

**CONTRIBUTION OF THE ETHANOL INDUSTRY TO
THE ECONOMY OF THE UNITED STATES IN 2014**

Prepared for the Renewable Fuels Association by

John M. Urbanchuk

Managing Partner

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The U.S. ethanol industry experienced a record-breaking year in 2014. Industry output increased an estimated 7.4 percent to set a new record of 14.3 billion gallons. The year started off with strong year-over-year gains in ethanol production as producers responded to sharply lower feedstock prices. A record 2014 corn crop continued to push feedstock prices lower throughout the year. Ethanol and co-product prices remained favorable through the third quarter and were reflected in positive industry profitability. The collapse in global oil prices accompanied by record levels of ethanol production in the fourth quarter helped drive ethanol prices lower and strained profitability. Average cash market corn prices for 2014 were about a third lower than during 2013 while ethanol prices were only 10 percent lower for the full year. According to Iowa State University, net returns over variable costs for a typical Iowa dry mill ethanol plant increased 54 percent for all of 2014.¹

On the demand side, consumption of finished motor gasoline increased 0.6 percent for the first 11 months of 2014 while domestic ethanol consumption increased 2.0 percent suggesting that further gains are being made in higher blends of ethanol. While still small relative to domestic use, ethanol exports posted a 38.6 percent increase for the first 11 months of 2014.

One of the most significant developments in 2014 was the completion of the first three of the nation's commercial scale second-generation ethanol plants (the POET/DSM Project Liberty facility in Emmetsburg, IA; Quad County Corn Processors plant in Galva, IA; and Abengoa's Hugoton, KS facility). These facilities were christened in the fall of 2014 and began commercial production. A fourth plant,

¹ 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 14, 2015

DuPont's cellulosic ethanol facility in Nevada, IA, is nearing completion and is expected to produce in early 2015.

The ethanol industry benefitted from a diversification of feedstocks and co-products. In particular an increasing share of dry mill ethanol plants are recovering industrial corn distillers oil (CDO) and yields have increased reflecting improvements in technology. This co-product is proving to be an additional revenue stream for ethanol producers and an increasingly important feedstock for the biodiesel industry.

Ethanol consumption reached 10 percent of the motor gasoline supply and the industry hit the so-called "E10 blend wall." The fact that domestic use of ethanol grew at three times the rate of growth in gasoline consumption suggests that gains are being made in the consumption of higher blends of ethanol.

Reflecting this, the number of refueling stations offering E85 and E15 continued to expand during 2014, with stations offering E85 increasing by an estimated 8.3 percent from 2013 levels.²

However, 2014 was not without challenges. Opposition to the Renewable Fuels Standard (RFS) from oil, livestock and poultry, and food industries continued throughout the year and regulatory pressures continued to challenge the renewable fuels industry. The regulatory environment added to industry uncertainty in 2014. EPA did not issue a final Renewable Volume Obligation (RVO) under the RFS for 2014 and decided to postpone release of the proposed 2015 RVO until the spring of 2015. Finally, failure of the U.S. Congress to authorize extensions of tax credits for cellulosic and advanced biofuels until late December 2014 increased the level of uncertainty for investors. The tax credits were made retroactive until January 1, 2014, but expired again on December 31.

According to the Renewable Fuels Association (RFA), at year's end the ethanol industry comprised approximately 213 plants in 29 states with nameplate capacity of 15.1 billion gallons and operating at an annualized rate of 14.3 billion gallons.³ At year's end 100 million gallons of new capacity were under construction.

² http://www.afdc.energy.gov/fuels/stations_counts.html

³ The 14.3 billion gallons represents RFA's estimate of annualized production at the end of 2014.

This study estimates the contribution of the ethanol industry to the American economy in 2014 in terms of the employment, income, and Gross Domestic Product (GDP) directly and indirectly supported by the industry.

Expenditures by the Ethanol Industry in 2014

Ethanol producers are part of a manufacturing sector that adds substantial value to agricultural commodities produced in the United States and make a significant contribution to the American economy.

Expenditures by the ethanol industry for raw materials, other goods, and services represent the purchase of output of other industries. The spending for these purchases circulates through the local and national economy, generating additional value-added output, household income, and employment in all sectors of the economy.⁴ Ethanol industry expenditures can be broken into three major categories: construction of new production facilities, ongoing production operations, and research and development.

