ABF Economics
Agriculture and BioFuels Consulting, LLP

Impact for the U.S. Economy from Implementation of §45Z of the Inflation Reduction Act (IRA)

Prepared by Agriculture and Biofuels Consulting LLP

August 1, 2023

Executive Summary

Section 45Z of the Inflation Reduction Act (IRA) provides a tax credit for the domestic production of clean transportation fuels including ethanol, biodiesel, and sustainable aviation fuels. Also known as the Clean Fuel Production Credit, the tax credit applies to fuels produced after December 31, 2024, and sold before Dec. 31, 2027. The base amount of the credit for nonaviation fuels is $0.20 a gallon multiplied by an emissions factor. This base credit can be increased to $1.00 per gallon (a multiple of five) for transportation fuel produced in facilities that meet prevailing wage and apprenticeship requirements outlined in the IRA.[1]

The Section 45Z tax credit will provide significant financial incentive for ethanol producers to make necessary capital expenditures to capture and process CO_2 and for farmers to increase production of low carbon intensive corn for ethanol production. These incentives are expected to more than double the current number of ethanol plants capturing CO_2 (from 50 to 124) and capture of CO_2 (from 9.5 million tons to 23.8 million tons) over the three-year period of the tax credit.

Qualification for the tax credits provided by §45Z is determined by reductions in the carbon intensity (CI) of ethanol. The main ways the CI of ethanol can be reduced are through increasing the recovery of CO_2 by ethanol producers, use of renewable natural gas (RNG), and utilization of corn produced using practices that reduce its CI and, in turn, ethanol produced from low CI corn. Currently a relatively small percent of ethanol plants capture and market CO_2.

A combination of operational changes by ethanol producers and increased use of low CI corn feedstock is expected to result in at least a 50 percent reduction in the carbon intensiveness of ethanol leading to a $0.55 per gallon tax credit. Since low CI corn plays a substantial role in this reduction, ethanol producers

[1] 26 U.S. Code § 45Z - Clean fuel production credit. Cornell Law School Legal Information Institute. Accessed May 11, 2023

are expected to share $0.10 per gallon (3.3 cents per bushel) of the credit with farmers supplying low CI corn and pay a 10.3 percent premium for qualifying feedstock.

The ethanol industry is expected to increase capital expenditures by $2.3 billion. Corn growers are expected to spend $6.8 billion to produce 2.4 billion bushels of corn needed to produce the increased CO_2 volume and will realize an additional $1.9 billion in revenue. As shown in Table ES1 these impacts are expected to provide $21.2 billion in GDP for the U.S. economy, nearly $13.4 billion in household income, and support more than 192,000 jobs in all sectors of the national economy.

Table ES1
Economic Impact of the §45Z Tax Credit for the U.S. Economy

	GDP (Mil 2023$)	Employment FTEs	Income (Mil 2023$)
Ethanol Production	$8,867	59,785	$4,830
Agriculture	$8,876	98,028	$6,070
Construction	$3,416	34,596	$2,473
Total Ethanol	**$21,159**	**192,409**	**$13,372**

The net result of this is that both ethanol producers and corn growers will benefit. Importantly, the §45Z clean fuels tax credit will significantly help achieve the objective of reducing greenhouse gas emissions.

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Introduction

Section 45Z of the Inflation Reduction Act (IRA) provides a tax credit for the domestic production of clean transportation fuels including ethanol, biodiesel, and sustainable aviation fuels. Also known as the Clean Fuel Production Credit, the tax credit applies to fuels produced after December 31, 2024, and sold before Dec. 31, 2027. The base amount of the credit for nonaviation fuels is $0.20 a gallon multiplied by an emissions factor. This base credit can be increased to $1.00 per gallon (a multiple of five) for transportation fuel produced in facilities that meet prevailing wage and apprenticeship requirements outlined in the IRA.[2]

