Rural & Farm Finance
Policy Analysis Center
University of Missouri

Cost and Benefits of Lowering the Carbon Intensity of Corn Production

Dr. Alejandro Plastina

Director, Rural and Farm Finance Policy Analysis Center (RaFF)

2024 Indiana CCA Conference Program

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Rural & Farm Finance Policy Analysis Center
University of Missouri

https://ruralandfarmfinance.com/

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SCAN ME

Potential Paths to Cleaner Corn

Dr. Plastina speaks about the 45Z Tax Credit, which rewards e
producers for achieving a CI score below the qualifying thres
how this could incentivize corn growers to consider climate-
agricultural practices.

Learn more about how the 45Z Tax Credit could benefit corn
https://ethanolproducer.com/articles/calculating-paths-to-

Texas
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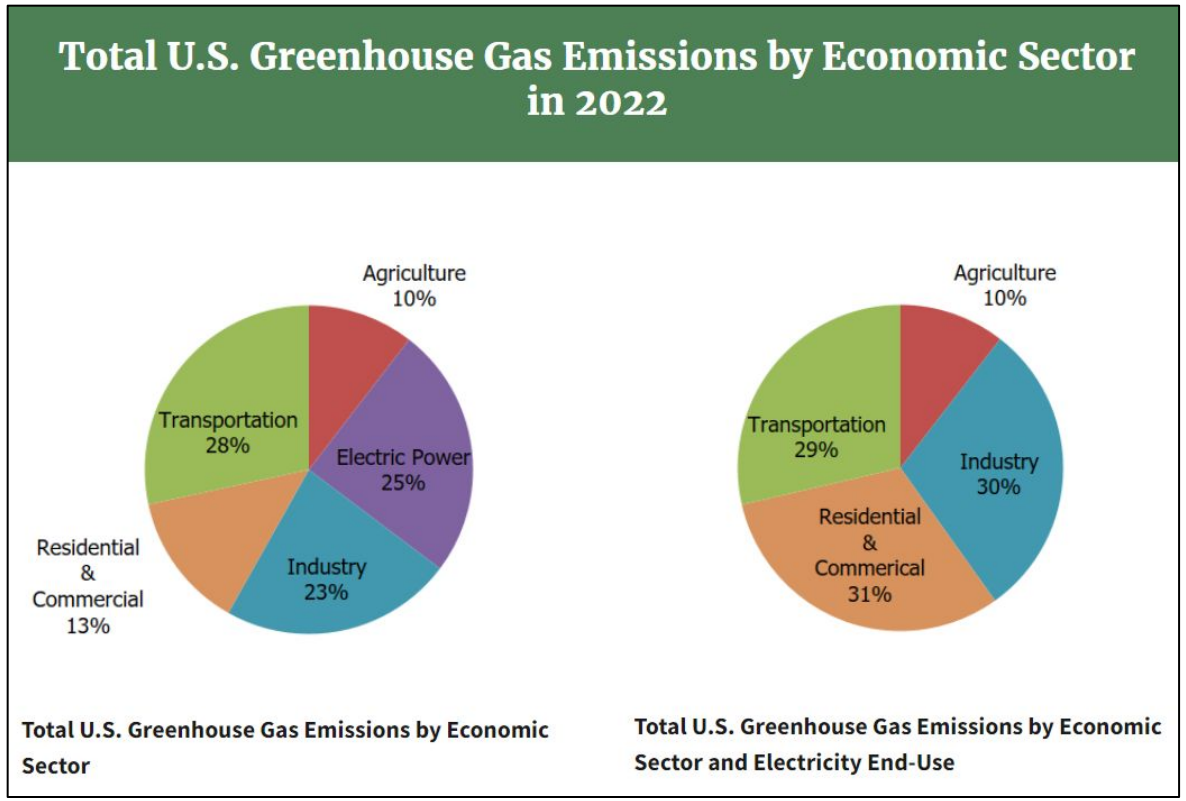
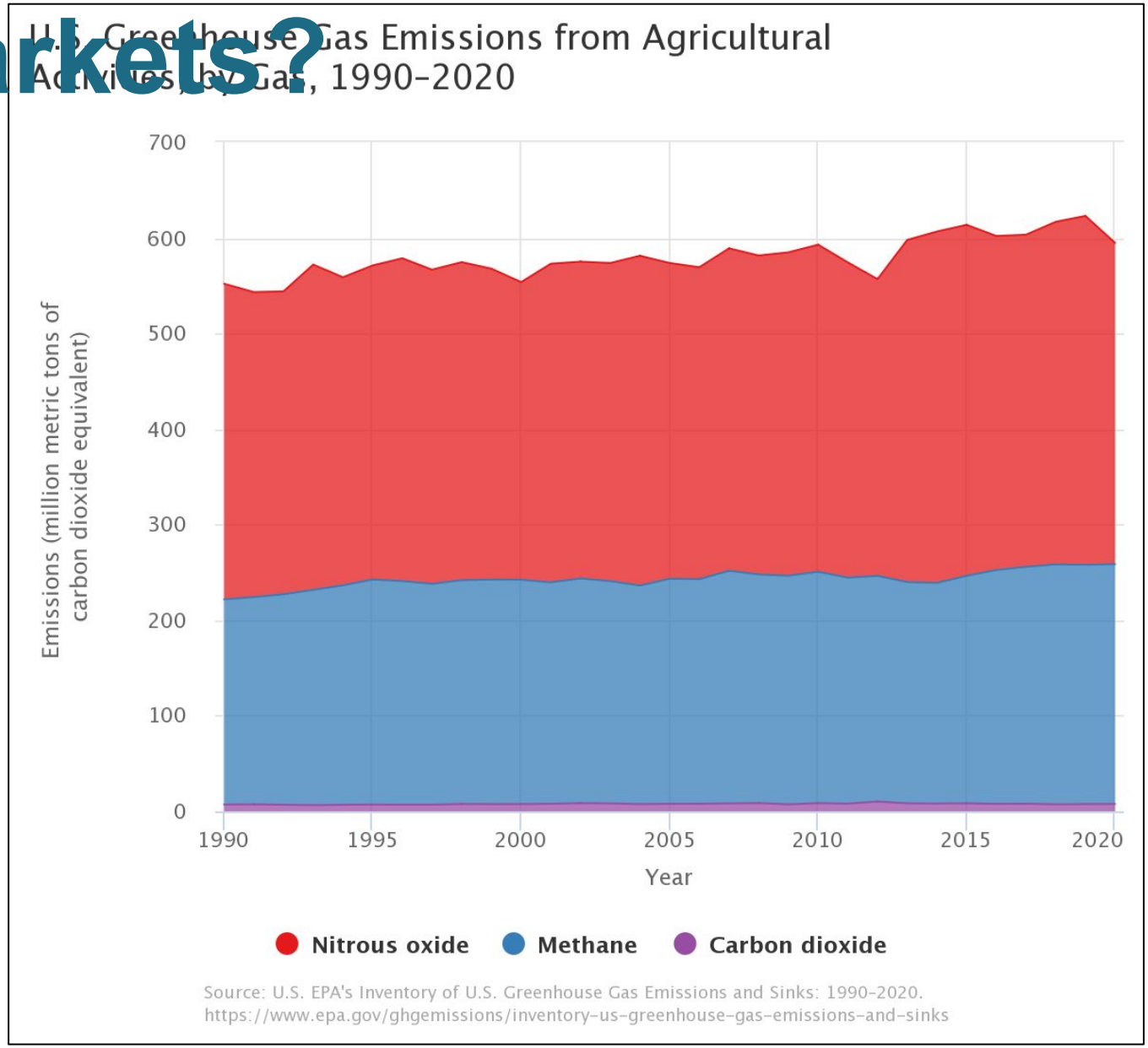
Business case for carbon markets

