CORN STOVER TO ETHANOL: MACROECONOMIC IMPACTS RESULTING FROM INDUSTRY ESTABLISHMENT

Marie E. Walsh(a), Burton C. English(b), R. Jamey Menard(b), Craig Brandt(a), Robert Wooley(c), Anthony Turhollow(a), and Daniel de la Torre Ugarte(b)[1]

ABSTRACT

We estimate the break-even total industry output, employment, and value added from establishing the first corn stover-to-ethanol plant in the 10 largest U.S. corn producing states. Additionally, the impacts from the total number of plants that could be established under a 30% increase in breakeven feedstock costs (farmer premium) and an ethanol market price of $0.33/liter ($1.25/gal) are estimated. Estimates include the one-time only construction impacts and annual industrial, agricultural, and transportation sector impacts. Direct, indirect and induced impacts are estimated. Results for the ten states indicate that for the first plant construction impacts include an increase in total industrial output of $45.6 billion, 449,739 jobs, and $21.8 billion in total value added. Operation of the plant adds $1.6 billion in total industrial output, 12,847 jobs, and $647 million value added annually. For the industry, an estimated 142 plants could be constructed producing 32.6 billion liters (8.6 billion gallons) of ethanol annually. The construction impacts of these plants is estimated to be $45.9 billion (total industrial output), 449,739 jobs, and $21.8 billion (total value added). Annual impacts from production are an estimated $21.9 billion (total industrial output), 174,899 jobs, and $9.1 billion (total value added).

Keywords: macroeconomic impacts, corn stover, ethanol, biomass, biofuels

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(a) Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, TN 37831-6205, USA; (b) University of Tennessee, Department of Agricultural Economics and Rural Sociology, P.O. Box 1071, Knoxville, TN 37901-1071, USA; (c) National Renewable Energy Laboratory, 1617 Cole Blvd., Golden Colorado 80401-3393, USA.

As an existing, abundant feedstock with wide geographic distribution, corn stover is a good candidate to become an important feedstock in a cellulose-to-ethanol industry. Establishment of such an industry will have substantial economic impacts in the regions where ethanol facilities are built. We estimate some of the potential macroeconomic impacts that might result from the development of a corn stover-to-ethanol industry. In particular, we estimate the break-even total industry output, employment, and value added resulting from the establishment of the first plant in each state examined, as well as the impacts resulting from the total number of plants that could potentially be established under different profitability scenarios. Estimates include the one-time only impacts resulting from plant construction as well as the annual impacts in the industrial, agricultural, and transportation sectors that result from the operation of the plant. Direct, indirect and induced impacts are estimated for each economic sector. Analysis is conducted for the ten largest corn states in the U.S. (Illinois, Indiana, Iowa, Kansas, Minnesota, Missouri, Nebraska, South Dakota, Ohio, Wisconsin). These states represent more than 80 percent of the typical annual corn production and acres in the U.S. The analysis is conducted in four stages--(1) estimate county corn stover quantities and costs, (2) estimate delivered corn stover costs to plants of a specified annual feedstock requirement, (3) estimate the cost of producing ethanol from corn stover, and (4) estimate the macroeconomic impacts.

ESTIMATE COUNTY LEVEL CORN STOVER QUANTITIES AND COSTS

Quantities and costs of collecting corn stover are estimated for each county in the ten states. Corn acres classified as highly erosive (e.g., an erosion index of 8 or higher) (USDA, 1992) are excluded from consideration. Assumed quantities needed to be left to maintain soil quality are subtracted from the total quantities of stover produced (Lightle, 1997)--a maximum of 45 percent of the residues generated are allowed to be collected. Corn yields and acres in future time periods are estimated based on those contained in the POLYSYS model, an agricultural sector model anchored to the USDA baseline projections of crop yields, acres, production quantities, demand quantities, production costs, and market prices (de la Torre Ugarte, 2000). The baseline projections are allocated across 305 agricultural districts based on recent production patterns. Table 1 summarizes the estimated state level quantities of corn stover that potentially could be collected for use in an ethanol industry.

