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Closing The Gap...When More Of The Less Is Needed

SUGAR BEETS PROJECT

Production of Sustainable Aviation Fuels (SAF)
from Ethanol

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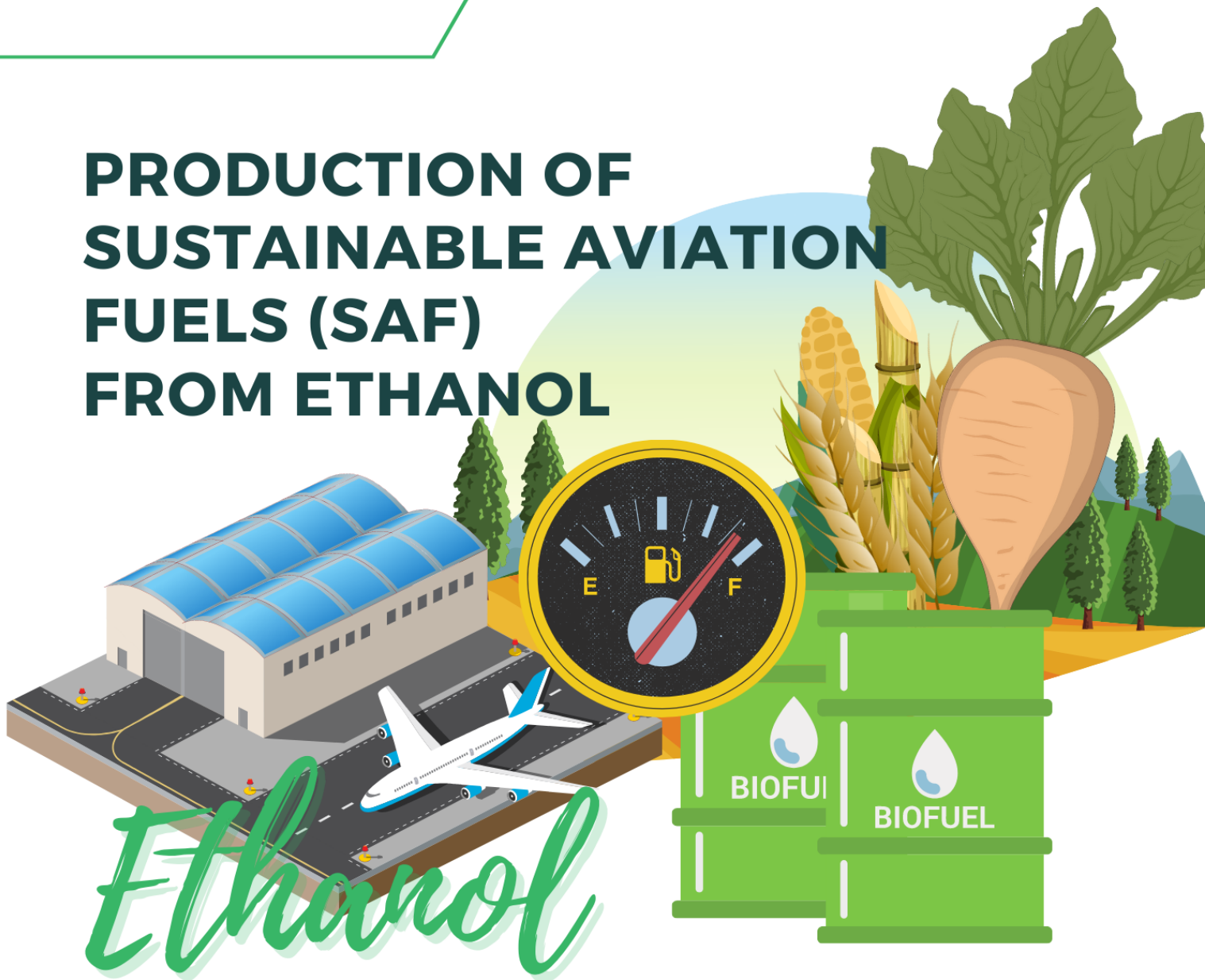
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PRODUCTION OF SUSTAINABLE AVIATION FUELS (SAF) FROM ETHANOL