For purposes of compliance with §45Z, carbon intensity (CI) is determined by the GREET model maintained by the U.S. Energy Department's Argonne National Laboratory. The amount of the $1.00 per gallon tax credit available to an ethanol producer is directly linked to reductions in the CI score of corn ethanol. A recent study published by Argonne National Laboratory reported that U.S. corn ethanol achieves a CI score of 54.[3]

Qualification for the tax credits provided by §45Z is determined by reductions in the carbon intensity (CI) of ethanol. The main ways the CI of ethanol can be reduced are through increasing the recovery of CO_2 by ethanol producers, use of renewable natural gas (RNG), and utilization of corn produced using practices that reduce its CI and, in turn, ethanol produced from low CI corn. Currently a relatively small percent of ethanol plants capture and market CO_2. The §45Z tax credit will provide an incentive for plants to invest in CO_2 capture.

Agriculture and Biofuels Consulting ("ABF Economics") was asked by Growth Energy estimate the impact of the tax credit provisions of §45Z for clean transportation fuels on the ethanol industry and agriculture

[2] 26 U.S. Code § 45Z - Clean fuel production credit. Cornell Law School Legal Information Institute. Accessed May 11, 2023
[3] Michael Wang, Uisung Lee, Hoyoung Kwon and Hui Xu. "Life-Cycle Greenhouse Gas Emission Reductions of Ethanol with the GREET Model". Presentation at the 2021 National Ethanol Conference. February 17, 2021. https://afdc.energy.gov/files/u/publication/ethanol-ghg-reduction-with-greet.pdf. The corn ethanol CI includes Land use change emissions.

sector and, in turn, the U.S. economy.[4] The economic impacts will be described in terms of additional value-added output (GDP), employment, and household income.

Methodology

The economic impact resulting from the §45Z tax credits will be provided by two primary sources:

- The capital expenditures associated with industry activities to increase capture and processing of CO_2.
- The expenditures by farmers to produce low CI corn for the ethanol industry and increase in farm income generated by higher prices for low CI corn.[5]

The impacts on ethanol and agriculture resulting from implementation of the §45Z tax credits are dependent on several highly interrelated factors:

- The amount of the tax credit for the ethanol industry that is determined by the reduction in the CI of ethanol.
- The impact of the realized tax credit on the net returns of ethanol producers and the number that will invest in CO_2 capture.
- The impact on corn prices from the demand for low CI corn and the willingness or farmers to produce low CI corn.

Producers can reduce the CI of ethanol and qualify for a §45Z tax credit in several ways including Carbon Capture and Sequestration (CCS), use of Renewable Power, use of Renewable Natural Gas (RNG) as a process fuel and using low CI corn as a feedstock. Each of these options has a different impact on GHG emissions, on lowering the CI of ethanol, and the ultimate size of the tax credit.[6] These options also have different costs that will affect the ability and willingness and ability of individual ethanol producers to adopt and implement. A study prepared by the State CO_2-EOR Deployment Work Group in 2017 examined two scenarios for capture and utilization of CO_2 from Midwest ethanol plants and estimated the capital cost per plant for CO_2 capture at an average of $30.5 million in today's dollars and operating costs of $9.89 per ton

[4] This study provides an analysis of the impact of the §45Z clean fuels tax credit on the ethanol component of transportation fuels.
[5] For purposes of this analysis, we assume that low CI corn would be produced on existing agricultural land and not land reclaimed or converted from previously non-agricultural uses.
[6] For a detailed discussion of these options and their potential impact on ethanol GHG emissions see "GHG Analysis of Dry Mill for Corn Ethanol Production under IRA" by Stefan Unnasch and Debasish Parida, Life Cycle Associates, LLC. December 1, 2022.

of CO_2 processed.[7] A recent GAO study estimated the combined capital and operating cost of CO_2 separation and capture at between $0 and $35 per metric ton.[8] It is important to note that these costs only reflect the capture of CO_2 and do not include transportation from ethanol plant to end use markets.

