CONTRIBUTION OF THE ETHANOL INDUSTRY TO THE ECONOMY OF MINNESOTA IN 2016

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Prepared for the Minnesota Bio-Fuels Association

John M. Urbanchuk
Managing Partner

Agriculture and Biofuels Consulting, LLP
218 Pueblo Road
Doylestown, PA 18901
www.abfeconomics.com
215-230-1834

ABF Economics
Agriculture and BioFuels Consulting, LLP

Executive Summary

From the farm to the fuel pump, the ethanol industry is a vital component of Minnesota's economy. Ethanol plants provide jobs and income not only for the people who work at the plants, but also for businesses that sell ethanol plants supplies including Minnesota farmers who produce most of the corn used by Minnesota's biofuels industry. Private and public sector biofuels research and development also contribute to the state's economy and Minnesota participates in the rapidly growing export markets for ethanol and co-products.

The impact of the ethanol industry on the Minnesota economy was estimated by applying economic impact multipliers to expenditures for goods and services purchased from supplying industries. This analysis was based on economic impact multipliers developed from the IMPLAN (Impact Analysis for Planning) economic model and database. IMPLAN was used to construct a model of the Minnesota economy including the sectors that support the ethanol industry, the links between them, and the level of economic activity. IMPLAN models generate a range of economic indicators that describe an economy, but the most commonly used are value added (GDP), labor income (also known as household earnings), and employment.

Minnesota's ethanol production of 1,189 million gallons declined 3.1 percent from 2015 levels as one of the state's plants was shut down for construction. Combined with lower prices for corn and other inputs, total spending to produce ethanol also declined over 2015 levels. The ethanol industry in Minnesota spent $1.8 billion on raw materials (mostly corn), other inputs, goods and services to produce ethanol and primary co-products DDGS and corn refiner's oil. When the impact of these expenditures circulate fully through the Minnesota economy, the ethanol industry:

- Generated $6.7 billion in gross sales for Minnesota businesses
- Accounted for more than $1.9 billion in state Gross Domestic Product (GDP)[1]
- Generated nearly $1.5 billion worth of income for Minnesota households
- Supported nearly 18,000 full time jobs in the state, and
- Contributed $80 million to state and local government tax rolls.[2]

[1] GDP is the value of the goods and services produced in the economy
[2] This study estimated the annualized impact of producing 1,189 million gallons of ethanol on Minnesota's economy. Figures reflect the capacity of ethanol plants operating at year's end.

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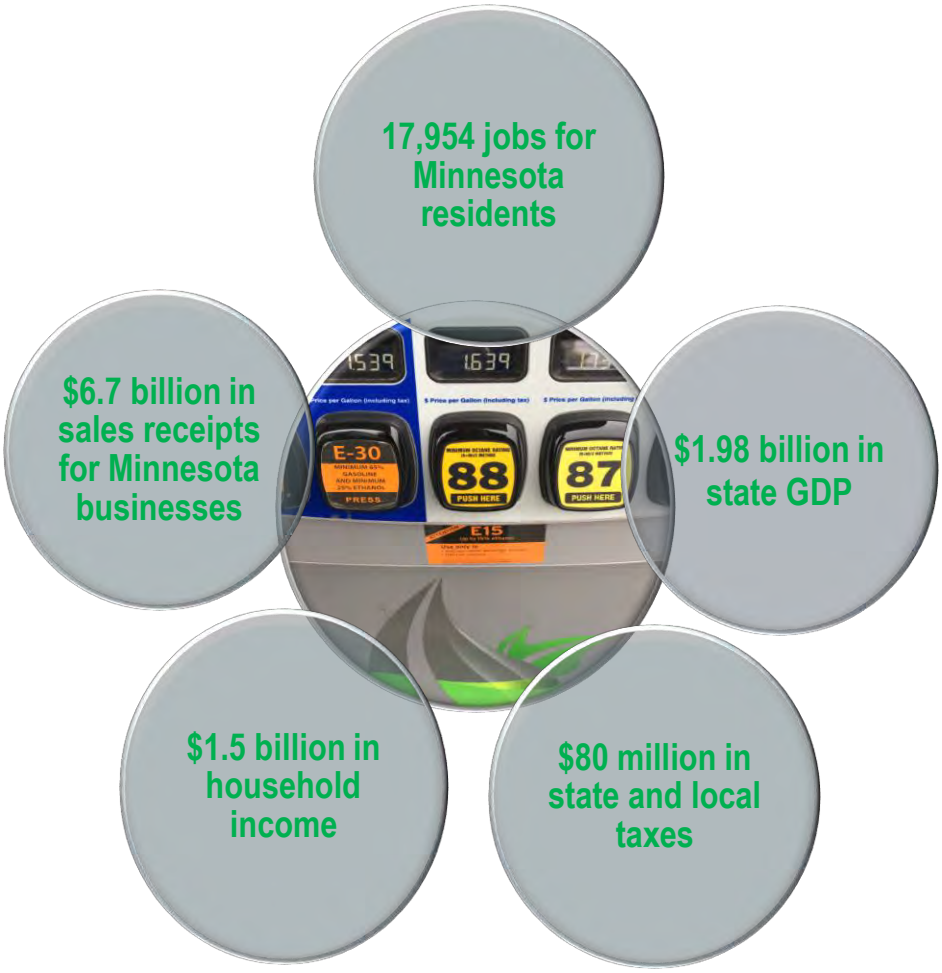
Annual Economic Impact of the Ethanol Industry in Minnesota