1. Construction

2014 was highlighted by construction of new cellulosic ethanol capacity. As reported by the RFA, 100 million gallons of new capacity was under construction at the end of 2014, of which an estimated 40 million gallons were for cellulosic and advanced biofuels. Reflecting this we included construction expenditures of \$600 million for 2014.⁵

2. Ongoing production operations

The industry spent nearly \$30 billion on raw materials, other inputs, and goods and services to produce 14.3 billion gallons of ethanol during 2014. Production costs were based on a model of dry mill ethanol production maintained by the author of this report. These estimates are consistent

⁴ Expenditures for feedstock and energy were estimated using 2014 calendar year average prices. Revenues were estimated using 2014 calendar year average prices for ethanol, Omaha Rack; Distiller's grains, corn gluten feed and meal, and corn oil. Prices were sourced from USDA/ERS and AMS, and EIA.

⁵ We assumed capital expenditures of \$2 per gallon for conventional corn ethanol capacity and \$12 per gallon for cellulosic capacity.

with generic dry mill ethanol costs, such as those published by Iowa State University.⁶ Table 1 details the expenditures by the ethanol industry in 2014.

Table 1
Estimated Ethanol Production Expenditures 2014

	Mil \$	\$/gal
Feedstock (corn)	\$20,429	\$1.43
Enzymes, yeast and chemicals	\$981	\$0.07
Denaturant	\$1,201	\$0.08
Natural Gas	\$2,445	\$0.17
Electricity	\$714	\$0.05
Water	\$236	\$0.02
Direct labor	\$866	\$0.06
Maintenance & Repairs	\$378	\$0.03
Transportation	\$109	\$0.01
GS&A	\$451	\$0.03
Total Operating Costs	\$27,811	\$1.95

The largest share of spending was for corn and other feedstocks used as raw material to make ethanol. The ethanol industry used 5.1 billion bushels of corn on a gross basis in 2014, valued at more than \$20.4 billion. Consequently, the ethanol industry is a major source of support for agricultural output and farm income. One of the most significant developments for the ethanol industry in 2014 was the record 14.2 billion bushel corn harvest which helped push calendar year average corn prices nearly 35 percent below 2013 average levels. Reflecting this, while the quantity of corn used for ethanol production increased, expenditures on corn -- the largest component of operating costs -- fell 31 percent for all of 2014.

This analysis estimates both the total production effect and the crop price (farm income) effects of ethanol production on agriculture based on a structural model of U.S. agriculture maintained by the author. The impact of demand for corn to produce ethanol on farm income was adjusted so as to not overstate the impact of ethanol demand on revenue for the corn sector. This was

⁶ See the Ethanol profitability spreadsheet maintained by Don Hofstrand "AgDecision Maker D1-10 Ethanol Profitability" available at <http://www.extension.iastate.edu/agdm/energy/xls/d1-10ethanolprofitability.xlsx>

accomplished by applying estimates of the effect of ethanol on corn prices taken from the literature to the share of corn demand accounted for by ethanol and actual change in corn prices.

The remainder of spending by the ethanol industry for ongoing operations is for a range of inputs such as enzymes, yeast and chemicals; electricity, natural gas, and water; labor; transportation; and services such as maintenance, insurance, and general overhead.

3. Research and Development

The renewable fuels industry is a significant engine for research and development (R&D) both in the public and private sectors. Much of the R&D activity in the biofuels industry is aimed at discovering and developing advanced biofuels feedstock and the technology needed to meet RFS2 targets for cellulose and 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 by private sector firms undertaking research in a wide range of biofuels activities. Based on a review of publically available data, we estimate that R&D expenditures for biofuels in the U.S. amounted to \$1.8 billion in 2014.⁷

4. Co-product value

Most ethanol is produced by dry mills that also produce valuable co-products in the form of distillers dried grains (DDGS) and (industrial) corn distillers' oil.⁸ The ethanol industry produced an estimated 43.4 million short tons of DDG and 3 billion pounds of industrial corn in 2014 with an aggregate market value of \$8.8 billion. It is notable that these co-products are produced with little additional expenditure.