Since a tax credit will show up as a new revenue line for an ethanol plant the tax credit will enable ethanol producers to pay a premium for corn that will help reduce the CI for ethanol. This higher price will partially offset the value of the tax credit for the ethanol plant but will benefit the corn farmer selling low CI corn. The technology for producing low CI corn is generally well known. Five agricultural practices have been identified for corn that would reduce the CI of ethanol:[9]

- Cover crops,
- Reduced tillage,
- Manure application,
- Improved fertilizer practices
- Usage of "green" or low-carbon ammonia for fertilizer.

USDA reports that 76 percent of corn acres in 2021 were planted with conservation tillage roughly split between no- till and mulch till.[10] However little data exists regarding the percentage of corn acres planted with the other four qualifying practices. Use of these practices could reduce the CI score for corn supplied to an ethanol plant by more than 25 points.[11] Adoption of these practices will depend on an adequate financial incentive and assurance of a market.

On the financial side, producing low CI corn adds value to the commodity. In fact, producing and guaranteeing via certification or some other method provides identity preservation that would differentiate low CI corn from generic No. 2 Yellow corn and will support a higher price. The impact of identity preservation on commodity prices is well studied and documented. The soybean industry has utilized identity preservation for soybeans sold in foreign markets for considerable time. The development of

[7] Capturing and Utilizing CO2 from Ethanol: Adding Economic Value and Jobs to Rural Economies and Communities While Reducing Emissions. White paper prepared for the State CO2-EOR Deployment Work Group. December 2017.
[8] GAO Technology Assessment. Decarbonization Status, Challenges, and Policy Options for Carbon Capture, Utilization, and Storage. GAO-22-105274. September 2022
[9] Op cit Unnasch and Pariada
[10] USDA Economic Research Service. "Adoption of conservation tillage has increased over the past two decades on acreage planted to major U.S. cash crops". https://www.ers.usda.gov/data-products/chart-gallery/gallery/chart-detail/?chartId=105042.
[11] Philip Brasher. "Big dollars for farmers at stake in rules for new biofuel tax credit". AgriPulse. 4/19/23

unique characteristics such as high oil, waxy, nutrient dense, and high amylose corn are other examples. A study by Elbehri and Paarlberg "…examined the price behavior for identity preserved and generic corn under different demand and competitive conditions".[12] The authors found that high amylose corn (most relevant to ethanol production) enjoyed a price premium of 9.8 percent on both high amylose and generic corn. Corn farmers producing certified low CI corn also can expect ethanol producers to share a portion of the tax credit they qualify for by using low CI corn. As discussed below we have assumed that 10 percent of the credit will be shared as a supplement to the price premium. Using the USDA/ERS 2022 estimated costs and returns for corn[13] as a base for comparison, this translates to more than an additional $125 per acre net return over operating costs for the average corn farm. This benefit is expected to increase farm income and provide an incentive to produce low CI corn.

Economic Impact

We have employed the IMPLAN economic multiplier model framework to estimate national level economic contribution of the ethanol and corn industries for this analysis. This model is constructed for the national economy based on current IMPLAN software and data.

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 GDP.
- Labor income is the sum of employee compensation (including all payroll and benefits) and proprietor income (income for self-employed work).
- Employment represents the annual average number of employees, whether full or part-time, of businesses producing output, expressed as full-time equivalent jobs.

The analysis presented in this study differs slightly from other studies of the economic impact of the ethanol industry we have conducted. First, we have restricted the analysis to the impact of the §45Z tax credit on the economy from the ethanol, corn, and construction industries. Exports and R&D were not included. Also, the added value of low CI corn was incorporated into ethanol expenditures while the cost to

[12] Ariz Elbehri and Philip Paalberg. "Price Behavior in Corn Market with Identity Preserved Types." Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, July 2003
[13] https://www.ers.usda.gov/data-products/commodity-costs-and-returns/commodity-costs-and-returns/#Recent%20Cost%20and%20Returns

produce low CI corn and the additional revenue represented by the farmer share of the tax credit and the price premium was evaluated as an impact on the corn industry.

