would not be able to meaningfully address the critical questions of energy independence and fossil fuel replacement.[108]

> **"Barring a drastic realignment of U.S. field crop production patterns, corn-based ethanol's potential as a petroleum import substitute appears to be limited by a crop area constraint."**
> *Congressional Research Service, 2006*

Environmental Effects of Corn-Based Ethanol

Ethanol is being widely promoted as a renewable, homegrown alternative to gasoline, naming corn as the fuel source for a cleaner future. "Live green, go yellow," is one industry slogan, alluding to both the color of corn and the yellow label on ethanol dispensing pumps. There has been a concerted effort to portray corn-based ethanol as a clean, environmentally responsible energy source. According to the Renewable Fuels Association, the national trade association that represents the U.S. ethanol industry, ethanol "dramatically" reduces tailpipe emissions and is "one of the best tools we have to fight air pollution from vehicles."[109]

The reality, however, is not this simple. "There's a lot of green in the money that's going into ethanol," says one University of Minnesota researcher, "but perhaps not so much green is coming out as far as the environment."[110] In fact, a study by the World Resources Institute concluded that the development of a corn-based ethanol market will negatively impact the environmental problems already degrading soil and water quality in the United States.[111] The study estimates that expected incentives for corn production, resulting from its increased market value, will lower enrollments in the Conservation Reserve Program, increase soil erosion, contribute to the eutrophication (algae blooms resulting from excessive nitrogen) of rivers and lakes, reduce fish habitat, and expand hypoxic (low-oxygen "dead zones" where life cannot flourish) zones. Indeed, the expansion of corn-based ethanol will exacerbate the environmental problems that already charcterize large-scale corn production.

In addition to the environmental concerns stemming from the cultivation of corn for ethanol, the processing of ethanol itself, as well as the burning of it as fuel, also has adverse effects on air and water quality. The following sections will explore the various ways in which all phases of ethanol's life-cycle—from the farm to the tail pipe—can be harmful to the environment.

Conventional Corn Production

Conventional corn production in the United States is characterized by intensive soil tillage, heavy application of chemical fertilizers and pesticides, and cultivation of genetically engineered crop varieties, all of which take a significant toll on soil, water, and environmental quality. Much of the intensity of corn farming is related to the failure of federal farm policy and the domination of corporate agribusiness. Since 1996, federal farm policy promoted commodity overproduction that has lowered the price of corn below the cost of production for much of the last decade. Agribusiness consolidation of suppliers and corn buyers has further disadvantaged corn farmers. Corn farmers buy expensive inputs from a consolidated industry – two firms control 58 percent of the corn seed market, for example.[112] To compensate for these pressures, corn farmers have pushed to get higher yields and generate additional bushels to sell at the low prices that have been the norm until the past year. Most farmers plant corn because it is a commodity desired by the food and feed industry. Corn is not only the most common feed at livestock processing operations but is a basic building block throughout the food processing industry.

Land Use

In 2006, 78.4 million U.S. acres were planted with corn.[113] In 2007, corn fields are expected to expand by 15 percent to meet higher demand caused by the growth of the ethanol industry.[114] This represents a planted area of 93 million acres of corn, the largest increase since the early 1944.[115]

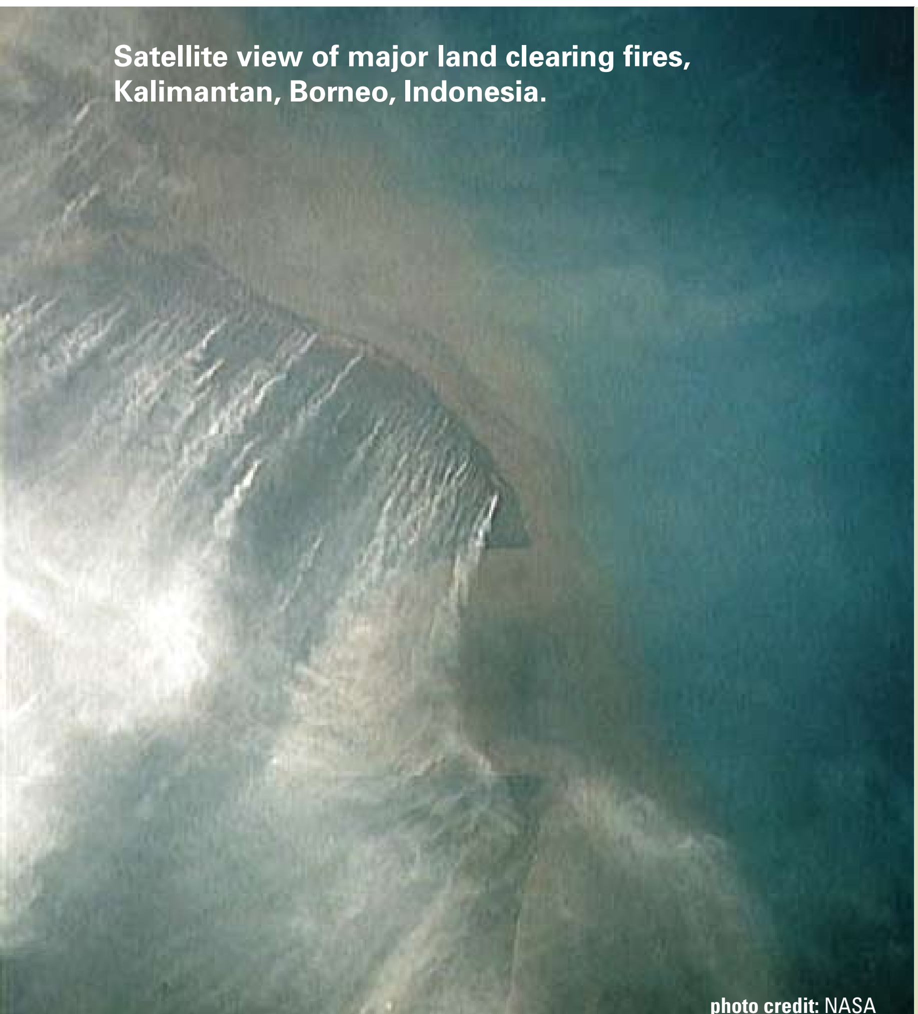
As corn prices continue to rise and government subsidies continue to flood the ethanol industry, there will be pressure to use a greater percentage of the corn harvest for ethanol production and to plant additional land with corn. There are only two ways to do this: by switching from other crops to corn or by appropriating currently idle lands for crop production.

Pressure on farmers to switch from soybeans or other crops to corn will contribute to the environmental problems already affecting industrial corn cultivation. Abandoning crop rotation to raise corn year after year will necessitate more fertilizer and pesticide use, due to increasing resistance of weeds and insects to chemicals meant to contain them, and further soil depletion. Moreover, as ethanol technology develops toward using crop residues as an additional feedstock, there will be less organic matter left on the fields after each harvest, diminishing soil fertility and speeding erosion.

As demand for ethanol feedstocks grows, there will be pressure to expand crop farming onto land that is currently fallow or in conservation programs in the United States, as well as to clear-cut rainforest in the developing world.

Some experts have expressed concerns about the possibility that demand for feedstocks, or "energy crops," will dissuade farmers from participating in the Conservation Reserve Program (CRP), the largest program that encourages conservation of private-lands in the country. The U.S. Farm Service Agency (FSA) oversees the CRP, which was set up more than 20 years ago as a voluntary program for farmers to set aside highly erodible and depleted lands for conservation. Under CRP contracts, landowners receive rental payments to establish long-term vegetative cover on eligible farmland. High demand for corn could deter farmers from putting acres into the CRP and could encourage farmers participating in the CRP to bring those acres back into production.

According to the FSA, by stimulating the cultivation of resource-conserving vegetative covers, the program protects topsoil from erosion, improves the condition of water bodies, and is a major contributor to increased wildlife populations in many parts of the country.[116] By the end of 2005, almost 35 million acres of cropland or pastureland across the country were under CRP contracts, resulting in substantial environmental benefits, including the sequestration of some 48 million metric tons of CO_2 annually.[117] However, as CRP contracts covering 26 million acres of land are due to expire at end of the decade,[118] there is concern for the long-term conservation of these lands. Steve Chick, head of the Natural Resources Conservation Service office in Nebraska, has stated his concerns over whether "people will be more reluctant to get into CRP contracts, because they are waiting to see if they can increase their production and get more money by raising corn for ethanol."[119]



These land clearing fires in the Kalimantan region are indicative of the deforestation associated with the expansion of palm oil plantations. The Kalimantan region is one of Indonesia's main producers of palm oil, a major feedstock for biofuel.

Deforestation

Significant expansion of biofuel feedstock production may cause widespread deforestation as land is cleared to make room for these crops. It is well known that destruction of the world's rainforests poses a major threat to the earth's capacity to absorb greenhouse gases, as well as to the survival of a large percentage of global biodiversity. What is less known is that the world's largest rainforest, the Amazon, is being clear-cut to make way for expanding crop production. In fact, soy production in Brazil has been a major force behind recent destruction of the Amazon.[120] As demand for soy increases with the promotion of biodiesel, and as Brazil's ethanol industry continues to put pressure on sugarcane supplies, it is likely that even more of the Amazon will be cut to make room for these crops.

Biofuel-driven deforestation is also already advancing in regions of Southeast Asia. The Malaysian government, for example, intends to develop three million hectares of new oil palm plantations by 2011 to meet the increasing global demand for biofuels,[121] even though oil palm production was responsible for an estimated 87 percent of the deforestation in Malaysia from 1985 to 2000.[122] In addition to decreasing biodiversity, deforestation limits the planet's ability to absorb CO_2 from the atmosphere, undermining one of the main justifications for using biofuels in the first place.[123]

Brazil-U.S. Ethanol Alliance

Brazil and the United States established a new partnership in March 2006 to boost the production of biofuels. This agreement, "Biofuels Strategy for Latin America and the Caribbean," aims to create an international market for ethanol by developing common standards for biofuels, expanding research programs, and building production alliances with other countries. The United States and Brazil are the two main ethanol producing countries in the world and account for 70 percent of global ethanol production, which reached 13.5 billion gallons in 2006.[124]

However, the Lula-Bush partnership is raising concerns about how this expanded market will impact the environment and the agricultural structures in the region, including effects from increasing deforestation, expansion of monocultures, soil erosion, land ownership concentration and rural conflict. Sugarcane, oil palm, and soy plantations are already supplanting forests and grasslands in Brazil, Argentina, Colombia, Ecuador, and Paraguay.[125] Moreover, expansion of tree and crop monocultures for biofuels production can potentially become a driving force for factory farming in Latin America, as land for cattle pastures becomes less available. As biofuel feedstock production expands, land use competition between farming sectors in the region is likely to increase and cattle ranchers are already feeling the crunch from growing industrial agriculture in Latin America.[126]

Eutrophication has been called "the most widespread water quality problem in the United States and many other nations."
Ecological Society of America, 1998

Soil Fertility and Erosion

A major problem with the expansion of corn production is that it is an input-intensive crop that puts enormous pressure on soils. Traditionally, most corn farmers have practiced crop rotation, which involves planting one crop (usually soybeans) one season, and another crop (corn) the next season on the same field.[127] This practice allows for the soil to regenerate fertility because each crop variety draws different nutrients from the soil while leaving different nutrients behind. Although most family farmers rotate a few different crops in their fields, some growers will solely plant whichever crop brings in the most money. With economists expecting 2007 corn prices to be 40 percent higher than 2006 prices,[128] more farmers may be tempted to plant only corn for a few straight seasons. Therefore, abandoning soil improving crop rotation for continuous corn growing will necessitate increased amounts of chemical fertilzers, which will also increase runoff and the deterioration of water quality.

Futhermore, tillage methods used for conventional corn production can contribute to soil degradation and erosion. Conventional tillage (which leaves less than 15 percent of crop residue on fields after harvest) and reduced tillage (which leaves up to 30 percent of residue), the two most intensive methods of crop field tillage, are common in U.S. corn farming. They make up three fifths of the corn acreage.[129] However, less intensive tillage, or conservation tillage, which is more beneficial for soil quality and helps guard against erosion, is practiced on 38 percent of corn acres and half the acres grown in the Southeast.[130] In addition, intensive tillage also releases atmospheric carbon stored in the roots of crops that would otherwise be sequestered in the soil, meaning that this practice also counters efforts to stem global warming.[131] (Greenhouse gas emissions will be discussed at greater length at the end of this chapter.)

Industrial monocultures – including corn, sugarcane, and soybeans – rely increasingly on just a few genetic varieties, which are displacing thousands of locally adapted varieties. Farmers raise these few varieties – there are two primary seed corn varieties grown in the United States – because that is what the oligopolistic corporate food processors, livestock operators and granaries demand. Along with deforestation resulting from expansion of industrial monocultures, this homogenization of the gene pool for agricultural crops, plus the widespread use of agrochemicals, is slowly undermining global and local biodiversity. This will have

Dead Zone in the Gulf of Mexico

Satellite image of the Dead Zone in the Gulf of Mexico: reds and oranges represent low oxygen concentrations, creating an environment very difficult for marine life to survive in.

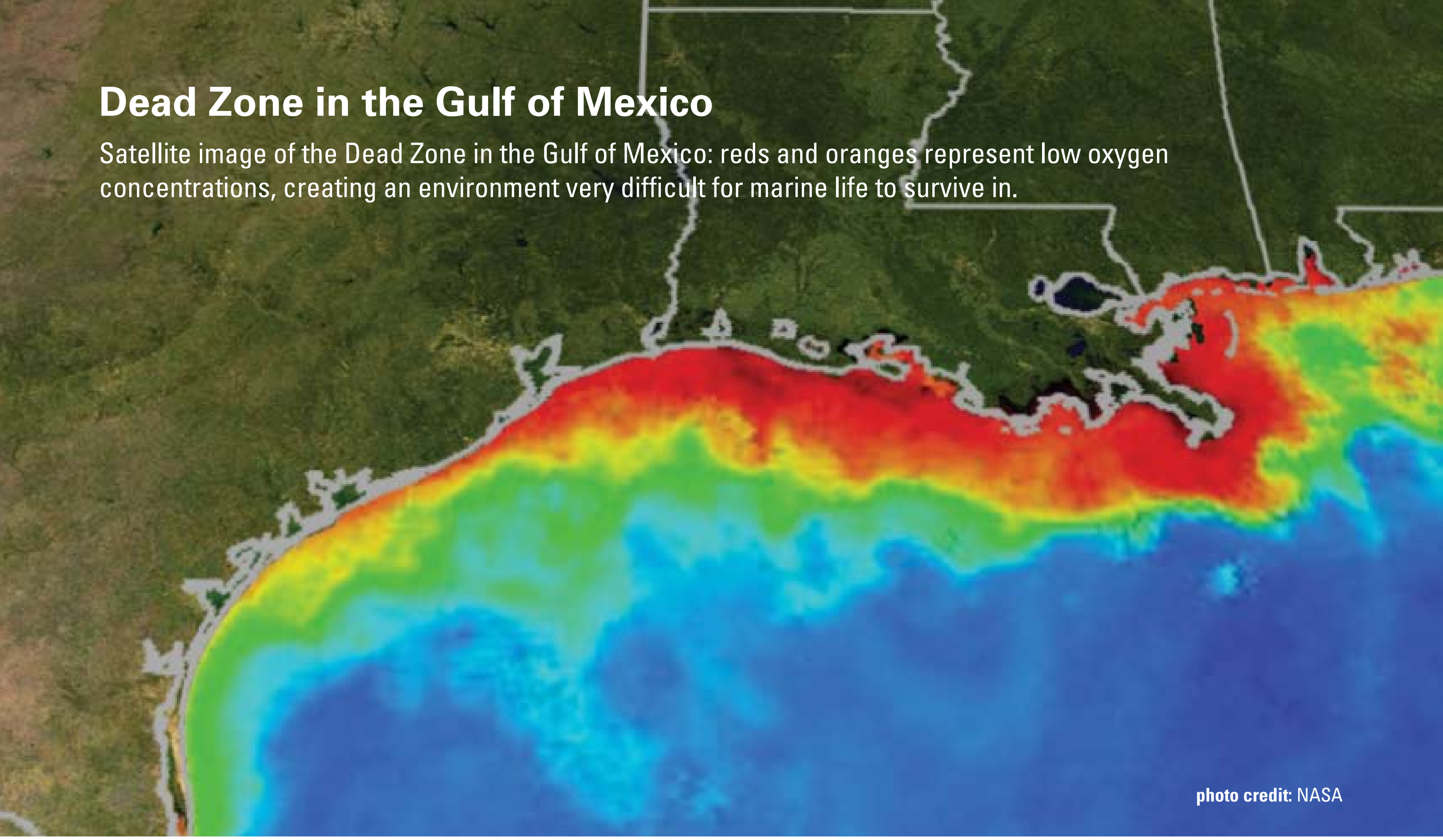


photo credit: NASA

Eutrophication caused by farm runoff has resulted in the formation of a 6,600 square mile "Dead Zone" along the coast in the Gulf of Mexico. The Dead Zone is about the size of the states of Connecticut and Rhode Island combined, with extremely low oxygen levels that cannot support fish and other aquatic animals, resulting in empty nets for local fishermen.[135] A 1995 flood aggravated this situation, increasing the size of the dead zone as more agricultural chemicals poured into the Gulf, leading the federal government to provide $15 million in disaster relief for fisherman affected by the catastrophe.[136]

immense negative impacts on global food security, ecological stability, and the environment.

