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Convergence of Agriculture and Energy: Implications for Research and Policy

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Introduction

Although biofuels have been identified as an important component of the national strategy to decrease U.S. dependence on imported oil, the ability to sustain a rapid expansion of biofuel production capacity raises new research and policy issues.

Access to an adequate energy supply at reasonable cost is crucial for sustained economic growth. Unfortunately, oil prices and the need to import from politically unstable countries lowers the reliability of the U.S. energy supply and hinders economic development. Although biofuels have been identified as an important component of the national strategy to decrease U.S. dependence on imported oil, the ability to sustain a rapid expansion of biofuel production capacity raises new research and policy issues. This document seeks to identify the most critical of these issues to help inform the policy development process. The goal is to enhance the long-term economic and environmental viability of the biofuel industry and its positive impact on agriculture, rural communities, and national security.

This commentary focuses on the key issues concerning corn-based ethanol production systems during the next 5 to 10 years.

The new Farm Bill will be a crucial driver of policies related to biofuels. Despite uncertainty related to global trade negotiations, key components of this bill must address agriculture's role in providing new sources of energy. Because grain-based ethanol is currently the only major source of biofuel for the United States, and because the magnitude of increase in grain-ethanol production is expected to have a large impact on commodity prices, agricultural profitability, and global food security, this commentary focuses on the key issues concerning corn-based ethanol production systems during the next 5 to 10 years. Much of the discussion also is relevant to fostering development and sustainability of other biofuel systems, including ethanol from sugar crops and ligno-cellulosic biomass, and biodiesel from oilseed crops.

The Ethanol Market

Ethanol production in the United States has grown dramatically in the past 25 years.

While ethanol production in the United States has grown steadily in the past 25 years, there has been a dramatic increase in recent years (Figure 1). Increases in ethanol prices since 2002 supported a rapid increase in annual production capacity, from 1.7 billion gallons in January 2000 to 4.3 billion gallons in January 2006. The locations of plants in

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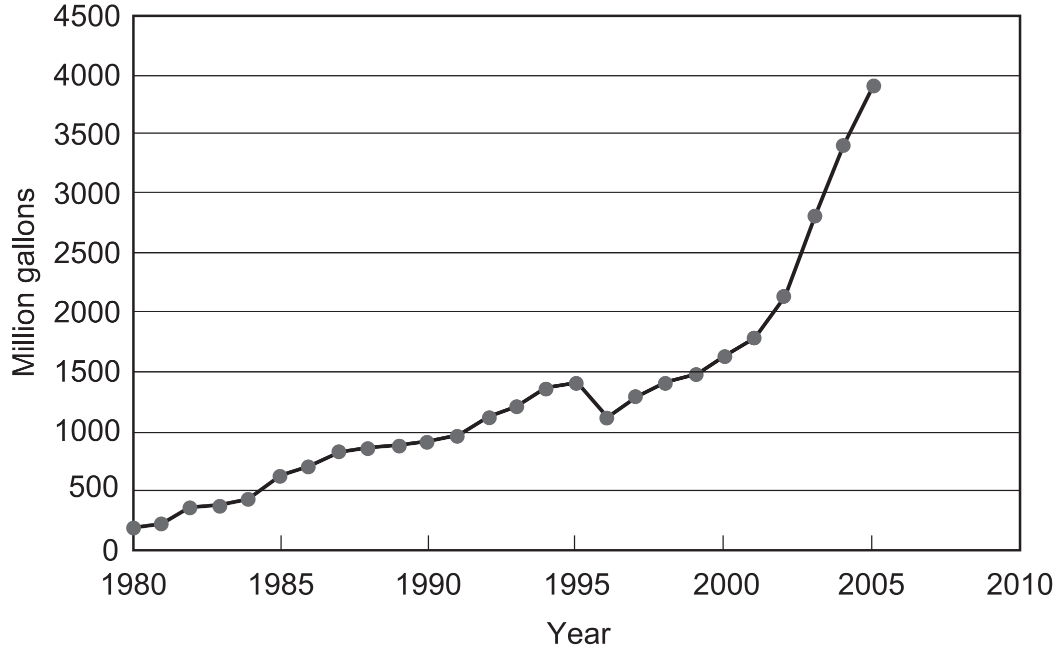

Figure 1. Grain-based U.S. ethanol production, 1980–2005.

operation and under construction are shown in Figure 2. By June 2006 there were 101 operating plants with 4.8 billion gallons of capacity; 34 new plants and 7 expansions were under construction, which will add 2.2 billion gallons of production capacity (RFA 2006). These data indicate that industry capacity will increase to 6.0 billion gallons by January 1, 2007 and to 7.0 billion gallons by January 2008. Many more plants and expansions are planned and should result in a continued rise in capacity through 2008 and beyond.

