Frequently Asked Questions:

Carbon Capture & Sequestration, CO_2 Pipelines, and the Future of Corn Ethanol

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What is carbon intensity and why does it matter for corn ethanol?

Carbon intensity (or "CI") is a measurement of the total greenhouse gas ("GHG") emissions associated with every stage in the production and use of transportation fuels. For ethanol, this includes emissions tied to planting, growing, and harvesting corn, as well as emissions from the ethanol biorefinery.

In recent years, state and federal laws have begun to require (or reward) reductions in the carbon intensity of transportation fuels. Under these laws, the use of fuels with high carbon intensity (like petroleum-based gasoline and diesel) will decline over time, while the use of fuels with low carbon intensity will increase. Thus, to remain competitive and maintain (or grow) market share, ethanol needs to continue to lower its CI over the long term.

What ethanol markets require reductions in carbon intensity? Is this just a 'California thing'?

While California was the first to adopt a **Low Carbon Fuel Standard** ("LCFS") requiring annual reductions in the carbon intensity of fuels, many other states have adopted—or are planning to adopt—similar programs. Oregon and Washington both have LCFS-like laws that require carbon intensity reduction, while New York, New Mexico, Minnesota, Illinois, Michigan, and other states are pursuing similar programs. There also is discussion in Congress today about potential adoption of a nationwide LCFS.

Together, **California**, **Oregon**, and **Washington** consume about **2 billion gallons** of ethanol annually (roughly equivalent to **700 million bushels** of corn), representing about **14%** of total U.S. ethanol demand. To maintain or grow the West Coast market for ethanol moving forward, ethanol producers will need to continue reducing the CI of the fuel they are producing.

In addition, key ethanol export markets require CI reductions as well. **Canada**, the **United Kingdom**, **Europe**, **Brazil**, **Japan**, and several other countries have existing laws that require lower-carbon fuels. In 2022, more than **800 million gallons** of U.S. ethanol (equivalent to **275 million bushels**) were exported to countries with clean fuel programs and CI reduction requirements. If we want to maintain or grow key biofuel export markets, the industry will need to continue reducing the CI of our ethanol.

Isn't ethanol already a low-carbon fuel?

Yes, today's corn ethanol is already a low-carbon fuel. According to the Department of Energy and California Air Resources Board, the CI of modern corn ethanol is approximately **40-50% lower** than the CI of gasoline (i.e., ethanol's CI is approximately 50-55 grams of CO_2/megajoule of energy, while gasoline is at 95-100 g/MJ). That's why blending corn ethanol has been an attractive method for meeting the CI reduction requirements of West Coast and international LCFS programs over the past decade.

However, the CI reduction requirements under these programs grow significantly more stringent over time. California, for example, has proposed a CI reduction schedule that requires fuels to achieve a 30% CI reduction versus gasoline by 2030 and zero GHG emissions (on a net basis) by 2045.

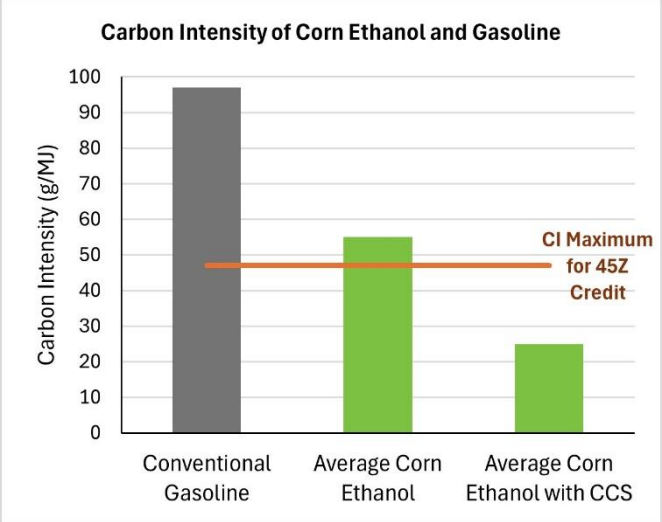
Because ethanol is often **limited to only 10-15%** of the gasoline blend, ethanol with a 40-50% CI reduction will not be sufficient by itself to help fuel suppliers meet their future CI reduction requirements. This speaks to the importance of pushing for the use of **higher ethanol blends (like E20-E30 and E85)** while **simultaneously working to lower ethanol's CI**.

