How far can corn take us? Evaluating the impacts of ethanol

Final Report

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1. Introduction

Encouraged by recent changes in the government's support for biofuels, the ethanol industry is undergoing a major expansion. Congress mandated the use of four billion gallons of renewable fuels by 2006, 7.5 billion by 2012, and will probably extend the number to 36 billion by 2022, although only 15 billion gallons will come from corn (Goodell 2007). The industry has far surpassed these requirements, producing 7.2 billion gallons already in 2007. Over 11 billion gallons are projected to be generated in 2008 (CFDC 2007).

Although this type of renewable fuel represents just a tiny fraction of the total fuel demand in the U.S., ethanol production is impacting many local communities and national markets. One impact is the tremendous local and national economic stimulus provided by the industry. However, there are doubts about ethanol's energetic and environmental benefits. And while there is an enormous pool of information on the subject, much of it is generated by subjective parties. The goal of this research project is to distill the information and to evaluate the entirety of the impact, primarily focusing on the economic and environmental effects. The project is supported by case studies, with the research team assembling information on local plant facilities and relying on personal interviews with community stakeholders to assess the local perspective.

The report begins with an introduction to the policy behind ethanol production. The causes behind the current governmental support for biofuels are examined Section 2, as well as the trends in ethanol production. The full extent of ethanol production chain touches a surprising range of stakeholders, which are reviewed in Section 3. The following section describes ethanol plant structure and their costs of production. Section 4 argues that the expansion of the ethanol industry is a nationwide issue that crosses local boundaries.

Another factor that brings ethanol production to the national arena is the vast federal, as well as state and local, government support for the sector. Section 5 overviews the variety of subsidies available and highlights the dependence of the ethanol industry on this support. Section 6 overviews the economic activity sparked by the industry. It evaluates the national and local effects, looks at the ownership and competitiveness of the ethanol production industry, and estimates the economic impacts created at every level of production. This section also considers other impacts, such as those imposed on the transportation network and other food prices. Requirements imposed on ethanol production facilities, as well as the potential concerns within a community are reviewed in Section 7.

Section 8 examines the pertinent environmental issues. The increased demand for ethanol has translated into a colossal increase in the demand for corn. This, in turn, has implications for farming practices, translating into potentially negative environmental effects. Since water supply is a growing concern in many communities, this issue is examined separately in Section 9. The following part examines potential obstacles to the continuation of the expansion. It mostly outlines the plants' relationships with the local community.

The research is buttressed by case studies. The team investigated about half (62) of the plants currently operational and conducted interviews with individuals in 26 communities where plants are located. Figure 1 shows the plants investigated by the team; the yellow markers indicate communities in which interviews were conducted.

Figure 1. Communities investigated and contacted by the team

In each town we contacted one or several of the following: extension agents, economic development professionals, tax directors, plant managers, planning & zoning administrators, public works officials, and small business owners. We asked them questions about general crop trends, siting of plants, financing of plants and incentives to build, infrastructure expansion, community buy-in, employment, and ripple economic effects in their communities. The findings of the interviews are presented throughout the report in the appropriate sections in text boxes.

Section 10 reviews whether there is enough evidence that ethanol is an energetically positive form of fuel, and assesses the overall logic behind biofuel's role in energy policy. Finally, the report closes with projections for the industry, overall conclusions of the study, and policy recommendations in Sections 11, 12, and 13, respectively.

2. Background & rationale for biofuels

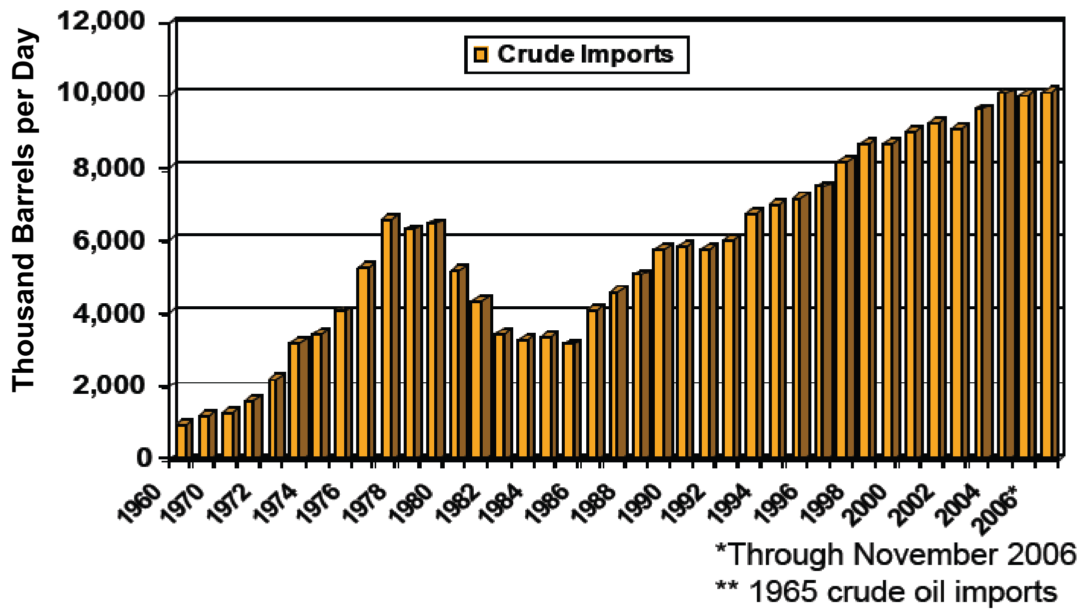
Like many fuels such as methanol, biodiesel, Fischer-Tropsch diesel, and gaseous fuels (e.g., hydrogen and methane), ethanol is produced from biomass. Ethanol is an alcohol and is produced using a process similar to brewing beer: starch crops are converted into sugars, the sugars are fermented into ethanol, and finally the ethanol is distilled into its final form. The product is primarily used for transportation (EERE 2006). The current production capacity in the United States is over 7 billion gallons per year, with nearly all of it produced from corn (RFA 2007).

The reason corn is the main feedstock for ethanol production in the United States is because of its abundance and relatively low price. Other crops, waste food, or beverage by-products are also used as feedstock, but in miniscule proportions compared to corn. There are two types of production methods - wet or dry mill – and both result in marketable by-products (EIA 2007b).

2.a. Rationale for biofuel production

According to the World Resources Institute (2006), rising aggregate demand for energy in the United States, skyrocketing per capita demand in rapidly developing countries (e.g., India and China), and national concern regarding energy security issues have increased attention toward the potential role of ethanol in the energy policy of the United States. All of these concerns are real, as is demonstrated by Figure 1 below. It shows the rapidly rising foreign imports of crude oil to the United States, tying our nation's energy supply to potentially unstable sources.

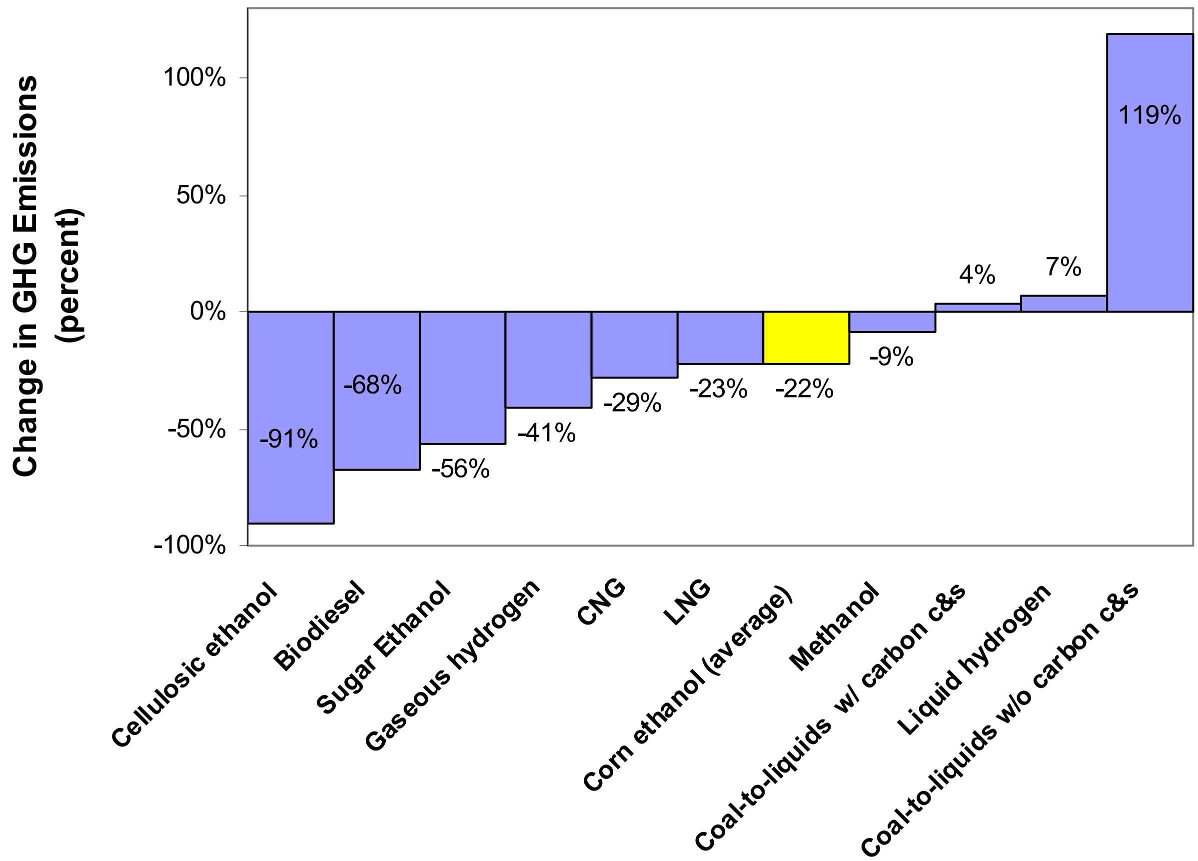
Figure 2. U.S. crude oil imports,1960 to 2006



Source: Davis 2007

The anthropogenic increase in greenhouse gases is often cited as a major reason to abandon fossil fuel use in favor of cleaner and more efficient energy technologies (Ulgiati 2001). Advocates of biofuels argue that, to the extent that biofuels are able to displace petroleum, they are also likely to produce benefits associated with decreased greenhouse gas emissions (e.g. CO_2) and improvements in air quality, although this is only true if clean sources of energy are used to power the plant itself (Marshall & Greenhalgh 2006). Figure 3 provides the theoretical reductions in carbon dioxide emissions during the fuel's production cycle. Additionally, ethanol has been used in gasoline blends to replace environmentally harmful additives, such as methyl tertiary butyl ether (MTBE), an oxygenate that has been found to contaminate drinking water. Its use has been largely discontinued in favor of ethanol as a replacement (Jack 2007).

Figure 3. Change in greenhouse gas emissions relative to gasoline



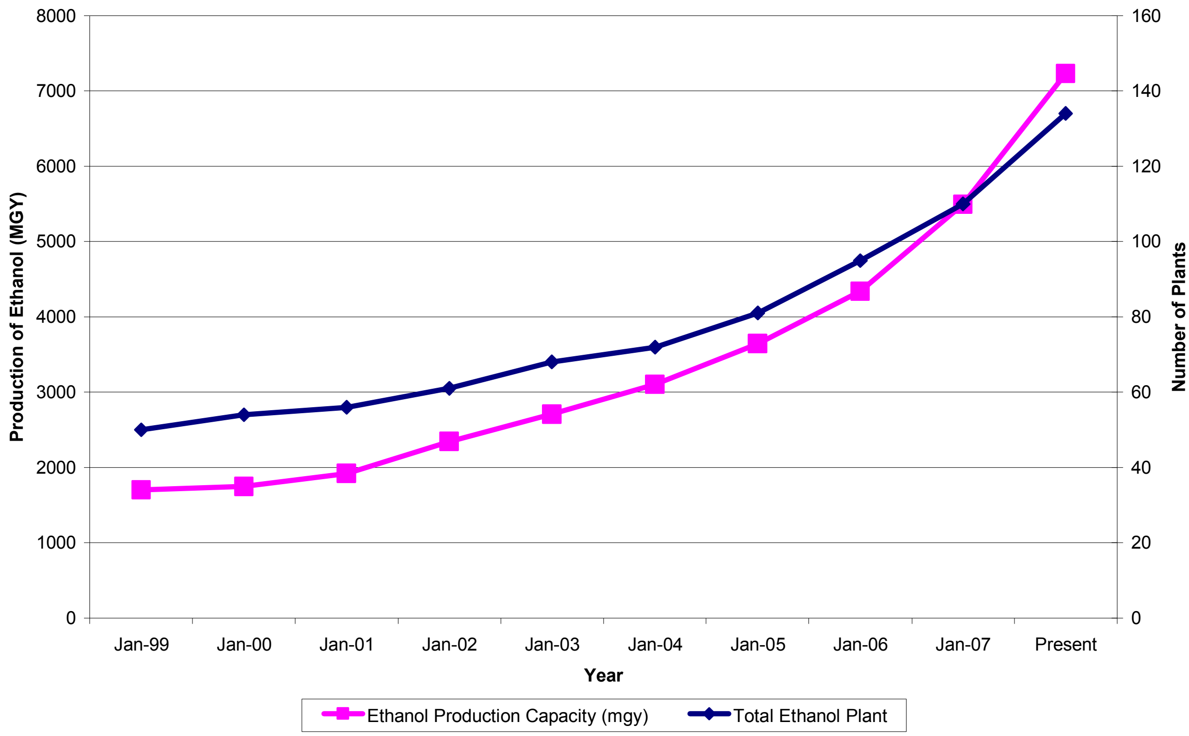
Source: EPA 2007

Additional justifications for ethanol production include health benefits (through protection of the ozone layer), reduced soot, particulate, and sulfur emissions, as well as reduction of automobile engine wear because of the optimized viscosity of ethanol (Mohamed 2007).

2.b. Agricultural policy and history of ethanol production

Ethanol advocates dating back to Henry Ford have described it as the "fuel of the future." This rhetoric is still abundant within the ethanol production community. Yet other participants in the ethanol debate question the feasibility and advisability of large-scale ethanol production based on issues ranging from energy efficiency to the overall environmental impact (Marshall & Greenhalgh 2006). Production has been on the rise in the United States since 1980, with dramatic increases since 2001. Between 1999 and 2006, the number of ethanol plants in the United States nearly doubled, accompanied by a rapid rise in production capacity (EERE 2006). Figure 4 presents the ethanol production and plant construction trends based on the latest statistics from the Renewable Fuels Association.

Figure 4. Ethanol production capacity and number of plants, 1999 to 2007

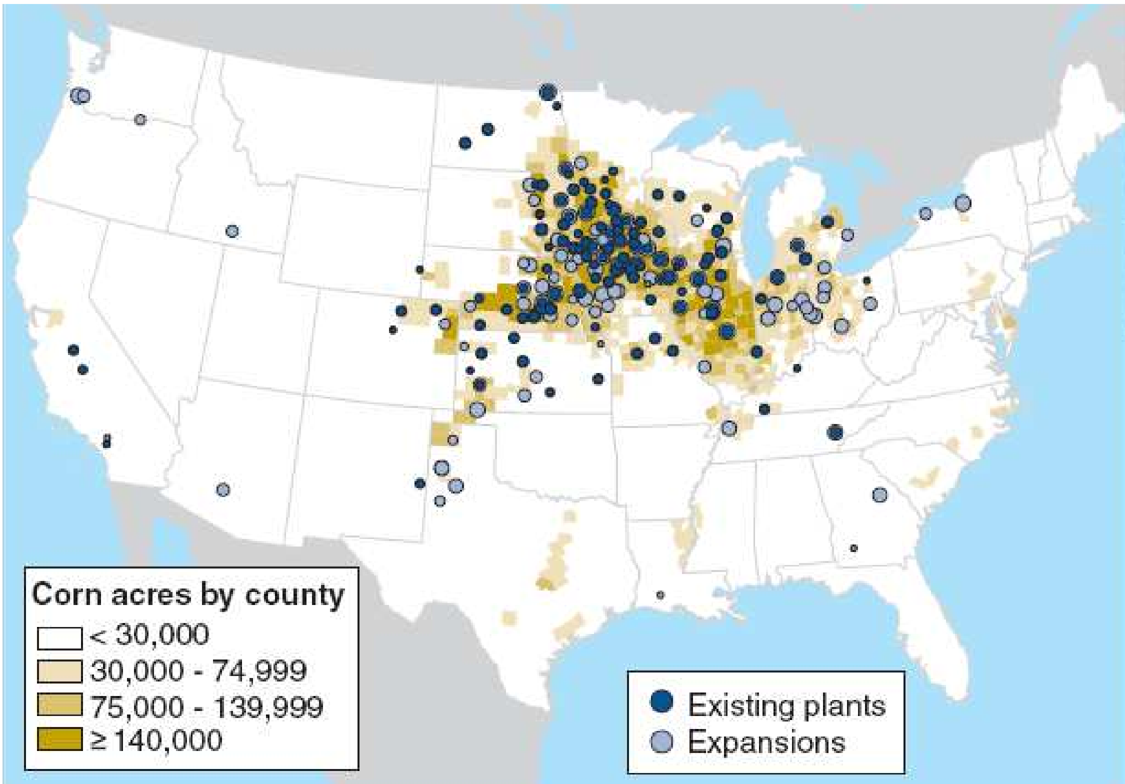


Source: RFA 2007

Such expansion of production is explained by not only the market conditions but also due to a wide range of state and federal incentives and policy factors. The most recent is the Renewable Fuel Standards of 2005 that mandated the use of 7.5 billions of gallons of biofuel by 2012. During the same year, the U.S. became one of the world's leading ethanol producers, generating 44.5% of the global production. It is second only to Brazil, which produces 45.2% of the global total (World Watch 2006).

Ethanol's expansion is directly linked to intensive corn production. According to the USDA's Acreage Report (June 29, 2007), farmers planted nearly 93 million acres of corn this year, an increase of 14 million acres, or 18.6%, from 2006. Based on the same data, much of the 2007 increase in U.S. corn acreage will come from a reduction in soybean plantings, which are down more than 11 million acres (15%) from 2006 (Westcott 2007a). Because of the availability of the feedstock, ethanol plants are geographically concentrated where corn crops are abundant, as seen in Figure 5.

Figure 5: Ethanol plants and corn acreage, April 2007

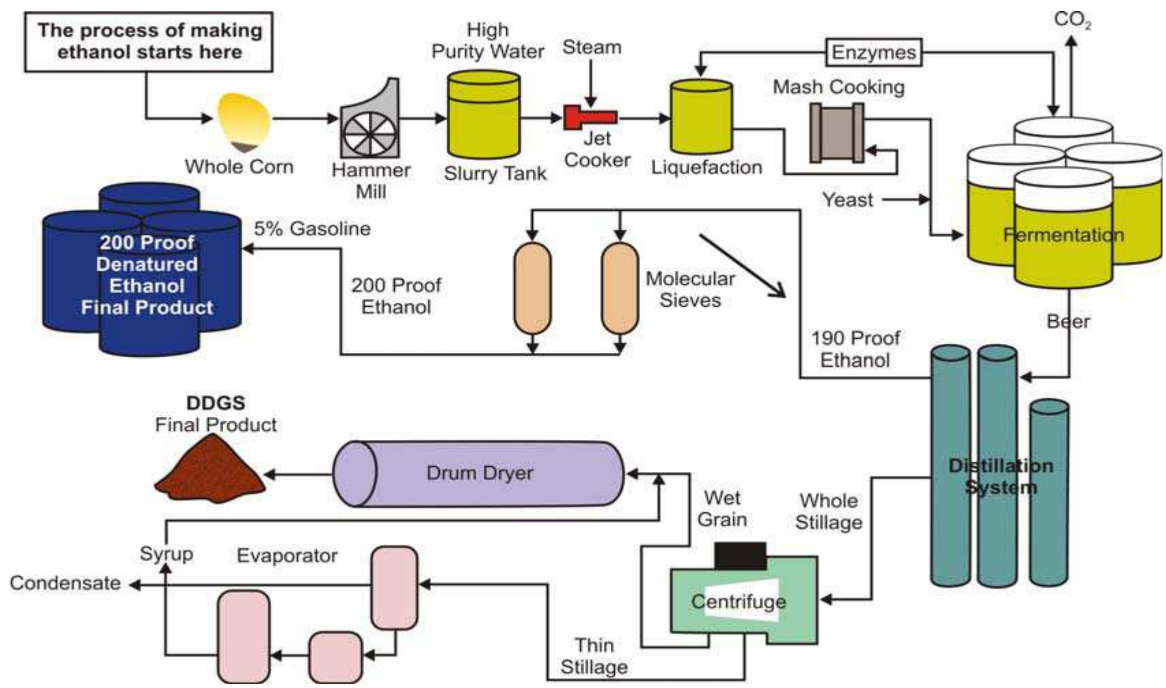


Source: RFA 2007

2.c. Ethanol production process

The figure below illustrates the general process of ethanol production. The raw material first undergoes milling, then liquefaction, fermentation, distillation, and finally dehydration. This results in 200 proof ethanol and byproducts of food-grade carbon dioxide and dried distillers grain with solubles (DDGS) used for livestock feed. DDGS replaces some of the corn and protein supplements ordinarily used in feed. Around 17.4 pounds of DDGS can be made from every bushel of corn (Baker et al. 2007).

Figure 6. General model of ethanol production



Source: NRC 2007

3. Stakeholder analysis

To analyze the economic and environmental impacts of ethanol production on communities across the U.S., a more thorough understanding of stakeholders is essential. Among the principal stakeholders are the following: citizens as final consumers; all the participants in the vertical supply chain of ethanol production; other affected industries; government agencies; oil companies; environmental groups; and automakers. Table 1 summarizes the stakeholders and their respective interests in the industry.

Table 1. Stakeholders affected by the ethanol industry

Stakeholder	Role
Citizens	These are the final consumers of ethanol. Citizens are able to influence governmental agencies and the private sector on future biofuel use through their voting and consuming power.
Ethanol producers up the chain (farmers supplying the feedstock, owners and employees of processing plants, the transport industry, blenders of ethanol and gasoline, and retailers of the product)	The primary motivation of these stakeholders is profit maximization. For example, for corn farmers ethanol plants represent an additional lucrative marketplace for their commodity. At every level of the supply chain, the participants are working to lower input costs and to increase the value of the outputs.

Participants in other affected industries (farmers, processors, and consumers of products indirectly affected by ethanol production, such as soybean and livestock farmers, or users of other corn products)	Because ethanol production takes land out of other productive uses, and tends to raise the price of corn, many other industries are impacted. Additionally, in the process of ethanol production, valuable co-products are generated. Their availability has resonant effects on the participants in those manufacturing sectors.
All levels of government (USDA, EPA, DOE, state and local governments, etc.)	Government policies set the course for ethanol production. Government agencies formulate, implement and enforce policy. (Section 5 describes the extent of government support at every level – national, state, and local - for the industry, and the industry's reliance on that support.)
Oil companies	Oil companies may be seen as competitors to ethanol producers for transportation fuel; in reality, the two are closely allied. Currently, ethanol is used primarily as an additive to gasoline. While this displaces some gasoline, both benefit from higher gasoline prices.
Non-profit organizations	Non-profit organizations interested in ethanol production largely fall within two groups: ethanol proponents and anti-ethanol groups. Pro-ethanol industry associations promote unobstructed ethanol production by emphasizing the positive economic impacts of increased production and the greenhouse gas benefits of ethanol relative to gasoline. Opponents include environmental groups, which publicize negative externalities of increased ethanol production including land conversion, pesticide use, stress on water supplies, and other pertinent issues. They are joined by groups concerned about increases in the price of corn and how that affects food, feed and other agricultural commodity prices.
Automakers	Automakers may be affected by any policies designed to support ethanol use. For example, standard automobile engines are not currently able to utilize fuel blended with anything more than 10% ethanol.

As is the case with many political issues deciding the fate of financially affected sectors, many of these stakeholders lobby on behalf of their interest. The current political situation pins corn farmers and ethanol plant owners against a surprising alliance between food industry groups and environmentalists. The food industry groups contend that higher corn prices increase other food prices adversely impacting their clients. The environmentalists, on the other hand, decry the environmental impacts of intensified corn production. This issue is at the crux of the Congressional debate on the new energy bill (Simon 2007).

4. National issues

Ethanol production is truly a national issue. While it is continuing to expand in the traditional corn-belt states, enthusiasm for it has spread to all corners of the country with plants under construction or operating in California, Oregon, Washington, Louisiana, Georgia, Texas, and New York. Over half of all states have ethanol plants (RFA 2007a). Ethanol is shipped and used throughout the country, sometimes very far from where it is produced; only five states - Iowa, Illinois, Minnesota, Nebraska, and South

Dakota - produce 80% of the total capacity (Parcell & Westhoff 2006). The largest ethanol market in the country is California (Schlatter 2006). Table 2 provides an overview of the existing and expanded capacity, total ethanol fuel-use and total ethanol used in gasohol.

Table 2. Extant and expected ethanol capacity by state, 2004

State	Existing Capacity*	Expanded Capacity	Total Ethanol Fuel-Use (millions of gallons) 2004**	Total Ethanol Used in Gasohol (millions of gallons) 2004***
AL	-	-	313,837	14,986
AK	-	-	3,209	2,634
AZ	55	-	-	13,020
AR	-	-	-	-
CA	121.5	233	15,779,408	588,743
CO	85	40	840,135	82,970
CT	-	-	1,590,629	20,478
DE	-	-	-	-
DC	-	-	-	-
FL	-	-	552	-
GA	.2	200	-	-
HI	-	-	-	-
IA	1252.5	1210	1,167,313	104,391
ID	4	90		-
IL	1515	1182.5	4,215,207	385,054
IN	292	393	1,480,385	131,143
KS	206.5	405	43,295	40,820
KY	38.4	57.4	302,696	57,484
LA	15.5	-	1,793	46,732
MA	-	-	-	857
ME	-	-	-	-
MD	-	-	3,033	231
MI	214	50	-	151,418
MN	528.1	295	2,766,931	275,210
MO	65	40	1,220,178	88,260
MS	-	60	-	-
MT	-	-	18,898	1,228
ND	320.5	-	105,022	11,133
NE	1249.5	1116	371,983	37,155
NM	30	-	64,975	6,027
NV	-	-	466,421	42,103
NH	-	-	-	-
NJ	-	-	-	1,056

NC	-	-	1,795	85,932
NY	-	264	-	22,440
OH	-	224	1,916,299	183,722
OK	-	-	-	-
OR	35	108	-	25,952
PA	-	200	-	6,673
RI	-	-	-	459
SC	-	-	-	-
SD	1761	1318	239,001	23,912
TN	67	138	-	-
TX		584	332,940	22,924
UT	-	-	-	3,129
VT	-	-	-	-
VA	-	-	32	79,725
WA	55	-	4,785	66,274
WI	278	322	1,085,639	107,877
WY	5	-	-	-
WV	-	-	12,660	16,783

Sources: * ACE 2007, ** RFA 2006, *** FHWA 2003

Although local communities are likely to feel the immediate effects of the recent ethanol boom, the overall impacts are inevitably national. Section 3 outlined the depth and breadth of stakeholder involvement.