These pledges require adopting low GHG emission technologies in the long run. Meanwhile, carbon credits are used to reduce net emissions.

What role for ag in voluntary carbon markets?





https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

Sources of Revenue from Carbon Farming

What is traded?	Carbon Offsets
Typical buyers	Large corporations
Typical goal	Reduce carbon footprint of the corporation
Farmers' role	Adopt conservation practice & reduce GHG emissions
Payments to farmers	$ per Mt CO_2e
Additionality	Required

Example: Offsets vs. Insets

Kraft Heinz

Achieve **net zero carbon emissions** by 2050, halving same by 2030.

Kraft Heinz can:

- Buy carbon credits from the forestry sector to reduce its net GHG emissions **carbon offsetting**
- Buy low-carbon intensity tomatoes to produce a low-carbon intensity ketchup **carbon insetting**

How to Farm Carbon?

Some agricultural practices can **remove GHGs*** from the atmosphere **or avoid GHG emissions**:

- Reducing tillage intensity
- Planting cover crops
- Reducing fertilizer rates, switching from commercial fertilizer to compost
- Converting marginal cropland to grassland
- Planting trees
- Reducing stocking rates on pastures

*Greenhouse Gases (GHGs): carbon dioxide, nitrous oxide, methane, etc.

U.S. Agricultural Carbon Initiatives…

… connect carbon credit demand and supply

agoro CARBON™ ALLIANCE

ESMC Ecosystem Services Market Consortium

CIBO TECHNOLOGIES

CORTEVA™ agriscience

BAYER

Soil and Water Outcomes Fund

indigo™

~~Nori~~

…using different models to quantify CO_2e

Plenty of Interest

Source: ESMC

Voluntary Ag Carbon Initiatives (Offsets & Insets)

- **Payments per Output** ($ per ton of CO2e removed/avoided)
  1. Carbon by Indigo 2. CIBO Carbon Credits 3. Corteva
  4. ESMC's Eco-Harvest ~~5. Nori~~ 6. Cargill's RegenConnect
  7. Soil and Water Outcomes Fund 8. TruTerra Carbon

- **Payments per Practice** ($ per acre, or $ per N reduction)
  1. ADM's re:generations 2. Bayer Carbon 3. Indigo Ag:Market+ Source
  4. PepsiCo-PCM 5. TrueTerra N Mgmt Incentive 6. TruTerra Finan. Assist.