Commercial Fertilizers

Corn is very nutrient-intensive, and growers turn to commercial fertilizers to maintain crop yields, especially during periods of persistently low prices. As a result, corn production consumes 40 percent of all commercial fertilizers used on crops in the United States; commercial nitrogen is applied to 98 percent of corn fields and commercial phosphate to 87 percent.[132]

The extensive use of commercial fertilizers in corn production is problematic because nutrients from these chemicals are known to runoff of fields and contaminate water systems. Excess nutrients in water systems cause eutrophication—an increase in plant growth in waterways that depletes oxygen levels in the water, making it impossible for most other aquatic life forms to survive.[133] Eutrophication resulting from excessive levels of nitrogen and phosphorous is the leading cause of impairment of surface waters in the United States, and has been called "the most widespread water quality problem in the United States and many other nations."[134]

According to the Cornell University Center for Environmental Research, most farmers apply over twice the amount of nitrogen fertilizers that their crops can put to use, allowing for the excess nitrogen to leach into the groundwater and access drinking water supplies.[137] When nitrogen fertilizer leaches into groundwater, it takes the form of nitrate.[138] Excess nitrate in drinking water has been linked to a number of adverse human health effects, including methemoglobinemia ("Blue-Baby Syndrome"), cancers (inducing ovarian, uterine, and bladder cancer), goiter, spontaneous abortion, and birth defects.[139]

While nutrient runoff from all agricultural fields represents a hazard, runoff from corn operations is of particular concern relative to alternative biofuel feedstocks. Corn is much less efficient than its cellulosic counterpart, switchgrass, at absorbing nitrogen from fertilizer. According to the NRDC, corn requires about three times the amount of nitrogen fertilizer as switchgrass, and corn fields lose about eight times the amount of nitrogen lost by switchgrass.[140] Coupled with current knowledge of the effects of nitrates on human and environmental health, these statistics make it clear that fertilizer use has important implications when weighing the pros and cons of corn-based ethanol.

Pesticides and Herbicides

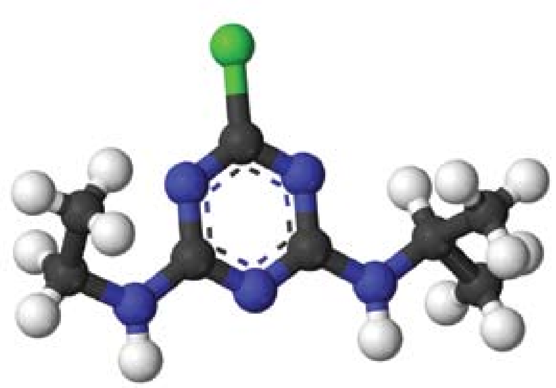
Corn farmers rely on various methods to control pests in their fields, including crop rotation, scouting, tillage, planting resistant biotech crops, and the application of pesticides.[141] Pesticides are substances used for controlling any unwanted plants, insects, or other organisms,[142] and they are regulated in the United States by the Environmental Protection Agency (EPA).

Some corn farmers use insecticides to ward off unwanted insects, however their usage is relatively low and varies depending on geographic location and weather. Herbicides, which are used to kill and control weeds, are by far the most commonly used agrochemicals in corn farming, applied to about 96 percent of U.S. corn acreage.[143] U.S. corn farmers rely primarily on one herbicide, atrazine, which is applied to of the country's corn acreage to control weeds in their fields.[144]

Atrazine is applied to roughly 75 percent of the U.S. corn crop,[145] and is consequently one of the most widely used pesticides in the world. The human and environmental health risks associated with this herbicide are many, although there is a good deal of controversy surrounding the validity of its risk assessments. The EU has banned the use of atrazine since 2004,[146] and U.S. consumer groups have called for its restriction by the EPA.[147]

Officially, the EPA has in the past considered this herbicide both a "likely" and "possible" human carcinogen, however the agency has most recently opted to regulate it using a "non-cancer endpoint."[158] Independent studies have shown that atrazine causes tumors in rats,[159] however, and that it is a potential human carcinogen.[160]

The EPA acknowledges that "there is significant, widespread exposure to atrazine and its metabolites in drinking water."[161] In order to combat water contamination from herbicides, the EPA has promoted the use of less toxic varieties that may bring down overall herbicide usage in the United States. One such herbicide is acetochlor, which was approved by the EPA in 1994 under the conditionality that this herbicide would reduce total corn herbicide use (replacing usage of herbicides like alachlor, metolachlor, atrazine, 2,4-D, butylate and EPTC).[162] The conditionality was easily met, and between 1994 and 1997, use of other herbicides fell by 184.1 million pounds on U.S. corn farms, while acetochlor use amounted to only 88.9 million pounds.[163]



Atrazine is known to stimulate enzymes which can alter hormonal development in wildlife. In fact, this herbicide has been linked to fish in the Detroit river that bear both male and female sex organs,[148] and has been know to turn frogs into "bizarre creatures bearing both male and female sex organs."[149]

Atrazine is toxic to fish and aquatic invertebrates[150] and has been linked to hormonal problems in frogs and fish.[151, 152] It also poses risks to aquatic and terrestrial plants,[153] and the NRDC has actually sued the EPA over its failure to protect endangered species from it.[154]

In humans, atrazine may pose risks to endocrinal development.[155] The EPA warns consumers that acute exposure to atrazine can cause "congestion of the heart, lungs and kidneys; low blood pressure; muscle spasms; weight loss, [and] damage to adrenal glands".[156] It also notes that long-term exposure can result in "weight-loss, cardiovascular damage, retinal and some muscle degeneration; [and] cancer."[157]

Although acetochlor has been instrumental in reducing total herbicide use and it is considered to be less toxic than atrazine and other pesticides,[164] this herbicide also poses health and environmental risks. The EPA has classified acetochlor as "likely to be carcinogenic to humans,"[165] and in lab tests it has proven to have adverse effects on mammals' reproductive systems, development, body weight, testes, and blood chemistry.[166] Acetochlor is also considered to be particularly risky for human females ages 13 and older.[167] Futhermore, the EPA has acknowledged that there is "relatively high potential for acetochlor residues to reach ground and surface water."[168] When released into the environment, the herbicide is "slightly toxic to mammals and birds," and highly toxic to fish, as well as some aquatic and terrestrial plants.[169]

As a condition of acetochlor's registration, the EPA required that further ground and surface water studies as well as endangered plant and animal investigations be performed in areas with high corn production.[170] One of these studies, which focused on 175 community water systems in corn-producing areas, detected acetochlor in just under 19 percent of drinking water samples.[171] Higher concentrations of the chemical were identified in drinking water samples in the months of May and June and in reservoirs near areas of "high corn intensity."[172] Degradates of acetochlor were identified in up to 42 percent of the samples.[173] Degradates are elements of a pesticide that have been broken up by environmental processes, and are known to bear some of the characteristics of the substance from which they are derived.[174] The study found that the acetochlor residues found "do not appear to represent a significant threat to human health."[175]

Over-application of herbicides in corn production can result in serious environmental and public health problems. Aside from the adverse effects of atrazine mentioned above, other herbicides and insecticides used in corn production, such as carbofuran, methomyl, methyl parathion, and terbufos are known to be highly toxic to birds, mammals, and fish.[176] Pesticides (including both insecticides and herbicides) used in corn production are potentially harmful to wildlife living near corn fields, as they are toxic to many animals if consumed and can also kill off vegetation that insects and animals rely on for food or shelter.[177]

In the spring time, when corn farmers apply the largest quantities of herbicides to their fields, rains wash these chemicals into the drinking water of nearly 12 million people throughout the central United States, and about 18,000 pounds of corn herbicides are carried into the Mississippi river every day.[178]

Corn herbicides are the most prevalent (both in terms of frequency and concentration) agricultural pesticides present in surface and drinking waters throughout the United States.[179] Given current knowledge of the potential carcinogenicity and other adverse health effects of herbicides used in corn production, it is clear that increases in these levels could pose a serious threat to human health.

Corn production consumes over twice the amount of pesticides than any other major crop in the United States.[180] In part, this is because corn is the most widely cultivated crop. Although technological improvements, such as the development of new herbicides like acetochlor, can help to reduce pesticide use in corn production, an increase in cultivated corn acreage to supply ethanol refineries would release greater quantities of toxic chemicals into the human and natural environment.

The EPA's approval and regulation of pesticides are based on the understanding that these toxic substances, though toxic, are to be released into the environment at levels low enough to be safe. Today's corn pesticide regulations are based on current and past corn production rates and pesticide usage levels.[181] If there were to be a significant increase in corn production, it could result in higher pesticide exposures and associated risks, even if producers apply these chemicals in accordance with EPA regulations.

Agrochemicals used in corn production are potentially harmful to wildlife living near corn fields, as they are toxic to many animals if consumed and can also kill off vegetation that insects and animals rely on for food or shelter.

photo credit: Morguefile

Genetically Modified Organisms (GMO) and Ethanol Feedstocks

Genetically Modified Organisms have had the genetic material from one organism inserted into their genetic makeup, resulting in an adoption of traits in plants or animals that cannot be achieved using traditional breeding methods. The two main forms of genetically modified crop varieties are herbicide-tolerant (HT), and insect-resistant (called Bt, after the bacterial toxin Bacillus thuringiensis).[182] Farmers who rely on herbicides can be dependent on HT crops that can survive the application of certain herbicides. Ninety percent of the acreage of GMO crops are grown from seeds sold by a single company, Monsanto.[183]

Corn is the third most popular GMO crop (behind soy and cotton),[184] and more than 60 percent of all corn now planted in the United States is GMO corn.[185] GMO corn has been available on the market since 1996, and today corn is the crop with the most deregulated GMO varieties.[186] Corn farmers have adopted genetically modified corn varieties primarily to maximize yield, especially during the low price environment that has prevailed since the first genetically modified corn varieties were adopted. Two thirds of corn farmers who shifted to HT corn and nearly four out of five farmers who shifted to Bt corn did so to increase yields.[187] As the ethanol industry puts pressure on farmers to achieve higher yields of corn per acre, there will be more incentives to genetically engineer strains specifically for ethanol production. Biotech industry efforts are already underway to create varieties engineered to convert more readily into ethanol.[188] Moreover, the U.S. Department of Energy currently provides funding for studies that look into genetic engineering of other biomass and feedstocks to be used specifically in ethanol production.[189]

Adverse Effects of GMO Crop Technology

More than a decade after GMO crops have been available in food, feed, and seed markets, questions remain unanswered regarding their health and environmental impacts. Engineered ingredients have shown up in processed foods as well as milk, eggs, and meat, raising concerns about the potential consequences for human health.[190] The environmental impacts of GMO crops are perhaps the issue most relevant to ethanol production. Although research on this subject is also lacking, the negative environmental impacts of GMO crops may include the transfer of genetic traits (such as herbicide resistance) to related species of plants, invasion and displacement of nearby plants and native species, and effects on insect and small animal species (particularly those living near Bt crops).[191] HT crops have also been found to increase usage of herbicides, raising total U.S. pesticide applications by over 50 million pounds in the first eight years that GMO crops were cultivated.[192]

Gene Pollution

It is practically impossible to contain gene pollution from the pollen of GMO crops that are cultivated outdoors, and there have been many cases in which genes from GMO crops have contaminated other crops both in the United States and abroad, resulting in billions of dollars in losses.[193] In Mexico, for example, prized corn varieties were found to have been contaminated with DNA from GMO corn, even though commercial cultivation of GMO crops was not yet approved in the country.[194] More recently, U.S. rice supplies were found to have been contaminated with an unapproved variety of GMO rice, resulting in major losses for U.S. rice farmers that were not able to export their product to countries banning GMO imports.[195]

Aside from its clear economic effects, gene pollution also poses risks for human health and environmental stability. GMO engineered for antibiotic resistance can spread these traits to other plants, increasing overall antibiotic resistance in the environment.[196] There are also GMO crops that contain allergens, and there have been cases where these allergens spread from GMO varieties to food crops, putting human health at risk.[197] In addition, there are still questions about the genetic stability of GMOs, and despite their potential for causing undesired mutation, no studies have concluded what this could mean for human health or the environment.[198]

Adoption and Regulation of GMO Technology

Recognizing the potential risks associated with GMO crops, 138 countries (over two-thirds of the world's sovereign nations) have signed the Cartagena Protocol,[199] which holds its signatories accountable for handling GMOs in a precautionary manner.[200] Some countries have taken even greater steps, with EU member states having banned certain GMO products and slow to approve the use of others, while Zambia, Mozambique, and Zimbabwe have turned away food aid from the United States because it contained GMO foods.[201] The United States is more lax than most when it comes to embracing and regulating GMO crops. The National Academy of Sciences (NAS) has reviewed the EPA's program for regulating crops engineered to produce insecticidal toxins and recommended that the agency strengthen its oversight,[202] and has also recommended significant changes in the EPA's regulatory program over GMO crops as a whole.[203]

Ethanol Processing and Use

As with the production of feedstocks for the ethanol industry, the processing and burning of ethanol also have significant negative effects on the environment and human health. Ethanol plants are known to use massive quantities of water, a scarce and valuable resource in many U.S. farming regions. The emissions released when ethanol is burned are an equally important concern, particularly in the context of global climate change.

Average water consumption for ethanol plants is about four gallons of water consumed per gallon of ethanol produced.

Water Use

Ethanol refineries require considerable amounts of water, taxing already strained water resources. A recent study by the Institute for Agriculture and Trade Policy estimates average water consumption for ethanol plants at about four gallons of water consumed per gallon of ethanol produced, indicating that water availability will be a major limitation to the potential of the ethanol sector, particularly west of the Missouri River.[204] Although ethanol plants have become more efficient in terms of water use, water conservation technology is limited. Even if technological innovation meets the Renewable Energy Association's estimate of three gallons of water to produce one gallon of ethanol, the construction of new plants will put significant pressure on water supplies, consuming an estimated 30 billion gallons in 2008.[205] As much as water efficiency in ethanol plants is due to improve, mainly through water recycling systems, the number of new plants alone has the potential to exert unsustainable pressure on the water resources in the Corn Belt, where most ethanol plants are located due to the availability of feedstock and lower transportation costs.

Refineries are also slated to be built near livestock facilities that consume distiller's grains, a by-product of ethanol production. Therefore, many regions that are already experiencing water supply concerns because of competing consumption needs from the development of factory farms and meat and grain processing plants will now have ethanol refineries to add to the mix.[206]

Water availability has already become a limiting factor in the siting of new plants. A proposed ethanol plant by Cargill in Pipestone, Minnesota, was not built because of water availability issues. The plant, with a production capacity of 100 million gallons of ethanol per year, would consume over 350 million gallons of water annually—a level of consumption that could not be supported by the local water system.[207] Minnesota's 15 ethanol plants are estimated to consume about two billion gallons of water annually. The Minnesota Corn Processors plant in Marshall, Minnesota—a facility that produces corn sweeteners and some 40 million gallons of ethanol each year, owned by the ethanol giant ADM—bought 469 million gallons of water in 2004 from Marshall's public utilities system, further depleting the already tight water supplies in the area.[208] According to Jay Trusty, executive director of the Southwest Regional Development Commission, two other plants under construction in the state, near Heron Lake and Atwater, "had to move from their original sites because there wasn't an adequate supply of water."[209] Water availability is also an issue in Nebraska, where a proposed Cargill ethanol plant was only approved after water use was reduced in the surrounding area to offset the needs of the new biofuel facility.[210]

Water, ethanol, and factory farms:

Regional water scarcity has put the public, the ethanol industry, and the agricultural sector in competition with each other for water resources. As many of the new refineries are located in farming areas, ground water is affected by pesticide contamination, so public drinking water is already compromised.[211] What's more, farms already require millions of gallons of water for irrigation and to sustain livestock.[212] In this context, it's clear that the addition of ethanol plants will put increasing pressure on already strained water resources.

This pressure is deepened by the development of factory farming operations. Livestock production is also water intensive, and blending the two industries may be a fatal combination. An individual hog, for example, uses some five gallons of water per day.[213] A factory farm with 10,000 hogs requires around 50,000 gallons of water every day, and more during hot weather. Cattle require some 20 gallons of water per head daily during the summer.[214] As factory farms are being increasingly sited near ethanol plants to take advantage of distiller's grain as feed, or ethanol plants are being built near factory farms to save on transportation costs of this grain, having both types of facilities in the same area greatly impacts regional water resources.

(For a more detailed discussion on the combined effects of ethanol and factory farms see chapter *Factory Farming for Energy* on page 34.)

Emissions—Is this Fuel Really Clean?

Understanding the levels of emissions reductions achievable through the use of biofuels is fundamental to evaluating their potential benefits. As biofuels are being promoted as the green alternative to gasoline, it is important to scrutinize their relative emissions benefits. The emissions of greatest concern, in terms of environmental stability and human health, are greenhouse gases, smog-causing agents, and air toxics.

Greenhouse gases are the causal elements of climate change, and diminishing these emissions is a central piece of the argument in favor of ethanol and other biofuels. The principle greenhouse gases of concern include carbon dioxide (CO_2), methane, and nitrous oxide (NO_X).[215] CO_2 is the greenhouse gas most emitted in the United States, and it is created primarily by burning fossil fuels.[216] Although CO_2 is the foremost greenhouse gas emitted from cars, one should not underestimate the impact of other greenhouse gases. NO_X, for example, is roughly 300 times as potent as CO_2 in terms of its contribution to global warming.[217]

Ethanol refineries are significant sources of greenhouse gases and other polluting emissions. Coal and natural gas are commonly burned in order to generate the enormous amounts of energy and heat needed to run biofuel refineries. These facilities discharge many of the same pollutants ethanol is intended to reduce, including CO_2, CO, NO_X, volatile organic compounds (VOCs), sulfur dioxide, and particulate matter.[218] Emissions from coal-fired ethanol plants are notably higher than those from plants running on natural gas. In fact, according to the DOE, ethanol produced using coal results in greater overall greenhouse gas emissions than gasoline.[219].While an estimated 85 percent of ethanol plants run on natural gas, as it is less capital-intensive to construct a plant that uses this highly manageable fuel,[220] as natural gas is becoming more expensive, more refiners are expected to turn to coal as their fuel source.[221]

According to the DOE, ethanol produced using coal results in greater overall emissions than gasoline.

Emissions Reduction Potential of Biofuels

Assessing the potential benefits of ethanol for emissions reductions is a complicated task. Comparing the current scientific research on this subject is tricky because there is very little harmony between different studies in terms of units of measurement, types and concentration of fuels, and specific emissions being studied. Many studies also neglect to assess the full life-cycle of biofuels, focusing only on tailpipe emissions. Life-cycle analysis is crucial, however, considering the prevalence of such practices as intensive-tillage and slash and burn, the use of fuel-burning machinery to produce and transport biofuels, and the use of fossil fuels to power refineries; all of which have a notable impact on overall emissions levels.

