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THE ETHANOL INDUSTRY in Nebraska

Relevant Research Results from IANR

University of Nebraska Lincoln

Briefing to Members of the Unicameral

IANR

BRIEFING PAPERS

ETHANOL PLANT OPERATION

(Curtis Weller and Loren Isom, Biological Systems Engineering)

Is it cheaper today to produce a gallon of ethanol with a dry-grind ethanol production process than to produce it following a wet-milling process?

This is not a question with a *yes* or *no* answer but rather an *it depends* answer because of numerous variables that can be factored into each process. Foremost are the different reasons for each process.

Wet milling corn was developed to recover starch. By-products from wet milling include oil, steep liquor, gluten meal and gluten feed. Only in the last 40 years has there been the demand and interest in converting the starch to sugars (glucose and fructose), ethanol or other chemical compounds such as polylactic acid, polyols and xanthan gum. Wet-milling plants are capital intensive and handle great quantities of various materials, and as a result margins have been historically small. Cargill (Blair) and ADM (Columbus) fit in this category and produce approximately 83 and 90 million gallons, respectively, of ethanol per year.

Producing ethanol was (and still is) the impetus behind using dry grinding, cooking and fermentation for corn. By-products from dry-grind ethanol production include carbon dioxide, condensed solubles and distillers grains. Dry-grind plants are not as capital intensive as wet-milling facilities. Chief Ethanol (Hastings), Abengoa Bioenergy (York), AGP (Hastings), Platte Valley Fuel Ethanol (Central City), KAAPA Ethanol (Minden), Aventine Renewable Energy (Aurora), Trenton Agri Products (Trenton), Husker Ag (Plainview) and Midwest Renewable Energy (Sutherland) fit in this category and are able to produce approximately 62, 55, 52, 40, 40, 40, 30, 23 and 15 million gallons, respectively, of ethanol per year.

Other variables that influence the cost of ethanol production (see *Figures 1* and *2*) are feedstock costs (greater than 60 percent of total costs), operating (labor, utilities, regulatory) costs, by-product drying costs, and type (corn, grain sorghum, potatoes) and quality (No. 2 vs. No. 3 or lower) of feedstock.

How has the dry-grind ethanol production process changed over the past 15 to 20 years?

Ethanol production from dry-grind processes has become more efficient over the past 25 to 30 years. Three primary contributors are: 1) refinement of process technology, 2) improvement in quality of inputs, and 3) greater recovery and use of by-products.

Process technology has seen the number of plants and capacity per plant increase, greater use of automated on-line measurement and control, replacement of organic solvents with molecular sieve technology for ethanol dehydration, greater energy reclamation from waste streams, more efficient cooking technology, more efficient by-product drying and use of thermal oxidizers to reduce emissions. In 1982 it was considered good to produce a gallon of ethanol using 55,000 Btu with capital costs of $2.25 per gallon of annual production. In 2004, on average, a gallon of ethanol can be produced for 30,000 Btu with capital costs of less than $1.25 per gallon of annual production.

Input quality has changed as specific corn hybrids with improved starch release and increased levels of recoverable starch have been identified for use in ethanol production. Enzymes of greater purity, activity and thermal stability than years ago are available. Current yeasts are better able to tolerate higher ethanol levels and temperature ranges than previous yeast strains.

Greater recovery and use of by-products now than in previous years almost allows the return from the by-products to cover all the costs of ethanol production except feedstock costs. Examples include carbon dioxide capture, production of a wider range of distillers grains products for feeding a greater variety of animals, and anaerobic digestion for methane.