Ethanol price is dependent primarily on gasoline price, which depends on the price of petroleum.

The rate of expansion depends largely on the continued profitability of ethanol production. Major factors affecting ethanol plant profitability are the price of ethanol and the costs of the feedstock (primarily corn) and the boiler fuel. Ethanol price is dependent primarily on gasoline price, which depends on the price of petroleum. When petroleum is $40 per barrel,

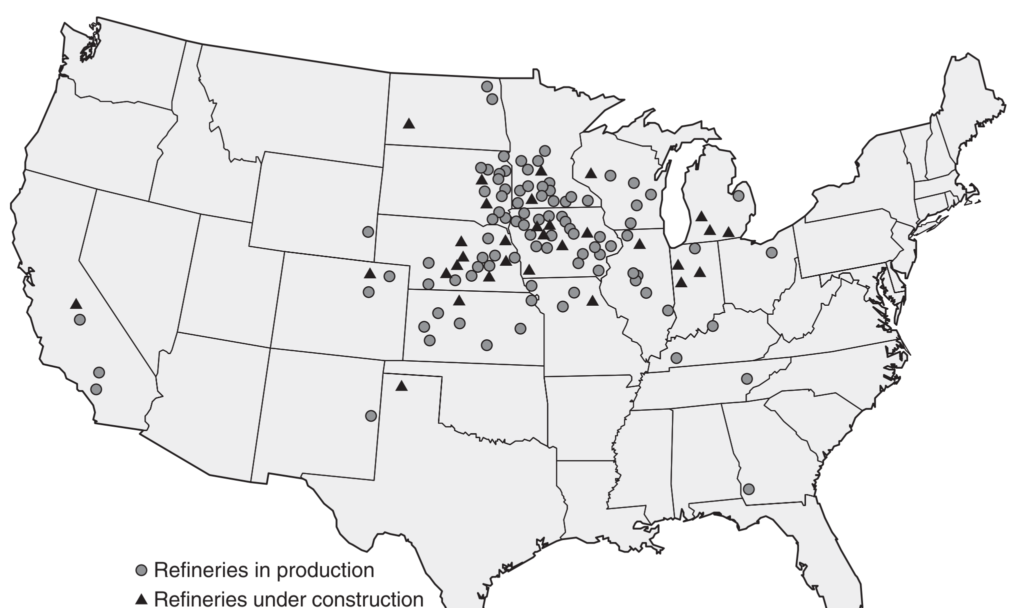

Figure 2. Ethanol refineries in production and under construction, January 2006 (RFA 2006).

wholesale gasoline is expected to be $1.20 per gallon. With a petroleum price of $50, $60, and $70 per barrel, the wholesale price of gasoline is expected to be $1.49, $1.78, and $2.07 per gallon, respectively (McCullough and Etra 2005). Average refiner acquisition costs of petroleum are expected to average $63 per barrel during 2006 and 2007, before declining to $53 per barrel by 2010 (USDOE–EIA 2006a,b). If this scenario plays out, wholesale gasoline prices should range between $1.86 to $1.57 per gallon.

For the foreseeable future, ethanol prices should continue to track the price of petroleum closely.

What does a scenario of increased ethanol production capacity suggest for ethanol prices? Ethanol prices reached historic highs during the summer of 2006 as the industry increased production to provide enough ethanol to replace all of the methyl tertiary-butyl ether (MTBE) used in gasoline. The industry should have enough capacity to supply the petroleum industry's requirements for oxygenates by the end of 2006. Ethanol prices for the last 3 months of 2006 and for 2007 are moderating, and the new ethanol production capacity should supply future needs without an excessive increase in ethanol prices. Hence, for the foreseeable future, ethanol prices should continue to track the price of petroleum closely.

If ethanol production remains relatively profitable, Congress may consider lowering the $0.51 blender's tax credit, which will result in ethanol prices lower than wholesale gasoline prices.