What is Carbon Capture and Sequestration (CCS) and how does it help ethanol's carbon intensity?

Carbon capture and sequestration ("CCS") is a method for reducing CO_2 emissions from industrial processes. CO_2 is captured at the industrial facility where it is produced then transmitted to a site where it can be permanently stored deep underground. The production of corn ethanol at a biorefinery creates CO_2 in two ways. First, CO_2 is generated when the starch is fermented into ethanol. Second, CO_2 is emitted as result of using natural gas, electricity, and other process energy sources at the biorefinery.

CO_2 from ethanol fermentation has been identified as one of the **purest, lowest-cost, and easiest sources** of CO_2 to capture and sequester. It is also **"biogenic"** CO_2, which means it comes from plant-based organic material, not fossilized carbon. Moreover, capturing CO_2 from ethanol fermentation results in a **true removal of atmospheric carbon** (i.e., the CO_2 started out in the atmosphere; it was then absorbed by corn plants via photosynthesis; it was then re-released during fermentation; and finally, it was captured and permanently removed).

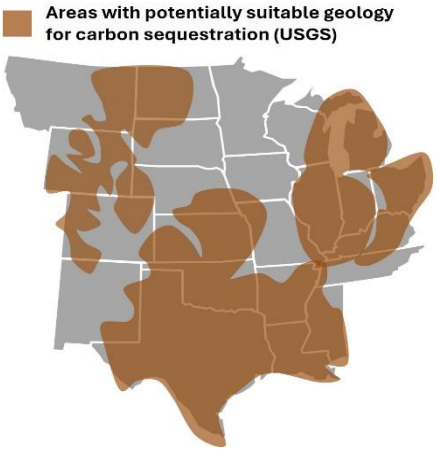
Adding CCS to an ethanol biorefinery results in a significant drop in the CI of the ethanol produced. Corn ethanol's CI falls from 50-55 g/MJ to just **20-25 g/MJ** when CCS is added, meaning the ethanol now achieves a **75-80% GHG reduction** compared to gasoline. The lower CI resulting from CCS helps ethanol remain highly competitive in U.S. and global markets where carbon reduction is required or rewarded. In fact, the 75-80% GHG reduction achieved by ethanol with CCS is similar to the GHG reduction achieved by a battery electric vehicle running on low-carbon electricity.



Why are CO_2 pipelines needed?

Storing CO_2 underground requires unique geological rock formations, which only exist in certain areas of the country. Certain parts of North Dakota, South Dakota, Nebraska, Kansas, Illinois, Indiana, Michigan, and Ohio have been identified as having potentially suitable geology for permanent underground CO_2 storage.

However, many ethanol biorefineries operate in areas where the underground geology is not suitable for CO_2 sequestration. Thus, pipelines are necessary to transport the captured CO_2 from these facilities to the nearest appropriate geological sequestration sites.



Are there tax credits available for capturing and sequestering carbon? Who receives them? Is this all part of a 'Green New Deal'?

The tax credit for carbon sequestration is **not new**. In fact, the CCS credit (known as the Section **45Q** credit) was first introduced into the tax code more than **15 years ago**. The credit was expanded and extended in the Bipartisan Budget Act, which was signed into law by President Donald Trump in 2018. In 2022, Congress again expanded and extended the credit as part of the Inflation Reduction Act. CCS tax incentives are **not** part of the "Green New Deal" that was introduced in both the U.S. House and Senate.

