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Ethanol Production and Employment

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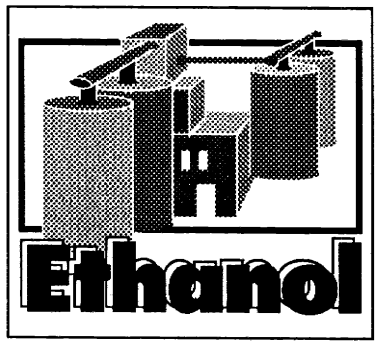

Increased U.S. production of ethanol could create 28,000-108,000 new jobs by the year 2000. Ethanol, distilled chiefly from corn, can be mixed with gasoline to reduce the level of hydrocarbon pollutants created by fuel combustion in gasoline engines. Job gains will be concentrated in the rural Midwest, where most of the Nation's corn is grown. Small communities elsewhere can benefit through new biomass technologies that can distill ethanol from energy crops, agricultural residues, and organic municipal waste.

If the United States were to increase production of ethanol to 2 billion gallons per year (more than double the current level of 900 million gallons per year) by 1995, an estimated 28,000 jobs would be created nationwide: 10,000 direct and indirect jobs from ethanol processing, 3,000 temporary jobs from construction, and 15,000 jobs from additional crop production. Under a second scenario, producing 5 billion gallons per year by the year 2000 would create an estimated 108,000 jobs nationwide: 34,000 direct and indirect jobs from ethanol processing, 14,000 temporary construction jobs, and 60,000 jobs from additional crop production.

Some of the increased employment from additional corn production would be offset by a decrease in soybean production since ethanol byproducts compete with soybean products. Because increased demand for corn would increase market prices for grains, added ethanol production would strengthen market orientation in the farm sector and lower government deficiency payments. The manufacturing sector could also gain jobs if instrumentation and plant equipment are purchased from U.S. companies. These job increases could be offset, by decreases in the petroleum industry.

Ethanol plants are highly capital-intensive, employing only about three workers per million gallons of annual production. Thus, ethanol plants offer limited opportunities to permanently increase local employment. However, integrating ethanol production with other agricultural activities, such as production of an ethanol feedstock or utilization of byproducts, offers added employment potential. In Garden City, KS, for example, ethanol byproducts are used in cattle feedlots and aquaculture. An Idaho plant uses waste from potato processing as an ethanol feedstock, and two California plants use cheese whey from dairy processing as a feedstock.

Ethanol production is concentrated in a few large plants in corn-growing areas of the Midwest. Thus, many of the 10,000 jobs (3,500 in plant operations, 6,500 in local retail trade, services, and supply industries) forecast in our 1995 scenario would be in farming areas with smaller cities. The year 2000 scenario forecasts even more jobs near crop-producing areas.

Constructing new ethanol plants or adding to current production facilities could create temporary jobs for local residents. The temporary workforce could reach as many as 3,000 jobs nationwide if ethanol production increases to 2 billion gallons per year and 14,000 jobs nationwide if ethanol production increases to 5 billion gallons per year.

Increased agricultural production may add more than 15,000 jobs nationwide when ethanol production reaches 2 billion gallons per year and about 60,000 new jobs nationwide with ethanol production at 5 billion gallons per year. Most of these jobs will be in rural settings. However, some farmers may choose to work additional hours rather than hire new

workers and some of the new jobs may be only part time or seasonal. Moreover, with ethanol production at 5 billion gallons per year, employment gains in the crop sector would be tempered by a probable reduction of jobs in the livestock sector because of increased feed prices.

Current Ethanol Production and Options for Expansion

U.S. ethanol production capacity is about 1.1 billion gallons (0.9 billion gallons produced and 0.2 billion gallons excess capacity) a year at 39 operating facilities. The eight largest plants account for 87 percent of ethanol output and range in production capacity from 40 to 280 million gallons per year. These eight largest plants use corn as a feedstock, and seven of these plants are in the traditional Corn Belt States (fig. 1). More than 95 percent of the Nation's ethanol is made from corn (table 1). About 6 percent of the 1990 U.S. corn crop was processed to make ethanol.