Spending associated with current ethanol production, new construction, and R&D circulates and re-circulates throughout the entire economy several-fold, stimulating aggregate demand, and supporting

⁷ 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, and Mary Solecki, Anna Scodel and Bob Epstein. "Advanced Biofuel Market Report 2013". E2 Environmental Entrepreneurs.

⁸ Industry estimates suggest that 85 percent of dry mill corn ethanol plants recover corn oil that is used as a biodiesel feedstock and as a feed ingredient by the livestock industry.

jobs and household income. In addition, expanded economic activity generates tax revenue for government at all levels.

Methodology

We estimate the impact of the ethanol industry on the American economy by applying expenditures by the relevant supplying industry to the appropriate final demand multipliers for value added output, earnings, and employment.

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 manufacturing operations, is a forward linkage. Natural gas production and transmission industries are linked through both forward and backward linkages to other economic sectors in each state's economy.

The household sector is linked to all sectors as it provides the labor and management resources. In turn, changes that affect incomes of the household sector 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 and this is a critical component of the national economy

This study uses an economic model known as IMPLAN (Impact Analysis for Planning) to develop a model of the national economy, including sectors that support the ethanol industry, the links between them, and the level of national 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 in an economy are linked together; and the output (i.e., sales) 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, a model for the U.S. economy was constructed using current IMPLAN software and the most recent data available. The 2013 IMPLAN update contains several major revisions and improvements which have been reflected in the differences in GDP and income. These updates include:

- Increased industry detail from 440 to 536 sectors, including differentiated energy production sectors (fossil, biomass, nuclear, etc.) and state and local government employment.
- Incorporation of updated Bureau of Economic Analysis (BEA) Benchmark input-output (I-O) tables released in 2014.
- Reflection of latest methodological revisions to BEA National Income and Product Accounts.
- Inclusion of data from the latest BEA regional economic accounts, the 2012 Economic Census, the 2012 Census of Agriculture, Bureau of Labor Statistics QCEW dataset, and preliminary 2012 Commodity Flow Survey results.

One major change in this year's analysis is the treatment of earnings (income) received by locally owned ethanol plants. The share of industry earnings accounted for by locally owned firms are treated as an addition to the household sector since the income is paid to local owners and their impact is estimated using multipliers for the household sector which has a different impact than conventional corporate income.

IMPLAN models provide three economic measures that describe the economy: value added, income, and employment.

- Value added is the total value of the goods and services produced by businesses in the country and is generally referred to as gross domestic product (GDP). It is equivalent to the sum of labor income, taxes paid by the industry, and other property income or profit.
- Labor income 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 farm income through higher crop receipts than would be the case without ethanol production.
- Employment represents the annual average number of employees, whether full or part-time, of businesses producing output. Value added including labor income and employment represent the net economic benefits that accrue to the nation as a result of increased economic output.

There are three types of effects measured with a multiplier: direct, indirect, and induced effects. 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). Finally, 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).

One change from previous years is the direct reflection of the additional value of output of co-products (DDG and industrial corn distillers' oil). Since these are co-products, and the backward linkages for their production is accounted for in the expenditures for ethanol production, the value for DDG and corn distillers oil was treated as income and value added only, and we applied income multipliers to the employee compensation portion to avoid double counting.

Results

The impact of the ethanol industry on the U.S. economy is summarized in Table 2. The full impact of the spending for annual operations of ethanol production, co-product output, and R&D is estimated to have contributed nearly \$54 billion to the nation's GDP in 2014. A significant component of this is from agriculture, reflecting the importance of ethanol demand to total corn utilization, the aggregate value of crop production, and crop receipts and farm income.