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CONTRIBUTION OF THE ETHANOL INDUSTRY TO THE ECONOMY OF MINNESOTA: 2016

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Introduction

Minnesota's ethanol industry continued to provide a significant contribution to the state economy in 2016. However, the year was challenging in several respects. Minnesota's 20 operating ethanol plants produced 1,189 million gallons of ethanol is 2016, 3.1 percent less than in 2015 requiring fewer bushels of corn than in 2015. Moreover the prices of most inputs, most notably corn and natural gas, were lower in 2016. Consequently expenditures to produce ethanol and co-products were reduced and, combined with lower output, generated a smaller impact on the state economy than in previous years.

Ethanol plants purchase agricultural raw materials (mostly corn), other inputs, and a wide range of goods and services such as industrial chemicals; electricity, natural gas, and water; labor; and services such as maintenance, insurance, and general overhead. In addition, funding for biofuels research and development from various sources including the federal government and the private sector benefit the state's economy. The nearly 1.2 billion gallons of ethanol produced in Minnesota last year used 410 million bushels of corn, or about 26.5 percent of Minnesota's 2016 1.54 billion bushel corn crop.

Expenditures on these goods and services represent the purchase of output of other industries and a substantial share of these dollars is spent in Minnesota and the economic impact stays in the state. Spending associated with ethanol production circulates throughout the entire economy several fold. Consequently, this spending stimulates aggregate demand, supports jobs not only in ethanol production but also jobs throughout the entire economy, generates additional household income, and provides tax revenue for state and local government.

At the request of the Minnesota Bio-Fuels Association (MBA), ABF Economics developed models to estimate the economic impacts of ethanol production in Minnesota. The following report summarizes our methods and results. This report: 1) summarizes current trends in the national biofuel industry, 2) outlines the methods used to estimate impacts, and 3) presents results of the models.

1. National Trends in Ethanol Production

The U.S. ethanol industry experienced another record-breaking year in 2016 despite a challenging economic and regulatory environment. Industry output through November 2016 was 3.5 percent above 2015 levels and was poised to set a new record of 15.2 billion gallons for the year. American corn growers also posted a record crop in 2016, which pushed feedstock prices lower throughout the year to the benefit of ethanol producers. Average Minneapolis cash market corn prices during 2016 were 7.1 percent lower than a year earlier. World oil prices also declined for all of 2016 leading to lower gasoline and ethanol prices. Minnesota ethanol prices were up 1.3 percent for the full year.[3]

On the demand side, consumers responded to sharply lower retail gasoline prices by increasing consumption of finished motor gasoline. Reflecting this, domestic ethanol use increased 2.9 percent during 2016 to record levels. Meanwhile, export markets proved to be one of the brightest elements of demand. While still small relative to domestic use, ethanol exports posted a 28 percent increase in 2016 and were expected to top one billion gallons, the largest level of exports in six years.

However, the ethanol industry continued to face both economic, regulatory, and trade challenges in 2016. The economic challenges included falling world crude oil and refined product prices. West Texas Intermediate crude oil prices bottomed out at $30 per barrel in February, the lowest monthly average price in more than a decade. Crude oil prices strengthened during the year but averaged an 11.4 percent decline for the year. Refined product prices followed the same pattern with regular gasoline (Omaha rack) prices falling 16 percent for all of 2016. Despite the decline in refined gasoline prices, the price of ethanol (FOB Minnesota plant) increased a modest 1.3 percent for all of 2016 averaging $1.44 per gallon. The coproduct markets were mixed in 2016. DDGS prices (10 percent moisture, FOB Minnesota plant) fell 18.3 percent while distillers' corn oil prices posted an 8.5 percent gain. The impact of these price changes were unsettling for ethanol profitability. According to Iowa State University, net returns over variable costs for a typical Iowa dry mill ethanol plant declined sharply in the first few

[3] No. 2 Yellow Corn, Minnesota and ethanol FOB Minnesota Source USDA/AMS https://marketnews.usda.gov/mnp/ls-report.

months of 2016 but recovered during the second half of the year so that returns for the year posted a small increase over depressed 2015 levels.[4]

The regulatory and trade environment also provided challenges for the industry. In November 2015, the EPA released the final volume requirements for 2016 under the Renewable Fuel Standard (RFS) program. The volumes required by the final rule for all biofuels remained well below the statutory requirements set forth by the 2007 law establishing the RFS. Specifically, EPA set the "renewable fuel" portion of the RFS (the category in which corn ethanol qualifies) 500 million gallons below the statutory level in 2016; that's roughly equivalent to the annual output of six average-sized ethanol plants. Further, certain regulatory barriers, including EPA's disparate application of volatility regulations to E10 and E15, also constrained domestic demand for ethanol.