- **Practice- and Outcome-based payments**
  1. Agoro Carbon Alliance 2. Locus Ag CarbonNow
  3. CIBO Carbon Bridge 4. Nutrien's Sustainable N Outcomes

Ag Carbon Initiatives

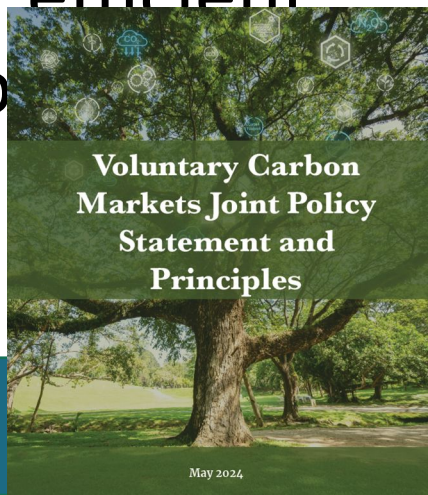
Characteristic	Indigo C[1]	CIBO CC[2]	Corteva	ESMC EH[3]	Nori	Cargill RC[4]	SWOF[5]	Truterra CP[6]	ADM R[7]	Bayer C[8]	Indigo MS[9]	PepsiCo-PCM	Truterra NMI[10]	Truterra FI[11]	Agoro C[12]	CarbonNow	CIBO CB[13]	Nutrien SNO[14]
Payment scheme																		
Output-based	Y	Y	Y	Y	Y	Y	Y	Y							Y	Y	Y	Y
Practice-based									Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Contract length																		
Individual contract (in years)	5	10	5	5	10	1	1	1	1	5	1	1	1	1	10	4	10	1
Possible renewals (in # of contracts)	2			3		U	U		U	3	U	U	U	U				9
MMRV																		
Years of hist. field mgmt. data	3-5		3-5	3	10	4	2-3	U		4		3	3	U	3	5		3
Soil samples	Y			Y			Y			Y					Y	Y	Y	Y
Remote sensing						Y	Y		Y	Y							Y	
Satellite imagery	Y								Y									
Carbon measurement																		
Climate Action Reserve	Y		Y															Y
Verra VM0042		Y													Y	Y	Y	
DNDC				Y														
COMET-Farm					Y		Y											
Unspecified								Y		Y			Y	Y				
Carbon registry	C	V	C		W			U		W			U	U	V	V	V	C
Carbon credit use																		
Offsetting	Y	Y	Y		Y			Y		Y			Y	Y	Y	Y	Y	Y
Insetting				Y		Y	Y	Y	Y		Y	Y	Y	Y			Y	
Test protocols (PCSA)									Y					Y				
Stacking of USDA payments	Y	Y	Y	Y	Y	Y	Y	U	Y*	Y		Y	U	U		Y	Y	U
Look-back payment	Y				Y				Y	Y	Y**							
Permanence assurance mechanism	Y				Y					Y					Y	Y		

Methods to Quantify Carbon Credits	Carbon Initiatives
• COMET Farm, https://comet-farm.com/	• Soil and Water Outcomes Fund
• Soil Metrics Greenhouse Gas Inventory Tool (GGIT), https://soilmetrics.eco/technology/ (based on COMET Farm)	• Indigo Ag • Corteva Carbon
• Operational Tillage Information System (OpTIS), https://www.ctic.org/OpTIS	• Cargill's RegenConnect™
• Denitrification-Decomposition (DNDC) Model, https://ctic.org/DNDC_Information	• ESMC's Eco-Harvest • Cargill's RegenConnect™
• Verra's VM0042, https://verra.org/methodologies/vm0042-methodology-for-improved-agricultural-land-management-v1-0/	• Agoro Carbon Alliance • CarbonNow • CIBO Carbon Credits
• SALUS (system approach for land use sustainability) https://www.cibotechnologies.com/salus-model/	• CIBO Carbon Credits

USDA, Dept. of the Treasury, Dept. of Energy Guidelines

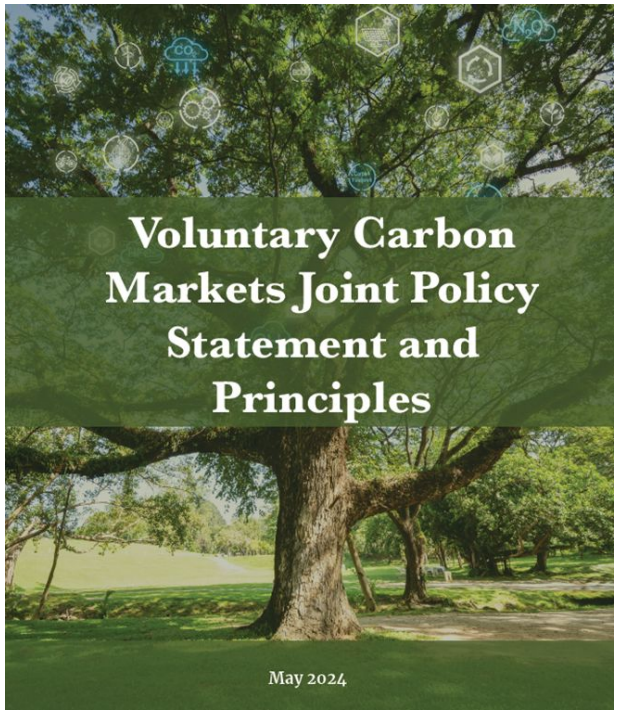
We encourage the U.S. private sector and other stakeholders in the carbon credit value chain to responsibly participate in Voluntary Carbon Markets, consistent with the principles below. These principles recognize the need for:

- credit integrity (i.e., "supply integrity");
- credible credit use (i.e., "demand integrity");
- and market-level integrity, including facilitating efficient market participation and lowering transaction co



Traits of “High-Integrity” Carbon Credits

a. Additional
b. Real and Quantifiable
c. Permanence
d. Unique
d. Robust baselines
e. Validation and verification



GHG removal/avoidance cannot be assessed by buyers/users

- **Need for Strong Measuring, Monitoring, Reporting, and Verification (MMRV) Systems**

What's the cost of cover crops and no-till in Indiana?