More than half of ethanol plants produce less than 10 million gallons per year. Many of these small plants are designed to use locally available feedstocks that would otherwise have to be disposed of. For example, cheese whey, potato waste, molasses, and brewery waste are relatively low-value residues from food processing that can be transformed into a higher value product and at the same time solve a disposal problem. Such feedstocks often come at low or even negative cost to the producer, and their disposal in the ethanol production process provides societal benefits.

Of the 27,640 new jobs that could result from raising ethanol production to 2 billion gallons, only a third are associated with building new plants (table 2). Another third of the employment gains would come from fuller utilization of existing plants, either by expanding production in plants with excess capacity or by bringing on line idled plants, and the rest would come from building additional capacity at operating plants. In contrast, when raising ethanol production to 5 billion gallons, building new plants

Figure 1
Eight largest ethanol plants in the United States

Seven of the eight largest ethanol plants are located in the Corn Belt.

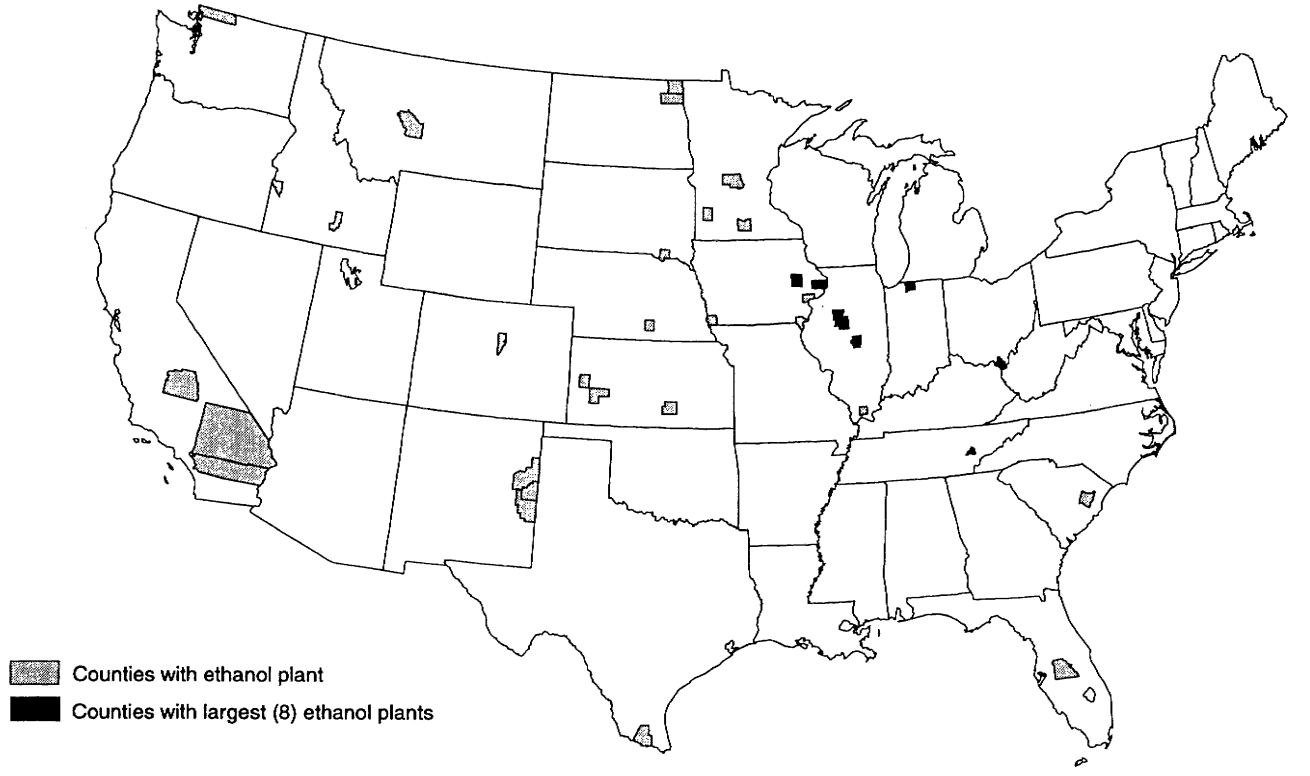

Table 1--Distribution of U.S. ethanol plants by primary feedstock
Over 95 percent of U.S. ethanol is made from corn.

