



## Further Perspective on Trends in the Operational Efficiency of the U.S. Ethanol Industry

Scott Irwin

Department of Agricultural and Consumer Economics  
University of Illinois

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A recent *farmdoc daily* article ([March 1, 2023](#)) examined trends in the operational efficiency of the U.S. ethanol industry. The analysis in the article uncovered tradeoffs in operational efficiency over time. Specifically, ethanol producers have increased ethanol and corn oil conversion rates at the expense of DDGS conversion rates. A reasonable presumption is that this was a rational response to the available technology for increasing efficiency and the economic incentives for production of ethanol and corn oil versus DDGS. The purpose of this article is to extend the analysis of physical conversion rates to revenues to determine the impact of the operational tradeoffs on the revenue stream of ethanol plants.

### Analysis

We begin by considering the same four measures of physical conversion rates that were presented in the *farmdoc daily* article of [March 1<sup>st</sup>](#). Table 1 presents annual averages of the four measures for 2015 through 2022. We omit 2014 in this article because data are not available for the full calendar year. The first operational efficiency measure that we computed is gallons of ethanol produced per bushel of feedstock processed. We computed this measure by dividing [monthly fuel ethanol production from the EIA](#) by the bushels of corn and sorghum feedstock used at U.S. dry and wet mill ethanol plants from the USDA's monthly [Grain Crushings and Co-Products Production report](#). One change from our earlier article is that ethanol conversion is shown in pounds per bushel of corn processed rather than gallons, in order to use the same units for all four measures. We assume that, on average, [a gallon of 190 proof ethanol weighs 6.8 pounds](#). Slightly different weights could be assumed based on the assumed proof of the ethanol and temperature. The other three other operational efficiency measures per bushel of corn processed shown in Table 1 are: i) pounds of DDGS, ii) pounds of corn oil, and iii) pounds of CO<sub>2</sub>. These conversion rates were also computed using data from the monthly *Grain Crushings and Co-Products Production* report. See the [March 1<sup>st</sup>](#) article for complete details on the computation of each of the four measures.

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**Table 1. Average Annual Physical Conversion Rates for U.S. Dry and Wet Mill Ethanol Plants per Bushel of Corn and Sorghum Processed in Pounds, 2015 - 2022**

Product	2015	2016	2017	2018	2019	2020	2021	2022	2022/2015 Change
Ethanol Production per Bushel of Corn and Sorghum Processed	19.23	19.55	19.53	19.53	19.91	19.75	19.87	20.01	0.78
DDGS Production per Bushel of Corn Processed at Dry Mill Plants	16.95	16.60	16.46	16.12	15.85	15.69	15.78	15.97	-0.98
Corn Oil Produced per Bushel of Corn Processed at Dry Mill Plants	0.60	0.68	0.74	0.75	0.76	0.80	0.84	0.87	0.28
CO2 Production per Bushel of Corn and Sorghum Processed	0.95	0.94	0.90	1.00	1.08	0.97	1.05	1.07	0.12
Loss per Bushel of Corn and Sorghum Processed	18.27	18.23	18.37	18.60	18.40	18.79	18.47	18.08	-0.19
Total (one bushel)	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00	0.00

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The data show a clear upward trend over time in the ethanol conversion rate, increasing from 19.23 pounds in 2015 to 20.01 pounds in 2022, a gain of 0.78 pounds. Over the same period, the DDGS conversion rate fell from 16.95 pounds in 2015 to 15.97 pounds in 2022, a drop of slightly less than a pound. Corn oil production increased by 0.28 pounds and CO2 increased by 0.12 pounds. Considering that an average bushel of corn weighs 56 pounds, none of the changes in conversion rates should be considered large in absolute terms.

