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Will SAF Turbocharge the Corn Ethanol Market?

The long-run outlook for the corn ethanol industry is questionable, due to a transition to electric and hybrid vehicles. One source of hope for the long run is the potential demand for producing Sustainable Aviation Fuel (SAF). SAF is a key component in the U.S. Aviation Climate Action Plan, a path to net-zero greenhouse gas (GHG) emissions in the aviation industry by 2050[1]. Demand for ethanol for SAF offers hope to the ethanol industry, but it depends a great deal on policy decisions that are being made now. Here we sketch out this story.

What is SAF?

Sustainable aviation fuel (SAF) is a drop-in alternative to petroleum jet fuel, made from renewable feedstocks with low Carbon Intensity (CI) that can reduce GHG emissions on a lifecycle basis[2]. SAF can be made via several pathways from various feedstocks, including the ethanol-to-Jet fuel (ETJ) pathway.

There are two different sets of requirements for a batch of fuel to be qualified as SAF, one by the International Civil Aviation Organization (ICAO), a UN agency of which the U.S. is a member, and the other as specified by the U.S. Inflation Reduction Act of 2022 (IRA). The ICAO requires that GHG emissions be reduced by 10% relative to petroleum aviation fuel, plus some additional restrictions with respect to sensitive land use and water use[3]. The IRA provides for a subsidy of SAF if it reduces GHG emissions by 50% or more. More on this below.

The current level of SAF production is miniscule relative to the potential market. However, many airlines have already tested or implemented SAF in their operations to varying degrees. Some of the major airlines that have used SAF include Alaska Airlines, KLM Royal Dutch Airlines, United Airlines, Lufthansa, British Airways, Qantas, Delta Air Lines, Scandinavian Airlines (SAS), Air France and Virgin Atlantic.

What is driving SAF?

While the air transport industry has committed itself to carbon neutrality by 2050[4], the current somewhat frenzied interest in the U.S. is due to the IRA, which established a tax credit for SAF that reduces GHG emissions by 50% relative to petroleum-based aviation

[1] US 2021 Aviation Climate Action Plan, https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf. The airline industry had earlier bought in to this goal: https://www.iata.org/contentassets/dcd25da635cd4c3697b5d0d8ae32e159/iata-agm-resolution-on-net-zero-carbon-emissions.pdf.
[2]GAO, 2023, Sustainable Aviation Fuel: https://www.gao.gov/products/gao-23-105300 .
[3]ICAO, 2022. CORSIA Sustainability Criteria for CORSIA Eligible Fuels. www.icao.int/environmental-protection/CORSIA/Documents/CORSIA_Eligible_Fuels/ICAO%20document%2005%20-%20Sustainability%20Criteria%20-%20November%202022.pdf
[4]www.iata.org/en/programs/environment/sustainable-aviation-fuels/

fuel. The credit is $1.25/gal plus an additional $0.01/gal for each percent reduction beyond 50%. The IRA specifies that this CI is to be determined using ICAO's CORSIA model or "similar methodology". But on Dec. 15, 2023, the Treasury Department and the IRS jointly issued guidance[5] that a GREET model could be used, but only a new version of GREET, to be known as 40BSAF-GREET, to be released in early 2024[6].

What is Carbon Intensity (CI)?

CI is an index of global warming potential, measured in liquid fuels as grams of CO_2e emitted per megajoule of energy released in combustion, or gCO_2e/MJ. (CO_2e measures lifecycle emissions of carbon dioxide or the equivalent in other greenhouse gases.) Emissions must be based on a life-cycle analysis (LCA) of the fuel. The CI for corn ethanol, for example, includes all aspects of corn production, ethanol processing, transportation, etc., and "Induced Land Use Change" (ILUC).

CI due to ILUC is intended to measure emissions from changes in land use (such as converting grasslands or forests to crops) anywhere in the world that result from the higher grain prices induced by using corn for ethanol. To estimate ILUC, one must estimate the effect of corn ethanol on corn price, and then the effect of that price change on land use everywhere in the world, and finally, estimate the emissions due to that amount of land use change. The ILUC component of corn ethanol CI has been hotly debated over the years, with estimates ranging from 3.9 to105 g CO_2e /MJ.

How is CI determined?

CI cannot be measured directly. It must be modeled by mathematical relationships based on science. Models such as these differ, with no objective way of determining which is most accurate. Scully, et al[7], reviewed 23 recent sources of estimates for U.S. corn ethanol CI (not *corn ethanol SAF*) and concluded that the central best estimate is 51.4 gCO_2e/MJ, compared to an average of about 96 gCO_2e/MJ for gasoline. The largest contributors to corn ethanol CI in that conclusion are 13.2 from corn farming (net of co-product credits), 29.6 from ethanol processing, and 3.9 from ILUC. Two models of particular importance here are:

GREET – is a model developed and maintained by the Department of Energy's Argonne National Laboratory. It is accepted by the U.S. government for determining how a fuel is categorized in satisfying the mandates and subsidies of the Renewable Fuels Standard. In 2019, GREET scored U.S. corn ethanol at an average CI of about 52 gCO_2e/MJ [8]. Components of that CI included 22.5 from corn production (attributable to fuel, fertilizer, change in soil carbon, etc., but net of credits for byproducts), 20.25 from ethanol processing, and 7.4 from ILUC (although GREET's 2023 default for ILUC was 8.6). Ethanol Producer Magazine reports that the carbon intensity added by upgrading to SAF is between 20 and 25 points, which would result in a GREET default CI for corn ethanol SAF at 72-77 gCO_2e/MJ[9] .

CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation, which is a modeling program of the **ICAO**. CORSIA developed and maintains a Carbon Emissions Calculator that estimates average corn *ethanol-based SAF* (ETJ) at 65.7 plus ILUC component of about 25 for a total about 90 gCO_2e/MJ. This compares to their estimate of average petroleum-based aviation fuel CI at about 89 gCO_2e/MJ[10].

Do GREET and CORSIA differ much in their estimates of the CI of ethanol-based SAF?

Yes, they do in some ways. According to CORSIA's supporting document, CORSIA's default estimate of the CI of SAF from corn ethanol is 90.6 gCO_2e/MJ, whereas

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[5]https://www.irs.gov/newsroom/treasury-irs-issue-guidance-on-sustainable-aviation-fuel-credit.

[6]The target date for release was March 1, but it has been delayed "a few weeks" https://ethanolproducer.com/articles/vilsack-release-of-40bsaf-greet-model-to-be-delayed-by-weeks-not-months.

[7]Scully, et al, 2021 Carbon intensity of corn ethanol in the United States: state of the science. https://iopscience.iop.org/article/10.1088/1748-9326/abde08 .

[8]See Scully, et al, above.

[9]"Waiting for Takeoff", Ethanol Producer Magazine, https://ethanolproducer.com/articles/waiting-for-takeoff.

[10]CORSIA Supporting Document: Life cycle assessment methodology, V. 4. 2021. www.icao.int/environmental-protection/CORSIA/Documents/CORSIA_Supporting_Document_CORSIA%20Eligible%20Fuels_LCA_Methodology_V4.pdf

they assert that GREET estimates it at 73 CO_2e/MJ (consistent with numbers we report above). Within those totals, CORSIA estimates default ILUC at 24.9 gCO_2e/MJ, while GREET currently estimates it at 8.6.

What do we know about the new GREET?

Not much. The USDA, DOE, EPA and DOT's Federal Aviation Administration formed the Sustainable Aviation Fuels Lifecycle Analysis Working Group to create the updated GREET model, referred to as 40BSAF-GREET. There are many components they could tweak in calculating CI for corn ethanol SAF. They might change the ILUC component (probably not reduce it, given that it is relatively low). They might decrease the average corn production component to reflect low-carbon farming practices. They might increase the average corn yield, the conversion rate of corn to ethanol, or the conversion rate of ethanol to SAF, any of which would decrease average CI.

Default or supplier values for CI?

The default CI is not really the thing that matters for qualification of a batch of fuel as SAF, but it gives an idea of how the model will evaluate fuels. Any particular SAF supplier can request a lower CI for its product, based on documentation of its supply chain combined with the analytical LCA methods of 40BSAF-GREET or CORSIA. This would be much like individual ethanol plants that have petitioned for low CIs to enter California's Low-Carbon Fuel market. On March 5, Brazilian corn-ethanol producer FS gained certification from CORSIA to produce SAF, for its second-crop corn ethanol.[11]

How big would the SAF market be?

Annual consumption of aviation fuel is returning to its pre-COVID levels of about 18 billion gallons within the U.S., and 90 billion gallons world-wide[12]. The federal government's "SAF Grand Challenge" is to produce 3 billion gallons of SAF per year by 2030, and about 35 billion gallons by 2050[13].

What would it mean for ethanol if the Grand Challenge were to be achieved using ethanol-based SAF? The ICAO reports that the conversion rate is 0.6 gal SAF per gallon of ethanol[14], so if ethanol were to capture the entire SAF market, it would imply a new demand of about 5 billion gallons of ethanol for SAF by 2030, and about 60 billion gallons by 2050. This compares to current production of corn ethanol of about 18 billion gallons per year. Note that corn ethanol SAF may be qualified by CORSIA to be counted by airlines toward their emissions reduction goals, even though its CI is not sufficiently low to qualify for the IRA tax credit. Other feedstocks, such as oilseeds and ethanol from sugar, will be eligible to compete for the SAF market, but the potential increase in demand for corn ethanol is substantial.

Conclusions

Based on the information available as of March 8, there appears to be a chance that in the long run, SAF could indeed turbocharge the corn ethanol industry. Current average estimates of the CI of ethanol-based SAF are too high for it to qualify for the IRA subsidy, but may still be sufficiently low to be qualified by CORSIA as SAF for the international airline industry. The new 40BSAF-GREET could considerably change its estimates of corn ethanol CI. But the default estimates of CI are not all that matters, given that the CI of a particular batch will be based on documentation of the producer's supply chain, combined with LCA model analysis. We must wait "a few weeks", as Secretary Vilsack suggested, for more clarity about the role of the new GREET model and how it will be interpreted by regulatory authorities.

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[11] https://www.argusmedia.com/en/news-and-insights/latest-market-news/2544002-iscc-clears-brazil-s-fs-corn-ethanol-for-saf
[12] Statista.com, accessed March 1, 2024, GAO, 2023; Report to Congressional Committees on Sustainable Aviation Fuel https://www.gao.gov/products/gao-23-105300 .
[13] GAO, 2023, Sustainable Aviation Fuel, https://www.gao.gov/assets/830/820353.pdf.
[14] ICAO, SAF Rules of Thumb https://www.icao.int/environmental-protection/Pages/SAF_RULESOFTHUMB.aspx

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