Table 2
Economic Impact of the Ethanol Industry: 2014

	2014	2014	2014
	GDP (Mil 2014\$)	Employment (Jobs)	Income (Mil 2014\$)
Ethanol Production	\$25,991	90,317	\$9,960
Direct	\$15,357	10,383	\$4,489
Indirect	\$5,721	26,170	\$2,665
Induced	\$4,913	53,765	\$2,806
Construction	\$803	8,217	\$544
Direct	\$277	3,041	\$235
Indirect	\$239	2,064	\$146
Induced	\$287	3,113	\$163
Agriculture	\$23,343	256,291	\$13,926
Direct	\$21	63,160	\$953
Indirect	\$16,005	113,188	\$8,789
Induced	\$7,317	79,944	\$4,184
Research and Development	\$2,605	24,388	\$2,270
Direct	\$918	7,366	\$1,115
Indirect	\$788	7,262	\$475
Induced	\$899	9,761	\$681
Total Ethanol	\$52,742	379,215	\$26,700
Direct	\$16,532	83,949	\$6,791
Indirect	\$22,753	148,684	\$12,075
Induced	\$13,457	146,582	\$7,834

Employment

Jobs are created from the economic activity supported by ethanol production. While ethanol production is not a labor-intensive industry (accounting for about 11,000 full time equivalent direct jobs nation-wide)⁹, the economic activity of supporting industries generates a substantial number of jobs in the nation. When the direct, indirect and induced jobs supported by ethanol production, construction activity,

⁹ The Census Bureau does not report employment in ethanol production.

agriculture, and R&D are included, the ethanol industry supported more than 379,000 jobs in 2014. The distribution by economic sector of jobs supported by the ethanol industry is summarized in Table 3.

Table 3
Employment Impacts by Industry 2014
(Full Time Equivalent Jobs)

Industry	Direct	Indirect	Induced	Total
Agriculture	55,910	23,270	2,619	81,799
Mining	0	4,773	792	5,564
Construction	4,082	11,888	3,401	19,371
Manufacturing	13,287	8,324	6,813	28,424
Transportation/Public Utilities	0	18,365	5,736	24,101
Wholesale/Retail Trade	0	25,653	31,287	56,941
Services	10,670	54,589	94,043	159,303
Government	0	1,822	1,891	3,713
Total	83,949	148,684	146,582	379,215

Since ethanol production is more capital intensive rather than labor intensive, the number of direct jobs supported by the ethanol industry is relatively small and is concentrated primarily in manufacturing and agriculture. Most agriculture jobs supported by the ethanol industry are jobs in support activities related to crop production, ranging from farm managers and bookkeepers to farm equipment operators. In addition, jobs supported by income generated and spent by employees supports a significant number of jobs in seemingly unrelated sectors such as retailers and service sectors. In general, as the impact of the direct spending by the ethanol industry expands throughout the economy, the employment impact expands significantly and is spread over a large number of sectors.

Income

Economic activity and associated jobs produce income for American households. The economic activities of the ethanol industry put nearly \$27 billion into the pockets of Americans in 2014. The distribution of income gains by industry are summarized in Table 4.

As is the case with employment, the direct impact on income by the ethanol industry is limited to manufacturing and services. However, the most significant impact of the ethanol industry is to increase income to farmers who benefit from the demand for feedstock, which leads to both increased production acreage and increased prices as well as earnings from locally-owned ethanol plants.

Table 4
Income Impacts by Industry
(Million 2014 \$)

Industry	Direct	Indirect	Induced	Total
Agriculture	\$1,816	\$8,061	\$85	\$9,962
Mining	\$0	\$294	\$97	\$391
Construction	\$399	\$284	\$160	\$844
Manufacturing	\$2,403	\$446	\$619	\$3,468
Transportation/Public Utilities	\$0	\$803	\$442	\$1,244
Wholesale/Retail Trade	\$0	\$677	\$1,439	\$2,116
Services	\$2,173	\$1,441	\$4,821	\$8,435
Government	\$0	\$69	\$171	\$240
Total	\$6,791	\$12,075	\$7,834	\$26,700

Tax revenue

The combination of GDP and household income supported by the ethanol industry contributed an estimated \$5.7 billion in tax revenue to the Federal Treasury in 2014. State and local governments also benefit from the economic activity supported by the ethanol industry, earning \$4.6 billion in 2014.