Table 1. Estimated Corn Stover Quantities That Can Be Collected for Use--Million dry MT (million dry tons)

	Year 2000	Year 2005
Illinois	10.7 (11.7)	12.3 (13.5)
Indiana	5.1 (5.6)	6.0 (6.6)
Iowa	11.8 (13.0)	13.8 (15.2)
Kansas	1.6 (1.7)	1.5 (1.7)
Minnesota	8.3 (9.1)	8.8 (9.7)
Missouri	1.9 (2.1)	2.0 (2.2)
Nebraska	8.8 (9.7)	9.6 (10.5)
Ohio	2.5 (2.7)	3.0 (3.3)
South Dakota	1.6 (1.7)	2.0 (2.2)
Wisconsin	2.9 (3.1)	3.4 (3.8)

Corn stover collection costs are estimated as a function of the quantity removed. We assume the corn grain is harvested with a six-row picker with the spreader turned off to form a windrow. Stover is collected as giant round bales (6' diameter x 5' wide, 1200 lbs dry) using a John Deere 566 baler equipped with a megatooth pickup, a Heartland 669 crop processor, and a meshwrap attachment and pulled by a 120 HP diesel tractor. Bales are moved to the field edge (staging cost) using an Inland 17 bale wagon attached to a JCB 3185 tractor. Estimated costs include depreciation, non-land capital, repairs, fuel/lube, and labor. A constant staging cost of $3.64/dry Mg ($3.31/dt) is used. Figure 1 shows estimated baling costs as a function of the quantity collected per acre.

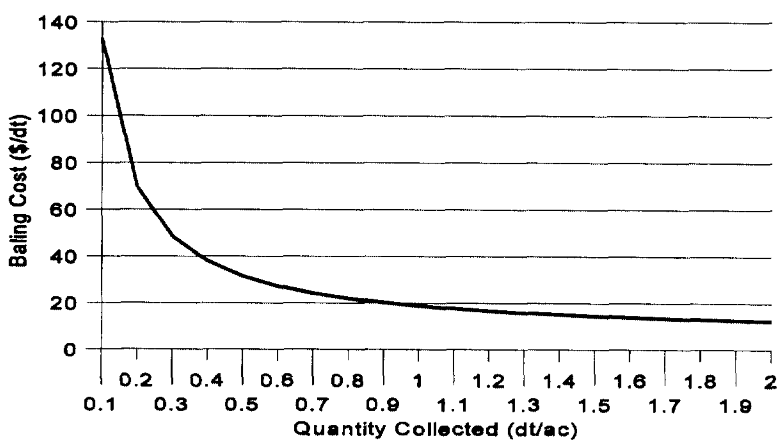

Figure 1. Estimated Baling Costs As a Function of Quantity Collected

ESTIMATE DELIVERED COST OF CORN STOVER

ORIBAS (Oak Ridge Integrated Biomass Assessment System), a GIS-based transportation model is used to estimate the delivered costs of biomass to hypothetical ethanol facilities (Graham, 1996). ORIBAS includes a complete road network for each state. Corn stover quantities are distributed across each county evenly. ORIBAS locates facilities based on delivered feedstock costs with the first plant being that which has the lowest delivered costs for quantities sufficient to meet its feedstock demands. Subsequent facilities have increasing delivered costs as they must either purchase feedstocks from areas that are more expensive and/or transport feedstocks farther to satisfy their feedstock needs. Delivered costs for different sized facilities are estimated. Figure 2 illustrates the estimated collection and transport costs (excluding farmer premium) for the first 15 plants of size 500 MT/day and 2000 MT/day that could be constructed in the state of Iowa.