Section 6, Economic activity, includes an analysis of the industry and its nation-wide economic impacts. The contribution of the industry to the total gross output is over $30 billion, and the direct and indirect jobs created just in 2005 numbered 6,500 (Urbanchuk 2006). Because of the ongoing expansion of the industry, feedstock inputs (mostly corn) are bought not just from local suppliers, but also from distant producers. Increased prices have contributed to rising farmland values, which rose by 67% from 2007 to 2003 (USDA 2007b). The products – ethanol, DDGS, and carbon dioxide – are marketed to every corner of the country.

The primary obstacles to continued expansion are directly connected to the nation's distribution capacity. There is also concern that rising grain prices stimulated by new demand for corn will impact other food prices, potentially affecting families countrywide. Extensive federal and state subsidies provided to the industry impact every tax-paying worker in the U.S. Finally, the environmental losses and benefits stemming from the government's energy policy will be felt nationally. All of these issues are deal with in the report separately.

5. Government relations: support

As was alluded to in Section 4 on national issues, ethanol would not be cost-competitive with gasoline if it weren't for government support. This section examines this relationship by first considering the industry's reliance on subsidies, then by summarizing national, state and local support structures and finally analyzing the distribution of benefits from the subsidies.

5.a. Reliance on subsidies

Whether or not ethanol is currently cost-competitive with gasoline is not a debate. It is widely agreed that under current technological processes and gasoline prices, ethanol production is not a cost-competitive alternative. Exactly how far ethanol falls short is not clear. One study cites that ethanol costs $0.50 more per gallon to produce than petroleum (Saitone 2007). Another study phrases the discrepancy differently. It finds that while the production cost of ethanol was $0.46 per energy equivalent liter (EEL) of gasoline, the price of gasoline was $0.44 per EEL in 2005. Without even considering making a profit, ethanol's production costs are greater than the entire price of gasoline (Hill 2006). This breakdown may shift as oil prices continue their ascent.

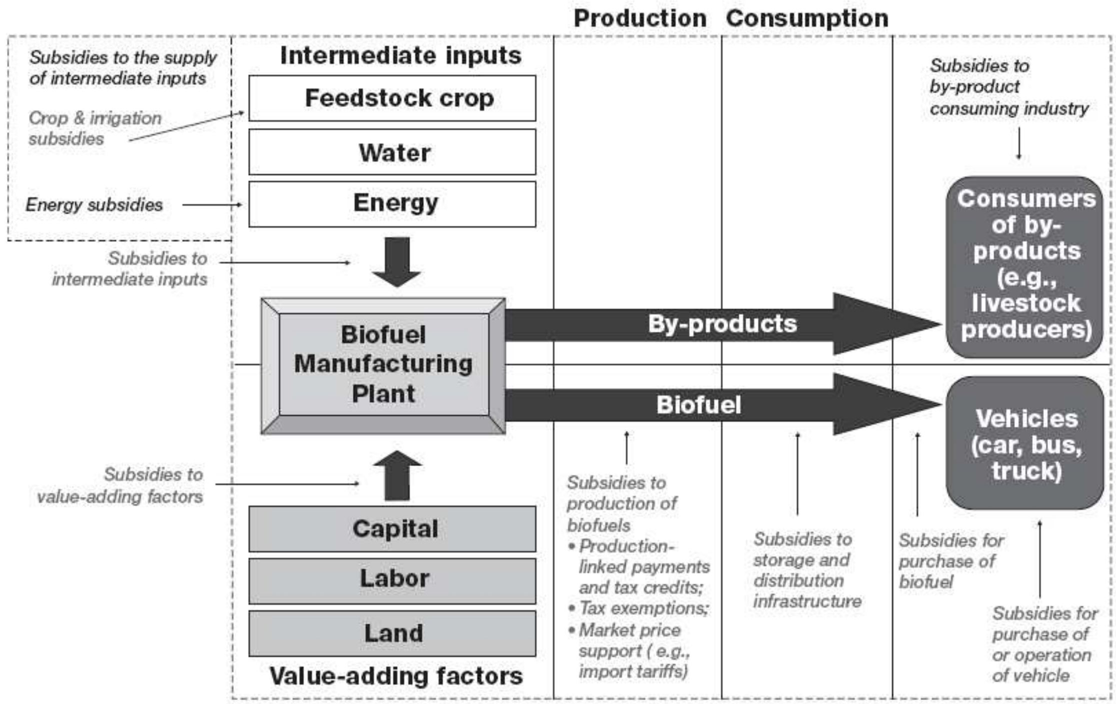
The industry freely acknowledges its reliance on the government support programs. Pacific Ethanol's filed prospectus states that "the production of ethanol is made significantly more competitive by federal tax incentives." The company further describes that the elimination of the largest programs, such as the Federal Excise Tax Credit and the Renewable Fuels Standards minimum level mandates, would have a grave material impact on the company's operations (Pacific Ethanol, Inc 2006). VeraSun Energy Corporation, the third largest producer of ethanol in the U.S. similarly acknowledged its dependency on subsidies. In its statement to the U.S. Securities and Exchange Commission the company wrote that the "U.S. ethanol industry is highly dependent upon a myriad of federal and state legislation and regulation and any changes in legislation or regulation could materially and adversely affect our results of operations and financial position" (VeraSun 2006).

Considering that federal, state and local subsidies amount to $5.1-6.8 billion annually (Koplow 2006), this reliance is not surprising. The sections below outline the subsidies available and consider the distributional impacts of this extensive support structure.

5.a.1. Summary of subsidies available

The availability of subsidies and other supportive mechanisms from federal, state, and local governments is expansive. A broad mix of policy tools is utilized and includes grants, tax breaks, lending and credit enhancement programs, regulatory mandates, funding for research and development, and direct payments. Producers can tap into subsidies at almost every point of the ethanol production process, and often several sources of support are available for each level (Koplow 2007). Figure 7 illustrates the types of subsidies provided at various stages of the biofuel supply chain.

Figure 7. Subsidies available for biofuel production and consumption



Source: Koplow 2007

The largest subsidies are provided to producers of feedstock crops, in most cases corn. Other subsidies lower the cost of building manufacturing plants by providing land for free or at a reduced cost, or by providing infrastructure support. Tax credits paid to blenders of gasoline and fuel support the actual output of the production process – ethanol, in this case. Price support for the ethanol product also comes in the form of tariffs. Finally, consumption of ethanol is buttressed by the renewable fuel standards and mandates for using ethanol-gasoline blends.

The stage is set through market price supports that act to suppress the price of domestic ethanol. These come in the form of tariffs and consumption level requirements, guaranteeing a baseline market for the commodity. The current tariff is $0.54/gallon and is applied to most countries' ethanol exports. Domestically produced ethanol is protected from foreign competition. The Federal Renewable Fuels Standards mandate that four billion gallons of renewable fuels is consumed by 2006, 7.5 billion by 2012, and potentially 36 billion by 2022, although only 15 billion gallons will come from corn (Goodell 2007).

Some states have their own requirements. Minnesota requires that gasoline sold in the state contain 20% ethanol by 2013. Iowa recently instituted a target to substitute 25% of its petroleum use with biofuels. Hawaii, Washington, Montana, Louisiana, and Missouri also passed mandates.

Corn production is one of the heaviest subsidized activities in the country. The average annual payment during 2000-2004 to crop producers was $4.5 billion. This number more than doubled to $9.4 billion in 2005. Based on the share of total corn used for ethanol production, between $820 and $1.4 billion went to support this point of the ethanol supply chain. It should be noted that more than 80% of the corn subsidy is captured by 10 states that have the largest ethanol capacity (Koplow 2006).

The development of production facilities and supporting infrastructures is subsidized through a variety of tools. Accelerated depreciation rates allow corporations to obtain higher than normal taxable income deductions and reach around $220 million annually. There are capital grants available to help finance production plants. Credit subsides in the form of loan guarantees, subsidized loans and tax-exempt bonds are utilized as well. There are property-tax abetments and exemptions, which are applied to purchasing equipment related to biofuel production. The government also provides incentives to develop biofuel-related demonstration projects and to encourage research and development. These grants and subsidies amount to $465 million per year. Finally, there are measures to encourage farmer co-operative ownership structure of biofuel plants. These allow private owners of biofuel facilities to sell to farmer cooperatives without immediately incurring a capital gains tax on the sale and cost around $20 million annually (Koplow 2006).

Consumption of the product is also mediated by government subsidies. Distributing ethanol to the public requires E85 pumps and the related tanks and equipment. Federal and local financial incentives can help pay for the required infrastructure by providing tax credits and other support structures. These subsidies range from $10-14 million in annual payments (Koplow 2006).

The most significant federal and state-support programs are aimed at encouraging higher levels of ethanol production. The Volumetric Ethanol Excise Tax Credit (VEETC) enacted in 2004 provides a tax credit to ethanol blenders. This is a limitless subsidy, awarded for every gallon of ethanol, and consists of a $0.51 credit per gallon of ethanol blended with gasoline (CFDC 2007). The total annual support from VEETC ranges from over $3 billion to $4.3 billion. Although discontinued in 2006, the USDA Bioenergy Program made a significant contribution to promote greater production levels. Between 2001 and 2005, payments for additional gallon of ethanol extended from $0.12 to $0.30 per gallon. The average annual payments reached $75 million. Some states allow a favorable tax rate for biofuels, which amounts to around $180 million in annual support. There are multiple state incentives available to blenders and retainers. This subsidy is estimated at an annual $121 million. Finally, the Federal Small Producer Tax Credit can be used by facilities producing less than 60 MGY. The credit is in the form of a $0.10 per gallon tax credit for the first 15 million gallons, and is effectively capped at $1.5 million per plant. Approximately $130 million per year total is available from this subsidy (Koplow 2006).

Table 3 provides a summary of the available subsidies and estimates the low and high annual values of the programs.

Table 3. Total annual value of federal, state, and local subsidies

	Millions of USD	
	Low	**High***
Market Price Support (Tariffs and Renewable Fuel Standards)	$1,188	$1,620
Input Support (corn subsidies)	$820	$1,368
Factors of Production Support		
Excess of accelerated over cost depletion	$220	$220
Federal grants, demonstration projects, R&D	$465	$465
Deferral of gain on sale of farm refineries to cooperatives	$20	$20
Consumption Support		
Credits and expensing for clean fueled vehicles and refueling infrastructure	$10	$14
Output Support (for ethanol)		
Volumetric Excise Tax Credit	$3,050	$4,365

	Millions of USD	
	Low	High*
USDA Bioenergy Program	$75	$75
Reductions in state motor fuel taxes	$180	$180
State production, blender, and retailer incentives	$121	$121
Federal small producer tax credit	$130	$130
2006 Estimate**	$5,123	$6,782
* The different between high and low estimates is in the inclusion of outlay equivalent value[1] for tax breaks in the high value, when appropriate		
**The cost of each program is an average value of a number of years.		
The 2006 estimate is lower than the total sum because it includes costs just for the year		

Source: Koplow 2006.

Another category of government support concerns regulatory exemptions. Some states allow ethanol facilities to forego some otherwise necessary regulatory requirements. For example, ethanol plants with a production capacity of less than 125 MGY are not required to conduct an environmental impact assessment in Minnesota. Nebraska allows publicly owned plants to exercise the power of eminent domain, which seizes private land to construct the production facility.

Some plants have used the available subsidies to the full extent. For example, owners of a plant in Ohio were able to secure 60% of the total capital needs through government-backed credits or grants. This $71 million, 20 MGY facility received public support through: a $500,000 USDA grant; $600,000 in Appalachian Regional Commission grants; $40,000 in training funds from the Ohio Department of Development; $400,000 in 629 Roadwork Development funds from the Ohio Department of Development; a $7 million Ohio Water Development Authority loan; a $600,000 Rural Pioneer loan; and over $36 million in Ohio Air Quality Development Authority Revenue Bonds. Although this is not a typical situation – the plant is situated on a former coal mine in an underdeveloped region of Ohio – this case highlights the extensive nature of available subsidies (Koplow 2006).

The current wave of major subsidies targets research and development in the industry and focuses on the expansion of cellulosic ethanol production. In 2007, the U.S. Department of Energy invested more than $1 billion to promote biofuels research and development. The subsidy includes $385 million for building six commercial-sized cellulosic ethanol plants, $375 million to establish three biofuels research facilities, and $200 million for pilot biorefineries (Ebert 2007).

The subsidies and other incentives vary from state to state and locality to locality. Table 4 summarized what types of incentives are available in which states.

Table 4. Incentives for ethanol production

Type of Incentive	States
Producer Production Incentives	Alaska, California, Florida, Iowa, Maine, Nebraska, Ohio

[1] Outlay equivalent value estimates the value of the subsidy to the recipient

Government renewable-fuel vehicle purchase mandates	Illinois, Indiana, Maryland, Minnesota, Mississippi, Missouri, Montana, Nebraska, North Dakota, Oklahoma, Pennsylvania, Texas, Virginia, Wisconsin, and Wyoming
Subsidies related to capital investment	Illionois, Iowa, Kentucky, Minnesota, Montana, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Oregon, Utah, Washington, Arkansas, Indiana, Missouri, Nebraska, Oregon, California, Hawaii, New Jersey
Subsidies to inputs	Arkansas, Minnesota, Iowa, Nebraska, New Mexico, New York, North Carolina, Ohio, Oregon, Virginia, Wisconsin, Colorado, Nevada, Illinois, California, Hawaii, Missouri, Montana, Washington
Research, development, demonstration and market promotion	Illinois, New York, Oklahoma, Minnesota, Nebraska
Consumption subsidies	North Carolina
Infrastructure-related subsidies	Colorado, Illinois, Indiana, Iowa, Kansas, Kentucky, Maine, Minnesota, New Jersey, Montana, North Carolina, Ohio, Oregon, Tennessee
Subsidies to biofuel-using capital (includes mandates for biofuel use)	Colorado, Georgia, Kansas, West Virginia

Source: Koplow 2006

Besides the obvious advantages of abundant local corn and extant (and in most cases upgraded) municipal utilities and infrastructure, the team encountered several different incentives and financing vehicles used by ethanol plants during their interviews. Some towns encourage development by establishing enterprise zones. The Hawkeye Renewables ethanol plant in Iowa Falls, IA enjoys Enterprise Zone benefits (Deimerly 2007). In Iowa, the Enterprise Zone program was established to encourage locating or expanding facilities in economically depressed areas of the state. Benefits include the following:

- "A local property tax exemption on the value added to the property.
- Additional funding for training new employees. If applicable, these funds would be in addition to those authorized under the Iowa New Jobs Training Program.
- A refund of state sales, service, or use taxes paid to contractors or subcontractors during construction.
- An investment tax credit of up to a maximum of 10% of the new investment in machinery and equipment, land, buildings, and improvements to existing buildings. This Iowa tax credit may be carried forward for up to seven years or until depleted.
- An additional research and development tax credit of up to 6.5%, which may be refundable. This Iowa tax credit is based on increasing research activities within the state and is available while the business is participating in the program for up to 10 years." (Chamber and Development Council of Crawford County 2007)

The Amaizing Grain plant was built in an enterprise zone in Denison, IA. In addition to the benefits above, the Amaizing Grain plant enjoys a refund in sales and use taxes for ten years at a rate of 100% for the first five years, then 90% and 75% over the course of the second five years (Jentz and Luensmann

2007). Hawkeye Renewables benefits from Enterprise Zone benefits as well as TIF financing (Deimerly 2007).

Tax Incremented Financing (TIF) zones are another popular financing mechanism. In Illinois,

> "Tax increment financing is a financing technique that cities may use to pay for public improvements such as land assemblage, building demolition, utilities, streets, and sidewalks. Property owners in the project area do pay their full share of taxes. Taxes generated by the increase in assessed valuation – the tax increment - go into a special allocation fund used to pay the bonds which financed the public improvement costs. This financing method is not a tool to speculatively prepare for development - tax increment financing requires an advance commitment by a developer to a project (illinoisbiz.biz)."

The town of Lena, IL, the site of the Adkins Energy ethanol plant, established two TIF Districts within Village boundaries in the year 2000. A further attempt is being made to make one of the TIF areas also available for Enterprise Zone benefits (villageoflena.com 2007). During their first five years in operation, 90% of their property taxes are placed in a TIF Fund. Over the next 18 years, they will give decreasing percentages of taxes as the years pass. The village will then use that money for any infrastructure needs. Before the plant came to Lena, the site was farmland, so the increase in assessed value of the site due to the plant's presence has led to over $300,000 invested in Lena's TIF fund (Buchenau 2007) (which is a lot of money in the budget of a town 0f 2,800 people).

In Michigan, special financing mechanisms in the Agriculture Renaissance Zone funnel a considerable amount of money from the state to the plants for construction. In one of these zones, Albion Township gave The Andersons ethanol plant forgiveness of their state and local business and property taxes for 15 years (Hennon 2007).

Bushmills Ethanol in Atwater, MN benefits from the Minnesota Job Opportunity Building Zone (JOBZ) program. Established the in 2002, the program exempts "corporate franchise tax; income tax for operators or investors, including capital gains tax; sales tax on goods and services used in the zone if the goods and services were purchased during the duration of the zone; property tax on commercial and industrial improvements but not on land… and; employment tax credit for high paying jobs" (Minnesota Department of Employment and Economic Development 2005) until 2016. Bushmills apparently also received a $5 million loan from Kandyohi County (Renquist 2007).

Red Trail Energy, LLC, in Richardton, ND benefits from a graduated exemption of their property taxes. The exemption is eased by 25% within four years. The first year the exemption is 100%, the following year it is 75%, the third is at 50% and the last year the exemption reaches 25% (Bryans 2007).

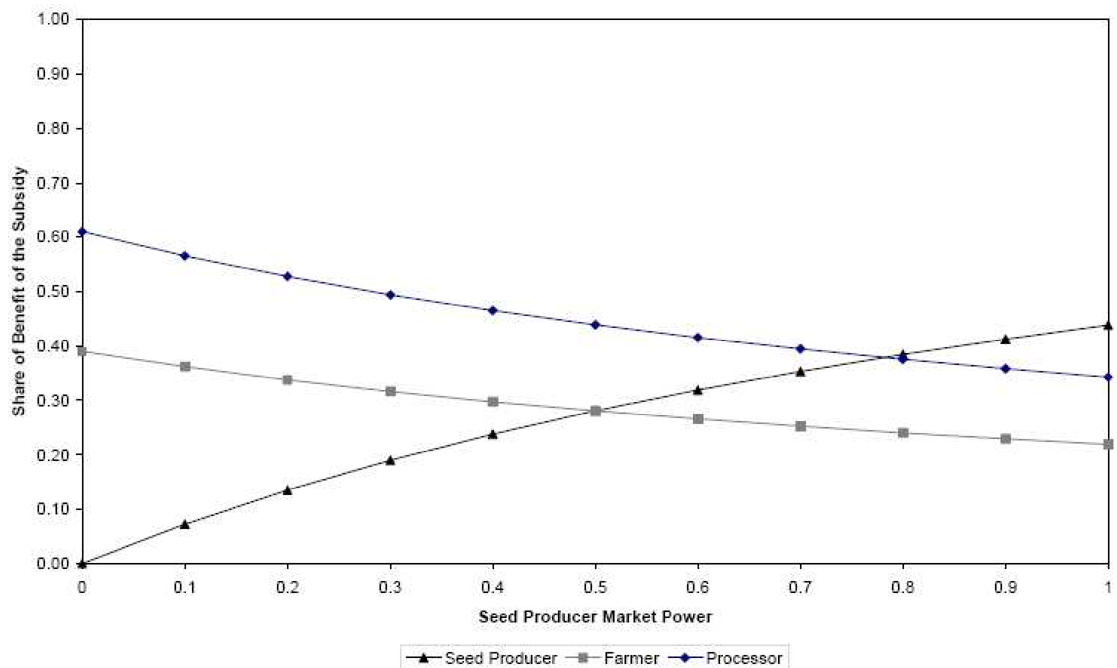
The variety and extent of subsidies allow nearly every ethanol plant to dip into government support. The complex mix of policy tools has interesting implications for ethanol producers along the entire production chain, especially how the benefits are distributed among the different players.

5.b. Distributional impacts of subsidies

The distributional impacts of subsidies are subject of much study. One deciding component is the concentration of market power among the different points of ethanol supply chain. As was discussed in Section 6, Economic activity, the ethanol production point is highly concentrated, with ten firms producing 60% of the output. Ethanol marketing is even more concentrated, with eight firms controlling 90% of the market. Seed producers who control the underlying inputs of corn production are also highly concentrated. Just four firms – DuPont, Monsanto, Novartis, and Dow – sell 69% of all corn seed in the United States (Saitone 2007).

A study done by the University of California, Davis looked at the distributional effects of market power. It found that ethanol processors capture around 60% of the subsidies benefits, while farmers receive the other 40%. When seed producers have oligopoly power and are incorporated into the model, they may obtain significant portions of the subsidy, at the expense of other participants. This is visualized in Figure 8.

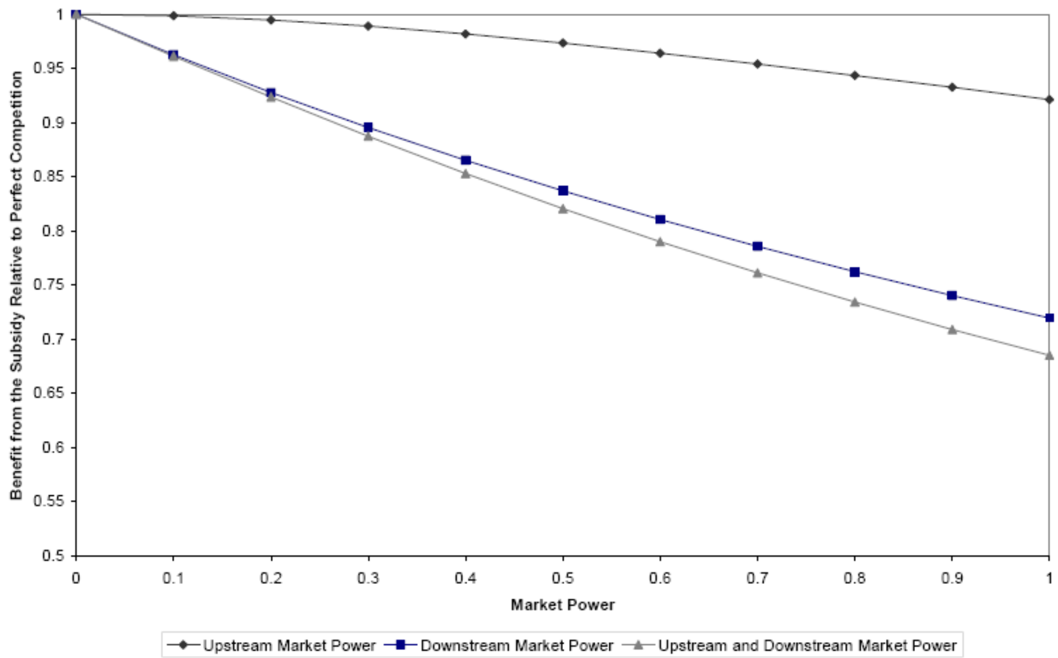
Figure 8. Share of benefits of the subsidy going to farmers and corn processors under seed producer oligopoly power



Source: Saitone 2007

In fact, market power does determine how much is captured by each participant, and as market power increases for each production point, overall benefits from the subsidies are reduced, as pictured in Figure 9. Upstream market power refers to seed producers, such as Monsanto and DuPont. Downstream market power refers to grain processors, such as Archer Daniels Midland and POET.

Figure 9. Reduction in subsidy benefits as market power increases



Source: Saitone 2007

A study done by a University of Maryland researcher found that while corn growers receive substantial benefits from the ethanol VEETC subsidy, ethanol producers receive significantly higher gains in the short term. The study estimates that corn producers get $425 million from the credit and plant owners receive over three times that number. However, in the long-term[2], the trend reverses with corn producers receiving $2,029 million and plant owners $875 million (Gardner 2007). Table 5 summarizes the study's findings.

[2] Long-term here means a 10-year period of adjustment

Table 5. Changes stemming from the VEETC subsidy of $0.51 per gallon

	Short Run		Long Run	
Change in Quantities	Mil. bu.	% change	Mil. bu.	% change
Corn	32	0.3	349	3.2
Corn in ethanol	140	7.2	1,024	71.7
Corn fed/exported	-107	-1.3	-674	-7.2
Changes in Prices	$ per bu. corn	% change	$ per bu. corn	% change
Corn	.04	1.3	.19	6.5
Ethanol	-.42	-8.2	-.37	-7.2
By-Product Feeds	-.01	-1.0	-.15	-2.1
Ethanol Plant	.82	20.7	.59	14.3
Gains from Subsidy	Mil. Dollars	% of P*Q	Mil. Dollars	% of P*Q
Corn producers	425	1.3	2,029	6.8
Ethanol plants	1,588	23.9	875	15.2
Ethanol buyers	818	8.1	553	5.5
By-Product buyers	28	1.4	228	12.1
Corn Feed/Export buyers	-350	-1.3	-1,959	-15.0
Sum	2,510		1,935	
Taxpayers	-2,600		-2,600	
Deadweight Loss	91		665	

Source: Gardner 2007

Notice that the current policy generates a deadweight loss of $91 million in the short run and $665 over the long-term.