Cereal rye, herbicide termination (NRCS):	No-till and strip-till (NRCS):
$	$24.28 /a
- EQIP pmt $ /a	- EQIP pmt $18.40 /a
Out of pocket cost: **$21.21/a**	Out of pocket cost: **$5.82/a**

Non-cash costs?

Management time, depreciation, etc.

Yield drag?

https://www.nrcs.usda.gov/getting-assistance/payment-schedules#I-M

How large does the Carbon Payment need to be?

Cereal rye, herbicide termination (NRCS): $85.23 /a

- EQIP pmt $63.92 /a

Out of pocket cost: **$21.21/a**

Example 1. Assume:

- Farmer willing to invest $5/a to improve soil health in the long run
- Cereal Rye reduces yields by 2 bu/a
- Corn price $4.10/bu
- Cost Calculation:

$21.21 – $5 + 2 x $4.10 = $ 24.41

Lowest carbon payment to break even: $24.41 /a

How much are Voluntary Carbon Initiatives paying?

- **Payments per Practice:**

  $5 - $15 per acre Insufficient < $ 24.41 per acre

- **Payments per Output:**

  $25 - $40 per $MtCO_2e$

  How much Carbon must by sequestered to break-even?

$24.41 per acre / $25 per $MtCO_2e$ = 0.98 $MtCO_2e$ per acre

$24.41 per acre / $40 per $MtCO_2e$ = 0.61 $MtCO_2e$ per acre

Annual average GHG emission reduction (COMET-P.)

	Cover Crops ($mtCO_2e$/acre)		
	Mean	Min	Max
Heartland	**0.282**	**-0.121**	**1.900**
Northern Crescent	0.089	-0.089	0.778
Northern Great Plains	0.047	-0.388	0.353
Prairie Gateway	0.146	-0.408	1.285
Eastern Uplands	0.353	-0.111	1.925
Southern Seaboard	0.297	-0.099	1.925
Fruitful Rim	0.188	-0.998	1.680
Basin and Range	0.027	-0.998	0.788
Mississippi Portal	0.615	-0.153	1.982
U.S. Total	**0.230**	**-0.998**	**1.979**

The net effect of cover cropping on GHGs is measured in metric tons of Carbon Dioxide Equivalent (CO_2e) units per acre.

The net effect is measured by comparing GHG emissions without cover crops and GHG emissions with cover crops

All GHGs are expressed in CO_2e units according to their relative global warming potential (gwp). Ex.: CO_2=1; N_2O=298; CH4=28 gwp units over 100 years.

Annual average GHG emission reduction (COMET-P.)

Cover Crops ($mtCO_2e$/acre)			
	Mean	Min	Max
Heartland	**0.282**	**-0.121**	**1.900**

$25/$MtCO_2e$ □Min 0.98 $MtCO_2e$	$40/$MtCO_2e$ □Min 0.61 $MtCO_2e$	$25/$MtCO_2e$ □Min 0.98 $MtCO_2e$	$40/$MtCO_2e$ □Min 0.61 $MtCO_2e$
Not Feasible	**Not Feasible**	**Feasible**	**Feasible**

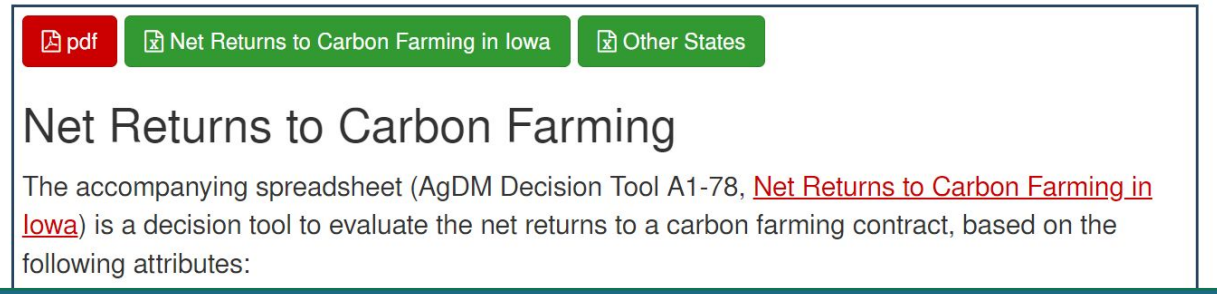
Heartland region (yellow): In counties with **high sequestration potential,** carbon payments may be sufficient when carbon price = **$25 per $MtCO_2e$**