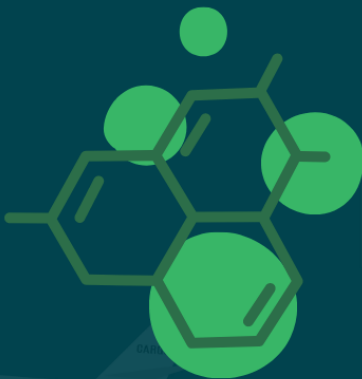
Ethanol is a type of biofuel that is produced from biomass, such as sugar beet, corn, sugarcane, and wheat. Ethanol can be used to produce SAF through a process called the ethanol-to-jet (ETJ) process.

THE ETHANOL-TO-JET (ETJ) PROCESS



1

The ethanol is heated and converted into synthetic kerosene (SK).



2

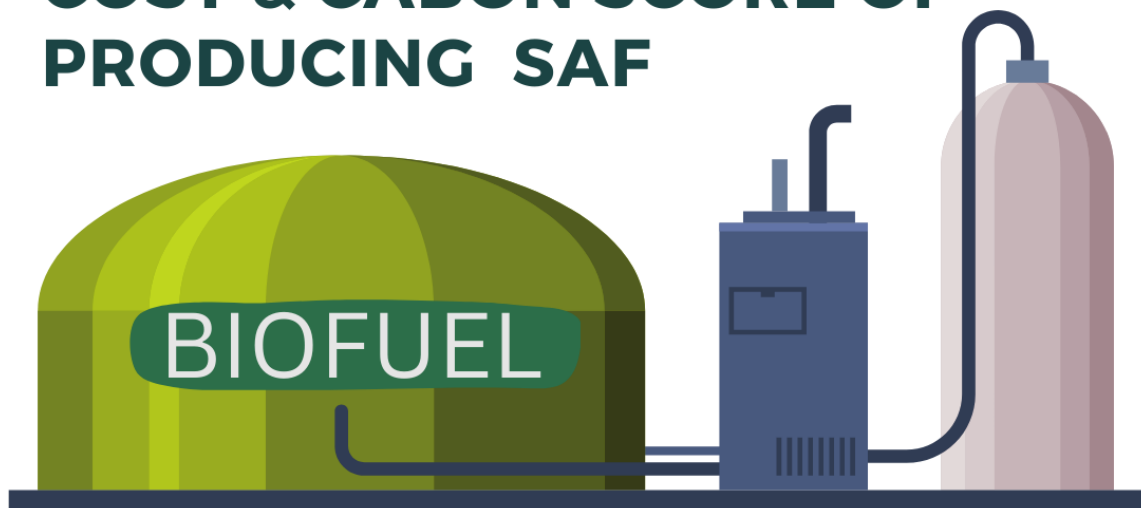
The SK is hydrogenated to remove the oxygen atoms and produce SAF.



3

The SAF is purified to remove impurities, such as water and sulfur.

COST & CARBON SCORE OF PRODUCING SAF



COST OF PRODUCING SAF FROM ETHANOL

\$1.77 PER GALLON

The cost of producing SAF from ethanol is estimated to be around \$1.77 per gallon. This is based on the estimated cost of ethanol from sugar, the estimated cost of the processing steps, and the estimated cost of the catalyst.