Different studies have produced different figures, but corn-based ethanol consistently shows less impressive greenhouse gases emissions reductions than other biofuels. DOE numbers show that, compared to gasoline, corn-based ethanol reduces greenhouse gas emissions by 18 percent to 28 percent, while cellulosic ethanol offers a reduction of 87 percent.[227] A 1999 report by the Argonne National Laboratory concluded that corn-based ethanol could only reduce emissions by up to 32 percent compared to gasoline, while cellulosic ethanol could attain up to 118 percent reductions.[228]

According to a study published by the European Commission, first-generation biofuels produced in the continent reduced greenhouse gas emissions by 35–50 percent.[229] The study also found that ethanol from sugarcane reduced greenhouse gas tailpipe emissions by up to 90 percent compared to gasoline, while biodiesel from palm oil and soy resulted in reductions of 50 and 30 percent, respectively.[230] The same report concluded that ethanol produced in coal-fired plants is estimated to lead to higher greenhouse gas emissions than the fossil fuel it replaces.

Similarly, a report by the National Renewable Energy Laboratory showed that soy-based biodiesel, in its unblended form, reduced carbon dioxide emissions by 78 percent, and lowered particulate matter and sulfur dioxide by 32 and 8 percent, respectively.[231] However, the same study linked biofuels to increases in other greenhouse gases, showing that both pure and 20 percent biodiesel emitted more oxides of nitrogen, and pure biodiesel yielded higher hydrocarbon releases.

Other studies, however, do not reflect so favorabley on corn-based ethanol. An assessment by the University of Minnesota, based on complete life-cycle analysis, calculated that corn-based ethanol only reduces greenhouse gas emissions by about 12 percent relative to gasoline.[232] Biodiesel, on the other hand, reduces emissions by 41 percent over diesel fuel, largely because it does not require distillation to be processed into fuel and because fewer fertilizers and pesticides are used in the cultivation of soybeans. [233]

Furthermore, a UC Berkeley study concluded that there is still great uncertainty regarding ethanol's greenhouse gas emissions reduction.[234] According to Dan Kammen, one of the report's authors, despite this uncertainty, the harmonized results of the current body of research point to a greenhouse gas emissions reduction between 10-15 percent when compared to gasoline.[235] The study also concludes that only cellulosic ethanol offers large reductions in greenhouse gas emissions.[236]

In addition to concerns over greenhouse gases, ethanol's true ability to reduce VOCs, ozone precursors, and other pollutants is uncertain, and its use has even been demonstratd to increase emissions of some harmful chemicals. Overall, adding ethanol to gasoline is not effective for reducing emissions of ozone precursors, according to the EPA and National Research Council.[237] In fact, ethanol may cause higher ozone levels under certain atmospheric conditions.[238] A recent study estimates that switching to E85 blends could result in higher ozone-related mortality, hospitalization, and asthma rates (9 percent higher in Los Angeles and 4 percent higher in the United States as a whole).[239]

Burning ethanol can increase the emission of air toxics such as aldehydes,[240] carcinogens commonly found in cigarette smoke.[241] Ethanol use also has shown to raise emissions levels of formaldehyde, which can cause respiratory and pregnancy-related problems; benzene, which causes blood disorders such as anemia; and 1,3-butadiene, which contain carcinogens.[243]

DOE numbers show that, compared to gasoline, corn-based ethanol reduces greenhouse gas emissions by 18 percent to 28 percent, while cellulosic ethanol offers a reduction of 87 percent.

photo credit: Warren Gretz

Therefore, it is urgent that there is further scientific research regarding the potential for emissions reductions associated with biofuels. This research should focus on the different types of biofuels, production methods (including feedstocks), and a complete set of possible emissions. Only after a more detailed scientific inquiry will it be possible to more accurately evaluate the real benefits of biofuels in terms of emissions reductions. So far, the available scientific evidence indicates that:

- Corn-based ethanol is the least effective of all biofuels.
- Using coal to power refineries can increase emissions in comparison to the gasoline fuel replaced.
- Biofuels may increase the emissions of certain polluting gases.

Air Emissions and Ethanol Refineries

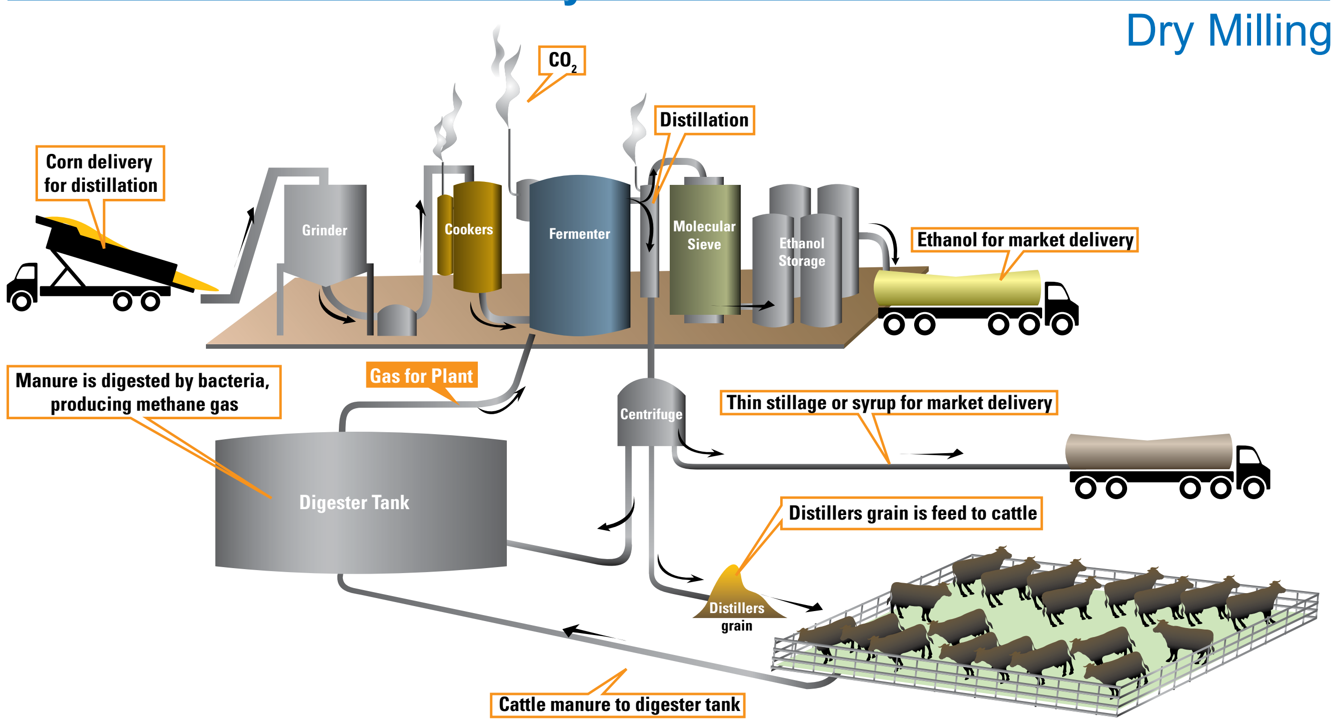
Ethanol producing facilities have been found to be in violation of clean air regulations by the EPA. In 2002, twelve ethanol refineries in Minnesota were forced to install pollution reduction equipment in order to cut their emissions of VOCs, CO, NO_x, particulate matter, and potential carcinogens such as formaldehyde. Federal and state officials fined the facilities from $29,000–$39,000 apiece for violating the Clean Air Act.[222] Gopher State Ethanol of St. Paul, MN actually went bankrupt in 2004 following four years of complaints and lawsuits over the chronic odor and noise emanating from its plant.

The EPA has reached settlements with Archer Daniels Midland (ADM), the largest competitor in the ethanol industry, owning 52 plants in 16 states. Cargill, the second largest ethanol company in the United States, has also settled with the EPA, promising to reduce emissions in its 27 plants. Together, settlements with these two firms have ostensibly resulted in the reduction of over one hundred thousand tons in air emissions from ethanol plants annually.[223]

In 2002, the EPA cracked down on emissions violations from ethanol plants, finding that many plants were in violation of Clean Air Act's New Source Review standards. Subsequently, many plants were forced to reduce their emissions, preventing the release of hundreds of thousands of tons of greenhouse gases and other gases into the atmosphere.[224]

More recently, however, the EPA made a U-turn on ethanol plant emissions. The regulatory body actually proposed new permit requirements for ethanol plants which would effectively increase the emissions threshold for facilities by 150 percent (from 100 tons per year to 250 tons per year).[225] The EPA's proposal has garnered criticism from environmental groups, who claim the agency is, "cutting corners now so the new wave of ethanol plants can be bigger, cheaper and dirtier."[226] Because hundreds of refineries may be built, the potential for serious environmental damage caused by these plants cannot be overlooked.

Ethanol Production with By-Products



FOOD, FEED, AND FUEL

Factory Farming for Energy

Although biofuels are often promoted as being favorable for farmers and rural communities, it is unclear how this rapidly growing industry will affect the agricultural economy—particularly small-scale operations—and who will reap the greatest financial rewards.

The price of corn, the nation's most abundant food crop, is one of the most closely watched indicators in the agricultural marketplace. The pressures that increased ethanol production place on corn prices are creating new classes of winners and losers in this delicate economic landscape. Corn prices are already reaching more than $4, up from about $2 a bushel for most of the last decade.[244] It should be noted that for the past 10 years, corn farmers earned little because prices were so low. As ethanol production grows, corn once destined for export or livestock feed will likely wind up in gas tanks. Even if corn yields improve, idle lands are brought into cultivation, and farmers switch other crops for corn, the expansion of ethanol production will continue to put pressure on the value of the grain. As corn prices increase, livestock and food industries are increasingly concerned about the effects this will have on their businesses.

At the same time, industrial-scale livestock operations, or factory farms, are taking advantage of the booming ethanol sector as a potential source for cheap feed. Ethanol plants produce byproducts that can be used as feed for animals, while factory farms can provide animal manure as fuel for ethanol plants. New ethanol plants and expanding ethanol production can reinforce and justify the trend towards giant animal operations. This can contribute to the further industrialization and concentration of the agricultural economy, to the detriment of rural communities, family farmers, and small landowners.

Increases in the price of corn will ripple through much of the agriculture sector. Ranchers who have benefited from low-priced corn for a decade are now threatening to drastically raise prices – although consumer retail prices for food did not decline when corn prices collapsed after the 1996 Farm Bill went into effect. Instead, industrial livestock operations received significant benefits from artificially low priced feed in the late 1990s and early in this decade. For example, a Tufts University study found that the chicken industry received an $11 billion subsidy in the form of cheap feed as a result of the 1996 Farm Bill.[245]

But the ethanol industry is promising to insulate the livestock industry from rising feed prices. One of the many byproducts of refining ethanol is a substance called distiller's grain, which is also left over from brewing beer. With 27 percent protein content, distiller's grain has long been used as feed for cattle and, to a lesser extent, pigs and poultry. Ample supplies of distiller's grain could cool demand for corn and soybeans, while holding down feed prices and providing an offset to high ethanol production costs.

The ethanol industry could also benefit from nearby factory farms by using methane derived from cow manure as fuel for ethanol refineries, and the conversion of manure into methanol, a component of biodiesel. These mutually dependent combinations could distribute the gains of the new ethanol boom throughout the factory farm, feed, and fuel chain production.

The surge in ethanol production could benefit the biofuel sector and secondarily pass benefits onto the industrial livestock industry. These arrangements could lead to further concentration and industrialization of agriculture. These trends have already eliminated more than 100,000 independent farms throughout the United States over the past decade, while causing major groundwater, surface water, air, and soil pollution.

Already, the ethonal refining industry is producing more feed byproducts than the livestock industry can consume in some places. For example, there is not enough livestock in Nebraska to consume all of the distiller's grain that will be generated by existing and planned ethanol refineries. The trade group Nebraska Cattlemen contends that the state's livestock industry will have to grow by 20 percent over the next two to three years in order to absorb the surplus. In this instance, the rise in ethanol production is used to justify additional industrial feedlots and meat processing plants. Nebraska already has 6.2 million cattle and calves, and 2.9 million pigs, ranking third and sixth in the country respectively, according to the USDA.

If unfolding events are any indication, the biofuel industry may find itself following the path of agribusiness toward greater consolidation after nearly a decade of declining consolidation. The top four ethanol producers' market share declined from 73 percent in 1995 to 49 percent in 2002,[246] in part as a result of incentives for farmer-owned and farmer cooperative ethatnol refineries. As recently as 2002, farmers were collectively producing more fuel than Archer Daniels Midland. During that year, the annual capacity of refineries averaged 30 million gallons. A new standard was established just two years later, when the country's first 100 million gallon operation opened in South Dakota. At least 15 more of these enormous refineries were soon under construction or in the works. Three-fourths of new ethanol production coming on line in next few years will likely come from large, non–farmer-owned facilities.[247] These new facilities are often more than double the size of the farmer-owned plants. The net result is less job creation and fewer economic benefits for the local economies, as the profits made by these large, far away investors will most likely be transferred elsewhere.

Ethanol and Factory Farming

The large-scale farming of corn for energy production has the potential to further entrench large-scale agribusiness. The present trend is towards large farms to grow corn, large confined feeding operations to grow animals, and an ethanol plant to provide a waste byproduct that can be used as feed for livestock.

The agriculture industry has changed a great deal over the last 20 years, moving towards large, industrial facilities, and away from family farms. These factory farms emphasize high volume and profit with minimal safeguards for human health, food safety, the environment, humane treatment of animals, and the rural economy. The factory farming model is largely a function of corporations that often seek to own or control all stages of production, from milling the feed to raising the animals, to slaughtering, packing, and marketing. Cargill, ConAgra, Tyson, and Smithfield dominate the livestock market by controlling all stages of production.[248] These companies have grown larger and fewer and the livestock sector more consolidated, with the majority of livestock on the market now produced under contract with one of these these corporations.

In terms of this trend in agriculture, it is the scale and concentration of these activities that are most troubling. For example, the number of dairy cows in the United States

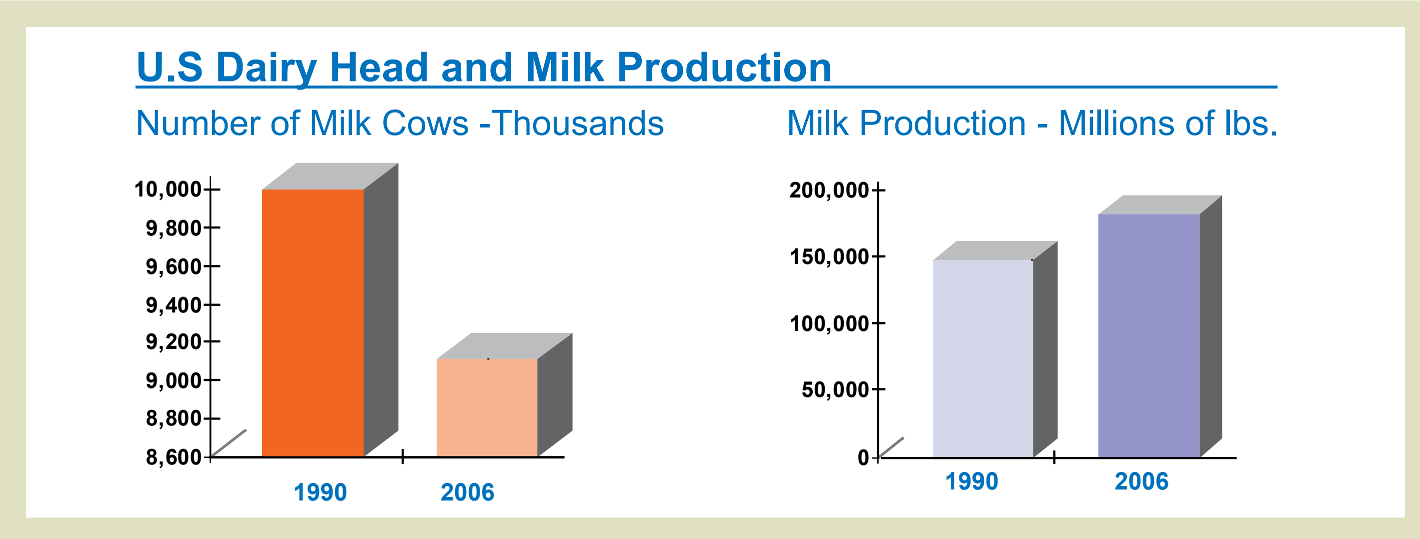


Figure 7: U.S. Dairy Head and Milk Production

Milk produced per cow increased 34 percent in this period, from 14,782 pounds in 1990 to 19,951 pounds in 2006.
Source: "Livestock and Animals: Milk Cows and Production." National Agricultural Statistics Services. Search criteria: U.S. & All States Data for Dairy; Milk Production, Milk Cows, Milk per Cow, Annual; 1990 to 2006. Available at: http://www.nass.usda.gov/QuickStats/

peaked at 25.6 million in 1944; since then, the number has fallen dramatically, to just over nine million in 2005. At the same time, the amount of milk produced by each cow has risen from 4,572 pounds in 1944 to 19,576 pounds in 2005.[249] The total number of farms that raise livestock declined by more than 60 percent between 1994 and 2001.[250]

Factory farms have abhorrent conditions, where animals are often crowded together, living in mud and their own waste, and do not graze on pastures. In many dairies, calves are separated from their mothers at birth and are often fed milk replacer, which can be made in part from the blood of other slaughtered cows. By nature, cows are vegetarians—they should not be fed any type of animal protein. While they are natural pasture grazers, they are often fed grains like soy and corn, as well as unsavory byproducts such as restaurant waste and poultry litter (which includes feathers, feces, and sometimes uneaten animal protein, such as cow parts).