As pointed out above, ethanol exports expanded significantly in 2016. However, the trade environment for both U.S. ethanol and co-products, notably DDGS, was hampered by restrictive trade barriers in key markets. China, the top market for DDGS exports in recent years, implemented anti-dumping and countervailing duties against U.S. DDGS. The duties imposed by China sharply reduced U.S. exports to that market, resulting in lower DDGS prices across the board. China's actions are likely to continue to depress the export market for DDGS, as Chinese officials announced earlier this month that the anti-dumping duty would be raised from the preliminary rate of 33.8 percent to a range of 42.2 to 53.7 percent. In addition, the anti-subsidy tariff will range from 11.2 to 12 percent over the next five years.[5] U.S. ethanol exports faced challenges as well, with the European Union continuing to enforce a 9.5 percent anti-dumping duty on ethanol imported from the United States. Before the duty was implemented in 2012, the EU served as a top market for ethanol exports. In June, the EU General Court annulled the duty, but the European Commission appealed the decision in August and the issue remains unresolved.

In addition to ethanol refining and agriculture, there is a significant amount of public and private sector funding for research and development aimed at discovering and developing advanced biofuels feedstock and the technology needed to meet the RFS2 targets for cellulosic and

[4] Iowa State University AgDecision Maker Ethanol Profitability and Biodiesel Profitability available at http://www.extension.iastate.edu/agdm/energy/xls/d1-10ethanolprofitability.xlsx and http://www.agmrc.org/renewable_energy/biodiesel/biodiesel-profitability accessed January 18, 2017

[5] "China to raise anti-dumping tax on US distillers grains" Chinadaily.com 2017-01/11

advanced biofuels. The primary public sector agencies underwriting R&D in biofuels are the U.S. Departments of Energy (USDOE), Agriculture (USDA), and Defense (DOD). In addition to the federal government, many states are funding R&D in feedstock as well as infrastructure. These public funds are being leveraged significantly by private sector firms undertaking research in a wide range of biofuels activities. We have assumed that R&D spending on biofuels continued to expand during 2016 as the need for new feedstocks grows. Reflecting this we assumed that industry R&D expenditures grew at the overall rate of inflation and totaled an estimated 865 million in 2016.[6] Minnesota participates in these R&D activities.

2. Methodology

Economic impact analysis measures the effects of an economic activity or event on a specific geographic area. For example, policy makers or business leaders may want to know how a proposed manufacturing plant would affect a regional economy, or conversely, they may want to know how closing a plant or military base would affect a community. In some cases, federal and state laws require economic impact studies before implementing a policy or project or changing tax policies. Regardless of the reason, impact studies provide useful information for guiding economic development and or to mitigate potential negative impacts. Economic impact analysis is an important decision making tool that can enhance the quality of decisions made, as well as the decision making process in both public and private sectors.

Basically, economic impact models are accounting frameworks for a predefined geographic area that measures how goods and services flow through different economic sectors including industries, households and governments. Spending, or the lack of spending by these sectors, is the primary driver in an impact model. Spending associated with renewable fuels production circulates throughout the entire Minnesota economy several fold. Consequently, this spending stimulates aggregate demand, supports the creation of new jobs, generates additional household income, and provides tax revenue for state and local governments. ABF estimated the impact of the ethanol industry on the Minnesota economy by applying expenditures by the

[6] Estimates of the amount of R&D spending on biomass and biofuels vary substantially. For a discussion of R&D spending on biofuels see "Agricultural Preparedness and the Agriculture Research Enterprise". President's Council of Advisors on Science and Technology. Washington DC, December 2012. A 2013 study prepared by Mary Solecki, Anna Scodel and Bob Epstein at E2 Environmental Entrepreneurs. "Advanced Biofuel Market Report 2013" suggests that R&D spending on biofuels approaches $1.7 billion. A (relatively) new report on federal spending on R&D in energy published by EIA ("Direct Federal Financial Interventions and Subsidies in Energy in Fiscal year 2013", March 2015) estimates Federal R&D expenditures for biomass of $300 million in FY 2013. This study does not include estimates for corporate (private sector) R&D.

relevant supplying industry to the appropriate final demand multipliers for value added output, earnings, and employment.

In this study, ABF used the IMPLAN (Impact Analysis for Planning) economic model to construct a model of the Minnesota economy including the sectors that support the ethanol industry, the links between them, and the level of economic activity. IMPLAN is a commonly used economic input-output (I-O) model. I-O models are constructed based on the concept that all industries within an economy are linked together; the output of one industry becomes the input of another industry until all final goods and services are produced. I-O models can be used both to analyze the structure of the economy and to estimate the total economic impact of projects or policies. For this analysis, ABF used a model of the Minnesota economy based on IMPLAN software and data to estimate economic impacts of the ethanol industry.