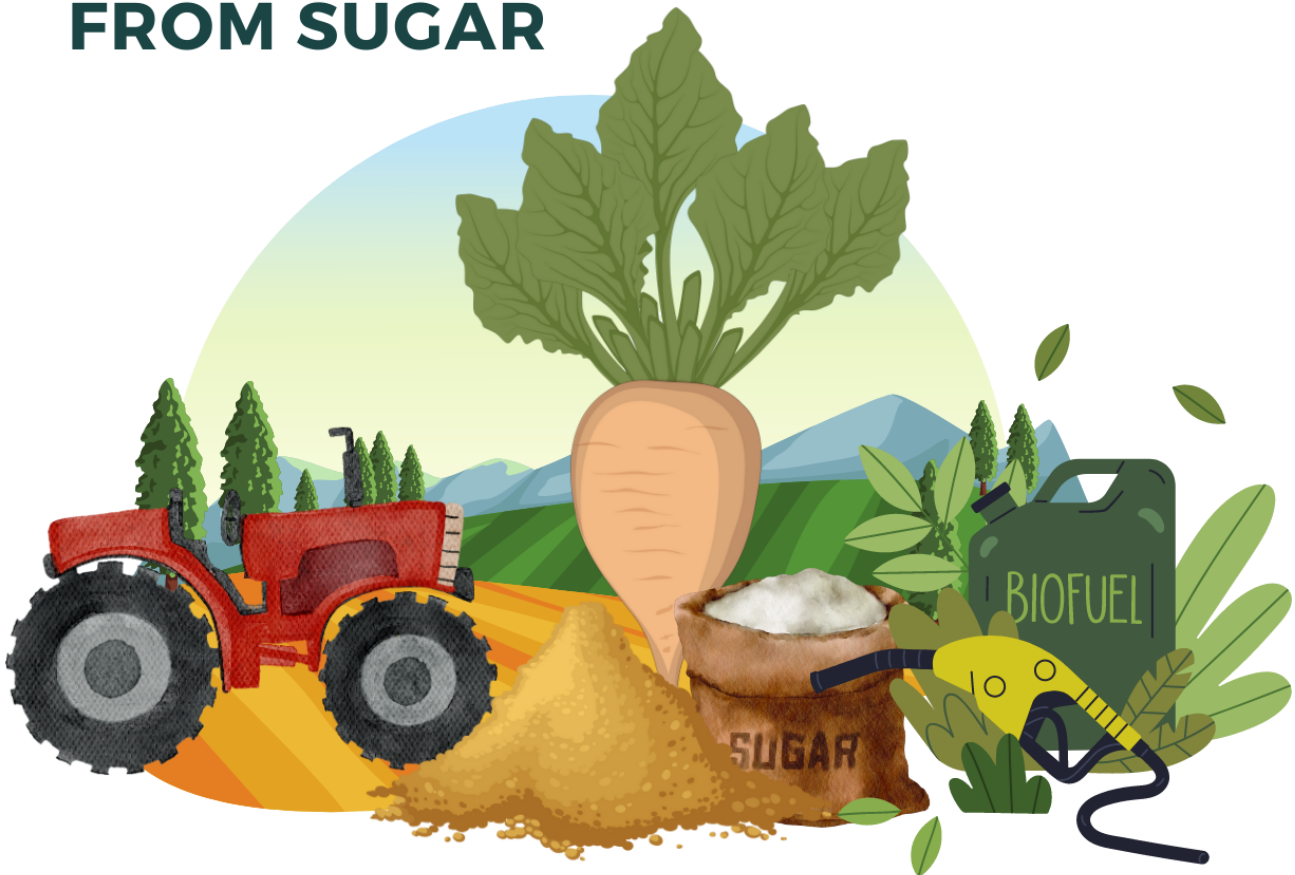
The production of SAF from ethanol is a promising alternative to conventional jet fuel. The cost of producing SAF from ethanol is estimated to be around \$1.77 per gallon, but it is expected to decrease as the technology matures and the scale of production increases. The Inflation Reduction Act of 2022 (IRA) provides tax credits for SAF that meets certain requirements, which will help to make SAF more competitive with conventional jet fuel.