Key Assumptions

The information and data presented above were used to estimate the size of a potential tax credit, the impact on net revenue for ethanol and corn producers, and the resultant increases in expenditures to produce low CI corn and qualifying ethanol with a §45Z tax credit. The analysis is based on several key assumptions derived from information and data discussed earlier. These and other key assumptions underlying the analysis are presented in Table 1.

- The GREET model will be updated annually and that the GREET-based emissions rate table for ethanol used by the Treasury Department to calculate GHG emission reductions will reflect the key technologies the ethanol industry and corn farmers use to reduce GHG emissions. Specifically for corn this will include credit for current use of cover crops and conservation tillage.
- A conservative 30-point reduction in the CI for ethanol resulting in a §45Z tax credit of $0.55 per gallon. We assume that most of the reduction will come from agriculture with the remainder from improvements in ethanol capture.
- 80 percent of the tax credit ($0.45/gallon) will be kept by the ethanol producer. The remainder ($0.10/gallon) will be shared with the corn grower. This amounts to 3.3 cents per bushel in addition to the 9.8 percent premium price for low CI corn providing a total benefit to corn farmers who supply low CI corn of 10.2 percent.
- Currently 25 percent of ethanol plants (50) capture CO_2. Within the three-year period of the tax credit, we expect the number of plants capturing CO_2 to increase to124 plants.
- U.S. corn farmers will not have a problem supplying the required low CI corn. The 124 ethanol plants will require 3,259 million bushels of corn. This amounts to 23 percent of the 2022 U.S. corn crop. Further we assume that 75 percent of this corn (2,444 million bushels) will be low CI corn.
- Capital and operating costs for capturing CO_2 are consistent with those presented by Unnasch and Parida. The aggregate capital cost to allow 75 ethanol plants to capture CO_2 is estimated at $2.275 billion. We assume that any new construction will enable CO_2 capture.

- The costs and impacts reflect only the capture of CO_2 and do not include transportation from ethanol plant to end use markets.
- In evaluating the impact of the tax credit on net returns for the ethanol industry we have not included potential revenue from marketing CO_2.

Table 1
Key Assumptions

	Baseline	45Z
Capacity (On-line Mil gal)	17,514	17,514
Total Ethanol Production (Mil Gal)	15,365	15,365
Total Corn Requirement (Mil Bu)	5,214	5,214
Corn for CO2 (Mil Bu)	1,303	3,259
Low CI corn supplied (Mil Bu)	0	2,444
EtOH CI Reduction mmBTU		30
45Z Tax Credit ($/gal)		$0.55
Tax Credit shared with Corn Farmer ($/gal)		$0.10
Price Premium for Low CI Corn	0.0%	10.3%
Plants capturing CO2	50	124
CO2 Yield (tons/Gal)	0.0025	0.0025
CO2 Production (Mil tons)	9.51	23.78
CO2 Operating Cost ($/ton)	$9.89	$9.89
New CO2 Plants	0	75
Capital Cost (Mil $)	$0	$2,275

§45Z Analysis

Ethanol

To analyze the impact of a tax credit we estimated the effect of higher costs and additional revenue on costs and returns for the ethanol industry consistent with the assumptions discussed above. The starting point was a Baseline Cost and Returns statement using 2022 production levels, production parameters and year-to-date prices for ethanol, corn and other major inputs. To this baseline we added production costs consistent with a 150 percent increase in the number of plants capturing CO_2.

Ethanol producers capturing CO_2 will face higher operating costs associated with feedstock and improved CO_2 recovery.