If ethanol production remains relatively profitable, Congress may consider lowering the $0.51 blender's tax credit, which will result in ethanol prices lower than wholesale gasoline prices. Although events of the past year may have enhanced consumers' demand for renewable fuels, these fuels must be priced competitively with gasoline for sales to increase. For these reasons, the industry can expect ethanol to sell at prices closer to the wholesale price of gasoline in 2007 and later years. With petroleum prices expected to range from $53 to $63 per barrel, ethanol prices should range from $1.50 to $2.00 per gallon in the foreseeable future.

A plant uses the same amount of corn whether it is making a large profit or losing money, because operating at capacity maximizes profit or minimizes losses.

Ethanol is a commodity, and dry mill ethanol plants, which make up most of the industry's capacity, are operated at maximum output to produce ethanol at the minimum cost per unit of output. Therefore, a plant uses the same amount of corn whether it is making a large profit or losing money, because operating at capacity maximizes profit or minimizes losses. The plant only shuts down and ceases using corn when doing so will lose less money than continuing operation.

How Does the Ethanol Production Cost Change as the Price of Corn Increases?

Consider the estimated costs of a typical Midwestern dry mill ethanol plant producing 48 million gallons of ethanol per year (Tiffany and Eidman 2003). Natural gas is bought at $10.00 per million Btu and corn at $2.00 per bushel. The plant produces 2.81 gallons of denatured ethanol, 17 pounds of distillers dried grains with solubles (DDGS), and 17 pounds of carbon dioxide (CO_2) per bushel. It sells the ethanol and the DDGS, but has no market for the CO_2. Assuming the plant receives no subsidies to pay part of the construction or operating costs, and that it sells the DDGS at $80 per ton, the net cost of ethanol production is $1.27 per gallon (Figure 3). Note that this analysis does not include the $0.51 per gallon federal excise tax exemption because this credit is paid to petroleum blenders and not to ethanol producers.

Net ethanol cost is sensitive to many factors, but the two most important are the cost of corn and the price of the boiler fuel.

Net ethanol cost is sensitive to many factors, but the two most important are the cost of corn and the price of the boiler fuel . At $2.00 per bushel, the cost of corn makes up $0.712 (or 56%) of the net ethanol cost per gallon. An increase of $1.00 per bushel adds $0.356 of additional cost per gallon. An increase (decrease) in the price of natural gas of $1.00 per million Btu raises (lowers) the cost per gallon of ethanol by $0.034. The breakeven cost of ethanol increases from $1.27 with corn at $2.00 per bushel to $1.63, $1.98, and $2.34 at corn prices of $3.00, $4.00, and $5.00 per bushel, respectively (Figure 3). Therefore, the ethanol industry could pay $2.35 per bushel for corn when ethanol is $1.50 per gallon (with natural gas at $10.00 per million Btu) and make normal profits, and pay $4.00 when ethanol prices are $2.00 per gallon. Until the price of corn reaches an amount that decreases profitability below normal amounts, the ethanol industry expansion is expected to continue.

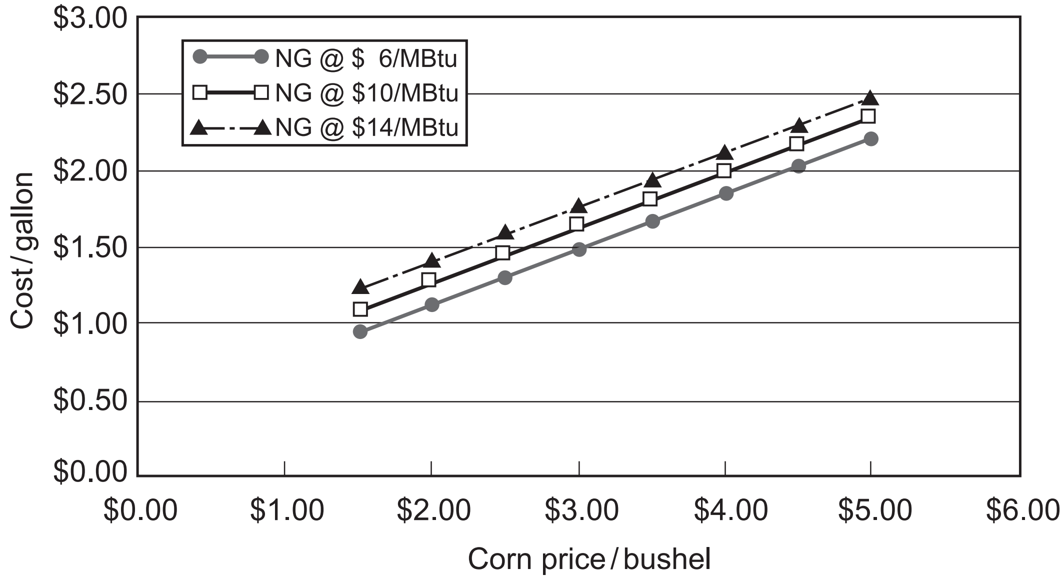

Figure 3. Net cost of production per gallon of ethanol at different natural gas (NG) prices per million Btu (MBtu).