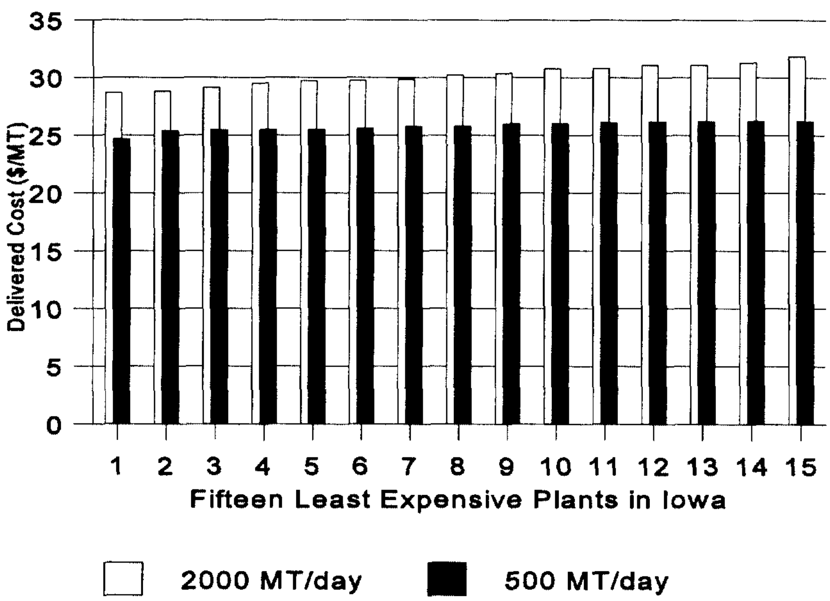

Figure 2. Effect of Facility Size on Feed Cost (100% Feed Availability)

The estimated transport and collection costs are higher if less than 100 percent of the estimated corn stover quantities that can be collected are actually available. Reasons for fewer quantities include weather which not only affects corn stover yields, but may prevent collection. Additionally, not all farmers may choose to participate or may not enroll all of their corn acreage into the program. Figure 3 illustrates collection and transport costs assuming only 50 percent of the estimated feedstocks can be used.

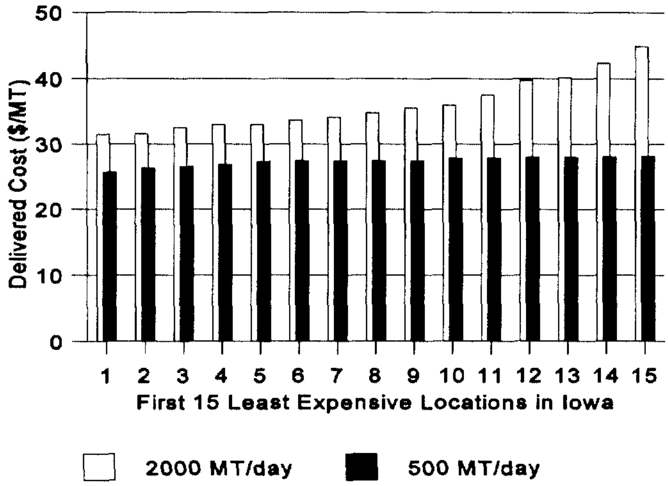

Figure 3. Effect of Facility Size on Feed Cost (50% Feed Available)

ESTIMATE COSTS OF PRODUCING ETHANOL FROM CORN STOVER

The costs of producing ethanol from corn stover for facilities of various sizes in several time frames were provided by the National Renewable Energy Laboratory. Costs include all capital costs as well as expenditures for chemicals and other raw materials, labor, waste treatment, and other inputs needed to produce ethanol. All costs were broken into categories that could be assigned to SIC (standard industrial classification) categories. For a 2000 MT/day (2200 tons/day) plant in the year 2005, estimated total investment costs are $173.3 million (equipment, construction cost, land, contingencies, etc.) and annual operating costs are $12.3 million (raw materials not including feedstocks, waste disposal, fixed costs, capital recovery cost assuming 18.2 percent capital recovery factor, and an electricity credit from use of lignin to produce electricity used by the facility with excess sold to the grid). Costs are in 1997 dollars. Assumed conversion efficiency is 272 liters/dry metric ton (79 gallons/dry ton) and capital and operating costs (not including feedstock cost) are $0.17/liter ($0.645/gallon) of ethanol produced.

ESTIMATE OF BREAKEVEN MACROECONOMIC IMPACTS--FIRST PLANT IN EACH STATE

The breakeven macroeconomic impacts of the first ethanol facility in each state is estimated using IMPLAN, a regional input-output model that estimates the economic flows to and from industries and institutions in a region (Minnesota IMPLAN Group, 1999). Impacts estimated include total industry output (i.e., the value of the production by the industry examined), employment, and total value added (i.e., employee compensation, taxes, dividends, etc.). For each impact category, direct (i.e., changes in the demand for a sector's product), indirect (i.e., inter-industry purchases resulting from changes in demand for a sector's product), and induced (i.e., changes in household spending power resulting from changes in demand for a sector's product) are estimated. Impacts are estimated for four economic sectors--a one-time only impact in the construction sector and annual impacts in the industrial, agricultural, and transportation sectors. Breakeven costs assume no premium is paid to the farmers to ensure participation (only the cost of collection and transport are included in the feedstock costs) and that the value of the ethanol is its production cost. Table 2 shows the combined one-time only construction costs (sum of direct, indirect, and induced impacts) and the combined total economic output, employment, and value added impacts (sum of the direct, indirect, and induced impacts in the industrial, agricultural, and transportation sectors) for each state for a 2000 MT/day (2200 ton/day) plant in the year 2005. Table 3 shows the breakdown of the impacts for the state of Iowa.