These unnatural dietary regimes and unsanitary living conditions drastically increase the potential for disease. To combat widespread outbreak of infections, factory farms administer huge quantities of antibiotics to their animals. Antibiotics are also used for non-therapeutic purposes, such as accelerating animal growth. The Union of Concerned Scientists estimates that 70 percent of antimicrobials (which include antibiotics) used in the United States are administered to livestock for non-therapeutic purposes. This corresponds to some 25 million pounds of antimicrobials used each year in livestock production, eight times the amount of antibiotics used in human medicine.[251]

This overuse of antibiotics is highly problematic because it leads to antibiotic resistance in humans and livestock, decreasing the effectiveness of these drugs to treat infections. The National Academy of Sciences estimated the annual cost of antibiotic-resistant bacteria to U.S. society and individuals to be some $4–5 billion.[252] Scientists warn that the high concentration of animals and overuse of antibiotics on factory farms increase the risk of widespread outbreaks of infectious disease. As noted in a scientific working group report recently published in Environmental Health Perspectives, antimicrobial overuse in factory farms has "intensified the risk for the emergence of new, more virulent, or more resistant microorganisms."[253] A troubling case was the 1998 outbreak of multi-drug-resistant campylobacteriosis caused by contaminated chicken, which affected some 5,000 people in the United States. The drugs that were used to treat the infection in humans didn't work because they had been used in the poultry that the patients consumed, causing the bacteria to become more resistant.[254] The World Health Organization, the United Nations' health agency, has recommended that antimicrobials be prohibited as growth promoters in animals and that antimicrobials not be used as an alternative to high-quality animal hygiene as a measure to overcome antimicrobial resistance.[255] In 1998, the European Union followed these recommendations and banned the use of antimicrobials prescribed for the treatment of human infections as growth promoters in animals. In the U.S., such use of these drugs is still allowed, thus huge quantities of antibiotics used for the treatment of human infections are still used in factory farms to make animals grow faster.

Furthermore, artificial growth hormone rBGH (recombinant bovine growth hormone) is still being used on dairy herds in the U.S. although it has been banned in the EU, Australia, Japan, and Canada. The synthetic hormone can lead to a 10-15 percent increase in milk production, but serious concerns have been raised worldwide about its carcinogenic effects. Studies conducted by Health Canada, Canada's equivalent of the U.S. Food and Drug Administration (FDA), have determined that administration of rBGH is harmful to the health of cows and interferes with reproductive functions.[256] It often leads to mastitis, a very painful udder infection (that can lead to pus getting into the milk), as well as inflammation and swelling that can lead to lameness from swollen joints.

Of equal concern, is the fact that the larger and more concentrated the farming operation, the greater the environmental impact. These farms accumulate vast amounts of liquid and solid waste in open-air lagoons, filled with millions of gallons of feces, urine, and water. Just one 1,200-pound dairy cow produces the same amount of waste as 23 human beings. A factory dairy farm with 10,000 cattle, produces as much manure as a city of 230,000 humans, only without the proper waste treatment systems one would find in a city.

Waste lagoons often leak and pollute surrounding land and groundwater. In fact, a study done at North Carolina State University estimated that as many as half of the existing lagoons are leaking badly enough to contaminate groundwater.[257] In some instances, overfilled manure lagoons have burst, flooding millions of gallons of liquid manure into rivers, lakes, streams, and estuaries. The health consequences for humans can be equally severe. One extensive study in New Mexico found dangerously elevated levels of nitrate, ammonia, chloride, nitrogen, and total dissolved solids in the groundwater.[258] Each of these pose enormous health risks—nitrates in drinking water, for instance, can be deadly to infants and has also been linked to spontaneous abortions.

Furthermore, factory farms consume massive amounts of water, which in many areas is rapidly depleting aquifers. For example, the Ogallala aquifer, which is the largest aquifer in the nation and supplies water from Texas to South Dakota, is being drained by unsustainable practices, including those on factory farms.

Factory farms also affect rural communities when pollution causes illness among local residents, lowers property values, and negatively affects local economies. Through contract growing, a remote corporation, not the livestock owner, controls all aspects of raising the animals. But it is the farmer that shoulders the risk, debt payments on barns and facilities, waste, and dead animal disposal.

- The FDA estimates that 76 million cases of food borne illness occur each year, 5,000 of them resulting in death.[259] In 2000, the USDA estimated that 70 percent of all food borne illness in the United States could be traced to contaminated meat.[260]
- According to a 2002 Iowa State University study, exposure to airborne factory farm emissions can lead to tension, depression, reduced vigor, fatigue, confusion, nausea, dizziness, weakness, fainting, headaches, plugged ears, runny nose, scratchy throat, and burning eyes.[261]
- The USDA estimates that animals in the U.S. meat industry produced 1.4 billion tons of waste in 1997—30 times the nation's volume of human waste and five tons of animal waste for every U.S. citizen.[262]
- In 1995, 25 million gallons of animal waste spilled from an eight-acre lagoon into North Carolina's Neuse River, killing 10 million fish and closing 364,000 acres of coastal wetlands to shell fishing.[263]
- Factory farms are quickly taking over the livestock industry. In the poultry industry, 98 percent of all poultry is now produced by corporations, forcing family farms out of business.[264]

Good for Business, Bad for the Environment

Biofuel and livestock interests alike are feverishly searching for ways to jointly profit from the development of the ethanol market. Ethanol plants are being developed to take advantage of factory farm manure sources and factory farms are locating near ethanol plants to access feed byproducts. This creates a mutually supporting justification for refineries and feedlots.

- In the Texas Panhandle town of Hereford, Panda Ethanol is constructing an ethanol plant to be fueled by methane derived from cow manure collected from large cattle feedlots. Located in what Panda's CEO calls "the Saudi Arabia of manure," the facility already has contracts in place for one million tons of manure and will have a producing capacity of 115 million gallons of ethanol per year. In exchange, cattle will be fed distiller's grain from the ethanol refinery.[265]
- In Oshkosh, Wisconsin, Utica Energy sells 1,350 tons of distiller's grain a day to dairy farmers within a 100-mile radius.
- At its massive Circle Four hog-finishing complex in southwest Utah, Smithfield Foods is planning a facility to convert manure from 23 farms—housing 250,000 animals—into the biodiesel component methanol.
- Bunge Ltd., a multinational food, animal feed, and fertilizer conglomerate with operations in North and South America, Europe, China, India, and elsewhere, has also entered the ethanol business, having announced plans in May, 2006 to build the largest ethanol refinery in the Southeast, a 60 million-gallon-per-year facility in Mississippi. With $24 billion in annual sales, the White Plains, NY–based corporation is the world's largest oilseed processor and dry-miller of corn, and the largest supplier of fertilizer to South America.

Another example of this trend toward consolidation is the Grand Valley State University's alternative energy center, which recently announced plans to develop an animal waste-to-energy plant co-located with the county's largest dairy factory farm. The fanfare surrounding the project included the statement that "The plant offers an environmentally friendly disposal system for factory farm wastes and produces electricity from a renewable 'green' fuel source."[266] The new plant will use manure from the 1,000 cows of the den Dulk Dairy factory farm in Ravenna Township, which produce some 155 million pounds of waste annually. The project, which is funded by a $1 million grant from the Michigan Public Service Commission, gave up considering a smaller dairy farm because the economies of scale with den Dulk made it a more attractive business.

These arrangements tend to exacerbate existing environmental problems, instead of providing sound, clean alternatives to the growing of food, raising of animals, or production of fuel for transportation. In this case, the project will give den Dulk a way out of its animal waste quagmire, not only using public monies, but also giving this factory farm an incentive to continue to produce more manure. (The den Dulk factory farm currently stores its animal waste onsite and eventually spreads the manure-waste mix on farm fields across Wesern t Michigan.)

Synergies between large ethanol refineries and factory farms may be good for business, but could also increase harm to the environment, public health, and animals.

Eat It or Burn It?

Biofuels have already begun to affect the structures of food production and the price of food in global markets. It is almost completely unknown how the emergence of biofuels as a major energy source will affect global food security and food economies, as it diverts massive amounts of corn and agricultural resources into gas tanks. It is clear, however, that this emerging industry will have an effect on food supplies and prices, and it is imperative that this is taken into consideration when weighing the pros and cons of ethanol's expansion.

Corn is one of the cheapest foodstuffs in the United States. This is because the 1996 Farm Bill and the 2002 Farm Bill encouraged significant overproduction of staple commodities, especially corn. Corn was sold at prices significantly lower than the cost of production and farmers received emergency payments to compensate for historically low prices.[267] As a result, the grain has been stuffed into as many products as possible, serving as cheap filler in animal feed and replacing more expensive ingredients in processed foods, like sugar.

Livestock Feed

Corn is a crop of primary importance to the U.S. meat and dairy supply, because it is a principle component in livestock feed. About 60 percent of U.S. corn and 47 percent of soy are used as livestock feed,[268] and as ethanol's demands on the corn market is raising corn prices, the meat industry's feed costs are also going up.[269] These higher costs will inevitably be passed on to consumers in the form of higher meat and milk prices – although meat processors did not pass on the savings from low-priced corn in the late 1990s. As corn prices go up and the ethanol industry demands even more of the country's corn supply, pressure will increase to expand the amount of land dedicated to corn crops to keep the livestock industry from losing all profitability.[270]

An alternative to corn in animal feed is soy, but its production is likely to drop as high corn prices give farmers incentives to switch their acres to corn. Soy is also becoming increasingly important as a source of biodiesel, and it is possible that biodiesel demand for soy will drive up the price of this crop even more, making it unaffordable as livestock feed as well.

In early 2007, Tyson Foods, Inc.'s CEO warned consumers that they should expect "significantly higher" food prices as a result of the strain that ethanol was putting on U.S. corn

About 60 percent of U.S. corn and 47 percent of soy are used as livestock feed.

supplies [271]. After the 1996 Farm Bill, the chicken industry essentially received an $11 billion subsidy in the form of low-priced feed but retail whole chicken prices remained flat when the corn price collapsed after the legislation went into effect. Tyson Foods is the world's largest meat producer, supplying food to millions of people in the United States and abroad, and boasting annual revenue of over $6.5 billion.[272]

A potentially positive side effect of this livestock feed scenario is that more animals will be set out to pasture as a feed alternative, which can result in better treatment of the animals as well as more responsible stewardship of the land on behalf of the meat industry. It is equally, or perhaps more likely, however, that livestock producers will offset high corn and soy prices with other low-cost, low-quality feed inputs, or by moving their operations abroad, where feed costs may be the same but labor, permits, and other inputs may be less costly.

In sum, U.S. meat and dairy prices will go up as a direct and immediate effect of the biofuel industry's heavy consumption of feed grains.

Processed Foods

Although Americans consume most of their corn indirectly as meat, eggs, and dairy products, the grain is also an essential ingredients in many processed foods, particularly in the form of high fructose corn syrup. The average American consumes over 40 pounds of this substance every year,[273] as it is used as a sweetener in beverages, snack foods, and a host of other food products. As a result, about 10 percent of the caloric intake of Americans is composed of corn-based sweeteners.[274]

As corn-based commodities become more expensive, processors and consumers will look for substitutes to replace them with. In the case of corn syrup, sugar is an obvious choice. Sugar, however, is also becoming more expensive, as Brazil (the world's leading sugar producer) is using sugarcane as a primary ethanol feedstock. The country has already converted half of its sugar output (and 10 percent of the world's sugar supply) to ethanol, causing the price of sugar to double.[275]

In order to overcome high ingredients costs, producers may be able to find or invent alternatives to sugar and corn syrup. In the short-term, however, the costs will be passed along to consumers in the form or price increases for processed foods.

Exports and Global Markets

The United States is the largest corn-producing nation in the world, and 65 percent of international corn exports come from this country.[276] Exports represented about 19 percent of the U.S. corn crop in 2006.[277] The amount of U.S. corn dedicated to ethanol was also roughly 18 percent in the same year.[278] As ethanol production grows and consumes a larger portion of corn stocks, corn exports are expected to decline.[279] We have already seen signs of this, as corn exports dropped during market year 2007 and domestic consumption of the grain rose.[280] According to the Institute for Agriculture and Trade Policy, given current corn yield growth rates, if all of the ethanol plants proposed as of late 2006 are actually constructed, not only will exports drop, but the Midwest will actually face a corn deficit by 2008.[281]

Due to U.S importance as a global supplier of corn, the domestic ethanol industry will have a large impact on global food prices. The countries that rely on our corn use it to feed their livestock as well as their people, and as exports fall short of international demand, not only will prices go up, but countries will have to look elsewhere for corn, or perhaps look for alternatives to the grain entirely. Some of the top importers of U.S. corn, like Japan and Canada,[282] will probably be able to absorb the price hike without experiencing any long-term problems. However, developing countries that import U.S. corn, such as Indonesia and Egypt, may experience greater political and socio-economic instability as a result of exorbitant food prices.[283] In Mexico, this has already occurred.[284]

U.S. meat and dairy prices will go up as a direct and immediate effect of the biofuel industry's heavy consumption of feed grains.

In Mexico, high corn prices have spurred popular outcry and caused economic hardship for many. Tortillas, a staple food in Mexican culture, have become increasingly expensive of late, aggravating an already volatile political and economic climate and intensifying the struggles of wage-earners making less than $5 a day. In order to cope, poor Mexicans have been turning to less nutritious foodstuffs, such as instant noodles, to sustain themselves.[285]


photo credit: morguefile

This sensitivity of nations around the world to U.S. corn prices is the result of a global corn market that is already distorted by U.S. farm policies that create incentives to over-produce staple commodities that keep the price below production costs, which in turn depresses corn prices in developing countries. By dumping U.S. corn on the world food market, the transnational agribusiness and grain trade has contributed to both the downfall of local production of corn in developing countries, as well as their dependency on cheap imported grain. Such a deregulated world market greatly benefits multinational grain traders, and thus they are supportive of expanding the ethanol economy in hopes to advance their market dominance. However, the further development of such a distorted global market will only exacerbate the existing problems associated with corn dumping.

Resource Limitations

The limited availability of the world's arable land means that total food supplies may suffer if biofuel feedstock takes priority over food crops.[286] Projected surges in global population and decreases in sub-tropical arable land due to less rainfall[287] make it clear that a reduction in the amount of land currently devoted to food production could have grave implications for international food security. Farmers in the developing world could shift to biofuel feedstocks, removing food acreage from production and potentially eroding food security.

Views about this issue vary widely. At one extreme is the National Corn Grower's Association (NCGA), which claims that the U.S. corn supply is more than adequate to meet food and ethanol needs, highlighting that corn growers have been responding to high demand with production increases.[288] At the other end of the spectrum, Lester Brown of the Earth Policy Institute warns that world grain supplies have fallen short of demand for the sixth year since 1999.[289] Brown has also cautiones that price increases resulting from a grain shortage may become "life threatening" for the world's poorest populations.[290]

Regardless of viewpoint, it is clear that the growth of the ethanol industry is resulting in increased corn demand and production. While the effects are not yet clear, current trends toward increased industrialization and concentration of agricultural production of feedstocks and factory farming of animals have the potential to severly threaten the quality of public health and environmental resources.

A reduction in the amount of land currently devoted to food production could have grave implications for international food security.

ETHANOL BUSINESS:

DOLLARS AND POLITICS ON THE FARM

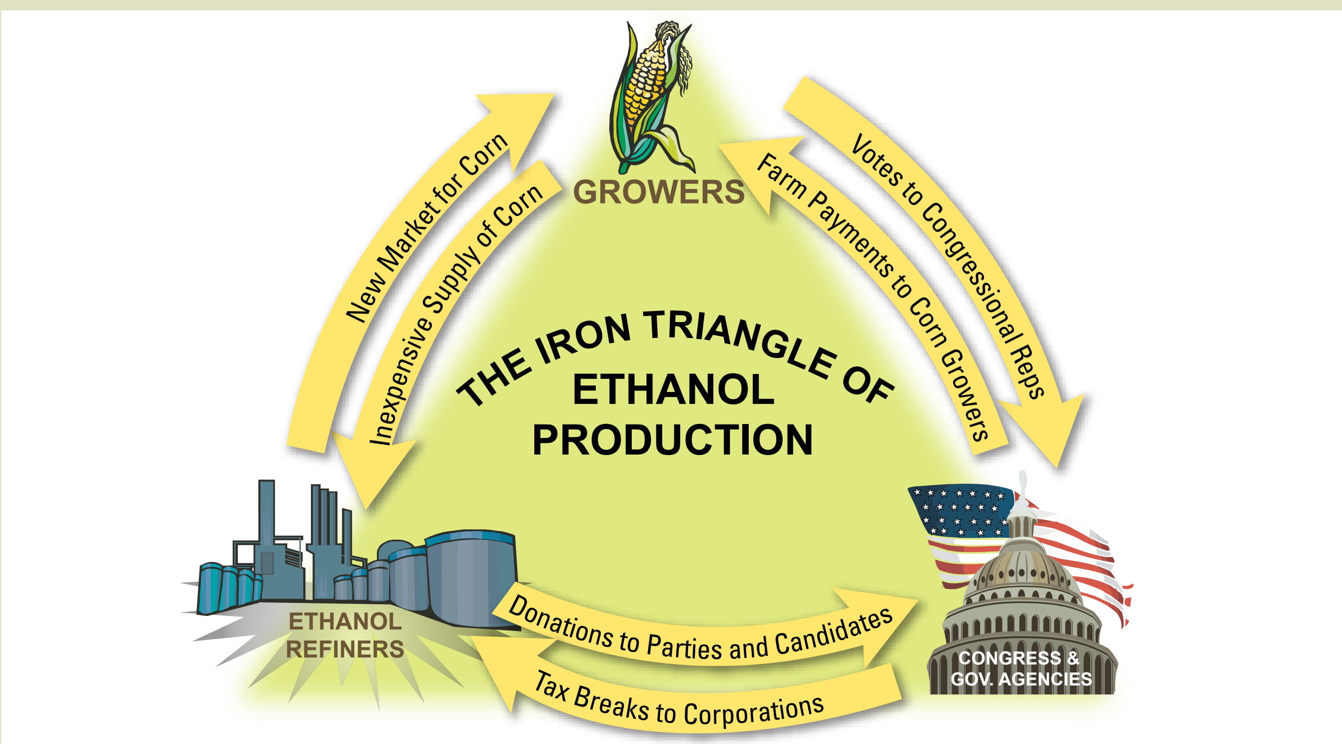
The Iron Triangle of Ethanol Production

The U.S. ethanol industry has become locked into an iron triangle of production. An iron triangle is a three-fold policy-making relationship that places the interests of its participants ahead of public policy considerations. Included in the triangle are:

- the corporate ethanol refiners that benefit from ethanol production subsidies and commodity-production driven farm policy;
- the congressional representatives who garner electoral and financial support from passing legislation friendly to the ethanol industry; and
- farmers who receive a subsidized market for their crops and commodity program payments. Ethanol has entered a stage of production where its success is dependent upon the furthering of the interests of the members of the triangle more than it is dependent upon its merits as an alternative fuel.