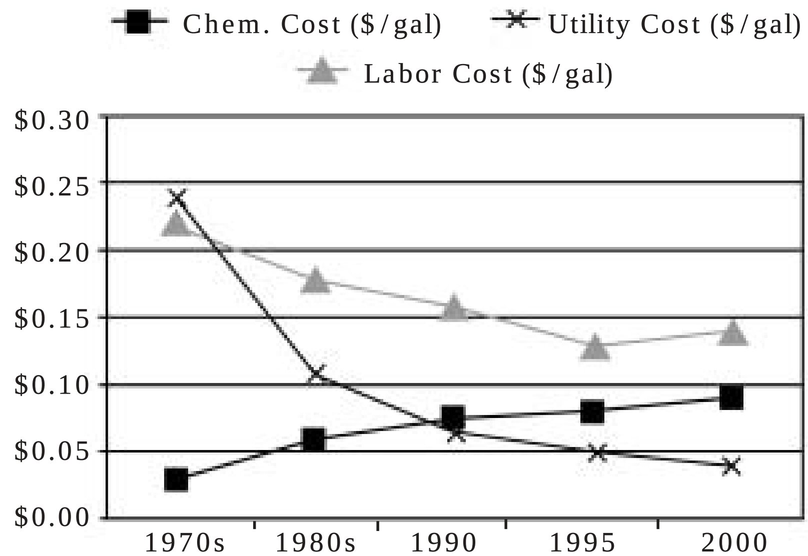

Figure 1. Changes in major operational costs other than feedstock costs for dry-grind ethanol production over the last 30 years. ***(Source: Fuel Ethanol, A Technological Evolution, Novozymes and BBI International, June, 2004.)***

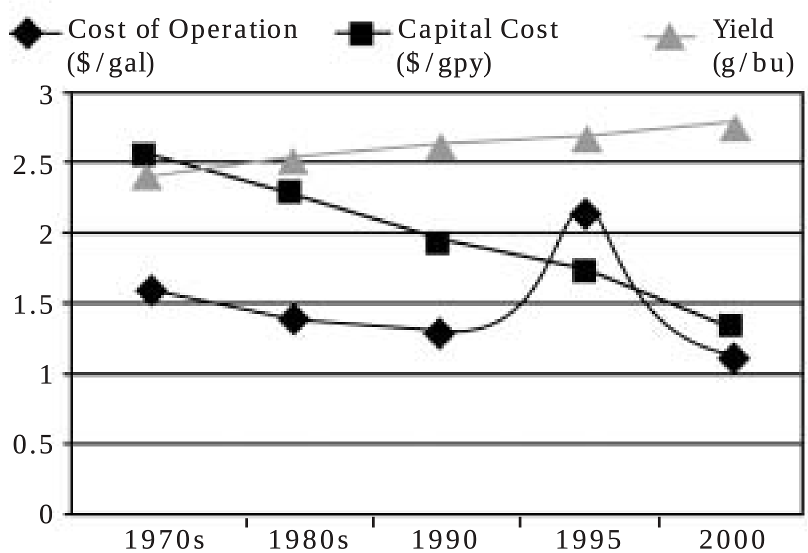

Figure 2. Changes in dry-grind ethanol production costs and yield of ethanol over the last 30 years. ***(Source: Fuel Ethanol, A Technological Evolution, Novozymes and BBI International, June, 2004.)***

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ENERGY EFFICIENCY IN THE ETHANOL INDUSTRY

(Dan Walters, Agronomy and Horticulture)

Is corn-based ethanol an energy efficient alternative for the United States?

Corn-based ethanol is a sensible fossil fuel substitute only if the fossil fuel (gasoline, diesel, electricity) inputs for producing the crop, transporting grain and processing ethanol are less than the net energy value of the ethanol produced. Studies by the University of Nebraska, USDA-ERS, and others confirm that the energy output for corn-based ethanol is ~+30 percent greater than the fossil fuel energy input consumed in its manufacture. Improved energy efficiency of modern farming practices and advances in ethanol plant technologies have made this possible.

Does the energy consumed in irrigating corn reduce the energy efficiency of corn-based ethanol?

Irrigated corn consumes nearly twice as much fossil fuel energy as dryland corn; however, this does not change the energy output/input ratio of ethanol production because the primary effect of irrigation is to increase the net yield of grain (on average by +60 percent) and increase the efficiency with which nitrogen fertilizer is used by the crop. (Nitrogen fertilizer is 25 percent to 30 percent of the net energy input in corn production). These two factors result in equivalent energy input/output ratios for irrigated and dryland corn. An added benefit of Nebraska irrigated corn is that it offers a level of stability against drought in the supply of grain to distillation plants.