Overall, government subsidies for ethanol production at every point of the supply chain are very large. This created a reliance on the scheme by participants on all levels, who receive significant benefits in the short and long-term. The distribution of the benefits depends on the market competitiveness of seed, corn, and ethanol producers.

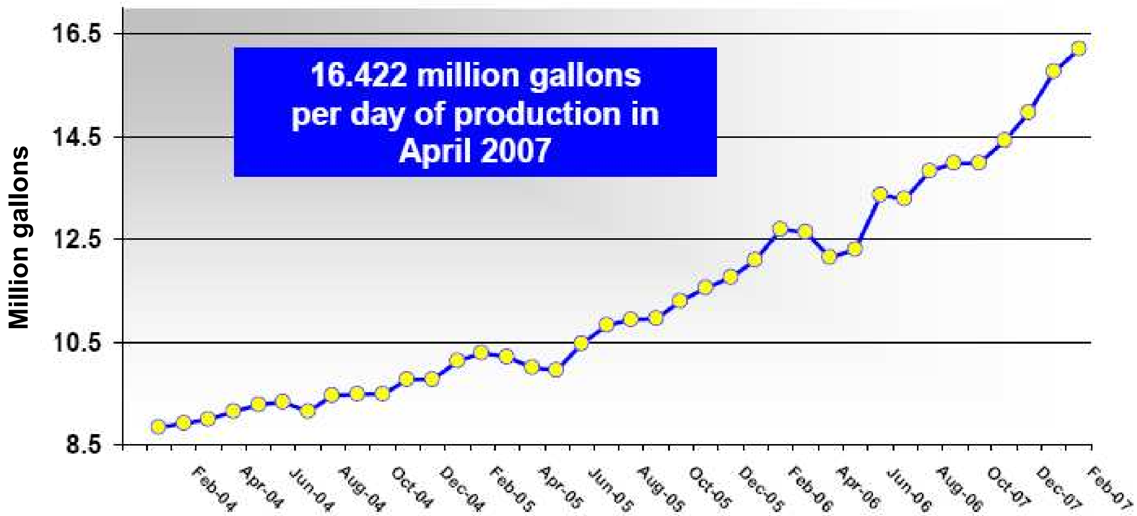
6. Economic activity

Within the current policy framework, the economic impacts of ethanol production are intrinsically linked to crude oil price dynamics, subsidies and foreign tariffs. First, ethanol is blended with gasoline to increase the oxygen content of gasoline, which helps to burn the gasoline molecules more completely. Sold as one product, higher prices of gasoline at the gas pump yielded record profits for the oil companies and have boosted ethanol sales and revenue at the same time. Nearly half of the nation's gasoline contains ethanol (CFDC 2007). Plus, because the most significant subsidies are given to blenders of ethanol and gasoline, ethanol and gasoline production become even more tightly linked to one another. International competition has been kept away by the presence of foreign tariffs, preventing cheaper ethanol from countries like Brazil from entering the domestic prices.

The major economic impacts derived from ethanol production can be divided into two portions. The first is the actual production of the biofuel, and the impacts are related to constructing and operating the plant, as well as distributing and selling the product. The more significant economic contribution is derived from the industry's creation of a new market for corn. In 2007, around 20% of all corn grown in the United States was used in the ethanol production process. This new market, in combination with the actual plant operations, has stimulated corn prices and created potent ripple economic effects for the hosts of ethanol facilities.

These factors assisted by the federal government's enthusiasm and support for ethanol production and subsequent incentives have boosted the economic profitability of constructing ethanol plants. A report commissioned by an industry association called the ethanol industry "one of the most significant success stories in American manufacturing over the past quarter-century" (Urbanchuk 2005). As has been previously discussed, there is an ongoing surge in plant construction and expansions. Figure 10 outlines the trend in monthly daily production from February 2004 to February 2007, which reached nearly 16.5 million gallons per day.

Figure 10. U.S. fuel ethanol monthly daily average production



Source: Ethanol Market 2007

The future potential for continued expansion is very real. More and more Americans are driving with nearly two thirds of the population registered as drivers. Around 141 billion gallons of gasoline are used annually, providing a stable market base for ethanol-gasoline blends (CFDC 2007). The total capacity of the ethanol industry will be around 11.5 billion gallons by 2009 (Elam 2007) and will rise to 15 billion by 2015 (Babcock 2007).

The profits recently reaped by ethanol producers have enticed others onto the playing field. Whether this enthusiasm is justified and for how long ethanol will be a profitable venture remains to be seen. The next section explores what ethanol plants' national and local economic impacts may be. It looks at the economic impacts of ethanol plants stemming from the plant construction, the marketing of its product and co-products, the improved demand for the plant's feedstock, and then examines any opportunity cost effects associated with increased feedstock demand.

6.a. Overall impacts

The major economic impacts derived from ethanol production can be divided into two portions. The first is the actual production of the biofuel and the impacts are related to constructing and operating the plant, as well as distributing and selling the product. The more significant economic contribution, however, is derived from the industry's creation of a new market for corn. In 2007, around 20% of all corn grown in the United States was used in the ethanol production process. This new market, in combination with the actual plant operations, has stimulated corn prices and created potent ripple economic effects for the hosts of ethanol facilities.

The economics of an operational ethanol plant hinges on the cost of its inputs – the feedstock and energy and water costs; plus processing costs – including employment, overhead, taxes; and the market price of ethanol and co-products. Some studies consider the entirety of the impact. These studies often provide data on the national economic impact. As was discussed in Section 4, economic and other impacts of ethanol production stretch beyond regional boundaries. The national economic stimulus is considered in this sub-section.

A large portion of the economic impact of ethanol plants is the local supply of feedstock. In the United States, that feedstock is usually corn. In fact, as of October 2007, fewer than 70 million gallons of ethanol are produced annually with a feedstock other than corn, representing less than 1% of total capacity (RFA 2007a). The major impact of ethanol plants lies in providing another market for the corn. Across the nation, farmers' newfound enthusiasm for biofuels is primarily a response to the sudden increased demand for an extensively grown (and extensively subsidized, as was discussed in Section 5 on government support) commodity.

The economic impact of the ethanol industry is divided into several parts - purchases made, output created and sold; earnings retained, employment created, and taxes contributed to the state and local budgets. All of these pertain to various phases of ethanol production, starting from the initial construction to the economic stimulus provided during annual operations. According to a report paid for by an industry association, the overall market value of the industry's production (counting commodity taxes, and intermediate goods and services, also known as gross output), including annual operations and new plants being constructed was valued at $25.1 billion in 2004. This economic stimulus helped support 147,206 jobs; added $1.3 billion of tax revenue for the federal budget and $1.2 billion for state and local governments; and reduced the U.S. trade deficit by $5.1 billion (representing less than 1% of the total U.S. trade deficit). In 2005, the picture improved even more. The contribution to the gross output rose by nearly 30% to reach $32.2 billion. The number of jobs supported increased by over 6,500; and $1.9 billion of tax revenue was added to the federal budget and $1.6 billion for local and state governments (Urbanchuk 2005; Urbanchuk 2006).

Tables 6 and 7 summarize the economic impacts purportedly received from the ethanol industry for years 2004 and 2005.

Table 6. Economic impact of ethanol industry in 2004

Industry	Purchases (Mil 2004$)	Impact Output (Mil 2004$)	Impact Earnings (Mil 2004$)	Impact Employment (Jobs)
Construction	$1,055.6	$3,545.2	$1,074.0	32,363
Plus initial changes		$1,055.6		
Total		**$4,600.8**	**$1,074.0**	**32,363**
Annual Operations				
Feed Grains (Corn)	$3,087.0	$8,514.3	$1,997.0	85,311
Industrial chemicals	$406.7	$1,228.1	$292.4	7,106
Electric	$133.0	$310.6	$68.7	1,677
Natural gas	$907.1	$3,011.9	$523.7	13,192
Water and water treatment	$34.7	$102.8	$27.4	779
Maintenance and repair	$80.0	$253.7	$80.1	2,483
Business Services	$56.0	$107.2	$35.4	670
Earnings paid to households	$173.0	$375.2	$105.7	3,626
Subtotal	**$4,877.5**	**$13,903.7**	**$3,130.4**	**114,844**
Plus initial changes:				
Value of ethanol production		$5,456.0	$173.0	
Value of co-products		$1,143.9		
Total Annual Operations		**$20,503.6**	**$3,303.4**	**114,844**
Grand Total		**$25,104.4**	**$4,377.4**	**147,206**

Source: Urbanchuk 2005

Table 7. Economic impact of ethanol industry in 2005

Industry	Spending (Mil 2005$)	Impact Output (Mil 2005$)	Impact Earnings (Mil 2005$)	Impact Employment (Jobs)
Construction	$2,433.2	$8,328.8	$2,560.0	65,842
Plus initial changes		$2,433.2		
Total		**$10,762.0**	**$2,560.0**	**65,842**
Annual Operations				
Farm Products/Agriculture	$2,901.3	$8,020.3	$1,531.0	52,095
Industrial chemicals	$361.4	$1,211.2	$256.6	5,481
Electric, natural gas, water	$1,374.8	$4,390.1	$800.7	20,976
Maintenance and repair	$82.6	$219.0	$77.9	2,227
Business Services	$103.1	$292.3	$103.2	2,460
Earnings paid to households	$251.9	$586.9	$163.1	4,643
Subtotal	**$5,075.0**	**$14,719.8**	**$2,932.5**	**87,883**
Plus initial changes:				
Value of ethanol production		$5,467.5	$251.9	
Value of co-products		$1,244.0		
Total Annual Operations		**$21,431.2**	**$3,184.4**	**87,883**

Source: Urbanchuk 2006

The private sector has invested over $10 billion in ethanol production facilities. If the optimistic estimates for future growth hold, the total investment is expected to be $40 billion by 2009 (CFDC 2007).

6.b. Local impacts

The previous section summarized what the nationwide economic contribution of the ethanol industry may be. But the currently operating 130 plants (RFA 2007b) are located mostly in small communities, where the capital expenditure required to construct an ethanol plant may be one of the most significant investments in the area. In fact, for 124 [3] communities with an ethanol plant, on average the median household income was nearly 25% lower than the state's figure. Less than 1% of these communities had an income higher than the state's average (city-data 2007).

As was mentioned previously, over 80% of total US ethanol capacity is generated in just five states – Iowa, Illinois, Minnesota, Nebraska, and South Dakota - although 26 states are home to at least one plant (Parcell & Westhoff 2006, RFA 2007b).

The economic impacts of an average 50 MGY and 100 MGY plant are summarized in Table 8. Because of the economies of scale, the effects of a 100 MGY plant are somewhat less than twice that of a 50 MGY plant.

Table 8. Annual economic impact of ethanol plants of different capacities

	50 MGY	100 MGY
Annual Expenditures (Mil 2005 $)	$46.7	$88.2
Gross Output (Mil 2005 $)	$209.2	$406.2
GSP (Mil 2005 $)	$115.0	$223.4
Household Income (Mil 2005 $)	$29.7	$51.2

Source: Urbanchuk 2006

The rise in economic activity and availability of new jobs contributes to higher levels of income. An operational 50 MGY ethanol plant is estimated to add $30 million to the local economy on an annual basis. A 100 MGY plant will contribute $50 million annually (Urbanchuk 2006).

All towns experienced a surge in temporary employment during the construction phase of the plants that the team contacted for interviews. Albion, MI brought in workers from out of state for a year to pour cement 24 hours a day (Hennon 2007). Plants required anywhere from 100 to 325 personnel during the peak construction. For towns with populations of just several hundred people, this has a big positive effect on the local economy.

A study on the economic impacts of South Dakota's ten ethanol plants was completed in 2004. It accounted for the differences in plant capacity and economies and scale, availability of local feedstock, and three multiplier effects. One multiplier considered is the output multiplier, which represents the change in the economy stimulated from delivering one dollar of additional 100% ethanol to the market.

[3] Data was available for 124 communities, although the actual number of plants is higher.

Another multiplier is the value-added impact, and the third is employment created. Each multiplier includes direct, indirect, and induced effects.[4] In total, the study found that plants in South Dakota generated over a billion dollars in total output, generated over a quarter of a billion dollars in new wealth (i.e. value-added), and stimulated the creation of nearly three thousand jobs. Table 9 breaks down those numbers into direct, indirect, and induced tiers. Notice that because $4.75 million was given away in state subsidies, this figure is subtracted from the value-added wealth (Stuefen 2005).

Table 9. Economic contribution of ethanol plants to South Dakota's economy

	Total Output (millions)	**Value-Added (millions)**	**Employment**
Direct	675.500	64.375	472.9
Indirect	301.839	144.827	1,756.3
Induced	77.230	46.002	743.1
Total	**1,055.398**	**250.454***	**2972.2**

*This number reflects the costs of a $4.75 million state subsidy
Source: Stuefen 2005

The size of the economic contribution is tied to growing the feedstock locally. However, unless the plant is a cooperative to which farmer-investors are contractually obligated to provide corn, there is no way of knowing exactly how much local or regional corn is going to a plant. However, it makes simple economic sense for plants which are not owned by cooperatives to buy corn locally or regionally because using local corn immediately cuts the cost of that corn by a minimum of $0.10 per bushel, which adds up quickly to plants purchasing hundreds of thousands of bushels of corn a year (Lindenmier 2007). Aventine Renewable Energy in Pekin, IL, continually purchases corn from local farmers and elevators using forward physical contracts. They do occasionally bring corn in by rail to keep the local farmers honest (Nelson 2007). "Local" usually equates to the surrounding seven or eight counties or a maximum of 50 miles (though it is often less than that).

Increased employment is a big deal for many communities hosting ethanol plants. An ethanol plant creates opportunities for blue- and white-collar workers. The nationwide average annual salary is estimated at $43,000 (Parcell & Westhoff 2006). A survey by the Nebraska Ethanol Board found that in the state, the average ethanol-related salary was around $49,000 in 2006. This is 43% higher than Nebraska's average of $34,300 (Nebraska Ethanol Board 2007).

Other surveys found high job satisfaction within the industry. One indicated that 79% of respondents have a high level of satisfaction with their job. Corporate managers achieved an average rating of 4.6 on a 5-point satisfaction scale. Tenure was found to be stable with 75% of respondents working at the plant for the last five to seven years. Over 20% have been with the same plant for 10 years or more (Bryan 2006).

A plant's contribution to the local economy can be considerable. Studies have found that depending on the plant's size and location, the indirect employment effects of each plant is between $25 million and $282 million. Taking capacity into account, the total labor income effect is estimated to be between $0.10 per gallon and $0.50 per gallon (Parcell & Westhoff 2006). For a 100 MGY plant, this contribution would amount to $50 million.

[4] The initial response is the direct effect, and any secondary inter-industry responses are the indirect effects. Induced effects stem from changes in overall income as a result of producing the extra ethanol.

Moreover, as incomes in the community grow because of greater employment, other economic sectors are stimulated, leading to increases in jobs there. An Iowa State researcher estimated that every 40-employee ethanol plant adds 155 total jobs to the local economy (Parcell & Westhoff 2006).

6.c. Type of ownership and competition

Although the 203 plants currently operating or being constructed are owned by 125 different companies (RFA 2007a) nearly 60% of the market is supplied by 10 largest producers. Table 10 summarizes the market share distribution and ownership type for these market leaders.

Table 10. Ten largest ethanol producers

Rank	Producer	Capacity, October 2007 (MGY)	Market Share	Ownership Type
1.	POET	1100	16%	Private
2.	Archer Daniels Midland	1070	15%	Public
3.	VeraSun	560	8%	Public
4.	US Bio Energy	300	4%	Public
5.	Hawkeye Energy Holdings	220	3%	Private
6.	Aventine Renewable Energy, Inc	207	3%	Public
7.	Abengoa Bioenergy	198	3%	Private
8.	The Andersons	165	2%	Public
9.	Ag Processings	152	2%	Public
10.	Cargill	120	2%	Private

Source: RFA 2007a

The biofuel industry has attracted some big-name investors. Microsoft founder Bill Gates and Richard Branson, the founder of the British multinational corporation Virgin Group, are investors in the sector (CFDC 2007).

6.c.1. Ownership

Although ethanol plant ownership by farmers and small companies is still widespread, the industry is undergoing consolidation (Ethanol Statistics 2007). Currently, farmers own about 40% of the ethanol plants in the United States. But corporations are involved in the merger, acquisition, and expansion of ethanol capacity and are increasing their market share in the process (Haarlander 2007). According to the USDA, nearly 90% of the capacity recently completed or undergoing construction is not farmer owned (Borst 2006). Supporters of the trend contend that outside investors are necessary to fully realize biofuel potential, while opponents insist that local ownership keeps more money in the community and keeps the focus of the enterprise long-term.

The cooperative ownership structure usually involves several hundred partners and is often organized as limited liability companies (LLCs) which enable a favorable “partnership” tax arrangement. Other co-operatives allow outside investors (NCGA 2007). Farmers are able to pool their resources through cooperatives, and they invest in ethanol plants to hedge against lower corn prices and to take advantage of the dividend income (Morris 2007).

Some studies have shown that local ownership has a greater impact on the local economy through two mechanisms. First, white-collar high paying jobs necessary for running a company, such as accounting, administrative and marketing functions are filled by local community members, who will likely spend their income in the area. Similarly, dividend payments paid to local investors are more likely to be spent locally. According to a 2006 study at the Iowa State University, a plant with local majority ownership can input as much as three times more money into the regional household incomes (Lavigne 2007).

Out-of-state and international investors are acquiring an increasingly larger ownership share of ethanol plants. For example, in Iowa, the majority of projected ethanol production is owned by non-local investors. Companies from Austrialia, Israel, and India, as well as large U.S. private equity groups, venture capitalists, and public corporations are entering the industry. In just four years, private equity investing in Iowa increased nearly 500% from $185 million in 2002 to $1.1 billion in 2006 (Lavigne 2007). This trend is also encouraged because newer plants tend to have larger capacities, making them more expensive to build. Plus, plant building costs have been increasing on their own – going from $1.40 per gallon of ethanol capacity to $2. Both of these factors make it harder for farmer-owned cooperatives to collect the required capital and compete with outside investors (Campbell 2007).

Some states have actively battled against this trend, redesigning their subsidy programs to encourage local ownership. In Missouri, only majority farmer-owned ethanol plants are eligible for discretionary state tax incentives (Borst 2006). Minnesota's state policies strongly support farmer ownership. More than 75% of ethanol plants in the state are majority farmer-owned (Smith 2007).

Besides the potentially foregone local economic impact, non-local ownership in large ethanol plants distorts ethanol's role in the nation's energy policy. Absentee owners may derive a large portion of their profits not from the actual ethanol produced, but from the appreciated value of the plant when it is sold. Thus, the primary concern may be to inflate the value of the plant, rather than promote the production of the biofuel (Morris 2005).

Many of the ethanol plants we contacted are run as cooperatives. In this arrangement, farmer-investors enter into contracts in which they must provide, for instance, one bushel of corn per share held (Buchenau 2007). Minimum investment is usually on the order of thousands of shares, and usually you must be a resident of the state. At least in the case of the Al-corn Clean Fuels plant in Claremont, MN, you can sell your shares at any time, but you may only sell to another shareholder or, any shareholder can arrange to sell shares to anyone but once a price is agreed upon, that price will offered to the rest of the shareholders and they get the chance to buy the shares first (Schlaak 2007). In some cases members may opt out but only by paying a fee (Carlson 2007).

On the plant side, if the demand for feedstock outpaces the rate at which members can supply the corn, arrangements may be made with other suppliers. In Lena, IL, Adkins Energy, LLC owns both the Adkins Energy Cooperative, the plant where ethanol is produced, and the Pearly City (grain) Elevator, which provides corn for the plant whenever farmer-investors cannot (Buchenau 2007, Buchanan and Ledue 2007). Both entities utilize local corn from northern IL and southern WI.

6.c.2. Competition

As mentioned above, the ethanol industry tends to be highly concentrated with ten ethanol producers controlling 60% of the market. Whether this poses problems associated with imperfect markets is not certain. The Federal Trade Commission looked into the issue in 2005 and concluded that since new plants and owners are still entering the market, this reduces the risk of concentrated ownership and non-competitive behavior (Koplow 2006).

Ethanol marketing portion of the ethanol industry is highly concentrated. Around two-thirds of the ethanol produced is sold to the gasoline industry by just three firms – ADM, Ethanol Products and the Renewable Products Marketing Groups. More than 90% of ethanol marketing is controlled by only eight firms (Koplow 2006).

This consolidation may have detrimental effects on competition and long-term prospects for the business. If biofuels are to be successfully incorporated into the nation's energy policy, a measured long-term perspective is essential. As one article in the Des Moines Register put it, "long term to a hedge fund is five years. Long term to a farmer is a generation" (Lavigne 2007).

6.c.3. Profitability

Companies have enjoyed substantial revenue growth during the height of the industry boom. Returns on capital last year reached 73% in the sector, but have fallen to 13% this year (Ethanol Statistics 2007). This drop is attributable to high corn prices and transportation costs and falling ethanol prices. Economies of scale are crucial in maintaining price competitiveness, and small operations may be going out of business in the near future (Cox 2007).

For example, for Aventine Renewable Energy, gross profits declined significantly in the latest quarter, according to its SEC filings (Yahoo! Finance 2007 ARE). Higher cost of corn and lower ethanol prices are blamed. Similarly, higher corn prices are blamed for lowering ADM's profits from its corn processing division (Yahoo! Finance 2007 ADM).

The stock prices for the publicly traded companies also reflect the recent changes in the company's profit margins and the dampened enthusiasm for the sector. VeraSun's stock opened at $28 per share in June 2006. It dropped in price almost immediately and continued falling throughout the Fall of 2006. Although it recovered somewhat in December of that year, its current value of $10.61 per share is nearly three times lower than the original stock price. Similarly, US BioEnergy's stock opened at $14.25 per share in June 2006. It peaked in January 2007 at $17.20 per share, but has since suffered a significant loss. The current price per share stands at $7.50 (Yahoo! Finance 2007 VeraSun).

6.d. Plant construction

Most plants built today are dry mills and average in capacity around 100 million gallons per year. In January 2006, around 70% of all plants were dry mills with an average capacity of 42 MGY (Urbanchuk 2006).

The initial capital investment required to build an ethanol plant can represent a significant boost to the local economy. The estimated average construction cost for a new dry mill ethanol plant is around $1.40 per gallon[5] (Urbanchuk 2005). An investment of $70 million is required to build a 50-mgy plant. An expansion costs approximately $1.00 per gallon (Urbanchuk 2006). Currently 84 plants are either being built or undergoing expansion, representing a total increase of over 6,600 million gallons in

[5] Although this number has recently increased to $2 per gallon, as described above.

capacity (RFA 2007 overview). If half of that capacity is from new plants being built and the other half from expansions, the total construction cost is nearly $8 billion.

6.d.1. Siting of plants

Locating the plants close to dairy or livestock operations can save energy – both in transportation and drying costs. The valuable distillers grains co-product used as livestock feed can be transported quickly to the nearby dairy or livestock producer without needed to be dried and stored. Additionally, the manure can be utilized to produce heat or electricity for the plant (Baker et al. 2007).

This closed-loop system is being recently employed at the E3 BioFuels Genesis plant in Mead, Nebraska. Besides the accrued environmental benefits, the energy savings are substantial. On average, a dry-mill ethanol plant uses over 36,000 Btu of thermal energy to produce one gallon of ethanol. Wet-mill plants use over 40% more energy to produce the necessary electricity for ethanol production (Shapouri et al. 2002). A dry-mill ethanol plant producing 50 million gallons per year will use 1.8 trillion Btu per year. The Genesis plant generates 25 million gallons of ethanol, requiring 900 billion Btu annually. If this energy requirement were met by electricity purchased at Nebraska industrial sector energy prices in July 2007 (EIA 2007a), the price tag would amount to $4.8 million. E3 BioFuels plant converts livestock manure and corn cellulose byproducts to biogas, which can be used to provide the energy for the plant's boiler (E3 BioFuels 2007).

Plants of larger capacity offer some economies of scale to the producers. The average expenditures for a 50 MGY ethanol plant are approximately $46.7 million (2005 dollars), whereas a 100 MGY ethanol plant necessitates around $88.2 million in expenditures for goods and services. Lower capital costs and savings in labor costs represent the most significant economies of scale for larger plants (Urbanchuk 2006).

Almost all plants are sited on agricultural fields, once host to rows of corn or soybeans. Planners, financiers, and builders of plants all over the country are very conscious of their proximity to the channels by which their product is shipped and transported. Almost all the plants contacted by the team were sited on spots where some manner of infrastructure was already in place. Most plants are situated adjacent to or very close to rail, and most times an interstate highway as well. The developers of the Adkins Energy ethanol plant in Lena, IL, were looking at two different sites for their plant, the other being Bridehead, WI. They chose Lena because of its close proximity to rail (Buchenau 2007). The Aventine Renewable Energy plant in Pekin, IL, is located on the Illinois River, where cargo ships have easy access to the plant (Brown 2007). Illinois River Energy was originally going to locate right on the river too; however, when they started the planning process six to seven years ago, a study showed that Rochelle, approximately 15 miles from the river, was the perfect location for an ethanol plant because two mainline railroads (Union Pacific and Burlington Northern) go through it, as does a smaller municipal railroad, and at the time the perception was that the ethanol would largely go west. Because of the proximity to rail and the fact that corn transported by boat makes for a more expensive feedstock, the cost model pointed to rail-heavy Rochelle (Anderson 2003).

Some plants took advantage of abandoned infrastructure, such as the grain facility in Denison, IA, which had formerly been operated by Archer Daniels Midland. Though ADM ceased operations at the site, there was infrastructure in the form of several large bins capable of storing hundreds of thousands of bushels of corn. The builders of the Amaizing Energy ethanol plant were able to save substantial funds by building on this site (Jentz and Luensmann 2007). The Andersons ethanol plant in Albion, MI likewise enjoyed the benefits of an extant grain elevator (Hennon 2007). Aventine Renewable Energy refurbished a sugar beet plant, in existence since the late 1800s, at the site of their Pekin, IL plant which has been producing ethanol since 1981 (Aventine Renewable Energy 2007).