At the center of this iron triangle is corn. Federal farm policy has been designed to encourage over-production of basic commodities that are purchased by food processors, meat processors, feedlots, graineries and milling companies. U.S. farmers have responded by increasing production acres and total crop output. The overabundant supply of corn drove prices down by about 25 percent after the 1996 Farm Bill went into effect. Corporate buyers benefited from these low prices. Farmers needed emergency farm payments during the 1996 Farm Bill and what are known as counter-cyclical payments for low farmgate (or, the price of the agricultural product when it leaves the farm) prices under the 2002 Farm Bill. In total, federal farm payments to corn producers amounted to $51 billion between 1995 and 2005 primarily to compensate for artificially low prices. This made corn the crop with the highest level of farm payments in the U.S.[291]

The ethanol industry enjoys government subsidies at many levels. Gasoline refiners who add ethanol can claim a $0.51 per gallon tax credit, which amounted to some $2.5 billion in 2006.[292] Additionally, tariffs of $0.54 per gallon deter imported ethanol from Brazil. In short, corn provides the basis for the iron triangle of ethanol, and all those involved in the iron triangle must work to protect the production, processing, and sale of corn for ethanol to promote their own financial well-being.

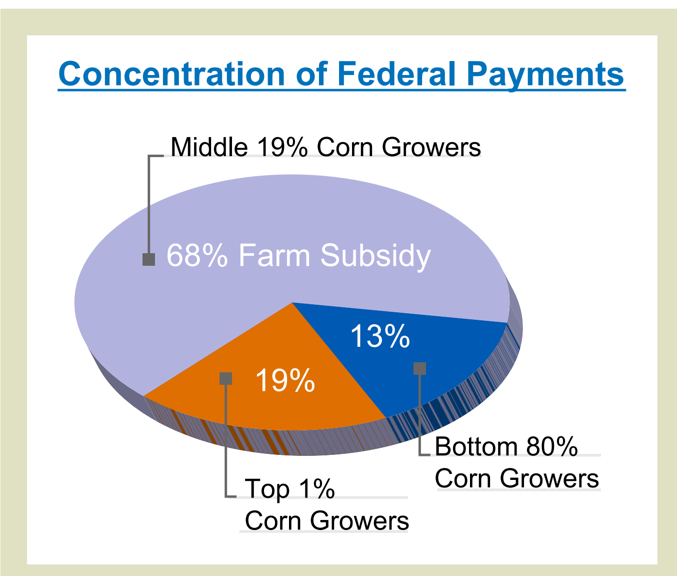


Politics and Ethanol

The main recipients of subsidies that benefit ethanol production aren't family farmers but large industrial farms and agribusiness corporations. Figure 8 demonstrates the concentration of corn program payments to three different groups of farmers, showing that the top 1 percent of corn growers received 19 percent of all payments.[293] The average payment in this top class of producers was $628,000 annually.[294] Most corn farmers received payments to cover their losses from selling their crops below the costs to bring the crops to market—the seed, fuel, fertilizer, herbicides, harvesting, and marketing costs. The bottom 80 percent of producers received 13 percent of the United States Department of Agriculture corn subsidies.[295]

Large industrial farmers aren't the only groups that make out well from government subsidies to grow corn for ethanol. Ethanol refineries have benefited (until recently) from low cost corn and production subsidies for each gallon they produce. As the nation's largest ethanol producer, ADM has received over $10 billion in subsidies between 1980 and 1997 because of the $0.54 per gallon ethanol tax break.[296] Indeed, according to a 1997 Cato Institute study, every dollar in profits earned by ADM costs taxpayers $30.[297]

Figure 8: Concentration of Federal Payments



Source: Environmental Working Group Farm Subsidy Data Base. Available at: http://www.ewg.org/farm/progdetail.php?fips=00000&progcode=corn&page=conc

Figure 9: Money Donated by ADM During Election Cycles

Election Cycle	Total Contributions
2006	$137,750
2004	$104,125
2002	$1,970,060
2000	$949,650
1998	$759,525
1996	$1,009,601
1994	$1,092,503
1992	$1,530,425
1990	$300,700
Total	**$7,854,339**

Source: "Donor Profiles: ADM." Center for Responsive Politics. Available at: http://www.crp.org/orgs/summary.asp?ID=D000000132&Type=A

Political contributions by major players in the ethanol industry can help explain many legislative outcomes. Soft money contributions from ADM and its former chairman Dwayne Andreas have been documented extensively in the press. Audubon Magazine reported that, "in 1994, a few days after Andreas cut a $100,000 check at a presidential fund-raiser, President Bill Clinton tried to push through a rule requiring that about 10 percent of all gasoline contain ethanol, explaining that the mandate would create "thousands of new jobs" and be "good for our environment, our public health, and our nation's farmers."[298] PBS also reported that, "Andreas has continued donating generously to many Democratic and Republican candidates—"tithing," he calls it. Over the years he has given money to Senator Bob Dole, President Clinton, President Bush, President Carter, Michael Dukakis, Jack Kemp, and Jesse Jackson, among others."[299]

According to the Center for Responsive Politics, ADM's political action committees (PACs) and employees have given more than $2.1 million in federal campaign contributions since 2001, with 63 percent of that total going to Republican candidates.[300] Table 2 lists the amount of money that ADM has donated through employees or PACs during each of the last nine election cycles. On a larger scale, agribusiness lobbyists have funneled more than $190 million into federal election campaigns since the 2000 election.[301]

In July of 2006, the watchdog group Public Citizen asked government administrators to put pressure on ethanol refiners to comply with campaign contribution disclosure rules. Public Citizen alleged that ADM had violated the Lobbying Disclosure Act by not disclosing its public-relations work as lobbying activity. In responding to the complaint, the corporation denied any wrongdoing but stated that it "has begun an expanded presence in Washington and is taking incremental steps toward increased government relations activities." Furthermore, Public Citizen noted that lobbying records of the Renewable Fuels Association, which represents ADM and other ethanol producers, revealed a discrepancy of some $1.2 million in unreported third-party lobbying efforts since 1999. As Tyson Slocum, director of Public Citizen's energy program put it, "Whoever has the most powerful lobby, whoever gives the most campaign contributions—their version of policy is what gets implemented. And that's why the ethanol lobby is front and center on the alternative-fuel path."[302]

Indeed, Bob Dole was known as "Senator Ethanol" because of his longtime, staunch support of federal tax subsidies for corn-based ethanol. Many congressional fans of ethanol, like Dole, are current or former representatives of corn states who claim it has helped ease U.S. dependence on foreign oil.[303] The influence of the Corn Belt in Congress has helped to maintain the federal farm program for corn and has now found a new ally in the ethanol industry.

Agribusiness lobbyists have funneled more than $190 million into federal election campaigns since the 2000 election.

Expansion of the Iron Triangle: Ethanol and American Energy Policy

President George H.W. Bush's first major tax law, the Revenue Provisions of the Omnibus Reconciliation Act of 1990, created numerous energy tax incentives, including the introduction of the tax credit for small producers of ethanol used as a motor fuel.[304] The law provides for an income tax credit of $0.10 per gallon ($4.20 per barrel) for up to 15 million gallons of annual ethanol production by a small ethanol producer. A small ethanol producer was defined as having an ethanol production capacity of less than 30 million gallons per year. The credit is strictly a production tax credit available only to the manufacturer who sells the alcohol to another person for blending into a qualified mixture in the buyer's trade or business, for use as a fuel in the buyer's trade or business, or for sale at retail where such fuel is placed in the fuel tank of the retail customer.[305]

The Energy Policy Act of 1992 law further increased the incentives for biofuels: (1) added an income tax deduction for the costs, up to $2,000, of clean-fuel powered vehicles; (2) liberalized the alcohol fuels tax exemption; (3) expanded the Internal Revenue Service Code §29 production tax credit for nonconventional energy resources; and (4) liberalized the tax breaks for oil and gas.[306] EPACT 1992 also defined ethanol blends with at least 85 percent ethanol as "alternative transportation fuels." It also required specified car fleets to begin purchasing alternative fuel vehicles, such as vehicles capable of operating on E85. EPACT 1992 also provided tax deductions for purchasing (or converting) a vehicle that could use an alternative fuel such as E85, and for installing equipment to dispense alternative fuels.[307]

It is worth noting that even the legislation directed at supporting alternative fuels offers some, be it relatively minor, tax relief for the oil and gas industry, in the form of new tax incentives or liberalization of existing tax breaks.[308]

On October 22, 2004, President Bush signed into law the American Jobs Creation Act of 2004. This law significantly changed the way taxes are collected on gasohol and other ethanol blends, providing a new excise tax credit system for all ethanol blends and biodiesel. Effective January 1, 2005, the law eliminated the reduced rate of excise tax for gasohol blends containing 10 percent, 7.7 percent, and 5.7 percent ethanol, and instead, provides a $0.51 cents excise tax credit for each gallon of ethanol blended with gasoline. The new excise tax credit system is called the "Volumetric

Ethanol Excise Tax Credit" (VEETC). This Act replaced the excise tax exemption that was originally created by the Energy Tax Act of 1978, which was subsequently changed in the Omnibus Budget Reconciliation Act of 1990, which was itself modified by EPACT 1992. VEETC extends the ethanol tax incentive to 2010 and deposits all taxes paid on gasohol and other ethanol blends into the Highway Trust Fund (while the credits are paid for out of the General Fund). Additionally, under the Act, farmer cooperatives are now also allowed to claim the small ethanol producer tax credit that was created in the Omnibus Budget Reconciliation Act of 1990.[309]

Lowering costs for ethanol blenders lowers prices for wholesalers and retailers, while passing the benefits upstream to corn growers and processors. Thus, the law strengthens the relationship between each of the interest groups in the ethanol iron triangle. However, the bill was passed without consideration of the macro-level consequences to the environment and the potential sustainability of ethanol as a viable alternative fuel.


photo credit: Morguefile

Riding the Ethanol Wave

State Support and Ethanol Production

Many states vested in ethanol production have passed their own types of ethanol subsidy laws, with some states making direct payments to ethanol producers. For example, a South Dakota subsidy program provided $3.1 million to ethanol plants in just three towns in 2001.[310] Minnesota awards ethanol manufacturers a $0.20 per gallon "producer incentive," a policy that effectively boosted the state's annual ethanol output.[311] Nebraska is equally generous. For each gallon of ethanol produced, taxpayers pay about 60 cents in federal subsidies and 20 cents in state subsidies.[312] Twenty states have already approved tax credits or other incentives to build ethanol and biofuel production plants that are similar to those now being used in Minnesota and Nebraska.[313]

Minnesota has by far been one of the most aggressive states in passing ethanol legislation. In 1987 the state legislature attempted to capitalize on Minnesota's largest crop—corn—by granting the Minnesota Department of Agriculture $100,000 per year to conduct an ethanol promotion program.[314] This same year, the Minnesota Ethanol Commission was established to promote the production and use of ethanol in the state.[315] In 1995, the commission's purpose was furthered by a statutory goal to develop 220 million gallons of Minnesota ethanol production.[316] This goal was quickly surpassed. Minnesota produced 550 million gallons of ethanol in 2006 and five new ethanol plants are under construction in the state, adding to the existing 16 refineries.[317]

Minnesota also has 226 public ethanol pumps, nearly one-third of the 755 public pumps nationwide.[318] Additionally, by 2010, cars in the state must begin running on 20 percent ethanol.[319] Many Minnesotans believe that ethanol will play a large role in the transition from oil to something else.[320]

In 2005, Corn Plus, a 750-member farmer co-op, was the first in the world to make ethanol production truly energy efficient. Most ethanol facilities use one unit of energy to make about 1.6 units of ethanol. Corn Plus, using assorted efficiencies, has improved that ratio to nearly one to six. The introduction of the fluidized bed biomass incinerator allowed for such effectiveness. This incinerator burns a recycled ethanol byproduct, the syrup, to make steam that powers the plant. Since pioneering the technology, Corn Plus has diminished its natural gas consumption by more than half.[321]

In order to protect its promising new industry, the state has taken steps to combat the influence of corporations like ADM in their state-subsidized ethanol industry. During the summer of 2002 the farmer-owned Minnesota Corn Processors cooperative, formerly owned by 5,500 Minnesota farmers and the second largest ethanol producer in the country, voted to sell all its shares to ADM. Most farmers who sold their shares to ADM believe they were given false information by the cooperative's Board of Directors regarding the true value of the plant. As a direct result of the controversial ADM purchase, a new state law was introduced in 2003 to ensure that members of agricultural cooperatives would have access to more information and have more direct influence over their co-op's policies.[322]

Another result of the sale of the cooperatively-owned ethanol plant to ADM was a law that strengthened the Minnesota ethanol producer payment program. This 2003 amendment restricts producer payments to only those facilities owned by a majority of farmers. Furthermore, the new law requires the repayment of subsidies if the ethanol plant is sold to a corporation whose shareholders do not consist of a majority of Minnesota farmers.[323]

The Minnesota model of ethanol production provides an alternative scheme for how government intervention in ethanol production can yield the most profitable results for local producers. By requiring that farmers be the majority shareholders in order for ethanol production plants to receive state subsidies, the Minnesota law directs financial resources to moderately sized family-owned farms. Thus, this law keeps financial resources in the rural community where the corn is grown and production occurs. Because those profiting from the sale of ethanol are local farmers and not larger corporate interests (like an out-of-state corporation such as ADM), revenues are re-invested in the local economy.

Twenty states have already approved tax credits or other incentives to build ethanol and biofuel production plants.

Countering the Ethanol Wave

Dismantling the Iron Triangle: Revealing Ethanol for What It Is

Table 10 ("Government Support for BioFuels") lists the amount of money earmarked for each subsidy program, as it was outlined in the Energy Policy Act of 2005. This money adds to the total amount that the Ethanol Iron Triangle will consume from U.S. taxpayers. For example, Section 1342, Title XIII, Subtitle D of EPACT 2005 provides a tax credit equal to 30 percent of the cost of alternative refueling property, and up to $30,000 for business property. Qualifying alternative fuels are natural gas, propane, hydrogen, E85, or biodiesel blends of B20 or more. Buyers of residential refueling equipment can receive a tax credit for $1,000. For non-taxpaying entities, the credit can be passed back to the equipment seller. The credit is effective on purchases put into service after December 31, 2005 and the tax credit expires December 31, 2009.[324] Additionally, EPACT 2005 modifies the definition of "small ethanol producer" so that facilities that produce up to 60 million gallons per year (previously 30 million gallons per year) are eligible for the tax credit.[325] The policy relationships embedded in the Ethanol Iron Triangle, based on ever growing "tax incentives" and subsidies, will be perpetuated until the policy is uncovered as the irrational optimism that it is.

What this makes clear is that each member of the Ethanol Iron Triangle has ignored the long-term unsustainable characteristics of the fuel because of the strong short-term financial incentives that legislative mandates have brought each component. The Ethanol Iron Triangle needs to be exposed as an unsustainable policy. If ethanol is truly as revolutionary and feasible as its supporters suggest, it should not require the financial and legal protection given to the Ethanol Iron Triangle.

Figure 10: Government Support for Biofuels, Energy Policy Act of 2005

Government Support for Biofuels Energy Policy Act of 2005		
Program	Fiscal Years	Total Amount
Sugarcane Ethanol Program	2005–2007	$36 million
Cellulosic Biomass Ethanol & Municipal Solid Waste Loan Guarantee Program	N/A	$1 billion
Cellulosic biomass ethanol conversion assistance	2006–2008	$750 million
Ethanol production at Mississippi State and Oklahoma State universities	2005–2007	$12 million
Renewable Fuels Research and Development Grants	2006–2010	$125 million
Advanced Biofuels Technology Program	2005–2009	$550 million
Sugarcane Ethanol Loan Guarantee Program	N/A	Up to $50 million per project

Source: Energy Policy Act of 2005, Alternative Fuels Data Center, U.S. Department of Energy. Available at: http://www.eere.energy.gov/afdc/laws/epact_2005.html

Corporate Average Fuel Standards: Efficiency, Loopholes, and the Way Forward

As a result of the 1973 oil crisis, Congress passed the Energy Policy and Conservation Act of 1975,326 which established the Corporate Average Fuel Economy (CAFE) program. This program requires automobile manufacturers to increase the average fuel economy of the passenger car and light truck fleets sold in the United States and cut gas consumption. The CAFE program established a process where fuel economy is expressed in miles per gallon (mpg) of a carmaker's fleet of passenger vehicles or light trucks that weigh 8,500 pounds or less.

The clear result of the CAFE program has been increased fuel economy of the nation's light-duty vehicle fleet during the past 22 years.[327] "According to the National Academy of Sciences, the CAFE program has been particularly effective in keeping fuel economy above the levels to which it might have fallen when real gasoline prices began their long decline in the early 1980s."[328] And, in fact, "if fuel economy had not improved, gasoline consumption (and crude oil imports) would be about 2.8 million barrels per day higher than it is, or about 14 percent of today's consumption."[329]

Despite initial success, the CAFE program has languished in recent history and the standards have not changed much since 1985. Provisions in Department of Transportation (DOT) appropriations bills have actually "prohibited the agency [DOT] from changing or even studying the CAFE standards."[330] Furthermore, numerous manufacturers have chosen to pay CAFE penalties rather than attempt to comply with the regulations. In fact, carmakers such as BMW, DaimlerChrysler, Ferrari, Lotus, and Porsche have all failed to reach the car or light truck fuel requirements in different model years. As a result, in 2001, Congress requested the National Academy of Science to conduct a study to evaluate the effectiveness and impacts of CAFE, and the committee recommended significant changes to CAFE.