To understand how the economy is affected by an industry such as ethanol production, it is necessary to understand how different sectors or industries in the economy are linked. For example, in the renewable fuels production sector, the ethanol industry buys corn from the agriculture sector; which in turn, buys inputs from other suppliers such as fertilizer and pesticide producers that also purchase products from a range of other industries. These are referred to as backward linkages. Use by other sectors of natural gas as an input, such as other manufacturing operations, is a forward linkage. Natural gas production and transmission industries are linked through both forward and backward linkages to other economic sectors of the state's economy.

The household sector is linked to all other sectors as it provides the labor and management resources. In turn, changes that affect household incomes typically have significant impacts compared to a change in the sales of other sectors. This is because households typically spend most of their income on both retail and service goods, both of which are critical components of the economy.

Table 1 shows estimated 2016 expenditures for the Minnesota ethanol industry. Expenditures are a combination of input price and quantity used for ethanol production. The Minnesota prices for corn and natural gas – the two largest cost elements and ethanol, DDGS, and Corn refiner's oil (the major outputs) are shown in Appendix A.

Each type of expenditure is linked to an appropriate IMPLAN sector, and analyzed using IMPLAN software. In addition to the impacts of these expenditures, our analysis includes corporate income of the ethanol plants, and income generated by locally owned and cooperative ethanol firms. All corporate income generated by the ethanol industry that stays in the state is included in GDP impacts. Corporate earnings transferred to firms outside of Minnesota are leakages for the economy and are not included. A review of ownership of ethanol firms based on information provided by MBA suggests that approximately two-thirds of the state's ethanol plants are locally owned or have significant local ownership. The earnings of locally owned firms are treated as an addition to the household sector since the income is paid to Minnesotans so their impact is more accurately estimated using multipliers for the household sector.

Table 1
Minnesota Ethanol Costs and Returns: 2016

Ethanol Industry Expenditures	**Mil $**
Corn	$1,316
Enzymes, Yeast and Chemicals	$86
Denaturant	$56
Electricity	$62
Natural Gas	$144
Water	$15
Direct labor	$40
Maintenance & Repairs	$32
Transportation	$9
Professional Services	$45
Total Operating Costs	**$1,805**
Change from 2015	-12.0%
Revenues	
Ethanol	$1,712
Distiller's Dried Grain	$408
Corn Refiner's Oil	$67
Total Revenues	**$2,188**
Change from 2015	-13.9%
EBITA	**$383**
Change from 2015	-21.7%

Multipliers measure three types of impacts: direct, indirect, and induced impacts:

- Direct effects are the known or predicted changes in the economy.
- Indirect effects are the business-to-business transactions required to produce direct effects (i.e., increased output from businesses providing intermediate inputs).
- Induced effects are derived from spending on goods and services by people working to satisfy direct and indirect effects (i.e., increased household spending resulting from higher personal income).

Multipliers are calculated from I-O models that are constructed from data for a specified geographic area. The economy in question is divided into a number of producing industries or sectors that sell and purchase goods and services to and from each other, and these inter-industry purchases and sales are key data in I-O models. Sector goods and services are purchased by domestic households, international customers in the form of exports, government (federal, state, and local), and for private sector investment. Purchases that are not part of an economy's supply chain are final demand. For example, wheat farmers sell wheat to mills that produce flour and sell it to food manufacturers and bakers that make bread. Those food manufacturers then sell the bread to wholesale and retail outlets, and ultimately consumers purchase the bread to eat. Consumer purchases are final demand. For an economy with n sectors, if X_i represents total output for sector i, Y_i represents final demand for sector i products, and z_{ij} represent inter-industry flows, then:

$$X_i = \sum_{j=1}^{n} z_{ij} + Y_i \qquad (1)$$

If a_{ij} represents the I-O technical coefficients where $a_{ij} = z_{ij} / X_j$ so that sectors use inputs in fixed proportions (i.e., constant returns to scale Leontief production function) then the above equation becomes:

$$X_i = \sum_{i=1}^{n} a_{ij} X_i + Y_i \qquad (2)$$

The standard formulation of the basic I-O model and its application, in matrix notation is:

Transactions balance:	$X = AX + Y$	(3)
Solving for X:	$X = (I - A)^{-1}Y$	(4)
For a change in Y:	$\Delta X = (I - A)^{-1}\Delta Y$	(5)

Where X is the gross output column vector, A is the matrix of fixed I-O coefficients, Y is the final demand column vector, and I is the identity matrix. This model measures changes in output given changes in final demand (i.e., consumption, investment, government, or exports). The Leontief inverse, $(I - A)^{-1}$, provides the I-O multipliers used to determine impacts. Elements of the matrix are very useful and important as each number in the matrix represents a series of direct and indirect effects. Gross output requirements are translatable into employment coefficients in a diagonal matrix that one can use with the Leontief inverse to estimate employment impacts. Similar calculations produce value-added (GDP) and income multipliers.

When using IMPLAN an important consideration is the definition of the geographic area used in a study. Economies extend far beyond political boundaries, and workers and their incomes and transactions among industries flow across political boundaries. Thus, some indirect effects are likely to occur beyond the geographic region under study. These are called leakages, as opposed to linkages (supplier-purchaser relationships) within a region, and smaller geographic regions such counties will have more leakages. In contrast, a larger area such as a state or nation will have relatively fewer leakages.