Marion Co., IN: 0.27 $MtCO_2e$ < Min 0.61 MtCO2e □ Not feasible to break-even

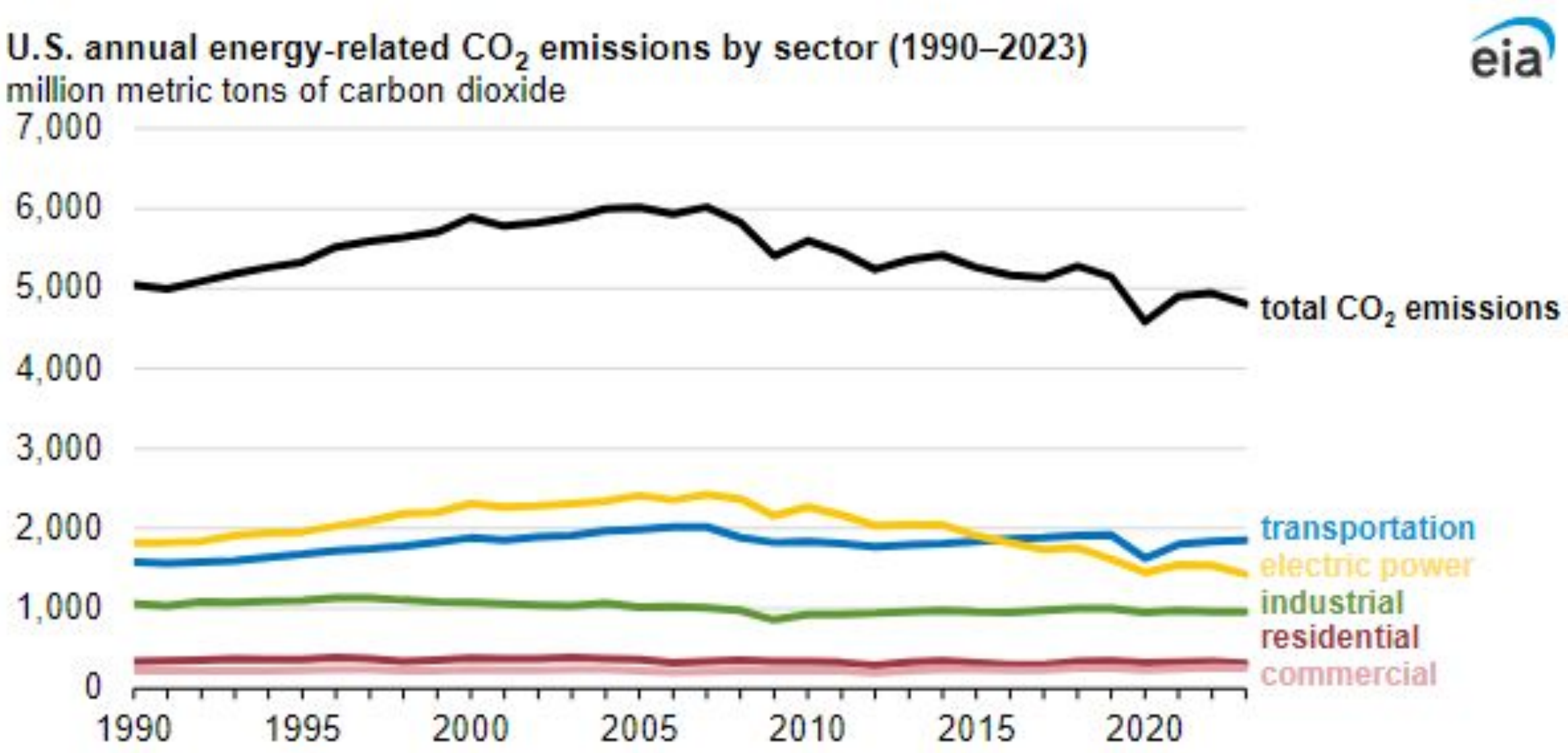
Is Carbon Farming Profitable in Your Farm?

- DECISION TOOL: Ag Decision Maker File A1-78
- **66 practices** for working croplands
- Payments: **per-practice** & **per-output**
- **Stacked cost-share** payments
- By county for the 50 states
- Net GHG emission reduction estimates from COMET-Planner

https://go.iastate.edu/B46UXX



Clean Fuel Production Credit: 45Z Federal Tax Credit (2025-2027)



Lower GHG emissions from the electricity sector drove down total US emissions. The next policy goal is to reduce transportation emissions.

45Z Federal Tax Credit to Fuel Refineries (not farmers)

Tax Credit per gallon of Clean Fuel sold = Pmt. Rate × EF

EF = [1- ($kgCO_2e$ per mmBTU/ 50 $kgCO_2e$ per mmBTU)]

Payment Rate	Base Rate	Premium Rate ^
Non-Sustainable Aviation Fuel (Non-SAF)	$0.20	$1.00
Sustainable Aviation Fuel (SAF)	$0.35	$1.35

^Wage and apprenticeship requirements are met by fuel refinery.

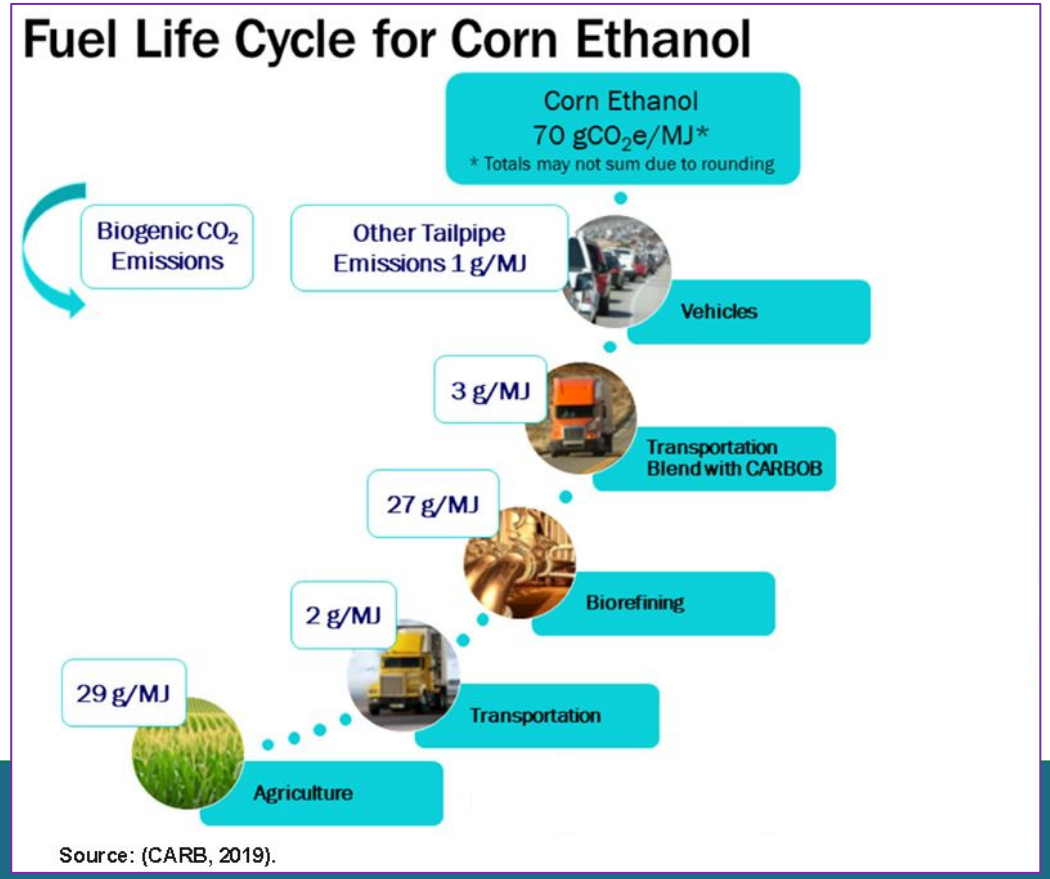
Example: Non-SAF, base rate, 25 kg CO_2e/mmBTU