Red Trail Energy in Richardton, ND, was established not primarily to take advantage of local corn, of which there is not a lot compared to other areas (though of course there is plenty of corn in ND), but rather to take advantage of abundant cheap fuel to run the plant, lignite coal, and what they knew would be a reliable market post-production: a substantial cattle population that would make quick work of the DDG co-product (Hoff 2007).

Heartland Grain Fuels operates plants in Aberdeen and Huron, SD. When we asked the City Planner in Huron if there were any "lessons learned" from the Aberdeen plant, which was built in 1992, used in the planning for the Huron plant, which was built in 1999, the story he told was one of social preferences with respect to siting conflicting with infrastructure needs. In a perfect world the Huron plant would have been built west of town a few miles out, instead of on the east side where it ended up, because in the winter the northwest winds carry the plant odors over the city. But because the plant requires large grain elevators, all of which are in or immediately adjacent to the east side of the city, the strictly economic benefit of existing infrastructure won out. As far as other lessons, Aberdeen and Huron (particularly the City Engineers and Waste Water Superintendents in both cities) also discussed with other quite a bit the expected water demands and waste water capacity and minimum treatment requirements (Borkosky 2007).

Though not many interviewees came right out and said it, it is likely that siting of most plants was the result of a competitive process designed to benefit as much as possible from public subsidies and incentives (Renquist 2007).

6.e. Revenue Sources

The revenue of an average dry-grind ethanol plant comes from three sources. Around 80% of the total is received from ethanol sales. The sales of DDGS account for 19% of the plant's revenue. The sales of the second by-product, carbon dioxide, constitutes just one percent of the total revenues (Tiffany 2003).

Being the primary product of ethanol plants, ethanol's price is one of the key determinants of the overall profitability. Prices are far from stable or predictable. Significant price fluctuations have been the norm. For example, within the first five months of 2005 the commodity's price dropped by around 25% from the 2004 average. The following four months saw a dramatic increase of 55% of the 2004 average – an increase of 80% from the low price point. During the last few months of 2005, the prices decreased again, only to rise by 16% above the 2005 average in the first quarter of 2006 (Pacific Ethanol, Inc. 2006).

The sudden drop of ethanol prices in the fall of 2007 have caused some analysts to re-think the long-term profitability of the ethanol industry. In late September of 2007, ethanol prices fell to $1.55 a gallon from around $2 in May – representing a 30% decline (Kraus 2007). A respected investment banking firm - Friedman, Billings, Ramsey Group – lowered its price forecast for the commodity by about 7% from $2.20 to $2.05 for the year 2007. The firm's longer-term price forecast for the years 2008-2019 was lowered from $1.95 to $1.80 per gallon of ethanol (Guitierrez 2007). The major market for ethanol in the form of gasoline containing 10% ethanol became saturated as the expansion of early- and mid-2000s gained speed. The price of ethanol peaked in June 2006 at $5 per gallon, but has been falling ever since (Etter 2007). Today, the oil refiners that purchase ethanol to blend in need pay only about $1.85 a gallon for it. The prices have rebounded somewhat from that low, and Table 11 lists the current listed price.

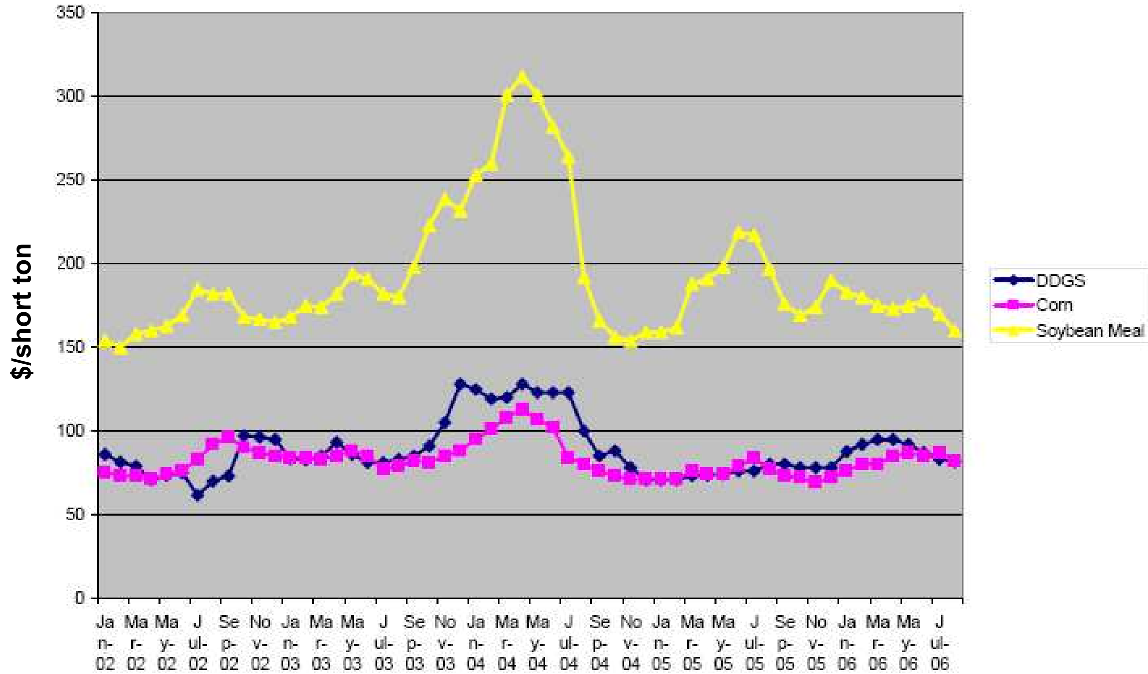
Table 11. State average fuel ethanol rack price, November 13, 2007

State	Price ($/E-100 gallon)	Change from Last Week ($)
Colorado	2.3626	0.0000
Iowa	1.8875	0.0557
Illinois	2.0426	0.0379
Indiana	2.0898	0.0556
Kansas	2.0166	0.0549
Minnesota	1.9092	0.0855
Missouri	1.9477	0.0986
Montana	1.9800	0.0990
North Dakota	1.9328	0.1189
Nebraska	2.0519	0.1243
Ohio	2.6799	0.0424
Oregon	1.9800	0.0000
South Dakota	1.9644	0.1284
Washington	1.9800	0.0660
Wisconsin	2.0051	0.0737
Wyoming	2.0863	0.0887
Today's Average	**2.0573**	
Average Change from Last Tuesday		**0.0706**
Last week's change		**0.0671**

Source: Kment 2007

The price of DDGS can fluctuate considerably, as well. Figure 11 below summarizes the pricing trend in the last few years.

Figure 11. Wholesale DDGS prices and near-month corn and soybean meal futures, 2002 to 2006



Source: US Grains Council 2006

The USDA reports that DDGS is currently[6] selling at around $108-$115 per ton, representing a slight increase in price from September 2007.

Increased DDGS supply generated by the boom in ethanol production can shift prices downward, undercutting the co-product's profitability. However, with more swine and poultry producers incorporating DDGS in the feed rations and expanding export markets for the commodity, the demand for the product may keep apace with the supply, continuing to provide a stable source of income for ethanol producers (US Grains Council 2006).

Carbon dioxide, another co-product produced during the fermentation process, is marketed for such diverse purposes as beverage carbonation, food processing, municipal water treatment, fire suppression and other agricultural purposes (POET 2007). The prices tend to be low and will depend on any carbon dioxide regulations legislated in the future.

6.f. Expenses: growing and supplying the feedstock

Overall, it is estimated that the ethanol industry spent more than $5.1 billion on raw materials, other inputs, goods and services in 2004. Over 60% of that figure was spent to purchase around 1.25 billion bushels of corn. The rest of the money was spent on industrial chemicals; electricity, natural gas, and water; labor; and maintenance and overhead costs (Urbanchuk 2005). Biofuel production creates a new

[6] For the week of November 15, 2007.

market for feedstock suppliers, and the economic impacts have resonated throughout the corn farming communities.

Corn is the most common feedstock used in ethanol production in the U.S. The increased production of ethanol has had a tremendous impact on corn, its prices, and its producers and sellers. The share of corn used for ethanol as opposed to other purposes has grown over the years. In 2007, around 20% of all corn crops went to produce the 5.9 billion gallons of ethanol. The Farm Foundation predicts the percentage to rise to 27% in the 2007-08 marketing year to produce 8.8 billion gallons of ethanol. An additional 10 million acres of corn will be planted to meet the increased demand. All together corn producers have committed to planting 90.5 million acres of corn at the beginning of this year. This will be the highest acreage dedicated to corn since the World War II era (Robinson 2007). The actual acreage planted in 2007 was even higher at over 93 million acres.

Although the price of corn depends on many factors and varies geographically, recent corn prices are slowly approaching the $4 threshold at around $3.70 per bushel (USDA 2007a). Prices of futures contracts for the commodity for the 2007-2008 marketing year are already trading from $3.69 to $4.04, although the USDA projects the weighted average price for the year to fall close to $3.50. Corn prices have undergone a sharp increase within the last several years – with overnight cash bids rising by nearly 30% from September 2006 to September 2007 (Good 2007). The prices are 65% higher now than the average price of the 2002 through 2005 corn crops (Babcock 2007). This development strains ethanol plants' production costs, but has contributed to the overall economic impact of the industry. An Ohio State University study found that the corn basis[7] strengthens on average by eight to nine cents in each location a new ethanol plant opens (Schlatter 2006). Another study found that for a 100 MGY ethanol facility, the prices of corn are expected to grow by $0.006/bushel. The annual corn crop cash receipts are estimated to increase by $74 million per year (Parcell & Westhoff 2006).

Another impact of higher corn demand is the effect on fertilizer prices. An extra 1 million metric tons per year was demanded in 2007, raising the price to $365 per metric ton, an increase of 35% (Jubak 2007). On the one hand, this contributes to the soaring corn prices, increasing the cost of ethanol production. On the other hand, it supplies extra income to fertilizer producers, providing an additional economic boost.

The value of farmland in the United States has risen dramatically. For the twenty states with operational ethanol plants, the average increase of farm value per acre increased by nearly 68% (RFA 2007a; USDA 2007b). While many factors contribute to this staggering growth in price, higher prices for corn and other commodities have certainly played a role. Using the current farm value price per acre, it is interesting to calculate the total value of farmland dedicated to corn grown for ethanol production. Assuming that all of the ethanol produced in a state is supplied by corn grown in the same state and using the standard bushels of corn per acre yield of 140 (Baker et al. 2007) and the current production yield of 2.75 bushels of corn per 1 gallon of ethanol, the value of farm land dedicated to corn utilized to make biofuel totaled over $50 billion. Table 12 below outlines the calculation.

[7] Corn basis is the difference between current price and the price of nearest futures contract on the commodity. If the difference is small (or narrow), the prices are considered stable, usually resulting in a greater profit for the farmer.

Table 12. Estimated value of farmland devoted to corn for ethanol

		Farm Value/Acre					
State	Ethanol capacity (MGY)	2007	2003	Change	Bushels of Corn needed*	Acres required**	Value of Corn Farm Land in 2007***
AZ	55	$3,400	$1,500	126.67%	20000000	142857.14	$485,714,285.71
CA	69	$6,000	$3,600	66.67%	25090909	179220.78	$1,075,324,675.32
CO	85	$1,250	$730	71.23%	30909091	220779.22	$275,974,025.97
IA	2610	$3,400	$2,010	69.15%	949090909	6779220.8	$23,049,350,649.35
IL	373	$4,330	$2,430	78.19%	135636364	968831.17	$4,195,038,961.04
IN	373	$4,000	$2,570	55.64%	135636364	968831.17	$3,875,324,675.32
KS	210.5	$1,090	$685	59.12%	76545455	546753.25	$595,961,038.96
KY	35.4	$2,850	$1,900	50.00%	12872727	91948.052	$262,051,948.05
MI	212	$3,950	$2,680	47.39%	77090909	550649.35	$2,175,064,935.06
MN	524.5	$2,780	$1,600	73.75%	190727273	1362337.7	$3,787,298,701.30
MO	195	$2,280	$1,470	55.10%	70909091	506493.51	$1,154,805,194.81
ND	50	$650	$425	52.94%	18181818	129870.13	$84,415,584.42
NE	716	$1,230	$775	58.71%	260363636	1859740.3	$2,287,480,519.48
NM	30	$610	$260	134.62%	10909091	77922.078	$47,532,467.53
OH	100	$3,800	$2,740	38.69%	36363636	259740.26	$987,012,987.01
OR	35	$1,650	$1,200	37.50%	12727273	90909.091	$150,000,000.00
SD	627	$820	$460	78.26%	228000000	1628571.4	$1,335,428,571.43
TN	67	$3,400	$2,400	41.67%	24363636	174025.97	$591,688,311.69
WI	410	$3,800	$2,300	65.22%	149090909	1064935.1	$4,046,753,246.75
WY	10.7	$560	$300	86.67%	3890909.1	27792.208	$15,563,636.36
			Average	**67.36%**		**Total**	**$50,477,784,415.58**

*2.75 bushels of corn > 1 gallon of ethanol
**U.S. corn yields averaged 140 bushels per acre (Baker et al. 2007).
***Assumes local state supply

6.g. Ripple Economic Impacts

As mentioned before, the major economic benefits created by ethanol production consist of those related to plant operations and those derived from the formation of a new market for the corn commodity. This has stimulated corn prices and created potent ripple effects for the communities home to biofuel plants.

A recent article in the National Geographic explored Nebraska's booming ethanol economy. The city of Wahoo, located 30 minutes west of Omaha, just north of Lincoln and 30 minutes south of Fremont, is near several ethanol plants and is the future home of a 110 MGY facility. There, many facets of the local economy are benefiting from the plants. For example, a local equipment dealership has sold twice as many corn harvesters (valued at around $200,000 each) in the span of three months as usual, and the tractor sales are up (Bourne 2007). The situation is similar in most communities.

Universally, the trucking industry has benefited from the new shipping opportunities on both sides of the plant: delivering feedstock into the front end and picking up ethanol and its co-products at the back end for shipment all over the country. Jobs related to trucking such as repair, trailer construction, etc. have all seen a boost because of ethanol (Jentz and Luensmann 2007, Ogren 2007).

Co-products from ethanol have also brought new commerce and created new markets in these towns. Plants generate several co-products, including wet and dried distillers grains (DDG), wet gluten, and food-grade CO_2. Though usually marketed by different companies, these co-products represent a valuable opportunity for plants, especially now that margins have become tight for ethanol producers. DDG is co-produced and marketed at every plant we contacted. In fact it has become an important component of feed for local livestock farmers, so much so that prices have risen substantially because of increased demand (Koenen 2007).

In Albion, MI, The Andersons ethanol plant was established in an area ripe for a market for CO_2. The Andersons partnered with Continental Carbonic Products to market their food-grade CO_2 for conversion to dry ice and use as a cleaner in factories nearby, including Kellogg's. Continental brought 50-80 jobs with it to Albion (Hennon 2007). The Albion plant is Continental Carbonic Products' largest plant, producing 340 tons of CO_2 products each day and will serve existing and new customers in the Michigan, Ohio, and Indiana regions (The Andersons 2005). Also in Albion, farmers are being encouraged to put any extra corn into storage so that they can sell it in the middle of winter, when they'll get a higher price, presumably building or renting their own storage facility (Hennon 2007). Either way this is yet another potential revenue stream in the town.

Kandyohi County, MN is the largest grower of turkeys in the nation and the second largest processor of turkey meat. The rising corn prices, although good for the farmer, has placed the turkey industry at a competitive disadvantage with areas that do not have ethanol plants. Though turkey farmers are still able to get their feed corn, the competitive advantage they used to have over other producers nationwide, because of the close proximity to cheap abundant corn, is eliminated by the jump in corn prices. Any new production capacity in the industry may locate elsewhere (Renquist 2007).

It turns out that the ripple economic effects of the ethanol boom depend a lot on who owns the acres of corn and on the resources of the closest town. In Tazewell County, IL, home of the town of Pekin and the site of the Aventine Renewable Energy ethanol plant, most of the farms are 3000-4000-acre corporate farms; there are no more small family farms that can reap the benefits of the premiums for corn. Even if there were family-owned corn farms, farmers don't have the local retail outlets (i.e. mom-and-pop stores) to spend their corn profits. They go to the big cities. So, at least in that part of the country, all the profits from corn go to big business, or the big city (Worner 2007).

Contrast this with the story of Rochelle, IL where local businesses are booming, and a new and unexpected market has been created. In 2004, before Illinois River Energy even began construction of their ethanol plant here, the city partnered with Union Pacific railroad to build a 1300-acre intermodal rail lot. At about the same time, the Asian DDG market exploded. Up to this time, 90% of the import containers to the U.S. were returning to their original point of export empty. Because the ethanol plant is located right on the rail line down the street from Rochelle's intermodal lot, the DDG co-product can simply be loaded directly into hopper cars at the plant and shipped to Asia in the cars that in the past had gone back empty. One hundred percent of Illinois River Energy's DDG now gets shipped out because the plant gets double the rate for DDG in hopper cars than in other modes of shipping. Though this is certainly a boon to Illinois River Energy and Rochelle, it's unclear what this may mean for the domestic DDG market, which is thriving but lacks standards. In any event the discovery of the heretofore empty cars was also a coup to grain elevators, which are now developing soy-derived specialty grains for markets in Asia (Anderson 2007).

Also in Rochelle, the farm equipment business is doing quite well. Leo Johnson of Johnson Tractor wouldn't discuss the financials of his company, but he did say that there is no doubt that farmers are spenders and want all the newest toys: if times are good, when their equipment begins to wear out farmers like to replace it with the newest and best. The stock prices of most equipment manufacturers such as CNH, John Deere, AGCO, among others, have doubled in the last year, giving a good indication of how the equipment business is doing. Retail nationwide is up about 10% this year, and most of the industry leaders are predicting increases of five to seven percent in the next year. In areas where there are plants, and in general, it has been good for corn producers, who tend to spend money locally and regionally. Leo himself has added employees, bought some trucks and other equipment (Johnson 2007).

Iowa Falls is another town which experienced remarkable ripple effects as a result of ethanol production in the town. Iowa Falls in fact benefits from two ethanol plants as well as a soy-based biodiesel plant, in addition to a livestock feed mill, and two of the largest hog producers in the country. In a perfect storm of market forces,

> "Crop farmers sell their corn and soybeans to the ethanol and soy processing plants. The plants sell their byproducts to the feed mill. The feed mill mixes the byproducts into feed for livestock. The livestock eat the feed and produce the manure that goes back on the soil to fertilize future crops and the cycle starts again (Perkins 2007)."

As a result, everything from farmland values to tax revenues for the city to the price for corn has increased. The latter makes livestock production more expensive, too (because of high prices for feed corn and DDG), but storefronts in downtown Iowa Falls are occupied at unprecedented rates and new businesses like restaurants and hotels have popped up (Deimerly 2007).

The Heartland Grain Fuels plant in Huron, SD is yet another site exemplary of what can happen when producers and consumers of corn products are properly aligned. Heartland is located in close proximity to partners South Dakota Wheat Growers (SDWG) and Dakotaland Feeds, who source Heartland's corn and process and ship its wet and dry distillers grains, respectively. After corn arrives at SDWG's facility, it is conveyed directly to Heartland Fuels' plant, and after the ethanol is produced, distillers grains are literally dumped down a chute (rather, a pneumatic conveyor) across the street to Dakotaland's mill, where it is processed and shipped (Whitty 2007).

Though the increase in the prices of corn and DDG is problematic to cattle farmers in some areas, in other parts of the country it is not. Cattle farmers in corn country (especially ND, SD, NE, and parts of MN) often grow their own silage[8] for use as feed. Thus, at least in these areas, high prices for corn are making an economic difference for the grain farmers but not animal farmers, who generally raise their own feed (Borkosky 2007).

6.g.1. Transportation

Because of its chemical composition, ethanol cannot be transported by existing pipelines, and has to be shipped by rail, truck, or barge. Railroad shipments are becoming increasingly popular in the industry, with many plants choosing their locations based on proximity to rail lines. Within five years – from

[8] Silage is corn that is chopped when green, is allowed to ferment, and in this form is more easily digestible by cattle.

2000 to 2005 – the number of carloads carrying ethanol more than doubled to 82,000, and the number of ton-miles almost tripled to 8.2 billion (Baker et al. 2007).

6.g.2. Food prices and others

One controversial issue has been at the forefront of discussions on ethanol production: whether higher corn (and other feedstock) prices lead to price increases in other foods, some of which may be critical staples. The actual price increase of a food depends on the proportion of corn used to manufacture the item. For example, in the case of animal products, such as eggs, pork, poultry, beef and dairy products, corn represents a significant input into the manufacturing process in the form of feed. For the myriad of other products utilizing corn, such as soft drinks, snack foods, and baked goods, the relative input from corn is very minor. A one-dollar can of soda manufactured with high-fructose corn sweetener may contain only around two cents worth of corn. Thus even a 100% increase in the price of corn would represent a negligible impact on the price (Jensen et al. 2007).

But even for the food items produced with relatively large amounts of corn, the total price increase has been found to be fairly small. A recent study at the Center for Agricultural and Rural Development at the Iowa State University investigated the impact of a 30% increase in the price of corn on certain food prices. The study findings are summarized in Table 13.

Table 13. Estimated increases in food prices generated from a 30% increase in the price of corn.

Food	Price Increase
Eggs	8.1%
Poultry	5.1%
Pork	4.5%
Beef	4.1%
Milk	2.7%
All food consumed at home	1.3%
All food consumed away from home	0.9%
All food consumed	1.1%

Source: Jensen et al. 2007

The small increases are due to the fact that corn makes up a small share of the total price of food consumed away from home, since many other types of costs are included in the price of preparing the food, minimizing the total impact of corn prices. With Americans dining out more frequently, the minor increases in prices of all food consumed make sense. An industry study found that the total cost of grain price increases constitutes $115 per year per person (Elam 2007). The negative impacts are not distributed equally, however. Since low-income Americans spend a much larger proportion of their income on food provisions, they will likely feel the effects of higher prices more strongly. The situation is similar in the international markets, particularly where direct expenditures on corn products are historically high. For example, an average Mexican consumer spends 12% of his or her food budget on corn products. Thus, increases in U.S. corn prices have a deeply felt impact on our southern neighbors, particularly those in the lower economic stratum (Jensen et al. 2007).

But corn is a ubiquitous input in everyday uses, and if prices continue to rise, the impacts may be felt in the prices of many products. Table 14 below summarizes the various uses of corn.

Table 14. Corn uses

Corn Starches	Corn Syrups	Dextrose
Industrial Uses	*Industrial Uses*	*Industrial Uses*
Adhesives, Cardboard, Construction Materials, Detergents, Paper, Textiles, Plasterboard	Adhesives, Animal Feed, Bookbinding, Laminated Building Products, Enzymes, Leather Tanning, Lubricating Agents, Metal Plating	Antibiotics, Enzymes, Coatings, Insecticides, Organic Solvents, Plasticizers, Shampoo
Food & Drug Uses	*Food & Drug Uses*	*Food & Drug Uses*
Antibiotics, Aspirin, Baked Goods, Candies, Condiments, Mixes & Instant Preparations, Processed Meats, Puddings	Baby Food, Bologna and Hot Dogs, Chewing Gum, Cookies & Crackers, Dessert Mixes, Fruit Drinks, Canned Foods, Cereals, Medicinal Syrups, Pickles, Salad Dressings, Seasoning Mixes	Brownies & Baked Goods, Canned Fruits, Cheese Spreads, Cured Meats (such as bacon), Dessert Mixes, Intravenous Solutions, Jams & Jellies, Soda Fountain Preparations, Marshmallows, Soups
	High Fructose Corn Syrups	*Fermentation & Other Chemical Products*
	Carbonated Beverages, Fruit Fillings, Cereals, Frostings, Ice Cream & Frozen Desserts, Pancakes, Pastries, Relishes & Sauces, Syrups & Dessert Toppings	Ethanol, Citric Acid, Lactic Acid, Essential Amino Acids, Sugar Alcohols

Source: Iowa Corn 2007

6.g.3. Impacts on government budgets

The economic trickledown does not stop at the private sector, but extends to public budgets and services. Despite local and state subsidies, local governments still benefit from sales and property taxes. For example, in South Dakota an estimated 6-7 million dollars were paid by ethanol plants for sales taxes. Half of the amount is attributable to the sales tax on energy expenditures, and the rest was sales tax paid on other purchases (Stuefen 2005).

The contribution of property taxes depends on the taxing scheme applied. Many plants in South Dakota, for example, are taxed through a discretionary formula or a tax incremental finance (TIF) tool. Both methods are designed to stimulate local economy, but do reduce the amount of property taxes collected. It is estimated that ethanol plants pay just over one million dollars in property taxes through tax incremental financing and local property taxes (Stuefen 2005).

In Nebraska, on the other hand, ethanol plants paid annually $3.4 million in local property taxes in addition to $2.5 million in payroll taxes (Ethanol Across America 2006)

While ethanol plants certainly do send money to state and local coffers, they also demand public services. Many plants required some sort of upgrade in infrastructure, including the road and utilities improvements. Several plants required the building of an electrical substation in order to provide the power needed to run the facility (Jentz and Luensmann 2007, Ogren 2007). In most cases the electrical utility built these substations, and then charged the plants a premium for their power in order to cover the cost of the new construction.

Most plants do not connect to municipal or other local potable water or waste water treatment facilities; instead they include these capabilities as part of the plant's functions (Jentz and Luensmann 2007). However, others take full advantage of the municipal potable water, waste water treatment facilities, and electrical utility (Anderson 2007). Some areas of the country are naturally endowed with abundant groundwater (Hennon 2007). Macon, MO was has experienced rapid growth in the past few years anyway, so the ethanol plant is jut one element of a city water supply under strain (Koenen 2007). Heartland Grain Fuels in Huron, SD, had to get permission to be a large water customer, as well as for the volume of water they would be sending into the city's water treatment facility. The city has specific limitations in terms of levels of total suspended solids (TSS) and biochemical oxygen demand (BOD) in the water and Heartland Grain is billed based on the amount of TSS and BOD in their water. They do some pre-treating at the plant but only down to the maximum that the city will allow (Borkosky 2007). Similar to some electrical utilities, in a few cases where water infrastructure expansion was needed, the city paid the upfront costs for the expansion and charges the plant a premium for the subsequent services provided (Borkosky 2007).