One additional conversion rate is added to Table 1 that was not included in our previous article. Assuming the average bushel of corn weighs 56 pounds (as noted above) we can compute the pounds of corn lost in the process of ethanol production. This “loss” is simply the difference between 56 pounds and the sum of the pound conversion rates in first four rows of Table 1. There is some lost material in each of the production stages for ethanol, such is the initial grinding of the corn. However, the vast majority of the residual loss computed here is in the form of CO2. It is well known that roughly equal amounts of ethanol and CO2 by weight are produced in the fermentation process (e.g., Mosier and Ileleji, 2006). The data in Table 1 bear this out. The average amount of ethanol produced per bushel of corn over 2015-2022 is 19.67 pounds. If we sum the CO2 production reported to the USDA and the loss, this averages 19.40 pounds for the same set of years. The difference is exceedingly small and matches quite nicely the prediction of the basic chemistry of fermentation. Another implication is that only about five percent of the total CO2 generated by U.S. ethanol producers is currently being sold in the market, with the rest being released at the plant.

As the next step in the analysis, Table 2 reports the conversion rates in Table 1 as percentages of a 56-pound bushel of corn. While ethanol is the largest percentage by weight, it still represents only a little over a third of a bushel of corn. CO2 production (CO2 reported to the USDA plus loss) is only a slightly smaller percentage, which will likely surprise many despite the firm foundation this has in the chemistry of fermentation. DDGS production is a bit less than 30 percent on average and corn oil production is very small, around 1.8 pounds on average. The changes in percentages over the sample period are quite small when considered relative to the total pounds in a bushel of corn. The largest change is a 1.7 percentage decline in DDGS production per bushel of corn processed.

**Table 2. Average Annual Physical Conversion Rates for U.S. Dry and Wet Mill Ethanol Plants per Bushel of Corn and Sorghum Processed in Percentages, 2015 - 2022**

<b>Product</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2022/2015 Change</b>
Ethanol Production per Bushel of Corn and Sorghum Processed	34.3	34.9	34.9	34.9	35.5	35.3	35.5	35.7	1.4
DDGS Production per Bushel of Corn Processed at Dry Mill Plants	30.3	29.6	29.4	28.8	28.3	28.0	28.2	28.5	-1.7
Corn Oil Produced per Bushel of Corn Processed at Dry Mill Plants	1.1	1.2	1.3	1.3	1.4	1.4	1.5	1.6	0.5
CO2 Production per Bushel of Corn and Sorghum Processed	1.7	1.7	1.6	1.8	1.9	1.7	1.9	1.9	0.2
Loss	32.6	32.6	32.8	33.2	32.9	33.6	33.0	32.3	-0.3
Total (one bushel)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0

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To convert the physical rates into economic terms, prices for the different products are needed. Annual average prices for ethanol, DDGS, and corn oil at Iowa ethanol plants are reported in Table 3. The averages are based on weekly observations and are used to simulate profits of a representative dry mill ethanol plant in numerous previous *farmdoc daily* articles (e.g., [February 10, 2022](#)). We were unable to locate a price series for industrial CO2, and therefore, omit CO2 from the remainder of the analysis. Given the small amounts of CO2 sold into the marketplace this is not expected to be a major limitation. It is interesting to observe that the prices of all three products increased substantially over the last eight years, led by corn oil which nearly doubled in value. The percentage increases in ethanol and DDGS were also impressive, with both surging more than 60 percent over 2015 through 2022.

**Table 3. Average Annual Price of Ethanol and By-Products at Iowa Ethanol Plants in Dollars per Pound, 2015 - 2022**

<b>Product</b>	<b>2015</b>	<b>2016</b>	<b>2017</b>	<b>2018</b>	<b>2019</b>	<b>2020</b>	<b>2021</b>	<b>2022</b>	<b>2022/2015 Change</b>
Ethanol	0.21	0.21	0.21	0.19	0.20	0.17	0.33	0.35	0.14
DDGS	0.07	0.06	0.05	0.07	0.07	0.08	0.10	0.12	0.05
Corn Oil	0.41	0.44	0.37	0.29	0.28	0.42	0.67	0.81	0.40
CO2	NA	NA	NA	NA	NA	NA	NA	NA	NA

Note: NA denotes not available.

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Table 4 presents the average annual revenue for ethanol and by-products at Iowa ethanol plants per bushel of corn processed. This is computed by multiplying the physical conversion rates in Table 1 by the average prices in Table 3. Ethanol revenue is still by far the most important determinant of total revenue, and it increased by just under \$3 per bushel over 2015 through 2022, or an increase of 74 percent. While small in absolute terms, corn oil revenue increased by nearly \$0.50 per bushel over the sample, which is almost a tripling of revenue. The surge in corn oil revenue was a function of increasing conversion rates and higher corn oil prices. The increase in DDGS revenue is not as large as for ethanol, but impressive nonetheless, surging over 50 percent for this time frame.