Recent fluctuations in natural gas prices have increased interest in replacing natural gas with a fuel of lower and less variable cost.

Recent fluctuations in natural gas prices have increased interest in replacing natural gas with a fuel of lower and less variable cost. A recent study provided a preliminary evaluation of three alternatives to natural gas: coal, corn stover, and DDGS (Nicola and Eidman 2006). The analysis indicates that a state-of-the-art 50 million gallon per year ethanol plant burning either corn stover at $50 per ton, DDGS at $66 per ton, or coal at $47 per ton would have capital and operating costs approximately $0.14 less per gallon than a plant burning natural gas at $10.00 per million Btu. At a natural gas price of $5.60 per million Btu, ethanol production costs per gallon would be the same as a plant using corn stover, DDGS, or coal at the above prices for these energy sources.

How Rapidly Is the Ethanol Industry Expected to Grow and What Is the Impact on Corn Markets?

Table 1 provides one scenario of growth in the ethanol industry over the next several years and the associated impact on corn demand. Ethanol production has been estimated on a marketing year basis (September through August). In this scenario, ethanol production increases

Table 1. Projected ethanol production and corn use by marketing year (9/1–8/31)[a]

Marketing year	2004/05	2005/06	2006/07	2007/08	2010/11
Ethanol produced (Bill. gal.)	3.7	4.6	5.9	7.0	9.7
Corn required (Bill. bu.)	1.32	1.65	2.11	2.51	3.46
Coproduct feeds produced (Dry equivalent) (Mill. tons)	11.02	13.71	17.58	20.87	28.79
Corn crop (Bill. bu.)	11.81	11.11	10.74	11.48	12.50
% of corn crop	11.2	14.8	19.6	21.8	27.6
U.S. farm corn price ($/bu.)	2.06	1.98	2.33	2.54	2.64

[a] Based on FAPRI 2006, baseline scenario.

more rapidly during the next 2 years and then more slowly, reaching a production level of 9.7 billion gallons by 2010–2011. The industry continues to expand because ethanol production is projected to be profitable given the expected price of gasoline, ethanol, and corn. As more corn is purchased by the ethanol industry, the price of corn increases, making corn production more profitable than competing crops, and farmers increase the acreage planted to corn. Harvested corn acreage is expected to increase by approximately 9%, from 73.6 million acres in 2004–2006 to 79.9 million acres in 2010. The additional land planted to corn likely will come from decreased soybean, wheat, cotton, barley, sorghum, and Conservation Reserve Program (CRP) acreage.

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Coproducts from ethanol production vary by ethanol plant type. Distillers grains with solubles can be produced in either dry (DDGS) or wet (WDGS) form. Dry mills represent the majority of ethanol plants and produce approximately 17 pounds of 13% moisture DDGS and 17 pounds of CO_2 per bushel of corn processed. Wet mills produce 12.4 pounds of corn gluten feed, 3.0 pounds of corn gluten meal, 1.6 pounds of corn oil, and 17 pounds of CO_2 per bushel of corn. Because the proportion of dry mill versus wet mill ethanol plants is changing over time and new technologies are being introduced that broaden the types of coproducts produced, Table 1 lists the amount of coproducts expected but does not separate the amounts by product type.

Coproducts from ethanol production vary by ethanol plant type.

Fuel ethanol production is a commodity business with little opportunity for product differentiation, which means a plant must be a low-cost producer to survive low-price periods. Many new Midwestern plants have annual capacities of 100 million gallons or more to take advantage of economies of scale. These plants are located in corn surplus regions to take advantage of low corn-acquisition costs (Figure 2). Typically, corn is delivered to these plants by truck, while both denatured ethanol and DDGS are shipped out by rail. Some Midwestern plants locate near large cattle feedlots or dairies and sell WDGS to save the cost of drying, which also reduces plant energy requirements substantially. Some plants are being built on the East and West Coasts; these destination plants plan to ship Midwestern corn in unit trains and sell the coproducts (ethanol, wet distiller grains, and CO_2) into local livestock feed markets at higher prices than those available in the Midwest. The organizations developing these destination plants will be competitive with the most efficient Midwest plants. If ethanol prices should fall to more historic levels of approximately $1.50 per gallon, however, then the most cost-competitive plants will be those with access to the lowest-cost grain and those that obtain the highest price for distillers grains while minimizing costs for drying and transport.