The Little Sioux Corn Processors plant in Marcus, IA drilled their own wells to access the rural water supply, lines which are provided throughout all 99 Iowa counties as a service to which consumers may subscribe (Ogren 2007).

Where there was a need for improved connectivity to rail and interstate highway, often the state or local government would provide upgrades, most of the time at their own expense. These included reinforcing or widening roads or bridges, extending roads, and creating exits from the highway. Little Sioux Corn Processors in Marcus, IA, received county, state, and federal grants for the pavement of access roads leading up to the plant (Ogren 2007).

The Illinois River Energy plant in Rochelle, IL benefits from Illinois municipal broadband internet, which is available state-wide along I-88. The city of Rochelle set it up for the whole town to use, including the plant (Anderson 2007).

7. *Government relations: requirements and concerns*

Just like any manufacturing operation, ethanol plants are required to obtain regulatory permits, abide by pertinent regulatory standards, and comply with pertinent laws. There are federal, state and local environmental laws and regulations for every step in the ethanol production process. Permits are required to discharge materials into the air, water and ground and to produce, store, handle, use, transport, or dispose hazardous materials. Many times the permits need to be renewed periodically. The owners of the plant are liable to comply with laws ensuring health and safety of the employees, and other regulations governing plants' operations. The road from the initial idea to producing the first gallon of ethanol is long and requires extensive knowledge of the legal requirements. This section outlines this process and considers what obstacles and concerns may be present.

Zoning changes and permitting requirements were time-consuming for most plants contacted by the team. Rezoning, for example from an agricultural to an industrial zone like in Albion, MI for The Andersons ethanol plant (Hennon 2007), requires the time and resources of public employees. Several plants ran into long permitting and/or rezoning processes in order to qualify for special financing or comply with local or state regulations. The permit for the Bushmills Ethanol plant in Atwater, MN Atwater is for Conditional Use, and it is located in an Agricultural Preservation Zone, which

> "is intended primarily for application in those areas of the County where it is desirable, because of the high quality of soils, availability of water and highly productive capability of the land, to preserve, promote, maintain and enhance the use of land that has been historically tilled. The land in this district also needs to be protected from poorly planned and scattered residential and other non-agricultural development. To protect and preserve natural areas and retain major areas of natural ground cover for conservation purposes. To stabilize increases in public expenditures for public services such as roads, road maintenance, snow removal, schools, police, and fire protection." (KCPC 2006)

The Conditional Use caveat indicates that, among other things,

> "the proposed use will not have significant negative impacts on groundwater, surface water, or air quality if operated according to all applicable Federal, State, and County regulations, including the conditions placed on the permit." (KCPC 2006)

7.a. Initial considerations

In the summer of 2006, the industry teamed up with the USDA to produce a guide for evaluating the feasibility of building an ethanol plant. The guide is aimed at parties considering an ethanol project and follows every stage of the process. The pre-feasibility evaluation seeks to answer the essential economic question of whether an ethanol plant located in the specific community could offer economic returns to its owners, investors, and operators. An assessment of such elements as the current and projected regional markets for the product and feedstock, prevailing ethanol, co-product and input prices, labor availability, capital and operating costs, and potential financing options are necessary. Many states, regions, and counties offer business development assistance, which may be able to help prospective owners find an appropriate building site, navigate the vast pool of government support programs described in Section 5, and develop a business plan.

Prospective owners need to do a search for an appropriate site and become educated on the required permits. Site selection needs to consider the distance to a reliable affordable energy source; a consistent supply of water; availability of transporting infrastructure, such as rail, highway, or barge; prevailing wind patters; presence of a buffer area for aesthetic purposes; and size requirements of road and rail configurations and expanded storage and potential future expansion capacity. State and federal construction permits to discharge air pollutants need to be obtained before groundbreaking begins. And state and federal operating permits have to be secured shortly after operations commence. There may be additional permits, such as for wastewater treatment and drinking water (CFDC 2006). An ethanol plant built in Illinois may be subject to as many as ten state and federal air quality permits, fourteen water permits, and eight land use permits (IL EPA 2007).

As part of developing a comprehensive business model, prospective plant investors need to evaluate federal, state, and local subsidies, and consider financing options for the investment. The plan needs to account for financing all plant equity – land, plant, equipment, other assets, initial losses, and working and operating capital. Many loans may offer favorable rate plans for co-operatives, which may help decide the ownership structure of the ethanol project (CFDC 2006). A recent survey of Midwestern rural bank presidents and chief executives found that nearly 60% think the benefits of ethanol are oversold (Journal Star 2007). This may impact the financing options available.

Overall, setting up an ethanol plant is a complicated process, which requires commitment to the project and a participatory approach.

7.b. Community relations

The aforementioned ethanol plant feasibility guide advises prospective owners to notify the community early through media announcements of public information meetings, newsletters, op-eds, and other outreach efforts. It warns that communities may be concerned about plant odor, dust, strain on infrastructure, general plant safety, air and water emissions, noise pollution, and plant site lighting. Working closely with the community can help ease the process. Establishing a positive working relationship with state and local officials, such as state regulatory agents and elected officials is another crucial step (CFDC 2006). When Western Wisconsin Renewable Energy Cooperative failed to meet seven standards contained in the local county's zoning ordinance, the cooperative worked together with the officials to address the issues and correct its application (County of Dunn 2003). The plant is now operational.

Communities in fact are concerned about some or all of these factors. For example, a proposed plant in Ravenna, Nebraska came under fire from some community members who suspected the plan was deliberately kept secret from the public. They also raised questions about increased levels of traffic; potential tax dollars diverted to grants for the facility; whether the economic benefits would be exported out of the immediate community; potential future relocation of the plant; increased load on the common energy; water and sewage networks; and potential environmental impacts of the plant (City of Ravenna 2007).

While in many cases plants have a positive relationship with the community, general opposition to ethanol projects seem to be rising. A recent article in the International Herald Tribune described the opposition of local farmers to a proposed plant in Sparta, Wisconsin. They are concerned about home values and consider the benefits promised by the industry over hyped. Opposition to plants is increasing in Kansas, Illinois, Indiana, Minnesota, and Iowa – some of the core ethanol-producing states. Many times disputes lead to legal confrontations, and investors are either kept waiting or give up as a result (Davey 2007).

There are also concerns about the environmental impacts. For example, Ace Ethanol LLC of Stanley Wisconsin failed to obtain a necessary environmental permit. This resulted in a $61,000 fine for the company. This was not the first offense, however, with previous violations resulting in $300,000 fines. In 2005 Utica Energy in Oshkosh paid $76,000 for air pollution violations (Cambrians for Thoughtful Development 2007).

Other plants in Wisconsin faced difficulties because of zoning regulations. Bids to change current zoning went unsuccessful when communities opposed plant construction (Cambrians for Thoughtful Development 2007). The area is already home to a farmer-owned ethanol facility - United Wisconsin Grain Producers. The city of Friesland, where the plant is located, does not have its own zoning nor does it conform to the county's zoning. The neighboring town of Cambria less than ten miles south of Friesland, however, does implement zoning practices within its jurisdiction. This proved to be the sticking point when another ethanol facility planned to move in. The Didion plant encountered intense opposition from the community, where fears of noise pollution, traffic congestion, and water supply concerns prevailed. The community is already home to a milling plant, and residents were skeptical of the demand on resources another facility would bring. At first zoning regulations were used to prevent the plant from moving in. Although plant owners initially moved to change the land use zoning ordinances, eventually, the plant was built just on the outskirts of the city, successfully avoiding regulation from the city (Calkins 2007). These types of interactions do not promote positive community relations and may lead to increased opposition from communities elsewhere.

Although there is some community opposition to ethanol plants, for the most part communities welcome the economic opportunity plants provide. This makes sense since plants provide employment opportunities and additional markets for the corn commodity. Nevertheless, community opposition may increase as plant ownership structure becomes less local, as described in Section 6 on economic activity, and the strain on environmental resources is felt, as is described below in Section 8 on environmental issues.

Most plant owners or builders of the plant contacted for interviews sought out and cultivated public support for their projects. Nearly all communities were very supportive of plants locating in their communities and farmers became investors in the new ventures. Public meetings throughout the planning process provided fora for citizens to provide input to the builders and make their concerns known (Jentz and Luensmann 2007).

Several plants were built by hometown folks who had the wherewithal to make a plant happen. The Little Sioux Corn Processors ethanol plant is also located right on the railroad, about a mile and a half outside of Marcus, IA. Two different families who owned the land sold it to a group of local individuals who were interested in building a plant on the property. Local investment and ownership was very important to the initial investors and many if not all of the investors live within a seven-county area. These local individuals, farmers, and the mayor formed a Limited Liability Company, ran an equity drive, and raised $35 million for the construction of the plant back in 2003, which would probably cost ca. $175 million today. The same group is now planning a soy biodiesel plant just down the rail line from the ethanol plant. An important element of this LLC configuration is that investment is only open to Iowa residents (similar business configurations exist in other states). Despite interest in the projects from across the country and both coasts, local ownership and management means that all the profits from the venture stays in state and local coffers (Ogren 2007).

In still other cities, citizens were actually the ones who actively sought out plants to open in their midst. Marilyn Hennon, Director of Albion (MI) Township Economic Development said that at the time that The Andersons were thinking about building a plant in her town, farmers had already approached her about it (Hennon 2007).

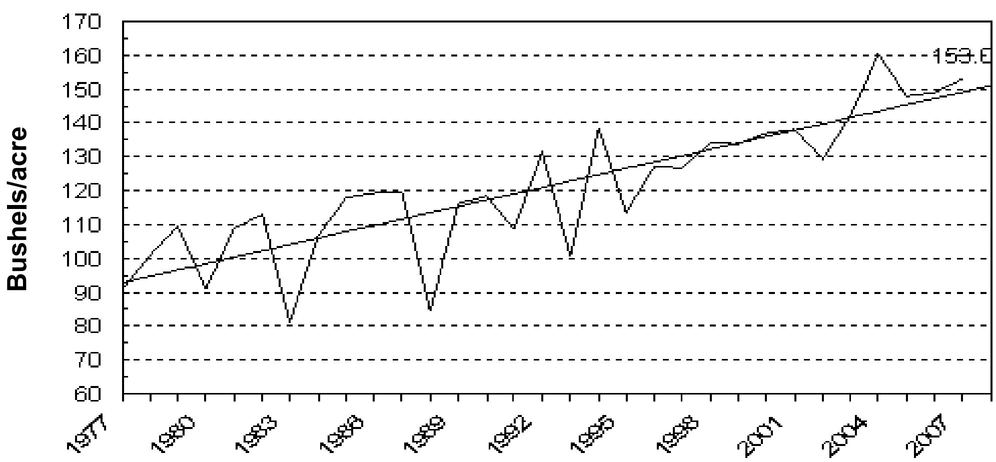
Some plants go above and beyond the normal routine of garnering public support for their project. The owners of Aventine Renewable Energy just built a new corporate headquarters in Pekin, IL, where they own an ethanol plant, in an empty building which used to house a grocery store. The occupation and continued use of this building, heretofore idle and generating no revenue, is a boon to town's budget (Brown 2007). Illinois River Energy in Rochelle, IL, is owned by U.K.-based GTL Resources, who plan to locate their U.S. corporate headquarters in the town (Anderson 2007).

Despite the majority of citizens who approve of and welcome ethanol plants in their community, there was opposition to several of the plants. There are often concerns about odors from plants, air emissions, and what the plant will look like. Even though farmers approached the economic development director about siting an ethanol plant in their town, a small number of citizens in Albion, MI raised concerns about noise, odor, and pollution. Since The Andersons plant slated for construction there included the very latest technology, none of these issues ended up being problematic (Hennon 2007). In Huron, SD, a very vocal minority of people were apparently allergic to some organic particle emitted by the Heartland Grain Fuels plant. One or two people even moved out of Huron. These concerned citizens were in the Mayor's office at least once a week. In response to these concerns, the stack height has been raised twice since the plant was constructed, and $1.2 million worth of scrubbers have been added to the stack (Borkosky 2007).

8. Environmental issues

The substitution of conventional fuels (e.g., gasoline, diesel) by biofuels is considered to be one potential way to reduce pollution and support sustainable agriculture. However, the production of this fuel may actually cause more pollution (Puppan 2002). Because of a strong national interest in greater energy independence, in this year's State of the Union address, President Bush called for the production of 35 billion gallons of ethanol by 2017. This would meet about 15% of the U.S. liquid transportation fuel demand (The National Academies 2007). Since current capacity stands at just over 7 billion gallons, reaching this goal would exact considerable increases in land area dedicated to corn production (Achenbach 2007), as well intensified production methods. Figure 12 demonstrates the yield gains in corn production generated by greater pesticide and fertilizer use and other agricultural practices.

Figure 12. U.S. corn yield, 1977-2007



Source: USDA NASS 2007b

To meet this ever-growing growing demand, significant developments have been made in the productivity of corn crops, resulting in a quadrupling of average corn yields over the last 50 years. These yield increases have resulted from a combination of improved seed varieties, greater fertilizer and pesticide use, and improved tillage, rotation, and irrigation practices used in the complex production systems that characterize modern agriculture (Christensen 2002). The cultivation of such energy crops also exacerbates several of the environmental problems associated with agricultural commodity production such as impacts on land, deforestation, monocropping, pollution, and water usage (Dufey 2007).

8.a. Land conversion and degradation

Corn production has a great impact on land conversion in the U.S. The USDA has already halted new enrollment of lands into general CRP acreage in 2007 (Roberts et al 2007), and anticipates that farmers are planning to put 4.6 million acres of CRP lands back into crop production when their contracts expire in the next four years (Westcott 2007b in Roberts et al 2007).

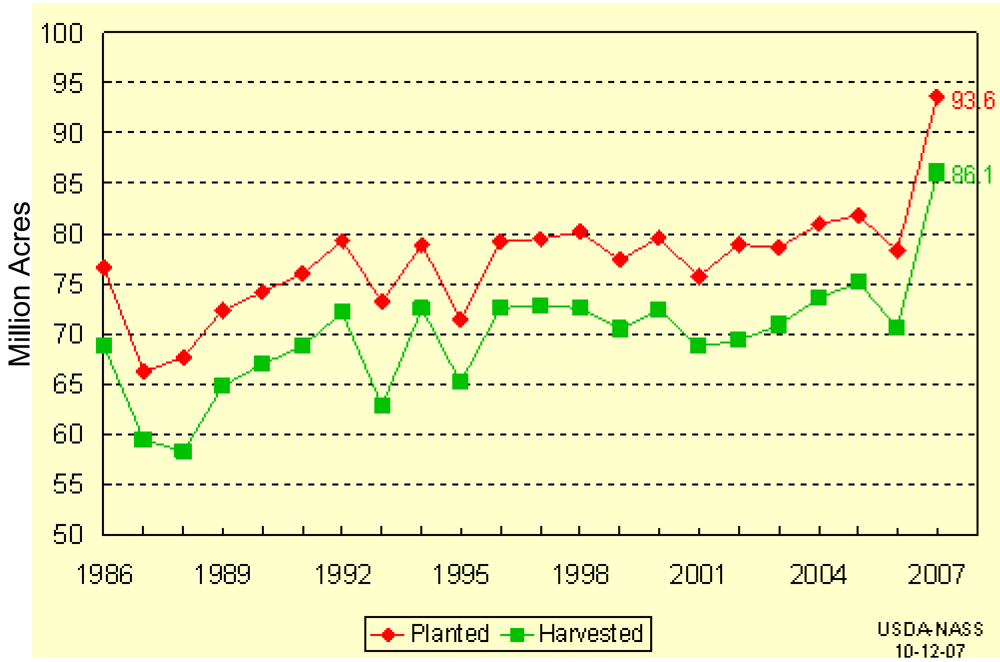
This situation is disconcerting in the state of Wisconsin, which is famous for its dairy products. Dairy production, however, is a process that readily leads to soil erosion, and traditionally farmers have used alfalfa rotation to replenish much needed nutrients. Much of the state's agriculture is connected to dairy production still, although with intensified dairy operations, this sector now uses less land than it did in the past. The rest of the land has been converted to soybean, corn, and wheat crops.

Columbia County, WI is home to one functioning ethanol plant and another one that is under construction. These ethanol plants require corn as a feedstock, whose subsequent demand has changed some agricultural practices in the region, potentially negatively impacting the quality of the soil and preservation of land. A particular concern voiced by the director of the county's Land and Water Conservation Committee is the reduced use of alfalfa and other bean rotations. As those rotations are phased out, more pesticides and fertilizer are applied resulting in nutrient runoff in the area. Additionally, as corn prices have doubled in some cases, land is being pulled from CRP and other riparian buffer preservation programs. Mr. Calkins noted that his office has received a lot of requests for clearing previously unused land to put into corn production. "At $1.50 per bushel of corn," he says, "people participate in the CREPs,[9] but as the price reached $3.00 per bushel, people are dropping out this year (Calkins 2007)." This concern is echoed by Kathleen Haas at a local Extension Center, who is similarly concerned about land conversion and decreased rotation practices (Haas 2007).

Although CRP acreage may comprise the majority of new cropland, expanded biofuels production will also put pressure on remaining tracts of native grassland. Recent analyses demonstrate that conversion of native grasslands is ongoing in parts of the Great Plains. Central North and South Dakota reportedly lost 144,000 acres to crop production between 1984 and 2002. A study focusing on Montana, South Dakota, and North Dakota revealed losses of over 60,000 acres of grassland in 2006 alone (Stephens et al. 2006, Roberts et al 2007). Higher corn prices and increased corn demand could accelerate already high rates of grassland conversion and loss (Roberts et al 2007). Figure 13 shows the increase in acreage of land devoted to corn in the U.S.

[9] Conservation Research Enhancement Program focused on riparian buffers

Figure 13. U.S. corn planted acreage , 1972 to 2006



Source: Source: USDA NASS 2007a

8.b. Air quality

Whereas the substitution of gasoline by ethanol causes a small decrease in the amount of ozone-forming hydrocarbons, the life cycle emissions of CO, NOx, and SOx are substantially higher. Nitrogen oxide emissions are almost exclusively the result of emissions from the soil enriched with high-nitrogen content fertilizer (Sheehan et al. 2004). Additionally, corn has the greatest application rates of both fertilizer and pesticides per acre, higher than for soybeans and mixed-species grassland biomass. Conversion from other crops or noncrop plants to corn would likely lead to much higher application rates of highly soluble nitrogen (The National Academies 2007). Furthermore, sulfur oxide emissions are almost exclusively due to combustion of lignin residue in ethanol facilities. Dramatically higher nitrogen emissions point out the importance of applying cleaner nutrient management practices. Sulfur oxide emissions in the ethanol facility could be improved through better pollution controls on the boiler/burner system (Sheehan et al. 2004).

8.c. Pollution associated with corn production

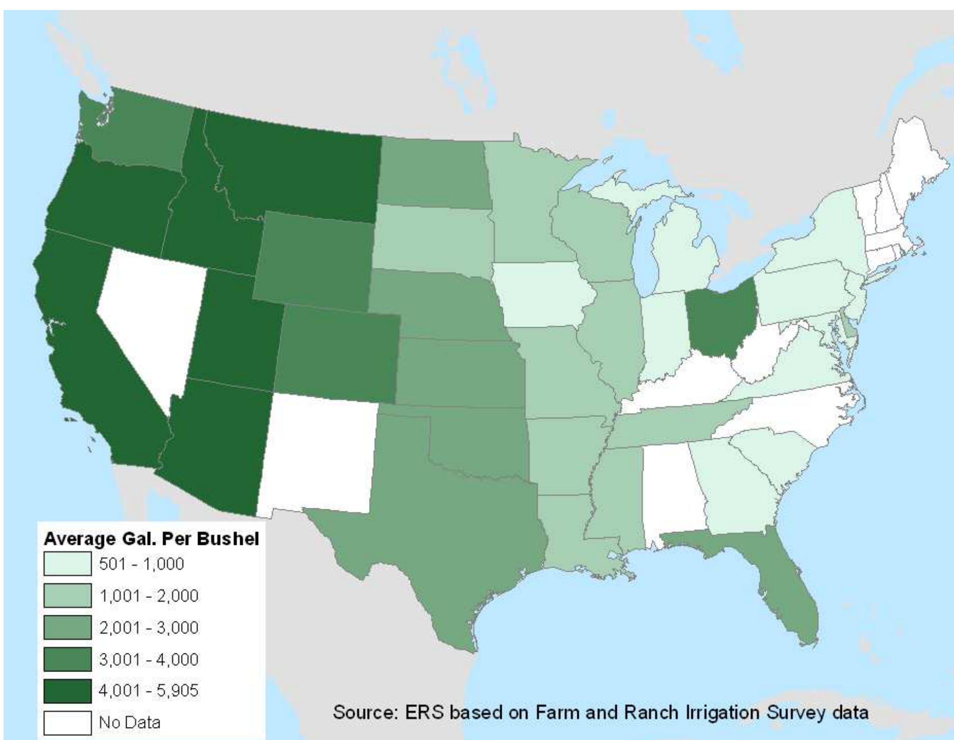
In 2002, corn comprises more than 25% of the nation's cropland, but accounts for 40% of annual commercial fertilizer use. Each year, corn producers make numerous resource management decisions that affect not only their economic well-being, but also the nearby environment (Christensen 2002). As is stated throughout this report, the major environmental impacts of ethanol production are associated with intensive growth of corn monoculture. In order to maximize yields, corn is heavily treated with chemical fertilizers and pesticides (Runge & Senauer 2007). These chemicals have serious implications for the environment; nutrient runoff enters rivers and streams where fish and other organisms can be harmed. Specifically, corn crops cause nitrogen runoff which can diminish the oxygen present in bodies of water. The following section addresses water quantity and quality concerns in more detail.

9. *Special focus: water concerns*

9.a. *Water quantity*

Corn is a thirsty plant. In Iowa, it takes an estimated 1081 to 1121 gallons of water to produce one gallon of ethanol before the corn even gets to the ethanol plant. In fully irrigated agriculture, like in southwestern Nebraska, crop water use increases substantially. In these areas, the average water use for that same gallon of ethanol is an estimated 780 to 1568 gallons of water (Varghese 2007, NRC 2007). Effects of irrigation on water resources are different depending on local conditions. Figure 14 shows the state-by state water requirements of irrigated corn in the continental United States. It demonstrates that the amount of rainfall and other hydroclimate conditions in a given area cause significant (ten-fold) variations in the water requirement for the same crop. The confined Cambrian-Ordovician aquifer in the Midwest has been drawn down by over 800 feet since 1850. For all practical purposes, this is basically an unsustainable use rate of the aquifer (NRC 2007). Regions where agriculture is rain-fed (i.e. the Corn Belt east of the Missouri River) will experience less stress on water resources, though drought remains a recurring issue in the Midwest and Great Plains (Keeny & Muller 2006). Water shortages may very well become the limiting factor to the expansion of the ethanol industry if water use efficiency is not made a top priority of policy makers.

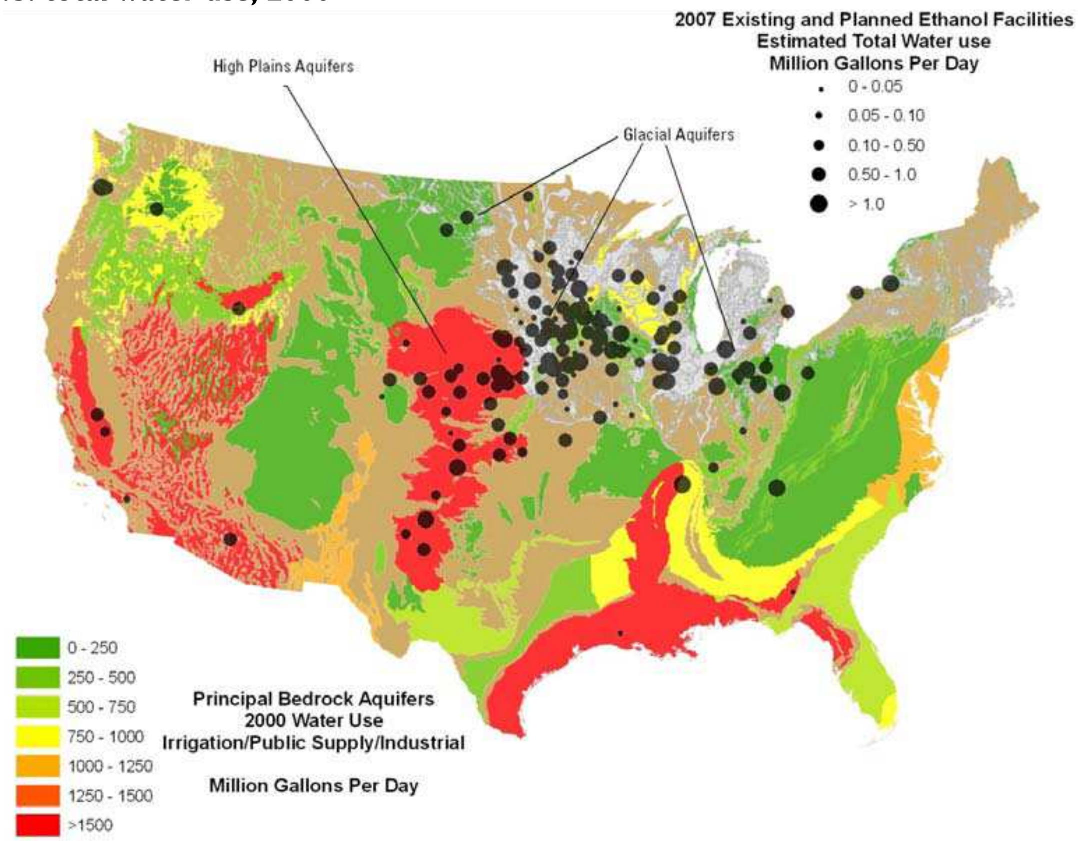
Figure 14. State-by-state water requirements of irrigated corn (gallons of irrigation water per bushel), 2003



Source: NRC 2007

When one moves into the ethanol plant, the water requirements per gallon are much less than those out in the field and technology has enabled increases in water-use efficiency in the last decade. In Minnesota some plants have improved their water use from 5.8 gallons of water per gallon of ethanol in 1998 down to 4.2 gallons in 2005 (Varghese 2007). Figure 15 shows the estimated total water use of extant and planned ethanol facilities, along with the principal bedrock aquifers of the U.S.