Are there any potential economic benefits to corn-based ethanol beyond a more stable corn grain market?

Under the Kyoto Treaty, global carbon trading markets are now operating whereby technologies that reduce the emission of global warming gases (mainly carbon dioxide from fossil fuels) are rewarded through payment. The federal government is examining alternatives to the Kyoto Treaty in an effort to reduce the United State's share of global warming gas emissions to the atmosphere and to allow U.S. industries to participate in carbon trading. Since corn ethanol is a biofuel, the offset in fossil fuel consumption it creates could be traded on the world carbon market, resulting in additional farm income. The EU is looking to open carbon trading on a state-level in the U.S. in the near future.

Are there potential environmental consequences of expanding the ethanol industry in Nebraska?

Intensifying corn production in Nebraska in response to increased demand for corn grain should not result in negative environmental impacts on soil or water quality as long as best management practices (BMPs) are followed. Promotion of prescribed BMPs will improve both nutrient and water use efficiency in corn production. Of concern is the concentration of phosphorus in distillers grain used for cattle feed and to enrich the total phosphorus in manures. Mismanagement of land-applied manure enriched in phosphorus may be detrimental to surface water quality. Technologies and BMPs are in place to deal with this hazard through prescribed comprehensive nutrient management plans (CNMP) enforced and promoted by the NE-DEQ, USEPA, NRCS and NRDs.

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FEED BY-PRODUCTS FROM ETHANOL

(Terry Klopfenstein, Animal Science)

What by-products are available and what is the terminology associated with them?

Two distinct milling industries in Nebraska produce quite different feed by-products. Wet milling (Cargill at Blair and ADM at Columbus) uses corn for ethanol, sweetener, and other products. The feed by-products are wet corn gluten feed and steep liquor. Dry milling, which includes all the other ethanol plants across the state, can use any grain, but corn and some sorghum are used in Nebraska. The major products produced in dry milling plants are ethanol and carbon dioxide. The feed by-products from this industry are wet distillers grains plus solubles (WDGS), dry distillers grains plus solubles (DDGS), and corn syrup (distillers solubles). In Nebraska, almost all the feed by-products are produced and marketed as wet feeds with moistures varying from 40 percent to 65 percent (i.e., dry matter of 60 percent to 35 percent). The main feed by-products of interest for ethanol plants (i.e., dry milling plants) in Nebraska are WDGS and distillers solubles . Because of the proximity of the feed markets (feedlot cattle) and the ethanol plants, the wet feeds can be used because transportation is minimal.

What cattle are available to use the by-products?

We usually have about 2.4 million cattle in feedlots, 2 million beef cows, 1 million stocker cattle and 70,000 dairy cows in Nebraska. If ethanol by-products were fed at an economical level to all groups, then 80 percent would be fed to feedlot cattle, 14 percent to beef cows, 4 percent to stockers and 2 percent to dairy cows. Therefore, the major focus has been on the use by Nebraska's feedlot industry. Because of transportation and handling and storage concerns, most beef cow and stocker producers will use dry by-products.

Why would wet feed by-products be used at all?

Using wet feeds is an advantage for Nebraska because the feed is actually better (i.e., more energy and better performance) for cattle compared to DDGS, and the plants avoid the expense of drying. In most plants marketing WDGS, not all the distillers solubles can physically be added back to the wet grains, so some solubles are marketed separately as a liquid.

What is the diet impact from feeding wet distillers grains plus solubles?