IMPLAN models generate a range of economic indicators that describe an economy, but the most commonly used are output (gross business revenues), value added (GDP), employment, and labor income (also known as household earnings):

- **Gross Output** is the value of production for all industries in an economy measured by gross sales revenues (i.e., sales).[7]
- **Value added** is the total value of goods and services produced by businesses in an economy. Generally referred to as **gross domestic product** (GDP), it is the sum of labor income, taxes paid by industries and households, and other property type income such as corporate profits. Value added including labor income and employment represent the net economic benefit that accrues to an economy as a result of increased economic output.

[7] Although output is a valid metric and important from the perspective of individual businesses, it does not measure the net value of production in an economy. For example, if a farmer sells corn to a mill for $1.00, and the mill processes the corn into feed and sells it for $3.00, the total output value would be $4.00. The net economic value (or value added) only counts the incremental increase in value, and includes the original $1.00 sales and the additional $2.00 in value added after the mill processed the corn into feed for a total value added of $3.00.

- **Labor income or Household Earnings** is the sum of employee compensation (including all payroll and benefits) and proprietor income (income for self-employed work). In the case of this analysis, demand for corn and other feedstock to produce ethanol supports household earnings through higher receipts than would be the case without ethanol production.
- **Employment** represents the annual average number of employees (full time equivalents), of businesses producing output.[8]

Changes to the Analysis

The major change to this year's analysis is the incorporation of the explicit impact of ethanol and DDGS exports. The methodology for estimating the impact of trade differs from that used for industry output.[9] We have estimated the impact of ethanol and DDGS exports by applying USDA Agricultural Trade multipliers for output and employment to the estimated value of exports for 2016. Since ethanol and DDGS are outputs of the chemical industry we used the USDA trade multipliers for the other organic chemicals industry. The USDA multipliers have three major components (or margins): production, transportation and warehousing, and wholesale/retail trade. Since IMPLAN already incorporates the impact of ethanol and DDGS production, to avoid double counting impacts we only applied the margins for transportation and trade to the value of exports. This represents the post-production (or ex-plant) impacts from exports. These results were added to the IMPLAN results. Since Iowa is the nation's largest ethanol producer the Iowa industry participates in the export market. Reflecting this we applied Minnesota's share of total production to the total national export impact.

3. Contribution of the Ethanol Industry to Minnesota

Ethanol manufacturing contributes significantly to the Minnesota economy, spending roughly $1.8 billion on raw materials, other inputs, goods and services to produce nearly 1.2 billion gallons of ethanol. Corn, which the industry uses as a renewable raw material to make ethanol, distillers dried grains with solubles (DDGS), and corn refiner's oil, accounts for nearly 73 percent industry purchases (natural gas was the second largest input at 7.3 percent of total production costs). In 2016 the Minnesota ethanol industry used about 410 million bushels of corn to produce ethanol, DDGS, and corn refiner's oil.[10]

[8] Employment numbers in this report are expressed in terms of full-time equivalent jobs.
[9] https://www.ers.usda.gov/data-products/agricultural-trade-multipliers.aspx
[10] The authors of this report recognize that the corn used in ethanol manufacturing might be grown regardless of the ethanol industry, albeit farmers would likely realize lower prices for their corn without the ethanol industry. Regardless,

In addition to providing a growing and reliable domestic market for Minnesota, the ethanol industry also provides the opportunity for farmers to enjoy some of the value added to their commodity by further processing. Locally owned ethanol plants, including cooperative farmer owned plants account for about 60 percent of Minnesota fuel ethanol plants and production capacity.

The remainder of the spending by the ethanol industry is for a wide range of inputs such as industrial chemicals; electricity, natural gas, and water; labor; transportation; and services such as maintenance, insurance, and general overhead. In addition the Minnesota ethanol industry purchased goods and services for expansion of production capacity and blender pumps to support distribution of higher blends of ethanol. Spending for these goods and services represents the purchase of output of other industries, many of which operate in Minnesota.

Table 2 summarizes results of our analysis. Ethanol manufacturing and supporting research and development (excluding expenditures on grain feedstock which is allocated to the agriculture sector) contributed $1.2 billion to Minnesota GDP based on economic conditions in 2016. Direct employment, including jobs at ethanol plants, amounts to 2,264 jobs in the state with household incomes totaling $378 million.[11] Note that the total income generated includes income (i.e., profits) to owners of locally owned plants, which is substantial. The Indirect contribution of ethanol manufacturing to GDP totaled $407 million, and consisted of GDP created by non-agricultural input suppliers such as natural gas companies, and induced GDP amounts to $376 million. Induced GDP comes from businesses that benefit from income spent by ethanol plant workers and owners, and income spent by employees who work in supporting industries. Indirect GDP totaled $376 million, and induced household earnings total $265 million.