Primary feedstock	Plants	Annual production capacity	Range of plant size	Share of total ethanol output
	Number	*---------Million gallons---------*		*Percent*
Corn	20	1,049.8	0.5-280	95.6
Milo	3	6.6	1.0-3.3	0.6
Wheat	3	8.2	1.0-5.2	0.7
Other grains	2	11.0	0.5-10.5	1.0
Cheese whey	3	4.1	0.7-2.2	0.4
Potato waste	2	6.0	3.0	0.5
Molasses	2	6.2	1.2-5.0	0.6
Brewery waste	4	6.1	0.7-2.0	0.6
Total	39	1,098.0	0.5-280	100.0

Source: Data from Information Resources, Inc. (IRI).

Table 2--U.S. ethanol industry options for expansion
U.S. employment gains are associated with (1) full utilization of existing or idled plants and (2) constructing new production capacity.

Item	Ethanol production capacity, U.S.[1]	Construction phase[2]	Production phase				All
			Ethanol plant operation			Agriculture[5]	
			Direct[3]	Indirect[4]	Total		
	Million gallons	*----------Number of new jobs----------*					
Current production	920						
U.S. ethanol production of 2 billion gallons per year (1995):							
Excess capacity in operating plants	210	--	630	1,130	1,760	2,820	4,580
Capacity of idled plants	183	--	550	990	1,540	2,460	4,000
Proposed expansion of operating plants	385	1,430	1,160	2,090	3,250	5,180	9,860
Proposed new plants	360	1,340	1,080	1,940	3,020	4,840	9,200
Total	2,058	2,770	3,420	6,150	9,570	15,300	27,640
U.S. ethanol production of 5 billion gallons per year (2000):							
Excess capacity in operating plants	210	--	630	1,130	1,760	3,130	4,890
Capacity of idled plants	183	--	550	990	1,540	2,720	4,260
Proposed expansion of operating plants	385	1,430	1,160	2,090	3,250	5,730	10,410
Proposed new plants	360	1,340	1,080	1,940	3,020	5,360	9,720
Required new plants	2,900	10,790	8,700	15,660	24,360	43,160	78,310
Total	4,958	13,560	12,120	21,810	33,930	60,100	107,590

[1] Based on data from Information Resources, Inc. (IRI). [2] To build a 100-million-gallon ethanol production facility takes 2 years and requires between 200 and 400 construction workers (300 full-time equivalents). This activity generates additional jobs (about 70) in local industries that supply or provide services to the construction industry. [3] A state-of-the-art 100-million-gallon ethanol facility with wet corn milling can require up to 300 workers. We assume this labor requirement does not change as the industry expands. [4] Includes employment increases induced by increased consumer expenditures for goods and services. [5] Includes nonfarm employment gains due to increased grain production and reduced production of soybeans. Total is allocated in proportion to all categories of future production.

would provide more than four out of five new jobs, about 10 percent of them construction-related. In both scenarios, jobs in agriculture account for more than half of all new jobs, or about 14 farm and farm-related jobs per million gallons of added output.

Effects of Increased Ethanol Production on the Farm Sector: Crop Substitution and Increased Farm and Farm-Related Employment

Corn is the primary feedstock for U.S. ethanol production, so substantial expansion in the ethanol industry would increase the demand for U.S. corn, raising corn prices and bringing more acres into corn production. Increasing annual ethanol production to 2 billion gallons by 1995 would increase the base level price of corn 1 cent per bushel and increase corn production and acreage about 3.4 percent. Producing 5 billion gallons of ethanol per year by 2000 would raise corn prices 19 cents per bushel and increase acreage and output by almost 12 percent (table 3).