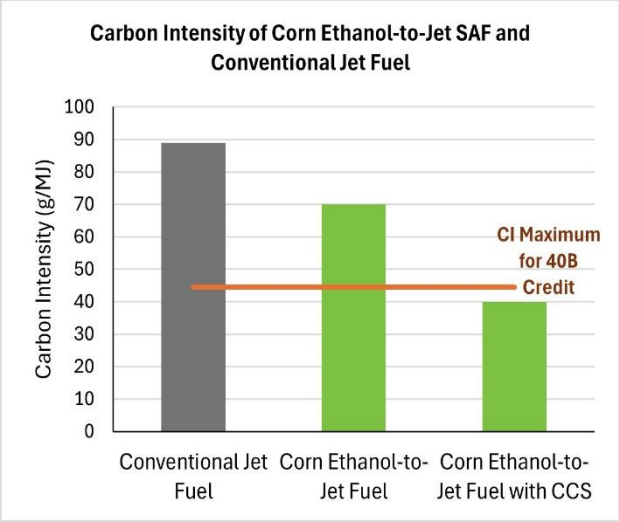
The 45Q credit provides **$85 per metric ton** of CO_2 sequestered in geological formations. This is equivalent to roughly **$0.23 per gallon of ethanol**, or $0.66 per bushel of corn used for ethanol. The credit is available to taxpayers who own qualified facilities for a period of **12 years** after the CCS equipment is placed in service. In the case of ethanol, the qualified facility could likely be either the ethanol biorefinery or the adjoining CCS facility.

The Inflation Reduction Act also included a Clean Fuel Producer Tax Credit (called the Section **45Z** credit), which provides a tax credit to the producer of a clean fuel based on the CI of the fuel. Clean fuels start generating credit at a CI of approximately 47 g/MJ (remember, most corn ethanol today is in the 50-55 g/MJ range, meaning it would not qualify for the credit). As the CI of the fuel drops, the value of the credit increases, reaching a maximum of **$1 per gallon** at a CI value of 0 g/MJ ("net zero"). Again, CCS can lower the CI of today's corn ethanol to roughly 20-25 g/MJ, which would result in a 45Z tax credit value of roughly **$0.50-0.60 per gallon**.

What is the link between CCS, pipelines, and sustainable aviation fuel?

In 2022, Congress passed a law creating a tax credit intended to spur production and use of **sustainable aviation fuel** ("SAF"), which is a renewable, lower-carbon form of aviation fuel. The tax credit (called the Section **40B** credit) is available to aviation fuel blenders; in order to qualify, SAF must reduce CI by at least 50% compared to conventional jet fuel. Like the 45Z credit, the value of the 40B SAF credit increases as the CI of the SAF decreases. SAF with a CI of 44 g/MJ would just meet the 50% reduction threshold and would generate a tax credit worth **$1.25 per gallon**; that value increases to a maximum of **$1.75 per gallon** for SAF with a CI of 0 g/MJ ("net zero").

Corn ethanol can be made into SAF using the ethanol-to-jet process. But SAF made from today's typical corn ethanol has a CI value of about 70 g/MJ, meaning it would not qualify for the tax credit on its own. However, with the addition of CCS, typical corn ethanol-based SAF could achieve a CI value of about 40 g/MJ, which would generate a tax credit worth roughly **$1.30 per gallon**. SAF is a **potentially enormous market opportunity for corn and ethanol**, as the U.S. aviation fuel market is roughly **25 billion gallons** in size. However, without CCS and pipelines to transport CO_2 from existing ethanol biorefineries, it could be exceedingly difficult for corn and ethanol producers to participate in the SAF opportunity.



Aside from CCS, aren't there other ways to reduce the carbon intensity of ethanol?

Yes. Adding CCS is not the only way for a biorefinery to lower the CI of the ethanol it is producing. A recent study identified more than two dozen technologies and production practices that can help move ethanol's CI closer to zero.

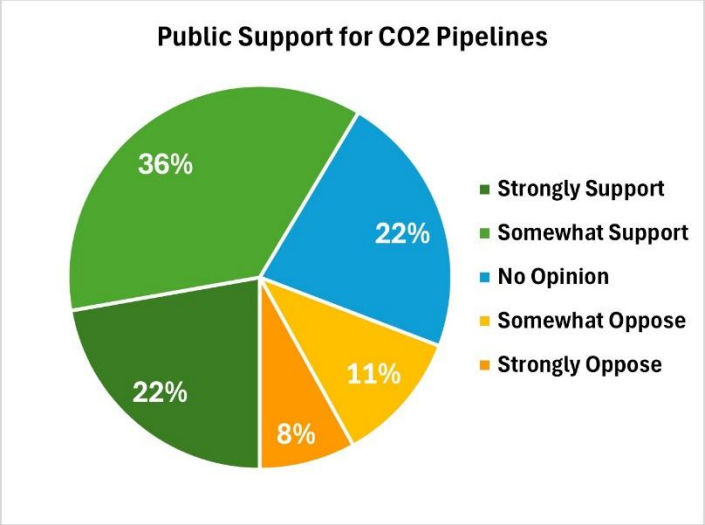
Replacing fossil-based natural gas and electricity use with renewable gas and electricity at the biorefinery (e.g., wind or solar) is one way to significantly reduce CI. Using captured CO_2 as a building block for new products, chemicals, and feedstocks is another way. Collaborating with farmers to further reduce the carbon intensity of corn production is yet another way (e.g., through adoption of cover crops, no-till, lower-carbon fertilizers, renewable fuels in farm machinery, etc.). However, current LCFS programs (like California) do not allow for the inclusion of low-carbon farming practices in CI calculations, and it is unclear how such practices may or may not be credited under the 40B and 45Z tax credit programs.