Crude oil displacement

Ethanol reduces our dependence on imported oil, expands the supply of motor gasoline, and reduces the U.S. trade deficit. The production and use of ethanol displaces crude oil needed to manufacture gasoline and expands the volume of motor gasoline available to consumers. According to the Energy Information Administration (EIA), U.S. dependence on imported oil and refined products has dramatically declined since peaking in 2005. The use of domestic biofuels (ethanol and biodiesel) is a contributor to the steady decline in oil import dependence. EIA reports that in 2013 imports accounted for about a third of our

crude oil and refined petroleum supplies, compared to 60 percent in 2005 and is the lowest level since 1985.¹⁰ The production of 14.3 billion gallons of ethanol means that the U.S. needed to import 515 million fewer barrels of petroleum products in 2014. This is roughly the equivalent of 18 percent of total expected U.S. crude oil and finished petroleum product imports in 2014.¹¹ Despite the recent decline in global oil prices, the value of the crude oil displaced by ethanol amounted to nearly \$49 billion in 2014.¹² This is money that stays in the American economy.

The importance of the U.S. ethanol industry to America's energy independence is expected to increase through 2015 as domestic oil producers close wells and cut output due to economic losses as oil prices remain below breakeven levels.

Challenges for 2015

The most significant challenges facing the renewable fuels industry in 2015 are likely to result from competitive pressures from falling world oil and refined product prices and an uncertain regulatory environment. The competitive environment for renewable fuels has deteriorated as refined product prices continue to fall along with world oil prices. As of this writing crude oil prices have fallen nearly 60 percent from their mid-2014 highs. Crude oil prices are now below the breakeven price for most new wells in North America.¹³ As the oil industry adjusts production in response to falling prices and supply and demand for petroleum comes into balance, the market for renewable fuels is expected to recover.

As pointed out earlier, EPA failed to release a final 2014 RVO and proposed 2015 RVO for renewable fuels. The delays in announcing RVO targets sends a negative signal to the investment community that will continue to restrain growth in new capital expenditures, particularly for second-generation biofuels

¹⁰ EIA. *Frequently Asked Questions. "How much petroleum does the United States import and from where?"* <http://www.eia.gov/tools/faqs/faq.cfm?id=727&t=6>. Accessed Jan 26, 2015.

¹¹ According to the EIA, the U.S. imported 2.7 billion barrels of crude oil and petroleum products during the first 11 months of 2014, implying an annual total of 2.9 billion barrels.

¹² Ethanol directly competes with and displaces gasoline as a motor fuel. According to the EIA, one 42 gallon barrel of crude oil produced 18.8 gallons of gasoline in 2014. Ethanol has a lower energy content (76,700 btu per gallon LHV) than gasoline (114,000 btu per gallon LHV), and thus it takes 1.48 gallons of ethanol to provide the same energy as one gallon of gasoline. Therefore, 14.3 billion gallons of ethanol are the equivalent of 9.7 billion gallons of gasoline. Since one barrel of crude produces 18.9 gallons of gasoline, it takes 514.5 million barrels of crude to produce 9.7 billion gallons of gasoline, the amount displaced by ethanol. This oil was valued at the 2014 average composite acquisition cost of crude oil by refiners of \$95.13/bbl.

¹³ Myles Udland, "Oil is still getting crushed – Citi Breakeven Oil Production Prices". *Business Insider*, December 8, 2014

capacity. Further, meeting the challenge of improving infrastructure for higher blends of ethanol by expanding investment in blender pumps will continue to be a challenge as long as RVOs are at or below “blend wall” levels. E15 has been approved for motor vehicles manufactured after 2001 and E85 is approved for flex-fuel vehicles. The number of E85 stations grew by more than 8 percent in 2014 but more is needed. Much broader consumption of E15 and E85 is necessary not only to meet the statutory requirements of the RFS, but also to meaningfully increase ethanol demand and support profitability in the industry. We expect the oil industry to continue supporting and encouraging attacks on the RFS, and creating hurdles to increased penetration of higher ethanol blends.

Finally, fiscal issues that impact tax policy and appropriations for blender pump investment may constrain the industry. The U.S. Congress allowed important tax incentives including the Cellulosic Biofuel Producer Credit to expire at the end of 2014. Failure to extend these important incentives will continue to increase uncertainty for the investment community and may constrain access to essential private capital.

Conclusion

The ethanol industry continues to make a significant contribution to the economy in terms of job creation, generation of tax revenue, and displacement of imported crude oil and petroleum products. The importance of the ethanol industry to agriculture and rural economies is particularly notable. Continued growth and expansion of the ethanol industry through new technologies and feedstocks will enhance the industry’s position as the original creator of green jobs, and will enable America to make further strides toward energy independence.