- As discussed earlier low CI corn is expected to command a premium price in the marketplace. Further we expect that ethanol producers will be willing to share a portion of the tax credit with corn growers in the form of an additional premium. Consequently, feedstock expenditures, the most significant operating cost, for producers using low CI corn will increase compared to costs faced by producers that do not purchase low CI corn. Reflecting the increase in the number of plants capturing CO_2, ethanol producers are expected to pay $1.6 billion (4.4 percent) more for corn than in a baseline with no §45Z tax credit.
- These producers also will face increased costs associated with CO_2 capture. The study prepared by Unnasch and Parida cited earlier suggested that operating costs for the capture of CO_2 are estimated at $9.89 per ton. As shown in Table 2 this amounts to $235 million bringing total operating costs to $44.3 billion, four percent more than without the tax credit stimulus.

Table 2
Impact of 45Z Tax Credit on Ethanol Costs and Returns

Operating Costs	**Baseline** Mil $/yr	**45Z** Mil $/yr
Generic Corn	$35,063	$12,904
CO2 Corn	$0	$23,712
Enzymes, Yeast, Chemicals	$1,792	$1,792
Nat Gas, Electric, Water	$3,629	$3,629
CO2 Capture	$94	$235
Other Operating Costs	$1,989	$1,989
Net Operating Costs	**$42,567**	**$44,261**
Revenue		
Ethanol	$34,725	$34,725
45Z Credit	$0	$3,241
DDG	$8,841	$8,841
Corn Oil, CGM, CGF	$3,450	$3,450
Total Revenue	**$47,015**	**$50,256**
EBIDTA	**$4,449**	**$5,995**
$/Gallon	**$0.29**	**$0.39**

The tax credit also will provide additional revenue for ethanol producers. As described above we expect a conservative 30-point decline in the CI of ethanol to provide a $0.55 cents per gallon tax credit. Sharing 10 cents of this with corn growers provides a net credit to ethanol producers of $0.45 per gallon. Applied to the 7.2 billion gallons of ethanol produced with low CI corn this provides revenue of $3.2 billion, more than enough to offset the higher costs. As a result, net income for the ethanol industry with the tax credit increases nearly 35 percent to nearly $6 billion or $0.39 per gallon. This is more than sufficient to justify the sharp increase in ethanol plants capturing CO_2.

Agriculture

Corn farmers will benefit from higher prices for identity preserved low CI . As described earlier we expect the identity preservation to provide a 9.8 percent price premium. When $0.10 per gallon of the tax credit (the equivalent of 3.3 cents per bushel) is added, the benefit to corn growers who will employ the techniques to produce low CI corn is 10.2 percent. Considering the nature of techniques corn growers can use to reduce CI, we do not expect corn production costs to increase significantly so the expenditures to produce low CI corn to meet §45Z requirements total $14.4 billion. However, the combined premium price and sharing of tax credit will add $1.94 billion to corn grower's net revenue.

Construction

Capital costs to add CO_2 capture to an additional 75 ethanol plants is estimated at $30 million per plant for a total CAPEX of $2.3 billion. The 35 percent increase in net returns from the tax credit is expected to provide an adequate incentive to make this investment. Not all plants are likely to make the necessary investment and the expansion will take place over the three-year life of the credit.

Economic Impacts

The additional spending by producers described above to produce ethanol and corn with a CI that qualifies for a $0.55 per gallon §45Z tax credit represents the purchase of output from other industries thereby generating additional economic activity in the form of value added (GDP). This economic activity will support jobs in all industries and generate additional income for American households.

Table 3 summarizes the impact of the §45Z clean fuels tax credit on ethanol production for the U.S. economy. The full impact of the spending for annual operations of ethanol production is estimated to have contributed $21.2 billion to the nation's GDP, 28 percent more than without the tax credit incentive. The

primary reason for the increased GDP impact can be traced to the combination of higher corn prices that boosts operating expenditures and the value of industry output.