Tax Credit per gallon of Clean Fuel sold = $0.20 × [1-(25/50)] = $0.10

Source: *https://crsreports.congress.gov/product/pdf/IF/IF12502*

45Z Federal Tax Credit to Fuel Refineries (not farmers)

- Rules and models for the 45Z tax credit under development.
- Examples based on current GREET model, similar to:



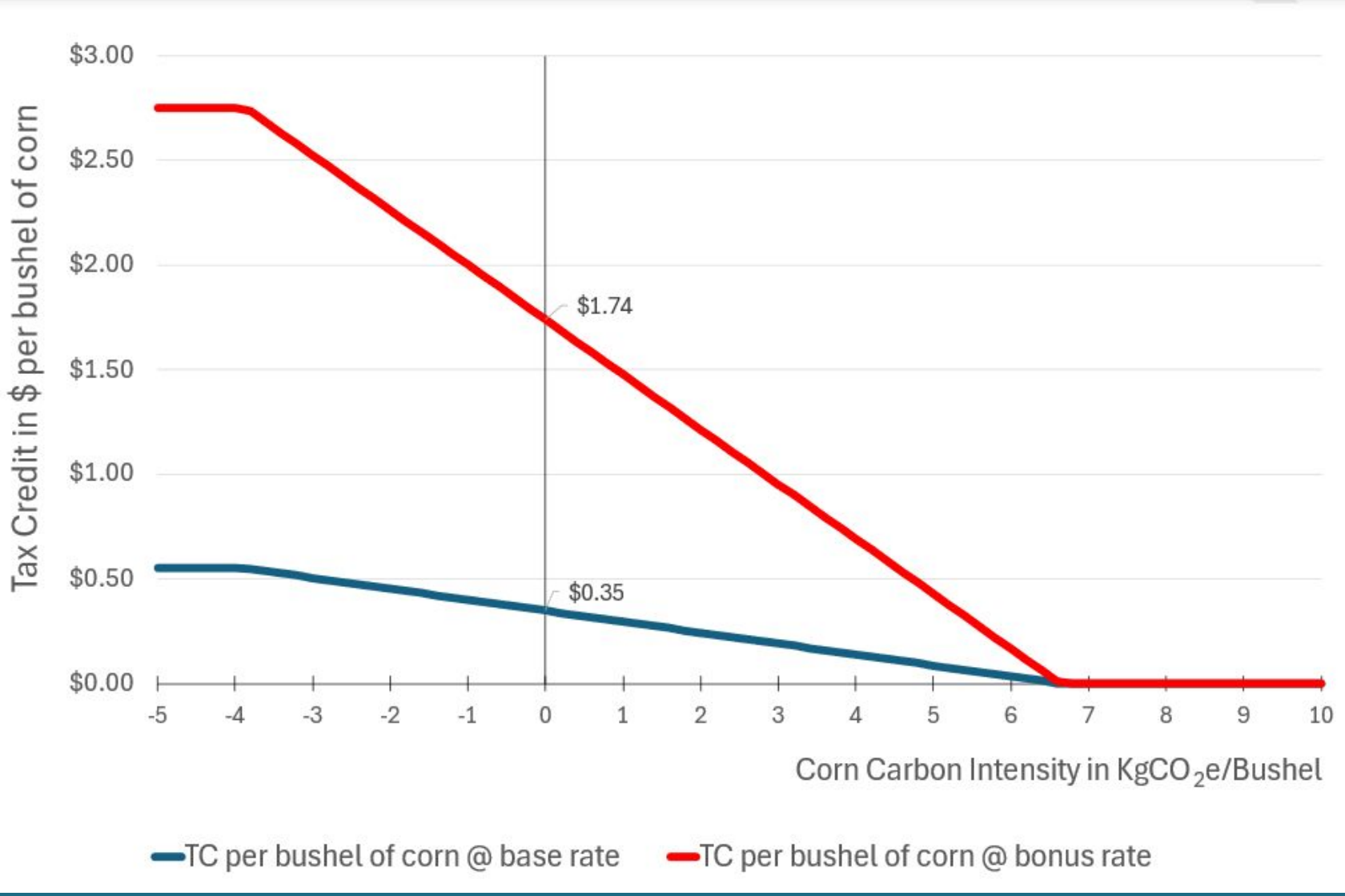
California GREET (Greenhouse Gases, Regulated Emissions, and Energy Use)