With more ethanol production, however, comes more corn gluten feed (a byproduct from ethanol production), causing a decline in soybean demand. Soybean prices would fall 6 cents per bushel and output would drop nearly 1 percent from base level in the 1995 scenario. With 5 billion gallons of ethanol production per year, soybean prices would fall 31 cents and production would drop 5.5 percent.

Prices and production of other grains, such as wheat, sorghum, oats, and barley, would also change with increased ethanol production. Overall, however, increased ethanol production would strengthen market orientation in the farm sector as prices for corn and other grains move higher and as government deficiency payments decline. The total deficiency payment for grains would drop only $7 million or 0.2 percent from baseline in 1995 if ethanol production reaches 2 billion gallons per year. However, production of 5 billion gallons of ethanol per year could decrease government deficiency payments by $870 million (22 percent) in the year 2000.

Most jobs created by the ethanol-induced demand for agricultural products would be in the farm and farm-related sectors. Ethanol production of 2 billion gallons per year by 1995 would create more than 15,000 farm and farm-related jobs (table 3). Increased corn sales account for the largest share (96 percent) of these employment gains. The drop in soybean sales accounts for more than half of the farm and farm-related job losses. Although output of the livestock sector would fall as feed prices rise, the change would be minimal.

Increasing ethanol production to 5 billion gallons per year by the year 2000 would create over 60,000 farm and farm-related jobs. Again, increased demand for corn accounts for almost 90 percent of these job gains, while soybean price and output declines account for nearly all the job losses.

Local Effects of Increased Ethanol Production

We selected three prototypical areas in the Corn Belt with population ranging from 150,000 to 450,000 to study possible differences in local job creation (employment multipliers) due to ethanol production. All three multi-county areas produce large quantities of corn and have adequate infrastructure (rail, roads, and waterways) to serve the needs of a 100-million-gallon ethanol plant. Corn is the dominant farm commodity produced in each area and, although each area's economy is somewhat diverse, farm employment and income are important to the local economic base.

Table 4 shows local effects (temporary and permanent) of building a 100-million-gallon ethanol plant and operating it under the two national scenarios. Employment figures of 300 employees for plant construction and 300 employees for operating a 100-million-gallon ethanol plant were suggested by ethanol industry experts (see "Individuals and Organizations Contacted"). Employment multipliers for either the construction or operational phase did not vary greatly by area population. These multipliers were estimated using input-output analysis at the regional level (see box, "Methodology").

Table 3--Adjustments in U.S. crop production due to increased ethanol production[1]
Increased corn sales more than offset decreases in other crop sales.

Commodity	Price	Acres	Production	Jobs
	$/bushel	*Million*	*Million bushels*	*Number*
U.S. ethanol production of 2 billion gallons per year (1995):				
Corn	0.01	2.6	294.3	18,600
Sorghum	0.02	0.0	0.1	--
Barley	-0.01	-0.1	-4.5	-300
Oats	0.00	0.0	1.3	--
Wheat	0.01	-0.5	-15.7	-1,500
Soybeans	-0.06	-0.5	-17.0	-2,200
Cotton	-8.30	0.0	0.1	700
Total				15,300
U.S. ethanol production of 5 billion gallons per year (2000):				
Corn	0.19	9.3	1,121.5	66,600
Sorghum	0.09	1.0	58.1	3,500
Barley	0.09	0.6	32.2	1,700
Oats	0.15	0.2	7.9	300
Wheat	-0.06	0.6	23.5	2,100
Soybeans	-0.31	-3.2	-117.8	-14,100[2]
Total				60,100

[1] Changes in price, acres, and production are derived from the USMP regional agricultural policy model (see House and others, 1993). Employment impacts are derived through national employment multipliers, which are based on a 43-sector aggregation of the 542-sector U.S. Department of Commerce input-output tables of the 1982 U.S. economy. These multipliers are adjusted for increases in labor productivity since 1982.
[2] Losses are concentrated in the Midwest and Delta States.
-- = fewer than 100.