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Can Enough Corn Be Produced for Food, Feed, and Fuel?

Corn production in the United States increased from 4.17 billion bushels in 1966 to 11.11 billion bushels in 2005 (USDA–NASS 2006). Approximately 80% of this increase resulted from higher crop yields and approximately 20% from expansion of crop area. During this 40-year period, corn yields rose at a linear rate of 1.8 bushels per acre per year (Figure 4). Public investment in agricultural research laid the foundation for this steady rate of gain through advances in crop breeding, nutrient management, conservation tillage systems, integrated pest management, and recombinant deoxyribonucleic acid (rDNA) technology that produced transgenic crops (often called GMOs). The private sector quickly exploited these breakthroughs by developing hybrids with greater stress resistance and yield stability, establishing commercial soil and plant testing laboratories, producing new farm implements for no-till systems, and developing crop consultant enterprises to help implement the more information-intensive crop and soil management practices that resulted from these technological advances (Duvick and Cassman 1999).

Corn production in the United States increased from 4.17 billion bushels in 1966 to 11.11 billion bushels in 2005.

The rapid expansion of ethanol production currently under way will require greater amounts of corn than previously predicted before the recent, abrupt rise in oil prices. In fact, U.S. ethanol production capacity will easily pass the 7.5 billion gallons per year mandated by the Energy Policy Act of 2005 (Table 1). A capacity of 10 billion gallons by 2010–2011 is more

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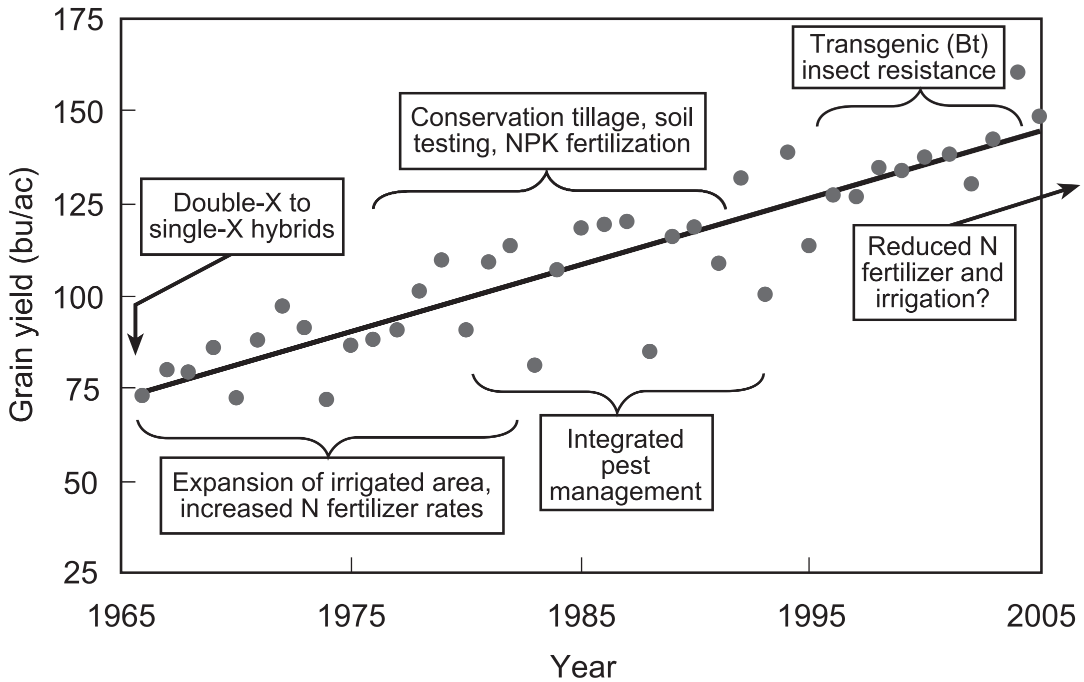

Figure 4. Corn yield trends in the United States from 1966–2005, and the technological innovations that contributed to yield increases. Rate of gain is 1.8 bushels per year (R^2 = 0.80).

likely. Some in the corn industry believe it will be possible to produce 16 billion gallons of ethanol by 2015 while also meeting corn grain requirements for human food and livestock feed (NCGA 2006). In addition to increasing average corn price (Table 1), rising corn demand for ethanol production will amplify price volatility as the market responds to news that will affect supply (such as drought or delayed plantings) or demand (such as increased exports).