More recently, President Bush proposed to increase CAFE standards by 4 percent annually into the middle of the next decade.[331] This fuel economy increase is estimated by the Administration to reduce gasoline consumption by up to 8.5 billion gallons per year by 2017. However, this proposed fuel economy increase isn't set at a specific number, and the standard for fuel standards are at the discretion of the Secretary of Transportation, based on cost/benefit analysis.

A general consensus appears to exist that the CAFE program needs to be fixed; the question that remains is how. Several aspects of the program discussed below are particularly problematic.

The SUV Loophole:

The CAFE standards fail to account for the vehicle market today. A large portion of the popular sport utility vehicles (SUVs), mini-vans, and pick-ups are classified as light trucks and therefore regulated less stringently. While the average fuel economy for cars is 27.5 mpg, the light truck average is only 22.7 mpg (2007 year model). This loophole reflects a past where light trucks were typically used by farms and other businesses and represented a much smaller share of the automobile market. Indeed, "the distinction between a car for personal use and a truck for work use/cargo transport has broken down….and has been stretched well beyond the original purpose."[332]

Over the past decade, however, these vehicles have dramatically increased their share of the new automobile market. According to the Congressional Research Service:

> In 1980, light trucks composed 19.9 percent of the U.S. new automobile market. By 2001, this figure had increased to 50.8 percent; SUVs alone accounted for 23.1 percent of the new vehicle market in 1999, while mini-vans accounted for 5.8 percent. However, a comparison of market share underestimates this growth and its consequences. While the number of passenger cars sold each year in the United States has decreased somewhat since 1980, the number of light trucks sold has more than tripled, from 2.2 million in 1980 to 8.7 million in 2001. In 2001, SUV sales alone (four million) nearly doubled total light truck sales for 1980. As a result, the total fuel usage and emissions attributable to these vehicles has increased.[333]

As more and more drivers use SUVs, mini-vans, and pick-ups as personal vehicles, CAFE standards continue to allow carmakers

photo credit: Warren Gretz

to get around tougher fuel mileage requirements, which in fact works as an incentive for automakers to put more of these vehicles on the market.

Revisions to CAFE standards should eliminate the separate standards for cars and light trucks and set a single standard for all passenger vehicles.[334] The so-called "light truck loophole" must not be allowed to continue and Congress should require substantial increases in light truck fuel economy standards, similar to those of passenger cars.

A study by the National Academy of Sciences found that light trucks could easily meet the same goals as passenger cars with currently available technology in engines, transmissions, and aerodynamics. The study concluded that "light duty trucks, including SUVs, pickups and minivans, offer the greatest potential to reduce fuel consumption."[335]

However, as the CAFE rules for lights trucks went through changes last year, not only was the "light truck loophole" maintained, but manufacturers were also encouraged to develop less efficient vehicles. This happened because the standards set different fuel economy targets for different-sized light trucks, based on the area bounded by a truck's four wheels, called its "footprint." The bigger the footprint, the lower the mileage requirement. For instance, the new efficiency standard for the Hummer H3 is 24.16 mpg by the 2011 model year. According to Auto Week magazine, if Hummer were to add two inches of track width and four inches of wheelbase to the H3 model, the fuel economy standard would drop by about 1 mpg.[336] Therefore, the clear trend in the industry, observers have acknowledged, will be to game the system in response to the new regulations and produce less efficient vehicles.[337]

The Flex-Fuel Vehicles Loophole:

The 1988 Alternative Motor Fuels Act, designed to decrease oil use, encouraged the development and use of alternative fuels by allowing manufacturers to increase their fleets' average fuel economy by building alternative-fueled vehicles. These flex-fuel vehicles (FFVs) are capable of running on E85. Automakers were attributed credits of 1.5 mpg toward meeting CAFE standards from production of FFVs. While this might seem of marginal benefit, the implications are nonetheless important. It allowed a number of U.S. automobile manufacturers to avoid penalties they otherwise would have been forced to pay on inefficient fleets—an estimated $1.6 billion in penalties were avoided this way.[338]

However, the problem with this CAFE credit is that it allows carmakers to receive credits toward meeting CAFE standards for every FFV produced, even if it never burns a drop of E85 fuel. Until EPACT 2005 required automobile manufacturers to label all dual-fuel vehicles to inform purchasers that the vehicles can be operated on alternative fuel, such as E85, most owners of FFVs were unaware of the fact. Consequently, very little ethanol was consumed in FFVs. While the goal of expanding the use of FFVs may be laudable, the practical effect of this loophole in the CAFE standards has been that it provides no incentives for actual use of alternative fuels, and, like the SUV loophole, it actually decreases the effective fuel economy by allowing manufacturers to delay putting more fuel-efficient vehicles on the road. The fundamental flaw in this program is that the production of an FFV does not mean that the vehicle will ever burn any E85 fuel; the CAFE credit standard does not also require that FFVs actually run on alternative fuel. In fact, it is estimated that currently FFVs run on ethanol blends less than 1 percent of the time.[339]

According to *Consumer Reports*, the existing loophole allows manufacturers to "pump out more gas guzzling large SUVs and pickups, which is resulting in the consumption of many times more gallons of gasoline than E85 now replaces."[340] Moreover, according to some experts, the FFV loophole has already increased domestic oil demand by 80,000 barrels a day, which could help drive total U.S. oil dependence to 200,000 barrels a day by 2015.[341] Thus, CAFE standards have been successful in promoting the development of FFVs but not in achieving the goal of promoting the actual use of alternative fuels. Between them, carmakers say they will produce around 600,000 FFVs this year, adding to the 6-plus million FFVs already on the road. The Chrysler Group announced plans to sell 250,000 FFV's in 2007 and 500,000 in 2008[342] and GM has announced plans to double production of FFVs to 2 million by 2010.[343] The main reason why there are so many FFVs registered in the U.S. has less to do with consumer-driven demand than with the long-standing policy that credits these vehicles with artificially high fuel economy ratings.[344]

At the same time, there are plans in Congress to either increase and/or extend the credit for selling FFVs. However, the National Academy of Science has recommended that the "CAFE credits for dual fuel vehicles should be eliminated."[345]

Focus on Fuel Economy & CAFE Generally:

Revising the CAFE program has the potential to provide a clear and useful signal to automakers that fuel efficiency is a national priority. Congress could do this in a way that provides the necessary time to perform the needed research and development, and build the needed infrastructure. Whether the goal is energy independence or decreasing oil use, the easiest and fastest solution—the proverbial "low hanging fruit"— is increasing fuel economy. The added benefit is that as we transition away from fossil fuel, we will require less fuel to accomplish that goal. We have the technical ability to use less fuel, what we have lacked is the political will. There is no doubt that American ingenuity can deliver a vehicle that maintains or improves safety and fuel economy if there is proper motivation.

For example, there is a wide disparity in fuel economy performance among the vehicles in today's fleet; Honda achieves far greater fuel economy than comparable Ford vehicles. Moreover, we have not progressed very far over the course of automotive history. In fact, the Ford Model-T could travel 24 miles on every gallon of gasoline while the average vehicle in Ford's fleet today gets a mere 19.1 miles per gallon.[346] The EPA's fuel economy ratings show that the most parsimonious models achieve 21 mpg in simulated city driving, and 31 mpg in simulated highway driving.[347] The least efficient models get only 14 mpg and 18 mpg, respectively.[348]

Research suggests that tremendous fuel economies could be obtained by a small adjustment in existing vehicle mileage requirements. For example, an increase in fuel economy of one mile per gallon across all passenger vehicles in the United States has been estimated to cut petroleum consumption by more than all alternative fuels and replacement fuels combined.[349]

There is much room for improvement in vehicle efficiency. Major oil consumption reductions could be achieved by developing and deploying efficiency measures such as reducing vehicle weight, improving aerodynamic features, increasing engine efficiency, and expanding hybrid technology that captures and uses energy otherwise lost in braking.

Gasoline Prices and Tax

Despite the political difficulties, the issue of fuel efficiency cannot be divorced from gasoline prices. In fact, according to the National Academy of Science, there is "marked inconsistency between pressing automotive manufacturers for improved fuel economy from new vehicles on the one hand and insisting on low real gasoline prices on the other. Higher real prices for gasoline—for instance, through increased gasoline taxes—would create both a demand for fuel-efficient new vehicles and an incentive for owners of existing vehicles to drive them less."[350]

For years various federal studies have been concluding that "a higher gasoline tax could encourage drivers to reduce gasoline consumption… and reduce the nation's dependence on oil…and decrease emissions of gases that pollute the air."[351] However, there have been no incentives for automobile manufacturers to improve fuel economy because gas prices in the U.S. have been low and consumers have preferred larger vehicles that emphasize performance over fuel economy.

CAFE standards must be considered in conjunction with gasoline prices and tax policy. Automakers have indicated that they would prefer a gasoline tax that would make it more expensive as a way to encourage changes in consumer buying patterns, rather than the regulation of fuel economy standards. In fact, General Motors Vice-Chairman Robert Lutz has compared CAFE standards to trying to fight obesity by halting the manufacture of large-size clothes.[352]

The example of the European Union is often quoted as a case of high gas prices and the consequential shift in consumer preferences resulting in higher fuel economy standards. In Europe, gas can cost as much as $6 a gallon; this has boosted the popularity of small and efficient cars, with many vehicles performing above 40 mpg.

But increasing gasoline taxes is highly unpopular with voters and consumers, so there is a lack of Congressional leadership on this issue. The impact and success of fuel economy standards has been dependent on the fluctuation of oil prices.

In sum, public policy discussions should focus first and foremost on a larger strategy to move toward a more sustainable transportation model focused on reducing total energy use. Instead of a silver bullet, we need a paradigm shift and a toolbox of measures that will reduce the huge amount of oil we use every day to move people and goods around. And in the absence of comprehensive solutions, we should not rush to arbitrarily anoint corn, switchgrass, or any other biofuel feedstock as the solution to our pressing energy crisis. Our transportation system is in need of an overhaul and we need bold action in the near and long term. The public policy discourse on biofuels cannot be divorced from vehicle fuel efficiency, infrastructure issues, and societal costs, as well as the pressing issues posed by global warming.

An increase in fuel economy of one mile per gallon across all passenger vehicles in the United States has been estimated to cut petroleum consumption by more than all alternative fuels and replacement fuels combined.

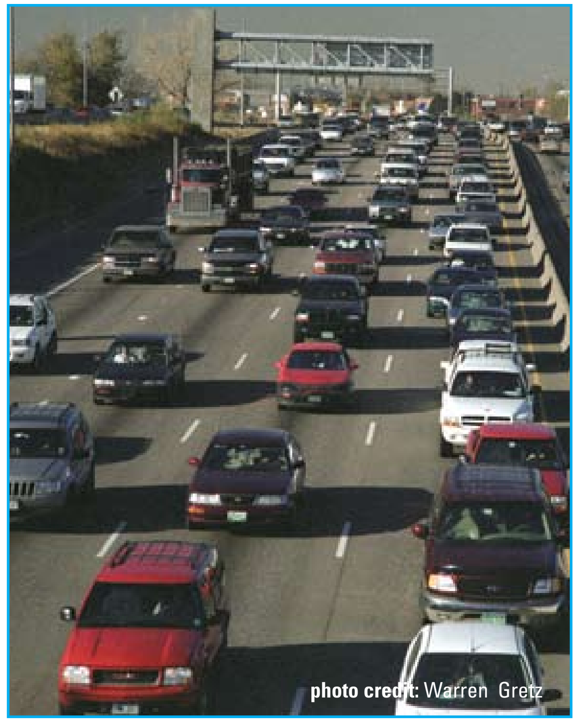


photo credit: Warren Gretz

To illustrate how FFVs interact with the various ethanol production subsidies, consider a 2007 Chevrolet Tahoe FFV (10 mpg simulated city driving and 15 mpg simulated highway driving), fueled exclusively by E85 over the period of one year.[353] Using the EPA's fuel-economy estimates about the mix between city and highway driving, it would cost the federal government $520 per year in tax credits if the vehicle were to run on E85.[354] If the vehicle is refueled exclusively on locally produced E85 in any one of the states that provides a 20¢/gallon tax credit (Maryland, Mississippi, Missouri, Oklahoma, South Dakota, Texas, or Wisconsin), the local taxpayers would be providing an additional $200 in subsidies to keep the Tahoe's tank filled.[355] The refiners, rather than the driver, would receive this money. Were all of America's six million FFVs to run on E85, the cost to the U.S. Treasury would be between $3 billion and $4 billion a year—depending on the actual fuel economy of the vehicles—just in tax credits alone.[356] Counting state incentives, the figure would rise to at least $5 billion.[357]

PART III: SECOND GENERATION BIOFUELS

Cellulosic Ethanol: Alternative to the Alternative

Better Than Corn

At this point in time, virtually all domestically produced ethanol comes from corn. But as the negative impacts of corn-based ethanol draw increasing criticism, cellulosic ethanol is being regarded as a more favorable alternative. Instead of using corn and soybeans, researchers are turning to non-food plants in hopes of meeting rising ethanol demands and finding a more sustainable gasoline replacement solution. They're already being called "energy crops," and they include tall grasses, such as switchgrass and miscanthus, and fast-growing trees including poplars, willows, and eucalyptus. Also being studied are farm byproducts such as rice hulls and straw, sugarcane waste ("bagasse"), corn stover (the leaves and stalks remaining after harvest), and wood chips, sawdust, paper pulp, and other agricultural wastes and forest residues.

Ethanol produced from these sources is called cellulosic because the sugar is pulled from their cellulose—the woody, structural part of the plant—rather than the starch, as is the case with corn. This cellulose can be extracted through various processes from the fibrous, photosynthetic part of the plant and then fermented into ethanol. Cellulosic ethanol has never been produced on an industrial scale and technological breakthroughs are necessary before it can be produced in a cost-competitive way. Most experts estimating that commercial production of cellulosic fuel is still some 5-10 years away.[358]

Until the notorious "addiction to oil" line in President Bush's 2006 State of the Union address, switchgrass was unknown to most people.[359] However, recent developments on cellulosic ethanol are showing promising prospects for the new fuel, and many are looking at cellulosic ethanol as the key to sustainable large-scale ethanol production. The 2008 federal budget provides $179 million for the Biofuels Initiative, which aims to accelerate cost reduction and commercial development of cellulosic ethanol.[360] Even the Energy Policy Act of 2005 had already set a target of 250 million gallons of cellulosic ethanol to be produced by 2013, and directed considerable funding for research, development, and demonstration projects using cellulosic biomass.


photo credit: Warren Gretz

Cellulosic ethanol energy ratios are more favorable than those of corn because the unused biomass called lignin, can be burned to supply all of the energy needs of the refinery.

Switchgrass once grew wild across the central and eastern United States, from the Gulf Coast to the Canadian border. It was especially dominant in the Great Plains. However, settlement, grazing, railroads, and food crops virtually eliminated it from the landscape, and it is now largely relegated to parks and other preserves. Today, the characteristics that once made switchgrass an agricultural nuisance have become prized in the search for an environmentally-sound gasoline replacement. It is a perennial, fast-growing plant that reaches up to 10 feet in height, with thick stems as strong as pencils. It also has an extensive root structure that helps retain soil nutrients and prevent erosion, thereby improving the soil quality of degraded lands. According to the Worldwatch Institute, switchgrass "can be harvested with less interference to the food economy and potentially less strain on land, air, and water."[361]

But what exactly are the advantages of switchgrass, willow, poplars, and other potential sources of cellulosic ethanol? What makes cellulosic ethanol more appealing as a fuel over current corn-based ethanol?

Cellulosic ethanol has more favorable energy ratios than corn and presents more room for productivity gains, making it appealing to investors, farmers, and refiners:

- Cellulosic ethanol production shows higher energy ratios than corn-based ethanol and soy-based biodiesel. Cellulosic ethanol can be produced with at a net energy gain of 80 percent, while corn nets only 25 percent (compared to gasoline, which actually consumes 25 percent more in its production energy than it yields). Cellulosic ethanol energy ratios are more favorable than those of corn because when the feedstock is converted into ethanol, about a third of its biomass remains unused. This material, called lignin, can be burned to supply all of the energy needs of the refinery.[362] Many paper mills already use waste wood to supply energy to run their operations and the same is expected for ethanol facilities that use cellulosic feedstocks.
- Near-term efficiency gains in cellulosic ethanol production are expected to greatly increase the number of gallons produced per ton of dry biomass, with some estimates suggesting that it can eventually reach 117 gallons of ethanol per ton of dry switchgrass.
- Because of their wide range and tolerance for degraded soils, cellulosic feedstocks can grow on marginal lands not suitable for agricultural crops, greatly expanding their potential growing area relative to corn and soy. Currently, some 90 million acres are planted with corn, out of the 250 million acres planted with the eight major field crops. Beyond this, there are 433 million acres of total cropland in the U.S. (including forage crops and temporarily idled or fallow cropland) and 578 million acres of permanent pastureland, most of which would be viable for switchgrass and other energy crops.
- Native species, such as switchgrass, have a natural resistance to pests and disease, resulting in higher, more dependable yields than domesticated corn. Some research plots have even produced switchgrass yields of 15 dry tons per acre per year, suggesting great long-run production improvement potential.[363] Higher crop yields per acre make the production of cellulosic ethanol more efficient and increases its cost-competitiveness. Moreover, an acre of switchgrass yields more ethanol

than an acre of corn or soybeans, and exponential yield increases are expected for cellulosic feedstocks, while corn and soy yields, even if expected to increase somewhat, are expected to soon reach their maximums. The natural pest resistance and climatic adaptations also make native plants less dependent on chemical pesticides and fertilizers to increase yields.