Table 2. Estimated Breakeven Macroeconomic Impacts of First Plant by State

	One-time only construction			Annual combined industrial, agricultural, and transportation		
	Total Industry Output (million $)	Employ-ment	Total Value Added (million $)	Total Industry Output (million $)	Employ-ment	Total Value Added (million $)
Illinois	349.6	3066	180.2	168.1	1231	78.2
Indiana	315.7	3084	141.3	155.4	1263	67.3
Iowa	304.4	3128	141.6	139.5	1107	53.9
Kansas	322.0	3335	149.1	169.9	1470	72.9
Minnesota	334.8	3220	159.3	151.9	1205	60.5
Missouri	344.3	3489	160.5	177.7	1683	86.7
Nebraska	313.4	3333	140.0	145.2	1195	56.6
Ohio	300.3	2820	137.2	159.0	1280	67.2
South Dakota	297.2	3224	125.8	132.1	995	41.2
Wisconsin	329.8	3357	156.5	156.9	1418	62.9

Table 3. Estimated Breakeven Macroeconomic Impacts of First Plant in Iowa

	Total Industry Output (million $)	Employment	Total Value Added (million $)
Construction (total)	304.4	3128	141.6
Direct	171.2	1073	64.0
Indirect	45.7	607	25.0
Induced	87.5	1448	52.6
Industrial (total)	102.7	668	34.8
Direct	57.8	105	11.4
Indirect	23.0	202	10.2
Induced	21.9	361	13.2
Agriculture (total)	23.5	271	12.6
Direct	12.6	110	6.3
Indirect	2.9	33	1.6
Induced	7.9	128	4.8
Transportation (total)	13.4	168	6.5
Direct	6.4	64	2.6
Indirect	2.9	36	1.5
Induced	4.1	68	2.5

ESTIMATE MACROECONOMIC IMPACTS OF AN ETHANOL INDUSTRY

We estimate the number of ethanol plants in each state that could potentially be constructed under several farmer premium (for feedstock) and market demand price (for ethanol) scenarios. For each additional plant, increases in both the price paid to the producer (farmer) for their residues and the costs of transporting the residues to the plant increase. As additional plants are added to the analysis, these increases change the level of impacts forecasted for the first plant. For this paper, we present the results of one scenario--a farmer premium of 30 percent above the estimated collection and transport costs and a market price of $1.25/gallon for the ethanol. Results are for a 2000 MT/day (2200 ton/day) plant in the year 2005. Table 4 shows the number of plants, the total ethanol production, and the estimated annual industrial, agricultural, and transportation impacts from the development of these plants for each state. Construction impacts would also occur and would add a one-time total industry output of $45.9 billion, add 449,739 jobs, and produce a total value added of $21.8 billion in the ten states.

Table 4. Combined Annual Industrial, Agricultural, and Transportation Impacts

	Number of Plants	Ethanol Production billion liters (billion gallons)	Total Industry Output (million $)	Employ-ment	Total Value Added (million $)
Illinois	32	7.4 (1.9)	5428.8	39840	2525.1
Indiana	11	2.5 (0.7)	1726.7	14058	747.8
Iowa	37	8.5 (2.3)	5210.7	41514	2015.4
Kansas	2	0.5 (0.1)	344.1	2988	147.9
Minnesota	22	5.1 (1.3)	3377.0	27862	1346.8
Missouri	3	0.7 (0.2)	538.6	5109	262.5
Nebraska	23	5.3 (1.4)	3372.2	27830	1316.7
Ohio	5	1.2 (0.3)	803.8	6490	340
South Dakota	2	0.5 (0.1)	267.4	2028	83.7
Wisconsin	5	1.2 (0.3)	793.2	7180	318.2

The analysis is preliminary and represents within state economic impacts rather than national economic impacts. Economic losses/gains that occur in states outside of the ten states considered in the analysis are not included. However, despite the limitations, the analysis indicates that substantial economic benefits can be achieved with the development of a corn stover to ethanol industry in the Midwest.

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