For now, CCS appears to be the most economically and technologically feasible method for reducing the CI of ethanol. The technology is proven and ready for broad deployment at a relatively low cost.

Does the public support CCS and these pipeline projects?

Yes. Recent polling of registered voters shows strong public support for using pipelines to facilitate permanent removal of CO_2 from the atmosphere. A December 2023 nationwide survey of 1,991 voters conducted by polling firm Morning Consult asked this question:

"*As you may know, some companies plan to capture carbon dioxide at ethanol production facilities and transfer it through underground pipelines to permanent storage sites to reduce the amount of carbon dioxide in the atmosphere in a process known as carbon sequestration. After learning more,* ***do you support or oppose efforts to sequester carbon using underground pipelines*** *to reduce the amount of carbon dioxide in the atmosphere?"*



In response, **58% expressed support** for CO_2 pipelines, with only 19% opposed and 22% with no opinion. Of those voters expressing an opinion on CCS, supporters outnumber opponents by a margin of **3 to 1**.

Why are some environmental groups opposed to CCS and pipelines?

That's **a good question**. For years, environmental activists have been advocating for laws and policies that reduce GHG emissions and remove CO_2 from the atmosphere. They have argued that reducing GHG emissions and battling climate change is in the public interest, and they have pushed the industrial sector to take immediate steps to cut carbon intensity.

Now, these same activist groups are raising opposition to CCS and the use of pipelines to remove CO_2 from the atmosphere. Some extremists, like Earthjustice, claim that CCS poses "safety and health threats" and "diverts resources away from real climate solutions like electrification." Shutting down CCS isn't Earthjustice's only goal—the group also wants to **end row-crop agriculture as we know it**. They erroneously claim that "massive production of corn destroys native habitats and poses a significant threat to biodiversity" and say using "biofuels produced from food crops is reckless." And they are not alone; other groups like the Sierra Club, Environmental Working Group, and National Wildlife Federation share the same anti-agriculture, anti-ethanol views.

In short, extreme environmental activists know that if CCS and CO_2 pipelines succeed, row-crop agriculture and biofuels will continue to grow and thrive—and that's not something they want to happen.

Why should farmers support CCS and pipelines?

Over the past 10 years, the U.S. ethanol industry has created a market for **53 billion bushels of corn**, valued at **$224 billion**. In fact, ethanol (and coproducts) has accounted for **37% of total U.S. corn demand** over the past decade, compared to 38% for livestock and poultry feeding. The emergence of the ethanol industry has unquestionably **added value to U.S. corn** and significantly boosted local basis prices. Protecting a major market that farmers have worked so hard to build over the past four decades will require adaptability, innovation, and recognition that global energy dynamics and consumer demands are rapidly evolving.

As world energy markets continue to transition and governments, businesses, and consumers increasingly demand lower-carbon fuels, ethanol producers must continue to reduce the carbon intensity of their products. To maintain or expand domestic and international demand, the industry will need to adopt new technologies to lower ethanol's CI and compete with other emerging low-carbon transportation options. This is true for both traditional ethanol markets like light-duty vehicle fuel and for new, emerging markets like sustainable aviation fuel.

For much of the ethanol industry, the most technologically and economically feasible way to reduce the CI of ethanol in the near term is CCS. And with federal and state policies in place that provide monetary incentives for CI reduction and CCS adoption, the **potential for new value generation in the Midwest farm economy is enormous**.

The future success of U.S. agriculture is inextricably linked to the future success and competitiveness of U.S. renewable fuels. We're in this together.