WDGS can be fed up to 40 percent of the diet DM (60 percent or more as is). A few consequences of using WDGS that limit feeding are high fat content (oil concentrated in WDGS from corn), higher dietary phosphorus which requires more management (phosphorus concentrated when WDGS is made from grain), and higher dietary sulfur. The sulfur can lead to health challenges if it is variable and a load arrives that is very high in sulfur. However, if these challenges can be managed, cattle performance will improve, depending on the amount included in the diet. Based on numerous research studies, primarily from Nebraska, WDGS contains approximately 157, 148, 139, 130, and 121 percent the energy value when replacing 10, 20, 30, 40, and 50 percent of the diet, fed in place of corn. WDGS can be quite variable in consistency and feedlots are concerned about moisture (i.e., DM), fat content, sulfur, and phosphorus. However, on average, WDGS contain 10 percent to 13 percent fat, 0.8 percent to 1.0 percent phosphorus, 30 percent to 34 percent protein, and 40 percent to 45 percent fiber.

Because of the digestible fiber replacing corn in these feedlot diets, traditional roughage such as alfalfa hay can be reduced or eliminated. In many situations, a lower quality alternative roughage may be used that contains little protein. The WDGS contain large amounts of protein and can replace the need for protein in the roughage. Therefore, more corn silage, cornstalks, wheat straw, or other alternative forages may be used with no impact on performance. Probably less than 10 percent of the alfalfa has been replaced in Nebraska feedlots.

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FEEDLOT ECONOMICS OF FEEDING BY-PRODUCTS TO CATTLE

(Galen Erickson, Animal Science)

What are the economic consequences for cattle producers of using WDGS?

Based on research conducted at the University of Nebraska over the past 20 years, wet distillers grains plus solubles (WDGS) are known to be an excellent feed for feedlot cattle, providing more energy, plenty of protein, and digestible fiber. Feedlot diets typically contain a small amount of roughage (such as alfalfa); a protein, mineral and vitamin supplement; and corn. Corn typically comprises 80 percent to 85 percent of the diet. When by-products are fed, they replace the protein in the supplement but primarily replace corn as the source of energy. These economic analyses primarily represent the replacement of corn in the feedlot diet. Some costs are increased by using WDGS because of the large amount of water (moisture) in the product. A ton of WDGS may contain up to 1,300 pounds of water, which must be hauled to and handled at the feedlot. The extra moisture has a very positive effect on the diet as it is fed to the cattle, and both the feedlot managers and the cattle like the by-products in the diet. In addition to the higher costs to transport WSGS to the feedlot from the ethanol plant compared to corn, there are increased costs of hauling the WDGS diets in feed trucks. Further, corn prices are likely increased because of demand for corn by the ethanol plant. This increases the price of corn for cattle feeders.

We have attempted to quantify the returns to cattle feeders by accounting for the increased value of WDGS compared to corn and then accounting for the extra costs of transportation, etc. Typically WDGS is priced relative to the price of corn and is now about 95 percent the price of corn on an equal moisture basis. Our calculations were made for inclusion rates in the diet from 10 percent to 50 percent. On average, if the feedlot is feeding WDGS at 20 percent to 40 percent of the diet (dry matter basis) and is within 100 miles of the plant, then returns are $15 to $25 per animal fed for 150 days. If the price of corn is increased by $0.05 per bushel by demand from the ethanol plant, then the returns to the cattle producer decrease by $3 per animal. An increase in corn price by $0.10 per bushel decreases returns by $6 per animal; however, the net return to cattle producers is still $9 to $19 per animal.

Clearly, feeding WDGS in Nebraska is good for cattle feedlots and for the ethanol plants. The economically optimal inclusion rates are 20 percent to 40 percent of diet dry matter, with higher inclusion rates warranted the closer the feedlot is to the ethanol plant. Currently, the feedlot industry is using 15 percent to 20 percent inclusion rates and WDGS are probably fed to 35 percent to 40 percent of the feedlot cattle in the state. Another 30 percent to 35 percent are probably fed wet corn gluten feed from the wet milling plants in Columbus and Blair.

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CORN PRICE EFFECTS IN THE VICINITY OF ETHANOL PLANTS

(Darrell Marks, Agricultural Economics)

What is the impact on local corn prices from ethanol plants in Nebraska?