Since ethanol production relies primarily on corn grown by Minnesota farmers, ethanol plants have a very large impact on agriculture, supporting 2,589 direct farm and farm-related jobs.[12] Most of the agriculture jobs supported by the ethanol industry are farm workers and laborers

corn production is currently a major part of the industry's supply chain, and thus should be included in an economic impact analysis, which by definition is distinct from a cost benefit analysis.

[11] The Census Bureau does not report employment in ethanol production. The number of direct jobs associated with ethanol production is based on an estimated industry average of 50 jobs per plant.

[12] Based on a review of the location of Minnesota's ethanol plants and the guideline that most ethanol pants procure their feedstock from within a 50-75 mile radius of the plant, we estimated that about three-quarters of the corn used to produce ethanol in Minnesota was grown by Minnesota farmers.

associated with corn production and harvest. However, a wide range of jobs in support activities related to crop production ranging from farm managers and bookkeepers to farm equipment operators are supported by ethanol production. As the impact of the direct spending by the ethanol plants expands throughout the economy, the employment impact grows significantly over a large number of sectors. Indirect and induced jobs supported by the agriculture output used by Minnesota ethanol producers amount to an additional 3,967 indirect jobs in the corn production supply chain, and 1,768 jobs in business supported by the household income generated by the ethanol industry.

Ethanol construction activity in Minnesota during was limited to expansion of existing plants. Information provided by the Minnesota Bio-Fuels Association indicates that the Minnesota industry spent more than $80 million on capital expansion during the year. In addition the ethanol industry supported the establishment of new flex-fuel pumps needed to support the demand for higher ethanol blends. During 2016 35 new E15 stations and 10 new E85 stations were opened and six new E15 stations opened in January 2017. The cost of this expansion took place in 2016. The expenditure for this investment is estimated at more than $10 million. Construction expenditures contributed $142 million to Minnesota GDP in 2016, supported 1,091 jobs in all sectors of the economy and generated $101 million in household income.

The contribution of exports of ethanol and DDG by the Minnesota industry is estimated to generate an additional $26 million of GDP and support 350 jobs in all sectors of the state economy

In total, ethanol plants, the corn used by them, and biofuels research contributed nearly $2 billion to GDP for Minnesota, supports 17,952 full time jobs in the state and puts nearly $1.5 billion worth of earnings in the pockets of Minnesota households. The total jobs and earnings estimates include all industries in Minnesota that support ethanol manufacturing; not only businesses that make up the supply chain such as corn farmers (i.e., indirect impacts), but also firms that benefit from the employee spending by workers that staff ethanol plants and supporting industries (i.e., induced impacts). For example, in terms of induced jobs the largest sectors in Minnesota impacted by ethanol production are retail trade and health care. When measured by household earnings, the sectors most affected include natural gas distributors (indirect), and the health care and banking and finance industries (induced).

Appendix B shows the major industries affected for both agriculture and ethanol manufacturing by GDP, household earnings and employment. Although, not shown in Table 2, we estimate (using IMPLAN) that state and local taxes generated by the ethanol industry totaled nearly $80 million in 2016.

Table 2
Contribution of the Ethanol Industry to the Economy of Minnesota 2016

	Sales Revenue (Mil $)	Gross Domestic Product (Mil $)	Employment (Full Time) Jobs	Household Earnings (Mil $)
Ethanol Mfg and R&D				
Direct	$2,464	$420	2,264	$378
Indirect	$974	$407	2,375	$330
Induced	$977	$376	3,552	$265
Total	**$4,415**	**$1,204**	**8,191**	**$973**
Agriculture				
Direct	$1,086	$82	2,586	$69
Indirect	$731	$380	3,967	$228
Induced	$265	$150	1,768	$90
Total	**$2,082**	**$612**	**8,321**	**$387**
Construction				
Direct	$95	$39	512	$36
Indirect	$40	$49	250	$33
Induced	$44	$54	329	$32
Total	**$178**	**$142**	**1,091**	**$101**
Exports (Indirect)		**$26**	**350**	**$14**
Total				
Direct	$3,645	$541	5,362	$483
Indirect	$1,745	$863	6,942	$605
Induced	$1,286	$580	5,651	$387
Grand Total	**$6,675**	**$1,984**	**17,954**	**$1,475**
Change from 2015	-9.5%	-6.9%	-0.9%	-7.9%

4. Co-Product Production and Fuel Co-Existing with Food

The ethanol industry produces valuable co-products in addition to biofuel. In order to produce 1.2 billion gallons of ethanol the Minnesota ethanol industry used approximately 410 million bushels of corn. The ethanol production process converts the starch in the grain to sugar which is then fermented and distilled into alcohol, most of which is used for fuel. It is important to

recognize that this process converts only the starch in the grain and leaves the remaining fiber, nutrients, and oil to be recovered as co-products used primarily as a feed ingredient for livestock and poultry. The refiners' oil recovered by corn dry mills has become an important feedstock for biodiesel production. Consequently the full food value of the corn used to produce ethanol is retained. This set of factors is of particular relevance as it demonstrates the production of biofuel can, and does, co-exist with food. By producing valuable feed ingredient co-products, the ethanol industry effectively reduces the amount of grain required by the livestock and poultry industry. A USDA study on the substitution of corn and soybean meal by ethanol co-products reported that one ton of DDGS could effectively replace more than 1.2 tons of feed consisting of corn and soybean meal.[13]