Increasing the rate of gain in corn yields above the current trend line will be required to expand ethanol production substantially beyond this target without major perturbation to national and global corn markets and other industries that rely on corn.

The rate of gain in corn yields ultimately will determine the ceiling on grain-ethanol production capacity that can be sustained without causing global food deficits, high corn prices, and pressure to expand corn production onto marginal land. For example, a 9.7 billion gallon annual production capacity in 2010–2011, shown in Table 1, would require 28% of U.S. corn production, assuming a harvested area of 79.9 million acres and a trend line yield of 156.4 bushels per acre. Increasing the rate of gain in corn yields above the current trend line will be required to expand ethanol production substantially beyond this target without major perturbation to national and global corn markets and other industries that rely on corn.

Can All the Coproducts Be Used?

The major market for coproducts is the cattle feedlot industry, unless DDGS are processed further into gluten feed, gluten meal, and corn oil.

The distillers grains complex represents valuable coproducts of ethanol production from corn grain. Distillers grains can provide from 35 to 40% of the total diet for feedlot cattle. For dairy cattle, the maximum amount of inclusion is much lower. Commercial swine and poultry rations are composed of 65 to 70% corn, such that small increases in corn prices have a large impact on profitability. Although DDGS also may be fed to swine and poultry, they are not effective substitutes at dietary amounts in excess of 10% for poultry or 20% for swine because of constraints related to digestibility, amino acid balance, and potential problems with mycotoxins. Moreover, unlike beef cattle, both swine and poultry can use only DDGS because WDGS are not effective as dietary substitutes for nonruminant animals. Hence, the major market for coproducts is the cattle feedlot industry, unless DDGS are processed further into gluten feed, gluten meal, and corn oil.

With increased ethanol production, more coproducts may be generated than cattle feedlots and dairies can use. If this situation occurs, coproducts can be burned as an energy

A trend toward using WDGS as cattle feed is emerging because of the lower energy requirements and greater potential profit.

source for ethanol plant operation or exported to foreign markets. But the energy requirements for drying coproducts for transport as DDGS represents roughly one-third the total energy used in a typical ethanol plant. In addition, the drying process may decrease nutritive value. Thus, a trend toward using WDGS as cattle feed is emerging because of the lower energy requirements and greater potential profit. Carbon dioxide, another coproduct, usually is vented to the atmosphere because of relatively weak markets. In some plants, CO_2 is captured, cleaned of impurities, and sold for use in carbonating beverages, flash freezing, dry ice production, or oil recovery from marginal wells.

Transportation costs are a critical factor in considering plant location.

Transportation costs are a critical factor in considering plant location. In addition to optimizing plant location, a move toward "closed-loop" ethanol plants adjacent to beef cattle feed lots is feasible. In this scenario, cattle are fed larger volumes of the coproducts, and cattle waste products and excess coproducts are used as additional fuel sources to replace a substantial portion of the natural gas used to power the biorefinery.

Increases in grain-to-ethanol conversion efficiencies are possible from genetic improvement of corn grain characteristics, improved ethanol plant design, and grain fractionation to use coproducts for biofuel production.

Increases in grain-to-ethanol conversion efficiencies are possible from genetic improvement of corn grain characteristics, improved ethanol plant design, and grain fractionation to use coproducts for biofuel production. Fractionation separates the seed coat fiber and germ from the starchy endosperm so that only starch is fermented. The germ can be used to produce biodiesel, and research is under way to use the fiber as a cellulosic feedstock for ethanol production, which would increase total biofuel output by approximately 10–20% from a corn-ethanol plant. Researchers are seeking ways to improve corn grain traits for conversion efficiency using biotechnology and traditional plant breeding methods. Other efforts target optimization of enzymatic processes governing ethanol fermentation and enhanced value and utilization of coproducts. Because the private sector conducts most of this research, little is published in scientific journals to protect intellectual property rights, making it difficult to gauge the progress and potential impact. Ultimately, broadening the use of distillers grains for nonruminant feed rations and other value-added uses will determine whether the coproducts generated from the rapid expansion of grain-ethanol production capacity can be used in a cost-effective and environmentally sound manner.