CARBON SCORE OF SAF PRODUCED FROM ETHANOL

SCORE **CO₂**
01 36 TONS

The carbon score of SAF produced from ethanol is estimated to be around 1.36 tons of CO₂e. This is based on the estimated carbon emissions from the production of ethanol, the conversion of ethanol to SAF.

COST OF ETHANOL FROM SUGAR



The cost of ethanol from sugar is estimated to be around \$1.27 per gallon using molasses as a feedstock using molasses is the closest thing comparable to sugar beet powder based on the concentration of sugar and the simpler production steps. This is based on the market prices of molasses in the United States. The cost of ethanol from sugar cane or sugar beets and that's fully refined is likely to be higher, as these feedstocks are more expensive.

The cost of converting ethanol to SAF is estimated to be around \$0.50 per gallon. This includes the cost of the catalyst, the cost of energy, and the fixed costs. The cost of the catalyst is the most significant cost factor, followed by the cost of energy.

The total cost of producing SAF from ethanol is estimated to be around \$1.77 per gallon. This is based on the estimated cost of ethanol from sugar and the estimated cost of converting ethanol to SAF.

The cost of SAF is expected to decrease as the technology for producing SAF matures and the scale of production increases. The International Air Transport Association (IATA) estimates that the cost of SAF could be as low as \$0.70 per gallon by 2030.

ESTIMATED COSTS FOR PRODUCING SAF FROM ETHANOL

COST OF ETHANOL

\$1.27

per gallon

COST OF CONVERTING ETHANOL TO SAF

\$0.50

per gallon

TOTAL COST OF PRODUCING SAF

\$1.77

per gallon

The cost of SAF is still higher than the cost of conventional jet fuel, but it is expected to become more competitive in the coming years. SAF is a promising alternative to conventional jet fuel, and it is expected to play an increasing role in the decarbonization of the aviation industry.

THE PROCESS OF PRODUCING SAF FROM ETHANOL CAN BE DIVIDED INTO THREE MAIN STEPS:



CONVERSION OF ETHANOL TO SYNTHETIC KEROSENE (SK)

In this step, the ethanol is heated and converted into SK in a reactor. The catalyst used in this step is typically a metal oxide, such as zinc oxide or cobalt oxide.



HYDROGENATION OF SK

In this step, the SK is hydrogenated to remove the oxygen atoms and produce SAF. The hydrogen is typically supplied by a hydrogen reformer.



PURIFICATION OF SAF

In this step, the SAF is purified to remove impurities, such as water and sulfur. This is done by distillation or adsorption.

The cost of each of these steps varies depending on the specific technology used. However, the overall cost of producing SAF from ethanol is expected to be lower than the cost of producing SAF from other feedstocks, such as biomass.

BREAKDOWN OF THE ESTIMATED COSTS FOR EACH OF THE PROCESSING STEPS

Conversion of ethanol to SK	\$0.30	per gallon
Hydrogenation of SK	\$0.20	per gallon
Purification of SAF	\$0.05	per gallon
Total cost of processing steps	\$0.55	per gallon

The total cost of producing SAF from ethanol is estimated to be around \$1.77 per gallon, as mentioned earlier. This is based on the estimated cost of ethanol from sugar, the estimated cost of the processing steps, and the estimated cost of the catalyst.

The cost of SAF is expected to decrease as the technology for producing SAF matures and the scale of production increases. The International Air Transport Association (IATA) estimates that the cost of SAF could be as low as \$0.70 per gallon by 2030.

INFLATION REDUCTION ACT OF 2022 (IRA)

The IRA provides a tax credit of \$1.25 per gallon for SAF that meets certain requirements. These requirements include having a minimum reduction of 50% in lifecycle greenhouse gas emissions compared to conventional jet fuel. The credit is available for SAF produced in the United States in calendar years 2023 and 2024.

The IRA also provides a tax credit of \$0.50 per gallon for SAF that has a lifecycle greenhouse gas emissions reduction of at least 75%. This credit is available for SAF produced in the United States in calendar years 2025 and 2027.