Agriculture: 41% of Corn Ethanol Emissions

Highest possible price premium for low CI corn, $/bu

Assuming:

- 100% pass-through to farmers
- Non-SAF
- Engineering process adds 18.4 $kgCO_2e$/mmBTU per gallon
- 2.75 gallons of ethanol per bushel of corn
- 233.85 mmBTU per bushel of corn



Carbon Intensity Score (CIS) Calculator for Corn

Goals:

- Calculate the average CIS of corn under current farming practices,
- Calculate the expected change in CIS under new farming practices,
- Project the Federal Tax Credit 45Z that ethanol plants would obtain from using the corn supplied by the farmer as feedstock
- Project the potential extra-revenue for the farmer

 22 states in the GREET model, results by county

Example for Marion County, Indiana

Assumptions:

- 80 acres, no cover crops, no manure use, conventional tillage
- Corn yield is 185 bushels per acre
- Nitrogen fertilizer: 1 lb N per bushel of corn
- Practice changes: add cover crops, switch to reduced tillage
- Ethanol plant meets labor requirements Pmt. Rate $1/gallon

Carbon Intensity Score Calculator

Ag Decision Maker File A1-80

Ag Decision Maker -- Iowa State University Extension and Outreach

Enter your input values in shaded cells.

1. Select the cell below and choose a state and a county from the dropdown menu

State	Indiana
County	Marion

2. Farming Practices

Corn Acres	80

Current farming practices		
Cover crop use	No cover crop	
Manure use	No manure	
Tillage practice	Conventional tillage	
Your fertilizer use	185	lbs of N/acre
Your yield	185	bushel/acre

^Decreases must be entered with a negative sign in front of the number. Example: A 10 unit decrease should be entered as "-10".

https://www.extension.iastate.edu/agdm/crops/html/a1-80.html

3. Your Carbon Intensity (CI) Score, based on R&D GREET Model (2023)*

Current farming practices	
CI Score from corn	6,880 gCO2e/bushel
CI Score from soil	456 gCO2e/bushel
Current Total CI Score	*7,336 gCO2e/bushel*

Note: gCO2e/bushel stands for grams of carbon dioxide equivale

Equivalent: using energy units instead of bushels:

Current farming practices	
CI Score from corn	31.07 gCO2e/MJ
CI Score from soil	2.06 gCO2e/MJ
Current Total CI Score	*33.13 gCO2e/MJ*

Note: gCO2e/MJ stands for grams of carbon dioxide equivalent emissions per megajoule of energy in ethanol fuel.
These calculations assume one bushel of corn yields 2.75 gallons of ethanol, and one gallon of ethanol contains 80.5324 MJ of energy.
You can modify these assumptions in the Details tab.

*Wang M et al. (2023) Summary of expansions and updates in R&D GREET 2023. Available at: https://greet.anl.gov/publications.

^The CI Score improves when the *New Total CI Score* is lower than the *Current Total CI Score*. Negative values for *Improvement in CI Score* indicate a worsening of the Total CI Score, and occur when the *New Total CI Score* is higher than the *Current Total CI Score*.

https://www.extension.iastate.edu/agdm/crops/html/a1-80.html

4. Highest Projected 45z Tax Credit (TC) for Ethanol Plants from Your Corn Production:

Basic Tax Credit	$	0.20	per gCO2e/MJ below Industry Average CI Score
Bonus Tax Credit*	$	1.00	per gCO2e/MJ below Industry Average CI Score

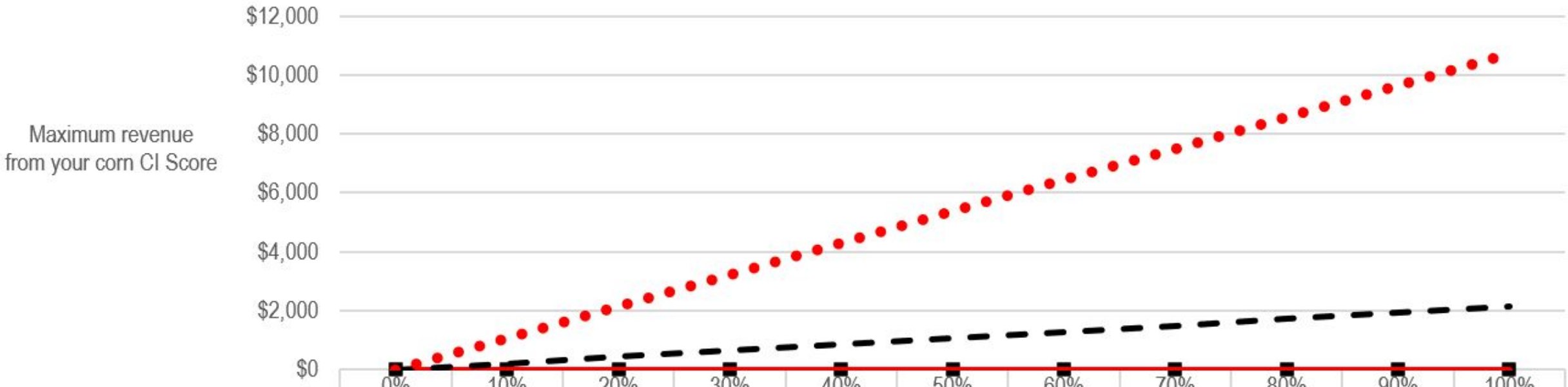
*Bonus Tax Credits can be claimed by ethanol plants that comply with additional wages and apprenticeship requirements.