Table 3
Economic Impact of the §45Z Tax Credit for the U.S. Economy

	GDP (Mil 2023$)	Employment FTEs	Income (Mil 2023$)
Ethanol Production	**$8,867**	**59,785**	**$4,830**
Direct	$1,532	5,657	$839
Indirect	$4,678	30,963	$2,482
Induced	$2,657	23,165	$1,509
Agriculture	**$8,876**	**98,028**	**$6,070**
Direct	$997	21,616	$1,313
Indirect	$4,547	47,306	$2,863
Induced	$3,332	29,106	$1,893
Construction	**$3,416**	**34,596**	**$2,473**
Direct	$1,223	16,786	$1,203
Indirect	$833	5,937	$497
Induced	$1,360	11,873	$772
Total Ethanol	**$21,159**	**192,409**	**$13,372**
Direct	$3,753	44,060	$3,355
Indirect	$10,057	84,205	$5,843
Induced	$7,349	64,144	$4,175

Because of the importance of feedstocks, agriculture continues to be a significant source of industry economic impact. This reflects the importance of ethanol demand to total corn utilization, the aggregate value of crop production, and crop receipts and farm income. Production of low CI corn for the ethanol industry contributes an estimated $8.9 billion to the U.S. economy while the manufacturing activity of ethanol production accounts for an additional $8.9 billion.

Employment

Jobs are created from the economic activity supported by ethanol and corn production. Ethanol production is not a labor-intensive industry (accounting for fewer than 10,000 full time equivalent direct jobs nation-wide)[14]. However, the economic activity of supporting industries generates a substantial number of jobs in all sectors of the national economy.

When the direct, indirect, and induced jobs supported by ethanol production, agriculture and construction are combined, the economic activity stimulated by the §45Z Tax Credit supports more than 192,000 jobs in all sectors of the economy. Since ethanol production is more capital intensive 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 producers and distributors of crop protection products, fertilizer, and farm equipment to farm service providers. In addition, 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 also expands and is spread over many sectors.

Income

Economic activity and associated jobs produce income for American households. The economic activity stimulated by the Clean Fuel Production tax credit puts $13.4 billion into the pockets of Americans. As is the case with employment, the direct impact on income by the ethanol industry is largely concentrated in manufacturing and services. In many respects, this mirrors the employment structure of the American economy. The most significant impact of the §45Z tax credit for ethanol will be increased income to corn farmers who benefit from the demand for low CI feedstock.

Conclusion

Section 45Z of the Inflation Reduction Act provides significant financial incentive for ethanol producers to make necessary capital expenditures to capture and process CO_2 and for farmers to increase production of low carbon intensive corn for ethanol production. These incentives are expected to more than double the

[14] The Census Bureau does not report employment in ethanol production. This analysis assumes the average ethanol plant employs approximately 50 full-time equivalent employees.

current number of ethanol plants capturing CO_2 and production of CO_2 over the three-year period of the tax credit.

A combination of operational changes by ethanol producers and increased use of low CI corn feedstock is expected to result in a 50 percent reduction in the carbon intensiveness of ethanol leading to a $0.55 per gallon tax credit. Since low CI corn plays a substantial role in this reduction ethanol producers are expected to share $0.10 per gallon (3.3 cents per bushel) of the credit with farmers supplying low CI corn and pay a 10.2 percent premium for qualifying feedstock.

The ethanol industry is expected to increase capital expenditures by $2.2 billion. Corn growers are expected to spend $6.8 billion to produce 2.4 billion bushels needed to produce the increased CO_2 volume and will realize an additional $1.9 billion in revenue. These impacts are expected to generate $21.2 billion in GDP for the U.S. economy, $13.4 billion in household income, and support more than 192,000 jobs in all sectors of the national economy.

The net result of this is that both ethanol producers and corn growers will benefit. Importantly, the §45Z tax credit will significantly help achieve the objective of reducing greenhouse gas emissions.