- Cellulosic ethanol offers advantages in terms of the sustainability of feedstock production and results in higher potential environmental gains.
- Cellulosic crops require far fewer inputs to grow than corn and, therefore, cause less environmental damage. In general, they require significantly less farm equipment, pesticides, herbicides, fertilizer, and water. This is a tremendous advantage over corn and the harmful environmental effects that result from industrial farming practices.
- If managed properly, tall grasses and trees can provide habitat for birds, small mammals, and other wildlife.
- The root structures of perennial grasses efficiently absorb water, nutrients, and fertilizer, reducing chemical runoff that leads to eutrophication downstream and soil erosion, both major problems with corn production. Over time, switchgrass can actually improve soil quality and fertility—even with regular, sustainable harvesting—and allow for crop rotation with corn and other food crops.
- Cellulosic crops can be grown on marginal land that cannot support food crops, and thereby does not affect food supplies or the food economy.
- Rural economies could benefit from cellulosic ethanol production. Because a variety of raw materials can be used, smaller, specialized refineries will likely be built. Cellulosic has the potential to be synergistically integrated into local agricultural systems, compared to the corn-based ethanol industry that is shifting to a larger-scale, corporate-owned model. Incentives could promote farmer-owned and community-based farms and processing plants, which are considered key to the industry's success. Because many of the raw materials will originate in rural communities, the combined benefits of new jobs, higher incomes, tax revenues, environmental conservation, redevelopment, and a sense of ownership should benefit those communities.
- Cellulosic ethanol results in higher reductions of greenhouse gass and other polluting emissions than corn-based ethanol.[364] Byproducts of fuel crops, such as lignin, can be used to power refineries in the place of fossil fuel–generated electricity, contributing to the overall greenhouse gas emissions reduction. Six representative studies found a similar potential for cellulosic ethanol to reduce emissions.[365]

The advantages of cellulosic ethanol have been highlighted in a recent study by the University of Minnesota, which found that biofuels derived from low-input high-diversity (LIHD) mixtures of native grassland perennials can provide more usable energy, greater greenhouse gas reductions, and less agrichemical pollution per hectare than can corn-based ethanol or soy-based biodiesel. The study found that high-diversity grasslands have increasingly higher yields—238 percent greater than monoculture yields after a decade. Moreover, LIHD biofuels can be produced on agriculturally degraded lands and thus neither displace food production nor cause loss of biodiversity via habitat destruction.[366]

With the Renewable Fuel Standard aiming at 250 million gallons by 2013, the race to develop commercially viable processes of producing cellulosic ethanol is well under way. Several research projects are being developed right now, as different companies try to get ahead of the game in the upcoming cellulosic ethanol market.

So far, the main barrier to the commercial development of cellulosic ethanol has been reducing the cost and improving the efficiency of enzymes used in the process. These enzymes break down cellulosic matter to yield sugars, which are then fermented to create ethanol. The sugar in corn starch dissolves relatively easily in water, but not so with cellulose. Elaborate pretreatment processes—such as enzymes, steam explosion, and organic solvents—must be used to break apart the cellulose and release the sugar. Technological breakthroughs are needed to develop economically viable means to separate cellulose from lignin (the chemical that accounts for the structural integrity of grasses and trees) and to extract fermentable sugars from cellulose. A DOE-funded research project reported a major breakthrough in 2004, when a 30-fold reduction in enzyme cost was achieved. The National Renewable Energy Laboratory (NREL) expects the price of these enzymes to drop by half in the next few years. A wave of partnerships has been sweeping the sector with the aim of developing enzymes and advanced process technologies that will make the production of cellulosic ethanol competitive with other fuels.

Just recently, the company Broin announced an extension of a partnership with Novozymes, a Danish biotechnology company, to further their collaboration in research and development of new enzymes.[367] The extended partnership between the two companies, which have jointly developed new enzymes and conversion processes in the last few years, aims to develop a commercially viable process to produce cellulosic ethanol. In addition, research is also underway to develop microbes ("smart bugs") that could consolidate the entire production process into one step.

Moreover, several cellulosic refineries are being built. Abengoa Bioenergy is building a cellulose-to-ethanol plant in Salamanca, Spain, which will demonstrate the commercial viability of the company's process technology.[368] The company has four conventional ethanol plants in the U.S., and is planning to add production of cellulosic ethanol to its facility in Colwich, Kansas, using a variety of feedstocks, including waste from grain crops.[369]

Iogen, a Canadian company, has been producing cellulosic ethanol at its demonstration plant in Ottawa since 2004, the only cellulosic ethanol demonstration facility in North America so far. At full capacity, Iogen's demonstration plant can process about 30 metric tons per day of feedstock, with an output of approximately 2.5 million liters of cellulosic ethanol per year. The plant uses wheat, oat, and barley straw as feedstock. Jeff Passmore, the company's Executive Vice President, identified southeast Idaho as a prime location for its first commercial cellulosic ethanol plant. At a hearing in June, Passmore told members of Congress, "Based on Iogen's experience with its demonstration facility, we are ready to break ground on a commercial-scale biorefinery in the summer of 2007, and [we] plan to be supplying ethanol to commercial markets by 2009."[370] Wall Street's interest in cellulosic ethanol became evident when Goldman Sachs announced it was investing in Iogen in May, 2006.[371] The global investment firm joined Royal Dutch Shell on the list of Iogen's shareholders.

Broin, based in Sioux Falls, South Dakota, is developing the first commercial-sized cellulosic plant in the United States. The Voyager Ethanol plant, located in Emmetsburg, Iowa, will use corn stover as feedstock and is expected to begin commercial production of cellulosic ethanol by 2009.[372] The plant is a $200 million expansion project that will convert an existing 50 million gallon-per-year conventional dry-mill facility into a 125 million gallon-per-year refinery producing cellulosic ethanol. The project will use advanced process technologies for cellulosic ethanol that were developed under a research initiative jointly funded by the DOE's National Renewable Energy Laboratory and South Dakota State University. Broin expects project LIBERTY, as the cellulosic program is known, to produce higher ethanol yields while consuming as much as 83 percent less energy than a conventional corn-to-ethanol facility.[373] The Voyager facility is also expected to create 220,000 tons of animal feed as byproducts of ethanol production.[374]

Massachusetts-based Celunol Corp, formerly BC International, is also scheduled to begin production of cellulosic ethanol at its demonstration plant in Jennings, Louisiana. The refinery will use patented pretreatment and hydrolysis technology to convert sugarcane, bagasse, and hardwood waste to ethanol.[375] The company has another pilot plant under construction in Osaka, Japan, and is involved in the development of other projects in several regions of the U.S., with plants sized at 25–50 million gallons per year.[376]

Another company with plans to commercialize cellulose-to-ethanol technology is Mascoma. The company plans to use agricultural and forestry wastes to produce ethanol and has drawn investments from the Silicon Valley investment guru Vinod Khosla. The company plans to develop a cellulosic ethanol facility in New York and estimates it will have a commercial plant running by 2008.[377]

Hybrid poplar plantation in Oregon.

Researchers are also focusing on fast-growing trees, such as poplars, as a potential feedstock for cellulosic ethanol production.

photo credit: Oak Ridge National Laboratory.

How Much Better?

While the broad designation of "cellulosic" biomass promises greater environmental benefits compared to starches, such as corn or soy, the relative impacts of the many cellulosic feedstocks warrant closer investigation. There is much dialogue and study within the scientific community concerning which biofuels hold the greatest potential in terms of output, cost effectiveness, and environmental footprint.

Investing time, land, energy, and money in short-sighted solutions will not only result in unnecessary environmental damages, but also impede a meaningful transition to the best possible production scenario for biofuels. Modern agriculture has demonstrated that we can grow any crop to the detriment of the land and the people farming it. We must remember that while some plants may hold certain benefits over others, it is the manner in which they are planted, grown, and harvested that are the measure of environmental impact. After all, it is not plants themselves that are sustainable, but rather the practices by which they are managed. **While there are environmental benefits inherent in cellulosic over corn for ethanol production, if these feedstocks are planted and harvested in unsustainable ways those, benefits could easily become moot.**

The extent of the potential environmental impacts of the two prominent categories of cellulosic fuels is largely unknown. In fact, the land-use methods associated with agricultural residues and energy crops, specifically grasses and fast-growing woody varieties, greatly impact the relative environmental footprint of that fuel source.

In general, ecosystem and environmental impacts will chiefly depend on what kind of land is being used, what is being grown, and in what manner. This may seem an obvious and overly general characterization, but there is much to consider. The wide diversity of potential feedstocks and landscape scenarios, taken with the massive scale of future cellulosic deployment, require significant attention in forming policies and practices that reflect prioritization of environmental sustainability.

The impacts of producing biomass for energy could in some cases degrade and in others improve environmental integrity, based on type of feedstock, cultivation methods, and land used.[378] For example, removing agricultural residues beyond what is needed to maintain and replenish soil organic matter (SOM) will exacerbate erosion vulnerabilities and negative environmental impacts from conventional row-crop production. On the other hand, transitioning vulnerable or low-yielding agricultural lands to energy crop production would enhance soil, water, and wildlife health. However, turning protected lands, such as those enrolled in the USDA Conservation Reserve Program, to energy crops will sacrifice ecological quality.

The potential yields and impacts of widespread cellulosic production are, at this time, combinations of extrapolation, projections, and hope. Estimations of yield increases for hybridized corn stalks, grasses, or trees are based on genomics applied to corn yields. The wildlife and carbon sequestration benefits of perennial grasses and trees are delicate, and depend largely on sustainable implementation and responsible land stewardship priorities. Therefore, before cellulosic biofuels are adopted as the alternative fuel, federal, state, and local planners must work in earnest conjunction with farmers, environmental scientists, conservationists, and other stakeholders to ensure that the great actual potential of cellulosic ethanol is not forsaken by flawed implementation and incentivization. In real terms, only programs that prioritize environmental protection, sustainability, and efficiency will be cost-effective and long-lasting, and deployment of a cellulosic biofuel economy should faithfully represent those imperatives.

Can agricultural residues play a meaningful role *in a sustainable ethanol economy?*

Agricultural residues describe the stalks and leaves of a plant which are left on the field in between harvesting and planting to conserve SOM and nutrients, and prevent erosion from wind and weather. Corn stover is viewed by some proponents, including the USDA and DOE, as the most immediate and promising cellulosic feedstock, as it is a readily available co-product of corn cultivation, can be cheaply collected, offers potential gains in corn biomass yields, and does not require that additional land be removed from food production.[379] Agricultural residues will most likely serve as the first major cellulosic feedstock, as they are viewed by some as waste, and because more favorable energy crops take years to establish. Farmers could theoretically harvest these residues and sell them to local ethanol refineries, increasing farm revenues with little extra cost and effort. However, while it seems a net energy gain to eliminate "waste," clearing farmlands of this nutrient-rich and protective layer could exacerbate soil erosion and decrease overall soil quality. And while agricultural residues have the advantage that they could be easily harvested with appropriate technology, there are doubts that this source can dependably supply enough tonnage to meet projected demand.

Claims that the contribution of corn stover and other agricultural residues to future biofuel supply will increase significantly with bioengineering and higher yields is debatable. There is staunch disagreement on whether or not corn yields have much room for growth, even under the most intensive bioengineering. There are scientists on both sides of the debate—those who claim that technology has brought corn a long way and that it has reached its maximum yield potential, and others who hold that yields could still be expanded. There is no debate, on the other hand, that the possibility for increases in corn yield pale in comparison to the largely untapped potential of cellulosic feedstocks. Therefore, agricultural residues such as corn stover should be viewed as a minor share of cellulosic ethanol supply, with dedicated energy crops providing the bulk of supply.

The key question is not how much stover is produced as a by-product of corn cultivation, but rather how much of this residue could be removed without compromising soil integrity. The estimations for what sustainable removal for corn stover would look like range from as much as 90 percent[380] to as little as 20 percent,[381] thereby precluding any stover volume projections at this time. A study published in January 2007 by researchers at National Renewable Energy Laboratory and Oak Ridge National Laboratory (ORNL) stated that only 30 percent of crop residues can be removed without threatening SOM retention and erosion.[382] This study maintains that "three regions of the country (central Illinois, northern Iowa/southern Minnesota, and around the Platte River in Nebraska) produce sufficient stover to support large biorefineries with one million metric tons (Mg) per year feedstock demands and that if farmers converted to universal no-till production of corn, then over 100 million metric tons (Mg) of stover could be collected annually without causing erosion to exceed the tolerable soil loss."[383] This indicates that removing agricultural residues is not necessarily an environmental detractor if done appropriately. However, there is justified concern that creating financial incentives for farmers to sell this material could encourage over-harvesting and result in further diminished soil and water quality.

Clearing farmlands of nutrient-rich, protective residues could exacerbate soil erosion and decrease overall soil quality.

Energy crops: Comparing the Alternatives

According to research and analysis conducted by ORNL and the DOE, perennial grasses and woody varieties hold the greatest long-term promise for biomass energy, over industrial wastes and agricultural residue. Switchgrass in particular has emerged as the favored species for energy crops based on its large ecological range, natural pest resistance, advantages for soil retention and carbon sequestration, and habitat creation.

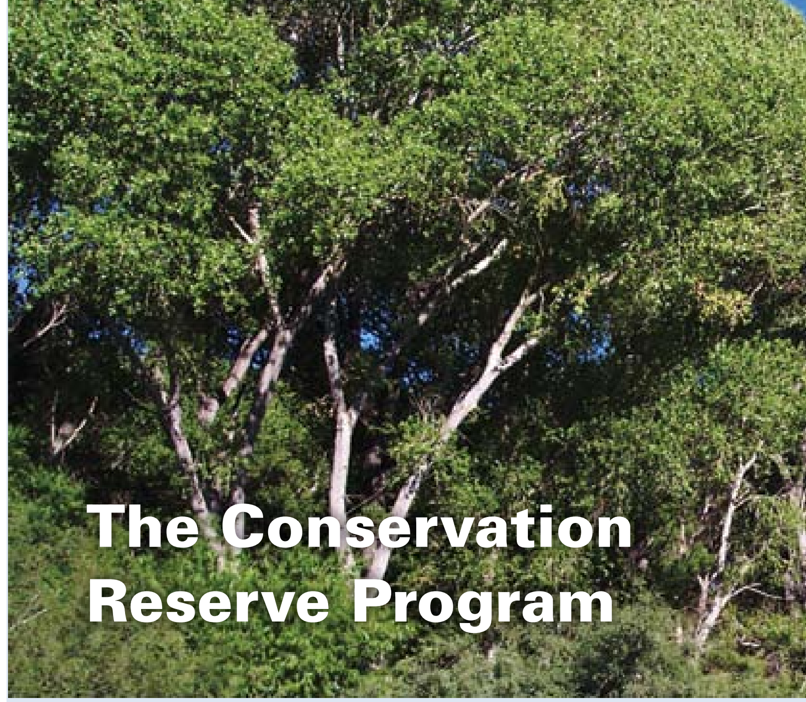
Perennial grasses and woody species hold inherent environmental protection value over agricultural crops. Grasses and trees with wide geographic range possess natural resistance to pests and are better adapted than food crops to grow on low quality soils. However, it is unclear how their beneficial characteristics will manifest themselves under agricultural cultivation practices. As energy crops, these feedstocks will be managed under an agricultural, rather than conservation, paradigm. In order to increase biomass yields and productivity, chemical fertilizers and herbicides, as well as genetic modification, will likely be employed to some extent.

One of the primary perceived benefits of switchgrass planting is that it would increase habitat for wildlife and native species, especially nesting birds of the Great Plains prairies. Scientists have set out to understand exactly how these ecological relationships would function in a scenario of harvested grass crops, and their results have been largely positive. Prairie ecology depends on periodic fire disturbance to maintain species diversity and richness. In grassland habitats, yearly harvesting of switchgrass has shown increases in species richness and density of certain bird species, as the cutting back mirrors the natural burn cycle of their ecosystem.[384] Also, the diversity within switchgrass's genus, *Panicum*, can be taken advantage of. For instance, there is an upland and lowland variety that could be appropriately deployed. Numerous studies focusing on Midwestern ecology have demonstrated that a patchy mix of harvested and unharvested switchgrass fields will maintain the greatest possible ecological benefits for nesting birds.[385] Furthermore, harvest during the winter season minimizes disruption of nesting birds' cycles, thereby promoting greater wildlife benefits alongside economic opportunity for farmers.[386]

In addition to perennial grasses, many scientists, farmers, and conservationists are looking to hybridized fast-growing tree varieties, such as poplars and willows, as ideal energy crops that offer added environmental and fuel-production benefits. According to researchers at the U.S. Forest Service, "Under optimal conditions, poplars can add a dozen feet of growth each year and reach maturity in as few as four years, permitting selective breeding for large-scale sustainable plantation forestry."[387] Despite this great potential, even less research has focused on woody crops than with switchgrass, making it difficult to draw conclusions about these crops' usefulness in biofuel production.

In comparison to perennial grass energy crops, it is expected that fast-growing hybridized trees will require even less water, fertilizer, and pesticide input. Another perceived advantage is less frequent habitat disruption and soil disturbance because of infrequent harvesting. Surveys of plots of hybrid poplars in the Midwest since the early 1990s have shown "that short-rotation woody crops can play a role in providing habitat for wildlife, particularly if these crops replace land uses that provide less diverse habitat and thus are of poorer quality than natural systems (i.e., agricultural lands)."[388]

However, while these plantings can be described generally as providing habitat for birds and mammals, the actual species observed using them tend to be migratory neo-tropical birds, generally characterized as successional species. Native species of management concern, which are largely absent from these plantings, tend to prefer the native forest interior.[389] Still, other studies have indicated that the primary deterrent to wildlife use is the age rather than composition of a forested stand,[390] suggesting that with time these plantation-forests could become home to critical species.



The Conservation Reserve Program

One of the primary arguments in favor of cellulosic energy crops for ethanol production is that they can be grown on marginal, unused, or depleted farm lands, thereby allaying concerns about land scarcity and food crop competition. However, the choice of land on which to grow energy crops should not compromise environmental health or conservation. Cellulosic energy crops can be grown on less fertile lands and can be of special benefit to highly erodible lands, bur their growth should not be confused or traded for true land preservation through standing native plant and animal communities.