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What Are the Environmental Impacts of Grain-Ethanol Systems?

The expansion of biofuel production has received relatively broad support from a number of environmental organizations.

The expansion of biofuel production has received relatively broad support from a number of environmental organizations. Such support is predicated on the view that substitution of ethanol for gasoline results in a number of environmental benefits, including a net decrease in emission of greenhouse gases (GHGs) and air pollutants. Results from most life cycle analyses indicate an estimated net decrease in CO_2 emissions of 12 to 50% compared with gasoline, although the magnitude of the estimated decrease differs depending on assumptions about grain production, ethanol plant design, and processing and use of coproducts (Farrell et al. 2006; Hill et al. 2006; Kim and Dale 2005; Wang, Saricks, and Santini 1999).

A key factor determining the net impact of ethanol use on GHG emissions is the overall energy efficiency of the grain-to-ethanol-and-coproduct utilization life cycle.

A key factor determining the net impact of ethanol use on GHG emissions is the overall energy efficiency of the grain-to-ethanol-and-coproduct utilization life cycle. For example, nitrogen fertilizer alone represents about one-half of all energy input to rain-fed corn production because nitrogen fertilizer production requires large fossil fuel energy input. In addition, the use of nitrogen fertilizer results in the release of nitrous oxide, a potent GHG, in rough proportion to the amount of fertilizer used (IPCC 2000). Therefore, improvement in nitrogen fertilizer efficiency leads directly to increased energy efficiency and a decrease in GHG emissions. Moreover, improved nitrogen efficiency minimizes the risk of nitrate leaching or runoff, which negatively impacts ground and surface water quality. Fortunately, U.S. corn producers are steadily improving nitrogen fertilizer efficiency, and continued support for research and extension on this topic can help maintain this trend (Cassman, Dobermann, and Walters 2002).

The need for increased corn production must not come at the expense of environmental degradation or conversion of fragile land from the CRP, which highlights the need for achieving accelerated yield gains while protecting soil and environmental quality.

The need for increased corn production must not come at the expense of environmental degradation or conversion of fragile land from the CRP, which highlights the need for achieving accelerated yield gains while protecting soil and environmental quality (Cassman 1999; Tilman et al. 2002). Moreover, higher average corn prices are likely to promote a shift of some soybean acreage to corn, which will result in more corn produced without rotation. Increased corn production without rotation with soybean will influence requirements for nitrogen fertilizer, pest pressure from diseases and insects, farm labor, and grain transportation and storage systems. Improved crop and soil management practices will be required to avoid negative effects on water quality and increased GHG emissions in cropping systems that rely more heavily on consecutive corn crops.

What Are the Economic Impacts on Rural Development?

Construction of an ethanol plant can revitalize a small rural community and become a cornerstone of its economy.

The economic impacts of a new ethanol plant include millions of dollars invested in construction and annual operating costs of between $59 and $112 million, depending on plant size and efficiency. In addition, grain procurement draws primarily from the local farm sector, additional skilled labor and professional jobs are created, expenses for energy procurement are significant, and state and local tax revenues are improved. In fact, construction of an ethanol plant can revitalize a small rural community and become a cornerstone of its economy.

Several studies (EAA 2006; Stuefen 2005; Swensen 2005) have estimated the economic impact of an ethanol plant on a rural community. Although methodologies differ, results estimate a large positive impact on the local economy, as well as on the broader state and national economies. Table 2 presents estimates of the direct economic impact of ethanol plants with 50 or 100 million gallon production capacity, assuming an ethanol value of $1.15 per gallon and corn priced at $2.25 per bushel.

Many of the indirect and induced benefits will extend to the regional, state, and national economies.

Additional indirect and induced (secondary) benefits accrue to the local economy (not presented in Table 2). These benefits include higher average prices for local grain producers, increased service-sector employment and sales of goods and services, and additional taxes generated. Broader secondary economic benefits also accrue to places outside the local economy from construction supplies, equipment, and nonlocal workers. Additionally, annual operational expenses will include materials for maintenance and repair obtained from other localities. Thus, many of the indirect and induced benefits will extend to the regional, state, and national economies.