Indirect employment, resulting from 300 construction jobs, ranged from an estimated 50 workers in the smallest area to 90 workers in the largest area. Indirect employment was much higher when associated with 300 plantworkers than with 300 construction workers because permanent employment has more significant local income effects. That is, additional household income over the long term results in greater spending for local goods and services and creates more jobs. Employment indirectly related to ethanol plant operation ranged from 680 workers in the smallest area to 500 workers in the largest area. The relationship between these latter employment gains (multipliers) and population size is not intuitively obvious, but when employment gains are averaged across the different areas, the resulting multipliers appear quite reasonable: 1.2 during the construction phase and 2.8 during the operating phase.

Construction activity generally led to 70 jobs in other local industries only during the construction phase while plant operations generated 540 permanent jobs in local businesses.

On average, the typical Corn Belt economy would benefit by 370 additional jobs in the construction phase and 840 jobs in the operation phase. These jobs are net of additional farm jobs resulting from increased ethanol production. Area job increases associated with farm sector changes would be small (30 jobs) under the 2-billion-gallon scenario, which forecasts small changes in farm production patterns. Under this scenario, the dominant change is increased corn production, but some of the resulting increases in farm income are offset by reductions in feedgrain deficiency payments. Under the 5-billion-gallon scenario, local employment gains associated with changes in the farm sector would average 180

Table 4--Employment impacts of a 100-million-gallon ethanol plant on three prototypical Corn Belt economies

Only a third of permanent new jobs are in the capital-intensive ethanol plant itself.

Item	Population of local economy[1]			Average area estimate
	150,000	250,000	450,000	
	Number of new jobs			
Temporary construction impact	350	370	390	370
Construction employment	300	300	300	300
Indirect employment	50	70	90	70
U.S. ethanol production of 2 billion gallons per year (1995):				
Permanent operation impact	1,010	870	830	870
Plant employment	300	300	300	300
Indirect employment	680	540	500	540
Agriculture[2]	30	30	30	30
Total impact (temporary plus permanent)	1,360	1,240	1,220	1,240
U.S. ethanol production of 5 billion gallons per year (2000):				
Permanent operation impact	1,120	1,020	1,000	1,020
Plant employment	300	300	300	300
Indirect employment	680	540	500	540
Agriculture[2]	140	180	200	180
Total impact (temporary plus permanent)	1,470	1,390	1,390	1,390

[1]These economies pertain to typical Corn Belt communities with a particular population size and do not refer to specific towns or cities.

[2]Includes farm and nonfarm jobs due to increased grain production and reduced production of soybeans.

jobs. Under this scenario, regional corn production would increase significantly and net farm income also would increase, despite a significant drop in deficiency payments. Annual net farm income in the typical Corn Belt economy increases roughly $10 million.

A new state-of-the-art 100-million-gallon ethanol facility could create 1,240 local jobs (temporary and permanent) under the 2-billion-gallon scenario and 1,390 total jobs under the 5-billion-gallon scenario. The relative impacts of additional employment depend on the size and diversity of the total employment base in the local economy. An area with 250,000 population is assumed to employ 100,000, so ethanol-induced changes represent a 1.2- and 1.4-percent addition to the local workforce, for the 2- and 5-billion-gallon scenarios.

Increased Ethanol Production and Rural Development Prospects

Increased ethanol production offers possibilities for increased employment in communities that can meet the infrastructure and raw material needs of large plants (100 million gallons per year). But, many isolated rural communities have neither an available supply of workers nor a transportation infrastructure adequate to supply corn to the plant or to ship ethanol and its byproducts to distant markets. Larger communities in the Corn Belt are the most viable candidates for these new ethanol-related jobs. These communities have an adequate labor force to construct and operate plants. Also, many of these communities already have grain production, handling, processing, and transportation as major parts of their economic base. Increased ethanol production would simply require an expansion of these activities.