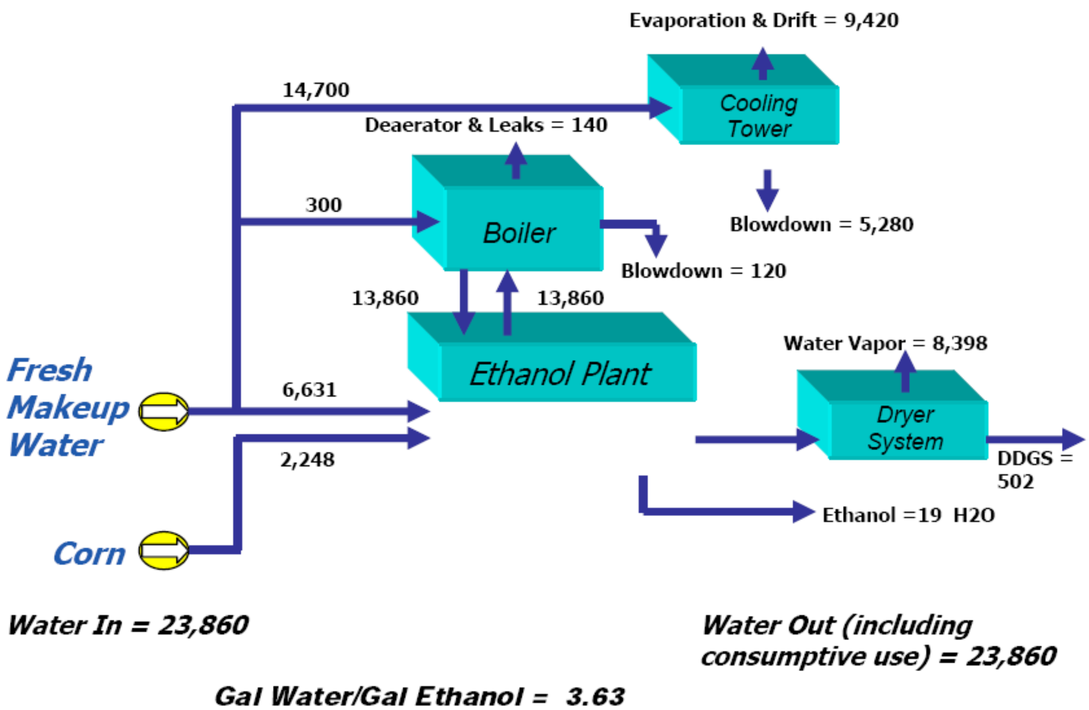
Figure 15. Existing and planned ethanol facilities, 2007, and principal bedrock aquifers of the U.S. total water use, 2000



Source: NRC 2007

It is important to remember that plants often draw their process water from municipal or county water systems, rather than a larger regional aquifer like irrigation systems. A typical 100 MMGY plant, using 350 million gallons of water per year, requires approximately the same amount of water as a city of 5,000 people (NRC 2007). Figure 16 shows the overall water balance in gallons per hour for a typical 50 MGY corn-based dry-mill ethanol plant.

Figure 16. Overall water balance of a typical 50 MMGY ethanol production facility



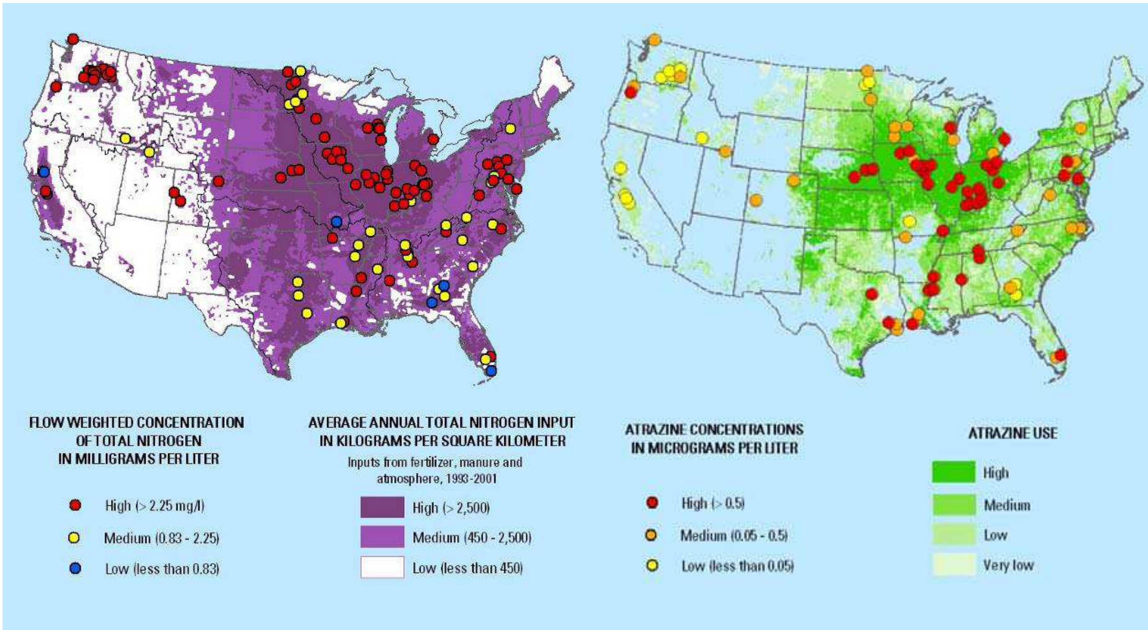
Source: NRC 2007

9.b. Water quality

9.b.1. River water quality

Corn is the most nitrogen-intensive of the major field crops. Figure 17 shows N inputs (such as fertilizer and manure) and the concentrations of nitrate in stream water on the left and stream concentrations of atrazine, a major herbicide used in corn cultivation on the right.

Figure 17. N fertilization rates and stream concentrations of nitrate (left), atrazine application rates and stream concentrations (right)



Source: NRC 2007

These maps show that the highest stream concentrations occur where the rates of application are highest, and that these rates are highest in the corn belt. These stream flows of nitrate mainly represent application to corn, which is already the major source of total N loading to the Mississippi River (NRC 2007).

Increased sediment runoff is the most important environmental effect in many regions, such as the upper Mississippi River. High sedimentation rates increase the cost of often-mandatory dredging for transportation and recreation. They also have consequences for ecosystems and sport fishermen; many of the backwater areas along major streams, which are important in the lifecycles of fish and their prey, are slowly filling in with sediment. One of the most likely causes of increased erosion in the near term may be the withdrawal of lands from CRP contracts as well as expansion of biomass production on non-CRP marginal land, due to increases in food and energy prices. High rates of withdrawal from the program in favor of growing biomass will have the effect of converting lands that may be helping to ameliorate water pollution into lands that are additional sources of water pollution (NRC 2007).

9.b.2. Offshore water quality

Biomass production affects offshore water quality considerably. Fertilizer nitrogen in the Mississippi River system is known to be the major cause of the hypoxic "dead zone" in the Gulf of Mexico. Hypoxic conditions result in other coastal water bodies as well, including the Chesapeake Bay. The conversion of other crops or non-crop plants to corn will undoubtedly lead to much higher application rates of nitrogen. Given the correlation of nitrogen application rates to stream concentrations of total nitrogen, and of the latter to the increase in hypoxia in the nation's water bodies, the potential for additional corn-based ethanol production to increase the extent of these hypoxic regions is considerable (NRC 2007).

9.b.3. Groundwater quality

Nitrogen fertilizers applied to corn fields have a direct impact on groundwater quality. Regardless of whether the fertilizer is applied as nitrate or nitrite, soil microorganisms convert much of any excess fertilizer N into nitrate, which, under anaerobic conditions in the soil or the groundwater, is then converted into nitrite. U.S. Environmental Protection Agency (EPA) water quality standards classify wells that have combined nitrate-nitrite levels greater than 10 milligrams per liter as impaired and recommend that water be treated to remove the nitrate and nitrite before consumption. Failure to do so can have significant health impacts, including causing "blue baby syndrome" in infants, when ingested nitrite binds with hemoglobin thus preventing oxygen transport. The probability of nitrate contamination of shallow groundwater correlates strongly with increased N fertilizer application, as well as with various other factors. The probability of encountering N levels above 4 milligrams per liter is greatest in the High Plains, which is characterized by high N fertilizer application rates (NRC 2007).

Some pesticides may also leach to groundwater. In a national study, pesticides were detected in 61% of shallow wells sampled in agricultural areas; though only 1% of these cases did any pesticide occur at concentrations greater than water quality benchmarks for human health. As with nitrate, pesticide contamination in groundwater is correlated with moderate to high application rates where soils are permeable and drainage practices do not divert recharge to surface waters, such as in parts of Iowa, Minnesota, and Wisconsin. It is reasonable to believe that groundwater quality issues associated with increased biofuels production may also be focused in these areas and others. Groundwater contamination problems take longer to develop and longer to fix than surface water problems. However, if corn-soy planting rotations were to convert to continuous corn plantings, the proportion of affected wells would increase over time. The area of the nation subject to having elevated groundwater nitrate and nitrite levels would also increase if corn were grown in new areas (NRC 2007).

9.b.4. Plant waste water quality

Though ethanol plants are designed to recycle water (Keeny & Muller 2006), they do produce several kinds of effluent. Cooling towers and water boilers accumulate salt deposits which must be occasionally discharged in a process called blowdown. Also, a brine waste is produced as a result of technologies used to make the pure water needed in ethanol production. These wastes are discharged in compliance with state-issued National Pollutant Discharge Elimination System (NPDES) permits, which often dictate levels of total dissolve solids (TDS), acidity, iron, residual chlorine, and total suspended solids (TSS) (NRC 2007).

High levels of biochemical oxygen demand (BOD, the oxygen used when organic matter is decomposed by microbes), is also symptomatic of waste water derived from the processing of ethanol co-products like wet and dry distillers grains. Discharge of high-BOD water to rivers and lakes is problematic because decomposition can consume all of the dissolved oxygen, suffocating aquatic animals (NRC 2007).

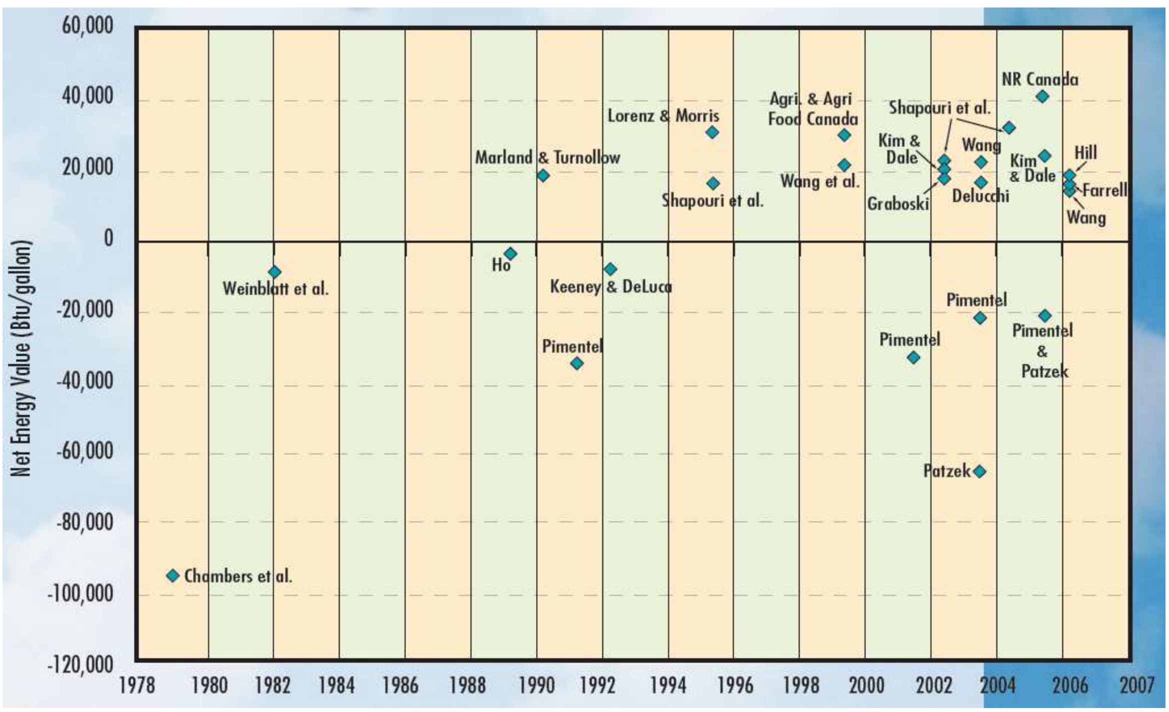
Currently, biofuels are a marginal additional stress on water supplies at the regional to local scale. However, significant acceleration of biofuels production could cause much greater water quantity problems depending on where the crops are grown. Growing biofuel crops in areas requiring additional irrigation water from already depleted aquifers is a major concern. These concerns, combined with competing uses for water including drinking water, cooling in other industrial applications, recreation, hydropower, and wildlife habitat, indicate that water may quickly emerge as the weakest link in ethanol capacity development (NRC 2007).

10.   Corn-based ethanol's role in energy policy

Up to this point, this report has been mostly focused on the economic impacts of corn-based ethanol production, which is fueled by government policies and support. However, the bigger picture needs to be considered. The role of corn-based ethanol in the nation's broader energy policy depends on its energy balance. Any fuel source should generate more energy than what is used to produce it in the first place. Ethanol's part in the energy policy only makes sense if it is an energy producer.

Unbiased information about the energy balance of ethanol is hard to come by. Even peer-reviewed investigations from academic and government researchers yield different results on both sides of the net energy balance line. Figure 18 shows studies analyzing the energy balance of ethanol production over the past 20 years. Energy balance is described as Btu content in a gallon of ethanol minus fossil energy used to produce a gallon of ethanol.

Figure 18. Studies of the energy balance of corn ethanol



Source: Wang 2007

The studies above the "zero line" found that ethanol has a positive net fossil energy value (that is, less fossil energy is used to produce ethanol than the energy that is available in ethanol). Studies below the "zero line" found that ethanol has a negative fossil energy value. Most of the studies show that ethanol has a positive net fossil energy value.

Ethanol opponent and Cornell professor Dr. David Pimentel has published several papers in peer-reviewed journals over 16 years describing a lifecycle analysis of ethanol and other biofuels. He consistently finds that fossil energy inputs to a gallon of ethanol exceed energy outputs from that gallon; in fact, ethanol production using corn grain requires 29% more fossil energy than the ethanol fuel produced(Pimentel 2005).

Dr. Michael Wang, at Argonne National Laboratory's Center for Transportation Research, developed a lifecycle model, the Greenhouse gases, Regulated Emissions and Energy use in Transportation (GREET) model, which shows that the fossil energy input per unit of ethanol is 0.78 million Btu of fossil energy consumed for each 1 million Btu of ethanol delivered. This contrasts with 1.23 million Btu of fossil energy consumed for each 1 million Btu of gasoline delivered.

The USDOE Energy Efficiency and Renewable Energy Biomass Program states that the net energy balance of corn-based ethanol is 1.34 (for every unit of energy it takes to make ethanol, we get one third more energy than gasoline); cellulosic ethanol, 2.62; soy-based biodiesel, 3.2; and corn stover, over 5 (EERE-BP 2007).

It turns out that it simply depends on how one defines "lifecycle," and which factors of production are included in the analysis. For example, Pimentel includes farm equipment and labor energy costs in his analysis, whereas Wang and others do not. Whichever value for net energy balance one uses, ethanol has only two-thirds the energy content of gasoline, so it takes almost one and a half times the amount of ethanol to go the same distance as gasoline. Pure ethanol is not compatible for use with current engine technology, though blends of up to 10% are compatible (Coyle 2007).

11. Projections

So far this report has outlined the complex political, economic, and environmental implications of the recent tremendous expansion of corn-based ethanol production. Whether this expansion will continue apace depends on several factors, the major ones being the ability of the industry to overcome infrastructural obstacles and to secure continued government support. The following section examines these, as well as the projected outlook for affected commodities – corn, other crops, and the potential impacts on food prices. Since economic impacts are the primary focal points of this report, the future losses and benefits are assessed in a sub-section. The final portion of this section considers the direction in which ethanol production may be shifting and analyze cellulosic feedstock sources and their potential future role in biofuels.

11.a. Obstacles to continued expansion

Inadequate transportation infrastructure may be the main obstacle to continued boom of the ethanol industry. The particular rail cars needed to transport the corrosive material are in short supply. There is a long backlog in orders for them. The Agriculture Department reported that the backlog from the first quarter of 2007 is for 36,166 rail tank cars, up from 10,000 in the third quarter of 2005. Accommodating long trains used for ethanol shipping requires large spurs, which are missing at many plants, and pumping ethanol from storage tanks to the rail cars at terminals is often inefficient because of the pumps' limited capacity (Krauss 2007).

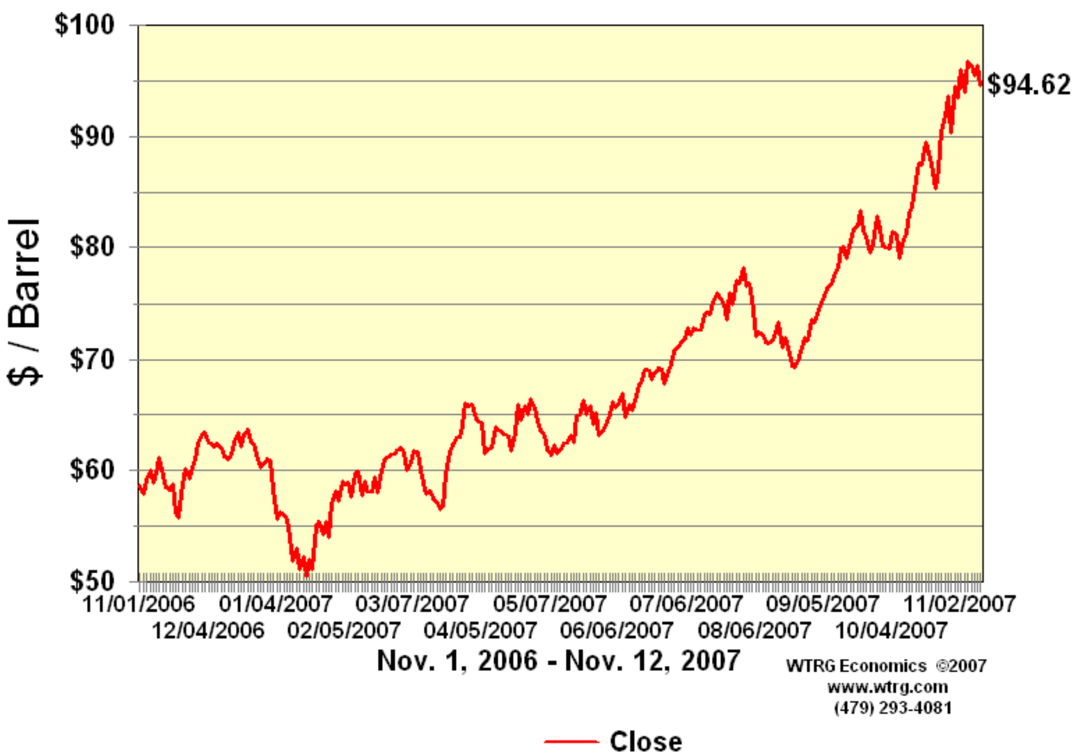
The recent boom in ethanol production flooded the E10 market, driving ethanol prices down. This, in concert with the rising price of the processes' major input – corn - have put a halt on some plant expansion and construction preparations (Krauss 2007). For example, a plant in Grafton, North Dakota, which has been in operation since 1983 and makes 10.5 MGY, recently announced its closure. Construction at three other plants was stopped recently; the rising prices of corn and lower prices of ethanol are cited as reasons (Davey 2007). This highlights the fragile economic relationship between supply and demand of corn. Running a profitable ethanol plant requires a relatively cheap input of corn (or other feedstock), but the booming expansion of the ethanol sector increases demand of corn and its price, undercutting the overall revenues of plants. The expansion will be forced to subside, the corn prices will likely fall, and a new equilibrium will be achieved. Throughout the process, however, there will be losers and winners. Some of the plants currently operating or being constructed will likely need to be decommissioned or consolidated with other plants.

11.b. But corn-based ethanol is still strong

Despite the recent slowing down of the industry's expansion, corn-based ethanol production is projected to continue apace, given the sector's profitability (buttressed by the rising crude oil prices) and government's generous support.

As noted before, ethanol profitability is tied to crude oil prices since they are sold as one product. Recently, crude oil prices have experienced record prices reaching nearly $100 per barrel. The underlying commodity of the New York Mercantile Exchange's oil future contracts is the West Texas Intermediate oil. Figure 19 reviews the commodity's prices over the last year.

Figure 19. Crude oil futures price, November 2006 to November 2007



Source: WTRG Economics 2007

An additional factor helping the industry is the expected reversal of the U.S. dollar's depreciation. The currency has depreciated considerably in the last few years, consistently falling against the euro, the British pound, the Canadian dollar, and others. Just this year, the U.S. dollar slipped 10 percent against the currencies of the U.S. biggest trading countries (Finch et al. 2007). This decline makes U.S. exports relatively cheap and other countries' imports in the U.S. relatively more expensive, protecting U.S. industries from overseas competition. The value of the U.S. currency is expected to rebound, however, making imports more attractive and slowing down exports of some U.S. crops, including corn (ERS 2007), potentially providing a stable source of feedstock for the ethanol industry.

The economic impact of the industry is projected to continue being strong. If the capacity expansions continue on track, producing 9.3 billion gallons of ethanol by 2015, an industry analyst predicts that around $83.1 billion (2005 dollars) will be contributed from spending for annual operations and capital expenditures on new capacity. Around 203,879 jobs will be supported, and $197.4 billion will be saved in U.S. trade deficit (Urbanchuk 2006).

Almost every single plant we talked to was cautiously optimistic about the future of ethanol and their plants. There were outliers on both sides, but for the most part, margins are tight, and managers and owners are paying very close attention to what's going on inside the Beltway as well as outside their front doors. In the words of one plant manager, "The success of the plants is very dependent on policies that require blending of ethanol in gasoline fuel (Zook 2007)." They are subject to the vagaries of two markets; corn on the front end, and ethanol on the back. When asked how their levels of production might change in response to feedstock prices, Les Nelson of Aventine Renewable Energy said, "You cannot simply look at feedstock prices. You have to look at the price of ethanol in conjunction with the price of the feedstock. For example, $4.00 corn is not a problem with $2.00 ethanol. However, $3.00 corn is expensive if you are only getting $1.40 for ethanol (Nelson 2007)." Vince McCabe of Illinois River Energy in Rochelle, IL similarly asserts that their production level depends on overall circumstances. They can slow production, and for instance when denaturing costs more, they can cut costs by changing the denaturing percentage. It's all about active risk management (McCabe 2007). Neill McKinstray, the Vice President and General Manager of The Andersons ethanol plant in Albion, MI, said that "due to high fixed costs and operating efficiencies, the production rate will not generally vary with feedstock price. We will run at 100%+ rate if incremental returns exceed incremental costs, or we will shut down completely (McKinstray 2007)."

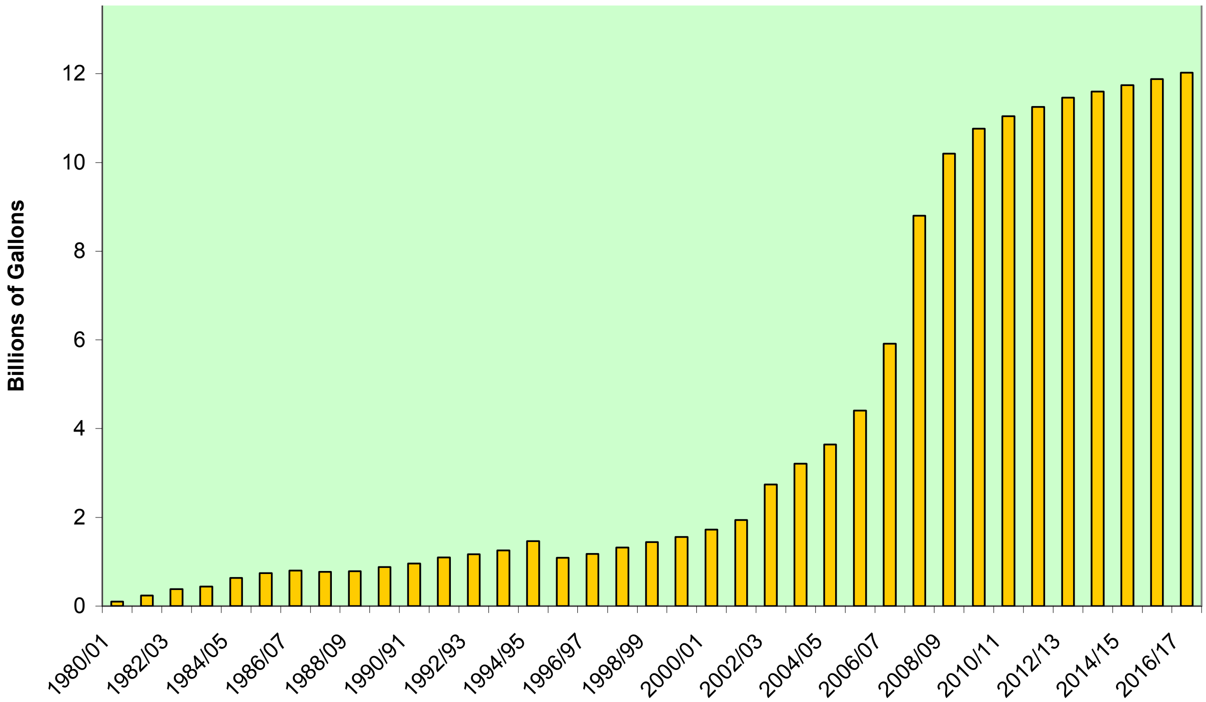
Leo Johnson of Johnson Tractor in Rochelle, IL is optimistic about the short-term future of ethanol. Many of the sharp marketers sold 2008's crop when the prices were high. If they get a crop they will be profitable, but they will complain if the price goes up. In the Midwest the temperate weather is rather consistent; farmers can bank on one-half to three-quarters of a crop and with that they will be profitable (Johnson 2007).