Table 2. Estimated annualized direct economic impacts of typical ethanol plants with different production capacities[a]

Annual production capacity	50×10^6 gallons	100×10^6 gallons
Initial construction cost (million $)	60	95
Annual operating cost (million $)	59	112
Permanent employment (jobs)	35	45
Payroll (million $)	1.5	1.9
Ethanol sales (million $)	57.5	115.0
Coproduct sales (million $)	12.0	24.0
Total revenue (million $)	69.5	139.0
Corn purchases (million bushels)	17.9	35.8
Corn purchases (million $)	40.4	80.8
Natural gas purchases (million $)	6.5	12.0
Electricity purchases (million $)	1.5	2.9
State and local taxes (million $)	1.2	2.4

[a] Estimates derived from EAA (2006), Petersan (2002), Stuefen (2005), and Swensen (2005). Values shown do not include operating costs for water, maintenance, repair, and management.

Research and Policy Implications

The long-term viability of an expanded grain-ethanol industry depends on its economic and environmental sustainability. The authors of this document have identified the following research needs.

Increase grain production substantially while protecting environmental quality and avoiding conversion of fragile CRP land for crop production.

- Research should emphasize accelerating the rate of yield gain, improving soil and water quality, and decreasing GHG emissions.
- Both agro-ecological systems research to develop improved crop and soil management practices and genetic improvement of complex traits such as yield potential will be required.
- Much of this investment must be made in the public sector because such research requires a longer-term horizon that is difficult to justify in the private sector.
- Ensuring the economic and environmental sustainability of the corn-ethanol industry is a critical foundation to support development of a viable cellulosic ethanol industry.

Understand the impact on U.S. food prices and on the livestock and poultry industries of diverting a much larger proportion of the corn crop for ethanol production.

- A steady increase in corn used for ethanol will result in higher corn prices, which likely will decrease profitability of livestock and poultry operations.
- Production and demand shocks (e.g., drought and unexpected purchases from foreign buyers) also will result in abrupt fluctuations in corn price and hence the profitability of livestock production—especially for poultry and swine operations.
- The impact on beef and dairy is less clear but also needs study.
- The impact of expected increases in corn prices on consumer food prices also deserves attention, especially for livestock products.

Improve knowledge of optimal, most cost-effective diets for each species of livestock and poultry, given the new realities of higher corn prices relative to other crops and a wider variety of coproduct feeds.

- Making optimal use of the coproduct feeds is critical to using the corn supply efficiently and minimizing the rise in feed and food prices.

Predict the impact of increased corn use for fuel production on U.S. corn exports and global corn prices, especially in populous developing countries that sometimes rely on grain imports.

- Higher world corn prices and smaller export supplies may increase the profitability of corn production in certain developing countries, stimulating an increase in their corn output, but may decrease corn availability in other countries, raising food costs and increasing the incidence of malnutrition.

Quantify the net environmental benefits of grain-ethanol systems based on a full-cost, life cycle accounting approach.

- Full-cost life cycle accounting considers all inputs and outputs, including environmental and health impacts, which provides quantitative comparisons of different systems, energy sources, and technologies based on monetary value, energy efficiency, or environmental quality parameters such as net GHG emissions.

- Whereas previous studies have focused on the current "average" methods for corn production, ethanol conversion, and coproduct use, future studies should evaluate state-of-the-art systems with best management practices, as well as improved technologies that promise greater efficiencies and a more positive environmental impact.
- Such "forward-looking" studies provide critical information to help guide policy development for biofuels as a component of our national energy supply portfolio.

The industry also would be enhanced by two new policies.

Modify the current federal tax credit ($0.51 per gallon ethanol) to be counter-cyclical, such that it applies only when the price of ethanol falls below a threshold somewhat above the breakeven cost of production, and use a sliding scale to provide a larger credit as prices fall further below the breakeven point.

- Given projections for future oil and gasoline prices, the current subsidy is not needed to maintain the industry when ethanol prices are favorable.
- The industry, which is reluctant to lose the subsidy because ethanol prices are subject to wide swings, argues that a safety net is needed to protect ethanol producers from bankruptcy during periods of low prices.
- This change would help allay concerns of many citizens about a highly subsidized corn-ethanol industry, while still providing a safety net.
- In addition, higher average corn prices due to increased demand from the ethanol industry will decrease the amount of federal subsidies paid to corn producers under the current Farm Programs.

Provide incentives to replace natural gas and coal used to produce energy in ethanol plants with biomass, which would decrease the use of fossil fuels and GHG emissions. Sources of biomass could include crop residues and crops specifically grown to produce biomass for fuel.

- These policies should provide funding for research, development, and implementation of new technologies in both feedstock production and handling as well as in ethanol plant design.
- Full-cost accounting of environmental impacts from deploying these biomass fuel systems should be included as part of this work.

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