Methodology

The USMP (United States Mathematical Programming) regional agricultural model and the IMPLAN (Impact Analysis for Planning) input-output model, along with trade multipliers based on the 1982 U.S. Department of Commerce national input-output tables, were used to determine national and local effects of increased ethanol production.

A spatial model, USMP incorporates government agricultural commodity programs and solves for equilibrium in all major factor and product markets. The model is used for policy and market alternatives analysis at the U.S. Department of Agriculture. In this analysis, USMP calculated changes in commodity prices, acres planted, and crop production resulting from increased ethanol output.

IMPLAN is a microcomputer-based system for constructing regional economic accounts and input-output tables. The IMPLAN system provides descriptive accounts of interindustry and intersector transactions, and it estimates employment and income effects stemming from changes in product demand, supply-side constraints on industry production, and structural changes in regional economies. The county-level database uses the 1977 U.S. industrial structure updated to 1985 prices for 528 industries.

In this analysis, IMPLAN describes interindustry relationships within each study area and is used to estimate the magnitude of total change in each economy after an initial change works its way through the local industries. Examples of initial change are ethanol plant construction, actual production of ethanol, and increased spending power in the farm sector because of increased agricultural production and prices. The wet corn-milling and construction sectors in each area were used to obtain local employment multipliers.

A community's success in attracting a new ethanol plant could mean roughly 370 jobs during the construction phase and about 840 jobs while the plant is in operation. For smaller communities with adequate resources, such increased employment prospects could mean significant increases to their economic base. These increases represent a major new growth opportunity, not only for the community, but also for the larger regional economy surrounding the new plant location.

The national scenario of 5 billion gallons of ethanol production per year could mean an additional 60,000 farm and farm-related jobs. A majority of these jobs would be in the major corn production areas of the Corn Belt, and thus will go to rural residents. This is particularly true in central Illinois and eastern Iowa where much of the Nation's corn is produced and many small and medium-size cities offer locational advantages for ethanol production facilities. More sparsely settled rural areas of western Iowa, eastern Nebraska, and southern Minnesota appear less likely candidates for ethanol plants because of transportation and general infrastructure shortcomings. However, some of these communities, as well as others in rural America, may still be able to attract small ethanol plants that can use a locally available, low-cost feedstock. Even a small facility contributes to overall growth in small towns and rural areas with less diverse economies. Thus, integrated ethanol production can be an effective way for the rural economy and the agricultural sector to realize the full benefits of ethanol production expansion.

Directions for the Future

Local communities could also benefit from emerging technologies that permit production of ethanol from renewable, nonfood feedstocks consisting primarily of cellulose. Organic wastes, agricultural crops, and forest products are all potential energy biomass feedstocks. Cellulosic conversion technology will make ethanol production possible in areas where a sufficient supply of energy biomass feedstock is available from agricultural activities (rural areas) or accumulation of waste products (urban or suburban areas).

Energy biomass feedstocks may include woody or herbaceous energy crops, byproducts or residues from forestry and agricultural operations, and organic municipal wastes. Energy crops include fast-growing trees (hybrid poplar, sycamore) that are grown using intensive farming practices and a variety of grasses (switchgrass, sudangrass) that can be grown and harvested like hay or silage. Introducing these crops into the local agricultural economy, particularly on marginal land, could lead to some increases in farm income and more jobs on and off the farm.

Because feedstock price is a significant element in determining the market price of ethanol and thus its competitiveness with gasoline, waste products or residues offer the advantage of a low or even negative feedstock cost. Some low-cost feedstocks are bagasse from sugarcane processing, corn and rice hulls from grain processing, rice and wheat straw, wheat mids, and corn stover. Negative costs are typically associated with municipal solid wastes (portion that is biodegradable), as well as solid and liquid wastes from agricultural processing, breweries, food processing, paper pulping, and wood processing.

New technologies generally imply smaller scale ethanol plants, located primarily in rural areas. Although some operations will locate in or near urban centers to solve problems of organic waste disposal, the general orientation will likely be rural America where most energy biomass is grown.