Current farming practices & Bonus Tax Credit			
Highest projected TC value	$	-	per gallon
Highest projected TC value	$	-	per bushel
Highest projected TC value	$	-	per acre
Highest projected TC value	$	-	per farm

New farming practices & Bonus Tax Credit			
Highest projected TC value	$	0.27	per gallon
Highest projected TC value	$	0.73	per bushel
Highest projected TC value	$	134.02	per acre
Highest projected TC value	$	10,721	per farm

What % of the TC will be passed-through to farmers?

6. Maximum amount you could receive for your corn from the ethanol plant, by share of Tax Credit passed-through:



	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Current Practice Basic TC	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Current Practice Bonus TC	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
New Practice Basic TC	$0	$214	$429	$643	$858	$1,072	$1,287	$1,501	$1,715	$1,930	$2,144
New Practice Bonus TC	$0	$1,072	$2,144	$3,216	$4,288	$5,361	$6,433	$7,505	$8,577	$9,649	$10,721

Share of tax credits passed-through to you

https://www.extension.iastate.edu/agdm/crops/html/a1-80.html

Examples for Non-SAF in Marion County, IN

Scenarios	Δyield bu/acre*	Yield bu/acre	ΔCI gCO_2e/bu	CI gCO_2e/bu	Lost Revenue^ $/acre	CI Revenue (base; bonus) $/acre	Pass Through Required to Offset Lost Revenue+ (base; bonus)
Baseline: CT		**185**		**7,336**	$0.00		-
CC	**-2**	**183**	**-3,683**	**3,653**	**$8.20**	**$26.8; $134.02**	**31; 6**
M	-5	180	-7,887	-551	$20.50	$66.05; $330.26	31; 6
RT	0	185	-456	6,880	$0.00	$0; $0	Ins.; Ins.
NT	-8	177	-1,039	6,297	$32.80	$1.37; $6.86	Ins.; Ins.
CC, M	-7	178	-9,959	-2,623	$28.70	$84.66; $423.32	34; 7
CC, RT	-2	183	-4,922	2,414	$8.20	$38.69; $193.45	21; 4
CC, NT	-10	175	-6,206	1,130	$41.00	$48.79; $243.95	84; 17
CC, M, RT	-7	178	-10,718	-3,382	$28.70	$91.74; $458.71	31; 6
CC, M, NT	-15	170	-11,986	-4,650	$61.50	$98.93; $494.66	62; 12

CT – Conventional Till, CC – Cover Crops, M – Manure, RT – Reduced Till, NT – No Till

* *1 lb N/bu* ^Corn price $4.10/bu Ins. – Insufficient

Examples for Non-SAF in Marion County, IN

Scenarios	Δyield bu/acre*	Yield bu/acre	ΔCI gCO_2e/bu	CI gCO_2e/bu	Lost Revenue^ $/acre	CI Revenue (base; bonus) $/acre	Pass Through Required to Offset Lost Revenue+ (base; bonus)
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CT – Conventional Till, CC – Cover Crops, M – Manure, RT – Reduced Till, NT – No Till

* *1 lb N/bu* ^Corn price $4.10/bu Ins. – Insufficient

Besides lost revenue from yield drag, can all costs be covered?

Cereal rye, herbicide termination (NRCS):

$85.23 /a

- EQIP pmt $63.92 /a

Out of pocket cost:

$21.21/a

No-till and strip-till (NRCS):

$24.28 /a

- EQIP pmt $18.40 /a

Out of pocket cost:

$5.82/a

Non-cash costs?

https://www.nrcs.usda.gov/getting-assistance/payment-schedules#I-M

Concluding Remarks

- Conservation practices provide multiple environmental benefits, but not all farms find those practice profitable.
- Stacking payments from cost-share programs (EQIP, CSP, etc.) and voluntary carbon initiatives brings some farmers closer to break-even and might help make a profit.
- 45Z Tax Credits paid to Fuel Refineries. Crop CI score is location- and practice-specific. Local price premiums for low-CI feedstocks might be insufficient to entice some farmers.

Actionable recommendations

- Run a quick & free CI assessment: AgDM File A1-78
- Explore Programs and Incentives
- Consult with Crop Advisors, Legal Advisors
- Stay updated on the topic
- Evaluate individual costs and benefits & ask plenty of questions before agreeing to change practices.

Free Resources

1) **Carbon Intensity Score Calculator**
https://www.extension.iastate.edu/agdm/crops/html/a1-80.html

2) **How to Grow and Sell Carbon Credits in US Agriculture**
https://www.extension.iastate.edu/agdm/crops/pdf/a1-76.pdf

3) **What's in Store for Voluntary Agricultural Carbon Markets?**
https://www.card.iastate.edu/ag_policy_review/article/?a=136

4) **Net Returns to Carbon Farming**
https://go.iastate.edu/B46UXX

5) **Carbon Farming: Stacking Payments from Private Initiatives and Federal Programs**
https://www.extension.iastate.edu/agdm/crops/pdf/a1-40.pdf

Thank you for your time!

Dr. Alejandro Plastina
Rural and Farm Finance Policy Analysis Center (RaFF)
University of Missouri
130 Mumford Hall
Columbia, MO 65211
(573) 882 – 3861

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