The Conservation Reserve Program (CRP) is a voluntary program that was authorized in the 1985 Farm Bill to provide farmers with economic compensation and incentives for turning highly eroded or unproductive agricultural lands toward conservation. The lands are planted with long-term cover with the express goal of improving water and soil quality, using erosion abatement plants. At its inception, the program had the dual purpose of restoring degraded croplands and giving farmers economic support during times when crop prices bottomed out. Currently, the program encompasses 36 million acres of environmentally sensitive lands, providing soil protection, riparian buffers, and wildlife habitat, and is the U.S. government's largest conservation program.[391] In its 20 years, the CRP is credited with reducing soil erosion by more than 40 percent and restoring more than 1.8 million acres of critical wetlands.

photo credit: Morguefile

While cellulosic production is lauded by many for their potential to dramatically widen the productive range of feedstocks, the central Great Plains states are presumed to be the place that will absorb this new agricultural sector to a large degree.[392] The savannas and grasslands of the Midwest represent the largest critically endangered ecosystem in the U.S.[393] According to the U.S. Fish and Wildlife Service, the Midwest region is home to over 50 percent of current CRP contracts and over 25 percent of total enrolled acreage (7.9 million).[394] Loss of these protected acres to energy crop production would be a major setback for water, soil, plant, and wildlife conservation efforts for the entire region.

Approximately three quarters of the program's enrolled acreage will expire in 2007, 2008, and 2009, raising fears that farmers will look to potential ethanol profits and plant their restored acres with corn or other energy crops. In 2006, Keith Collins, chief economist for the USDA, told Congress to expect conversion of 7 million acres of CRP lands to ethanol production.[395] A letter to Congress from a coalition organization representing millions of conservationists, hunters, and anglers claims that "altering the existing CRP priorities on millions of acres of enrolled land could dramatically reverse many of the gains realized to date in protecting our environment, improving water quality, and enhancing wildlife."[396] While much CRP land is currently planted with switchgrass, the conservation program bars harvesting, so even if no new planting took place, environmental protection would be diminished to varying extents.

The limitations of opening CRP land to energy crops have been acknowledged by the Natural Resources Defense Council (NRDC). In 2004, the NRDC developed a scenario for oil displacement in which biofuels would be grown on specifically designated lands (rather than buffer strips or reliance on agricultural residues), taking over a majority of croplands currently planted with soy production and one third to one half of lands protected under the CRP.[397] However, the author of their highly regarded blueprint, *Growing Energy: How Biofuels Can Help End America's* Oil Dependence,[398] stated in October, 2006 the he has now reconsidered whether or not the goals of the CRP are indeed interchangeable with effects of switchgrass cultivation:

> In NRDC's *Growing Energy*, when we looked at the amount of land needed to replace gasoline demand with biofuels, we assumed that about 50 percent of CRP land could be used to grow switchgrass for biofuels while still meeting environmental goals of the CRP. I now doubt that that's the case and I definitely don't think that opening CRP to harvesting of energy crops is the best way to encourage energy crops. [399]

Therefore, for cellulosic ethanol to assume a secure and sustainable role in petroleum displacement, existing farmland will have to be specifically allocated for its production. It must be understood that while switchgrass has a greater conservation value relative to corn row cropping, it should not been seen as interchangeable to equal in value, for wildlife or soil conservation, to untouched, diverse native plantings of the CRP. The environmental benefit of switchgrass comes when it is replacing traditional row crops, not already preserved areas.[400]

It is of key importance that in laying out of a national biofuels production plan that environmental and land-use concerns are taken into account alongside economic and fuel demand imperatives. The priorities of environmental protection and energy independence must be balanced, as policies that rob Peter to pay Paul will be detrimental to both efforts in the long run.

Loss of protected acres to energy crop production would be a major setback for water, soil, plant, and wildlife conservation efforts.

Input Demands of Cellulosic Ethanol

Because no commercial cellulosic ethanol refineries are currently operating, there are no concrete models by which to conclude what cellulosic's water intake needs will be. However, there are concerns that the added "pre-washing" or "pre-processing"[401] step necessary for breaking cellulose down into ethanol will be a serious limiting factor in determining where refineries can be built, possibly excluding arid western states from production of this fuel. While it is presumed that added water demand for processing will not be greater than water use for row irrigation, the number and density of refineries slated for the Midwestern region alone are cause for concern. Furthermore, this additional step will add a suite of largely untested chemicals that would be treated and discharged.

Fertilizers and pesticides will still be applied to cellulosic feedstocks, though in lesser quantity than for corn and soy. According to NRDC projections, which account for higher rates of uptake of chemicals through root mass, switchgrass yields 9.7 kg/hectare/year runoff of applied nitrogen (the chemical of utmost concern for eutrophication, along with potassium and phosphorus) as compared to 78.8 and 16.25 for corn and soybeans respectively.[402] But while the amounts of chemicals applied are lower and percentage runoff is less, they are by no means negligible. Concerns about chemical runoff from cellulosic feedstock fields become very significant when one considers the scale of cellulosic ethanol production that the federal government and environmental organizations are proposing.

Improving the cost of producing cellulosic ethanol (an enzymatic process) depends largely on transgenic and precision breeding—processes that involve genetic modification. Employing marker-assisted breeding would be a more sustainable method, with less potential for unintended negative environmental or health consequences. [403]

One of the major reasons for the selection of poplar and willow trees as energy crops is the ease with which they are genetically manipulated to accentuate their already favorable characteristics.[404] Poplars were the first tree to have their entire genome sequenced, and researchers at various DOE labs are working to isolate the cellulose polymers that can be manipulated to reduce the cellulose barriers to fermentation.[405]

Legislative Loopholes

One of the much-touted efficiency and environmental benefits of cellulosic energy production is that the unfermentable lignin component of cellulose can be burned to create ample energy to power the refining process. But if this input is supplemented or substituted by another power source, such as factory farm or industrial waste, then a large degree of greenhouse gas abatement and sustainability is also lost.

The boost provided to cellulosic ethanol by the 2005 Energy Policy Act was dampened by the addition of a single sentence in the eleventh hour before its passage (Title XV, section 1501). This sentence expanded the definition of "cellulosic" by stating, "The term also includes any ethanol produced in facilities where animal wastes or other waste materials are digested or otherwise used to displace 90 percent or more of the fossil fuel normally used in the production of ethanol."[406] According to David Morris of the Institute for Local Self-Reliance, this sentence changes everything:

> The average person reasonably would assume that a cellulosic ethanol mandate requires the production of ethanol from cellulose. That was clearly Congress' objective. But the new definition allows a corn-derived ethanol to be defined as producing cellulosic ethanol if waste materials supply 90 percent of the ethanol facility's energy needs. Waste materials already fuel several ethanol plants. Several new plants may adopt a similar strategy of substituting lower cost cellulosic wastes like wood wastes for high priced natural gas. Indeed, it is quite possible that by 2008 or 2009 at the latest, the nation will meet its Congressionally-mandated 2013 deadline for producing 250 million gallons of cellulosic ethanol, without actually deriving a single gallon of ethanol from cellulose![407]

In a move that effectively nullifies the supposed environmental gains from cellulosic ethanol production, the EPA has issued regulations for compliance with the renewable fuel standard that qualify "ethanol made from any feedstock in facilities using waste material to displace 90 percent of normal fossil fuel use".[408]

In another sphere, the industry is paying close attention to cost and efficiency benefits of co-firing cellulosic feedstocks in coal plants. Co-firing coal and biomass can reduce greenhouse gas emissions, improve cost/efficiency at up to 20 percent of plant input, and increase demand for (and price of) cellulosic feedstocks. [409] This, however, is not necessarily sustainable when taken in conjunction with the millions of acres that are slated for cellulosic ethanol cultivation.

RECOMMENDATIONS

Ethanol should not be seen as the solution to our pressing energy crisis. Any plan to expand the use of biofuels must be part of a larger strategy to promote an overall transition to a more sustainable transportation model that focuses on reducing total energy use. Instead of a silver bullet, we need a toolbox of measures that will reduce the huge amount of oil we use every day to move people and goods around. Ethanol, either from corn or from cellulosic feedstocks, is not the solution to green house gas emissions, high oil prices, or dependency on foreign oil. The potential of ethanol to displace gasoline is limited—there is just not enough land or water to produce ethanol in quantities that would significantly displace gasoline at projected demand levels without tremendous impacts on the environment and on food production.

Even cellulosic ethanol, a better alternative than corn-based ethanol, is limited by the environmental impacts of its large-scale production. Nevertheless, ethanol seems like an attractive solution to everyone: farmers gain with higher corn prices, agribusiness corporations and investors make big profits with the ethanol hype, politicians please their constituencies, and the scientific community gets funding for research and development projects. Ethanol indeed offers some advantages over oil and, if produced sustainably, can be an important contribution to mitigating the U.S. energy crisis. But there is legitimate concern that the current political craze over ethanol is merely an expedient to please selected constituencies and avoid the real measures that will result in genuine public benefits.

The crucial measures urgently needed to transition to a sustainable transportation model can be grouped into two main categories:

- Measures related to the production of transportation fuels, and
- Measures related to the demand for transportation fuels.

Recommendations on the production side:

1 Sustainable Fuel Standard

Biofuel promotion policies should be tied to a Sustainable Fuel Standard that requires sustainable production methods for both ethanol and feedstocks.

Sustainable Production of Feedstocks

This includes sustainable management practices of land, water, and soil use, and measures to reduce impacts on wildlife and natural ecosystems. Other criteria include bans on GMO crops and protected land conversion for biofuel crops; maintenance and development of land preservation programs; incentives for sustainable agricultural practices such as crop rotation, minimal use of inputs; disincentives for monoculture crops; and reduced tilling and replanting.

In particular, criteria for sustainable cellulosic feedstock production should include:

- Establishment of maximum harvesting levels for agriculture residues;
- Use of designated cropland rather than protected land conversion, with a ban on converting highly erodible land in the Conservation Reserve Program to crop production;
- Promotion of native species planted in diverse composition;
- Promotion of best-feedstock-production scenarios that would involve mixed perennial grasses and trees that can be harvested on a rotating basis;
- Financial support for small farmers growing energy crops in establishment years before crops can be harvested; and
- Development of woody crops and grasses in buffer areas between forest remnants and croplands that enhance biodiversity and habitat protection for threatened interior forest wildlife.

Sustainable Production of Ethanol

In addition to curbing the negative effects of feedstock production for ethanol, policymakers must take account of the environmental impacts that ethanol processing facilities can have. These include water consumption, refining methods, and the types of fuel used to power refineries.

In terms of water use, plants should be required to use the best technology available for filtering and using waste water, as well as minimizing total water usage as much as possible. Likewise, plants should be required to refine their product so that it is as "clean" as technologically possible in order to reduce ethanol's contributions to smog and other air pollutants. Coal fired ethanol refineries should no longer be eligible for ethanol production subsidies. Instead, small-scale cellulosic ethanol refineries should be encouraged to use lignin as a fuel.

Sustainable Fuel Standard Applied to Imports

The Sustainable Fuel Standard should also cover imports of biofuels and feedstocks, particularly regarding criteria on wages and labor conditions of rural workers abroad. The standard should also ensure that rainforests and other habitats are not razed to make space for more cropland for biofuel plantations, or for other crops displaced by biofuel crops. The best possible usage would be for local cultivation of biofuel feedstocks for local consumption as each mile traveled by feedstocks lowers its energy balance ratio.

2 Protection of Small Farmers and Local Economies

Sustainable ethanol production should also be tied with measures to secure distribution of revenues that benefit farmers and rural communities, by promoting local ownership. By both growing feedstock and processing it for ethanol, local communities can most fully reap the economic rewards of the ethanol industry. Locally owned plants are also more likely to be responsible in terms of minimizing plant emissions and responding to quality of life–related complaints made by neighbors.

Models for locally controlled ethanol plants have already been tested and lessons have been learned that can inform future initiatives in this arena. In Minnesota, for example, legislation helped to establish several ethanol processing cooperatives in the late 1980s. A state program gave the cooperatives incentives to keep ownership in state, and the cooperatives have supported local economies by buying raw materials from local producers and keeping most of their profits and dividends in the state.[410] What's more, the program led to the creation of about 1,400 well-paying jobs, and has kept as much as $80 million per year in Minnesota rather than spending it on foreign oil.[411]

3 Oil subsidies phase-out

Oil has been a mature industry for decades, and subsidies to oil and gas are now totally unjustified. While oil companies continue to make record profits, there is no rationale for public monies to continue to be allocated to the oil industry. The maintenance of subsidies to the oil industry continues to drain taxpayer monies that could be redirected to more sustainable energy policies.

Recommendations on the demand side:

The main goals of a sustainable energy policy must be to reduce energy consumption levels and increase efficiency in energy use. There are a number of measures that could help to achieve these goals in the transportation sector:

4 Create a comprehensive transportation program to drastically reduce fuel demand and limit the environmental impacts of transportation

A comprehensive, adequately funded federal plan should be implemented with the objective of radically reducing the amount of projected fuel demand and limiting the negative impacts of the transport sector on human health and the environment. Both at the federal and state levels, all energy, environmental, and transportation agencies should integrate these strategies into their respective programs.

5 Invest in public transportation

Public transportation should be adequately funded and should be considered as the policy of choice over those that promote further individual vehicle use. Investment in public transportation should be considered a top priority in areas where traffic congestion has become endemic as a fundamental measure to reduce travel delays, wasted fuel, and overall traffic jam costs.

6 Include external costs in the prices of fuel

Currently unaccounted externalities such as pollution, health problems, climate change, and other environmental costs should be assigned monetary values and reflected in fuel prices. Accounting for externalities would create a market mechanism that truly benefits cleaner fuels and penalizes more polluting options.

7 Promote the development of efficient car designs

Currently available technology allows for car designs that are much lighter and efficient, without degrading passenger security. The development of these designs should be encouraged by appropriate incentives and tax policies focused on both the production side (that promote the development of efficient designs by carmakers) and the demand side (that foster consumer demand for these vehicles).

8 Increase fuel efficiency

Increasing fuel efficiency is a robust tool to reduce gasoline demand and can be achieved through higher minimum-miles-per-gallon standards. Increasing fuel efficiency standards should be based on effective requirements that leave no room for loopholes.

9 Create vehicle emissions limits for new vehicles

While reducing fuel consumption, it is also crucial to limit the level of pollution allowed from new vehicles. The Supreme Court has affirmed the authority of the Environmental Protection Agency to regulate greenhouse gas emissions, and the EPA should act to limit permissible emissions for new vehicles. These regulations should include limits on motor vehicle exhaust and evaporative emissions as well as improvements in emission systems' durability and performance.

10 Develop a sound methodology for measuring life-cycle emissions and pollution for the different transportation fuels

There is an urgent need for a methodology to assess the entire life-cycle emissions associated with the use and production of the different transportation fuels. This methodology should consider not only tailpipe emissions, but also the emissions associated with the production of feedstocks and processing practices and include air pollutants and toxics, greenhouse gases, and water pollutants.

11 Traffic restrictions

Restrictions in traffic should be imposed in congested urban areas according to conditions relating to vehicle occupancy, size, emissions, and fuel consumption. The determination of these conditions and the levels of restrictions should be considered as part of overall policies to reduce transportation pollution.

12 Promote efficient urban planning

Urban planning and land use regulations should prioritize the need to reduce fuel use and curb transportation-based pollution. Urban sprawl expansion can be curbed by implementing land-use regulations, tax policies, and transportation planning frameworks that promote mixed-use urban areas and encourage the revitalization of city centers.

13 Plan and implement consumer education campaigns to promote efficient driving

Aggressive driving (speeding, rapid acceleration and braking) wastes fuel. Driving more efficiently can significantly increase gas mileage, while offering many safety advantages to all drivers and passengers on the road. Maintaining constant speed avoids the huge losses of gas that occur from rapid acceleration and breaking. Moreover, drivers can also be encouraged to use cruise control on the highway, remove excess weight from their vehicles and avoid excessive idling.

14 Promote the articulation between metropolitan planning organizations and local governments

Decision-making regarding transportation planning and land use changes has often been stalled because of inefficiencies and fragmentation in the decision-making process. Transportation and land-use planning aimed at reducing fuel demand and air pollution should be a priority for both metropolitan planning organizations and local governments. Efficient decision-making bridges should be created between these two kinds of entities.

CONCLUSION

America has a history of technological innovation. We can solve the energy and environmental crisis if we make the requisite commitments and establish focused and determined political leadership. There is no quick fix. Biofuels should be viewed not as a silver bullet, but, if produced sustainably, as an alternative in a comprehensive transition to a transportation model based on energy efficiency and conservation.

Cellulosic ethanol offers a better alternative than corn-based ethanol, but technological breakthroughs are needed for it to play a significant role. Moreover, cellulosic ethanol production is not inherently sustainable and there are potential environmental risks in its mass production. Given ethanol's shortcomings and limitations, we should be looking into other alternatives for the transportation sector. Conservation and efficiency measures are waiting to be implemented; an aggressive plan should be rapidly put in place to curb transportation greenhouse gas emissions and limit the country's dependency on foreign oil.

The biggest source of immediately available new energy is the energy that we waste every day. The opportunity costs associated with the large-scale transition to a biofuels transportation model should be weighed against the cost advantages of fuel demand reduction and conservation strategies. Ethanol can be part of the solution but, if not considered as a complement to the urgent measures needed to tackle the current U.S. energy crisis, it can be only a step back and a mere expedient to please selected constituencies.

photo credit: morguefile

ENDNOTES

1 According to the Renewable Fuels Association, as of June 14, 2007, there are 121 ethanol biorefineries with a total capacity of 6,332 million gallons per year and 75 sites under construction (7 of which are expansion projects; the others are new plants), resulting in a combined annual capacity of 12,578 million gallons per year.

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Analysis and Recommendations for U.S. Biofuels Policy

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