Individuals and Organizations Contacted

Martin L. Andreas, senior vice president, Archer-Daniels-Midland Company, Decatur, IL.

David E. Fowler, managing director, Bioenergy International, Gainesville, FL.

John F. Gerber, vice president, Bioenergy International, Gainesville, FL.

T. Jack Huggins, president and CEO, Pekin Energy Company, Pekin, IL.

Lonnie O. Ingram, University of Florida, Institute of Food and Agriculture Sciences, Gainesville, FL.

Bob Jones, director of marketing, Archer-Daniels-Midland Company, Decatur, IL.

Raphael Katzen, president, Raphael Katzen Associates International Inc., Cincinnati, OH.

Nate Kimpel, manager, New Energy Company of Indiana, South Bend, IN.

John E. Long, vice president, Research Division, Archer-Daniels-Midland Company, Decatur, IL.

Mike McFate, ethanol plant manager, Archer-Daniels-Midland Company, Decatur, IL.

Dermot O'Brien, ethanol plant manager, Golden Cheese Company of California, Corona, CA.

Lee Reeve, president, Reeve Agri Energy, Garden City, KS.

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U.S. Department of Agriculture
Economic Research Service

SUMMARY OF REPORT

Surge in Ethanol Production Would Benefit Grain Farmers

Number 19, June 1993

Contact: Robert House (202) 219-0689

A major expansion of ethanol production could increase U.S. farm income by as much as $1 billion (1.4 percent) by 2000, according to the U.S. Department of Agriculture report *Ethanol and Agriculture: Effect of Increased Production on Crop and Livestock Sectors* (AER-667). Because corn is the primary feedstock for ethanol, growers in the Corn Belt would benefit most from improved ethanol technology and heightened demand. Coproducts from the conversion process (corn gluten meal, corn gluten feed, and others) compete with soybean meal, so soybean growers in the South may see revenues decline. The U.S. balance of trade would improve with increased ethanol production as oil import needs decline.

Ethanol production is expected to rise to 1.2 billion gallons per year by 1995 and remain at that level. Ethanol's environmental benefits could lead to increased demand. This analysis looks at consequences for agriculture of two possible demand alternatives: producing 2 billion gallons of ethanol per year by 1995 (a 0.8-billion gallon increase over expected production) and 5 billion gallons by 2000 (a 3.8-billion gallon increase).

Ethanol is an attractive supplement to gasoline for many reasons. Increased ethanol use reduces levels of carbon monoxide and carbon dioxide emissions, and improves energy security by reducing reliance on oil imports, thereby improving the U.S. balance-of-payments account. Increased ethanol production also benefits agriculture. Wider use of ethanol would provide new uses for domestic farm resources, increase grain production, support grain prices, reduce deficiency payments, and increase total farm income. Boosting ethanol production to 5 billion gallons per year would lead to significant increases in farm income, particularly for grain farmers.

Corn. Most ethanol is processed from corn, but research aims at economical production of ethanol from biomass crops (energy sorghum, switchgrass, and other energy crops). In the near term, major increases in ethanol output would likely come from expanded corn production. Increased ethanol production will increase corn demand, leading to more production of and income from corn and other feedgrains. Increased competition for cropland will boost corn and other feedgrain prices if ethanol production is more than doubled. Feedgrain prices will change little if corn production expands on cropland not currently in production. Land idled in 1992 feedgrain acreage reduction programs, for example, could be employed to roughly double ethanol production without significant effects on feedgrain prices.

Soybeans. Increasing ethanol production increases the supply of ethanol coproducts--corn gluten feed, corn gluten meal, distillers' dried grains, and corn oil--which compete with soybeans in animal feed and vegetable oil markets. The increased competition exerts downward pressure on soybean meal and oil prices. At the same time, corn competes with other feedgrains and soybeans for land. Expanding ethanol production could lead to reduced soybean production, which would offset some of the price-dampening effects of increased coproduct production.

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