In the process of converting approximately 410 million bushels of corn into ethanol, the Minnesota ethanol industry produced an estimated 3.5 million tons of Dried Distiller's Grains (DDGS) and 244 million pounds of corn refiner's oil in 2016. This amount of distillers' grains is sufficient to meet the annual feed requirements of more than 2.5 million beef and dairy cattle, or the entire inventory of cattle and calves in Minnesota.[14] Moreover since DDGS is used as a feed supplement it displaces both corn and soybean meal.[15] Thus, given the availability of DDGS from ethanol production, the livestock and poultry industry requires less grain corn and soybean meal to feed the same number of animals and produce the same amount of meat and dairy products.

The corn refiner's oil produced as an ethanol co-product is used as a feedstock for biodiesel production, as an animal feed ingredient and as an intermediary for industrial products. If all of the corn refiner's oil produced by Minnesota ethanol plants was used as a biodiesel feedstock, it could produce more than 33.5 million gallons of biodiesel, or more than 26 percent of the biodiesel capacity of Minnesota's biodiesel plants.[16]

[13] Linwood A. Hoffman and Allen Baker. "Estimating the Substitution of Distillers' Grains for Corn and Soybean Meal in the U.S. Feed Complex". USDA/ERS FDS-11-1-01. Updated January 7, 2012
[14] Personal conversations with Dr. Caitlin Foley, Assistant Professor of Dairy Science at the University of Georgia suggest an average daily DDGS consumption of 5 to 10 lbs. per cow per day is a reasonable assumption. This is consistent with inclusion rates cited in the literature. USDA/NASS reported that Minnesota had 2.4 million cattle and calves in inventory on January 1, 2017.
[15] Corn refiners' oil also is used as a feed supplement and ingredient in compound feeds.
[16] http://www.eia.gov/biofuels/biodiesel/production/

CONCLUSION

The ethanol industry makes a significant contribution to the economy of Minnesota in terms of job and income creation and generation of tax revenue while producing a renewable fuel to displace refined petroleum products. The importance of the ethanol industry to Minnesota agriculture and rural economies is particularly notable. Continued growth and expansion of the ethanol industry through innovation and the use of new technologies and renewable feedstock will enhance the industry's position as the original creator of green jobs, and will enable Minnesota, and America, to make further strides toward energy independence.

Appendix A

Minnesota Prices

	Corn, Farm Price, MN 2015 ($/bu) /1	Corn, Farm Price, MN 2016 ($/bu) /1	Percent Change	Corn, No 2 Yel Minneapolis 2015 ($/bu) /2	Corn, No 2 Yel Minneapolis 2016 ($/bu) /2	Percent Change
Jan	$3.71	$3.47	-6.5%	$3.57	$3.18	-10.9%
Feb	$3.63	$3.31	-8.8%	$3.58	$3.08	-14.0%
Mar	$3.66	$3.25	-11.2%	$3.58	$3.26	-8.9%
Apr	$3.60	$3.37	-6.4%	$3.58	$3.47	-3.1%
May	$3.56	$3.49	-2.0%	$3.42	$3.61	5.6%
Jun	$3.46	$3.65	5.5%	$3.37	$3.77	11.9%
Jul	$3.65	$3.47	-4.9%	$3.71	$3.17	-14.6%
Aug	$3.46	$3.04	-12.1%	$3.37	$2.89	-14.2%
Sep	$3.42	$2.96	-13.5%	$3.29	$2.85	-13.4%
Oct	$3.49	$3.15	-9.7%	$3.33	$2.93	-12.0%
Nov	$3.42	$3.10	-9.4%	$3.34	$2.98	-10.8%
Dec	$3.43	$3.21	-6.4%	$3.27	$3.30	0.9%
Average	$3.54	$3.29	-7.1%	$3.45	$3.21	-7.1%

	Ethanol Minnesota 2015 ($/gal) /3	Ethanol Minnesota 2016 ($/gal) /3	Percent Change	Distillers Grains 10%,Minnesota 2015 ($/ton) /3	Distillers Grains 10%,Minnesota 2016 ($/ton) /3	Percent Change
Jan	$1.31	$1.29	-1.5%	$165.00	$117.40	-28.9%
Feb	$1.31	$1.30	-0.8%	$165.70	$118.95	-28.2%
Mar	$1.39	$1.29	-7.6%	$165.71	$119.45	-27.9%
Apr	$1.49	$1.42	-4.4%	$176.73	$112.08	-36.6%
May	$1.56	$1.48	-5.1%	$167.91	$128.46	-23.5%
Jun	$1.44	$1.53	6.3%	$146.38	$156.66	7.0%
Jul	$1.50	$1.44	-4.0%	$132.88	$137.15	3.2%
Aug	$1.41	$1.35	-4.6%	$141.75	$113.85	-19.7%
Sep	$1.43	$1.52	6.3%	$129.58	$110.72	-14.6%
Oct	$1.47	$1.51	2.7%	$108.97	$97.53	-10.5%
Nov	$1.43	$1.54	8.1%	$111.03	$97.88	-11.8%
Dec	$1.38	$1.67	21.1%	$112.59	$97.86	-13.1%
Average	$1.42	$1.44	1.3%	$143.68	$117.33	-18.3%