The following sections outline the projected trends for the sectors affected most by ethanol production.

11.c. Corn

The official projections indicate that the share of corn used for ethanol is expected to climb to 30% of the total crop, producing 12 billion gallons of ethanol by 2016-17. Figure 20 summarizes the projected increases in corn production (Collins 2007). However, it should be noted that given the current pace of expansion, these targets will likely be met far ahead of schedule, and 12 billion gallons of ethanol will likely be produced by 2009. And some experts project that under current federal policies and expected crude oil price trends, ethanol production from corn will reach nearly 15 billion by 2011 (Tokgoz 2007).

Figure 20. Historic and projected production of ethanol from corn, 1980 to 2016



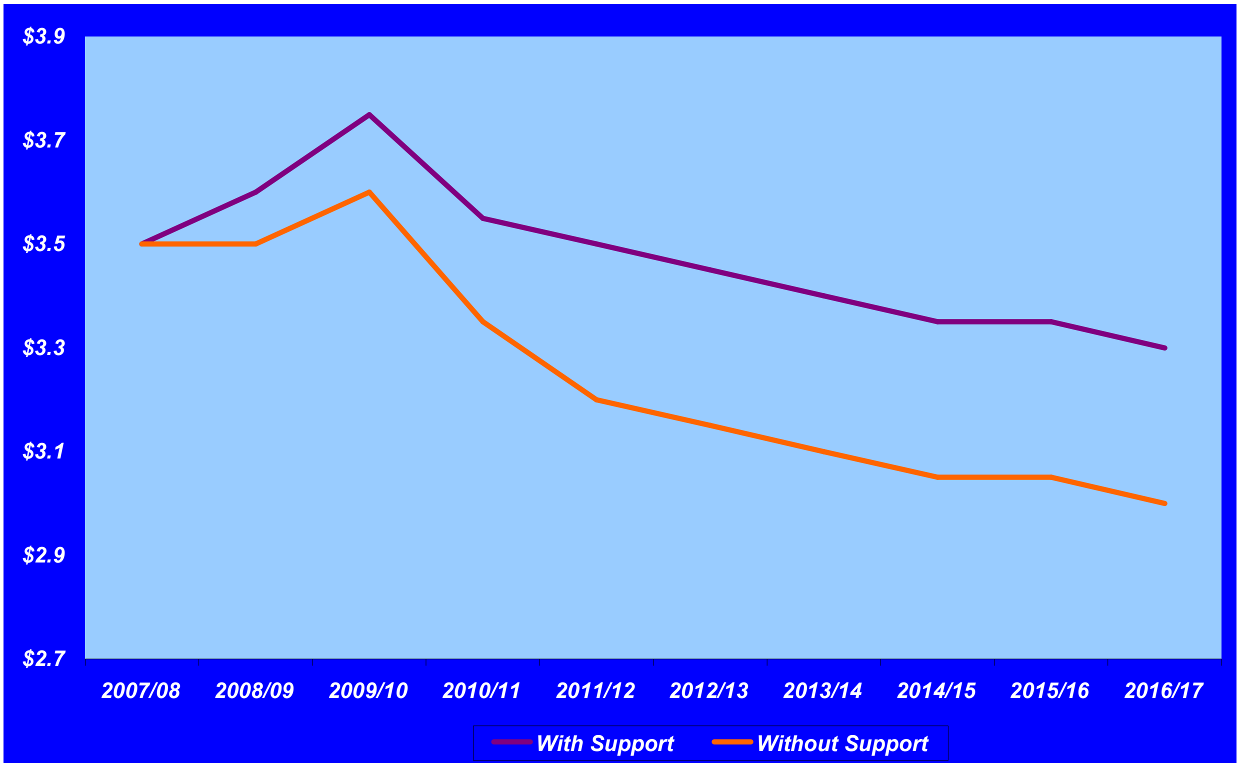
Source: Collins 2007

The reason for this expansion is clear. The current price spread between a gallon of ethanol and the price of corn required to produce it is nearly six times greater than what is minimally profitable (Robinson 2007).[10] Corn prices are expected to fall in the future, however. The USDA projects that the prices will begin to decline whether or not the current government support programs are retained.[11] If the support structure is removed, the price will decline by an additional $0.22 on average. Figure 21 visually illustrates the projections.

[10] The ethanol-corn price spread is defined by experts at the USDA as the price of wholesale ethanol multiplied by the number of gallons from a bushel of corn (assumed to be a constant 2.75) minus the bushel price of corn. The current price spread is $8 per bushel. The spread is profitable beyond $1.40 per bushel (Robinson 2007).

[11] The details of the support programs are discussed in the section "Government Relations: Support and Subsidies

Figure 21. Projected corn price per bushel, 2007 to 2017



Source: Collins 2007

However, others estimate that corn prices will not fall as dramatically, but will continue increasing until an equilibrium supply and demand point is reached. The price is projected to be $4.40 per bushel at that point, with nearly a quarter of cropland in the United States dedicated to corn growing for ethanol production (Tokgoz 2007).

The demand for corn is expected to remain strong and can be satisfied in a number of ways. Imports from other countries (particularly Canada) may provide an influx of corn supply. Achieving higher corn yields will certainly be a strategy pursued by U.S. farmers. The past decade (1997-2006) experienced a 20% increase in bushels of corn grown on an acre compared with the previous decade. It is possible that the yield can be increased further (Baker et al. 2007). In fact, industry groups expect the yield to increase from the current level of 2.75 gallons of ethanol per bushel of corn to 3 gallons by 2015 (Urbanchuk 2006).

11.d. Other crops

The recent record-breaking corn prices have motivated many farmers to produce corn rather another crop. The decreased supply of those crops, in turn, has had a positive impact on their prices. Certain crops – wheat and soybeans, in particular - are expected to rebound in response to the increased prices, although the longer term projections predict a more stable equilibrium. Overall, prices, domestic use, and exports are predicted to experience slight increases for the wheat sector up through 2015. Soybean plantings, which have seen a decrease of 8 million acres from 2006 (Wescott 2006), are expected to continue undergoing a slump as more acreage is dedicated to the high-priced corn.

Soybean prices will rise, as supply diminishes, equalizing the market, and prompting the return of some acreage to soybean production. Domestic use of soybeans is expected to rise slowly through 2015 (ERS 2007).

11.e. Food products and others

The recent surge in ethanol production and the resultant higher corn prices are suspected to increase prices for other U.S. commodities. As discussed above, these price increases are largely speculative and, if they do exist, are likely very minor. The major meat producers are concerned nonetheless, and a recent study conducted at the Iowa State University and supported by major food manufacturers' associations[12] attempted to project the future situation. One scenario assumed that crude oil prices will reach $65-70[13] per barrel, stimulating ethanol demand and in turn increasing corn prices to $4.42 per bushel. The effects on selected commodities are summarized in Table 15.

Table 15. Potential increases in meat prices under high crude oil and corn prices

	Pork	Broiler Chickens	Beef
Production Costs	+ 36.8%	N/A	N/A
Production	-9.2%	N/A	-1.6%
Retail Prices	+8.4%	+15%	+4%
Exports	-21%	-15%	N/A
Domestic Consumption	N/A	-4%	N/A

N/A: data not calculated
Source: GrainNet 2007

The global outlook for potential food price increases is not optimistic. An OECD/FAO report published in 2007 projects food price increases of 20% to 50% by 2016. While several drivers are at play, growing use of cereals, sugar, oilseeds and vegetable oils in the biofuels industry is one of the major contributors. The CEOs of Cargill and Nestle have warned that as land is diverted for energy crop cultivation, food prices may see a significant and long-lasting increase (Doornbosch et al. 2007).

11.f. Overall economic benefit

Without subsidies, it is questionable whether ethanol would be economically competitive with gasoline. For example, a study found that in 2005, the true production cost of ethanol (without subsidies) was $0.46 per energy equivalent liter of gasoline. The wholesale price of gasoline for the same period averaged $0.44 per liter. Ethanol is clearly not cost competitive with gasoline without subsidies. The federal government alone provides around $0.20 per energy equivalent liter in subsidies for ethanol, and usually more support is available from the state and local governments (Hill 2006). The competitive edge gained from the subsidies has contributed to the influx of ethanol production. In most cases, the local economic impact provided as a result is welcome and positive.

[12] Funding was provided in part by American Meat Institute, Grocery Manufacturers/Food Products Association, National Cattlemen's Beef Association, National Chicken Council, National Grain and Feed Association, National Pork Producers Council and National Turkey Federation (GrainNet 2007).
[13] As was previously noted, current crude oil prices are already beyond this estimate, ranging from $90-100.

An assessment done by the World Resource Institute in September 2006 analyzes expected economic impacts under varying production level scenarios (Marshall & Greenhalgh 2006). For example, if the annual production of ethanol reaches 15 billion gallons, compared to the baseline production of five billion gallons, the price of corn is expected to increase by 17.5% and farm income from corn would rise by 30.6%. On the other hand, losses are expected in soybean prices, farm income from soybeans, and farm income from livestock. Table 16 summarizes the results.

Table 16. Economic impacts of increased ethanol production under different capacities

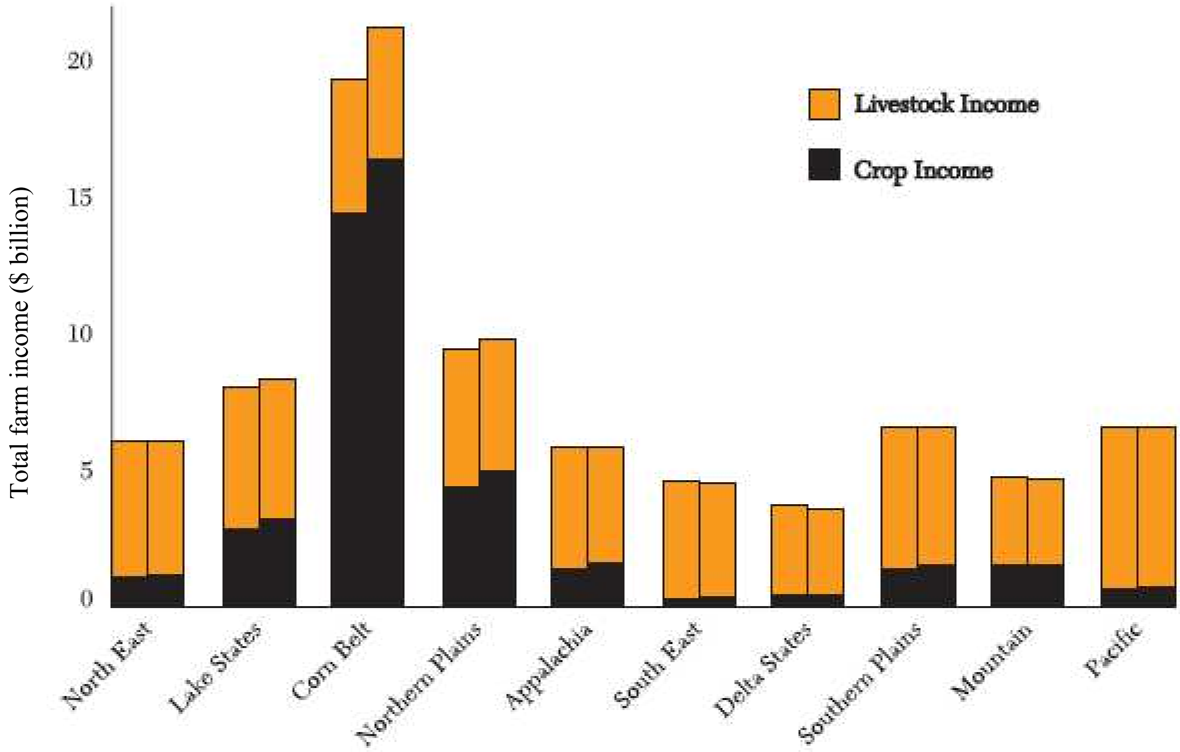
Economic Impact	Unit	5 BGY	7.5 BGY	10 BGY	12.5 BGY	15 BGY
Price of Corn	$/bu	$2.40	3.3	7.9	12.1	17.5
Price of Soybeans	$/bu	$5.60	-0.4	-1.6	-2.7	-3.6
Farm Income	$bill/yr	75	0.7	0.7	1.9	3.3
Cash Receipts	$bill/yr	208	0.7	1.1	1.9	3.0
Variable Costs	$bill/yr	133	0.6	1.3	1.9	2.9
Farm Income (Corn)	$bill/yr	16	3.7	8.5	18.0	30.6
Farm Income (Soybeans)	$bill/yr	5	-2.2	-7.4	-12.2	-16.3
Farm Income (Livestock)	$bill/yr	47	0.5	-0.4	-0.9	-2.3
Govt. Payments	$bill/yr	10	-7.5	-15.9	-17.5	-18.4

Source: Marshall & Greenhalgh 2006

This report assumes that corn prices will increase to $2.82/bushel when production is raised to 15 billion gallons of ethanol per year. Soybean prices will drop to $5.40/bushel. Livestock income and production are affected in two counteracting ways. One is the decrease in corn availability as a feedstock. The other is an influx of another feedstock, DDGS, which can be used to substitute soybean meal. The increased availability of this high-protein feed will initially benefit the livestock industry, although higher prices of corn and other feedmeals (which occurs as a result of higher demand for corn replacement in feed) eventually create losses for the sector.

The aggregate effect on farm income is still expected to be positive, meaning that profits for grain producers outpace losses in the livestock sector. These costs and benefits are decoupled geographically, and in certain regions, such as the Southeast and the Delta states (Louisiana, Mississippi, and Arkansas), the losses will not be compensated by the gains from elsewhere (Marshall & Greenhalgh 2006). Figure 22 shows changes in total farm income in different regions of the U.S. The first column is the farm sector income at a baseline production level of 5 BGY and second column is the farm sector income at 15 BGY.

Figure 22. Total farm income in U.S. regions



Source: Marshall & Greenhalgh 2006

Overall, the economic projections for ethanol plants are mixed. If bushel/acre yields keep increasing (an astonishing 225 bushel/acre yield was recently reported in Iowa (Achenbach 2007) then the ethanol plants' feedstock requirements may be met without straining some of the other sectors reliant on corn. Either way, this arrangement heavily depends on government subsidies and most of the economic impacts would be erased without this support, as is described in Section 5.

On the other hand, new feedstocks are gaining support in the industry. Several cellulosic sources are being researched and developed, promising to replace corn as the primary ethanol feedstock. This may have detrimental effects on the corn farmers for whom ethanol represents another value-added use for their commodity. Depending on where the new feedstocks will be grown, the local economic impact of ethanol production may be greatly diminished, cutting corn producers and the subsequent economic ripple effects out of the equation.

11.g. Projections for cellulose-based biofuels

Corn-based ethanol may become a thing of the past in the next few years. Cellulose-based biofuels are gaining popularity and research dollars from the federal and state governments. Recently, the US DOE announced its plans to invest nearly $400 million into six biorefinery projects within the next four years. The winning projects included plants ranging from 11.4 MGY to 125 MGY of ethanol in production capacity. The biomass utilized will be similarly variegated, and include feedstocks made from corn stover (i.e. everything but the sugar-rich kernels); wheat straw; milo stubble; switchgrass; yard; wood; and vegetative wastes; green and wood waste from landfills; agricultural residues including wheat straw, barley straw, and rice straw (DOE 2007).

The ideal feedstock needs to be a low-input, high-yielding crop, which thrives on marginal, low-productivity land (DiTomaso et al. 2007). Several grasses are promising candidates, including switchgrass. Another perennial grass, *Miscanthus*, may offer even more valuable biomass than switchgrass, because it has a broader leaf surface area, as well as a longer growing season and can yield more photosynthetic carbon per unit area compared to switchgrass (Kachan 2007). In fact, if only 20% of Illinois' agricultural area were converted to growing *Miscanthus*, 100% of the state's electricity needs will be met (Long 2007). The gains, however, depend on the specific ecological conditions. In Europe, for example, switchgrass was shown to be a more successful feedstock than *Miscanthus* (Lewandowski 1998), although newer studies may be warranted. Moreoever, because cellulosic sources do not constitute viable food supplies, they will not affect food prices or food availability.

Given the seeming success of cellulosic feedstock, why is most ethanol still produced from corn in the United States? The answer is that the process of breaking down cellulose into fermentable components is very expensive and reduces the amount of feedstock material available. A cellulosic plant can cost more than four times as much to build as an ethanol plant and will produce ethanol at a marginally higher cost than corn (Schubert 2006). Other considerations such as the effects on industries currently relying on potential feedstocks likes wood pulp need to be taken into account. Finally, the potential environmental effects of intensely growing new feedstock sources, such as the spread of invasive species or loss of biodiversity, need to be considered.

Nonetheless, there are promising techniques being explored to cut down the production cost and utilize the cellulosic feedstock potential. One firm is focusing on a patented fungus whose genes can easily break down the component material of cellulose, priming the fibrous portions for fermentation. This method is showing promise, and one of the leading ethanol producers, Abengoa, has made an investment into the technology. And the current leading cellulosic ethanol producer, Iogen, similarly utilizes fungal enzymes, and recently secured a sizeable investment from Goldman Sachs (Sanderson 2006). Another hopeful solution may come in the form of single-celled algae that are capable of producing 40 times more fuel as corn (Schubert 2006). Nonetheless, at current low production levels and remaining obstacles, cellulosic technology remains a future possibility.

Another issue to consider is the ease with which existing plants configured to process corn can switch to new feedstock sources. Some plants are designed with that goal in mind, although until there is an economically feasible cellulosic process, it is difficult to predict what the necessary technology will look like.

From our conversations with communities hosting ethanol plants, there were mixed findings regarding the conversion of factories to other feedstocks. Older factories will be harder and more expensive to retrofit. Several contacts expressed that any board is going to be willing to take a look at innovative ways to produce ethanol more efficiently. Les Nelson of Aventine Renewable Energy points out that as far as factory conversion, once the starch from your feedstock is removed, the process of fermenting and distilling is the same regardless of feedstock (Nelson 2007). The Andersons ethanol plant in Albion, MI can be converted relatively easily to use sorghum, though none is produced locally (McKinstray 2007).

Most plant contacts we interviewed, especially at newer plants, were confident that corn-based ethanol plants would be relatively easy to convert to different feedstocks, though not without modification. The problem, as succinctly defined by Steve Renquist from the Kandiyohi County (MN) Zoning Administration, is that we know how to grow, store, and transport, corn in the Midwest, and there are millions of acres of it (Renquist 2007)! There is simply not the capacity to produce any other feedstock on the massive scale of corn, which of course is bolstered by years of subsidization and is so pervasive in our economy and landscape that it seems unlikely that another feedstock could ever gain the economic traction (i.e. low production value) needed to upend corn as the feedstock of choice.

12. Conclusion

The proliferation of corn-based ethanol plants throughout the country has wide ranging implications. On the one hand, there are large economic benefits. Although ethanol plants themselves contribute positively to the community's economic situation, most benefits are derived from the creation of a new market for corn. The demand for corn used to produce ethanol was nearly absent just a decade ago. The current ethanol production uses up twenty percent of all corn, which has driven corn prices generating additional profits for corn farmers nationwide. The impacts on farmers of other commodities, as well as on livestock operations, have been mixed. Since more land is pulled into growing corn, the supply of land for other crops is reduced, diminishing the overall yields. This, however, can drive up the commodity's price, resulting in a positive outcome for the producer. Similarly, although livestock operators have seen feed costs increase, the prices have risen only marginally. The wider availability of DDGS, which is used as livestock feed, can help keep the prices in the sector steady. The overall net economic impacts seem to result in a positive contribution to the local economies.

But the side effects of this economic stimulus can not be overlooked. The environmental impacts of intense corn-production reverberate from pesticide use and ground water contamination to air pollution and loss of biodiversity. An already strained resource, water, will become especially crucial as its quality and availability diminish. Additionally, as an OECD/FAO report highlighted, fuel production from food sources can raise global food prices by as much as 50% within the next decade.

Higher food prices are occurring everywhere, and the debate remains whether corn and soy, cheap commodities worldwide, should be diverted from food production to sate the ravenous appetite for transportation fuel in developed and middle economy countries. Even dedicating all U.S. corn and soybean production to biofuels would meet only 12% of gasoline demand and 6% of diesel demand in the U.S. (Hill et al. 2006). World food prices rose 10% in 2006 because of increases in corn, wheat, and soybean prices, primarily from demand-side factors, including rising biofuel demand. In fact the Chinese government put a moratorium on expanded use of corn for ethanol because of rising feed prices, which caused pork prices to rise by 29% in the last two years (Conniff 2007). It is promoting other feedstocks that do not compete directly with food crops (e.g. cassava, sweet sorghum, and jatropha) (Coyle 2007).

Because of the skyrocketing price of corn and the resulting inflation of food prices, Mexico capped tortilla prices in early 2007. Likewise, food budgets were pressed in Brazil and other countries when real sugar prices hit a 10-year high in 2006. Biodiesel feedstock palm oil, exported by the Indonesian government was subject to an increased export duty in mid-2007 to slow the rising cost of cooking oil there. Long-held concerns about Japan's almost complete dependence on imports of feed grain and oilseeds to support its large livestock sector were recently rekindled (Coyle 2007).

Before reaching an overarching conclusion, the bigger goal of corn-based ethanol production needs to be considered. Ethanol is meant to be an integral part in our nation's energy policy. The energy policy aims to incorporate renewable sources of energy to meet our country's demand, reduce dependence on foreign sources, and diminish the detrimental environmental effects of oil use. Corn-based ethanol does not make a significant contribution to this goal. At the crux of the matter are the fuel's low (or possibly null or even negative) energy balance and the feedstock's high-use resource requirements. The best estimates place corn ethanol's energy balance at a positive 30%, while some maintain that its production is an energy loser. Either way, this is a very marginal benefit for the high price incurred in intense corn growing. Overall, corn-based ethanol is likely an intermediate step in energy policy, waiting to be replaced with higher yielding more environmentally friendly energy sources. How this step can be expedited while minimizing negative externalities is addressed in the next section on policy recommendations.

13. Policy Recommendations

The overall goal related to corn-based ethanol should be to move energy policy to a more sustainable source, while preserving economic benefits and minimizing environmental damage.

To shift energy policy to sources that are truly sustainable and generate much more energy than is used in manufacturing the fuel requires an honest assessment of many fuel types and sources. Incentives for using diverse renewable energy technologies such as wind and solar power need to be strengthened. As discussed above, cellulosic biofuels can also be part of the overall equation and their potential should be fully evaluated.

One of the major ways in which economic benefits can be preserved as ethanol production moves to take advantage of non-corn feedstocks is to shift farm policy. Instead of subsidizing the production of a certain commodity (in this case, corn), farm policy can be directed to support investments in biorefineries. By guaranteeing a certain return on an investment in an ethanol refinery, the government would release the farmer from her reliance on corn growing and allow the flexibility necessary to adjust to demand for new feedstocks. When the industry does shift to a more energetically efficient commodity, such as switchgrass, the corn farmer will be able to profitably switch alongside. Additionally, encouraging the marketing of all co-products can generate higher income for ethanol operations and eliminate some of the wastes created by the factory.

Another important step toward protecting economic gains is to support local ownership, which can generate nearly three times as much income for the local community. Government incentives should be made available primarily to locally owned facilities. This was implemented in Minnesota, where now nearly three quarters of all plants enjoy local ownership. Moreover, research and development produced with public money can be licensed to farmer-owned plants only.

On the other hand, it should be recognized that other energy-producing facilities can generate similar economic impacts. For example, the 1,300 residents of Roscoe, Texas are reaping benefits of an economic boom. In the town, the average wind speed blows at a fairly consistent 17 miles per hour. An Irish company spent more than $1 billion installing 640 huge windmills around Roscoe. Each turbine generates considerable income for the farmer on whose land the structure is placed (Burnett 2006). The town is enjoying benefits that are similar to those received from ethanol plants, which underscores the point that many forms of economic stimulus are welcome in communities.

Before the industry shifts to a more environmentally friendly feedstock, environmental damages related to intense corn production need to be mitigated. Better conservation practices in agriculture need to be encouraged. These include no-till or planning cover crops; protection of buffer zones; and continuation of soybean rotations. The Conservation Reserve Program should be updated to account for higher corn prices and land values. Finally, close-loop energy systems within ethanol (and other) plants should be encouraged. For example, a plant in Mead, Nebraska is set to employ a process where dairy manure powers the ethanol plant and the plant's DDGS is returned straight to the dairy operation.

As the industry moves to other feedstock sources, their potential negative environmental effects need to be evaluated. Some of the proposed plants are invasive species. *Miscanthus* is reported to not be a concern in this respect (DiTomaso 2007). The use of monoculture, in general, should be considered cautiously and preferably abandoned. A study by the University of Minnesota found that switchgrass plots with high plant diversity produced 180% more biomass than monoculture plots and were better suited to withstand adverse conditions such as droughts (Schubert 2006). Plant diversity also better preserves ecological health of the region and aids in controlling pest populations and spread of invasive species. All of these issues need to be evaluated as our country's energy policy responds to encountered obstacles and develops accordingly.

Works Cited

Achenbach, J. November 23, 2007. *So What's So Bad About Corn?* The Washington Post. Available online at: http://www.washingtonpost.com/wp-dyn/content/article/2007/11/22/AR2007112201442.html.

American Coalition for Ethanol (ACE). 2007. *Ethanol Facilities*. Available online at: http://www.ethanol.org/index.php?id=37&parentid=8

Anderson, Jason (City of Rochelle Economic Development Director). Telephone interview. October 2007.

Aventine Renewable Energy, Inc. 2006. Available online at: http://www.aventinerei.com/aventinerei.html.

Babcock 2007. *Farm Programs, Fuel Mandates, and Agricultural Prosperty*. Iowa Ag Review: (13) 3.

Baker, A., & Zahniser, S. May 2007. *Ethanol Reshapes the Corn Market.* USDA: Economic research Service: Amber Waves. Available online at: http://www.ers.usda.gov/AmberWaves/May07SpecialIssue/Features/Ethanol.htm

Borkosky, Ralph (Huron City Planner). Telephone interview. October 2007.