**Table 4. Average Annual Revenue for Ethanol and By-Products at Iowa Ethanol Plants in Dollars per Bushel Processed, 2015 - 2022**

Product	2015	2016	2017	2018	2019	2020	2021	2022	2022/2015 Change
Ethanol	4.03	4.15	4.11	3.79	3.94	3.45	6.51	7.01	2.98
DDGS	1.25	1.00	0.85	1.14	1.08	1.21	1.55	1.92	0.67
Corn Oil	0.25	0.30	0.27	0.21	0.21	0.34	0.56	0.71	0.46
CO2	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total	5.53	5.44	5.23	5.14	5.24	5.00	8.63	9.64	4.11

Note: NA denotes not available.

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The final step in the analysis is to compute the component revenues as a percentage of total revenue in order to obtain revenue shares. Table 5 shows these percentages. The share of total revenue attributable to ethanol sales was virtually unchanged at about 73 percent when comparing 2015 with 2022. The decrease in the DDGS share of revenue was almost exactly offset by the decrease in the corn oil share. The growth in the share from corn oil was impressive, increasing from 4.5 percent in 2015 to 7.3 percent in 2022.

It is interesting to compare the percentages for physical conversion rates in Table 2 with the revenue percentages in Table 5. For example, in 2022, ethanol represented 35.7 percent of the weight per bushel of corn processed, but 72.8 percent of revenue. DDGS represented 28.5 percent of the weight per bushel of corn processed and 19.9 percent of revenue. Corn oil only represented only 1.6 percent of the weight per bushel of corn processed but 7.3 percent of revenue. This highlights the high value of corn oil in the marketplace and its growing importance as a source of revenue for ethanol producers.

**Table 5. Average Annual Revenue for Ethanol and By-Products at Iowa Ethanol Plants in Percentage per Bushel Processed, 2015 - 2022**

Product	2015	2016	2017	2018	2019	2020	2021	2022	2022/2015 Change
Ethanol	73.0	76.2	78.5	73.6	75.3	69.1	75.5	72.8	-0.2
DDGS	22.5	18.3	16.3	22.2	20.7	24.2	18.0	19.9	-2.7
Corn Oil	4.5	5.5	5.2	4.2	4.1	6.8	6.5	7.3	2.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	0.0

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### Implication

Physical rates of converting corn into ethanol, DDGS, and corn oil are critical measures of operational efficiency for ethanol plants. However, this is not the entire story. Prices for these products determine the ultimate impact of these conversion rates on revenue. Not surprisingly, ethanol revenue is by far the most important determinant of total revenue, and it increased by just under \$3 per bushel over 2015 through 2022, or an increase of 74 percent. While small in absolute terms, corn oil revenue increased by nearly \$0.50 per bushel over the sample, which is almost a tripling of revenue from this product. The

surge in corn oil revenue is a function of increasing conversion rates and higher corn oil prices. The increase in DDGS revenue was not as large as for ethanol, but impressive nonetheless, surging over 50 percent during 2015 through 2022. Of particular interest is the fact that corn oil in recent years only represents a little less than two percent of the weight per bushel of corn processed but over seven percent of revenue. This highlights the high value of corn oil in the marketplace and its growing importance as a source of revenue for ethanol producers.

## References

Irwin, S. "Trends in the Operational Efficiency of the U.S. Ethanol Industry: 2022 Update." *farmdoc daily* (13):37, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, March 1, 2023.

Irwin, S. "Ethanol Production Profits in 2021: What a Ride!" *farmdoc daily* (12):18, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, February 10, 2022.

Mosier, N.S., and K. Ileleji. "How Fuel Ethanol is Made from Corn." BioEnergy: Fueling America Through Renewable Resources, Purdue Extension, ID-328, December 2006.  
<https://www.extension.purdue.edu/extmedia/id/id-328.pdf>