Traditional demand for corn in Nebraska has come from local livestock feeders and export markets. The introduction of ethanol plants in Nebraska add another source of demand, leading to an expected increase in local corn price. An analysis was conducted to examine the extent to which the introduction of a plant in central Nebraska in November 1995 impacted corn prices across the state. Using time series data of cash corn prices from 1993 to 2003 for 24 locations in Nebraska, changes in cash price levels at locations near the plants were compared to cash markets outside the expected area of influence of the ethanol plant both before and after the plant's construction. Results indicated that corn prices increased after the November 1995 plant construction in each Nebraska location considered, but the increase was only statistically significant at one-third of the locations (it should also be noted that the type of analysis used does not necessarily establish causation but correlation between the plant construction and corn price increases actually observed). The average corn price for the 1996 to 2003 period was $0.03 per bushel higher than the 1993 to 1995 period across all locations (after adjusting for other market effects), ranging from no increase up to $0.08 per bushel. It would be expected that the largest price impact would be observed closest to the plant, with declining price increases moving away from the plant location. The average price increase after 1996 was $0.042 per bushel for the locations within 50 miles of the plant, $0.035 per bushel for locations 50 to 100 miles to the plant, and $0.014 per bushel for locations more than 100 miles from the plant. This average impact is somewhat lower compared to a similar analysis in Missouri for a plant opening in 2000, where a $0.09 to $0.10 per bushel impact was observed directly at the plant (note that the Nebraska analysis focused on typical Nebraska cash corn market bids, not plant prices). Plant-level corn price data for recent ethanol plant openings indicate plant bids $0.069 per bushel higher than historical local corn prices. It's likely that as additional plants compete for corn in a given area, the local corn price will increase.

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EFFECTS OF ETHANOL EXPANSION ON THE NEBRASKA AG SECTOR

(Richard Perrin and Phillip Anthony, Agricutural Economics)

What would be the impact of a 50 percent increase in ethanol capacity on Nebraska agriculture?

The new ethanol plants constructed last year could increase ethanol production by nearly 60 percent, and other new plants are proposed. Below we present preliminary results from research conducted to determine the impacts of more ethanol production, *only in Nebraska*, on Nebraska agricultural markets, with other economic variables unchanged.

Effects on the corn market? The Nebraska corn price is highly buffered due to the large share (nearly half) of the crop exported from the state. This means that changes in use *within the state* will have small effects on corn price and on the total quantity produced. A 50 percent ethanol processing expansion in Nebraska alone would retain another 10 percent of the corn crop within the state, increase corn production negligibly, and increase Nebraska corn price by about $.04 per bushel. We note, however, that if ethanol production increased *in the rest of the country* at the same rate, Nebraska corn price would rise further, along with the rise in U.S. prices (probably less than another $.04 per gallon, though Gallagher has estimated impacts of about $.07 per bushel for a similar increase).

Annual average effects of a 50 percent increase in ethanol production in Nebraska.

		Quantity			*Price*		
		Base	*Change*	*%Change*	*Base*	*Change*	*%Change*
Corn (million bu)	production	1,150	11	1.0	$2.00	$0.04	1.9
	to ethanol	288	139	48.4			
	to feedlots	250	-28	-11.3			
	surplus exported	502	-98	-19.5			
Beef (million lbs)	production	4,450	290	6.5	$78.00	-$1.02	-1.3
Feeder calves (thousands)	total fed	5,476	344	6.3	$105.00	$7.91	7.5
source:	from Nebraska	1,516	46	3.0			
	from other states	3,960	298	7.5			
by-product use:	fed by-products	4,060	770	19.0			
	not fed by-products	1,416	-426	-30.1			
Alfalfa (thousand tons)	production	4,600	-517	-11.2	$75.00	-$13.82	-18.4
	fed to cattle	4,140	-686	-16.6			
	other uses and export	460	170	36.9			

Effects on cattle feeding? We estimate that the percentage of cattle being fed some by-products would increase from 75 percent to over 80 percent (with a 25 percent increase in feeding rate), and a 6 percent increase in the total number of cattle fed. We do expect that by-product-based rations will continue to reduce the cost of beef production, leading to average gains for cattle feeders of between $0.01 and $0.02 per pound of beef produced.