Borst, A. September 2006. *Bring It home*. USDA Rural Development. Available online at: http://www.rurdev.usda.gov/rbs/pub/sep06/bring.htm

Bourne, J. October 2007. *Green Dreams*. National Geographic. Available online at: http://ngm.nationalgeographic.com/ngm/2007-10/biofuels/biofuels-p2.html

Brown, Steve (Pekin, IL Planning & Development Director). Telephone interview. October 2007.

Bryan, T. December 2006. *2006 U.S. Ethanol Industry Salary Survey Report.* In Ethanol Producer Magazine. Available online at: http://ethanolproducer.com/article.jsp?article_id=2539&q=&page=3

Bryans, Diane (Stark County Tax Director). Telephone interview. October 2007.

Buchanan, J., & Ledue, N. April 2007. *Adkins Energy LLC.* Energy Exec. Available online at: http://www.energydigital.net/Adkins-Energy-LLC_2175.aspx.

Buchenau, Ron (Lena, IL Zoning and Planning Committee). Telephone interview. October 2007.

Burnett, J. November 27, 2007. *Winds of Change Blow into Roscow, Texas*. NPR. Available online at: http://www.npr.org/templates/story/story.php?storyId=16658695

Calkins, Kurt (Director of Land and Water Conservation Committee, Columbia County, WI). Telephone interview. October 2007.

Cambrians for Thoughtful Development. 2007. *Ethanol Plants in Wisconsin*. Available online at: homepage.mac.com/oscura/ctd/wisplants.html

Campbell, D. May 2007. *Producer Ownership of Ethanol a Major Plus for Rural America*. USDA Rural Development. Available online at: http://www.rurdev.usda.gov/rbs/pub/may07/producer.htm

Carlson, Don (Commodities Manager, Bushmills Ethanol, LLC). Telephone interview. October 2007.

Chamber & Development Council of Crawford County. *Enterprise Zone*. Available online at http://www.cdcia.org/enterprise_zone.asp.

Christensen, L.A. April 2002. *Soil, Nutrient, and Water Management Systems Used in U.S. Corn Production.* USDA Agriculture Information Bulletin No. 774. Available online at: http://www.ers.usda.gov/publications/aib774/aib774.pdf

Clean Fuels Development Coalition, The Nebraska Ethanol Board, and the U.S. Department of Agriculture (CFDC). 2006. *A Guide for Evaluating the Requirements of Ethanol Plants*. Available online at: https://www.ethanol.org/pdf/contentmgmt/guide_for_evaluating_the_requirements_of_ethanol_plants.pdf

Clean Fuels Development Coalition (CFDC). 2007. *The Ethanol Fact Book: a compilation of information about fuel ethanol.*

City-data.com. 2007. City-data statistics. Available online at: www.city-data.com

City of Ravenna. 2007. *Ravenna Proposed ethanol plant questions and answers*. Available online at: http://www.ci.ravenna.ne.us/questions.htm

Collins, K. March 28, 2007. *The New World of Biofuels: Implications for Agriculture and Energy*. EIA Energy Outlook, Modeling, and Data Conference. Available online at: www.eia.doe.gov/oiaf/aeo/conf/collins/collins.ppt

Conniff, R. 2007. *Who's Fueling Whom? Why the biofuels movement could run out of gas*. Smithsonian. Available online at: http://www.smithsonianmag.com/science-nature/presence-biofuel-200711.html.

County of Dunn. January 9, 2003. *Western Wisconsin Renewable Energy coop proposal to construct and operate a 40 million gallon per year ethanol production facility*.

Coyle, W. 2007. *The Future of Biofuels: A Global Perspective*. Amber Waves 5 (2007). Available online at: http://www.ers.usda.gov/AmberWaves/November07/Features/Biofuels.htm.

Davey, M. November 13, 2007. *In U.S. farm belt, ethanol plants hit resistance.* http://www.kfyrtv.com/News_Stories.asp?news=11656

Davis, Patrick. September 20, 2007. *Twenty-in-Ten Program*. United States Department of Energy Energy Efficiency and Renewable Energy Program.. Available online at: http://www.afvi.org/forum20sep07presentations/PatrickBDavis.pdf

Deimerly, Thomas (Executive Director, Iowa Falls Area Development Corporation). Telephone interview. November 2007.

DiTomaso, J.M.; Barney, J.N.; & Fox, A.m. November 2007. *Biofuels Feedstocks: The Risk of Future Invasions*. CAST Commentary. Available online at: http://www.cast-science.org/websiteUploads/publicationPDFs/Biofuels%20Commentary%20Web%20version%20with%20color%20%207927146.pdf

Doornbosch, R. & Steenblik, R. September 2007. *Biofuels: Is the Cure Worse than the Disease? Round Table on Sustainable Development.* FAO/OECD. Available online at: www.foeeurope.org/publications/2007/OECD_Biofuels_Cure_Worse_Than_Disease_Sept07.pdf

Dufey, A. 2007. *International trade in biofuels: Good for development? And good for environment?* International Institute for Environment and Development (IIED) Briefing. Available online at: http://www.iied.org/pubs/pdf/11068IIED.pdf

E3 BioFuels. 2007. *Closed Loop vs. Conventional Ethanol*. Available online at: http://www.e3biofuels.com/technology/ethanol-methods.php

Ebert, J. 2007. 2007: *A Banner Year for Biofuels Funding*. Available online at: http://ethanolproducer.com/article.jsp?article_id=3486

Elam, T.E. 2007. *Fuel Ethanol Subsidies: An economic perspective*. FarmEcon.Com. Available online at: http://www.bipac.net/gma/Ethanol_Analysis_ELAM_FINAL%209_19_07.pdf

Energy Information Administration (EIA). 2007a. *Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State*. Available online at: http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html

Energy Information Administration (EIA). 2007b. *Energy Kid's Page*. Available online at: http://www.eia.doe.gov/kids/history/timelines/ethanol.html

Ethanol Across America. 2006. *Issue Brief: Economic Impacts of Ethanol Production*. Available online at: www.ethanolacrossamerica.net/CFDC_EconImpact.pdf

Ethanol Market. 2007. *EthanolMarket.com, LLC*. Available online at: http://www.ethanolmarket.com/20070814EthanolMarket.pdf

Ethanol Statistics. 2007. *The United States Ethanol Market 2007*. Available online at: http://www.ethanolstatistics.com/Ethanol_Reports/The_United_States_Ethanol_Market.aspx

Etter, L. November 28, 2007. *Ethanol Craze Cools as Doubts Multiply*. Wall Street Journal. Available online at: http://online.wsj.com/article/SB119621238761706021.html?mod=todays_us_nonsub_page_one

Federal Highway Administration (FHWA) 2003. *Estimated Use of Gasohol*. Available online at: http://www.fhwa.dot.gov/policy/ohim/hs03/htm/mf33e.htm

Finch, G. & Xie, Y. November 13, 2007. *Central Banks Wrestle with Weak Dollar*. Bloomberg News. Available online at: http://www.iht.com/articles/2007/11/12/bloomberg/bxatm.php

Gardner, B. 2007. *Fuel Ethanol Subsidies and Farm Price Support*. Available online at: http://www.sustainability.umd.edu/ethanol_subsidy_07.pdf

Good, D. October 2007. *Corn: A Little Breathing Room*. University of Illinois: Grain Price Outlook. Available online at:
http://www.farmdoc.uiuc.edu/marketing/grainoutlook/html/101907corn/101907corn.html

Goodell, J. July 24, 2007. *The Ethanol Scam: One of America's Biggest Political Boondoggles*. RollingStone. Available online at:
http://www.rollingstone.com/politics/story/15635751/the_ethanol_scam_one_of_americas_biggest_political_boondoggles

GrainNet. May 17, 2007. *Study Warns United States Near Tipping Point in Corn-Based Ethanol.* GrainNet.com. Available online at:
http://www.grainnet.com/articles/Study_Warns_United_States_Near_Tipping_Point_in_Corn_Based_Ethanol-44328.html

Guitierrez, C. September 2007. *Balloon Punctured for Ethanol*. Forbes Magazine

Haarlander, L. May 10, 2007. *U.S. Ethanol Plants Seen Ripe for Wave of Mergers*. Reuters. Available online at:
http://www.reuters.com/article/companyNewsAndPR/idUSN1035466320070510?pageNumber=2

Hass, Kathleen (Community Resource Development at UW Extension, Columbia County). Telephone interview. October 2007.

Hennon, Marilyn (Economic Development Director, Albion Township). Telephone interview. November 2007.

Hill, J.; Nelson, E.; Tilman, D.; Polasky, S. & Tiffany, D. 2006. *Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels*. Proceedings of the National Academies of Science (130): 11206-11210. Available online at http://www.pnas.org/cgi/doi/10.1073/pnas.0604600103.

Hoff, Jody (Vice Chairman, Amber Waves). Telephone interview. October 2007.

Illinoibiz.biz. 2007. *Enterprise Zone Program Tax Questions and Answers*. Available online at:
http://www.illinoisbiz.biz/NR/rdonlyres/2B87CB05-3163-46E9-8FE4-652008D8723E/0/ezqa.pdf

Illinois Department of Commerce and Economic Opportunity (illinoisbiz.biz). 2007. *Enterprise Zone Program Tax Questions and Answers*. Available online at
http://www.illinoisbiz.biz/NR/rdonlyres/2B87CB05-3163-46E9-8FE4-652008D8723E/0/ezqa.pdf

Illinois Environmental Protection Agency (IL EPA). 2007. *Building an Ethanol Plant in Illinois: a guide to permit requirements, funding opportunities, and other considerations*. Available online at:
http://www.epa.state.il.us/agriculture/building-an-ethanol-plant.pdf

Iowa Corn. 2007. *Primary Products from Corn.* Available online at:
http://www.iowacorn.org/cornuse/cornuse_6.html

Jack, A. 2007. Let Them Eat Ethanol; The Hidden Costs of Biofuels. AmberWaves. Available online at:
http://www.amberwaves.org/articlePages/articles/alex/EthanolText.doc.

Jensen, H. & Babcock, B. 2007. *Do Biofuels Mean Inexpensive Food is a Thing of the Past?* Iowa Ag Review: Summer 2007, Vol. 13 No.3. Available online at: http://www.card.iastate.edu/iowa_ag_review/summer_07/article2.aspx

Jentz, Al, & Luensmann, Don (Amaizing Energy General Manager and Executive Director, Chamber & Development Council of Crawford County). Telephone interview. October 2007.

Johnson, Leo (Owner, Johnson Tractor). Telephone interview. October 2007.

Journal Star. October 19, 2007. *Most rural bankers surveyed think ethanol benefits are oversold.* Available online at: http://www.journalstar.com/articles/2007/10/19/news/business/doc4718e8aea26cc603006034.txt

Jubak, J. June 8, 2007. *How Ethanol Bites You in the Wallet*. MSN Finance. Available online at: http://finance.sympatico.msn.ca/investing/jimjubak/article.aspx?cp-documentid=4979796

Kachan, D. July 11 2007. *Miscanthus Bests Switchgrass, Researchers Find*. CleanTech.com. Available online at: http://media.cleantech.com/node/1452

Kandyohi County Planning Commission (KCPC). September 2006. *Kandyohi County Zoning Ordinance No. 9A*. Available online at http://136.234.79.235/Ordinances/09A-ZoningOrd.pdf

Keeney, D. & Muller, M. 2006. *Water Use by Ethanol Plants: Potential Challenges*. Minneapolis: The Institute for Agriculture and Trade Policy. Available online at: http://www.agobservatory.org/library.cfm?RefID=89449.

Kment, R. November 2007. *DTN Analysis*. Available online at: http://www.dtnethanolcenter.com/index.cfm?show=10&mid=32

Koenen, Joseph (Agricultural Business Specialist, Putnam County, MO). Email communications. October 2007.

Tokgoz, S.; Elobeid, A.; Fabiosa, J.F.; Hayes, D.J.; Babcock, B.A.; Yu, T.; Dong, F.; Hart, C.E. & Beghin, J.C. May 2007. *Emerging Biofuels: Outlook of Effects on U.S. Grain, Oilseed, and Livestock Markets.* Center for Agricultural and Rural Development: Iowa State University. Available online at: http://www.card.iastate.edu/publications/synopsis.aspx?id=1050

Koplow, D. October 2006. *Biofuels – at what cost? Government support for ethanol and biodiesel in the United States.* Available online at: http://www.globalsubsidies.org/IMG/pdf/Brochure_-_US_Report.pdf

Krauss, C. 2007. *Ethanol's Boom Stalling as Glut Depresses Price*. The New York Times.

Lavigne, P. April 29, 2007. *Biofuel Industry Branches Out, Outside Investors Flow In*. Des Moine Register. Available online at: http://www.desmoinesregister.com/apps/pbcs.dll/article?AID=/20070429/BUSINESS01/70428008/-1/biofuels

Lewandowski, I. 1998. *Switchgrass as a biomass crop in southern Germany compared to Miscanthus x giganteus.* BioBase. Available online at: http://www.eeci.net/archive/biobase/B10432.html

Long, S.P. 2007. *Research Reports: Miscanthus X Giganteus: An Adapted Biomass Crop for Permaculture, Air and Soil Enhancement.* Illinois Council on Food and Agricultural Research. Available online at: http://www.ilcfar.org/research/display.cfm?project_id=409

Marshall, L. & Greenhalgh, S. 2006. *Beyond the RFS: The environmental and economic impacts of increased grain ethanol production in the U.S.* World Resources Institute Policy Note. Available at: http://pdf.wri.org/beyondrfs.pdf

McCabe, Vince (Chief Operating Officer, Illinois River Energy). Telephone interview. October 2007.

McKinstray, Neill (Vice President & General Manager, Ethanol Division, The Andersons). Email communications. November 2007.

Minnesota Department of Employment and Economic Development. July 2005. *Job Opportunity Building Zones*. Available online at http://www.deed.state.mn.us/bizdev/PDFs/jobz.pdf.

Mohamed, F.A. 2007. *Biodiesel; A solution for Energy Security, Environment & Rural Development*. UNIDO. Available online at: http://www.unep.org/pcfv/PDF/fatin.pdf.

Morris, D. November 2005. *Do Bigger Ethanol Plants Mean Fewer Farmer Benefits?* Available online at: http://www.rurdev.usda.gov/rbs/pub/nov05/bigger.htm

Morris, D. 2007. *Energizing Rural America*. Institute for Local Self-Reliance. Available online at: http://www.americanprogress.org/issues/2007/01/pdf/rural_energy.pdf

The National Academies. October 2007. *Increase In Ethanol Production From Corn Could Significantly Harm Water Quality*. ScienceDaily. Available online at: http://www.sciencedaily.com-/releases/2007/10/071010120538.htm

National Corn Growers Association (NCGA). 2007. *Taking Ownership of Grain Belt Agriculture*. Chapter 2. Available online at: http://www.ncga.com/public_policy/takingOwnership/chap2.htm

National Research Council (NRC). 2007. *Water Implications of Biofuel Production in the U.S.* Washington, D.C.: The National Academies Press. Available online at: http://www.nap.edu/catalog/12039.html.

Nebraska Ethanol Board. 2007. News and Opinion: News Release Archive. Available online at: http://www.ne-ethanol.org/news/archive.htm

Nelson, Les (Aventine Renewable Energy Public Relations). Email communications. November 2007.

Ogren, Rod (Marcus for Progress). Telephone interview. November 2007.

Pacific Ethanol, Inc. June 23, 2006. *Prospectus: Rule 424(b)(3)*. Available online at: http://www.secinfo.com/dV3p8.v1Ge.htm

Parcell, J. L, & Westhoff, P. August 2006. *Economic Effects of Biofuel Production on States and Rural Communities.* Journal of Agricultural and Applied Economics. Available online at: http://findarticles.com/p/articles/mi_qa4051/is_200608/ai_n17176786

Perkins, J. April 29, 2007. *Biofuel fuels change in Iowa Falls*. Des Moines Register. Available online at: http://desmoinesregister.com/apps/pbcs.dll/article?AID=/20070429/BUSINESS01/704280111/1056/NEWS09.

Pimentel, D. & Patzek, T.W. 2005. *Ethanol Production Using Corn, Switchgrass, and Wood; Biodiesel Production Using Soybean and Sunflower*. Natural Resources Research 14 (2005): 65-76.

POET. 2007. *Overview. POET Corporation*. Available online at: http://www.ethanolproducts.com/products-co2.html

Puppan, D. 2002. *Environmental evaluation of biofuels*. Periodica Polytechnica (10): 95–116. Available online at: http://www.pp.bme.hu/so/2002_1/pdf/so2002_1_08.pdf

Renewable Fuels Association (RFA). 2006. *From Niche to Nation: Ethanol Industry Outlook 2006*. Available online at: http://www.ethanolrfa.org/objects/pdf/outlook/outlook_2006.pdf

Renewable Fuels Association (RFA) 2007a. *Ethanol Biorefinery Locations*. Available online at: http://www.ethanolrfa.org/industry/locations/

Renewable Fuels Association (RFA) 2007b. *Ethanol Industry Overview*. Available online at: http://www.ethanolrfa.org/industry/statistics/#EIO

Renquist, Steve (Kandiyohi County Zoning Administration). Telephone interview and email communications. October 2007.

Roberts, M.G.; Male, T.D. & Toombs, T.P. 2007. *Potential Impacts of Biofuels Expansion on Natural Resources; A case study of the Ogallala aquifer region*. Environmental Defense. Available online at: http://www.environmentaldefense.org/documents/7011_Potential%20Impacts%20of%20Biofuels%20Expansion.pdf

Robinson, E. May 11, 2007. *How Far Will Ethanol Boom Take Us?* Delta Farm Press. Available online at: http://deltafarmpress.com/biofuels/070511-ethanol-crops/

Runge, C.F. & Senauer, B. 2007. *How Biofuels Could Starve the Poor*. Foreign Affairs. Available online at: http://www.foreignaffairs.org/20070501faessay86305/c-ford-runge-benjamin-senauer/how-biofuels-could-starve-the-poor.html

Saitone, T.L.; Sexton, R.J. & Sexton, S.E. August 2007. *The effects of market power on the size and distribution of benefits from the ethanol industry*. Agricultural Issues Center: University of California. Available online at: http://aic.ucdavis.edu/publications/MarketPowerAndEthanolSubsidy.pdf

Sanderson, K. December 2006. *U.S. Biofuels: A Field in Ferment*. Business Feature. Nature (444), 673-676. Available online at: http://www.nature.com/nature/journal/v444/n7120/full/444673a.html

Schlaak, Lindsey (Al-corn Clean Fuels Administrative Assistant). Telephone interview and email communications. October 2007.

Schlatter, M. 2006. *Ethanol in an Era of High Energy Prices*. The Ohio State University. Available online at: https://kb.osu.edu/dspace/bitstream/1811/6005/1/Schlatter%20Final%20Paper.pdf

Schubert, C. July 2006. *Can Biofuels Finally Take Center Stage?* Nature biotechnology. (24) 7.

Shapouri, H.; Duffield, J. & Wang, M. July 2002. *The Energy Balance of Corn Ethanol: An Update.* United States Department of Agriculture. Available online at: www.usda.gov/oce/reports/energy/aer-814.pdf

Sheehan, J.; Aden, A.; Paustian, K.; Killian, K.; Brenner, J.; Walsh, M. & Nelson, R. 2003. *Energy and Environmental Aspects of Using Corn Stover for Fuel Ethanol.* Journal of Industrial Ecology. (7): 117-146.

Simon, R. November 28, 2007. *Ethanol a Sticking Point in Energy Bill.* Los Angeles Times. Available online at: http://www.latimes.com/news/nationworld/politics/la-na-ethanol28nov28,1,5629570.story?coll=la-news-politics-national&track=crosspromo

Smith, D. June 5, 2007. *Local Ownership of Biofuel Plants Key to Rural Development.* CenLamar. Available online at: http://cenlamar.wordpress.com/2007/06/05/local-ownership-of-biofuel-plants-key-to-rural-development/

Stuefen, R. M. December 2005. *The Economic impact of Ethanol Plants in South Dakota*. Available online at: http://www.sdcorn.org/documents/EAofEthanolPlants.pdf

The Andersons. October 2005. *Press Release: The Andersons Albion Ethanol Plant and Continental Carbonic Products Enter Into Supply Agreement.* Available online at http://phx.corporate-ir.net/phoenix.zhtml?c=96043&p=irol-newsArticle&ID=770877&highlight=

Tiffany, D.G. August 2003. *Factors Associated with Success of Fuel Ethanol Producers*. University of Minnesota: Staff Papers. Available online at: www.apec.umn.edu/staff/dtiffany/staffpaperp03-7.pdf

Ulgiati, S. 2001. *A Comprehensive Energy and Economic Assessment of Biofuels: When "Green" Is Not Enough*. Critical Reviews in Plant Sciences. (20): 71–106. Available online at: http://www.nelson.wisc.edu/outreach/biofuels/readings/comp_assess_biofuels.pdf

U.S. Grains Council. 2006. *Factors that Impact DDGS Pricing and Transportation*. Available online at: http://www.grains.org/galleries/DDGS%20User%20Handbook/10%20-%20Factors%20Affecting%20DDGS%20Pricing%20and%20Transportation.pdf

United States Department of Agriculture (USDA). 2007a. *Barge Terminal Daily Grain Prices*. USDA Market News. Available online at: http://www.ams.usda.gov/mnreports/MS_gr114.txt

United States Department of Agriculture (USDA). 2007b. *Land Values and Cash Rents: 2007 Summary.* Available online at: http://usda.mannlib.cornell.edu/usda/current/AgriLandVa/AgriLandVa-08-03-2007.pdf

United States Department of Agriculture Economic Research Service (ERS). 2007. *Briefing Rooms: Agricultural Baseline Projections: U.S. Crops, 2007-2016.* Available online at: www.ers.usda.gov/Briefing/Baseline/crops.htm

United States Department of Agriculture National Agricultural Statistics Service. (USDA NASS). October 12, 2007(a). Corn: Acreage by year, U.S. Available online at: http://www.nass.usda.gov/Charts_and_Maps/Field_Crops/cornac.asp

United States Department of Agriculture National Agricultural Statistics Service. (USDA NASS). November 9, 2007(b). Corn: Yield by Year, U.S. Available online at: http://www.nass.usda.gov/Charts_and_Maps/Field_Crops/cornyld.asp

United States Department of Energy (DOE). February 28, 2007. *DOE Selects Six Cellulosic Ethanol Plants for Up to $385 Million in Federal Funding*. Press Release. Available online at: http://www.doe.gov/news/4827.htm

United States Department of Energy Energy Efficiency and Renewable Energy Program (EERE) 2006. *Biomass energy databook Edition 1*. Available online at: http://cta.ornl.gov/bedb/pdf/Biomass_Energy_Data_Book.pdf

United States Department of Energy Energy Efficiency and Renewable Energy Biomass Program (EERE-BP). 2007. *Net Energy Balance for Bioethanol Production and Use*. Available online at: http://www1.eere.energy.gov/biomass/net_energy_balance.html.

United States Environmental Protection Agency (EPA). 2007. *Greenhouse Gas Impacts of Expanded Renewable and Alternative Fuels Use.* Available online at http://www.epa.gov/otaq/renewablefuels/420f07035.htm.

Urbanchuk, J. M. 2005 *Contribution of the Ethanol Industry to the Economy of the United States.* Available online at: http://www.ethanolrfa.org/objects/documents/114/economic_contribution_2004.pdf

Urbanchuk, J. M. 2006. *Contribution of the Ethanol Industry to the Economy of the United States.* Available online at: http://www.ethanolrfa.org/objects/documents/576/economic_contribution_2006.pdf

Varghese, S. 2007. *Biofuels and Global Water Challenges*. Minneapolis: The Institute for Agriculture and Trade Policy. Available online at: http://www.iatp.org/iatp/publications.cfm?accountID=451&refID=100547.

VeraSun Energy Corporation. March 30, 2006. *Form S-1*. http://yahoo.brand.edgar-online.com/fetchFilingFrameset.aspx?FilingID=4311106&Type=HTML

Village of Lena. 2002. Available online at http://www.villageoflena.com/

Wang, M. 2007. *Ethanol; the complete energy life cycle picture*. Argonne National Lab: USDOE Energy Efficiency and Renewable Energy Biomass Program. Available online at: http://www.transportation.anl.gov/pdfs/TA/345.pdf.

Wescott, P.C. 2007a. *Ethanol Expansion in the United States: How Will the Agricultural Sector Adjust?* USDA Economic Research Service Report No. FDS-07D-01. Available online at: http://www.ers.usda.gov/Publications/FDS/2007/05May/FDS07D01/fds07D01.pdf.

Westcott, P.C. 2007b. *U.S. Ethanol Expansion Driving Changes Throughout the Agricultural Sector*. AmberWaves. Available online at: http://www.ers.usda.gov/AmberWaves/September07/Features/Ethanol.htm

Whitty, G. February/March 2007, *Co-Partners in Co-Products*. Feed & Grain. Available online at: http://www.feedandgrain.com/publication/article.jsp?id=456.

Worldwatch Institute. 2006. *Biofuels for Transportation: Global Potential and Implications for Sustainable Agriculture and Energy in the 21st Century.* Available online at: http://www.worldwatch.org/node/4081

Worner Keith (UIUC Extension Tazewell County, IL). Telephone interview and email communications. October 2007.

WTRG Economics. 2007. *NYMEX Crude Oil Futures.* Available online at: http://www.wtrg.com/daily/clfclose.gif

Yahoo!Finance. 2007. *Archer-Daniels-Midland Co.* Available online at: http://finance.yahoo.com/q/pr?s=ADM

Yahoo!Finance. 2007. *Aventine Renewable Energy Holdings, Inc.* Available online at: http://finance.yahoo.com/q/pr?s=AVR

Yahoo!Finance. 2007. *Verasun Energy, Corp.* Available online at: http://finance.yahoo.com/q/pr?s=VSE

Yahoo!Finance. 2007. *U.S. BioEnergy Corp.* Available online at: http://finance.yahoo.com/q/pr?s=USBE

Zook, Jim (General Manager, US Bio Woodbury). Telephone interview. November 2007.