Factor in the subsidies and credit from the IRA, the estimated cost of producing SAF from ethanol is reduced to around \$0.97 per gallon in calendar years 2023 and 2024. This is based on the estimated cost of ethanol from sugar, the estimated cost of the processing steps, and the estimated cost of the catalyst, minus the tax credit.

The estimated cost of producing SAF from ethanol is reduced to around \$0.52 per gallon in calendar years 2025 and 2027. This is based on the estimated cost of ethanol from sugar, the estimated cost of the processing steps, and the estimated cost of the catalyst, minus the tax credit for SAF with a lifecycle greenhouse gas emissions reduction of at least 75%.

SUBSIDIES AND CREDIT FROM THE IRA

The subsidies and credit from the IRA will help to make SAF more competitive with conventional jet fuel. This is expected to encourage the production of SAF and help to reduce the greenhouse gas emissions.

BRIEF SUMMARY:

COST OF ETHANOL FROM SUGAR

\$1.27

per gallon

COST OF CONVERTING ETHANOL TO SAF

\$0.50

per gallon

COST OF PROCESSING STEPS TO PRODUCE SAF

\$0.55

per gallon

COST OF THE CATALYST FOR PRODUCING SAF

\$0.10

per gallon

**IRA TAX CREDIT
(SAF THAT MEETS CERTAIN REQUIREMENTS)**

\$1.25

per gallon



THE CARBON SCORE OF SAF PRODUCED FROM ETHANOL

The carbon score of SAF produced from ethanol is estimated to be lower than the carbon score of conventional jet fuel. This is because SAF does not contain any fossil fuels, and the carbon emissions from its production are relatively low.



STEP	CARBON SCORE
Production of ethanol	1.00
Conversion of ethanol to SAF	0.10
Processing steps	0.26
TOTAL	1.36

The unit of measurement for the carbon score is tons of carbon dioxide equivalent (CO₂e). This means that the carbon score of 1.36 for SAF produced from ethanol is equivalent to 1.36 tons of CO₂e.



NOTE:

The average passenger car emits around 4.6 tons of CO₂ per year. So, the carbon score of 1.36 for SAF produced from ethanol is equivalent to the emissions of about 300 passenger cars per year.

RELEVANT LINKS AND INFORMATION

- The cost of ethanol from sugar: This information is from the U.S. Department of Energy's (DOE) Biomass Program. The DOE estimates that the cost of ethanol from sugar is around \$1.27 per gallon using molasses as a feedstock.
- The cost of converting ethanol to SAF: This information is from a study by the National Renewable Energy Laboratory (NREL). The NREL study estimates that the cost of converting ethanol to SAF is around \$0.50 per gallon.
- The cost of the processing steps: This information is from a study by the International Air Transport Association (IATA). The IATA study estimates that the cost of the processing steps for producing SAF from ethanol is around \$0.55 per gallon.
- The cost of the catalyst: This information is from a study by the DOE's Biomass Program. The DOE study estimates that the cost of the catalyst for producing SAF from ethanol is around \$0.10 per gallon.
- The subsidies and credit from the Inflation Reduction Act of 2022 (IRA): This information is from the text of the IRA. The IRA provides a tax credit of \$1.25 per gallon for SAF that meets certain requirements. These requirements include having a minimum reduction of 50% in lifecycle greenhouse gas emissions compared to conventional jet fuel. The credit is available for SAF produced in the United States in calendar years 2023 and 2024.
- <https://biofuelscentral.com/honeywell-revolutionizes-ethanol-to-jet-fuel-technology-to-meet-rising-demand-for-sustainable-aviation-fuel/>
- <https://dspace.mit.edu/bitstream/handle/1721.1/140169/Kelso-wtkelso-MS-AeroAstro-2021-thesis.pdf?sequence=1&isAllowed=y>

**For inquiries,
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