	Refiners Corn Oil 2015 (cents/lb) /4	Refiners Corn Oil 2016 (cents/lb) /4	Percent Change	MN Nat Gas Industrial 2015 ($/mcf) /5	MN Nat Gas Industrial 2016 ($/mcf) /5	Percent Change
Jan	26.97	24.31	-9.9%	$5.89	$4.37	-25.8%
Feb	27.13	26.00	-4.1%	$5.83	$4.22	-27.6%
Mar	28.45	28.30	-0.5%	$5.82	$3.65	-37.3%
Apr	25.50	30.38	19.1%	$4.55	$3.35	-26.4%
May	27.38	30.42	11.1%	$4.19	$4.25	1.4%
Jun	28.13	28.00	-0.4%	$4.62	$3.71	-19.7%
Jul	25.20	25.83	2.5%	$4.53	$4.11	-9.3%
Aug	23.50	26.80	14.0%	$4.68	$4.09	-12.6%
Sep	22.75	27.88	22.5%	$4.17	$4.09	-1.9%
Oct	23.57	28.38	20.4%	$4.24	$4.20	-0.9%
Nov	22.94	27.00	17.7%	$4.13	$4.27	3.4%
Dec	22.90	27.00	17.9%	$4.24		-100.0%
Average	25.37	27.52	8.5%	$4.74	$4.03	-15.0%

Updated 2/17/2017

Sources

1. USDA/NASS Agricultural Prices
2. USDA/ERS Feedgrains Database
3. USDA/AMS Market News
4. USDA/AMS Livestock, Poultry & Grain Market News. USDA Daily Ethanol Report
5. EIA Natural Gas Prices. http://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SMN_m.htm

Table B-1
Top 10 Industries Impacted by Ethanol Manufacturing
2016 Employment

Sector	Employment
Heathcare	1,600
Natural gas distribution	427
Full-service restaurants	302
Limited-service restaurants	275
Accounting services	253
Real estate	242
Banking and Finance	213
Wholesale trade	189
Retail - General Mdse	179
Legal services	178
Total Top 10	3,857
Source: ABF Economics using IMPLAN Pro™ data and software	

Table B-2
Top 10 Industries Impacted by Ethanol Manufacturing
2016 Household Income

Sector	Mil $
Heathcare	$142.4
Natural gas distribution	$118.5
Banking and Finance	$61.1
Wholesale trade	$45.4
Maintenance and repair	$38.8
Accounting services	$36.5
Legal services	$36.5
Insurance carriers	$27.2
Truck transportation	$16.0
Water, sewage	$14.2
Total Top 10	$536.2
Source: ABF Economics using IMPLAN Pro™ data and software	

Table B-3
Top 10 Industries Impacted by Ethanol Manufacturing
2016 GDP

Sector	Mil $
Natural gas distribution	$132.8
Heathcare	$131.3
Real estate	$78.9
Wholesale trade	$60.1
Banking and Finance	$50.6
Insurance carriers	$34.1
Legal services	$28.9
Petroleum refineries	$21.8
Accounting services	$20.5
Maintenance and repair	$18.7
Total Top 10	$577.6
Source: ABF Economics using IMPLAN Pro™ data and software	

Table B-4
Top 10 Industries Impacted by Ethanol Related Agriculture
2016 Employment

Sector	Jobs
Grain farming	2,851
Agriculture Services	760
Real estate	537
Wholesale trade	489
Insurance carriers	451
Banking and Finance	430
Healthcare	380
Maintenance and repair	337
All other crop farming	319
Employment services	318
Total Top 10	6,873
Source: ABF Economics using IMPLAN Pro™ data and software	

Table B-5
Top 10 Industries Impacted by Ethanol Related Agriculture
2016 Household Income

Sector	Mil $
Agriculture Services	$71.6
Grain farming	$59.9
Real Estate	$30.9
Wholesale trade	$22.9
Banking and Finance	$19.6
Insurance carriers	$18.4
Healthcare	$18.4
Maintenance and repair	$13.8
All other crop farming	$7.9
Truck transportation	$7.2
Total Top 10	$271.0

Source: ABF Economics using IMPLAN Pro™ data and software

Table B-6
Top 10 Industries Impacted by Ethanol Related Agriculture
2016 GDP

Sector	Jobs
Real estate	$98.9
Agricultural Services	$97.8
Grain farming	$58.7
Wholesale trade	$44.7
Agriculture Services	$47.3
Healthcare	$37.7
Insurance carriers	$25.4
Banking and Finance	$21.5
Petroleum refineries	$16.2
Maintenance and repair	$15.2
All other crop farming	$13.9
Total Top 10	$430.1

Source: ABF Economics using IMPLAN Pro™ data and software