Effects on the cow-calf industry? Because of the increase in cattle feeding, feeder calf prices would be bid up by nearly $8/cwt. Nebraska cow-calf producers will be able to supply some of these additional calves, but the majority of the increase will come from other states (nearly two-thirds of feeders now come from out of state.)

Effects on the alfalfa market? Feedlots feeding wet by-products have been able to substitute other roughages for alfalfa (a total reduction of about 10 percent). We have limited knowledge about the potential extent of this substitution. Based on our preliminary assumptions, we think increased by-product production might reduce alfalfa use in feedlots by as much as another 16 percent, with an 18 percent reduction in alfalfa price.

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NEBRASKA'S COMPARATIVE ADVANTAGE IN ETHANOL PRODUCTION

(Richard Perrin, Agricutural Economics; and Curtis Weller and Loren Isom, Biological Systems Engineering)

Is it cheaper to produce ethanol in Nebraska than elsewhere in the Midwest?

Basic ethanol production costs in Nebraska are about the same as in Iowa, but about 5 percent to 6 percent lower than in Illinois and Indiana. These comparisons (see the last column in the table below) are based on differences in input prices, without considering subsidies from local, state or federal governments.

In addition to differences due to input prices, ethanol plants that can avoid the cost of drying by-products can reduce ethanol costs by about $0.17 per bushel processed, or about 5 percent of the total cost of ethanol production. Wet by-products are good cattle feed but are too bulky to ship very far. In Nebraska, we estimate that wet by-products are now fed to about 75 percent of fattening cattle, at low rates that could be increased substantially, leaving a large potential market for wet by-products from new and/or expanding wet by-product plants in the state. We believe that other Corn-Belt states have smaller potential markets for wet by-products.

The table below shows that Iowa corn prices (average over the past five years) are lower than Nebraska prices by about 3 percent, but this cost advantage is offset by higher prices for fuel, labor and management. Relative to Illinois and Indiana, however, Nebraska ethanol producers face lower average prices for all these inputs. (Prices of other ethanol inputs such as capital, chemical and repair costs are unlikely to differ across these states.)

Relative ethanol production costs, Nebraska vs other states.

		Cost componet			Total cost relative to Nebraska
		Fuel	Labor/Mgt	Corn	
		($/mBTU)	($/year)	($/bu)	
Ethanol budget share		13.0%	3.5%	60.0%	
Nebraska prices		$5.80	$24,245	$2.06	
Cost relative to Nebraska production with drying of by-products:					
Nebraska	**w/o drying***	0.080			0.95
Illinois	**price**	$7.28	$26,730	$2.13	
	rel to Neb.	1.25	1.10	1.03	1.05
Indiana	**price**	$6.97	$28,460	$2.16	
	rel to Neb.	1.20	1.17	1.05	1.06
Iowa	**price**	$6.39	$26,740	$1.99	
	rel to Neb.	1.10	1.10	0.97	1.00

*Estimated cost of $0.46 per bushel is reduced by $0.17 per bushel for wet by-products.

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IMPORTANT ETHANOL ISSUES THAT HAVE NOT BEEN ADDRESSED BY IANR RESEARCH

Ethanol policies in Nebraska can be informed in part by these summaries of research at IANR. Below we note some significant issues that have not been addressed by IANR research to date and identify some relevant research done by others on those issues.

What are the impacts of ethanol plants on the local and state economies?

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Petersan, D. 2003. "Estimated Economic Effects for the Husker Ag Ethanol Plant at Plainview, Nebraska." Economic Development Department, Nebraska Public Power District, Columbus, Neb.

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Are the ethanol subsidies at the federal, state and local level good public investments?

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What effects would a nationwide increase in ethanol production have on agricultural markets?

Alston, J. and E. D. Beach. 1996. "Market distortions and the benefits from research into new uses for agricultural commodities: Ethanol from corn." *Resource and Energy Economics* 18:1-29.

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